Wisconsin DNR Forest Health 2021 Annual Report

White oak severely defoliated by *Lymantria dispar,* Linda Williams

WISCONSIN DEPT. OF NATURAL RESOURCES

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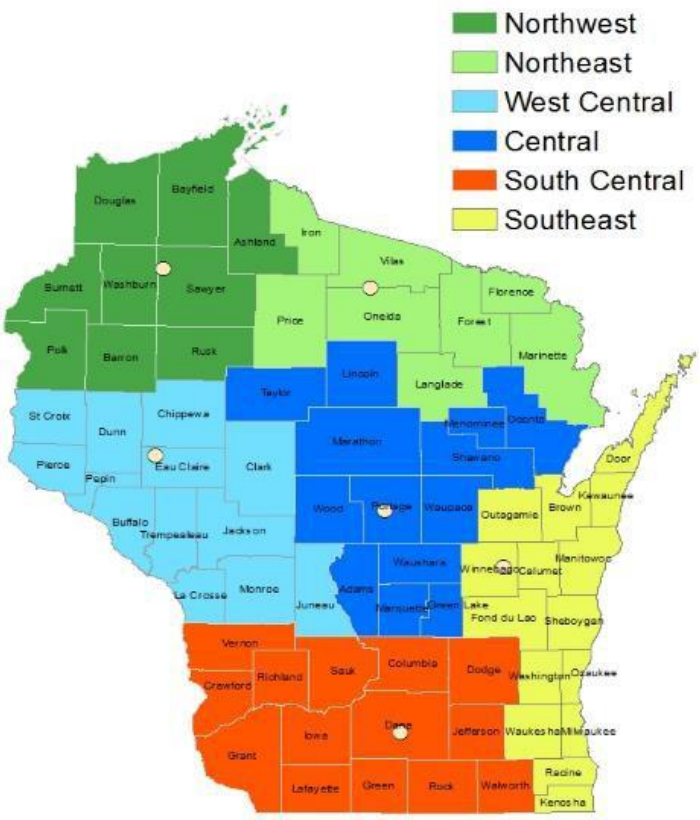

Figure 1. Locations and zones of forest health specialists as of Dec. 2021.

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Staff Update

The Forest Health Program bid farewell but not goodbye to Eleanor “Elly” Voigt this fall when she took a full-time plant pathologist position with our sibling state agency, the Department of Agriculture, Trade and Consumer Protection (DATCP). We are sad to see her go but are delighted that we will continue to see her occasionally in the cooperative work of our two agencies. She will even eventually be able to meet all the team members in-person, something Elly has yet to do since her tenure overlapped the period of COVID-19 precautions which prevented our regular in-person meetings. We are all waving to the camera, Elly!

In September, Brenna DeNamur joined the team as the new Forest Health Outreach Specialist working in Madison. She’s focusing on newsletter coordination, partnership building and social media and has gotten off to a fast start!

Also in September, Jacquelyn “Jaqi" Christopher took on the Invasive Plant Specialist position, working closely with Mary Bartkowiak, the Forest Invasive Plant Program Coordinator, in the Rhinelander Service Center. She has worked for the DNR since 2016 but in the wildlife program. Her responsibilities include coordinating the Weed Management Area – Private Forest Grant Program and supporting DNR staff and partners with invasive plant detection and control efforts.

Impacts Of COVID-19 On Forest Health Program

COVID-19 safety measures continued to impact the Forest Health Program in 2021, but to a much lesser degree than 2020. Field work and site visits were allowed throughout the year and aerial survey recommenced in June. The Forest Health Lab operated at normal capacity with many additional safety measures in place. All other program staff returned to their offices in July. Professional conferences were cancelled or transferred to the virtual format. Opportunities for in-person trainings, outreach and education slowly reemerged in mid-summer, but most presentations remained in the virtual format.

The Forest Resource In Wisconsin

Wisconsin's forests (Figure 2) are critical for providing wildlife habitat, clean air and water, reducing erosion and improving the quality of life in urban and rural areas. Forests are also important to Wisconsin's economy for wood products, recreation and tourism. Current information on the forest resource in Wisconsin is available here.

The area of forestland in Wisconsin has steadily increased in recent decades and currently stands at approximately 17 million acres (Figure 3). This is an increase of 1.6 million acres since 1983. Wisconsin now has more forested area than at any time since the first forest inventory was conducted in 1936. Over 46% of the state's land area is forested, primarily in the northern and western areas of the state.

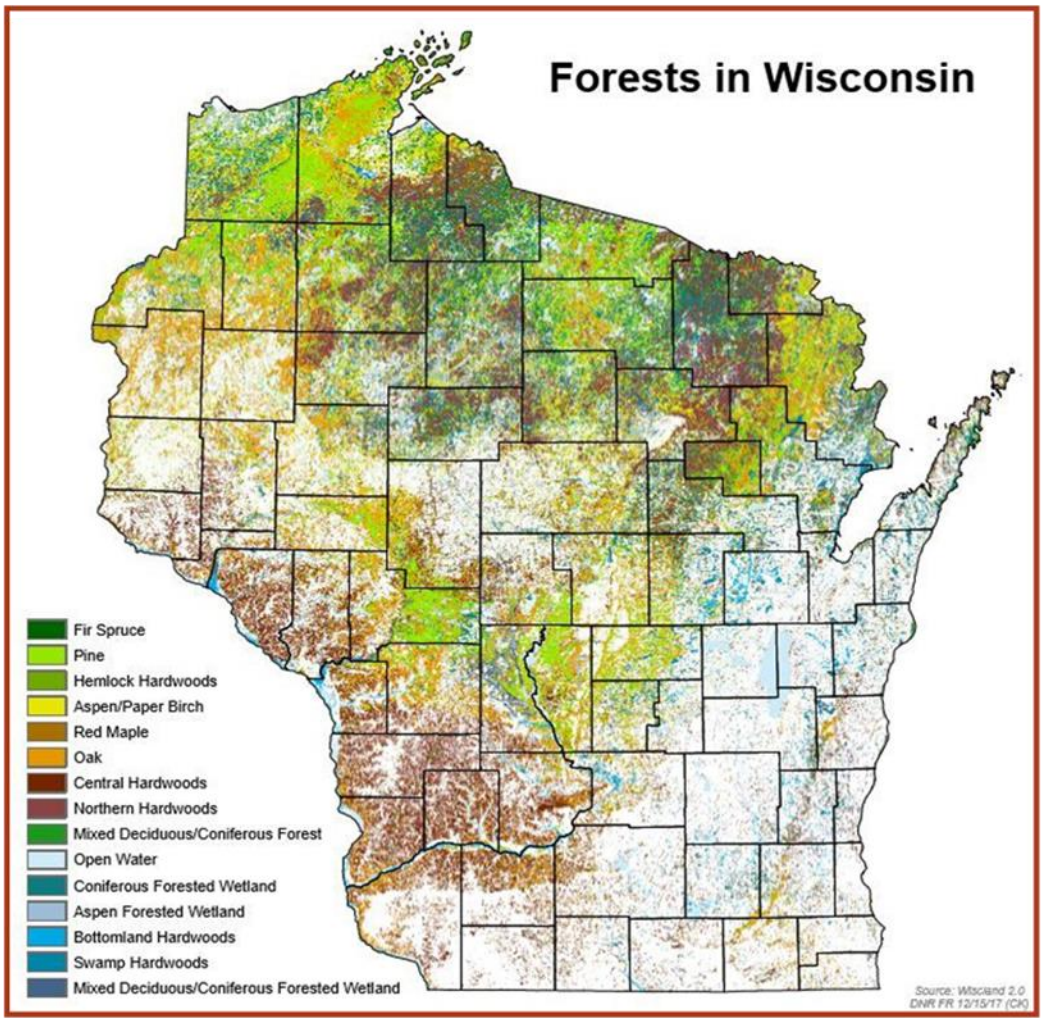
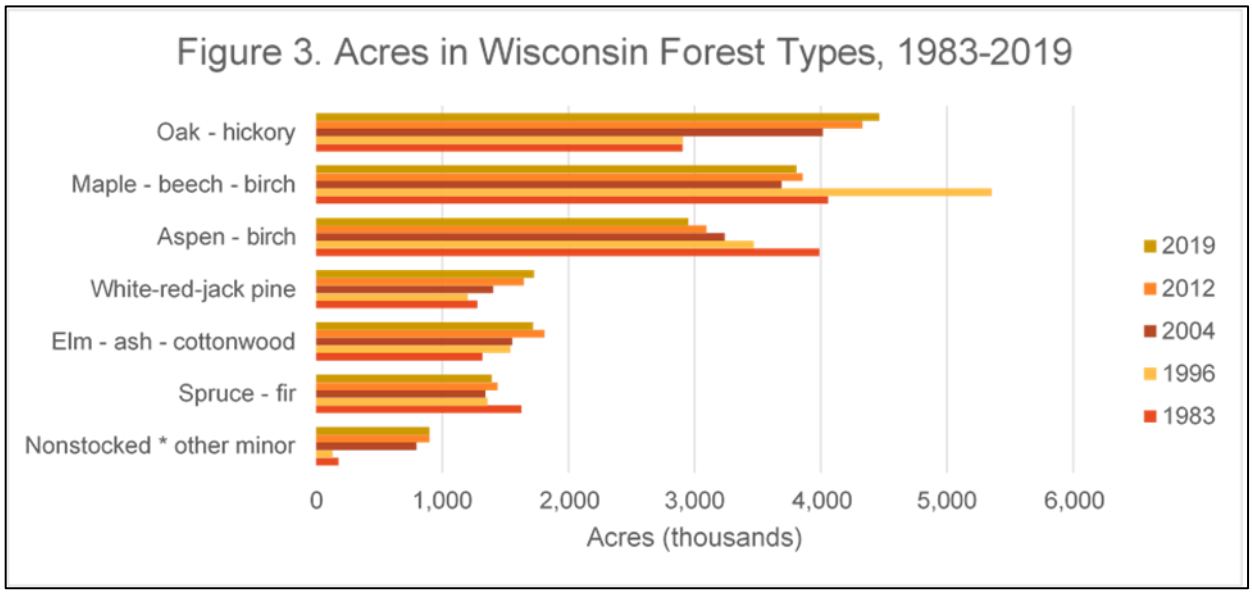


Figure 2. Wisconsin forest cover map. Source: WISCLAND land cover, Wisconsin Dept. of Natural Resources, 2017 (latest version).

Wisconsin's forests are composed primarily of hardwood species. The most abundant forest types are oak-hickory at 26% of total forested acreage, maple-beech-birch at 22% and aspen-birch at 17% (Figure 3). Lowland forest dominated by elm and ash account for 10%. Conifer types, mainly pine and spruce-fir, represent about 18% of the forested area. Wisconsin forests are mostly mature with the greatest proportion of stands in the 61-80 year class. The decline in acreage of the early successional aspen-birch forest type is related to the maturing of Wisconsin's forests. About 70% of Wisconsin's forest lands are privately owned, 10% are federally owned and the remaining is split among state, local government and tribal ownership.



Forest Health Laboratory Update

Two new instruments were purchased to improve the capability and efficiency of laboratory services that the Forest Health Lab provides. Promega Maxwell RSC, an automated DNA extraction instrument, has dramatically reduced the number of hours that were spent to extract DNA manually in the past. Bio-rad CFX Opus 96 Real-Time PCR will expand the laboratory's molecular diagnosis capabilities to keep abreast of rapidly advancing molecular techniques.

