# Wisconsin DNR Forest Health 2022 Annual Report

Defoliation by oak leaf roller, Linda Williams

WISCONSIN DEPT. OF NATURAL RESOURCES

## Table Of Contents

# Wisconsin DNR Forest Health Program Staff

## District Staff


**Linda Williams**
Forest Health Specialist
Northeast zone, Woodruff
920-360-0665
Linda.Williams@wisconsin.gov

**Paul Cigan**
Forest Health Specialist
Northwest zone, Hayward
715-416-4920
Paul.Cigan@wisconsin.gov

**Todd Lanigan, retired July 2022**
Forest Health Specialist
West central zone, Eau Claire
715-839-1632
Todd.Lanigan@wisconsin.gov

**Mike Hillstrom**
Forest Health Specialist
South central zone, Fitchburg
608-513-7690
Michael.Hillstrom@wisconsin.gov

**Bill McNee**
Forest Health Specialist
Southeast zone, Oshkosh
920-360-0942
Bill.McNee@wisconsin.gov

**Alexandra Feltmeyer**
Forest Health Specialist
Central zone, Plover
715-340-3810
Alexandra.Feltmeyer@wisconsin.gov

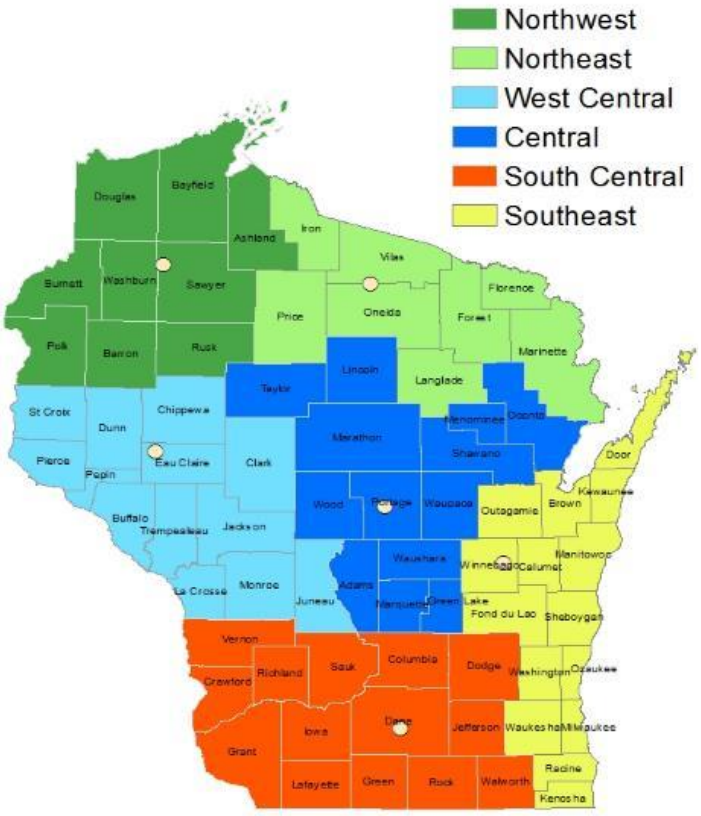




**Figure 1. Areas of responsibility and location of home offices for forest health specialists.**

## Statewide Staff

**Becky Gray**
Forest Health Program Team Leader
Fitchburg
608-220-3022
Rebecca.Gray@wisconsin.gov

**Andrea Diss-Torrance**
Invasive Forest Insects Program Coordinator
Madison
608-516-2223
Andrea.DissTorrance@wisconsin.gov

**Kyoko Scanlon**
Forest Pathologist
Fitchburg
608-235-7532
Kyoko.Scanlon@wisconsin.gov

**Mary Bartkowiak**
Invasive Plants Program Coordinator
Rhinelander
715-493-0920
Mary.Bartkowiak@wisconsin.gov

**Brenna DeNamur**
Outreach and Communications Specialist
Fitchburg
608-335-0167
Brenna.DeNamur@wisconsin.gov

**Scott Schumacher**
Plant Pest and Disease Specialist
Fitchburg
608-516-1294
Scott.Schumacher@wisconsin.gov

**Bernie Williams, retired Aug 2022**
Invasive Plants and Earthworm Specialist
Madison
608-444-6948
Bernadette.Williams@wisconsin.gov

**Jacquelyn Christopher**
Invasive Plant Specialist
Rhinelander
715-492-0391
Jacquelyn.Christopher@wisconsin.gov

**Ethan Wachendorf**
Lab Assistant
Fitchburg
ethan.wachendorf@wisconsin.gov

**Phyllis Ziehr**
Clerical Assistant
Fitchburg
608-275-3210
Phyllis.Ziehr@wisconsin.gov

**Staff Update**

After 30 years as the forest health specialist in Eau Claire, Todd Lanigan retired. He rode off in style in his ’57 Chevy!

Bernie Williams retired from her role as DNR expert on invasive earthworms at the end of August. Bernie reached celebrity status through her presentations on invasive worms and plants across Wisconsin and the country. During her career with the DNR, she was awarded Outstanding Contribution to Accomplishing the Division of Forestry's Purpose in 2018 for her role in developing Best Management Practices for Invasive Species and the DNR Invasive Species Rule (NR40), and her dedication to outreach and education. We will miss Bernie's humor and crazy (but informative!) stories and wish her all the best as she takes her garden, travels and cat collection to the next level.

## 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 at dnr.wi.gov.

Wisconsin’s forestland area 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 regions of the state.

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.

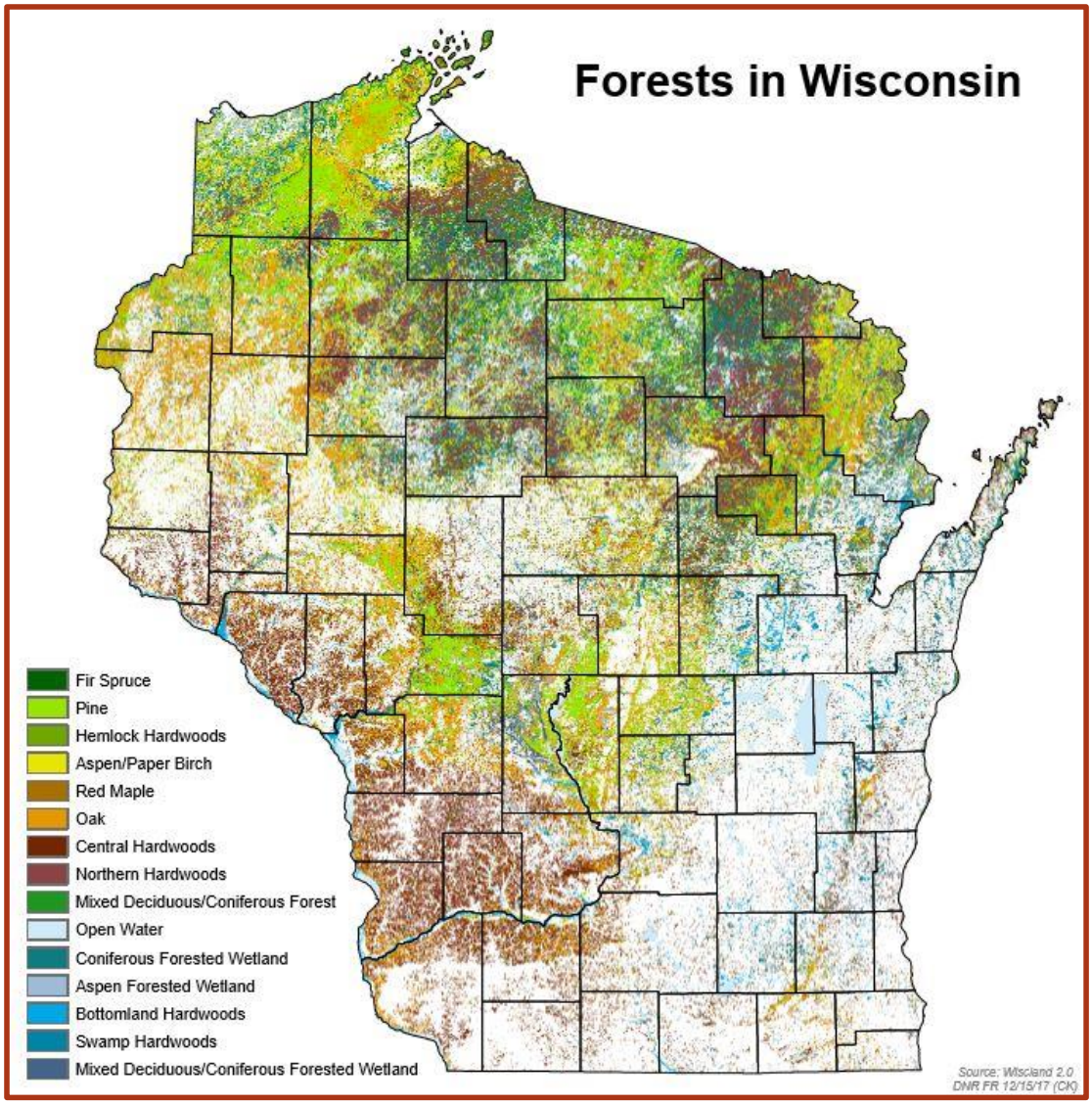



**Figure 2. Wisconsin forest cover map. Source: WISCLAND land cover, Wisconsin Department of Natural Resources, 2017 (latest version)**

