Wisconsin DNR Forest Health 2015 Annual Report

Fruiting bodies of “Chicken of the Woods” fungus.
Photo by Scott Schumacher.

WISCONSIN DEPT. OF NATURAL RESOURCES

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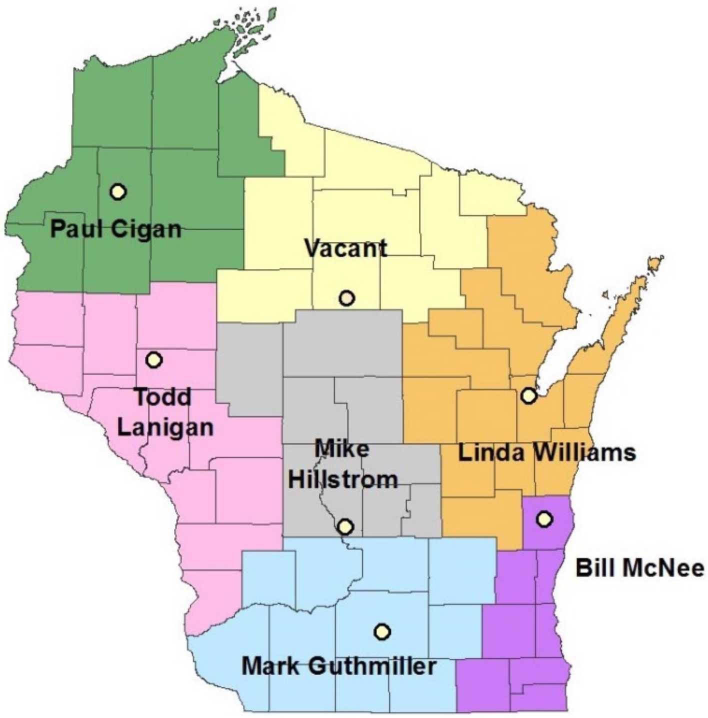
(as of December 31, 2015)



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Forest Resources in Wisconsin

Wisconsin's forests 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 the economy of Wisconsin for wood products, recreation and tourism. The primary and secondary wood products industry is one of the five largest employers in the state and puts Wisconsin first in the nation in the production of fine paper, sanitary paper products, children's furniture and millwork. The annual value of these products is about $20 billion. Forest and water resources in Wisconsin are a primary tourism attraction for both residents and visitors. The variety of Wisconsin's forest ecosystems supports a great diversity of wildlife species, while recreational use of the forests continues to grow and expand.

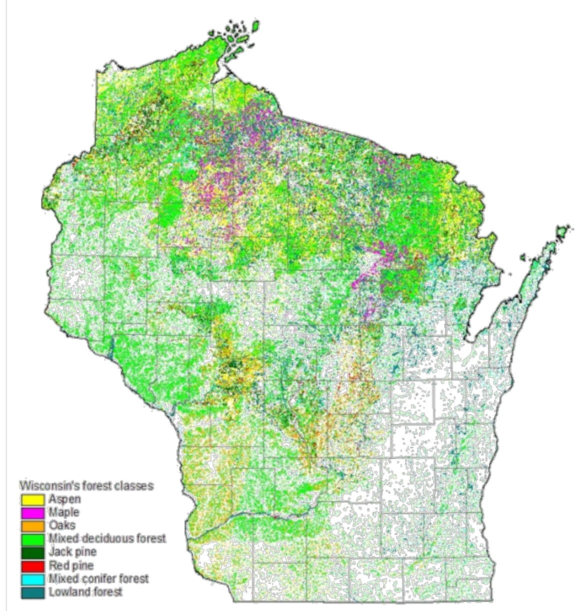

Figure 1. Wisconsin forest cover map.

Area of Forests by Type and Age Class

The area of forest land in Wisconsin has been steadily increasing in recent decades, and currently stands at approximately 16.6 million acres (Figures 1 and 2). This is an increase of 1.8 million acres since 1983 and 860,000 acres since 1996. Most of Wisconsin's forest lands are privately owned. Wisconsin now has more forested area than at any time since the first forest inventory in 1936, and over 46% of the state's land area is forested.

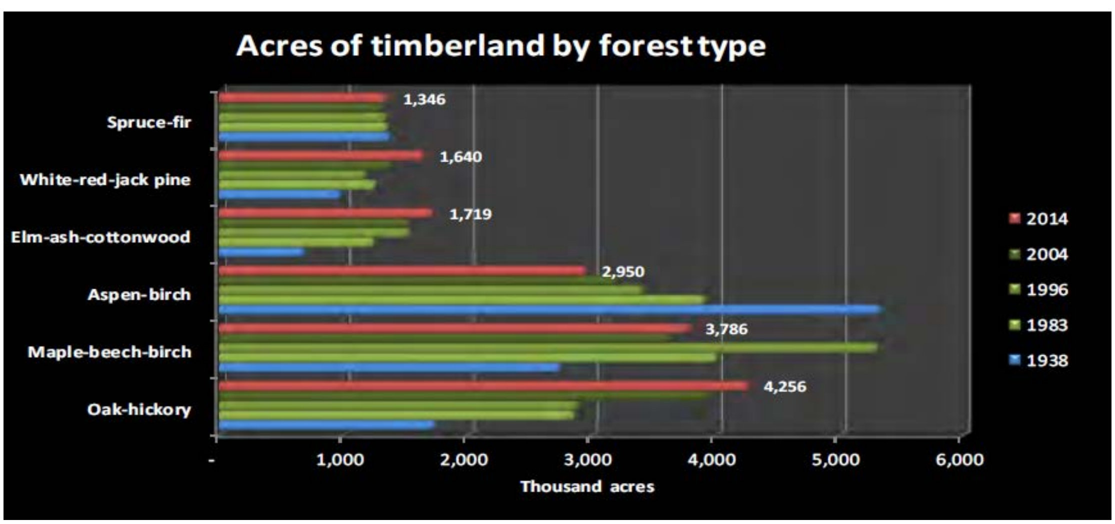

Figure 2. Wisconsin timberland area by forest type (FIA data, US Forest Service).

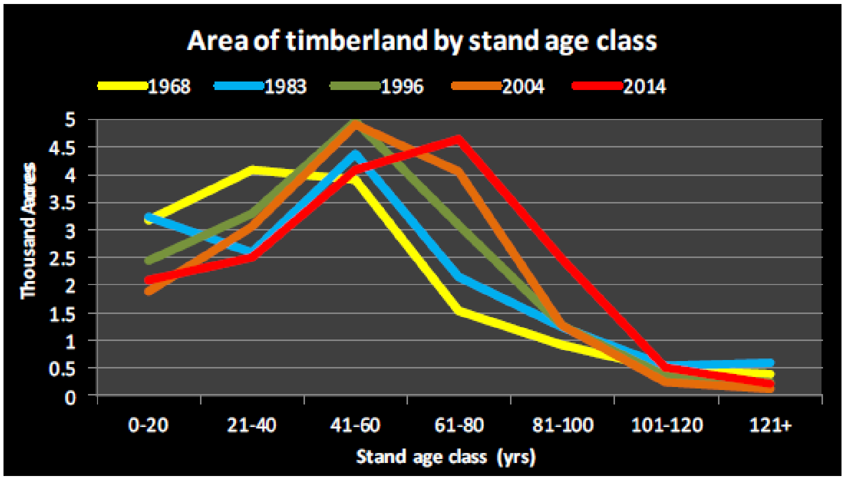

Figure 3. Timberland acreage by stand age class (FIA data, US Forest Service).

