Forest health highlights of Wisconsin
Annual Report 2008

Compiled and edited by Forest Health Protection Program Staff

Wisconsin Forest Health Protection Program
Division of Forestry
WI Dept of Natural Resources

Cover photo by Mick Skwarok

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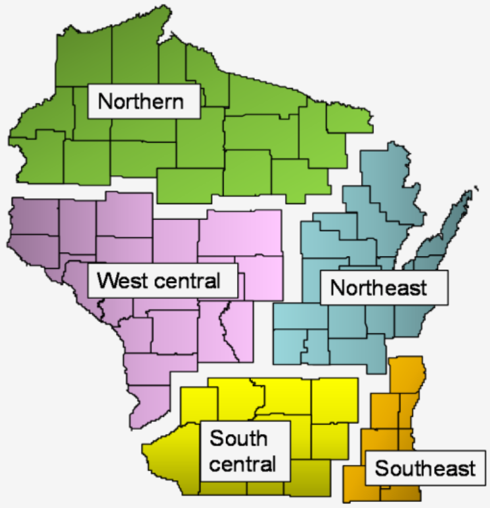

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Resource Update

Wisconsin's forests are critical for providing wildlife habitat, clean air and water, managing erosion, and improving our quality of life in urban and rural areas. Forests are also important to the economy of Wisconsin, not only in the form of wood products, but also for 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 value of shipment 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.

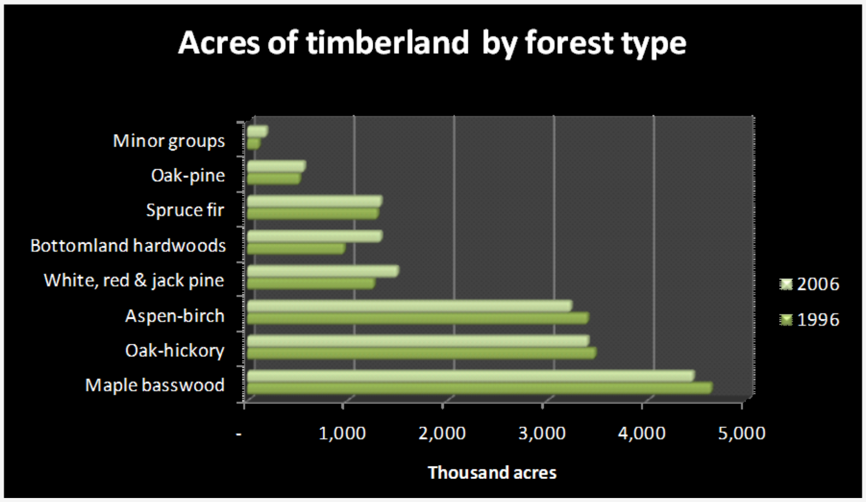


Figure 1. Thousand acres of timberland by forest type group, 1996 and 2006 (FIA data USDA Forest Service).

The area of forest land in Wisconsin has been steadily increasing in recent decades and currently stands at approximately 16 million acres, representing over 46 percent of the total land area. The state now has the most forest land that it has had at any time since the first forest inventory in 1936. Wisconsin's forests are predominately hardwoods, with 81% of the total timberland area classified as hardwood forest types (Figure 1). The primary hardwood forest types in the state are maple-basswood, at 28% of all timberland, oak-hickory at 22% of total acreage, and aspen-birch which covers 21% of Wisconsin's timberland area. Conifer types, mainly red, white and jack pines and spruce-fir, represent about 19% of the timberland. In addition, our forests are becoming middle-aged (Figure 2) with less acreage in young and very old stands and a sharp increase in stands 60 to 100 years old.

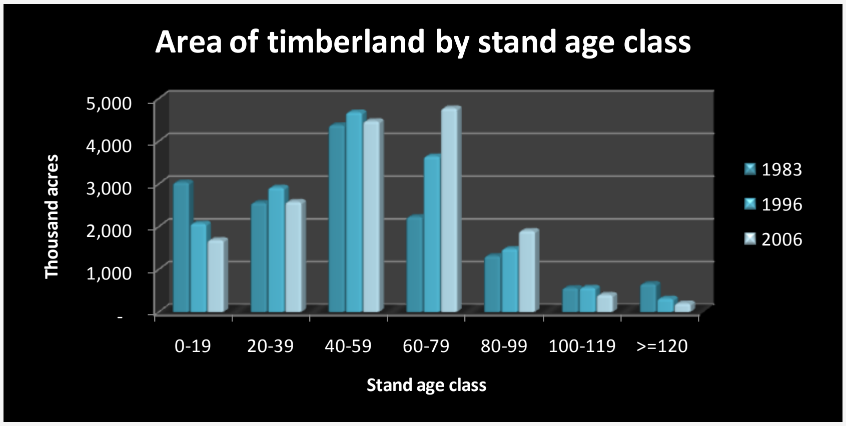


Figure 2. Thousand acres of timberland by stand age class 1983, 1996 and 2006 (FIA data USDA Forest Service).

Exotics

Emerald Ash Borer – *Agrilus planipennis*

Status of Distribution

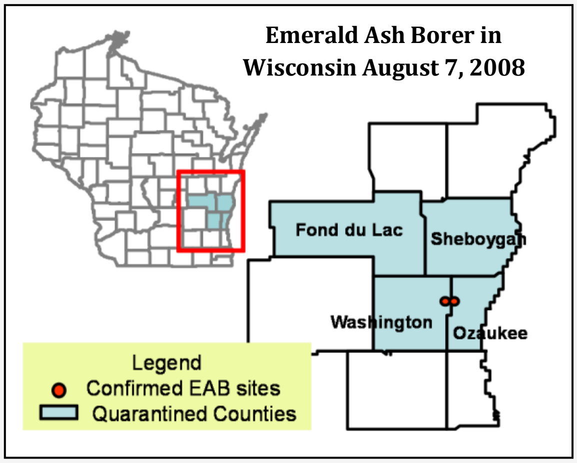


Figure 3. Location of known EAB infestations and quarantined counties, August 2008 (DNR).

After five years of surveying for the Emerald Ash Borer (EAB), this insect was confirmed as being present in northwest Ozaukee and northeast Washington counties in August, 2008 (Figure 3). A combination of trapping, an alert landowner and observant DNR and Department of Agriculture, Trade and Consumer Protection (DATCP) staff lead to these finds. A third confirmation occurred in November in the Silver Lake area, Kenosha County. The Kenosha County find includes two infested trees that were purchased from a nursery in northern Illinois and planted in August at a private residence. The trees have been removed and shipped back to Illinois. Emergence of adults from these two trees after arrival in Wisconsin was unlikely due to the late summer planting. A survey of the area surrounding the Kenosha County find revealed no additional infested trees. Nationwide, several new locations of EAB significantly expanded the area of known distribution (Figure 4, next page). In addition to Wisconsin's infestations, new finds most notable to the Midwest area included locations in Michigan's Upper Peninsula (Keweenaw, Houghton, Delta and Schoolcraft counties) and northeastern Illinois, 20 miles from Wisconsin's border.

Ozaukee and Washington County Infestations

An ongoing delimitation survey including communities within a ten-mile radius of Newburg was conducted by DATCP, and has identified additional suspect trees that will be revisited for further examination through December, 2008. Infested trees that have been confirmed positive due to the presence of larvae are located in Fireman's park in the Village of Newburg and in a six-acre privately-owned woodland approximately 1.5 miles east of Newburg (Figure 5). Some of the infested trees are along the banks of the Milwaukee River. The origin and age of these infestations are still being investigated. Many of the infested trees are larger than 8" in diameter and show signs of woodpecker activity, bark splits and galleries (Figure 5).

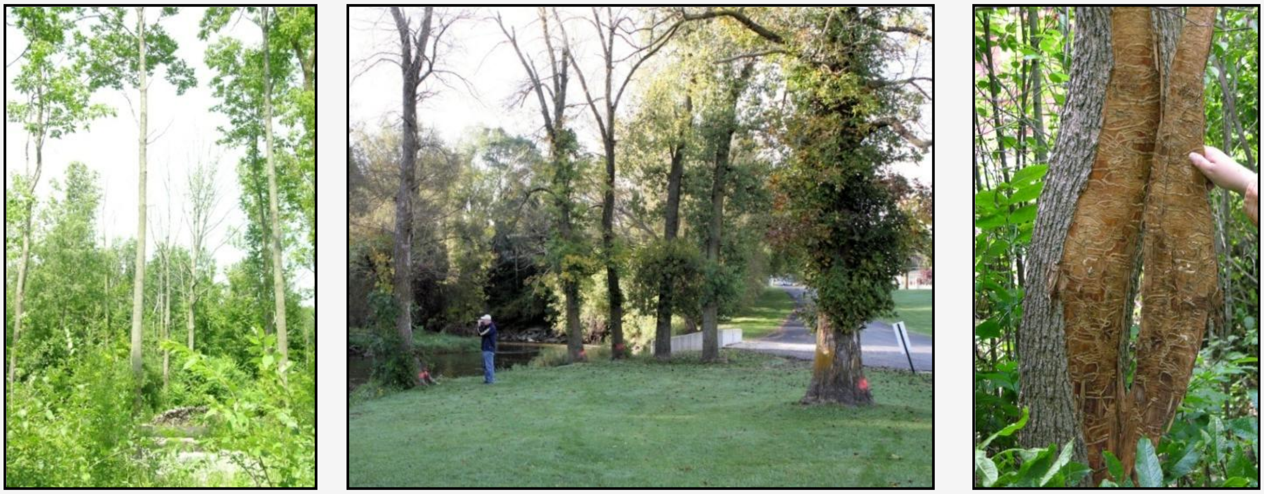
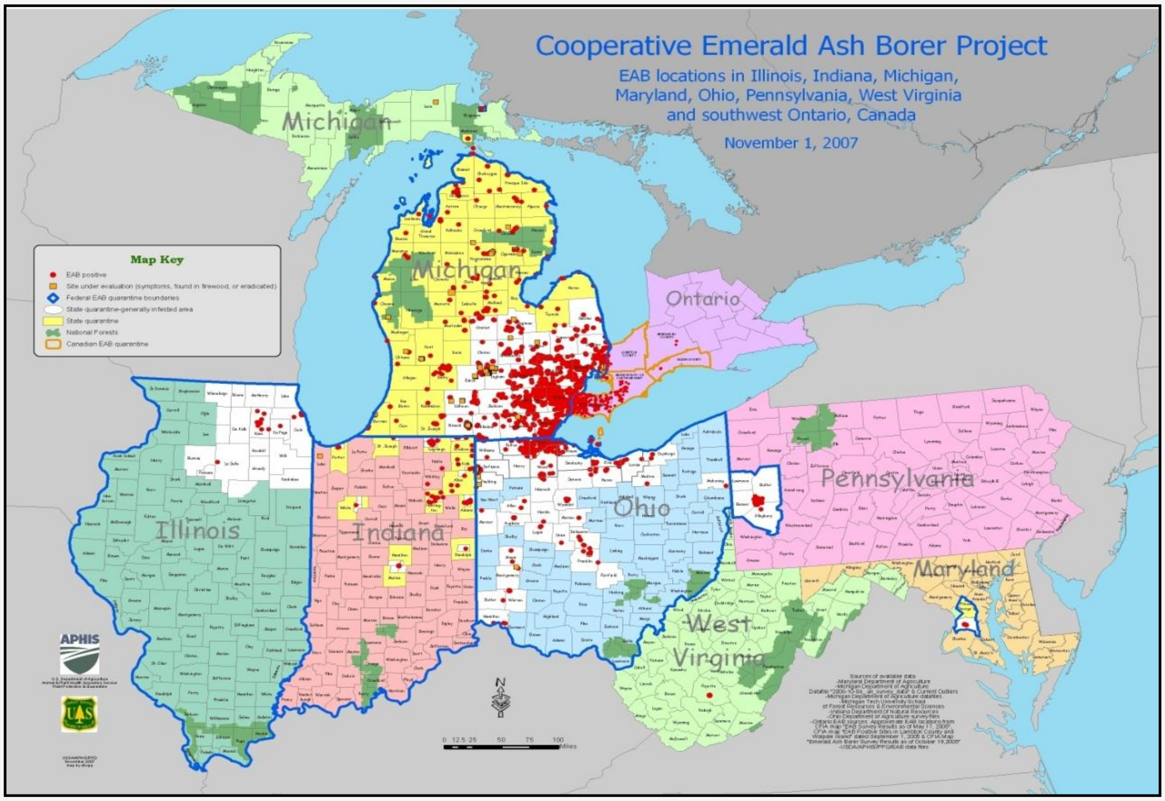


Figure 5. Left: Dead and declining ash in EAB infested area of Ozaukee County (M. Guthmiller). Middle: Ash trees in EAB infested park in the Village of Newburg, Washington County (J.Roe). Right: Larval galleries of EAB in infested woodland of Ozaukee County (M.Guthmiller).



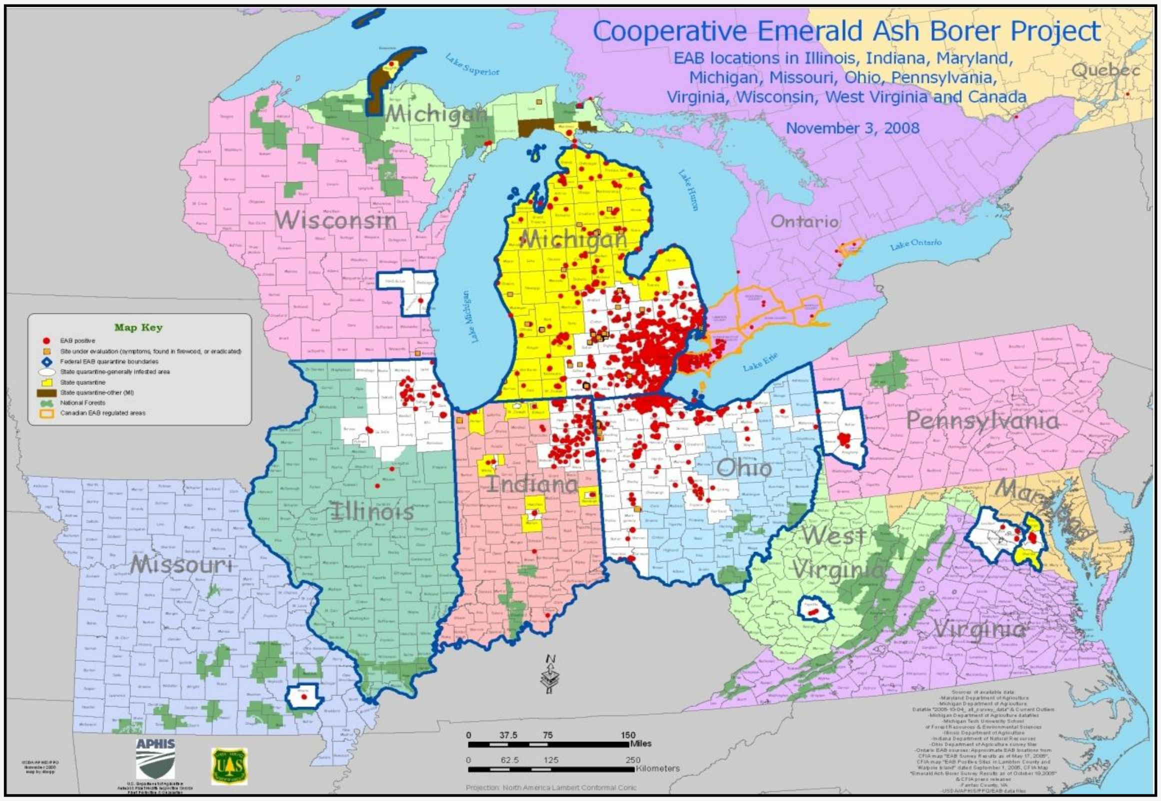


Figure 4. Known locations of EAB and quarantined counties. Top: November 2007. Bottom: November 2008.

Joint DATCP and DNR surveys of woodlands in the infested area are planned from December, 2008 through 2009. These surveys will help identify additional infested trees and provide data regarding the location and volume of infested and uninfested ash trees.

There are approximately 4.6 and 7.2 million ash trees >1" in diameter in Ozaukee and Washington counties, respectively (Figure 6, USDA FIA data 2007). The landscape within two miles of the Village of Newburg primarily includes small woodlots interspersed with agricultural lands. Forest types are primarily bottomland hardwoods and central hardwoods.

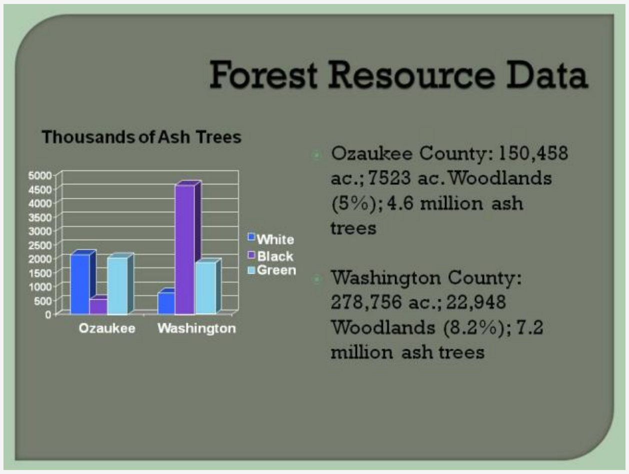


Figure 6. Number of ash trees (>1" diameter) in Ozaukee and Washington counties (USDA FIA data 2007).

Response Strategy

After completion of the delimitation survey (Spring, 2009), a response strategy will be developed by the EAB ICS team. Options for a response are heavily influenced by the age and extent of the infestation, available funds, and public participation in the management effort.

