Wisconsin Forest Health Highlights

Division of Forestry
WI Dept of Natural Resources

December 2006

This year, a severe summer drought caused plantings of tree seedlings to die in areas scattered across northern Wisconsin. Oak and pine, already stressed by past years of low moisture, finally succumbed to infestations by the two-lined chestnut borer (oak) and pine bark beetle (pine). Dieback in aspen was also observed in droughty areas. Shagbark and bitternut hickory throughout southern Wisconsin also continued to die as a result of past droughty years and infestations by the hickory bark beetle. Populations of the jack pine budworm continued to decline in northwestern parts of the state but continued to rise and feed on both red and jack pine in west-central and north-central Wisconsin. Surveys for exotic species including the emerald ash borer, beech bark disease, Sirex woodwasp and *Phytophthora ramorum* (the cause of sudden oak death) all returned negative results. Gypsy moth populations remained low, due to a collapse in 2004 but have continued to rise in scattered areas of south-central Wisconsin.

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THE RESOURCE

—Forests are 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 support a great diversity of wildlife species, while recreational use of the forests continues to grow and expand. The area of forestland in Wisconsin has been steadily increasing in recent decades and currently stands at almost 16.0 million acres, representing 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. The primary hardwood forest types in the state are maple-basswood, with 4.4 million acres or 28% of all tiimberland, oak-hickory on 3.4 million acres or 22% of total acreage and aspen-birch which covers 3.2 million acres or 21% of Wisconsin's timberland area. Conifer types, mainly red, white and jack pines and spruce-fir represent about 3 million acres or 19% of total timberland areain the state.

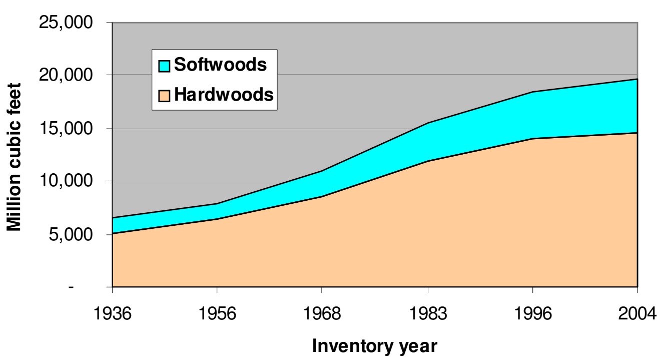


Figure 3. Growing stock volume (in million cubic ft) on timberland in Wisconsin, 1936-2004 (based on FIA inventory data).

EXOTICS

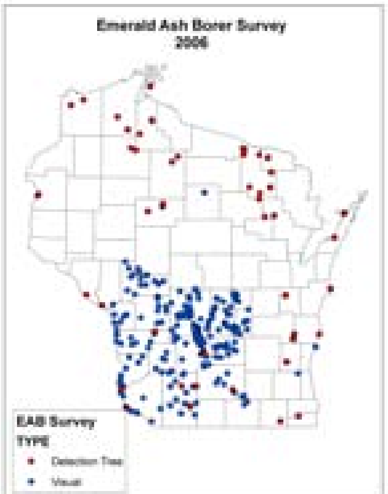
Emerald Ash Borer

Detection Tree Surveys

In an effort to detect the Emerald Ash Borer before the infestation becomes widespread in Wisconsin, the DNR conducted both detection-tree and visual surveys throughout the state. Detection tree surveys for 2006 were contracted with scientists at Michigan Tech University and coordinated by Bill McNee, north-eastern region gypsy moth suppression program coordinator. One hundred thirty-one detection trees (girdled ash trees with tangle foot painted on the stem) were established on 21 state park

properties. These trees were visited throughout the summer and examined for the presence of adults stuck in the tangle foot. Fifty-three of the detection trees were felled and peeled in the fall in order to look for developing larvae. The rest of the detection trees will be felled in 2007.

Detection trees (set up in 2004 and 2005) were felled and peeled during 2006 on the following state forests: Kettle Moraine, Governor Knowles, Brule River, Flambeau River, Northern Highland American Legion, Peshtigo River, and Point Beach. Seven detection trees were monitored along a 23-mile stretch of the Lower Wisconsin Riverway between Mazomanie Beach in Dane County and Long Island in Richland County. In November, detection trees were felled and the bark peeled to look for developing emerald ash borer larvae or their serpentine galleries in the cambium layer. No emerald ash borer larvae were detected during bark peeling. However, other larvae, including one species of a metallic wood-boring beetle and a long-horned beetle were detected and are in the process of being identified. Ash bark beetle and ash cambium miner galleries were evident in the cambium layer and red-headed ash borer galleries were detected in the sapwood.



Visual surveys

Visual surveys were also conducted at 235 private and county campgrounds and recreational areas throughout South central and Southwestern Wisconsin. More than 24,000 campsites were visited, while surveying more than 3500 ash trees. These surveys resulted in finding no emerald ash borers, but also revealed several locations that will require follow-up surveys in 2007 to monitor declining ash. The overall health of the ash trees surveyed was good, with only minor insect and disease findings such as ash plant bug, ashleaf gall mite, ash flowergall mite and the leaf disease anthracnose.

Past survey results and other information related to EAB in Wisconsin is available on the following webpage: http://dnr.wi.gov/org/land/Forestry/FH/Ash/.

