Wisconsin DNR Forest Health 2013 Annual Report

Bark beetle galleries in spruce. Photo by Mary Bartkowiak.

WISCONSIN DEPT. OF NATURAL RESOURCES

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The Spooner Forest Health Zone position is currently vacant

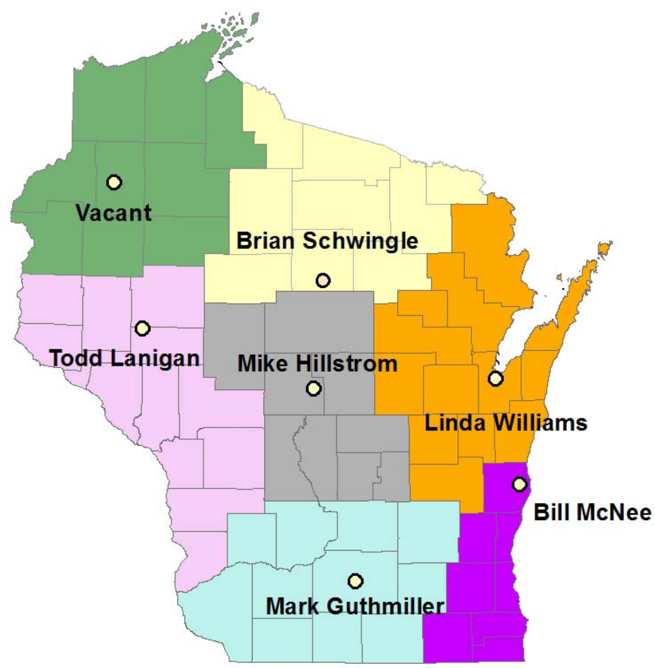

Figure 1: office location and area of responsibility of forest health staff assigned to zones

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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.

Area of forests by type and age class

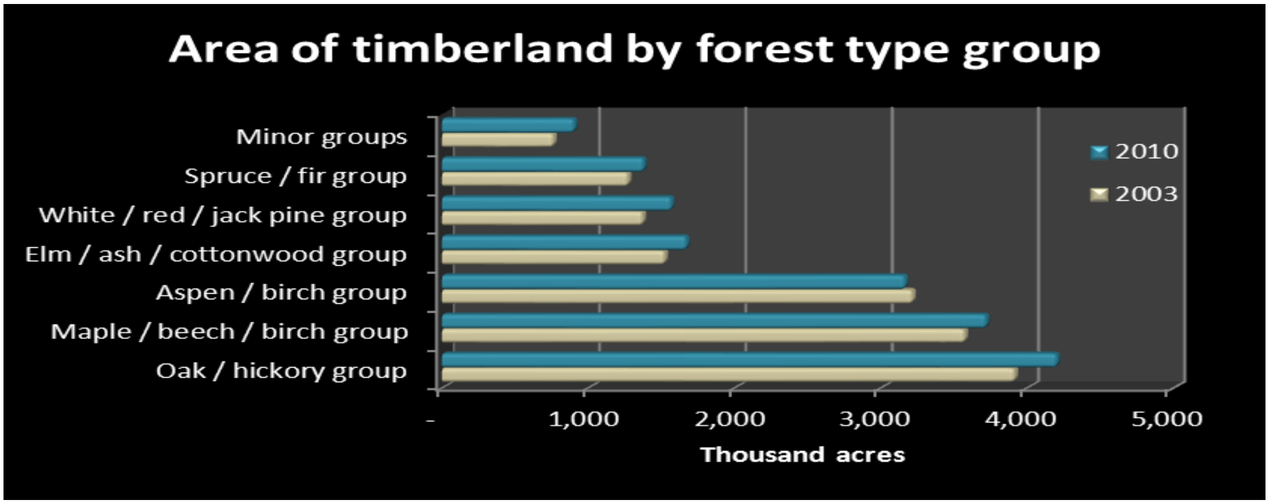


Figure 2: Wisconsin timberland area by forest type in 2003 and 2010 (FIA, USDA Forest Service)

The area of forest land in Wisconsin has been steadily increasing in recent decades and currently stands at approximately 16.6 million acres, representing over 46 percent of the total land area. Wisconsin now has more forested land than at any time since the first forest inventory in 1936.

Wisconsin's forests are predominantly hardwoods, with 78% of the total timberland area classified as hardwood forest types (Figure 2). The primary hardwood forest types are oak-hickory at 25% of total forested acreage, maple-beech-birch at 22% and aspen-birch at 19%. Conifer types, mainly red, white and jack pines and spruce-fir, represent about 22% of the timberland. 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).

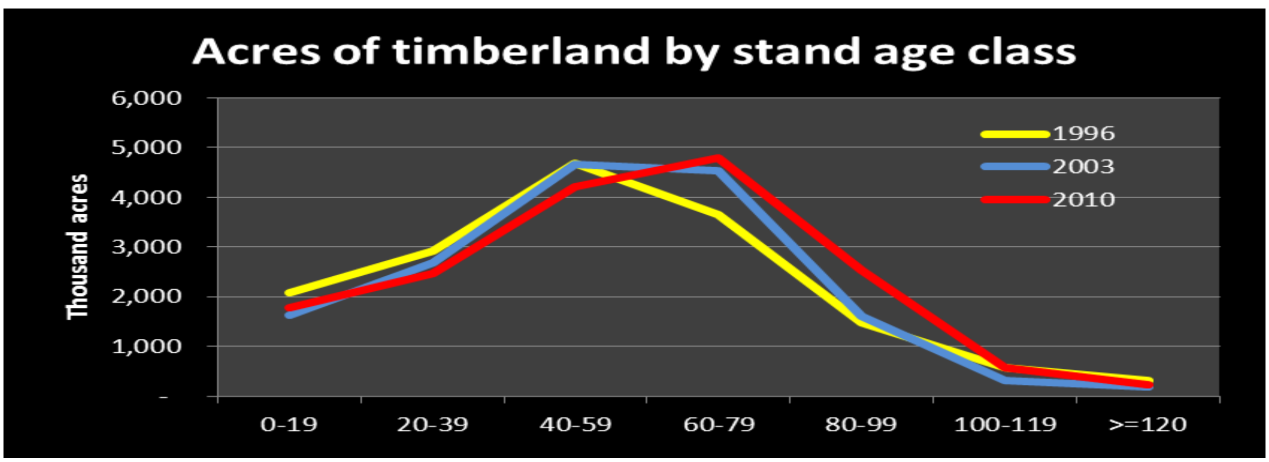


Figure 3: Timberland acreage by stand age class in 1996, 2003 and 2010 (FIA data, USDA Forest Service)

Volume and trends in major species

Since 1996 there have been some dramatic changes in growing stock volume of major species groups (Figure 4). The greatest volumes of any major species in 2010 were in the soft maple group (red and silver maple) and in northern red oak. The large volume of red oak is important because this species is affected by major insects and diseases, including gypsy moth and oak wilt.

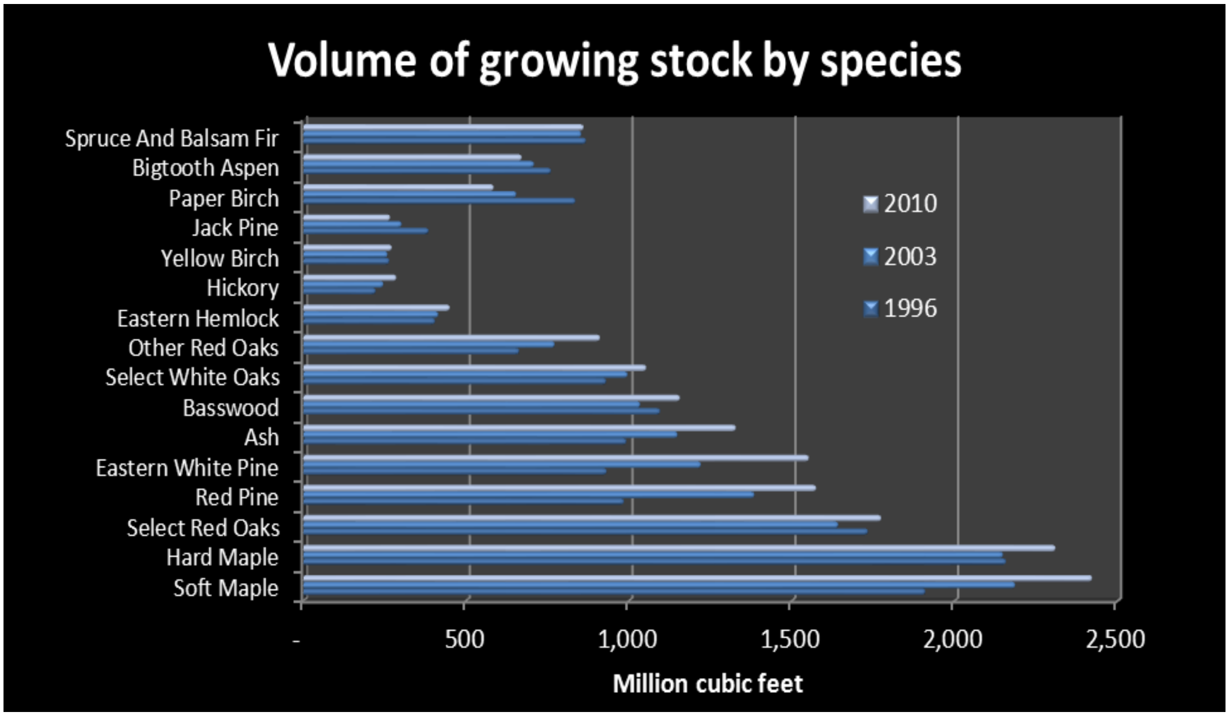


Figure 4: Volume of growing stock by species group in 1996, 2003 and 2010 (FIA data, USDA Forest Service)