Outreach And Education

The Forest Health Team delivered effective communications while facing a year of change in 2021. For the first third of the year, Elly Voigt handled outreach and education for the team as she had in late 2020. But as the lab technician duties ramped up with the growing season, Elly shifted back to that work. While the team continued to send out pre-planned outreach during the summer, we were excited to welcome Brenna DeNamur in September as a full-time Outreach Specialist. One of Brenna's goals is to increase the team's presence on social media. Facebook and Twitter posts now accompany most press releases.

Monthly newsletters are the core of the outreach and education of the Forest Health Program. Forty-six newsletter articles were distributed to 4,223 subscribers (as of Nov. 30). Our subscribership has increased by 639, an 18% increase over last year. To better reach important audiences, we worked with the Wisconsin Arborists Association, which will now link to our newsletters in their member publications. We plan to reach out to other Wisconsin forest and forest industry associations to make a similar arrangement to connect with their members.

Despite continuing precautions to prevent transmission of COVID-19, forest health staff presented to over 2,500 individuals in 52 different audiences. Topics included forest health issues, invasive species management, plant diseases and worms. As would be expected, these were presented virtually or outdoors.

Non-Native Forest Health Threats

Beech Bark Disease

Beech bark disease is a fatal disease complex of American beech (*Fagus grandifolia*) involving a scale insect (beech scale, *Cryptococcus fagisuga*) and one of several *Neonectria* or *Bionectria* fungi. In 2009, a heavy infestation of beech scale and mortality of beech were detected for the first time at a site in Door County. Surveys done in the following years indicated that beech scale had spread through most of the Wisconsin range of American beech. In 2017, *N. ditissima* was isolated from beech firewood at the original detection site. Door County remains the only Wisconsin county where both beech scale and beech bark disease have been found (Fig. 4).

Figure 4. Counties with beech scale detections are shown in blue.

Site visits in eastern Wisconsin during 2021 indicated that populations of beech scale remained very low outside of Door County. Beech scale populations in Door County were variable and ranged from very low to very high.

One notable site containing American beech in Washington County was evaluated this summer. The UW-Madison Plant Disease Diagnostics Clinic confirmed the presence of the native fungus, *Bionectria ochroleuca* (formerly known as *Nectria ochroleuca*), in samples taken from a pocket of dead and dying beech at a rural residential property in the Town of Wayne. *Bionectria ochroleuca* is one of the fungal species involved in the beech bark disease complex, but its role is not fully understood. This is believed to be the first identification of *B. ochroleuca* from American beech in Wisconsin.

Beech scale was not observed on these declining trees or on healthy beech located at the property. Thus, beech bark disease was unlikely to be the cause of tree mortality since this disease requires the presence of beech scale. It is believed that high precipitation levels incited

tree decline, and signs of Armillaria root disease were seen. The site had been visited two years earlier, and at that time the decline was attributed to below-ground factors. The importance of *B. ochroleuca* in contributing to tree decline at this site is unknown. Staff have also been monitoring for signs of beech leaf disease during site visits where American beech was present. Beech leaf disease is not known to be in Wisconsin, and the closest known location is in Ohio.

Emerald Ash Borer (EAB, *Agrilus planipennis*)

Distribution Of EAB In Wisconsin

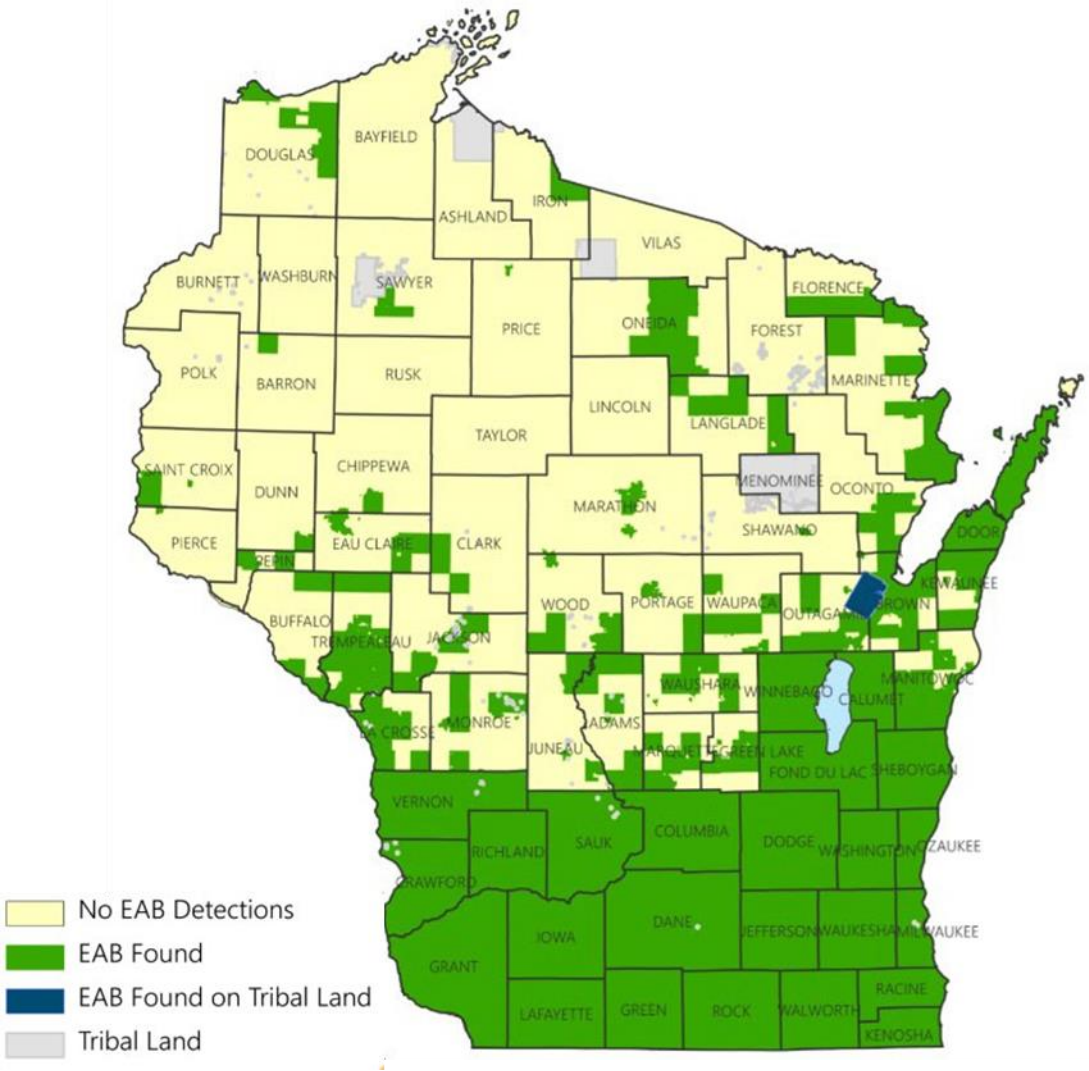


Figure 5. Map of municipalities where EAB has been confirmed as of Dec 14, 2021. Green tinted areas are non-tribal lands where EAB has been confirmed, dark blue are tribal lands where the pest has been found. Cream and gray municipalities are where EAB has not been confirmed on non-tribal lands, respectively.

In 2021, EAB was confirmed for the first time in Barron, Iron and Langlade counties. It has now been found in 61 of the 72 counties in Wisconsin. While the federal quarantine on EAB has been rescinded, the state continues to track confirmations of the invasive pest at the municipal level for use in local planning and management of the ash resource (Figure 5).

Although there was no trapping for EAB by federal or state agencies in the summer of 2021, detections were confirmed by forest health staff and state entomologists from images or samples sent to them. For a historical review of the spread of EAB in Wisconsin since its initial identification in 2008, see the report on this species in the Wisconsin DNR Forest Health 2016 Annual Report and subsequent annual reports.

Damage From EAB In Wisconsin

Ash decline and mortality continued its inexorable spread in 2021 (Figure 6). Mortality has progressed along the Mississippi and lower Wisconsin Rivers. In five counties in that area, ash mortality now exceeds 95%. The extent of mortality is especially evident in the riverine forests previously dominated by green ash. Mortality among white ash in the uplands is not as noticeable, as they are a smaller component of those forests. This is the end stage of mortality that has been ongoing since 2016 in this area and the decline that preceded mortality. The area of extirpation in eastern Wisconsin continued to move northward in the previously ash rich forests of Sheboygan County. Statewide, the area where ash mortality exceeds 95% increased to 142,453 acres replacing much of the area in the "more than fifty percent (>50%) mortality" category from last year, currently at 87,007 acres. Ash is functionally extinct in counties in the southeast and along the Mississippi River, though these will be good areas to survey for potentially resistant individuals, called “lingering ash” to be added to the resistant ash breeding effort. The leading edge of >50% decline advanced modestly in central counties, northwards in Manitowoc County, in the communities of the Fox River Valley, and in the northern infestation near Rhinelander in Oneida County. Statewide, the area with >50% decline stands at 114,843 acres. Ash mortality progressed in the greater areas of Madison and Green Bay.

Forest health staff have mapped the full extent of ash decline from EAB since it was first observable on a landscape scale in 2012. Mortality was added the following year and mortality exceeding 95% of the ash population in 2019. To best represent the level of damage and distribution on the landscape, we have produced maps that show the complete distribution of ash at three cumulative levels of damage. Forest health staff defined polygons of three levels of impact on the ash population in an area: >50% dieback, >50% mortality and >95% mortality. With the help of USDA Forest Service staff, the ash distribution data collected by the Forest Inventory and Analysis Program was then layered onto the damage polygons to produce maps, such as Figure 6. Together, we are producing maps on the progression of damage to ash from EAB to be presented as part of a story map on EAB, its spread and impacts over time in Wisconsin. We expect to make this available to the public in 2022.