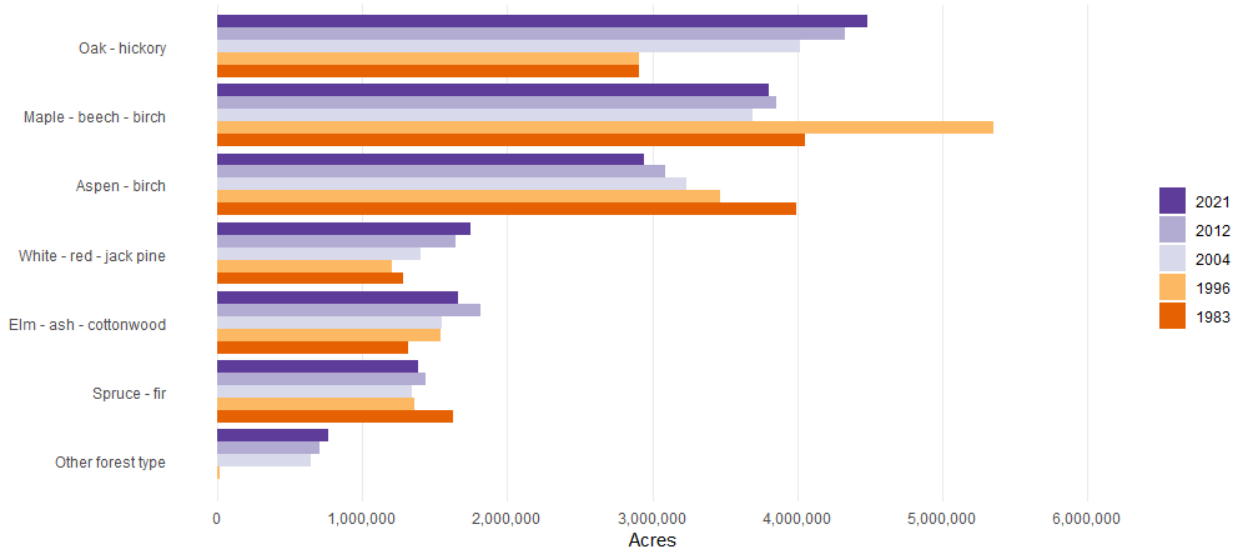



**Figure 3. Acres in Wisconsin forest types 1983-2021**

# Outreach And Education

The Forest Health Team has had a busy year between annually planned communications and special projects. As part of our regular outreach plan, 49 articles were distributed to 4,800 subscribers of the monthly Forest Health Newsletter. Our subscribership has increased by 577, a 14% increase from last year. We had eight press releases and 11 Facebook posts for our typical yearly notices, as well as special reports on insect identification, goat grazing and limiting the spread of invasive plants during hunting season. Forest health staff gave 47 presentations to over 2,000 individuals. Topics included new and developing forest health threats, non-native worms and management options for invasive plants, pests and diseases. We kept the information in the DNR forest health webpages up to date, which was visited 36,845 times this year. This summer, forest health team members worked with the Brule River State Forest and Office of Communications staff to produce and disseminate a video on using goats to control invasive plants in the state forest. This video has been viewed over 2,000 times on YouTube since being released at the end of August.

In January, the forest health team was challenged with the need to transition the common name of a high-profile forest pest, *Lymantria dispar*. In 2021, the Entomological Society of America (ESA) retired the common name gypsy moth at the request of the Roma people of North America, as the name contained an ethnic slur for that group. The ESA worked with stakeholders to select a new common name for the species, spongy moth, and that name was released in January. As we expected a spongy moth outbreak in Wisconsin in the spring of 2022 and aerial sprays and other treatments were planned for the spring, the state agencies involved with the management of and education about the pest decided to start the transition to

the new name immediately. Brenna DeNamur, the Outreach and Education Specialist in the DNR Forest Health Team, led the collaboration with the Wisconsin Department of Agriculture, Trade, and Consumer Protection (DATCP) and the University of Wisconsin-Extension to develop and implement an outreach plan. The name was changed to spongy moth on all agency's webpages and educational documents in use and all internal and external communications. The state cooperative spongy moth portal was updated and improved. Because we developed and implemented our plan for name transition so early, we provided our plan as an example for other states to use in their planning process. It was posted for state agency access at the ESA and Northeastern and Midwestern State Foresters Association websites.

# 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 beech scale infestation and beech mortality 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).

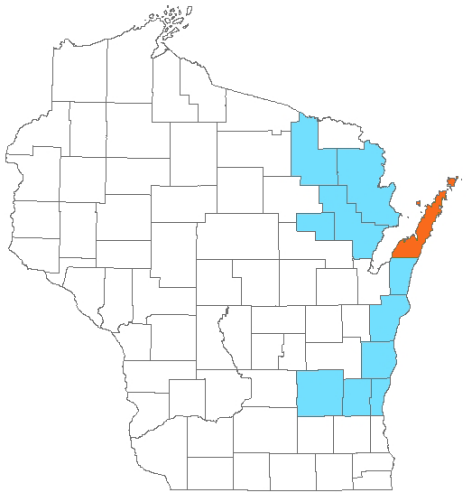


**Figure 4. Counties with beech scale detections are tinted blue. Mortality from beech bark disease is limited to the area tinted orange.**

Site visits in eastern Wisconsin during 2022 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.

## Beech Leaf Disease (BLD)

Beech leaf disease (BLD), a destructive disease of beech trees, is not yet known to be in Wisconsin. However, recent discoveries of the disease in Virginia, New Hampshire and Michigan highlight the continued importance of monitoring BLD's expansion. The confirmation of the disease in St. Clair County, MI in July of 2022 is of particular interest. Due to the potential for BLD to move into Wisconsin, as the eastern portion of the state overlaps with the American beech tree's native range, staff have been monitoring for signs of beech leaf disease during site visits where American beech is present.

**Figure 5. Symptomatic thickening, puckering and chlorosis of BLD. Photo Credit: Ohio State University**

Symptomatic trees can be identified by dark striping or banding between leaf veins on multiple tree leaves. This can be most easily spotted from the undersides of leaves while looking up into the canopy. More severe symptoms include leaf distortion, such as curling, puckering, thickening and developing leathery texture or necrotic leaf tissue (Figure 5). Other symptoms include aborted buds, branch and tip dieback and premature leaf drop leading to a thinning canopy. Saplings and younger beeches can die within 3-5 years of symptom development. Recent research has identified *Litylenchus crenatae mccannii*, a newly described roundworm, as a necessary condition for symptom development. Early detection techniques are in development, and staff will continue to be vigilant into 2023.

## Emerald Ash Borer (EAB, *Agrilus planipennis*)

Distribution Of EAB In Wisconsin

In 2022, EAB was confirmed for the first time in Ashland, Bayfield, Forest, Lincoln, Menominee and Langlade counties (Figure 6). It has now been found in 66 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

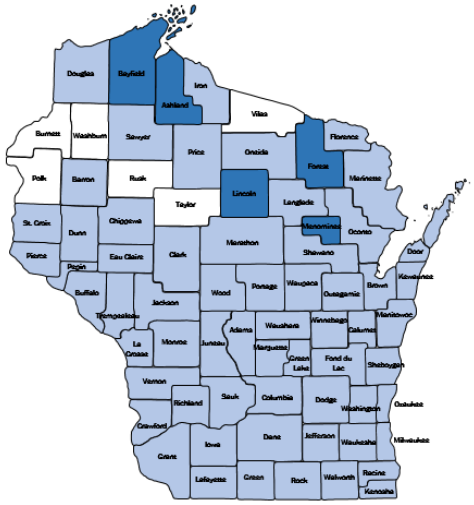



**Figure 6. EAB confirmed in 2022 are tinted dark blue; light blue counties were confirmed previously.**

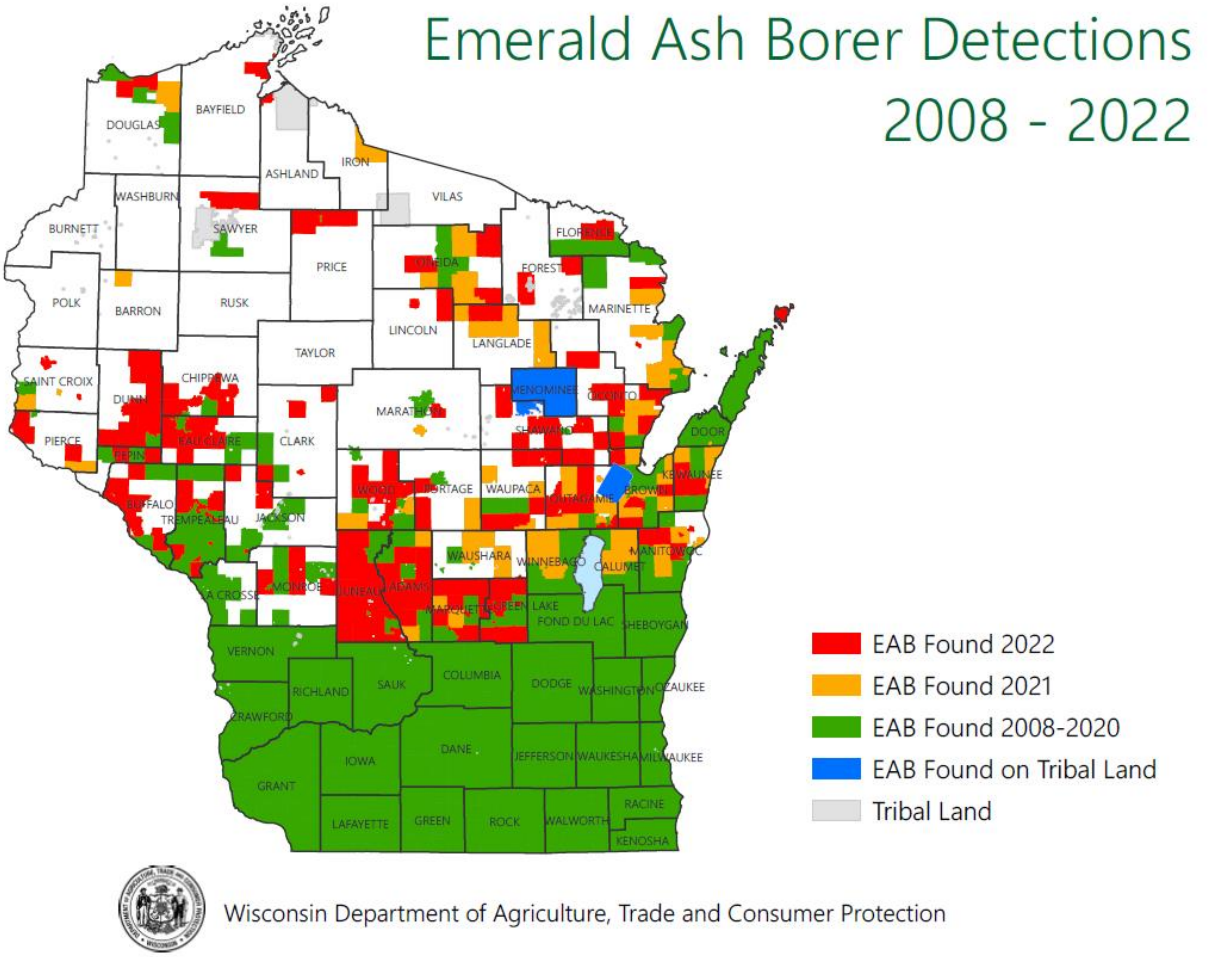



**Figure 7. Municipalities in Wisconsin where EAB has been confirmed as of Dec. 14, 2022**

the ash resource (Figure 7). Although there was no trapping for EAB by federal or state agencies in the summer of 2022, detections were confirmed by forest health staff and state entomologists from images or samples sent to them by the public or cooperators. 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 due to EAB continued its inexorable spread in 2022 (Figure 8). Mortality has progressed along the Mississippi, its tributaries in the southern half of the state and the lower Wisconsin River. Ash mortality exceeds 95% six years after it was first seen in this area of the state. 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