The greatest volume gains between 1996 and 2010 were in eastern white pine (+67%), red pine (+60%) and black and northern pin oaks ('Other Red Oaks' +38%). In the future, ash populations will be dramatically affected by emerald ash borer, which has been found in Wisconsin. The volume of elm (American elm, slippery elm, rock elm and Siberian elm) has increased 14% in the last 14 years, evidence that this species group may be recovering from heavy losses due to Dutch elm disease.

The greatest volume losses between 1996 and 2010 have been in jack pine (-31%), paper birch (-30%) and bigtooth aspen (-12%). These changes are due to a combination of natural succession and harvest losses that have not been replaced. Several species with volume declines are of commercial importance.

Invasive Species Issues

Annosum Root Rot

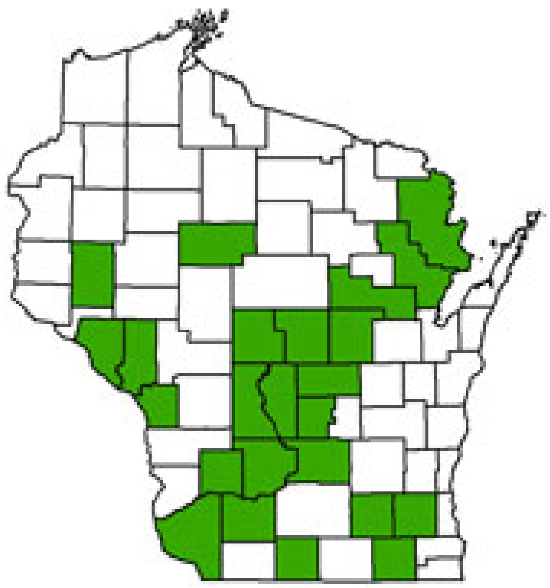


Figure 5: Counties with annosum root rot detections

Annosum root rot, a major disease of Wisconsin pines that is also found on other conifers, was first detected in Adams County in 1993 and is now found in 24 counties (Figure 5). In 2013, the disease was found in Grant County for the first time. The site was on state land in the Lower Wisconsin State Riverway, west of Muscoda. Characteristic conks were found at the base of dying trees and stumps (Figures 6 and 7), and the pathogen, *Heterobasidion irregulare*, was confirmed by a lab test. A stand evaluation is planned in 2014.

A risk-based guide to reduce the likelihood of annosum root rot introduction into pine stands was implemented on state lands in May 2013. This guide determines whether a fungicide treatment should be done at the time of harvesting to prevent infection through freshly-cut stumps.

The guide is now in use on state properties, and is available online for use by landowners and property managers at [the forest health pages of the WI DNR website, under annosum root rot]

Figure 6: Annosum conks (fruiting bodies) form at the base of a pine tree with old needles embedded within the conk

Figure 7: New white pore surface forming on the previous year's conk

Annosum Root Rot Host Susceptibility Study:

A greenhouse study was conducted between May 2012 and September 2013 to assess the pathogenicity of *Heterobasidion irregulare*, the pathogen causing annosum root rot, on various tree species. Seedlings of seven species native to Wisconsin were selected (cherry, red oak, hemlock, jack pine, red pine, white pine and white spruce). Seedlings used in the study were all 2-0 stock, with the exception of hemlock, which was 3-0 stock (seedling age depended on availability in state nurseries). In Wisconsin, annosum root rot has been confirmed in the field on all of the tested species except hemlock. However, mortality from the disease has only been confirmed on the three pine species.

Fresh wood samples were collected in April 2012 from red and white pines infected with *H. irregulare* in a Marquette County pine stand. Pure culture plates of two pathogen isolates were obtained from the fresh wood samples. One isolate was obtained from red pine and the other was isolated from white pine.

On May 16, 2012, potted seedlings were artificially inoculated with one of the isolates of *H. irregulare* using conidia and mycelial growth. Bark was removed and two circular wounds were created by a metal core sampler (5 mm in diameter) at the base of each seedling. The wounds were filled with an agar plug containing the pathogen and then wrapped with Parafilm. Eleven seedlings of each species were treated with the red pine isolate and another eleven seedlings were inoculated with the white pine isolate. As a control, eleven seedlings were wounded and treated with a blank agar plug. The seedlings were kept in the greenhouse during the winter of 2012-13 due to low mortality of tree species other than red pine. The crown condition and height/caliper growth of each seedling were assessed and recorded in May, July and September of 2012 and 2013. Re-isolation of *H. irregulare* from the wood was attempted when a seedling died, or at the end of the study in September 2013 if the seedling was still alive. Wood slices from each seedling were plated onto selective media.

Two months after inoculation, mortality was observed on four tree species (jack pine, red pine, white pine and white spruce). Mortality was highest for red pine, including controls. By July 2013, some species had high mortality in both treated and control seedlings. In contrast, only one red oak seedling died and all black cherry seedlings survived the two-year study. It is suspected that four spruce seedlings treated with blank agar plugs (controls) may have died in 2012 due to the wounds created in the study. High mortality of conifers in 2013 may have been caused by excess watering and/or overwintering conditions in the greenhouse.

The area under the disease progress curve (AUDPC) was calculated using crown conditions over time for the sum of the 2012 data and for the sum of 2012-2013 data. Analysis of variance (ANOVA) and post-hoc Tukey's HSD tests were used to analyze the effect of pathogen inoculation on disease progression. Preliminary data analysis showed a statistically significant difference in crown conditions between red pine controls and the red pine isolate treatment. A significant difference was also seen on red pine seedlings, between the white pine isolate treatment and red pine isolate treatment for the 2012 data. There was no significant difference between red pine controls and the white pine isolate. No overall significant differences were observed for the 2012-2013 data.

Analysis of variance (ANOVA) and post-hoc Tukey's HSD tests were used to analyze the effect of pathogen inoculation on height and caliper growth for the host species with enough surviving samples (white spruce, white pine, hemlock, red oak and cherry). No significant differences between controls and treatments were observed on any of the seedling species.

Although different pathogen isolates were used in previous studies, the results were similar in some species. Re-isolation rates were consistently low on hemlock and red oak (Table 2). While red pine is considered the most susceptible species, its re-isolation rate was consistently low compared to some other tested species. In Wisconsin only one spruce sapling has been found to have a fruiting body of *H. irregulare*, although the tree has not shown any symptoms of annosum root rot. Greenhouse studies have shown that the pathogen is able to colonize spruce. Further data analysis is in progress.

Table 1: Success rates of H. irregulare re-isolation following tree death or study conclusion (n=11/tree species/isolate).

Seedling species	White pine isolate re-isolation	Red pine isolate re-isolation	Combined re-isolation rate (%) 2012-13 data	Combined re-isolation rate (%) 2011 data	Combined re-isolation rate (%) 2010 data
White spruce	73%	64%	68%	91%	50%
White pine	0%	0%	0%	27%	60%
Red pine	9%	9%	9%	14%	10%
Jack pine	27%	9%	18%	50%	90%
Hemlock	0%	0%	0%	9%	n.a.
Red oak	0%	0%	0%	9%	10%
Cherry	36%	55%	46%	55%	20%

Beech Bark Disease

Figure 7: A high population of beech scale on trunk of tree

Beech scale (*Cryptococcus fagisuga*), the insect associated with beech bark disease, is now present at low populations throughout most of the range of American beech in Wisconsin. High populations of beech scale (Figure 9) and incidence of beech bark disease have only been found in Door County, where high populations can now be found in scattered areas including Washington Island, Rock Island, Whitefish Dunes State Park, and localized areas to the south and to the east of Sturgeon Bay. An aerial survey showed that decline and mortality continue to expand in areas east of Sturgeon Bay, with some new areas of decline now visible from the air. Most beech trees at the initial 2009 detection site (east of Sturgeon Bay) appeared to be dead or in significant decline. Additional information about beech scale, beech bark disease and forest management can be found online at the Wisconsin DNR website, keyword beech bark disease.

