Wisconsin Forest Health Protection
Annual Report 2009

Compiled and edited by Forest Health Protection Program Staff

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

WISCONSIN DEPT. OF NATURAL RESOURCES

Cover photo of Ichneumonid wasp
by Todd Lanigan

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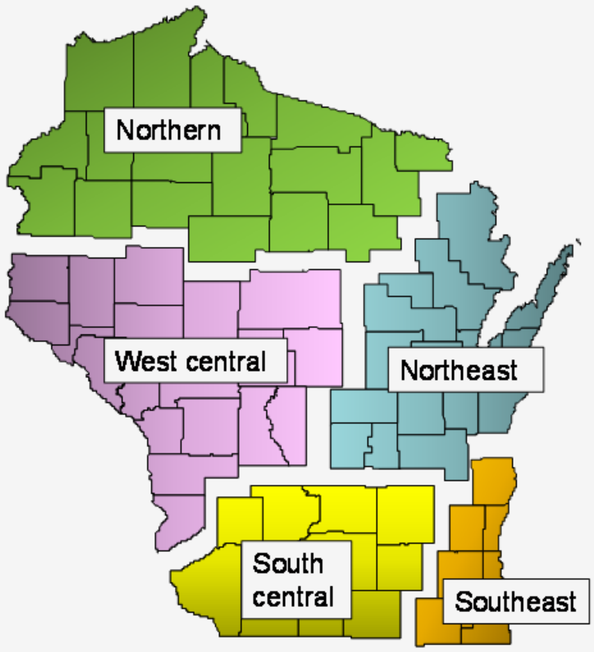

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Resource Update

Wisconsin's forests are critical for providing wildlife habitat, clean air and water, reducing erosion, and improving our quality of life in urban and rural areas. Forests are also important to the economy of Wisconsin, not only in the form of wood products, but also for recreation and tourism. The primary and secondary wood products industry is one of the five largest employers in the state and puts Wisconsin first in the nation in the production of fine paper, sanitary paper products, children's furniture, and millwork. The value of shipment of these products is about $20 billion. Forest and water resources in Wisconsin are a primary tourism attraction for both residents and visitors. The variety of Wisconsin's forest ecosystems supports a great diversity of wildlife species, while recreational use of the forests continues to grow and expand.

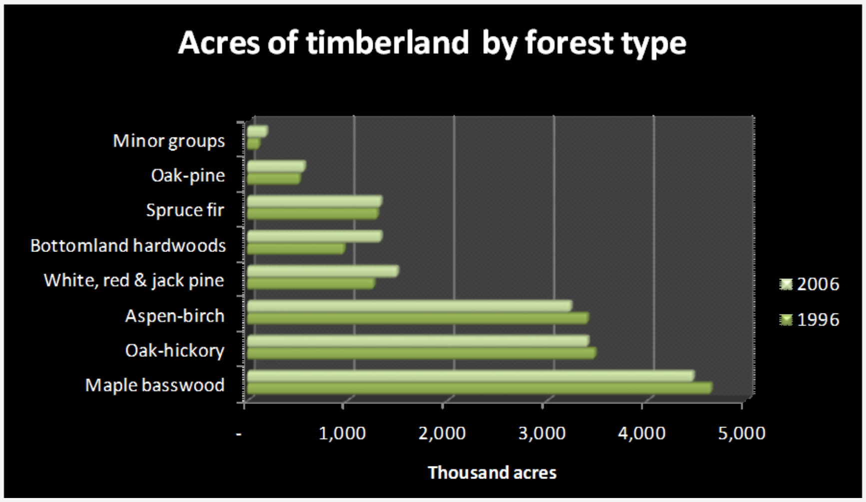


Figure 1. Thousand acres of timberland by forest type group, 1996 and 2006 (FIA data USDA Forest Service).

The area of forest land in Wisconsin has been steadily increasing in recent decades and currently stands at approximately 16 million acres, representing over 46 percent of the total land area. The state now has the most forest land that it has had at any time since the first forest inventory in 1936. Wisconsin's forests are predominately hardwoods, with 81% of the total timberland area classified as hardwood forest types (Figure 1). The primary hardwood forest types in the state are maple-basswood, at 28% of all timberland, oak-hickory at 22% of total acreage, and aspen-birch, which covers 21% of Wisconsin's timberland area. Conifer types, mainly red, white and jack pines and spruce-fir, represent about 9% of the timberland. In addition, our forests are becoming middle-aged (Figure 2) with less acreage in young and very old stands and a sharp increase in stands 60 to 100 years old.

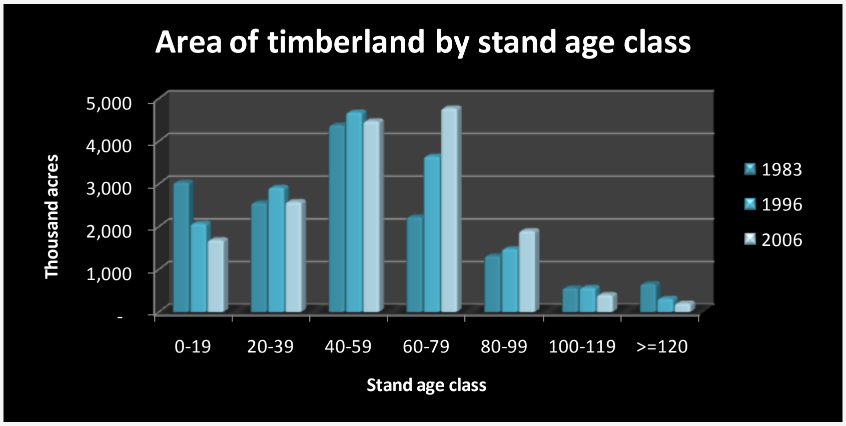


Figure 2. Thousand acres of timberland by stand age class 1983, 1996 and 2006 (FIA data USDA Forest Service).

Exotics

Emerald Ash Borer (EAB) Program Update

For the latest information, visit http://www.emeraldashborer.wi.gov/

Current status of EAB in Wisconsin

The Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP) is the lead agency in Wisconsin for detecting populations of EAB. Due to their excellent work and reports from observant landowners, DNR staff and arborists, emerald ash borer has been found in five locations - Newburg, Kenosha, Franklin, Green Bay, Oak Creek, and Victory (Figure 1). Infested trees were detected in Newburg, Victory and Franklin; adult beetles were detected on traps in Kenosha and Green Bay. Eleven counties are currently quarantined. The first population discovered at Newburg in Ozaukee County appears to have been there since 2004 and infested trees have been found over two miles from the apparent center of the infestation. (Figure 2, left). The population in Victory (Figure 2, right) on the west side of the state has been confirmed as being present in 2006 but was likely there prior to 2006 due to the presence and extent of dead trees. Dr. Nathan Siegert, Michigan State University conducted the work associated with aging the infestations. The ages of infestations in Green Bay, Kenosha and Franklin have not yet been determined.

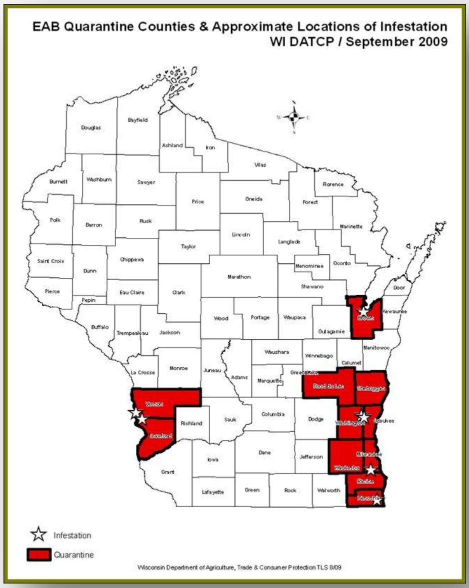


Figure 1. EAB quarantine counties & approximate locations of infestation.

Summary of Activities

It is important to note that while we currently have limited options for controlling EAB, there is a lot we can do to slow the impacts and reduce the cost this pest will have on our communities and forests. DNR, DATCP, UW Extension and research, USDA Forest Service and Animal Plant Health Inspection Service (APHIS) are working together to identify the scope of the infestations and assist communities, landowners and businesses in dealing with the implications of EAB.

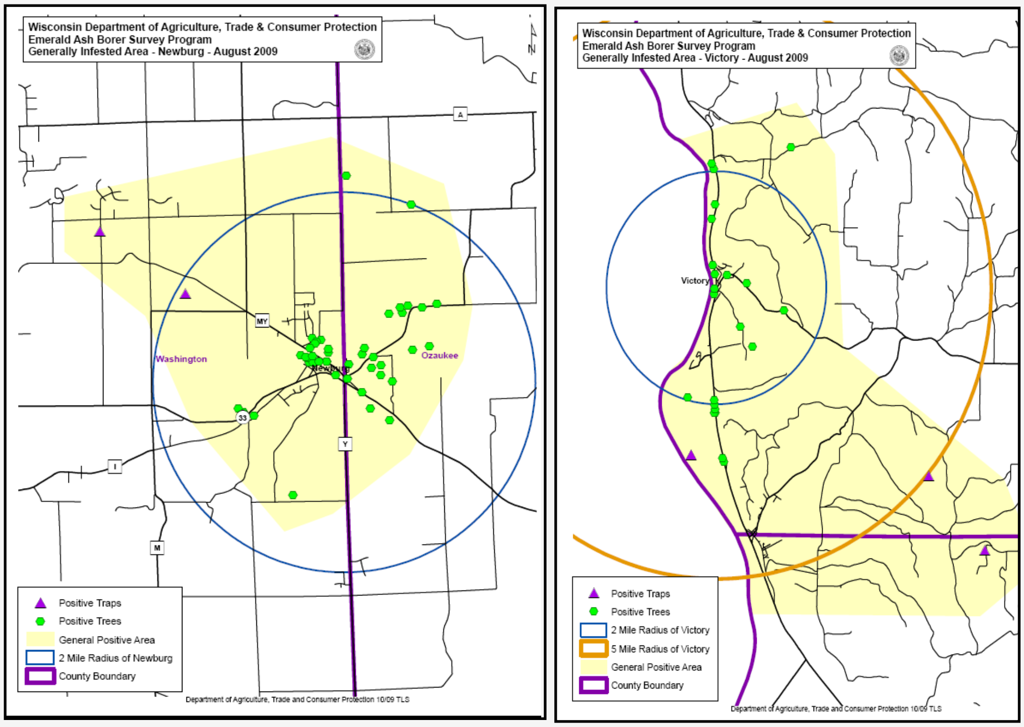


Figure 2. Area infested with emerald ash borer in Newburg (left) and Victory (right) Wisconsin.

Surveys

Surveys are conducted to identify locations where EAB has become established in order to focus public information, regulation and control efforts. USDA APHIS currently provides support for the trapping program and has provided support for visual and detection tree surveys in the past. DNR, DATCP and Extension staffs

Table 1 . State park or state forest and county where detection trees are being monitored.

Big Bay State Park	Ashland
Copper Falls State Park	Ashland
Merrick State Park (North)	Buffalo
High Cliff State Park	Calumet
Lake Kegonsa State Park	Dane
Peninsula State Park	Door
Potawatami State Park	Door
Amnicon Falls State Park	Douglas
Pattison State Park	Douglas
Long Lake - Kettle Moraine State Forest	Fond du Lac
Mauthe Lake - Kettle Moraine State Forest	Fond du Lac
Nelson Dewey State Park	Grant
Wyalusing State Park	Grant
Pike Lake State Park	Washington
Governor Dodge State Park	Iowa
Blue Mound State Park	Iowa/Dane
Richard Bong State Rec. Area	Kenosha
Yellowstone Lake State Park	Lafayette
Point Beach State Forest	Manitowoc
Interstate State Park	Polk
Devil's Lake State Park	Sauk
Kohler-Andrae State Park	Sheboygan
Perrot State Park	Trempealeau
Wildcat Mountain State Park	Vernon
Big Foot Beach State Park	Walworth

also recognize that many initial finds are made by the general public; public education and the EAB reporting line (administered by DATCP) contribute significantly to the survey effort.

a. **Traps –** Traps appeal visually to EAB which are attracted to vertical shapes and the color purple and are also baited with tree oils, the scent of which is similar to that of distressed ash trees (Figure 3). Insects landing on the traps are caught in a sticky material that coats the trap. In 2008, a trap detected EAB at Newburg within days of its find in dying trees. In 2009, a total of 6,920 traps were set. Seven traps were positive for EAB, resulting in three new counties reporting this insect – Brown, Crawford and Kenosha. Traps were deployed near currently known populations to define the area infested, on a grid in several east-central counties and along the border with the Upper Peninsula of Michigan, and at sites determined to be of

Figure 3. Emerald ash borer trap (photo by Jennifer Statz).

high risk for introductions across the state. A map of the 2009 EAB trapping program can be viewed here, http://emeraldashborer.wi.gov/articleassets/2009_Trapping_Plan_5_09.pdf

b. Detection trees/destructive survey - Open grown ash are girdled to stress them and make them more attractive to EAB looking for a site to lay eggs. A sticky band may be placed on the girdled trees to potentially catch adults. Surveyors return in the fall or following year to peel the tree's bark and determine if any larvae are present. Alternatively, a pre-stressed ash may be selected for cutting and peeling, skipping the girdling step. Detection trees are generally thought to be a more sensitive method of detecting EAB than are the traps yet are more labor intensive. This technique has been used by DATCP in intensive surveys in quarantined counties and by DNR in a survey of state lands determined to be of higher risk of introduction. Between the years of 2006-2008, Michigan Tech University in cooperation with DNR, girdled over 250 black, green and white ash trees in and around campgrounds in Wisconsin state parks and forests in an effort to detect emerald ash borer. During the winter of 2009, 37 trees that were girdled in 2006 or 2007 were felled and the bark removed using a drawknife to determine the presence of emerald ash borer in 21 state parks and forests (Table 1). The number of windows (see Figures 4a & 4b) created is based on the tree's diameter by peeling thin layers of bark. Findings from the survey include damage from the following species: native ash bark beetles, cambium miners (Figure 4c), carpenter worms, and clearwing moths (Figure 4d). To date, the detection trees in this survey have not yielded emerald ash borer. Nearly 100 girdled ash trees from 2008 are scheduled to be felled and peeled during the winter of 2009-2010 to conclude the detection tree survey with Michigan Tech.

c. Biosurveillance – See special report on the use of a natural predator, *Cerceris planipennis*, to detect EAB (pg 13).

Figure 4 (photos by Bob Murphy)
a. Todd Lanigan (DNR) peeling off bark, looking for emerald ash borer galleries
b. "Windows" peeled in an ash
c Zigzag damage from ash cambium miner
d. Clearwing moth damage

Preventing or slowing spread

a. **Quarantines -** Federal and state quarantines have been placed on 11 counties in Wisconsin. Quarantines are effective at regulating businesses that move potentially infested wood or nursery stock. They do allow for movement of wood and wood products if treated or movement timed to prevent possible spread of EAB. Businesses interested in movement of regulated wood enter into a compliance agreement to do such treatments or modify their schedules of movement with state and federal regulators (DATCP and APHIS).

b. **Redirection of adult EAB such as "islands of attraction" -** This technique is experimental but is being tested at the River Edge Nature Center in Newburg, by DNR forest health staff (see special report, pg 11).

c. **Regulation of firewood onto state lands –** DNR is in the third year of prohibiting from state lands firewood originating from more than 50 miles from the property or campground and it is the fourth year DNR has prohibited firewood from out of state onto state lands. This regulation of wood provides some protection for state lands but it also provides an unparalleled opportunity to educate the public on the risks of moving firewood. Parks staff are among the most trusted sources of information for the public and the camping registration process offers several opportunities to give the "don't move firewood" message. A survey of campers in 2006 and 2008 showed a significant increase in their awareness of the risk of transmission of invasive pests in firewood and of the threat of emerald ash borer. It also showed that campers were changing behavior given this information. Campers reported that they reduced the amount of firewood they moved and the distance they moved it since 2006. It is pleasing that the public appears to be generalizing their behavior regarding firewood movement. Not only are they not bringing wood to state campgrounds, they are moving it less even when camping elsewhere.

d. **Certification of firewood dealers -** The state lands prohibition of firewood from beyond 50 miles does have an exemption for firewood from dealers certified by DATCP as having treated their wood to prevent survival and transmission of pests and diseases. DATCP developed the certification requirements and volunteer program. As concerns and increasing regulation of firewood may lead to a larger market for treated wood in this and other states, markets for certified firewood are expected to increase.

Slowing the rate of population increase

a. **Phloem reduction -** This technique to reduce the buildup and spread of EAB by reducing the amount of ash phloem available for consumption in an area is still in development. It is consistent with recommendations being made by DNR staff to reduce the ash component of both rural and urban forests in an effort to reduce the ecological and fiscal impact of ash mortality. To begin working with rural woodland owners, an inventory of selected forest lands within three miles of Newburg was coordinated by Julie Peltier, DNR forester for Ozaukee and Washington counties. DNR forestry staff, along with Town and Country Resource Conservation and Development and private consultants will be working with these landowners to facilitate timber sales that not only reduce ash to reduce host material but also ensure sustainable management practices.

b. **Biological controls -** Wisconsin has received federal approval to introduce the three species of parasitoids available from federal agencies for introduction against EAB. DATCP staff are currently working on the state permit. The interagency Science Panel has provided guidance on issues to be considered in such an introduction and the Operations Group is developing an operational plan for introductions with input from this guidance.

c. Pesticides - DATCP staff worked to get special approval for the use of emamectin benzoate (Treeage), for use in Wisconsin. Dr. Chris Williamson, UW Extension, working with entomologists in several other states has developed a guide to insecticides for use against EAB. This can be viewed at http://emeraldashborer.wi.gov/articleassets/InsecticideOptionsForProtectingTreesFromEAB.pdf .

Education and communication

DATCP, DNR and partners at UW-Extension, USDA APHIS and Forest Service have been coordinating efforts in this area, to produce a consistent message and reach a wider audience. Movement of infested firewood by the general public is thought to be a leading source of new infestations especially from quarantined areas where commercial sources such as nurseries and wood industries are well regulated. The public has also served as the initial reporter of several new infestations. Public support will be necessary for communities to successfully minimize the impacts EAB could have on them. For these reasons, public communication and education are important goals for the overall EAB program. Awareness of the threat of EAB and methods to avoid spreading the pest is communicated through both general and targeted methods. General awareness messages include radio spots, billboards, a quarterly newsletter, posters at boat landings and on public bulletin boards, and interviews with the media. Targeted awareness efforts include notification of firewood regulation during the reservation process at state campgrounds, presentations and booths at special interest conventions, postcards to landowners from out of state or from particular areas, and notices included with licenses for fishing, ATV's, snowmobiles or boats. Once the public is aware of EAB, they need a source of reliable information on the issue. The website http://emeraldashborer.wi.gov is the primary source for EAB information for Wisconsin residents. The section on resources provides a variety of publications, audio and video educational shorts and newsletters with the latest developments on EAB and its management in Wisconsin. It also includes specific information for homeowners, communities, professionals and woodlot owners, signs and symptoms, the option to report a potential infestation and where to go for more specific information.

