Forest Health Conditions in Wisconsin

Annual Report 2003

Compiled and Edited by:

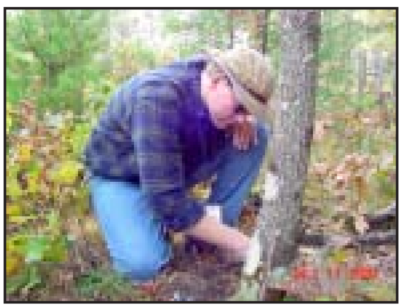
Division of Forestry
Forest Health Protection Staff
Wisconsin Dept. of Natural Resources
PO Box 7921
Madison WI 53707

Table of Contents

Forest Protection

Todd Lanigan
Forest Pest Specialist
West Central Region
Eau Claire 715-839-1632
Todd. Lanigan@dnr.state.wi.us

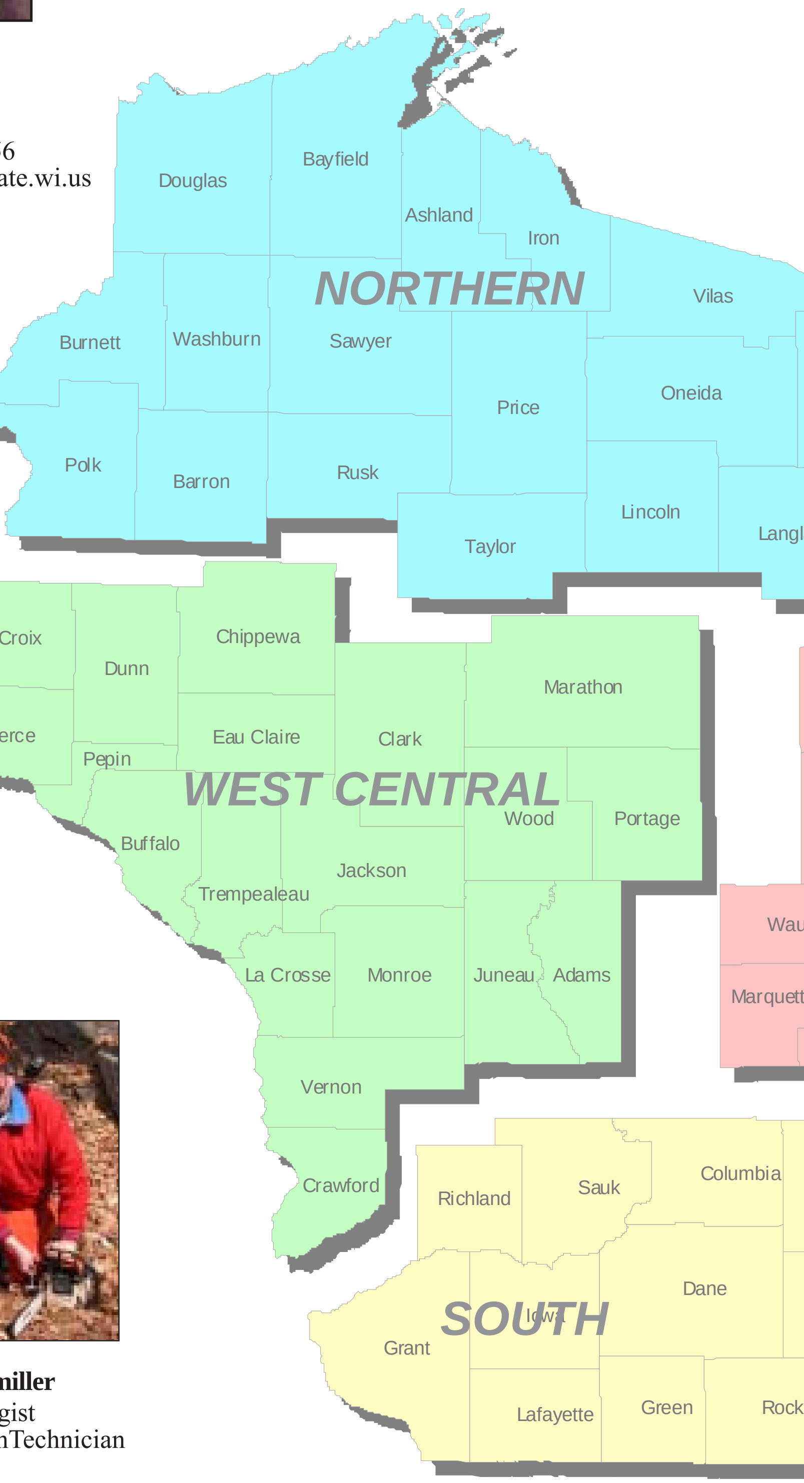
Shane Weber
Forest Entomologist
Northern Region
Spooner 715-635-4156
Shane. Weber@dnr.state.wi.us



John Kyhl
Forest Entomologist
Gypsy Moth Suppression Coordinator
Southeast
Milwaukee 414-263-8744
John. Kyhl@dnr.state.wi.us

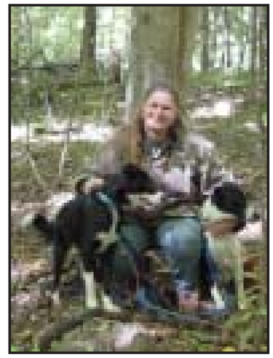
Bill McNee
Gypsy Moth Suppression Coordinator
Statewide
Green Bay 920-492-5930
Bill. McNee@dnr.state.wi.us

Mark Guthmiller
Senior Biologist
Forest Health Technician
Statewide
Madison 608-275-3223
Mark. Guthmiller@dnr.state.wi.us



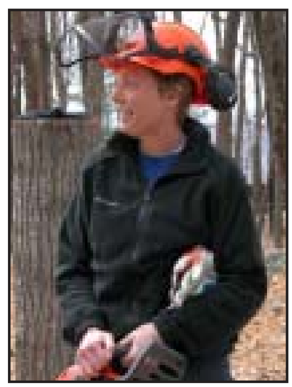
Health Staff

Kyoko Scanlon
Forest Pathologist
Statewide
Madison 608-275-3275
Kyoko. Scanlon@dnr.state.wi.us