Chestnut Blight Study

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

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

An 89 acre hillside in West Salem, Wisconsin 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. 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.

The fungus that causes chestnut blight, *Cryphonectria parasitica*, can become infected with a virus that debilitates it (known as a 'hypovirus'). Virus-containing fungal strains grow more slowly than the normal strains, allowing the tree's natural defenses to combat the disease (Figure 10). 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 3,318 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 debilitated forms by their color and appearance on agar media.

Figure 9: Cumulative number of chestnut cankers at the West Salem site 2000-2013

A general summary of findings are:

- Many trees have died from chestnut blight, although they continue to produce abundant sprouts.
- The introduced virus has spread significantly on trees that contain treated cankers.
- 40% of the trees that were treated with virus-infected strains remain alive with good evidence that infections are callusing. Improvement in crown health on these trees also is evident. Fourteen percent of untreated trees in the stand remain alive.

Summary of 2013 findings:

- Movement of the hypovirus to untreated trees has increased in all areas of the stand.
- 137 new cankers were detected in 2013.
- Virus treatment appears to play a role in tree longevity. Tree survival in the area where the virus was first introduced (and where the disease was first discovered) is about 50%. This is in contrast to more recently infected areas, where the number of infected trees has increased sharply and survival is about 14%.

Emerald Ash Borer

The summer of 2013 marked the fifth anniversary of finding emerald ash borer (EAB), *Agrilus planipennis*, in Wisconsin (Figure 12). DNR worked with private landowners, communities and public land managers to detect EAB infestations, manage current infestations, and prepare forests so that future impacts of the insect are reduced. Reducing future EAB impacts can be accomplished through timber harvests, urban tree removals, insecticide treatment of high-value ash, and encouraging the growth of tree species not susceptible to EAB infestation.

Figure 11: Left - aerial photo of EAB mortality near Newburg in Ozaukee County in August 2013. Right – the same property one year earlier. This property looked intact when EAB was found nearby in 2008

At known infestations, aerial and ground surveys found that EAB impacts continued to increase in both rural and urban forests. Dramatic increases in tree mortality were observed at many sites, due to a rapid buildup of EAB populations aided by the 2012 summer drought (Figure 13). The thinning canopies of infested ash trees could be seen at many locations, most notably in southeast Wisconsin.

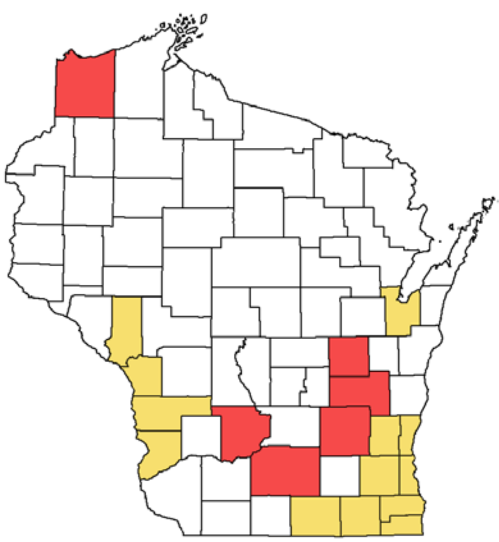


Figure 12: counties with first detections of EAB in 2013 are shown in red. Counties in yellow had first detections in previous years

In 2013, EAB was found in six additional counties (Dane, Dodge, Douglas, Fond du Lac, Sauk and Winnebago) (Figure 9). Nineteen of Wisconsin's 72 counties have known infestations.

Signs of EAB were also found in Jefferson County, but life stages were not seen.

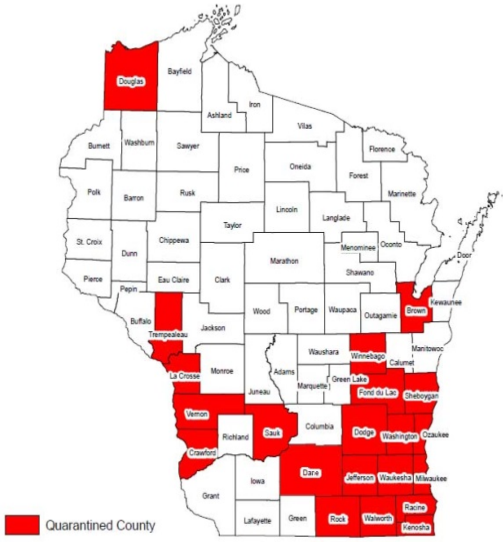


Figure 13: counties quarantined for EAB, Dec 2013

Dane, Dodge, Douglas, Jefferson, Sauk and Winnebago Counties were added to the EAB quarantine area in 2013 (Figure 15). Fond du Lac County had previously been quarantined in 2008 but EAB was not detected at that time. The pest was detected at several DNR properties in 2013: Harrington Beach State Park in Ozaukee County, Kettle Moraine State Forest-Northern Unit in Fond du Lac County, Mirror Lake State Park in Sauk County, and New Munster State Wildlife Area in Kenosha County. In 2013 there was a dramatic increase in the number of communities where EAB has been detected, primarily in southeast Wisconsin but increasingly in other parts of the state. The large number of EAB detections also increased the area of Wisconsin where insecticide treatment of high-value ash should be considered. 9,700 square miles (18% of Wisconsin's land area) was within 15 miles of a known EAB infestation at the end of 2013.

New 2013 municipal detections (Village or City):
Dane Co. – Madison
Dodge Co. – Watertown
Douglas Co. – Superior
Kenosha Co. – Bristol
La Crosse Co. – Holmen, Onalaska
Milwaukee Co. – Greendale, Greenfield,
South Milwaukee, Wauwatosa,West Allis
Ozaukee Co. – Fredonia, Saukville
Racine Co. – Burlington, Racine
Rock Co. – Beloit
Walworth Co. – Darien, Delavan, Elkhorn, Genoa City, Sharon, Walworth, Whitewater, Williams Bay
Waukesha Co. – New Berlin, Oconomowoc, Waukesha

The Douglas County detection in the City of Superior is about 120 miles from any other known infestation, and DNR has been working with the forest industry and other partners to address silviculture, transport, education and marketing concerns.

Figure 14: double decker EAB trap at state park

Forest Health staff placed 44 double-decker EAB traps (Figure 16) at a number of state properties in 2013. This trap has been shown to be effective at finding low populations of EAB. This trapping effort was successful, as the pest was detected on these traps at three state properties – Harrington Beach State Park, Kettle Moraine State Forest Northern Unit, and Mirror Lake State Park.

For the past three years, stingless Asian wasps have been released in select infested areas to act as parasitoids of EAB life stages, and help reduce emerald ash borer populations. The parasitoids were produced and supplied by the USDA EAB Parasitoid Rearing Facility in Brighton, Michigan.

Fourteen states, including Illinois, Michigan and Minnesota, have also released these wasps. Two species, *Tetrastichus planipennisi* (Figure 17) and *Spathius agrili,* attack EAB larvae beneath the bark. *Spathius agrili* releases were discontinued in northern states, including Wisconsin,after the 2012 releases. A third wasp species, *Oobius agrili*, attacks EAB eggs on the bark surface. In 2011 the three species were first released in Wisconsin near Newburg (Ozaukee County), and in 2012 the wasps were released near Victory in Vernon County.

In 2013, *T. planipennisi* and *O. agrili* were released at three sites in Kenosha, Racine and Walworth Counties in southeast Wisconsin between mid-May and mid-June. A total of approximately 2,700 *T. planipennisi* and 1,600 *O. agrili* were released in 2013. Researchers from the University of Wisconsin, Madison were able to recover *T. planipennisi* at the 2011 release site in Ozaukee County, indicating that the wasp has established a breeding population and is attacking EAB larvae.

More information about EAB in Wisconsin can be found online at: Wisconsin's EAB website, emeraldashborer.wi.gov.

Firewood Regulations

In response to increasing risks of introducing emerald ash borer and other invasive, wood-borne pests and diseases, the DNR is proposing to reduce the distance from which firewood must originate in order to be brought into a state property. Firewood must currently originate from within 25 miles of a property, and DNR is proposing to reduce this distance to 10 miles. Certified firewood is exempt from the restriction because it has been treated to eliminate pests.

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. Interestingly, there were more public comments on this proposed decrease to 10 miles than for previous tightening of this regulation. Input included requests to prohibit all untreated wood from entering state lands and to keep the regulation at 25 miles, but no one had suggested loosening the regulation of wood. If adopted, the 10 mile restriction would take effect in the spring of 2014.

Note: The 10 mile restriction was approved by the Natural Resources Board on January 22, 2014.