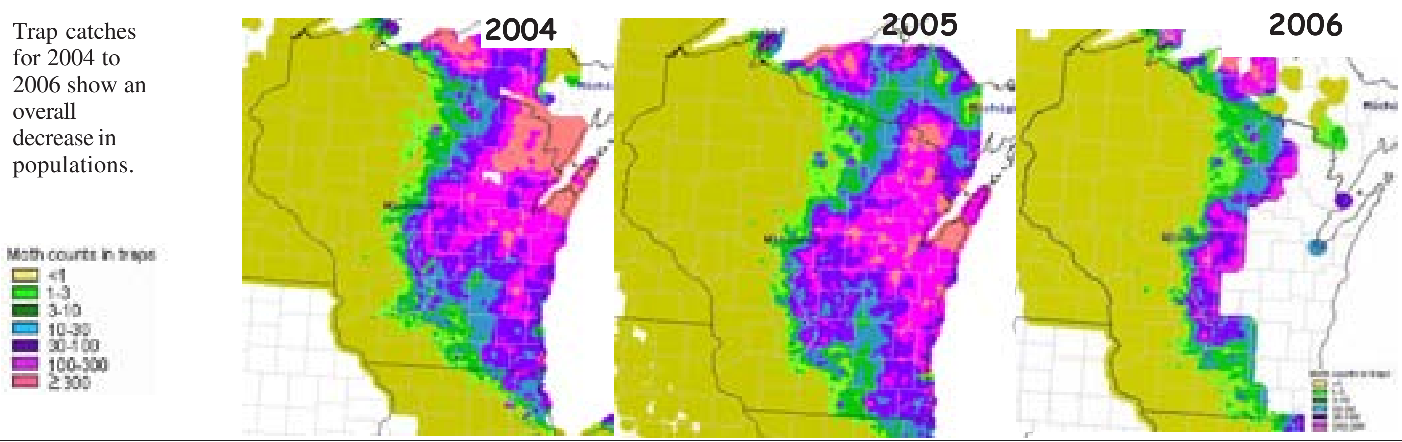
Gyspy Moth 2006

Suppression:
Gypsy moth populations remained low due to a collapse in 2004, but have continued to rise since then due to the warm, dry summers of 2005 and 2006. South-central Wisconsin is looking like the next region of the state to see widespread outbreaks. This area is very favorable gypsy moth habitat, with a lot of oak growing on sandy soils. Populations in eastern Wisconsin have also risen but remain relatively low. There were a number of reports of individual trees being defoliated, but there were no larger patches of defoliation reported.

This year's DNR suppression program was very small, with 4 participating counties and approximately 1,500 acres sprayed. Treatments were conducted at a dosage of 36 BIU. At present, the 2007 spray program is likely to be even smaller, as several counties have been hesitant to participate due to the lack of federal cost sharing. However, this trend is likely to reverse if populations continue increasing as they have in the past 2 years. In eastern Wisconsin, numerous spots are simmering at levels too low to spray in 2007, but could easily qualify for spraying in 2008.

Slow The Spread:
In Wisconsin, the slow-the-spread program is conducted by the Wisconsin Dept. of Agriculture, Trade, and Consumer

Trap catches for 2004 to 2006 show an overall decrease in populations.



Protection (DATCP). Eighty-seven sites in 21 counties were treated, for a total of 157,000 acres (DATCP submitted data).

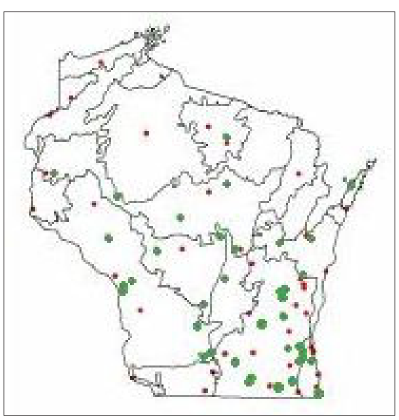
Btk was applied twice at 24 BIU's to 27, 025 acres, on 43 sites, and in 17 counties.
Gypchek (NPV) was applied once to 6,124 acres, on 16 sites, and in 4 counties.
Pheromone flakes were applied to 123,602 acres, on 28 sites, and in 9 counties.

Gypsy Moth Trapping:

2006 was the first year that no widespread gypsy moth trapping was conducted in eastern Wisconsin, where the moth is widespread and has been well established for 10 years or more. DNR staff felt that the trapping information in these counties was no longer worth the cost of obtaining the data. In western Wisconsin, DATCP continued trapping. A total of 92,209 moths were captured in 31,813 traps. Trapping grids were set at 1 per sq mi, 1 per 4 sq mi, or 1 per 9 sq mi. 200 delimitation blocks were set at 4 per sq mi or 9 per sq mi. Traps were set in 49 Wisconsin counties. Only 5 counties reported a zero moth capture (Buffalo, Pepin, Pierce, Polk and Washburn Co.). Cooperators caught 29,146 moths in 588 traps – mainly in the Apostle Islands

Sudden Oak Death

This was the third year Wisconsin surveyed oak stands within 0.25 miles of nurseries that have received plant material from infested areas of California. All samples in 2004 and 2005 were negative for the presence of *Phytophthora ramorum*, the fungus that causes sudden oak death. In 2006, 38 sites were sampled; 118 foliage samples were collected. Sampling in all of Wisconsin's ecological landscapes revealed negative results, but vigilance remains the prudent course of action, as over 80 Wisconsin nurseries received stock from a known infected California wholesaler in 2003.

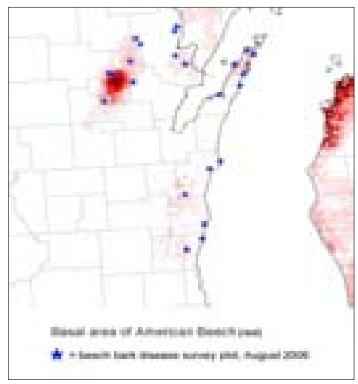


SOD tissue sampling 2004-2006 by WDNR Ecological Landscapes (green=2004 and 2005; red=2006). Twenty-one locations have been sampled in multiple years.

Tentatively, UW Stevens Point professor Neil Heywood and students from the Department of Geography & Geology, in cooperation with WDNR, DATCP, and USDA Forest Service personnel, again will conduct a surveillance survey during 2007, but now with focus upon water sampling. SOD monitoring surveys within Wisconsin between 2004 and 2006 have yielded *no confirmed positives*. Additional information regarding symptoms and prevention is available through a USDA National Forest Service web site:
www.na.fs.fed.us/spfo/pubs/pest_al/sodeast/sodeast.pdf

Beech Bark Disease

Beech bark disease, caused by a combination of a scale insect (*Cryptococcus fagisuga*) and a fungus (*Nectria coccinea var. faginata or N. galligena*) has not been observed in Wisconsin but is present in the eastern upper peninsula of Michigan. Twenty-three early detection plots established in eight counties on state, county, city or private land were all negative for the presence of beech bark disease. Plots were established where the incidence of beech and probability of human transport of infested wood were highest. A minimum of 30 trees at each site were examined for the presence of the scale that is found at the advancing front of this disease.

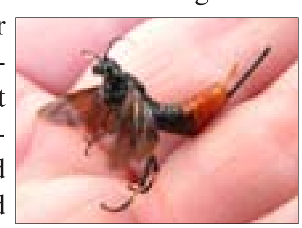


Siricid Woodwasp (European)

2006 Survey Interim Summary

Overview:

Wisconsin is currently considered low risk for establishment of and susceptibility to *Sirex noctillio* but is at a higher risk for possible introduction in or near Milwaukee and Green Bay. The primary goal of this survey is to test and compare three detection methods for the presence of Siricid wasps. The three methods tested were 1) Lindgren funnel traps baited with a Siricid lure (70%alph/30%beta pinene) using a dry collection cup with a pesticide kill strip 2) Sircid intercept panel trap also baited with a Siricid lure (70%alph/30%beta pinene) using a water kill collection cup, and 3) detection tree stressed by frill cut with herbicide treatment. This interim summary covers the



first two methods. The detection tree survey will be completed next spring when the trees will be felled and peeled to look for Siricid larvae. A secondary goal was to survey a portion of the Kettle Moraine State Forest Northern Unit for the presence of *Sirex noctillio.*

Survey set up:
Three sites were located in the Kettle Moraine State Forest Northern Unit in Southeast Wisconsin. The three sites were mature red pine plantations with some level of stress due to insect, disease, and/or overstocking. Within each site 5 repetitions of the three survey methods were randomly set up in a grid pattern. Each repetition was set up ~ 1 chain apart. Traps were checked every three weeks and any Siricids caught were collected and stored in 90% rubbing alcohol.

