Wisconsin Forest Health Protection

Annual Report 2011

Compiled and edited by Forest Health Protection Staff

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

Photo: Blowdown in Forest County on April 12, 2011 (Wisconsin DNR)

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Wisconsin DNR Forest Health Staff

Staff Update

After spending the last 9 years as the DNR Forest Health Program Coordinator, 20 years as a DNR Forest Pathologist, and 33 years as a DNR employee, Jane Cummings Carlson retired at the end of June 2011. She will be remembered for her technical and organizational abilities and for her friendliness towards all people that she worked with. In addition to coordinating the forest health program, she achieved noted success working with a number of projects including forest health monitoring, chestnut blight research, butternut canker research, master logger certification, NR40 implementation and emerald ash borer response.

Shane Weber, Plant Pest and Disease Specialist in Spooner, retired from the DNR effective December 2, 2011 with over 31 years of dedicated service. Throughout his career, Shane was northwest Wisconsin's "go to man" when it came to the identification and management of insect and disease pests, particularly jack pine budworm. He was known for his very practical forest management expertise and ability to unite science with the art of practicing forestry. Shane enjoyed sharing his love of baseball with all around him, especially the little league teams that he coached for 30 years. Shane's presence and experience will be sorely missed by all who worked with him.

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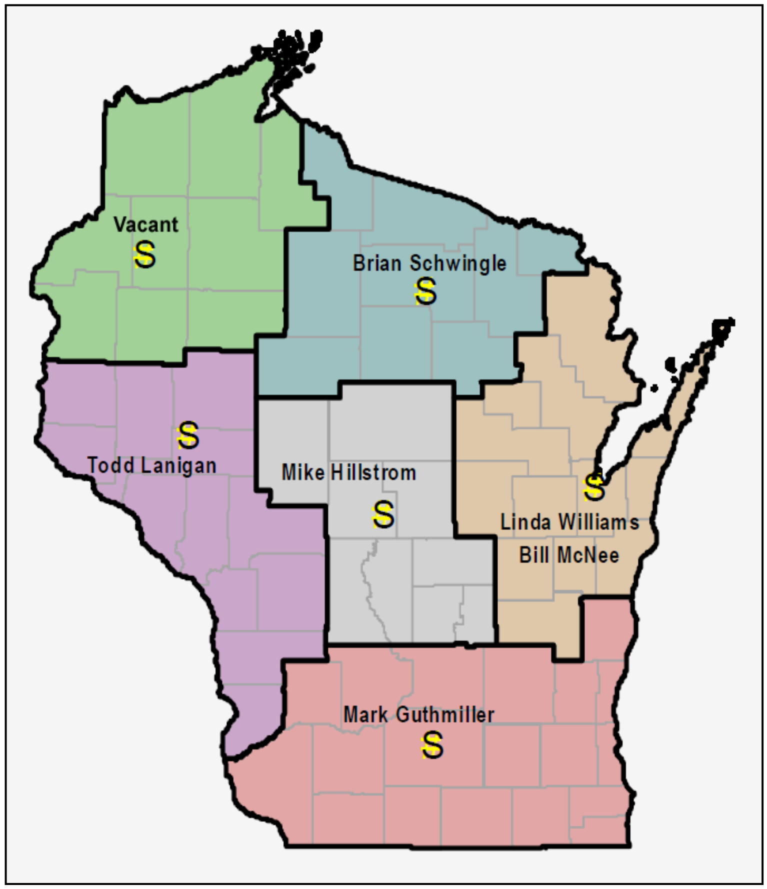

Figure 1. Regional DNR forest health staff as of December 2011.

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Resource Update

Wisconsin's forests are critical for providing wildlife habitat, clean air and water, managing erosion, and improving the 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 annual value of these products is about $20 billion. Forest and water resources in Wisconsin are a primary tourism attraction for both residents and visitors. The variety of Wisconsin's forest ecosystems supports a great diversity of wildlife species, while recreational use of the forests continues to grow and expand.

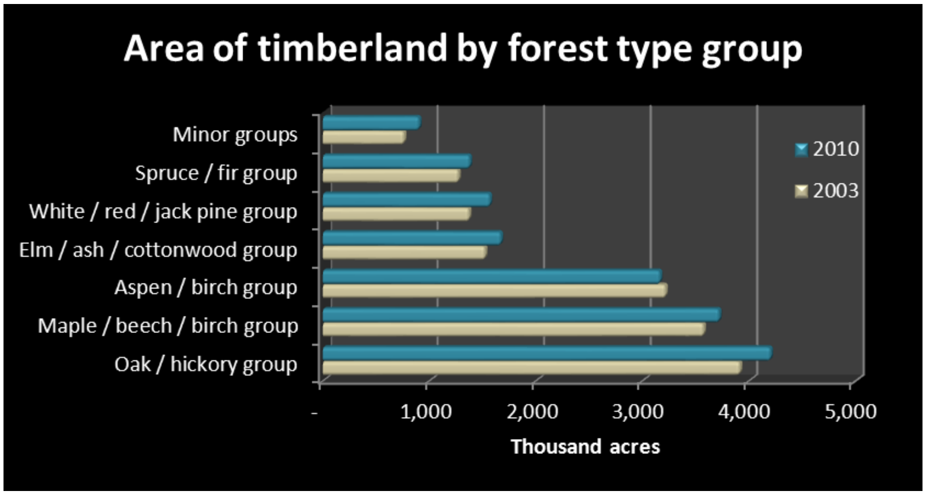


Figure 1. Area of timberland by forest type group in 2003 and 2010 (FIA data USDA Forest Service).

Area of forests by type and age class

The area of forest land in Wisconsin has been steadily increasing in recent decades and currently stands at approximately 16.6 million acres, 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 78% of the total timberland area classified as hardwood forest types (Figure 1). The primary hardwood forest types in the state are oak / hickory at 25% of total acreage, maple / beech / birch at 22% and aspen / birch at 19%. Conifer types, mainly red, white and jack pines and spruce-fir, represent about 22% of the timberland. In addition, Wisconsin 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.

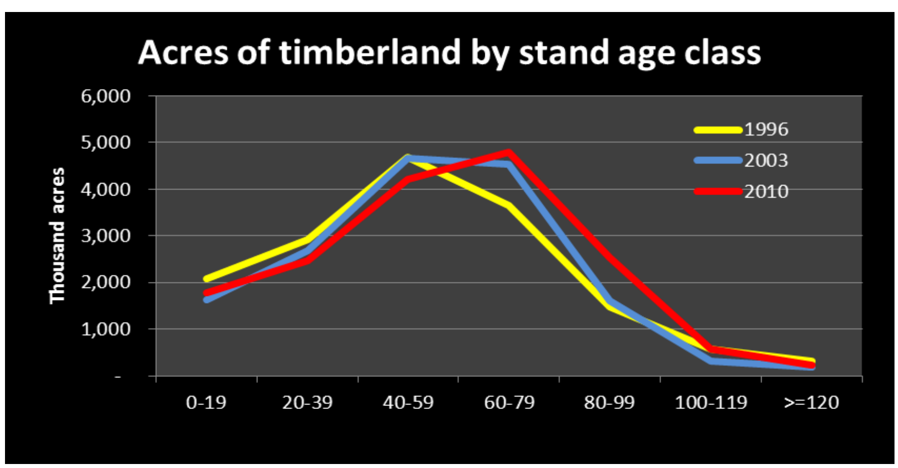


Figure 2. Area of timberland by stand age class in 1996, 2003 and 2010 (FIA data USDA Forest Service).

Volume and trends in major species

Since 1996 there have been some dramatic changes in growing stock volume of major species groups (Figure 3). The greatest volumes of any major species in 2010 were in the maple group and northern red oak. This is important because red oak is affected by major forest health issues including gypsy moth and oak wilt.

The greatest percentage volume gains in the last 14 years have been in eastern white pine (67%), red pine (60%) and black and northern pin oaks (38%). The volume in elm (American elm, slippery elm, rock elm and Siberian elm) has increased 14% in the last 14 years, suggesting that this species group may be recovering from heavy losses mainly due to Dutch elm disease.

The greatest percentage volume losses in the last 14 years have been in jack pine (31%), paper birch (30%), bigtooth aspen (12%) and quaking aspen (3%). This change is due to a combination of natural succession and harvest losses that have not been replaced.

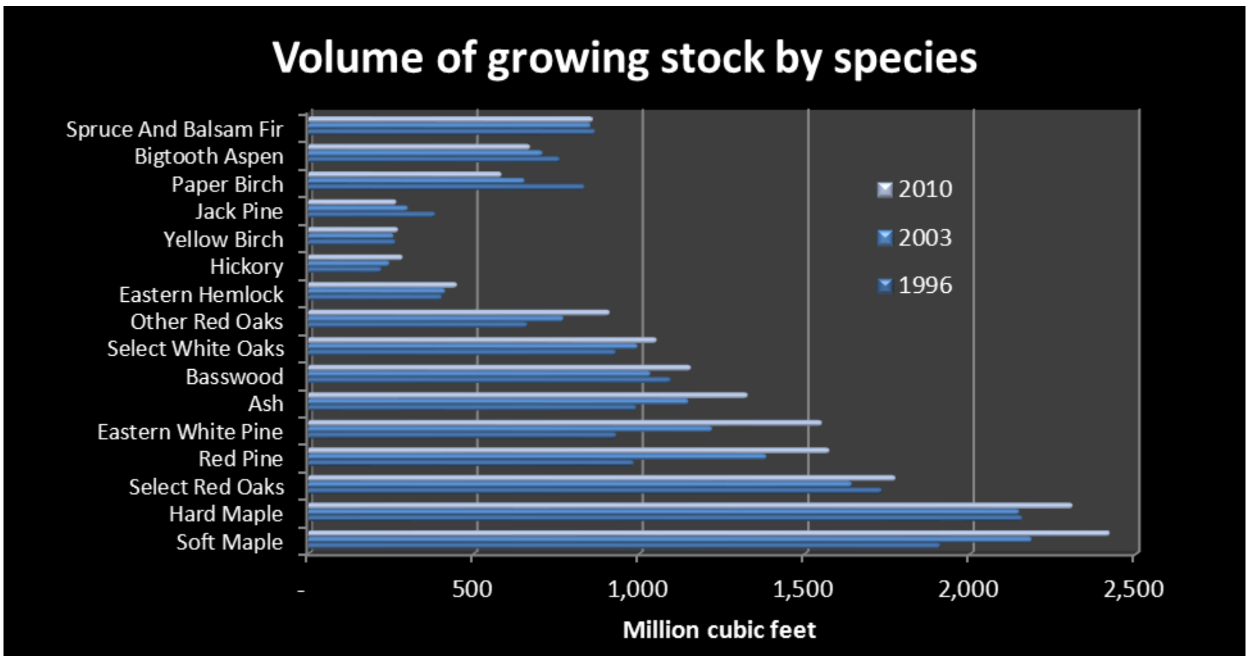


Figure 3. Trends in volume of growing stock by species group (FIA data USDA Forest Service).

Exotics

Annosum Root Rot

Annosum root rot is caused by the fungus, *Heterobasidion irregulare* (formerly *Fomes annosus*, or *H. annosum*). The fungus causes a decay of the roots and lower stem and often kills infected trees (Figure 1). In Wisconsin, annosum root rot has been primarily found on red pine and occasionally on white pine. The primary mode of infection is through freshly cut stumps. Spores land on the stump, grow through the root system and infect adjacent healthy trees through root contact. Understory seedlings and saplings are also subject to infection and mortality. Fruit bodies may be found at the root collar of dead and dying trees and infected stumps.

In 2011, annosum root rot was confirmed in Marinette County for the first time, in the Town of Amberg. A complete survey was conducted in the red pine stand where it was first identified. Additional disease pockets were found, with fruiting bodies on seedlings, stumps and dead or declining trees. Pockets ranged in size from a single tree to three-quarters of an acre. Annosum root rot is now known to occur in 23 counties (Figure 2).

In December 2011, a *Heterobasidion* sp. fruiting body was detected on a spruce seedling in a Wood County pine plantation. This is the first known observation of *Heterobasidion* on spruce in Wisconsin.

Figure 1. Annosum root rot infection center with dead and dying red pines.

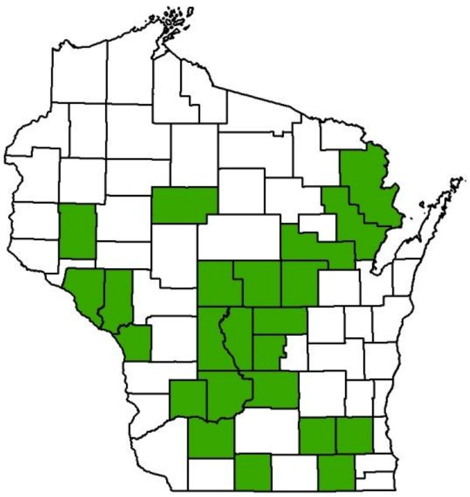


Figure 2. Wisconsin counties where annosum root rot has been detected.

A study to test the pathogenicity of *H. irregulare* was conducted in the greenhouse in 2011. Seedlings of seven species that are native to Wisconsin (black cherry, hemlock, red oak, jack pine, red pine, white pine and white spruce) were selected for this study. Each seedling was artificially inoculated with one of the two isolates from Wisconsin on July 6, 2011. For each of the seven species, eleven seedlings were inoculated with one isolate, another 11 seedlings with the other isolate and 11 seedlings were treated with water agar as a control (a total of 33 seedlings for each species). The health status of the seedlings has been monitored on a monthly basis.

Beech Bark Disease

Beech bark disease, a disease of American beech (*Fagus grandifolia)* caused by a 'scale' insect (beech scale, *Cryptococcus fagisuga*) (Figure 3) and one of several fungi, was detected in Door County in 2009. The disease was found several miles east of the city of Sturgeon Bay, in a woodlot and a lakeshore residential area. Many trees were heavily infested with beech scale, and beech trees had been dying for several years prior to the discovery. The method of scale introduction into this area is unknown.

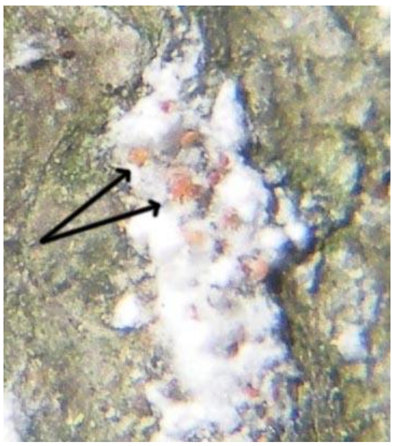


Figure 3. Live beech scales (yellow and red dots) inside the scales' wooly wax.

Surveys to determine the distribution of beech bark disease and beech scale have continued since the initial detection (Figure 4). Wind and birds are likely dispersing immature beech scales from the Sturgeon Bay detection area, the generally-infested area of western Lower Michigan, and from isolated infestations in the Upper Peninsula of Michigan. Surveyors looked for characteristic white, woolly wax on the bark of beech trees, and the scale species was identified by Dr. Phil Pellitteri at the University of Wisconsin Insect Diagnostic Lab. Beech scale has been found in Door, Kewaunee, Manitowoc, Marinette, Oconto, Ozaukee, Sheboygan and Washington Counties. Sampling conducted in Dodge, Menominee and Milwaukee Counties in 2011 did not find the insect.

With one exception, all sites away from the initial detection area had very low populations of beech scale, and only occasional scale fluff was seen on beech trees. Field observations in 2011 found no widespread, noticeable increase in the amount of beech scale at sites where the scale had previously been found at low numbers. The noteworthy exception was a whitewashed beech tree on the northwest side of Washington Island at the tip of Door County. This site is about 20 miles from the established disease area near Escanaba, Michigan. The amount of scale observed at the Washington Island site suggests that the scale has been present longer than at most other regions of Wisconsin's infested area.

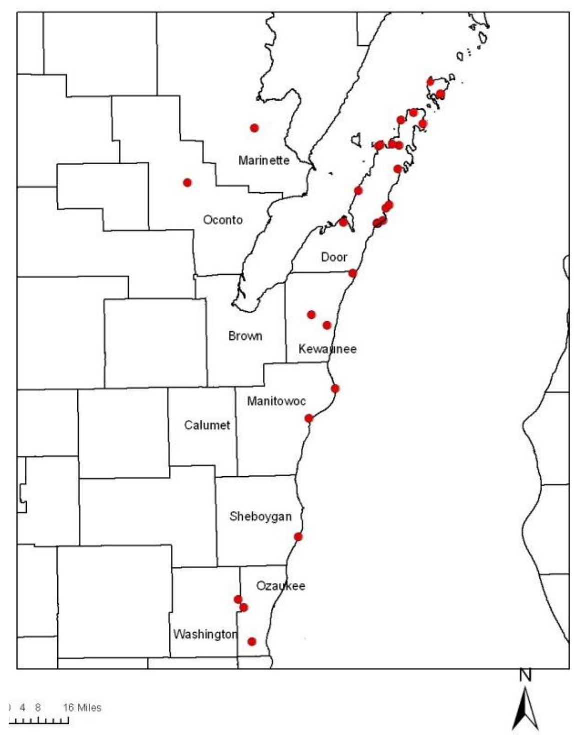


Figure 4. Location of beech scale detections as of December 2011.

In September 2011, an aerial survey was done in Door County to look for beech bark disease-impacted trees (Figure 5). Premature color change in beech, presumed to be an indicator of a tree stressed by beech bark disease, was only seen where beech bark disease or high beech scale populations were already known. The disease-infected areas east of Sturgeon Bay had expanded in size and additional tree mortality was observed, but no new pockets of the disease were detected.

DNR Forest Health staff have produced 3 factsheets and brochures for the public. These are:

- 'Beech Bark Disease - Best Management Practices for Reducing Movement of the Beech Scale'
- 'Homeowner's Guide - How to Detect and Control Beech Bark Disease'
- 'How to Identify the Beech Scale in the Field'

These documents are available online at: http://www.dnr.wi.gov/forestry/FH/bb.htm.

Beech bark disease results when beech scale colonizes beech trees and makes them susceptible to invasion by fungi, including *Neonectria coccinea* var. *faginata* and/or *Neonectria galligena*. A third species of fungus, *Neoneoctria ochroleuca,* has been found in association with beech bark disease in Pennsylvania, West Virginia and Ontario, Canada. Research has shown that less than 5% of American beech are resistant to the disease and another small percentage are partially resistant. The majority of beech trees are susceptible and will die from beech bark disease. Decay fungi and wood-tunneling insects structurally weaken infected trees, and make them very susceptible to trunk breakage during high winds. Thus, infected trees should be removed from areas where they are a safety hazard.

Figure 5. Beech bark disease-infected trees and beech mortality at the first detection site in Door County. Photo taken in mid-September 2011.

Beech scale is native to Europe and was introduced into Nova Scotia, Canada around 1890. The insect was first observed in the northeast United States in the early 1930s. Beech bark disease has been moving west and south across the United States since that time. The disease was first detected in Michigan in 2000. The scales are spread by the wind, birds, and as hitchhikers on infested firewood. If beech scale or beech bark disease is suspected on trees (Figure 6), contact a DNR Forest Health specialist. For more information on beech bark disease, visit: http://www.dnr.wi.gov/forestry/FH/bb.htm.

Figure 6. White 'wool' produced by beech scale.

In 2011, the University of Wisconsin – Stevens Point established a number of long-term monitoring plots across the range of American Beech in Wisconsin. Data collection will include forest composition and state, tree health metrics, and scale/fungi infestation levels. The plots will be used to monitor forest composition and structure, to identify and monitor the impacts of beech bark disease on beech stands in Wisconsin, and to determine the relationships between beech bark disease and declines using tree, stand and site variables. This data will also be integrated with GIS software to map the occurrence and severity of beech bark disease, as well as identify areas at high risk and prioritize future research and monitoring needs. Data collection began in the summer of 2011 with the establishment of 17 plots across 8 counties, and will be expanded in the summer of 2012 to include plot locations in all Wisconsin counties containing populations of beech.