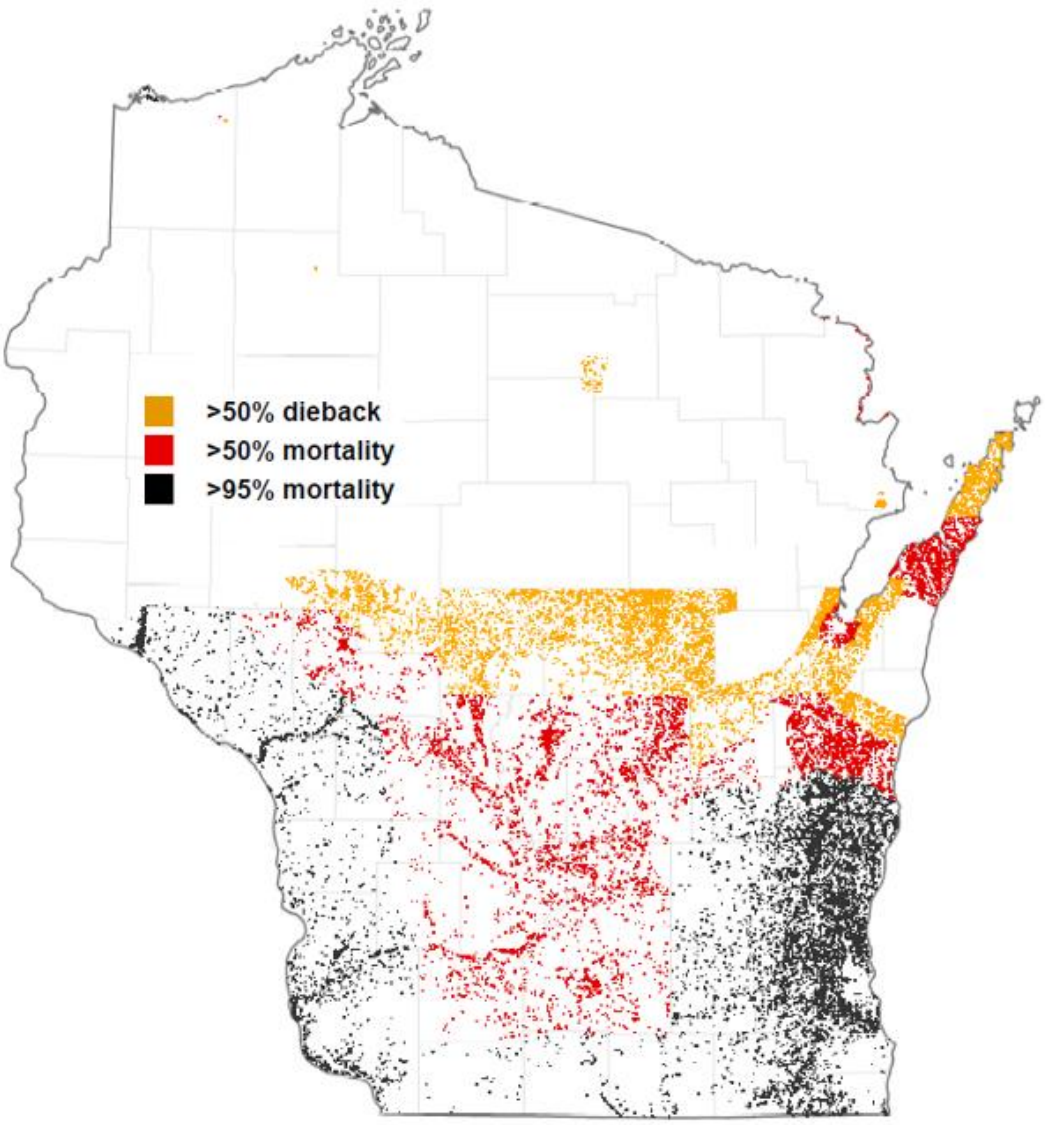



**Figure 8. Damage from EAB to ash mapped from general observations of forest health specialists in 2022. The area where damage occurred is masked with an abundance of ash, giving a stippled appearance.**

noticeable as they are a smaller component of those forests. The area of extirpation in eastern Wisconsin continued to move north and westward. Statewide, the estimated area where ash mortality exceeds 95% increased to 212,125 acres from last year's ~142,300 acres. The area where mortality exceeds 50% expanded across southcentral counties for an estimated 160,900 acres, up from ~109,500 in 2021. The area of decline is greater than 50% of the ash also increased northward and is estimated at 163,000 acres. Ash is functionally extinct in counties in the southeast and along the Mississippi River. However, these will be good areas to survey for potentially resistant individuals in the coming years. These survivors are called "lingering ash,"

and locally adapted genes are needed to breed EAB-resistant ash for restoring Wisconsin forests.

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 exceeded 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 2023.

Biological Control Of EAB

2022 was the 12th year that natural enemies of EAB had been released in Wisconsin. All are tiny wasps, specific or nearly so to EAB, and the public is unlikely to ever see them due to their size. *Tetrastichus planipennisi*, *Spathius galinae* and *Oobius agrili* were released monthly between mid-June and mid-September. *T. planipennisi* and *S. galinae* attack EAB larvae beneath the bark, and *O. agrili* attack EAB eggs on the bark surface. These introductions will provide downward pressure on EAB populations in the future, allowing for the survival of ash trees with partial resistance to EAB.

Most of the parasitoids released were supplied by the USDA APHIS Plant Protection and Quarantine EAB Parasitoid Rearing Facility in Brighton, Michigan and released by APHIS staff. Release sites of the lab-reared insects were selected with significant input from forest health program staff. Parasitoids were released for the first time at one site in Marathon County in Wisconsin (Figure 9). Five sites in Calumet, Green Lake, Manitowoc, Portage and Winnebago counties received a second year of releases. Parasitoids of EAB have now been released in 25 of Wisconsin's 72 counties. Of the 18,684 lab-reared parasitoids released, *T. planipennisi* accounted for 40%, *S. galinae* for 20%, and *O. agrili* for 40%.

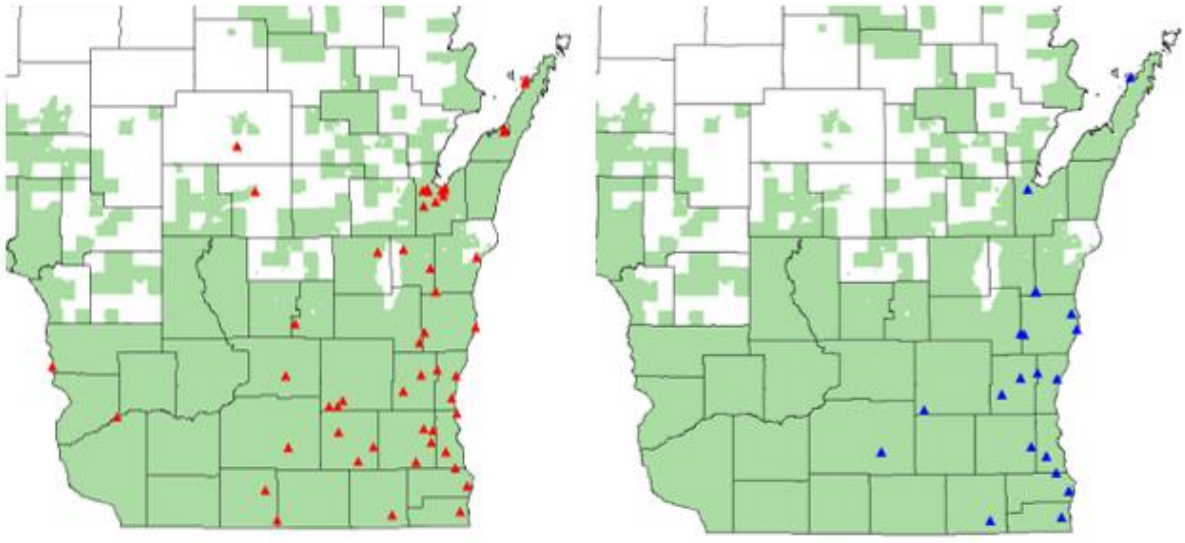


**Figure 9. The map on the left shows locations where parasitoids of EAB have been introduced from 2011 - 2022. The map on the right shows locations where parasitoids were recovered from 2016 - 2022. Green-tinted areas are where EAB has been confirmed.**

Recovery surveys are done three years after introductions by state forest health program staff. In 2022, dead *T. planipennisi* adults were recovered from EAB galleries at a former release site at Kiel Marsh Wildlife Area in Manitowoc County. Two Spathius of unknown species were also recovered at this site. They have been sent for identification, and at the time of publication, it is not yet known if they are a native species or one of the two introduced in Wisconsin. *T. planipennisi* has now been found at 17 previous release sites and two non-release sites (Figure 9). Other released species have not yet been recovered.

Wisconsin's first release using parasitoids collected from a population established in the state was done this summer. Ash stems infested with EAB were collected as part of a winter parasitoid recovery survey at a site in Green Bay where wasps were released several years ago. Wisconsin forest health staff were able to rear out 150 *T. planipennisi* adults from these stems for introduction to High Cliff State Park in Calumet County. We plan to repeat the distribution of wasps from wild populations as the opportunity presents itself.

A recovery survey was done at Kohler-Andrae State Park in Sheboygan County to try to recover additional specimens of the wasp that DNA testing had previously identified as the EAB parasitoid, *Spathius agrili*. This species is rarely recovered in any state and would have dispersed from releases done 10 years ago at a site approximately 20 miles away. Four EAB-infested small ash stems were cut in the immediate vicinity of the tree where *S. agrili* was identified by DNA testing in 2021. These stems were incubated in cardboard tubes to rear out any EAB parasitoids. The only parasitoids that emerged from these ash stems were *T.*

*planipennisi*, which had been previously recovered from this site. An additional recovery attempt is planned for 2023.

## Heterobasidion Root Disease (HRD, *Heterobasidion irregulare*)

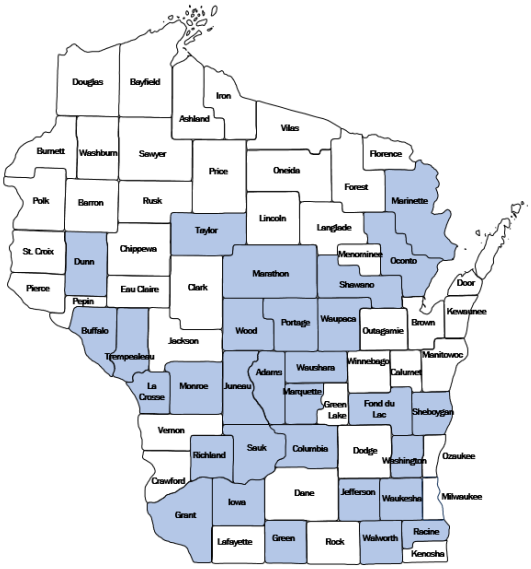



**Figure 10. HRD has been confirmed in counties tinted blue.**

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 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. No new county detections were made in 2022. 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.