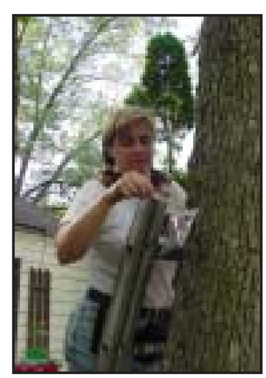


Linda Williams
Forest Entomologist
Northeast Region
Green Bay 920-492-5872
Linda. Williams@dnr.state.wi.us

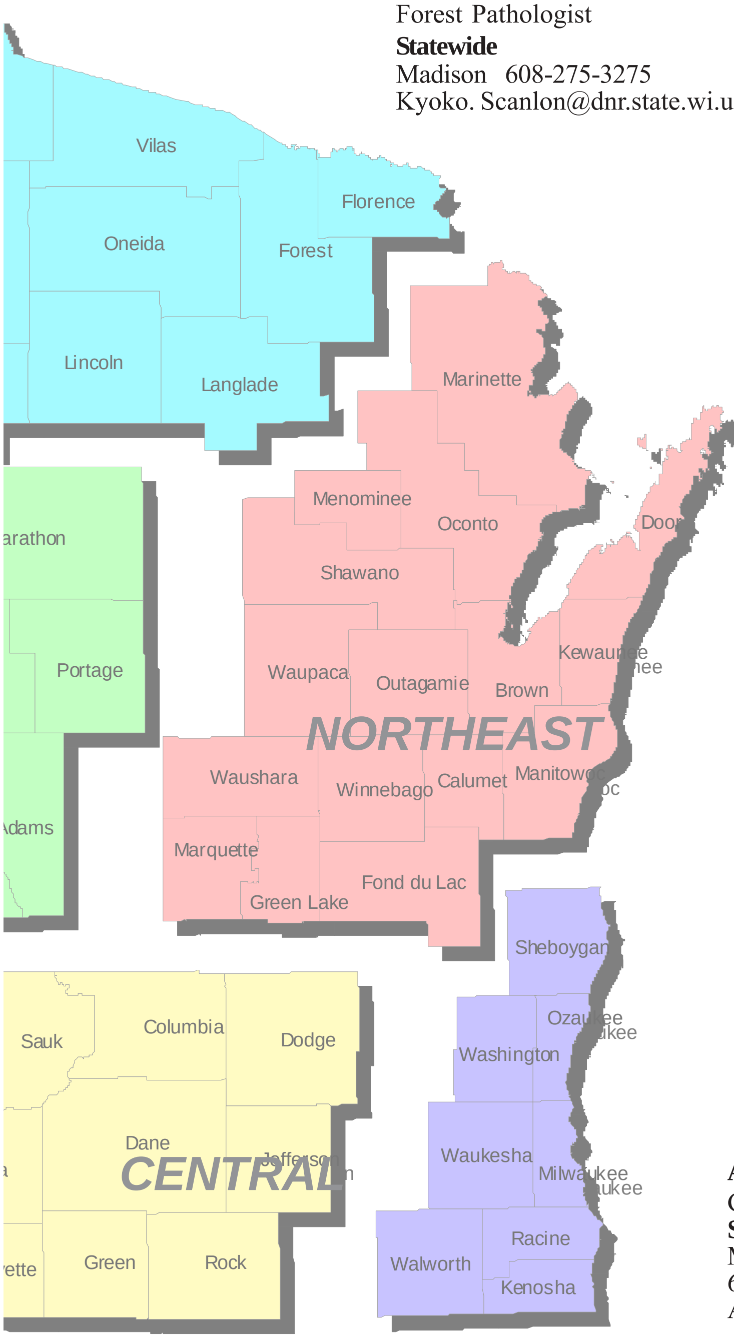
Sally Dahir
Forest Health Technician
Statewide
Madison
608-275-3319
Sally. Dahir@dnr.state.wi.us



Jane Cummings Carlson
Forest Health Coordinator
Statewide
Madison
608-275-3273
Jane. Cummings-carlson@dnr.state.wi.us



Andrea Diss
Gypsy Moth Program Coordinator
Statewide
Madison
608-264-9247
Andrea. Diss@dnr.state.wi.us



Emerald Ash Borer

ó Forest health specialists from the Lake States area have their antennae up these days on the lookout for an exotic insect, the Emerald Ash Borer (EAB), *Agrilus planipennis*. This insect has NOT been detected in Wisconsin but is present in Michigan. Discovered in Michigan in May 2002, EAB is native to Asia. It is suspected that EAB was initially introduced on material that came into the Detroit International Airport, although other introduction sites are possible. EAB was likely introduced at least 5 years prior to the actual discovery. Since the initial discovery in Michigan where 13 counties are now under quarantine, EAB has also been found across the border in Ohio, and Windsor Ontario, Canada. There are some additional spot infestations at a few nurseries in Michigan, in Hicksville Ohio which is near the Indiana border, in Indiana, and at a nursery in Maryland where the trees came from Michigan.

Figure 1.Adult Emerald Ash Borer

Hosts and Life cycle

All species of ash native to Wisconsin including black, green and white are hosts for this insect. The adult is a small brilliant green beetle about the same size as a Bronze Birch Borer. In Michigan the adults are present from the end of June to the first week in August. The emergence hole is an obviously D-shaped hole (Figure 2), about 3-4 mm in diameter. You can easily fit two D-shaped exit holes on the top surface of a pencil eraser (with some room to spare). Adults can lay up to 90 eggs and fly about 3 miles a day to find the perfect tree with the perfect spot for each separate egg. Upon hatching, the tiny larvae bore under the bark and begin feeding in the cambium of the tree.