Emerald Ash Borer

<u>Current Status of EAB in Wisconsin</u>

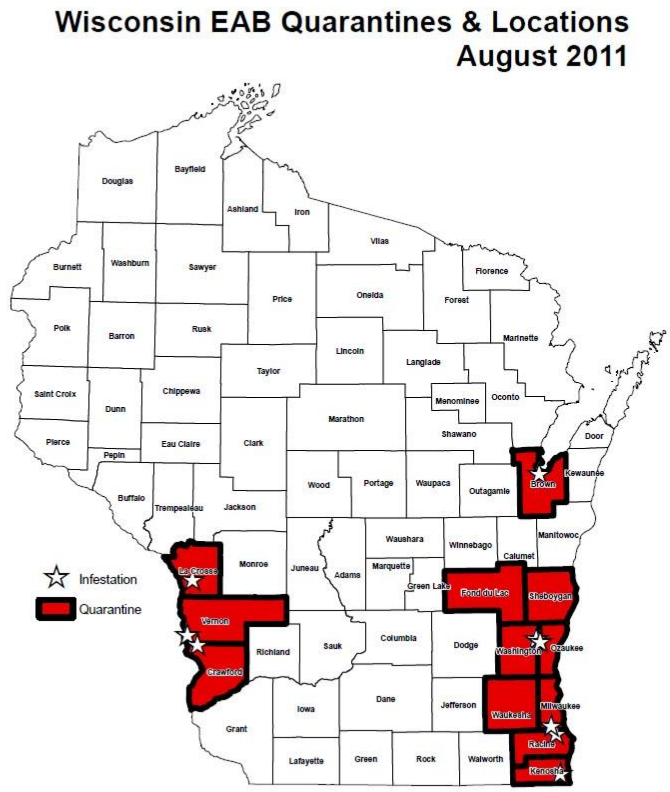


Figure 7. Location of known EAB infestations and counties quarantined for EAB.

In the three years since EAB was first detected in Wisconsin, the pest has been found in a number of locations. There are currently four locations where infested trees have been found, and two locations (Brown County and La Crosse County) where adult beetles have been caught on a trap but no infested trees have yet been found (Figure 7). The Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP) is the lead agency in Wisconsin for detecting populations of EAB. In 2011 approximately 5,300 purple panel traps were set by DATCP, and adult beetles were trapped in Racine County and La Crosse County for the first time.

Notable new finds for 2011 include the City of Kenosha, where infested trees were located after two consecutive years of trapping adult beetles, and the Town of Medary in La Crosse County, where 6 adult beetles were found on one trap in August 2011.

<u>EAB Program Management Strategies</u>

Strategic Plan: In 2011 the Wisconsin Cooperative Emerald Ash Borer Program revised its Strategic Plan, which can be found at: www.emeraldashborer.wi.gov.

Local Response Units: The state EAB Operations Group provided guidance and assisted with implementation of a multi-site response strategy. To view the response strategy, visit: www.emeraldashborer.wi.gov. This strategy was developed to transition from one statewide Incident Management Team overseeing all infestations to multiple response units, organizing at the local level and coming together for one year to develop and begin implementing a response. The four components of the response unit are survey, management, outreach and and regulation. Plans are to review this strategy and change as needed.

Salvage and Preemptive Removal of Ash in Rural Woodlands: Over the past two years, grant funds obtained from the USDA Forest Service supported hiring staff for Resource Conservation and Development (RC&D) to implement salvage and preemptive removal of ash in the vicinity of Wisconsin's two first known EAB infestations at Newburg and Victory. The abundance of small woodlots in these areas often requires coordination of landowners to effectively carry out a timber sale. Harvesting will occur on approximately 400 acres. The volume of timber marked for harvesting is approximately 450,000 board feet in the Victory area and 150,000 board feet in the Newburg area. Timber harvesting in these areas will continue into 2012.

Silvicultural Guidelines: DNR has prepared silvicultural guidelines for land managers and woodlot owners, and these guidelines include recommendations for woodland managers in and around infested areas. To view these guidelines, visit:
http://www.emeraldashborer.wi.gov/articleassets/Management_Guidelines_for_Wisconsin_Forests.pdf.

Urban Ash Guidelines: A set of guidelines has been developed for managing ash in Wisconsin's urban forests to reduce the impacts of EAB. To view these guidelines, visit:
http://www.emeraldashborer.wi.gov/articleassets/Managing_Urban_Ash.pdf.

Outreach and Education: The Wisconsin Cooperative Emerald Ash Borer Program produced 7-foot tall, free-standing banners this year to help spread the word about the dangers of firewood movement. These banners were placed in cities already infested with emerald ash borer, in Milwaukee at Miller Park, at REI stores outside of Milwaukee, in DNR service centers and elsewhere. These high quality banners will continue to tour around the state and can be ordered by agencies, businesses and organizations who want to help share the message in an indoor space.

Figure 8. UW-Madison researcher Todd Johnson releases natural enemies of EAB in a heavily infested forest near Newburg, May 2011.

The program also partnered with the Milwaukee Brewers in 2011. The Brewers maintain emerald ash borer traps and interpretive information that were installed at Miller Park. These serve as eye-catching outreach tools as game attendees see them, ask questions, and read available literature.

Biological Control: In 2011, researchers from UW-Madison released three species of small, stingless wasps at the Riveredge Nature Center near Newburg to help reduce emerald ash borer populations (Figure 8). The two species released in May, *Tetrastichus planipennisi* and *Spathius agrili*, attack the EAB larvae beneath the bark. A third wasp species, *Oobius agrili*, attacks the EAB eggs and was released later in the summer once the EAB adults were laying eggs.

Insecticide Treatments: The focus of this management option was on providing information for property owners, tree-care professionals and government officials on the insecticide products and practical aspects of utilizing insecticides.

Figure 9. Stingless EAB natural enemy wasps on foliage near Newburg, shortly after initial release.

Natural Enemy Wasp Releases at Newburg

In 2011, researchers from UW-Madison released three species of small, stingless wasps at the Riveredge Nature Center near Newburg to help reduce emerald ash borer populations (Figure 8). These wasps are parasitoids, insects that feed on other insects and ultimately kill their host. The selected parasitoids are host specific to EAB and are natural enemies of the beetle in its native range in China. They will not eliminate EAB, but will help to reduce its population levels and hopefully slow tree mortality.

The two species released in June, *Tetrastichus planipennisi* and *Spathius agrili*, attack EAB larvae beneath the bark (Figure 9). In total, approximately 4,300 individuals were released. A third wasp species, *Oobius agrili*, attacks EAB eggs and was released in July once the EAB adults were laying eggs. About 1,600 *Oobius* were released. The wasps were mass-reared at an APHIS Biocontrol Rearing Facility in Brighton, Michigan, and shipped to Wisconsin for release. So far, several hundred thousand wasps have been released in a number of states including Illinois, Michigan and Minnesota.

Figure 10. Dr. Krista Ryall discusses EAB survey methodology in Green Bay.

<u>EAB Detection Using Branch Sampling</u>

In January 2011, a new EAB survey technique (Figure 10) was demonstrated in Green Bay by Dr. Krista Ryall of the Canadian Forest Service in Sault Ste. Marie, Ontario. The technique involves peeling mid-crown ash branches to look for EAB larvae and galleries, and has been shown to be an effective method of finding EAB before trees show symptoms of infestation (Figure 11). It is anticipated that this survey method will be used by arborists and municipal forestry crews as part of their regular work to prune and remove trees. Formal surveys can also be conducted using a grid or tree inventory. Similar training sessions or presentations were also held later in the year in Brown and Milwaukee Counties. The methodology is available at:
http://www.oakville.ca/Media_Files/forestry/EABbranchsamplingRyall2010.pdf.

Figure 11. Mid-crown ash branches are peeled to look for EAB larval galleries (not found in this branch).

<u>Emerald Ash Borer Detection Efforts in Wisconsin</u>

Detection of EAB in Wisconsin continued to be of the highest priority in 2011. Early EAB detection gives landowners and communities more management options, such as salvaging live ash trees or beginning insecticide treatments before there is major tree decline.

DNR survey efforts in 2011 used two EAB detection methods that are effective at finding low population densities of the pest, when the ash trees are not yet showing any symptoms of EAB infestation. One detection method was the use of a double-decker detection trap. This trap type has been shown to be more effective at attracting EAB adults than other traditional trapping methods, and also is more effective at detecting beetles at very low population densities (Poland *et al*. 2011). The second survey method used was *Cerceris* biosurveillance, which is a technique used to detect EAB through observation of the ground nesting wasp, *Cerceris fumipennis* (Hymenoptera: Crabronidae). This wasp has proven to be an excellent hunter of buprestid beetles, often collecting native specimens that are new state records as well as exotics such as EAB (Marshall *et al*. 2005; Careless 2009).

Double-Decker Detection Traps

A double-decker trap is attractive to EAB because of its tree-like silhouette, purple color and baited lures. The trap consists of two purple-colored, tri-fold panel traps attached to a 3 meter tall PVC pole (Figure 12, left). Each of the panels is coated with sticky glue and baited with a lure (Figure 12, right). The top panel is equipped with an alcohol leaf blend lure, Z-3-Hexanol, which has proven to be attractive to EAB in scientific studies. The lower panel is equipped with a Manuka oil lure. Manuka oil has been found to simulate the cues given off from a stressed ash tree, which is attractive to EAB. For a complete description of the double-decker trap and its assembly, please visit www.emeraldashborer.info/Research.cfm.

Twenty state properties were selected and one double-decker trap was placed near ash trees at each location in May 2011 (Figure 13). Properties were selected based on the amount of ash present, the existence of a campground facility and the number of out of state visitors to the property. Effort was made to place each trap in an open area and near a campground or other high use area.

Figure 12. Left. Installation of a double-decker EAB detection trap at a high use area at Mirror Lake State Park. Right. Manuka Oil lure attached to the lower panel of a double-decker EAB detection trap.

Research has shown that EAB are most active in sunny locations, and are more likely to visit a trap in such a location compared to a shaded area.

All twenty traps were installed by June 1, prior to adult beetle flight. The lures used for the traps are effective for six to eight weeks, and both lures on each trap were replaced by July 31. At the time of lure replacement, beetles resembling EAB were collected from the panel traps and then examined. Traps were revisited at the end of August and checked again for EAB before being taken down for the season. No EAB adults were found on any of the 20 traps.

Future trapping plans include use of the double-decker trap for EAB detection efforts in 2012. Staff are planning to increase the number of traps deployed statewide and at each trapping site.

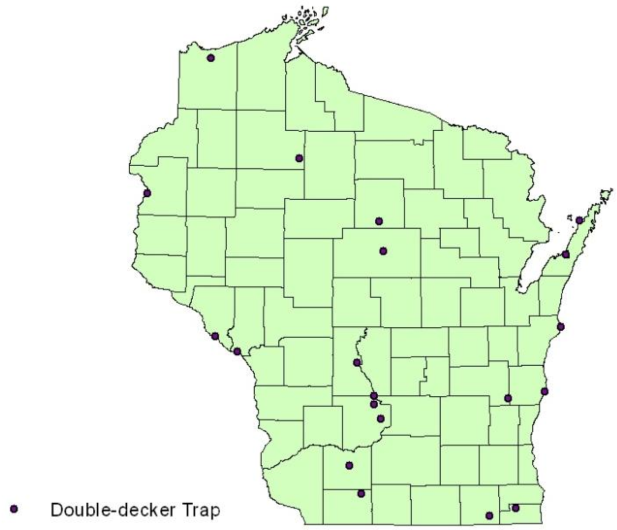


Figure 13. Location of state parks and forests where EAB double-decker traps were installed in 2011. Each property had one double-decker trap.

List of State Parks and Forests with an EAB Double-Decker Detection Trap

Amnicon Falls SP	Kohler-Andrae SP
Big Foot Beach SP	Merrick SP
Bong Rec. Area	Mirror Lake SP
Buckhorn SP	Peninsula SP
Council Grounds SP	Perrot SP
Devils Lake SP	Point Beach SP
Flambeau River SF	Potawatomi SP
Governor Dodge SP	Rib Mountain SP
Interstate SP	Rocky Arbor SP
Kettle Moraine Northern Unit	Yellowstone SP

Cerceris fumipennis Biosurveillance

Biosurveillance using the beetle-hunting wasp, *Cerceris fumipennis*, was also conducted in 2011. This year's work was similar to past survey work that was conducted with the wasp during 2009 and 2010. Current survey efforts focused on monitoring for EAB at a select number of *Cerceris* colonies.

Figure 14. Adult female *Cerceris fumipennis*.

Cerceris fumipennis is a solitary, ground nesting wasp that relies solely on Buprestid beetle prey as a food source for its offspring. The wasp is about the size of a common yellow jacket and is mostly black in color (Figure 14). *Cerceris fumipennis* has distinctive markings for identification purposes: smoky blue–gray colored wings, three circular yellow patches on the face, and one creamy

Figure 15. Left. *Cerceris fumipennis* nesting grounds in hard packed, sandy soil at a baseball diamond. Right. Round entrance of *Cerceris fumipennis* nests, with dropped beetle prey outside one nest.

yellow band on the abdomen. *Cerceris* nests are predominantly clustered in open areas of hard packed, sandy soil and among sparse vegetation (Figure 15). Nests are often found in areas frequented by human disturbance, such as under-maintained baseball diamonds, informal parking areas, sand and gravel pits and fire pits at campgrounds. *Cerceris* forages for its beetle prey in nearby wooded areas. Once *Cerceris* locates its prey, the beetle is paralyzed with a sting and then brought back to the wasp's nest. Nest entrances are surrounded by fine sand, about the diameter of a pencil in size and are directed straight down into the ground (Figure 15, right). Beetles are stored in an earthen cell in the underground nest and serve as food for developing wasp larvae. *Cerceris* collects a wide diversity of Buprestid beetle prey, including EAB, to provision its nest (Marshall *et al*. 2005; Careless 2009). Despite the use of the wasp's stinger to paralyze its beetle prey, the wasp does not sting people.

Past *Cerceris* nest detection work was conducted in 2009 and 2010 and was a partnership between WI DNR and the Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP) (Figure 16). A total of 38 nesting grounds have been located in 19 counties. Of the 38 nesting grounds that were located, there were a total of 943 individual nests among all sites and the number of nests per site ranged from 1 to 285. There was an average of 34 nests per site. Sites with fewer than 25 nests, found at 76% of the sites, are not ideal locations for conducting biosurveillance. In general, biosurveillance for EAB works best when conducted at sites where the colony size is more than 25 nests and there is an ash resource in the vicinity. More details regarding nesting ground locations can be found in the 2009 and 2010 Forest Health Annual Reports.

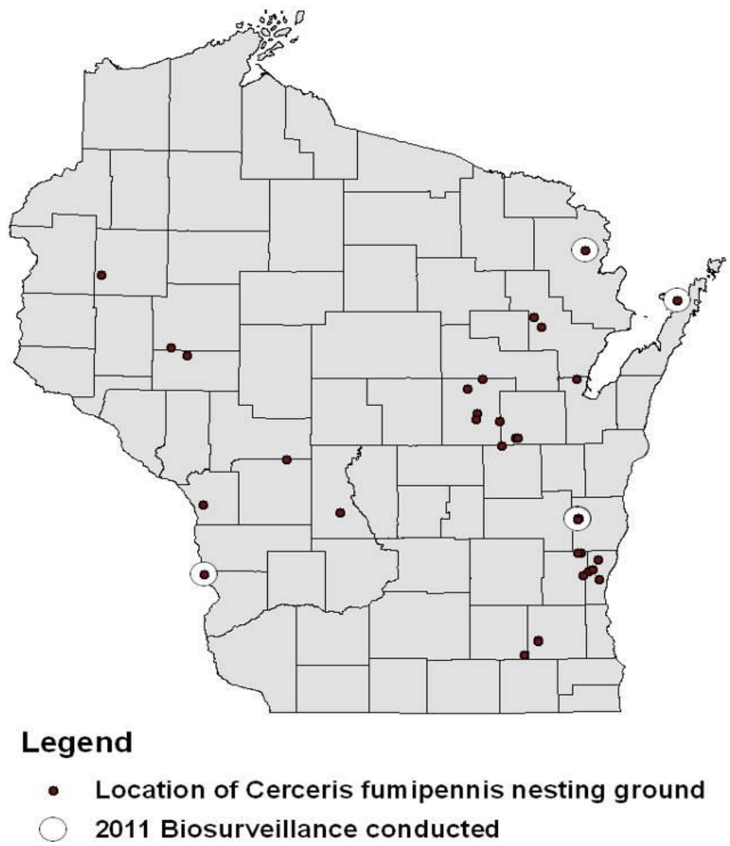


Figure 16. Known locations of *Cerceris fumipennis* nesting grounds, and location of sites where biosurveillance was conducted in 2011.

When conducting biosurveillance, a surveyor can watch wasps as they return to their nests with prey and identify the prey. Collection of the beetle prey is most easily accomplished by placing a plastic cup over nest entrances and using a sweep net to collect the prey-laden wasp as it circles the nest. During 2011, biosurveillance was conducted at four *Cerceris* nesting grounds in Wisconsin (Figure 16 and Table 1). Wasp emergence began during the first week of July at the DeSoto site in Crawford County, and all wasp activity was concluded by the middle of August. One to three biosurveillance visits were made to each of the four sites, and an average of two hours was spent collecting beetles during each site visit (Table 1). Research has shown that in order to accurately account for the beetle diversity within the foraging area, it is important to collect a minimum of 50 beetles throughout the EAB flight season (Careless 2009).

In all, a total of 146 beetles were collected from the four sites and none of the beetles collected were EAB. Most of the collected beetles were either *Dicerca* sp. (45%) or *Chrysobothris* sp. (31%). Only 12% of the specimens collected were *Agrilus* sp., the genus that includes emerald ash borer.

Table 1. Location of *Cerceris* nesting grounds where biosurveillance for EAB was conducted in 2011.

Biosurveillance Dates	County	Site Location	Site Description	No. Nests	No. Buprestids Collected
07/19/2011 07/26/2011	Marinette	Amberg, WI	Baseball diamond	120	47
07/14/2011 07/21/2011 07/29/2011	Crawford	DeSoto, WI	Undeveloped Lot	110	63
08/03/2011 08/04/2011	Door	Peninsula State Park Nature Center	Parking area	32	22
08/04/2011	Sheboygan	Kettle Moraine – North Greenbush Group Camp 5	Campsite	24	14

Emerald ash borer detection efforts in 2012 will most likely not include *Cerceris* biosurveillance. One reason for not continuing this type of survey is due to the short period of overlap between the peak flight seasons of *Cerceris* and EAB. Flight data from Wisconsin infestations have shown EAB emergence and peak flight period to be from early June to mid-July. In contrast, *Cerceris* emergence begins in early to mid-July and its flight ends by mid-August. The naturally occurring *Cerceris* populations that have been located so far are often not found in high risk areas, and many of the sites have little or no ash trees nearby. Another reason to discontinue biosurveillance is that the colony size at 76% of the sites was less than 25 nests, and thus too small to effectively conduct biosurveillance.

Despite these obstacles, the use of *Cerceris* biosurveillance as an EAB detection tool may be revisited in the future, pending further scientific development of mobile colony guidance and testing. To date, mobile colony work is in its infancy but has the potential to provide surveyors with the flexibility needed to use *Cerceris* as a successful detection tool for EAB in the future.

References

Careless, P.D. 2009. Biosurveillance: utilizing the beetle hunting wasps (*Cerceris fumipennis*, Hymenoptera: Cabronidae) to detect infestations of emerald ash borers (*Agrilus planipennis*, Coleoptera: Buprestidae). MSc Thesis, University of Guelph, Guelph, Ontario, Canada. 149pp.

Careless, P.D., Marshall, S.A., Gill, B.D., Appleton, E., Favrin, R. and Kimoto, T. 2009. *Cerceris fumipennis* - A Biosurveillance Tool for Emerald Ash Borer. Canadian Food Inspection Agency, 18 pp.

Marshall, S.A., Paiero, S.M. and Buck, M. 2005. Buprestid sampling at nests of *Cerceris fumipennis* (Hymenoptera: Crabronidae) in southern Ontario: the first Canadian records of three buprestids (Coleoptera: Buprestidae). Can. Entomol. 137: 416-419.