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 2022. Sample processing and analysis are in progress by Michigan State University's Dr. Monique Sakalidis. This study is expected to be completed in 2024. 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.

A field study is being conducted to assess the susceptibility of red pine stumps created in the winter to infection by H. irregulare when exposed in the spring. The study area is in Northern Highland – American Legion State Forest. Thirty wood discs were collected in the spring of 2022 from stumps created in the winter of 2022. Samples were inoculated with a spore solution of H. irregulare in the Forest Health Lab, and the growth of the pathogen was examined for up to 21 days. Data analysis is in progress.

## Introduced Basswood Thrips (*Thrips calcaratus*)

Moderate to severe thrips damage was first observed on basswood in Wisconsin in 1980, but the damage was incorrectly attributed to our native thrips. Additional research identified the culprit as an exotic thrips species, the introduced basswood thrips (*Thrips calcaratus*). Since identification, the invasive thrips population has resulted in two outbreaks causing extensive defoliation in the mid-1980s and late 1990s. The first population outbreak caused the most damage and lasted 5-6 years. The second outbreak in the mid-1990s affected fewer acres and lasted only two years. Since then, the population and the amount of damage have remained low, a common population dynamic of a newly established pest (Figure 11).

In 2020, damage from introduced basswood thrips was noted in Forest, Marinette, Oconto, Sawyer and Rusk counties; however, due to restrictions on the aerial survey during the first year of COVID-19, the damage was not mapped. In 2021, introduced basswood thrips caused 50-75% defoliation over more than 20,000 acres in Sawyer and Rusk counties in northwest Wisconsin. In combination with concurrent frost damage, trees were roughly 50% defoliated. This was the second year of heavy defoliation in that area. Damage was also noted in 2021 but not mapped in Florence, Forest, Marinette, and Oneida counties in northeast Wisconsin. In 2022, high pest populations were noted in Forest and Oconto counties but not mapped. Spring was delayed, compressing leaf expansion of all species into a short period and making detection of scattered damage done in the bud stage of basswood hard to distinguish from the rest of the canopy.

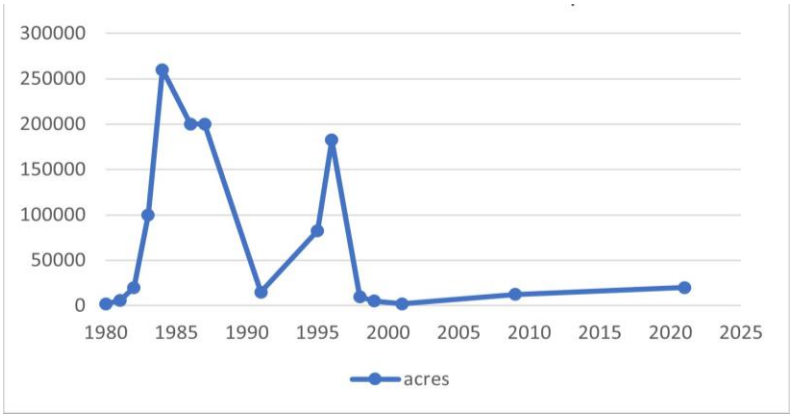



**Figure 11. Acres defoliated by introduced basswood thrips**

## 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 plant suppression fund.

The WMA-PFGP provides funding to groups for invasive plant management on non-industrial private forest land of fewer than 500 acres. Projects funded by the WMA grant completed by June 2022 included conducting inventory, control and monitoring on over 400 acres of private land; various print and social media campaigns reached over 44,000 people; and 288 people attended in-person events. For FY23 (July 2022-June 2023), the WMA funded five projects, which will be completed in the coming year(s). These projects include outreach/education,

restoration, inventory, control and monitoring of invasive plants. One project that has already been completed is the cutting and herbicide treatment of Japanese wisteria on private land in Langlade County. Japanese wisteria is a plant prohibited under the state invasive species law NR 40. Plants detected must be controlled and, if possible, eliminated.

Forest health team members provide guidance and administer funding for invasive plant control in the northern state forests. Species controlled include buckthorn, wild parsnip, garlic mustard, black and bristly 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 there take action to prevent their introduction and spread. A special project this year was the use of goats to control buckthorn in the Brule River State Forest. This was part of an integrated pest management plan with additional mechanical and chemical control to be considered for future control. By deploying browsers instead of chemical herbicide, the forest was able to reduce the amount of pesticide used to control invasive plants in the forest.

The state forest health program's plant suppression fund continued support of wild parsnip control on the Bearskin State Trail in north central Wisconsin, where wild parsnip is still uncommon. This is the fourth year of control along the recreation trail, which is considered a high-priority area to prevent the spread of this invasive plant that damages natural communities and poses a human health threat. Progress is clearly visible, with smaller populations appearing along the trail and reduced seed heads, which is encouraging. Multiple years of control are typically needed to clear an area of this species.

A new research project was initiated on the Coulee Experimental State Forest in 2022. To better understand the phenology of Japanese stiltgrass, the team is collaborating with UW-La Crosse to apply growing degree days for specific lifecycle events. This work will help to guide future management decisions regarding the control of this aggressive grass in Wisconsin. This project will continue throughout the growing season in 2023.

<u>Biological Control Of Buckthorn Using Fungi</u>

Glossy and common buckthorn are exotic invasive plants widespread in Wisconsin and other states. They are serious threats to the regeneration of native tree seedlings and understory species. Once established, buckthorn management is labor-intensive, costly and requires repeated treatments. Biological control for invasive buckthorn would be a great help in reducing the impacts of these species on forests.

In 2021 and 2022, the Forest Health Lab received two sets of samples of symptomatic buckthorn. One sample exhibited multiple well-defined cankers on their stems/branches, and the other showed diffuse cankers on stems down to root collar areas underneath dead bark. In both cases, the impact on buckthorn was severe within the stands. The lab staff isolated multiple organisms from discolored wood and identified the species through DNA sequencing as *Diplodia seriata, Phaeoacremonium fraxinopennsylvanicum, Cytospora leucostoma,* and *Diatrypella verruciformis*.

Dieback and mortality of buckthorn have also been observed in Minnesota. Dr. Robert Blanchette, a forest pathology professor at the University of Minnesota, has investigated the potential use of these pathogens as biocontrol agents against buckthorn and demonstrated some promising preliminary results. The Wisconsin DNR plans to collaborate with Dr. Blanchette, the Minnesota Department of Natural Resources and the Minnesota Department of Agriculture to investigate the potential for biological control of buckthorn using fungi in 2023.

## 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 depend 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. The 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 leaf litter, and it is this accelerated stripping of leaf litter that is cause for our concern.


**Figure 12. Jumping worms have been found in counties tinted blue.**

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 46 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 verified by Bernadette Williams (WDNR) or Anne Pearce (UW Extension) from images or samples. The public is encouraged to submit findings to EDDMapS to continue tracking jumping worms. Species found 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.*

## 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 1940s, it was noted that oak wilt had a distinctly 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 fewer oaks of the red oak group. The 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.

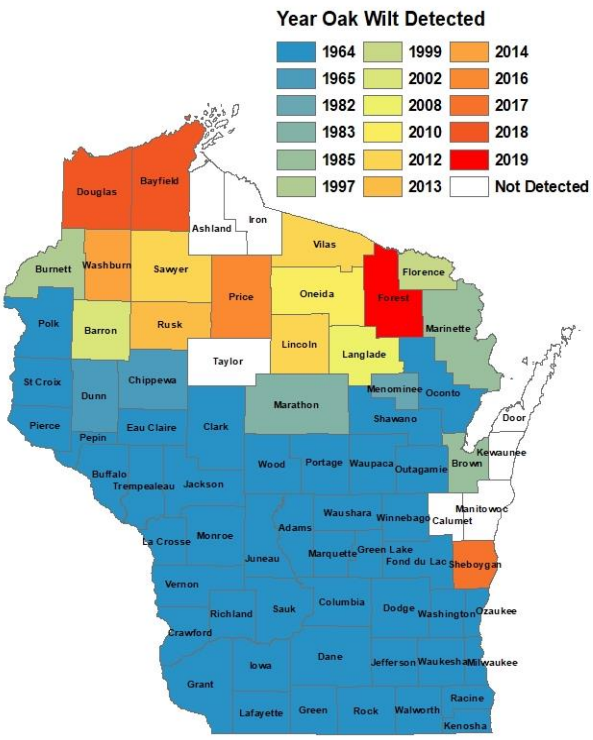



**Figure 13. Counties where oak wilt has been found and the year it was confirmed.**

Once initial detection was confirmed in 1944 and symptomology was better understood, there were more reports from counties in the central and south-central portions of the state. However, it was not until 1964 that the Wisconsin DNR developed a disease distribution map by county. At that 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 13). 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 14). In

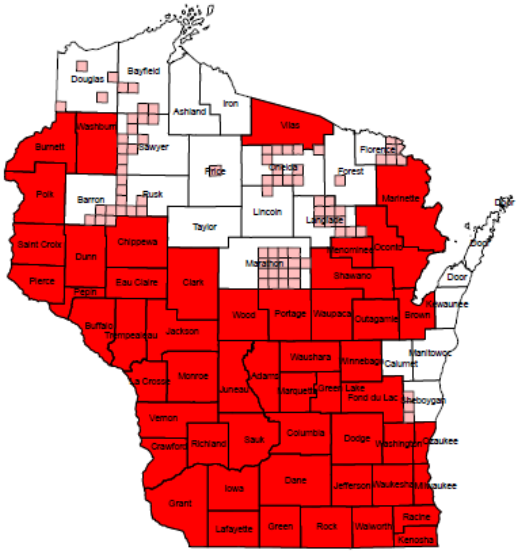


**Figure 14. Oak wilt is generally established in counties tinted red. Townships tinted pink are those where oak wilt has been confirmed in otherwise uninfested counties.**

2022, oak wilt was detected in five new townships: Crescent, the western part of the Town of Pelican and the northwestern part of the Town of Minocqua in Oneida County, and the towns of Price and Ainsworth in Langlade County. Oak wilt is actively managed throughout Wisconsin at the private and state level. In 2021 and 2022, a grant from the Forest Service to suppress oak wilt along the leading edge of its range was used to control oak wilt pockets in northeastern and northwestern Wisconsin.