Further information, including options for chemical control, silvicultural guidelines, preparedness activities for communities, an easy guide to quarantine regulations and bi-weekly updates of survey activities can be found at:
http://www.emeraldashborer.wi.gov/

How You Can Help

- Know the signs of EAB and **report suspicious trees** to the DATCP hotline: 1-800-462-2803
- **Don't move firewood** long distances. Ash firewood is known to be one of the most common carriers of EAB; other injurious insects and diseases such as the fungus that causes oak wilt and life stages of the gypsy moth are also transported on firewood. Obtain your firewood from a source close to your destination.
- If camping at a DNR-managed property, **follow the firewood rules**.
- **Follow the quarantine regulations**. Ozaukee, Washington, Fond du Lac and Sheboygan counties are under quarantine. Ash products such as logs, nursery stock, pallets and hardwood firewood (any species) cannot be moved outside of the quarantine without state or federal inspection and certification. For further information on quarantine regulations, contact Bob Dahl, DATCP regulatory section, 608-224-4573.
- Continue to **follow sustainable forest management practices**. Consult with your forester and the publication "Preparing Wisconsin's Forests for Emerald Ash Borer" for guidance at:

http://www.emeraldashborer.wi.gov/

Emerald Ash Borer Visual Survey 2008

For the fifth consecutive year, WI DNR conducted visual surveys for the emerald ash borer in Wisconsin. All of the properties surveyed were private or county campgrounds located in west central and northern Wisconsin (Figure 7). Michigan Technological University (MTU) was contracted to not only conduct the visual survey, but also to provide education and outreach opportunities concerning emerald ash borer to campground managers.

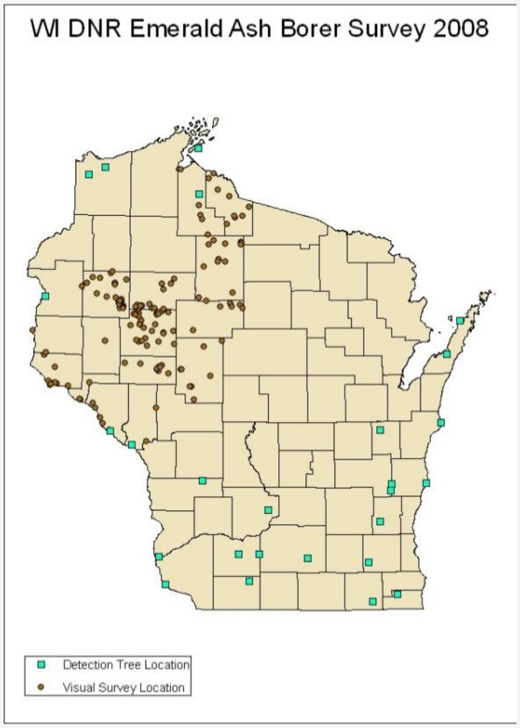


Figure 7. Locations of detection tree and visual surveys.

Surveys were conducted by touring campsites and making a visual assessment of the health of the ash resource in the campground. Emerald ash borer has a high risk for introduction through firewood transmission, therefore, surveying campgrounds where firewood is burned is crucial.

Visual surveys were conducted in 119 private and county campgrounds across 15 counties in west central and northern Wisconsin. Counties surveyed included Ashland, Barron, Buffalo, Chippewa, Clark, Dunn, Eau Claire, Iron, Pepin, Pierce, Price, Rusk, St. Croix, Taylor and Trempealeau. Visual surveys began in early June and ended early September. Just over 4700 campsites were surveyed, leading to the evaluation of 1042 ash trees for the presence of the emerald ash borer. Characteristic symptoms of an emerald ash borer infestation when present in ash are epicormic sprouting, branch dieback, and woodpecker feeding. Characteristic signs include D-shaped exit holes, serpentine galleries beneath the bark and the presence of emerald ash borer larvae or adults. Our visual survey efforts detected no emerald ash borer infestations in the private and county campgrounds surveyed.

In addition to emerald ash borer detection during visual surveys, observation of other commonly encountered, but non-threatening ash insect pests and diseases, were recorded during the surveys. Insect pests observed included the ash bark beetle, the ash borer clearwing moth, and the redheaded ash borer based on exit-hole evaluation. Foliar and bud insects such as the ash flower gall mite, ashleaf gall mite, and ash plant bug were observed as well. Diseases observed included anthracnose on the foliage and brooms on the main stem, possibly a symptom of ash yellows. Anthracnose was widespread across all survey sites, however, just three campgrounds had ash trees exhibiting the brooming associated with ash yellows.

Emerald Ash Borer Detection Tree and Panel Trap Surveys

In 2008, DNR continued a detection tree survey for emerald ash borer at 25 state parks and forests across Wisconsin. All of the properties included in the survey had detection trees monitoring for EAB in the last two years. Michigan Technological University (MTU) was again contracted for the preparation, maintenance and peeling of detection trees as well as the use of purple panel traps at these state properties. MTU was also contracted to conduct the same surveys on national forests in Wisconsin.

Figure 8. Girdled ash tree for EAB detection (R. Pinski).

Detection trees are girdled at waist height, with a sticky band of Tanglefoot wrapped around the tree above the girdle (Figure 8). Girdling stresses the tree, causing chemical and visual changes that attract EAB adults. The sticky band is used to trap adult beetles during their flight period (primarily June through August).

Three hundred detection trees were used this year; 150 were newly-created and 150 had been prepared in 2006 or 2007. Detection trees have been shown to increase in attractiveness the longer they have been girdled. Sticky bands were examined every two weeks between June and August, and any beetles resembling EAB were removed and cleaned for identification.

In October and November, after the adult flight period had ended, survey crews felled and peeled up to six detection trees at each park or forest to look for emerald ash borer larvae beneath the bark. No EAB larvae were found during the peeling of these trees. 157 detection trees remain for peeling in future years.

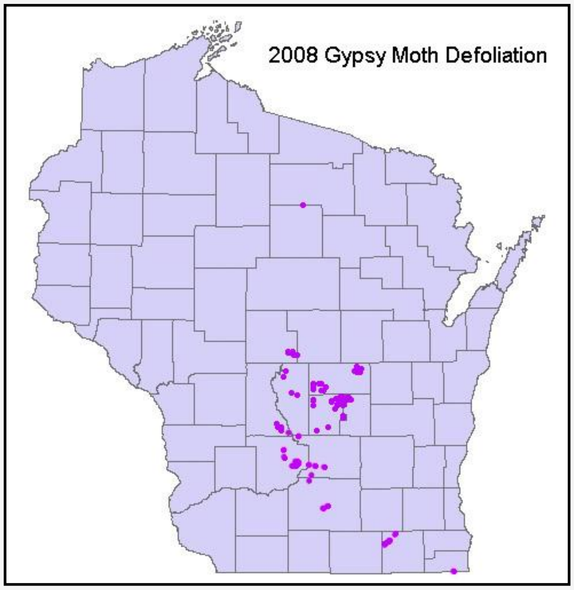
In addition, 24 purple panel traps were hung in the state parks and forests where detection trees were established (Figure 9). National forests in Wisconsin had an additional 26 purple panel traps installed. Traps are hung in an open-grown or edge ash tree. The purple color is attractive to adult beetles. The panel traps are made of corrugated plastic board and are sticky on the outside in order to trap landing adult beetles. Each trap is baited with Tea Tree oil, which contains compounds that are attractive to EAB adults. No EAB adults were collected from any of the panel traps placed on DNR properties.

Figure 9. Purple panel trap for EAB detection (R. Pinski).

Gypsy Moth Program

Suppression Treatments

Acreage treated in the suppression program increased from 1,235 acres in 2007 to 12,523 acres in 2008 reflecting increasing populations in central and northeastern Wisconsin due to favorable weather in the summer of 2007. A total of 133 sites were treated in 16 counties: Adams, Brown, Columbia, Dane, Door, Green Lake, Juneau, Marathon, Marinette, Marquette, Menominee, Milwaukee, Outagamie, Rock, Sauk and Waushara. Of these acres, 11,940 were treated at 36 CLU's (Cabbage Looper Units) of Foray 48B and 583 acres at four sites were treated with Gypchek at $4x10^{11}$ OB/ac (Occlusion Bodies). Treatments were done between May 19 and June 2 by Al's Aerial Spraying of Ovid, MI at a cost of $29.71 per acre. Treatments at all but one block were successful at keeping defoliation below 50% on 80% of the trees in the block, meeting the suppression program's goal. A 27-acre spray treatment in Madison was considered unsuccessful due to reinvasion from outside the block. Three other spray blocks in southern Wisconsin had some defoliation but in these cases the level was below 50%.



Population Growth and Defoliation

Aerial defoliation surveys mapped a total of 8,683 acres of defoliation in 2008 down from 22,994 acres in 2007. Most defoliation was light but some patches were moderately or heavily defoliated. No defoliation was seen in Marinette County (northeast Wisconsin), where most of the defoliation occurred last year. The outbreak there appears to have largely collapsed. Poor hatch was widespread in central and northern counties, possibly due to fluctuating weather conditions this spring prior to hatch and this may have contributed to lowered population and defoliation levels.

Defoliation Mapped in Aerial Survey by County

Adams 69 ac.	Juneau 119 ac.	Portage 8 ac.	Wood 215 ac.
Columbia 285 ac.	Kenosha 2 ac	Sauk 4,270 ac.	
Dane 32 ac.	Marquette 904 ac.	Walworth 1,040 ac.	
Green Lake 232 ac.	Oneida 27 ac.	Waushara 1,480 ac.	

Widespread NPV and *Entomophaga maimaiga* mortality was observed across the quarantined counties. The parasitoid fly, *Compsilura concinnata*, was active at Rocky Arbor State Park in an area with an exceptionally high population of gypsy moth in 2007 and where the population of gypsy moth was moderately high again this past summer.

Predictions for 2009 Suppression Program

Despite mortality and poor hatch, populations in many areas remain high enough to be potential candidates for suppression spraying in 2009. An increased number of calls from the Milwaukee area suggest that populations may be building in southeast Wisconsin. Counties generating the most public calls to the DNR gypsy moth program were Dane, Milwaukee, Kenosha, Walworth, and Adams. Several state parks are currently planning suppression sprays. Some of these parks had portions treated in 2008 including Devils Lake, Rocky Arbor, Mirror Lake, Lake Kegonsa, Roche-a-Cri and the Dells of the Wisconsin River State Natural Area. Others are treating for the first time in this outbreak cycle including Big Foot Beach and Tommy Thompson State Parks.

Beech Bark Disease

Beech bark disease, caused by a combination of a scale insect (*Cryptococcus fagisuga,* Figure 10) and a fungus (*Neonectria coccinea var. faginata* or *N. galligena*), has not been found in Wisconsin, but continues to advance westward through the Upper Peninsula of Michigan.

Figure 10. Scale nymph (*Cryptococcus fagisuga*)

Survey plots (Figure 11) in eight Wisconsin counties did not find beech scale or beech bark disease in August, 2008. Thirty to fifty beech trees at each site were examined for the presence of the scale and disease. All survey sites were on state, county, city, or private land. Survey sites were selected by incidence of beech, likelihood of human transport to the site, and FIA data.

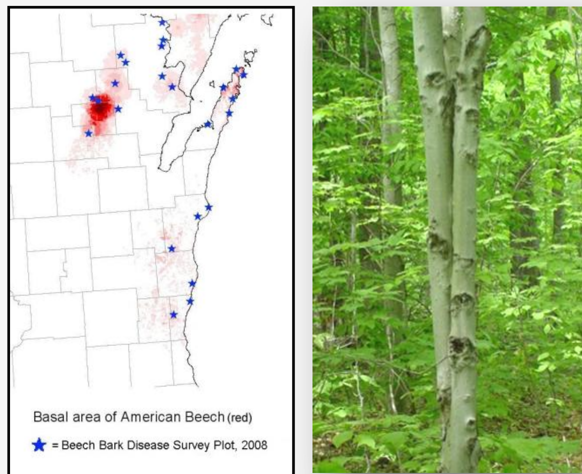


Figure 11. Left: Survey sites for beech bark disease. Right: Symptoms of beech bark disease (B. McNee).

Hemlock Woolly Adelgid - *Adelges tsugae*

Surveying for hemlock woolly adelgid (*Adelges tsugae*) on state and privately-owned land was completed in May and June, 2008. Survey sites were primarily identified through modeling that chose census tracts based upon hemlock abundance, tree nursery locations, and housing density (Figure 12).

Within each identified census tract, one to two likely introduction sites, such as campgrounds and residential neighborhoods, were selected for examination. At each site, two branches from opposite sides of 30-50 hemlock were examined for the presence of the adelgid's egg sacs. No signs of hemlock wooly adelgid were found.

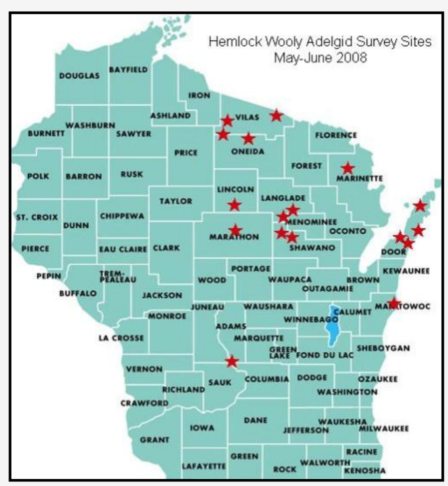


Figure 12. Hemlock woolly adelgid survey sites.

Sirex noctilio Survey

Overview

Sirex noctilio (Hymenoptera: Siricidae), commonly known as the European woodwasp, is an exotic woodwasp of Eurasian origin and a relative newcomer to North America (Figure 13). The European woodwasp has the ability to attack and kill all North American pine species, therefore posing a serious threat to the pine industry as well as natural forests of Wisconsin. This insect was first detected in Oswego County, New York in 2004.

Figure 13. Adult female *Sirex noctillio* (S. Kinelski, Bugwood.org).

Since its detection, European woodwasp has expanded its range and is now widespread throughout New York state and has also crossed into neighboring Pennsylvania, Vermont, Michigan and Ontario, Canada. To date, there have been no detections of European woodwasp in Wisconsin. Despite this fact, there is significant risk of introduction due to transmission of this pest in solid wood packing material originating from Europe and arriving at our ports or by movement of infested pine logs or or firewood that originate from European woodwasp-infested areas of the eastern US. All of Wisconsin's native pine species are considered vulnerable, including jack pine (*Pinus banksiana*), eastern white pine (*P. strobus*) and red pine (*P. resinosa*). European woodwasp is primarily attracted to trees that are slightly stressed or in decline, but healthy trees may also be attacked.

Figure 14. WI DNR *Sirex noctilio* survey sites 2008.

Site Selection and Set-up

Twenty detection sites were selected to survey for European woodwasp across the southern half of Wisconsin (Figure 14). Site selection criteria included a preference for mature red pine stands (some stands were red and white pine mixed) and the presence of some level of stress due to insect, disease, invasive plant competition and/or overstocking. In addition, some of the sites were located near busy transportation corridors, both railway and interstate, which pose an elevated risk for invasive species introductions into an area.

Figure 15a. Intercept panel trap used for European woodwasp detection (M Guthmiller).

Figure 15b. Lindgren funnel trap used for European woodwasp detection (M Guthmiller).

All detection sites were located on county, school forest or state forest lands. Sites were located in Black River State Forest (3 sites), Jackson County Forest (1 site), along the Lower Wisconsin River Way (6 sites), WI Dells area (4 sites), Kettle Moraine State Forest- Northern Unit (3 sites) and the Kettle Moraine State Forest- Southern Unit (3 sites).

At 16 of the 20 sites, two traps were deployed at each site, one intercept panel trap (Figure 15a) and one Lindgren funnel trap (Figure 15b). However, the four sites in the Black River State Forest and Jackson County Forest had three or four traps per site and all were intercept panel traps. Traps within the same site were spaced approximately 100m apart. All traps were equipped with a synthetic lure (70% α-pinene + 30% β-pinene). Traps were hung from a rope that was suspended between two trees at approximately seven feet. Traps were deployed late June and taken down late October. Lures were refreshed every six weeks and wet collection cups were used to kill trapped insects. Collection cups were filled with LowTox Antifreeze and were examined for woodwasp adults every three weeks. Insects collected were preserved in 80% ethyl alcohol until identification in the laboratory.

Results

A total of 191 woodwasps were collected during the survey and zero were identified as the European woodwasp. In total, five woodwasp species were collected and all are considered native to Wisconsin. The five species collected, with the number collected in parenthesis, include: *Urocerus albicornis* (1), *Urocerus cressoni* (56), *Tremex columba* (7), *Sirex edwardsii* (73), *Sirex nigricornis* (54).

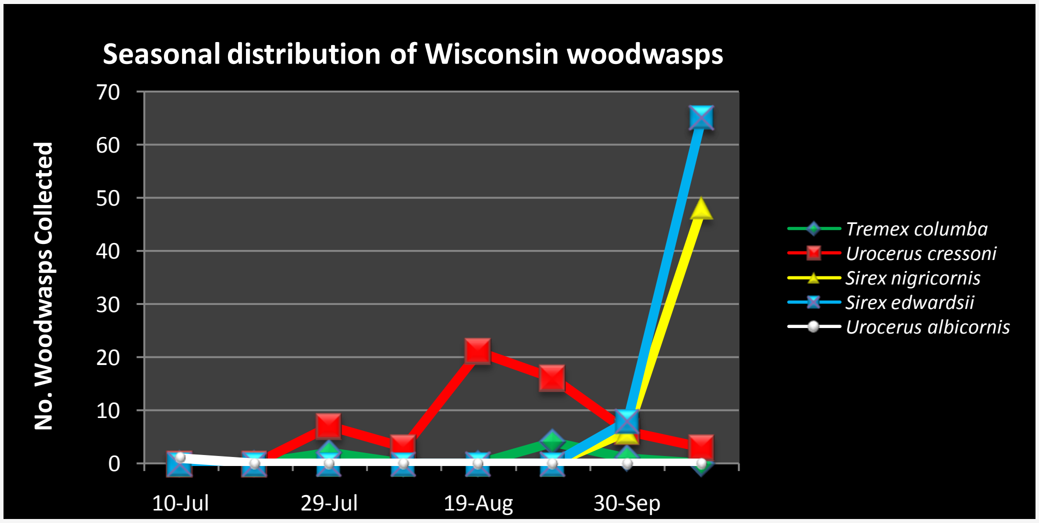


Figure 16. Seasonal distribution of Wisconsin native woodwasps collected during 2008 survey season. Collection methods included Lindgren funnel and intercept panel traps baited with a 70% α-pinene + 30% β-pinene lure (R. Pinski).