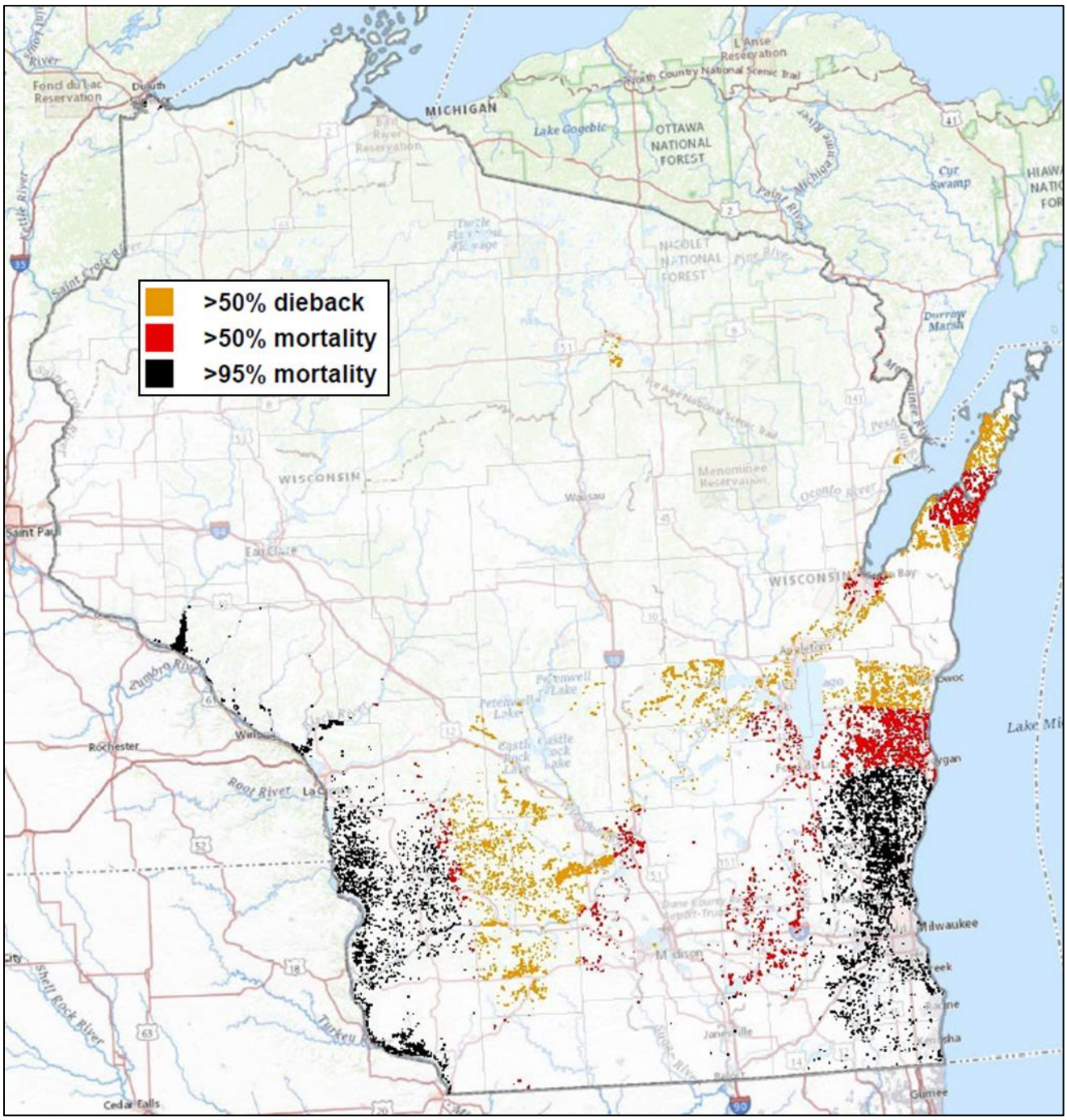


Figure 6. Damage from EAB to ash mapped in 2021. Area where damage occurred is overlaid with location of ash giving a stippled appearance. Crown decline predominated in areas marked in yellow. Mortality predominated in areas marked in red. Mortality in excess of 95% of the population including mortality that occurred in previous years, is tinted black.

Biological Control Of EAB

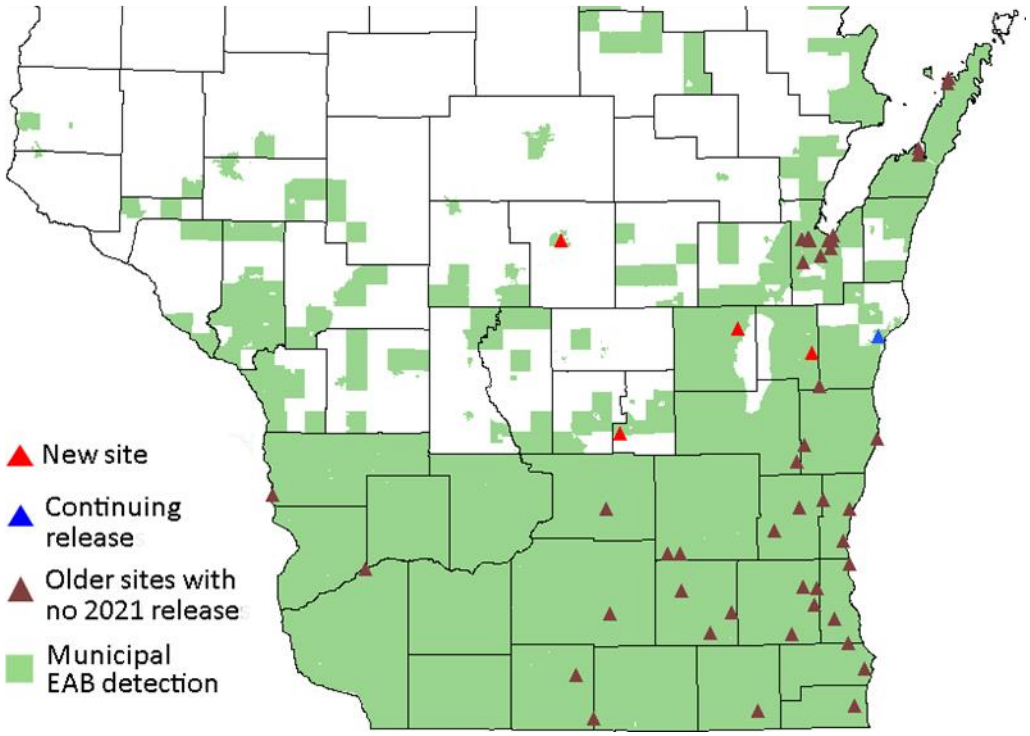


Figure 7. Map of release sites of EAB biocontrol agents 2011-2021 overlaid on locations where EAB has been confirmed present indicated in green.

2021 was the 11th year that natural enemies of EAB have been released in Wisconsin (Figure 7). All are tiny wasps that the public is unlikely to ever see them due to their size. The non-native wasps also specialize on EAB as their host, rarely parasitizing other insects. *Tetrastichus planipennisi* (Figure 8), *Spathius galinae* and *Oobius agrili* were released monthly between mid-June and mid-September.

The *Tetrastichus* and *Spathius* wasps attack EAB larvae beneath the bark, and the *Oobius* wasps attack EAB eggs on the bark surface. These introductions will provide downward pressure on EAB populations in the future, allowing for survival of ash trees with partial resistance to EAB. Parasitoids are reared by the USDA APHIS Plant Protection and Quarantine EAB Parasitoid Rearing Facility in Brighton, Michigan. The wasps are supplied to states with established populations of EAB at no cost. Releases were performed by a APHIS seasonal employee and sites were selected

Figure 8. Pupae of T. planipennisi

with significant input from forest health program staff. Recovery surveys were done by staff of the state forest health program.

A total of 20,599 wasps from three different species were released between mid-June and mid-September: *T. planipennisi* (59%), *S. galinae* (15%) and *O. agrili* (26%). First releases were done in Calumet, Green Lake, Portage and Winnebago counties. Biological controls of EAB have now been introduced in 21 Wisconsin counties.

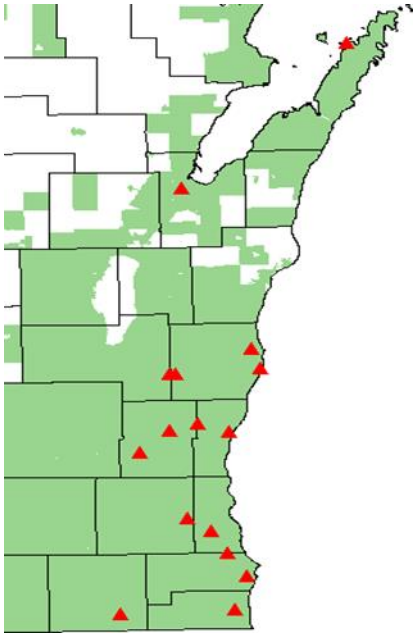


Figure 9. Red triangle mark sites where EAB biological controls were recovered in 2013-2021

Recovery efforts were encouraging in 2021. First-ever recoveries of *T. planipennisi* were made in Sheboygan (two sites) and Fond du Lac counties (one site). That species has now been confirmed established at 16 sites in 11 counties in southeast Wisconsin (Figure 9). One site in each new county had no previous releases of the wasp, demonstrating that the wasp had naturally dispersed there, in one case from a surprising distance. *T. planipennisi* was found at a site in Sheboygan County approximately 7 miles from the nearest release made three years earlier. To try to recover the egg parasitoid, *O. agrili*, bark samples from several 2020 and 2021 release sites were incubated, but we are not yet successful in recovering this species. We have yet to recover *S. galinae* as well. However, APHIS scientists were able to detect DNA of *Spathius agrili* from wasp specimens collected at Kohler-Andrae State Park in Sheboygan County. The site is approximately 20 miles away from the nearest release *S. agrili* made 10 years ago. Although *S.agrili* has rarely been recovered in any state, this could demonstrate long-term establishment and long-distance, natural dispersal of this species, normally considered not cold hardy enough to thrive in Wisconsin. Further surveying will be done in the winter of 2022 to verify if the species is truly established, or if the species identification is an artifact of DNA testing methodology.

Heterobasidion Root Disease (HRD, *Heterobasidion irregulare*)

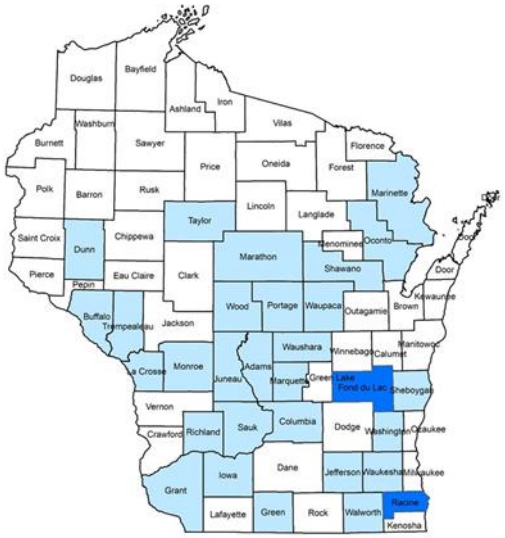


Figure 10. Counties where HRD has been confirmed as of Dec. 2021. Counties in dark blue were confirmed in 2021. Counties in light blue were confirmed in previous years.

Heterobasidion root disease (HRD), caused by the fungus *Heterobasidion irregulare*, is one of the most destructive conifer diseases in temperate regions of the northern hemisphere. Trees infected with HRD exhibit thin crowns, growth loss, wood decay and/or mortality. Mortality often occurs as an expanding pocket of dead trees. The pathogen is both an immediate and long-term concern because it can persist in a stand, making it difficult to regenerate the stand to desirable species. HRD was first detected in Wisconsin in 1993 in Adams County. While native to North America, it may not be native to Wisconsin. It is currently found in 30 of the state's 72 counties (Figure 10), in red and white pine and spruce plantations.

In 2021, Fond du Lac and Racine counties were confirmed for the presence of HRD for the first time (one and two sites, respectively). All three sites were thinned pine plantations. DNA testing was conducted at the DNR Forest Health Lab and confirmed the identity of the fungus as *H. irregulare*. The trees adjacent to the infected stumps did not show visible signs of infection at any of these sites. The Fond du Lac County site and one Racine County site were thinned but no treatment was done to prevent infection by HRD. Freshly cut stumps were treated in 2017 at the other Racine County site. The two infected stumps found were within a few feet of each other and a possible explanation is that they were missed during treatment.

Research On HRD

The study to evaluate the efficacy of Cellu-Treat® and Rotstop™C, commercially available fungicides to prevent the spread of HRD, continued in 2021. Sample processing and analysis are in progress by Michigan State University, Dr. Monique Sakalidis. This study is expected to be completed in 2022. This work is being done by researchers at the University of Wisconsin-Stevens Point and Michigan State University, in collaboration with forest health staff from the Wisconsin and Michigan DNRs. It is funded by a Pesticide Impact Assessment Program grant from the Forest Service.

Invasive Plants

The Forest Health Program administers three funds that support statewide terrestrial invasive plant control efforts: the Weed Management Area-Private Forest Grant Program (WMA-PFGP), the fund for control of invasive plants on the northern state forests and the Forest Health Program's suppression fund.

Figure 11. Jaqi Christopher with a new PlayCleanGo boot brush station at the NHAL State Forest.