Wisconsin's forests are predominantly hardwoods, and the most abundant forest types are oak-hickory at 25% of total forested acreage, maple-beech-birch at 23% and aspen-birch at 18%. Conifer types, mainly pine and spruce-fir, represent about 18% of the forested area. Since 1938, the acreage in aspen-birch has decreased by over 2 million acres and the acreage of oak-hickory has increased by over 2 million acres. Acreage in northern hardwoods and bottomland hardwoods has each increased by over 1 million acres.

Wisconsin's forests are becoming middle-aged, with less acreage in young and old stands and a sharp increase in stands 60 to 100 years old (Figure 3). From 1968 to 2014, acreage in stands 40 years old or less decreased from 50% of all acres to only 29%. However, this trend may be changing. Since 2004, acreage in young stands (less than 20 years old) has increased 11% and acreage in stands over 100 years old has doubled.

Volume and Trends in Major Species

As of 2014, there is an estimated 21.6 billion cubic feet of wood in Wisconsin's forests, an increase of 39% since 1983 (Figure 4). The greatest volume of any major species in 2013 is in soft maple (red and silver maple), where volume has nearly doubled since 1983. The second highest volume is in sugar maple, where volume has increased by 60% since 1983. Aspen ranks third by volume but its total has decreased 13% over the last 30 years. Northern

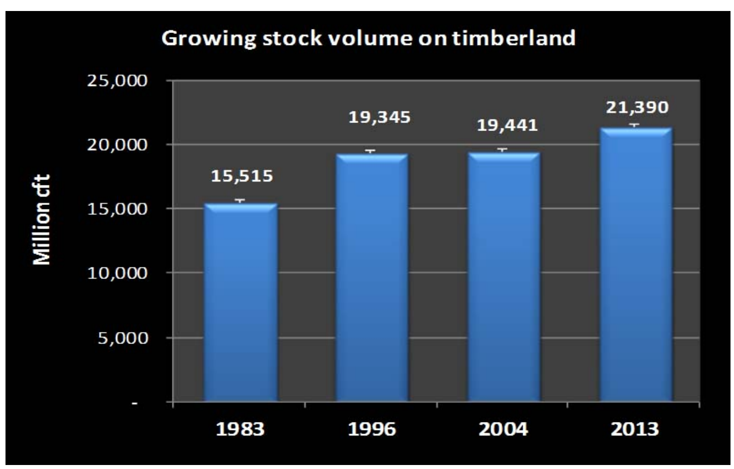

Figure 4. Volume of growing stock (FIA data, US Forest Service). 2014 data is not shown.

red oak ranks fourth, but its volume has decreased by 10% since 1983.

The greatest percentage volume gains in the last three decades have been in black walnut (409%), white pine (201%), tamarack (137%), red pine (122%) and soft maple (100%). The greatest percentage volume losses in the last three decades have been in jack pine (58%), paper birch (53%), balsam fir (26%), elm (23%) and aspen (12%).

Exotic Species Issues

Beech Bark Disease

Field observations in 2015 found that Door County continues to be the only Wisconsin county with high populations of beech scale (*Cryptococcus fagisuga*), as well as tree decline and mortality associated with beech bark disease (Figure 5). In 2015, an additional high population of beech scale was detected in a 9-acre parcel about 6 miles northeast of Sturgeon Bay. High scale populations and tree mortality have been noted in the local area since the first detection of beech scale and beech bark disease in Wisconsin in 2009.

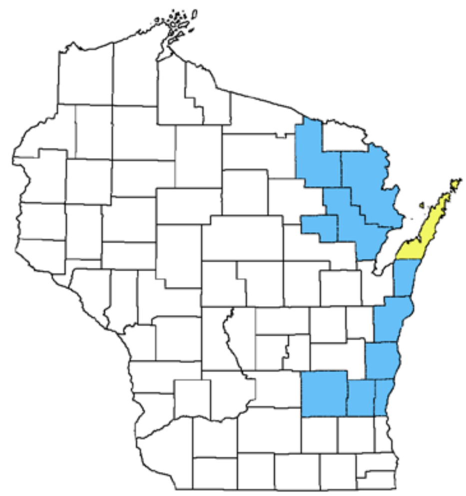

Figure 5. Counties with beech scale detections are shown in blue. Door County (yellow) is the only county to show beech bark disease and tree mortality.

Approximately 0.1-5% of American beech are considered resistant to beech scale. Identification, protection and propagation of resistant trees offer hope for a future healthy beech resource, and are therefore part of sustainable forestry. Three trees that fit the criteria for potentially-resistant trees were identified at the Door County site where beech bark disease was first detected in 2009. Dormant stem pieces were collected from these trees in winter 2015 and sent to the USDA Forest Service, Northern Research Station in Delaware, Ohio for grafting.

Chestnut Blight Study

(Prepared by Mark Double and William MacDonald, West Virginia University)

An 89 acre hillside in West Salem (La Crosse County) was permanently altered when American chestnut seed was planted there in the late 1880s. Chestnut trees flourished, and by the early 1990s more than 3,000 stems could be identified (Figure 6). They now range in size from less than 1 inch to more than 60 inches in diameter. The stand, currently considered the largest American chestnut stand in North America, is 375 miles west of the natural range. The site was free of chestnut blight until 1987, when cankers were observed on four trees. The discovery of blight presented an opportunity for researchers from Cornell University, Michigan State

University, West Virginia University, University of Wisconsin - La Crosse and the Wisconsin Department of Natural Resources to initiate collaborative studies in 1992 using a biological approach to control the disease.

Figure 6. Mature American chestnut at the West Salem site.

The fungus that causes chestnut blight, *Cryphonectria parasitica*, can become infected with a virus that weakens it (known as a 'hypovirus'). Virus-containing fungal strains grow more slowly than the normal strains, allowing the tree's defenses to combat the disease. In an effort to initiate biological control, virus-infected strains of the fungus have periodically been introduced into small punch wounds around the margin of cankers.

Since 1992, researchers have identified 3,490 cankers and many of them have been treated with the virus-containing strain of the fungus. Because spread of the virus-infected strains cannot be detected visually, the only way to evaluate virus spread is to remove small bark samples from each canker, isolate the fungus, and determine whether it has acquired the virus. Normal fungal cultures can be distinguished from the weakened forms on agar media (Figure 7).