Poland, T., McCullough, D.G. and Anulewicz, A.C. 2011. Evaluation of Double-Decker Traps for Emerald Ash Borer (Coleoptera: Buprestidae). J. of Econ. Entomol. 104: 517-531.

Firewood Surveys

In an effort to understand how aware Wisconsin residents and visitors are with regard to forest invasive species and firewood's role in moving them to new areas, DNR staff surveyed state park campers in 2006, 2008 and 2010 (Table 2).

Table 2. Results of state park camper surveys in 2006 and 2010.

Proportion of state park campers who:	2006 survey	2010 survey
Were aware of emerald ash borer	29%	95%
Were aware of firewood transport restrictions	68%	94%
Agreed that stopping long distance firewood movement is important	78%	89%
Were transporting firewood from home	44%	15%

The survey found that "doing the right thing" was the strongest motivator for influencing camper behavior with regard to moving firewood. These results illustrate the importance and effectiveness of a consistent, widespread outreach campaign regarding firewood movement in Wisconsin. Messaging and awareness is changing behavior to help achieve desired outcomes. The surveys also pointed to concerns campers have about new firewood rules and availability that can be addressed in the coming year.

Private campground owners were surveyed in 2011 to better understand their level of awareness, perception of threat to their property, and strategies to reduce potential threats. The information obtained will help to guide future outreach efforts. 91% of campground owners were aware of emerald ash borer, though only 71% believe it is a threat to their campground. This makes sense, as many campgrounds do not have ash trees. 90% of campground owners felt that stopping long distance firewood movement is important. This suggests an understanding that emerald ash borer is not the only threat moving on firewood. However, only about half of campground owners restrict firewood movement onto their properties. Preventing the spread of invasive species was the most frequently mentioned reason for providing aged or otherwise "safe" wood. The survey also found that campground owners wanted to see more public education, more information sent directly to them, and a state-wide firewood ban implemented by state agencies rather than by campground owners.

All of this information helps to better understand what information still needs to be shared, with whom, and strengthens the argument for the importance of education and outreach in pest management.

DNR also leveraged its ability to build awareness of firewood movement in Wisconsin by offering free publications to all campground owners who received a survey to complete. 40,000 publications were sent directly to campground owners who requested them to share with their visitors. Partnering in this way helps spread the forest health messages across the state quickly and efficiently.

Gypsy Moth

Defoliation and Population Trend

Outbreak populations of gypsy moth (Figure 17) collapsed statewide in 2010 from the combined effects of starvation and disease. In 2011, aerial surveys did not detect any visible defoliation attributable to gypsy moth, in stark contrast to nearly 347,000 acres of defoliation in 2010 (Figure 18, left). DNR received a very small number of nuisance complaints and populations of this pest appeared to be low across the state this year.

Figure 17. Gypsy moth caterpillar.

Tree recovery was very good in the areas heavily defoliated in 2010 (Figure 18, right). The summer of 2010 was very wet and helped to reduce tree stress.

Suppression Program

The suppression program treated 2,885 acres at 37 sites in 8 counties, a decrease from 5,574 acres in 2010. 2,285 acres were treated with Foray 48B using ¾ gallon per acre (36 CLU per acre) and 600 acres at 3 sites were treated with Gypchek at 1 gallon per acre ($4x10^{11}$ OB/ac). Treatments were contracted to Al's Aerial Spraying at $38.65 per acre for all blocks. Treatments began May 24 in the southern counties and ended June 2 in northeast Wisconsin. This was an unusually late start due to the cool spring weather.

Aerial and ground examination of suppression treatment sites indicated 100% successful protection. In the DNR suppression program, success is defined as keeping defoliation to less than 50% on 80% of the block.

Figure 18. Left. Legend Lake in Menominee County following gypsy moth caterpillar defoliation, June 2010. Right. The same area at Legend Lake in June 2011.

Gypsy Moth Outreach and Education

The suppression program strives each year to improve gypsy moth outreach and education to Wisconsin residents, while increasing efficiency at the same time. In 2011, program staff shifted from manually managing the gypsy moth spray notification email list to using Gov Delivery services. Gov Delivery manages subscribe and unsubscribe requests automatically and tracks the results by date. It also tracks how many subscribers open and read the spray notification messages and how many click on links provided in the messages. This information will greatly improve the ability to understand when specific information is most valuable to subscribers, allowing for more improvements in the future.

Switching to Gov Delivery saved hundreds of hours of staff time this year, while subscriptions jumped 25% in a mere two months. Gov Delivery was also used to deliver seasonal management tips to subscribers once the spraying had been completed. This resulted in additional media attention beyond the expected response to regular, spray season news releases because the listserve included staff at media outlets.

Risk Mapping for Gypsy Moth Using WISFIRS - Peshtigo River State Forest

Risk mapping has been recognized as a key component of the Division of Forestry Strategic Direction for 2011. As part of this initiative, forest health personnel launched a test project using WISFIRS data to develop models for predicting the probability of gypsy moth defoliation and mortality. WISFIRS is a spatial database of public lands containing stand-level data such as: Major and minor forest types, basal area of the stand and the four major species, stand age, site index, soil texture, habitat type and many other descriptors. These variables can be combined and prioritized to determine the probability of stand defoliation by gypsy moth as well as the risk of mortality given high levels of defoliation. Because this data is spatially explicit, these variables can be categorized, weighted, and overlain to determine an overall risk for each stand.

Figure 19. Johnson Falls Flowage in the Peshtigo River State Forest.

Determining the extent to which a particular pest or disease will affect a stand and cause mortality is an important criteria in prioritizing harvest schedules. Managers may have preferred species and they may know where their properties tend to have drier, sandier soils, but it becomes much more difficult to decipher where these coincide, especially if advanced stand age and over-stocking may further complicate the situation. Risk mapping is merely a process that determines where and to what extent these variables coincide on a landscape, and thereby direct management activities to those areas.

The western section of the Peshtigo River State Forest (Figure 19) was selected for use as a case study property. This section has a large acreage of oak and aspen, two forest types that are preferred by gypsy moth (Figure 20). There are about 3,000 acres (41% of total acreage) in oak and scrub oak and another 1,900 acres (26% of total acreage) in aspen. Together these forest types provide almost 5,000 acres of preferred habitat for gypsy moth. Of these 5,000 acres, about two thirds have at least 40 ft^2 of basal area in preferred species[1] (Figure 22a). In addition, 86% of these 5,000 acres are categorized as having either a dry-dry mesic or very dry-dry habitat type (Figure 22b). These two characteristics, high basal area of preferred species and dry habitat type, make this State Forest a likely target for gypsy moth.

The model predicts where, if conditions are suitable, defoliation and/or mortality is most likely to occur. Suitable conditions include the existence of high densities of over-wintering egg masses as well as warm and dry spring and summer weather favorable for larval survival.

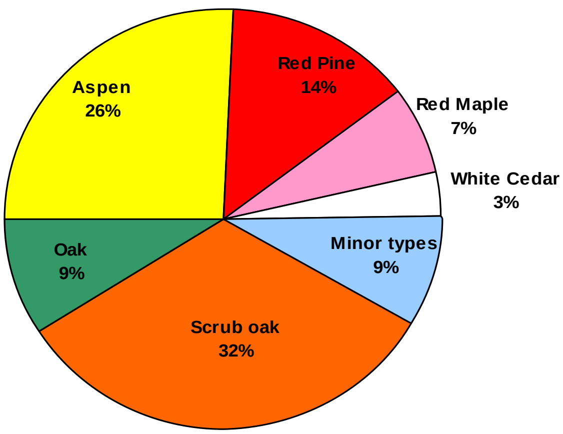
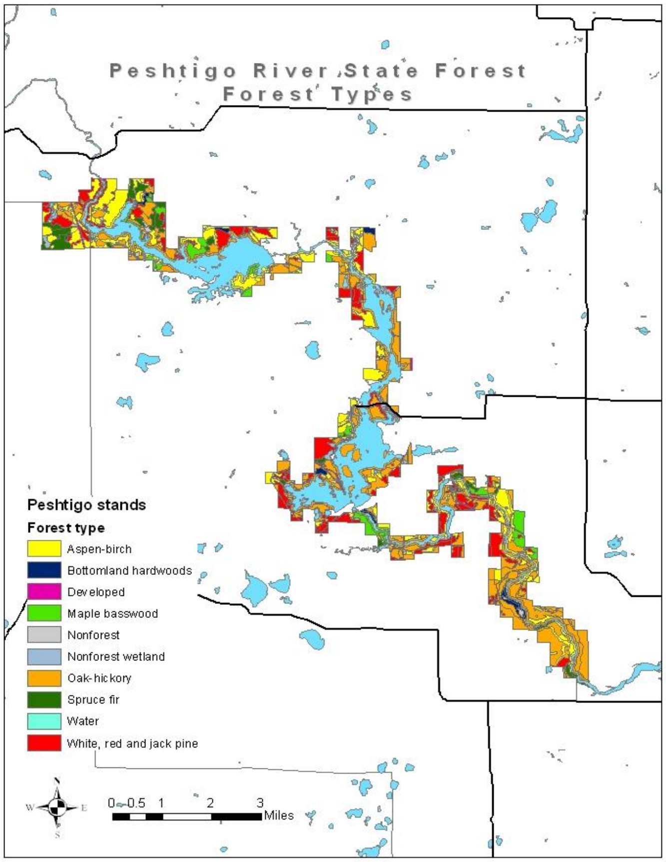


Figure 20. Forest types in the western section of the Peshtigo River State Forest.



The model has two parts:
Susceptibility: What is the likelihood of gypsy moth defoliation given suitable conditions?
Vulnerability: What is the likelihood of mortality given heavy defoliation?

The susceptibility model was based by percentage weight on:
75% Basal area of preferred species (see footnote 1)
20% Habitat type; presence of a very dry-dry type
5% Size class of the stand; seedling and sapling stands were excluded

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[1] Preferred species include all oak, aspen, American basswood, white birch, tamarack and willow.

The results of the susceptibility model determined which areas could be considered to be at low, moderate, or high risk for defoliation. The vulnerability model was restricted to stands which were determined to have either a high to very high risk of defoliation. This model was based by percentage weight on:

70% Habitat type; very dry and wet types were considered most likely to have mortality

15% Advanced stand age; increasing risk was correlated with years past recommended rotation

15% Overstocking; increasing risk was correlated with basal area above the "A line" on species-specific stocking tables

Results

The predicted risk of defoliation by gypsy moth on the Peshtigo River State Forest western section is shown in Figure 22c and the predicted risk of mortality given a high risk of defoliation is shown in Figure 22d. The risk of defoliation depends for the most part on the basal area of preferred species (Figure 22a), as reflected by the weighting in the susceptibility model, and on habitat type (Figure 21, top). The risk of mortality, on the other hand, depends mostly on habitat type but increases with both increased overstocking and increased age past rotation (Figure 21, bottom).

According to the WISFIRS database, the Peshtigo River State Forest has scheduled about 1,900 acres to be harvested in the next five years with another 780 acres in the following ten years. About half of this harvesting will be in oak forest types and a quarter in aspen. As shown in Table 3, the average basal area of all species as well as preferred species is higher in oak stands that are not scheduled to be harvested and

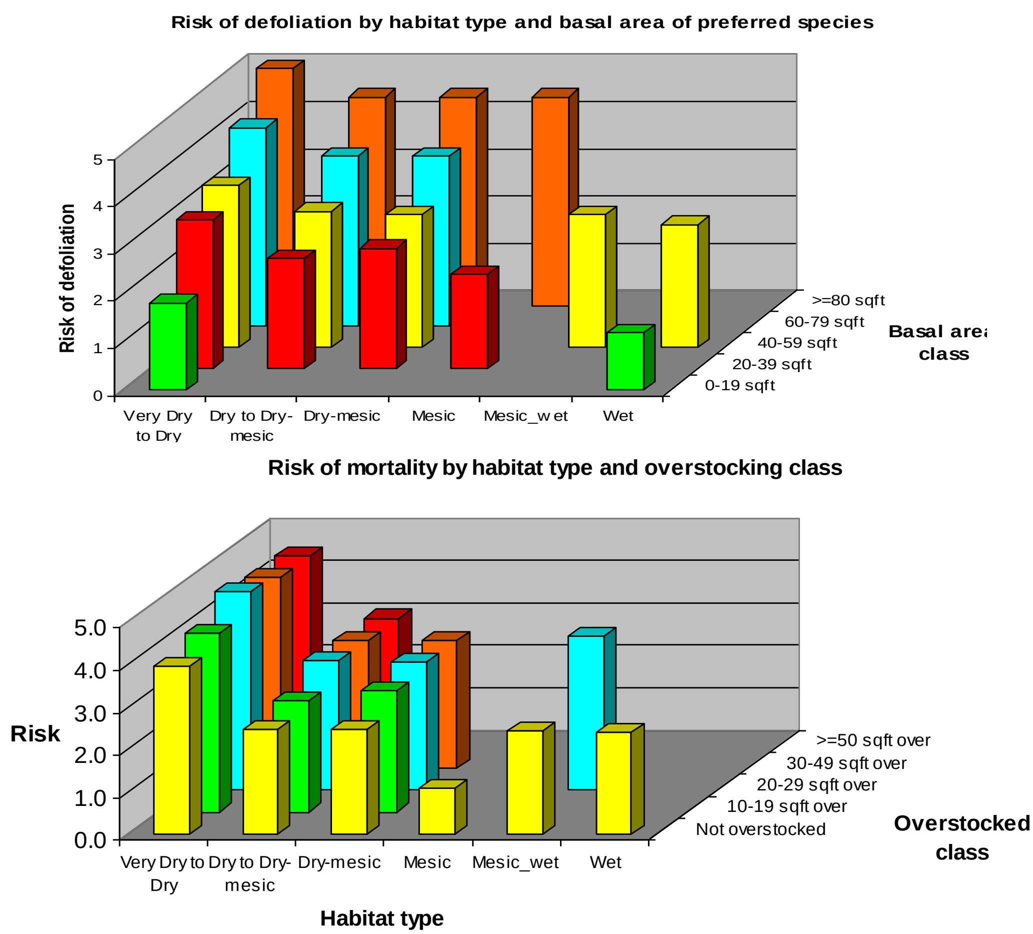


Figure 21. Top. The risk of defoliation depends mainly on habitat type and the basal area of preferred species. Bottom. The risk of mortality is mainly dependent on habitat type, and to a lesser extent, on overstocking.

lower on oak stands that will be harvested. In aspen and birch types, the reverse is true. Scheduled stands have higher basal areas. Average stand age is higher in stands that are scheduled for harvesting on all types except white birch.

Table 3. The average basal area of preferred species, average basal area of all species and average stand age of stands that are either scheduled to be harvested in the next five years or are not scheduled for harvest.

Forest Type	Average stand BA		BA of preferred species		Average stand age	
	Harvest scheduled in 1-5 yrs	Not scheduled	Harvest scheduled in 1-5 yrs	Not scheduled	Harvest scheduled in 1-5 yrs	Not scheduled
Scrub oak	76.9	82.5	50.3	58.6	82.6	77.3
Aspen	99.5	61.6	51.7	43.9	52.3	42.9
Oak	97.1	101.0	75.3	57.2	85.2	81.6
White Birch	140.0	116.7	140.0	65.0	82.0	84.7
Total	**88.3**	**76.6**	**55.7**	**53.1**	**72.8**	**65.3**

Table 4. Percentage of acres by mortality risk category and harvest schedule category. The top of the table is the percentage of acres in each harvest period, for each mortality risk category (read this part of the table across). The bottom of the table is the mortality risk for all acres to be harvested in each harvest period (read this part of the table down).

Risk of mortality	Scheduled to be harvested in the next 1-5yrs	Scheduled to be harvested in the next 6-15 yrs	Not scheduled	Total
Moderate to very high	18%	8%	74%	100%
Low	32%	11%	56%	100%
Not susceptible	29%	12%	59%	100%
Moderate to very high	15%	17%	27%	23%
Low	13%	11%	10%	11%
Not susceptible	72%	72%	63%	66%
Total	100%	100%	100%	100%

Table 4 shows the percentage of acreage by risk and harvest category. Of all acres rated to be moderate to very high for mortality risk due to gypsy moth defoliation, only 18% are scheduled to be harvested in the next five years. Three-quarters are not scheduled for harvest within the next 15 years. Moderate to very high risk stands make up almost a quarter of all acreage (1,650 acres) in the Peshtigo River State Forest, but they represent only 15% of acreage to be harvested in the next five years. Eighty-five percent of acreage to be harvested is in either low risk stands or stands that are not susceptible to defoliation due to either young age or lack of preferred species.

Conclusions

Risk modeling can be a useful tool to predict where, given suitable conditions, defoliation and mortality might occur. This in turn, can aid in developing mitigation strategies as well as focusing survey efforts. Land managers on the Peshtigo River State Forest have long recognized the potential for gypsy moth defoliation due to high acreages of over-aged oak and aspen forest located on sandy soils. They also have multiple management goals that impact decision-making for any one stand. For instance, many of the scrub oak stands are located along waterways or public use areas, where management options may be limited. As stated at the outset, risk modeling is merely a tool that can be used to supplement the decision-making process.

It was found that models can be easily implemented and fine-tuned to each property using the WISFIRS database. The models are based on in-depth discussion with local forest health experts and land managers and review of the scientific literature. Future risk modeling would consist of two steps, first expanding a given model (in this case gypsy moth) to several other properties in order to fine-tune it, and second, devising models for other pests and diseases, repeating the whole process for each one. Possible candidates include white pine blister rust, annosum root disease of red pine, oak wilt, emerald ash borer and jack pine budworm.

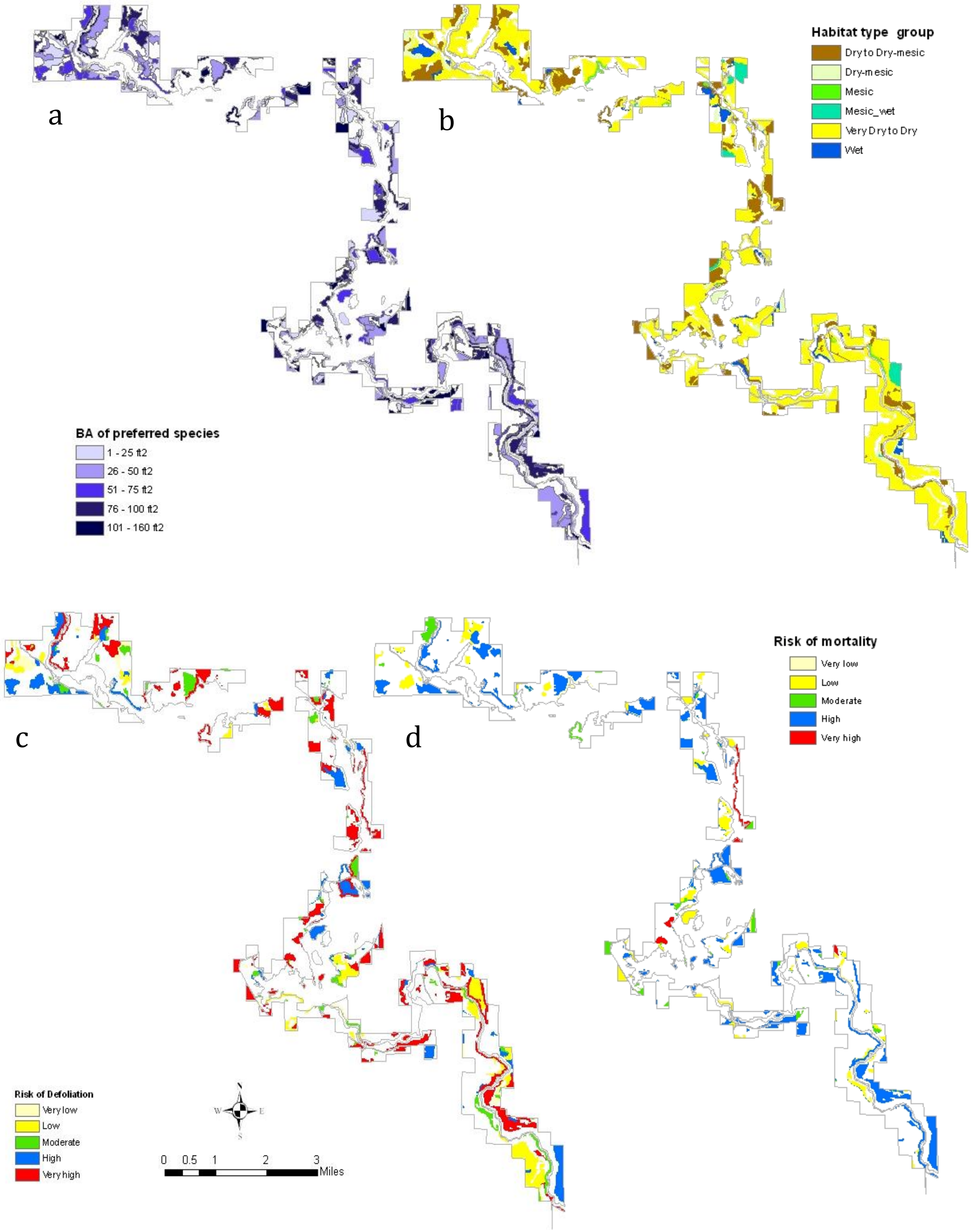


Figure 22. a. Basal area of preferred species - highest in the oak and aspen forest types. b. Habitat type groups - much of the Peshtigo River State Forest is very dry and sandy. c. Risk of defoliation - highest where the basal area of preferred species is highest. d. Risk of mortality - highest where the habitat type is very dry to dry.