The Weed Management Area-Private Forest Grant Program (WMA-PFGP) provides funding to groups for invasive plant control on non-industrial private forest land of less than 500 acres. In 2021, four grants were awarded for various projects that include numerous outreach and education events, on the ground control, monitoring and afforestation.

The Forest Health Program administers funds for invasive plant management on the northern state forests. Species controlled on those properties include buckthorn, garlic mustard, black locust, Japanese knotweed and Japanese stilt grass. While some of these plants are common in southern counties, they are rare in the Northwoods, and the state forests take action to prevent their introduction and spread. In addition to survey and control work, PlayCleanGo boot brush stations were installed at popular trails within the forests to allow visitors to clean their boots of attached seeds before and after enjoying the trails (Figure 11). These boot brush stations also include a display educating users on the importance of arriving clean and leaving clean in prevention of the spread of many invasive plants.

The Forest Health Program's suppression fund continued to support control of wild parsnip on the Bearskin State Trail and Amur cork tree on the Northern Highlands American Legion State Forest. In 2021, cork trees were found along a popular trail system, so the annual survey and control project there will be continued. The suppression fund was also used to control common buckthorn at Castle Mound Campground and Japanese knotweed at Mirror Lake State Park.

Along with internal partners from the Forest Ecology and Economics section within DNR Forestry, the Forest Health Program initiated a garlic mustard research project. The study will look at the overall impacts of garlic mustard on the regeneration of northern hardwoods in the Langlade County Forest. Concerns regarding the impact of herbicides on mycorrhizae along with the allelopathic influence from the garlic mustard on this beneficial fungus is paramount in the study. Field work will begin in 2022.

Invasive Worms (*Amynthas* spp.)

Forest communities in Wisconsin evolved following glaciation, which eliminated worms from soils across the state. As a result, many of our native tree and herbaceous species are dependent on the thick layer of slowly decomposing leaf litter on the soil that can persist only in the absence of worms.

European worms have been slowly spreading in Wisconsin for two centuries, inadvertently brought by early colonists and spread by human agriculture. Movement of worms into woodlands has accelerated in recent decades as more people move into and recreate in the Northwoods. Where present, European worms slowly consume the leaf litter layer, resulting in reduced survival of native tree seedlings and wildflowers. In recent years, new non-native worms from Asia have been found in Wisconsin. This group of related species is referred to as "jumping" worms. Unlike the European worms, the jumping worms are parthenogenetic, which greatly increases their ability to successfully establish from a small starting population or even one individual. Population growth is rapid as is the consumption of the leaf litter, and it is this accelerated stripping of leaf litter that is cause for our concern.

Figure 12. Tinted counties represent the known distribution of jumping worms in Wisconsin 2021.

Jumping worms continue to be a concern for forest managers in Wisconsin. Jumping worms were first identified in Dane County in 2013 and have since been reported in 45 of the state's 72 counties in communities and residential settings (Figure 12). There is no formal survey for jumping worms in Wisconsin. All specimens are submitted by the public and are typically collected near where the submitter lives. Verified species in Wisconsin are *Amynthas tokioensis*, *A. agrestis* and the closely related *Metaphire hilgandorfi*. *A. tokioensis* is the most common of the three species. *A. agrestis* typically appears in combination with *A. tokioensis.* In 2021, forest health staff received fewer reports of new populations than in previous years. This may be due to summer drought in southern Wisconsin where jumping worms are more common, suppressing population growth and activity of these surface-dwelling worms and making them less noticeable to the public than in previous years.

Now that the vermicide Early Bird is no longer available, localized suppression of worm populations that have reached damaging levels is no longer possible. Producers of vermicides are aware of the market among gardeners and managers of ornamental plantings, and some products using plant-derived saponins are being tested for this market. Development of a product for use with ornamental plantings is of interest to forest managers as it may allow

treatment of small infestations in woodlands if found early.

Lymantria dispar, Common Name Is In The Process Of Replacement

In 2021, Eau Claire and Richland counties were added to the quarantined area for *L. dispar* by APHIS. Currently, 52 of Wisconsin's 72 counties are regulated in the eastern two-thirds of the state where it is going through its typical population cycle (Figure 13). Wisconsin DATCP's Slow the Spread (STS) program found reproducing but isolated populations in 10 non-quarantined counties, approximating the leading edge of spread westward. Most of those locations will be treated to reduce populations to levels where they cannot contribute to spread. Typically, a county is quarantined only when the STS program no longer treats reproducing populations detected there.

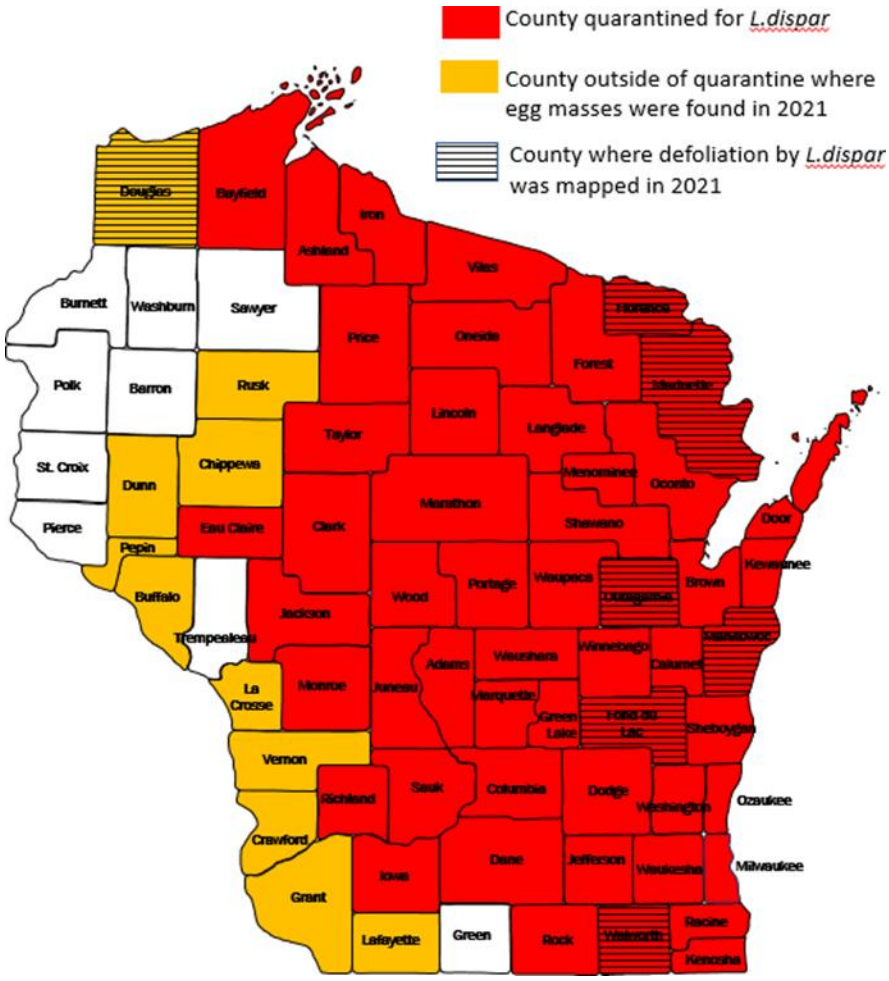


Figure 13. Counties where L. dispar is quarantined for, where it caused defoliation, and where egg masses were found outside of the quarantined area in 2021.

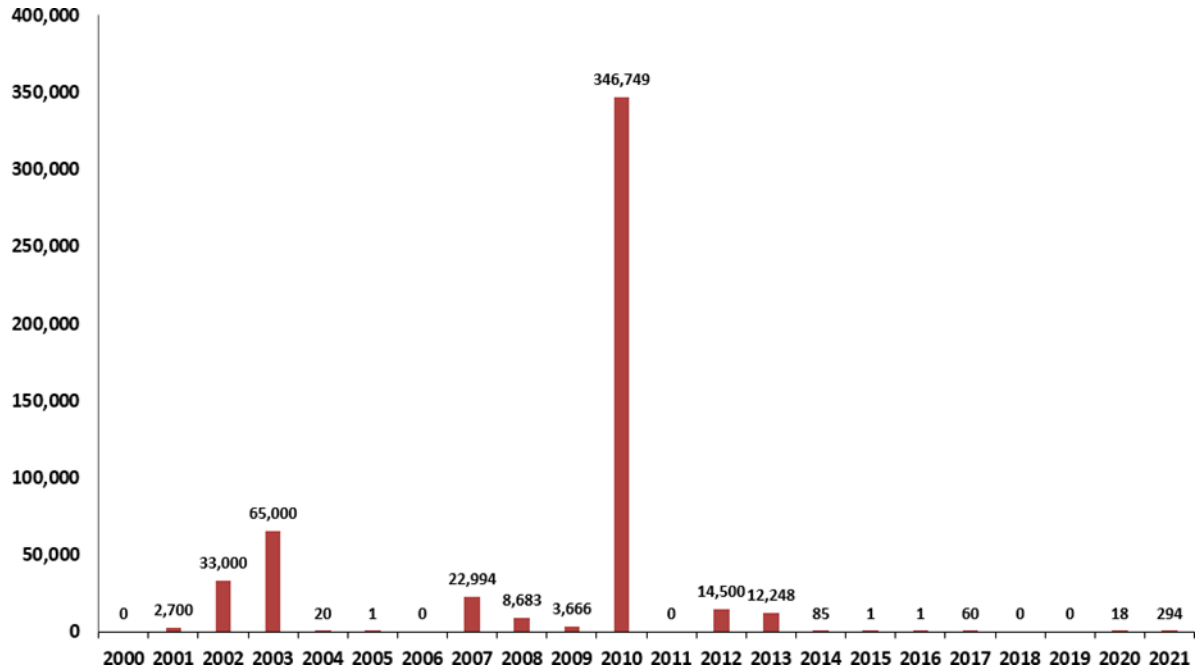


Figure 14. Number of acres damaged by Lymantria dispar each year since 2001 when first defoliation in Wisconsin was recorded.

Since 2014, the population of *L. dispar* has been low, and the number of acres damaged insignificant (Figure 14). However, there are indications that the population is rising. Warmer winters in 2019-2021 and drier spring weather during 2020 and 2021 appear to have contributed to an increase in *L. dispar* populations in the eastern counties. The STS program moth trapping data showed a 19% jump in the number of males caught in the western third of the state from 2020. In the areas where the moth is established, there was an increased volume of nuisance reports and life stage observations, and a total of 294 acres of defoliation was mapped at a handful of sites in the counties of Douglas, Florence, Fond du Lac, Manitowoc, Marinette and Walworth. Swamp white oak, red oak, bur oak, aspen and willow species were primarily affected. These stands ranged from young to mature, and defoliation intensity ranged from light to severe. At a trailhead in the Southern Unit of the Kettle Moraine State Forest (Walworth County), the local population was so high on open grown oaks that the trees were stripped, except for wads of adhered-together leaves, larval skins, pupal cases, adults, and egg masses, giving these trees an unusual appearance (Figure 15). The high number of egg masses there and at Devil's Lake State Park pose a threat of wider defoliation in spring 2022 and forest health staff and park managers

Figure 15. Wads of webbed together leaves and L. dispar life stages, inset is a close up.

planned and startedimplementation of a two-part control program. This fall, park staff applied Golden Pest Spray Oil to egg masses that could be reached to help reduce the starting population next spring. This will be followed by an aerial spray of a *Bacillus thuringiensis kurstaki* based insecticide in May 2022.

Figure 16. Closeup of the tiny egg parasitoid, O. kuvanae, parasitizing L. dispar eggs.