5. Reducing economic impacts of EAB

a. Workshops - In spring of 2009, infested ash were cut and destroyed in Fireman's Park in Newburg, as part of the Wisconsin Arborists' Association day of service. Local interest was high in this activity and the opportunity was used to educate urban and rural landowners on many aspects of EAB biology and management. Two workshops were conducted in October, 2009; one for municipalities within approximately 10 miles of Newburg and one for forest landowners within approximately 3 miles of Newburg. These workshops were supported by a USDA Forest Service grant. The workshops were a joint effort between DNR, UW-Extension, DATCP and Town and Country Resource Conservation and Development. The sessions covered options to reduce the impact of EAB through sustainable forestry practices, regulatory issues, status of EAB in Wisconsin and options for utilization. These workshops are expected to be used as prototypes for similar workshops around the state for municipal forest managers and private arborists hosted by the Urban Forestry Program staff.

b. Guidance to communities in developing ash conversion/EAB response plans - This is a high priority goal for the DNR Urban Forestry Program. Support materials including the EAB Toolkit and municipal planning guidelines have been prepared and are available through the state EAB website.

c. Grants to support inventories and development of response plans by communities - The urban forestry grant program is currently the only source of cost sharing for community EAB preparedness and response. Go to http://www.dnr.wi.gov/forestry/UF/grants/ for more information on this program.

d. Silvicultural guidance for woodlot owners - This guide has been developed and is available at http://www.emeraldashborer.wi.gov/articleassets/EABWIManagementGuidelinesBS.pdf. An update is currently in development dealing specifically with woodlots within several miles of known EAB infestations. Local DNR foresters are working with owners of larger forested lands to accelerate ash removal near known infestations of EAB.

e. Facilitation of group contracts for tree removal and utilization - A list of wood residue brokers assembled by DNR wood utilization specialists is available at http://www.emeraldashborer.wi.gov/articleassets/wood_residue_brokers.pdf . The DNR forester for the Newburg area is working with owners of small woodlots there to set up a group contract for harvesting ash. DNR Urban Foresters are developing guidance for communities that wish to facilitate a community contract for residents who need tree removal and chipping services.

f. Ending production of ash at state nurseries - Given the current poor expectation for long term survival of ash in woodlots, state nurseries have stopped producing ash for distribution.

6. Research

EAB is a new significant forest pest and research is needed on techniques for detection and management. DNR, DATCP and UW Extension staffs are working on a range of studies that will provide information helpful to managing EAB in Wisconsin. DNR is supporting research on multitemporal Land Sat imagery analysis to detect ash in forest stands. Work is being conducted by Dr. Phil Townsend, and graduate student, Bernie Isaacson UW-Madison.

a. DNR is supporting research on hyperspectral imagery analysis to detect stressed ash, oak, beech and hemlock in forest stands. Work is being conducted by Dr. Rich Hallett, University of New Hampshire and USDA Forest Service.

b. DNR and DATCP staffs are participating in biosurveillance of EAB using *Cerceris fumipennis*.

c. DNR and DATCP staffs are participating in a survey of native relatives of EAB.

d. DNR staff conducted baseline and follow-up surveys of camper awareness of EAB and the risk of moving firewood. Firewood use behavior and the importance of firewood availability were also studied.

e. DNR is testing the use of “islands of attraction” in limiting spread of expansion of EAB populations.

f. UW-Extension is testing a variety of chemical controls.

Emerald Ash Borer: Using Sink Trees to Focus EAB Population

River Edge Nature Center, Newburg, WI

"Sink" trees, when used as part of an EAB program, are ash trees that have been girdled in spring-early summer to induce the production of volatile chemicals that attract EAB. Preliminary research has shown that sinks may influence the movement of adult emerald ash borers by attracting them more effectively than surrounding healthy ash. These trees were located in an area considered to be the center of the infestation and are meant to draw the beetles towards the center and away from the edges of the infested area (Figure 5).

Sink trees are being tested as part of a landscape-level management tool to influence the movement of EAB back into the center of the infestation. Sink trees can also be used to reduce the number of insects in an infestation if the infested portions of the tree are cut and destroyed or utilized before adult insect emergence in the spring.

Sink trees were established in the Newburg, WI EAB infestation (River Edge Nature Center Property) on June 3, 2009 (Table 2). Five groups of three trees each were girdled. Trees were selected with the following criteria:

1. Located within 60' of walking trail. This was requested by the property manager. The plan for the property includes felling ash trees close to walking trails to reduce hazards to patrons. Choosing trees close to the trail supports the property plan. The sink location was chosen to remain close to (within .5 mile) the most heavily infested trees but in areas where there was phloem available for EAB feeding.
2. Trees were among the largest in diameter, in the localized area and had full crows receiving sunlight.
3. Trees were grouped in clusters.

Table 2. Cluster, tree number and diameter of River Edge Nature Center sink trees.

Cluster ID	Tree Number	Dbh (in.)	8' Logs (no.)	Board Feet of Volume
A	1	11.4	1	20
A	2	15.1	4	150
A	3	12.9	2	50
B	1	17.0	6	240
B	2	12.1	2	40
B	3	11.8	1	20
C	1	12.6	3	70
C	2	14.6	4	120
C	3	9.5	0	
D	1	13.6	3	90
D	2	15.0	3	80
D	3	12.6	2	50
E	1	18.2	3	140
E	2	16.1 codominant	5	190
E	3	18.4 codominant	4	200

Trees were marked with the cluster ID and tree number. A sign was attached to each tree that described the project.

Data Collection and Management of Sinks:

Trees must be cut and infested material destroyed when the ground is frozen and before May 15, 2010. The Department of Natural Resources will work with the River Edge Nature Center property manager to plan and implement this. Data will be collected on the number of larvae and pupae present in the sinks and compared to the number of larvae and pupae in non-girdled trees.

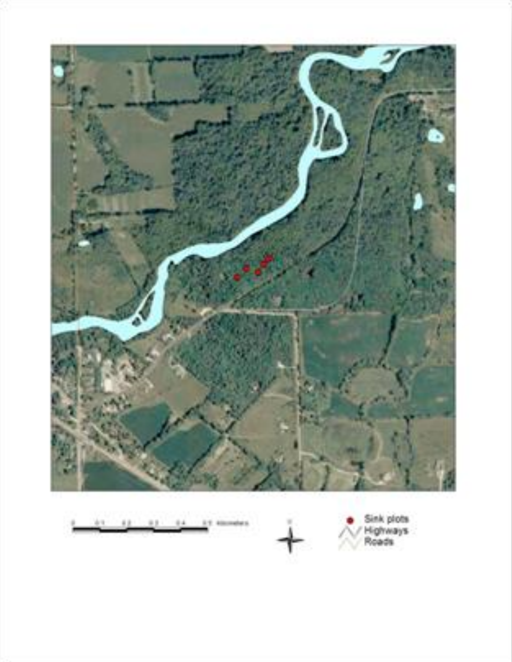


Figure 5. Location of sink trees at River Edge Nature Center in Newburg, Wisconsin (map by Sally Dahir).

Wisconsin DNR and DATCP Investigate Using a Wasp to Detect Emerald Ash Borer

What is *Cerceris fumipennis* and how can it help to find EAB?

Current methods used to detect emerald ash borer (EAB) infestations in Wisconsin include baited purple panel traps, destructive tree peeling, detection trees and visual surveys. These survey techniques are not only marginally successful at detecting EAB infestations during their infancy, but are also costly and time intensive. Meanwhile, EAB continues to make its presence known in Wisconsin, with multiple infestations known across the state. As the end of 2009 nears, seven counties in Wisconsin contain one or more EAB infestations; including Brown, Crawford, Kenosha, Milwaukee, Ozaukee, Vernon and Washington counties.

New research by Philip Careless (University of Guelph, Ottawa, Canada) has found promise in a native solitary wasp, *Cerceris fumipennis* (Say), to be used to detect EAB. This wasp from the Crabronidae family hunts for a specific group of beetles to feed her young, taking only beetles in the same family as EAB (Buprestidae). By watching what beetles a wasp brings to her nest, a surveyor can determine if EAB is located within the 2 km foraging radius she travels away from her nest. While the thought of working with this wasp may sound risky, *C. fumipennis* is docile with people and doesn't sting even when handled.

This summer, forest health staff from DNR and the Department of Agriculture Trade and Consumer Protection (DATCP) surveyed for the presence of naturally occurring nests of *C. fumipennis* in Wisconsin. Once a nesting site was identified, surveyors monitored wasps at select sites to determine what species of Buprestid beetles were being brought back to the nests, namely if any of the beetles were EAB.

***Cerceris fumipennis* colony detection in Wisconsin**

The first objective of the survey was the identification of naturally occurring *C. fumipennis* nesting sites in Wisconsin, with emphasis to locate sites 1) near known EAB infestations in the vicinity of Newburg and Victory and 2) on our state park and forest lands.

The aim of *C. fumipennis* detection near the Victory and Newburg infestations was to compare any results of EAB detection by *C. fumipennis* with those of the baited panel traps placed by DATCP within the delineated boundary of these infestations. Aerial photography was examined for potential *C. fumipennis* sites within a 16 km radius of the two infestations, and potential detection sites were mapped prior to field visits. Sites selected from aerial photography were biased towards sand and gravel pits, baseball diamonds and vacant lots.

Once potential nesting sites were exhausted near Newburg and Victory, scouting for *C. fumipennis* sites was refocused to counties with predominantly sandy soil or a high incidence of sand and gravel pits. Among the counties identified for our survey as having concentrations of sandy habitat or abundant pits were Barron, Dane, Jackson, Juneau, La Crosse, Monroe,

Table 3. List of State Park and Forest lands visited during 2009 *C. fumipennis* survey.

	WI State Parks and Forests	*C. fumipennis* detected?
1	Amnicon Falls State Park	No
2	Big Foot Beach State Park	No
3	Blue Mound State Park	No
4	Copper Falls State Park	No
5	Devil's Lake State Park	No
6	Governor Dodge State Park	No
7	High Cliff State Park	No
8	Interstate State Park	No
9	Kettle Moraine State Forest- North	Yes
10	Kettle Moraine State Forest- South	Yes
11	Kohler-Andrae State Park	No
12	Lake Kegonsa State Park	No
13	Merrick State Park	No
14	Pattison State Park	No
15	Peninsula State Park	Yes
16	Pike Lake State Park	No
17	Point Beach State Forest	No
18	Potawatomi State Park	No
19	Richard Bong State Rec. Area	No
20	Whitefish Dunes State Park	No
21	Wyalusing State Park	No
22	Yellowstone Lake State Park	No

Outagamie and Sheboygan counties. Due to time and travel constraints, detection work in these counties was not extensive.

The detection of *C. fumipennis* nesting sites on state park and forest lands focused on those properties considered high risk. The risk assessment for state properties was measured by the 1) potential for EAB introduction by firewood and 2) popularity of the property, with respect to number of visitors each year. A list of the state lands surveyed for *C. fumipennis* can be found in Table 3. When surveying for *C. fumipennis* on state properties, surveyors focused their efforts in group camp areas, picnic and recreation areas, trail heads and informal parking areas. Despite the suitable habitat that campsites provide for *C. fumipennis* nesting, state park and forest campsites were largely avoided during the survey since they were usually occupied. However, group camp areas were included in the survey since there was more of a vacancy during the week.

Identification of *C. fumipennis* nesting grounds

Cerceris fumipennis nesting grounds are commonly found in open areas of hard-packed sandy soil with sparse vegetation and are in close proximity (200 meters) to the woody habitat that supplies their Buprestid beetle food source. Nests are identified by a circular entrance hole that travels straight down into the ground and is about the diameter of a standard pencil (Careless *et al.*, 2009). The nest entrance is completely surrounded by and centered within a tumulus of soil that is about 4 cm in diameter (Figure 8).

Figure 8. *Cerceris fumipennis* nest entrance with tumulus present (photo by Renee Pinksi).

Surveyors focused on the identification of female *C. fumipennis* since the male wasps do not hunt for beetle prey or live in ground nests. Female *C. fumipennis* are about the size of a common yellow jacket and are most easily identified by 1) three creamy yellow patches between their eyes, 2) dark smoky blue/black wings and 3) a conspicuous creamy yellow abdominal band (Figure 9). During the survey, sites were not considered positive for *C. fumipennis* unless visual identification of the female was made, rather than just basing it on nest architecture. Visual identification is most easily made by looking into a nest entrance and recognizing the female facial pattern when they are guarding their nest. Additionally, one *C. fumipennis* voucher specimen was collected from each site and submitted to the University of Wisconsin Insect Research Collection for positive identification.

Figure 9. Definitive characteristics of *C. fumipennis* female include Left: three yellow patches between eyes and Right: smoky blue wings and mostly black body with yellow band on abdomen. (photo by Jeff Roe).

All survey guidance for this project and detailed information on *C. fumipennis* biology and behavior was obtained from *Cerceris fumipennis- a Biosurveillance Tool for Emerald Ash borer* (Careless *et al.*, 2009).

Biosurveillance of *C. fumipennis* for EAB

The subsequent objective of this survey was to conduct biosurveillance of *C. fumipennis* for EAB. Biosurveillance was conducted by placing a cardstock collar over the entrance of the wasp nest (Figure 10). The collar has a hole punched on either end, with one hole to be placed over the nest entrance and the other for insertion of a golf tee to hold the collar in place. A wasp is easily able to enter and leave her nest through the hole in the collar, however when returning with prey to her nest she is unable to fit. At this time, a surveyor is easily alerted to her presence with prey by her incessant buzzing. The surveyor can then collect her and her prey with a sweep net. Once in the net, the wasp typically releases the paralyzed prey immediately and then she can be released from the net unharmed. Upon release, the wasp heads back out on another foraging trip.

Figure 10. *Cerceris fumipennis* nest entrance covered with collar used to conduct biosurveillance for EAB(photo by Jeff Roe).

Scientific studies have found that in order to fully represent the entire Buprestid beetle diversity within a foraging area, a minimum of 50 beetle prey must be collected during biosurveillance (Careless 2009). Ideally, no more than 20 beetle prey are to be collected per biosurveillance visit and visits should be spaced out across the EAB flight season. *Cerceris fumipennis* is most active on warm sunny days (soil temp >29 C) between the hours of 11:00 am and 5:00 pm (Careless *et al.*, 2009). Surveyors made every effort to account for these aspects while conducting all biosurveillance.

Results: Where is *C. fumipennis* in Wisconsin?

A total of 116 prospective *C. fumipennis* nesting sites were visited across 28 counties during the detection survey (Figure 11). Twenty-six of these sites were positively identified for *C. fumipennis* (Table 4) and 90 sites were negative for the wasp. However, 30 of the negative sites were noted as potential *C. fumipennis* nesting grounds worth revisiting for possible positive identification next year. These potential sites displayed nests with the characteristic entrance and tumulus; however no *C. fumipennis* wasps were encountered. It is worth noting that many more than these 116 sites were identified in initial mapping efforts; however upon visiting the majority of these sites, it was quickly determined that they were unsuitable habitat for *C. fumipennis* (land was under development, inadequate soil type, no wooded area nearby, etc.) and no location data was recorded.

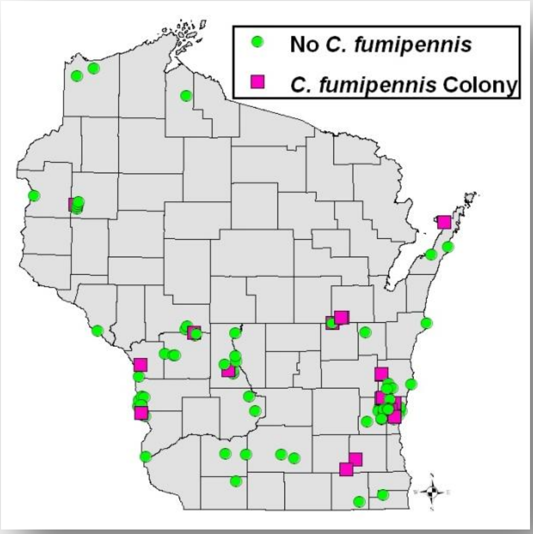


Figure 11. Locations of *C. fumipennis* colonies detected statewide. Pink squares designate a site positive for *C. fumipennis* nesting ground. Green circles designate a site that was surveyed for *C. fumipennis*, but the wasp was not found.

Municipal parks and ball diamonds yielded no confirmed *C. fumipennis* nesting sites, despite the success Maine had using this site type as an aid in finding wasp colonies during 2008 (Colleen Teerling, personal communication). Surveyors found that most ball diamonds in the areas surveyed were well-maintained and used frequently, possibly creating too much disturbance for *C. fumipennis* to nest successfully. However, Wisconsin surveyors did find *C.*

fumipennis nesting grounds primarily in abandoned or infrequently used sand and gravel pits and in the compacted area around campfire pits in camping areas, with 12 and 11 sites, respectively. Because of the initial success with sand and gravel pits, focus on subsequent detection work outside the infested EAB area was turned almost exclusively to these site types. Additionally, lone wasp sites were located near a nature center overflow parking

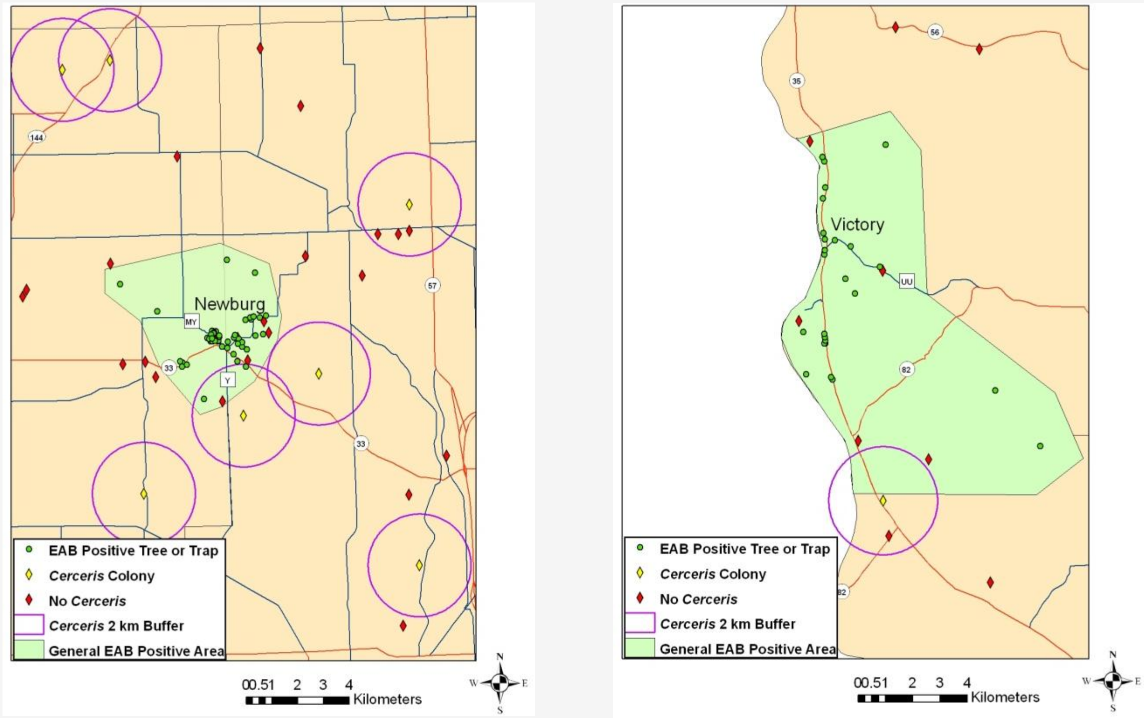


Figure 12. Proximity of an active *C. fumipennis* colony to the EAB infestation near Newburg (left) and Victory (right). Emerald ash borer positive trees or traps are designated by green circles and the generally infested area is shaded light green. Colonies of *C. fumipennis* are designated by yellow diamonds and 2 km buffers are shown in violet to represent the maximum foraging distance of *C. fumipennis*.

area, in a high foot traffic area and in an abandoned residential lot. Despite the lack in success of finding *C. fumipennis* colonies in baseball diamonds, they will not be ruled out as productive sites in future surveys.

The first *C. fumipennis* detection occurred on July 13 near Newburg in Ozaukee County (Table 4). *Cerceris fumipennis* activity, including nest maintenance, nest guarding and provisioning for young, continued throughout the summer at this site. A decrease in colony activity became noticeable during the first week in September. The number of nests within a colony varied across sites, ranging from 1- 285 nests and averaged 29 nests per colony (n=26). Site 353, which contained 285 nests, was atypical of what we commonly encountered during the survey. This fertile site was located in Crawford County and found in a patchy mowed grassy area used infrequently for campfires. It is worth noting that the number of nests found within a site varied by visit, and was dependant on site disturbances such as rainfall. After a significant rainfall, the tumulus is washed away and the nest entrance becomes filled with soil and it can take a day for the wasp to dig herself out. Unfortunately, if the wasp was caught away from her nest during the disturbance, she is unable to return to her nest.