Hemlock Wooly Adelgid

Surveying for hemlock wooly adelgid (*Adelges tsugae*) on state, county and privately-owned land was completed in May and June 2011. Survey sites were chosen because of introduction risk at tree nurseries, campgrounds, recreation areas or seasonal homes (Figure 23, left). At each site, two branches from opposite sides of 30-50 hemlock were examined for the presence of the adelgid's white, wooly egg sacs (Figure 23, right). If present, the egg sacs would be most easily seen from late fall through early summer. No signs of hemlock wooly adelgid were found in 2011. For more information on hemlock wooly adelgid, visit: http://www.dnr.wi.gov/forestry/FH/hwa.htm.

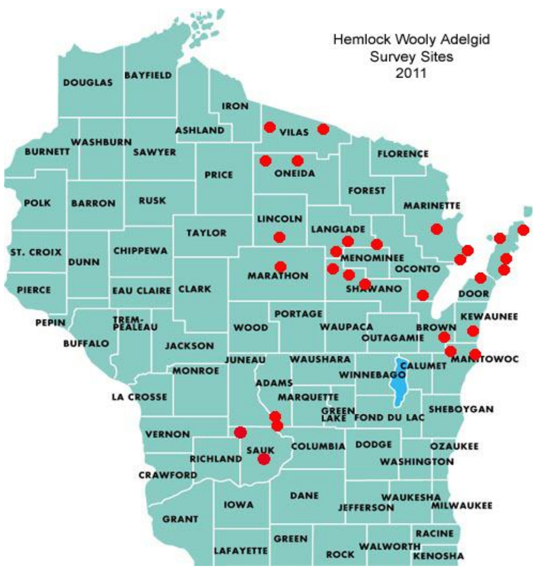


Figure 23. Left. 2011 hemlock wooly adelgid survey sites. Right. Hemlock wooly adelgid egg sacs in the eastern United States.

Invasive Plants

Best Management Practices (BMPs) - Outreach has become the main focus of the BMPs. Many training sessions were developed to focus specifically on the Forestry BMPs. Many more talks were given throughout the year for all the tracks (Forestry BMPs, Recreation BMPs, Urban Forestry BMPs, and Transportation and Utility Corridor BMPs) to dozens of audiences with great success. The ROW track has had great momentum with many partners assisting with the outreach. Individual audience handouts were developed for the Recreation and Urban Forestry tracks. The BMPs and outreach materials can be found at: http://dnr.wi.gov/invasives/bmp.htm.

NR40 - Invasive species identification, classification and control - Education has continued to be the focal point and as mentioned above, personnel spoke at many conferences and conducted training sessions across Wisconsin. Educational materials and resources are continually being developed by DNR staff to be available for educating citizens and stakeholders about the rule. The focus was primarily on nurseries and Master Gardeners.

The process to revise NR40 began in 2011, and many more terrestrial plant species will be assessed for possible coverage under the rule. Many of the plants are those that are in the green industry trade. For additional information about NR40, go to http://dnr.wi.gov/invasives/classification/.

Figure 24. Invasive plant display at State Fair, 2011.

Outreach and education - As stated above, 2011 was a successful year in providing many people across the state with a better understanding of invasive plant issues. The obvious marriage of the BMPs and NR40, with the common goal of prevention, has made the outreach effort more effective and efficient. However, prevention is not possible without some level of understanding of the impacts of invasive plants and the ability to identify them.

Wisconsin State Fair - Invasive plants, insects and diseases were again the focus of several displays at the State Fair, which reaches many thousands of people (Figure 24).

State Forests invasive plant management plans - Funds were received from the USDA Forest Service to do surveys of southern State Forests, and to develop invasive plant management plans based on the recent surveys and any survey data the properties already have. Surveys will be focused on high-use recreation areas such as trails, campground sites and picnic areas. The goal of developing these plans is to provide land managers with some clear priorities in their efforts to control invasive plants.

Suppression - Funds were again received from the USDA Forest Service for control and suppression of invasive plants that threaten forests. The funding allowed DNR to continue the effort of controlling plants that are detected early (before they become widely established) and those plants that impact high quality sites. These treatments are critical for slowing the spread of highly invasive species. In 2011 there were two reports of a previously unknown plant species in Wisconsin: Amur cork tree and Japanese wisteria. Both control projects will be funded with this grant.

Thousand Cankers Disease and Black Walnut

Wisconsin has approximately 19 million eastern black walnut (*Juglans nigra*) trees. Black walnut is a highly valued tree species for its quality of wood and wildlife benefits. The black walnut resource is primarily located in southern Wisconsin, with the highest densities occurring in the southwest corner of the state (Figure 25). Black walnut trees also represent a small component of the urban forest in Wisconsin and are a desirable species grown in plantations. Wisconsin exports $4 million in black walnut veneer logs and lumber annually.

Thousand cankers disease (TCD) is a newly recognized disease that infects a variety of species of walnut trees (*Juglan*s sp.). In Wisconsin, both black walnut and butternut (*Juglans cinerea*) are susceptible to TCD, with black walnut being particularly susceptible. Thousand cankers disease was first observed in New Mexico in the 1990s and has since spread to eight Western states (Figure 26). In 2010 TCD was discovered in eastern Tennessee within the natural range of eastern black walnut. Since this discovery, TCD has been detected in several additional counties in eastern Tennessee, as well as in Pennsylvania and Virginia. To date, TCD has not been found in Wisconsin.

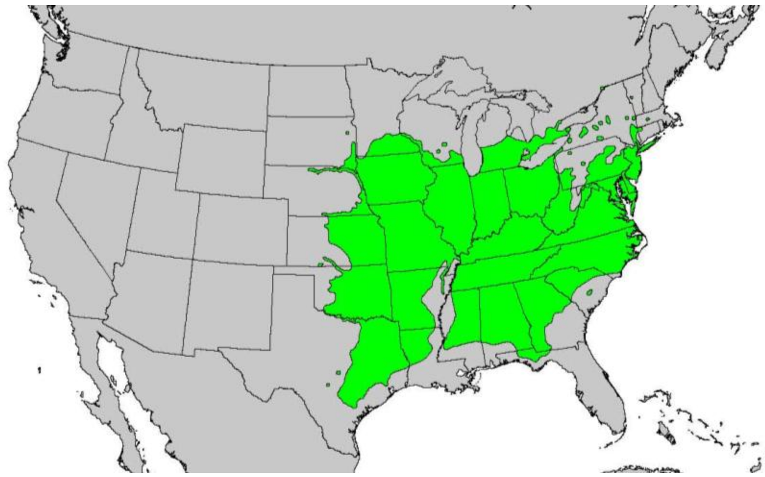


Figure 25. Distribution of eastern black walnut (in green). Map courtesy of USGS, www.thousandcankers.com.

The name "Thousand Cankers Disease" describes the multiple cankers that develop under the bark of infected walnut trees (Figure 27). Thousand cankers disease is due to the walnut twig beetle (WTB, *Pityophthorus juglandis*) and *Geosmithia morbida,* a fungus carried by the beetle. Walnut twig beetles feed beneath the bark, dispersing *G. morbida* as they tunnel through the tree. Eventually, cankers from the *Geosmithia* fungus develop under the bark and become numerous enough that symptoms of infection become visually apparent. A tree that has TCD will progress from crown thinning and yellowing of foliage to foliar wilting and branch dieback. Symptoms can occur over a 2-3 year period prior to tree death.

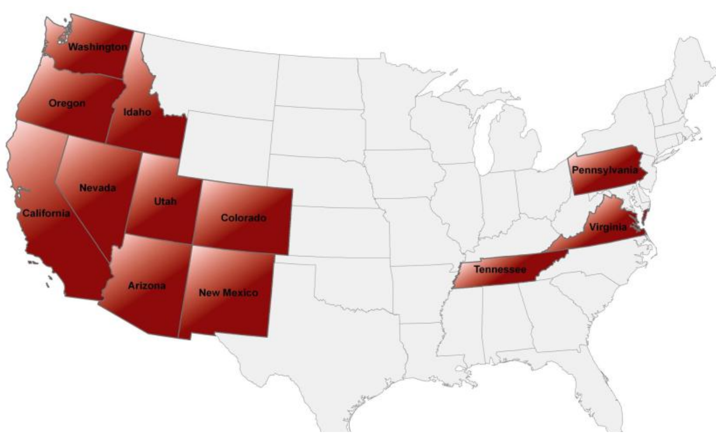


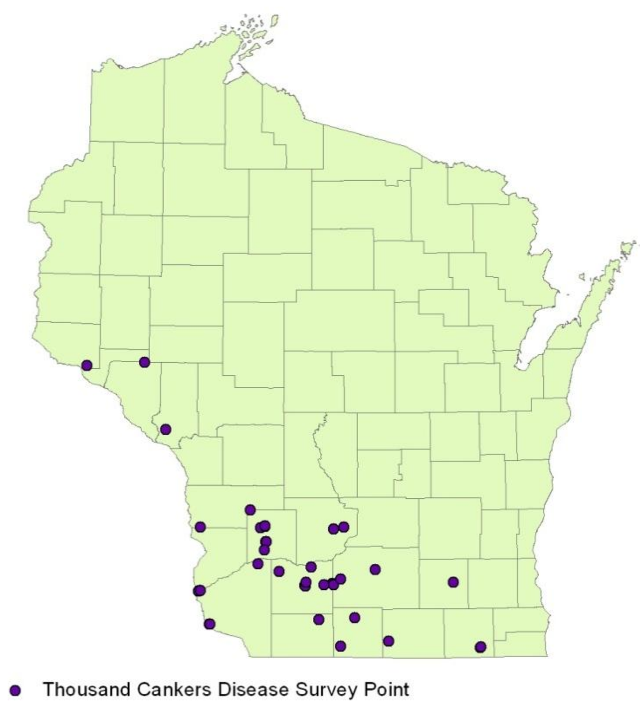
Figure 26. States where thousand cankers disease has been detected. Map courtesy of Pennsylvania Department of Agriculture, www.thousandcankers.com.

Figure 27. A tree infected with TCD develops numerous cankers beneath the bark. Photo courtesy of Whitney Cranshaw, Colorado State University, www.Bugwood.org.

Surveys for TCD were conducted in Wisconsin during the summer of 2011, when crown decline symptoms were most evident. An exploratory branch cutting technique, similar to the one used when looking for emerald ash borer-infested ash trees in urban areas (Ryall 2010), was used to look for signs of TCD. Survey efforts were prioritized to address: 1) reports of dead or declining walnut from private landowners, DNR foresters and state land managers; and 2) state park lands in southern Wisconsin known to have a walnut resource. Branch samples were collected from declining walnut trees when possible, but it was necessary to sample healthy trees at some of the state park sites.

When conducting surveys, two branches per tree were selected and cut off with a pole saw. Preference was given to branches 1-3" in diameter and those with evidence of decline. Each branch sample was then cut into three 18" sections beginning from the cut end of the branch. Samples were either peeled on site or bagged and brought back to the laboratory. Prior to branch peeling, bark was examined for evidence of WTB exit holes. Branches were then peeled with a knife and the phloem layer was checked for WTB galleries, WTB life stages and *G. morbida* cankers.

A total of 44 samples were collected during TCD survey efforts (Figure 28). Eleven state parks in southern Wisconsin were visited and a total of 21 samples were collected at these sites. The remaining 23 samples were collected from various sites owned by 17 private landowners. There were no signs of either *G. morbida* cankers or WTB in any of the samples that were processed. However, there were numerous other walnut



State Park Property	County
Big Foot Beach	Walworth
Blue Mounds	Iowa
Browntown-Cadiz Sprgs.	Green
Devil's Lake	Sauk
Governor Dodge	Iowa
Governor Nelson	Dane
Nelson Dewey	Grant
New Glarus	Green
Tower Hill	Iowa
Wyalusing	Grant
Yellowstone	Lafayette

Figure 28. Locations where walnut trees were surveyed for TCD. Of those properties surveyed that were public, the table at right lists the State Park properties that were visited during TCD survey efforts.

decline pests and pathogens observed in the samples. These issues are covered in greater detail in the 'Walnut Decline' article found in this annual report.

Future Surveys - Wisconsin DNR is planning continued detection efforts for TCD in 2012. Future survey work will likely include the branch survey method and the use of a baited detection trap specific to WTB. The availability of a baited detection trap will allow for expanded TCD survey efforts.

Quarantine established for TCD in Wisconsin - Thousand cankers disease can spread via transportation of firewood, nursery stock and unfinished or untreated black walnut products. Consequently, the Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP) enacted regulations that took effect August 1, 2011, to prohibit bringing potentially-infested walnut items into Wisconsin from states known to harbor TCD. Regulated articles include all hardwood firewood, nursery stock, unprocessed lumber and woodchips from *Juglans* species. Importers can get exemptions from the rule if they can certify that the material they want to bring to Wisconsin has not been exposed to TCD or has been treated. Items such as treated lumber, furniture and food nuts are not regulated. The official DATCP news release can be read at http://datcp.wi.gov/uploads/News_and_Events/pdf/ThousandCankersReg.pdf.

References

Ryall, K.L., Fidgen, J.G. and Turgeon, J.J. 2010. Detection of emerald ash borer in urban environments using branch sampling. Natural Resources Canada, Canadian Forest Service, Great Lakes Forestry Centre. 3 pages.

Ash Map Project

Prepared by Bernard Isaacson
University of Wisconsin – Madison

Introduction

In order to determine management strategies for the anticipated impacts of emerald ash borer, information is needed about the status of ash trees (*Fraxinus* sp.) in Wisconsin. Though some public properties have detailed inventories that include the location of stands of ash trees, until the production of this ash map product there was no detailed, state-wide dataset showing the location of ash trees. With direction and funding from the Wisconsin DNR, the University of Wisconsin - Madison established a method to map ash using Landsat and MODIS satellite imagery. The objectives of this project were twofold:

1) Determine a method to map ash trees that is reproducible, spatially robust, and detailed
2) Apply this method to Landsat imagery to produce a statewide map of ash trees

Phenology, the chronological sequence of life history events, has been shown to improve forest classification in remote sensing. Studies have typically utilized phenological state within well-timed images to classify forest types of interest. However, the date on which particular phenological events occur shifts slightly from year to year due to inter-annual differences in weather. Nevertheless, there is consistency in the relative order of the same event among members of a plant community. In the upper Midwest, ash trees are some of the last species to leaf out in the spring and the first to drop leaves in the fall. This trait has been used to thematically delineate dense communities of black ash in forest type mapping. However, the techniques used in the past did not meet the requirements of the first objective, so project staff worked to develop new methodology that would produce the best possible map product.

Research into the first objective produced a novel technique that fused data from separate satellite sensors to observe the phenology of different forest tree species. This work is under review for publication as of the date of this document. The second objective, a map of ash, was completed in late 2010 and was provided to the Wisconsin DNR in early 2011. The method can be spatially generalized and was extended to the entire state of Wisconsin to produce a 30-meter resolution map describing ash abundance (Figure 29). End-users should pay attention to the benefits and limitations of this product to ensure best use.

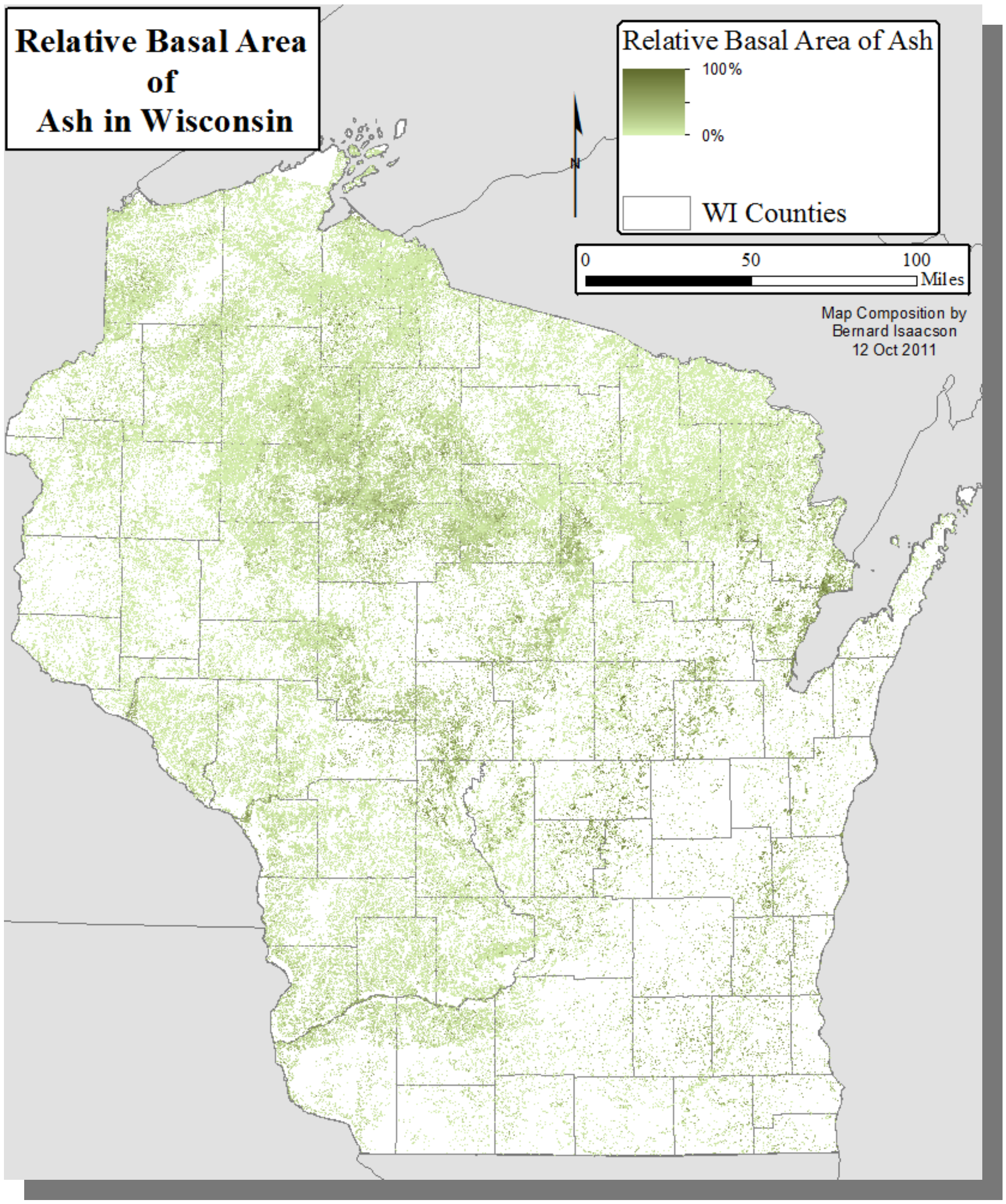


Figure 29. Ash abundance in Wisconsin by relative basal area.