A general summary of findings are:

- Trees have continued to die from chestnut blight at the West Salem site, although many trees have produced abundant sprouts.
- The hypovirus has spread on trees that contain treated cankers.
- 24% of the main stems that were treated with virus-infected strains remain alive, with callousing infections (Figure 8). Crown health is improving. 9% of untreated trees remain alive.

Summary of 2015 findings:

- Movement of the hypovirus to untreated trees has increased in all areas of the stand.
- Seventy-five cankers were newly discovered in 2015. Nearly 3,500 cankers have now been detected, up from about 2,900 in 2010.

Figure 7. Virulent (virus-free) isolate of the chestnut blight fungus, *Cryphonectria parasitica*, on agar media at left, and virus-containing strain of the chestnut blight fungus on agar media at right.

- 517 live chestnut stems were pre sent in 12 permanent plots that were established in 2001. As of 2014, 35% of the original stems in the 'Disease Center' plots remained alive, compared to 18% in the 'Disease Front' plots and 22% in the 'Beyond the Disease Front' plots. Some tree mortality may be attributed to the harsh winters of 2013-14 and 2014-15.
- Chestnut sprout numbers have increased significantly, as mortality of the original stems has resulted in additional light reaching the understory.
- The pathogen's Vegetative Compatibility Type WS-1 continues to be dominant in the stand, although its frequency has decreased from 100% in 1995 to 74% in 2014. Types WS-2 and WS-3 were found at rates of 4% and 7%, respectively.

Figure 8. Callus formation that results from a virus-containing infection.

Jumping worms (*Amynthas spp.*)

Wisconsin's first detection of jumping worm (*Amynthas spp.*, Figure 9) occurred in Madison in October 2013. Since then, infestations have been reported from additional counties and are concentrated in urban areas. It is believed that the worms are not spreading rapidly on their own. Currently, there are no verified occurrences of jumping worms in rural forests.

Figure 9. Jumping worm.

While assessing new infestations, it was realized that these worms were easily spread in nursery stock, soils and mulch. Jumping worm introduction and spread thus far appears to be been accidental. To reduce future spread, DNR staff worked with partners such as the Green Industry, local governments, master gardeners and researchers to develop Best Management Practices (BMPs) and increase public awareness of jumping worms. In the winter and spring of 2015, DNR staff met with these partners to develop general Best Management Practices to minimize the spread of jumping worms. DNR staff developed a webpage (dnr.wi.gov, Keyword: jumping worm) and two publications to highlight the BMPs, and have partnered with the UW Extension First Detectors Network to develop a centralized method of reporting suspected infestations.

A revision of Administrative Rule NR 40, Wisconsin's invasive species rule, was completed and the changes became effective on May 1, 2015. Because jumping worms had been found at numerous sites, their NR 40 classification was changed from 'Prohibited' to 'Restricted.'

Emerald Ash Borer (EAB)

Impacts from EAB increased in both rural and urban forests in 2015. Mortality was common in eastern counties where EAB has been established the longest, while thinning canopies were predominant further inland and along the Mississippi River. In Figure 10, clouds of red points describe the extent of areas within which damage from EAB has been recorded, but these points were not individually surveyed.

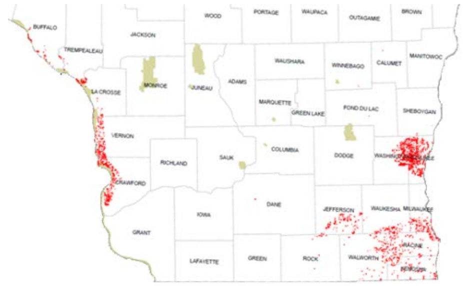

Figure 10. Red points indicate distribution of ash within areas where EAB is causing damage.

Detection of EAB involved both setting traps and confirmation of samples or photos submitted by municipal staff or the public. Current detection efforts are a multi-agency effort with participation by staff from the DNR, Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP), University of Wisconsin Extension, USDA Forest Service and USDA Animal and Plant Health Inspection Service (APHIS).

In 2015, most new communities where EAB was confirmed were within the quarantine in the southeastern counties and Dane County (Fig. 11). EAB was found for the first time in six counties: Green, Jackson, Lafayette, Marquette, Outagamie and Richland (Fig. 12). Only two counties were added to the quarantine in 2015: Jackson and Marquette. The other counties where EAB had not been previously found were already part of the quarantine.

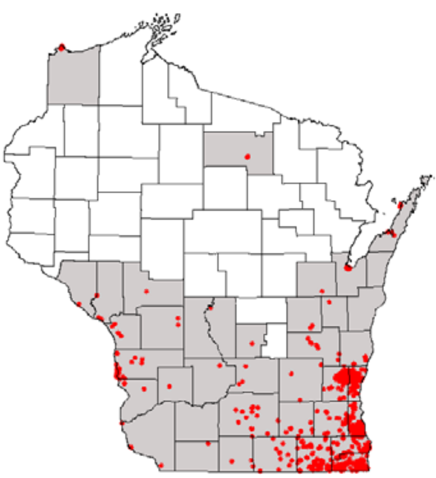

Figure 11. Counties quarantined for EAB are shaded. Locations where EAB has been confirmed are indicated by red points.

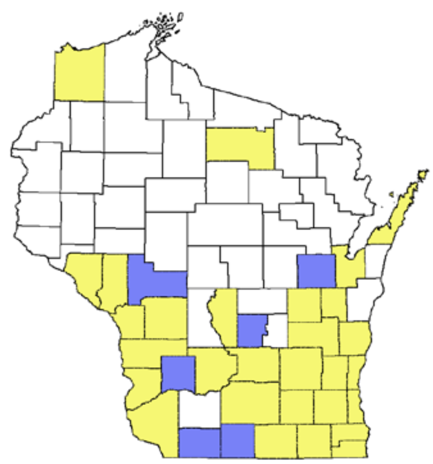

Figure 12. EAB was detected in 2015 in blue counties. Counties in yellow had first detections in previous years.

A list of all locations where EAB has been confirmed is online: http://emeraldashborer.wi.gov.

In 2015, EAB was confirmed in the following cities and villages:

- Columbia Co. - Portage
- Crawford Co.- Gays Mills
- Dane Co.- Brooklyn, Cambridge, Oregon, Verona
- Dodge Co.- Beaver Dam
- Fond du Lac Co.- Fond du Lac
- Green Co. - Monroe
- Jackson Co. - Black River Falls
- Milwaukee Co. - Hales Corners
- Outagamie Co. - Appleton
- Ozaukee Co. - Thiensville
- Racine Co. - Mount Pleasant, Rochester, Waterford
- Rock Co.- Edgerton, Milton
- Sheboygan Co. - Oostburg
- Washington Co.- Germantown
- Waukesha Co.- Eagle, Elm Grove, Hartland

DNR traps targeted State Park and Forest campgrounds at high risk of introductions of the pest. In 2015, DNR trapping detected EAB at Yellowstone Lake State Park in Lafayette County and Wyalusing State Park in Grant County. A trap set by APHIS caught EAB in Marquette County for the first time, and a DATCP trap found EAB in Richland County for the first time.