Just three of the *C. fumipennis* positive sites discovered were located near the Newburg and Victory EAB infested areas. Two of the sites were less than 2.4 km outside the Newburg delineated boundary (Figure 12, Left) and one site was located just outside the Victory delineated boundary (Figure 12, Right), however no sites were found within the confirmed EAB generally infested areas.

Of the state lands surveyed, just three of the 22 properties had *C. fumipennis* detected. Nesting grounds were found at Peninsula State Park (one site) near an overflow parking lot by the nature center and in group campsites scattered throughout the Kettle Moraine State Forest-Northern Unit (seven sites) and Southern Unit (three sites) (Table 4). Despite the low number of *C. fumipennis* found nesting on state properties, it is possible that the wasp is present, but did not turn up in the specific areas where surveyors focused during the investigation; namely group camp areas, picnic and recreation areas, trail heads and informal parking areas.

Results: Biosurveillance of *C. fumipennis* for EAB

Biosurveillance was initially conducted at 13 of the 26 sites positive for *C. fumipennis*. However, many of these sites contained fewer than 30 nests (Table 4), and biosurveillance was not deemed fruitful given the time constraints. Hence, surveyors choose to continue on with biosurveillance at only four of the 13 sites for the remainder of the survey.

Biosurveillance was conducted July 13 through August 25, but all sites were not monitored throughout the duration of this period given that *C. fumipennis* sites were being newly identified as the survey season progressed. Despite the fact that *C. fumipennis* was observed into the month of September, provisioning was seemingly minimal by the last week of August and biosurveillance was ended at this time.

The time spent monitoring a site during biosurveillance ranged from 15-240 minutes per visit, but on average was 104 minutes (n=24). The number of beetles collected per hour ranged from 0 - 11.2 across all sites, and on average surveyors collected 2.6 beetles/hour (n=24). In addition to beetles collected via biosurveillance, there was also an opportunity to collect beetles that had been dropped by the wasp near nest entrances. These dropped beetles were collected across all sites and totaled 19. Although surveyors did not reach the intended goal of 50 total prey collected per site, the four most productive sites did produce 15, 20, 30 and 49 total Buprestids (Table 4), when adding together dropped beetles and those collected during biosurveillance at each site.

Regardless of the close proximity of three of the *C. fumipennis* nesting grounds to EAB infested areas, no EAB prey was collected from these, or any other biosurveillance site during the survey. Interestingly, the *C. fumipennis* site located just outside the Victory infestation (Figure 12, Right) was not identified until August 10. Therefore, surveyors may have missed the EAB flight season and there would have been no EAB adult beetles for the wasp to bring back, even if EAB was in the vicinity. Despite the fact that no EAB were collected, a total of 128 other

Figure 13. Species diversity of Buprestidae beetles collected during *C. fumipennis* biosurveillance survey. Beetle identification in progress (photo by Renee Pinski).

Buprestidae were collected, with 114 of the beetles coming from the top four producing colonies monitored during biosurveillance. Insect identification of the captured prey is currently underway, but preliminary results display diversity across numerous genera of the Buprestidae collected (Figure 13). Preliminary identifications show representatives of *Agrilus* spp., *Buprestis* spp., *Chrysobothris* spp., *Dicerca* spp., and possibly one species each of

Eupristocerus, *Actinodes* and *Brachys*. *Dicerca* spp. accounted for 66% of the collected prey and *Agrilus* spp. made up 11%.

Near the end of August surveyors conducted several excavations of *C. fumipennis* nests. Individual wasp nests were dug up and the nest contents, adult female wasps and individual cells within the nest, were collected and examined. Numerous larvae were extracted from these cells and identified to the family Crabronidae in the laboratory, thus suggesting that these larvae were indeed *C. fumipennis* (Figure 14). The majority of beetles found stored in cells had already been fed upon by *C. fumipennis* larvae, therefore species identification of the beetle prey was not possible and it is undetermined if EAB could have been collected by the wasp earlier in the season and prior to biosurveillance.

Figure 14. Suspect *C. fumipennis* larvae (size ¾") collected from excavated cells in nest. Larva on right is covered with sand and beetle exoskeleton (photo by Renee Pinski)..

What is next for *C. fumipennis* in Wisconsin?

In upcoming survey seasons, it is our hope to improve this unique system of using a wasp to detect the presence of EAB. Based on other scientific trials in 2009, progress was made with improving the ability to make these wasp nests mobile. Having the capability to move *C. fumipennis* wasps in artificial nests away from their natural locations greatly increases the usefulness of this system not only as an effective initial detection tool in areas where these wasp may not be naturally found, but also as a more sensitive delimiting tool that can be used to better define the outer boundary of a known EAB infestation.

Based on initial nest detection data collected this year, surveyors will be better equipped to conduct more comprehensive biosurveillance of the newly identified *C. fumipennis* colonies in the upcoming survey season. The three *C. fumipennis* nesting grounds located just outside the Newburg and Victory EAB infested areas can now be monitored earlier in the season and parallel EAB emergence in these areas. These three sites can also be used as indicators to alert us as the boundary of the infested area expands over time. As these data are collected over subsequent survey seasons, we will also be able to watch for fluctuations in native beetle diversity as the EAB population increases.

References

Careless, P.D. (2009). 2008 *Cerceris fumipennis* Project Report for CFIA and USDA. Submitted on November 22, 2008 to Vic Mastro, USDA. pp. 60.

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, pp. 16.

Table 4. Location of *C. fumipennis* nesting grounds. Supporting information includes date of discovery, site description, number of nests present and cumulative number of Buprestids collected during the duration of the biosurveillance survey.

Date detected	County	Site	Site description	Number of nests	Total number Buprestids collected
07/13/2009	Ozaukee	106	gravel pit	45	49
07/15/2009	Ozaukee	107	gravel pit	1	0
07/15/2009	Door	Peninsula State Park- Nature Center overflow parking	parking lot	20	20
07/15/2009	Ozaukee	141	vacant lot	32	3
07/20/2009	Washington	213	gravel pit	5	0
07/21/2009	Ozaukee	131	gravel pit	5	1
07/23/2009	Waukesha	Kettle Moraine Southern Unit Pinewoods Group A	campsite	3	1
07/23/2009	Waukesha	Kettle Moraine Southern Unit Pinewoods Group B	campsite	19	0
07/28/2009	Jefferson	Kettle Moraine Horse Camp 559, 561	campsite	7	2
07/29/2009	Washington	201	gravel pit	21	1
07/29/2009	Washington	222	gravel pit	77	15
08/03/2009	Barron	502	sand pit	7	0
08/10/2009	Crawford	353	campsite	285	30
08/11/2009	Sheboygan	Kettle Moraine Northern Unit Greenbush Group 1	campsite	25	0
08/11/2009	Sheboygan	Kettle Moraine Northern Unit Greenbush Group 3	campsite	14	0
08/11/2009	Sheboygan	Kettle Moraine Northern Unit Greenbush Group 4	campsite	17	0
08/11/2009	Sheboygan	Kettle Moraine Northern Unit Greenbush Group 5	campsite	7	0
08/11/2009	Sheboygan	Kettle Moraine Northern Unit Greenbush Group 6	campsite	10	0
08/11/2009	Sheboygan	Kettle Moraine Northern Unit Greenbush Group 7	campsite	9	0
08/11/2009	Sheboygan	Kettle Moraine Northern Unit Greenbush Group 9	campsite	29	1
08/11/2009	La Crosse	601	gravel pit	64	5
08/17/2009	Outagamie	910	gravel pit	4	0
08/17/2009	Outagamie	912	gravel pit	8	0
08/17/2009	Winnebago	901	gravel pit	25	0
08/19/2009	Juneau	1006	gravel pit	15	0
08/25/2009	Monroe	723	high foot traffic area	10	0

2009 Gypsy Moth (*Lymantria dispar*) Program

Suppression Program

The suppression program treated 10,563 acres at 135 spray blocks in 23 counties, down from approximately 12,500 acres in 2008. Most acres, 10,002, were treated with the *Bacillus thuringiensis* based insecticide Foray. Two rates were used: 9,618 acres were treated with Foray 48B at ¾ gallon per acre (36 CLU/ac) and 384 acres at seven sites with Foray 76B at 1/3 gallon per acre (25.3 CLU/ac). The remaining 561 acres were treated with the gypsy moth specific viral insecticide, Gypchek in 1 gal of Carrier 38A/acre ($4x10^{11}$ OB/ac). Treatments were contracted to Al's Aerial Spraying at $32.49 per acre for all blocks. Treatments began May 21 in the southern counties and ended May 31 in the Wausau area. All blocks were successful by the program standards of preventing >50% defoliation on >80% of the trees in the block and nearly all blocks had much higher levels of suppression of the gypsy moth population than non-treated adjacent areas.

2009 Gypsy Moth Suppression Program.

In Figure 15 below, the locations of gypsy moth suppression spray blocks are indicated by black dots. Counties where suppression program treatments were done are highlighted in rust.

The 2009 program was unusual because the Federal Aviation Administration for the first time required the use of a twin engine spray plane over some blocks in urban areas. The Cessna Skymaster used was much noisier than the single engine, turbo prop Ag Tractors normally used. The pump installed in the Skymaster to supply the booms was also slower than those in the Ag Tractors which required the Skymaster to fly over each swath three times to lay down the same amount of pesticide. The combination of increased noise and time over the block caused a great increase in the number of complaint calls and calls to local 911 or other emergency lines. In some areas that had been treated in previous years the number of these calls went from a handful to over 600. To address the amount of time the plane spent over the block, we switched on the last seven blocks to the more concentrated 76B formulation of Foray and reduced the amount of pesticide applied from 36 to 25.3 CLU's. The 25 CLU application level has been used by other suppression programs and it was successful in suppressing the larval population below target levels. Unfortunately, the number of complaints during the application from these seven blocks

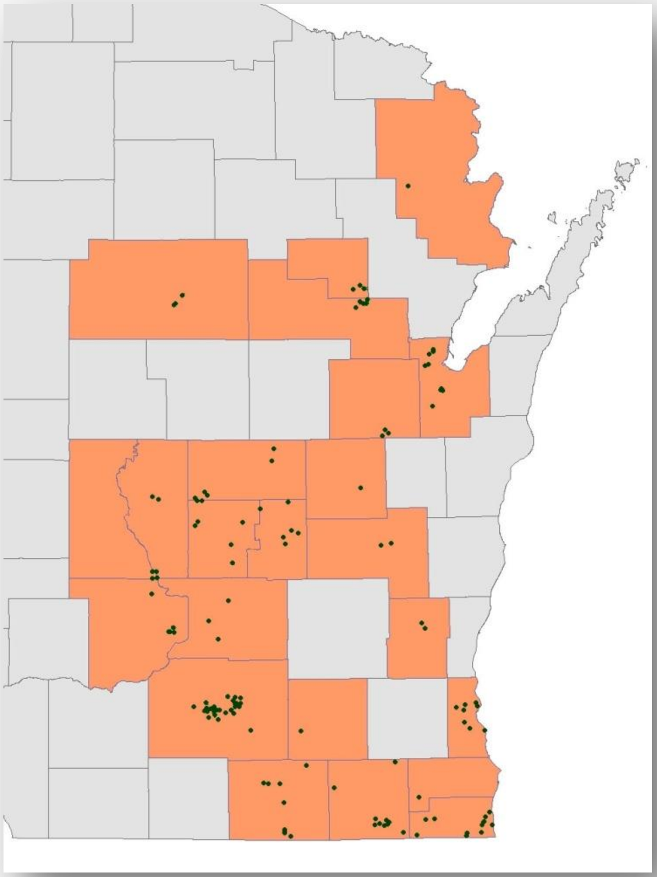


Figure 15. Gypsy moth spray blocks in 2009.

remained higher than for blocks treated by single engine planes.

Public notification for the Suppression Program continued to improve. Subscription to the email notification service doubled in 2009 to over 1,000 subscribers. This was the third year the Suppression Program offered an email notification subscription option to those who wished to be notified of spray activities as plans changed during the spray season – sometimes daily. The 2009 spray program was the second year the DNR call center provided live handling of calls. This service was a great help in dealing with the large number of calls to the program from residents concerned by the loud twin engine plane. Being able to offer immediate answers and reassurance by a live staff person helped reduce the public relations impact of this unanticipated problem. Having the call center staff handle all but the most technical of calls also significantly reduced the extra workload that otherwise would have fallen entirely on the staff already fully engaged in running the spray program.

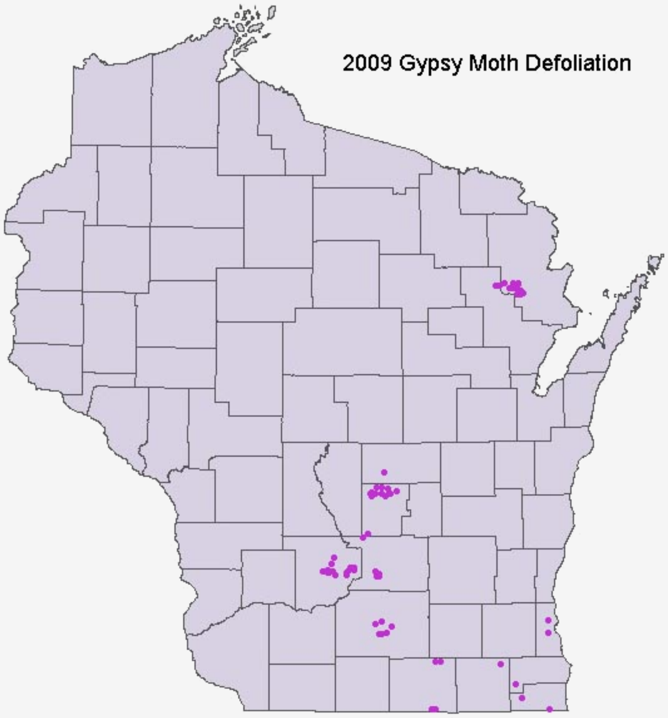


Figure 16. Area of defoliation from gypsy moth in 2009.

Defoliation and Public Nuisance

Aerial surveys detected a total of 3,666 acres of defoliation this summer (Figure 16), as compared to 8,659 acres in 2008 and approximately 23,000 acres in 2007 (Table 5). The majority of the defoliation in all years was light; in 2009 only 40 acres were moderately and 35 heavily defoliated out of the total. The gypsy moth population in Marinette County appears to be increasing to outbreak for the third time in Stephenson Township, an area characterized by dry, sandy soils and contiguous stands of northern pin oak. Cycles of gypsy moth outbreaks are expected to be more frequent in these sorts of areas, the last outbreak there collapsed at the end of 2004. The outbreak in the Baraboo hills area of Sauk County appears to be increasing over a wider area. Next year we may see an increase in intensity of defoliation.

Table 5. Acres defoliated by gypsy moth

County	Acres defoliated
Columbia	116
Dane	102
Kenosha	3
Marinette	662
Marquette	312
Milwaukee	4
Oconto	55
Racine	3
Rock	23
Sauk	2,379
Walworth	1
Waushara	6
Total	3,666
Severity category	**Acres affected**
Light	3,591
Moderate	40
Heavy	35

The number of public nuisance calls dropped dramatically this year with declining gypsy moth populations. Population collapse in central Wisconsin was probably due to a combination of spraying, cool summer weather, disease, and poor hatch. Dane, Milwaukee and Oconto counties generated the most public calls to the DNR gypsy moth program.

Mortality

Scattered NPV and *Entomophaga maimaiga*–caused mortality was observed in southern counties, where the weather was wetter than in the north. Northern Wisconsin has been dry for the past few years and not surprisingly less *Entomophaga* was observed. Poor hatch was widespread in the central counties, possibly due to fluctuating weather conditions this spring prior to hatch.

Distribution of *Entomophaga maimaiga*

While *Entomophaga* has followed behind newly established populations of gypsy moth (Hajak), Forest Health staff collect fungus killed gypsy moth larvae when convenient and redistribute the ground cadavers in leading edge populations on state lands to ensure the disease is active there as soon as possible. Previous research had shown spores remain viable in soil for at least seven years and the fungus is specific to gypsy moth so there is no disadvantage of seeding the fungus into very low populations of the host. In 2009 ground cadavers were distributed in January and November at several state lands in southwest Wisconsin.

Beech Bark Disease

Beech bark disease, a disease of American beech (*Fagus grandifolia)* caused by a scale insect and one of several fungi, was detected in Door County in late August, 2009. This was the first find of this disease in Wisconsin. Affected trees were in a rural forested area several miles east of the city of Sturgeon Bay. Many trees were found to be heavily covered with white woolly materials produced by the beech scale (*Cryptococcus fagisuga)*. Beech scale identification was confirmed by Phil Pellitteri, University of Wisconsin Extension Entomologist. Beech mortality had been observed by a landowner for a few years prior to the confirmation of this disease. Heavy scale populations and tree mortality due to the disease were also found in a residential area approximately one mile east of the first find.

A press release to announce the first find of this disease in Wisconsin was sent out in September. A separate letter that explained the disease in detail was also sent to hundreds of landowners and homeowners whose property was near the detection site.

Surveys to delineate the extent of infestation by the beech scale followed soon after the detection. Surveyors looked for characteristic white woolly materials on the bark of beech trees. A sub-set of samples were delivered to the University of Wisconsin to confirm the identification of the scale. As of December 2009, the beech scale has been found throughout much of Door County, except for the southwestern edge of the County. Though the distribution is widespread, infestation levels are light or very light in most survey sites located away from the initial detection area (Figure 17). The distribution may extend further south and additional surveys are scheduled this winter in northern Kewaunee County to try to determine the southern edge of the infestation. The identification of the fungi associated with beech bark disease has not been made at the time of this printing, as survey efforts have been focused on the delineation on the scale infestation. Collection of the fungi for identification is planned this winter.

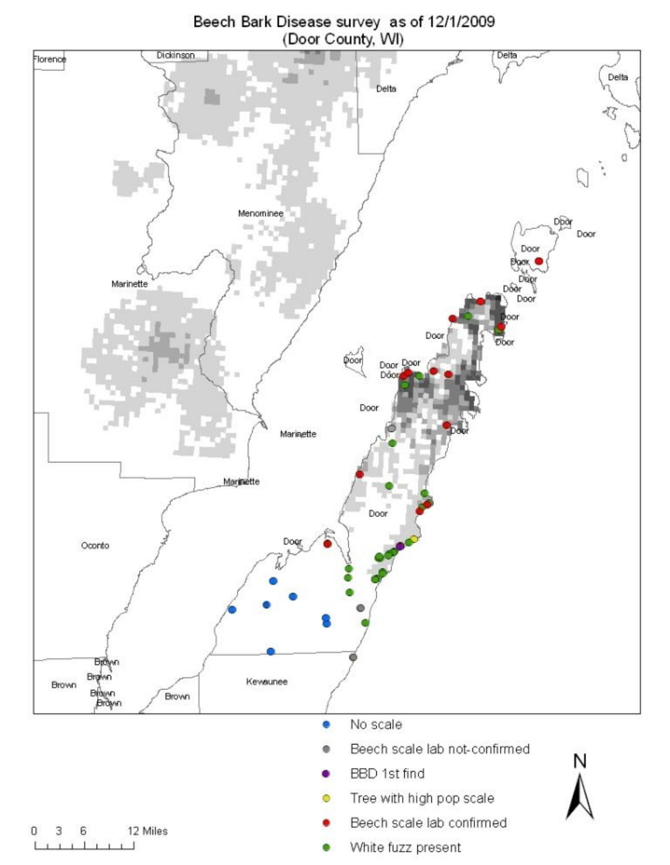


Figure 17. Beech scale survey results as of December 1, 2009, overlaid with beech concentration based on FIA data (grey shading). Red dots indicate the sites confirmed with the beech scale. Blue dots mean that no scale was visible at the site. Gray dots indicate that suspicious white woolly substances were detected and collected for lab analysis, however, there was not enough scale remaining to identify the genus of the scale in the samples. Negative samples may have contained portions of scale bodies, but were missing a critical part for identification (photo by Kyoko Scanlon).