Methods

The approach for characterizing phenology by species across climatic gradients incorporated ground-based data, a rich Landsat time series, and MODIS phenology products. The calendar-date timing of Landsat data were standardized using the MODIS products, and vegetation indices from the date-standardized Landsat data were then used with the ground data to perform analyses of species phenology across the landscape.

Ground Data Methodology:
1. Collect forest composition data from plots on public lands. Plot design was specially tailored to the needs of the satellite data planned for use. Most ground data was collected in the Flambeau River State Forest and the Kettle Moraine State Forest (Northern Unit).

Satellite Data Methodology:
1. Acquire and process appropriate Landsat and MODIS images, as well as phenology products
2. Create and rescale phenology products for areas and times where data are missing or poor
3. Calculate greenness for all pixels, and arrange order of Landsat pixels using phenology data
4. Model phenology for individual Landsat pixels across the state
5. Find relationship between ground data and timing of senescence
6. Apply relationship to phenology map to produce a statewide map of ash
7. Check results

Limitations

After collecting a limited validation dataset in the winters of 2010 and 2011, it was determined that there were several limitations to the map product. These issues are important to consider for any use of the map. While it may be possible to correct them in a future iteration, these drawbacks are the result of project methodology and data sources, suggesting that efforts to counteract them will require intensive efforts. The map is a snapshot in time, derived from Landsat imagery from 2001-2007. While large disturbances, such as downbursts, fires, and forest clearing, were accounted for, the techniques did not account for less-intense disturbances, such as mild silvicultural treatments. Forests that have been actively managed since 2001 will likely not be accurately characterized.

Other limitations of the imagery from this time period are apparent. Gaps are present in the data in areas not covered by the satellite footprints, such as northern Bayfield County, far western Polk and Burnett Counties, and northern Door County. Areas using more data from Landsat 7 suffer from data gaps resulting from satellite malfunction. These areas are characterized by alternating strips of high and low ash, trending WNW-ESE. This is a problem in southeast Marinette County, western Taylor County, southern Rusk County, northeast Chippewa County, central Wood County and central Juneau County.

Plant communities observed throughout the state complicated efforts to map ash. The quality of predictions in lowland areas was diminished by the forest mask used, which was dependent on the quality of winter imagery available. In areas dominated by lowland brush such as alder (greater than 6 ft., generally), willow, or dogwood, reliability is hindered. Such areas may not have an ash component, but are sometimes mislabeled as high-ash. The forest mask also causes problems when considering forest density. All of the training data was collected in forested stands with basal areas greater than 60 ft^2/ac (14 m^2 /ha). However, the forest mask included forests less dense than this. Therefore, any predictions by the map in areas of low density are outside the range of the original data and are less reliable.

Predictions for lowlands should be more reliable than upland predictions, as the project observed a wide range of ash densities in lowlands, and only a limited range in uplands. Even the 'ashiest' upland stands in the training dataset had only ~40% ash relative basal area. Predictions for uplands that exceed this percentage are outside the range of the original data. A mitigating consideration, though, is that the observed upland ash stands behaved the same way as the lowland ash stands, giving some basis to apply the same model across soil drainage types.

Finally, no effort was made to map ash in urban areas, restricting the analysis to areas that are predominantly forested. While this reduces the utility of the product for many end-users, the complexities of the urban environment make the project method untenable in cities.

<u>Product Utility</u>

Despite its limitations, the map product can be useful for many applications. As scale is made broader, the results are more robust, and large properties or administrative zones are likely to have good estimates of ash density. For those responsible for modeling the risk of EAB spread, the map presents the opportunity to incorporate ash distribution into models. Similarly, this product may enhance planning for DATCP's trap monitoring project. Trap distribution could take into account differing densities of ash, by prioritizing areas with more habitat for the beetle or by simplifying the task of locating ash trees within sample grids.

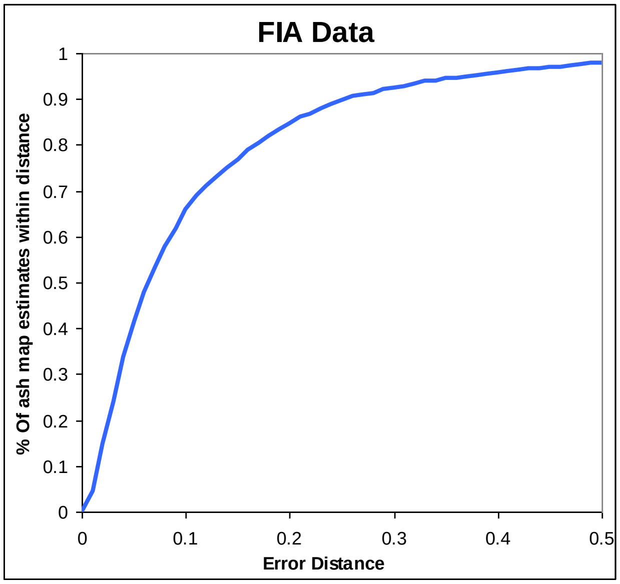


Figure 30. Ash map accuracy with FIA data. Error distance is the difference in relative Basal Area between the ash map prediction for ash and the ground-based observation. Y-axis is the percent of points where the 'error' is less than or equal to the error distance.

This map may enable land managers to prioritize areas for immediate reconnaissance or management. As EAB looms, it is important to quantify the ash resource, not only to know what may be lost but also to evaluate potential for recovery. Prescriptions for areas anticipated to be affected may be accelerated by the knowledge provided from this map, as a way to get ahead of the challenges posed by the insect. Additionally, invasive species management can be targeted – ahead of time – on the ash stands that will be disturbed by the insect.

Resource managers concerned with rare or threatened species, as well as those interested in overall ecosystem function, may find much utility from this product. For creatures whose habitats overlap with stands of ash, the ash map may direct attention to locations where habitat is most in danger of changing.

<u>Further Steps</u>

Field data collected in the past year is currently being examined to assess and validate the map product. A preliminary investigation using USFS FIA data showed that for 86% of cases, the map prediction of ash relative basal area was within 20% of the actual relative basal area (Figure 30). Work is also being done to establish which plant communities are problematic for this map. Preliminary analysis indicates that low basal area stands, as well as mixed lowlands with a high silver maple component, are poorly characterized by this method. Further work along this avenue of approach should be useful to managers in determining where to be skeptical of the map product, especially when expert knowledge conflicts with the map predictions.

Crazy Worms (Amynthas agrestis)

Crazy worms *(Amynthas agrestis)*, commonly called "Alabama Jumpers," are Asian earthworms that were introduced to the United States over a century ago through the horticultural trade. They have not been found in Wisconsin, and are presently categorized as Prohibited under Invasive Species Rule NR 40. Crazy worms are best identified as the only worms exposed on the soil surface, and if touched they will likely slither away like a tiny, FAST snake. They are very fast and very difficult to grab.

Crazy worms are an *epigeic* species (soil surface dweller) and feed on leaf litter. Their rate of consumption is about 5 times greater than other surface-dwelling earthworms. Crazy worms die off in the winter as they do not burrow into the ground. Eggs left on the soil surface are the first worm eggs to hatch in the spring. Crazy worms are commonly mistaken for other epigeic/endogeic species such as Red wigglers *(Lumbricus rubellus)* and Compost worms (*Eisenia fetida*).

Crazy worms are smaller and farther down on the food chain than other surface-dwelling earthworms. They have a "bottom-up" impact on native fauna and destabilize the "base" of the food chain. Unlike most invasive earthworms, *A. agrestis* are aggressive invaders - they don't stay where they're put. A crazy worm that is introduced to a suburban garden is as likely to migrate into a nearby forest as it is to stay in the garden. *Amynthas agrestis* have a tough, protective cuticle and they begin thrashing or flipping wildly if disturbed. Research suggests they may be better adapted to evade predators (which might otherwise help control their spread) than other earthworms.

In 3 seasons of conducting earthworm surveys in 20 counties, surveyors have yet to encounter a crazy worm in Wisconsin. Numerous reports have all turned out to be the more common Red wiggler (*Lumbricus rubellus)*.

Hardwood Health Issues

Alder Flea Beetle

For the second consecutive year, alder leaves were made brown and lacy (Figure 1) across much of northern Wisconsin by the alder flea beetle (*Altica ambiens*). In spotty locations, the damage was severe (e.g. Rhinelander and Monico). The impact to alders should be minimal since this is a late season defoliator. Populations should decline in 2012 or 2013 because infestations are reported to last 2 to 3 years before the flea beetles become unnoticeable.

Figure 1. Typical alder flea beetle damage on alder in northern Wisconsin in 2010 and 2011.

Ash Yellows

Ash yellows is caused by a phytoplasma, a wall-less bacteria-like microorganism. Symptoms of ash yellows include small, yellow foliage, slow twig growth, a thin crown, branch dieback, vertical cracks on the trunk, and brooms on the stem or at the base of the tree (Figure 2). Mortality of infected white ash in the forest setting has been observed. Sampling in 2011 did not detect ash yellows in any new counties. Ash yellows has been confirmed in 26 counties in Wisconsin and testing continues.

Figure 2. Tree infected with ash yellows shows yellowed sprouts. Photo from www.forestryimages.org.

Aspen Leafblotch Miner

As in 2010, the lower crowns of sapling to pole-sized aspens looked shabby all over much of northern Wisconsin (Figure 3). The culprit was the caterpillar of the aspen leafblotch miner (*Phyllonorycter* sp.). Damage was severe in Forest, Langlade, Lincoln, Oneida and Vilas Counties. Defoliation was moderate in Price and Sawyer Counties on trees up to 20 feet tall. It is doubtful that the aspen leafblotch miner significantly harms aspens since the leaf damage only reaches severe levels in the later growing season.

Figure 3. An aspen leafblotch miner larva and the damage it causes.

Bur Oak Blight

Since the 1990s bur oak blight (BOB) has been reported in Midwestern States including Iowa, Kansas, Minnesota, Nebraska and Wisconsin. The disease is believed to be caused by a new species of *Tubakia* fungus. *Tubakia dryina* has been known to be the causal agent of Tubakia leaf spot. However, BOB is considered a blight disease and not a leaf disease. In a severe BOB case, all the leaves on a tree will die late in the season. Upon further investigation by Dr. Tom Harrington of Iowa State University, *T. dryina* is now considered a species complex, and one species of *Tubakia*, currently called "BOB *Tubakia*" or "*Tubakia* sp. BOB," is associated with the disease.

Bur oak blight symptoms usually start appearing in late July and early August. Infected leaves develop purple-brown lesions along the midvein and major lateral veins on the underside of leaves. Later, chlorosis and necrosis expand on leaves and affected leaves wilt and die. Severely affected trees may die after many years of infection in combination with other pest issues. Severe symptoms of BOB have been observed only on *Quercus macrocarpa var. oliviformis*, a variety of bur oak that produces smaller acorns.

Bur oak blight has been confirmed in Dane, Green, Iowa, Kenosha, Rock, Sauk, Walworth and Waukesha Counties on bur oak. In 2011, leaf and twig samples were sent from Wisconsin to Iowa State University for the identification of "*Tubakia* sp. BOB." The samples were collected mainly from bur oak trees that were experiencing late season leaf necrosis. Laboratory analysis is in progress.

A pest alert was recently developed by the USDA Forest Service and can be viewed at:
http://na.fs.fed.us/pubs/palerts/bur_oak_blight/bob_print.pdf.

Butternut Canker - Update on Butternut Trial

The year 2011 was the 17th year of the butternut (*Juglans cinerea*) trial. The purpose of the study, conducted on the Menominee Nation, is to assess tree survival and cankering due to butternut canker *Ophiognomonia clavigignenti-juglandacearum* (syn. *Sirococcus clavigigenti-juglandacearum*). Project purpose, design and earlier findings are reported in the 2010 Forest Health Annual Report.

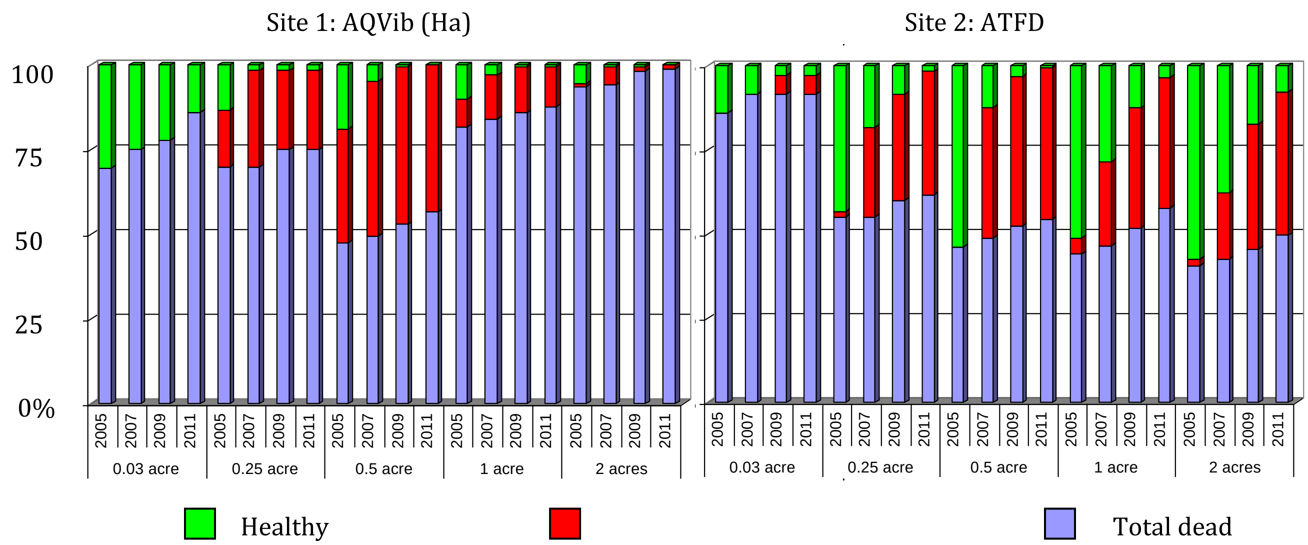


Figure 4. Four year summary of survival and cankering data for the Menominee butternut trial.

Tree survival and cankering were monitored again in 2011 (Figure 4). Most trees (81%) on the lower quality AQVib(Ha) site were dead. On the better quality ATFD site, 56% of trees were dead. At both sites, more than 90% of live trees were cankered. Only 7 trees on the poorer site and 22 trees on the richer site were canker-free (healthy) in 2011. This is out of a total of 1,196 trees planted in 1994.

In 2012, the DNR Forest Health group hopes to collaborate with Menominee disease specialists to estimate canker severity on each tree. This will help identify individuals that may have some resistance to the disease. The study will continue to monitor survival and cankering as well as the presence of butternut reproduction. As of 2011, nuts had not yet been observed.

Cherry Scallop Shell Moth

Cherry scallop shell moth (*Hydria prunivorata*) caused minor to moderate damage on black cherry trees in southeast Wood and central Oconto Counties. The caterpillars feed on the inside of leaves that they tie together into tube-like nests. Damage becomes obvious in late July or early August as chewed leaves turn brown and die (Figure 5). Cherry scallop shell moth can affect entire trees and cause branch dieback if damage occurs concurrently with another stress such as drought. Populations are typically kept in check by an egg parasitizing wasp in the genus *Telenomus*.

Figure 5. Leaves tied together and eaten by cherry scallop shell moth larvae.

Chestnut Study: A West Salem Overview

Prepared by Mark Double and William MacDonald
West Virginia University

The 90 acre West Salem (La Crosse County) stand of native mixed hardwoods was permanently altered when American chestnut seeds were planted there in the late 1880s. The generation of chestnut trees that developed flourished in this environment, and by the early 1990s more than 3,000 stems could be identified. They now range in size from <1 inch to >60 inches in diameter. The stand, currently considered the largest stand of American chestnut in North America, is 375 miles west of the natural range.

The stand was free of chestnut blight until 1987, when cankers were observed on four trees (Figure 6). The dilemma created by the discovery of blight presented an opportunity for researchers from Cornell University, Michigan State University, West Virginia University, University of Wisconsin-La Crosse and the Wisconsin Department of Natural Resources to initiate collaborative studies in 1992 using a biological approach to disease control.

Figure 6. Lethal chestnut blight canker on the main stem. Photo from www.forestryimages.org.

Cryphonectria parasitica, the fungus that causes chestnut blight, can itself become infected with a virus (known as a 'hypovirus') that weakens the fungus. When virus-containing strains infect the bark of chestnut, they grow more slowly than the normal strains, allowing the tree's own natural defenses to combat the disease. In an effort to initiate biological control, virus-infected strains of the fungus were introduced into the stand between 1992 and 1997 by making small punch wounds around the margin of cankers and introducing the virus-laden strains of the fungus into the wounds. During this six-year time frame, nearly 700 cankers were treated on 135 American chestnut trees.

It is not possible to visually evaluate spread of the virus-infected strains of *C. parasitica*. The only way to evaluate virus spread is to remove small bark samples from each canker, isolate the fungus in the laboratory, and determine whether it has acquired the virus. Normal fungal cultures can be distinguished from the virus-infected forms by their color and appearance on agar media. This laborious task has been conducted by the research team. After the 1997 research season, the collaborators decided to cease treating cankers to see if the virus would continue to spread in the absence of further introductions. From 1998-2000, treatments ceased although the annual canker sampling and evaluation continued. During this 3-year period, an additional 900 cankers on 365 trees were monitored for virus acquisition.

After an assessment of the disease and virus spread was made in 2000, it became clear that the disease had reached a level that made sampling all cankers within the stand impossible. Therefore, 12 permanent plots were established within the stand for sampling. The 12 plots were located randomly throughout the stand but were assigned to represent areas of both high and low disease incidence. Because virus spread was not as significant as had been anticipated, virus-infected strains were reintroduced into the 12 permanent plots beginning in 2003. These inoculations and canker sampling have continued through 2011. A general summary of findings are:

- The epidemic of chestnut blight at the West Salem chestnut stand continues. Many trees have died although they continue to produce abundant sprouts.
- The introduced virus has spread significantly on trees where cankers have been treated.
- Fifty-one percent of the trees that were treated with virus-infected strains remain alive, with good evidence that infections are callusing. Improvement in crown health on these trees also is evident. Forty-one percent of untreated trees in the stand are alive.

Summary of 2011 findings:

- Movement of the hypovirus to untreated trees has increased in all areas of the stand.
- A total of 3,040 cankers have been detected in the 12 plots since 1992. 159 cankers were newly discovered.
- Mortality in the 'Disease Center,' 'Front' and 'Beyond the Front' plots is 56%, 55% and 51%, respectively.
- The percentage of infected trees has remained relatively constant in the 'Disease Center' plots (92-98%) between 2001 and 2011. In contrast, the number of infected trees has risen sharply in the 'Disease Front' plots (29% to 95%) and 'Beyond the Front' plots (11% to 91%).
- Reservoirs of hypovirulent fungal inoculum, provided by scratch-wounding areas of the bark, were not as effective as punch-treatments in disseminating hypovirus inoculum to new infections.
- Vegetative compatibility testing continues. WS-1 continues to be the dominant vegetative compatibility type in the stand. Its frequency has declined from 87% in 2009 to 77% in 2011. WS-2 and WS-3 were found at rates of 2% and 16%, respectively.

Hypovirus treatment appears to play a role in tree longevity. 57% of the trees in the Disease Center that initially were treated from 1992-1997 were alive in 2011. Only 40% of the trees infected between 1998-2002, in the absence of hypovirus treatment, remain alive.

Columbian Timber Beetle

Some silver maple stands in northeast Wisconsin have been affected by significant staining (Figure 7) caused by attacks from Columbian timber beetle (*Corthylus columbianus*) and beech timber beetle (*Xyloterinus politus*). This staining causes logs to be reduced in grade. Repeated attacks by Columbian timber beetle do not kill the tree or weaken it. Any new wood put on after attacks subside will be clear wood, although the staining caused by beetle attack will remain in the tree. A site visit conducted in June 2010 found that the only reliable method for determining if a tree was infested with Columbian timber beetle was to cut it down and check both a horizontal section and a vertical section to look for the characteristic staining. In May 2011, additional wood samples were collected to determine whether Columbian timber beetle or beech timber beetle were more prevalent, but no insects emerged from the samples.