Results of intercept panel and Lindgren funnel traps:
Collection Date:
7/12/06 - 3 collected from Intercept Panel trap, 1 from Lindgren funnel trap
7/31/06 - 10 collected from Intercept Panel trap, 0 from Lindgren funnel trap
8/23/06 - 0 collected from Intercept Panel trap, 1 unidentified hymenopteran from funnel trap
10/12/06 – 2 collected from Intercept Panel Trap, 0 from Lindgren funnel trap

Totals:
Intercept panel trap- 15 Siricids females
Lindgren funnel trap- 1 Siricid female, 1 unidentified hymenopteran with abdomen missing

There appears to be 6 possible different species of Siricids based on abdomen and antennae color patterns. None appear to be *Sirex noctillio*. Specimens still need to be identified.

Comments:
Intercept panel traps seemed to outperform the Lindgren funnel traps in catching Siricid woodwasps. Some of the variation could be due to kill cup method. Peak catch occurred between July 12 and July 31st. An interim report on survey methods and results will be submitted to the WI Forest Health annual report for 2006.

HARDWOOD PESTS

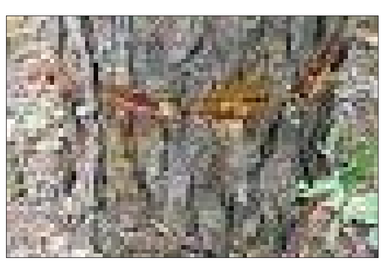
Ash Yellows

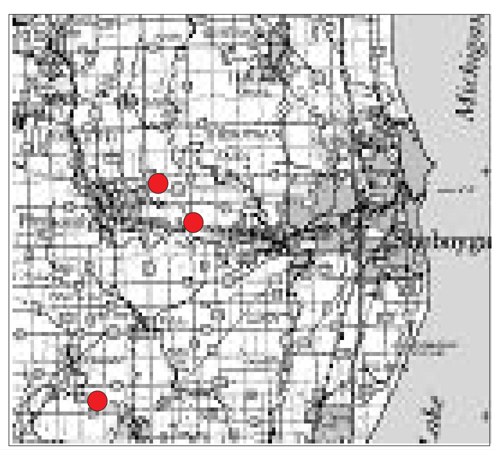
Ash yellows is caused by a phytoplasma, a wall-less bacteria-like microorganism. Symptoms of ash yellows include yellow/sub-normal size foliage, slow twig growth, thin crown, branch dieback and vertical cracks on the trunk near the ground, as well as brooms. In 2006, ash yellows was confirmed in Columbia County, based on the presence of brooms. Ash yellows is confirmed in 17 Counties in Wisconsin.

County distribution of ash yellows as of November 2006.

Visual surveys conducted to detect the emerald ash borer in 2005 showed that approximately 1/3 of the trees examined exhibited branch dieback. Other problems recorded on the trees included yellow leaves, epicormic sprouting, tufted foliage at tips of twigs, and bark cracks. These symptoms that indicate stresses and reduced vigor were attributed to wounds, girdling, improper planting, and water stress. Furthermore it was suspected that some of these trees may be infected with ash yellows. In the summer of 2006, leaf and wood samples were collected from trees that were showing branch dieback from 8 campgrounds and 2 forest stands throughout the state. Some of the sampled trees also exhibited yellow/subnormal size leaves, slow twig growth, and/or epicormic sprouting, but no brooms. Samples were tested for the presence of

Far left: Lingren funnel trap
Near left: Intercept panel trap
Below: Frill cut and herbicide detection tree.
Right: Three sites were located in the Kettle Moraine SFNU

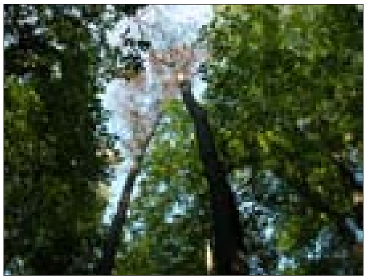




phytoplasma through the genetic analysis by Dr. Glen Stanosz, University of Wisconsin, Department of Plant Pathology. All of the samples were negative for phytoplasma.

Hickory decline/mortality

Dieback and mortality on hickory continued to be a problem in southern and central Wisconsin in 2006. Mortality was seen both on bitternut and shagbark hickory. The symptoms progress from thinning crowns to branch mortality to complete tree mortality. Epicormic branches often sprout from the main stem only to wilt and die .



Thinning and dead hickory crowns

Historically, research has found hickory mortality to be associated with attacks by the hickory bark beetle (*Scolytus quadrispinosus*) following periods of drought. More recent research, however, suggests that two recently named fungi, *Ceratocysis caryae* and *C. smalleyi*, could cause canker and limited wilt disease in hickory. At this point, little is known about the relative role of these fungi and their distribution in Wisconsin.

In the summer of 2006, the USDA Forest Service conducted a survey to detect the presence of *Ceratocystis* spp. on declining hickory trees in Wisconsin and some neighboring states. Wood samples were collected from 8 stands throughout Wisconsin where hickory dieback and mortality have been observed. Eighteen isolates of *C. smalleyi* and/or *C. caryae* were obtained from 6 of the 8 stands sampled. Species identification of these isolates is in progress by Dr. T.C. Harrington from Iowa State University. The USDA Forest Service plans additional field evaluations to determine relationships between hickory decline/mortality and stand and landscape level factors, provided additional funding. This project would investigate the role of *Ceratocystis* spp. and other fungi in the decline and mortality process.

Wilting leaves on hickory

Oak Wilt

A four year study on overland infection of oak during summer and fall began in 2006. The risk of the oak wilt fungus spreading via insect vectors has been shown to peak from mid-April through early to mid-July. As a result, pruning and cutting of red oaks in the spring is highly discouraged. Following early July, the risk of infection has been shown to significantly decrease. However, there is still an uncertain level of risk associated with cutting and pruning oak in the summer and early fall.