Wisconsin DNR has been working closely with the Wisconsin Department of Agriculture, Trade and Consumer Protection, and discussing options for the management of the disease, including potential regulatory actions. In the meantime, outreach efforts to educate landowners and homeowners in Door County have been initiated. Development of factsheets to help the public with the detection and management of this problem is in progress.

Wisconsin DNR Forest Health Protection has been conducting detection surveys of the beech scale and the beech bark disease since 2005. Survey plots were located in eight Wisconsin counties and examined every year (Figure 18). In 2009, thirty to fifty beech trees at each site were examined for the presence of the scale and disease, beginning in September. All survey sites were on state, county, city, or private land. Selection of survey sites was based on abundance of beech, proximity to out of state positives for the disease, and likelihood of human transport to the site through firewood. Beech scale was not detected outside of Door County in 2009. This survey will continue in 2010 in counties except for Door County.

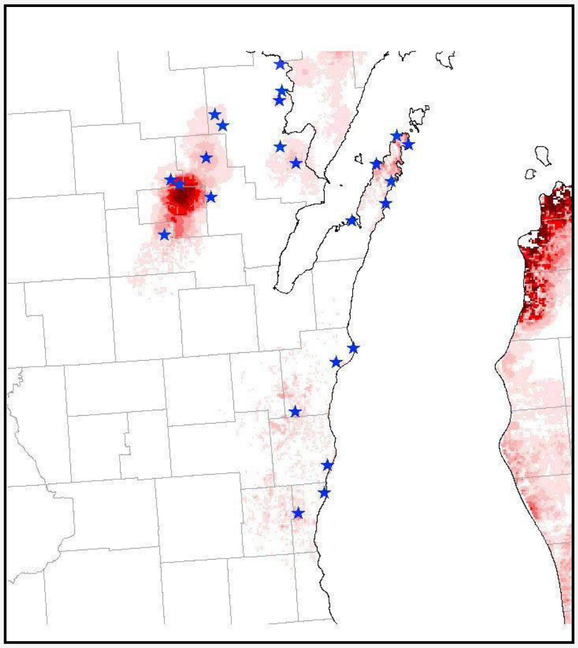


Figure 18. Beech scale and beech bark disease detection survey plots. Red shading represents the presence of beech. Blue stars represent plot locations(map by Bill McNee).

Beech bark disease results when an exotic scale insect, *Cryptococcus fagisuga,* colonizes beech and makes them susceptible to invasion by fungi, including *Neonectria coccinea* var. *faginata* and/or *Neonectria galligena* (Figure 19). 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 only a small percentage (<5%) of American beech is resistant to this disease; another small percentage will be partially resistant while the majority of the beech population is susceptible and will suffer mortality. Infected trees are structurally weakened and very susceptible to trunk breakage during high winds, and should be removed from areas where they are a safety hazard. This susceptibility is due to invasion by decay fungi and wood-tunneling insects.

Native to Europe, the scale was introduced into Nova Scotia, Canada around 1890 and was first observed in northeastern United States in the early 1930s. The disease has been moving west and south across the United States since that time. This disease was first detected in Michigan in 2000. The scale insects are spread by the wind, birds, and as hitchhikers on infested firewood.

Figure 19. American beech with scale (white material) and black tarry spots on the bark. A tarry spot is an indicator of infection by canker-causing fungi (photo by Linda Williams).

Management strategies are influenced by the amount of beech present and distance from an infestation.
For an overview of management options, visit: http://www.co.bay.mi.us/Docs/Health/GypsyMoth/BeechBark.pdf and http://dnr.wi.gov/forestry/FH/exotics/exotic-bb.htm.

If you suspect you may be seeing beech bark disease, contact your DNR forest health specialist: http://dnr.wi.gov/forestry/Fh/staff/index.htm

Hemlock Wooly Adelgid – *Adelges tsugae*

Surveying for hemlock wooly adelgid (*Adelges tsugae*) on state, county and privately-owned land was completed in May and June 2009. Survey sites (Figure 20) were primarily identified through modeling that chose census tracts based on hemlock abundance, tree nursery locations and housing density.

Within each identified census tract, one or two likely introduction sites, such as campgrounds and residential developments, were selected for examination. At each site, two branches from opposite sides of 30-50 hemlock were examined for the presence of the adelgid's wooly egg sacs. If present, the egg sacs would be most easily seen from late fall through early summer. No signs of hemlock wooly adelgid were found.

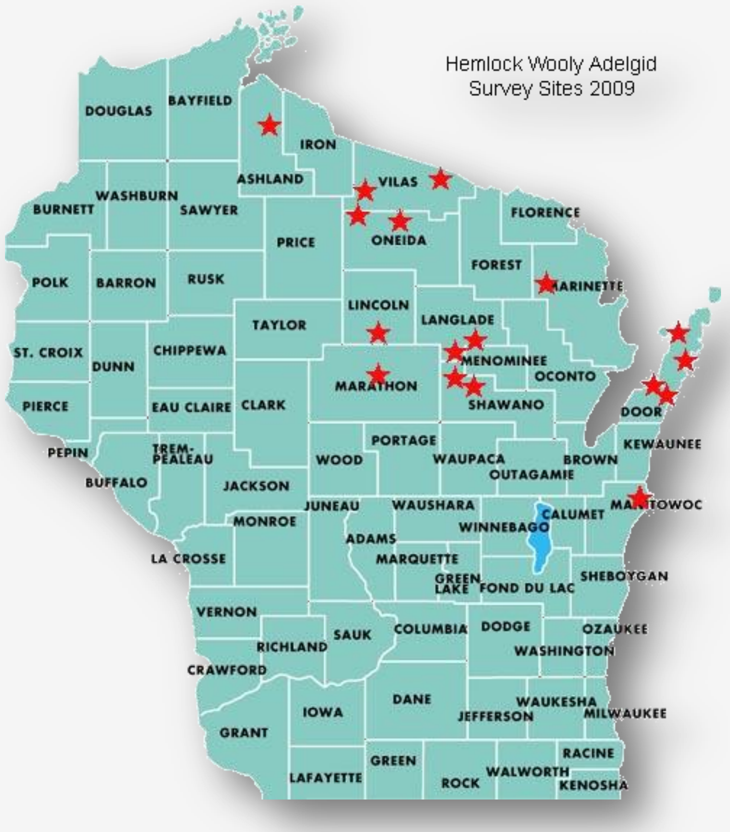


Figure 20. Hemlock Wooly Adelgid survey sites in 2009 (map by Bill McNee).

Invasive Plant Activities

Best Management Practices

The Wisconsin Council on Forestry (WCOF) identified and ranked invasive species as the most critical issue facing Wisconsin's forests and thus created the Forest Invasives Leadership Team (FILT) which in turn initiated efforts to collaboratively develop voluntary Best Management Practices (BMPs) to limit the introduction and spread of invasive species (Figure 21). Four BMP tracks were created to fully address the issue of invasive species in Wisconsin's forests, including: Forestry BMPs, Recreation BMPs, Urban Forestry BMPs, and Transportation and Utility Corridor BMPs.

Figure 21. Left: Equipment may be cleaned with a broom and shovel. Right: Keep a brush handy to clean off boots. (photos by Tom Boos)

The BMPs provides voluntary guidelines with the primary goal to limit the introduction and spread of invasive plants, insects and diseases. All four tracks are finalized and can be found at: http://dnr.wi.gov/forestry/Usesof/bmp/

Herbicide Use Updates

The tables that reside on the Forestry webpage were updated and revised to include many more species and up to date information. The goal is to have them pertain to more land management activities beyond forestry, while keeping the information necessary for foresters in tact. http://dnr.wi.gov/forestry/Fh/weeds/

Also, a page has gone up on the intranet to summarize all the critical information related to pesticide use, i.e. manual codes, certifications, approvals, reporting, etc.

Outreach and Education

With the adoption of NR40 (Wisconsin's invasives species rule) and the finalization of the BMPs, there is a great need for education and outreach. Along with other staff, the process is in place to enhance the DNR website with accurate and consistent information on invasive plants, as well as a page to simplify NR40. Likewise, we recognize the importance of identification of invasive species and have developed a pocket sized field guide.

State Forests Invasive Plant Management Plans

Based on previous inventories of invasive species, Invasive Plant Management Plans have been written for each of the Northern State Forests in 2008 and implementation began in 2009. The goal is to have a plan written for each state forest by the end of 2010. The plans are intended to guide management by aiding in the short and long term prioritization of control of key species. Prioritization is based on the proximity of infestations to high quality natural areas, limitations to tree regeneration, and level of distribution.

NR40- Invasive Species Identification, Classification and Control

The Wisconsin Department of Natural Resources Invasive species law (NR40) is now official as of September 1st. The rule establishes a classification and regulatory system for invasive species restricting actions such as sales, transportation, planting, or releasing listed species to the wild without a permit. The rule classified species as prohibited or restricted species. They are defined below.

Prohibited species are not yet in the state or only exist as small populations, but have the potential to cause significant damage if they are allowed to spread and become established. It is illegal for people to transport, import, possess, transfer, sell and introduce these species without a permit. Landowners will be expected to control prohibited species found on their property.

Restricted species are invasive species that are already too widespread to expect statewide eradication. For this classification it is illegal for people to transport, import, transfer, sell and introduce these species, but people may possess plants.

DNR has pledged to work cooperatively with local units of government, businesses, and landowners to educate people on how to identify these species (specifically plants), develop practices to prevent spread, and assist in finding funding to control prohibited populations. This rule does give DNR staff the right to inspect property for prohibited species and control these species (with landowner permission or a judicial inspection warrant). If the prohibited species is not controlled upon order, DNR or its designee may control it and recover expenses it incurs. Educational materials and resources are currently being made by DNR staff and will be available throughout to educate citizens about the rule.

While the rule exempts people who incidentally or unknowingly transport, possess, transfer or introduce a listed invasive species, knowledgeable citizens must demonstrate that they took reasonable precautions to prevent movement of listed species. More guidance and information on how to interpret this rule will be extended this fall and winter as interpretations of the rule occur.

To see additional information about NR40, go to http://dnr.wi.gov/invasives/classification/

Hardwood Health Issues

Oak Wilt – *Ceratocystis fagacearum*

Oak wilt is caused by the fungus, *Ceratocystis fagacearum*. The fungus attacks water and nutrient conducting channels in the trees and induces the plugging of these channels (Figure 1). Oak wilt is most common in the southern 2/3 of Wisconsin and it has been spreading northward as the disease was found in Florence County (1999), Barron County (2002), and Langlade County (2008).

Figure 1 . Streaks in xylem are symptoms of oak wilt (photo by Brian Schwingle).

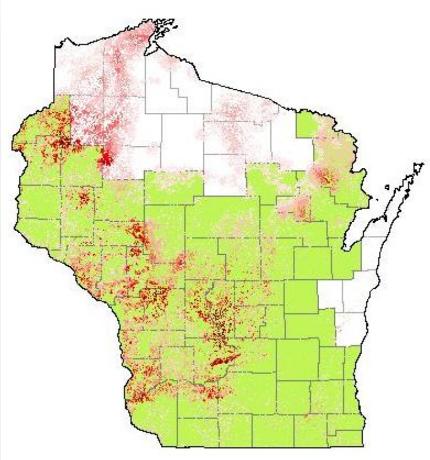


Figure 2. Oak wilt positive counties are shown in green and the basal area of oak is shown in red (map by Sally Dahir).

No new counties were confirmed for the presence of oak wilt in 2009 (Figure 2). However, additional infection sites were detected in counties where oak wilt had been previously confirmed. In Langlade County, there was an additional detection in White Lake Township. There were two pockets of oak wilt in Florence Co., totalling 2.5 acres. Aerial survey of this disease was also conducted over the northern border of current oak wilt infection centers in northern Wisconsin. Through the aerial survey, two suspicious pockets were recorded in Florence County. Site visits of the suspicious pockets are scheduled for the summer of 2010.

For more information about oak wilt in Wisconsin, please visit the WI DNR Forest Health Protection website at http://dnr.wi.gov/forestry/Fh/oakWilt/.

Thinning Study Related to Overland Spread of Oak Wilt: Update

This year was the final year of a four-year study to determine the impact of thinning oak stands on overland infection of oak by *Ceratocystis fagacearum,* the cause of oak wilt. The purpose of the study was to determine the relative risk of thinning oaks in the period between mid-July and mid-October, considered to be a low to moderate risk period.

In response to concerns from land managers, the study was crafted to quantify the relative risk of cutting oaks during this interval. Study sites, where harvesting of oak occurred between July 15th and October 15th, were surveyed to determine the presence and location of oak wilt pockets. These stands were revisited the following year in order to compare the number of new oak wilt pockets in sites with pre-existing oak wilt to the number of new pockets in stands without previous disease. Study sites were chosen in Adams, Clark, Jackson, and Waupaca counties. Oak wilt is found in all of the counties. Six plots were placed in stands where the disease existed. Three plots were thinned from August to mid-September. Another three plots were not thinned and used as control. Nine plots were placed in stands where the disease was not confirmed. Six plots were thinned in August to October and three plots were not thinned and used as control. Although tree mortality was observed in some of the plots, oak wilt was not confirmed through a lab test for any of the additional mortality. Many wood samples that were collected to test for oak wilt exhibited extensive galleries caused by the two-lined chestnut borer. Data analysis is still underway.

Oak Regeneration in Oak Wilt Pockets

This year was the third year of a study following the survival of oak regeneration, both stump sprout and acorn origin, in harvested stands infected with oak wilt (Figure 3). The objectives of this study were 1) to compare twelve-year survival rates of oak seedlings, saplings and sprouts in infected and uninfected areas of harvested oak wilt stands and 2) to determine the oak stocking level for oak regeneration of seedling and stump sprout origin at periodic intervals following harvesting and biannually up to twelve years.

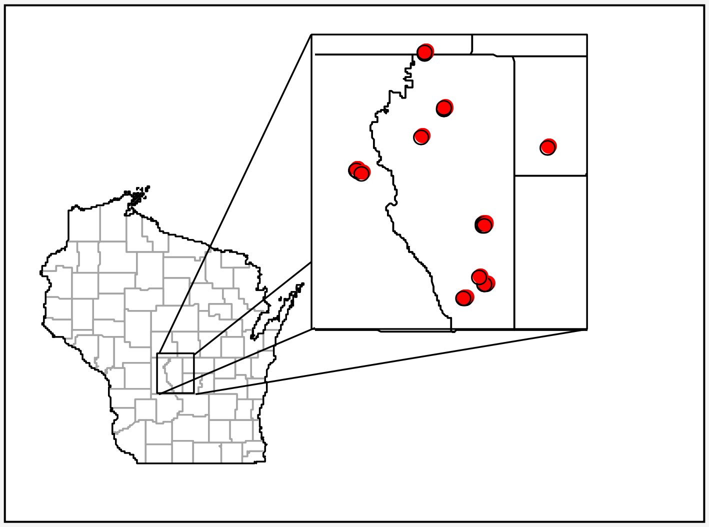


Figure. 3 Sites for oak regeneration survey.

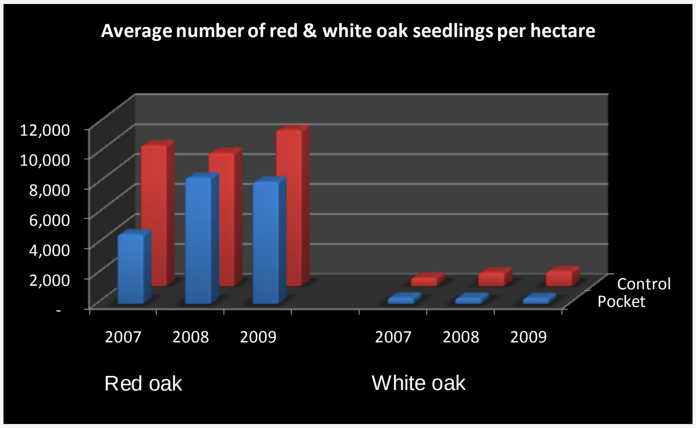
The methodology for plot location and setup are discussed in Forest Health Highlights of Wisconsin Annual Report 2008 (pg. 18). These plots were resurveyed during July and August 2009 and the results are presented here.

The density of red oak seedlings, averaging over 10,000 seedlings per hectare in 2009, has remained fairly constant since 2007 (Figure 4 top). For both red and white oak, seedling densities are consistently higher on the controls compared to plots in oak wilt centers. The density of white oak seedlings, averaging only 680 per hectare in 2009, has increased on the control plots and remained fairly constant in the infection centers.

The number of red oak sprouts per stump initially increased and then decreased in the last year (Figure 4 bottom). Stumps which had not produced any sprouts for three years were assumed to be dead, and were, therefore, excluded from the analysis.

The number of white oak sprouts per stumps has consistently declined and is higher on the control plots.

As yet, the data only show a somewhat higher density of regeneration, both seedling and sprout, on the control plots compared to the oak wilt plots but there is not enough data as yet to draw many conclusions. Plots will be revisited in 2010.



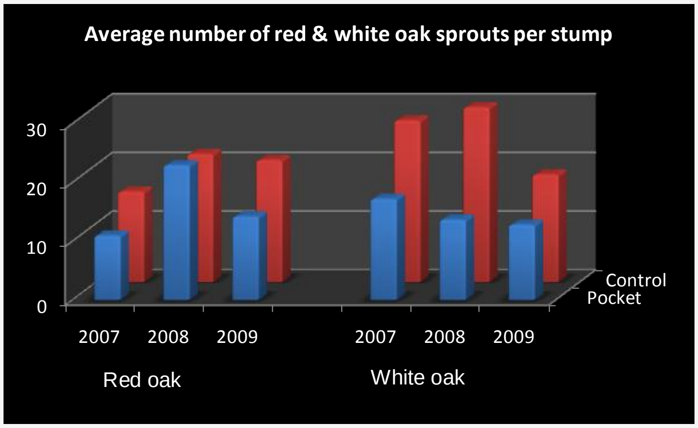


Figure. 4. Number of seedlings (top) and sprouts (bottom) of red and white oak in control plots and infection centers.

Bacterial Leaf Scorch – *Xylella fastidiosa*

In 2009, Wisconsin participated in a survey supported by the U.S. Forest Service to investigate the geographic distribution and host range of Bacterial Leaf Scorch (BLS) in north-central states. This project was initiated in 2008, and continued to 2009. In 2008, BLS was confirmed on the bur oak samples collected from a woodland stand in Dane County. This was the first confirmed case of bacterial leaf scorch in Wisconsin.

This summer, leaf and twig samples were collected from symptomatic trees (including trees previously reported as positive) throughout Wisconsin and sent to a lab at Michigan State University to perform a genetic test. Results are not available yet at this moment.

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

Aspen Mortality

An additional 158 acres of declining aspen stands were tallied in Oneida and Vilas counties in 2009. This adds to the 243 acres and 74 acres that were identified in 2008 and 2007, respectively. This acreage by no means represents all the declining aspen acres in north-central Wisconsin, but rather, it represents the acreage that was verified on the ground to be declining.

Figure 5. This pocket of dying aspens in Langlade County was associated with winding galleries and D-shaped exit holes of the bronze poplar borer (photo by Brian Schwingle).

The organisms responsible for contributing to aspen decline are a flatheaded wood borer, identified as the bronze poplar borer (*Agrilus granulatus liragus*), *Armillaria*, and the fungus that causes Entoleuca (Hypoxylon) canker. The wood borers were identified by rearing them out of log sections from declining trees cut on Oneida County land. Extensive aspen decline has been observed in northern Wisconsin, northern Minnesota and the Upper Peninsula of Michigan.
Symptoms of the current aspen decline dieback and mortality (Figure 5). The average stand diameter of declining aspen stands ranges from about 4 to 12 inches DBH. Field observations by several foresters indicate quaking aspens are more susceptible to decline than bigtooth aspens. On average, declining aspen stands have a current basal area of 37.5 ft^2/acre, and they have lost 13 ft^2/acre of basal area and 1.8 cords/acre in the last two years. Assuming these numbers represent declining aspen stands across north-central Wisconsin, roughly 850 cords have been lost in these surveyed stands over the last two years.