The introduced egg parasitoid wasp, *Ooencyrtus kuvanae* (Figure 16), was observed at several sites where *L. dispar* egg masses were common, as far west as Spring Green. The extended warm weather this fall enabled several generations to complete development before the hard freeze killed immatures still in the host eggs. Fertilized female wasps will overwinter in the duff layer and emerge in April to lay one more generation into the *L. dispar* eggs.

Additionally, there is currently a national effort to change the common name of *L. dispar*. The Entomological Society of America (ESA) sets English language common names for insects in North America. In June, ESA adopted new rules for common names that no longer allow references to ethnicities, races, or people groups. In July, ESA announced that it would no longer allow the use of “gypsy” in insect common names, recognizing it is a racial slur. Andrea Diss-Torrance joined ESA’s mission in establishing a new name, which will be announced in early 2022. Diss-Torrance’s input as a forest pest manager and her help in reaching out to and engaging applied stakeholders has been useful to ESA, especially during the present *L. dispar* outbreak in eastern states. Engaging the diversity of stakeholders, ESA received over 200 proposals for a new common name, and over 1000 ballots were cast on seven finalist names. Once the name is selected, ESA will be engaged in encouraging its use both directly and by providing educational resources for use by stakeholders. The Forest Health Team is preparing to transition to the new name, along with the other Wisconsin agencies dealing with this insect.

Oak Wilt (Bretziella fagacearum)

Oak wilt is a fungal disease that was documented killing red oaks as far back as 1881 and was confirmed in Wisconsin in 1944. In the southern part of the state in the late 1940’s, it was noted that oak wilt was having a distinct negative impact on oak savannah ecosystems in the absence of fire. It was predicted that oak wilt was present even before settlement, which explained why oak savannahs are dominated by bur and white oak, containing far less oaks of the red oak group. Origins of the fungus are still not definitively known; however, it is suggested that due to the limited genetic variation of the fungal species, it is likely not a native pathogen and

originated from South America.

Once initial detection was confirmed in 1944 and symptomology was better understood, there were more reports from counties in the central and south-central portion of the state. However, it was not until 1964 that the DNR developed a disease distribution map by county, at which time oak wilt was found in the lower two-thirds of the state, except the Door Peninsula and adjoining counties along the shoreline. In the 1980s, detection and sampling methods became more accurate and additional detections to the north were recorded. Since then, forest health staff have tracked the continuous northward expansion (Figure 17). Currently, oak wilt is known to be present in all but seven counties in the central-north and along the Lake Michigan shore from the Door Peninsula south to Manitowoc County. However, oak wilt may only be present in part of some northern counties (Figure 18). In 2021, oak wilt was

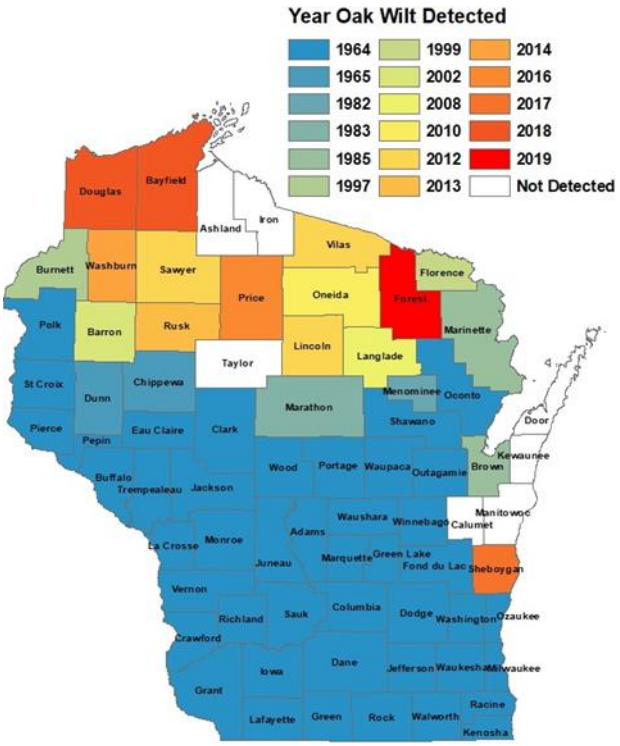


Figure 17. Map of counties where oak wilt has been confirmed and the year it was found.

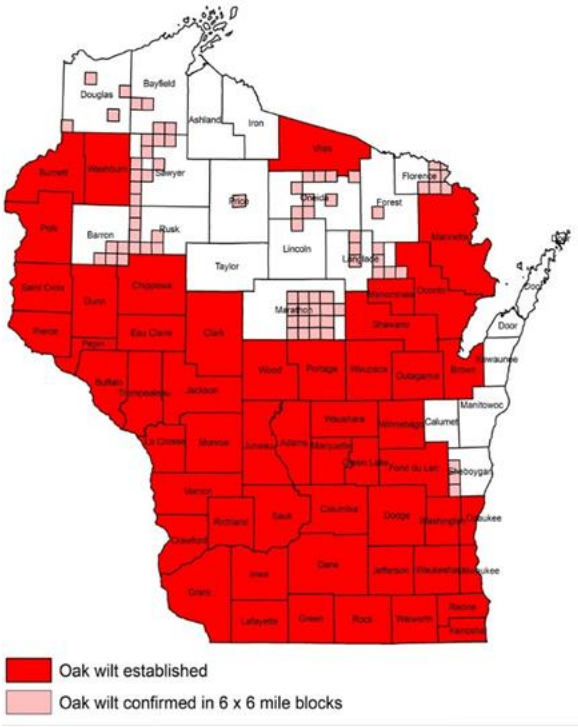


Figure 18. Oak wilt is generally established in counties tinted red. It has been confirmed in townships tinted pink in otherwise non- infested counties, Dec. 2021.

detected in four new townships: Highland (Douglas County), Woodboro and Newbold (Oneida County), and Evergreen (Langlade County). Currently, oak wilt is actively managed throughout Wisconsin at the private and state level, and in 2021, a grant from the Forest Service for suppression of oak wilt along the leading edge of used to control oak wilt pockets in northeastern and northwestern Wisconsin.

<u>Oak Wilt Suppression Program</u>

In 2021, the Forest Health Program received funding from the Forest Service to cover a portion of the cost associated with performing oak wilt control in the northern leading edge of its distribution in Wisconsin. This program was offered to qualifying non-federal public lands and private lands located in Bayfield, Douglas, Langlade, Oneida, Sawyer, Vilas

and Washburn counties. Based on research

described below, the Forest Service allowed containing infection pockets by killing oaks with a likelihood of being root grafted with a symptomatic tree. This was done by girdling or cutting the trees and treating the wound/stump with herbicide. These treatments are much more practical than trenching or uprooting, which had previously been the treatments eligible for suppression funding. Twenty-three stands were treated by contractors to contain oak wilt infection. The program was well received in the target area and the Forest Health Program has requested additional funding from the Forest Service to continue oak wilt suppression in northern counties in 2022.

Research On Oak Wilt

Once one tree in a stand is infected with oak wilt, the disease can spread through root grafts to kill all connected oaks in the stand. Oak wilt can be contained by breaking these root grafts to uninfected trees. This is currently done by trenching or uprooting oaks, but these both require expensive equipment and access to the site, which limits their practical use in forests. Some forest managers have tried creating a buffer of dead roots around infections by killing potentially connected trees with girdling and application of herbicide. To formally test this technique and make its use eligible for grant support from the Forest Service, DNR staff started a five-year study in 2015 to evaluate the effectiveness of this method. Results from this study show that the technique can be used successfully to contain pockets of oak wilt infection when the number of trees showing symptoms of the disease is low at the time of treatment. Oak wilt pockets with more than four infected trees at the time of treatment were significantly more likely to spread beyond the treated area (Bronson et al. In Prep.).

Sudden Oak Death *(Phytophthora ramorum)*

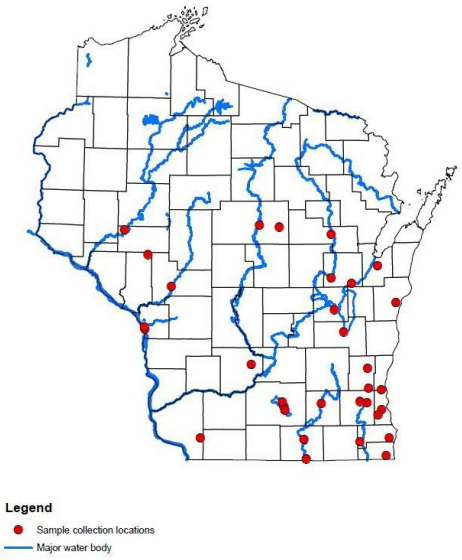


Figure19. 2020-2021 collection sites of the Phytophthora ramorum stream bait survey.

Phytophthora ramorum is a fungus-like organism that causes the death of a wide range of trees and shrubs, but it is the destructive impact on oaks in states along the Pacific coast that led to its common name, sudden oak death (SOD). In 2019, DATCP was alerted that 59 retail stores and nurseries in Wisconsin had received nursery stock possibly infected with *P. ramorum*. Unfortunately, notification came too late to retrieve all the stock shipped. However, DATCP was still able to test plants from 43 businesses, and one sample tested positive for *P. ramorum*. This result was concerning as it suggested that some of the already sold plants may have been carrying the disease. Wisconsin was not the only state where potentially infected plants were shipped from the quarantine-violating nursery, so the Forest Service supported detection surveys in states that received the potentially infected stock. Forest health staff conducted stream bait surveys in forested environments near retail stores and nurseries that may have received nursery

stock infected with *P. ramorum*. These detection surveys were scheduled to start in the spring of 2020. However, due to the COVID-19 restrictions, no fieldwork was allowed until the end of June 2020.

During 2020, staff were able to collect samples from 19 sites. The stream bait survey continued during 2021 to reach our goal of at least 30 sites sampled; we collected 10 samples during the spring and five samples during the fall baiting periods. Project sampling is complete, as we surpassed our goal, sampling a total of 34 sites (Figure 19). All the samples that we collected in 2020 tested negative for *P. ramorum*. The testing of samples from 2021 is not yet complete.

Native Health Threats To Hardwoods

Bur Oak Blight (*Tubakia iowensis*)

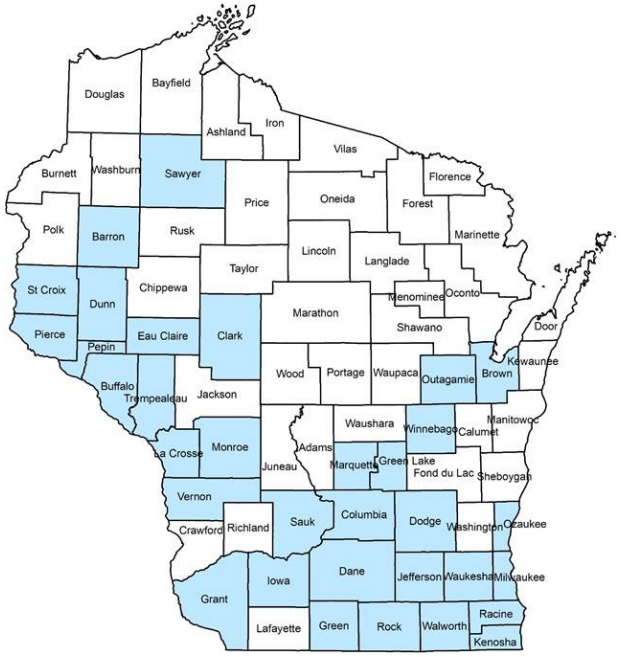


Figure 20. Counties tinted blue are where bur oak blight was confirmed in previous years.