In response to concern from land managers, a study was crafted to quantify the relative risk of cutting during this moderate risk time period. Study sites, where harvesting of oak will occur between July 15th and October 15th, were sampled to determine the species composition, oak wilt presence, and the location of oak wilt pockets. The date of timber harvesting will be used to group the harvests into three, month long groups for comparison. In half of the sites oak wilt will be present in the stand and in half of the sites oak wilt will be absent. In subsequent seasons following cutting, all sites will be examined to determine if new oak wilt pockets erupt. The number of new oak wilt pockets will be compared between sites with oak wilt and those without and between groups based upon harvest month.

Figure 1. Seventeen oak wilt study sites were established in central Wisconsin.

Information from this study will be used to determine if there is a variable level of risk associated with cutting oak between July and October. This summer, the first phase of sampling began in seventeen study sites including 5 control sites where no cutting will occur (see map). Information from this study will be used to clarify oak management recommendations.

Oak dieback and mortality

Branch dieback and mortality of white and bur oaks have been observed in southern Wisconsin in recent years. It is suspected that affected trees were stressed by one or multiple factors, including frost, oak tatters, Anthracnose, Tubakia leaf spot (*Tubakia dryina*), mites, and drought. Once the trees were stressed, they were attacked and killed by secondary pests such as the two-lined chestnut borer

(*Agrilus bilineatus*) and Armillaria root disease. This year, some of the recently dead trees and trees exhibiting dieback were tested for the presence of oak wilt (*Ceratocystis fagacearum*); oak wilt was found to be present in a few of the symptomatic trees

Tar spot on Norway Maple

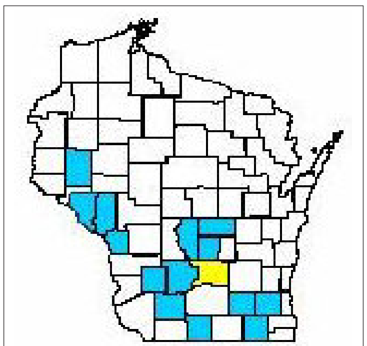
Tar spot was observed causing severe leaf spotting and defoliation on Norway maple in Waukesha County throughout the Village of Chenequa. It was also observed causing similar problems on Norway maple in a city park in the city of Sturgeon Bay in Door County. A report also came in from a homeowner in Sheboygan County this year. The early cool wet spring weather likely played a role in the outbreak of this leaf spot disease.

Based on host information it was likely *Rhytisma acerinum* causing the problem. According to Wayne Sinclair's book, Diseases of Trees and Shrubs, this species of *Rhytisma* was first described in Europe and subsequently found in Ohio in 1940. In the 1980's, it caused outbreak levels in Norway maple in New York but was often misidentified as the native *Rhytisma americanum* species. Speckled tar spot caused by *R. punctatum* is also mentioned as common but has a similar host range as *R. americanum* with a few exceptions

CONIFER PESTS

Annosum Root Rot

In 2006, Annosum root rot was found in a red pine stand in Columbia County (shown in yellow on the map). Infection was found on a 47-year old red pine plantation that was last thinned in 2001. It is suspected that fresh stumps provided an entry court for the fungus, and the disease has spread to nearby trees through root contact. This brings the total number of counties with this disease to 15 (Adams, Buffalo, Columbia, Dunn, Green, Iowa, Jefferson, LaCrosse, Marquette, Richland, Sauk, Trempealeau, Walworth, Waukesha, and Waushara).



County distribution of Annosum root rot as of November 2006.

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. A publication outlining the symptoms/signs and management recommendations for Annosum root rot can be obtained at : http://www.dnr.state.wi.us/org/land/forestry/fh/fhissues/annosum.htm

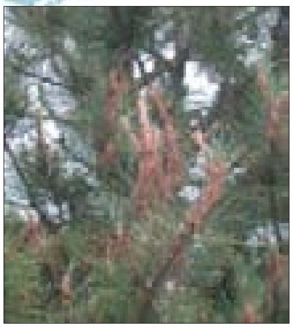
Diplodia on red pine seedlings

Over the last few years, the DNR state nurseries have implemented an aggressive management plan to monitor and control Diplodia shoot blight and canker. The disease is caused by the fungus, *Diplodia pinea* and most often infects red pine although infection has also been observed on other field-grown pine species. 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. In 2006, the state nurseries in cooperation with Forest Health Protection began an intensive sampling and testing protocol to monitor for Diplodia spores on red pine seedlings. The Forest Health lab processed 435 red pine samples over a period of several weeks. The results of this testing have allowed the state nurseries to improve management of the disease to ensure that only the highest quality seedlings are shipped to their customers. Nursery-grown red pine seedlings will continue to be monitored and tested in 2007.

Jack Pine Budworm

Northwestern Wisconsin
The population of jack pine budworm *(Choristoneura pinus pinus* Freeman) dropped significantly in northwestern Wisconsin in 2006 but was on the rise in west-central Wisconsin. The only area in northwestern Wisconsin that experienced heavy to severe defoliation was 3,000 acres in Bell and Bayview townships, Bayfield County. Polk, Burnett, Washburn, Douglas, and Sawyer counties suffered only moderate levels of defoliation. The total number of acres defoliated in 2006 was 110,700, compared to 222,500 in 2005. Pupal surveys indicate a continued decline for jack pine budworm in northwestern Wisconsin in 2007.

West-central Wisconsin
Jack pine budworm has preferred jack pine as its favorite host as long as forest health specialists have been monitoring Wisconsin's populations (1959) and has only been occasionally

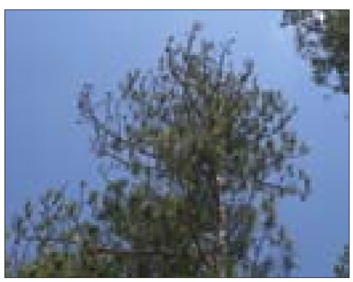


Jack pine budworm feeding on red pine

found feeding on red pine. Yet during the late summer/early fall of 2004, defoliation was observed in a 20-30-year-old red pine plantation in Adams County. Entomologists have thought this insect would not likely complete its life cycle on red pine because the needles of red pine are too thin for the female to lay her eggs on the needle surface. In 2004, the budworm successfully placed egg masses on red pine needles.

In 2005, jack pine budworm expanded into more red pine plantations in Adams County; both young (20-30-year-old) plantations and older (35+ year-old) plantations were affected. Jack pine budworm was also found in young (20-30-year-old) red pine plantations in Eau Claire, Juneau, and Wood counties.