Gypsy Moth

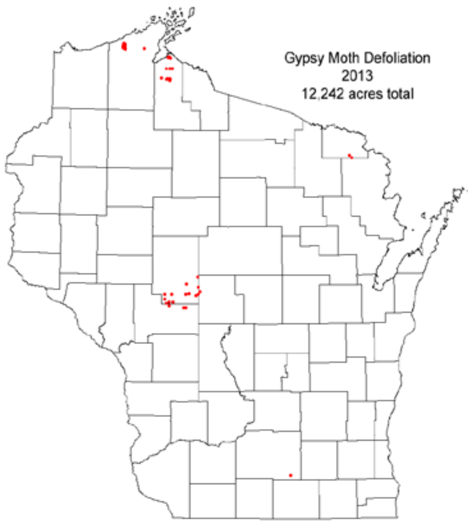


Figure 16: location of defoliation by gypsy moth in 2013

Aerial surveys mapped 12,242 acres of gypsy moth (Figure 18) defoliation in the summer of 2013 (Figure 14). 11,637 of these acres were light or moderate defoliation of aspen and oak in Ashland and Bayfield Counties. 242 acres of heavy defoliation (>50%) was recorded statewide. Larval mortality in one ground-truthed defoliated stand in Ashland County was low. Areas of Bayfield County that were defoliated in 2012 were not defoliated in 2013, and caterpillar mortality at these sites was nearly 100%. Caterpillar mortality in Florence County was nearly 100%.

In southeast Dane County, only 15 acres of lowland willow and fence row hardwoods were defoliated. Caterpillar mortality from *Entomophaga maimaiga* and Nucleopolyhedrosis virus (NPV) was instrumental in helping keep populations low elsewhere in the southern counties.

Only one treatment area participated in the DNR gypsy moth suppression program in 2013. A 229 acre treatment block at Governor Dodge State Park in Iowa County was aerially treated with Btk. The treatment was successful at preventing defoliation. Fall egg mass surveys indicated a reduced population and no additional treatments were planned in 2014 for this property.

More information about gypsy moth in Wisconsin can be found online at: [Wisconsin's gypsy moth portal, gypsymoth.wi.gov]

Invasive Plants

Education and Outreach:

Figure 17: Display of invasive plants

Education and outreach is a fundamental component of the Terrestrial Invasive Plants Program and the greatest tool in preventing their spread (Figure 19). In 2013, staff provided over 110 training sessions to diverse audiences across the state. Additional publications and webpages added in 2013 included 18 new Wildcards, 51 new species factsheet webpages, and a "What Hunters Need to Know" brochure on Best Management Practices.

Invasive Plant Inventories:

An extension to the 2006 Wisconsin State Forest Invasive Plant Inventory (WisIPI) program was implemented in southern State Forests, with the objective of gathering comprehensive baseline data about invasive plant distributions and abundance. The inventory focused on high traffic areas including recreational trails, campgrounds, boat launches, timber sale areas and utility corridors. Collected data will aid in the development of invasive plant management goals and objectives.

Point Beach State Forest, Kettle Moraine State Forest - Northern and Southern Units, and all Kettle Moraine satellite units (including Pike Lake, Loew Lake and Lapham Peak) were inventoried in 2013. A total of 396 miles of trails and over 700 campsites were surveyed. Property-specific invasive plant management plans will be drafted to support the State Forests' efforts to identify and manage invasive plants. These efforts may include managing new outbreaks, controlling populations affecting tree regeneration, and identification and control of populations that are likely to spread. Mapping the current extent of invasive plant infestations on State Forest lands will highlight distribution and migration patterns, and identify emerging threats (versus common invaders) to aid in measuring the progress of future management programs.

In partnership with the University of Wisconsin-Superior Lake *Superior Research* Institute, invasive plant inventories were conducted on the Chippewa, Florence, Langlade, Lincoln, Marathon, Oneida and Vilas County Forests. Funding to conduct these inventories was provided from a USDA Forest Service grant.

Species in the Spotlight:

Figure 18: Japanese barberry understory in southern Wisconsin

Throughout much of Wisconsin's southern forests, and with increasing reports in northern Wisconsin, two common ornamental species are rapidly naturalizing - winged euonymus (or burning bush, *Euonymus alatus*) and Japanese barberry (*Berberis thunbergii*, Figure 20). Invasive plant inventories confirm that these species pose a serious threat to the health of Wisconsin's forests. These two species are being recommended for inclusion in the Invasive Species Rule NR 40 revision, which will restrict further sale of these species.

Early Detection and Suppression:

The final funds available from a USDA Forest Service - Forest Health Protection grant were distributed to numerous multi-year projects to combat early-stage detections of invasive plants. Over the three years of the grant, 27 projects were completed, totaling 6,587 acres and 214 miles of roadside surveyed for priority invasive species. In addition, 18 invasive species were treated on 1,832 acres (accounting for multi-year projects) and 53 miles of trails and roadsides.

Two first detections of high-priority invasive plants were effectively controlled through these funds: Policemen's helmet (*Impatiens glandulifera*) and Asian wisteria (*Wisteria spp*). The success of this program underscores the importance of implementing an early detection strategy and having continual flexible funding for this purpose.

Invasive Species Regulation

Invasive Species Rule NR 40 is in the process of being revised. As part of this process, the Forest Health Team recommended adding to the 'Prohibited' list:

- Mountain pine beetle, *Dendroctonus ponderosae*, and its associated blue stain fungi, *Grosmannia clavigera* and *Ophiostoma montium*.
- Walnut twig beetle, *Pityophthorus juglandis*, and the pathogen causing thousand cankers disease of walnut, *Geosmithia morbida*, which is carried by walnut twig beetles.

The team recommended down-listing emerald ash borer, *Agrilus planipennisi*, from 'Prohibited' to 'Restricted,' since the pest is now established in many counties in Wisconsin. The team also recommended removing beech scale, *Cryptococcus fagisuga*, from the list of regulated species since the scale has naturally spread across most of the range of its host in Wisconsin.

Forest pests and diseases listed in NR 40 are unique in that some of them are also quarantined at the state or federal state level. This led to the situation of double regulation for quarantined species such as emerald ash borer within quarantined counties, where the quarantine allowed movement of infested wood but NR 40 prohibited it. To prevent this conflict between regulations and improve the utilization of potentially-infested wood, the Forest Health Team has proposed NR 40 revisions that permit the movement of potentially-infested materials within a quarantine area. To avoid accelerating spread within quarantined counties, the team developed precautions that can be used to reduce this risk while utilizing potentially-infested wood.

Oak Wilt

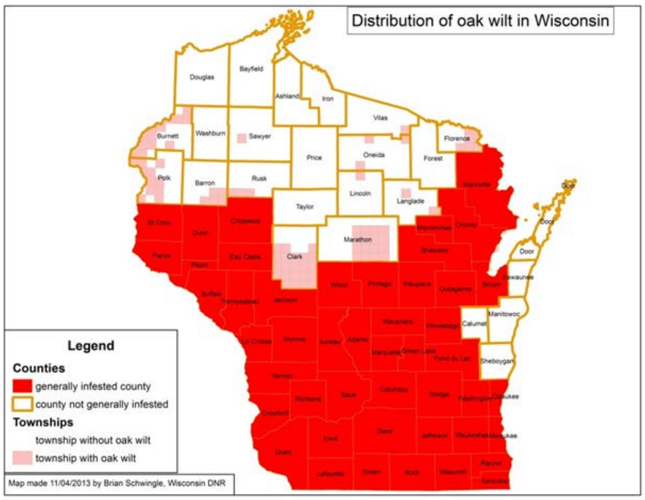


Figure 19: Distribution of oak wilt in Wisconsin. Generally-infected counties are highlighted in red. Townships where oak wilt is present but uncommon are highlighted in pink

Oak wilt, caused by the fungus, *Ceratocystis fagacearum,* is a serious disease that is almost always fatal to black, red and pin oaks. Oak wilt is common in the southern two-thirds of Wisconsin (Figure 21). The disease is still uncommon in northern Wisconsin, but forest health staff and UW-Extension cooperators have recently discovered several new disease centers in northern counties.

In 2013, oak wilt was confirmed in Rusk County for the first time. Subsequent investigations found oak wilt in three townships (Rusk, Big Bend and Washington). Two private property owners tried two different control strategies, with the advice of DNR staff. Rusk County is considering the implementation of oak wilt harvesting restrictions on county lands, following the DNR oak harvesting guidelines.

Figure 20: A “bronzing” oak leaf typical of oak wilt

A first detection of oak wilt was also made on the Northern Highland American Legion State Forest (NHAL), in the Oneida County Town of Woodruff. A residual oak was damaged during logging in June 2013 and became infected. This diseased oak (Figure 22) was noticed by DNR staff in early September and confirmed to have oak wilt through laboratory testing. Foresters soon eradicated the disease by breaking root grafts with a bulldozer and burning the diseased tree and stump. Beginning in 2014, the State Forest plans to restrict harvesting between April 15 and July 15 in its oak stands that are located in Vilas and Oneida Counties.