Bur oak blight (BOB), caused by the fungus *Tubakia iowensis,* has been confirmed in 33 counties in Wisconsin since it was first detected in 2010 (Figure 20). BOB symptoms are most common in the lower half of bur oak canopies. Wedge-shaped yellow and brown patches on the leaves and purple/black leaf veins are the most obvious symptoms of the disease. Trees may decline over many years as the fungus that causes BOB spreads through the canopy. Wet to very wet weather between 2016 and 2020 made conditions ideal for BOB infection, and it was found in many new counties during this period. With the return of more normal precipitation in 2021, all detections made this year were in counties where it had previously been found. There was no observed range expansion.

Hardwood Defoliators

Basswood Thrips

Basswood thrips caused 50-75% defoliation over more than 20,000 acres in Sawyer and Rusk counties in northwest Wisconsin in 2021. This was the second year of heavy defoliation in this area. Damage was also discovered in Florence, Forest, Marinette and Oneida counties in northeast Wisconsin. In combination with concurrent frost damage, trees were roughly 50% defoliated.

Black Walnut Defoliator (*Gretchena amatana*)

Figure 21. Silken webbing covering the trunk of a defoliated black walnut tree in

In 2020, forest health staff in Wisconsin, Minnesota and Iowa received calls about black walnut stands being defoliated and webbed (Figure 21). In 2021, the defoliation expanded to multiple additional black walnut stands in southwest Wisconsin, while northeastern Iowa and Minnesota continued to see damage. Molecular work completed by DATCP identified the larvae causing the damage as a native Tortricid moth, *Gretchena amatana*. While the larval host plant of *G. amatana* is unknown, other *Gretchena* larvae also feed on Juglandaceae host plants. The Forest Health Team's goal for 2022 is to capture moths at black lights and rear moths from caterpillars to confirm the identity and to learn more about the life cycle and damage caused by *G. amatana*.

Cherry Scallop Shell Moth (*Hydria prunivorata*)

A severe outbreak that had persisted since 2016 in the same 1700-acre area in southeast Wisconsin ended last year, and no damage was observed from this insect in 2021. It is unknown why this outbreak continued for so long in this location, but the accumulated stress is resulting in decline and mortality of cherry trees.

Elm And Maple Spanworms (*Ennomos subsignaria* and *E. magnaria*)

Defoliation at Devil's Lake State Park and surrounding areas in Sauk County increased significantly in 2021. Greater than 50% defoliation occurred on maple, oak, ash, hickory and basswood. Elm spanworm also caused damage in Chippewa and Dunn counties.

Forest Tent Caterpillar (*Malacosoma disstria*)

Populations remained low in 2021, and only light defoliation was recorded in a few locations in Oneida and Sawyer counties. The last forest tent caterpillar outbreak in Wisconsin ended in 2002. In the 20th century they could be expected every ten years, so another large-scale outbreak is overdue.

Green Striped Mapleworm (*Dryocampa rubicunda*)

Over 700 acres of red maple were defoliated more than 75% in Burnett County.

Linden Looper (*Erannis tiliaria*)

Defoliation by linden looper occurred in northern Wisconsin but was difficult to quantify in some areas because of simultaneous damage from basswood thrips and frost.

Saddled Prominent (*Heterocampa guttivitta*)

A localized outbreak of the native caterpillar, saddled prominent (Figure 22), continued in central Door County. A total of 132 acres of defoliation were reported in the Towns of Egg Harbor, Gibraltar and Jacksonport. This defoliation primarily affected large sugar maple and American beech. Several landowners reported that this was the second year of the outbreak, while one landowner reported a third consecutive year. Long-term impacts are usually minor because this is a late-season defoliator that causes defoliation from July to September.

Figure 22. Saddled prominent caterpillar in Door County, July 2021. Actual size is roughly 1.25 inches in length.

Saddled prominent has a history of unexpected, localized outbreaks lasting 2-3 years in Door County. The northern half of the Door Peninsula and offshore islands (Chambers, Rock and Washington) have traditionally been the reported locations of this pest. Older forest health annual reports from the 1950s to 1990s had reported occasional outbreaks in several other counties (Marathon, Marinette and Shawano). However, since 1997 the only reports of this insect causing defoliation have been from Door County. The reason for this is unknown.

Other Oak Health Issues

Oak wilt, *Lymantria dispar* and saddled prominent are covered in other sections of this annual report. This section covers the other issues, pests and diseases impacting oaks in 2021.

Anthracnose sp.

A fungal leaf disease that causes blotches of dead leaf tissue. Symptoms often occur in the spring but can occur at any time of the year and are more common in years with cool and wet spring weather. The weather has been abnormally wet in the state since 2016, and though precipitation declined to more normal levels this year, severe symptoms were observed in Oconto, Sawyer, and Washburn counties.

Decline In White Oaks

Decline has continued in the same locations in central and southcentral Wisconsin since 2019. Drought in the early 2010's followed by historically wet conditions in 2016-2020 and repeated spring frost damage are the primary abiotic stressors contributing to decline.

Stem And Leaf Galls

Oak apple galls and others caused by cynipid gall wasps were plentiful this year around the state. While they elicit interest from the public, none of these galls create health problems for the tree.

Oak Twig Girdler (*Oncideres cingulate*) And Oak Twig Pruner (*Anelaphus parallelus*)
These beetles were active in western Wisconsin. These insects feed in a way that causes branch tips to break off and fall to the ground in mid- to late-summer. Although it may appear that there are many branch tips laying on the ground, the damage is often minimal.

Pine Oak Gall Rust (*Cronartium quercuum*)
This fungus causes small tan flecks on leaves and this year symptoms were severe in some areas of Vilas County. Small, stringy fruiting structures emerge from the underside of the leaf but do not do any lasting damage to oak trees.

Tubakia Leaf Spot (*Tubakia dryina*)
This disease was severe in scattered trees in central and northern Wisconsin. It caused severe leaf defoliation in the lower crown of oaks. Leaves typically turn mostly brown, and some leaves drop from the tree prematurely. Symptoms were noted in Oneida and Vilas counties in north-central Wisconsin and scattered in several counties in central Wisconsin.

Yellows Diseases (*Candidatus Phytoplasma fraxini*)

Yellows diseases are caused by phytoplasmas, plant-parasitic bacteria that lack cell walls. They cause mortality of ash and elm and may be detrimental to other tree species. In host trees, infection symptoms include dense branch growth, formation of branch clusters (i.e., witches' brooms), dwarfed or malformed foliage, foliar discoloration (e.g., yellowing), growth decline, vertical bark cracks, crown thinning, dieback and/or mortality. These symptoms can be easily misdiagnosed as being due to environmental problems. Recent phytoplasma detections on species other than ash and elm have generated concerns about the potential impact of phytoplasma on hardwood regeneration.

Ash yellows is the most observed phytoplasma disease in Wisconsin. First confirmed on white ash in 1987, the disease has since been confirmed in 32 counties in Wisconsin (Figure 23) and in 16 tree and shrub species using the genetic testing method of polymerase chain reaction (PCR). Host species confirmed with phytoplasma include American beech, ash (black, green, and white), black walnut, butternut, chokecherry, elm, hazelnut, bitternut and shagbark hickories, lilac, red maple, white mulberry, white spruce and swamp white oak.

Figure 23. Counties in Wisconsin where phytoplasma has been confirmed are tinted blue.

Research
Between 2019 and 2021, the Forest Health Program collaborated with the University of Wisconsin-Madison Plant Disease Diagnostics Clinic (UW PDDC) to investigate phytoplasma in trees in Wisconsin. This project was funded by the DNR

Applied Forestry Bureau Research Fund and Forest Health Research Fund. Samples were tested using PCR assays at the UW PDDC. Phytoplasmas found in samples were identified to taxonomic groups/subgroups using DNA sequencing (with cloning techniques used as needed). Sequence similarity was analyzed by an interactive online phytoplasma identification platform (iPhyClassifier) and BLAST (Basic Local Alignment Search Tool). This was the first molecular-level analysis and classification of phytoplasmas on multiple tree species in Wisconsin.

A total of 196 foliage/twig samples were collected from 156 trees in 15 counties (Columbia, Crawford, Dane, Dodge, Grant, Green, Iowa, Jefferson, Price, Richland, Rusk, Sauk, Sawyer and Vilas) in 2019 and 2020. Samples were collected from 23 genera of plant species, including: *Acer, Betula, Carya, Cornus, Corylus, Euonymus, Fagus, Fraxinus, Helianthus, Juniperous, Juglans, Morus, Picea, Prunus, Ptelea, Quercus, Rhubus, Robina, Salix, Spirea, Syringa, Tilia* and *Ulmus*. All samples were tested using two molecular methods (endpoint PCR and qPCR). Some discrepancy was found between the results of two methods. For more information about the comparison of two methods, please contact Kyoko Scanlon, DNR Forest Pathologist (Kyoko.Scanlon@Wisconsin.gov).

Native Health Threats To Conifers

Caliciopsis Canker Disease (*Caliciopsis* spp.) And White Pine Bast Scale (*Matsucoccus macrocicatrices*)

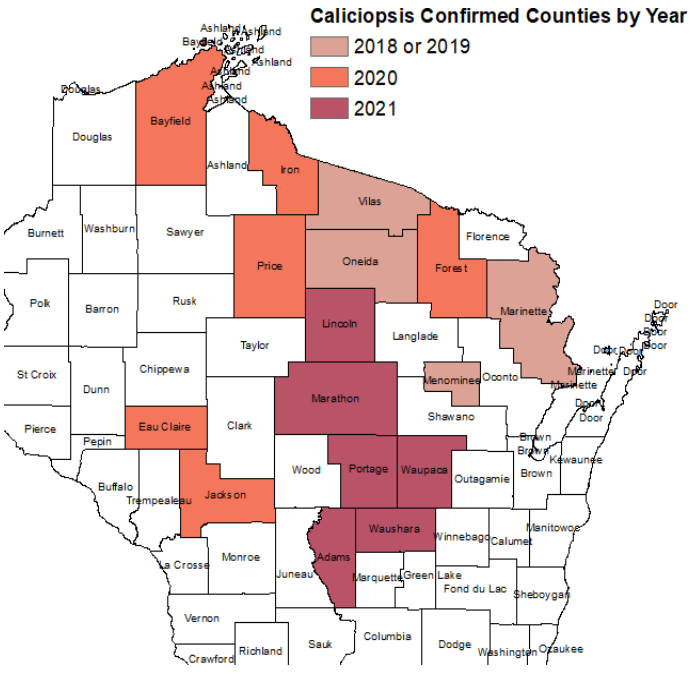


Figure 24. Counties where Caliciopsis canker associated with white pine bast scale has been confirmed and the year first observed.

Caliciopsis canker is a recently detected disease complex in Wisconsin, though it has been causing branch losses in Eastern white pine since the late 1990's in the northeastern states, Quebec and Ontario. The first observations in Wisconsin were made in 2018 on pole-sized white pine in the northern part of the state. In 2021, Caliciopsis canker was found in Adams, Lincoln, Marathon, Waupaca, Waushara and Portage counties (Figure 24). Previously, it had been confirmed in Marinette, Oneida, Bayfield, Eau Claire, Forest, Iron, Jackson, Price and Vilas counties. Though Caliciopsis canker associated with white pine bast scale were first observed in 2018, there is a record of *Caliciopsis spp.* in Menominee County in 2002.

Caliciopsis spp. causes small cankers, and as the number of cankers

increases, they eventually girdle the branch, causing the foliage to brown and die. These symptoms can be mistaken for those of white pine blister rust. It appears that *Caliciopsis* spp. is associated with the native white pine bast scale (*Matsucoccus macrocicatrices*) as they often co-occur, though their relationship is not fully understood. Bast scale was associated with heavy flagging in northwestern Wisconsin this year. It is possible that Caliciopsis canker was involved, although none was confirmed in this area. Bast scale by itself has not previously been known to cause problems in white pine, and there may be additional factors involved when branch mortality like this occurs.