Figure 7. Wood stain in trees infested by Columbian timber beetle.

Dutch Elm Disease

Dutch elm disease (Figure 8) appeared to be a common tree-killing agent in a large portion of northern and central Wisconsin. The percentage of elms affected seemed high. Formal surveys for Dutch elm disease are not conducted, so it is impossible to say whether or not it was more common this year than in other years.

Figure 8. Elm with characteristic flagging due to Dutch elm disease. Photo from www.forestryimages.org.

Eastern Tent Caterpillar

Eastern tent caterpillars (*Malacosoma americanum*) were commonly observed this year in parts of central and southern Wisconsin. In general, populations were lower than in the previous few years. Defoliation-level populations were seen in southeast Wood County, northern Adams County and southwest Portage County. The majority of the defoliated trees survived and put out a second set of leaves in July. A high population was also reported in Rock County near Janesville. Eastern tent caterpillar in this area caused some heavy defoliation to a woodlot edge and migrating caterpillars created a nuisance for adjacent homeowners.

A few diseased larvae were observed in Dane County. According to the scientific literature, an NPV virus occasionally affects this species but not to the level observed in gypsy moth. When present, NPV is often observed with dead larvae hanging on the outer portion of the tents they make (Figure 9). More information on eastern tent caterpillars is available at: http://learningstore.uwex.edu/Assets/pdfs/A2933.pdf.

Figure 9. Eastern tent caterpillar killed by an NPV virus.

Elm Spanworm

Southern Wisconsin saw elm spanworm (*Ennomos subsignaria*) defoliation mixed with forest tent caterpillar defoliation for the second year in a row. Aerial and ground surveys found that in the Baraboo Hills area of Sauk County, about 4,400 acres of moderate defoliation was caused by the two defoliators. A majority of the defoliation in this area was moderate and attributed to elm spanworm. Pockets of heavy defoliation were due to either forest tent caterpillar or a combination of forest tent caterpillar and elm spanworm (Figure 10). An

Figure 10. Left. Dark phase of elm spanworm indicative of outbreak populations. Center. Elm spanworm rolls up webbing into a ball to hold on to. This was a common observation. Right. Pink areas in Sauk County were moderately defoliated by forest tent caterpillar and elm spanworm in 2011.

area east of Natural Bridge State Park (Sauk County) had some of the heaviest elm spanworm populations observed. Damage was evident on numerous species including basswood, elm, maple, ironwood and others.

Fall Webworm

Populations of fall webworm (*Hyphantria cunea*) were occasionally observed throughout Wisconsin in 2011. The insect was noted most frequently in Lincoln, Price, Richland and Sawyer Counties. Fall webworm (Figure 11) is typically seen on alder, elm, walnut and birch, although it can feed on over 100 species of broadleaf plants. As a late season defoliator it is not considered a major forest pest.

Figure 11. Fall webworm larvae.

Forest Tent Caterpillar

Defoliation Reports

In northern Wisconsin, forest tent caterpillar (*Malacosoma disstria*) numbers appeared to be on the increase in 2011. Approximately 500 to 1,500 acres of aspen had scattered light or moderate defoliation in Polk County around Balsam Lake and in Iron County west of Pine Lake. Approximately 25 acres of heavy defoliation was seen in Burnett County in the Town of Wood River.

In southern Wisconsin, forest tent caterpillar defoliation was mixed with elm spanworm defoliation for the second year in a row. Aerial and ground surveys found approximately 11,400 acres of moderate defoliation in Grant and Crawford Counties that was primarily caused by forest tent caterpillar (Figure 12). In the

Baraboo Hills area of Sauk County, about 4,400 acres of moderate defoliation was caused by both forest tent caterpillar and elm spanworm.

Winter 2010-11 Egg Mass Survey Study

Three sites east of Devils Lake in Sauk County were selected to test survey protocols for predicting defoliation by forest tent caterpillar. The survey protocol called for cutting two 6-12" dbh aspen trees at each site and counting all the egg masses found on the twigs of each tree (Figure 13, left). Egg mass counts at the three sites ranged from 0 to 15 egg masses per tree. Based on these results, the survey predicted scattered areas of light to moderate defoliation in spring 2011.

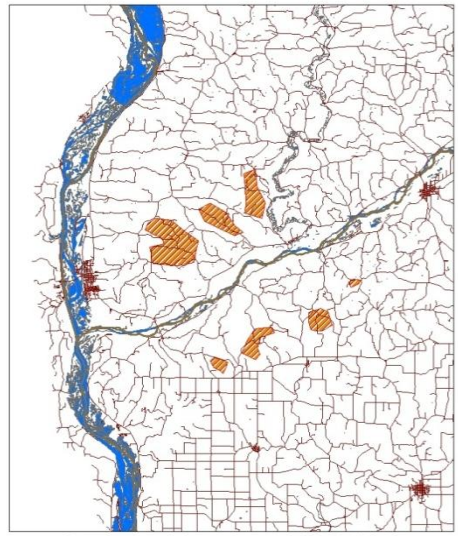


Figure 12. Orange areas in Crawford and Grant Counties were moderately defoliated by forest tent caterpillar in 2011.

Subsequent aerial surveys did not detect visible defoliation at the three sampling sites. Ground evaluations were not done, so survey protocols for forest tent caterpillar remain questionable in predicting damage. General observations indicate smaller populations at these survey areas in 2012.
Some egg masses at the sites contained eggs but were only partially covered with the protective "spumulin" coating found on tent caterpillar egg masses (Figure 13, right). Dr. Ezra Schwartzberg, a Post-Doctoral Researcher at UW–Madison, collected the egg masses for research on forest tent caterpillar parasitoids. He found that these partially-covered masses were still viable and had about 80% hatch.

Figure 13. Left. Conducting an egg mass survey for forest tent caterpillar. Right. Viable egg masses only partially covered with "spumulin" (protective covering).

Hickory Mortality

Scattered dieback and mortality of bitternut and shagbark hickory has been observed throughout Wisconsin during the last six years. Indiana, Iowa, Minnesota, New York and Ohio have also reported this phenomenon. Symptoms include dieback and wilting or browning of leaves. Tree mortality occurs two or three years after an initial appearance of symptoms. Dr. Jennifer Juzwik, research scientist with the USDA Forest Service, has confirmed the fungal pathogen, *Ceratocystis smalleyi*, as being a virulent pathogen and causing small cankers in the sapwood of affected hickory trees. The number of cankers on a tree can be significant and cankers can be found throughout the tree, giving it an unofficial name of '100 Canker Disease.' The cankers reduce sap flow, causing a limited vascular wilt. Hickory bark beetle (*Scolytus quadrispinosus*) can spread the spores of *C. smalleyi* from tree to tree, but only one of hickory bark beetle or *C. smalleyi* may also be found in trees. For more information, visit: http://www.nrs.fs.fed.us/pubs/jrnl/2010/nrs_2010_park_001.pdf.

Maple Webworm

In July 2011, approximately 1,400 acres of moderate defoliation by maple webworm (*Tetralopha asperatella*, Figure 14) was confirmed by ground surveys in western Columbia County and far eastern Sauk County (Figure 15). This area also had minor problems with forest tent caterpillar and elm spanworm earlier in the summer, and some damage was still present. The area likely had an earlier population of leafrollers or spanworms, whose rolled leaves were utilized for egg laying by maple webworm.

Figure 14. Color variation of the maple webworm.

Maple webworm was last reported to have caused defoliation in the late 1950s. For more information about maple webworm, visit: http://www.forestpests.org/vermont/maplewebworm.hml and http://maple.dnr.cornell.edu/insectsdisease/MapleLeafrollers.html.

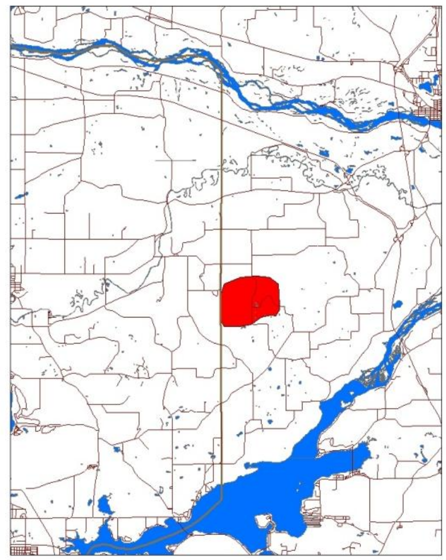


Figure 15. Red area in Columbia County was moderately defoliated by maple webworm in 2011.

Oak Wilt

The 2010 discoveries of isolated oak wilt infections in northeast Oneida County and Langlade County (Figures 16 and 17) spawned a greater emphasis on oak wilt survey and outreach in 2011 in these counties. Presentations on oak wilt were given to a number of groups, including lake associations, local government officials, tree care businesses and foresters. Property owners in a heavily infected area of southeast Langlade County were mailed oak wilt educational materials and encouraged to control oak wilt on their properties. These outreach efforts, along with local press releases and interviews, created greater local interest and awareness of oak wilt and should be considered a successful effort at minimizing the short term impact of oak wilt.

<u>Control Efforts</u>

The owner of the isolated oak wilt-infected tree in northeast Oneida County had the infected tree removed in December 2010 before it could produce pressure pads and spores. All oaks that were potentially root-grafted with the infected tree were injected with fungicide in spring 2011 to avoid wilt and spore formation. This site was monitored and will continue to be examined for a number of years.

To control oak wilt in the isolated location in central Langlade County, a county forester cut down all oaks that were grafted with infected oaks, plus an additional tier of oaks, in early March 2011. This effort will avoid any above-ground spore production in the future. It also will avoid additional infection since the disease will eventually run out of host material below ground. In September 2011, oak wilt was also detected in southeast Langlade Co. on the west side of Wisconsin Highway 55. The landowner plans to remove the infected tree in 2011 and attempt experimental herbicide treatment of adjacent grafted oaks.

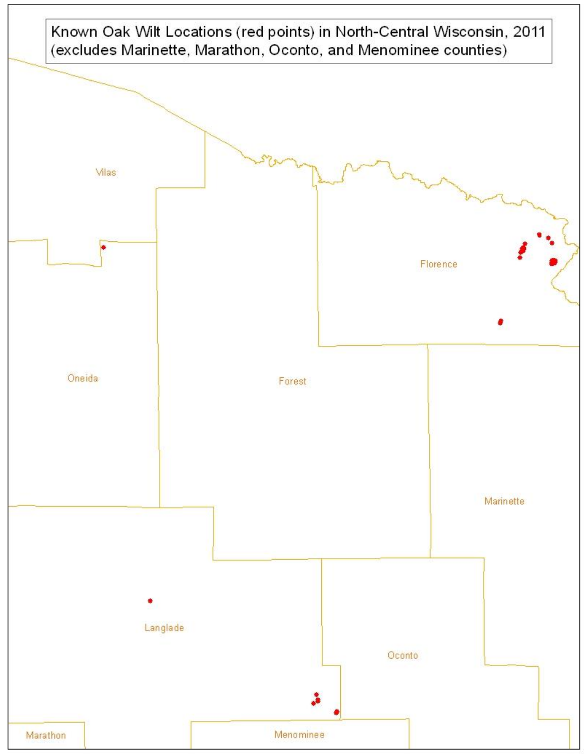


Figure 16. Locations of known oak wilt pockets in the eastern counties of the DNR northern region. Sites in Marathon, Marinette, Menominee and Oconto Counties are not included.

<u>Oak Wilt Surveys</u>

No additional wilting oaks were found in Oneida County in 2011. Early detection ground surveys were intense and the area was closely inspected from the air. An oak wilt detection flight was flown in late July over portions of Florence, Forest, Langlade, Oneida and Vilas Counties. The only new oak wilt pockets found were south of Spread Eagle in Florence County, which was already known to be heavily infected. The primary deduction from the flight was that oak wilt is not yet well established in central Langlade and northeast Oneida Counties. To date, property owner and forester reports of wilting oaks have proven equally or more important than aerial surveys for early detection.

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

An herbicide field trial was initiated at the Nine-Mile Recreation Area in the Marathon County Forest in 2003, as an alternative to physical root severing by a vibratory plow. Trees within grafting distance were identified by using Johann Bruhn's model, and these trees were treated with Garlon 4 (active ingredient: triclopyr) in early July 2003 and early July 2004. Details of the treatments can be found in the 2004 Forest Health Annual Report.

In 2005, a new oak wilt pocket was found in the Marathon County Forest, approximately 1/4 mile from the original herbicide trial site. Seventeen trees were treated in late June 2006. In 2008, a pocket of dead trees was found at the south end of the property, approximately 1.5 miles from the original pocket. Another oak wilt pocket was found in 2010. Both pockets were treated with Garlon 4 in the same way.

As of fall 2011, no additional symptomatic trees have been found in any of the four pockets that were treated with an herbicide. These stands will continue to be monitored through weekly visits by county forest personnel during the summer of 2012. DNR staff thank Doug Brown, a Marathon County Forester, and Tom Lovlien, Marathon County Forest Administrator, for providing periodic updates on the progress of the trial.

Figure 17. Tree killed by oak wilt in Oneida County, 2010.

A similar herbicide treatment was implemented on 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 identified by a professional arborist and marked trees were killed with Garlon 4 in early July 2006.

One large red oak that was away from the treated Dane County pocket was confirmed to have 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. Both pockets have been monitored annually by DNR Forest Health staff. No symptomatic trees were found outside of the treated pockets in 2011.

Marathon County Forest, USDA Forest Service and WI DNR staff have initiated discussions to investigate this method further using a systematic approach with additional sites. A grant opportunity will be explored to pursue it further.

Post Oak Locust

Post oak locusts (a.k.a. post oak grasshoppers) and feeding damage were seen in central and western Wisconsin in 2011 (Figure 18). In Adams County, 120 acres of light to moderate damage was seen east of Rome. In Eau Claire County, there was light to heavy defoliation at Tower Ridge County Recreation Area. Light to moderate defoliation was also reported northeast of Millston on the Black River State Forest in Jackson County. Post oak locust is an easy species to identify because as their scientific name (*Dendrotettix quercus*) suggests, they feed on oak trees. Very few grasshopper species feed in trees. The large head and red coloration on the largest segment of the hind legs also help identify this species (Figure 18, left). This locust is well known for large, periodic outbreaks that occur from southern New York to Tennessee and from Wisconsin to eastern Texas. Several years of heavy defoliation can cause tree mortality, but researchers studying this species do not recommend spraying large areas with insecticide. It is difficult to treat an entire oak canopy and grasshoppers are highly mobile. In most cases the outbreak will be short-lived and no long-term damage will be done to the trees. Post oak locusts emerge from eggs laid in the soil near margins of oak

Figure 18. Left. A post oak locust feeding on an oak leaf near Rome, WI in July 2011. Right. Feeding damage.

woods in late May or early June, and mature in early July. Mating and egg laying occur in mid-July. A biological control bait that contains the protozoan *Nosema locustae* (trade names NOLO Bait or Semaspore) may help control young grasshopper populations.

Squirrel Damage on Sugar Maple

During March and April 2011 there were numerous reports of squirrels causing damage to sugar maples in Shawano and Oconto Counties, as well as south of Minocqua (Oneida Co.) and near Lac du Flambeau (Vilas Co.). Damage was confirmed by measuring the width of the tooth marks on the branches. Squirrels chew the bark off branches in the crowns of trees. These de-barked branches may be girdled if the damaged area surrounds the branch, or multiple spots of damage on a single branch can cause some dieback. This dieback may not show up for a year or two, depending on the health of the tree and the severity of the squirrel damage.

At one Oneida County site, the top kill and girdling done to overtopped and intermediate sugar maple saplings and poles was moderate to severe on 13 acres of forest. As spring came and leaves began to emerge, the top kill and girdling became more evident. Some branches, although severely damaged, were able to leaf out in the spring. As summer progressed, the leaves on these branches suddenly turned brown and died. Northeast Wisconsin also generated a few reports of squirrel damage on spruce. Squirrels nipped off the branch tips, which often ended up littering the forest floor.

Sugar Maple Flagging

A noteworthy phenomenon was observed on sugar maple in northcentral and northeast Wisconsin in late June. Scattered branch death was reported from Iron and Vilas Counties southeast to Shawano and Oconto Counties (Figure 19, left). The prevalence and severity was low, but the symptoms were widespread. At most 25% of sugar maples in any given area had flagging branches, and on those trees, roughly 1% of the branches were impacted. The areas with the most obvious disease were just east of Eagle River (Vilas County) and in eastern Langlade County.

Unidentified black, fungal fruiting bodies were associated with these symptoms (Figure 19, right). Fungi that can cause such symptoms and have black fruiting bodies are *Stegonsporium pyriforme*, *Valsa abiens* and *V. ceratosperma* (anamorphs of the *Valsa* sp. are *Cytospora* sp.). All of these fungi are known to be opportunistic pathogens, infecting trees and causing symptoms after droughts or after unusual freezes, for example. It is also possible that the fruiting bodies were from an innocuous saprophyte. The broad distribution of the dieback on sugar maples strongly indicates a unique environmental event as the inciting factor. Widespread freezing temperatures across northeast Wisconsin on May 27 may have been the inciting factor, and some low-lying areas likely experienced additional freezing temperatures on June 12 (e.g. the Crandon and Ironwood areas).

Figure 19. Left. Branch flagging from an unidentified cause was frequently seen on sugar maples in northern Wisconsin in 2011. Right. Typical fungal fruiting bodies found at the base of flagging sugar maple branches in northern Wisconsin.

Walnut Dieback and Cankers: A Possible Decline Disease

Figure 20. Top. *Agrilus* beetles collected from declining walnut in Richland County. Bottom. Larva observed beneath the bark of black walnut.

Surveys for thousand cankers disease (TCD) were conducted in 2011 on both natural and plantation stands in southern and central Wisconsin. While this year's surveys did not confirm the presence of either the walnut twig beetle or the *Geosmithia* fungus associated with TCD (see the Thousand Cankers Disease section in this annual report for more information), varying levels of dieback were observed on individual black walnut trees as well as entire stands of walnut. Although variable, the highest levels of dieback were often observed in plantation stands in low ravine areas. There appears to be a number of pest and disease issues associated with this possible "decline" of walnut. Site, soils, and possible phytoplasma diseases could be long term predisposing factors. Cold injury to tissues could be playing a short term inciting role. Contributing factors may include ambrosia beetles, fusarium canker, nectria canker, buprestid beetles and/or a walnut scale. Other pathogens may also be involved with the "decline" being observed.

One of the most commonly observed signs in 2011 was that of buprestid beetles, likely in the genus *Agrilus*. In 2010, a plantation in Richland County was surveyed and two adult beetles (Figure 20, top) were reared from black walnut trees exhibiting dieback. With help from UW Madison Entomologist, Nate Hoftiezer, the beetles were determined to likely be either *A. transimpressus* or possibly the less common *A. cliftoni*. Both collected specimens were female, but male specimens are needed to confirm species identification. Both mentioned species are native to Wisconsin. The role of *Agrilus* sp. in the observed decline is not certain. Observations of larvae (Figure 20, bottom), galleries and D-shaped exit holes were commonly found on dead 1-3" branches. Branch flagging, with clusters of yellow foliage, was also commonly associated with signs of *Agrilus* attack on live tissues. Further attempts at rearing and identification are needed to confirm that these are native borers commonly being observed.

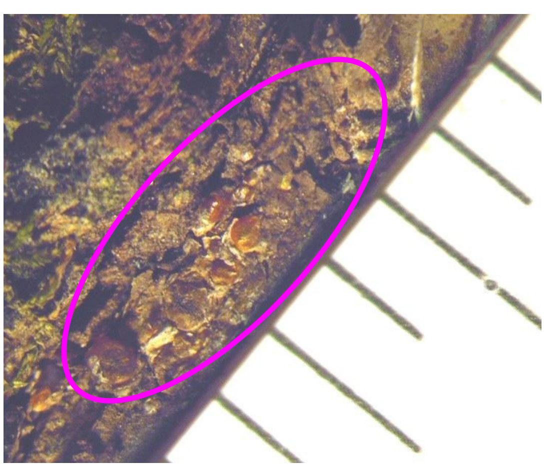


Figure 21. Left. Clusters of small obscure scales less than 1/8" in size. Right. Close-up photo of obscure scale.