Range expansion was found in several counties already known have oak wilt:

- Burnett County: Oak wilt was confirmed for the first time in Daniels Township. Aerial surveys and ground-truthing documented severe impacts from oak wilt in West Marshland, Grantsburg and Anderson townships.
- Oneida County: The southwest part of the county had a first detection on the north side of Lake Nokomis. Oak wilt appears to have been present for several years prior to detection. The disease was also found on the NHAL State Forest (noted on the previous page).
- Marathon County: Although oak wilt has been present in Marathon County for many years, 2013 saw a significant increase in the number of infected townships. Significant disease expansion was noted around Wausau. The most concerning finds were east of the known epicenters in the Mosinee and Wausau areas.

Oaks also experienced a significant increase in two-lined chestnut borer (TLCB) damage in 2013, most likely as a result of the severe drought in 2012. It was not uncommon for oaks to have a combination of oak wilt, two-lined chestnut borer and Armillaria root disease. With the variety of pests attacking oaks it was critical to confirm oak wilt via lab test before active management occurred.

<u>Oak Wilt Herbicide Barrier Trial Update:</u>

In Wisconsin, herbicides have been used as a potentially effective mechanism to limit the underground spread of oak wilt in stands where physical root severing by a vibratory plow is not a viable option. In this method, trees within grafting distance (identified through Johann Bruhn's model) are treated with Garlon 4 (active ingredient: triclopyr) prior to harvesting. Currently, three stands treated with this method are being monitored by DNR and county forestry staff:

- In the Nine-Mile Recreation Area of Marathon County, a field trial to create a barrier between infected and uninfected trees was initiated in 2003 (for the details of the treatment, please refer to the 2003 Forest Health Annual Report). Since then, several new oak wilt pockets have been found and treated in the same way in 2005, 2008, 2010, 2012 and 2013. All of the treated pockets have been monitored by county forest personnel during the summer. As of late 2013, no additional symptomatic trees had been found in any of the pockets that were treated with herbicide. DNR staff thank Doug Brown, a Marathon County Forester, and Tom Lovlien, Marathon County Forest Administrator, for providing periodic updates on the progress of the trial.
- A similar herbicide barrier treatment was implemented on a private property in Dane County in 2006. One large red oak that was approximately 500 feet away from the original oak wilt pocket was confirmed to have oak wilt in 2007, and this second pocket was treated with herbicide in the summer of 2008. Both pockets have been monitored by DNR Forest Health staff annually. In 2013, no infected trees were found adjacent to these treated pockets. However, a new oak wilt pocket was found approximately 200 feet from one of the treated pockets. The landowner plans to treat the area in 2014 by applying herbicide to oaks within grafting distance.
- In 2013, a barrier treatment was performed at two oak wilt pockets on a private property in Iowa County. This stand will also be monitored annually by Forest Health staff.

Results to date indicate that using herbicide to limit underground oak wilt spread may be an effective treatment method. The Forest Health Program is interested in trying this method in a variety of stands where other methods are not feasible, to determine if it is effective in various stand types.

Walnut Twig Beetle Surveys

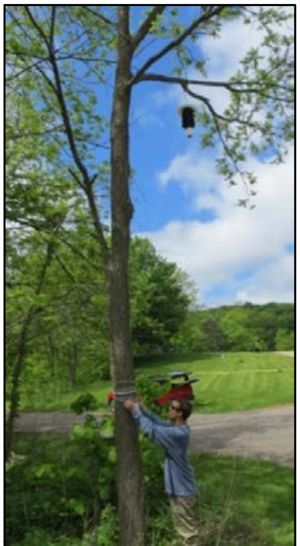
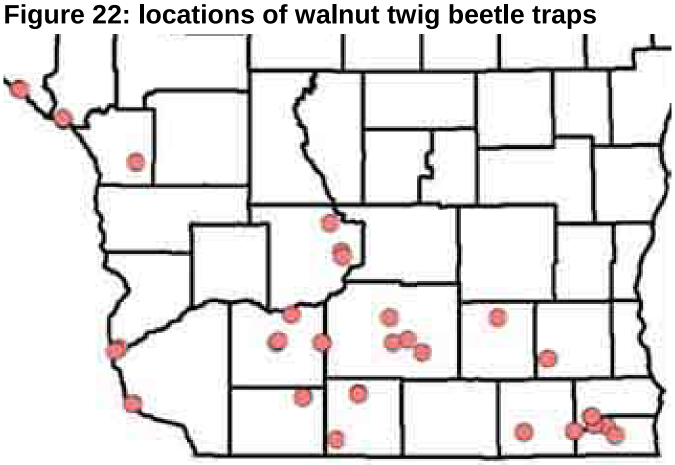


Figure 21: trapper hanging a walnut twig beetle trap

Figure 22: locations of walnut twig beetle traps



In 2013, 45 funnel traps baited with walnut twig beetle lures were placed at 24 sites from Buffalo County southeast to Kenosha County (Figures 23 and 24). All traps were checked multiple times during the field season, and all samples were examined for suspect beetles. No suspect walnut twig beetles were detected.

Hardwood Health Issues

Basswood Defoliation

Late season basswood defoliation (Figure 25) occurred for the second consecutive year in a number of northeast and northern counties. In 2012, the defoliation was noticed too late to identify the culprit, although casebearer pupal cases were found. In September 2013, the defoliation was noticed while the defoliator was active, and samples of a micro-Lepidoptera were collected (Figure 26). Some of the tiny caterpillars were killed, and some were allowed to pupate. Based on the pattern of the defoliation, the caterpillar, the shape of the pupal cases, and the species of tree being defoliated (only basswood), *Bucculatrix improvisa* is believed to be the responsible species. This tiny caterpillar is a "window feeder" that only feeds on one epidermal layer of the leaf. Defoliated leaves that are held up to the light have the appearance of a window with wax paper over it. After sufficient damage, the leaves turn brown and the tree drops them. There are 2 generations of *B. improvisa* per year.

Figure 23: Basswood defoliation believed to be caused by the larva of Bucculatrix improvisa.

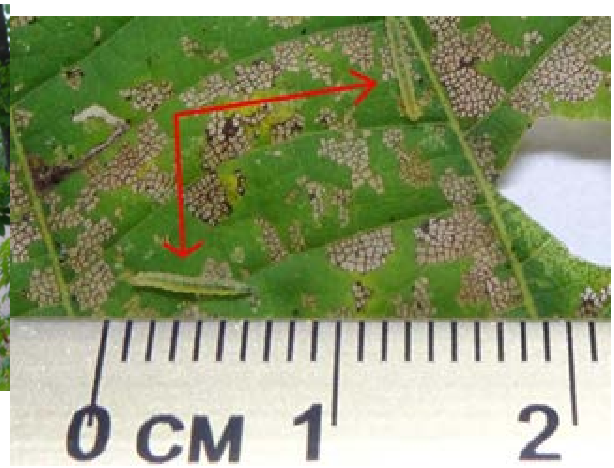


Figure 24: larvae of Bucculatrix improvisa

Bucculatrix improvisa defoliation was observed in Ashland, Bayfield, Florence, Forest, Iron, Langlade, Oconto, Oneida, Price and Vilas Counties. Although this is the second year of significant defoliation in some areas, it occurs so late in the season that the health effects on the tree should be negligible.

Black Canker of Willow

Figure 25: Symptoms of black canker of willow

Leaf necrosis and twig cankers were observed on willows in Ashland and Bayfield Counties during the summer of 2013 (Figure 27). The damage was most severe along the shore of Lake Superior. Symptomatic leaves were shriveled with brown or black lesions. Twig cankers were observed as necrotic areas, starting at attachments of symptomatic leaves and petioles. Samples were collected from the City of Ashland (Ashland Co.) and the City of Washburn (Bayfield Co.) for further examination in the lab. The fungus, *Glomerella* spp., was confirmed microscopically on symptomatic twig cankers from both samples.

Black canker of willow, caused by the fungus *Glomerella miyabeana,* has been reported throughout the eastern U.S. The fungus often exists with another pathogen, *Venturia saliciperda* (the cause of willow scab), to cause serious damage to susceptible willow species. However, *Venturia* spp. was not isolated from either sample from Ashland or Bayfield Counties in 2013.