As part of a study to determine the distribution and incidence of Caliciopsis canker on eastern white pine in the Lake States, forest health staff sent wood samples with fruiting structures of *Caliciopsis* spp. to Dr. Monique Sakalidis and her graduate student Rebecca Harkness at Michigan State University. They will identify the species of *Caliciopsis* and provide a better understanding of this recently emerging disease in the upper-Midwest.

Eastern Larch Beetle (*Dendroctonus simplex*)

Eastern larch beetle (ELB) is a native bark beetle that infests its host tree species, eastern tamarack, throughout its entire North American range. The beetle kills trees by tunneling and feeding under the bark, severing the nutrient flow. Annual mapping efforts over the last 20 years by the forest health staff have shown an increasing acreage of tamarack mortality caused by ELB. In 2021, ELB continued to cause mortality of tamarack in northern Wisconsin. Much of the damage in recent years, just over 1000 acres mapped in 2021, has occurred in flood-damaged stands. Regenerating impacted tamarack stands can be difficult, so forest health staff are working with Marcella Windmuller-Campione at the University of Minnesota to expand her tamarack silviculture research into Wisconsin.

Jack Pine Budworm (*Choristoneura pinus*)

This native insect goes through periodic outbreaks about every 10 years, which is related to the maturity of jack pine stands. Population outbreaks are triggered by improved nutrition supplied

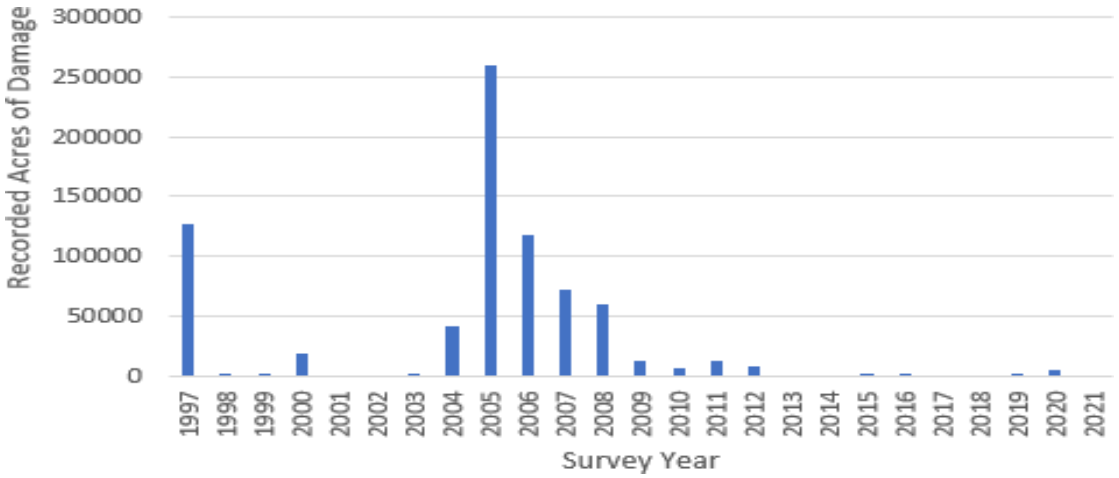


Figure 25. Acres damaged by jack pine budworm 1997-2021

by pollen cone buds, produced in abundance in mature and overmature jack pine. During outbreaks, the budworm defoliates jack pine stands, often killing their hosts. Fire typically follows defoliation and tree mortality, clearing stands and setting the stage for regeneration of jack pine seedlings from seeds released from serotinous cones. In the last 20 years, we have seen one significant outbreak, which took place 2004-2008 (Figure 25). Since 2009, the population of the budworm has remained low, and defoliation has been small, localized and managed with silviculture of its host. For example, in 2020, about 2,250 acres were moderately damaged by the pest in Juneau County. That summer an egg mass survey predicted moderate to severe defoliation. A spring harvest then captured the value of the pines, and the site is now regenerating to aspen.

Pine Wood Nematode (*Bursaphelenchus xylophilus*)

Pine wood nematode (PWN) was found infecting Scotch pine in Waushara County in 2019, but there have been no new reports in the last two years. Symptoms of pine wood nematode include rapid crown browning (within three months) in late summer, rapid drying of wood and the presence of blue-stain fungi in the wood. While PWN is not known to cause severe disease in pines native to the Midwest, non-native pines planted in Wisconsin, such as Scotch and Austrian, are highly susceptible (Figure 26).

PWN is native to North America but was first found in Wisconsin in 1980. It has since been found across the state. PWN is carried to susceptible trees by long horned beetles, such as the native white spotted sawyer beetle. Wisconsin's native long horned beetles usually only attack dying and dead trees, which suggests that the potential for PWN to affect healthy native trees is relatively low.

Figure 26. Scotch pine dying from pine wood nematode.

Spruce Budworm (*Choristoneura fumiferana*)

Spruce budworm outbreaks occur about every 30-50 years and typically last about 10 years. The current outbreak, which most agree started in 2012, may continue for a few more years before collapsing (Figure 27). Our last outbreak in Wisconsin occurred from 1970-1980 with

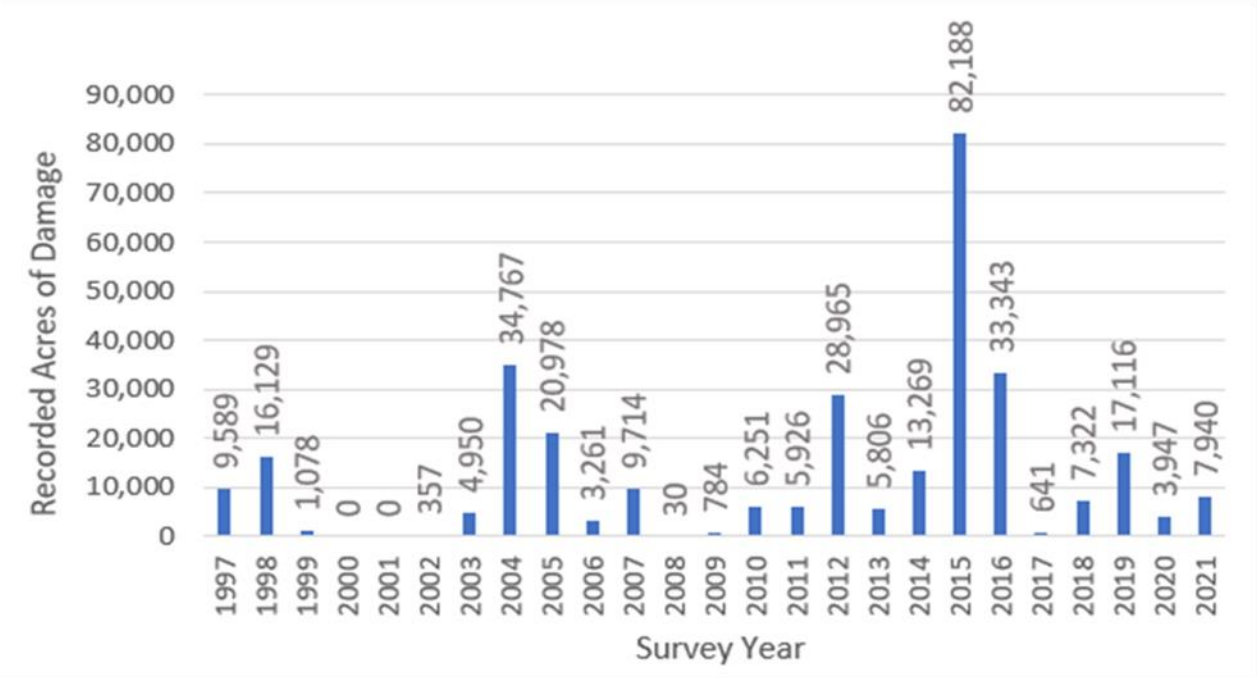


Figure 27. Observed acres of damage by spruce budworm 1997-2021.

180,000 acres impacted in the final year of the outbreak. Spruce budworm does not completely disappear in between outbreaks, and there are often a few areas of defoliation each year somewhere in the state. Other neighboring states also experience this constant presence. But these lingering populations are different than the vast areas of significant defoliation and tree mortality that occur during an outbreak. Literature indicates that some budworm populations will collapse once they have exhausted the food source in an area. This is happening in some places where trees that have been moderately or severely defoliated for consecutive years are now dead or dying, including areas in the Town of Phelps in northeastern Vilas County, areas in the Towns of Boulder Junction and Plum Lake in central Vilas County, the Town of Cable in southern Bayfield County and some localized areas in northern Marinette County and northern Forest County (Figure 28).

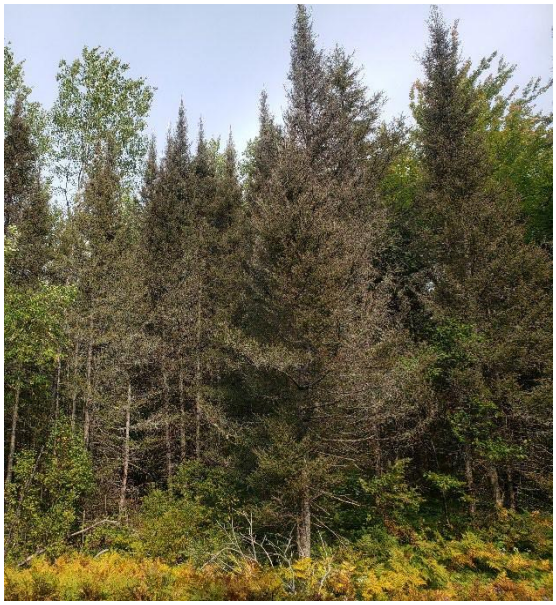


Figure 28. Tree mortality from repeated defoliation by spruce budworm.

Acreage of damage may be higher than captured in mapped data in 2018-2021. Like what we saw in 2018 and 2019, rainfall in the spring of 2021 promoted good growth on the trees, so even though defoliation was present, it was more difficult to detect due to the plentiful growth. This may have led to an undercount of the acres damaged by the budworm in these three years. While defoliation appeared widespread in 2020, the very low mapped acreage was because an aerial survey was not done; precautions to prevent the spread of COVID-19 were impossible in the small cockpits of survey planes. Comparison of acres of damage mapped before the use of sketch mappers in 2004 and after must be done with caution. Hand drawn maps may generalize the area impacted and result in larger acreage compared to more precise digitized damage.

As in past years, balsam fir was more heavily defoliated than spruce. Dead and dying balsam fir has the potential to increase fire danger, especially in areas where widespread mortality is occurring. It was suggested that the Greenwood fire, which burned over 26,000 acres in northern Minnesota this summer, burned longer, hotter and faster because of tree mortality caused by repeated defoliation by spruce budworm. Drought and high winds in Minnesota also contributed to the severity of that fire, but it's important to be aware of the increased risk to an area if tree mortality from spruce budworm has occurred.

Figure 29. Balsam fir sawfly feeding on balsam fir needles.

For the third year in a row, forest health staff noted a few balsam fir sawflies in areas where spruce budworm is defoliating balsam fir stands. These balsam fir sawflies all appear to be the "dark morph" color (Figure 29). Balsam fir sawfly hatches later than spruce budworm and feeds on the previous year's needles. In these areas, spruce budworm is still the primary defoliator, so it's unclear how significant this problem is. However, a Canadian Forest Service document mentioned an association between the two. Wisconsin also saw what might be called "outbreaks" of balsam fir sawfly in the late 1950s and again in the late 1980s.