Biological Control of EAB

In 2015, approximately 12,700 *Tetrastichus planipennisi* and 3,200 *Oobius agrili* wasps were released at four sites in Jefferson, Racine, Rock and Waukesha Counties between mid-June and mid-July (Figure 13). The parasitoids were produced and supplied by the USDA APHIS Plant Protection and Quarantine (PPQ) EAB Parasitoid Rearing Facility in Brighton, Michigan. Parasitoids have been released at 12 sites in Wisconsin since 2011. *Tetrastichus planipennisi* has been recovered at the 2011 release site. Recovery surveys have not yet been done at the other sites.

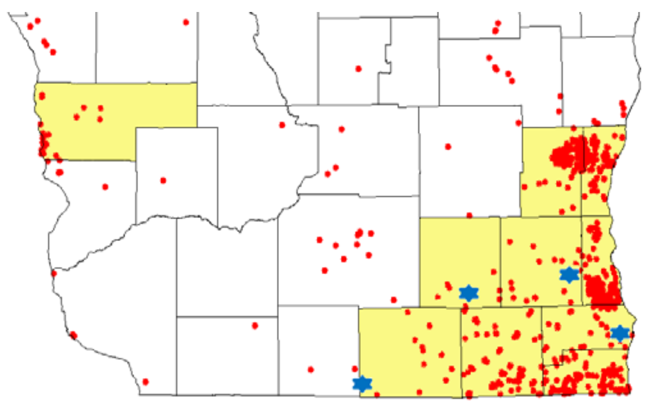

Figure 13. 2015 EAB parasitoid release sites are indicated by blue stars. Wasps have been released in counties shaded yellow, and red dots indicate an EAB detection.

Firewood Regulation

Firewood that may enter DNR-owned property has been regulated since 2006, when out of state wood was first prohibited. In 2007, wood originating more than 50 miles from the destination property was added to the prohibition. In 2010, this allowable distance was decreased to 25 miles and in 2014 it was decreased again to 10 miles. Wood certified as being treated to kill infesting organisms has always been allowed in regardless of origin. This regulation was linked with public outreach that encouraged campers to buy firewood near where it would be burned.

In order to detect changes in awareness and behavior, campers were surveyed in 2006, 2008, 2010, 2012 and 2014. Continued analysis of these surveys in 2015 indicates that education, linked with regulation, was successful in increasing awareness of pest and disease spread through firewood movement and in motivating campers to reduce their movement of firewood. For more information on this study, contact Dr. Andrea Diss-Torrance.

Gypsy Moth

In 2015, the DNR suppression program treated a single 41 acre site in Rock County, and foliage was successfully protected. This was the fourth consecutive year of treating only a single site. No defoliation was heavy enough to be detected in aerial surveys in 2015, although scattered reports of nuisance caterpillars and light defoliation of individual trees came from southeast Wisconsin, Columbia, Dane, Jefferson, Marathon, Portage, Rock, Sauk, Washington and Wood Counties. The fungus, *Entomophaga maimaiga*, and Nucleopolyhedrosis virus (NPV) were observed killing gypsy moth caterpillars in southern Wisconsin this year. In March 2015, Taylor County became the 50th Wisconsin county to be under quarantine for gypsy moth (Figure 14).

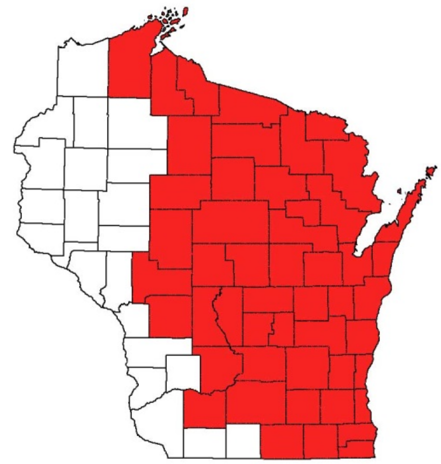

Figure 14. Counties quarantined for gypsy moth are shown in red.

Heterobasidion Root Disease (Annosum Root Rot)

Heterobasidion root disease (HRD) is considered to be one of the most destructive conifer diseases in the northern hemisphere. HRD, caused by the fungus, *Heterobasidion irregulare*, was first detected in Wisconsin in 1993 in Adams County. Most infections in Wisconsin have been in red and white pine plantations. The disease has since been found in 24 counties (Figure 15), although no new counties were added in 2015. However, additional infection sites were found in Columbia, Jefferson, Marquette and Waukesha Counties.

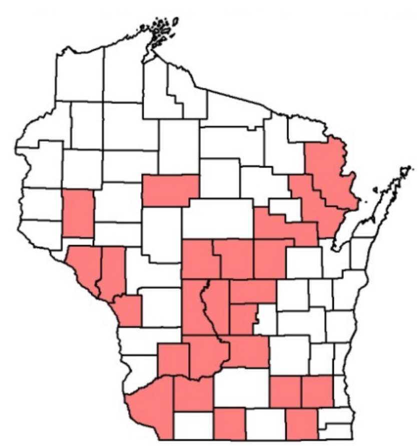

Figure 15. Counties where heterobasidion root disease has been detected are shown in orange.

In 2015, Forest Health staff found HRD in a white spruce plantation that is located in both Jefferson and Waukesha Counties. DNA testing by the Forest Pathology Laboratory at the University of Minnesota confirmed that the pathogen was *H. irregulare*. Previously, the pathogen had only been found in individual white spruce trees growing in infected pine plantations. The spruce stand was surveyed in November 2015, and *H. irregulare* conks were found to be widespread on the stumps.

Invasive Plants

The Forest Health team undertook several efforts to control invasive plants in 2015. These efforts included awarding grants through the Weed Management Area – Private Forest Grant Program (WMA-PFGP), rapid response grants and suppression grants. In addition, staff participated in field efforts to eradicate Policeman's Helmet (*Impatiens glandulifera*) in Mount Horeb. This invasive plant is a 'Prohibited' species in Wisconsin.

Six WMA-PFGP grants totaling $57,000 were awarded to weed management groups throughout the state. These grants assist groups that identify invasive plants, provide educational outreach, control infestations and monitor their populations. The Weed Management Area program also awarded three rapid response grants to control early detection populations of invasive plants. Seven suppression grants of approximately $20,000 were awarded to control invasive plants, especially 'Prohibited' and newly-established species, in forests on private and public lands.