Figure 2. D-shaped exit holes.

The larvae feed in a winding serpentine pattern (Figure 3), eventually reaching 1 to 1 Ω inches in length. Larvae may be ready to emerge as adults after a single year of feeding but are capable of taking 2 years to complete development. The mature larvae have segments that appear to be bell-shaped. The larvae will bore just into the sapwood to create a pupal chamber prior to emerging as adults.

Figure 3. Serpentine galleries

Large numbers of larvae (Figure 4) can be found in a relatively small area of cambium. Their feeding disrupts the water and food conducting ability of the tree causing decline and death. At low population densities the larvae act like two-lined chestnut borers or bronze birch borers, but at high population densities they can act like bark beetles, seeming to mass attack a tree and doing significant damage to the cambial layer. Larvae will feed on all species of ash, but in Michigan they appear to be killing green ash and all green ash cultivars, more easily than they are killing white ash. It is not known at this time whether white ash is more resistance, less attractive to the beetle, or is able to withstand more damage than green ash before showing decline. In Michigan, EAB is infesting both urban and forest trees but shows a slight preference for open- grown sun-warmed trees.

Figure 4. EAB larva.

Survey plans for 2004

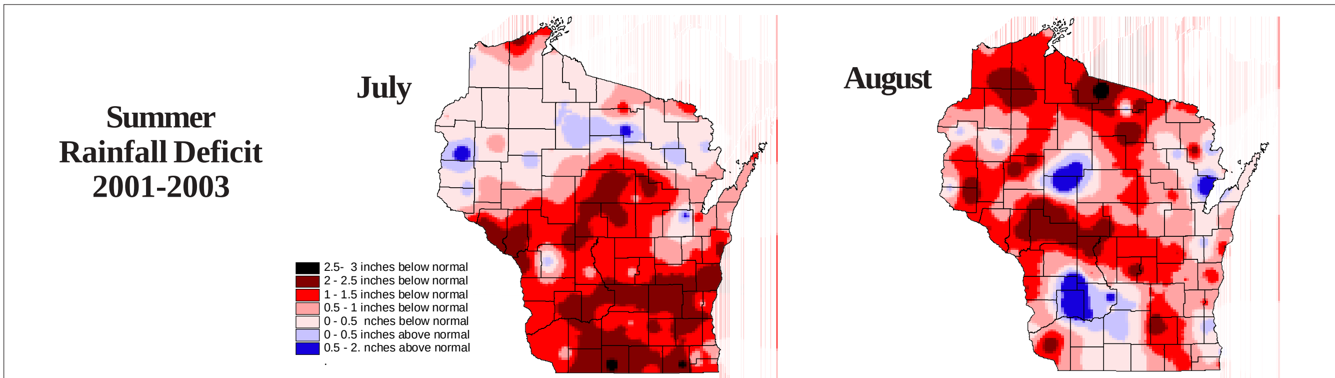
In 2004, the forest health program will be conducting a survey of Wisconsiní s state parks and forests. These areas are at a high risk for introduction of this insect as it is most likely to enter the state via infested firewood. A statewide coordinated effort is also under way to survey nurseries and communities at high risk. Other agencies involved include the Wisconsin Department of Agriculture, Trade and Consumer Protection, USDA Forest Service and Animal Plant Health Inspection Service, and the University of Wisconsin.

Spruce Needle Drop

ó Spruce Needle Drop (SNeeD) is a disease that causes needle and shoot blight on Colorado blue spruce, black hills spruce, and white spruce. Isolating the causal agent has been difficult. A fungus identified as *Setomelanomma holmii* has been found on many of the symptomatic trees, though it is not known if this fungus is causing the disease itself or if it is a secondary pest. Symptoms include needle chlorosis, yellow banding on needles, needle death, needle drop, and twig mortality. Small black fruiting bodies can be found scattered over the twigs and branches in late May and early June. Further research needs to be done on SNeeD to help us understand how this disease affects the trees, if the identified fungus is actually causing the disease, what conditions promote SNeeD, and how itís spread. This disease was first detected in 1998 in Wisconsin and has been found in over 20 counties since then.

Drought - Sphaeropsis and TLCB

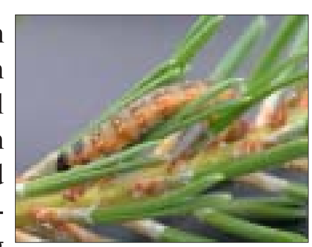
ó Localized areas of the state, including the northwest and west-central areas in particular, received levels of precipitation far below normal for the third year in a row. Oak, already stressed by defoliation by the forest tent caterpillar and gypsy moth, showed signs of stress through dieback and mortality; particularly in the northern and west-central regions. Sites with sandier soils appeared to suffer higher levels of dieback and mortality. Organisms including the



Average precipitation deficit for July (left) and August (right) 2001-2003 compared to 30 year normals. Normal rainfall totals are about 4 inches per month statewide so a deficit of 2 inches is 50% below normal.

two- lined chestnut borer and Armillaria root disease were quick to infest declining oaks. Red pine also showed signs of drought stress late in the fall of 2003. Foliage was beginning to turn red-brown and orange in October in northwest, west-central and southeastern Wisconsin. Investigations revealed the presence of Sphaeropsis shoot blight and canker on drought-stressed trees. This disease is ubiquitous in Wisconsin and progresses more rapidly in drought-stressed red pine. Jack and white pine foliage was also turning brown in late fall of 2003, yet the influence of Sphaeropsis on these species is not as well defined. Bark beetles, often associated with drought-stressed conifers, have not reached outbreak population levels yet. If precipitation levels do not return to normal or above by the spring of 2004, continued mortality of oak, red, white and jack pine is expected, particularly where these species are growing on lower-quality sites.

