FOREST HEALTH ANNUAL REPORT

DEPARTMENT OF NATURAL RESOURCES

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Cover photo: regional forest health specialist investigating cause of death on basswood.

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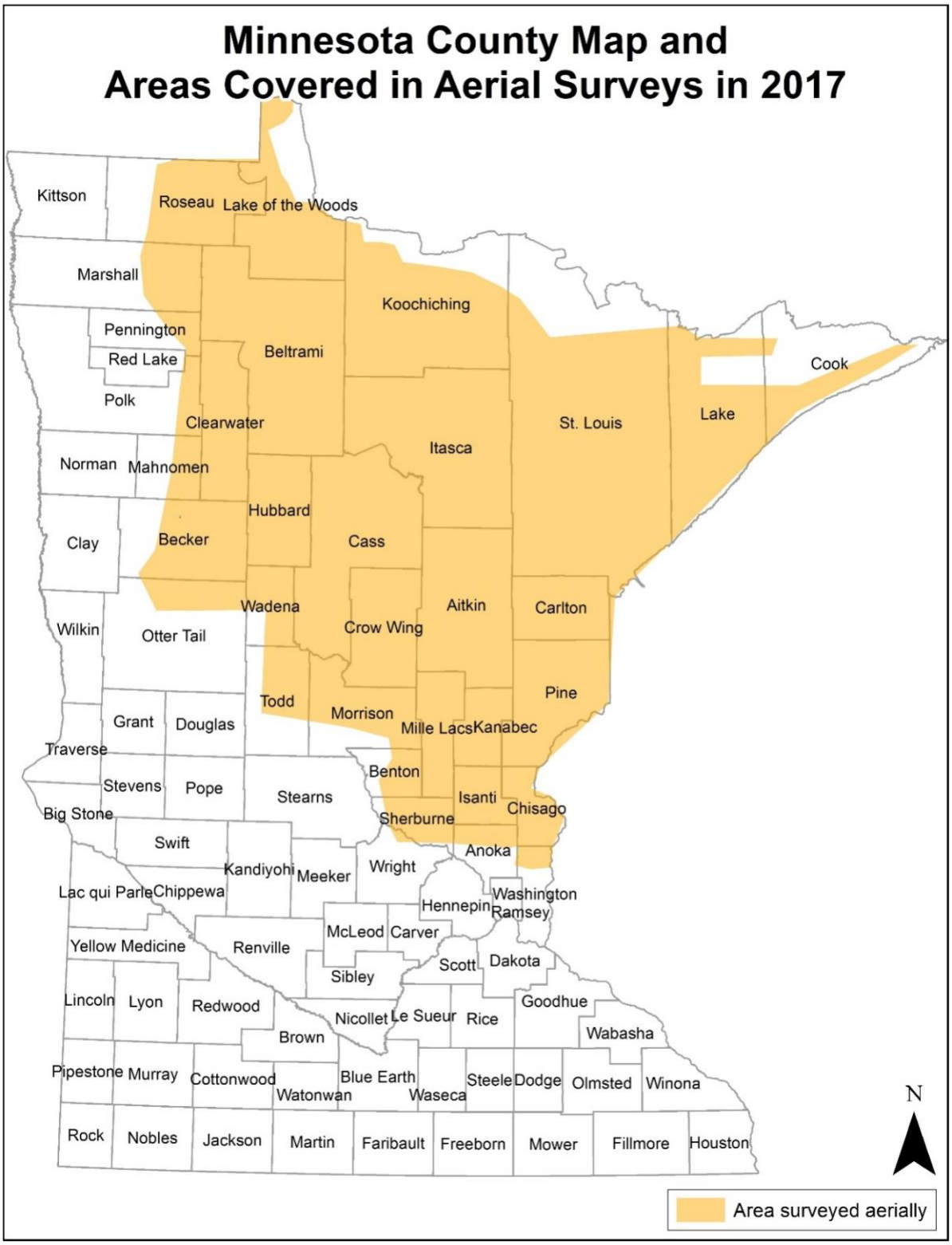
Forested Areas Surveyed Aerially in 2017



Annual Aerial Survey

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 picked up with surveys are large insect outbreaks, wind events, and fire damage; other problems such as root diseases cannot be consistently detected from the air. 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 are incorporated into a US Forest Service national database and can also be found in the Minnesota Geospatial Commons (keywords "forest health"). The summary table below shows the amount of acres damaged by insects, disease, and other factors.

Comparison of aerial survey results from 2015 to 2017

Damage agent	Acres affected in 2015	Acres affected in 2016	Acres affected in 2017	Comments
Eastern larch beetle	33,786	67,983	211,131	2017 was another record year in terms of both new damage observed and total damage observed in a single year.
Spruce budworm	105,522	130,514	68,213	
Forest tent caterpillar	65,750	14,798	40,433	The 2016 value is an underestimate due to partial survey coverage of the state.
Oak wilt	Not surveyed	Not surveyed	23,697	Only about one-third of the known range of oak wilt in Minnesota's forests was surveyed, so this is an underestimate.
Larch casebearer	14,220	15,286	21,938	
Aspen and birch decline	38,948	15,052	19,054	

Damage agent	Acres affected in 2015	Acres affected in 2016	Acres affected in 2017	Comments
Flooding	1,066	5,692	6,427	Not all flooded forests can be surveyed each year, so these numbers are underestimates
Wind damage	3,232	18,953	6,037	
Jack pine budworm	5,210	2,392	4,275	The 2016 value is likely an underestimate due to storm interference with aerial survey.
Twolined chestnut borer	106	607	2,845	The values in 2015 and 2016 are underestimates due to suboptimal survey timing and incomplete survey coverage.
Hail	Not detected	454	3,479	
Bark beetles on pine, spruce, and fir	3,154	65	1795	The 2016 value was an underestimate but still accurately reflected a declining trend in bark beetle populations. All but four acres in 2017 were on pines.
Wildfire	7,507	1,557	333	Unobserved fire damage occurring after aerial survey is complete usually leads to an underestimate of damaged acres each year.
Northern hardwood decline	4,768	1,214	15	

Damage agent	Acres affected in 2015	Acres affected in 2016	Acres affected in 2017	Comments
Emerald ash borer	Not Surveyed	3715	Not surveyed	Only Winona and Houston counties were surveyed in 2016, so this is an underestimate.
Birch leafminer	Not detected	932	Not detected	The 932 acres observed in 2016 belonged to a single localized outbreak that was not observed again in 2017.

Forest Pest Conditions Report

This 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 Reporter database used to produce the national Forest Insect and Disease Conditions Report.

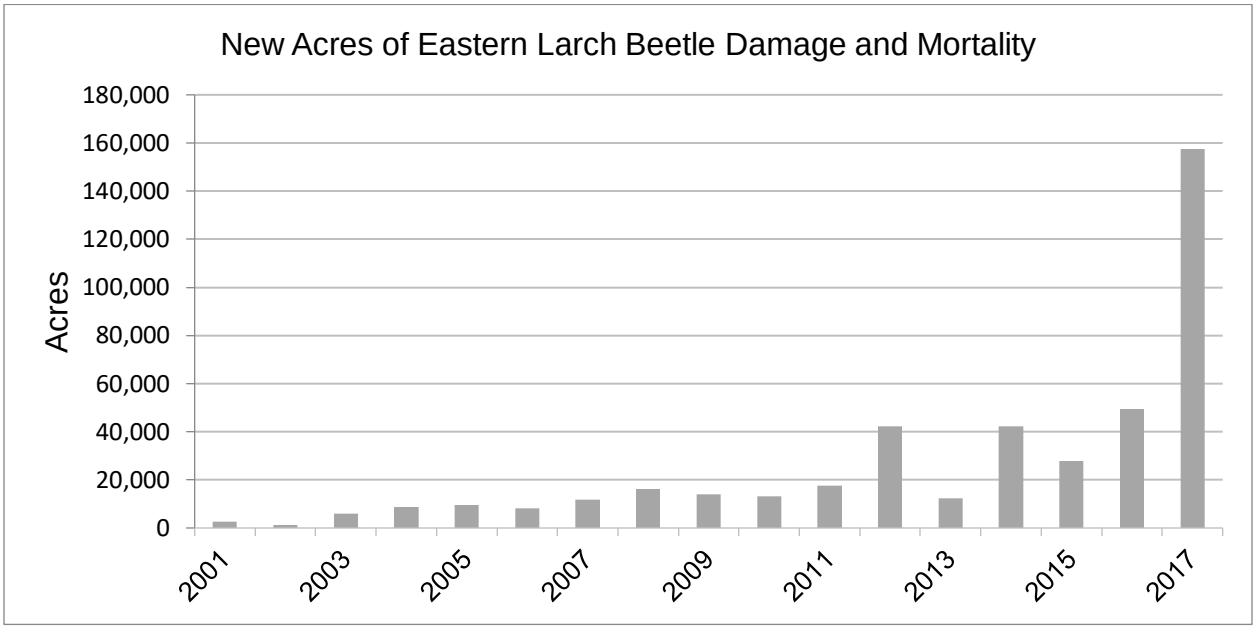
Insects

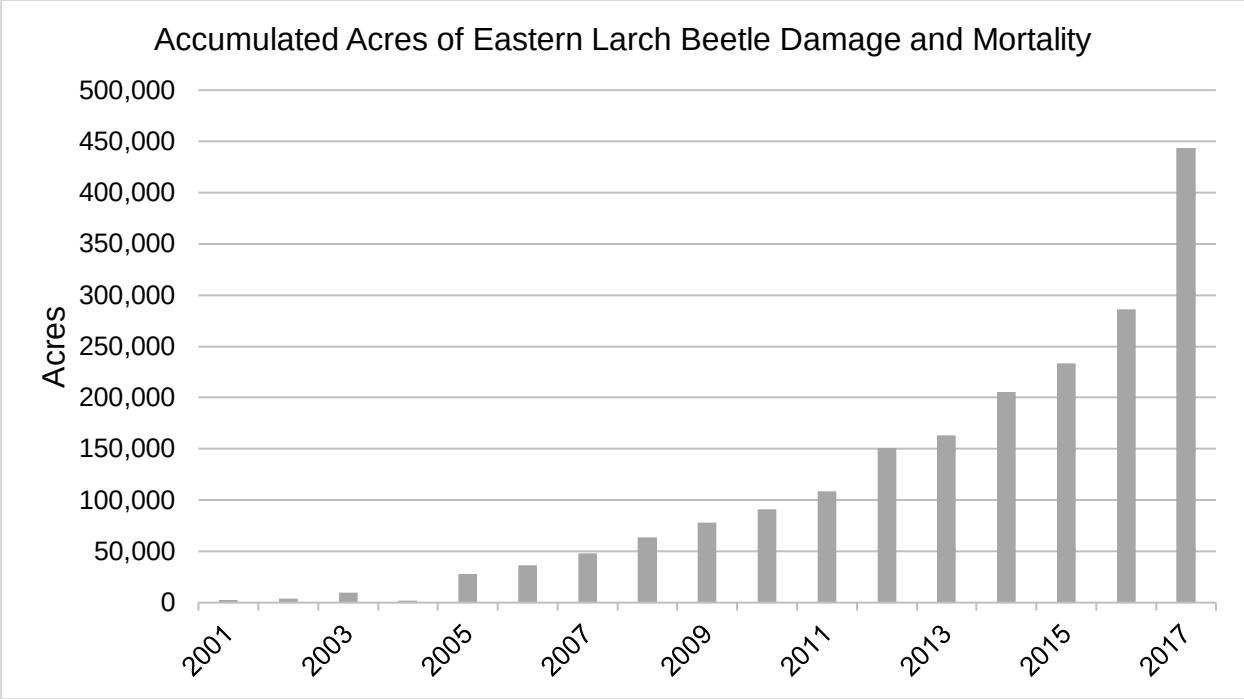
Eastern larch beetle

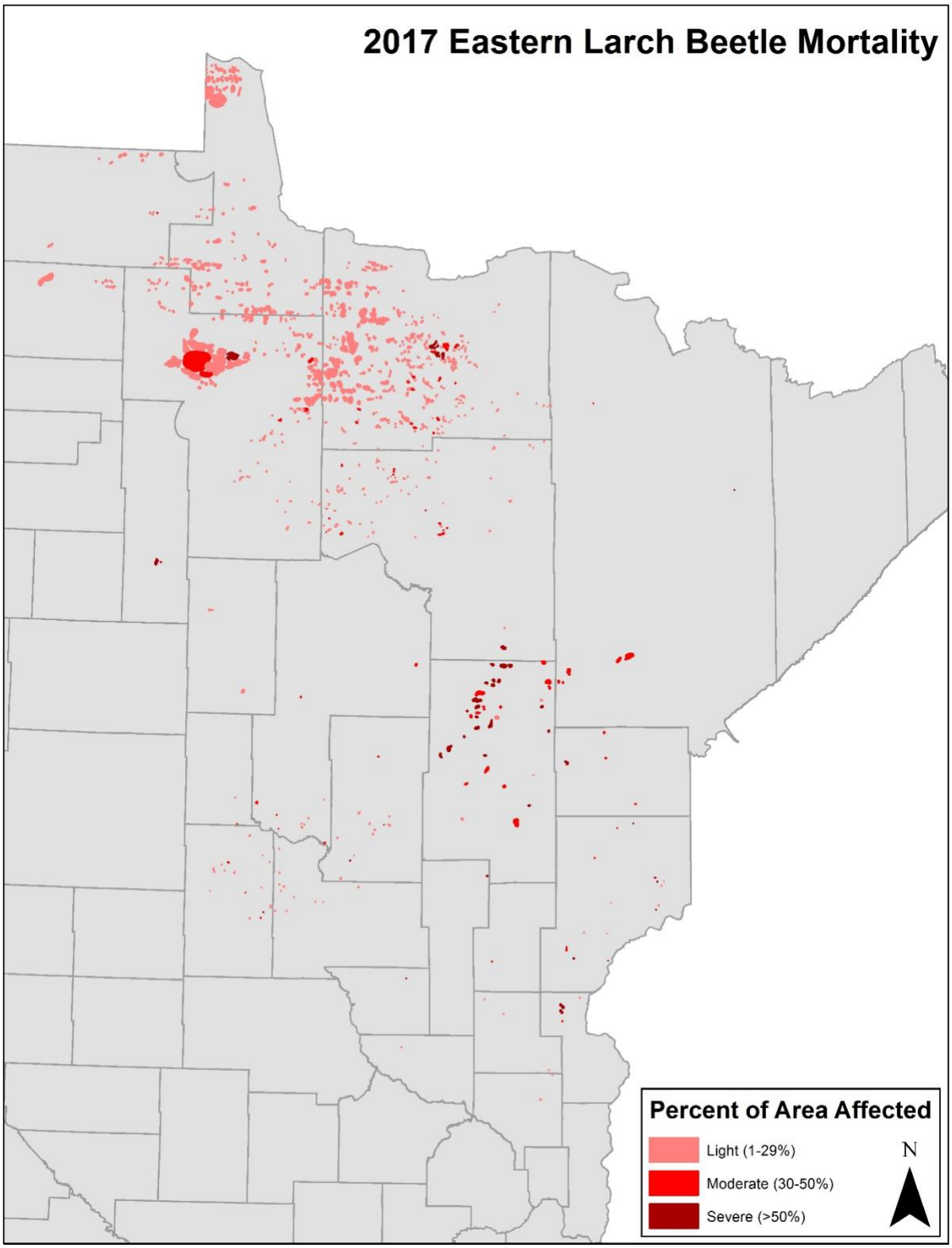
Eastern larch beetle (ELB) is a native bark beetle that attacks tamarack. We saw another record-setting year of acreage affected by ELB in 2017. Since 2001, accumulated acres of tamarack affected by ELB has reached 440,353 acres statewide. Newly-documented damage greatly increased from 49,517 acres in 2016 to a daunting 157,542 acres in 2017. This increase is due in part to the fact that a large portion of Koochiching Co. was not surveyed in 2016; however, this alone cannot account for the entire increase. Although a large proportion of the damage area currently consists of only light damage (less than 30 percent of trees impacted), ELB should be expected to spread throughout these areas until mortality becomes severe in the upcoming years.