Invasive Species Rule NR 40 Revision

The revision of Administrative Rule NR 40, Wisconsin's invasive species rule, was completed and the changes became effective on May 1, 2015. Prior to implementation, the proposed revisions were made available to the public through the DNR website and two public hearings, and were previewed with affected industries. Seventy-nine species were added to the list of regulated species, including 69 plant species and two terrestrial invertebrates that are both listed as a 'Prohibited' species – mountain pine beetle (*Dendroctonus ponderosae*) and walnut twig beetle (*Pityophthorus juglandis*). Newly added plant species listed as 'Restricted' cannot be imported into Wisconsin after May 1, 2015. However, 'Restricted' plants already in the state can continue to be sold, purchased and planted during the phase-out period (5 years for trees and shrubs and 3 years for other plants).

Oak Wilt

Oak wilt is caused by the pathogenic fungus, *Ceratocystis fagacearum*, and is lethal to northern pin, northern red and black oaks in Wisconsin (Figure 16). Oak wilt is widespread in the southern two-thirds of the state, but is uncommon in northern Wisconsin (Figure 17). However, DNR forest health staff continue to find isolated disease centers in northern Wisconsin each year.

Figure 16. Oak wilt spore mats on a dead red oak.

In 2015, first detections were made in townships of several northern counties where oak wilt had been previously detected: Burnett Co. (Meenon Township), Rusk Co. (Wilson and Strickland Townships), Vilas Co. (Conover Township) and Washburn Co. (Evergreen Township). Additionally, oak wilt spore mats were found on dead oaks in two Rusk County townships (Murry and Wilkinson) but lab testing has not confirmed the pathogen identity. Oak wilt was found on the Chippewa County Forest for the first time, although the disease was already known to occur in that county.

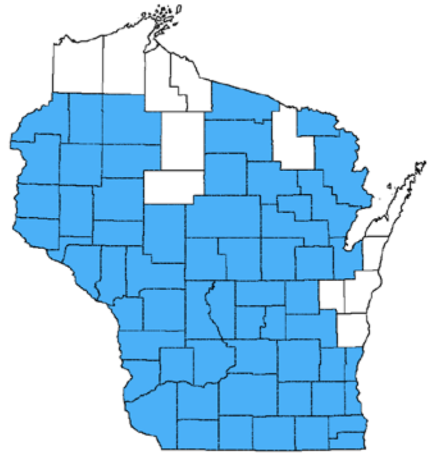

Figure 17. Counties with known oak wilt infections are shown in blue.

Oak Wilt Herbicide Barrier Update

In Wisconsin, herbicides have been used since 2003 as an experimental mechanism to limit the below-ground spread of oak wilt in stands where physical root severing is not practical. With this method, trees within grafting distance (identified through Johann Bruhn's model) are frill-girdled and then treated with Garlon 4 (active ingredient: Triclopyr) prior to harvesting (Figure 18). Treated sites are being monitored annually by DNR and/or Marathon County forestry staff, and results so far are promising. The Rusk County Forestry Department has also been trying this herbicide treatment in several infected stands.

In 2015, DNR received a federal grant to formally evaluate the effectiveness of the frill-girdle herbicide method to control below-ground spread of oak wilt. More than two dozen oak wilt pockets in central and northern Wisconsin were treated in 2015, and it is expected that additional pockets will be treated in 2016. Detailed field data will be collected during the 5 years of this study.

Oak Harvesting Guidelines

Last year, DNR began a review of the oak harvesting guidelines that were implemented in 2007. The purpose of the review was to ensure that the guidelines are based on current research and operational data, and that oak harvesting is done within the framework of sustainable forest management. The review process included expert review and stakeholder advisory committee input and approval.

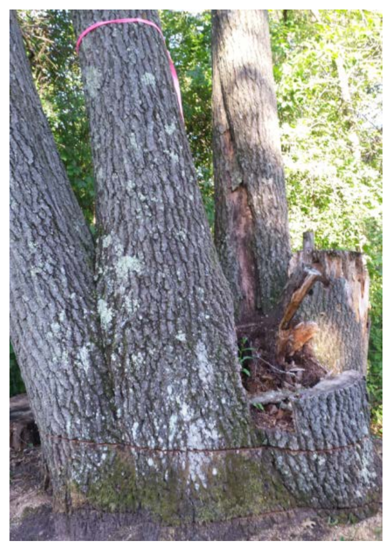

Figure 18. Large northern pin oak treated with the frill-girdle herbicide method.

The review structure consisted of the following groups:

- Advisory Committee: Representatives from industry, government, landowners and non-profit groups.
- Science Sub-Committee: Addressed science-based concerns and new research.
- Economics and Implementation Sub-Committee: Addressed economic concerns and field practicality.
- Technical Team: Gathered relevant information and provided recommendations that were used for discussions by the committees.

Under these guidelines, harvesting-restricted periods to prevent oak wilt infection remain unchanged from the former guidelines (April 1-July 15 in southern Wisconsin, and April 15-July 15 in northern Wisconsin). However, the revisions provide additional flexibilities in the timing of oak harvesting while still protecting stands from oak wilt. After a period of public input, the draft guidelines were approved by the Advisory Committee groups and Forestry Division Administrator in September 2015. The revised guidelines will take effect on January 1, 2016. The revised guidelines can be found on the DNR website, dnr.wi.gov, keyword: oak wilt.

Walnut Twig Beetle and Thousand Cankers Survey

Walnut twig beetle, *Pityophthorus juglandis*, is a very small beetle native to the southwest US and is the main vector of thousand cankers disease of black walnut. To date, Wisconsin has not found walnut twig beetle or thousand cankers disease, caused by the fungal pathogen, *Geosmithia morbida*. In 2015, Forest Health staff continued monitoring for the beetle and disease in southern and west central Wisconsin. Thirty-five Lindgren funnel traps were placed in 11 counties, primarily at state park and wildlife properties and a few county park properties (Figure 19). Traps were checked and samples collected three times during the growing season.

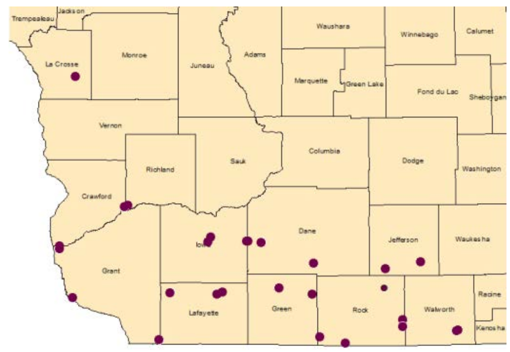

Figure 19. DNR walnut twig beetle trap locations in 2015.

Additional trapping for walnut twig beetle was conducted by staff from the Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP), primarily at municipal wood waste sites and sawmills. A combined total of 63 traps were placed at 33 sites by both agencies. No suspect beetles or fungal cultures were found during any sample screening.