Norway Maple Sudden Branch Mortality

Figure 26: sudden branch mortality in Norway maple

Observations of sudden branch mortality began in July on some Norway maples in Brown, Marinette, Oconto and Winnebago Counties (Figure 28). Leaves remained on the dead branches. No insect problems or physical damage were noted on the branches that died. Samples were collected and sent to Dr. Brian Hudelson at the UW-Madison Plant Disease Diagnostics Clinic. Most samples that were collected yielded no pathogens, but one sample from Brown County had fruiting bodies that were identified as *Tubercularia* spp. Dr. Hudelson noted that "this fungus has been reported as an asexual stage of *Nectria*, a common canker fungus." With the limited pathogen recovery, it is thought that drought stress and/or girdling root issues may be the primary causes of the sudden branch mortality.

The sudden branch mortality on Norway maple seen in 2013 is different from the branch flagging that is sometimes common on sugar maples in the late summer. The branch flagging that was seen on sugar maples, prevalent in Lincoln and Oneida Counties this year, is due to an assortment of biotic issues including sapsucker damage, squirrel damage from the previous winter, and eutypella canker.

Phytoplasmas

Figure 27: a witches broom of dense shoots with stunted and chlorotic leaves, symptomatic of infection by phytoplasma

Phytoplasmas are wall-less, bacteria-like microorganisms that can cause small and yellow foliage, slow growth, thin crowns, branch dieback and vertical cracks near the base of the host species. Infected trees and stumps may produce clusters of upright, spindly shoots that look like a broom (Figure 29). Phytoplasmas have been detected on ash, black walnut and butternut in Wisconsin using Polymerase Chain Reaction (PCR) testing. The disease caused by phytoplasma on ash is known as ash yellows, and mortality of white ash has been observed in forest settings.

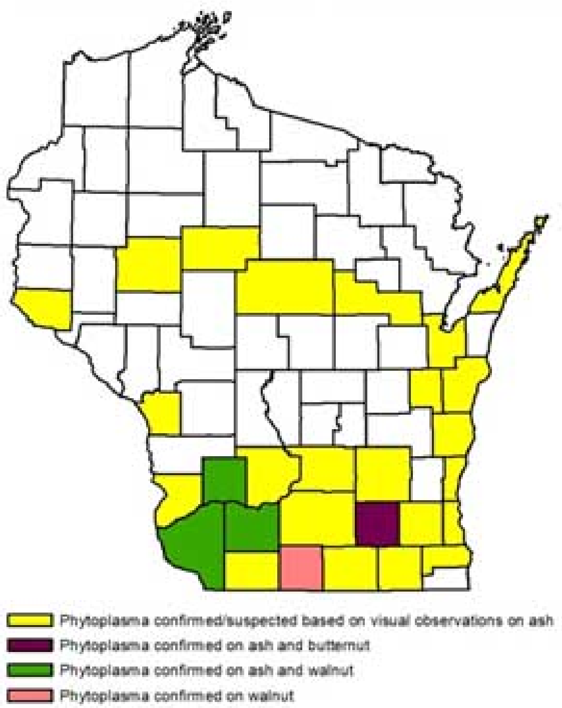


Figure 28: Phytoplasmas have been detected in all colored counties

In 2013, Green and Lafayette Counties had first Phytoplasma confirmations (Figure 30). A total of 27 samples were collected for testing, including 11 ash, 8 black walnut, 2 elm and one box elder, raspberry, bush honeysuckle, hackberry, basswood and bitternut hickory sample. Five ash samples tested positive in Brown, Dane, Jefferson, Lafayette and Sauk Counties. Two black walnut samples from Grant and Green counties tested positive for Phytoplasma. The effect of phytoplasmas on the health of black walnut and butternut in Wisconsin is unknown.

Spring Defoliators

Eastern tent caterpillar, *Malacosoma americanum*, populations crashed in 2013 after approximately 5 years of high populations. A combination of natural controls in 2012 and the cool, wet spring in 2013 ended this extended outbreak.

No forest tent caterpillar, *Malacosoma disstria*, damage was observed in 2013. Caterpillars were present in areas where damage was expected but the cool, wet spring likely prevented any significant defoliation from occurring.

Populations of other spring defoliators, such as elm spanworm, remained low in 2013.

Two-Lined Chestnut Borer

Figure 29: Two lined chestnut borer larvae, this oak was simultaneously infected with oak wilt

Two-lined chestnut borer (TLCB), *Agrilus bilineatus*, mortality and branch flagging were most noticeable in western Burnett County. The most severely infested oaks were scattered across 2,500 acres from Anderson to Jackson townships. Burnett County was believed to be highly susceptible in 2013 because of the 2011 northwest Wisconsin windstorm, 2012 summer drought and 2013 damaging spring snowfall.

Localized increases in TLCB activity were also noted in Adams, Clark, Eau Claire, Grant, Iowa, La Crosse, Marathon, Pierce, Polk, Portage, Richland, Sauk, Trempealeau, Walworth and Wood counties in drought-stressed oaks. Numerous sites in southern Wisconsin were found to have TLCB and oak wilt in the same trees (Figure 31). *Armillaria* fungi were often associated with TLCB-infested trees as well.

Conifer Health Issues

Eastern Larch Beetle

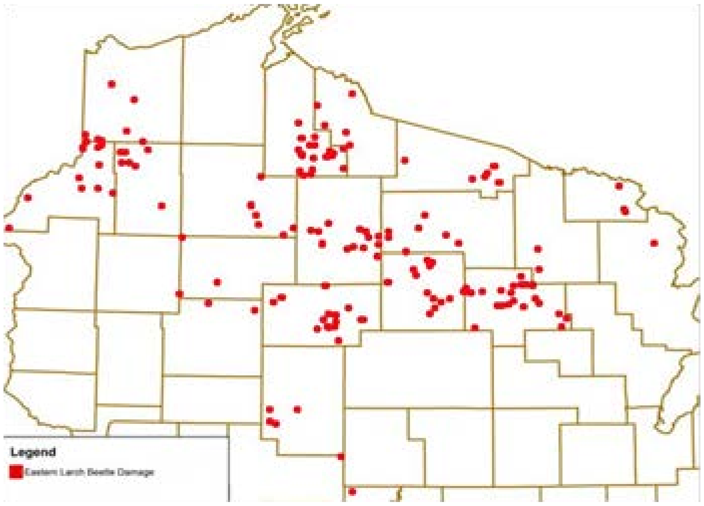


Figure 30: Location of tamarack stands infested with eastern larch beetle from 2012 - 2013

Aerial surveys identified 1,300 acres of tamarack mortality due to eastern larch beetle. This area adds to the 730 acres of infested tamarack that were mapped in 2012. The infested stands mapped in 2013 were widely scattered and were in Burnett, Chippewa, Clark, Douglas, Florence, Jackson, Juneau, Langlade, Lincoln, Marinette, Oneida, Price, Rusk, Sawyer, Taylor, Vilas and Washburn Counties. Eighty infested stands were mapped (Figure 32), and seven of those areas were greater than 40 acres. When combined with the infested stands observed in 2012, the widely scattered distribution of eastern larch beetle damage suggests that Wisconsin's eastern larch beetle population may be behaving like the population in Minnesota, where noticeable mortality has occurred since 2000. Recent research suggests that eastern larch beetle may go through two generations in a single year in Minnesota, which is a first find for this species and contributes to the severity of the outbreak there.

Tamarack mortality was also seen in Columbia County at a site that had experienced several years of larch casebearer defoliation and stress from the 2012 summer drought. Eastern larch beetle was found in the lower bole and *Leptographium* black stain fungi were associated with the eastern larch beetle attack areas. Adult spruce engraver beetles, *Scolytus piceae*, were collected from the branches. Tamarack is listed as a secondary host for this engraver beetle.

Jack Pine Budworm

Jack pine budworm larval and/or egg mass surveys were conducted in 17 counties where jack pine is common. Populations were found to be low or very low, and defoliation is not expected in 2014. Very few larvae were found in central Wisconsin, likely due to a scarcity of male pollen cones which are the preferred food source of jack pine larvae. Only one egg mass was found in western Wisconsin, in Jackson County. The jack pine stand where it was found is younger than stands where jack pine budworm would normally be found but the egg mass could have originated from moth dispersal during 2012's unexpected outbreak.

Nursery Disease Issues

Testing Red Pine Seedlings for Asymptomatic Infection by *Diplodia pinea:*

In the State Nurseries, healthy-looking red pines have been annually tested since 2006 to assess asymptomatic infection by *Diplodia pinea*, the pathogen causing Diplodia shoot blight/collar rot. In 2013, the testing was conducted using seedlings from Griffith Nursery near Wisconsin Rapids. The asymptomatic infection rate has consistently been below 3% at Wilson Nursery, and it was decided that annual testing was not necessary at this location. However, tests will be conducted every 2 to 3 years to ensure that asymptomatic infection rates remain low. Seedling production has ceased at Hayward Nursery in northwest Wisconsin.

In August 2013, the forest health lab tested 315 asymptomatic 1-0, 2-0 and 3-0 red pine seedlings from Griffith Nursery for the presence of *D. pinea*. This was the first year that 1-0 seedlings were tested. The asymptomatic infection rate was low in all of the age classes tested (Table 3), and no asymptomatic infections were detected in any of the 1-0 seedlings.