Eastern larch beetle prefers large, mature trees and is removing them from our forests at an alarming rate. In light of the outbreak, we recommend that managers attempt to actively manage stands in order to establish the next generation of trees on the site. Ideally this would be done prior to or in the early stages of eastern larch beetle infestation. Although regeneration does exist under some stands with severe mortality, many others have become excessively wet following the loss of tree cover or have now been invaded by plant species that outcompete tamarack seedlings. Unfortunately, poor markets and difficult winter access have made tamarack management exceedingly difficult in recent years. At the same time, lack of management could result in the loss of much of this forest type.

Eastern larch beetle galleries




Accumulated Acres of Eastern Larch Beetle Damage and Mortality
Acres
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
2001
2003
2005
2007
2009
2011
2013
2015
2017

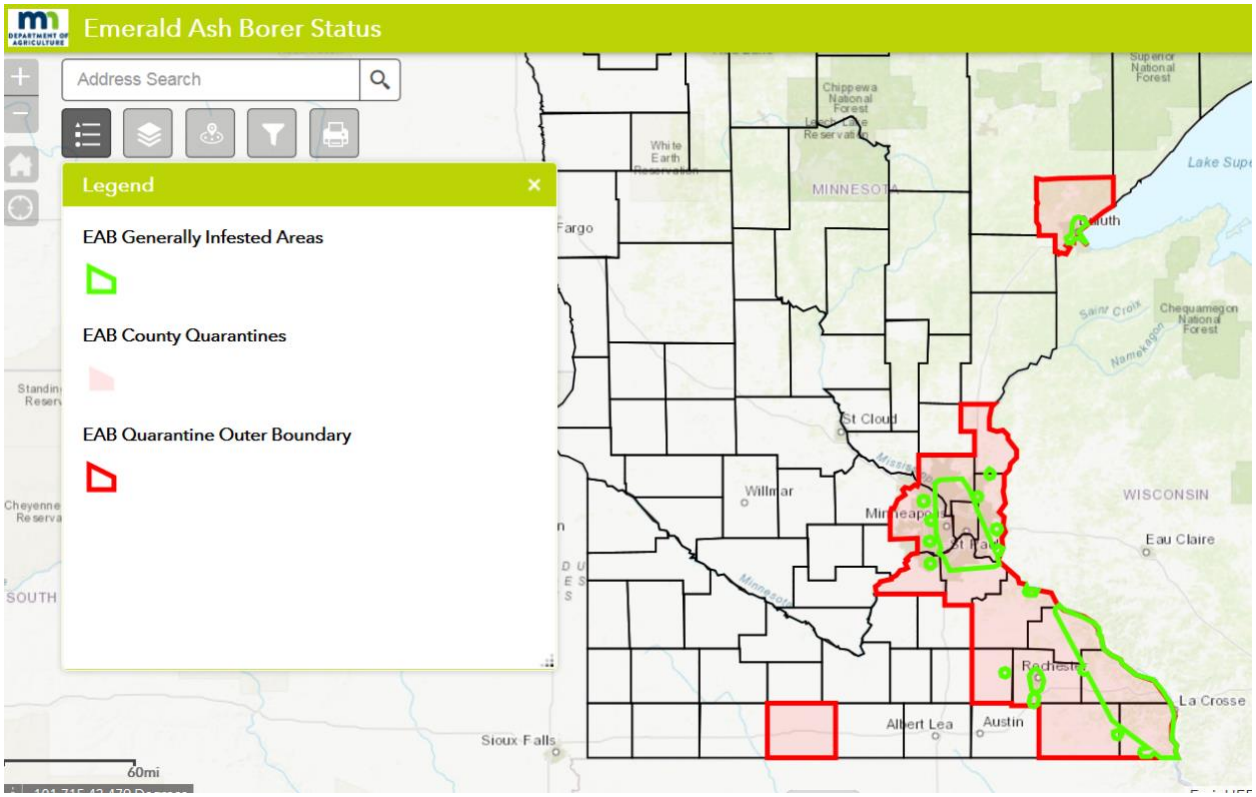

2017 Eastern Larch Beetle Mortality
Percent of Area Affected
Light (1-29%)
Moderate (30-50%)
Severe (>50%)
N

Emerald ash borer

The Minnesota Department of Agriculture (MDA) continues to be the lead agency for the emerald ash borer program in general. For the past two years, USDA Animal and Plant Health Inspection Service (APHIS) has taken over emerald ash borer (EAB) monitoring with panel traps. EAB was found for the first time in Martin and Goodhue counties in 2017.

MDA conducts parasitoid releases in various parts of the state where EAB has been detected (see map). In 2017, staff released 68,496 parasitoids, including *Tetrastichus planipennisi*, *Oobius agrili*, and *Spathius galinae*. Each site averaged between 8,000 and 10,000 released parasitoids.

Release sites were distributed as follows: Two sites in Winona and Wabasha Counties, five sites in the Twin Cities metro area, and one site in Duluth. MDA continues to confirm parasitoid survival and reproduction.



Counties with EAB quarantine and generally infested areas within the counties

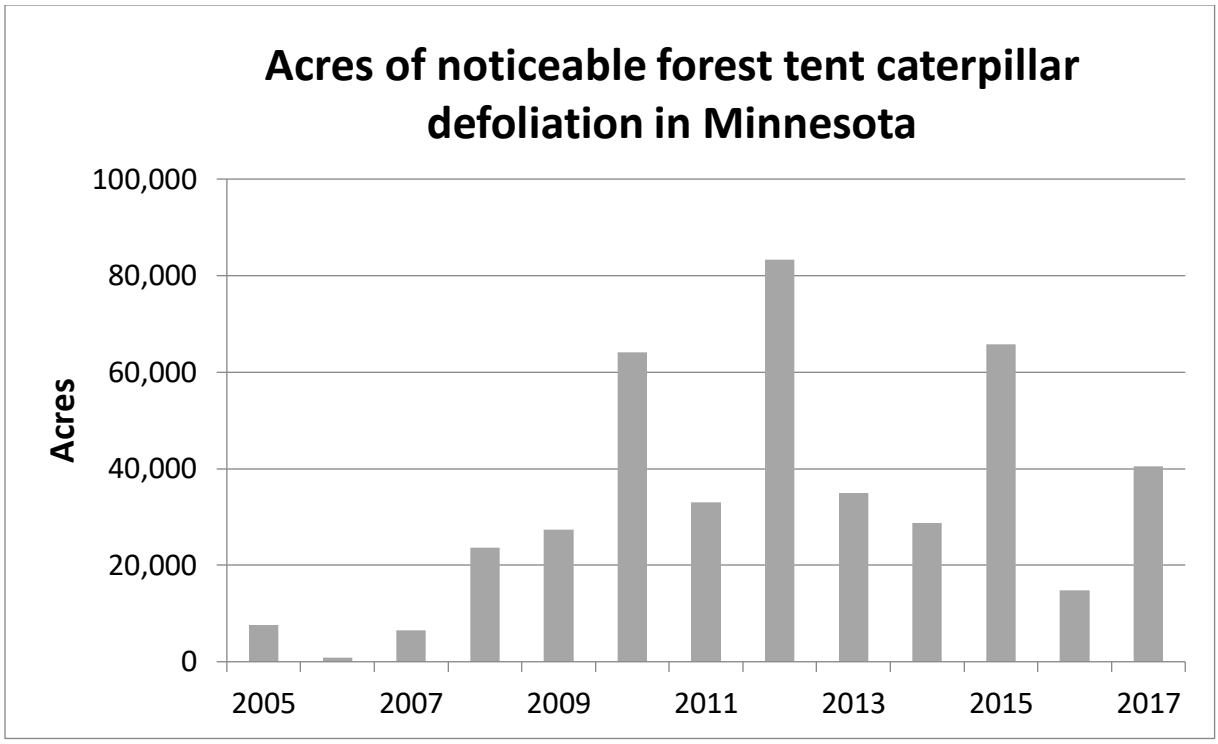
Forest tent caterpillar

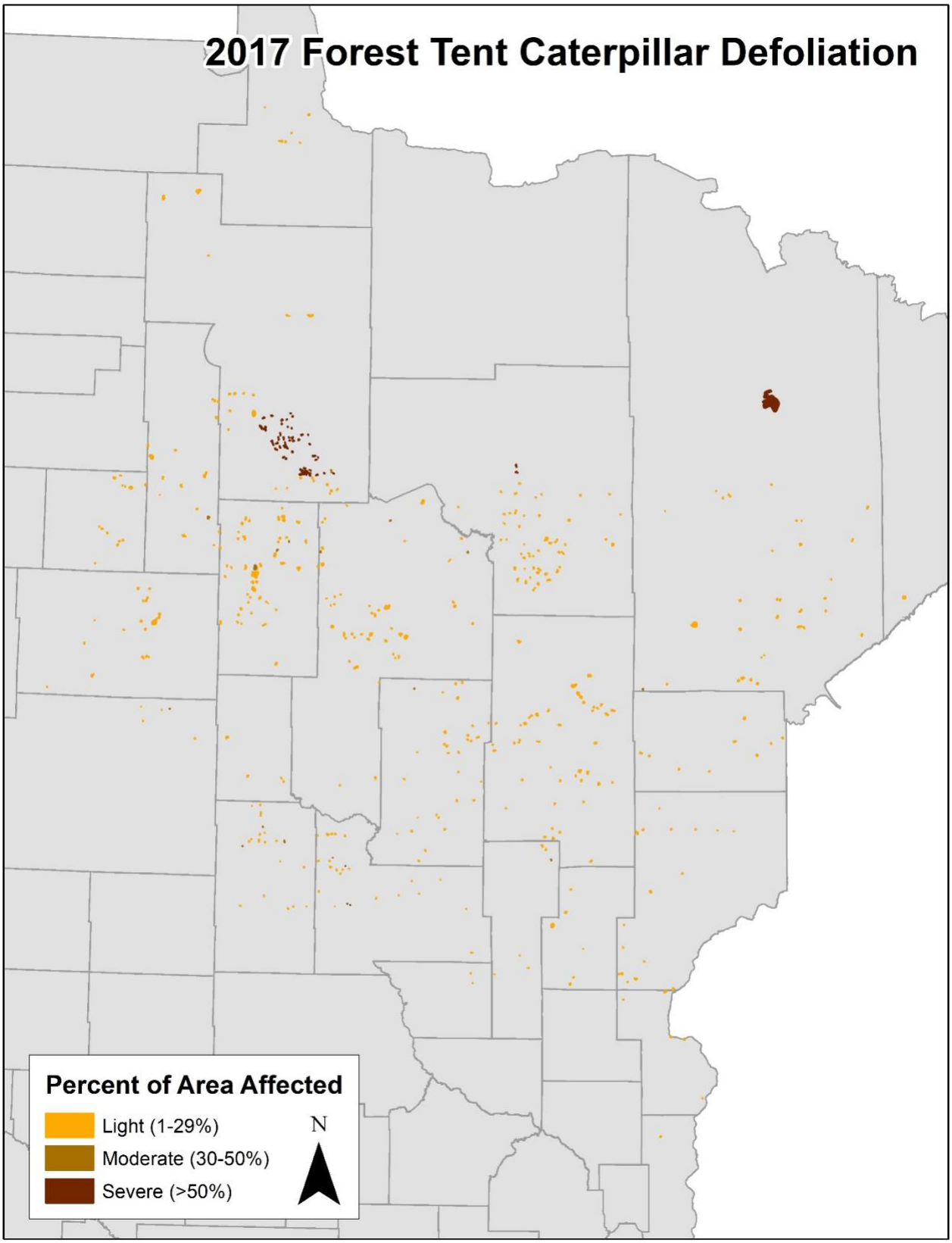
In 2016, only 14,725 acres of hardwoods were recorded with noticeable levels of defoliation by forest tent caterpillar (FTC), a sharp decrease from the 65,750 acres recorded in 2015. This marked decrease was mainly due to severe weather events in 2016 that prevented us from conducting our early aerial survey flights.