Butternut Silvicultural Trial: 2009 update

Butternut (*Juglans cinerea*) in Wisconsin has suffered extremely high mortality rates in the past two decades due to infection with butternut canker caused by the fungus *Sirococcus clavigignenti-juglandacearum*. A project was initiated in 1994 on the Menominee Indian Reservation to evaluate growth of butternut on two habitat types (AQVib(Ha) which is dry mesic and ATFD which is mesic) and 5 sizes of canopy opening . The hypothesis being tested is whether growth rate and survival to reproductive age are affected by site fertility and light exposure. If butternut can grow and produce seed on better habitat types – before dying from infection, we will be able to maintain this tree as part of our forest ecosystem on selected sites.

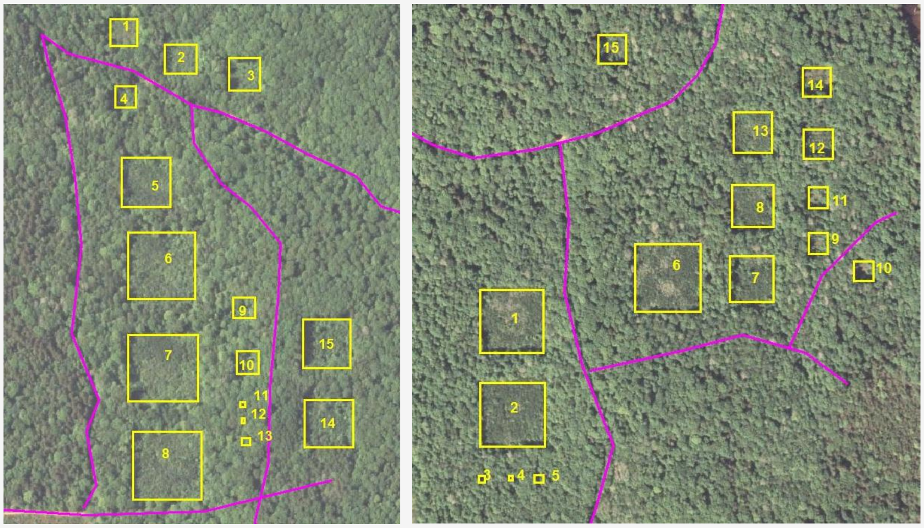


Figure 6 . An aerial view of the canopy openings where butternut was planted in 1994. Left is the AQVib(Ha) site and on the right is the ATFD site. Opening sizes vary from 0.03 acre to 2

Fifteen openings were created at each of two sites, including three each of 0.03 acre, 0.25 acre, 0.5 acre, 1 acre, and 2 acres (Figure 6). Approximately 600 trees were planted at each site. The plots were surveyed for survival from 1995 to 1999 and 2004 to present, for height and diameter from 1994 to 1999 and again in 2004, and for canker formation from 2005 to 2009. We surveyed in April 2009 to evaluate canker formation and survival rates.

Canker formation rates

We first started surveying for cankers in 2005 when about one quarter of live trees were cankered. The percent with cankers has increased in 2009 to about 83% of all trees, 94% on the dry mesic site and 78% on the mesic site. Part of this rate increase is due to the sharp decrease in the numbers of live trees.

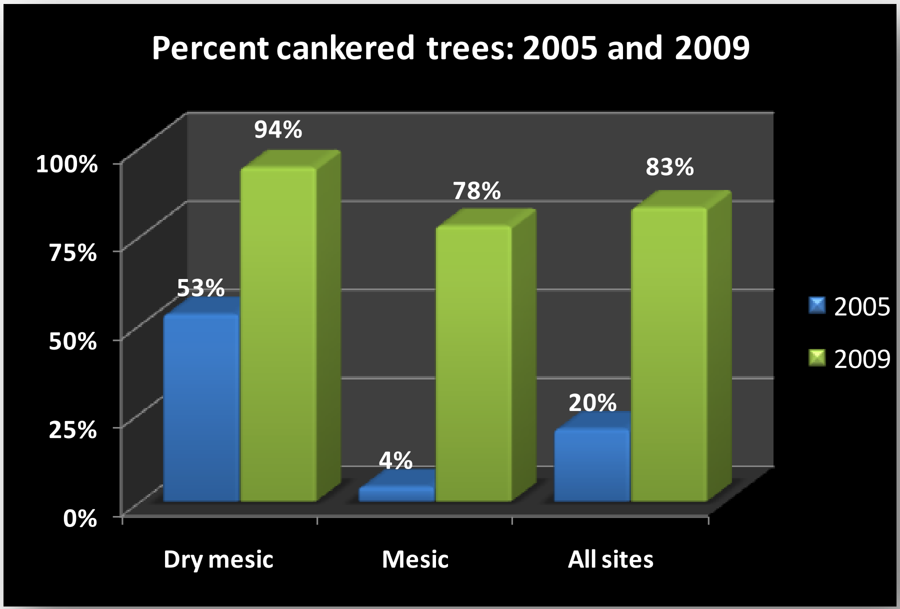
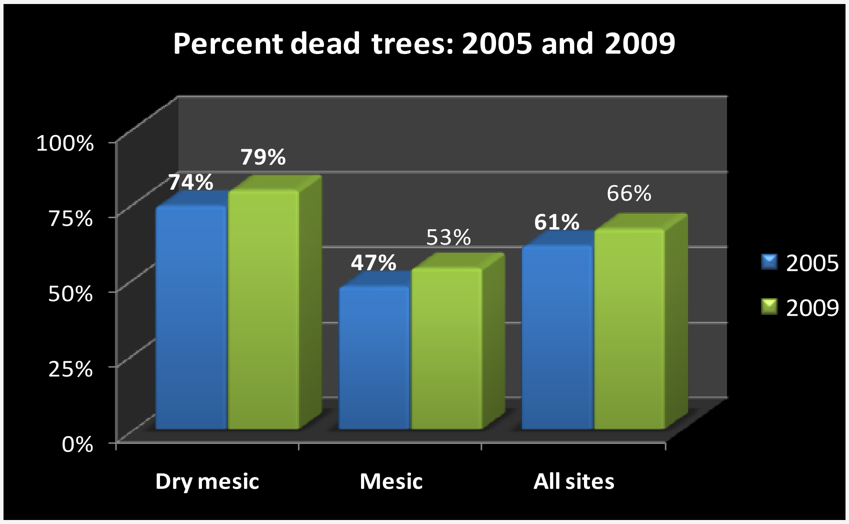


Figure 7 . Percent of cankered trees on the mesic and dry mesic sites in 2005 and in 2009.

Initially, the dry mesic site had much higher rates of cankering than the mesic site (53% compared to 4%). This was probably due to the fact that, at the time of plot establishment, several infected butternut were found in the forest surrounding the dry mesic site whereas none were found surrounding the mesic plots. Since then, cankering rates have quickly caught up on the mesic site, with a 200% increase in the number of cankered trees in 2006 and 100% in 2007 (Figure 7).

Tree Mortality

Tree mortality rates, on the other hand, have been quite similar on the two sites since 2005 (Figure 8). Many trees died initially, probably as a result of normal attrition and competition for light. Recent mortality is more likely due to infection with butternut canker than to competition. For instance, of trees that were newly cankered in 2006, 5% were dead one year later and 10% were dead three years later. Trees which died in the first year were much smaller in diameter (average 2.2 in) and height (averge 15.7 ft) than those that survived three years (average 4.5 in dbh and 23 ft). Uncankered trees had the same initial diameter and height (4.4 in dbh and 23.5 ft) as those that died after three years.



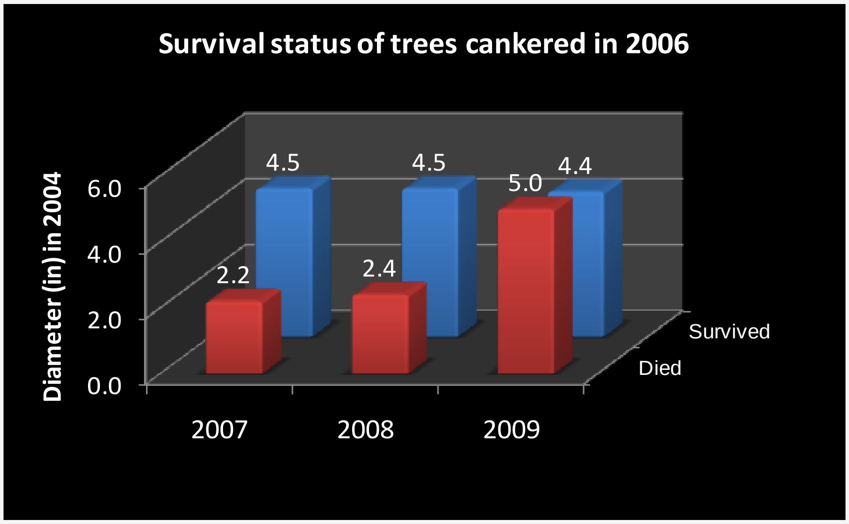


Figure 8.. Top: Mortality rates are higher on the dry mesic site compared to the mesic site but have increased only 5% in the last five years. Bottom: Average diameter in 2004 for trees which survived or died in 2007-2009. For trees newly cankered in 2006, larger trees survived longer than small ones.

Butternut trees will begin reproducing at approximately 20 years of age which would occur in 2014-2015. Initially, we thought that the low rate of cankering on the mesic site would guarantee that there would be many trees surviving to this age. However, the recent dramatic increase in the number of cankered trees on this site may change our hypothesis. Our data so far show that larger cankered trees survive longer than small ones which makes sense. Height and diameter of surviving trees, last measured in 2004, will be updated in 2010.

Maple petiole borer - *Caulocampus acericaulis*

Maple petiole borer (*Caulocampus acericaulis*) is a tiny sawfly larvae that bores into the petiole of maples and feeds within the petiole creating a weak spot. This weak spot will break allowing the leaf to drop to the ground (Figure 9). Damage is usually light and of little or no consequence to the tree. This spring the forest floor in many northeast Wisconsin counties was completely covered with green maple leaves that had fallen to the ground after being damaged by maple petiole borer. The number of leaves lying on the ground was much greater this year than in past years, but the crowns of the trees still appeared to have sufficient foliage and didn't seem to suffer any long term stress.

Figure 9. Damage from maple petiole borer (photo by Linda Williams)

Gouty oak gall – *Callirhytis quercuspunctata*

Gouty oak gall is caused by a tiny gall wasp. In some areas of northeastern Wisconsin the damage to swamp white oaks from gouty oak gall (*Callirhytis quercuspunctata*) was quite severe with nearly 100% of the twig tips and leaves being affected.

In the spring, the tiny adult gall wasp lays her eggs on an oak branch or twig, the eggs hatch, and the larvae begin to feed on the leaves. This first stage of a complex life cycle creates a blister-like leaf gall along larger leaf veins, causing the leaf to curl, become distorted, and stop growing (Figure 10, top). The second stage in the life cycle is a knotty twig gall that begins to form in mid-summer (Figure 10, bottom) and becomes fully mature after 1 to 2 years when the tiny gall wasps will pupate and later emerge as adults. Severely affected trees can have branch dieback or branch mortality and young trees may be badly disfigured.

The damage to some swamp white oaks this year was so severe that extensive dieback and possibly mortality in some younger trees is expected to occur in 2010.

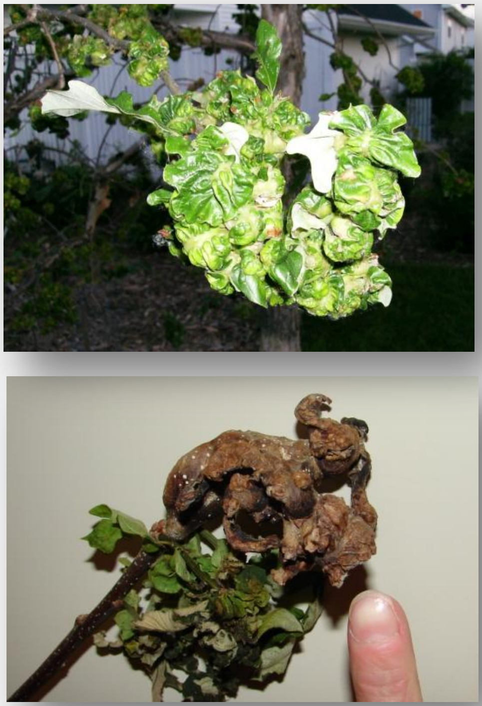


Figure 10. Top: deformed and curling leaves. Bottom: knotty twig gall (photo by Linda Williams)

Basswood Thrips - *Thrips calcaratus*

In a blast from the distant past, introduced basswood thrips made an unwelcome appearance in the Blue Hills (Wilkinson, Atlanta, Murry and Wilson townships) of Rusk County (Figure 11). Approximately 5,000 acres of small and large sawtimber basswood suffered defoliation from this insect. While there had been small pockets of thrips in northwest Wisconsin (Bayfield, Ashland, Sawyer counties) recently, the Blue Hills had escaped significant damage for over fifteen years. Roughly half of the affected area occurred in Wilson Township with a 2,500 acre area of moderate to heavy defoliation. The remaining 2,300 acres of defoliation was light to moderate in intensity and spread across Wilkinson, Atlanta and Murry Townships in several scattered, small spots.

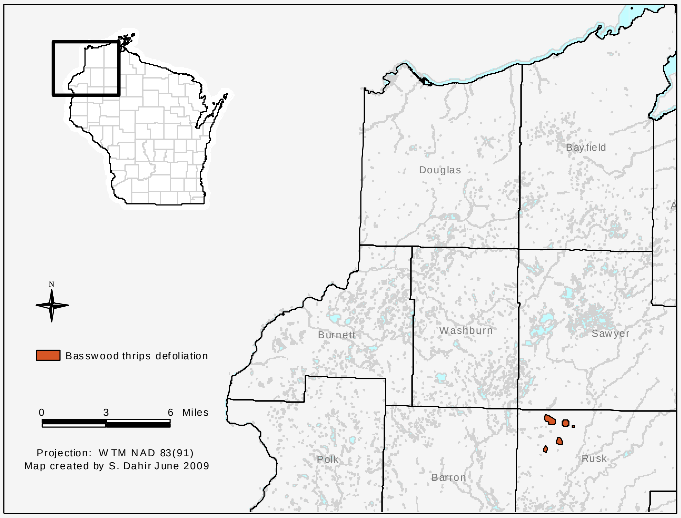


Figure 11 . Basswood thrips defoliation in Rusk County in 2009 (map by Sally Dahir).

Surveys of thrips damage on basswoods in Forest County revealed 2600 acres affected. Moderate damage (33-66% of foliage affected) was recorded on 99% of these acres. Symptoms included thin crowns, stunted leaves, chlorotic and necrotic leaves, and defoliation (Figure 12). The presumed species of thrips is the introduced basswood thrips (*Thrips calcaratus*).

Figure 12 . Left: Thin-crowned Forest County basswoods indicate infestation by introduced basswood thrips. Right: A basswood leaf damaged by the introduced basswood thrips (photos by Brian Schwingle).

Ash Yellows

Ash yellows is caused by a phytoplasma, a wall-less bacteria - like micro-organism. Symptoms of ash yellows include yellow/sub-normal size foliage, slow twig growth, thin crown, branch dieback and vertical cracks on the trunk near the ground, as well as brooms on the stem or at the base of the tree (Figure 13). Mortality of infected white ash in the forest setting has been observed.

Figure 13 . Small yellow leaves may be symptoms of ash yellows (Kyoko Scanlon).

In the summer of 2009, leaf and wood samples were collected from trees that were showing dieback from various sites throughout Wisconsin. Samples were tested for the presence of phytoplasma through the genetic analysis (Polymerase Chain Reaction test) by Dr. Glen Stanosz, Univ. of Wisconsin, Dept. of Plant Pathology. Based on symptoms and results of the genetic analysis, Walworth and Crawford counties were added to the list of counties confirmed with ash yellows. In Wisconsin, ash yellows is currently confirmed in 25 counties (Brown, Calumet, Chippewa, Columbia, Crawford, Dane, Dodge, Door, Grant, Jefferson, La Crosse, Manitowoc, Marathon, Milwaukee, Ozaukee, Pierce, Racine, Richland, Rock, Sauk, Shawano, Sheboygan, Taylor, Walworth, and Waukesha, Figure 14). In 2009, monitoring efforts to evaluate the disease progress of ash yellows was initiated using a stand with a high white ash component in Richland County.

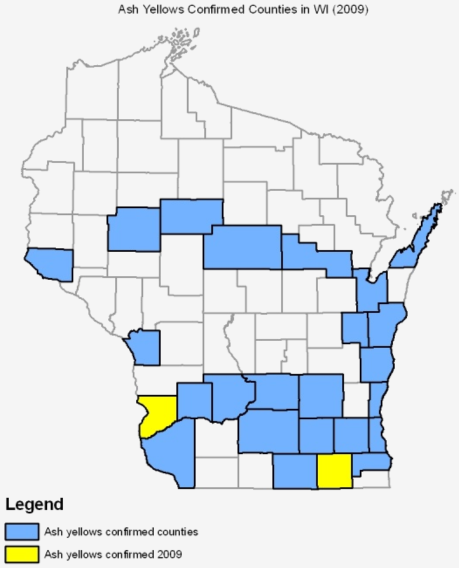


Figure 14 . Ash yellows occurs in 25 counties as of 2009. Yellow counties were newly confirmed in 2009 (map by Kyoko Scanlon).

In 2009, dieback and mortality of white ash had been observed in the stand for two years. Samples taken from this stand have been positive for phytoplasma through the genetic test. Though no brooms were detected last summer, this summer, they were easily found on dead trees and stumps of the trees that died in 2008 and were harvested that winter. A dozen white ash trees with varying degrees of crown dieback were marked in July to monitor symptom development over the years.

Willow flea weevil - *Rhynchaenus rufipes*

Significant defoliation of willow by willow flea weevil (*Rhynchaenus rufipes*) occurred in Brown, Oconto, and Shawano counties in northeast Wisconsin. Damage was severe, and the trees appeared brown and "dried up" from a distance. Just 2mm long, the adults are small black weevils that will quickly drop from the leaves and branches when disturbed.

Figure 15. Adult willow flea weevil and leaf showing holes from feeding.

Defoliation starts in the spring when adults emerge from overwintering spots and begin to feed, chewing small round holes in the leaves (Figure 15). Eggs are laid and the immature stage of the weevil emerges and feeds inside the leaves, mining out leaf material and leaving dead brown blotches on the leaves. The larvae pupate and the adults emerge in early fall to feed on the leaves, once again leaving tiny round feeding marks. The adults will overwinter and emerge in the spring to feed on the opening buds and new leaves and additional defoliation should be expected in 2010.

Jumping oak galls – *Neuroterus saltatorius*

Galls were seen on the leaves of bur and white oaks in Dane, Richland, and Sauk Cos. The galls were also present in high numbers in the WCR as well, from St Croix to Portage to Juneau to La Crosse counties and areas in-between. The jumping oak gall is caused by the gall wasp, *Neuroterus saltatorius*. Infestation on leaves causes discoloration on the leaf surface. Heavily infested leaves may prematurely fall. On the underside of the leaves, small pinhead-size round galls are seen on a saucer-like depression.

The jumping oak gall has two generations per year. The first generation wasps emerge from last year's galls in the spring. They are all female and lay eggs on newly expanding leaves. The eggs hatch into both male and female as a second generation. They mate, and females lay eggs on leaves. These galls fall to the ground when mature, and overwinter. Each gall contains one insect.

Sometimes heavy infestations are observed on some trees while neighboring trees are much less affected. It is believed that the difference in the level of infestation by the jumping oak gall has much to do with the timing of bud opening. Infestations by the jumping oak gall are not considered to cause any long-term negative effect on the health of the trees, and control is not necessary.

They received the name "jumping-oak gall" because these galls "jump" or bounce on the ground when the galls fall to the ground. If you want to see them jump and dance, please check it out at this website - http://www.youtube.com/watch?v=iyuSb2jH7jg.