Peak collection for *U. cressoni* was during the month of August, whereas *S. edwardsii* and *S. nigrocornis* peaked during the month of October (Figure 16). Conversely, *T. columba* was collected consistently throughout the trapping season.

In addition to our trapping effort, a visual assessment of stand health was conducted near the trapping site. Distinct symptoms are associated with a European woodwasp infestation and include needle droop in the crown, with needles changing in color from green to red to brown, or dead crowns and numerous resin beads on the midbole. None of these symptoms were observed in our study sites.

State Forest Invasive Plant Species Management Plans

Over the last few years, the state forests (Figure 17) have been inventoried for invasive plant species. Now that the base data is collected, we have been undergoing a process of developing Invasive Plant Species Management Plans for each State Forest. The goal is to develop a dynamic plan to assist the property managers in the control of invasive plants by setting priorities in the short term and adapting to forest management o prevent the introduction and spread of invasive plants.

Best Management Practices for Invasives Species

The Wisconsin Council on Forestry (WCOF) identified and ranked invasive species as the most critical issue facing Wisconsin's forests. Invasive species, including plants, insects and diseases can cause tree mortality and impact forest regeneration and productivity. In response WCOF created the Forest Invasives Leadership Team (FILT) which in turn initiated efforts to collaboratively develop voluntary Best Management Practices (BMPs) to limit the introduction and spread of invasive species.

Four BMP tracks were created to fully address the issue of invasive species in Wisconsin's forests, including: Forestry BMPs, Recreation BMPs, Urban Forestry BMPs, and Transportation and Utility Rights-of-Way BMPs. The Office of Forest Science received a US Forest Service State and Private grant to provide technical and logistical assistance to make this happen. There are four parallel tracks being developed addressing invasive plants and forest pests and diseases: Forestry, Recreation, Urban Forestry and Right-of-ways. All four tracks are underway, while the Forestry track is near completion and will be available to the public early next year.

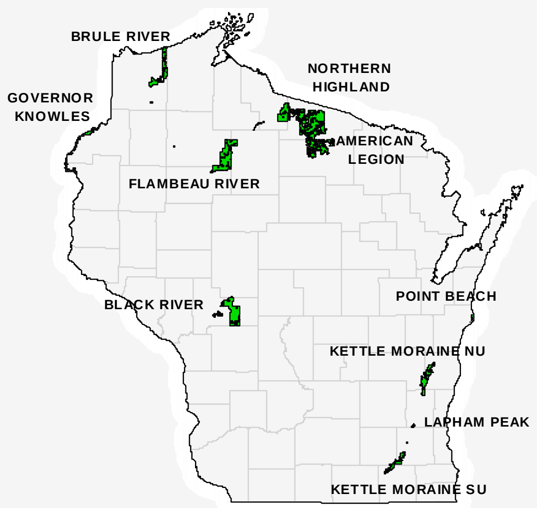


Figure 17. Wisconsin's state forests.

Hardwood Health Issues

Oak Wilt: Status and Pilot Suppression Project

A serious disease of oak, oak wilt, was confirmed in Langlade County in 2008 for the first time. Oak wilt is caused by the fungus, *Ceratocystis fagacearum*. The fungus attacks water and nutrient conducting channels in the trees and induces the plugging of these channels. Oak wilt is most common in the southern two thirds of Wisconsin and has been spreading northward (Figure 1). The disease was recently found in Florence County (1999), Barron County (2002), and Langlade County (2008).

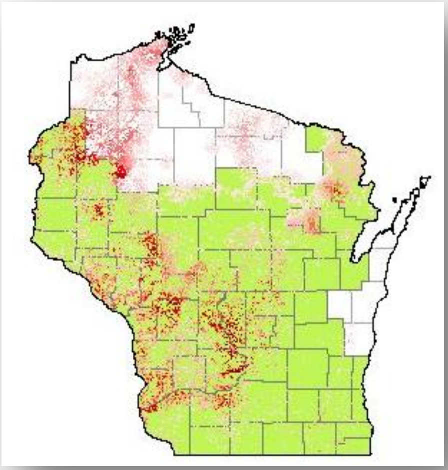


Figure 1. Oak wilt positive counties are shown in green (Langlade County is new in 2008) and the basal area of oak is shown in red (S.Dahir).

This was the second year of a pilot oak wilt cost-share suppression project called the Lakewood Area Oak Wilt Suppression Program. It was offered to three townships in Oconto County and two townships in Marinette County that were adjacent to the Chequamegon- Nicolet National Forest. As a cooperative project between the USDA Forest Service and the Wisconsin Dept. of Natural Resources, it was designed to manage oak wilt mainly on private properties within and near the national forest by providing a financial incentive to property owners to take measures to control spread of the disease.

A full-time summer staff person was hired to contact property owners with oak wilt and encourage their participation. Site visits were made upon property owner's request.

Unfortunately, federal funding for the program was removed in August 2008, and cost-share could no longer be offered.

2008 Updates on the oak wilt herbicide trials

1. Nine-Mile Recreation Area in the Marathon County Forest

In 2003, an herbicide field trial was initiated in the Nine-Mile Recreation Area in the Marathon County Forest as an alternative to physical root severing by a vibratory plow. Trees within grafting distance were identified by using Johann Bruhn's model. These trees were treated with Garlon 4 (active ingredient: triclopyr) in early July 2003, and additional trees were treated in early July 2004 (for the details of the treatment in 2004, please refer to an article, titled "Oak wilt Marathon County Control Trial: 2004 updates on the herbicide trial in the Nine-Mile Recreation Area on the Marathon County Forest, page 16). In 2005, the site was closely monitored and no additional trees exhibited symptoms of oak wilt. However, a new oak wilt pocket was found in the Marathon County forest, approximately 1/4 mile from the original herbicide trial site.

In 2006, the original site was again closely monitored throughout the growing season. No further spread of the disease was detected. The new oak wilt pocket that was found in 2005 was treated with Tahoe 4 (active ingredient: triclopyr) in late June, 2006. Trees within grafting distance were determined using Johann Bruhn's model. No additional oak wilt was found in the Nine-Mile Recreation Area in 2006 or 2007, thus no herbicide treatment was conducted in 2007 or 2008. In 2008, no additional trees that exhibited the symptoms of oak wilt were found either at the original pocket or the new site that was identified in 2005.

In 2008, a pocket of dead trees was found at the south end of the property, approximately 1.5 miles from the original pocket. The pocket will be monitored and samples will be collected to test for oak wilt in 2009.

Both the original and new oak wilt pockets will continue to be monitored weekly by county forest personnel during the summer of 2009. We thank Doug Brown, a Marathon County Forester, and Tom Lovlien, Marathon County Forest Administrator, for providing us with periodic updates on the progress of the trial.

2. Private property in Dane County

A similar herbicide treatment was implemented in a private property in Dane County in 2006. Oak wilt was found at the site in 2005 and dead trees were removed in December 2005. Trees within grafting distance were determined by a professional arborist and marked trees were killed using Garlon 4 in early July 2006. Stumps, girdled trees and surrounding healthy trees were located using GPS tecnology in late July. The site was re-visited by the WI DNR Forest Health personnel in late summer 2007 and 2008. No symptomatic tree was found outside of the treated pocket in 2007 or 2008.

One large red oak that was away from the treated pocket was confirmed with oak wilt in 2007, and this second pocket was treated with herbicide in the summer of 2008. Two small red oak trees just outside of the second pocket were found to be infected with oak wilt in 2008. However, since there was no red oak tree within grafting distance, additional treatment was not performed.

This site will be visited again in 2009 to survey for any additional oak mortality.

Thinning Study Related to Overland Spread of Oak Wilt: Update

A multiple year study of overland infection of oak during summer and fall began in 2006 and entered its third year in 2008. The purpose of the study was to determine the relative risk of thinning oaks in the period between mid-July and mid-October, considered to be a low to moderate risk period.

In response to concern from land managers, a study was crafted to quantify the relative risk of cutting oaks during this interval. Study sites, where harvesting of oak occurred between July 15th and October 15th, were surveyed to determine the presence and location of oak wilt pockets. These stands were revisited the following year in order to compare the number of new oak wilt pockets in sites with pre-existing oak wilt to the number of new pockets in stands without previous disease.

In 2006, five harvested and six control stands were surveyed and then revisited in 2007. Most new mortality was adjacent to former pockets but a few dead trees were far enough from the original oak wilt infection center to warrant sampling. However, oak wilt was not confirmed upon lab examination of branch and stem samples. One stand with several newly dead oaks, which was originally surveyed in 2007 and confirmed negative at that time, was resampled in 2008 but oak wilt was still not confirmed. However, numerous galleries of the two-lined chestnut borer were identified and could possibly explain the mortality.

In 2007, ten new stands were evaluated. Half of these (five stands) had been harvested between mid-July and mid-October of 2007, and five were unharvested controls. Three of the harvested stands were positive for oak wilt prior to harvest as were three of the five control stands. These stands were resurveyed in 2008 and the same pattern as seen the previous year was revealed: more oak wilt mortality adjacent to former pockets and new mortality that could not be confirmed as oak wilt. One harvested stand in Clark County had numerous scattered dead red oaks. Branch samples, however, were negative for oak wilt.

This is the final year of this study. Results are expected to be available in 2009.

Oak Wilt Regeneration Study

As of 2008, only 17 of the 72 counties in Wisconsin remained free of oak wilt. Statewide, black oak (*Quercus velutina)* and northern pin oak (*Quercus ellipsoidalis)* have a mortality to growth ratio of approximately 40% compared to an average 22% for all species. In the central sands, northern red oak (*Quercus rubra)* mortality is over 50% of new growth.

Many of these oak stands with high mortality due to oak wilt are harvested and either planted to another species or allowed to regenerate to oak. Oak grows well on these sites but we do not know whether the new regeneration will succumb to the fungus or will remain healthy. We also do not know if seedling survival (acorn source) will be different from the survival of sprouts from infected stumps.

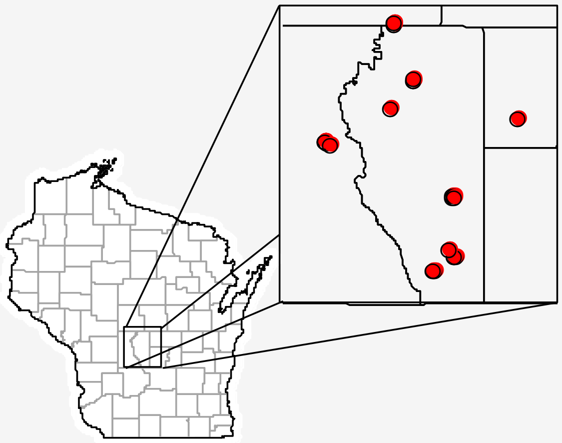


Figure 2. Location of study sites for oak wilt regeneration study.

In a study by Tyron et al (1983)[1], the authors compared the number of oak seedlings and sprouts between infected parts of oak wilt stands and uninfected areas. They found no difference in the number of healthy oaks seedlings or sprouts between the two areas and concluded that root grafting as well as overland spread were minimal at this age. This study, however, did not monitor survival over time.

The objectives of this study were 1) to compare 12-year survival rates of oak seedlings, saplings and sprouts in infected and uninfected areas of harvested oak wilt stands and 2) to determine the oak stocking level for oak regeneration of seedling and stump sprout origin at periodic intervals following harvesting and biannually up to 12 years.

During the summer of 2008, permanent plots were established in ten recently harvested stands in Wisconsin (Figure 2). All stands were surveyed prior to cutting to determine the GPS location of infection centers and uninfected parts of the stand. After harvest, between two and four plots were established in each stand, half in infection centers and half in a uninfected part of the stand. Saplings were mapped and recorded by species. Stumps were mapped, tagged and recorded for species, diameter inside bark, and the number of sprouts (Figure 3 top). Seedlings were mapped and counted by species within 1-2 meter subplots (Figure 3 bottom).

These stands will be revisited every summer for 12 years to monitor for seedling and sprout survival. Samples will be taken from dead individuals to be analyzed for the presence of oak wilt.

Figure 3 . Top: Cut stump were tagged and measured. Bottom: seedling plot with flags (S. Dahir).

[1] Tyron, E.H., Martin, J.P. and MacDonald, W.L., 1983. Natural regeneration in oak wilt centers. For. Ecol. Manage., 7:149-155.

Postoak Locust - *Dendrotettix quercus*

Postoak locust, USDA Forest Service, Bugwood.org.

This insect caused significant defoliation of red and black oak in Jackson and Wood counties in 2007 but was difficult to find in 2008. Scattered dieback was evident in oak that was heavily defoliated in 2007.

Below normal soil moisture during the growing season contributed to the stress, initiating dieback and decline.

Oak Timberworm – *Arrhenodes minutus*

Figure 4. Oak timberworm adults (M. Guthmiller).

In June, large numbers of oak timberworm adults (Figure 4) were observed on recently cut oak stumps and logs that were being removed following mortality from gypsy moth defoliation and drought at Rocky Arbor State Park. Oak timberworm, *Arrhenodes minutus,* is a primitive weevil and is a major cause of defect and degrade in oak timber. Signs of this insect have been observed in southern Wisconsin in previous years. This insect is well known for its ability to degrade the quality of oak lumber. The distribution and impact is unknown.
For more information:
http://www.fs.fed.us/r8/foresthealth/pubs/oakpests/p21.html
For a close up view of this insect:
http://bugguide.net/node/view/54687

Bacterial Leaf Scorch

This summer, Wisconsin participated in a survey supported by the USDA Forest Service to investigate the geographic distribution and host range of Bacterial Leaf Scorch (BLS) in the north central states. Leaf and twig samples were collected from symptomatic trees throughout southern and central Wisconsin and sent to a lab at Michigan State University to perform a genetic test. Of 13 samples from 11 sites, two out of the three bur oak samples collected from the same site in Dane County tested positive for BLS. This is the first confirmed case of bacterial leaf scorch in Wisconsin. The tests were repeated twice in the same lab and the positive samples will be tested in a second lab for confirmation. The Wisconsin DNR plans to collect more samples with similar leaf symptoms to evaluate the extent of this disease in 2009.

BLS is caused by the bacterium *Xylella fastidiosa*. Hosts include oak, maple, elm, ash, and other deciduous trees. The pathogen lives in the xylem vessels of host plants. Infected leaves exhibit scorch symptoms with irregular margins. The pathogen is transmitted by xylem-feeding insects, such as leafhoppers and treehoppers. The disease has been found throughout the east, southeast, and some mid-west states.

Aspen Leaf Problems

Scattered defoliation of aspen was observed throughout central and northern Wisconsin in 2008. Damage was observed both on quaking and bigtooth aspen (Figure 5). There was significant variability in the level of damage among different clones within the same stand.

Various pathogens that cause leaf diseases, such as Septoria leaf spot, Venturia leaf blight, Marssonina leaf spot, Alternaria leaf blight, and Phyllosticta leaf spot, were detected from symptomatic leaves with necrotic blotches. Several insects, including shining chafer beetle (*Dichelonyx elongata*), and large aspen tortrix (*Choristoneura conflictana*), were also found to be contributing to the defoliation.

Figure 5. Symptoms on quaking aspen (K. Scanlon).

It is suspected that above average precipitation in the spring contributed to the widespread development of the leaf diseases.

Aspen Mortality across Northcentral Wisconsin

Since 2007 we have been surveying areas where trembling aspen is declining. Typical symptoms of this problem include low stocking, loss of basal area from year to year, scattered 5-10 foot tall aspen snags resulting from 4-6 inch diameter stems snapping in two, pocket mortality, trees with minor to severe dieback, and trees with chlorotic foliage (Figure 6).

Figure 7. Zig-zag feeding galleries from a flatheaded wood borer on the sapwood of an aspen showing severe dieback (B. Schwingle).

Southern Ashland and Iron counties, northern Price, western Oneida, northern Lincoln, and Vilas counties have declining aspen forests. The same problem has been reported in Minnesota as well. These declining stands have undergone a variety of stresses (i.e. inciting factors to decline) since the beginning of the decade: at least three years of defoliation by the forest tent caterpillar and large aspen tortrix followed by several years of drought.

These factors have made the aspens susceptible to several opportunistic agents that are killing them (i.e. contributing factors to decline), namely a flatheaded wood boring beetle (*Agrilus sp*., Figure 7), which we tentatively have identified as the bronze poplar borer (*Agrilus liragus*), and the root rotting fungus Armillaria (Figure 8). The bronze poplar borer starts attacking stressed trees towards the top of their crowns, which makes initial problem identification difficult.

Figure 6. An aspen infested with flatheaded wood borers. Note the severe dieback in the canopy, and the stunted, yellow leaves (B. Schwingle).

Surveys have shown that an aspen with severe dieback and chlorotic foliage inevitably is infested with either flatheaded wood borers, *Armillaria*, or both. Observations indicate that flatheaded wood borers, more so than *Armillaria*, are more involved in causing the ultimate death of aspens, although it is difficult to say with certainty as *Armillaria* could be infecting root systems far from the root collar where it is nearly impossible to dig and investigate.

Additional associations with aspen decline are the fungus (*Entoleuca mammata*) that causes hypoxylon canker as well as ambrosia beetles and associated sapwood staining. Aspen showing some dieback (i.e. < 20% of the canopy), but with healthy green foliage, have not yielded any pests associated with their roots or stems. These trees could be displaying dieback from water shortage. It is not known if these relatively healthy trees will succumb to flatheaded wood borers.

Figure 8. Part of a mycelial fan of Armillaria at the base of an aspen with severe dieback. Armillaria is also causing sapwood discoloration, which is moving up from the root collar (B. Schwingle).

Butternut: Silvicultural Trial

Butternut (*Juglans cinerea*) in Wisconsin has suffered extremely high mortality rates in the past two decades due to infection with butternut canker . A project was initiated in 1994 on the Menominee Indian Reservation to evaluate growth of butternut on two habitat types (AQVib(Ha) and ATFD) and 5 sizes of canopy opening. The hypothesis being tested is whether growth rate and survival to reproductive age are affected by site fertility and light exposure.