In 2017, however, weather was much more cooperative, and surveys for FTC were completed by the end of June. We mapped 40,433 acres of FTC defoliation. Defoliation was scattered across the northern half of the state, with a single large area of defoliation in northern St. Louis County that has had consistent FTC activity for several years (see map). Producing a second flush of leaves is energetically taxing for trees and can eventually result in significant damage to branches or whole trees. In areas with repeated heavy defoliation, tree death and branch dieback can occur. If you are a forest manager, consider regenerating aspen stands nearing rotation age in areas with multiple years of severe FTC defoliation.

From 2004 to 2016, our surveyors recorded very light levels of defoliation that likely had minimal impact to tree health. In the chart below, we excluded those levels of defoliation. See the 2015 annual report for a chart showing of all levels of defoliation by FTC.

Forest tent caterpillars aggregating on the trunk of a basswood near Grand Rapids.


Acres of noticeable forest tent caterpillar defoliation in Minnesota
Acres
100,000
80,000
60,000
40,000
20,000
0
2005
2007
2009
2011
2013
2015
2017


2017 Forest Tent Caterpillar Defoliation
Percent of Area Affected
Light (1-29%)
Moderate (30-50%)
Severe (>50%)
N

Gypsy moth

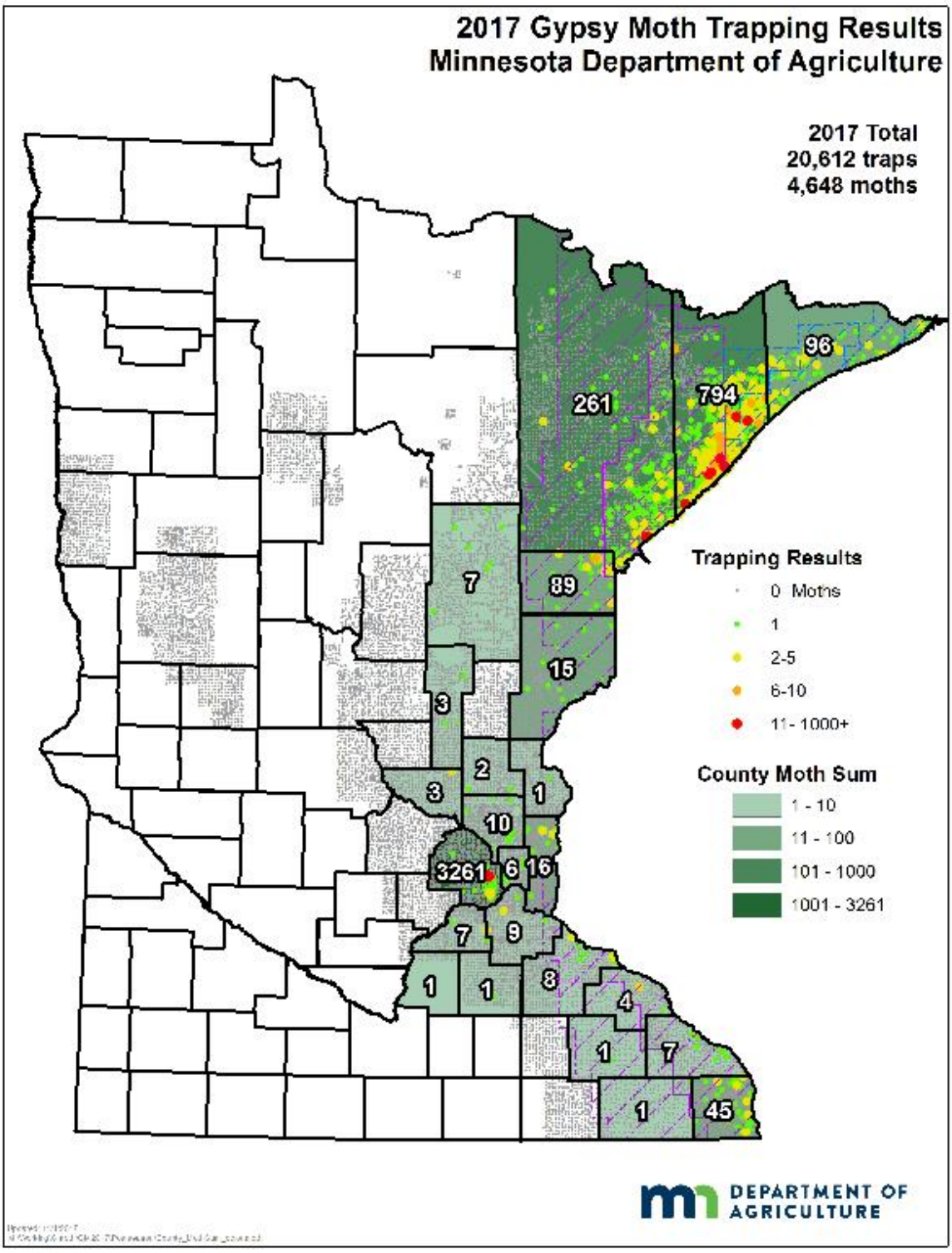
The gypsy moth program is led by the Minnesota Department of Agriculture Division of Plant Protection. The following is an excerpt from a report on the 2017 survey year.

Trapping: In 2017, MDA placed 20,554 survey detection traps within their survey grid (an additional 405 traps were placed by other cooperators; see map, next page). Statewide moth captures totaled 4,648, more than double the 2016 catch, but still much lower than an all-time high of 71,258 moths caught in 2013. Of the moths captured, 70 percent were caught at the proposed treatment site in the Minneapolis Lowry Hill neighborhood (see photo below).

Treatments: Treatments are based in part on egg mass surveys. There were three treatment blocks in 2017 totaling approximately 2,885 acres. Applications of *Bacillus thuringiensis* var. *kurstaki* were made to 1,120 acres across two sites in Hinckley (Pine Co.) and Richfield (Hennepin Co.) An application of SPLAT (mating disruptor chemical) was applied aerially to 1,765 acres in Winona County.

Emergency Quarantine: On July 1, MDA issued an *emergency* quarantine for a 66-acre block in Minneapolis after confirming hundreds of gypsy moth caterpillars in a residential neighborhood. MDA learned about this infestation from a citizen's report. Follow-up moth surveys captured 3,237 moths, the highest single-site capture in Minnesota history.

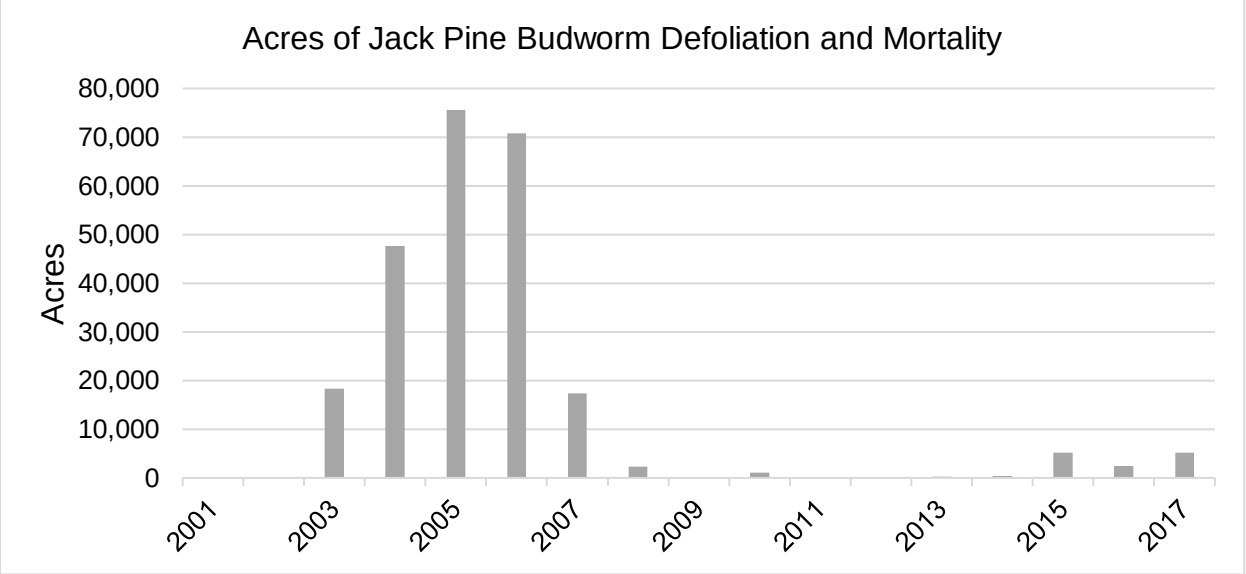
Adult female gypsy moths and egg masses on a tree in Lowry Hill neighborhood in Minneapolis


2017 Gypsy Moth Trapping Results
Minnesota Department of Agriculture
2017 Total
20,612 traps
4,648 moths
Trapping Results
0 Moths
1
2-5
6-10
11 - 1000+
County Moth Sum
1 - 10
11 - 100
101 - 1000
1001 - 3261
96
794
261
89
7
15
3
2
3
1
10
3261
6
16
7
9
1
1
8
4
1
7
1
45
DEPARTMENT OF AGRICULTURE

Jack pine budworm

Jack pine budworm (JPBW) is a native defoliating caterpillar of jack pine. As in 2016, damage from JPBW in 2017 was primarily concentrated along the border of southern Cass County and northern Morrison and Todd counties, in the areas surrounding the towns of Staples, Motley, and Pillager. Overall acreage affected increased from 2,392 acres in 2016 to 4,275 acres in 2017, perhaps validating our suspicion that considerable damage was missed due to delayed aerial surveys in 2016. Approximately two-thirds of the polygons mapped represent defoliation, and one-third of the polygons represent mortality resulting from the ongoing JPBW outbreak in this area over the past several years. Much of this mortality is now associated with stress-induced attack by *Ips* bark beetles.

In the far northwestern part of the state, JPBW outbreaks occur roughly every 10 years. Two new damage areas there are suspected to be due to JPBW, but due to limited summer accessibility, this will be verified during winter 2018. If the damage is due to JPBW, it would fit the expected pattern of outbreak cycling and could indicate the beginning of an outbreak forming in the far northwestern reaches of Minnesota over the next several years.



Japanese beetles

As in 2016, Japanese beetles fed heavily on basswood, paper birch, cherry, wild grape, and many other species in the urban areas of central and southern Minnesota in the summer of 2017. Damage was seen as far north as North Branch in Chisago County. Since Japanese beetles defoliate trees in the latter half of summer, trees do not produce a second set of leaves. This is less stressful on the trees than when trees are defoliated earlier in the season and are forced to produce another set of leaves. Landowners can expect trees impacted by Japanese beetle in the previous two years to produce a healthy set of leaves in 2018.

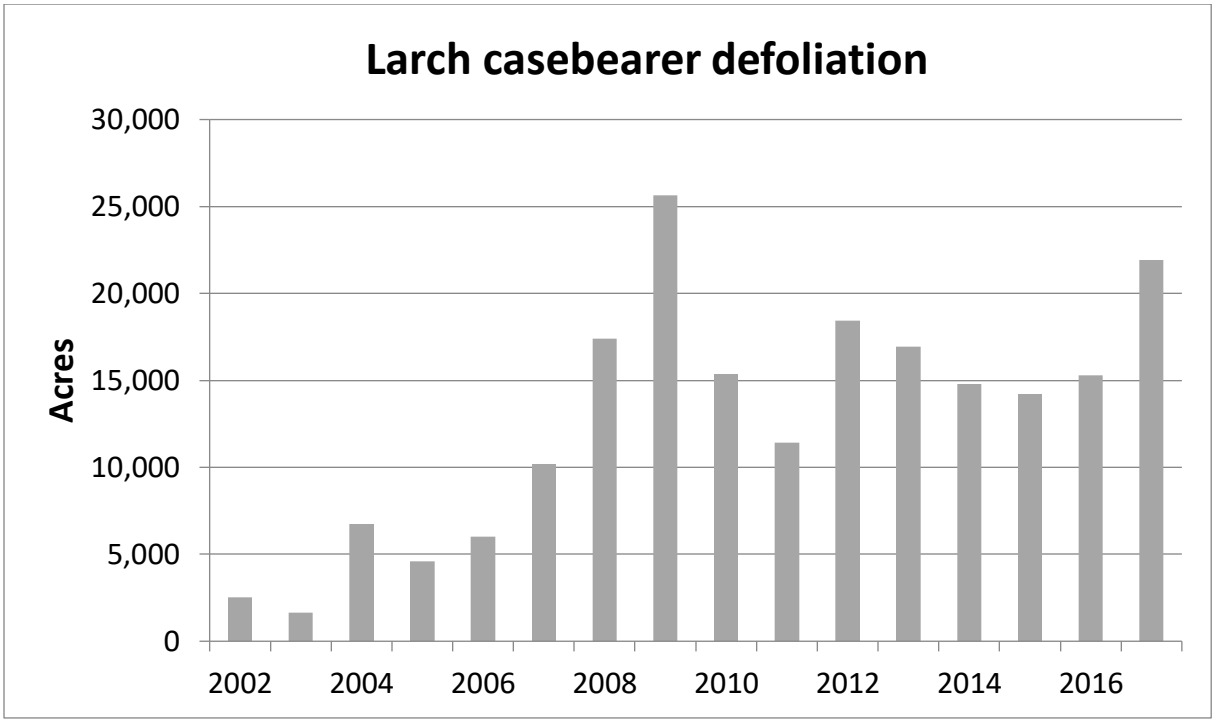
There were higher populations of Japanese beetles in the early 2010s in southern Minnesota. Several dry summers caused the higher beetle population to decline, so we expect the current high population to decline once we experience another summer drought.