In 2006, jack pine budworm was observed defoliating red and jack pine in Adams, Eau Claire, Juneau, and Wood counties: defoliation of jack pine only was observed in Jackson and Monroe counties. In Juneau County, budworm was found in a red pine plantation that was planted in 1996. Budworm was discovered for the first time defoliating young red pine plantations (14-30 year old) in Dunn and Portage counties. The pattern of defoliation in these young stands was very typical of jack pine budworm; feeding starts at the top and continues down the crown. Open grown trees usually have more defoliation than trees inside the plantation. Typical top dieback and mortality is occurring in these red pine plantations.



Defoliated red pine crowns in 20 year old plantation.

Defoliation in the 35+ year-old red pine plantations was very different from typical budworm feeding in the same age class of jack pine. In this older red pine, budworm was observed feeding on an individual tree, causing heavy defoliation; the surrounding trees had light to moderate levels of needle loss. This pattern is scattered throughout affected plantations. In similarly-aged jack pine, trees throughout a stand will be defoliated, with a few nonaffected trees scattered throughout the stand.

Pine bark beetles, red turpentine beetles, and pine sawyers can be found in the defoliated red pine plantations. Jack pine budworm appears to be thriving on red pine and the population shows no signs of decline at this time.

A request for funding to partner with entomologists at the University of Wisconsin Stevens Point and Madison has been submitted to the USDA Forest Service. If funded, a 2-year investigation of red pine as a host for jack pine budworm will be initiated.

Red Pine Pocket Mortality

DNR-UW Madison Collaborative Study

Year three of the five year collaborative study between the DNR and Dr. Kenneth Raffa, UW-Madison Department of Entomology concluded with completion of the third year of insect monitoring and tree evaluations, as well as the initiation of two studies involving Southern Illinois University and Ohio State University. All studies hope to better our understanding of the driving forces involved with this destructive red pine phenomenon.

Red Pine Pocket Mortality is complex interaction of various agents contributing to pockets of tree death throughout Wisconsin, changing the landscape as it spreads within a stand. Our emphases are on insect vectors of tree weakening fungi, fungal spread by means of root grafting, insect biodiversity and red pine physiological response within and outside the stands. Through trapping we are monitoring the populations and predators of insect carriers of fungi, *Leptographium* spp and *Ophiostoma* spp. Root weevils, the red turpentine beetle (*Dendroctonus valens)*, and bark beetles (*Ips* spp.) are the main culprits responsible for transporting the fungi to the tree. From previous studies, root insects, such as weevils, enter the tree root collar, spreading *Leptographium* fungi, stressing the tree, thereby making the tree susceptible to bark beetle attacks and spread of their associated fungus, *Ophiostoma.* Root grafting between healthy and diseased trees facilitates fungal spread and pocket formation.

Figure 1. Red pine pocket mortality study sites

The study includes 31 sites (Fig. 1) in central and southern Wisconsin on both private and public lands. Eight sites are asymptomatic controls, and 10 sites are untreated symptomatic conteen manipulated sites have had their root grafts severed 10 meters in advance of the last symptomatic tree. We hypothesize that severing the roots will obstruct transmission of the fungus to healthy trees.

Over the past three years traps were placed at each site to monitor insect populations. At all root-severed sites 12 jug traps and pitfall traps baited with either terpene delta-3-carene (jug trap) or terpene alpha-pinene (pitfall trap), were set two rows outside of the sever line. Lures are used to mimic red pine's resin production in response to an insect attack. The asymptomatic and untreated symptomatic sites have four of each trap. In addition, four 12-funnel Lindgren funnel traps were placed at the 31 sites, two traps baited with Ipsenol and two with Ipsdienol and Lanierone. These pheromones are utilized to monitor bark beetle population densities.

We conducted sampling of jug and pitfall traps (456 traps total) from early April until mid-July and funnel traps (124 total traps) from April until mid-September. Insect identification of 34 insect species in 10 families is ongoing. We anticipate completing the 2005 samples by Spring of 2007. Annual tree evaluations concluded in November 2006. Bark beetle and pine sawyer exit holes, the number of pitch tubes caused by the red turpentine beetle, a sub-sample of 24 trees per site for root collar weevil damage and the tree condition based on crown health were recorded. Of the nearly 10,000 trees in the study, 464 trees have died to date, with 80% of the mortality in the southernmost regions (Fig.2).

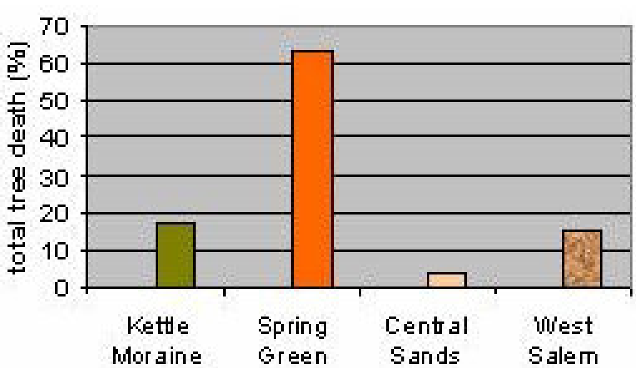


Figure 2. Total tree mortality from 2004 to 2006

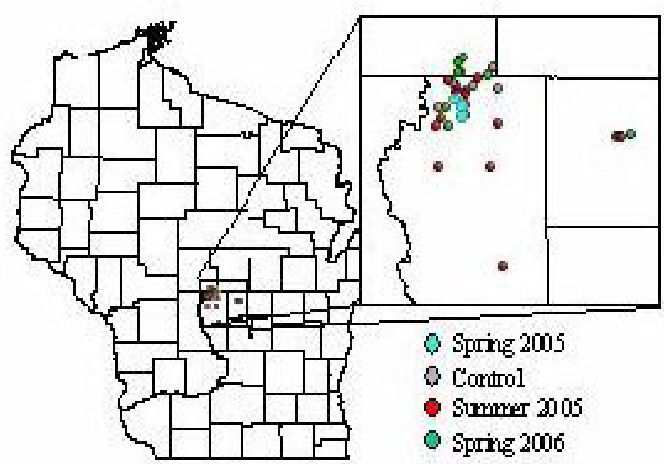
Field work for a tree physiology study began in late May and concluded at the end of June. Two sites in the regions of Kettle Moraine (Southern Unit), Spring Green and West Salem, were selected for the experiment. Ohio State University will analyze the tree defense response to induced fungal inoculation. This study aims to further our understanding of physiological differences among trees within the pocket and those along and those beyond the pocket margin.