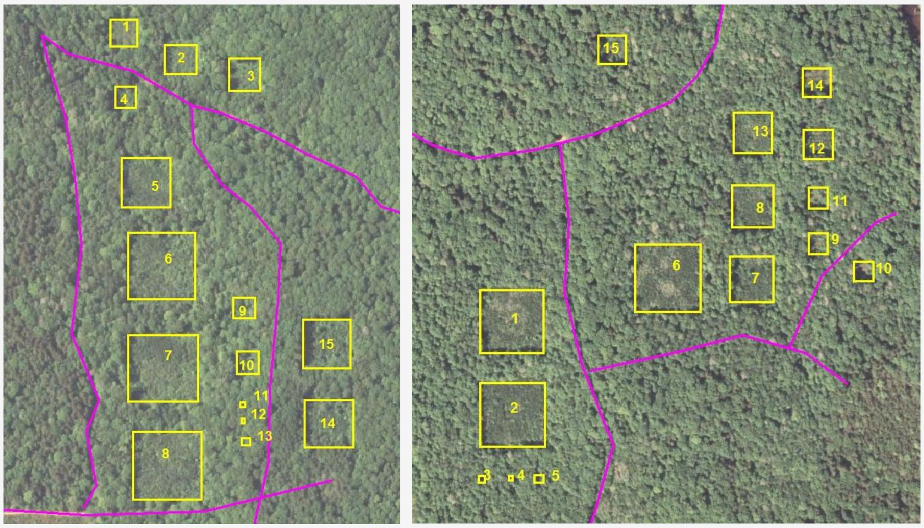


Figure 9. An aerial view of the canopy openings where butternut was planted in 1994. Left is the AQVib(Ha) site and on the right is the ATFD site. Opening sizes vary from 0.03 acre to 2

Fifteen openings were created at each of two sites, including three each of 0.03 acre, 0.25 acre, 0.5 acre, 1 acre, and 2 acres (Figure 9). Approximately 600 trees were planted at each site. The plots have been surveyed several times since planting to evaluate survival and canker formation. The AQVib(Ha) site had much higher rates of cankering initially probably due to several infected butternut in the surrounding forest; a survey of an area covering 200 ft in all directions revealed that, around the AQVib(Ha) plots, 12 of 14 butternut were infected, whereas there were no butternut surrounding the ATFD site.

Annual mortality which was high in the initial years after planting is now about 5-6% per year (Figure 10). As of 2004, half of the originally planted trees (1,196) were dead. As of 2008, 63% had died. We first started surveying for

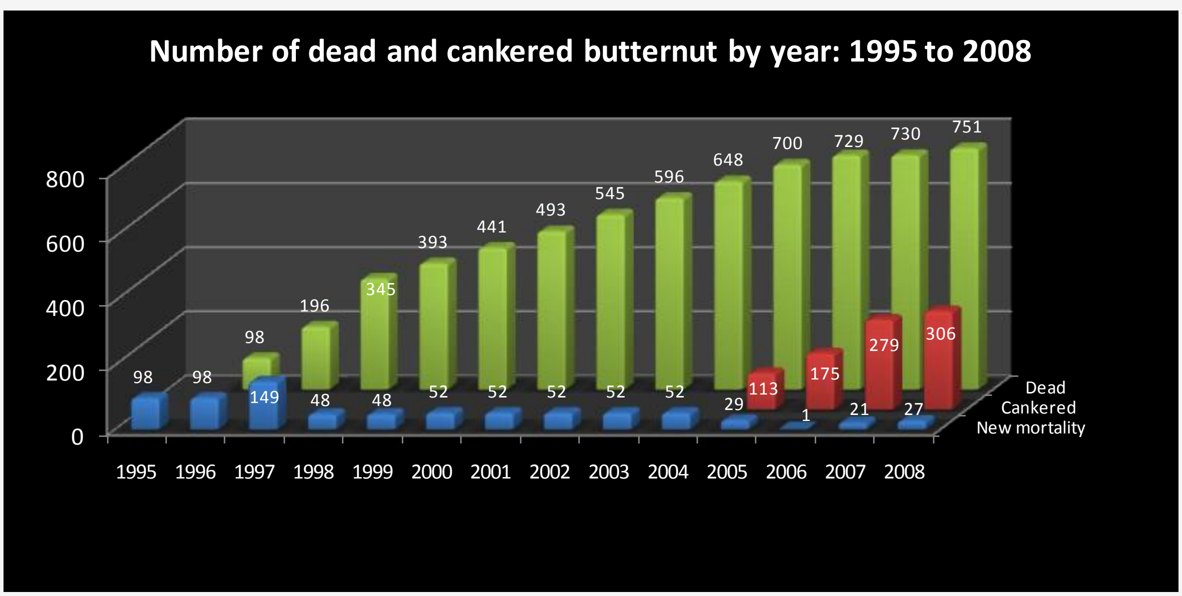
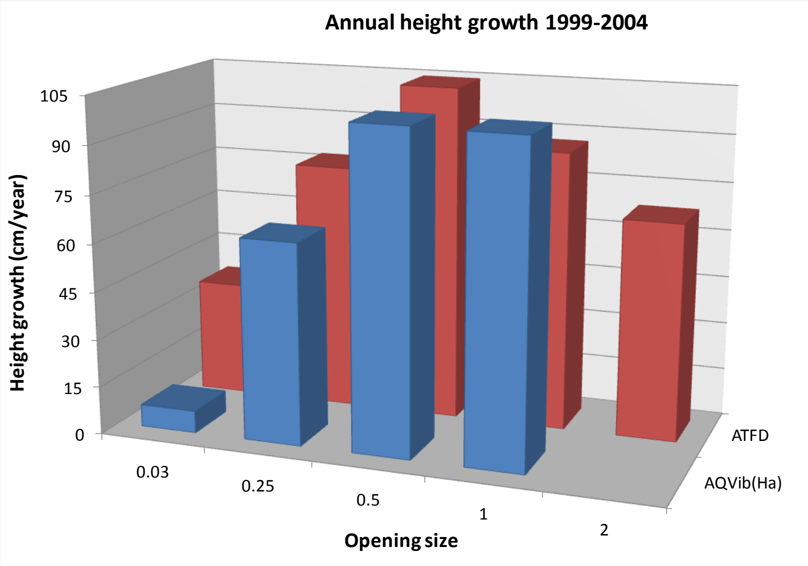


Figure 10 Annual mortality and the cumulative number of cankered and dead trees from 1995 to 2008.

cankers in 2005 when about one quarter of live trees were cankered. The percent with cankers has increased in 2008 to about 75% of all trees, 89% on the AQVib site and 66% on the ATFD site.

Annual height growth which had initially been highest on the ATFD or more mesic site, is now equal on the AQVib(Ha) and ATFD plots. Annual height growth has been consistently highest in the 0.5 acre gaps with the 0.25, 1 acre and 2 acre gaps somewhat lower and 0.03 acre gaps much lower (Figure 11). Annual diameter growth is greatest in the 0.5 acre gaps and now higher in the AQVib(Ha) overall.

Figure 11. Left: Butternut seedlings in the smallest openings (0.03 acres) showed very poor height growth and high mortality.
Right. Butternut seedlings in the 0.5 acre openings showed the best height and diameter growth on both sites.



Annual height growth is highest on the 0.5 acre openings regardless of site quality.

Based on the data collected to date, one could conclude that the 0.5 acre gap openings are best for height and diameter growth, irrespective of habitat type. Also, the AQVib(Ha) and ATFD are close enough in site quality to allow approximately equal growth rates. Mortality rates seem highly dependent on height. This makes sense because short trees will not have access to light. For trees below about 1 m, mortality rates are very high on all sites, whereas for trees over 1m in height, annual mortality rates range from 2.7% to 6.9%. The mortality rate for 2008 by site was c. 4 % for the ATFD site and 10% for the AQVib(Ha) site.

Butternut trees will begin reproducing at approximately 20 years of age. We can forecast that on the ATFD site, there will be many trees that survive to this age. Given current rates of cankering on the AQVib(Ha) site and the probable fact that these trees will die within the next 10 years, there will be few if any trees surviving on this site.

Bruce Spanworm and Linden Loopers in Lincoln and Langlade Counties

Bruce spanworms (*Operophtera bruceata*, Figure 12 top) are green inchworms that were eating holes in sugar maple and aspen leaves during the first two weeks of June in southwestern Lincoln and eastern Langlade counties. Occasionally, understory sugar maple leaves were severely damaged.

Linden loopers (*Erannis tiliaria,* Figure 12 bottom) were more abundant the second week of June in the same areas, and they were eating holes in basswood, sugar maple, and bigtooth aspen leaves. Overall, leaf damage was very light in the affected areas.

These two inchworms are immature forms of moths, generally referred to as hunter's moths, which you may have seen in November of 2007 and 2008. Adults of linden loopers and bruce spanworms are gray to brown, quarter-sized nondescript moths fluttering everywhere in the woods in late fall.

Figure 12 . Top: A bruce spanworm blends in while feeding on a sugar maple leaf. Bottom: A linden looper feeding on sugar maple (photos by B. Schwingle).

Eastern Tent Caterpillar - *Malacosoma americanum*

Webs created by the eastern tent caterpillar were common and widely scattered throughout southern and southeast Wisconsin and less common in northeast and northwestern parts of the state. Cherry and other species in the genus *Prunus* are the favored hosts. This native caterpillar is capable of completely defoliating its host in spring; if more than 50% of a tree's leaves are eaten, the tree will likely respond by producing a second flush of leaves later in the season. Though the production of a second set of leaves is a tree's excellent defense mechanism, the process will further stress the trees. In a yard tree setting, it is a good idea to take measures to maintain the overall health of the trees by watering during dry periods, properly mulching, and minimizing injuries on trees trunks, etc.

Infestations are commonly seen on open grown trees and trees on the roadside or along fence rows. The caterpillars hatch when the buds begin to open, and construct a silken tent on a fork of branches. They continue to feed for about six weeks and pupate.
For further information: http://learningstore.uwex.edu/pdf/A2933.pdf

Spring and Early Summer Fungal Leaf Diseases

Cool and wet conditions in the spring created a favorable environment for infection and spread of a group of closely-related fungi that all cause a leaf symptom called anthracnose. Brown and black blotches on broad leaf trees followed in some cases by leaf drop were observed on ash, maple and oak, widespread throughout southern and northcentral Wisconsin (Figure 13).

Figure 13. Anthracnose on silver maple (K. Scanlon).

In the early stages of disease development, leaves appeared water soaked or mottled with light to dark brown or black spots. As infection developed, spots expanded and coalesced. Warm and dry summer weather halted disease development. In most cases, fungal leaf diseases do not seriously affect the health of the trees and control is not necessary.

Greenstriped Mapleworms in Vilas & Oneida County on Red Maples

Greenstriped mapleworms (*Dryocampa rubicund,* Figure 14) defoliated red maples during the month of August in Oneida and Vilas counties and localized areas of Menominee and Shawano counties. This was the second year of red maple defoliation in the Eagle River area, where 320 acres were affected this year. Much of the defoliated area remained green, since the mapleworms only fed on the understory red maple component. These caterpillars are late season defoliators that stress hosts less so than early season defoliators, borers and/or *Armillaria*.

Figure 14. A greenstriped mapleworm larva. Note the horns projecting out behind the orange head on the right (photo by Kerri Ison, UW-Extension).

White Ash Dieback and Mortality – Ash Yellows, Drought, Other Unknown Causes

Dieback and mortality of dominant and co-dominant white ash was investigated on one site in Richland County after foresters reported observing this throughout the county. Affected trees show thin crowns, reduced twig growth, branch dieback and mortality (Figure 15). Some of the affected trees have numerous small holes on the main stem (Figure 16). These holes extended into the wood without feeding galleries and are suspected to be overwintering galleries of the ash bark beetle (see next article). Excavation of the branches exhibiting dieback revealed no galleries of the ash bark beetle, thus, their role in this decline is not considered significant. Root systems of some of the affected trees were excavated for possible root diseases. Roots were clean and moist without any visible discoloration or signs of Armillaria root disease.

Figure 15. An affected tree with a thin crown, reduced twig growth, and branch dieback (K. Scanlon) .

Figure 16. Numerous small holes are revealed when the bark was peeled (K. Scanlon).

Two trees exhibiting dieback were tested for the presence of a phytoplasma that causes ash yellows. One of the samples was positive; this tree's crown was dead with epicormic sprouts on the main stem (Figure 17). This is the first confirmation of ash yellows in Richland County. Ash yellows and low moisture during the growing season are the suspected causes of dieback and mortality of these ash trees.

Figure 17. A tree that was positive for ash yellows. Note epicormic branches (K. Scanlon).

Early Ash Leaf Drop

Several events this spring caused ash around the state to drop leaves and appear thin and sparse. Due to cool spring temperatures, ash trees, which normally leaf out later than most species, leafed out even later than usual. Several mid-May freezes, as well as patchy frost around the state, damaged newly expanding leaves or caused tender leaves to die. Additionally, anthracnose, a fungal leaf disease, is commonly seen when the spring weather is cool and wet as we saw this spring (Figure 18).

Figure 18. Anthracnose on ash leaves (L. Williams).

Leaf damage tends to be more severe on the lower crown if anthracnose is the culprit whereas frost damage will be more severe in the upper portions and the outer edges of the tree. Trees will purge leaves infected with anthracnose early in the year. If a tree drops too many leaves in the spring it will attempt to send out a second set of leaves to sustain it through the summer and we saw this across the state. It did not appear that these trees sustained any long-term health effects.

Ash Bark Beetle Overwintering Gallery

When peeling ash trees searching for emerald ash borer larvae, irregularly shaped circular holes on the bark surface may be observed. These holes are 2-3mm in diameter and are typically found on the main stem of the tree (Figure 19). These holes tunnel through the rough outer bark of the ash tree and end abruptly at the phloem layer. There are no galleries present beyond this short tunnel.

Figure 19. Top: View of overwintering gallery with outer layer of bark removed. Middle: Termination of overwintering gallery in phloem tissue. Bottom: 2-3 mm exit holes on main stem (R. Pinski).

The insect creating these short tunnels is the ash bark beetle (family Scolytidae, *Hylesinus* spp.). There are three species of ash bark beetles commonly found in Wisconsin; eastern (*Hylesinus aculeatus,* Figure 20), northern (*H. criddlei)*, and the white-banded ash bark beetle (*H. fasciatus)*.

Figure 20. Eastern ash bark beetle adult. (photo by J.R. Baker & S.B. Bambara, North Carolina State University, Bugwood.org).

Ash bark beetle adults construct their galleries in the rough outer bark of ash trees in late fall in order to create a protected chamber to spend the winter. Adults emerge from their hibernation chamber the following spring and search for a more suitable site to lay their eggs. Ash bark beetle adults typically excavate their egg galleries in weakened or stressed twigs and branches in the upper crown of ash trees. Removal of bark beetle infested branches will help to prevent the movement of beetles to nearby healthy trees.

White Birch Mortality

Widespread mortality of white birch across the northern portions of the state is due to Bronze Birch Borer, *Agrilus anxius*, attacking these trees that are under drought stress. For the last three summers the northwoods have had summer droughts (Figure 21). This continued stress has allowed our native insect, the Bronze Birch Borer, to start attacking and killing trees. Larvae damage trees by feeding in the cambium layer (Figure 22). Repeated attacks disrupt nutrient and water transport and mortality occurs. These attacks should stop when the trees recover from the current stresses. Unfortunately, the northern portions of the state experienced another droughty period during late summer this year.

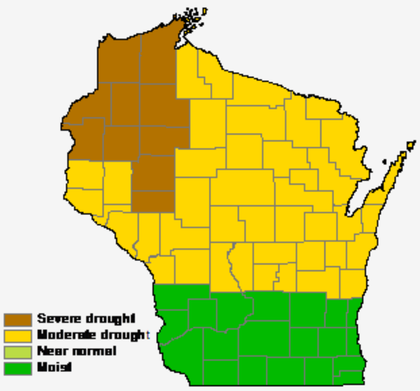


Figure 21. Palmer drought severity index for 2005-2007 growing season (S. Dahir).

Figure 22. Raised galleries apparent under the bark (S. Katovich, USFS).

Ash Yellows

Ash yellows is caused by a phytoplasma, a wall-less bacteria-like microorganism. Symptoms of ash yellows include yellow/subnormal size foliage (Figure 23), slow twig growth, thin crown, branch dieback and vertical cracks on the trunk near the ground, as well as brooms.

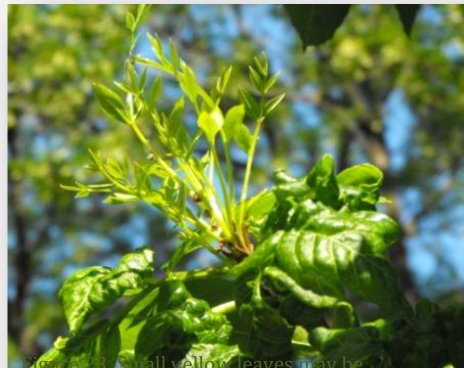


Figure 23. Small yellow leaves may be symptoms of ash yellows (K.Scanlon).

In the summer of 2008, leaf and wood samples were collected at nine sites from trees that were showing dieback. All of the sampled trees were exhibiting crown dieback and epicormic sprouting. Some sampled trees also exhibited yellow/subnormal size leaves, slow twig growth, and/or brooms. Samples were tested by Dr. Glen Stanosz (University of Wisconsin, Department of Plant Pathology) for the presence of phytoplasma using genetic analysis techniques (Polymerase Chain Reaction test).

Based on the symptoms and results of genetic analysis, Pierce, Racine, and Richland counties were added in 2008 as counties confirmed with ash yellows (Figure 24).

In Wisconsin, ash yellows has been found in 23 counties (Brown, Calumet, Chippewa, Columbia, Dane, Dodge, Door, Grant, Jefferson, La Crosse, Manitowoc, Marathon, Milwaukee, Ozaukee, Pierce, Racine, Richland, Rock, Sauk, Shawano, Sheboygan, Taylor, and Waukesha counties).

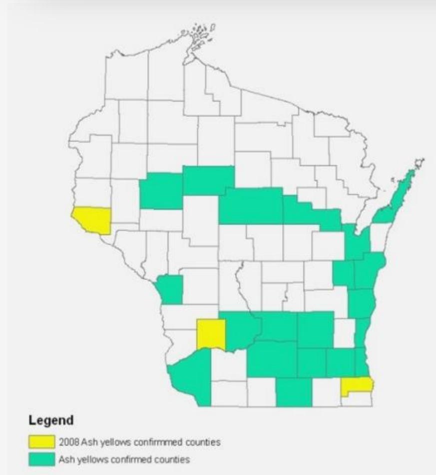


Figure 24. Three new counties were added in 2008.