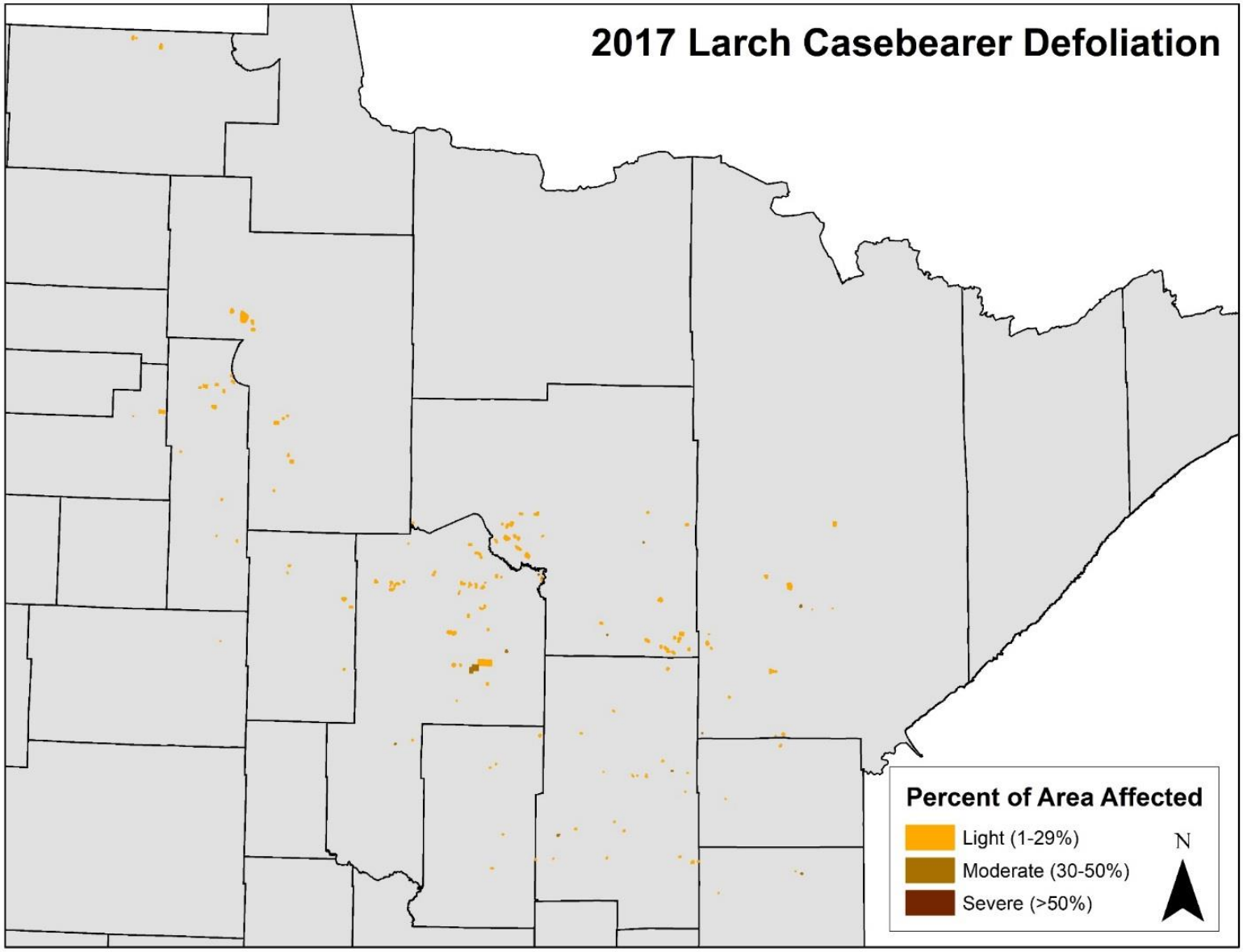
Four basswoods in Hastings have a rusty cast due to defoliation by Japanese beetle.

Larch casebearer

Larch casebearer is a non-native caterpillar that feeds on tamarack. It first began causing noticeable defoliation in 2000. The area affected increased 43 percent from 15,286 acres in 2016 to 21,938 acres in 2017. The majority of acres affected in 2017 consisted of small, diffuse patches spanning the north central and Arrowhead regions. Most new defoliation was concentrated in Cass County (see map), with very little geographic overlap compared to 2016. Factors contributing to the larch casebearer outbreak are largely unknown, but the continual spread over the past several years suggests that acreage affected will likely increase in 2018 as well. Research looking at factors contributing to the current outbreak of larch casebearer in Minnesota is currently underway in the University of Minnesota Department of Entomology forest entomology lab.

Larch has an advantage over other conifers when it comes to dealing with defoliating insects. Being deciduous conifers, they can produce a second flush of foliage when summer defoliators damage early-season needles. While this process is stressful and uses up a large amount of energy, most tamaracks can tolerate defoliation for a few consecutive years before serious dieback or mortality occurs.




2017 Larch Casebearer Defoliation
Percent of Area Affected
Light (1-29%)
Moderate (30-50%)
Severe (>50%)
N

Rose chafers

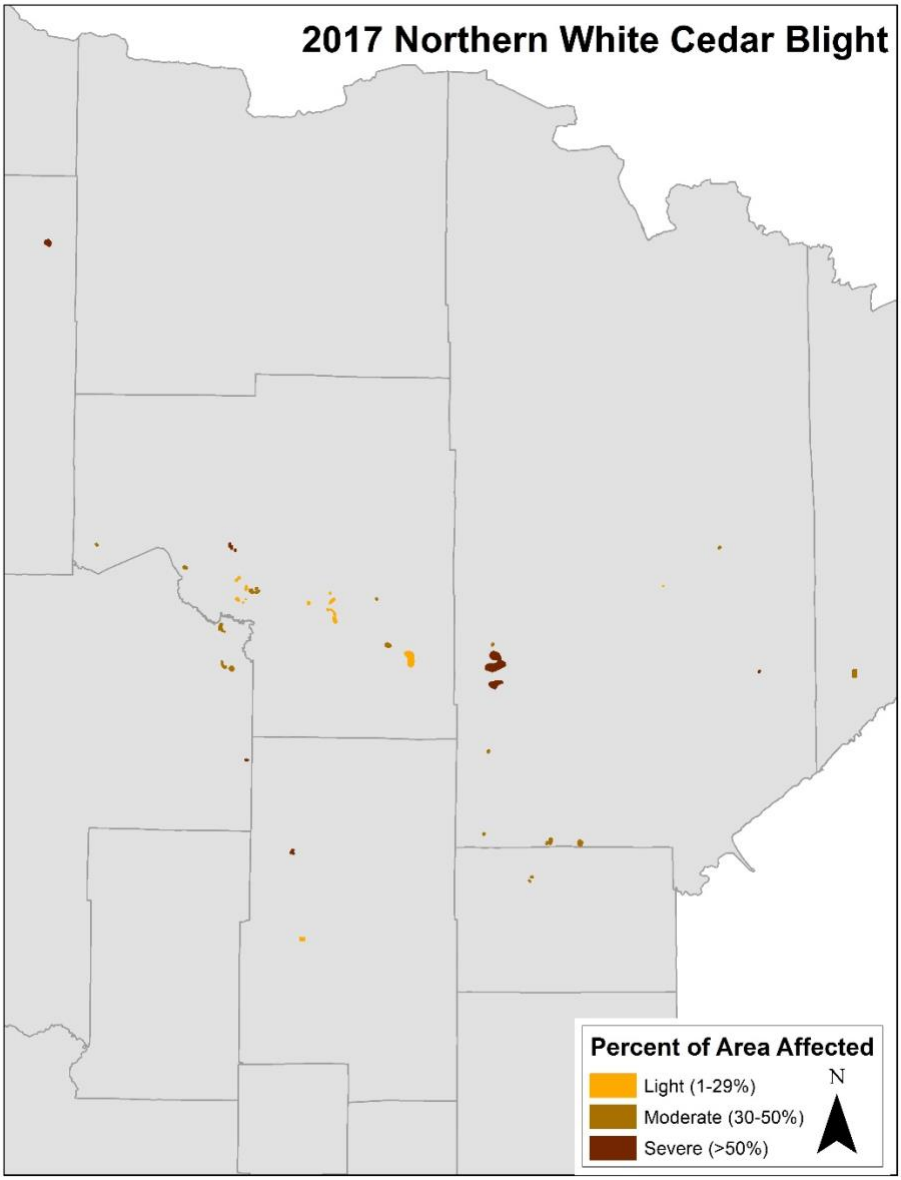
Contrary to their name, rose chafers feed on just about any plant. Minnesotans in Itasca County were reminded of that this year when many experienced intense defoliation of yard trees, shrubs, and gardens. Adults have a single generation each year, emerging in May and June and feeding on flower blossoms, fruit, and foliage. Adult beetles also produce a toxin that can be harmful to birds and pets if eaten. Larvae develop as grubs underground and feed on the roots of grasses; however, they do not usually cause problems in lawns or landscapes. These beetles are common, especially near sandy soils, so homeowners should be aware of their relative risk which, in all cases, is fairly low. Depending on tree species affected and the severity of the infestation, several chemical insecticides are available, or homeowners can simply physically remove beetles and place them in a pail of soapy water to kill them.

Adult rose chafer. Photo by Clemson University-USDA Cooperative Extension, Bugwood.org

Maple leaf skeletonized by rose chafers. Photo by Michigan State University Extension

Shoot mining on northern white cedar

There was a widespread outbreak of an *Argyresthia* leafmining caterpillar on northern white cedar (*Thuja occidentalis*) needles in 2017 (see map). Affected cedars appeared blighted. Lab analysis in spring 2018, as well as damage to the same stands in 2018 and subsequent ground-truthing by local foresters, confirmed the presence of an *Argyresthia* leafminer. Forest health staff will monitor the activity of this moth species in the coming years. While eastern locations in Maine and Quebec have reported significant damage from arborvitae leafminers in the past, we are not aware of previous reports of significant damage by *Argyresthia* species from Minnesota, Ontario, or Manitoba.



Spruce budworm

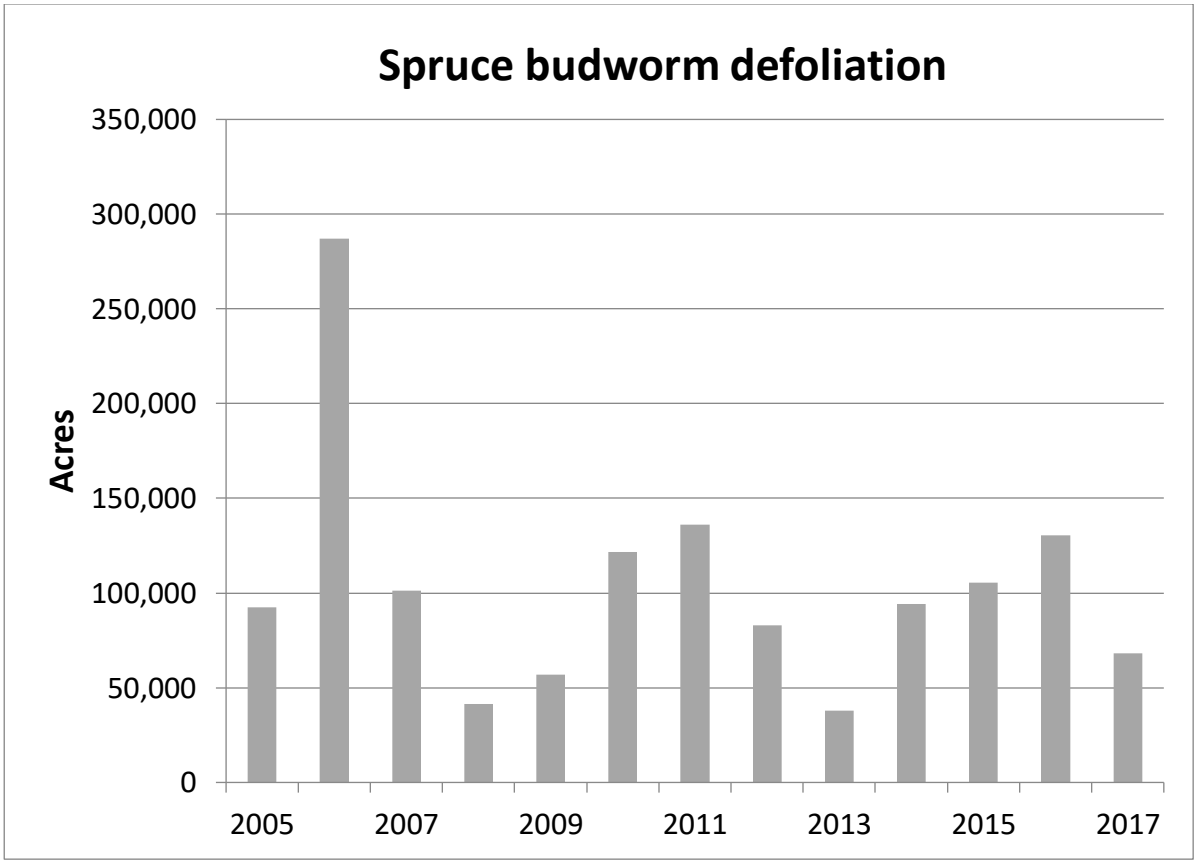
Spruce budworm (SBW) is a native, needle-feeding caterpillar that prefers balsam fir but also commonly feeds on white spruce. The insect has a consistent annual population in Minnesota, which is very different compared to other regions in the US and Canada that experience large outbreaks every 30-40 years. Because of this phenomenon, the DNR Division of Forestry has aerially mapped spruce budworm activity since 1954.