**Figure 15. Oak wilt symptoms on white oak leaves.**

Oak Wilt Suppression Program

Oak wilt is actively managed throughout Wisconsin at the private and state level. In 2021 and 2022, a grant from the Forest Service to suppress oak wilt along the leading edge of its range was used to control oak wilt pockets in northeastern and northwestern Wisconsin. In 2022, the Forest Health Program received a second year of funding from the Forest Service to financially assist qualifying private landowners with oak wilt control. Qualifying landowners in seven northern Wisconsin counties along the oak wilt leading edge were offered oak wilt control services performed by a private contractor. The program covered 100% of the costs of performing oak wilt control measures that directly mitigate above- and below-ground disease transmission while allowing landowners to optionally cover the costs of elective work related to the disease control process (e.g., brush chipping, stump removal). Treatment methods to address belowground transmission involved establishing herbicide barriers around the perimeter of infection centers using a variety of different physical techniques, including frill girdle, cut stump, hack and squirt, and hatchet girdle. A single-tree herbicide treatment (i.e., rapid response) using the frill-girdle herbicide method was utilized in a specific case where an individual infected oak not associated with an established disease center was identified in the early stages of oak wilt symptom progression. Treatment methods targeting overland transmission included on-site diseased wood exclusion (i.e., sealing wood with a covering). Six sites were treated by contractors in 2022, and the Forest Health Program has requested additional funding to continue oak wilt suppression activities in northern counties in 2023.

Use Of Growing Degree Day Model Of Oak Wilt Vector Activity To Allow Continued Harvesting

Because of the threat of oak wilt overland transmission, harvesting in oak stands is restricted from April 15 - July 15 on state lands in the northern half of Wisconsin. This period corresponds to when the beetle vectors are active, spores are being produced and wounds on oak are susceptible to infection. But spring weather is delayed some years, and every day that can be added to the harvesting season greatly benefits the logger. For this reason, the Forest Health Program supported research on the activity of oak wilt beetle vectors and developing a growing

degree day (GDD) model for when they become active in spring. Based on this model, harvesting restrictions may be relaxed if the beetles are unlikely to be active yet in an area. In 2022, spring temperatures were very late to increase. Starting April 15, forest health staff ran the model for local areas requesting an extension and determined if the beetles were still likely to be inactive. This procedure was repeated each week as temperatures warmed, and harvesting was extended by three weeks in some north-central counties. This was a good example of using a model and an exception in restrictions, as several timber sales were completed in the extra time allowed.

Research On Oak Wilt

Oak wilt is introduced to a new area by insect vectors moving spores from infected wood to fresh wounds on an un-infected oak. Once a tree is infected, the disease spreads throughout its vascular system and can move into neighboring oaks through root grafts. To contain new oak wilt infections in a stand, foresters at Menominee Tribal Enterprise have been killing oaks by girdling them and applying herbicide as soon as they show any wilting branches. The intent is to prevent the spread of the fungus into the root system and, from there, into adjacent oaks connected by root grafts. They have successfully prevented the underground spread of oak wilt using this technique they call “rapid response.” To formally test this technique, Wisconsin DNR forest health staff are collaborating with the Michigan and Minnesota DNR forest health programs and scientists from the Forest Service on an 8-year study funded by the Forest Service.

## Spongy Moth (*Lymantria dispar dispar*) - Formerly Known As Gypsy Moth

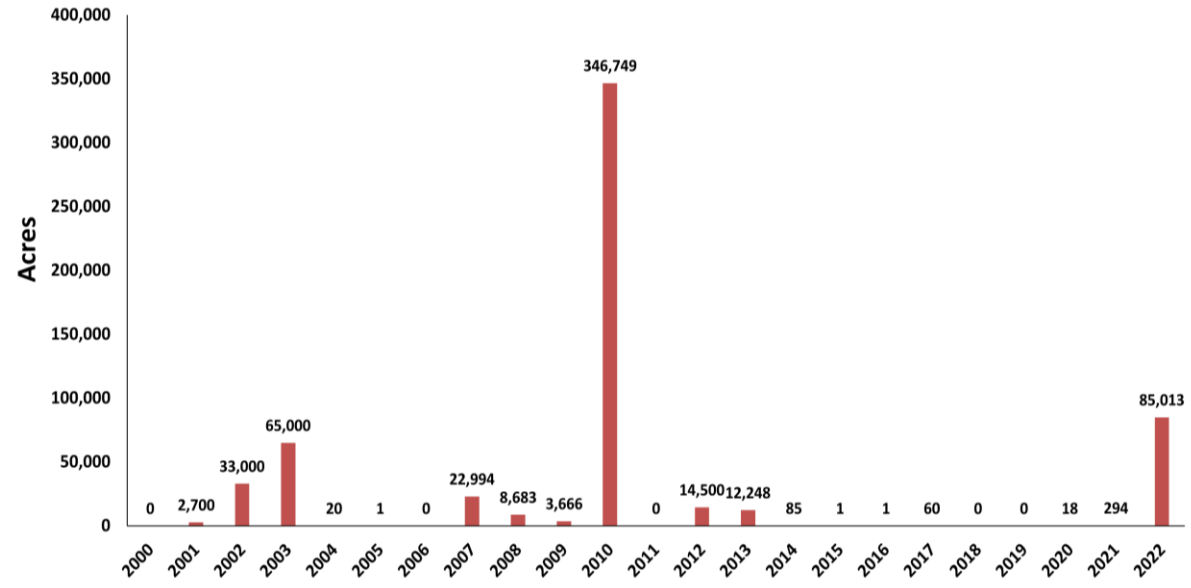



**Figure 16. Acres defoliated by spongy moth 2000-2022.**

Between 2014 and 2020, the spongy moth population was low, and defoliation was inconsequential. However, much drier spring weather during 2020, 2021 and 2022 appears to have released the pest population. The modest increase in 2021 of observed caterpillars and feeding damage preceded an explosion of spongy moth in 2022 in both southern and northern regions. A total of 85,013 acres of defoliation were mapped this summer, much of that severe. This was the second-largest total area of defoliation observed since the first report in 1997 of a few acres of defoliated shrub willow near Green Bay (Figure 16). In Bayfield County in the far northwestern part of the state, 80,162 contiguous acres of aspen were moderately to heavily defoliated. In the Baraboo hills of Sauk County, 1,852 acres were damaged, primarily oak. Scattered stands dominated by oak in Walworth (1,126 acres) and Jefferson (971 acres) counties were completely stripped of leaves. These were the largest areas mapped, but feeding damage from spongy moth was also noted in many other counties across the state, indicated with horizontal hash marks in Figure 18. Dry spring and summer weather was unfavorable for the infection of spongy moth by the pathogenic fungus, *Entomophaga maimaiga.* Southeastern counties, where the fungus caused the collapse of outbreaks in 2004 and 2010, were especially dry for the second year, favoring survival of larvae. While present, there was little impact on spongy moth populations from either this fungal disease or the NPV virus, even where larvae defoliated their hosts early and many appeared dead of starvation.

High numbers of egg masses near areas damaged in 2022 indicate that the population is still high and rising. We expect defoliation in 2023 will occur again in these same areas and will likely expand and develop in new areas with abundant preferred hosts. If dry spring weather continues in 2023, defoliation may be extensive across the area where spongy moth is established. Outreach to landowners, foresters, communities and public land managers emphasized the need to conduct egg mass surveys in areas they would protect if threatened with defoliation and to act if high numbers of egg masses are present.

Currently, 52 of Wisconsin's 72 counties are quarantined for spongy moth; these are tinted red in Figure 17. 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.

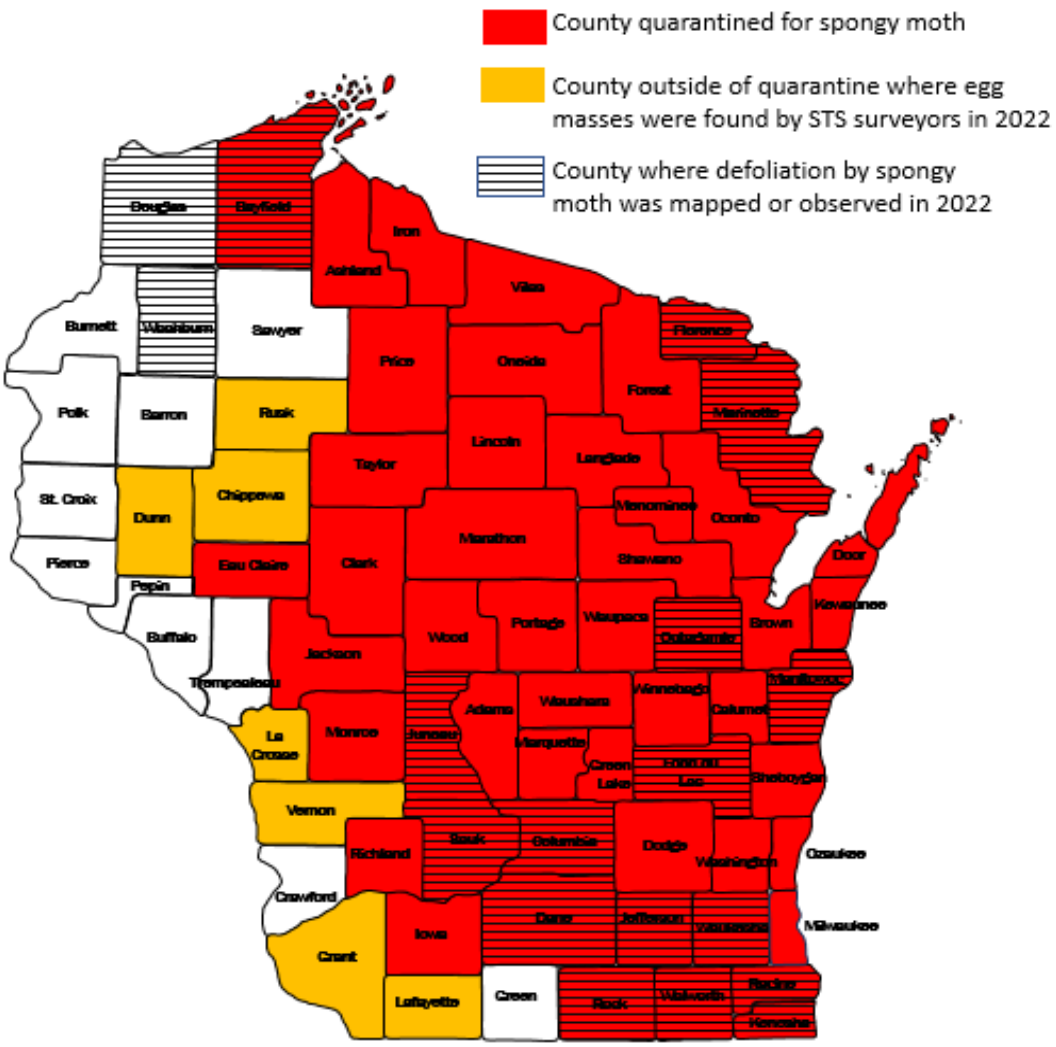



**Figure 17. Wisconsin counties in 2022 quarantined for spongy moth; those where defoliation from the pest was observed and those counties outside the quarantine where egg masses were found by STS surveyors.**