Pigeon Tremex

Pigeon tremex (Figure 25), *Tremex columba*, sometimes called Pigeon Horntail, is an insect which attacks stressed and dying hardwoods. The last three dry/droughty summers have put some trees under enough stress that pigeon tremex is able to attack them.

Although they prefer to attack maple pigeon tremex is also attacking beech, hickory, and ash in northeastern Wisconsin. Adult females use their ovipositor to deposit eggs under the bark of trees. The female also deposits some fungal spores of the canker rot fungus, *Cerrena unicolor,* to help rot the wood where the larvae will be feeding. Larvae need the canker rot fungus to help decay the wood so that they can eat it. Mature larvae create a tunnel the diameter of a pencil. Larval galleries can be as short as 15mm or as long as two meters! In Wisconsin larvae take two years to complete development. Since pigeon tremex prefer dead, dying, or highly stressed trees, they are usually considered a secondary pest.

Figure 25. Pigeon tremex (L. Williams).

Bronze Birch Borer (*Agrilus anxius*)

Dry conditions during the growing season for three years in a row stressed paper birch throughout northwest Wisconsin (Figure 26). The bronze birch borer is native to Wisconsin. This insect maintains its population by

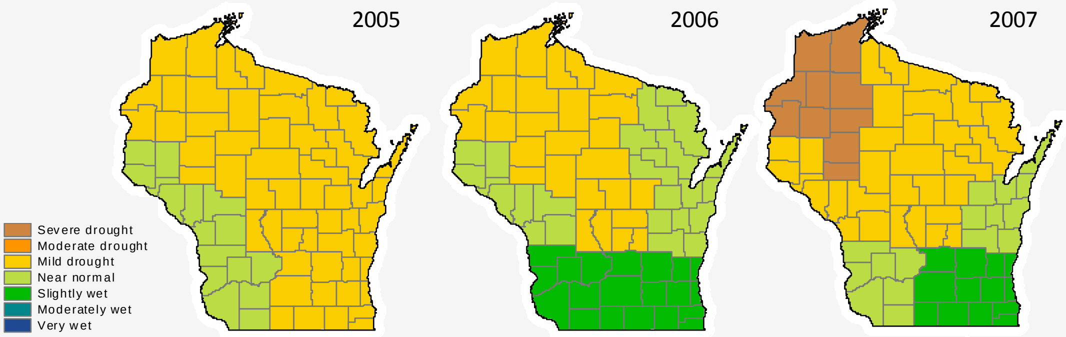


Figure 26. The Palmer Drought Severity Index shows mild drought conditions during the growing season (May, June, and July) in northwestern Wisconsin in 2005 and 2006 and severe drought in 2007 (Sally Dahir).

infesting birches that are weakened or stressed by drought, old age, insect defoliation, soil compaction, or a stem or root injury. Widespread mortality of birch in Wisconsin has occurred following severe drought and was last recorded following the late 1980's - early 1990's drought.

Symptoms of infestation in 2008 included dieback (branch mortality in the upper and outer part of the crown) and mortality of the whole tree. Dieback and mortality was observed on paper birch that were scattered throughout the affected area (Figure 27). Most stands included a mix of paper birch, red maple and northern pin oak; quaking aspen and jack pine were also present in a small proportion of the affected stands.

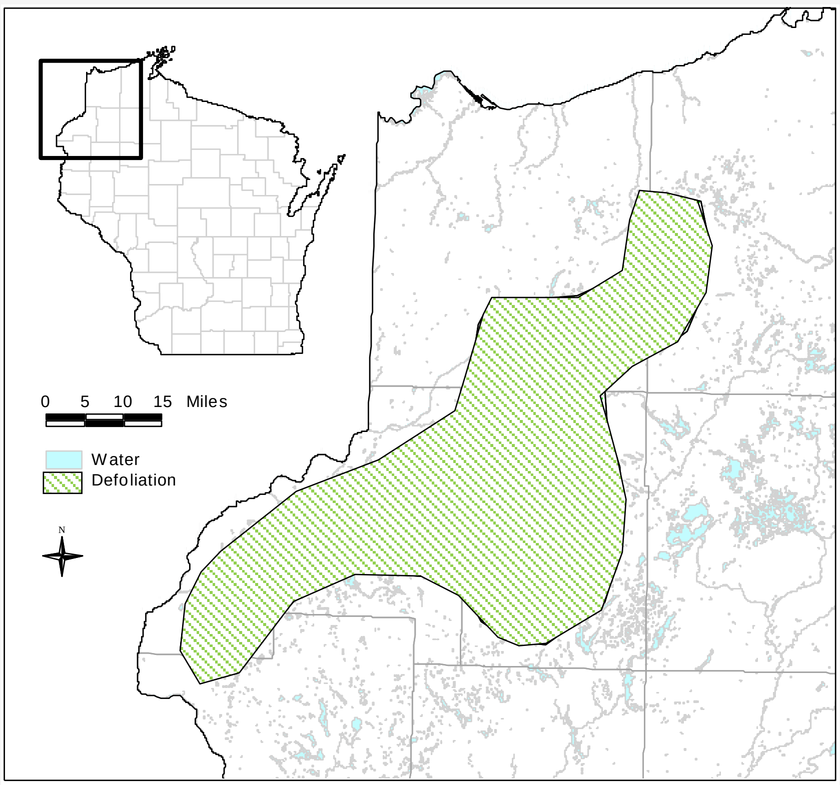


Figure 27. Approximate area of defoliation from the bronze birch borer in 2008 (Sally Dahir).

Trees with crown dieback are expected to die in 2009 if below average rainfall continues in the spring. Symptoms were more common and more severe on sites where sand was a higher component.

Conifer Health Issues

Hemlock Dieback in Northcentral Wisconsin

A more thorough survey of hemlock with dieback was conducted in 2008 after severe dieback of hemlock was noted on 260 acres in northeast Vilas County late in 2007. Hemlocks with dieback of approximately 10% or less of the crown were found in Vilas, Oneida, Forest, Lincoln, and Langlade counties (Figure 1). The percentage of hemlocks showing dieback in the areas surveyed ranged from less than 10% to 70%.

Figure 1. Hemlocks with canopy dieback growing in Oneida County (B. Schwingle).

Hemlocks surveyed were growing in a variety of conditions, ranging from undisturbed forests to recently thinned forests to roadside forests to residential lakeshore properties. No disease signs were present on the root collar areas or the branches of these symptomatic hemlocks, and the only insect signs present were exit holes and feeding galleries in the outer bark of these trees. Since the exit holes and galleries were present in the outer bark, and they were present on trees without dieback, it is unlikely that the causal insect is doing any damage to the hemlocks. Identification of this outer bark inhabitant is pending. One insect that could cause dieback in the canopy is the hemlock looper (*Lambdina fiscellaria*). No larvae of this looper were found in 2008 surveys, nor were any locations with looper feeding damage found.

The dieback in the upper crowns of these hemlocks indicates they are physiologically stressed. Widespread dieback across northern Wisconsin on not only hemlock, but a variety of other species (e.g. oak, birch, maple, aspen, ash), indicates an abiotic factor is causing the dieback, and that factor is likely drought stress given the precipitation in this area over the last few years. Stressed hemlocks do become susceptible to various organisms, such as the hemlock borer (*Melanophila fulvoguttata*).

Hemlock borer was found in 2008 killing hemlocks in scattered locations in Iron County and northern Oneida County. However, the only instances when hemlock borer was infesting more than one hemlock at a given site was when there was a past disturbance, such as installing septic systems next to homes.

Hemlock Looper on Cedar

Northern white cedar in a small localized area of Door County was once again affected by Hemlock Looper (*Lambdina fiscellaria*). The population exploded last year, completely defoliating groups of mature northern white cedar trees. Other trees were partially defoliated, with upper crowns being completely defoliated and lower crowns maintaining some foliage.

Defoliated trees, and the portions of the trees that were completely defoliated last year, did not recover this year and areas of morality were apparent from the air. Hemlock looper is a tiny caterpillar that is a messy feeder, taking bites out of foliage, and then moving on. The partially eaten scales of northern white cedar then turn brown and fall off. Young larvae feed on new foliage; older larvae can feed on older foliage.

Figure 2. Left: Hemlock looper on cedar (L. Williams) Middle: Defoliated hemlock branch (L. Williams) Right: Aerial view of hemlock defoliation (B. McNee).

This insect usually has very localized outbreaks where small patches will be completely defoliated and nearby stands will have minimal damage; this is the case in Door County. Based on population surveys this year, the outbreak appears to be collapsing and only minimal defoliation occurred this year.

Larch Casebearer – *Coleophora laricella*

Approximately 400 acres of tamarack in Lewiston Township, Columbia County, were defoliated by the larch casebearer. New needles were pushing out where we surveyed and no mortality was observed in this area at this time. In addition to larch casebearer, some spidermite webbing and eggs and decay in a few root systems were detected but these issues appeared to be secondary to the casebearer.

For more information on this insect: http://www.na.fs.fed.us/spfo/pubs/fidls/larch/larch.htm

Balsam Fir Tip Dieback - *Delphinella balsamae.*

Necrosis of current year's shoots of balsam fir Christmas trees was observed in plantations and natural stands in Price and Sawyer counties. Konnie Jerabek, a Department of Agriculture, Trade and Consumer Protection survey specialist worked with Dr. Glen Stanosz, Department of Plant Pathology, UW-Madison, to identify a fungus associated with the necrotic shoots as *Delphinella balsamae.*

Figure 3. Balsam fir tip dieback (Konnie Jerabek)

Symptoms included current year's needles turning brown within a few weeks after emerging. On some trees, the youngest foliage remained green while older needles on the current year's shoot turned brown. Affected shoots and needles typically desiccated and fell off by mid-summer. This disease was tentatively identified in 2001 in Dane and Waushara counties.

For more information on this disease:
http://imfc.cfl.scf.rncan.gc.ca/maladie-disease-eng.asp?geID=1000081

Pine Needle Rust

Severe infections of Pine Needle Rust (*Coleosporium asterum*) occurred in Waupaca and Marinette Counties on red pine. Pine needle rust kills older needles on seedlings and younger trees up to the sapling stage, primarily on red pine but also on Scotch and jack pine. The alternate host of this rust disease is Goldenrod and other asters.

Figure 4. Pine needle rust on needles (photo by Linda Williams)

Some of the sites where pine needle rust was severe were new plantings or one year old plantings and it was difficult to find the seedlings amongst all the competition, including the alternate host for this rust disease, goldenrod. Other sites were older (5-8 years old) and damage to old needles was so severe that the plantation had a brownish cast when observed from a distance.

Figure 5. A severely infested seedling, (photo by Ben Baumgart, DNR Forester)

Control is best accomplished by mowing or herbiciding the goldenrod and aster plants in the vicinity. This fungus generally will not kill the tree since it just affects the older foliage and not the new emerging growth but the newly planted trees which were severely affected this year may experience slow growth rates since they had minimal new needles to carry them through after their older needles were infected.

Sawflies

Sawflies were found feeding on many species of trees this year. Some of the most commonly found were European pine sawfly (*Neodiprion sertifer)*, yellowheaded spruce sawfly (*Pikonema alaskensis*, Figure 6), dusky birch sawfly (*Croesus latitarsus)*, and oak slug sawfly *(Caliroa annulipus*).

Figure 6. Yellowheaded spruce sawfly (L. Williams).

Extensive defoliation of young red pine by European pine sawfly (Figure 7) occurred last year in many counties in northeast Wisconsin and populations continued to be high this year throughout the region. Preferred hosts include red, Scotch, Austrian, and mugo pines. Defoliation is limited to the second year needles, but repeated defoliation is putting some young trees under stress.

Figure 7 European pine sawfly (L. Williams).

In Oconto County, the newly expanding needles of young white spruce trees were being fed upon by yellowheaded spruce sawfly which feeds singly on the needles and can cause significant defoliation. All spruce, including Norway spruce, are reported hosts of yellowheaded spruce sawfly and spruce growing in full sunlight are preferred.

Dusky birch sawfly is a native sawfly that was found feeding on birch in Green Lake County. Small trees may be completely defoliated, but damage from this insect is usually minimal as was the case this year.

Oak slug sawfly is a small, slimy-looking sawfly that was found defoliating oak in several counties in northeast Wisconsin. Damage is usually minimal since defoliation occurs late in the year.

Figure 8. Arborvitae sawfly (L. Williams).

A few other sawflies found in 2008 included: Arborvitae sawfly (*Monoctenus melliceps*, Figure 8) feeding on northern white cedar in Door County, elm sawfly (*Cimbex americana)* and willow sawfly (*Nematus ventralis)* which defoliated willow in several counties, and introduced pine sawfly (*Diprion similis*) on white pine.

Mortality of Red Pine in Northern and Northeast Wisconsin

This year several different problems caused decline and mortality in red pine stands in the northeast . *Ips pini* (the pine engraver bark beetle) was found causing mortality on small clusters (typically 5-10 trees) of drought-stressed sapling to sawtimber-sized red pines throughout 2008. Thinning operations between April and August during a very dry 2007 created slash at several of these locations where the bark beetle was able to build up its population, and when the slash was no longer suitable for food, emerging bark beetle adults focused their attacks on the residual stressed pines. At one site, a tree was struck by lightning, which spawned death of surrounding trees due to an *Ips* infestation. Affected areas included eastern Vilas, eastern Oneida, northeast Lincoln, and northeast Florence counties. After pine engraver attack, the upper crown foliage of infested pines suddenly turned orange and upper crown bark fell off before lower foliage completely turned orange and died. Signs of the bark beetle were very small exit holes peppering the bark surface and feeding galleries etched on the inside of the bark and on the sapwood surface. These signs did not appear until the infested tree had been dead for quite some time.

Figure 9. Ips bark beetles killed these red pine saplings in Oneida County. It is rare to see I. pini kill such small red pines, but during extreme drought, it happens (B. Schwingle).

In contrast to the pine death caused purely by the pine engraver bark beetle, the pathogenic root fungus *Leptographium* causes slower host death. Leptographium is a perennial problem, whereas *I. pini* may only affect a given stand during one year. *Leptographium* is reported to be carried to trees by several weevils and bark beetles. Affected areas found this year include western Oneida and northern Lincoln counties. Last year, *Leptographium* was found associated with pine mortality at two sites in Vilas County. *Leptographium*-infested pines display very thin canopies, and their structural roots have black, resin-encrusted bark with discolored sapwood. Plantations affected by *Leptographium* and its associated insect vectors show classic signs of Red Pine Pocket Mortality —pines toward the center of the symptomatic pockets are often dead, and trees radiating out from the center are in various stages of decline. After trees have been stressed by *Leptographium* and its vectors, *Ips pini* and/or *Armillaria* often, but not always, finish off the trees. In contrast to Red Pine Pocket Mortality in southern Wisconsin, Red Pine Pocket Mortality pockets in northern Wisconsin may or may not contain signs of the red turpentine beetle, a vector of *Leptographium*.

Figure 10. Leptographium has infected this red pine's roots in Vilas County. The canopy is still green, but very thin, which is a common symptom of Leptographium (B.Schwingle).

Finally, death caused purely by *Armillaria* root rot was observed in a Forest County red pine plantation of large sawtimber-sized red pines. Two, half-acre sized areas of infected trees were found in this plantation. It is unusual to see *Armillaria* killing many large pines. However, since *Armillaria* is an opportunistic pathogen of drought-stressed pines, the death of these large red pines is a testament to the very dry conditions we have experienced lately in the Northwoods.

An Update of Trapping Red Turpentine Beetles (*Dendrotonus valens*)

The spring of 2008 was the fourth year of trapping red turpentine beetles (*Dendroctonus valens*) in Wisconsin. Our initial hypothesis was that harvest time of year was not correlated with beetle densities during spring flight, comparing stands harvested during the previous summer and fall to stands harvested in the three months preceding spring flight (February, March and April).

Figure 11. Milk jug trap with delta-3-carene lure (S. Dahir).

Traps were devised using milk jugs, a catch jar with insecticide strip, and a pheromone (delta-3-carene) lure (Figure 11). Ten traps were placed on the south or west edge of each stand to attract beetles flying in from other stands. There were basically two categories or regions in which stands were located: 1) Category A: large continuous blocks of red pine in Adams and Wood counties and 2) Category B: isolated red pine stands scattered throughout Adams, Wood, Waushara, Portage, Waupaca and Jackson counties

Results over the four years are shown in Table 1. Season of thinning is the most significant factor with a *p*-value of 0.027. Category is also significant (*p*-value of 0.051). This may be due to the fact that, in Category A, large contiguous blocks of pine are thinned at one time creating a strong attractant for beetles emerging near the harvested area, especially if these harvested areas had high beetle densities the previous year. Stands in Category B, which are mostly isolated, with little red pine and virtually no harvesting activity in the vicinity, may not have a source of beetles within flying distance. This may explain the finding that season of thinning was a stronger factor in Category A than in Category B stands. The acreage of red pine has increased significantly on Category A as seen from satellite imagery (Figure 12).

Table 1. Results of ANOVA comparing beetles densities by season-thinned and region.

Source	Sum-of-Squares	df	Mean-Square	F-ratio	*p*-value
Category	5565.4	1	5565.4	3.926	0.051
Season	7184.8	1	7184.8	5.068	0.027
Category * Season	3754.1	1	3754.01	2.648	0.108
Error	116245.8	82	1417.6		

Season = Spring-thinned vs Summer-thinned

Figure 12. Satellite (Landsat) imagery of Plum Creek lands taken in 1989 (left) and 2001 (right) shows the increase in red pine (shown in red).

In 2009, we will continue trapping *D. valens* in order to determine if numbers continue to rise due to thinning of large blocks of pine. Beetle densities in the last two years were 100% higher than densities in the preceding two-year period regardless of when the stand was thinned during the year. However, for stand thinned in the spring, the increase is 368%.