Columbian timber beetle- *Corthylus columbianus*

Since first being documented as present in Wisconsin back in October 1998, the Columbian timber beetle, *Corthylus columbianus*, has become fairly common to see in southern Wisconsin on white and red oaks. Although it has an exotic name, the beetle is considered native to the eastern US (Figure 16) and can infest various hardwood species. Here in Wisconsin we have had a number of reports of the beetle in Dane County and Columbia County this year. Columbian Timber beetle was also reported in Northeast region causing defect in soft maple back in 2008.

Figure 16. Native range of Columbian timber beetle.

Columbia timber beetle is not thought to be a health threat to the trees infested but does create staining and defects that can degrade the value of lumber. Signs of this beetle include small wet ooze marks on the main bole of the tree (Figure 17). If one takes a pocket knife and peels back the outer bark one can find

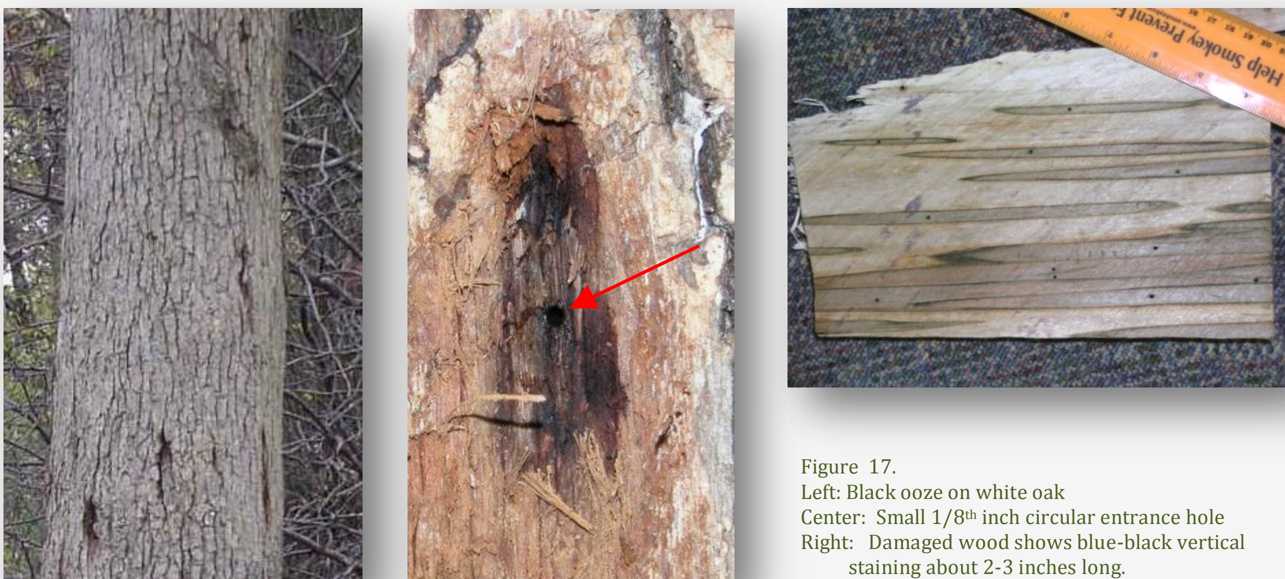


Figure 17.
Left: Black ooze on white oak
Center: Small 1/8th inch circular entrance hole
Right: Damaged wood shows blue-black vertical staining about 2-3 inches long.

a single entrance hole usually in the middle or top part of the black ooze area. When damaged trees are sawed the wood inside will have blue-black vertical staining associated with the holes bored by this ambrosia beetle.

Twolined Chestnut Borer – *Agrilus bilineatus*

The two-lined chestnut borer, a flatheaded borer, continued to infest oaks in west-central Wisconsin, causing scattered dieback and mortality. Moisture deficits, particularly during the summer months, continue to stress oak, making them more susceptible to infestation.

Ash bark splitting

From Wausau, east to the lakeshore, and south to Fond du Lac, ash in many communities developed long vertical cracks in the bark, which widened into large elliptical dead spots on the main stem and some branches. Trees were an assortment of ages, an assortment of planting dates, and from an assortment of nurseries, but all were ash. The most common cultivar affected was Autumn Purple. Other cultivars affected include Skyline and Cimarron.

The areas of split bark generally started within a foot of the ground, and could be found all the way up into the branches (Figure 18). The most common location for splits seemed to be from 1-3 feet above ground level. The average bark split was approximately 12 inches long and 4 inches wide, but there was a wide array of split sizes and locations. Split bark, with the associated dead spots underneath, occurred on all sides of trees, regardless of orientation to roads, sidewalks, shade, reflective surfaces, or compass direction. They all appeared to have occurred at the same time based on amounts of callus tissue formed (probably fall 2008 or very early spring 2009).

Figure 18. Bark splits in ash (photos by Linda Williams).

After examining numerous ash trees with the same symptoms, some possible causes have been eliminated. This list is as follows:

- Insects - no insect damage was associated with these bark splits
- Disease - samples sent to Kyoko Scanlon (DNR Pathologist) revealed no canker fungi that would have caused these splits
- Mechanical - due to the widespread nature it is improbable that mechanical damage could occur to all of these trees at the same time
- Sunscald - splits occurred on all sides of trees and in the crown, not consistent with sunscald
- Herbicides - these trees were planted at varying times over the last 3-8 years so herbicide use in the nurseries or after planting was ruled out
- Planting stress - these trees were planted in assorted years, and some were yard trees, so this was ruled out

That leaves abiotic issues as the culprit. This damage may be water related, perhaps a dry period in 2008, followed by a wet period and rapid growth or rapid cell expansion which split the bark when the bark could not respond quickly enough. Or perhaps moisture issues and a long, cold winter combined to create the split bark plaguing these trees. All trees appear to be growing callus tissue to cover the wounds and appear to be recovering.

Hickory dieback/mortality

Dieback and mortality on hickory continued to be a problem throughout the natural range of bitternut and shagbark hickory in Wisconsin in 2009. In some stands, mortality of bitternut hickory was close to 100 percent. The symptoms progress rapidly from thinning crowns to branch mortality to complete tree mortality. Epicormic branches often sprout from the main stem only to wilt and die later and sunken cankers or bleeding cankers can often be found on main stems of these trees. Dieback and mortality occur on both bitternut and shagbark hickory, although mortality appears to be more prevalent on bitternut hickory.

Historically, hickory mortality was attributed to attacks by the hickory bark beetle (*Scolytus quadrispinosus*) following periods of drought. More recent research, however, indicates that hickory mortality is due to a complex of biotic and abiotic factors, including the hickory bark beetle and other insects, and the fungi *Ceratocystis smalleyi* and *Fusarium solani*.

Studies on hickory mortality, initiated by the USDA Forest Service in 2006, continued in 2009. Following is the progress of the studies accomplished by the USDA Forest Service:

Multiple year monitoring plots were established in two eastern Wisconsin locations during summer 2009. Six to eight, apparently healthy bitternut hickories were selected for each plot. The plots are adjacent to areas of stands with advanced hickory decline and mortality. Data on tree size, tree crown condition, stem damage present, and other stand information were collected for each plot in August 2009. Plots will be visited two times per growing season during the next 3 years in order to assess the rate at which hickories become affected and decline progresses within individual trees and whether mortality results.

The USDA Forest Service also investigated the role of *C. smalleyi* in hickory mortality by evaluating (1) the effect of multiple *C. smalleyi* infections on tree health, (2) host resistance response to *C. smalleyi* infection, (3) association between hickory bark beetle attacks and bark/sapwood cankers and (4) *C. smalleyi* – hickory bark beetle relationship.

In 2009, identifications of all fungal isolates collected during field surveys conducted in 2007 and 2008 were completed. These isolates were obtained from cankered stems of dying hickory in Wisconsin as well as other midwestern states, including IN, MN, and OH. Based on morphological characteristics and DNA sequences, isolates were identified as *C. smalleyi, F. solani, and Phomopsis* spp. Koch's Postulates were performed to demonstrate that *C. smalleyi* is the cause of diffuse cankers with reddish inner bark and sapwood on pole-timber size bitternut hickory. Based on results of the field surveys conducted in six states, the most common cause of rapid crown decline and bitternut hickory death was attributed to hickory bark beetle attacks and the numerous, associated stem cankers. An interim report from the Forest Service states "Coalescing larval galleries is not what is killing the affected hickory. Rather, it appears that either the coalescing of hundreds of stem lesions or cankers associated with beetle attacks is the cause. Preliminary results show *C. smalleyi* and *F. solani* are causes of these cankers. Other, as yet undetected, fungi may be involved. Further work is underway to test this hypothesis. However, control of hickory bark beetle is the key to managing hickory decline. Survey data suggests that reducing density of bitternut hickory in a stand may greatly reduce tree decline and mortality during bark beetle outbreaks. Sanitation is also recommended, but is difficult for landowners to accomplish."

Field studies by the Forest Service are scheduled to continue to 2010. We thank Dr. Jenny Juzwik, Research Plant Pathologist with USDA Forest Service, and her staff for the excellent research work and for sharing their study results with us.

Hickory Bark Beetle - *Scolytus quadrispinosus*

In southeast Langlade County, one forest stand of 55 acres was found in 2009 containing bitternut hickories that were dying due to hickory bark beetles (Figure 19).

Symptoms and signs were on 20 – 30 large saw-sized nearly dead hickories. Bark beetle exit holes were prolific above mid-bole and adults were still emerging in early August. Bark beetle species identification was based on the characteristic gallery pattern where the main egg-laying gallery is parallel with the branch or trunk.

Hickory bark beetles continued to expand bitternut hickory mortality in northeastern Marathon County this year, where mortality was recorded first in 2007

Figure 19. Dead hickory (photo by Brian Schwingle)

Heavy Red Maple Seed Crop

Red maple is notorious for producing prolific seed crops. This year red maple brought forth a seed crop of truly extraordinary magnitude. Red maple trees across northern Wisconsin often appeared solid pink to red as their entire upper crowns consisted of ripening samaras (helicopter seeds). Once seedfall was complete the upper 1/3 – 2/3 of some red maple crowns had foliage that ranged from sparse to nonexistent. This occurs because the tree puts almost all the energy of its first flush into making seeds rather than leaves. Usually the trees will put on a second flush of leaves and be fine. However, during dry periods some trees will fail to reflush adequately. These red maples will exhibit some dieback of branches in the upper crown.

Poplar Borer –*Saperda calcarata*

A few stands of mixed hardwoods were examined in Marathon and Monroe counties where aspen decline and mortality was reported. Signs included wet spots on the bark of newly declining trees, and bark splits on older declining and dead aspen. In all cases, the trees were being attacked by the Poplar Borer, *Saperda calcarata*, a longhorn beetle. Close examination of the wet spots reveled small cracks in the bark. Dead aspen or declining aspen that were likely attacked a year ago had bark cracks only. Larval galleries were found in all trees, declining and dead, under the bark. Armillaria root disease was also present in the trees, and is contributing to the decline and mortality.

The larvae are yellow-white, legless, and can be up to 1.25 inches long. The adult poplar borer is grayish-blue with spots. The female beetle lays her eggs in late spring and early summer in small slits she chews in the bark. The larvae bore into the wood and create galleries under the bark as they feed. The larvae feed in the sapwood, but will bore into the heartwood. Attacks are heavier in poorly stocked and thinned stands. The poplar borer has a two year life cycle.

Conifer Health Issues

Incidence of Hemlock Dieback in Northern Wisconsin

Figure 1 . A hemlock in southeastern Oneida County with light dieback, most likely from recent drought (photo by Brian Schwingle).

Hemlocks have been noted as showing dieback in parts of northern Wisconsin since 2007 (Figure 1). To estimate the percentage of hemlocks with these symptoms, three hemlock stands (a total of 290 acres) in northern Florence County were surveyed. In each stand, approximately 40% of the hemlocks had light dieback (<25% of the crown affected), and in two stands, about 5% of the hemlocks had died. The mortality was associated with *Armillaria* root disease and the hemlock borer (*Melanophila fulvoguttata*). The dieback was not associated with these biotic agents. Two of the stands had been thinned, and dieback was distributed evenly across these stands. In contrast, hemlock dieback was clumped in the third, unthinned stand around a recent blowdown. Therefore, dieback appeared to be associated with recent disturbance in the three stands. These 290 acres surveyed in 2009 contribute to a total of 1440 acres across north-central Wisconsin found to have hemlocks with dieback between 2007 and 2009.

Balsam Fir Mortality

A common site across north-central Wisconsin in 2009 was dead, fiery orange, understory balsam firs (Figure 2). Many of these dead balsams had signs of Armillaria root disease and balsam fir bark beetles (*Pityokteines sparsus*) on them. One characteristic of balsam fir bark beetle galleries is that the main egg-laying gallery is oriented perpendicular to the trunk (Figure 3). Armillaria root disease seems to be the primary mortality agent on these balsam firs. One survey conducted in northern Oneida County found that 100% of about 30 understory, recently dead, balsam firs were infected by *Armillaria* sp., and none of them were infested by balsam fir bark beetles.

Figure 2. These dead Langlade County balsams were a common site in the Northwoods this year. These balsams died from Armillaria. (photo by Brian Schwingle)

Figure 3 Left: Balsam fir bark beetles make very small exit holes. These were made on dying balsams in Vilas County.
Right: Balsam fir bark beetles typically make egg-laying galleries across wood grain and larval feeding galleries with wood grain like these on Vilas County balsam firs. (photos by Brian Schwingle)

Red Pine Mortality in Northern Wisconsin

Red pines that were dying or changing color were frequently reported in 2009, and due to the importance of early detection of Annosum root rot, nearly all reported sick red pines were inspected. Due to time constraints, not all dying red pine acreage was totaled. For 19 of these locations, acreage was not estimated but mortality was assessed.

These stands were located in an area from Ashland County, east to Florence County and south to Marathon County and all areas in-between. The number of dying red pines at these 19 sites ranged from 1 to 35 with an average of 7 dead or dying red pines. For sites where acreage was estimated, 58 acres of dead or dying red pines were found. Consult the table above for the cause of death of these red pines.

Causal Agent of Red Pine Mortality	Percent of 2009 Red Pine Mortality
Armillaria root disease	**30%**
***Armillaria* root disease and *Ips* sp.**	**19%**
Armillaria root disease*, *Ips* sp., and *Leptographium* sp.	**16%**
***Ips* sp.**	**13%**
Leptographium* sp.	**13%**
***Leptographium* sp.* and *Ips* sp.**	**6%**
Unknown	**3%**

*** Note that fungal spores of *Leptographium* are vectored to trees by multiple species of weevils and bark beetles. In some instances in 2009, pitch tubes, likely those from red turpentine beetles (*Dendroctonus valens*), were found associated with *Leptographium*-infected red pines.**

Pine needle rust - *Coleosporium asterum*

Pine needle rust (*Coleosporium asterum*) kills older needles on seedlings and younger pines up to the sapling stage, primarily on red pine but also on Scotch and jack pine, and was found in Waupaca and Waushara counties in 2009 (Figure 4). The alternate host of this rust disease is goldenrod and other asters. Some of the sites where pine needle rust was severe were newer plantings where it was difficult to find the seedlings amongst all the competition, including the alternate host for this rust disease, goldenrod.

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

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

Sawflies

High populations of European pine sawfly (*Neodiprion sertifer,* Figure 5) once again occurred in Waupaca, Waushara, and Marquette counties in northeast Wisconsin. European Pine Sawfly caterpillars are dark green in color with 3 pale stripes on the body and a black head and feed in groups, primarily on red pine and Scotch pine. Damage can be severe but is usually limited to defoliation of the 2nd year needles. Tree growth rates can be reduced since only 1 year's needles will be left on the tree to produce food. Control options include squishing colonies by hand, spraying colonies with a soapy water mixture, or spraying the insects with a general insecticide. This is the second or third year of large populations in many of these areas.

Figure 5. European pine sawfly (photo by Linda Williams).

For the second year in a row yellowheaded spruce sawfly (*Pikonema alaskensis,* Figure 6) were found feeding on white spruce in Oconto County. This year Norway spruce and blue spruce were fed on as well. Yellowheaded spruce sawfly feed singly on the needles and can cause significant defoliation although it is usually patchy or limited to just a few trees. Spruce growing in full sunlight are preferred.

Figure 6. Yellowheaded spruce sawfly (photo by Linda Williams).

Arborvitae Sawfly (*Monoctenus juniperinus.* Figure 7) was found feeding on northern white cedar in Door County. Arborvitae sawflies feed singly rather than in groups as many sawflies do. Damage is usually minimal.

Figure 7 . Arborvitae sawfly (photo by Linda Williams).

The sawfly *Nematus hudsoniimagnus* was found feeding on cottonwood and can be found on poplar as well but their feeding is usually of little consequence. Although the larvae were defoliating entire leaves the overall damage to the trees was fairly minimal.

Several unidentified sawflies were found feeding on ironwood and willow later in the summer. None of these seemed to do any significant defoliation. A few other sawflies found in 2009 included: Oak slug sawfly on oak, elm sawfly and willow sawfly which defoliated willow in several counties, and introduce pine sawfly on white pine.

Hemlock looper - *Lambdina fiscellaria*

Figure 8. Defoliated northern white cedar in Door County (photo by Linda Wiliams).

Northern white cedar in a small localized area of Door County was surveyed for Hemlock Looper (*Lambdina fiscellaria*) in 2009. The population of this native insect exploded in a small area near Forestville in 2007, completely defoliating patches of mature Northern white cedar trees (Figure 8). Defoliated trees, and the portions of trees that were completely defoliated in 2007, did not recover and areas of morality were apparent from the air.

Hemlock looper is a tiny caterpillar which is a messy feeder, taking bites out of foliage and then moving on. The partially eaten scales of northern white cedar then turn brown and fall off. Young larvae feed on new foliage (Figure 9); older larvae can feed on older foliage.

This insect usually has very localized outbreaks where small patches will be completely defoliated and nearby stands will have minimal damage; this was the case in Door County. Population surveys in 2008 showed the outbreak to be collapsing.

Based on population surveys in 2009 the outbreak has collapsed. Other insects, including arborvitae sawfly, were present and causing some defoliation.

Figure 9. Larvae of the hemlock looper feeding on new foliage of northern white cedar (photo by Linda Willians).

Red Pine Needle Midge

A red pine needle midge, likely *Thecodiplosis piniresinosae*, was causing red pine needle death on approximately 5,000 acres from northwest Adams County to southeast Wood County. The damage was light on each individual tree, only causing the new needles immediately below the terminal bud to be stunted and turn brown (Figure 10). At the base of these needles underneath the fascicle sheath, one could see a very small area on one or both of the needles where a midge had eaten a notch. Across the landscape, nearly all pole-sized red pines were infested, and nearly all shoots were infested evenly on individual pole-sized pines.

Figure 10. Damage on red pine from needle midge (photo by Brian Schwingle)

Eastern Larch Beetle - *Dendroctonus simplex*

Four tamarack stands in Lincoln County and a tamarack stand in eastern Forest County were found to be infested by the eastern larch beetle (Figure 11). Damage by this bark beetle species is easily identified by finding characteristic long, egg-laying galleries paralleling the trunk.

At one site in Lincoln County, the four-eyed spruce beetle (*Polygraphus rufipennis*) was found, along with the eastern larch beetle, associated with dying tamaracks. Adults of both bark beetle species were found overwintering in trees from 2008 to 2009.

Total tallied mortality caused by the eastern larch beetle in these two counties was 36 acres in 2009. About 90% of this acreage had over 50% of the tamaracks dead or dying.

Figure 11. Eastern larch beetle damage (photo by Brian Schwingle).

Annosum root rot – *Heterobasidion annosum*

Figure 12 . An annosum conk on a balsam fir seedling (photo by Sally Dahir).

Annosum root rot is caused by the fungus, *Heterobasidion annosum*. The fungus causes a decay of the roots and butt and often kills infected trees. In Wisconsin, Annosum root rot has been found primarily 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. Fruit bodies may be found at the root collar of dead/dying trees and stumps of infected trees (Figure 12).