An aerial spray was done to treat 320 acres of state land to prevent the defoliation of high-value trees in areas of high public use: 267 acres over day-use areas and campgrounds at both ends of Devil's Lake State Park (Sauk County) and 53 acres at the John Muir and Nordic trailheads/day-use areas on the Kettle Moraine State Forest – Southern Unit (Walworth County). The bacterial insecticide Foray (*Bacillus thuringiensis* kurstaki) was used as it has been in state spongy moth suppression projects since 2000. The number of egg masses at these sites was very high, leading to concerns that the early instars would cause enough leaf loss before the aerial spray that its efficacy would be compromised; aerial sprays are normally applied 10-14 days after peak hatch. Three ground-based treatments were used. At both properties, egg masses on some trees were treated with Golden Pest Spray Oil (GPSO) to kill the eggs before they hatch (Figure 18). At Devils Lake State Park, Lepitect (acephate) was injected into the soil around trees in early May that weren't treated with GPSO in the picnic areas at the north and south shores (Figure 19). At the Southern Unit of the Kettle Moraine State Forest, Arbormectin (emamectin benzoate) was injected into selected large oaks at the trailhead area in early May. Injection wounds were sealed to minimize the risk of oak wilt infection. The treatments successfully kept defoliation below 50% of 80% of the aerially sprayed area, which is how successful suppression is defined. However, there were spots within the sprayed areas where defoliation was noticeable, and some trees had >30% defoliation which was more damage than we have seen in previous suppression projects. There was no significant difference in the visually rated level of defoliation between trees that received ground-based treatments and an aerial spray of Btk with nearby trees in the picnic area that only received the aerial spray. However, we observed that defoliation was noticeably higher in trees that received only the aerial treatment, just upslope of those that received both aerial Btk and ground-based treatments. Forest health staff continue to investigate and recommend spot supplemental treatments in

**Figure 18. Arborist applying GPSO using a high-pressure hose.**

**Figure 19. Soil injection of Lepitect (Acephate) into the root zone of a young oak.**

addition to aerial sprays of Btk, where egg mass numbers are very high and the trees are individually valuable.

### Sudden Oak Death *(Phytophthora ramorum)*

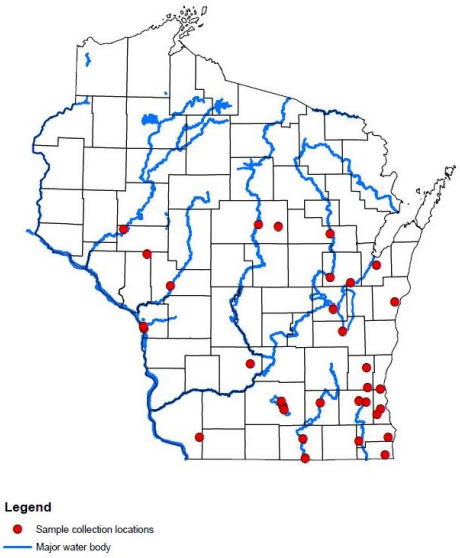



**Figure 20. Locations of stream bait survey sites and the river systems with which they are associated.**

*Phytophthora ramorum* is a fungus-like organism that causes the death of a wide range of trees and shrubs, and the destructive impact on oaks in states along the Pacific coast 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 could still 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. 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* (Figure 20). These detection surveys were scheduled to start in the spring of 2020. However, due to 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. We collected 10 samples during the spring and five samples during the fall baiting periods for a total of 34 sites samples in the two years of the survey. Testing of the samples was completed in 2022; all the samples were negative for *P. ramorum*.

## Native Health Threats To Hardwoods

### Bur Oak Blight (*Tubakia iowensis*)

Bur oak blight (BOB), caused by the fungus *Tubakia iowensis,* was confirmed in Fond du Lac County for the first time in 2022. BOB has now been confirmed in 34 counties in Wisconsin since it was first detected in 2010 (Figure 21).

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


**Figure 21. Wisconsin counties tinted blue are those where BOB has been detected. The dark blue county is Fond du Lac where BOB was detected for the first time in 2022.**

BOB infection, which was found in many new counties during this period. With the return of more normal precipitation in 2021 and 2022, detections in new counties have slowed considerably. All detections made last year were in counties where it had previously been found, and this year only one new county has been added to the range of this disease.

## Co-Infection Of Bur Oak Blight And Oak Wilt

Samples of bur oak (*Q. macrocarpa*) branches from four trees visually symptomatic for bur oak blight (Figure 22) were collected from a property in southern Winnebago County in mid-September. As expected, the pathogen causing BOB was found in the leaf samples. However, DNA testing using PCR (polymerase chain reaction) technology indicated that DNA of the oak wilt pathogen, *Bretziella fagacearum*, was present in the woody tissue of a branch from two of the four trees sampled. This co-infection of the blight and oak wilt was a surprising result. The site was revisited in mid-October to collect additional branches from the two co-infected trees to determine how widespread the oak wilt pathogen was within them. PCR testing of the additional branches found only one to be oak wilt positive. It was a side branch about 2.5 feet from a branch tip that tested positive in September. Pathogen viability in these samples is unknown.

**Figure 22. Foliar BOB symptoms on a branch which contained DNR of the oak wilt pathogen.**

Bur oaks are moderately resistant to oak wilt; typically, only a few symptomatic branches are found in the crown at any one time. Our results show that co-infection may occur of both BOB and oak wilt. Tree health specialists should be aware of this possibility when diagnosing ailing bur oak. Without a PCR test, an oak wilt infection could be missed, which could compromise the successful treatment of a bur oak infected with both pathogens.

## Hardwood Defoliators

Black Walnut Defoliator (*Gretchena amatana*)

In 2020, forest health staff in Wisconsin, Minnesota and Iowa received calls about black walnut stands being defoliated and webbed. In 2021, the defoliation expanded to multiple additional black walnut stands in southwest Wisconsin, and damage continued in northeastern Iowa and Minnesota. Molecular work completed by DATCP identified the larvae causing the damage as a native Tortricid moth, *Gretchena amatana*. The Forest Health Team planned in 2022 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*. However, no damage was observed, the population of the pest appears to have collapsed, and no specimens could be collected.

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

Populations of elm and maple spanworm collapsed in 2022 after several years of significant defoliation at Devils Lake State Park and nearby areas of the Baraboo hills. Unfortunately, spongy moth is causing increasing damage in the same areas. See the report on that species.

Forest Tent Caterpillar (*Malacosoma disstria*)

Localized, light outbreaks of forest tent caterpillar continued in Oneida and Sawyer counties in the same general areas as in 2021. No significant expansion of the defoliated area was observed. The last forest tent caterpillar outbreak in Wisconsin ended in 2002. In the 20th century, they could be expected every 10 years, so another large-scale outbreak seems overdue.

Saddled Prominent

A localized outbreak of the native caterpillar, saddled prominent, collapsed in 2022 after 2 or 3 consecutive years of defoliation at sites scattered across central Door County. Long-term impacts from saddled prominent outbreaks are usually minor because this is a late-season defoliator and the loss of leaves late in the season is not as stressful for trees. Saddled prominent has a history of irregular, localized outbreaks lasting 2-3 years in Door County. In the last 25 years, this pest has been reported in the northern half of the Door Peninsula and offshore islands (Chambers, Rock and Washington). However, there are records of outbreaks between the 1950s and 1990s in other counties: Marathon, Marinette and Shawano.

## Oak Leafroller (*Archips semiferanus*)

An outbreak of oak leafroller, *Archips semiferanus*, was observed in many parts of Wisconsin this year. Oak leafrollers are native, early-season defoliators of oak (Figure 23).

**Figure 23. An oak leaf with feeding damage and webbing. The yellow arrow indicates a larva leaf roller and the red arrow points to a pupa.**

In northwestern Wisconsin, approximately 112,000 acres of severe defoliation were mapped across Barron, Rusk, Sawyer and Washburn counties. In northeastern Wisconsin, over 16,000 acres of severe 75-100% defoliation was mapped in Marinette County. About 25% defoliation was noted in Forest, Marathon, Oneida, Vilas and Waupaca counties, and there were areas of severe damage in northern Oconto County. In central Wisconsin, small defoliating populations were observed in Marathon and Waupaca counties. In southern Wisconsin, 50-100% defoliation was mapped at Blue Mound State Park, and both spongy moth and oak leafroller were reported defoliating oaks at a campground in Columbia County (Figure 24).


**Figure 24. Counties where damage from oak leafroller was observed in 2022.**

Oak leafroller defoliation showed up a few weeks before spongy moth defoliation in nearby areas. Some oak leafroller defoliation may have occurred in the same areas as spongy moth, or homeowners may have mistakenly identified the defoliation as that of spongy moth. After the caterpillars were done feeding, the trees in areas of severe defoliation sent out new leaves, which had a noticeable reddish hue. This coloring remained for about a month.

# Native Health Threats To Conifers

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

Caliciopsis canker is a recently detected disease complex in Wisconsin. However, it has been causing branch losses in eastern white pine since the late 1990s 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 2022, Caliciopsis canker was found for the first time in Clark, Oconto, Outagamie, and Sheboygan counties. (Figure 25). Previously, it had been confirmed in Adams, Lincoln, Marathon, Waupaca, Waushara,

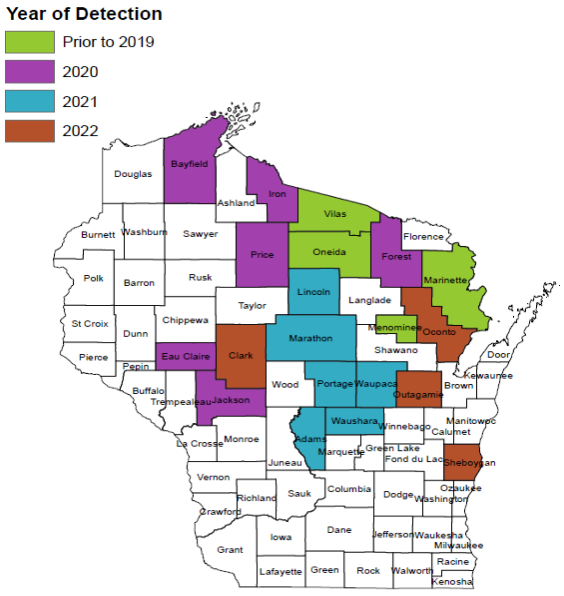



**Figure 25. Counties and year where Caliciopsis canker associated with white pine bast scale has been found.**

Portage, Marinette, Oneida, Bayfield, Eau Claire, Forest, Iron, Jackson, Price and Vilas counties. Though Caliciopsis cankers 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.

As part of a study to determine the distribution and incidence of Caliciopsis canker on eastern white pine in the Great 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 are identifying the samples to species of *Caliciopsis* and noting relationships with hosts to provide a better understanding of this recently emerging disease in the upper Midwest.