We will also trap red pine turpentine beetles on privately owned sawtimber red pine. These stands have seen significant mortality and red pine turpentine beetle may be a factor. The dead trees are continually removed throughout the summer creating fresh stumps which may be serving as an attractant to emerging adult beetles. We plan to place traps from April to mid-July in order to monitor the effect of fresh stumps in the summer. Traps will also be placed in control or nonthinned parts of the same stand to determine whether the stumps are serving as the attractant.

Diplodia on Red Pine Seedlings in State Nurseries

Over the last few years, the state nurseries have implemented an aggressive management plan to monitor and control Diplodia shoot blight and canker, caused by the fungus, *Diplodia pinea*. Some evidence suggests the presence of this fungus, coupled with increased seedling stress, could lead to seedling mortality. Recent research revealed that the fungus could persist in or on the seedlings without showing symptoms, and become active once a tree is stressed - primarily from moisture deficit. To limit seedling exposure to the fungus and subsequent infection, nursery staff assisted by pathology staff devised a series of actions: removal of all mature red pine found in and around the nurseries' properties, increased applications of fungicides, and annual testing of nursery stock. These measures have helped limit the exposure and subsequent infection of our red pine.

Since 2006, the state nurseries and Forest Health Protection have tested asymptomatic red pine seedlings for Diplodia infection (for the details of the test, please refer to the Forest Health Conditions of Wisconsin Annual Report 2007, p33). In 2008, the forest health lab processed 750 apparently healthy 2-0 red pine seedlings to detect the presence of the pathogen. Samples were collected from all of the 3 state nurseries (Table 1).

Nursery	Total number of seedlings tested	Total positive for Diplodia infection	% positive for Diplodia infection	% positive for Diplodia infection 2007
Hayward	330	22	6.67%	1.88%
Griffith	330	21	6.36%	8.12%
Wilson	90	0	0.00%	2.96%

Table 1. 2008 Diplodia asymptomatic seedling test of 2-0 red pine seedlings from State Nurseries

No sample from Wilson Nursery was found positive with *D. pinea*. Infection rate continued to decrease in Griffith Nursery. Though there was a slight increase in the asymptomatic infection rate in Hayward Nursery, the infection rate was low in all nurseries and below the 10 percent threshold tolerance level. Sampling of nursery-grown red pine seedlings will continue in 2009 to ensure that only the highest quality seedlings are shipped to their customers.

Red Pine Pocket Mortality Study Update

Fieldwork for the red pine pocket mortality collaborative study with Dr. Ken Raffa, UW-Madison, Department of Entomology, concluded this year after five years of data collection and various side studies. In 2008, we completed trap deployment, biweekly insect collection, initiated a new study and continued evaluating trees for insect damage.

Figure 13. Red pine pocket at Bakkens Pond near Spring Green WI. Rusted tops of 2008 mortality with dense understory filling in (R. Murphy).

In late March, Lindgren funnel traps, jug traps and pitfall traps were again placed in the 31 plots of the study. Biweekly sampling of these traps began in mid-April and concluded in mid-September. Approximately 3,800 trap samples were collected in 2008. Captured insects are currently being identified and tabulated.

In mid-June, we initiated a tick (deer and wood ticks) study with Dr. Susan Paskewitz, UW-Madison, Department of Entomology, to investigate whether the agents responsible for red pine pocket mortality are elevating tick populations in and around the red pine pockets. The study compares tick populations of asymptomatic red pine stands with symptomatic red pine stands. As a pocket develops, understory vegetation, such as blackberry, prickly ash, buckthorn and white pine, fill in the area of red pine mortality, providing a sanctuary for deer and small mammals, which serve as tick vectors. To sample for ticks, a cloth drag was pulled at ground level in 50 meter intervals along the pocket margin and again ten meters outside the pocket's edge. At every 50m we removed our capture and placed the ticks in vials with alcohol. We replicated this sampling in healthy red pine plots. Sampling occurred in the mornings when ticks are most active. Two rounds of sampling of the 31 plots were conducted, once in mid-June and again in mid-August. Figure 14 shows average deer tick captures for the first round of sampling (mid-June) in symptomatic and asymptomatic controls. This simple breakdown shows deer tick numbers are more prevalent in areas of decline versus healthy stands. A UW-Eau Claire student is currently tabulating the second round of sampling and will provide further analysis.

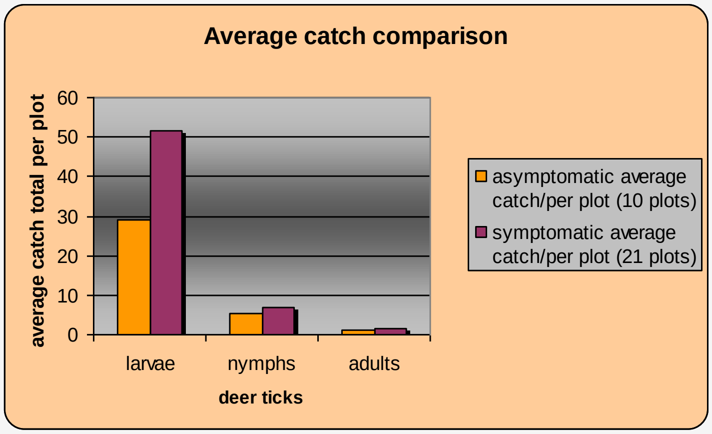


Figure 14. Average deer tick captures in symptomatic and asymptomatic areas (R. Murphy).

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We are currently in the process of finishing tree evaluations and plot clean-up. Statisticians from the University of Wisconsin-Madison and the University of Northern British Columbia will now analyze the vast data compiled over the past five years.

We would like to thank the landowners and land managers who allowed us access to their red pine stands. Thanks to all those who helped with the various studies over the past five years.

Jack Pine Budworm – *Choristoneura pinus*

Statewide, surveys indicate populations of the jack pine budworm are declining in most locations but are still causing detectable defoliation in a few locations on red and jack pine.

Figure. 15. Red pine in Oneida County with a thin crown from partial defoliation by the jack pine budworm. Note the neighboring pines are not defoliated as badly (B. Schwingle).

Jack pine budworm on jack pine

Vilas and Oneida counties

Vilas County forestry staff and DNR Oneida/Vilas forestry staff surveyed 27 Vilas County jack pine stands for early instar larvae in early summer of 2008. Only 4% of those stands yielded high numbers. Several Vilas County Forest stands were surveyed for late instar larvae, of which none yielded numbers suggesting there would be severe defoliation. Last year, Vilas County did survey some stands where late larval instar surveys predicated defoliation to be severe, so populations on that county forest did decline from 2007 to 2008. Northern Highland American Legion staff sampled late jack pine budworm instar populations on that state forest, and they found that, on average, their populations decreased nearly 90% from 2007 levels.

Polk, Burnett, Washburn, Douglas, Bayfield and Sawyer counties

A significant decline in the population of jack pine budworm was detected in these counties in 2008 with the exception of Douglas and Bayfield counties, where moderate to high populations could cause defoliation in 2009

Table 2. Number of acres of jack pine defoliated by the jack pine budworm in northwest Wisconsin, 2006 to 2008.

	Acres defoliated		
County	**2006**	**2007**	**2008**
Polk	7,400	0	0
Burnett	19,000	1,800	0
Washburn	22,800	0	500
Douglas	25,700	20,700	2,200
Bayfield	32,600	26,400	0
Sawyer	3,200	0	0
Total acres	**110,700**	**48,900**	**2,700**

(Figure 16 next page). Overall, approximately 2,700 acres were defoliated in northwest WI in 2008 versus 49,000 in 2007 (Table 2) . This significant change in the number of acres defoliated was due in part to the caterpillars completing their development on current-year's foliage only and not feeding on older foliage.

West central Wisconsin

Early or late larval and/or egg mass surveys were conducted in Adams, Clark, Dunn, Eau Claire, Jackson, Juneau, Monroe, Pierce, Portage, St. Croix and Wood counties. Survey results indicate declining populations of jack pine budworm in Adams, Clark, Dunn, Eau Claire, Juneau, Monroe, Portage, St. Croix and Wood counties. Scattered sites in Jackson and Pierce county may experience moderate to high defoliation in 2009.

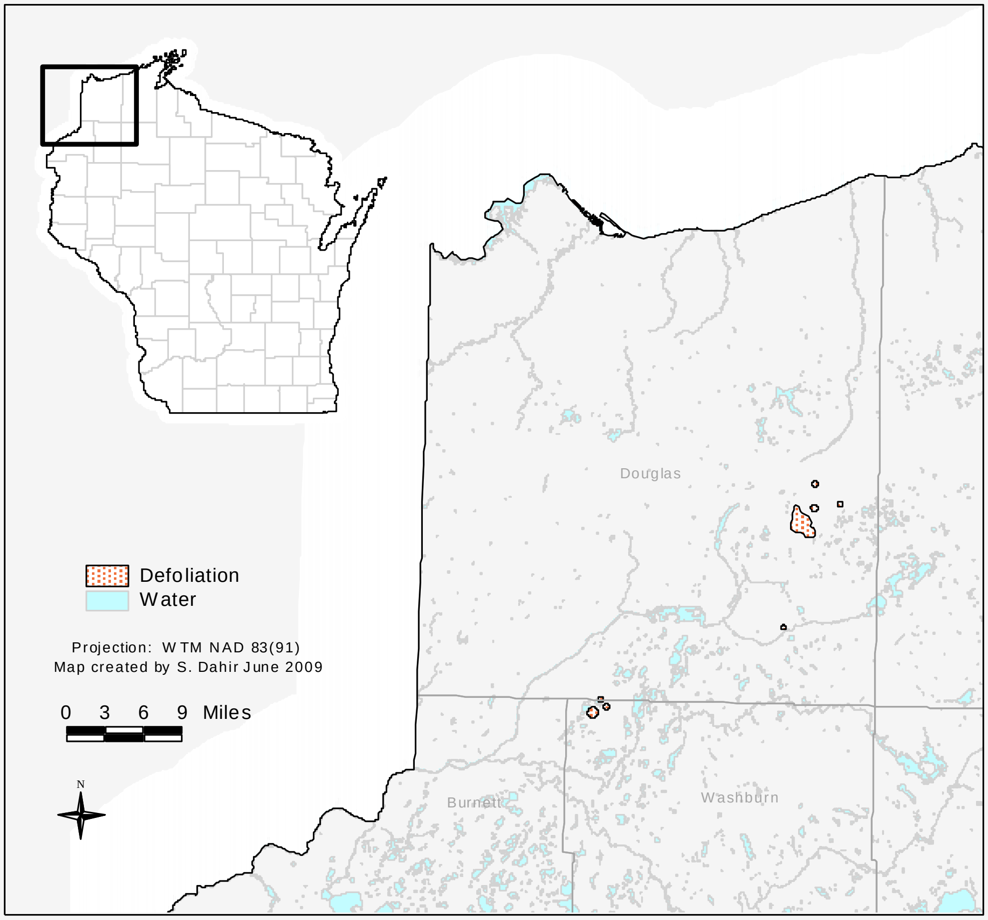

Figure 16. Jack pine budworm defoliated 2,700 acres in Douglas and Washburn counties in 2008 (S. Dahir.

Jack pine budworm on red pine

Several plantations containing pole to large sawtimber-sized red pines did undergo light to moderate defoliation by jack pine budworm in western Oneida and Vilas counties in 2007. In 2008, those red pine plantations did not seem to contain trees that were damaged further. However, a plantation containing sawtimber-sized red pines was partially defoliated in 2008 and reported for the first time. This stand is located in northwestern Oneida County. Roughly, between 5 and 15% of the red pines in that stand were severely defoliated by the budworm and those were scattered. Defoliation was most severe at the base of the canopy where male cones tend to develop. This tendency towards focusing attacks on isolated, large red pines seems to be the typical defoliation pattern of jack pine budworm in sawtimber-sized red pines, and it could be caused by individual trees producing heavier male cone crops than their neighbors, due to various conditions. Male cones are a nutrient-rich food source for robust larval development.

In west central Wisconsin, budworm populations remain at high levels in unthinned 20-30-year-old red pine stands. In red pine stands of the same age and population levels, budworm numbers dropped significantly or disappeared from 2007 to 2008 after the stands were thinned. Observations on the effectiveness of thinning in reducing budworm populations will continue in 2009.

Jack Pine Budworm Survey: Procedures and Results 2008

Early Larval Survey

This survey is done on a yearly basis and is a key indicator of the presence of destructive budworm populations. Thirty shoots and staminate flowers that can be reached from the ground are checked for larvae. Since staminate flowers are often scarce, a majority of shoots are usually used. A high plot, considered sufficient to cause moderate to severe defoliation, is defined as any plot with a count of 10 or more infested shoots and flowers.

Early larval populations: 2008

County	Number of plots	Number infected shoots	Infected shoots/plot	Number high* plots	Percent high plots
Polk	15	4	0.27	0	0
Burnett	24	34	1.42	0	0
Washburn	21	44	2.10	0	0
Douglas	54	257	4.76	8	14.8
Bayfield	32	230	7.19	9	28.1
District	146	569	3.90	17	11.6

*High plots are defined as any one plot which contains 10 or more infested shoots or flowers.

Early larval population trend: 2008

	Number of infested shoots per plot						Percent high plots				
County	**2004**	**2005**	**2006**	**2007**	**2008**	**Change 2006-2007**	**2004**	**2005**	**2006**	**2007**	**2008**
Polk	0.93	3.87	7.53	3.33	0.27	**-92%**	0.0	6.7	26.7	6.7	0
Burnett	0.67	5.08	6.42	4.75	1.42	**-70%**	0.0	25.0	25.0	16.7	0
Washburn	0.86	9.14	8.14	2.95	2.10	**-29%**	0.0	52.4	38.1	0	0
Douglas	1.78	11.39	8.63	5.24	4.76	**-9%**	0.0	53.7	38.9	20.4	14.8
Bayfield	2.25	16.38	12.50	11.34	7.19	**-37%**	0.0	78.1	68.8	68.8	28.1
District	1.48	10.35	8.93	5.97	3.90	**-35%**	0.0	49.3	41.8	26.0	11.6

Pupal Survey

This survey is also conducted annually and gives a good indication of the kinds and numbers of pupal parasites in the population as well as next year's population of jack pine budworm. It is done in July when most insects are in the pupal stage. Some adults may already have emerged, but empty pupal cases are collected and counted as emerged moths. At each stop, pupae are collected on a time basis. If five pupae are not found in five minutes, the collection is terminated. If five pupae are found in five minutes or less, the collection is continued until 25 pupae are found or until 15 minutes have elapsed. The time required to find 25 pupae is then recorded. Adults, parasites and non-emergence are recorded for each pupae.

Pupal survey: 2007

				Moths		Parasites		Not emerged	
County	**Total Pupae**	**Total Minutes**	**Pupae/ Min**	**No.**	**Percent**	**No.**	**Percent**	**No.**	**Percent**
Polk	2	75	0.03	1	50.0	1	50.0	0	0
Burnett	67	150	0.45	46	68.7	17	25.4	4	5.9
Washburn	72	131	0.55	32	44.4	28	38.9	12	16.7
Douglas	435	413	1.05	264	60.7	133	30.6	38	8.7
Bayfield	335	267	1.25	214	63.9	94	28,1	27	8,0
District	911	1,036	0.88	557	61.1	273	30.0	81	8.9

Pupal population trends: 2008

County	**2005 Pupae/min**	**2006 Pupae/min**	**2007 Pupae/min**	**2008 Pupae/min**	**Percent change 2007-2008**
Polk	1.34	1.28	0.12	0.03	-75.0
Burnet	1.26	1.73	0.75	0.45	-40.0
Washburn	2.28	1.56	0.72	0.55	-23.6
Douglas	2.21	1.63	1.14	1.05	-7.9
Bayfield	2.41	2.08	1.74	1.25	-28.2
District	**2.06**	**1.71**	**1.12**	**0.88**	**-21.4**

Parasite and Predator Complex This survey involves a careful examination of all the budworm pupae collected which do not produce moths. Adult specimens are compared to a reference collection. Any unknown adults are sent to UW Madison for identification. Pupal cases from which nothing emerges are dissected to determine the cause of failure.

Parasites and Predators: 2008

Parasite/ Predators	Polk	Burnett	Washburn	Douglas	Bayfield	Total	Percent of Parasitized	Percent of Total
Itoplectes	1	7	18	29	16	71	26.0	7.8
Scambus	0	0	1	7	4	12	4.4	1.3
Phaogenes	0	3	3	9	12	27	9.9	3.0
Pteromalids	0	0	0	13	12	25	9.2	2.7
Tachinids	0	3	4	25	15	47	17.2	5.2
Brachmeria	0	1	0	0	0	1	0.4	0.1
Predators	0	3	2	50	35	90	32.9	9.9
Total	**1**	**17**	**28**	**133**	**94**	**273**	**100**	**30.0**

Annosum Surveys

County Survey

A survey of Wisconsin's counties was initiated in 2007 to document the extent of infection with *Heterobasidium annosum* (see Forest Health Conditions of Wisconsin: Annual Report 2007). As of that time, there were 15 counties in which annosum had been confirmed. Initially, we ranked the 57 remaining counties as to risk for annosum based on proximity to positive counties and acreage of red pine in the county. Counties were classified in one of four categories (Figure 17): 1) annosum confirmed, 2) high risk, to be surveyed in 2007, 3) moderate risk, to be surveyed in 2008 and 3) low risk, to be surveyed in 2009 or 2010.

In the fall of 2007, we contacted DNR foresters in 12 counties in the second category to determine sites for sampling. Each site was surveyed for visible conks and samples were taken from decayed wood. These samples were examined visually and plated on agar. As reported last year, three new counties were confirmed positive for annosum at that time: Portage, Juneau and Wood counties.

Nineteen more counties were surveyed in October, 2008. Most of these counties, however, had either no reported acreage in red pine, or small stands which had no problems with pine mortality. Twenty sites were visited and sampled. None of these stands had visible conks and we do not as yet have the results of laboratory analysis.