In 2009, Annosum root rot was confirmed in two additional counties - Shawano and Waupaca counties. Currently, this disease is known to occur in 20 counties, including Adams, Buffalo, Columbia, Dunn, Green, Iowa, Jefferson, Juneau, La Crosse, Marquette, Portage, Richland, Sauk, Shawano, Trempealeau, Walworth, Waukesha, Waupaca, Waushara, and Wood.

Since 2007, a statewide survey of Annosum root rot has been conducted. In 2009, northern Wisconsin was surveyed. Pockets of red pine mortality that had been previously identified by a forestry professional were visited and surveyed for the existence of a fruit body of Annosum root rot. Decayed wood samples were also collected and will be examined for the growth of the pathogen in the lab. This survey will continue until snow accumulation prevents detection of the fruit bodies.

Once the disease exists in a stand, it is very difficult to control. Prevention of this disease is the best approach. The Wisconsin DNR recommends that freshly cut stumps be treated with fungicides during thinning. Two products are currently available in Wisconsin to prevent Annosum root rot. Sporax (sodium tetraborate decahydrate) is granular and can be applied using a salt-shaker style container or a special dispensing unit made of a PVC pipe and a plastic nozzle. Cellu-Treat (disodium octaborate tetrahydrate) is a water-soluble powder and can be applied using a backpack sprayer or an attachment to a wood harvester. Currently, there are a few loggers in Wisconsin whose processors are equipped with a spray application device.

For more information about Annosum root rot, please visit the WI DNR Forest Health Protection website at http://dnr.wi.gov/forestry/Fh/annosum/.

Diplodia (*Diplodia pinea*) on red pine seedlings in state nurseries

Over the last few years, the state nurseries have implemented an aggressive management plan to monitor and control Diplodia shoot blight and canker, caused by the fungus, *Diplodia pinea* (Figure 13). Some evidence suggests the presence of this fungus, coupled with increased seedling stress, could lead to seedling mortality. Recent research revealed that the fungus could persist in or on the seedlings without showing symptoms, and become active once a tree is stressed - primarily from moisture deficit. To limit seedling exposure to the fungus and subsequent infection, nursery staff assisted by pathology staff devised a series of actions: removal of all mature red pine found in and around the nurseries' properties, increased applications of fungicides, and annual testing of nursery stock. These measures have helped limit the exposure and subsequent infection of our red pine.

Figure 13. Discoloration caused by Diplodia collar rot.

Since 2006, the state nurseries and Forest Health Protection have tested asymptomatic red pine seedlings for Diplodia infection (for the details of the test, please refer to the Forest Health Conditions of Wisconsin Annual Report 2007, p33). In 2009, the forest health lab processed 687 apparently healthy 2-0 red pine seedlings to detect the presence of the pathogen. Samples were collected from all of the 3 state nurseries (Table 1).

Table 1. 2009 Diplodia asymptomatic seedling test of 2-0 red pine seedlings from State Nurseries

Nursery	Total number of seedlings tested 2009	Total number of seedlings positive for Diplodia 2009	% positive for Diplodia infection 2008	% positive for Diplodia infection 2009
Hayward	283	5	6.67%	1.77%
Griffith	299	14	6.36%	4.68%
Wilson	105	2	0.00%	1.90%

The infection rate was less than 5% in all nurseries. This is well below the 10 percent threshold tolerance level that has been used for management purposes. Plans to conduct the test in 2010 will be discussed with the DNR State Nursery Program this winter.

Red Pine Pocket Mortality Study Recap

The five year Central and Southern Wisconsin Red Pine Pocket Mortality study concluded in 2008. The long term study, performed in collaboration with primary investigator, Dr. Ken Raffa, UW-Madison Dept. of Entomology seeks a better understanding of the progression of red pine pocket mortality. Better understanding interactions between below and above ground herbivory and landscape alterations as the incipient mortality spreads, may provide insight into human maladies. As gaps left behind by pocket mortality are filled in, the dense vegetation provides sanctuary for carriers of ticks, and thereby increasing the risk for tick borne pathogens. The following is a general summary of completed fieldwork.

Figure 14. Red pine study regions (map by Robert Murphy).

Throughout the study's duration we collaborated with a number of colleagues including: Dr. Dan Young (insect biodiversity study) UW-Madison, Dr. Volker Radeloff (study plot mapping) UW-Madison, Dr. John Reeve (insect dispersal study) Southern Illinois University, Dr. Enrico Bonello (red pine chemistry) Ohio State University, and Dr. Susan Paskewitz (tick study) UW-Madison. Locations for the study were selected in four regions of central and southern Wisconsin (Figure 14). Both private and public lands were used.

The study's core involved annual trapping of insect vectors (root weevils, red turpentine beetles and *Hylastes* spp. and associated predators) of the fungi *Leptographium* spp. By weakening the tree, these fungi increase susceptibility of attack from *Ips* spp. A total of 34 species commonly found in traps were identified each year. Three types of traps were employed: funnel traps, pitfall traps and a milk jug traps (Figure 15). Traps were baited with a specific lure for each of the main target insects. In addition to the insect vectors, the fungi can be transmitted to healthy trees via root grafts. In an attempt to contain the fungi, we separated roots ten meters outside the symptomatic portion of the pocket using a trenching machine. In all, we severed the roots at 13 sites, and used eight symptomatic sites in their natural state and ten healthy asymptomatic control sites. Each autumn after the insect flight season trees at all 31 sites were assessed for insect damage and mortality. The number of pitch tubes from the red turpentine beetles, the presence of engraver beetle exit holes, the presence of wood borer exit holes, and a subsample for root weevil damage around the root collar of the tree were recorded. During the course of the study a total of 826 trees died.

In 2004 and 2005 trees within the study sites were mapped. Nearly 10,000 trees were spatially referenced using a Topcon Total Station. The mapping will aid in spatial statistical analysis.

In 2004, preliminary work began on comparing insect biodiversity between declining and healthy stands. The following year all sites were engaged in the study. Flight intercept traps consisting of a ~3x5 sheet of plastic tied to two trees with a planter box receptacle below, were placed near each pocket's center and outside of the pocket. Two flight intercept traps were used per pocket. Three pitfall traps were set inside the pocket and three outside of the pocket. Approximately 75,000 insects were collected during the summer of 2005.

In 2006, a tree chemistry study was initiated in collaboration with Ohio State University. This research compares the tree's defense components in resin and tree tissue inside and outside pockets. Four transects of red pine at each site were inoculated with fungi to assess the tree's response. Two transects were inoculated with *Leptographium* *terebrantis* and two with *Ophiostoma ips* at six study sites. Lesions from the inoculations were measured and surrounding tissue extracted for analysis.

Also in 2006, an insect dispersal study with Southern Illinois University initiated in Kettle Moraine Southern Unit and Black River State Forest. This study aims to shed light on pocket interconnectedness by better understanding the range of two red pine colonizers (the pine engraver and red turpentine beetle) and a predator (the checker beetle). These insects were captured on site, marked with paint and released from the center of a grid of funnel

Figure 15. Left: Pitfall trap employed to survey root weevils. Center: Jug trap baited with red turpentine beetle lure. Right: Lindgren funnel trap used to monitor bark beetle populations (photos by Robert Murphy).

traps (11 traps per spoke, 44 total traps) set at specified intervals up to two kilometers from the center point.

During the summer of 2007, an extensive red pine vegetation survey commenced. Flora composition was compared between healthy and declining stands to further understand above and below ground insect-fungal interactions' impact on the landscape. At each site four transects were established from the pocket's center point to 20 meters outside the pocket's edge. Every five meters a one meter diameter sample consisting of light penetration, percent ground cover, percent cover at 1.5m high and plant species were recorded. All trees within 2.5m of the transect were identified. Tree height, diameter at breast height and location in relation to the transect were also documented.

In 2008, a study to assess gap formation and increased tick activity took place. At each site, a cloth was dragged along the edge of red pine mortality and ten meters outside from the pocket margin. Every 50m the drag cloth was cleaned of tick larva, nymphs and adults. The 31 study sites were sampled once in July and again in August. The data amassed from 2008 paved the way for another year of work on the subject, spearheaded by David Coyle, UW-Madison Dept. of Entomology, through a grant from the Centers for Disease Control.

The studies involved with this extensive research on red pine pocket mortality are currently in various stages of analysis. Thanks to all the land managers and private landowners for their help.

Trapping Red Turpentine Beetles -*Dendroctonus valens:* Update

We initiated a study in 2004 to determine if the time of year in which red pine was harvested was correlated with the density of red turpentine beetles (*Dendroctonus valens*) trapped during spring flight in April and May. We compared stands harvested during the previous summer and fall to stands harvested in the three months preceding spring flight (February, March and April). Turpentine beetles were trapped during their spring flight period from 2005 through 2008 in order to determine if the date of thinning was correlated with densities. Stands which had been thinned in the preceding summer and fall were compared to stands thinned from February through May of the year trapped.

Stands trapped were in two general categories:

Category 1: <u>large contiguous blocks of red pine</u> in northern Adams and southern Wood counties and

Category 2: <u>isolated red pine stands</u> scattered throughout Adams, Wood, Waushara, Portage, Waupaca and Jackson counties

An ANOVA (analysis of variance) done in 2008 showed that both Season of Thinning (p=0.027) and Category (p=0.051) were significant.
We hypothesized that, in Category 1, large contiguous blocks of pine if thinned at one time, would create a strong attractant for beetles emerging near the harvested area, especially if these harvested areas had high beetle densities the previous year.

To test this hypothesis, we tested three new variables which might account for the difference in category

1. Basal area of red pine in the vicinity of the stand
2. Volume of recent cordwood harvest in the vicinity of the stand
3. Acreage of recent harvest in the vicinity of the stand

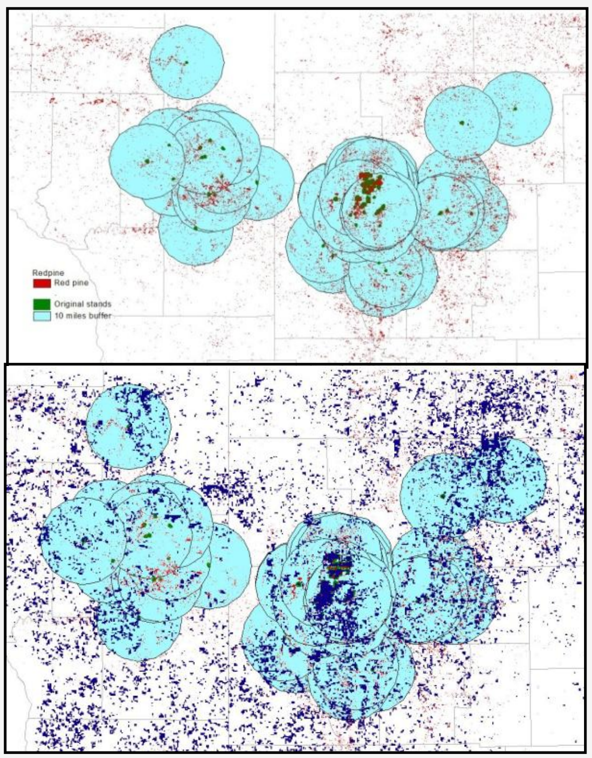


Figure 16. Top: Basal area grid of red pine overlaid on ten mile buffer zones around each trapped stand. Bottom: Taxlaw properties overlaid on trapped stands (maps by Sally Dahir).

To test the first variable, we used a basal area grid of red pine (provided by USDA Forest Service, Forest Health Technology Enterprise Team in Fort Collins CO) and measured the total basal area within a ten- mile neighborhood of each stand (Figure 16, top). We tested significance using linear least squares regression and a 0.3 root transformation of the dependent variable (to approximate normality). Neither basal area or acreage of red pine were significant (p>0.3).

The second variable we tested was the cordwood volume of harvest within the ten-mile neighborhood. Cordwood and log volume harvested on taxlaw land is recorded by 40 acre parcel and stumpage year (Nov 1 of previous year to Oct 31, year of record). We could then sum up the total cordage harvested both in the year preceding and the year of harvest of the stand in which beetles were trapped. The analysis was restricted to areas where there was little non-taxlaw red pine as harvests here would not have been recorded. For instance, several stands in Jackson County were on county and state forest lands and had to be excluded from the analysis. (Figure 16, bottom). The only significant variable in this linear regression analysis was the amount of cordage harvested the year before the trapped stand was cut and only for trapped stands that had been thinned in the spring (R^2=0.37, p=0.000).

A separate part of this analysis looked at all red pine harvested on taxlaw properties in Adams, Juneau and Wood counties, regardless of proximity to the trapped stand. This was done because of the large acreage of taxlaw red pine in this region. This analysis was limited naturally to trapped stands in those three counties. Interestingly, the

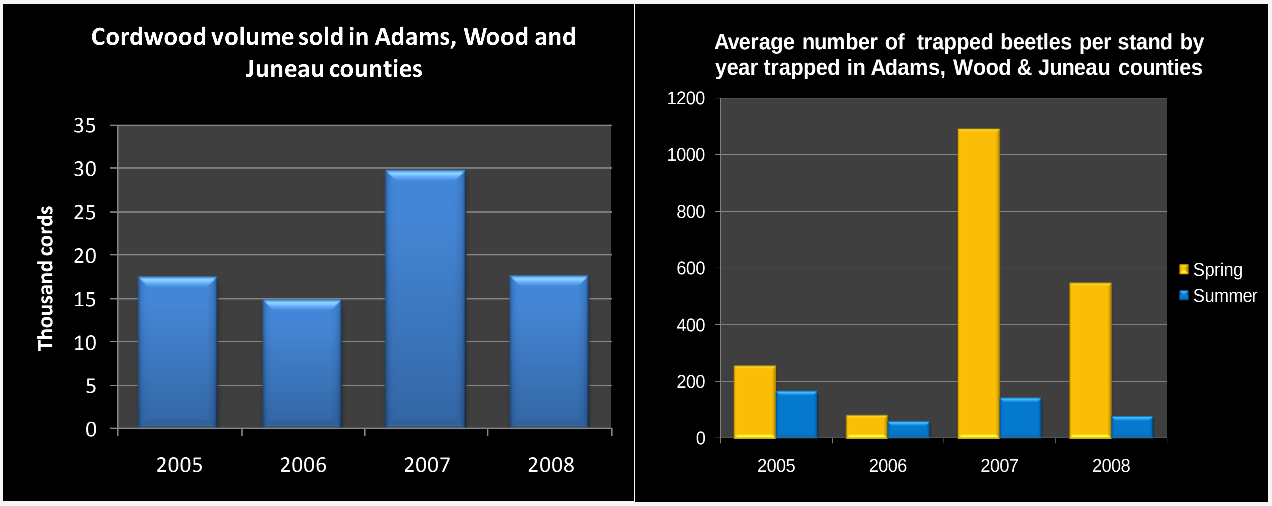


Figure 17 . Comparison of the amount of red pine cordwood harvested annually on taxlaw properties in Adams, Wood and Juneau counties and the number of beetles trapped from 2005 to 2008.

pattern of harvest volumes is mirrored by the pattern of beetle densities in these counties: 2007 having the highest value and 2006 the lowest (Figure 17). The results of linear regression analysis are significant (*p*=0.000) with an R^2 of 0.59. In other words, almost two-thirds of the variance in the number of beetles per stand is explained by harvest volumes in the three county area. The two variables which were most significant were harvest volume during the year the trapped stand was cut as well as the year preceding stand harvest, but only for spring-thinned stands.

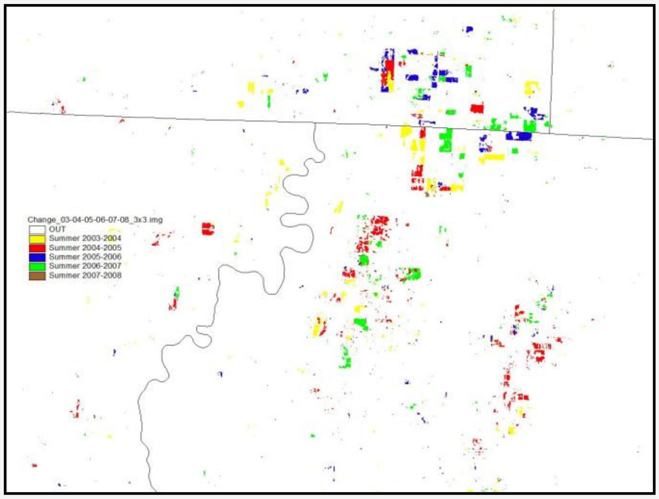


Figure 18. Areas of harvested red pine as determined by Landsat image analysis from 2003 to 2008. (Map by Sally Dahir)

The final variable, acreage of harvest activity, is still being investigated but methodology will be explained here. Landsat imagery was used to delineate red pine in the northern Adams-southern Wood county region. Multitemporal imagery was further analyzed to determine if reflectance in band five or mid-infrared had changed over time which may reflect harvest. An initial assessment is presented in Figure 18. As this data is still being analyzed, results are not presented here.

Our original ANOVA showed that stands that were thinned in the spring before flight attracted more turpentine beetles (*Dendroctonus valens*) than stands thinned the previous summer or fall. However, this relationship did not hold for stands in the western part of the sampling area where there is less red pine and most is in isolated stands. This analysis helped to show that the amount of wood harvested has a dramatic effect but only for stands thinned in the spring. It seems that the amount of time between harvest and trapping can affect the dryness of stumps and their attractiveness to flying beetles, regardless of the amount of stump surface. Since beetles are looking for fresh stumps with ample food supply for their larvae, they are more attracted to newly cut stumps and live trees than to stumps that have dried out or trees that have been dead for a while. The conclusion may be drawn that if large amounts of red pine are to be harvested, the best time to do this in order to avoid attracting turpentine beetles would be the summer or fall.

We plan to survey the study area to determine if these higher densities of beetles has resulted in any significantly higher mortality of red pine. Aerial and ground surveys will be used.

Jack Pine Budworm - *Choristoneura pinus pinus*

The summer of 2009 witnessed a continued decline in jack pine budworm populations in northwest Wisconsin. The pupal survey indicated an overall decline of approximately 14% from the previous year. In 2009, this insect stayed loyal to its host tree (jack pine), displaying not the slightest inclination to feed on red pine as it has in west-central Wisconsin.

Despite the overall decline, budworm's fall toward endemic status was far from uniform. The acreage of defoliation actually increased from 2,700 acres in 2008 to 4,650 in 2009 (Figure 19). The main positives from last year were the drop in population to endemic levels in Polk and Burnett counties and a substantial drop (-27% in pupal population) in Bayfield County. The increase in acreage and intensification of defoliation occurred in an area straddling the Washburn and Douglas County line, just west of the Minong Flowage. The increase in budworm pupal numbers from this area produced a 40% population increase for Washburn County. Douglas County presents a mixed but somewhat troubling picture. Overall the county has a small (9%) decline in budworm pupal numbers, however there were two areas (>10,000 acres each) with borderline high populations – yielding detectable defoliation. One area was along County Hwy A in Highland Township. The other area was in Gordon Township along County Hwy Y. These areas could mark the last stand of the 2004-2007 budworm outbreak or the beginning of a new rise in the population of this insect.

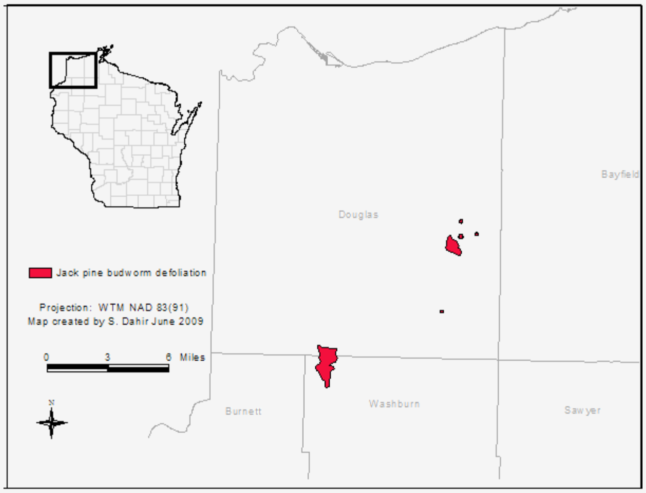


Figure 19. In 2009, 4,650 acres were defoliated in Douglas and Washburn counties (map by Sally Dahir).