The first year of an insect dispersal study involving Southern Illinois University was also completed. Experiment sites were selected in Kettle Moraine (Southern Unit) and in Black River State Forest. Three insects prevalent in red pine pockets include the bark beetle pine engraver *Ips pini*, the lower stem invader red turpentine beetle *D. valens* and their predator, the checkered beetle *Thanasimus dubius*. A population of each of these insects was captured on site, marked, released from a central location and recaptured using funnel traps. The study seeks to learn the dispersal behaviors of these insects and the interconnectedness of existing red pine pockets to newly forming pockets. The experiment will be replicated in 2007 in Black River State Forest.

Time of year of thinning & turpentine beetle numbers

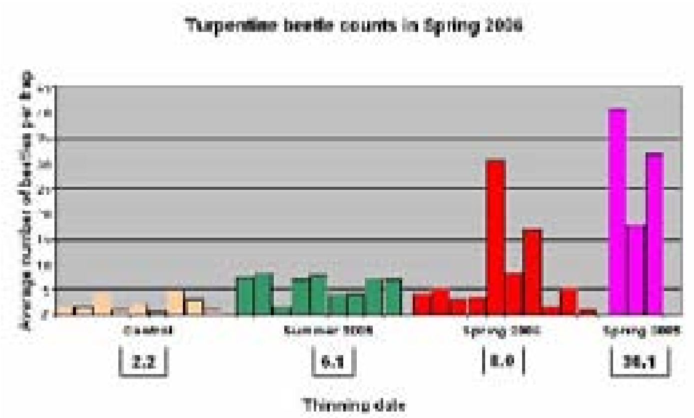
Red turpentine beetles (*Dendroctonus valens*) were trapped again in the spring of 2006 with varying results. This is a continuation of a project begun in 2005 comparing beetle densities in stands thinned the previous summer (7-9 months previous) to denisties in recently thinned stands (1-3 months previous). The hypothesis being tested is whether stands thinned several months prior to beetle flight (summer-thinned stands), would have lower beetle densities than stands thinned shortly before flight (spring-thinned stands) because the cut stumps would be drier and less attractive to emerging beetles. The results in 2005, revealed a significantly higher number of beetles in the summer-thinned stands as hypothesized but the variability between stands was quite high.

In 2006, in order to reduce this site-to-site variability, traps were placed in stands all within one area of the central sands



on property belonging to Plum Creek (see map). Traps were also set in the Samsel property in Waupaca County where thinning occurs year round. We also decided to trap in red pine that hadn't been thinned in more than 5years as a comparison or control. This would have meant 3 cateogories of stands; controls, summer 2005-thinned, and spring 2006-thinned. However, 3 of the stands which had been categorized as thinned in the summer of 2005 had actually been thinned in the spring of 2005, adding another category: spring 2005-thinned.

The results of the 2006 trapping (see chart) continue to support the hypothesis that thinning time of year is correlated with beetle populations but there is still very high variability within each category. Beetle counts in the control and the summer 2005 groups are consistently low with limited variability but both spring-thinned groups show greater variability with several stands having very high numbers of beetles. Interestingly, on the Samsel property, where spring-thinned, summer-thinned and controls are located within a short distance of each other, the hypothesis holds quite strongly, i.e. the spring-thinned stands have much higher beetle counts than the summer-thinned or control stands.



We plan to conduct the trapping again in 2007, with even greater attention paid to locating stands within a similar geographic area and to determining more exactly the start and end dates of thinning to better categorize stands. In addition ,we will monitor stands that showed high counts in the past 2 years to see if the density of beetles remains high or decreases.

ABIOTIC

Hail Damage

Northeast Wisconsin

During the summer 2006, several hail storms produced damaging hail in the northeast region. Hail as large as 3 inches in diameter was observed and damage was most severe on young trees. Branches were broken and bark was badly damaged on both young and old trees. Bark that was damaged by hail later dried and split further as the summer progressed creating further damage. Red pine trees in several stands became infected with Diplodia following the hail damage, they were later attacked by bark beetles, and mortality is beginning to show up. Some locations experienced multiple hail storms throughout the summer.

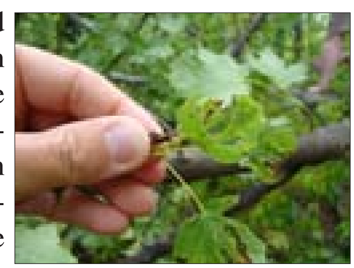
Hail and Diplodia canker

On June 25, 2006, a slow-moving severe thunderstorm hit north of Poynette, Columbia County with golf-ball size hail.

By early August, red pine plantations in the affected area exhibited severe branch dieback. Laboratory examinations revealed branch cankers caused by the fungus, *Diplodia pinea*, starting from wounds inflicted by hail. In severely affected areas, damage reached 80-100 % of the crown, and the entire crown appeared reddish brown. Approximately 117 acres of pole-size red pine plantations suffered damage, and more than 6,000 cords of red pine were salvage harvested. Although branches of nearby white pine were also injured by hail, they sustained only minor branch tip mortality.

Sugar Maple Defoliation

Sugar maple defoliation was observed in June. Symptoms were noted in Vilas, Forest, and Florence counties. Linden Looper was initially suspected as caterpillar samples had been received from the field and the Forest Service reported extensive defoliation in the western Upper Peninsula as well. Several sites were visited in June and many dominant/co-dominant sugar maples showed extensive defoliation in the upper crowns. Closer examination revealed dead buds, small dead leaves, leaves with a tattered appearance, a heavy seed crop, and minimal insect feeding. The culprit was most likely wind and frost.



On May 12, when new, tender leaves were just emerging and expanding, Wisconsin had an entire day of very strong winds across the state. These strong winds damaged the tender leaves, as the leaves continued to grow and expand the damaged part (primarily the tissue between the leaf veins) turned brown and fell out, giving the leaf a tattered, defoliated look. Additionally, these tender leaves in the upper crowns were affected by a late frost which occurred after the Memorial Day weekend. Frost damage to young leaves was common in the crowns of defoliated trees. At the time of the site visit the trees were sending out a second set of leaves to replace the damaged ones. There was very little branch dieback so I expect that longterm health effects will be minimal.

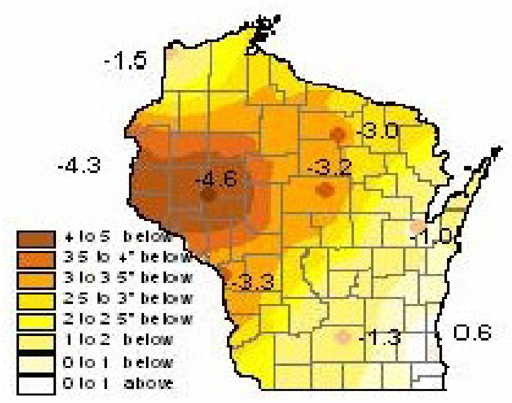
Frost damage on emerging sugar maple leaves.