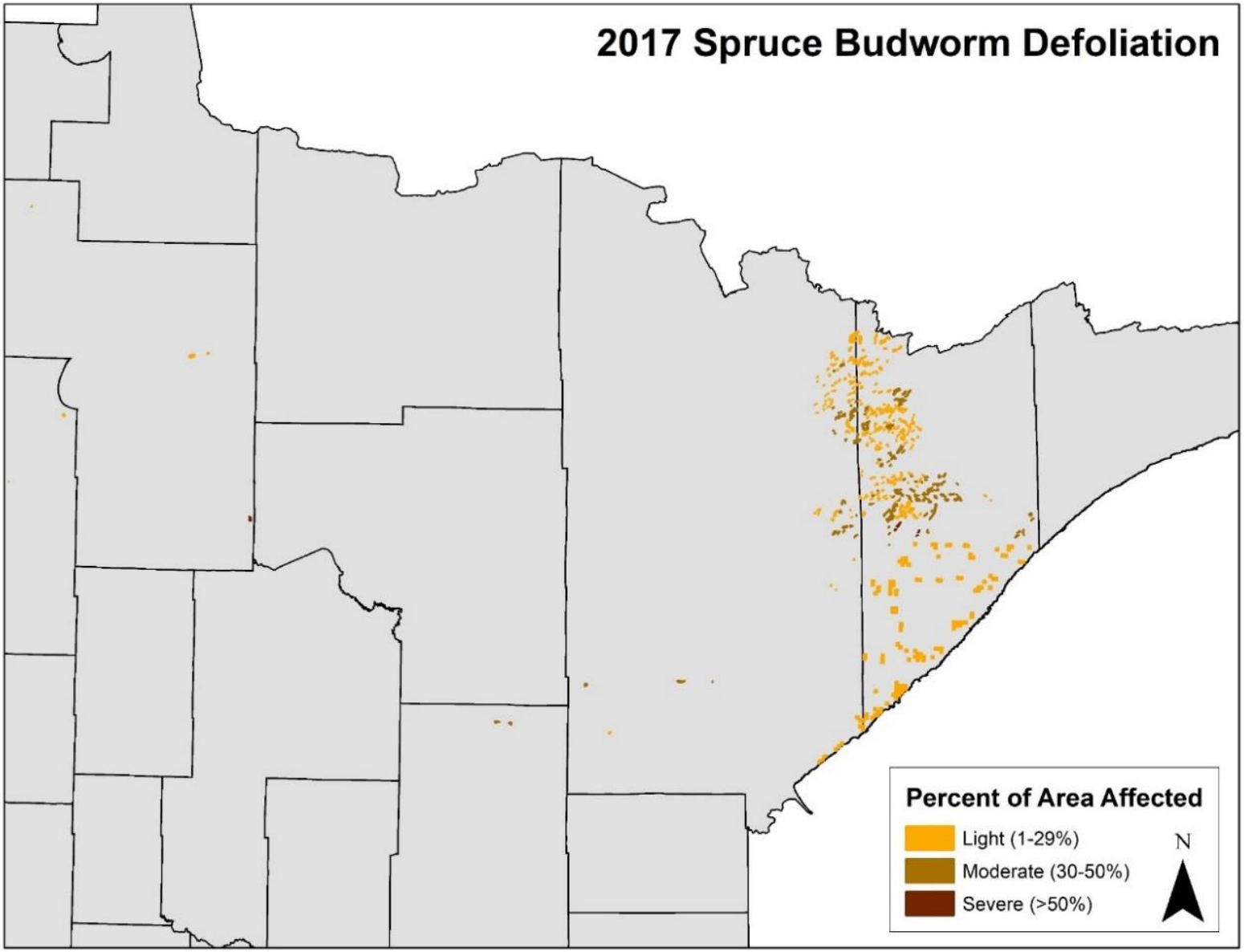
The area mapped with defoliation or dying trees from SBW declined significantly from 130,514 acres in 2016 to 68,213 acres in 2017. Moderate to severe damage is still noticeable in the Arrowhead region, though, from previous years' budworm activity. Affected areas were slightly farther east this year with 85 percent of the defoliation and mortality occurring in Lake County (see map). This eastward movement has been a trend of the current SBW outbreak, which began in western Koochiching County in the mid-1990s.

Areas of St. Louis and Lake counties that have experienced moderate to severe defoliation for several consecutive years will likely see additional defoliation and mortality continue for the next few years. While active defoliation has moved farther east, balsam fir and white spruce that were defoliated repeatedly in past years were subject to several years of stress, and continue to decline even after SBW has stopped feeding. Balsam fir begins to die within a few years of sustained defoliation, while white spruce may sustain five to seven years of defoliation before dying.

Decreases in damaged acres have been recorded several times since the current outbreak began in the mid-90s and does not necessarily mean that damage is subsiding. Because Minnesota has an on-going, conspicuous population of SBW, when one "outbreak" stops, another appears in an adjacent area. Expect continued defoliation in Lake County with possible new infestations in nearby areas, especially those farther east along the North Shore. We expect mortality of spruce-fir stands in the Arrowhead region, and recommend sustaining forests in that area by encouraging a diversity of species while salvaging dying timber from decay. Outside the defoliated area, properly-timed thinnings in white spruce stands makes them more resilient to spruce budworm in the future.

Spruce budworm feeding and webbing on a balsam fir.




2017 Spruce Budworm Defoliation
Percent of Area Affected
Light (1-29%)
Moderate (30-50%)
Severe (>50%)
N

Twolined chestnut borer

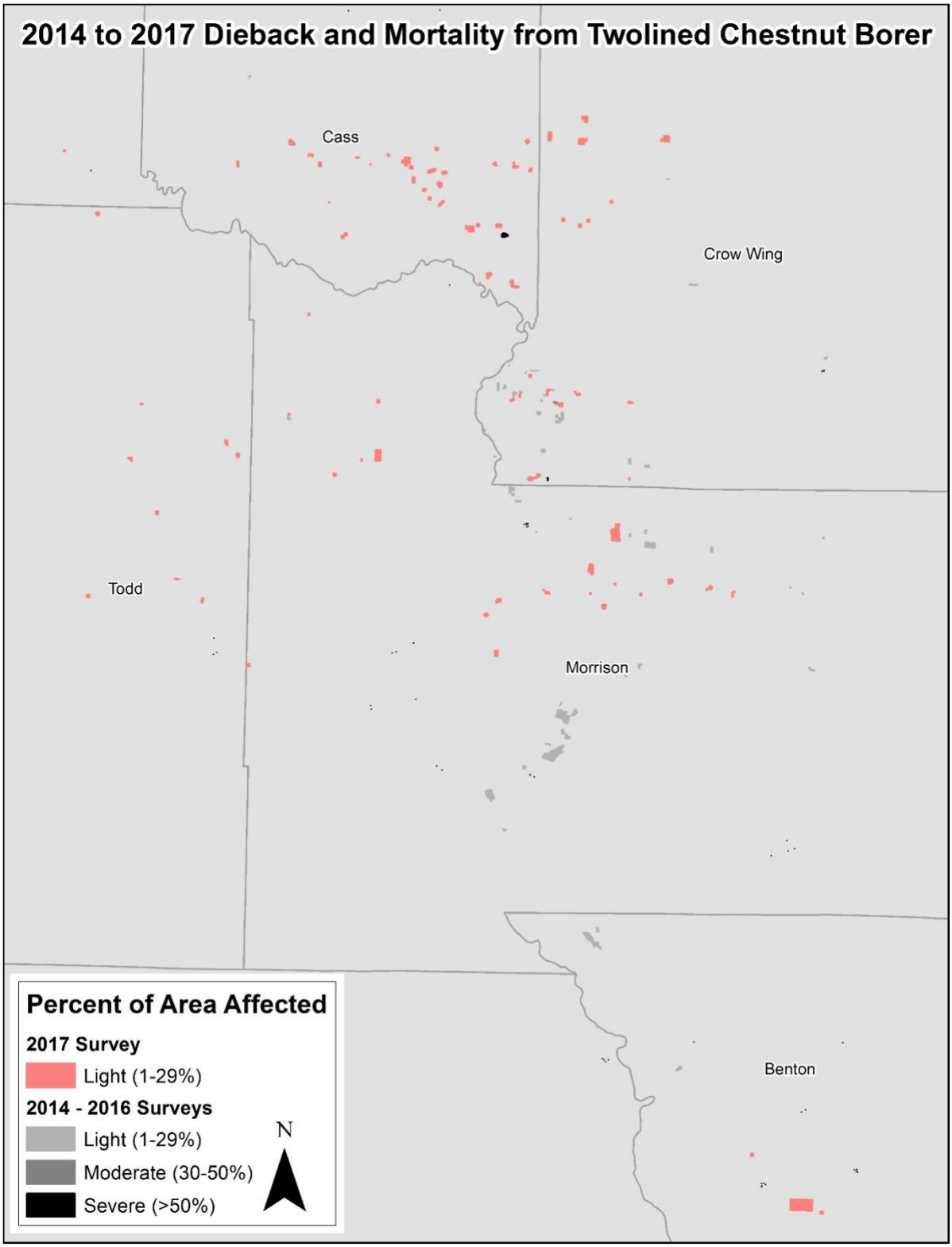
Twolined chestnut borer (TLCB) is a native phloem-feeding beetle that attacks stressed oaks. Two tree-stressing events in central Minnesota recently promoted TLCB populations and subsequent dieback and mortality to oaks: (1) two consecutive severe droughts late in the growing seasons of 2011 and 2012 and (2) a severe July wind storm in 2015 that damaged a large area north of Pillager in southern Cass County.

From 2014 through 2017, we mapped extensive oak dieback and mortality from the Clear Lake area in Sherburne County to Fort Ripley in Crow Wing County. Mortality rates appeared to have peaked in 2014 or 2015. This mortality was due to TLCB attacks on oaks initially stressed by the severe droughts in prior years. Twolined chestnut borer was also found attacking oaks from central Minnesota to the east, but at lower levels. If infested forests receive adequate precipitation and are not defoliated in 2018, we expect to detect fewer oaks impacted by TLCB in 2018.

In 2017, we also mapped widespread oak dieback and mortality for the first time across much of southern Cass County. This was due to TLCB attacking wind-damaged oaks that were stressed following the 2015 wind storm.

Altogether, we mapped 2,850 acres impacted (damaged or killed) by TLCB in 2017. From 2014 through 2017, the mapped areas impacted by TLCB in Cass, Crow Wing, Wadena, Todd, Morrison, Benton, and Sherburne counties totaled 4,620 acres. Over 75 percent of this damage was in Cass, Crow Wing, and Morrison counties.

Scattered oaks dying from twolined chestnut borer in a wind damage-salvaged area of the Pillsbury State Forest.


2014 to 2017 Dieback and Mortality from Twolined Chestnut Borer
Cass
Crow Wing
Todd
Morrison
Benton
Percent of Area Affected
2017 Survey
Light (1-29%)
2014 - 2016 Surveys
Light (1-29%)
Moderate (30-50%)
Severe (>50%)
N

Branch tip flagging on oaks

Scattered dead shoots in red oak canopies were commonly seen across much of central and southern Minnesota in 2017 (Figure 1). The blighted shoots were usually associated with oak bullet galls (Figure 2), made by tiny cynipid gall wasps. In a smaller number of cases, we found *Botryosphaeria* cankers causing dead shoots on red and white oaks. *Botryosphaeria* is a fungal pathogen, and this is the second year in a row that *Botryosphaeria* shoot blight has been relatively common on oaks throughout most of the state.

There is no record in Minnesota of widespread serious damage from cynipid galls or *Botryosphaeria* twig cankers, so we expect the blighted shoots to fade over time and trees to fully recover. Individual smaller oaks can suffer considerably from twig galls and *Botryosphaeria*, and pruning away dying shoots in the winter, proper irrigation, and mulching will reduce their impact.

Figure 1. A red oak in Pine County with branch flagging from oak bullet galls.

Figure 2. Damaged oak shoot with two round, hard bullet galls on the dead portion.

Diseases

Anthracnose on ash and bur oak

For the last three years, anthracnose on ash has been widespread across central and southern Minnesota, and 2017 represents the second year in a row where this disease has been widespread on ash across northeastern Minnesota. Anthracnose on bur oaks was reported from Pine to Nicollet County starting in early June.

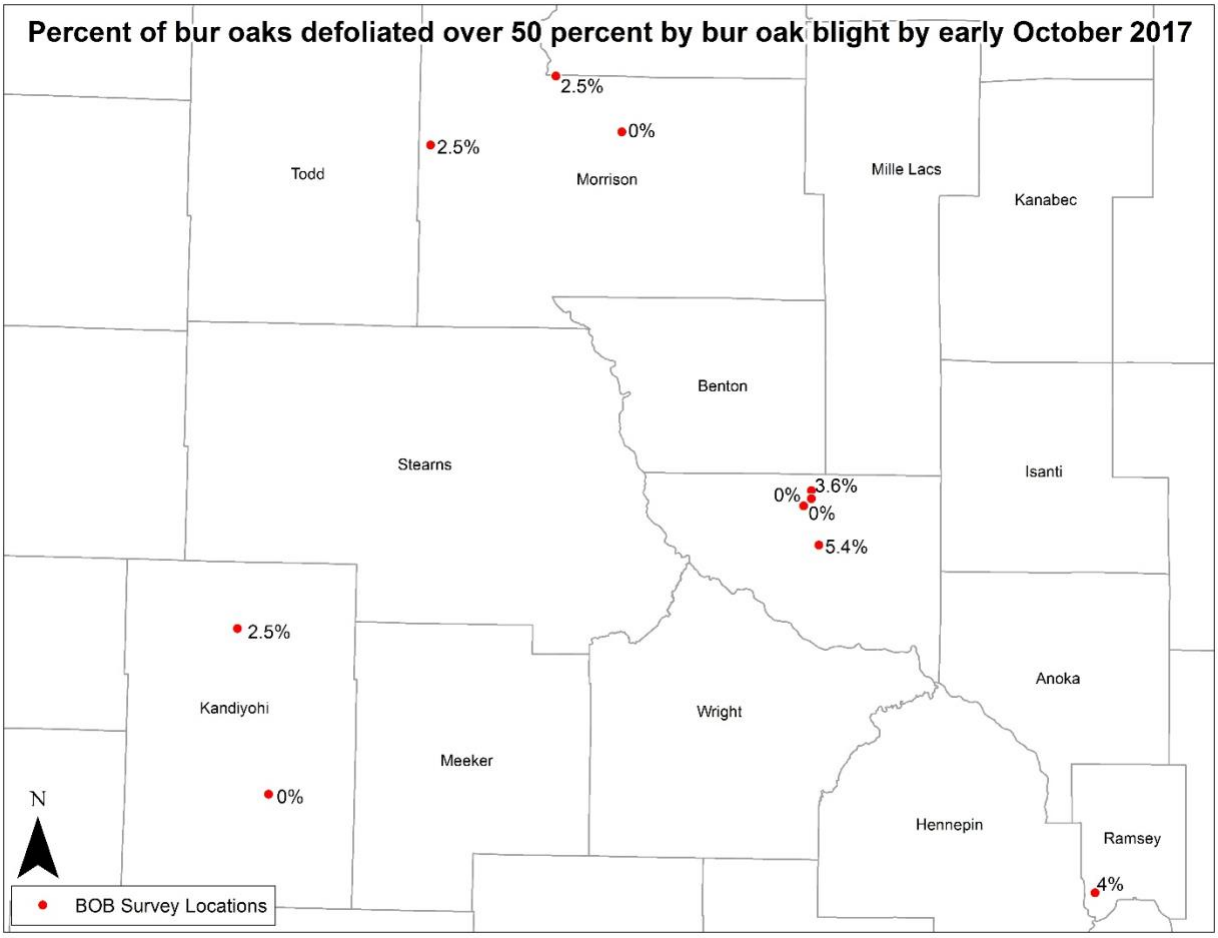
Anthracnose is a fungal leaf disease that affects many tree species (birch, oak, maple, elm and more) and is associated with cool, wet weather. Symptoms appear in the spring and early summer, and they include brown irregular spots on the leaves that may lead to curling, cupping, or general distortion. On ash, anthracnose can cause sudden leaflet loss in May. Infections are most common in the lower branches of the tree but can progress upward through the canopy in severe cases. While aesthetically displeasing, fungal leaf diseases such as anthracnose usually do not cause significant harm to the tree or require any form of control. Keep trees vigorous and healthy by using proper pruning techniques and mulching, which reduce tree stress and help trees withstand secondary pests and weakening pathogens such as those that cause anthracnose.