Budworm populations remained low in Adams, Clark, Dunn, Eau Claire, Juneau, Monroe, Pierce, Portage, St. Croix, and Wood counties. Jack pine budworm populations have increased in Jackson County in a small jack pine area of county forest (Figure 20), where there is some top kill and tree mortality already present in the jack pine stands. Based on egg mass counts in this area, the potential for severe defoliation exists for the spring and summer of 2010.

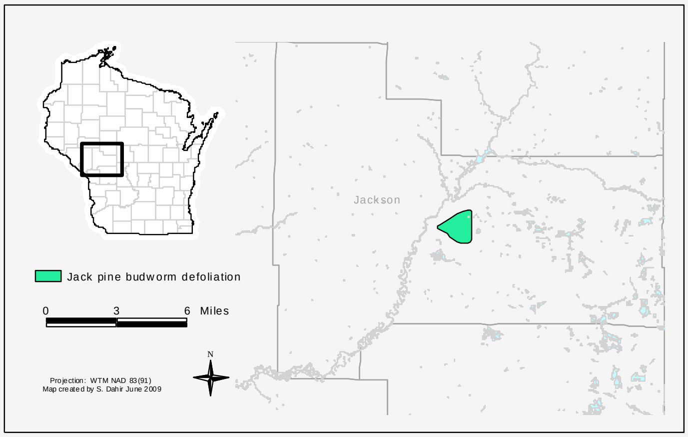


Figure 20. Jack pine budworm defoliation in Jackson County (map by Sally Dahir).

Jack Pine Budworm Survey in Northwest Wisconsin: Procedures and Results 2009

Early Larval Survey

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

Early larval populations: 2009

County	Number of plots	Number infested shoots	Infested shoots/plot	Number high* plots	Percent high plots
Polk	15	6	0.40	0	0
Burnett	24	15	0.63	0	0
Washburn	21	33	1.57	1	4.8
Douglas	54	157	2.91	2	3.7
Bayfield	32	90	2.81	0	0
District	**146**	**301**	**2.06**	**3**	**2.1**

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

Early larval population trend: 2008

County	2005	2006	2007	2008	2009	Percent change 2008-2009	Percent high plots 2005	Percent high plots 2006	Percent high plots 2007	Percent high plots 2008	Percent high plots 2009
Polk	3.87	7.53	3.33	0.27	0.40	**+50**	6.7	26.7	6.7	0	0
Burnett	5.08	6.42	4.75	1.42	0.63	**-56**	25.0	25.0	16.7	0	0
Washburn	9.14	8.14	2.95	2.10	1.57	**-25**	52.4	38.1	0	0	4.8
Douglas	11.39	8.63	5.24	4.76	2.91	**-39**	53.7	38.9	20.4	14.8	3.7
Bayfield	16.38	12.50	11.34	7.19	2.81	**-61**	78.1	68.8	68.8	28.1	0
District	**10.35**	**8.93**	**5.97**	**3.90**	**2.06**	**-47**	**49.3**	**41.8**	**26.0**	**11.6**	**2.1**

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

Pupal survey: 2009

				Moths		Parasites		Not emerged	
County	**Total Pupae**	**Total Minutes**	**Pupae/ Min**	**No.**	**Percent**	**No.**	**Percent**	**No.**	**Percent**
Polk	4	75	0.05	4	100	0	0	0	0
Burnett	29	130	0.22	22	75.9	4	13.8	3	10.3
Washburn	125	162	0.77	84	67.2	25	20	16	12.8
Douglas	419	435	0.96	272	64.9	90	21.5	57	13.6
Bayfield	202	222	0.91	124	61.4	60	29.7	18	8.9
District	**779**	**1,024**	**0.76**	**506**	**65.0**	**179**	**23.0**	**94**	**12.0**

Pupal population trends: 2009

County	2006 Pupae/min	2007 Pupae/min	2008 Pupae/min	2009 Pupae/min	Percent change 2008-2009
Polk	1.28	0.12	0.03	0.05	**+100**
Burnet	1.73	0.75	0.45	0.22	**-51.1**
Washburn	1.56	0.72	0.55	0.77	**+40**
Douglas	1.63	1.14	1.05	0.96	**-8.6**
Bayfield	2.08	1.74	1.25	0.91	**-27.2**
District	**1.71**	**1.12**	**0.88**	**0.76**	**-13.6**

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

Parasites and Predators: 2009

Parasite/ Predators	Polk	Burnett	Washburn	Douglas	Bayfield	Total	Percent of Parasitized	Percent of Total
Itoplectes	0	2	16	36	22	76	42.5	**9.8**
Scambus	0	0	0	5	4	9	5	**1.2**
Phaogenes	0	0	1	15	17	33	18.4	**4.2**
Pteromalids	0	0	0	2	1	3	1.7	**0.4**
Tachinids	0	0	3	15	7	25	14	**3.2**
Brachmeria	0	0	0	0	0	0	0	**0**
Predators	0	2	5	17	9	33	18.4	**4.2**
Total	**0**	**4**	**25**	**90**	**60**	**179**	**100**	**23**

Jack pine gall rust surveys in Wisconsin state nurseries update: 2009

Introduction

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

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

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

The objectives of the surveys were; 1: to quantify the incidence of symptomatic seedlings of jack pine gall rust in state nurseries at the time of lifting; 2: to quantify the incidence of gall/swelling development of healthy-looking seedlings over time; and 3: to quantify the growth of galls and their affect on seedling health. This survey was initiated in 2008 and continued into 2009. For the results of this survey in 2008, please refer to the Forest Health Conditions in Wisconsin, Annual Report 2008.

Materials and Methods

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

In 2009, approximately 1000 seedlings were randomly selected in a way that would be a good representation of the entire 1-0 stock in the nursery at the time of spring lifting. In all three nurseries, only 1-0 seedlings were lifted for jack pine this spring. Each seedling was thoroughly examined for the presence of swelling/galls. The number of galls per seedling and the locations of galls were also recorded. In Griffith Nursery and Wilson Nursery, the survey was conducted in the nursery at the time of lifting on April 13 and April 9, 2009, respectively. Seedlings in Hayward Nursery were brought back to the lab in Fitchburg on April 27 and examined on May 1-2.

2. Re-examination of non-symptomatic seedlings out-planted in 2008 to monitor the development of galls/swellings

Seedlings that appeared healthy with no galls or swellings were planted in nursery properties in the spring of 2008. In Wilson Nursery, 70 1-0 seedlings were out-planted in the nursery property where an irrigation system was available and 100 seedlings were planted in a grassy area without irrigation on April 10, 2008. In Griffith Nursery, 100 2-0 seedlings were planted in an irrigated bed and another 100 seedlings were planted in a non-irrigated bed on April 28, 2008. In Hayward Nursery, 100 2-0 seedlings were planted in an irrigated bed and another 100 seedlings were planted in a non-irrigated bed on May 12, 2008. The purpose of the use of irrigation was to maximize the survival rate by eliminating water deficiency as a potential factor for seedling mortality. Planting in a non-irrigated site was considered to represent a situation similar to normal planting in the field for reforestation. Herbicides were used in non-irrigated sites to reduce grass competition. Each seedling was examined in the fall for the development of galls/swellings.

In the fall of 2008, all out-planted seedlings were examined for the presence of galls. In Griffith Nursery, 5 out of 100 seedlings exhibited galls in the irrigated bed and 8 seedlings produced galls in the non-irrigated bed. There was no gall development on any of the seedlings out-planted in Hayward Nursery or Wilson Nursery. All of the galled seedlings were pulled out from the bed in Griffith Nursery in the spring of 2009. The galled seedlings from Griffith Nursery were transplanted into pots and placed outside the greenhouse in Fitchburg for monitoring. Each remaining seedling was examined in the fall of 2009 for the development of galls/swellings. The number of galls per seedling and the locations of galls were also recorded.

Figure 21. A small gall that was visible on a 1-0 PJ seedling at the time of lifting (photo by Kyoko Scanlon)

3. Outplanting of non-symptomatic 1-0 seedlings in 2009 to monitor the development of galls/swellings

Seedlings that appeared healthy with no galls or swellings were planted in a nursery property in spring 2009. In Wilson Nursery, 100 1-0 seedlings were out-planted in the nursery property where an irrigation system was available and another 100 seedlings were planted in a grassy area without irrigation on April 9, 2009. Similarly, in Hayward Nursery, 100 1-0 seedlings were planted in an irrigated and in a non-irrigated bed on April 27, 2009. In Griffith Nursery, 100 1-0 seedlings were planted in an irrigated bed and another 100 seedlings were planted in a non-irrigated bed on April 20, 2009. Additionally, 100 apparently healthy seedlings were randomly collected from Griffith Nursery. These seedlings were potted and placed in the greenhouse in Fitchburg to limit additional inoculum exposures in 2009.

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

Jack pine seedlings that contained at least one gall or suspicious swelling were brought back from each nursery. These galled seedlings were transplanted into pots on May 5-6, 2009, and placed outside to monitor the further growth of galls and the health status of galled seedlings. Ten healthy-looking seedlings from Hayward Nursery were planted in a pot as a control. The size and location of each gall or swelling was recorded at the time of planting. Each seedling was examined and the size of each gall was measured and recorded in the fall.

<u>Results</u>

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

In Hayward Nursery, out of the 1006 seedlings examined, there were no seedlings that exhibited a discrete swelling or gall. There were 6 seedlings that exhibited a suspicious swelling. In Griffith Nursery, out of 1083 seedlings, 45 seedlings had at least one visible gall or swelling. The percent infection rate was 4.2%. There were 6 seedlings that exhibited a suspicious swelling. In Wilson nursery, out of the 1005 seedlings examined, there were no seedlings that exhibited a discrete swelling or gall. There were 5 seedlings that exhibited a suspicious swelling.

2. Re-examination of non-symptomatic seedlings out-planted in 2008 to monitor the development of galls/swellings

In Hayward Nursery, all out-planted seedlings were examined on October 9, 2009. Out of 80 remaining seedlings, there was no additional mortality in the irrigated bed planted in 2008(Table 2). Out of 51 remaining seedlings, one seedling died in the non-irrigated bed during the summer of 2009. The dead seedling did not have any galls. There were no seedlings that exhibited galls in the irrigated bed in Hayward Nursery in 2009 while 4 seedlings exhibited at least one gall in the non-irrigated bed (7.8%).

Figure 22. Multiple galls on one seedling. This 2-0 PJ seedling was planted in the spring of 2008. The photo was taken on Nov 23,2009. (photo by Kyoko. Scanlon)

In Wilson Nursery, out-planted seedlings were examined on October 29, 2009. There was no mortality on seedlings in the irrigated bed in 2009 as well as in 2008. Though 22 seedlings were lost in 2008, only 2 seedlings died in 2009 in the non-irrigated bed. One seedling from the irrigated bed and two seedlings from the non-irrigated bed exhibited gall(s). None of the dead seedlings had galls.

In Griffith Nursery, out-planted seedlings were examined on November 23, 2009. Out of 95 remaining seedlings, 2 seedlings died in 2009 in the irrigated bed. There was no mortality in the non-irrigated bed. Discrete galls developed in 23 seedlings in the irrigated bed and 27 seedlings in the non-irrigated bed (Figures 21 & 22). The seedlings were not treated with a fungicide in this study to assess the natural level of infection. Griffith Nursery applies a fungicide to control this disease as part of their normal operation. The incidence rate in this study in Griffith Nursery is not a reflection of the quality of the jack pine stocks in Griffith Nursery.

Table 2: The number of seedlings that developed galls during the summer 2009. The seedlings were planted in the spring of 2008. The seedlings were not treated with a fungicide in this study to assess the natural level of infection.

Nursery	Seedling age	Total no. of remaining seedling in irrigated bed	Total no. of seedlings with galls in irrigated bed	Total no. of remaining seedlings in non-irrigated bed	Total no. of seedlings with galls in non-irrigated bed
Hayward	3	80	0 (0%)	51	4 (7.8%)
Griffith	3	95	23(24.2%)	99	27 (27.2%)
Wilson	2	70	1 (1.4%)	78	2 (2.6%)

3. Outplanting of non-symptomatic 1-0 seedlings in 2009 to monitor the development of galls/swellings

Though mortality rate was minimal in the irrigated bed in all three nurseries, much higher mortality was observed in the non-irrigated bed (Table 3). In Hayward Nursery, 97% of the seedlings planted in the non-irrigated bed died in 2009. No gall was found in any of the seedlings in the non-irrigated bed in all three nurseries. Infection rate of 1-0 seedlings in the irrigated bed in Griffith Nursery was 3%

Table 3: The number of dead seedlings and seedlings with galls. One hundred seedlings were planted in the irrigated bed and non-irrigated bed respectively in the spring of 2009.

Nursery	Mortality in irrigated bed	Total no. of seedlings with galls in irrigated bed	Mortality in non-irrigated bed	Total no. of seedlings with galls in non-irrigated bed
Hayward	0	0	97	0
Griffith	1	3	7	0
Wilson	1	1	12	0

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

All galled seedlings and seedlings that showed a suspicious swelling were planted in a pot in spring 2009. These potted seedlings were examined on November 5, 2009 and the size and location of each gall were recorded. All of the suspicious 6 seedlings that were brought back from Griffith Nursery had a swelling at the node just above the soil line. At the time of initial examination, all of the 6 suspicious swellings had a similar appearance. Two out of the 6 suspicious swellings developed to a distinct gall. Three out of the 6 suspicious seedlings died in 2009. One of them had a gall. In Hayward Nursery, 5 seedlings had a suspicious swelling at the node just above the soil line and one seedling had a swelling below the soil line. In Wilson Nursery, out of 5 suspicious seedlings that were brought back, 3 seedlings had a swelling at the node just above the soil line and the rest had a swelling below the soil line. None of the suspicious seedlings that were brought back from Hayward and Wilson Nurseries developed into a distinct gall.

On July 31, 2009, 100 1-0 seedlings that were collected from Griffith Nursery, potted, and placed in the greenhouse, were examined for the existence of galls. Eleven seedlings exhibited at least one gall. One seedling had two galls and the rest carried only one gall per seedling. Two seedlings died in 2009, however, they didn't have any galls. Further analysis on the number of galls per seedling and locations of galls is in progress.

Discussion

It was previously thought that 1-0 seedlings may not exhibit symptoms at the time of lifting even if they are infected. However, the detection of galls on 1-0 seedlings at the time of lifting in Griffith Nursery proved that exhibited symptoms of gall rust could occur on 1-0 seedlings. The seedlings were sown in the fall of 2007 and germinated in the spring of 2008. This finding stresses the importance of examining seedlings before planting, including 1-0 seedlings.

The gall incidence rate of 1-0 seedlings (4.2%) in Griffith Nursery was approximately half of what was observed on 2-0 seedlings (7.3%) in 2008. No 1-0 seedlings from Hayward and Wilson Nurseries exhibited galls at the time of lifting. It is suspected that abundance of jack pine and black oak in the vicinity of the nursery property contributed to the higher incidence rate of jack pine gall rust in Griffith Nursery compared to other nurseries. Symptomatic seedlings are culled without being shipped for graded stocks. For bulk orders, nurseries include an information sheet with sorting guidelines and encourage landowners to remove galled trees before planting. Thus, the number of galled seedlings that are shipped and out-planted should be less than the incidence rate in this study. Since the infection rate may vary year to year depending on the weather conditions, visual inspection of galls on jack pine seedlings will be conducted again at the time of lifting in the spring of 2010.

It was noteworthy to find a much higher rate of gall development in 2009 on the 2-0 seedlings that were planted in 2008 (24.2% in the irrigated bed, 27.2% in the non-irrigated bed) compared to the additional infection rate in 2008 (5% in the irrigated bed, 8% in the non-irrigated bed). Disease incidence rate increased more than three times in

2009 on three year-old seedlings compared to the same seedlings when they were two years old in 2008. It was interesting to learn the difference in disease incidence between the seedlings that were placed in the greenhouse (11%) and the seedlings that were out-planted (3% in the irrigated bed and 0% in the non-irrigated bed). Previously, it was predicted that the seedlings in the greenhouse would have lower disease incidence compared to out-planted seedlings since out-planted seedlings will have longer periods of exposure to spores. The difference between the results in 2008 and 2009 cannot solely be explained by varying year-to-year environmental conditions as the incidence rate increased in one experiment and was lower than expected in the other experiment while both experiments were conducted in the same location in Griffith Nursery during the same season. One hypothesis to explain the results is that disease incidence may be enhanced or discouraged by growing conditions of the host. The 2-0 seedlings that were out-planted in 2008 grew significantly in 2009, whereas the 1-0 seedlings that were out-planted in the spring of 2009 did not have much growth. The 1-0 seedlings that were kept in the greenhouse appeared healthier and more vigorous than the out-planted ones.

Mortality of the 1-0 seedlings was higher in the non-irrigated bed than in the irrigated bed in all three nurseries. It appears that water deficiency and competition with other plants were major causes of mortality. There were no galled seedlings found in the non-irrigated bed in any of the three nurseries. Again, vigor of the host materials may have some affect on either the susceptibility to infection or disease symptom exhibition. Analysis on the size and locations of the galls as well as the number of galls per seedling from the data collected in 2009 is in progress.

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Winter burn on conifers

The bright sunshine and climbing temperatures of the past fortnight (April 1-14, 2009) have marked the welcome return of spring to Wisconsin. Unfortunately an unsightly reminder of the cold hard winter of 2008-2009 greeted landowners as the balmy breezes melted the last remnants of winter snow. Most spruces (both white and blue), most Scots pines, some red and white pines, and even some balsam firs are showing obvious symptoms of winter burn.

The symptoms for winter burn on all trees except blue spruce are shockingly orange-red needles concentrated on the tops of small conifers and on the outer branch tips (Figure 23). On blue spruce the needles turn a nasty purplish brown instead of orange. Winter burn is not caused by any insect or disease. It is a physiological disorder which

Figure 23. Winter desiccation on red pine (photo by Linda Williams).

should really be called winter drying or winter desiccation. During sunny, windy, and relatively mild days in late winter and early spring the needles of young conifers begin to transpire pumping moisture out of the needles. Unfortunately the roots of these small trees are locked within frozen ground and cannot replenish the moisture being lost from the needles. As the needles lose more moisture they desiccate, turn orange, and die. The needles most exposed to sun and wind display the symptoms first and worst. This makes the tops of the trees and the outer branch tips look the reddest. Portions of the tree crown near the ground are often perfectly normal as they were protected by being under the snow when the injury occurred.

The good news with winter burn is that, as bad as it looks, it is rarely fatal. In fact, most trees will recover on their own since the damage is usually confined to the needles, leaving the buds and the twig cambium unharmed. The bad news is that there is no effective treatment for winter burn since it is not caused by any insects or diseases. The other bad news is that winter burn can be fatal especially to small trees if the moisture stress is severe enough to dry out the entire crown of the tree. This severe form of winter burn is very rare in Wisconsin but quite common along the front range of the Rockies where it goes by the rather elegant name of Chinook injury since symptoms follow in the wake of Chinook winds which can raise temperatures 60 to 80°F in a few hours.

Winter burn has been quite common across northern Wisconsin. Small, open grown, ornamental spruce trees appear to be most heavily affected. Most of these trees will recover, looking much better as new growth appears and the damaged needles fall off the tree. There are two similar looking problems that can be confused with winter burn: salt damage and *Rhizosphaera* needlecast of blue spruce. Salt damage is very similar to winter burn except the damage is confined to well travelled roads and often is much more severe on the side of the tree facing the road. *Rhizosphaera* needlecast produces the same purplish brown needle discoloration but the off-color needles are found on the interior branches in the bottom of the crown while the top of the tree and outer branch tips appear normal. This is an important distinction because *Rhizosphaera* is a common disease which can be controlled and cured with fungicides sprays.