Heavy rain and anthracnose

In 2006, precipitation for April and May was above average for many areas in Wisconsin. Cool and wet conditions in the spring created a great environment for the spore production and spread of various foliar fungi, including anthracnose. Anthracnose was observed on a variety of broadleaf trees, including ash, hickory, maple, oak, and walnut. Infected leaves show irregular necrotic spots or blotches. Heavy infection could cause leaves to curl and twist, and prematurely drop to the ground. Severe damage was observed in parts of southern Wisconsin, where above average precipitation continued through early summer. In most cases, anthracnose does not seriously affect the health of the trees and control is not necessary.

Severe drought in Northern Wisconsin

Severe drought in northern Wisconsin during the growing season affected many species of trees but was most evident on the conifers. The injury from drought was amplified by the already drought-stressed status of the forests from low moisture levels in 2005. Red pine in northern Burnett and Washburn counties and southern Douglas County were killed by Armillaria root disease, Diplodia pinea shoot blight and canker and Ips pini bark beetles - all organisms associated with drought-stressed trees. As the summer progressed, red pine infested with Ips pini could be found throughout northwestern Wisconsin as the pine foliage faded from green to yellow to tan. Newly planted seedlings of many species were killed from lack of moisture. The two-lined chestnut borer, an Agrilus beetle that infests drought-stressed oak was also very active in northwest Wisconsin, killing oak on the driest sites. Drought-stressed balsam fir also experienced mortality as it was infected by Armillaria root disease and infested with balsam fir bark beetle. Early fall color, another symptom of drought stress was observed on white birch in northwestern Wisconsin.



Departure from normal precipitation for June and July 2006 (inches).

SPECIAL REPORTS

Mapping ash distribution

Using multi-temporal satellite imagery:

The prediction of and response to the probable invasion of EAB depends on accurate knowledge of where ash occurs in the state and at what density. Until the emergence of satellite imaging, we had no way to predict this especially at a scale that might be useful to land managers. Landsat imagery has been used in the past, to map broad landuse categories such as agricultural lands, coniferous forests, and wetlands but, to date, has not been practical in delineating more specific forest types.

Prof. Phil Townsend of the Univ. of Wisconsin Dept of Forest Ecology and Management, however, has been successful in mapping ash species with a high degree of accuracy based on the differing phenology of this genus (Townsend and Walsh, 2001*). For instance, ash will leaf out later and lose its leaves earlier than other tree species in mixed deciduous and lowland forests. Green healthy foliage reflects highly in the near infrared and absorbs strongly in the red. Therefore, a high ratio of infrared to red reflectance would indicate healthy green foliage and a lower ratio would indicate unhealthy or defoliating crowns. In addition, ash species, with the exception of black ash in lowland areas, occurs only sporadically in the forest and therefore, will make up only a portion of a 30m Landsat pixel. However, the pattern of reflectance of that pixel will be different than a pixel with no ash; infrared

* Townssend, P.A. and S.J. Walsh. 2001. Remote sensing of forested wetlands: application of multitemporal and multipectral satellite imagery to determine community composition and structure in Southeastern USA. Plant Ecology 157:129-149.

reflectance decreasing as the proportion of defoliated ash increases. To illustrate, Figure 1 shows a fall image of a deciduous forest in Potawatomi State Park, Door County, in which the defoliating ash crowns stand out clearly from the surrounding foliated crowns. Figure 2 shows the same image with an overlay of what a Landsat image of the area might look like. The corresponding ratios of infrared to red are shown for each pixel. Note that the infrared reflectance is higher for the greener appearing pixels.

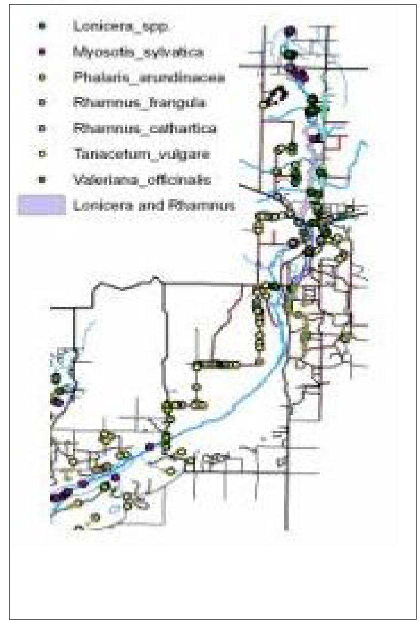
Because Landsat satellites record images about every 15 days, it is possible to capture images in which ash is defoliated and other species are still green as well as dates in which all trees have healthy green crowns (ie. midsummer). By comparing these images with knowledge of the density of ash in a particular stand, one can derive a formula for predicting ash density which can be applied to all the pixels in an image and then extrapolated to a larger area. Accurate ground truthing is essential to this process.

In this pilot study, we visited the Flambeau River State forest and ran transects to determine the overall proportion of ash in several stands known to contain ash. At each point, GPS coordinates were taken and the basal area of ash and other species was recorded. Figure 3 shows some of these points and the corresponding percentages of ash basal area. We are now in the process of acquiring Landsat images and performing radiometric calibration to allow image-to-image comparisons. Once this is done, the ground-truthed plot data can be used to detect changes in areas known to have higher densities of ash and compared to areas with little or no ash.

State Forest Invasive Plant Survey

Sarah Herrick, Survey Coordinator

Invasive plants are non-native species that become established in natural plant communities and wild areas, replacing native vegetation. When a plant species is introduced to a new area, it is no longer regulated by the insects, fungi, disease, grazing, or competition that controlled its population in its native habitat. While most horticultural plants can not survive Wisconsin's climate, and thus do not become invasive, the absence of natural enemies allows some introduced plants to outcompete native vegetation and become problem species. Allowing these pests to spread unchecked has serious consequences for the ecological and economic health of Wisconsin forests.



Map of common invasive species in the Brule River State Forest

During the spring, summer, and fall of 2006 the Wisconsin Department of Natural Resources Division of Forestry coordinated a survey of invasive plant species on priority sites in

Figure 1. Defoliated ash crowns appear purplish in this photo of the Potawotami State Park.