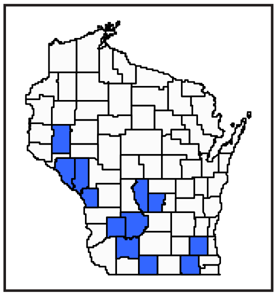
Jack Pine Budworm



Larval stage of the JP budworm

ó In the summer of 2003, moderate defoliation by the jack pine budworm was observed in the Northern Region. Approximately 1,500 acres were defoliated in Burnett and Washburn counties, with small pockets of defoliation in Lincoln, Oneida, and Vilas counties. Larval and pupal surveys also detected a rapid increase in the jack pine budworm population in these areas. Given favorable weather conditions, we should expect more widespread defoliation in 2004 and possibly a full-scale outbreak in 2005. Populations are also increasing in Adams, Clark, Eau Claire, Jackson, Juneau, and Monroe counties. Based on egg mass counts, expect to see light defoliation in Adams and Monroe counties, light to moderate defoliation in Clark, Jackson, and Juneau counties, and light to heavy defoliation in Eau Claire County in 2004.

Annosum Root Rot Update



ó In 2003 two additional counties (Dunn and Waukesha) were confirmed to have Annosum root disease *(Heterobasidion annosum).* This brings the total number of counties with annosum to twelve: Adams, Buffalo, Dunn, Green, Iowa, La Crosse, Marquette, Richland, Sauk, Trempealeau, Walworth, and Waukesha counties. In Wisconsin, annosum root disease has been observed primarily in red pine plantations, occasionally in white pine, and once attacking an individual jack pine. The primary mode of infection for annosum root disease is through freshly cut stumps. Spores land on the stump, germinate and grow through the root system to adjacent healthy trees, causing a ìpocketî of mortality.

A publication outlining the symptoms/signs and management recommendations for annosum can be observed at the following website: www.dnr.state.wi.us/org/land/forestry/fh/fhissues/annosum.htm. For a copy, email:jane.cummings-carlson@dnr.state.wi.us or call 608-275-3273.

Southern Pine Engraver

Introduction/Symptoms:

The lack of precipitation the past couple of years made conditions favorable for an increase in bark beetle populations in red pine plantations in southern Wisconsin. If dry conditions persist additional damage is likely to be observed. The map on the left shows locations in Wisconsin where southern pine engraver was observed causing mortality.

The southern pine engraver, *Ips grandicollis*, is often associated with attacks caused by the more common pine engraver, *Ips pini*. In stands recently observed, the southern pine engraver is initiating attacks in the upper most portions of red pine crowns, killing individual branches (Figure 2) and eventually the entire tree, in the absence of, or prior to, attack by *I. pini.*

Figure 2.The initial attack showing mortality of individual branches in the upper crown of red pine.

Close inspection of dead branches, reveal the nuptial chamber (Figure 3) and gallery mining (Figure 4) caused by the southern pine engraver. As the branches in the upper crown die, the bark beetles then move into the main trunk and eventually girdle and kill the entire tree. As the population builds, adjacent trees are attacked and eventually a ìpocketî of dead trees is created.

Figure 3. Nuptial chamber with gallery tunneling in small branches.

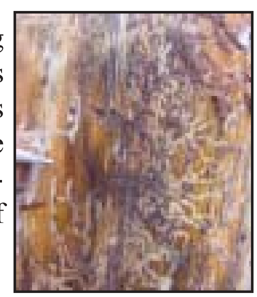


Figure 4. Typical galleries.

Biology:

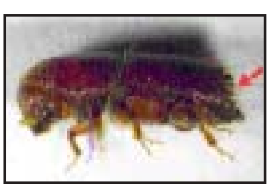


FIgure 5. Southern pine engraver adult.

The adult southern pine engraver overwinters in the duff layer. Note the five projections on back wing cover (Figure 5). In the spring it emerges and seeks out fresh slash, logs, or stressed trees to breed in. The males initiate a reproductive attack and create a nuptial chamber to mate with multiple females. The females create egg niches to lay their eggs. The eggs hatch and small cream colored larvae chew galleries just under the bark layer in the phloem tissue which eventually girdles and kills the tree as shown in the picture above and to the right.

The beetles may go through 2-3 generations per season. Windstorms or summer tree harvesting operations can allow for excessive breeding material and rapid population build up. Dead trees, with loose bark, are no longer suitable breeding material and pose no risk in beetle population buildup.

Management Recommendations:

Maintain stand vigor by avoiding over-stocking and by avoiding over-mature stands.
If low vigor due to drought or defoliation, consider pre-salvage harvest.
Storm-damaged material should be harvested or monitored for build up of the bark beetle population.
Thinning is best done between September and March.
If summer thinning is necessary:

∑ Tops should be utilized down to 2-inch top.
∑ Leave branches attached to stem wood to speed drying.
∑ Remove cut products from stand within 3 weeks of cutting.
∑ Beetle population in slash should be monitored: if dangerous level occurs, mangle bark by driving over it with a tracked vehicle or chip slash.

If a group of trees are attacked, a well-timed harvest of attacked and adjacent low-vigor trees during the growing season may eliminate or help to reduce local populations.

Additional Observations:

Figure 6. Sphaeropsis shoot blight associated with southern pine engraver infested trees. Note the stunted growth of dead shoot tips.

The fungal shoot blight disease, *Sphaeropsis sapenia* (Figure 6), has also been observed attacking these trees and is likely an additional factor in the ability of the southern pine beetle to successfully attack the crown branches Armillaria root rot (Figure 7) and turpentine beetle attacks may also be present in these affected stands.

Figure 7. Armillaria mycelial fan under bark of recent dead red pine tree.

Winter Injury on Conifer Roots

Lack of snow cover and deep frost caused significant damage to the roots of conifer tres especially in the West Central Region. By spring of 2003, affected trees exhibited browning of needles, and branch dieback and mortality. Affected tree species included red, white, jack and scotch pines, cedars, spruces, firs, and yews.