Hardwood Issues

Basswood Defoliation

Several defoliators were active on basswood this year, including the scarab beetle that was noted in 2014 (*Dichelonyx subvittata*, Figure 20), basswood leaf roller (*Pantographa limata*), speckled green fruitworm (*Orthosia hibisci*) and introduced basswood thrips (*Thrips calcaratus*).

Due to frost damage and the combined feeding of these insects, basswood crowns appeared thin in many stands in Forest, Marinette, Oconto and Vilas Counties.

Figure 20. Scarab beetle (*Dichelonyx subvittata*).

Bur Oak Dieback and Mortality

Numerous reports of dead and declining bur oak were received in southern Wisconsin this year. These areas included sites in Dane, Dodge, Iowa, Jefferson, Rock and Waukesha Counties. The drought of 2012 likely initiated the dieback and allowed *Armillaria* fungi and two-lined chestnut borer to attack the trees. Bur oak blight did not appear to be a major issue at most of these sites. Only one site in Waukesha County had a positive test for oak wilt in bur oak.

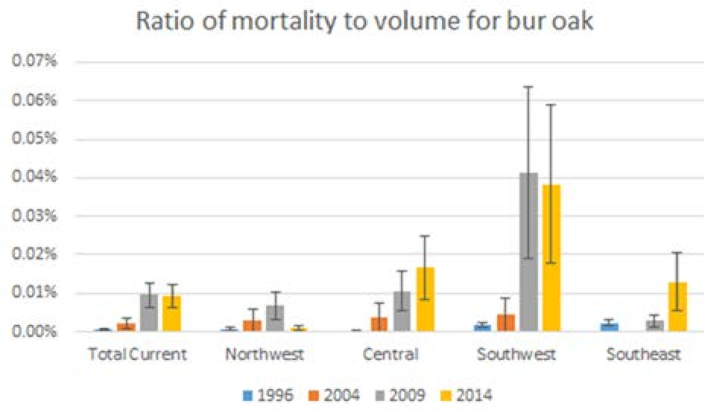

Figure 21. Ratio of mortality to volume for bur oak by region of Wisconsin (source: Wisconsin DNR).

DNR Forest Inventory and Analysis staff evaluated bur oak data from recent years, and found elevated mortality in 2009 and 2014 in southwest, southeast and central Wisconsin (Figure 21). Southwest Wisconsin has 28% of the state's bur oak volume, but experienced 52% of the mortality from 2009 to 2014.

Dead Oak Leaves Retained

Last year, Forest Health staff noticed oak trees that retained dead leaves throughout the summer (Figure 22), never dropping the dead leaves from 2013. This was a widespread observation throughout much of the northern half of the state last year. In 2015, however, the problem was limited to very small areas in Florence, Forest, Oneida and Vilas Counties. The dead leaf retention seemed limited to young trees, whereas in 2014 it could be found on any size of oak. It is hypothesized that the severe winter of 2013-14 played a part in the large number of oaks that had this problem in 2014 and the milder winter of 2014-15 resulted in less leaf retention.

Figure 22. Dead oak leaves from 2014 remaining on the twigs long into the 2015 growing season.

Fall Webworm

Fall webworm impacts were widespread across Wisconsin in August and September, but most of the damage was light defoliation of a few branches or scattered trees. However, one site in Monroe County and one site in Shawano County had unusually severe outbreaks. In Monroe County, a five acre stand of black ash was almost completely webbed and defoliated (Figure 23). Understory cherry was also defoliated. Other patches of severe defoliation were found on this and nearby properties. The most severe fall webworm damage is often discovered along river corridors, so perhaps the stream running through this property was a contributing factor.

Figure 23. Several acres of black ash and cherry trees defoliated by fall webworms in Monroe County.

Hickory Mortality

Mortality of bitternut hickory continued to be observed in Green Lake, Marathon, Shawano and Waupaca Counties (Figure 24). The primary cause is believed to be hundred cankers disease, an insect and disease complex that started causing hickory mortality in Wisconsin around 2005. USDA Forest Service researchers found that the native hickory bark beetle, *Scolytus quadrispinosus*, and the wilt fungus, *Ceratocystis smalleyi*, are the major agents in this mortality. Ambrosia beetles and unidentified fungi were also present at a Green Lake County site.

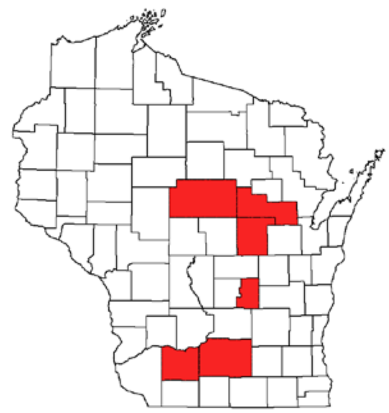

Figure 24. Counties with reported hickory mortality.

Continued mortality of hickory was seen at Governor Nelson State Park in Dane County, likely caused by Phomopsis galls and hundred cankers disease. Some bitternut hickory trees at the park showed symptoms of phytoplasma infection, which was confirmed through lab testing. It is not known what role phytoplasma infection may be playing in the observed dieback and mortality. More information can be found in the 'Phytoplasma' section of this Annual Report.

Mortality of mature bitternut hickory was observed in an upland stand on the Lower Wisconsin State Riverway in Iowa County. Hundred cankers disease appears to be the main mortality factor. Fusarium canker was confirmed from the base of one tree. In addition, extensive Phomopsis galls and symptoms of phytoplasma infection were seen on sapling and pole size bitternut hickory adjacent to this stand. This site will be considered for phytoplasma testing in 2016.

Maple Dieback and Mortality

In 2015, Forest Health staff received far fewer reports of maple dieback and mortality than in the previous year. Scattered, light dieback of sugar maple (along with white ash and trembling aspen) was reported in northwest Rusk County. This phenomenon was first observed by the Rusk County Forestry Department in 2013 and may be linked to abiotic, inciting factors such as the 2012 drought.

In southern Wisconsin, some symptoms that were present on red maple in 2014 were indicative of phytoplasma infection. A number of red maple sites were tested this year and confirmed for the presence of phytoplasma. The role of phytoplasma in the dieback and mortality is unknown. More information can be found in the 'Phytoplasma' section of this Annual Report.

Phytoplasma

Phytoplasmas are wall-less, bacteria-like microorganisms that act as pathogens in infected trees, causing small and yellow foliage, slow growth, thin crowns, branch dieback and vertical bark cracks. Infected trees and stumps may produce clusters of spindly shoots that are known as a 'witches broom' because they resemble a broom. The phytoplasma-caused disease on ash is known as ash yellows, and mortality of infected white ash has been observed in forested settings. Phytoplasmas have been detected in ash, black walnut and butternut in Wisconsin using Polymerase Chain Reaction testing.

Figure 25. A black ash tree infected with phytoplasma in Rusk County.