Ash anthracnose. Photo by Bruce Watt, Univerisyt of Maine, Bugwood.org

Bur oak blight

Bur oak blight (BOB) is a native leaf disease of bur oak that causes leaves to brown and sometimes drop in late summer. In our 2006 annual report, forest health staff noted an increase of BOB in southern Minnesota. That trend appears to have continued for the past 10 years and has likely been promoted by consecutive years of wetter-than-average springs. To our knowledge, the abundance and severity of BOB across Minnesota has not been evaluated.

In an effort to evaluate BOB frequency and aggressiveness, forest health staff and volunteers looked at 417 bur oaks in 10 plots spanning four counties in 2017. We found zero to five percent of the bur oaks surveyed in the 10 plots had 50 percent or greater defoliation by early October, 2017 (see map below). Forest health staff plan to repeat these surveys periodically to assess the severity of BOB over time.



The same oak affected by bur oak blight photographed in September of 2014–2017, left to right, in Sibley State Park.

The same oak as in the above series of photographs but photographed in May 2017.

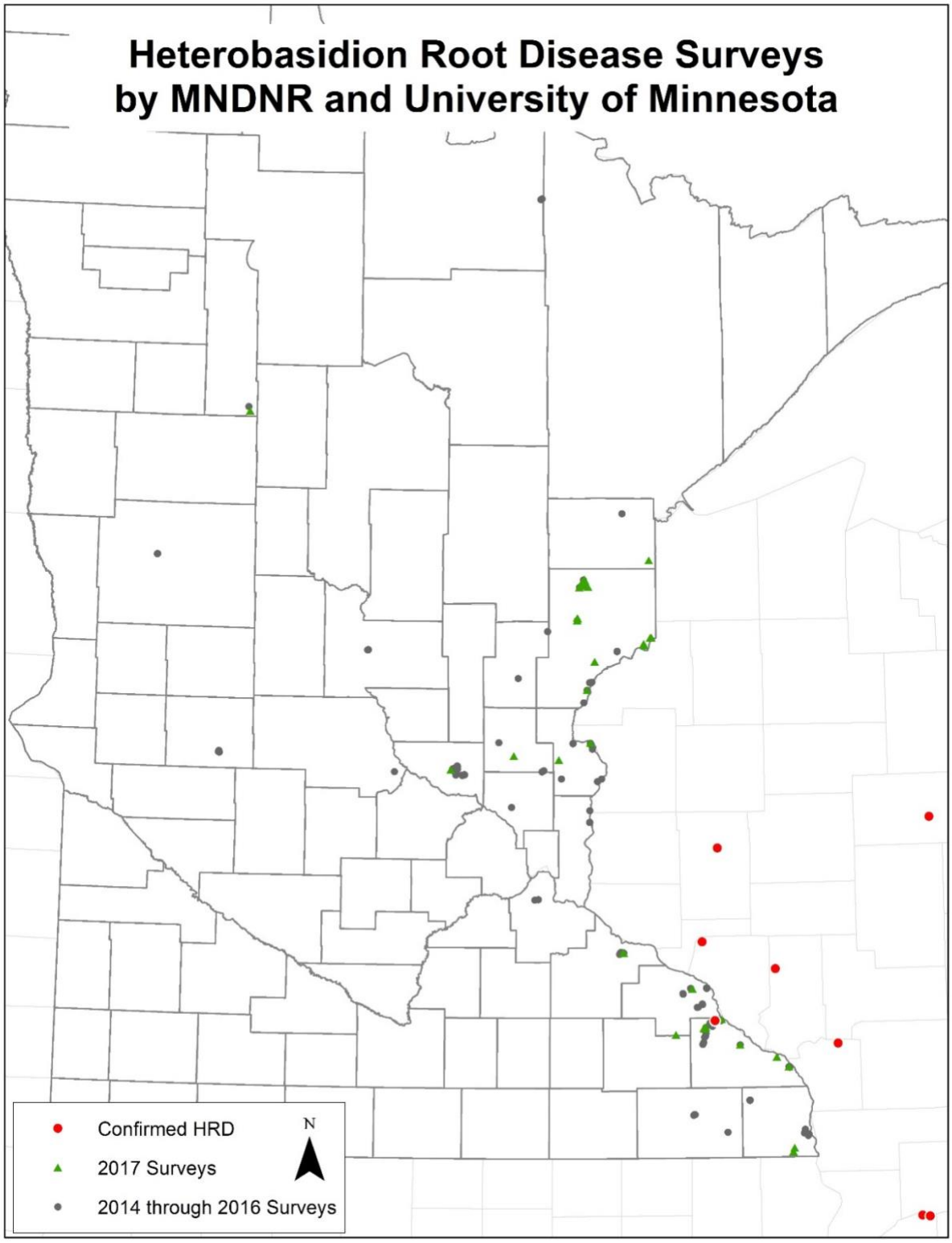
Heterobasidion root disease

Heterobasidion root disease (HRD), formerly called Annosum root disease, is a potentially serious and persistent fungal disease in pine plantations that was first confirmed in Minnesota in 2014. University of Minnesota staff discovered the disease in a state-managed red pine plantation in Winona County, where it had infected at least eight pines. In 2017, DNR forest health staff collected samples for HRD detection from three locations, and University personnel collected samples from 36 sites. No additional HRD locations were confirmed in 2017.

From 2014 through 2017, 204 locations were surveyed for HRD in Minnesota (see map). About half of these surveys were conducted by DNR forest health staff, and half were done by University personnel. None found additional HRD. To stop the inevitable outward movement and persistence of HRD in the infected Winona County plantation, we decided to take steps toward eradicating it. A logger felled all pines on the infected site in January and February of 2017. Shortly afterward, forest health staff applied a fungicide (disodium octaborate tetrahydrate, trade name Cellu-Treat®) onto cut stumps to protect them from being infected by *Heterobasidion* spores. In October, stumps in the infected zone and those within 50 feet were pulled out to stop the disease from spreading underground through roots. To prevent any infected, extracted stumps from producing disease spores, DNR Forestry staff plans to burn the extracted stumps on-site during winter, 2017-2018.

Recent research shows there may be a significant risk of infection within about one mile of HRD because fungal spores are windblown. Thinning and cutting in the coldest winter months when spores are not abundant reduces the risk of infection, so DNR Forestry plans to only thin nearby state-owned plantations in the winter. Surveys to detect additional *Heterobasidion* will continue on the remainder of the stumps on the infected site for the next several years.

Diseased pines and stumps were left on-site to avoid moving the disease.



Surveys for Heterobasidion root disease in Minnesota and confirmed locations. Points in Wisconsin come from a correspondence with Wisconsin DNR staff in 2015.

Needle disease of pines

Wet weather in the spring and summer of 2016 created conditions in 2017 for widespread needle disease, or needle cast, of pines (most likely from *Dothistroma* or *Lophodermium* fungi) in northeastern Minnesota. In mature trees, symptoms occurred mostly in the lower crown, where the microclimate favors disease spore production and spread more than in the upper crown. The spores infect new growth in summer and fall, and depending on the needle pathogen, needles turn brown either in the fall when infection occurs or in the following spring.

Similarly, some ponderosa and Austrian pines in the Afton and Stillwater areas of Washington County had severe needle disease in 2017, appearing to be from *Dothistroma*. Precipitation during the growing season in those areas was above average from 2014 through 2016, favoring the development and spread of fungal needle diseases.

Needle casts can look similar to some abiotic agents such as salt or hail, so spores need to be present in order to confirm a pathogen. This can be difficult to detect because spores require specific environmental conditions and are not produced consistently. *Lophodermium* and *Dothistroma* can be problems in nurseries and Christmas tree plantations but generally are not problems in our mature native pine forests. For very small-scale outbreaks or in situations where tree aesthetics are important, controlling weeds and spacing trees to allow for better air flow may lessen disease. In nurseries and Christmas tree plantations, a registered fungicide might be necessary for control. The wet growing season in 2017 in northeastern, central, and southern Minnesota means that many pines may exhibit similar symptoms in 2018. We will continue to monitor symptoms in the coming spring and summer.

Red pine stand showing symptoms of needle cast infection in St. Louis County.

Oak wilt

Oak wilt is a non-native pathogen that is fatal to red and bur oaks and can often be fatal to white oak. The disease is common in east-central and southeast Minnesota but has been confirmed only recently farther north and west. Forest health staff are tracking its spread into uninfected parts of northern Minnesota and undocumented areas of southern Minnesota. Even though oak wilt has been present in Minnesota since at least the 1950s, we have a lot of oak forest yet to lose to oak wilt. Sixty percent of the DNR's red oak stands are still not within the known range of oak wilt (see map below).

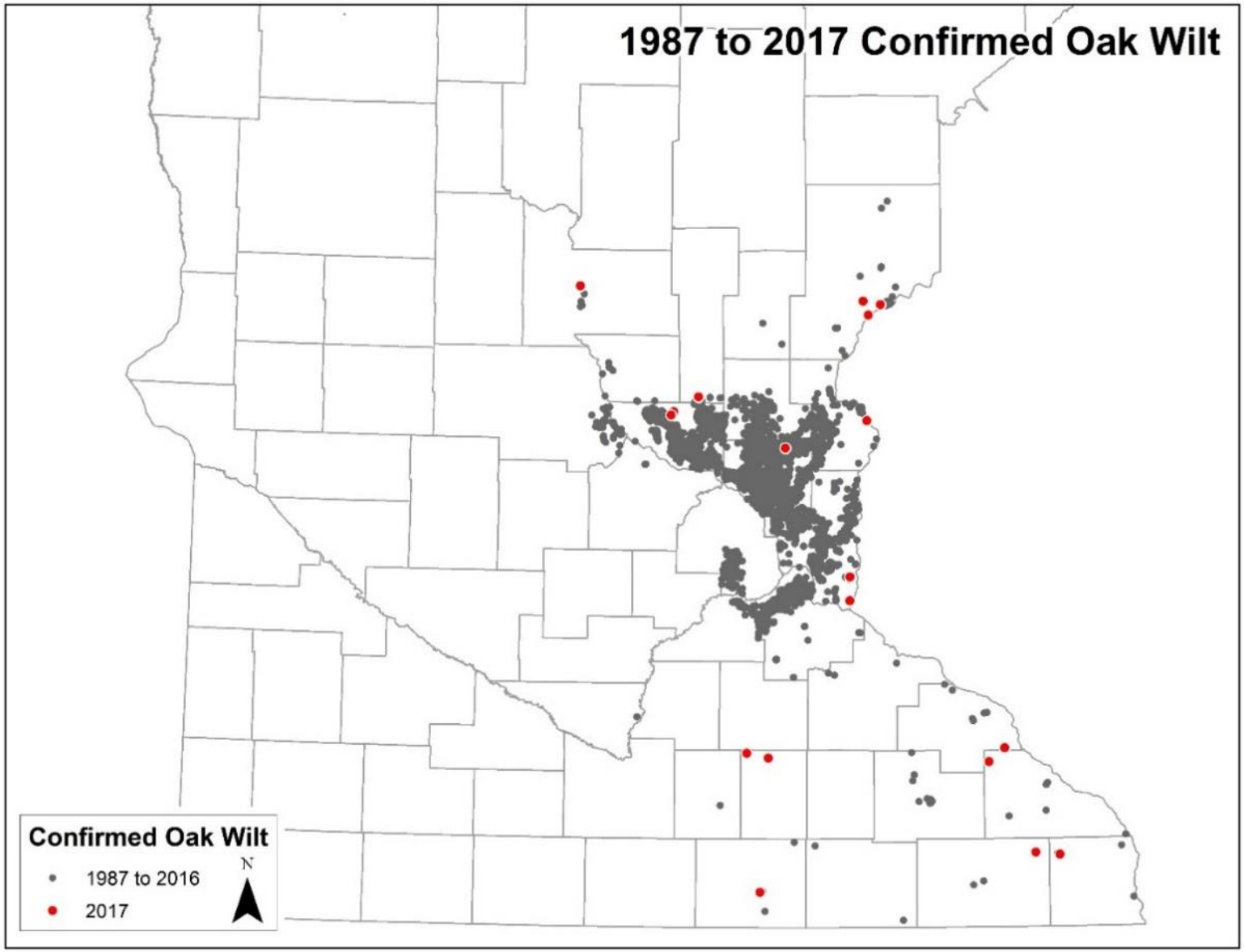
Forest Health staff confirmed oak wilt in Steele County for the first time in 2017. Two forests were found with the disease, one dominated by red oak and the other dominated by bur oak. The disease center in each forest covered roughly half an acre, suggesting that oak wilt had been present in Steele County for many years prior to confirmation and supporting our observations that oak wilt can be a serious threat to bur oak.