Proportion of Forest Land and Timberland

ó The area of forestland in Wisconsin has been steadily increasing in recent decades and currently stands at 15.7 million acres, representing 46% of the total land area. This is an increase of almost 1 million acres since 1983. The state now has the most forest land it has ever had at any time since the first forest inventory in 1936. Wisconsinís forests are predominately hardwoods, with 84% of the total timberland area classified as hardwood forest types. The primary hardwood forest type in the state has changed from the 1930ís when aspen-birch comprised 40% of timberland (Figure 1). As our forests have aged, these types which dominated on cut-over land have been replaced by later

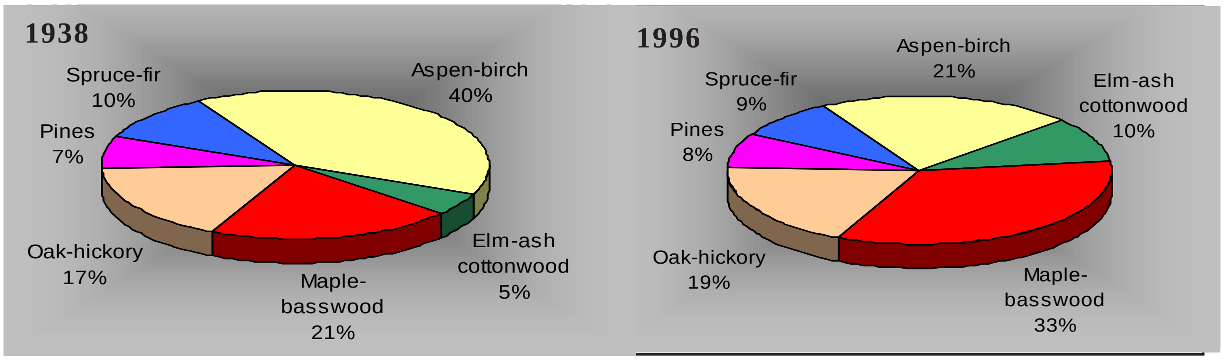


Figure 1. Percentage of timberland by forest type, 1938 and 1996. Data taken from 1938 and 1996 FIA surveys.

successional species such as maple-basswood, and oak-hickory which together account for 52% of timberland acreage.

Timberland is defined as forest land that is producing, or is capable of producing, more than 20 cubic feet per acre per year of industrial wood crops under natural conditions, that is not withdrawn from timber utilization, and that is not associated with urban or rural development.

Ownership of Wisconsinís Timberland

ó Individual private landowners are the largest group of timberland owners in Wisconsin, owning 57% of all timberland in 1996 (Figure 2). Counties and municipalities are the largest group of public owners, holding 15% of the total area of timberland in Wisconsin. The public owns a total of 30% of all timberland. The percentages of ownership have remained relatively constant since the forest inventory in 1956.

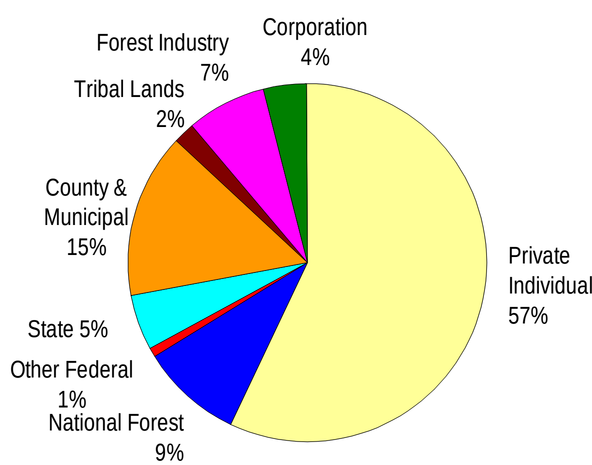


Figure 2. Forest ownership. (1996 FIA data)

Growing-stock Volume of Wisconsinís Timberland

ó Growing-stock volume on timberland in Wisconsin increased from 16.5 billion cubic feet in 1983 to 18.5 billion cubic feet in

1996, reflecting an increase in both area and stocking during the 13 years between inventories. In both 1983 and 1996, hardwoods accounted for $^3/_4$ of all growing-stock volume. Acreage in seedling-sapling stands had been decreasing and acreage in sawtimber stands had been increasing since 1938 reflecting the natural aging of forests since the turn of the century. However, since 1983, the area in young forests has increased and the acreage in sawtimber has decreased, especially in stands over 120 years of age (Figure 3).

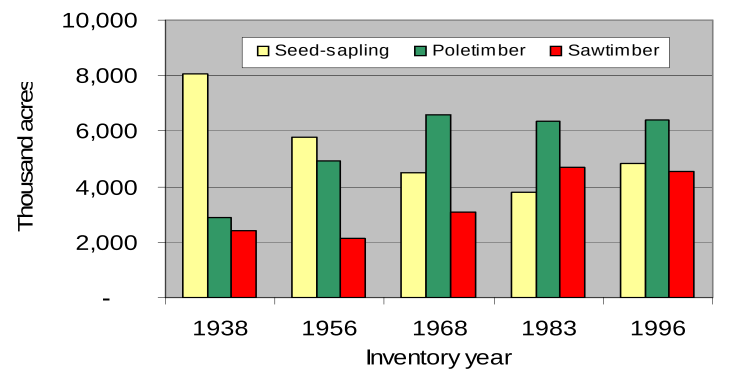


Figure 3. Acreage by size class on timberland in Wisconsin, 1938-1996. Data taken from 1996 FIA survey.

Most Common Species Groups of Wisconsinís Timberland

ó The species groups with the most growing-stock were aspen, red oak, hard maple, and soft maple (Figure 4). The conifer species groups with the most growing-stock in 1996 were red pine and white pine.