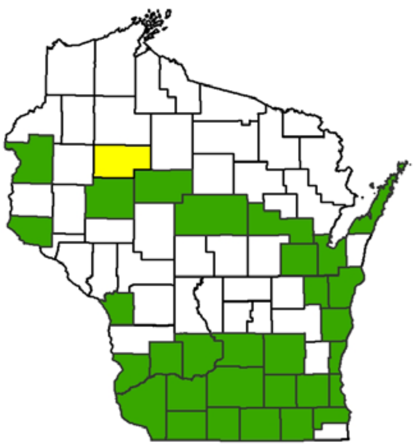

Figure 26. Rusk County (yellow) had a first phytoplasma detection in 2015. Counties with earlier confirmations are shown in green.

In 2015, 30 samples were collected from a number of tree and shrub specimens that showed symptoms of infection. Phytoplasma was confirmed on red maple, shagbark hickory and bitternut hickory for the first time in Wisconsin, in counties where phytoplasma had already been found on other species. Samples were also collected from *Amelanchier spp.,* river birch, hackberry, bur oak, white oak and silver maple, but the test results were all negative.

Phytoplasma was detected for the first time in Rusk County, on a symptomatic 14 inch diameter black ash tree (Figures 25 and 26). Interestingly, the tree had epicormic sprouts but not brooms.

Scale Insects

Very heavy populations of Lecanium scale (*Parthenolecanium spp.*, Figure 27) were observed in Brown, Door, Kewaunee, Marinette, Oconto, Oneida, Rock, Shawano, and Vilas Counties. The heaviest populations in the northern counties were found on oak, maple and cherry, with light populations on hazelnut. Central Wisconsin had widespread reports of high scale populations on oaks. In Rock County, high numbers of Lecanium scale were observed on shagbark hickory. In Door and Kewaunee Counties, maple and ash had the heaviest populations, with light

Figure 27. Heavy Lecanium scale infestation on an oak

infestations on dogwood. Fungal disease and a tiny parasitic fly were commonly found in scale populations in these two counties.

Kermes scale was observed causing damage to sapling red oak in a plantation in Richland County. The magnolia scale, *Neolecanium carnuparvum,* was reported at high numbers on planted magnolia in southeast Wisconsin.

Two-Lined Chestnut Borer

The drought of 2012 brought on increased activity by two-lined chestnut borer (*Agrilus bilineatus*) through 2014, especially in central and southern Wisconsin. In southern Wisconsin, fewer oaks were infested this year, although branch flagging was still evident. Scattered branch dieback and tree mortality continued to be observed in west central Wisconsin.

In the City of Spooner (Douglas County), two-lined chestnut borer was responsible for moderate to severe dieback and tree mortality in mature northern pin oaks bordering a recent housing development.

Walnut Dieback and Mortality

Walnut dieback and mortality subsided in 2015 after several years of increased reports following the drought of 2012. Various factors such as canker fungi, sapsucker injury, ambrosia beetles and cold injury were implicated in the earlier reports. Several walnut stands were tested for phytoplasma infection in 2015 and lab results came back negative. More information can be found in the 'Phytoplasma' section of this Annual Report.

Conifer Issues

Eastern Larch Beetle

Wisconsin continues to see increased tamarack mortality from eastern larch beetle infestation (Figure 28). This insect attacks stressed tamaracks, and once eastern larch beetle starts causing mortality in a stand it is common to see further mortality in that stand or area. The tree stress could be caused by drought, prolonged flooding, a drop in the water table, defoliation, etc. Many tamaracks have been under stress from the drought of 2012 and scattered larch casebearer defoliation in 2014, which set the stage for eastern larch beetle outbreaks.

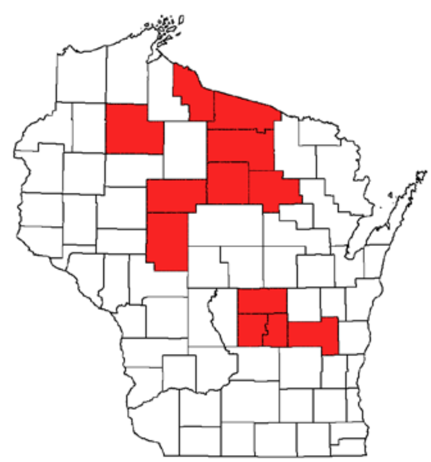

Figure 28. Counties with reported mortality from Eastern larch beetle are shown in red.

Mortality was observed in Taylor County in tamarack-black spruce stands. Scattered mortality of tamarack was also observed in Clark, Fond du Lac, Green Lake, Iron, Langlade, Lincoln, Marquette, Oneida, Sawyer, Vilas and Waushara Counties. Some of this mortality occurred during the winter of 2014-15 following severe defoliation by larch casebearer in 2014.

Larch Casebearer

Larch casebearer defoliation, which mines out the needles of tamarack (Figure 29), was patchy in 2015. Approximately 700 acres of moderate defoliation, across four tamarack swamps, was observed in Marquette and Waushara Counties. Small patches of defoliation were found in Iron, Oconto, Oneida, Sawyer, Shawano and Vilas Counties.

Figure 29. Larch casebearer defoliation.

In April and May, abundant larch casebearer caterpillars were seen in Forest, Oneida and Vilas Counties and another year of significant defoliation was predicted. Unexpectedly, widespread defoliation did not occur and very few caterpillars or pupae were found when sites were revisited. It is believed that frosts as late as June 6 killed many of the caterpillars.

Spruce Budworm

Widespread spruce budworm defoliation of balsam fir and spruce was found in a number of northern counties in 2015 (Figure 30). Northern Marinette and eastern Florence Counties had widespread moderate to severe defoliation, with some areas suffering their fourth year of significant defoliation from this insect. Northern Vilas County had some areas of severe defoliation and other areas with lighter levels of defoliation. Widely scattered patches of moderate to severe defoliation were observed in Ashland, central Oconto, Oneida and northwestern Portage Counties. One site in Vilas County had defoliation of tamarack that was within a stand of balsam fir.

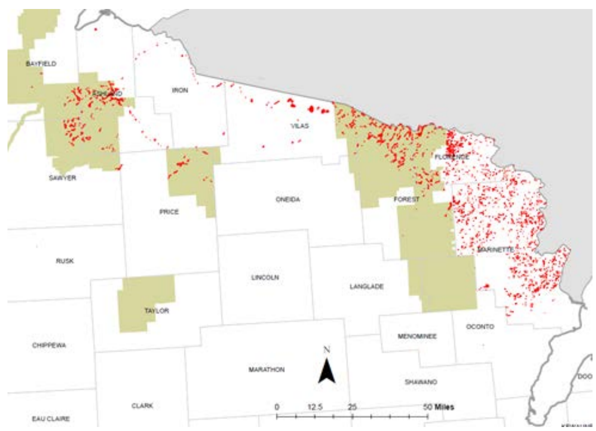

Figure 30. Red dots indicate locations of spruce budworm defoliation reported in 2015.