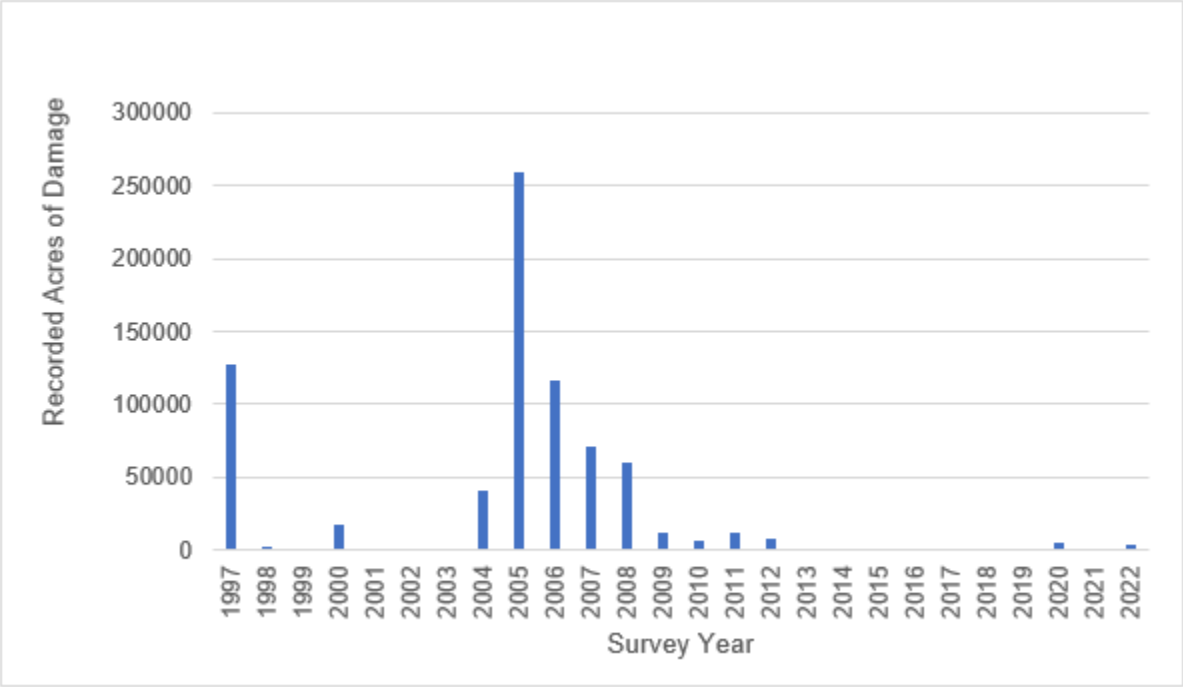



**Figure 26. Acres of defoliation caused by jack pine budworm 1997 - 2022.**

## Jack Pine Budworm (*Choristoneura pinus*)

This native insect goes through periodic outbreaks about every 10 years. Outbreaks are related to the maturity of jack pine stands. Population outbreaks are triggered by improved nutrition supplied 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 the regeneration of jack pine seedlings from seeds released from serotinous cones. In the last 20 years, we have seen one significant outbreak, which occurred from 2004-2008 (Figure 26). Since 2009, the budworm population has remained low, and defoliation has been small, localized and managed with the 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. In 2022, only 3,432 acres were damaged by the budworm, and it is likely to be managed similarly.

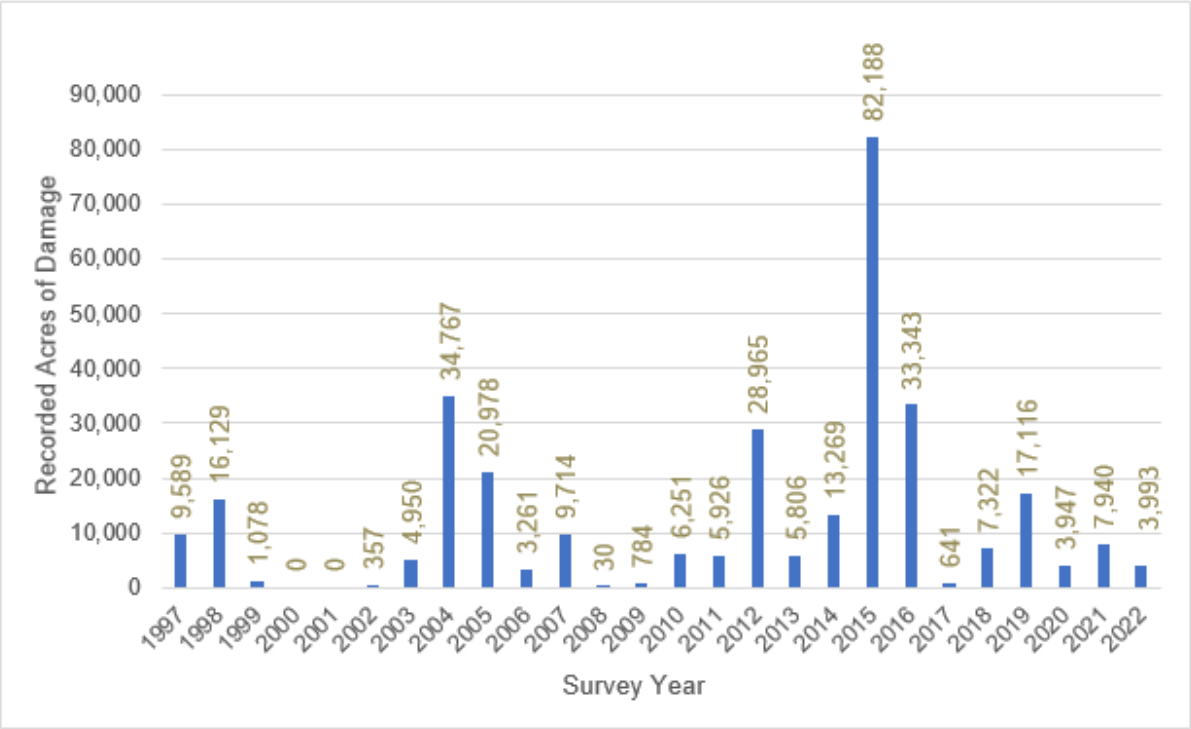



**Figure 27. Acres of defoliation by spruce budworm 1997 - 2022.**

## Spruce Budworm (*Choristoneura fumiferana*)

Spruce budworm (*Choristoneura fumiferana*) outbreaks occur 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. Our last outbreak in Wisconsin occurred from 1970-1980, with 180,000 acres impacted in the final year of the outbreak. Spruce budworm does not completely disappear between outbreaks, and there are often a few areas of defoliation each year in the state. Other neighboring states also experience this constant presence. But these lingering populations differ from 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 Vilas County, southern Bayfield County and some localized areas in northern Marinette County and northern Forest County. As in past years, balsam fir was more heavily defoliated than spruce.

This year, 3,993 acres of damage from spruce budworm were mapped (Figure 27). However, aerially mapping defoliation was made difficult this year for reasons explained below, and the amount of damage may be underestimated. The long cold spring of 2022 resulted in decreased visibility of budworm feeding activity. Budworm caterpillars are wasteful feeders and clip needles that they don't consume. These needles then get stuck in webbing produced by the larvae (Figure 28). Eventually, those needle fragments turn rusty brown, and the clumps are easily visible from a distance in mid-July. This year, however, the buds broke in March following normal warming temperatures, but then the weather turned very cold for several weeks. During the cold period, needle expansion virtually stopped. However, budworm caterpillars continued feeding on the paused foliage. By the time temperatures warmed up enough for bud growth to resume, many of the needles in the bud had been completely consumed, resulting in bare twigs. No needle fragments were left uneaten to turn rusty, and the only evidence of feeding damage was the twigs and a subtle lack of the bluish cast of new needles against older foliage. While the naked twigs were visible close-up, they weren't at aerial survey distances. This year's possible undercount of damage follows several years where defoliation may have been undercounted. In 2018, 2019 and 2021, abundant rainfall in spring stimulated plentiful growth, which masked the clumps of rusty needle fragments. And in 2020, an aerial survey was impossible due to precautions against COVID-19.

**Figure 28. Spruce budworm caterpillar amidst expanding balsam fir needles**

# Damage From Abiotic Causes

## Precipitation And Temperature

After widespread drought in the latter half of 2021 and through the winter, precipitation was closer to the 1980-2010 average in 2022 (Figure 29) though still drier than the period of wet conditions 2014-2020 (Figure 30). We have concerns, however, as over half the state had drought conditions as trees went into dormancy this fall which could result in damage during the winter of 2022-2023 (Figure 31). Temperatures were below average from January through April, leading to a later start to the growing season than in recent years (Figure 32). Perhaps because of the late spring, no frost damage was reported in 2022. Summer and fall temperatures were at or slightly above average.

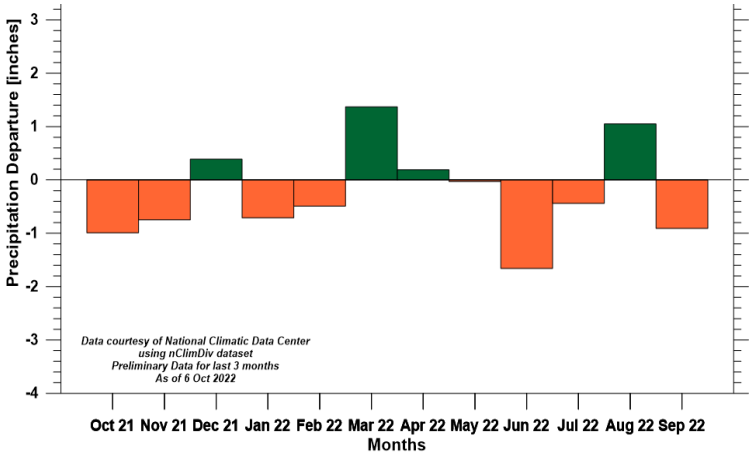



**Figure 29. Twelve-month statewide precipitation departure from the 1981-2010 average, Oct. 2021 to Sept. 2022, WI State Climatology Office**