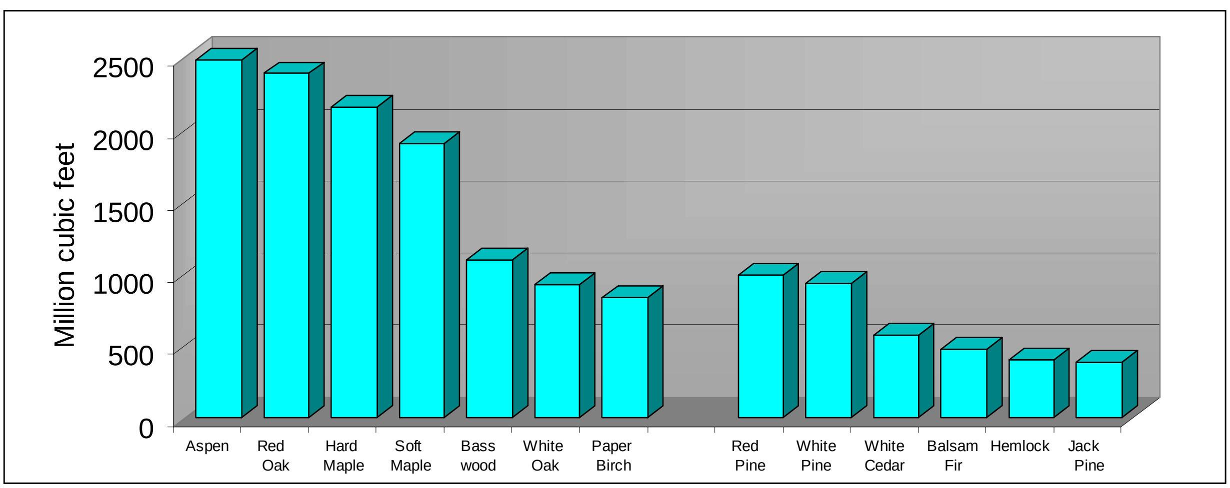
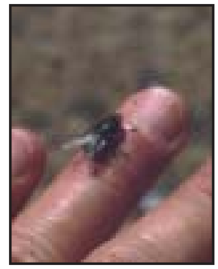


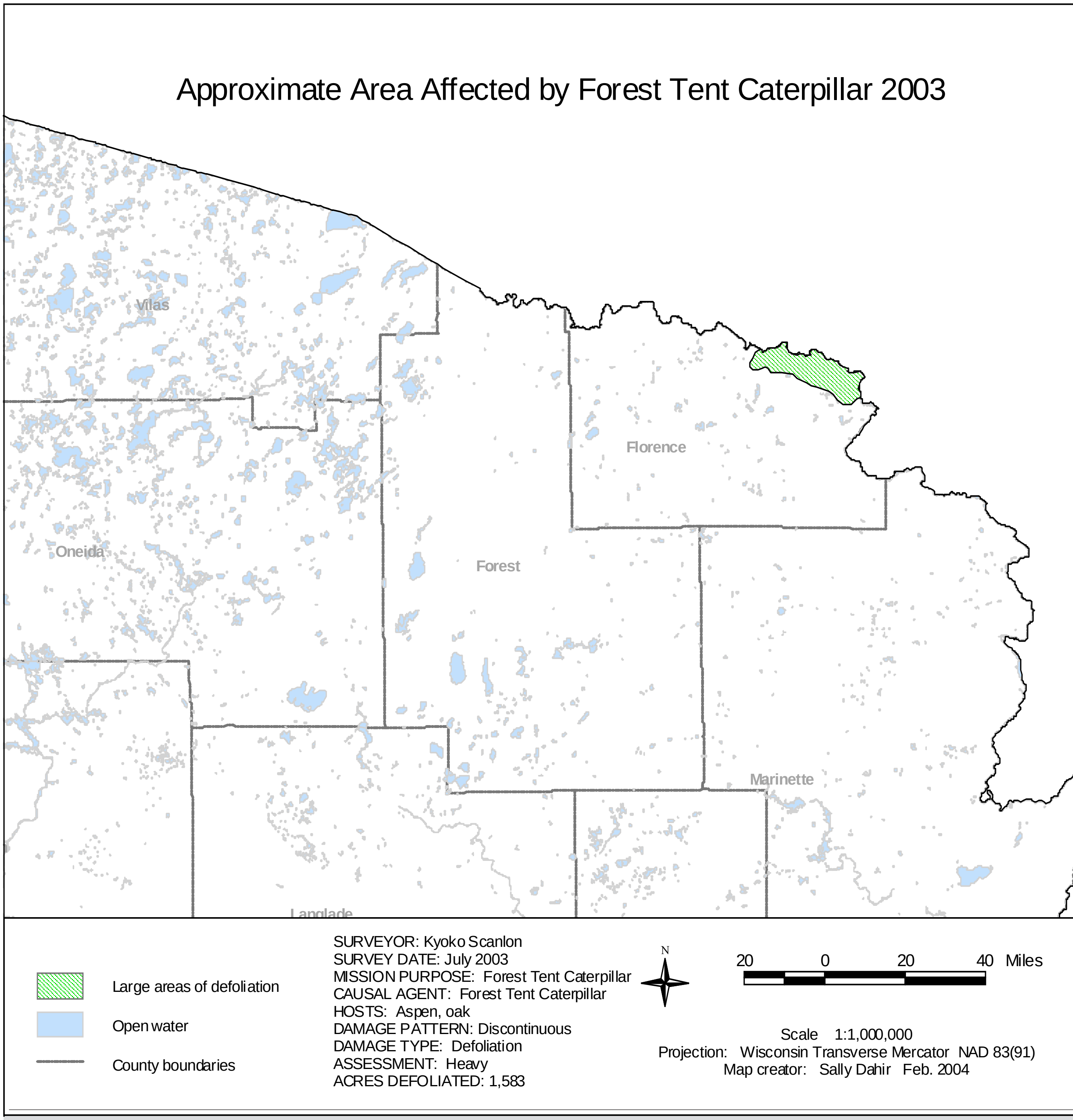
Figure 4. Most common hardwood and conifer species (in million cubic feet) on timberland in Wisconsin. Data taken from 1996 FIA survey.