Another commonly observed insect was a species of scale (Figure 21). The scales were often deeply embedded in bark crevices and cracks, and often took microscopic observations to detect. In December of 2010 samples of "a walnut scale" from a site in western Dane County were collected and sent to Phil Pellitteri at the University of Wisconsin-Madison Insect Diagnostics Lab for identification. Additional samples were later sent in 2011 to the University of Wisconsin and Dr. Pellitteri was able to confirm the scale as *Quadraspidotiotus juglans-regiae*, the "walnut scale." Walnut scale is listed as a pest on Persian walnut, *Juglans regia,* as well as other hardwood species. In the book, "Insects that Feed on Trees and Shrubs," by Johnson and Lyon, it is stated that this scale has not been found on other species of walnut such as *Juglans nigra*, the native black walnut. This armored scale insect causes damage by sucking sap from the tree, and to a lesser extent by forming layers of encrusted scale shells that limit branch photosynthesis. It is uncertain what role, if any, the scales are playing in the decline of the walnut. With a few exceptions, scale numbers don't appear to be so high as to be a stress to the tree on their own. It is possible that the scales could be associated with phytoplasmas, nectria canker, and/or fusarium canker.

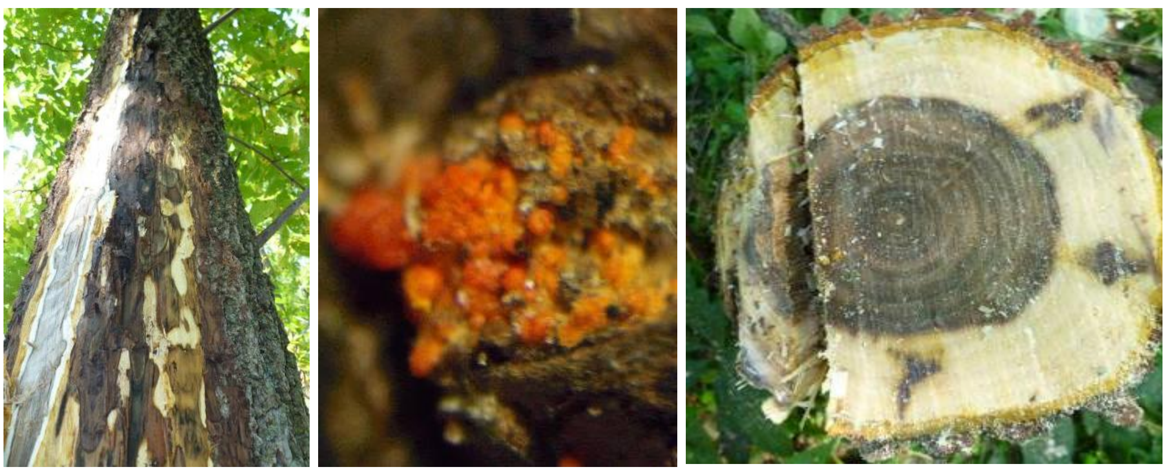


Figure 22. Left. Necrotic canker-like lesions in sapwood beyond suspect fusarium canker callus ridge. Scales were prevalent in this area. No bark beetle activity was observed. Center. Perithecia indicative of nectria canker. Right. Cross section of walnut showing ambrosia beetle attacks deep into the sapwood.

In western Dane, eastern Iowa, Rock and Sauk Counties, some walnut trees were confirmed to have nectria canker (Figure 22, left and center). In these instances there was an association with walnut scale as discussed above. In one case, fruiting by *Nectria* sp. was occurring on top of a cluster of scales.

Another association commonly observed was the ambrosia beetle, *Xylosandrus germanus* (Figure 22, right), and cankers that are suspected to be caused by *Fusarium* sp. (based on field observation of typical elongate basal cankers and not by lab culturing). Further testing would be necessary to confirm presence of the *Fusarium* fungus.

It was very common to find evidence of ambrosia beetle entrance holes in the canker face (Figure 23, left). By August it was possible to see *X. germanus* re-invade beyond the callus ridge of the canker (Figure 23, right). Discolored wood from one of these attacks was collected, isolated and confirmed for *Fusarium sp*. Fungal spread could be due to passive infection of the tunneling wound or vectoring by the ambrosia beetle.

Figure 23. Left. Suspect fusarium canker with small ambrosia beetle attack holes on the canker face.
Right. Ambrosia beetle attacks in green sapwood outside the canker face.

Studies conducted in the Midwestern States in the early 1970s (e.g. Kessler 1974) mentioned this potential "symbiosis" between the *Fusarium* fungus and ambrosia beetles. A 1993 journal article (Carlson *et al.* 1993) about plantation surveys for walnut stem cankers conducted in Illinois, Iowa, Minnesota, and Wisconsin mentioned the infrequent relationship (1.6%) between fusarium canker and attack by ambrosia beetles. The 2011 DNR walnut surveys suggest that the association of ambrosia beetle and fusarium canker may be on the increase in Wisconsin.

At some sites, epicormic branching with stunted shoots and small, chlorotic or mottled leaves was observed (Figure 24, left). The scientific literature mentions black walnut as a host for phytoplasma diseases, which these symptoms can be indicative of. A few sites were sampled for the presence of phytoplasmas but results were inconclusive. Additional testing is needed.

At two sites, a very small bark beetle about the size of the walnut twig beetle was collected. The sample was sent to Steve Krauth, at the University of Wisconsin-Madison Insect Research Collection. The beetle was identified as *Psuedopityophthorus minutissimus*. One of the primary distinguishing features between the walnut twig beetle and *P. minutissimus* is the frontal pubescence between the eyes of *P. minutissimus* (Figure 24, right).

Figure 24. Left. Epicormic walnut shoot with stunted leaves. Right. *Psuedopityophthorus minutissimus* adult showing the frontal pubescence not found on the walnut twig beetle.

References

Kessler, K.J., Jr. 1974. An Apparent Symbiosis Between Fusarium Fungi and Ambrosia Beetles Causes Canker on Black Walnut Stems.

Carlson, Jane Cummings, *et al.* 1993. Survey of Black Walnut Canker in Plantations in Five Central States.

Conifer Health Issues

Balsam Fir Branch Death

Two diseases were commonly seen on balsam firs in Clark, Florence, Forest, Marathon, Oneida and Vilas Counties in late June 2011. One disease caused new shoots to curl and die (Figure 1). This symptom resembled frost damage and the majority of the symptoms were congregated on the lower third of the crown. Delphinella shoot blight was the probable cause of this disease based on symptom expression (not from fruiting bodies or fungal growth on media).

Figure 1. Delphinella shoot blight infection on balsam fir.

The other disease on firs commonly seen in the previously mentioned counties was branch flagging in the lower half of the crown (Figure 2). This second disease affected branches after the new growth had fully elongated, and sometimes dead portions of branches extended to the bole. There were no fruiting bodies on the trees and laboratory fungal isolation did not confirm a fungal association with these symptoms. However, the lack of mechanical damage, lack of signs of insect infestation and the congregation of diseased branches in the lower canopy strongly suggest a fungus as the causal agent.

Figure 2. An unknown disease, pictured here, struck many northern Wisconsin firs in June 2011.

The following fungi are described as causing such symptoms on firs: *Dermea balsamea*, *Ptebnimyces balsamicola* (anamorph *Phacidiopycnis balsamicola*), and *Diaporthe lokoyae* (anamorph *Phomopsis lokoyae*). All of these fungi are apparent opportunists that cause diseases when firs are predisposed by factors such as frost or wounds. It is suspected that infection occurred after a late spring frost in 2011 or after damaging windy conditions during wet periods. There were widespread freezing temperatures across northeast Wisconsin on May 27, and some low-lying areas likely experienced freezing temperatures on June 12 (such as in the Crandon and Ironwood areas). In Christmas tree plantations, disease incidence could have increased if shearing operations took place during very wet conditions in late 2010.

Cedar Bark Beetles

A small infestation of cedar bark beetles (*Phloeosinus* sp.) was observed on the DNR office grounds in Fitchburg (Dane County) this spring (Figure 3). Some off-colored foliage and thin crowns appeared on a few northern white cedars in 2010 and a few trees started to exhibit browning in the upper canopy during the winter. Cedar bark beetles are generally considered non-aggressive and only colonize stressed trees. The trees impacted at this site were under excess water stress due to lack of proper drainage after the parking lot was re-paved. To reduce spread, the DNR operations crew removed and destroyed the most infested trees that were likely to die this year.

Figure 3. Left. Thinning and browning canopy of northern white cedar. Right. Pre-emergent cedar bark beetle adult collected from an infested tree.

Diplodia pinea Testing in State Nurseries

Over the past six 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 due to moisture deficit). To limit seedling exposure to the fungus and subsequent infection, nursery and pathology staff devised a series of management actions: Removal of all mature red pine found in and around the nurseries, increased applications of fungicides and annual testing of nursery stock. These measures have helped limit the exposure and subsequent infection of red pine seedlings.

Table 1. Results of Diplodia testing on asymptomatic 2-0 and 3-0 red pine seedlings from Wisconsin state nurseries.

Nursery	Total number seedlings tested 2011	Total positive for Diplodia 2011	Percent positive for Diplodia 2011	Percent positive for Diplodia 2010
Hayward	209	19	9.09%	3.03%
Griffith	160	11	6.86%	3.85%
Wilson	219	0	0%	0%

Since 2006, nursery and forest health staff have tested asymptomatic red pine seedlings for *Diplodia* infection. Details of the test can be found in the 2007 Forest Health Annual Report. In 2011, the forest health lab processed 588 asymptomatic healthy 2-0 and 3-0 red pine seedlings to detect the presence of the pathogen. Samples were collected from all of the three state nurseries (Table 1).

In 2011, all three state nurseries had a *Diplodia* infection rate below the 10 percent tolerance level that has been used for management purposes. The overall asymptomatic infection rate has been below 10% at all three nurseries for the last four years. Plans to conduct the test in 2012 will be discussed with nursery program staff this winter.

Jack Pine Budworm

West Central Wisconsin

Jack pine budworm populations increased in red pine stands in Dunn and Pierce Counties after a two year hiatus. The budworm population that was building in jack pine in Monroe County collapsed. In Jackson County, 118 acres of moderate to heavy defoliation was reported from both jack and red pine stands.

Figure 4. Defoliation of overstory (left) and understory (right) pine by jack pine budworm larvae.

An abnormal pattern of budworm defoliation was seen at a site on the Jackson County Forest (Town of Manchester, East). The red pine stand is 54 years old, 77 acres in size and was last thinned in 2004. The typical pattern of jack pine budworm defoliation seen in the past in "older" red pine stands was not seen in this stand. There was widespread defoliation (Figure 4, left) with moderate to heavy defoliation in the center of the stand and less severe defoliation toward the edges. Jack, red, and white pine in the understory were defoliated, some of them are severely (Figure 4, right).

The edge of the stand primarily contained jack pine and that was not defoliated. If jack pines were directly under the red pine on the edge of the stand, they were defoliated. If there was red or white pine that went out into the jack pine a little ways, the red or white pines were defoliated.

The pattern of the defoliation on individual trees was also interesting. It appeared as if most of the trees had an intact upper crown but the lower crown was defoliated. However, there were individual trees or small pockets of trees where the entire crown was defoliated.

Northwest Wisconsin

Despite increasing numbers of jack pine budworms in northwest Wisconsin, there was very little damage from them. Defoliation in northeast Bayfield County (~4,000 acres) was of moderate to high severity, whereas in eastern Douglas County and southwest Bayfield County, there was ~6,000 acres of light defoliation (Figure 5). In most areas, feeding was dominated by very small, light-feeding individuals. The only area with many large budworms was in Bayfield County, north of the Valhalla ski area in the Chequamegon-Nicolet National Forest. This area is the only spot predicted to have significant defoliation in 2012.

The region's parasitism rate was average in 2011. The mix of parasitoids indicates an old budworm population in the Towns of Swiss (Burnett County) and Barnes (Bayfield County).

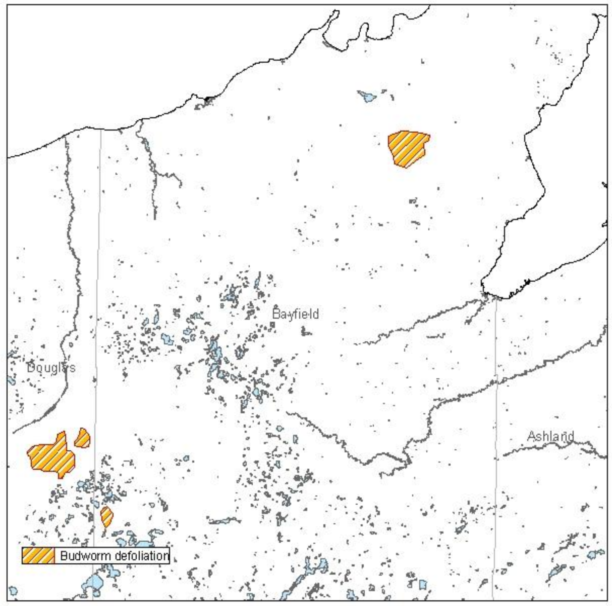


Figure 5. Jack pine budworm defoliation in Bayfield and Douglas Counties in northern Wisconsin.

Jack Pine Budworm Survey in Northwest Wisconsin: Procedures and Results

Early Larval Survey

This survey is done on a yearly basis and is a key indicator of the presence of destructive budworm populations. At each survey site, 30 shoots and staminate flowers that can be reached from the ground are checked for larvae. Since staminate flowers are often scarce, shoots are usually used. A high count, considered sufficient to cause moderate to severe defoliation, is defined as any plot with a count of 10 or more infested shoots and flowers. Larval populations began to rise in 2011 (Figure 6, Tables 2 and 3).

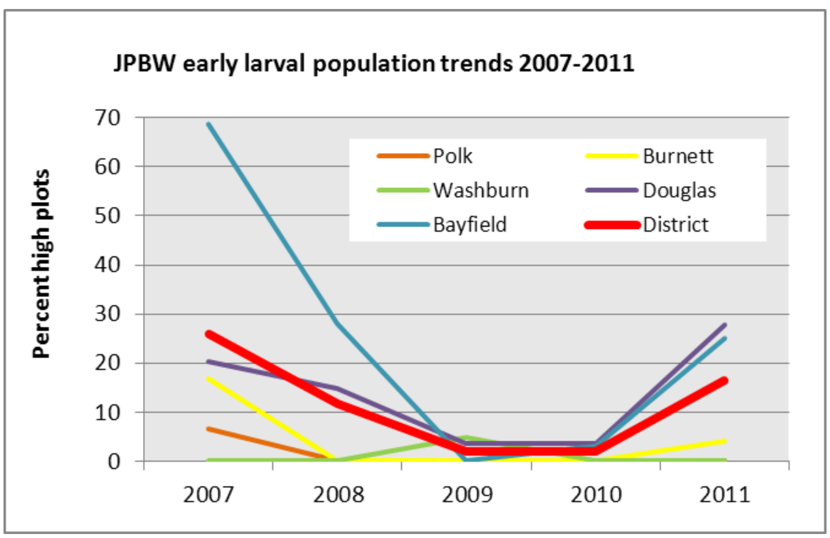


Figure 6. Jack pine budworm population trends in northwest Wisconsin.

Table 2. 2011 jack pine budworm early larval population survey results for northwest Wisconsin.

County	Number of plots	Number of infested shoots	Infested shoots per plot	Number of high plots*	% high plots
Polk	15	6	0.40	0	0
Burnett	24	19	0.79	1	4.2
Washburn	21	21	1.00	0	0
Douglas	54	304	5.63	15	27.8
Bayfield	32	223	6.97	8	25.0
District	**146**	**573**	**3.92**	**24**	**16.4**

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

Table 3. 2011 jack pine budworm early larval population trends in northwest Wisconsin.

	Average No. of Infested Shoots Per Plot						Percent High Plots				
County	**2007**	**2008**	**2009**	**2010**	**2011**	**% change 2010-11**	**2007**	**2008**	**2009**	**2010**	**2011**
Polk	3.33	0.27	0.40	0.40	0.40	**0**	6.7	0	0	0	0
Burnett	4.75	1.42	0.63	0.46	0.79	**+72**	16.7	0	0	0	4.2
Washburn	2.95	2.10	1.57	1.14	1.00	**-12**	0	0	4.8	0	0
Douglas	5.24	4.76	2.91	2.07	5.63	**+171**	20.4	14.8	3.7	3.7	27.8
Bayfield	11.34	7.19	2.81	2.78	6.97	**+150**	68.8	28.1	0	3.1	25.0
District	**5.97**	**3.90**	**2.06**	**1.66**	**3.92**	**+136**	**26.0**	**11.6**	**2.1**	**2.1**	**16.4**

Pupal Survey

The pupal survey is also conducted annually and gives a good indication of the abundance of pupal parasitoids in the population, as well as forecast next year's population of jack pine budworm. It is done in July when most budworms are in the pupal stage. Some adults may already have emerged, but empty pupal cases are collected and counted as emerged moths. Pupal collection is timed at each survey site. If fewer than 5 pupae are found in 5 minutes, the collection is terminated. If at least 5 pupae are found in 5 minutes, then 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. Pupal cases are reared, and the number of pupal cases with emerged adult moths or emerged parasitoids, and non-emergent pupal cases, are recorded for each site (Tables 4 and 5).

Table 4. Jack pine budworm pupal survey results, 2011.

County	Total Pupae	Total Minutes	Pupae/ Min	Emerged Moths No.	Emerged Moths Percent	Emerged Parasites No.	Emerged Parasites Percent	Nothing Emerged No.	Nothing Emerged Percent
Polk	4	75	0.05	3	75.0	1	25.0	0	0
Burnett	74	150	0.49	32	43.2	31	41.9	11	14.9
Washburn	198	172	1.15	108	54.5	59	29.8	31	15.7
Douglas	598	383	1.56	347	58.0	200	33.4	51	8.6
Bayfield	390	214	1.82	213	54.6	152	39.0	25	6.4
District	**1,264**	**941**	**1.34**	**703**	**55.6**	**443**	**35.0**	**118**	**9.4**

Table 5. Rate of jack pine budworm pupa collection indicates population trends, 2008-2011.

County	2008 Pupae/min	2009 Pupae/min	2010 Pupae/min	2011 Pupae/min	Percent change 2010-2011
Polk	0.03	0.05	0.13	0.05	-61.5
Burnett	0.45	0.22	0.37	0.49	+32.4
Washburn	0.55	0.77	0.89	1.15	+29.2
Douglas	1.05	0.96	1.09	1.23	+12.8
Bayfield	1.25	0.91	0.94	1.25	+33.0
District	**0.88**	**0.76**	**0.85**	**1.06**	**+24.7**

<u>Parasitoid and Predator Complex</u>

This survey involves a careful examination of all the collected budworm pupae from which a parasitoid emerged (Table 6). Adult specimens were compared to a reference collection. Any unknown adults are sent to UW Madison for identification. Pupal cases from which nothing emerged were dissected to attempt to determine the cause of failure.

Table 6. Predator and parasitoid complex and percent of parasitism by county.

Parasitoid/ Predators	Polk	Burnett	Washburn	Douglas	Bayfield	Total	Percent of Parasitized	Percent of Total
Itoplectes	1	11	15	70	44	141	31.8	**11.2**
Scambus	0	5	11	22	11	49	11.1	**3.9**
Phaogenes	0	3	13	28	26	70	15.8	**5.5**
Pteromalids	0	0	2	2	11	15	3.3	**1.2**
Tachinids	0	4	9	39	29	81	18.3	**6.4**
Predators	0	8	9	39	31	87	19.7	**6.9**
Total	**0**	**31**	**59**	**200**	**152**	**443**	**21.2**	**7.4**

Jack Pine Gall Rust Surveys in Wisconsin State Nurseries

In the Wisconsin state nurseries, stem and branch galls (Figure 7) are occasionally detected on jack pine seedlings at the time of lifting. Surveys to evaluate the incidence of gall rusts on jack pine seedlings were initiated in 2008 and continued in 2011 at the three nurseries (Wilson Nursery in Boscobel, Griffith Nursery in Wisconsin Rapids and Hayward Nursery in Hayward).