In 2017 we aerially surveyed oak wilt from southern Benton to southern Sherburne counties and east to northern Washington and Chisago counties. We documented 23,700 acres impacted by oak wilt to some degree. Some of the woodlots in that zone have been devastated by the disease over the years, but in most circumstances, oak wilt currently affects less than 10 percent of the forest canopy in any given area.

The likelihood of successfully slowing oak wilt's expansion across the landscape is greatest at the edge of its geographical range, where it is found at low densities and where few landowners are impacted. Oak wilt in St. Croix State Park in Pine County fit those criteria, and in the hope of slowing the spread of oak wilt there, we applied for and received a US Forest Service oak wilt suppression grant in 2017, with which we treated twenty-six oak wilt mortality centers. In addition, the DNR Division of Parks and Trails and Division of Forestry staff helped two private landowners adjacent to the park control oak wilt on their properties. Forest health staff will monitor all the sites until 2022 to ensure that oak wilt was successfully eradicated.

Increasing oak wilt awareness to landowners and managers is a critical part of slowing the spread of oak wilt. DNR forest health staff collaborated in March 2017 with Pine County Soil and Water Conservation District staff to present information at a Hinckley landowner workshop on oak wilt prevention and identification. The DNR forest health unit also made a press release on oak wilt prevention in April.

Oak wilt killing pockets of oaks in Cambridge, Isanti County.


1987 to 2017 Confirmed Oak Wilt
Confirmed Oak Wilt
1987 to 2016
2017
N

Update on *Diplodia* testing at Badoura State Forest Nursery

In 2016, elevated levels of latent *Diplodia* infection caused the Badoura State Forest Nursery to destroy between 400,000 and 500,000 red pine seedlings in order to avoid distributing unhealthy seedlings. Seedlings that were destroyed all came from a single nursery field that, for reasons still undetermined, was disproportionately affected by *Diplodia*. All fields with two- and three-year-old red pine seedlings were evaluated in 2017 for latent *Diplodia* infection levels. Tests found that only two of 784 (0.26 percent) seedlings had latent *Diplodia* infections, which is well below our current acceptable threshold of 10 percent infection. These seedlings will be sold and distributed in 2018 and younger red pine seedlings remaining in the nursery will be evaluated before their eventual sale and distribution in upcoming years.

To determine the consequences of planting seedlings with a known percent of latent *Diplodia* infection, 616 bare-root seedlings from the affected field in the Badoura nursery were transplanted to a vacant field at the General Andrews Tree Improvement Center in April 2017. To compare mortality of infected and uninfected stock, 628 containerized seedlings donated from PRT (our containerized seedling supplier) were planted adjacent to the bare-root seedlings from Badoura. Plantings were monitored throughout the 2017 season for mortality.

Forest health staff completed the final assessment of disease and mortality for the year in October 2017. While initial laboratory results indicated that about 15 percent of the bare-root seedlings tested positive for latent *Diplodia* infection, we observed 61 percent seedling mortality through the first season. Although some bare-root seedlings had deteriorated to the point that cause of death could not be determined, we estimated that over two-thirds of observed mortality was attributed to *Diplodia* collar rot, likely stemming from pre-existing latent infection at the time of planting. Containerized stock tested negative for *Diplodia*, but we observed 24 percent mortality at the end of the first season. Another pathogen, *Cylindrocarpon*, is speculated to have been a major source of mortality for containerized seedlings based on laboratory results.

We will continue to assess seedling survival in the General Andrews field in 2018 and beyond. Based on preliminary results, the decision of the Badoura State Forest Nursery to destroy the remainder of these infected seedlings was more than justified.

Diplodia-killed shoots on a young red pine seedling.

Venturia shoot blight

Bigtooth aspen regeneration affected by *Venturia* shoot blight was first reported near Cloquet in 2016, followed by areas near Cloquet and Brainerd in 2017. Additionally, reports from neighboring Wisconsin indicate above-average levels of *Venturia* shoot blight might also be found in other areas of the Great Lakes Region.

Venturia leaf and shoot blight is a fungal disease that spreads through windblown spores landing on newly-expanding leaves and moving through the leaf petioles into new shoots. Wilted shoots form a distinct shepherd's crook with blackened, discolored leaves (see photo below) remaining attached until they eventually weaken and break off. *Venturia* is usually observed in areas with dense, young aspen regeneration that facilitate disease spread. The disease is more common when there is wet spring weather during shoot elongation and does not usually cause significant damage unless the leader is killed for multiple years. While *Venturia* can affect multiple poplar and cottonwood species, it was observed primarily on bigtooth aspen in 2017.

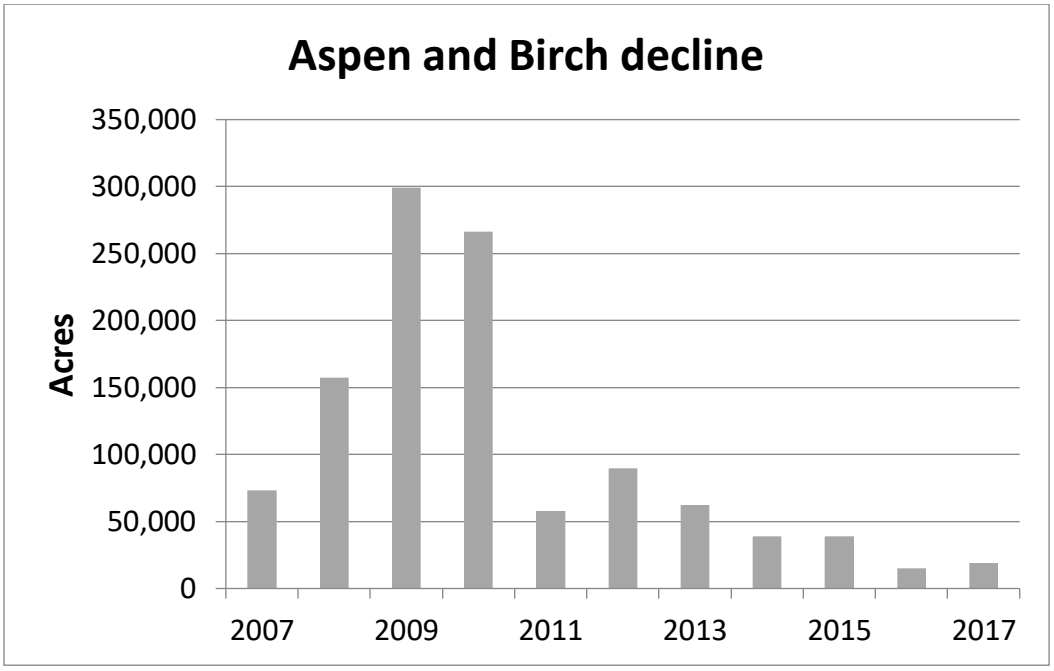
We will continue to monitor the situation, but *Venturia* typically requires no management action. Although low levels of *Venturia* shoot blight are not uncommon in young aspen stands in Minnesota, the areas observed near Brainerd in the Pillsbury State Forest were severely affected throughout. Despite the severity of the damage, saplings observed in the Pillsbury State Forest earlier this season were already pushing out a second set of leaves on affected shoots and are expected to make a full recovery.

Venturia shoot blight affecting aspen saplings in an area with abundant regeneration.

Environmental Stress Agents

Aspen and birch decline

Declining aspen and paper birch have been persistent issues across the Minnesota landscape for many years. After a sharp increase in the number of acres affected in 2009, noticeable dieback and mortality have decreased year to year until 2017. While a slight uptick was observed this year, recorded acreage was still low compared to previous years. In 2015, almost 39,000 acres of aspen and birch were in a state of decline, and that number dropped significantly to just over 15,000 acres in 2016 with a slight increase to just over 19,000 in 2017. Most of the acres currently affected consist of pure aspen with only 910 acres containing a paper birch component. Fewer current acres of aspen and birch decline may be related to increased harvest of declining stands. Multiple wetter-than-average years have likely also helped stands recover from several years of moderate to severe drought.

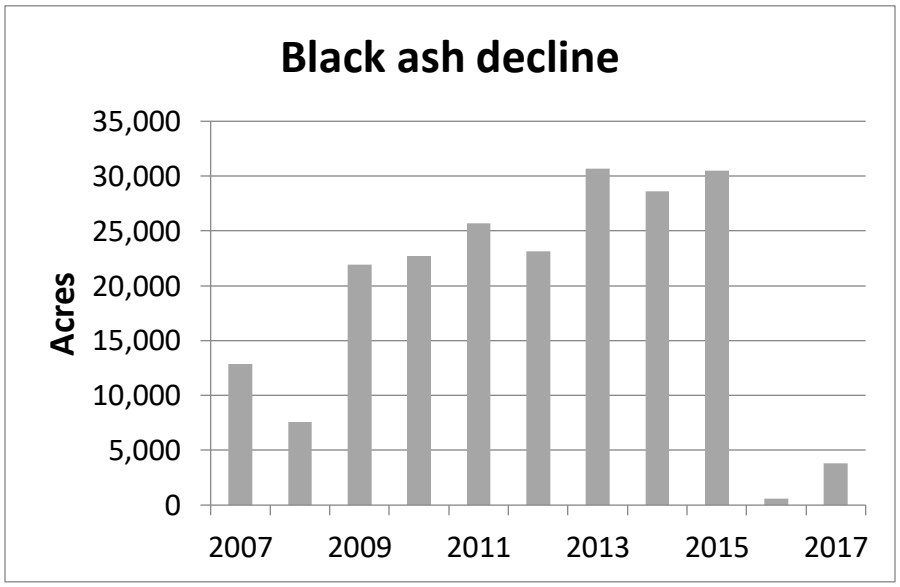


Black ash decline

Black ash decline, characterized by stunted leaves, branch dieback, epicormic sprouts, and tree death, is a condition commonly encountered in Minnesota. Symptoms are often associated with poor site quality (flat, water-saturated soil) and proximity to roads. Several factors play into the latter associations, such as road construction that changes water flow and salt de-icing sprays that are associated with reduced tree vigor.

Aerial surveyors detected 20,000 to 30,000 acres of black ash decline from 2009 to 2015. Aerial surveyors in the past two years have not documented nearly that level of decline (see graph), but we still suspect that significant amounts of declining black ash are still on the landscape. There is a possibility that there has been a peak in declining black ash stands. We have learned that between changing surveyors and years it is very difficult to document black ash decline consistently, so we no longer survey for black ash decline annually.

The presence of black ash decline in central and northern Minnesota forests will make early detection of emerald ash borer (EAB) exceedingly difficult. Not only will the symptoms of black ash decline disguise the presence of actual EAB infestations, but black ash stands are often in standing water with limited or no access. Only after several years of infestation will we be able to detect EAB by aerial survey.

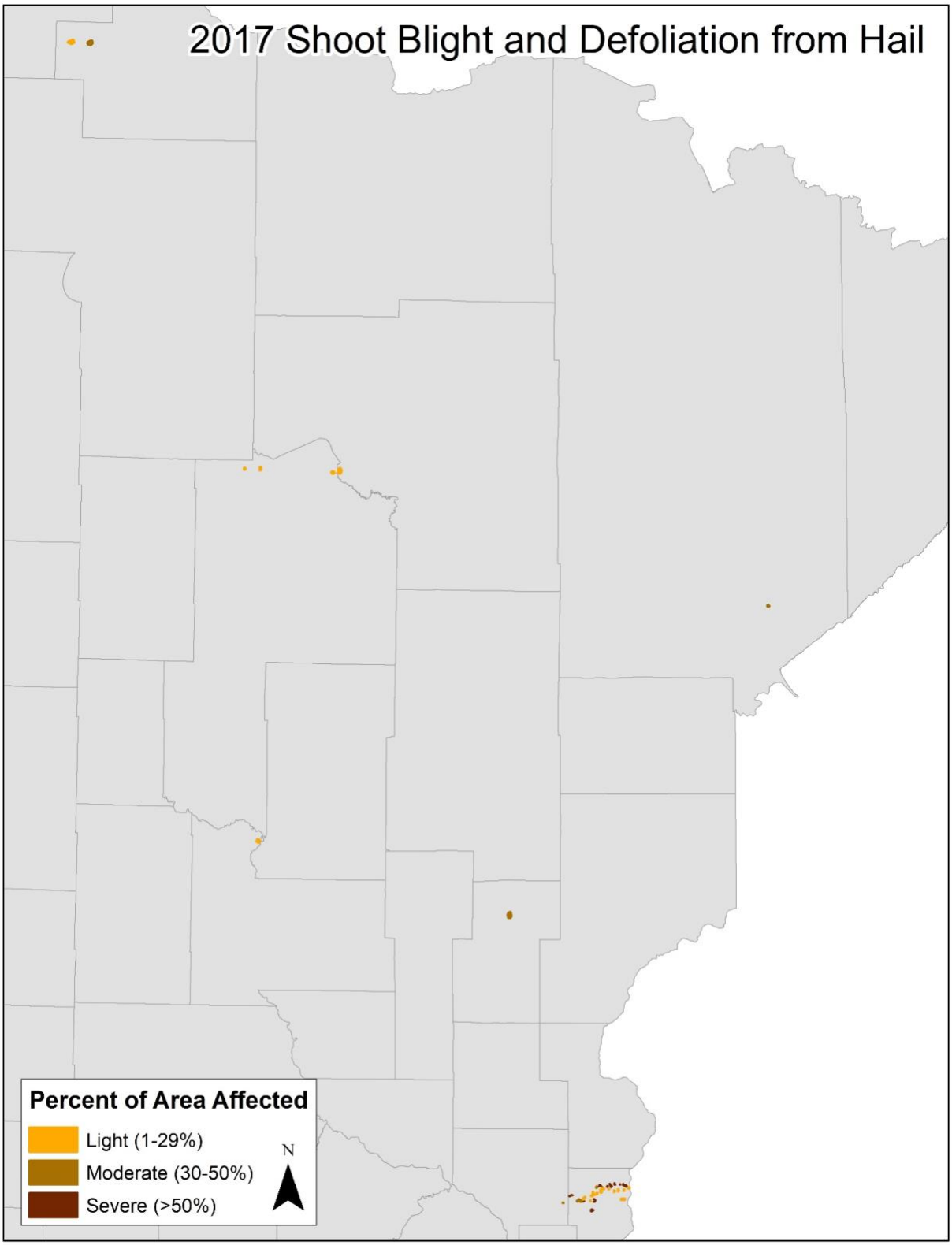


Hail damage

Strong hail storms damaged trees in several counties in Minnesota during summer 2017. The DNR forest health unit mapped about 3,479 acres that had hail damage, almost all of which were associated with four separate storm systems in northern Washington County, northern Cass County, Lake of the Woods County, and northern Kanabec County (see map below). In Washington and Cass counties, red pine was the only species that appeared to suffer from hail damage, even though the hail made small wounds on all tree species (see photo below). The red pine quickly developed blighted shoots after the storms. The hail wounds associated with blighted shoots were either newly infected by *Diplodia* or triggered latent *Diplodia* infections to cause disease, which often happens when red pine is damaged by hail. Red and jack pine were damaged in Lake of the Woods County. In addition to pines suffering heavy shoot blight, northern hardwoods were heavily defoliated by hail in the northern Kanabec County area.