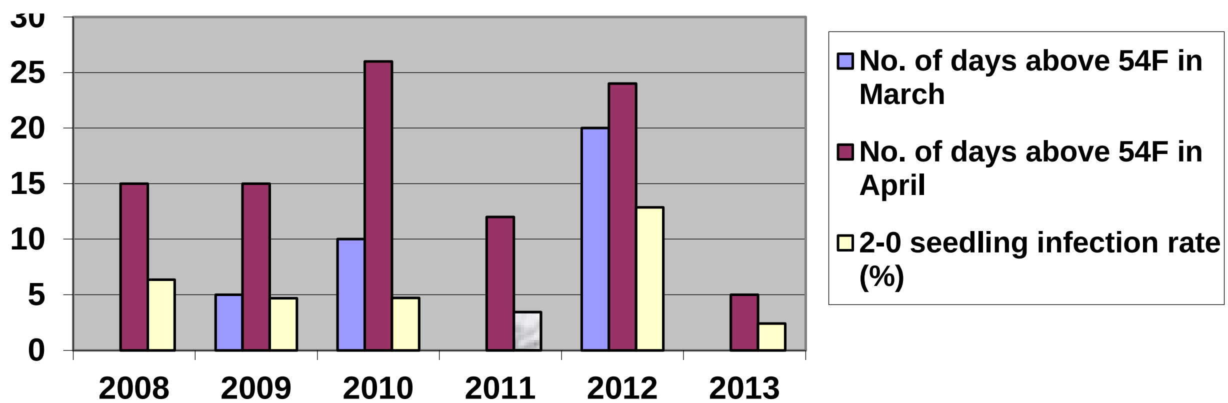
Table 2: Infection rates of Diplodia pinea in asymptomatic red pine seedlings from Griffith Nursery

Seedling Age Class	Total number of seedlings tested in 2013	Total positive for Diplodia infection 2013	% positive for Diplodia infection in 2013
1-0	120	0	0%
2-0	165	4	2.4%
3-0	30	2	6.7%

Testing in 2012 found that the overall asymptomatic infection rate for 2-0 seedlings from Griffith Nursery was unusually high (12.9%). In 2013, red pine seedlings were only sold from the planting blocks where the infection rate was less than 10% a year earlier. Potential causes of the unusually high infection rate at Griffith Nursery in 2012 were investigated. 2008-2013 weather data from Wisconsin Rapids were analyzed in order to evaluate the effect of environmental factors on the year-to-year variation in asymptomatic infection rates (Figure 33).

Spores of *D. pinea* germinate on water agar at temperatures ranging from 12ºC (54ºF) to 36ºC (97ºF) and percent germination is highest at 24ºC (75ºF) (Brookhouser and Peterson 1971). Red pine shoots are most susceptible to infection by the pathogen when buds are opening and shoots are elongating (Brookhouser and Peterson 1971). In Wisconsin, this critical period of shoot growth occurs usually between late April and June (Palmer and Nicholls 1985). However, the temperatures in spring 2012 were abnormally high. In March 2012, there were 20 days when the daily high temperature was above 54ºF, compared to the previous four-year average of 3.8 days. Furthermore, there were 10 days when the daily high temperature exceeded 70ºF in March 2012, compared to two days in 2010 and zero in other study years. The 2012 warm weather continued into April and buds started to open much earlier than normal. Griffith Nursery started fungicide applications two weeks earlier than normal, and the first application was made on April 27, 2012. It is suspected that the unusually warm weather in March and April

Figure 33: Number of days when the daily high temperatures exceeded 54F in March and April in Wisconsin Rapids, and the asymptomatic infection rate of 2-0 seedlings



made seedlings susceptible to *D. pinea* infection prior to fungicide applications.

Based on the analysis, the State Nursery Program decided to apply fungicides in early April if needed due to warm spring temperatures. Additional fungicide applications in April were not needed in 2013 as Wisconsin experienced an unusually cold March and April.

References:

Brookhouser, L.W. and Peterson, G.W. 1971. Infection of Austrian, Scots, and Ponderosa Pines by *Diplodia pinea*. *Phytopathology* 61:409-414.

Palmer, M.A. and Nicolls, T.H. 1985. Shoot blight and collar rot of *Pinus resinosa* caused by *Sphaeropsis sapinea* in forest tree nurseries. *Plant Dis*. 69(9):739-740.

Jack Pine Gall Rust Surveys:

Figure 31: Jack pine seedlings were hand-lifted in mid-April to examine the existence of galls for the fungicide treatment study.

In the Wisconsin state nurseries, stem and branch galls are occasionally detected on jack pine seedlings at the time of lifting (Figure 34). Annual surveys to evaluate the incidence of gall rusts on jack pine seedlings at the time of lifting were initiated in 2008. During the five years of surveys (2008-2012), incidence of galls was consistently less than 5% at Hayward and Wilson Nurseries (details can be found in the 2012 Forest Health Annual Report). Thus, survey and management efforts were focused on Griffith Nursery in 2013.

In order to evaluate the effect of additional fungicide applications on the incidence of galls, a small-scale fungicide study was initiated at Griffith Nursery in 2012. The typical fungicide protocol to control jack pine gall rust at this nursery has been six biweekly applications of fungicide (Bayleton, aka triadimefon), starting five weeks after germination.

In 2012, six rows of 1-0 jack pine seedlings were treated with nine biweekly applications instead of the typical six. As a control, two middle rows were treated with the typical six biweekly applications. In mid-April 2013, 1,000 seedlings that had received the additional treatment and 1,000 seedlings that had received the routine application were randomly hand-lifted. No galls were detected on any of the seedlings from either treatment.

Asymptomatic 1-0 jack pine seedlings with no visible galls or swelling were randomly collected

from each treatment at Griffith Nursery and potted in late April 2013. One hundred seedlings from the standard treatment and 100 seedlings from the test treatment were planted in plastic

pots and placed in the greenhouse to limit additional inoculum exposure. Each potted seedling was examined for the presence of galls in July and October. No seedlings from either treatment produced a gall over the summer. This was the first time since 2009 that no galls were detected on 1-0 seedlings from Griffith Nursery. Since no galls were detected, it was not possible to evaluate the benefits of additional fungicide applications. This fungicide study may be repeated in the future.

Aeciospore Production Study:

Eighty four galled jack pine seedlings that were potted between 2008 and 2011 were examined for sporulation (the production of pycnia and aecia) in May 2013. Seventeen of 84 seedlings were found to have sporulated. No seedlings potted in 2011 developed aecia in the spring of 2013, although some exhibited pycnia formation.

Thirteen of the 17 galled seedlings that were producing aecia were examined to determine whether the seedlings were infected with the pathogens causing eastern gall rust or western gall rust (information about the test protocol can be found in the 2011 Forest Health Annual Report). All sporulating seedlings originated from Griffith Nursery. Average germ tube lengths for all tested seedlings were approximately within the range of *Cronartium quercuum*, the pathogen causing eastern gall rust, and much longer than the range of *Peridermium harknessii*, the pathogen causing western gall rust. Western gall rust is considered to be more aggressive and damaging to pines because it can complete its disease cycle without an alternate host, which is required by the pathogen causing eastern gall rust.

Between 2011 and 2013, the germ tube study was conducted on a total of 41 potted jack pine seedlings. Thirty seven seedlings originated from Griffith Nursery and two seedlings each originated from Wilson and Hayward Nurseries. All 41 seedlings were determined to be infected with the pathogen causing eastern gall rust.

White Pine Blister Rust Survey at Wilson Nursery:

Figure 32: Aecial blisters on 3-0 white pine seedling at the time of lifting, 2012, Wilson Nursery

A survey to evaluate the incidence of blister rust on white pine seedlings was conducted in 2013 at Wilson Nursery. Stem cankers and aecial blisters have occasionally been detected on 3-0 white pine seedlings at the time of lifting (Figure 35). In mid-April 2013, 1,000 white pine seedlings were randomly dug from Wilson Nursery beds. Each seedling was thoroughly examined for the presence of cankers and/or aecial blisters, and none were evident at the time of lifting.

Figure 33: Moderate defoliation of balsam fir

In addition, 100 seedlings were randomly collected from the lifted stock and potted on May 1 for examination throughout the growing season. No cankers or blisters were detected on the potted seedlings during the summer. Potted seedlings were stored in a cooler at Wilson Nursery for the winter. The pots will be placed outside in early spring 2014 to examine the development of aecial blisters. A similar survey may be conducted in 2014.