Forest Tent Caterpillar

ó The outbreak of the forest tent caterpillar (*Malacosoma disstria*) **i**n northern Wisconsin is finally over. There was virtually no defoliation in the northwest, and a few scattered pockets in northeastern Wisconsin. We did, however, have pockets with very high populations of friendly flies (*Sarcophaga aldrichi*). These flies, which parasitize cocoons of the forest tent caterpillar, were abundant in areas that had high caterpillar populations in 2002, especially in parts of Douglas, Bayfield, and Florence counties. Despite the current abundance, populations are down significantly from 2002. These populations will drop even further in 2004 as a result of the steep decline in the numbers of forest tent caterpillars this year.

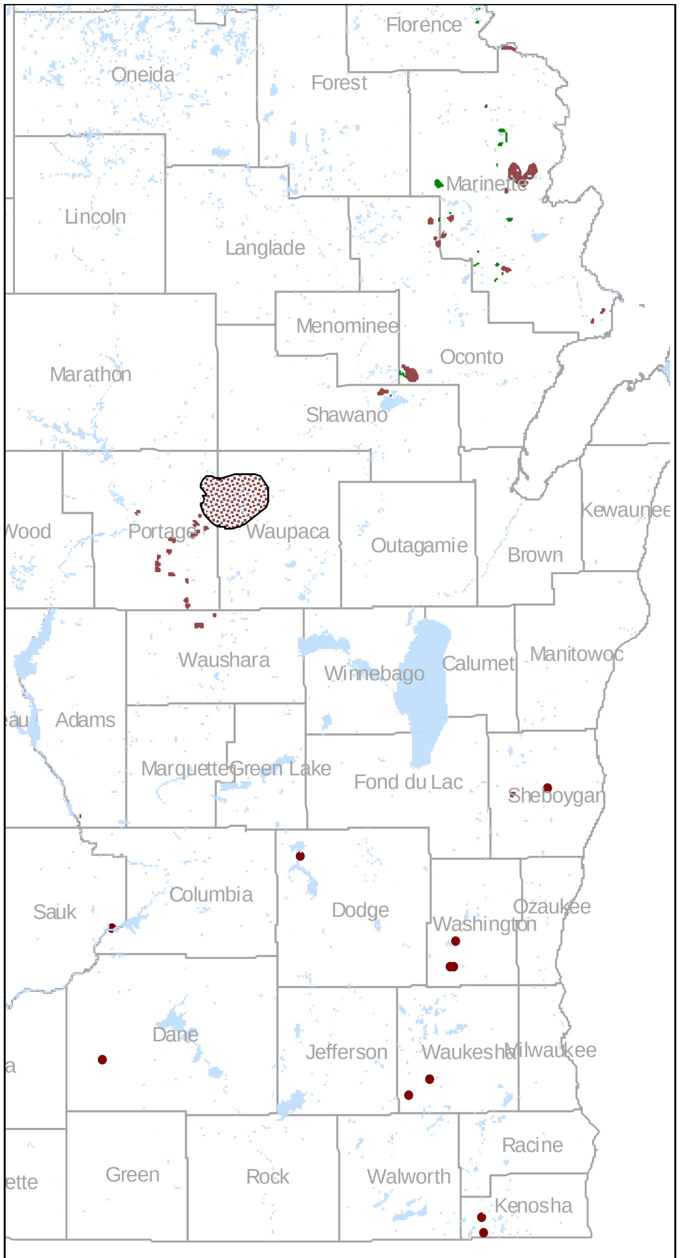


Friendly flies



Gypsy Moth

Bill McNee
Gypsy Moth Specialist Coordinator
Green Bay Wisconsin



In 2003, gypsy moth (*Lymantria dispar*) populations in eastern and central Wisconsin continued the steady increase we have seen in these areas since 2000. Outbreaks caused moderate to heavy defoliation over 65,000 acres this year, up from 24,000 acres in 2002. The intensity and extent of defoliation was reduced in last yearís hotspot, Marinette County (13,000 acres down from 33,000), in part due to poor egg survival. Populations were up dramatically in western Waupaca, eastern Portage, and adjoining areas of Waushara counties which accounted for about 40,000 acres of defoliation this summer. The acreage treated in the suppression program reflected the gypsy moth population increase, 26,000 acres were treated with Bt, up from 6,000 in 2002. Spray treatments were successful in the prevention of defoliation in all but 2 of the 177 treatment blocks (99% success rate).

Results of the trapping program indicate that we can expect to see further increases in the caterpillar population and their defoliation in the central counties of Shawano, Portage, Waupaca, and Waushara in 2004. Florence, Forest and Langlade may have pockets of defoliation. In Marinette and Oconto counties, trap catch numbers are still high and we can expect defoliation but probably in areas that previously had not been heavily defoliated. Populations of gypsy moth in Waushara, Washington, Milwaukee, Kenosha and Racine counties are uniformly high and we can expect defoliation in many communities and wooded areas next June.

SURVEYOR: Bill McNee
Mark Guthmiller
DATE: July 2003
MISSION PURPOSE: Gypsy Moth
CAUSAL AGENT: Gyspsy Moth
DAMAGE TYPE: Defoliation
AGENT(S): Gypsy moth
HOSTS: Aspen, Oak
ASSESSMENT: Very light/moderate/Heavy
PATTERN: Contiguous/scattered
ACRES DAMAGED: 94,755

Highways
County boundary
Open water

Defoliation level
Moderate-Heavy
Scattered light - heavy
Very light-moderate
Defoliation <10 acres

20 0 20 40 Miles

1:1,600,000
Wisconsin Transverse Mercator NAD83(91)
Map creator: Sally Dahir Feb 2004

N

Herbicides as a Treatment to Limit the Underground Spread of Oak Wilt.

Jane Cummings-Carlson
Forest Health Coordinator
Madison WI

Various herbicides have been tested in the Lake States Region over the past decade, as a management tool to limit the underground spread of oak wilt. However, trials using this method of basically forming a root graft barrier to movement of the disease have not had promising results. Several products have been shown to be ineffective in completely killing the oakís root system in a timely manner.