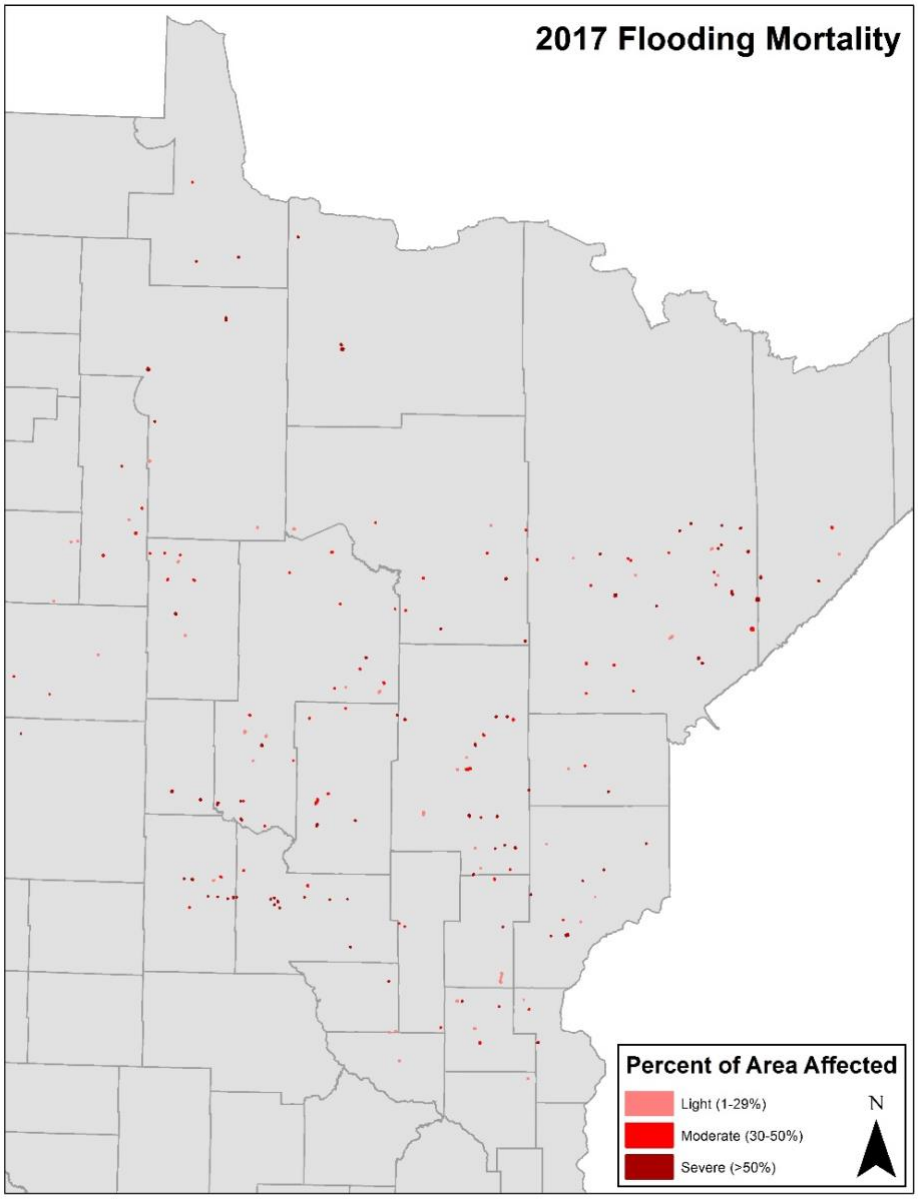
The storm in Washington County caused concern among tree owners, so the DNR forest health unit authored a press release that encouraged landowners to wait until winter to cut down heavily-damaged pines. In many circumstances, lightly- to moderately-damaged red pines will survive. For those red pines that lose over 50 percent of shoots, opportunistic bark beetles may attack and kill them in the coming years.

Red pines with shoot blight from Diplodia infection after hail damage, Washington County, 2017.


2017 Shoot Blight and Defoliation from Hail
Percent of Area Affected
Light (1-29%)
Moderate (30-50%)
Severe (>50%)
N

Flooding damage

Scattered areas of flooding were common across most of the survey area in northern Minnesota, increasing somewhat from 5,692 acres in 2016 to 6,427 acres in 2017. Similar to 2016, more flooding or high water damage likely occurred after aerial survey was complete or in southern areas of the state not included in the survey area. Some of the visible flood damage might be the legacy of 2016, which was the second-wettest year in state history. Precipitation levels, shown on maps from the State Climatology Office, were once again at or above normal in 2017 except in northwestern Minnesota, which was the only forested portion of the state to experience any drought conditions (drought ratings of abnormally dry or moderate drought).

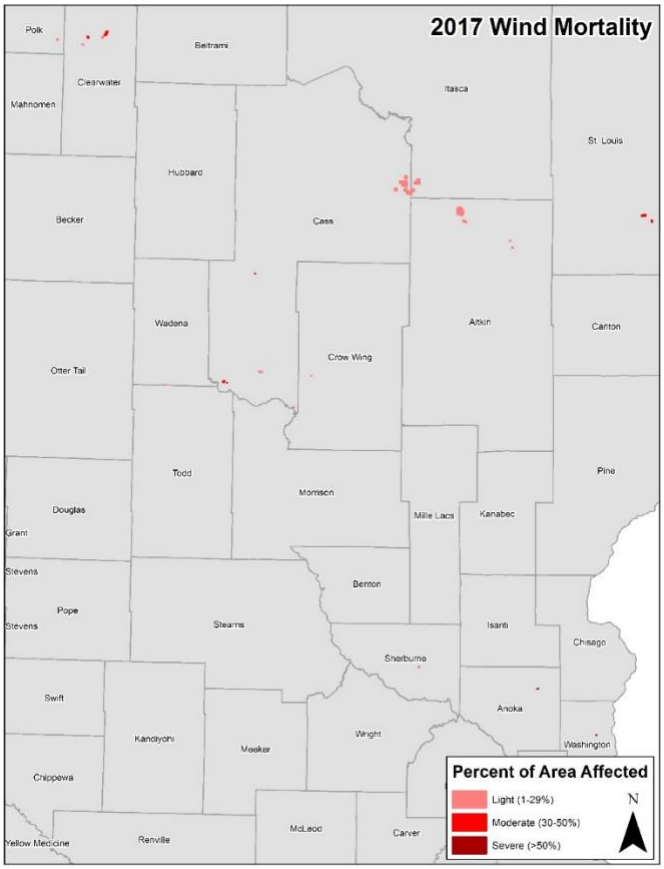


Wildfire damage

At the time of aerial survey, we observed fire damage in four separate areas covering 332 acres. This is about an 80 percent reduction in mapped fire damage from 2016. In at least two instances, red oaks were damaged after prescribed burning became too intense, killing trees outright or causing injuries, making them susceptible to secondary mortality agents such as twolined chestnut borer or *Armillaria* root disease. Statewide, weather was frequently unfavorable for burning conditions, resulting in a relatively inactive spring fire season. On state lands, wildfire burned a total of 797 forested acres from January through the end of October 2017.

Wind damage

The majority of wind damage in 2017 can be attributed to two major storm systems that passed through Minnesota in early June and early July (described in the early July issue of the State Climatology newsletter), bringing intense rain, large hail, and strong winds with gusts up to 70 mph (the July storm system also resulted in tornado damage in Nicollet and Blue Earth counties, not included in our surveys). The mapped area of wind damage is a 70 percent reduction from 18,953 acres of wind damage during 2016. Most of the 2016 wind damage was caused by major straight-line wind events that resulted in large blowdown areas near the Boundary Waters Canoe Area Wilderness in the northeastern part of the state.



Other tree pest and tree health events noted in 2017

Pest or event	Pest stage of cause	2016 (county in which observed)	2017 (county in which observed)
Sapsuckers	Adult sapsuckers	Not documented	March 31 (Itasca)
White pine blister rust	Orange spores on cankers	Not observed	April 28 (Sherburne) May 15 (Beltrami)
Eastern tent caterpillar	Early instar caterpillars	April 29 (Pine) May 25 (Cass)	May 10 (Beltrami) May 31 (northern St. Louis)
Sudden ash leaflet drop	Anthracnose	May 16-19 (Dakota, Fillmore)	May 14-23 (Dakota, Hennepin, Scott, Waseca)
Pine-pine or Pine-oak gall rust	Orange spores on galls	Not observed	May 15 (Beltrami)
Ips bark beetle species	Egg-laying	May 16 (Kanabec)	Not documented
Cedar-apple rust	Telial horns on junipers	May 26 (Goodhue, Sherburne)	May 19 (Anoka)

Pest or event	Pest stage of cause	2016 (county in which observed)	2017 (county in which observed)
Linden looper	Caterpillars 1 inch long	May 24 (Ramsey)	Not documented
Jack pine budworm	2nd or 3rd instar larvae	May 25 (Crow Wing)	May 24 (Beltrami)
Fall cankerworm	Caterpillars feeding on boxelder, elm, and ash	Not observed	May 26 (Ramsey)
Forest tent caterpillar	Caterpillars 1-1.25 inch	May 31 (Itasca)	June 1 (Crow Wing)
Twolined chestnut borer	Pupae still in trees	Not documented	June 1 (Crow Wing)
Cedar shoot blight	Browning foliage	Not observed	June 1 (Itasca)
Reports of leaf disease on bur oak	Anthracnose	Not documented	June 7-July 14 (Kanabec, Morrison, Pine, Sherburne)
White-spotted sawyer	Adult	June 8 (Wright)	Not documented
Giant ichneumon wasp	Adults on dying sugar maple	June 8 (Wright)	Not documented

Pest or event	Pest stage of cause	2016 (county in which observed)	2017 (county in which observed)
Oak wilt symptoms	First symptoms noted for the year	Not documented	June 12 (Sherburne)
Rose chafers	Adult chafers on yard trees	Not documented	June 20 (Itasca)
Jack pine budworm	Late instar larva and pupa	Not documented	June 23 (Morrison)
Forest tent caterpillar	Pupa	June 18 (Itasca)	June 23 (Morrison)
Venturia shoot blight	Dead leaves and shoots on saplings	Not documented	June 23 (southern Cass)
Japanese beetle	Adult	Not documented	June 25 (Dakota)
Oak apple gall wasps	Adults emerging from galls collected in the field	Not documented	June 26 (southern Cass)
Oak wilt	Spore pad on red oak	May 1 (Dakota)	June 26 (Washington)
Oak wilt	Spore pad on bur oak	Not documented	June 27 (Steele)

Pest or event	Pest stage of cause	2016 (county in which observed)	2017 (county in which observed)
Birch leafminer	3rd and 4th instar larvae	June (Cass)	June 27 (Beltrami)
Woolly alder aphid	On silver maple	Not documented	July 2-4 (Pine) July 17-18 (Beltrami, Itasca)
Japanese beetle	Abundant adults	Not documented	July 4 (Dakota)
Spruce budworm	Adult moths	July 7 (St. Louis)	Not documented
Jack pine budworm	Adult moths	July 8 (Beltrami)	Not documented
Dutch elm disease	Wilting branches	Not documented	July 10 (Itasca)
Cottony ash psyllid	Nymphs on black ash	August 3 (Dakota)	Not documented
Dutch elm disease	Wilting trees	Not documented	August 31 (southern St. Louis)
Oak wilt	Spore pad in autumn	Not documented	September 26 (Pine)

Forest Pest First Detector Workshops

Now in its tenth year, the Forest Pest First Detector program continues to train dozens of volunteers to respond to reports of exotic forest insects and diseases. Reports are 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), and trained First Detectors are contacted by the MDA to connect them to a caller located in their part of the state. The First Detector responds to help diagnose the issue and report their findings to MDA.

The First Detector team consists of agency partners who organize registration, give presentations, and proctor the Tree Inspector Certification exam at the workshop locations. The team includes staff from the University of Minnesota and U of M Extension, the Minnesota Department of Agriculture, and the Minnesota Department of Natural Resources.

Two workshops were held this year in Oakdale and Cloquet. This was the initial year of a new approach to the workshop called a "flipped classroom." The flipped classroom reverses the traditional format of focus on the lecturer and participants listening to presentations to delivering some of the content online before the workshop and participants walking through stations and interacting with each other and the subject experts at the workshop. Pest identification and quiz stations included emerald ash borer, velvet longhorn beetle, Asian longhorn beetle, gypsy moth, brown marmorated stink bug, Oriental bittersweet, thousand cankers disease of walnut, and oak wilt. Workshop subject experts also gave traditional presentations on quarantines and identifying diseases. Forty-six people attended the workshops and 17 signed up to become Forest Pest First Detectors.

The transition and success with the flipped classroom education delivery model inspired the new Minnesota Aquatic Invasive Species (AIS) Detectors program to use the flipped classroom model. The documented successes of the new style of education delivery in both AIS Detectors and Forest Pest First Detectors resulted in a 2017 Innovative Program Award for the Flipped Classroom Model from the Minnesota Association of Natural Resources Extension Professionals, and a tentative acceptance of a peer-reviewed academic article on flipped classrooms in the Journal of Extension's upcoming innovative technology and programming issue.