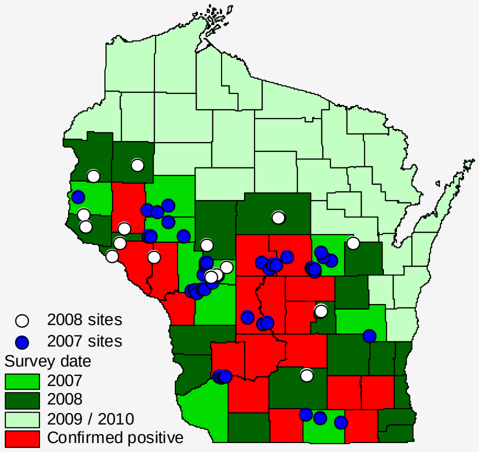

Figure 17. Counties with confirmed annosum, survey year for counties without confirmed annosum and sites already surveyed in 2007 and 2008 (S. Dahir).

Annosum Regeneration Survey

A second project was initiated in May 2008 to determine the survival outcome for regeneration in six stands infected with annosum (Figure 18a). Four to five plots were established within annosum infection centers in each stand. All saplings were tagged and surveyed for conks within a five-meter permanent plot. All seedlings were flagged and tallied by species within one to two meter subplots (Figure 18b).

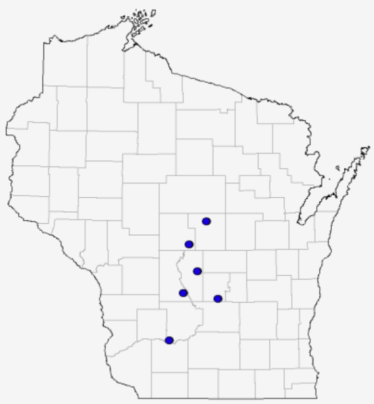

Figure 18. a. Location of annosum regeneration plots. b. Seedlings were flagged within 1-2 meter subplots (graphics by S. Dahir).

Plots will be revisited each year for five years to determine which species survive and which are infected with annosum.

Jack Pine Gall Rust Surveys in Wisconsin State Nurseries 2008

Introduction

Gall rust is found on various species of pines, but especially common on jack pine in Wisconsin. Infected pines will have swollen, woody, round galls on stems and branches. Infections on stems slow growth and could cause mortality. Infection on branches causes branch death. Young seedlings are often girdled and killed rather quickly (Anderson, 1963). Galled trees are also subject to stem break off. Gall rust can be a serious problem in nurseries, plantations, and natural stands. In nurseries, losses frequently exceed 25 percent (Anderson, 1963). Galls that form on the main stems of seedlings usually lead to mortality within 4 years.

Pine gall rust is caused by the fungus. There are two fungal species that cause gall rust on jack pine in Wisconsin. One is the eastern gall rust or pine oak gall rust, caused by the fungus, *Cronartium quercuum*. This fungus requires oak as an alternate host to complete its life cycle. The other is the western gall rust or pine-pine gall rust, caused by the fungus, *Peridermium harknessii*. This fungus does not require an alternate host to complete its life cycle. Both fungi create galls of the similar shape, and these two fungi cannot be distinguished by the size, shape, or location of the galls (Sinclair and Lyon, 2005). Microscopic examination is needed to differentiate the two fungi (Anderson and French, 1964). Based on the survey that was conducted in Wisconsin in 1963 and 1964, pine-oak gall rust was distributed throughout the natural range of jack pine and pine-pine gall rust was found in limited areas in the north central Wisconsin (Anderson, 1965).

Though the incidence of gall rusts on jack pine seedlings was considered very low at Wilson and Hayward Nurseries, and it was estimated average 3-5% of total jack pine seedlings at Griffith Nursery, systematic surveys of the actual occurrence of the disease in the state nurseries was not conducted in recent years. A systematic survey of gall rusts on jack pine in the state nurseries will provide us with a clear picture of the current situation of this disease in the nurseries. Swellings or galls appear on seedlings near the end of the first or during the second growing season following infection (Anderson, 1963). Investigation on the rate of latent symptom development of asymptomatic seedlings at the time of shipping is also needed in order to capture the total infection rate.

The objectives of the surveys were; 1: to quantify the incidence of symptomatic seedlings of jack pine gall rust in state nurseries at the time of lifting; 2: to quantify the incidence of gall/swelling development of healthy-looking seedlings over time and 3: to quantify the growth of galls and their effect on seedling health.

Materials and Methods

1. Visual inspection of gall formation on 2-0 jack pine seedlings

In 2008, approximately 1000 seedlings were randomly selected in a way that would be a good representative of the entire 2-0 stock in the nursery at the time of lifting in the spring. Each seedling was thoroughly examined for the presence of swelling/galls. The number of galls per seedling and the locations of galls were also recorded.

This survey was conducted in Hayward and Griffith Nurseries. Since Wilson Nursery only carried 1-0 jack pine seedlings, this survey was not conducted in Wilson Nursery. It was considered that 1-0 seedlings may not exhibit symptoms even if they are infected.

2. Outplanting of apparently healthy seedlings to monitor the development of galls/swellings

Apparently healthy seedlings were planted in a nursery property in the spring 2008. In Wilson nursery, 70 1-0 seedlings were outplanted in the nursery property where irrigation system was available and 100 seedlings were planted in a grassy area without irrigation on April 10, 2008. In Griffith nursery, 100 2-0 seedlings were planted in an irrigated bed and another 100 seedlings were planted in an non-irrigated bed on April 28, 2008. In Hayward nursery, 100 2-0 seedlings were planted in an irrigated bed and another 100 seedlings were planted in an non-irrigated bed on May 12, 2008. The purpose of the use of irrigation was to maximize the survival rate by eliminating water deficiency as a potential factor for seedling mortality. Planting in a non-irrigated site was considered to represent a situation similar to normal planting in the field for reforestation. Herbicides were used in non-irrigated sites to reduce grass competition. Each seedling was examined in the fall for the development of galls/swellings.

3. Potting of galled seedlings to monitor the growth of galls/swellings

One hundred 2-0 jack pine seedlings that contained at least one gall were selected at the time of lifting in Griffith nursery. Seven galled seedlings were also brought back from Hayward Nursery. These galled seedlings were transplanted in a pot on May 8, 2008, and placed outside to monitor the further growth of galls and the health status of galled seedlings. Twelve healthy-looking seedlings from Hayward Nursery were planted in a pot as a control. The size and location of each gall was recorded at the time of planting. Each seedling was examined and the size of each gall was measured and recorded on November 5, 2008.

Results

1. Visual inspection of gall formation on 2-0 jack pine seedlings

In Hayward nursery, out of the 1010 seedlings examined, 7 galls exhibited discrete swelling or gall. The percent infection rate was 0.7%. All of the 7 galled seedlings contained only one gall per seedling. 6 out of 7 seedlings had a gall or swelling on a main stem. One seedling had a branch gall. In Griffith nursery, out of 1117 seedlings, 81 seedlings had at least one visible gall or swelling. The percent infection rate was 7.3%. 74 seedlings contained only one gall (91.4%) whereas 7 seedlings had 2 galls per seedling.

2. Outplanting of apparently healthy seedlings to monitor the development of galls/swellings

In Hayward nursery, all out-planted seedlings were examined on October 28, 2008. As many as 20 seedlings died in an irrigated bed, and 49 seedlings died in a non-irrigated bed during the summer. One possible reason for a high level of mortality in a non-irrigated bed was a mower oil spill while maintaining the bed. Planting was performed on a sunny day in mid-May. Planting late in the spring and weather conditions during planting may have contributed to poor survival rate of out-planted seedlings in Hayward Nursery. However, no galls were detected on either live or dead seedlings.

Figure 19: A large gall on a main stem that was developed during the summer of 2008 in Griffith Nursery (K. Scanlon)

In Wilson nursery, there was no mortality in an irrigated bed. Twenty-two seedlings were found dead in a non-irrigated bed. Although a herbicide was applied to suppress grass competition in the non-irrigated bed, it was suspected that the application was not enough or was not timed correctly for the maximum effectiveness. No galls were found on any of the seedlings in Wilson Nursery.

In Griffith Nursery, 5 seedlings died in an irrigated bed, and another 1 seedling was dead in a non-irrigated bed. In an irrigated bed, 5 seedlings developed discrete galls (Figure 19). Four out of 5 galled seedlings appeared healthy, though one galled seedling was dead. In a non-irrigated bed, 8 seedlings had galls or swelling. All of the galled seedlings were healthy. Out of 13 galled seedlings, 10 seedlings contained only one gall. There were 2 seedlings that had 2 galls. In both seedlings, one was on the main stem and the other was on a side branch. There was one seedling that contained 4 galls next to each other on a main stem. Seven seedlings had a gall or galls on a current-year growth, and 6 seedlings contained a gall on a first or second-year growth.

Nursery	Seedling	Total no. of seeding in irrigated bed	Total no. of seedlings with galls in irrigated bed	Total no. of seeding in non-irrigated bed	Total no. of seedlings with galls in non-irrigated bed
Hayward	2-0	100	0 (0%)	100	0 (0%)
Griffith	2-0	100	5 (5%)	100	8 (8%)
Wilson	1-0	70	0 (0%)	100	0 (0%)

Table 1: The number of seedlings that developed galls during the summer 2008

3. Potting of galled seedlings to monitor the growth of galls/swellings
Approximately 1/3 of the potted galled seedlings died in 2008. Half of the healthy seedlings (control) also died. The size of a gall was interpreted as gall radius by subtracting the diameter of a seedling from the horizontal diameter of a gall. The rate of growth was calculated by subtracting gall radius in November from gall radius in May. Approximately ¼ of existing galls shrunk over the summer (Figure 20). Many of the galls that shrunk were on dead tissues. Dead tissues mean that either the entire seedling was dead or a localized

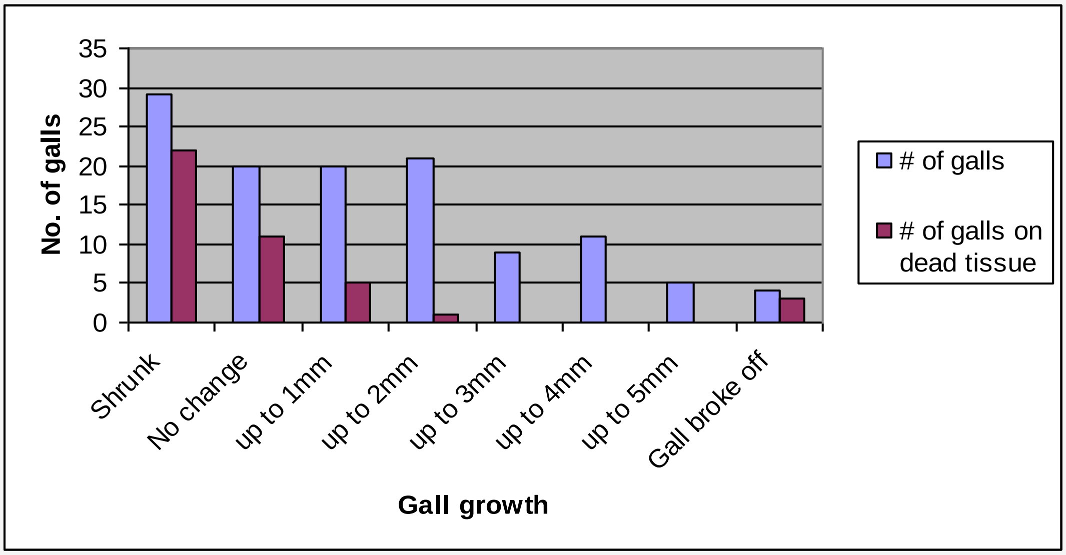

Figure 20: The change in the size of galls on 2-0 seedlings over the summer 2008

area where a gall existed was dead. It is suspected that shrinking of most of the galls occurred due to the drying of the wood tissue where the galls resided. The rate of gall growth varied from shrunk to up to 5mm of gall radial growth. Among the galls that grew on live seedlings, the average rate of gall radial growth was 2.2mm.

Discussion and plans for 2009

As it was expected by the nursery manager, the incidence of galls on 2-0 jack pine seedlings at the time of lifting was very low (0.7%) in Hayward Nursery. In Griffith Nursery, the gall incidence was a little higher (7.3%) than previously estimated (3-5%). It is suspected that abundance of jack pine and black oak in the vicinity of Griffith Nursery contributed to the higher incidence rate of jack pine gall rust in Griffith Nursery, compared to Hayward Nursery. Although the incidence rate in Griffith Nursery was over 5%, it is believed that the number of seedlings with visible galls that were shipped and planted would be less than it was recorded in this study. All nurseries examine jack pine seedlings for the existence of galls prior to shipping for graded stocks. Symptomatic seedlings are culled without being shipped for graded stocks. For bulk orders, nurseries include an information sheet with sorting guidelines and encourage landowners to remove galled trees before planting. Thus, the number of galled seedlings that are shipped and out-planted should be less than the incidence rate in this study. Since the infection rate may vary year to year depending on the weather conditions, visual inspection of galls on jack pine seedlings will be conducted again at the time of lifting in the spring of 2009.

It was noteworthy to find additional gall development on 6.5% of out-planted seedlings in Griffith Nursery. There are two scenarios for the additional gall development. First explanation is that the seedlings were infected with the fungus in 2007, but swelling/gall development did not occur until the summer of 2008. The second scenario is that the seedlings were exposed to additional inoculum during the summer of 2008, and galls started to become visible by the fall of 2008. In order to distinguish the two scenarios, in 2009, it is planned that 100 healthy-looking jack pine seedlings from Griffith Nursery will be planted in a pot and placed in a greenhouse for the summer of 2009 to avoid exposures to additional inoculum. All of the out-planted seedlings will be monitored for one more year in 2009 for gall growth and additional gall development.

Although there was a high mortality on potted galled seedlings, it is unlikely that the mortality was caused by the galls. It is suspected that the soil mixture was too heavy for jack pine. The live seedlings will continue to be monitored for 2009. Additional galled seedlings will be planted in a pot with lighter soil mixture in 2009, and gall growth will be monitored. It is expected that some of the galls on potted seedlings will be ready to sporulate by the spring of 2009. If sporulation occurs, we plan to conduct a lab test to identify the causal fungus.

Acknowledgements

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Fungicide efficacy test to prevent Annosum Root Rot in Wisconsin

Introduction

Annosum root rot, caused by the fungus, Heterobasidion annosum, is considered among the most important and destructive diseases affecting conifers in the north temperate regions of the world. The disease was first identified in Wisconsin in 1993, and is currently confirmed in 18 central and southern counties.

Once the disease exists in a stand, it is very difficult to control it. Prevention of this disease is the best approach. Fresh cut stumps can be treated with fungicides to prevent Annosum root rot. Fungicides will help prevent new infections, but will not stop the growth of the pathogen if the stump is already infected. Fresh cut stumps must be treated as soon as possible after cutting and no later than one day after cutting. This treatment is currently recommended throughout the state of Wisconsin.

Two products are currently registered and labeled as a fungicide to prevent Annosum root rot in Wisconsin. Sporax (sodium tetraborate decahydrate, manufactured by Wilbur-Ellis Company) is granular and can be applied using a salt-shaker style container or a special dispensing unit made of a PVC pipe and a plastic nozzle. Cellu-Treat (disodium octaborate tetrahydrate, manufactured by Nisus Corporation) is a water-soluble powder and can be applied using a backpack sprayer or an attachment to a harvester.

The efficacy of the two chemicals in preventing the disease has been well documented (Pratt, 1996; Woodward *et al.*, 1998). However no efficacy study was conducted in Wisconsin, using a local isolate of *H. annosum*. The objective of this study was to evaluate the efficacy of the two chemicals that are currently recommended for use as a fungicide to prevent Annosum root rot in Wisconsin, using a fungus isolated in Wisconsin.

Materials and Methods

Wood materials were obtained from sawlog-size red pine trees in Menominee Forest, Wisconsin in August, 2008. Annosum root rot has not been found in Menominee County (as of Jan 2009). Wood cookies (cross-cut section of wood) that were approximately 2-inches thick were made from the base of five trees, using a chainsaw. Five cookies were sliced from each of the 5 trees, totaling 25 cookies. Each wood cookie was cut in half, creating 50 half cookies.

The pathogen that was used in this study was isolated from an infected red pine seedling in Wild Rose, WI. The site was confirmed with the disease in 2005, and 5 pocket centers were recorded based on the follow-up survey of a 54-acre red pine plantation. Pure culture of the isolate was made on PDA (Potato Dextrose Agar). Three-week-old culture plates were flooded with sterile distilled water, and the surface was scraped with an inoculating loop to make a conidial suspension for inoculation.
Two chemicals were tested in this study. One was a granular material, Sporax, using a salt shaker like dispenser with a long PVC handle (Figure 21a). The other was a water soluble material, Cellu-Treat. This

Figure 21a. Granular Sporax was applied to half cookies using a salt shaker-like dispenser with a long PVC handle
Figure 21b. Water-soluble Cellu-Treat was applied to half cookies using a backpack sprayer (Graphics by K. Scanlon)..

material readily dissolves in water. One pound of Cellu-Treat was mixed in 2 gallons of water and the solution was applied using a backpack sprayer (Figure 21b). Both chemicals are registered in Wisconsin and labeled for use as a fungicide to prevent Annosum root rot.

The half cookies were randomized and 15 half cookies were applied with Sporax, and another 15 half cookies were applied with Cellu-Treat in the field. The edge of each cookie was painted either orange or blue to identify the treatment method. The amount of chemicals applied on each cookie was the same as a forester usually applies to a stump for this type of treatment. Twenty cookies were not treated with either chemical to be used as control.

All of the cookies were taken back to the lab, and 45 wood cookies were sprayed with *H. annosum* conidial solution the next day, approximately 24 hours after the fungicide treatment in the field. The solution was applied in a way the entire surface was evenly and sufficiently wetted. Three days after the pathogen solution was sprayed, 12 small wood chips were aseptically removed from each cookie and cultured on each of the 2 selective media - OPP and PPP media (Worrall, 1991) in an attempt to re-isolate the pathogen.

Results

The pathogen was re-isolated from 60% of the cookies when no fungicide was applied (Table-1). No pathogen was isolated form negative control cookies (no artificial pathogen application). Out of the 15 cookies, no cookies that were treated with Sporax and the pathogen yielded the pathogen. Two out of the 15 samples that were treated with Cellu-Treat and the pathogen yielded the pathogen. The reduction in pathogen re-isolation was 100% with Sporax, and 78% with Cellu-Treat.