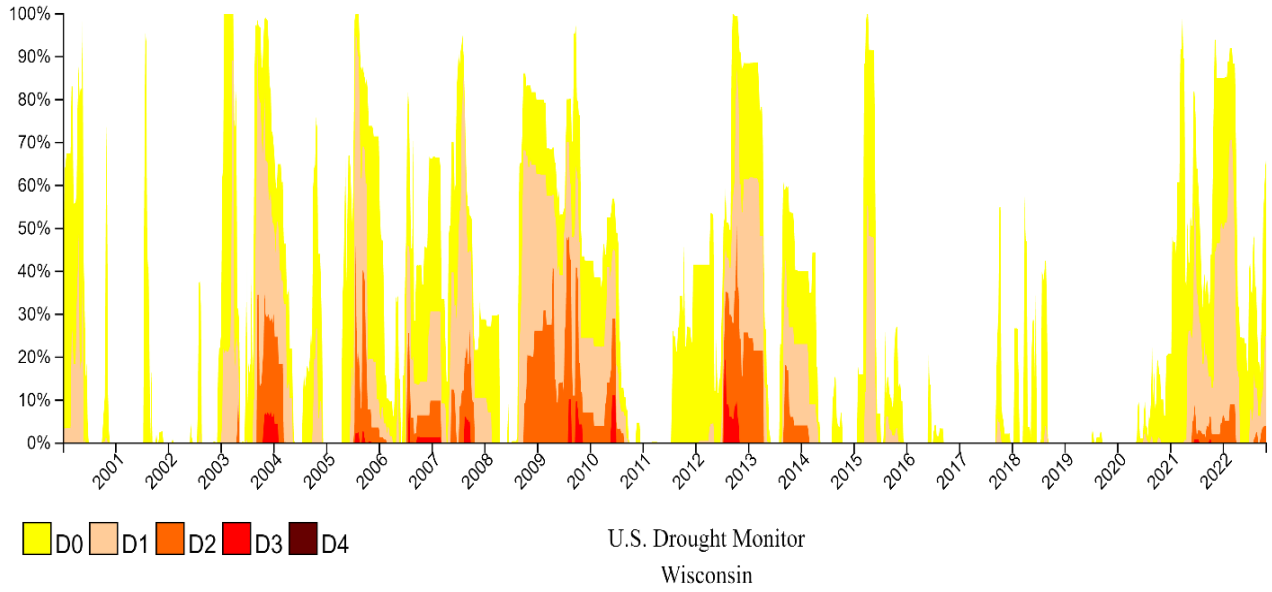



**Figure 30. U.S. Drought Monitor data for Wisconsin, 2000-2022. Scale is from D0, Abnormally Dry to D4, Exceptional Drought. NOAA at Drought.gov**

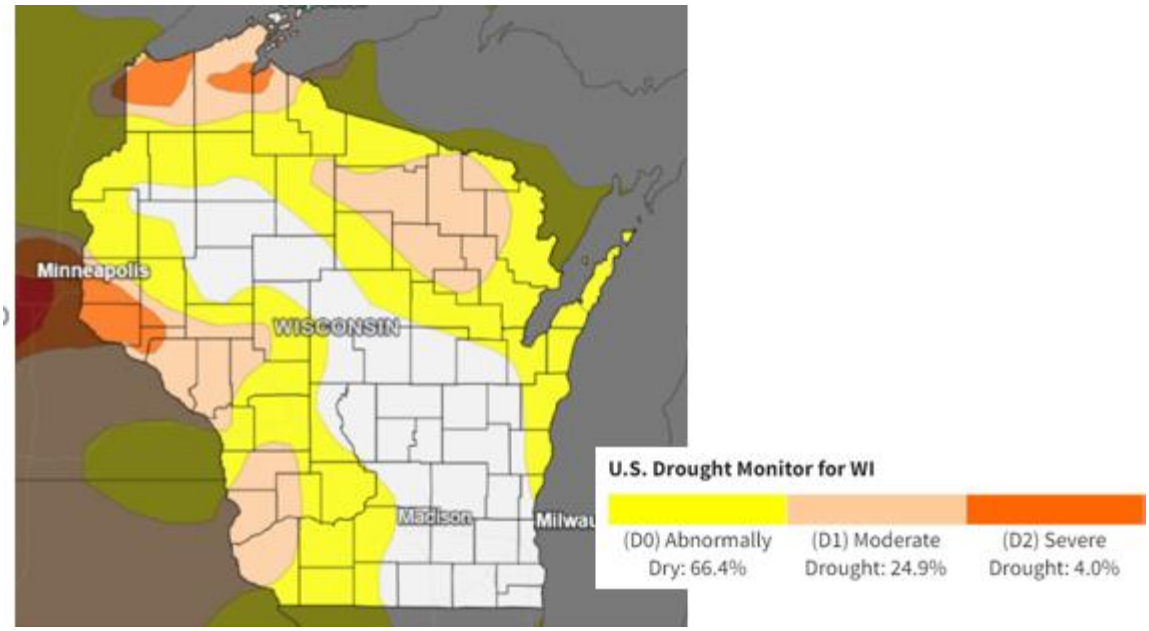



**Figure 29. U.S. Drought Monitor data for Wisconsin, October 25, 2022. Map by NOAA at Drought.gov.**

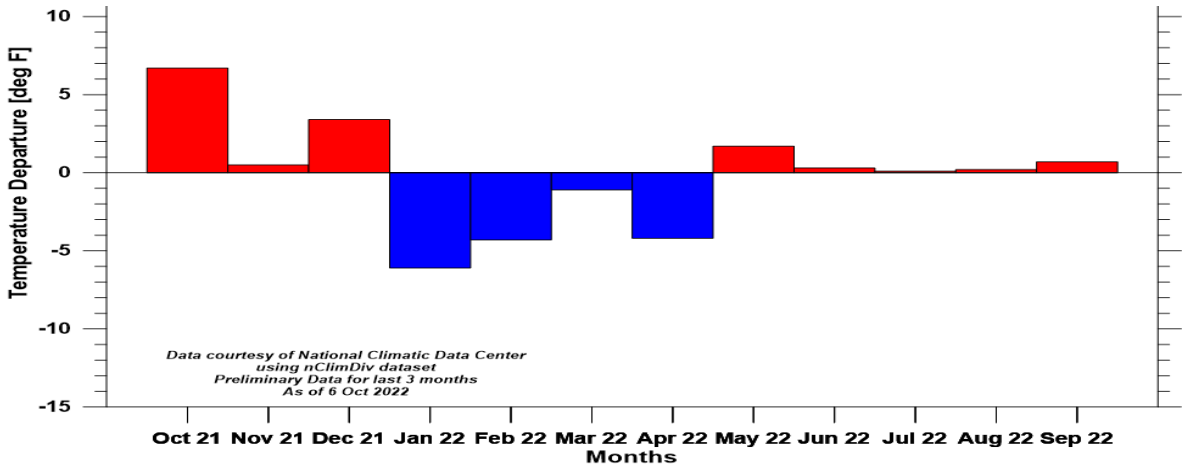



**Figure 30. Twelve-month statewide temperature departure from 1981 - 2022 average, Oct. 2021 through Sept. 2022. Wisconsin State Climatology Office.**

## Flooding

Despite drought conditions continuing in parts of Wisconsin in 2022, we continue to map flood damage from several historically wet years from 2017-2020. Water levels dropped considerably, but mortality continued in floodplain forests along the Wisconsin and Mississippi River corridors in southern Wisconsin. Bark beetles and Leptographium continued to cause mortality of red pine damaged by high water tables in central and northeast Wisconsin.

Widespread, heavy decline and mortality continued among many tree species on low-lying sites in east-central and northeast Wisconsin. Over 45,000 acres of damage were mapped in 2022. 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) (Figure 33). 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, physical deterioration of the dead trees, and the difficulties of conducting forest management on wet sites.

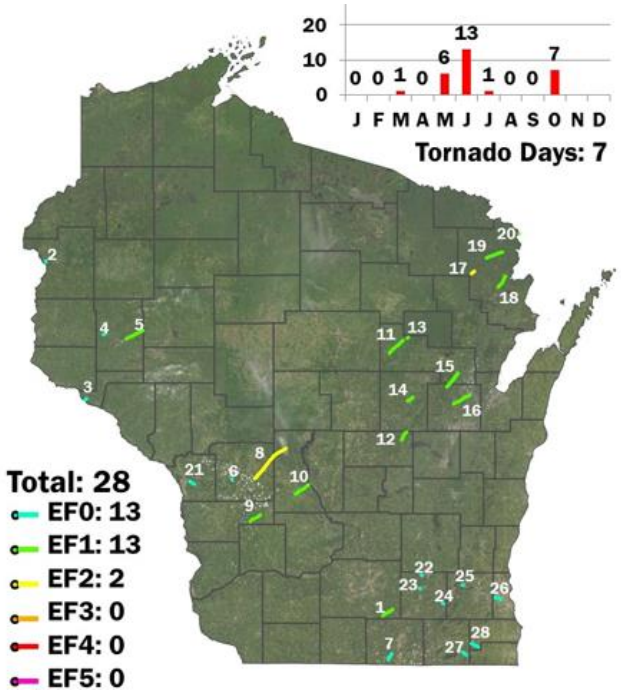
A decline in the level of Lake Michigan likely reduced or ended flooding stress in forest stands directly affected by the lake's level. Several sites in Door County that are aerially monitored each year did not have noticeable levels of new flooding-related discoloration/mortality adjacent to mortality that was noted in previous aerial surveys (Figure 34).

**Figure 31. Tree mortality and cattail ingrowth along shore of Mauthe Lake, Fond du Lac Co. Tree mortality was due to EAB, Dutch elm disease and flooding.**

**Figure 32. Mink River estuary in Door Co. Previous tree mortality visible as gray skeletons but no new mortality is seen.**

## Storm Damage

Storms produced 28 tornadoes, slightly above the average of 23, on seven days in 2022 (Figure 35). Thirteen tornadoes, including two EF2s, and straight-line winds damaged more than 7000




acres of forest during severe storms on June 15. Wisconsin also broke its record for most tornadoes on a day when seven were recorded on October 12, breaking the previous record of four.

A severe storm on May 9 produced golf ball-size hail and high-speed winds, which caused catastrophic injury to trees across more than 96,000 acres in Burnett and Polk counties in northwest Wisconsin. Aspen, locust and pine were the most severely impacted, with oaks showing more moderate damage.

**Figure 33. Locations of tornadoes reported in Wisconsin in 2022. Map by National Weather Service.**

# 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. The 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 0.8% (252 seedlings tested, and two tested positive for Diplodia). This was lower than the rate in 1-year-old seedlings in 2021 of 1.9% (260 seedlings).
- The infection rate for 2-year-old seedlings (308 seedlings tested) was 2.6%. It was slightly higher than the rate in 2-year-old seedlings of 1.1% (267 seedlings) but significantly lower than in 2-year-old seedlings of 6.3% (252 seedlings) in 2020.
- The infection rate for 3-year-old seedlings (276 seedlings tested) was 1.8%, which was similar to the rate in 3-year-old seedlings (240 seedlings tested) of 1.7%.

### 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. Only one species of rust fungus has been identified there, *Cronartium quercuum* (pine-oak gall rust). In the spring of 2022, 1000 seedlings of each of the 1 and 2-year-old cohorts of jack pine were visually inspected for galls at the time of lifting. No visible gall was found for 1-year-old jack pine (0.2% in 2021) and 1.5% for 2-year-old jack pine (1.9% in 2021). Monitoring for galling will be repeated in spring 2023.

## Acknowledgements

Projects and this report were partly funded through a grant awarded by the U.S. Forest Service Northeastern Area State and Private Forestry. The USDA is an equal opportunity provider and employer.

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**Lipstick apple rust on crabapple leaf**