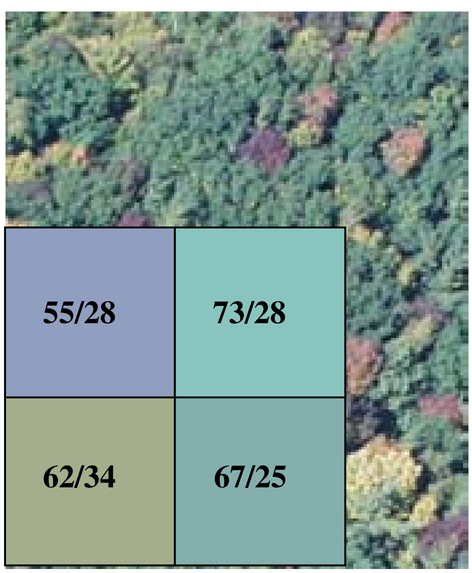


Figure 2. Same image with overlay of Landsat pixels showing infrared to red ratio for each pixel.

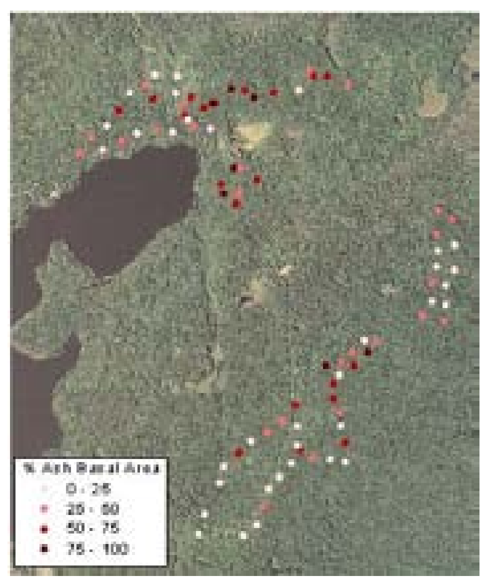


Figure 3. Flambeau River State Forest with plots showing percentage of ash.

Wisconsin's northern State Forests for the purpose of collecting information on the ecology of invasive plants, mapping the current existence and extent of invasive plant infestations within the state forests, establishing a baseline GIS database to aid in the development of invasive plant management goals and objectives, increasing departmental and public awareness of invasive plant issues, and creating support for management and prevention programs. Results contained in this report are from surveys conducted in the Black River SF, the Brule River SF, the Flambeau River SF, the Governor Knowles SF, the Northern Highland-American Legion SF, and the Peshtigo River SF. The northern and southern units of the Kettle Moraine State Forest were surveyed in a separate effort.Invasive plants are found throughout Wisconsin,

Invasive Species of Great Concern

Garlic Mustard (*Alliaria petiolata*)

The shade tolerant herb garlic mustard is a serious invader of forest understories in southern Wisconsin; however, survey results indicate that it is not yet widespread in the northern State Forests. Small populations were found along trails and in campground in Northern Highland, Governor Knowles, Flambeau River, and Black River State Forests. Control measures have already begun in these areas to ensure that these populations do not spread, and become a problem.Garlic mustard is thus far absent from the Brule River and Peshtigo River State Forests.

Garlic mustard along a trail in the Governor Knowles State Forest

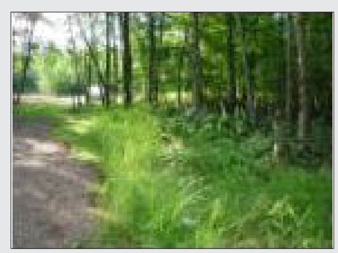
Buckthorn in the Black River State Forest

Non-native honeysuckles (*Lonicera* spp.) and buckthorns (*Rhamnus* spp.) are among the most widespread invaders of forest understories. Survey crews located relatively large populations of these species in and around campgrounds, boat landings, and trails in all six of the surveyed forests. Results also indicate many areas where buckthorn and honeysuckle are not present. Preventing the spread of these pests into new areas should be a top priority. Other invasive shrubs and small trees like Japanese barberry and black locust are present in one or more of the forests, but are uncommon, and not widespread.

Buckthorn in the Black River State Forest

Reed Canary Grass (*Phalaris arundinacea*)

This cool season grass is a serious invader of open and forested wetlands and moist uplands in Wisconsin. Survey results indicate is it is widespread in all of the state forests, and among the species most commonly observed during the survey. It was most often observed in low areas along trails and roads.



Reed canary grass in the Flambeau River State Forest

Common Reed Grass (*Phragmites australis*)

This warm-season grass is a major problem in wetlands and shorelines in eastern Wisconsin. Survey results indicate that it is not widespread on state forest land, though a few small populations were present in wetter areas within the Governor Knowles and Brule River Forests. This species may be out-competed by the much more pervasive reed canary grass, but populations should be monitored to in case they begin to spread.

Spotted Knapweed (*Centaurea biebersteinii*)

Spotted knapweed was the most commonly observed invasive species on State Forest land. It is widespread in open areas, and while it doesn't pose a significant threat to forested habitats, it severely reduces grassland biodiversity, and quickly invades following disturbance. Large populations were present in all six of the surveyed forests.

Spotted Knapweed in the Governor Knowles State Forest

Leafy Spurge (*Euphorbia esula*)

Leafy spurge is present in four of the six forests included in this survey. However, it is only common in the Peshtigo River State Forest where it is a pervasive invader, dominating most open areas within the forest. Thus far nothing has been done to control the species, and at this point it will require a substantial effort to control the population.

but very little information exists on their status in state forests, in particular those forests in the northern areas of the state. Each State Forest identified a list of priority search areas for invasive plant surveys. Priority areas include corridors along roads and trails, homesteads, boat landings, river ways, timber sales, gravel pits, recreational sites and campgrounds. Survey crews used maps and other available information to identify priority areas within each forest, and developed a survey schedule for these areas based on phenology. Priority areas were surveyed in as close to their entirety as was feasible to avoid gaps that could result in undiscovered populations and affect subsequent management decisions. Surveys were conducted on foot, or by bicycle, motorized vehicle, or canoe/kayak.

Garlic mustard control in the NHighland AL

The survey results provide information about the extent of several species that are of great concern in Wisconsin's forests. These plants are causing serious ecological damage to significant areas of the upper Midwest. While not all of these plants are widespread in Wisconsin, they spread aggressively and can become problematic if allowed to spread.

Survey crews recorded over 5,000 observations of 114 species of invasive/non-native plants in the state forests. Eleven species or groups of species accounted for 78% of these observations: spotted knapweed, non-native thistles, Eurasian honeysuckles, reed canary grass, common St. John's-wort, common tansy, buckthorn species, garden valerian, butter-and-eggs, forget-me-nots, and sheep sorrel. The location of each observation was recorded using GPS technology, and will be compiled in an invasive plant GIS database. Detailed reports are being prepared for each forest, along with a report detailing the overall results of the survey.

To obtain copies of reports or data files please contact: Sarah Herrick, Sarah.Herrick@dnr.state.wi.us, (608)267-7689

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