Treatment	No. of cookies	No. of cookies with pathogen isolated	% of pathogen isolation
No pathogen	5	0	0%
Pathogen only	15	9	60%
Pathogen + Sporax	15	0	0%
Pathogen + Cellu-Treat	15	2	13%

Table-1: Number of cookies where H. annosum was re-isolated.

Discussion

According to the literature review that included 85 reports of chemical efficacy experiments to prevent Annosum root rot, evaluation of infection was most commonly achieved by incubation of discs cut from the stumps (Pratt, 1996), similar to this study. A major difference was an interval between pathogen inoculation and extraction of wood material for assessment. In the review, the interval was anywhere from 7 weeks to over a year. In this study, the wood chips were removed 3 days after the pathogen inoculation. Based on the summary in the review, the mean incidence of infection of Borax (Powder) was 10% on treated stumps versus 60% on untreated stumps (number of experiments:22). When the liquid form of disodium octaborate was used, mean incidence of infection was 19% on treated stumps versus 52% on untreated stumps (number of experiments:34). The average infection rates were comparable to the results of this study despite the variance in experiment methods used to test the efficacy. The method used in this study may have a potential to test efficacy of the two fungicides against specific pathogen isolates effectively and much more quickly than traditionally used methods. Literature suggests that there is variability in the efficacy of the borate chemicals among host species. For example, chemicals appear to be more effective on pine than other conifers due to resin production and the abundance in areas with less rainfall (Pratt, 1996). Evaluation of fungicide efficacy on various conifer species other than red pine, using local *H. annosum* isolates in Wisconsin should be conducted.

This study confirmed that sodium tetraborate decahydrate (Trade name: Sporax) and disodium octaborate tetrahydrate (Trade name: Cellu-Treat) are effective to a local *H. annosum* isolate from Wisconsin when the appropriate application technique is used. If funding becomes available, this test should be repeated with other isolates of H. annosum that were collected from a wide geographic range within Wisconsin and with different conifer host species. It would be interesting to test different isolation intervals to evaluate the effect of incubation periods on the rate of re-isolation from wood.

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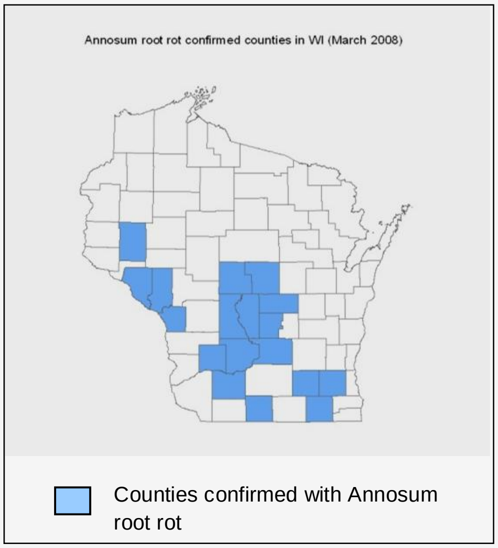

Introduction

Annosum root rot, caused by the fungus, *Heterobasidion annosum*, is considered among the most important and destructive diseases affecting conifers in the north temperate regions of the world. The disease was first identified in Wisconsin in 1993, and is currently confirmed in 18 central and southern counties (see map). Over 200 woody species have been reported as hosts. However, in Wisconsin, red and white pine trees are most commonly found infected with this disease particularly in plantation-grown stands subjected to thinning. Infected trees will show thin crown, yellowing or browning foliage, and eventually die. Infection on understory seedlings and saplings is also common.

The majority of infection in a plantation occurs when basidiospores land on a fresh cut stump created by thinning. Spores are most often produced when the temperature is between 41º - 90º F and can be carried in the wind over hundreds of miles, though most spores are deposited within 300 feet. The fungus colonizes the stump tissue, moves into the root tissue and progresses from tree to tree via root contact at the rate of approximately 3.2- 6.5 feet per year. Due to the underground spread through root contact, a pocket of dead trees infected with the disease continues to expand over the years. Infection through root and lower stem wounds can also occur, though it is considered a minor factor at this point.

Once the disease exists in a stand, it is very difficult to control it. Prevention of this disease is the best approach. Fresh cut stumps can be treated with fungicides to prevent Annosum root rot. Fungicides will help prevent new infections, but will not stop the growth of the pathogen if the stump is already infected.

Fresh cut stumps must be treated as soon as possible after cutting and no later than one day after cutting. This treatment is currently recommended throughout the state of Wisconsin.

Two products are currently registered and labeled as a fungicide to prevent Annosum root rot in Wisconsin. Sporax (sodium tetraborate decahydrate, manufactured by Wilbur-Ellis Company) is granular and can be applied using a salt-shaker style container or a special dispensing unit made of a PVC pipe and a plastic nozzle. Cellu-Treat (disodium octaborate tetrahydrate, manufactured by Nisus Corporation) is a water-soluble powder and can be applied using a backpack sprayer or an attachment to a harvester.

As awareness of this disease increases among forestry communities, more landowners and foresters have been considering the use of fungicides to protect fresh cut stumps from being infected with *H. annosum*. When such a treatment is considered, cost-benefit assessment is needed to justify the cost of fungicide application, including the cost of materials and labor.

Approach

The process for the analysis would be roughly divided into three steps. Some are easier to quantify than others. The first step is to calculate the cost of application, for example, to treat one acre of a red pine plantation. The second step is to calculate the loss in timber sale value by including a fungicide application into a timber sale prospectus. This was originally planned to be accomplished by comparing timber sale bidding results that included fungicide application with similar timber sales that did not include fungicide application. Unfortunately, there has not been a timber sale that did not include the treatment, near the areas where timber sales included fungicide applications. However, several DNR foresters stated that they felt that neither the number of bids nor bidding price was compromised by adding the treatment to their timber sale prospectus.

The third step would be calculating the loss in timber value due to Annosum root rot because the stand did not receive a preventive practice. This requires some modeling and risk assessment. In a study that was conducted in the southeastern US, the cost of treating stumps was estimated at $7.41/hectare ($3/acre) compared with losses of up to $106/hectare ($42.91/acre). However, we need to generate similar numbers that apply to the Lake States Region.

The WI DNR together with the USDA Forest Service and the University of Wisconsin submitted two grant proposals to conduct risk assessment of Annosum root rot. Fortunately, one federal grant was awarded and this will enable us to initiate some survey work in 2009, to better understand the impact of this disease in Wisconsin. Though no special funding was available in 2008, the WI DNR decided to conduct a preliminary study to evaluate the validity of the approach. This report will summarize the preliminary study that was conducted in 2008 as part of economic analysis.

Materials and Methods

This preliminary study focused on the first step of the economic analysis. A study was conducted in Menominee Forest to calculate the cost of fungicide application. This study was completed with the full support and help from the Menominee Forest staff. Two stands were selected for this study. One was a stand that needed row thinning, and the other stand required selective harvesting. Two plots were created and treated for each of the two stands. The number of stumps within a plot, average diameter of the stumps within a plot, the amount of fungicide used, and time spent for the application were measured and recorded.

Figure 22 Sporax application using a salt-shaker like device with a PVC pipe (left), and CelluTreat application using a back pack sprayer (right).

Two application methods were tested. One was a granular material, Sporax, using a salt shaker like dispenser with a long PVC handle. The other was a water soluble material, Cellu-Treat. This material readily dissolves in water. One pound of Cellu-Treat was mixed in 2 gallons of water and the solution was applied using a backpack sprayer (Figure 22).

For row thinning, two rectangular plots that were 300 feet long with 2 rows (approximately ¼ acre) were created. For a selectively harvested stand, two 1-acre square plots were created. For selectively harvested plots, each stump was flagged in order to minimize the time spent looking for a stump.

Results

For row thinning, plot 1 had 53 stumps that needed to be treated, average 5.6" in stump diameter. Plot 2 contained 48 stumps, average 6.1" in stump diameter. Based on the results (Table 1), the average cost of a fungicide treatment on a row thinned stand, when there are 214 trees/acre and average stump diameter is 5.8", was $23.4/acre for Sporax, and $13/acre for Cellu-Treat. Cost included the cost of the material, plus applicator's labor as $20 per hour plus benefit ($20 per hour plus benefit = $26/hr ($0.43/min)). Average cost of the material was $9.3/acre for Sporax and $1.1/acre for Cellu-Treat. The total cost did not include time for clearing slash as slash was already cleared. Menominee Forest had asked a logger to clear the stumps during felling operations. The cost also excluded the time for traveling to a site and for mixing the fungicide.

Table 1. The time and cost of fungicide applications in a row thinned stand. Cost : Sporax $62.50/25lb ($2.5/lb), Cellu-treat $61.25/25lb ($2.45/lb) Labor: $20 per hour plus benefit = $26/hr ($0.43/min)

Plot number	Plot 1	Plot 1	Plot 2	Plot 2
Treatment	Sporax	Cellu-Treat	Sporax	Cellu-Treat
Time spent/plot	9.5 min	6 min	6 min	7 min
Chemical used/plot	1.00 lb	0.10 lb	0.75 lb	0.12 lb
Cost/acre	**$28**	**$12**	**$19**	**$14**

For selectively harvested plots, each stump was flagged in order to minimize the time spent looking for a stump. However, in plot 2, a lot of time had to be spent to look for stumps for the first run because of thick shrub growth. Plot 1 contained 56 stumps with average 14.3" stump diameter. Plot 2 contained 49 stumps, with average 14.5" stump diameter. Based on the results (Table 2), average cost of treating a selective harvested stand that contained 53 trees/acre with average 14.4" in stump diameter was $15.5 per acre for Sporax and $7.5/acre for Cellu-Treat. Average cost of the material was $3.8/acre for Sporax and $0.6/acre for Cellu-Treat. In both a row thinned stand and a selectively harvested stand, total cost for Cell-Treat was about half as much as Sporax. Except for plot 2 of the selectively harvested stand, the time that was spent for application was very similar between Sporax and Cellu-Treat.

Table 2. The time and cost of fungicide applications in a selectively harvested stand. Cost : Sporax $62.50/25lb ($2.5/lb).

Stands	Row thinned stand	Row thinned stand	Selectively harvested stand	Selectively harvested stand
Treatment	No. of stumps covered by 1lb of Sporax	No. of stumps covered by 1lb of Cellu-Treat	No. of stumps covered by 1lb of Sporax	No. of stumps covered by 1lb of Cellu-Treat
Label direction	278 stumps	2222 stumps	44 stumps	354 stumps
Field test	58 stumps	459 stumps	35 stumps	233 stumps

Furthermore, the comparison of label direction and actual amount used in a stand was made by simple calculations. Label directions for Cellu-Treat label was recently changed from "1lb of Cellu-Treat covers 800 square feet of surface" to "400 square feet". This was based on some efficacy test results. Sporax label states that "one pound of Sporax covers 50 square feet of surface. When average stump diameter is 5.8", based on the label direction, one pound of Sporax should cover 278 stumps. However in the field test, one pound of Sporax covered 58 stumps. For Cellu-Treat, the difference was similar. In the field study for row thinning, the amount of chemicals used was approximately 5 times as much as the amount the label directions suggested. The difference between label direction and the actual amount used in the field test was not as prominent in a selectively harvested stand (Table 3).

Table 3. Comparison of label directions and actual amount of chemicals used in a stand

Plot number	Plot 1	Plot 1	Plot 2	Plot 2
Treatment	Sporax	Cellu-Treat	Sporax	**Cellu-Treat**
Time spent/plot	18 min	17 min	37 min	**16 min**
Chemical used/plot	1.75 lb	0.30 lb	1.25 lb	**0.15 lb**
Cost/acre	**$12**	**$8**	**$19**	**$7**

Summary and discussion

In row thinned stands, treatment roughly cost $23/acre for Sporax, and $13/acre for Cellu-Treat. In selectively harvested stands, treatment roughly cost $16/acre for Sporax, and $8/acre for Cellu-Treat. The cost difference between row thinning and selective harvesting was mainly due to the difference in the number of stumps treated. In both cases, Cellu-Treat treatment cost approximately half of the cost for Sporax. It should be noted that this cost calculation did not include the time for clearing slash as slash was already cleared. The cost also excluded the time for traveling to a site and for mixing a fungicide. When the total operation cost is estimated, such expenses should also be included in the cost calculation. Recently, cost analysis was conducted independently by the DNR foresters in the Kettle Moraine State Forest, Southern Unit. In the application form where they requested funding for fungicide treatment practice in the state forest, the foresters estimated that it would cost $3,500 in order to hire an applicator to treat 127 acres of pine plantations ($27.6/acre).

Both Sporax (saltshaker with a tube) and Cellu-Treat (backpack sprayer) treatments took similar amount of time to treat (30 min/acre/214 trees for a row-thinned stand; 17 min/acre/53 trees for a selectively harvested stand). For both application methods, time spent for actual application was 2-4 seconds per stump depending on the size of a stump. The majority of time was spent walking from one stump to another. It takes less time per stump with row thinning because these stumps are lined up neatly, but with row-thinning more trees need to be thinned, and inevitably it will take more time per acre.

The cost of chemicals per acre was much less with Cellu-Treat than that of Sporax. The cost of Cellu-Treat was approximately 15% of the cost of Sporax. However, one advantage of Sporax is that it can be applied in winter when the outside temperature is below freezing. Since Cellu-Treat needs to be mixed with water, it cannot be applied under freezing temperatures. The Annosum Root Rot Committee is working with the manufacturer and WI Department of Agriculture, Trade and Consumer Protection to explore a possible use a certain additive that can be mixed to prevent the solution from freezing.

The actual application time by using either a salt shaker or a backpack sprayer did not differ in time spent for application. If an attachment to a harvester is used for treatment, it should save application time significantly. It is estimated that such a mechanized application will require an additional 2-5 seconds per stump after felling, and no walking from stump to stump will be needed. A mechanized fungicide application will eliminate the time needed to clear the slash and a separate resource to apply a fungicide manually. Logistics planning would be simpler as both felling and fungicide application will be accomplished at the same time. Several loggers have already purchased an attachment to a processor from manufacturers, such as Ponsse and John Deere or invented a home-made device. More loggers in Wisconsin are seriously considering attaching a liquid pesticide application device to offer this service while harvesting is done. It is hoped that this type of investment will provide loggers with a more competitive advantage in the long term.

In the field test, a larger amount of chemicals was used than label directions. The difference was larger when the chemicals were applied to smaller-diameter stumps. When chemicals are applied to a stump, a small amount of material would be wasted in order to ensure the full coverage of the entire stump surface. It is suspected a larger amount of materials could be wasted per stump when a smaller-diameter stump is treated proportionally compared to a larger-diameter stump. This is an issue that a land manager and/or an applicator should understand when they plan such a treatment and estimate the cost of material.

Plan for 2009

This is a preliminary test that was conducted with no available grant money. A larger-scale study is needed to provide more statistical significance. If resources are available, we plan to do a similar study with more stands in 2009. We also plan to contract out one of the loggers who now has an attachment on their processors and conduct a similar study this year.

The WI DNR received a federal STDP (Special Technology Development Program) grant together with University of Wisconsin and USDA Forest Service in 2009. With this grant, the WI DNR will survey more red pine plantations where thinning was conducted from 1999 to 2003 within Annosum confirmed counties, to evaluate the severity of damage caused by this disease. The relationship between certain site factors (soil type, drainage, water table, previous land use, etc.) and severity of the damage caused by the disease will also be investigated. This effort should help provide data for analyzing the cost of not-treating a pine plantation.

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Abiotic

Impact of the 2008 floods on Wisconsin's Forests

In June, 2008, Wisconsin received several heavy rainfalls that caused a significant increase in the amount of water flowing through streams and rivers in southern Wisconsin. The United States Geological Service (USGS) tracks streamflow through streamgages. Figure 1. illustrates the 28-day average streamflow for a period ending Monday, June 30. The data illustrates the high or much above normal status of streams and rivers throughout southern Wisconsin. This extraordinary amount of water overflowed riverbanks, flooding urban, agricultural, forest, wetland and grassland areas. As of June 27, 2008, the Federal Emergency Management Agency (FEMA) had declared 30 counties eligible for individual and/or public disaster assistance. Figure 2 illustrates areas of probable flooding (red). This preliminary information suggests approximately 7,000 acres of wetland forests or forestlands have been flooded.

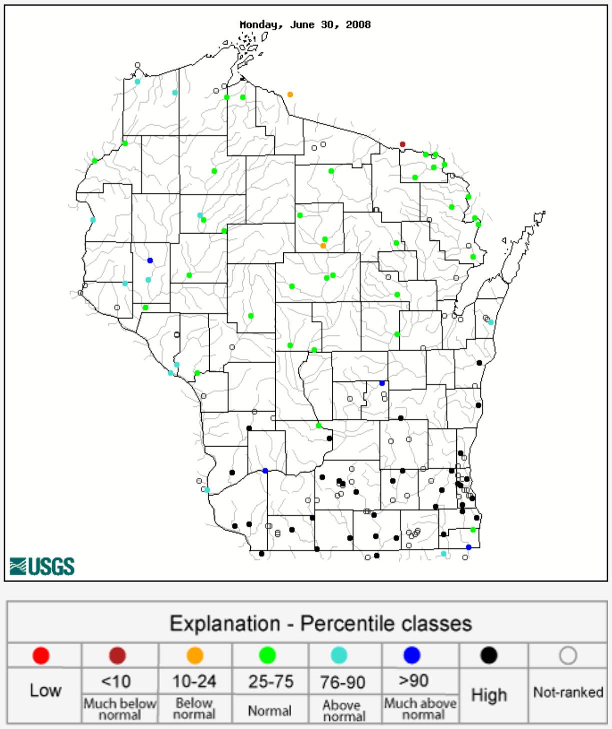

Figure 1. Twenty-eight day average streamflow compared to percentiles of historical 28-day average streamflow for the day of the year. Only streamgages having at least 30 years of record are used.

Tree damage

The worst mortality occurred to regeneration both in the Sauk County Community Forest where red and white pine saplings were affected and in Pine Island State Wildlife Area, (Caledonia Township in Columbia County) where hardwood regeneration was killed.

In addition, individual tree mortality occurred in parts of Spring Green which had persistent elevated water tables. This however, was restricted to the most severely saturated sites. Occassional tree uprooting or tipping also occurred in other parts of the flooded area when water rushed down valleys and small streams. Landowner reports, for the most part, were minimal.

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