Regional budworm outbreaks occur every 30-50 years and can last 10-15 years. Wisconsin's last outbreak ran from 1970 to 1980. Mature balsam fir and spruce are the primary targets, although younger balsam or spruce can be defoliated as well. Repeated defoliation can cause top-kill and eventually whole tree mortality.

State Nursery Disease Studies – *Diplodia pinea*

In the Wisconsin state nurseries, healthy-looking red pine seedlings have been annually tested to assess asymptomatic infection by *Diplodia pinea*, the pathogen causing Diplodia shoot blight and collar rot. In July 2015, the forest health lab processed 495 two and three year-old asymptomatic seedlings collected from Griffith State Nursery in Wisconsin Rapids, and 280 two year-old seedlings from Wilson State Nursery in Boscobel. After eight weeks of incubation, asymptomatic infection rates at Griffith Nursery were 14.1% for two year-old seedlings and 4.2% for three year-old seedlings. At Wilson Nursery, the asymptomatic infection rate for two-year old seedlings was 6.8%. A 10% infection tolerance level has been set for management purposes. At Griffith Nursery, the only two year-old red pine seedlings that will be sold in 2016 will be lifted from planting blocks where the infection rate averaged 7.4%.

In October 2015, 270 1-0 seedlings from Wilson State Nursery were examined. Preliminary analysis of one year-old seedlings after five weeks of incubation showed an infection rate of 0.3%.

Abiotic Issues

2015 Weather

Temperatures in 2015 were near average except for a very cold February (Figure 31). Monthly precipitation levels were no more than one and a half inches above or below normal in 2015. According to the U.S. Drought Monitor at the University of Nebraska – Lincoln, no area in Wisconsin experienced consistent drought conditions in 2015. Drought conditions did not exceed a moderate level in any part of the state in 2015 (Figure 32).

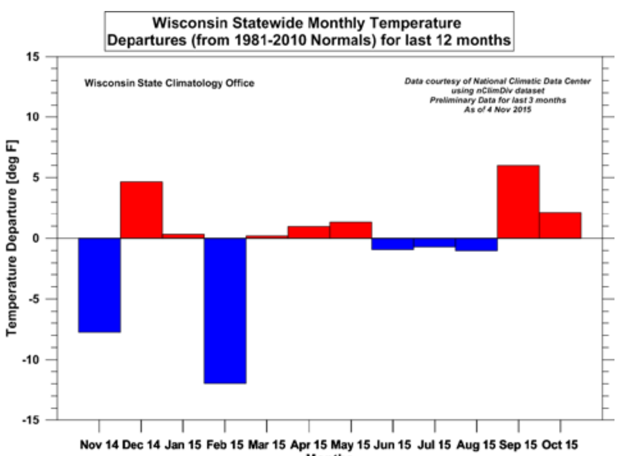

Figure 31. Statewide monthly temperature (°F) departure from normal for 2015. Source: Wisconsin State Climatology Office.

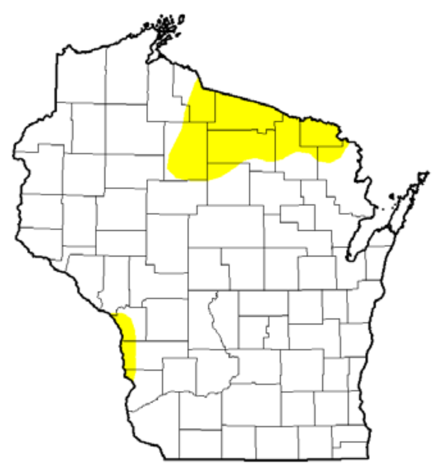

Figure 32. Map of 2015 precipitation levels as of December 1. Yellow areas indicate an abnormally dry condition. Source: UNL Drought Monitor.

Frost Damage

Frost damage impacted trees across much of the state in spring 2015, with the worst damage occurring in northern Wisconsin (Figure 33). Some trees were damaged three or more times by separate frost events that occurred in April, May and early June. Oaks experienced the most severe frost damage, but damage was also noted on maple, ash, basswood and spruce. Open areas such roadsides, stand edges and seed trees left in recently cut stands suffered the worst damage.

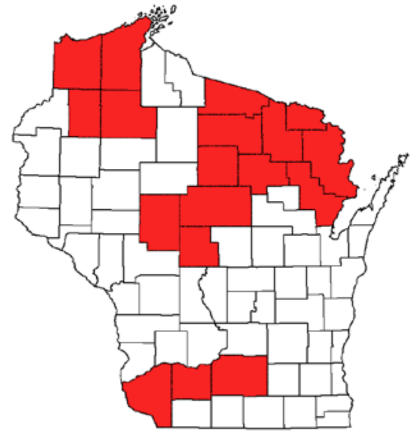

Figure 33. Counties with reported frost damage are shown in red.

Storm Damage

Parts of southern Wisconsin experienced storm damage in 2015, while delayed impacts of an extensive and severe storm in September 2014 were observed in the state's northern half (Figure 34).

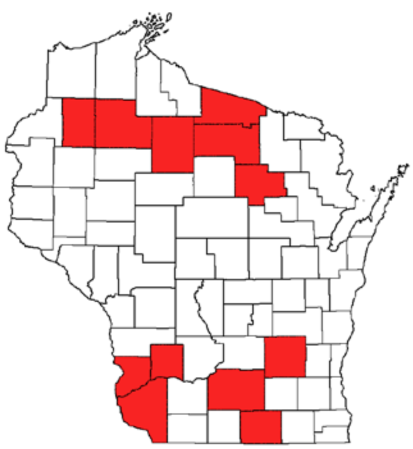

Figure 34. Counties with reported storm damage are

In southern Wisconsin, numerous areas experienced tree-damaging storms in 2015. In Grant County, approximately 4,700 acres were impacted in the Village of Cassville, Town of Cassville and Town of Waterloo. In Crawford County, approximately 4,500 acres were impacted in the Towns of Marietta, Scott, Steuben and Wauzeka. Approximately 650 acres were impacted by storms in the Town of Richwood in Richland County. Additional localized storm damage occurred in Dane, Dodge and Rock Counties.

In northern Wisconsin, a catastrophic hailstorm in September 2014 damaged trees across approximately 30,000 acres in Langlade, Oneida, Price, Sawyer, Vilas and Washburn Counties (Figure 35). Storm trackers reported quarter-sized and larger hail in areas across the storm path, resulting in scattered tree damage of moderate to high severity. Strong winds also broke the main stems and branches of many trees while uprooting others, and the damage was immediately noticeable in fall 2014.

Figure 35. Hail damage seen in Washburn County - crown thinning in the mature red pine, and discoloration in young red pine (lower left) and balsam fir (middle right).

Delayed impacts of the hail injury, such as branch flagging, top kill, and mortality, became visible in affected areas in spring 2015. Forest health staff received a large number of reports of brown branches on pines, spruce, and fir.

Acknowledgements

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