Spruce Budworm

Spruce budworm caused no noticeable defoliation in 2013, likely due to cold and wet weather slowing larval development and washing away damaged needles. Close inspection of new fir and spruce shoots indicated budworm activity (Figure 36) in scattered stands from Ashland and Price Counties east to Marinette County. Egg mass surveys predict 2014 defoliation in Ashland, Florence, Forest and Price Counties. Defoliation in parts of Florence County could be moderate in severity.

Scattered mortality from spruce budworm was found in eastern Florence County and adjacent parts of northern Marinette County. The Florence County townships with the highest concentration of fir mortality are northern Florence, eastern Fence and Fern. These areas have experienced at least 3 consecutive years of spruce budworm defoliation.

Abiotic Issues

Drought and Conifers

The severe summer drought of 2012 set the stage for widespread conifer problems in 2013 across many west central and northwest counties. The most heavily impacted species was red pine, followed by spruce and tamarack. Jack pine, white pine, fir and cedars fared better than the previous three species. Damage and/or mortality was caused by pine engraver beetle (Ips), Pityogenes beetle, eastern larch beetle, spruce bark beetle, red turpentine beetle, Diplodia shoot blight, Rhizosphaera needle cast, Armillaria and Leptographium root rots, as well as a drop in the water table.

In Taylor County, increased mortality was observed in red pine, white spruce, balsam fir and northern white cedar. Damage was less severe than in areas to the south. The majority of the pine mortality was due to pine engraver beetle (*Ips pini*), spruce mortality due to four-eyed spruce bark beetle (*Polygraphus rufipennis*) and *Ips* spp., northern white cedar mortality due to cedar bark beetle (*Phloeosinus* spp.), and balsam fir mortality due to balsam fir bark beetle (*Pityokteines sparsus*). Taylor County and surrounding areas had the state's largest soil moisture deficit during 2012's unusually warm March. Taylor County also experienced significant drought conditions between July and September 2012.

Widespread damage was seen in central Wisconsin from Ips, turpentine beetles and Armillaria root rot. Damage was seen in all stand ages, especially on poor quality soils. In one 15-20 foot

tall, mixed red and white pine stand in Waupaca County, the red pines were dying or being attacked by bark beetles (some were just "off color" but were fully infested), whereas the white pines appeared to be doing just fine.

Germann Road Fire in Douglas County

On May 14, 2013, an accidental fire started near Germann Road in the Town of Gordon and burned over 8,000 acres of woodlands in the Towns of Gordon and Highland. A post-fire survey of the burned area revealed some forest health issues:

- Pine engraver beetles were infesting the pockets of residual pines, and boring dust and exit holes were visible. Many of the attacked trees had fading crowns, but some of the attacked trees still had green crowns. Pine engraver beetles were emerging from several log decks. Larvae of the predaceous checkered beetle (aka clerid beetle) were also found under the bark.
- Red turpentine beetle pitch tubes were present on some of the pines, but activity was very spotty.
- White-spotted sawyers were abundant in the dying and dead pines. There were various sizes of larvae under the bark and they could be heard chewing in the logs and residual trees. Log values may be decreased due to the heavy woodborer activity in them.
- Initially, very little evidence of *Armillaria* fungi was found in the pines and no *Armillaria* was found in the aspen and oak sprout regeneration. A later site visit indicated that *Armillaria* had colonized the dead and dying pines, but had not colonized any of the aspen or oak sprouts that were examined. *Armillaria* could still pose a problem for the aspen and oak regeneration.

A fungus was observed to be growing on the dead aspen, and it made them look much whiter than normal. The fungus is believed to be *Leucostoma niveum*, an opportunistic pathogen that colonizes injured stems and twigs of aspen, willow and poplar.

Storm Damage

Most counties in western Wisconsin experienced late spring snow storms in 2013. However, Crawford County had rain and Vernon County had ice that brought some limbs down. Reports indicated that Barron, Chippewa, Douglas, Dunn, Eau Claire, LaCrosse, Monroe, Pierce, Polk, St. Croix, and Trempealeau Counties had bent trees, branch and trunk breakage, and some tree tipping. Pines appeared to have the most bent trunks, broken branches and tops. Open-grown white pines had the most broken branches. There are salvage harvests in progress or planned in Dunn County in jack and red pine stands, and in Pierce County in red pine stands. Some campgrounds had to clean up pine branches that snapped off.

Aspen, oak and white birch also suffered bent trunks and branch and trunk breakage. In Barron County, some 10-25 year old aspen stands had pockets of total collapse. The crowns of 30 foot oaks were bent to the ground in one area of Trempealeau County.

Weather Conditions

The year 2013 started with below-average temperatures and above-average rainfall, and these patterns continued into early summer (Figure 37). Late summer and fall were drier and warmer than normal, resulting in abnormally dry conditions in southern Wisconsin and severe drought conditions in western counties. Despite the dry conditions in the latter half of the year, a majority of Wisconsin ended the year with normal or above-average precipitation (Figure 38).

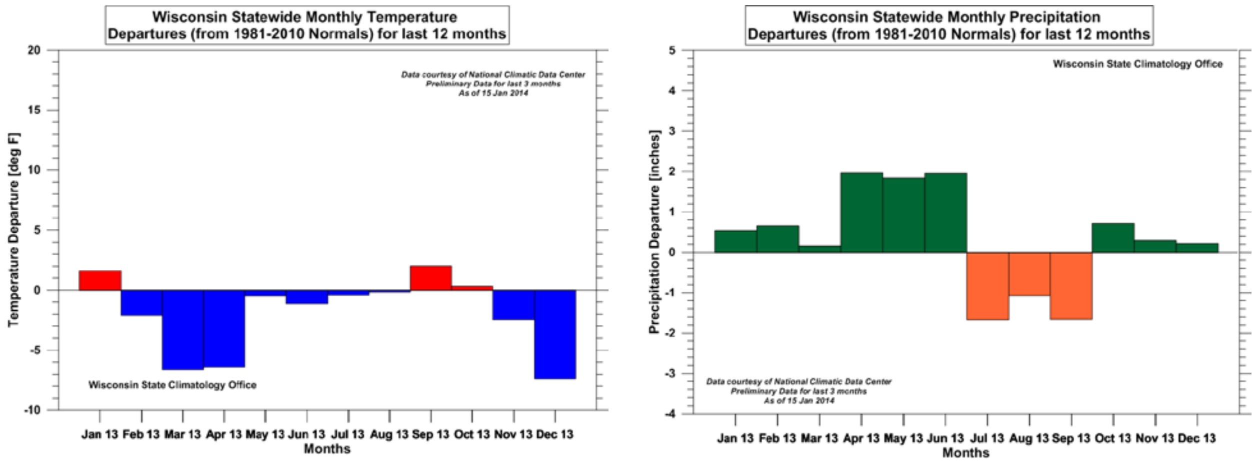


Figure 34: Statewide monthly temperature (°F) and precipitation (inches) departures from normal during 2013. Source: Wisconsin State Climatology Office,

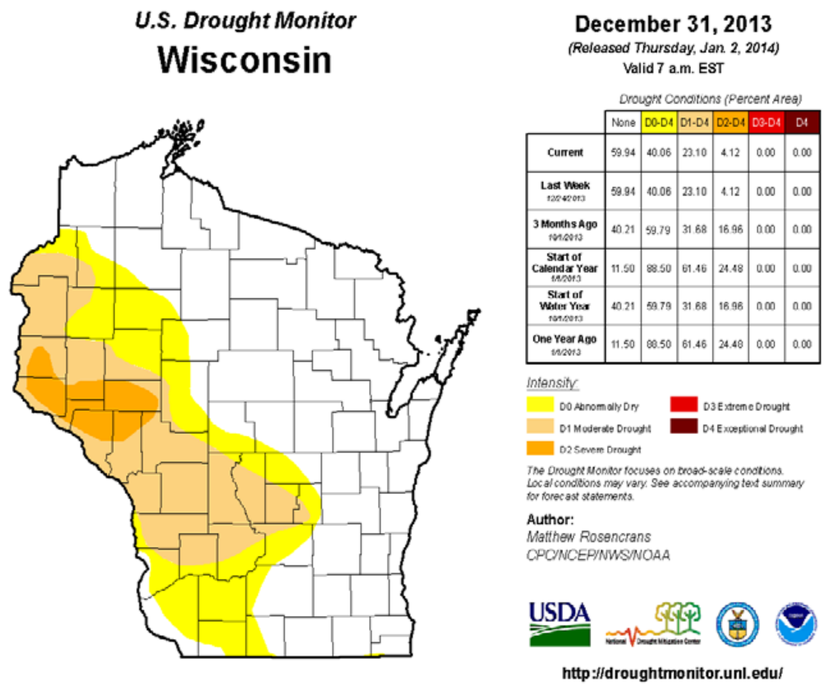


Figure 35: Drought conditions in Wisconsin as of December 31, 2013. Source: U.S. Drought Monitor, http://droughtmonitor.unl.ed