White Pine Health Issues

There were few reports of pathogens and other health issues on white pine in 2021, in stark contrast to the situation in 2020. The pathogens seen in 2020 (Wisconsin DNR Forest Health 2020 Annual Report) subsided with the decline in precipitation to more historically average levels in 2021, following five years of very high precipitation. Foliage chlorosis was observed in northern Jackson County, and the fungal pathogen *Diplodia* spp. was detected from the symptomatic samples.

Damage From Abiotic Causes

Precipitation

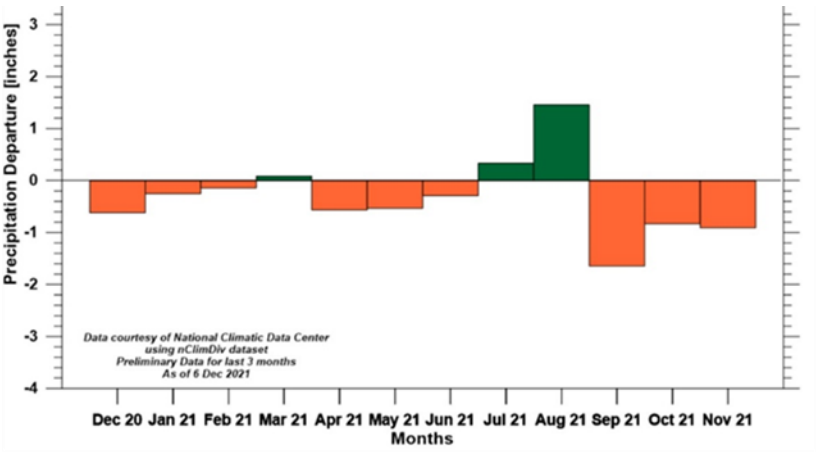


Figure 30. Twelve-month statewide precipitation departure from 1981-2010 average between December 2020 and 2021. Map by Wisconsin State Climatology Office.

Statewide precipitation in 2021 has been slightly below its long-term (1981-2010) average for most of the year (Figure 30). The return to more average precipitation was a notable change from the wet conditions persistent since 2013 and the record-setting precipitation in 2019 (Figure 31). However, wide variation in monthly precipitation was seen among regions in 2021 (Figure 32).

Figure 31. Statewide Palmer Drought Severity Index from 2000-21. Since 2016, statewide precipitation has been well above the current normal of 0.75 determined from the period 1980- 2010. In 2021, precipitation returned to the current normal. Map by NOAA National Centers for Environmental Information

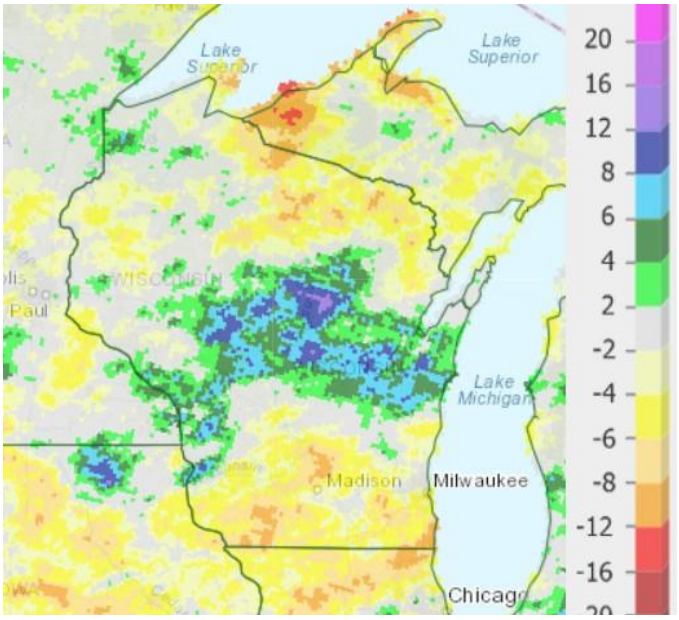


Figure 102. Year-to-date precipitation departure from normal (inches) as of November 17, 2021. Edited from a map by NOAA Advanced Hydrologic Prediction Service.

According to the U.S. Drought Monitor, dry conditions have been present in southern counties and in the far north since the start of the growing season. Moderate drought conditions began in parts of the southern counties in early April. Parts of far southeast Wisconsin (Kenosha, Racine and Walworth counties) reached the "extreme drought" classification during two periods (June 15-July 13 and Sept 21-Oct 5). Precipitation was generally above average in the central and east central counties, contributing to another year of tree decline and mortality on wet sites.

Flooding Damage

Heavy decline and mortality continued among many tree species at low-lying sites across much of Wisconsin (Figure 33). Mortality is likely due to a combination of new and lingering flooding stress and concurrent infestation by insects, such as emerald ash borer (ash species), two-lined chestnut borer (oaks) and eastern larch beetle (tamarack). Flood-tolerant species, such as silver maple and tamarack, have been impacted over large areas of Wisconsin. Mortality has also been common along the edge of lakes and ponds that have had higher water levels over the past few years. There is currently a limited ability to conduct active forest management at many of these sites due to poor pulpwood markets and the difficulties of conducting forest management on wet sites.

Figure 33. Mortality of bottomland hardwoods along the Wisconsin River near Millville in southwest Wisconsin.

Aerial surveys mapped nearly 60,000 acres of flood damage in 2021. More than 26,000 acres of flood-damaged bottomland forest were mapped along the Wisconsin and Mississippi Rivers in southwest Wisconsin. Another 10,000 acres of flood damage to spruce and tamarack forests

were mapped in northwest Wisconsin. Eastern larch beetle contributed to the mortality of flood-damaged tamarack. The remaining 24,000 acres were flooded bottomland hardwoods mapped in east-central Wisconsin. Lingering flood damage from 2016-2020 continued to be mapped despite dry conditions in many parts of Wisconsin in 2021.

Frost

Figure 34. Oak leaves damagae by freezing temperature after expansion May 28th.

Following more than a week of temperatures in the 70s and a high of 80 degrees Fahrenheit across northern Wisconsin, the night of May 28, 2021 sent temperatures plunging into the mid-20s. This frost/freeze event strongly impacted oaks in areas of central and northern Wisconsin, the leaves of which had already expanded. Some leaves were completely killed while others were only partially killed (Figure 34). The remaining living tissue continued to grow, but the dead tissue caused these leaves to become permanently distorted. Heavily damaged branches produced a new set of leaves while still retaining any partially damaged foliage. Location of the damage in the canopy varied. Damage was most severe in young oaks in open areas where pooling cold air was able to submerge the entire tree. In some forested areas with closed canopies, only the top portions of the trees exposed to cold air above the canopy were impacted. Large trees in open areas had the opposite pattern of damage, where the lower canopy was severely impacted by a layer of cold air that settled near the ground. Trees in these open environments would have a “waterline” of frost-damaged leaves below which all the leaves were dead and all those above were unaffected.

Tornadoes

According to the National Weather Service, there were 31 reported tornadoes in Wisconsin in 2021 (Figure 35). Fifteen of these were classified as EF-0 (with winds 65-85 mph), fifteen were classified as EF-1 (with winds 86-110 mph) and one was classified as EF-3 (with winds 136-165 mph). On average, Wisconsin experiences 23 tornadoes annually (EF-0 or greater).

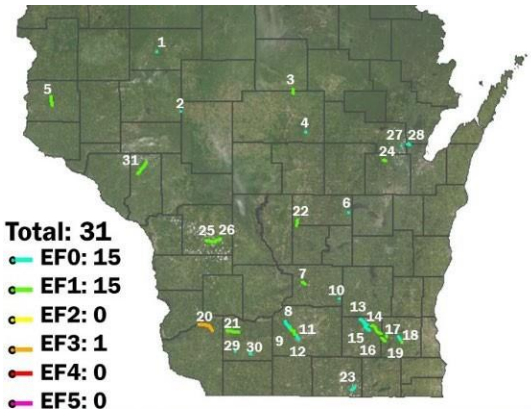


Figure 35. Map of Wisconsin tornadoes reported in 2021. Map by National Weather Service.

Seventeen tornadoes occurred during severe weather July 28-29, and six tornadoes occurred during strong storms on August 11. The lone EF-3 tornado occurred in the Boscobel area (Grant County) on August 7 and was 10.6 miles in length

and 1,100 yards wide. Media reports indicated that tree damage in 2021 was mostly seen on residential properties that were in agricultural areas. Moderate forest damage was reported for over several hundred acres in Dane County, over about 300 acres in Monroe County and over about 4,000 acres in Grant County.

Health Issues At State Nurseries

Asymptomatic Infection By *Diplodia sapinea* In State Nursery Stock

Asymptomatic infection by *Diplodia sapinea* in red pine seedlings can result in failure of the plantation if the disease becomes symptomatic after planting. To prevent this, healthy-looking red pine seedlings from the Wilson State Nursery are tested annually to assess for asymptomatic infection prior to sale. Asymptomatic infection rate must be 10% or less or the stock will not be sold.

- One-year-old red pine seedlings had an asymptomatic infection rate of 1.9% (260 seedlings tested). This was lower than the rate in one-year-old seedlings in 2020 of 3.1% (287 seedlings tested).
- The infection rate for two-year-old seedlings (267 seedlings tested) was 1.1%. It was significantly lower than the rate in two-year-old seedlings of 6.3% (252 seedlings tested) in 2020.
- The infection rate for three-year-old seedlings (240 seedlings tested) was 1.7%, lower than the rate in 2020 of three-year-old seedlings (279 seedlings tested) of 5.7%.

It is believed that below-average precipitation during the critical periods for infection by the pathogen created a less favorable environment for the pathogen and helped fungicide application effectiveness.

Survey Of Galls On Jack Pine Seedlings At The Wilson State Nursery

The incidence of galls on jack pine seedlings caused by rust fungi has typically been very low at the Wilson State Nursery, and only one species of rust fungus has been identified there, *Cronartium quercuum* (pine-oak gall rust). In 2020, the gall incidence rate was 0.2% for one-year old jack pine and 1% for two-year-old jack pine. This rate was higher than desired, so monitoring for galling continued this year. In the spring of 2021, 1000 seedlings from each of the one-and-two-year-old cohorts of jack pine were visually inspected for the presence of galls at the time of lifting. The gall incidence rate continued at about the same levels as last year: 0.2% for one-year-old jack pine and 1.9% for two-year-old jack pine. Monitoring for galling will continue in 2022.

Cherry Leaf Spot (*Blumeriella jaapii*)

Severe necrosis and defoliation on choke cherry, caused by *Blumeriella jaapii*, were observed in 2020 in the Wilson State Nursery. Cherry leaf spot caused by *B. jaapii*, is a major disease of cherry in the Great Lakes region. Since site-specific resistance to sterol demethylation inhibitor fungicides was recently reported in populations of *B. jaapii*, forest health staff suspected that the rapid disease spread may have occurred during the time that demethylation inhibitor fungicides were applied as part of the rotation of fungicides. In 2021, the nursery dropped demethylation

inhibitor fungicides, such as Eagle (myclobutanil) and Bayleton (triadimefon), from the fungicide regimens on choke cherry and applied a rotation of 3336 (Thiophanate-methyl), Manzate (zinc ion and manganese ethylenebisdithiocarbamate), Benlate (Benomyl) and Chlorothalonil. In 2021, the disease severity decreased significantly, and only minor defoliation was observed, likely from the adjustments in the fungicide regimens and drier weather.

Acknowledgements

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