Fifteen hundred seedlings were randomly selected from each age class at each nursery at the time of spring lifting in 2011. Seedlings were collected from late March to mid-April. At Hayward Nursery, both 1-0 and 2-0 seedlings were included in the study. At Wilson Nursery, only 1-0 seedlings were lifted and at Griffith Nursery, only 2-0 seedlings were lifted. Each seedling was thoroughly examined for the presence of swelling or galls. The number of galls per seedling and the locations of galls were also recorded. A summary of four years of results is shown in Table 7.

Figure 7. Gall on young jack pine at Griffith Nursery.

The surveys have found a wide year-to-year fluctuation in infection rates. For example, at Griffith Nursery, infection rates for 2-0 seedlings have ranged from 7.3% to 32.6%. Late spring frosts and dry weather during aeciospore dissemination limit the spread of fungal spores (Nighswander and Patton 1965). Effects of specific local weather conditions, such as precipitation, wind velocity and temperature, on the frequency of gall incidence are being analyzed.

In all of the state nurseries, symptomatic seedlings are culled from graded stock before shipping. For bulk orders, nurseries include an information sheet with sorting guidelines and encourage landowners to remove galled seedlings before planting. Thus, the number of galled seedlings that are shipped and out-planted should be less than the incidence in this study.

Table 7. Incidence of visible galls on jack pine seedlings at the time of lifting from state nursery beds.

Nursery	Seedling age	2008	2009	2010	2011
Hayward	2-0	0.7%	-	3.4%	0.7%
Hayward	1-0	-	0.0%	0.0%	0.1%
Griffith	2-0	7.3%	-	32.6%	18.5%
Griffith	1-0	-	4.2%	2.4%	-
Wilson	1-0	-	0.0%	0.5%	0.4%

Seedlings that appeared healthy, with no galls or swellings, were planted at Griffith Nursery in the spring of 2011 in order to evaluate the incidence of gall formation after being lifted and sold. Due to the lower incidence of gall presence at Wilson and Hayward Nurseries in previous years, no additional seedlings from these nurseries were planted for the survey. One hundred 2-0 seedlings were planted in an irrigated bed and another 100 2-0 seedlings were planted in a non-irrigated bed on May 3, 2011. The purpose of using irrigation was to maximize the survival rate by eliminating water deficiency as a potential factor in 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.

In the fall of 2011, out-planted seedlings were examined for the presence of galls. There was no incidence of galls found on any of the 2011 out-plantings at Griffith Nursery. Additional infection was observed on seedlings that were planted in 2010 or earlier in all three nurseries, though infection rates were low. As in 2010, a portion of the seedlings in both the irrigated and non-irrigated beds at Griffith Nursery were infested with the redheaded pine sawfly (*Neodiprion Lecontei*) from mid-July through September. Affected seedlings were 5 - 95% defoliated by the end of September. Seedlings severely defoliated in 2010 suffered mortality in 2011.

In addition, apparently healthy seedlings with no visible galls or swelling were randomly collected from lifted stock from all the three nurseries in the spring of 2011, and potted to evaluate gall formation later in the season. One hundred apparently healthy 2-0 seedlings from Griffith Nursery, 50 each of 1-0 and 2-0 apparently healthy seedlings from Hayward Nursery, and 50 apparently healthy 1-0 seedlings from Wilson Nursery, were potted on May 13, 2011 and placed in the greenhouse to limit additional inoculum exposure. The number of galls per seedling and the locations of galls were recorded in July and October. The percentage of seedlings that produced galls in the greenhouse was less than 5% for all of the three nurseries (Table 8). One seedling from Griffith Nursery and 2 seedlings from Hayward Nursery produced a gall by the end of July.

Table 8. Number of potted seedlings that appeared healthy with no visible galls or swelling during lifting, and later developed a gall.

Nursery	**Seedling age**	**Number of galled seedlings (percent) evaluated on 7/29/2011**	**Number of galled seedlings (percent) evaluated on 10/21/2011**	**Total number of galled seedlings (percent)**
Hayward	1-0	2 (4%)	0 (0%)	2 (4%)
Hayward	2-0	0 (0%)	0 (0%)	0 (0%)
Griffith	2-0	1 (1%)	2 (2%)	3 (3%)
Wilson	1-0	0 (0%)	1 (2%)	1 (2%)

Previously, it was predicted that seedlings in the greenhouse would have lower disease incidence than out-planted seedlings, since out-planted seedlings will have longer periods of exposure to pathogen spores. However, the incidence rate in the greenhouse was higher (3%) than that of 2011 out-planted seedlings (0%) at Griffith Nursery. This result was consistent with observations in 2009 and 2010. One hypothesis to explain the results is that disease incidence may be enhanced or discouraged by growing conditions of the host. Vigorously growing seedlings may be favorable for the exhibition of galls. Further data analysis of gall location, gall size and seedling height growth is currently in progress.

In the spring of 2011, galled seedlings that were potted in 2008, 2009 and 2010 were examined for the production of pycnia and aecia. Out of 124 seedlings examined, 25 galled seedlings sporulated in the spring of 2011 (Table 9). The status of pycnia and aecia formation was recorded from late April to late May on a weekly basis. None of the seedlings that were potted in 2010 developed aecia, though approximately half of 2-0 seedlings and three-quarters of 1-0 seedlings examined had a gall with pycnia. The majority of 2-0 seedlings that were potted in 2008 had galls that formed either pycnia or aecia.

Table 9. Number of potted seedlings that produced aecia or pycnia in 2011.

Nursery	Year potted	Seedling age at the time of potting	Number of seedlings with aecia	Number of seedlings with pycnia only	Number of seedlings w/o aecia or pycnia	Total number of seedlings
Hayward	2009	1-0	0	4	0	4
Hayward	2010	2-0	0	5	2	7
Griffith	2008	2-0	18	18	4	40
Griffith	2009	1-0	5	7	3	15
Griffith	2010	2-0	0	11	12	23
Griffith	2010	1-0	0	21	7	28
Wilson	2008	1-0	1	1	0	2
Wilson	2009	1-0	1	0	0	1
Wilson	2010	1-0	0	3	1	4

Microscopic examination of germ tubes was done on the 25 galled seedlings to distinguish *Cronartium quercuum* (eastern gall rust) from *Peridermium harknessii* (western gall rust) (Anderson and French 1964). Twenty-three seedlings from Griffith Nursery and 2 seedlings from Wilson Nursery were tested. Aeciospore germination rates varied from 10% to more than 95% per seedling. Three plates were prepared for each seedling. Thirty germ tubes (10 germ tubes per petri plate) were randomly selected for each galled seedling and the length of each germ tube was recorded after 24 hours of incubation at 18.5°C. Average germ tube lengths for all tested seedlings were within the range of *Cronartium quercuum*.

Detailed results of the jack pine gall rust study in 2008, 2009 and 2010 can be found in the Forest Health Annual Reports for these years.

References

Anderson, G.W. and French, D.W. 1964. Differentiation of *Cronartium quercuum* and *Cronartium coleosporioides* on the basis of aeciospore germ tubes. Phytopathology 55: 171-173.

Nighswander, J.E. and Patton, R.F. 1965. The Epidemiology of the Jack Pine - Oak Gall Rust (*Cronartium Quercuum*) in Wisconsin. Canadian Journal of Botany 43: 1561-1580.

Spruce Budworm

Widespread spruce budworm damage occurred for at least the second consecutive year in northern Forest County and several parts of Florence County (Figure 8). It is not possible to report how many acres were impacted because aerial surveys of the cover type were not done. Balsam fir in northern Forest County (Alvin Township) and near Argonne suffered light to heavy defoliation by spruce budworm. It was also noted that spruce budworm has caused heavy spruce mortality in several swamp conifer stands in eastern Florence County.

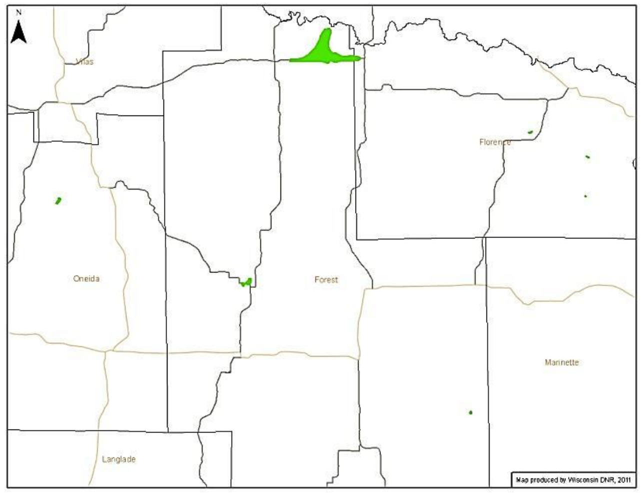


Figure 8. Areas of spruce budworm defoliation in northeast Wisconsin in 2011.

In northwest Wisconsin, spruce budworm damage was non-existent in extreme northeast Sawyer County (between Ghost and Clam Lakes) where it had caused problems in prior years.

Spruce Diseases

Wet weather in late summer 2010 and spring 2011 created ideal conditions for the development of fungal infections on spruce this year (Figure 9). Colorado blue spruce was the most commonly affected species but other spruce species were also impacted. Symptoms ranged from needle death on lower branches to tree mortality. Infection started on lower branches and worked up the tree, killing infected branches in more severe instances. Symptomatic spruce were common in central and southern areas of Wisconsin in 2011.

Figure 9. Spruce impacted by Rhizosphaera needle cast.

Several fungal diseases and a possible pathogen were confirmed on symptomatic spruce in Wisconsin: Rhizosphaera needle cast, *Stigmina lautii,* and Phomopsis tip blight and canker. In 2011 it was reported that *Rhizosphaera* and *Stigmina* likely weakened the trees and *Phomopsis* may be responsible for killing branches. A different disease, spruce needle rust, was noted in several areas of Oneida County on Colorado blue spruce.

Abiotic Issues

Frost Damage

Red oaks over a large portion of north central Wisconsin sustained leaf damage (Figure 1) from a May 27 frost (Figure 2). Damaged oaks were seen in Langlade, Oneida and Vilas Counties, although the damage likely covered more area than those three counties. It was commonly observed that lower leaves froze while upper leaves escaped damage. This pattern was typical but did not always occur. A second set of leaves was observed flushing from damaged oaks on June 6 (Figure 1, right).

Figure 1. Left. Typical late spring frost damage on oaks. Lower leaves froze while upper leaves escaped damage. This pattern is typical but does not always hold. Right. Emerging red leaves after frost killed the first set, now crispy yellow.

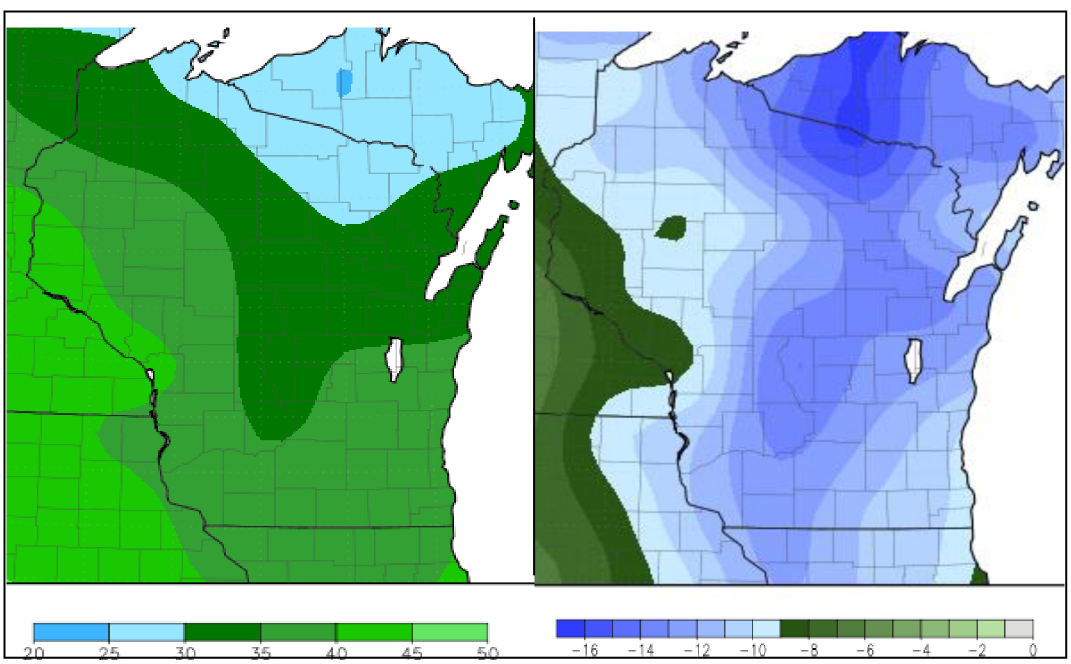


Figure 2. Left. Observed minimum temperatures (°F) on May 27, 2011. Right. Departure from normal minimum temperatures (°F) on May 27, 2011.
Source: Midwestern Regional Climate Center, Univ. of Illinois at Urbana, Champaign

Storm Damage

Wind damage (Figure 3) was apparent following a number of storms in Wisconsin. Some of these events produced contiguous forest damage that was easily mapped (Table 1). Not all wind events caused forest damage that was reported by foresters or that was logical to map, and those are presented in Table 2. The storms summarized in Table 2 were either very small sections of damage or widely scattered trees that were snapped or uprooted.

Figure 3. A young pine plantation on industrial forestland in Forest County was destroyed by the April 10, 2011 tornado that started near Argonne.

Table 1. Storms that damaged significant and contiguous forested areas in 2011.

Date	Storm Type	Approximate Area Damaged	Damage Length (miles)	Severity Rating	Acres Encompassed by Storm	Approximate Forest Acres Damaged
4/10/2011	Tornado	Merrill to Russell Township, Lincoln Co.	14	EF3	5,700	3,900
4/10/2011	Tornado	Towns of Summit & Parrish, Langlade Co.	5.5	EF1	1,700	1,700
4/10/2011	Tornado	Argonne (Forest Co.) through Fence Township (Florence Co.)	22	EF2	6,300	900
4/10/2011	Tornado	Armstrong Creek, Forest Co.	5	EF1	720	190
4/10/2011	Tornado & hail	Juneau, Adams & Waushara counties	17	EF2	5,600	3,900
5/22/2011	Tornado & hail	Juneau, Wood & Portage Counties	37	EF2	28,000	16,800
7/1/2011	Extreme wind event	Polk Co. to Douglas, Bayfield & Ashland Counties	n/a	n/a	130,776 acres (119,000 in Burnett & Douglas Counties)	n/a
8/23/2011	Tornado	Clark	7	EF2	1,200	250

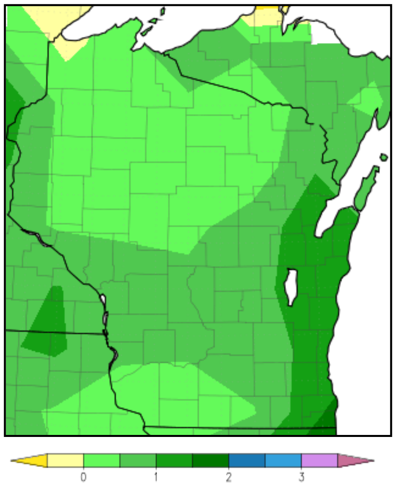
Table 2. Wind event locations and dates where there were many reports of scattered tree damage.

Date	Storm Type	Location	Comments
5/22/2011	Wind	Sawyer Co. northeast into southern Iron Co.	
5/22/2011	Tornado	Western Taylor through Price Co.	Rated EF0
5/22/2011	Tornado	La Crosse area	Rated EF2
6/8/2011	Wind	Grant Co. northeast to Manitowoc Co.	Included an EF1 tornado in Dane Co.
7/17/2011	Wind	Bayfield Co. southeast to Door Co.	
7/18/2011	Wind	La Crosse east to Green Bay	
7/19/2011	Wind	Bayfield Co. southeast to Washington Co.	
7/23/2011	Wind	Eau Claire area to Monroe Co.	
7/30/2011	Wind	Northeast quarter of state	
8/6/2011	Wind	Lincoln Co. southeast to Shawano Co.	
8/19/2011	Tornado	Marinette Co.	Rated EF1
9/2/2011	Wind	Southern third of Wisconsin	

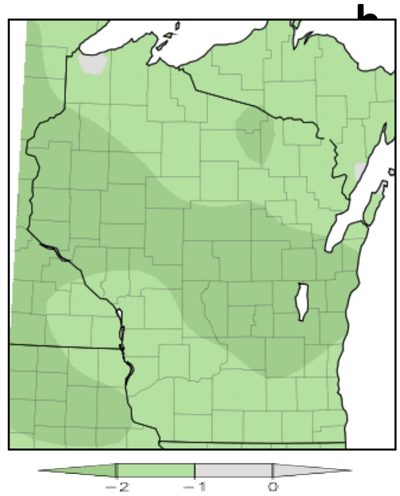
Weather Maps

Statewide, spring weather (March, April and May) was colder and wetter than normal (Figures 1a and 1b). Precipitation averaged about 1 inch above normal but varied across the state. For instance, April precipitation (Figure 1a) ranged from almost normal in the west to three inches above normal in the eastern part of the state. Temperatures in March through May averaged about two degrees below normal. Temperatures in March averaged three to four degrees below normal in central and northwest Wisconsin. April temperatures (Figure 1b) averaged two degrees below normal in most of central and northeast Wisconsin. In contrast, late summer and fall were warmer and much drier than normal (Figures 1c and 1d). Precipitation in August through October ranged from about an inch below normal in the south to six to seven inches below normal in west central Wisconsin (Figure 1c). Temperatures for this same period ranged from normal in the south to five or six degrees above normal in central and eastern Wisconsin (Figure 1d).

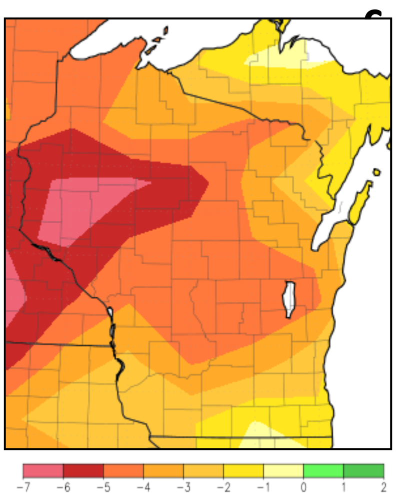
a



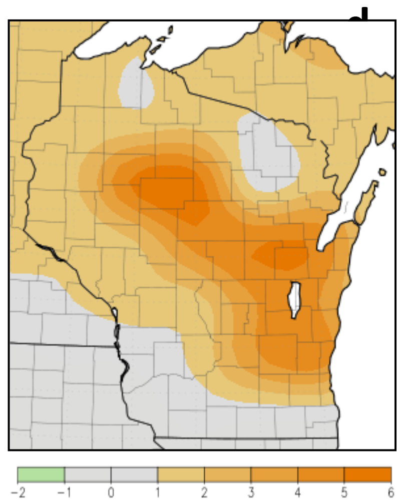
Total precipitation (inches)
Departure from mean March - May 2011



Temperature
Departure from mean March - May 2011



Total precipitation (inches)
Departure from mean August-October 2011



Temperature
Departure from mean August-October 2011

Figure1a. Precipitation departure from normal (inches) for March 1 through May 31, 2011.
1b. Temperature departure from normal (°Fahrenheit) for March 1 through May 31, 2011.
1c. Precipitation departure from normal (inches) for the period August 1 through October 31, 2011.
1d. Temperature departure from normal (°Fahrenheit) for the period August 1 through October 31, 2011.

Source: Wisconsin State Climatology Office (http://www.aos.wisc.edu/~sco/clim-watch/index.html#30day)