Application of Garlon 4 to girdled tree.

Recent trials conducted in Marathon County have shown promising results with Garlon 4 applied during June. The timing of this application has the benefit of yielding rapid mortality of treated trees. **The use of this product as a root barrier to the movement of oak wilt is still experimental. The following project was initiated to test this procedure.**

During the summer of 2002, symptoms of oak wilt appeared in the Nine-Mile Recreation Area on the Marathon County forest. Isolations confirmed the presence of this disease on 2 sites. County forest officials decided to attack this infection aggressively with an herbicide treatment that has shown promising results in limited trials.

The following plan was developed.

1. All infected trees were cut and removed during the fall and winter of 2002.
2. All trees within grafting distance of infected trees were treated with Garlon 4 during June of 2003. Johann Bruhnís model was used to determine which trees were likely to be grafted to known infected trees.
3. Each treated tree was girdled twice with a chain saw at approximately 1-2' above the root collar. Garlon 4 was applied to the girdle and on the bark down to the root collar.
4. Treated trees were removed during the fall/winter of 2003'-î04.

Herbicide treatment resulted in quick mortality giving promising results.

During the summer of 2003, two additional infected trees were observed on one of the sites. These trees were likely infected through underground spread. Analysis showed that the herbicide treatment should have been applied to these 2 trees during the 2003 treatment. They had not been treated because of a slight miscalculation of the Bruhn model. During the summer of 2004, this site will be reevaluated and any trees potentially grafted to the newly infected trees will be treated with Garlon 4.

Drought Stress: Sphaeropsis and Two-lined Chestnut Borer

Jane Cummings-Carlson
Forest Health Coordinator
Madison WI

Two major weather phenomena are working in concert with several organisms to affect the health of Wisconsinís oak and pine resource. The two weather factors include:

1) a continuation of a 10-15 year trend of higher minimum temperatures, especially for the winter season
2) a dramatic decrease in precipitation in all regions except the northeast.

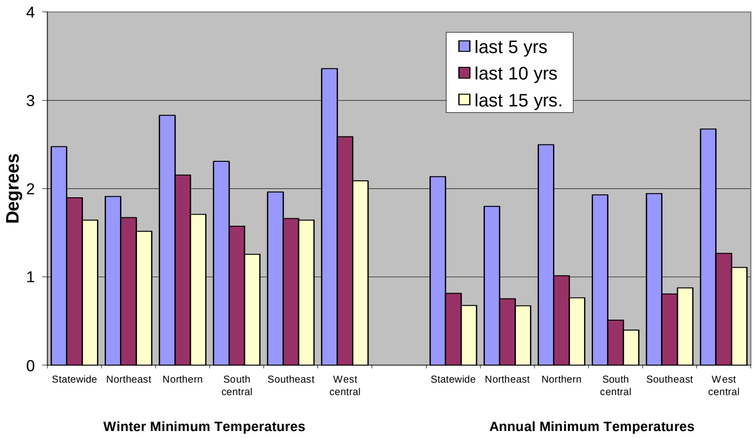


Figure 1. Degrees above normal (1960-2003) for average minimum temperatures in the last 5, 10, and 15 year periods.

Both the increased minimums and decrease in precipitation were worse in the west-central and northern regions than elsewhere in the state (Figure 1). These 2 regions make up the bulk of forestland in Wisconsin, with 52% or 8.2 million acres in the northern region and 24% or 3.8 million acres located in the west-central region. It is also important to notice that the increase in the last 5 years from 1999-2003 has risen more steeply than for the preceding period, especially for the annual minimum temperatures. For instance, the average annual minimum increased 163% in the last 5-year period compared to the last 10 years, whereas the average minimum increased only 20% for the last 10-year period compared to the last 15. This trend is also true but to a lesser degree for winter minimums (30% and 15% respectively). This may indicate that the trend is accelerating, though minimum temperatures this winter (2003-2004) have been near normal.

Also, precipitation this summer has lagged far below normal, with a 4-inch average deficit for the state and as high as 7 inches below normal for the west-central region (Figure 2). Only the northeast region had fairly normal amounts of precipitation.

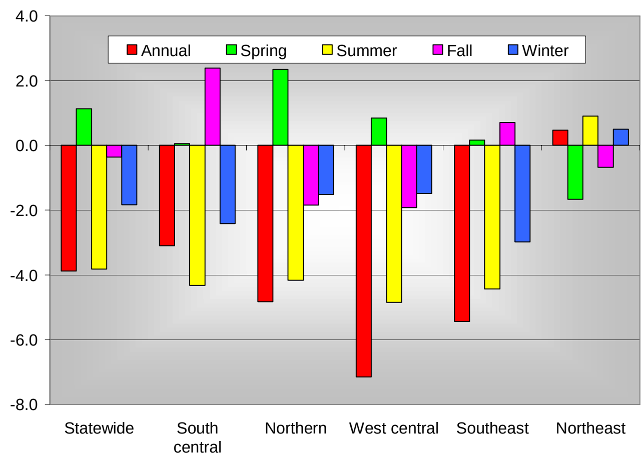


Figure 2. Departure from normal precipitation (inches) by region.

Populations of the two-lined chestnut borer (*Agrilus bilineatus*) have been building, particularly in northern Wisconsin, as a result of repeated defoliation by the forest tent caterpillar (*Malacosoma disstria*) and in central Wisconsin as a result of defoliation by the gypsy moth (*Lymantria dispar*). The two-lined chestnut borer has long been recognized as an insect that infests oaks under stress from moisture deficit. Populations of this insect remain low during times of normal precipitation; the borer maintains low levels by infesting low vigor oaks. Outbreaks of this insect occurred during the last two major droughts which occurred in 1976 and from 1988 to 1990. Stands where harvest activities occurred during years of peak defoliation and drought were particularly susceptible to mortality.

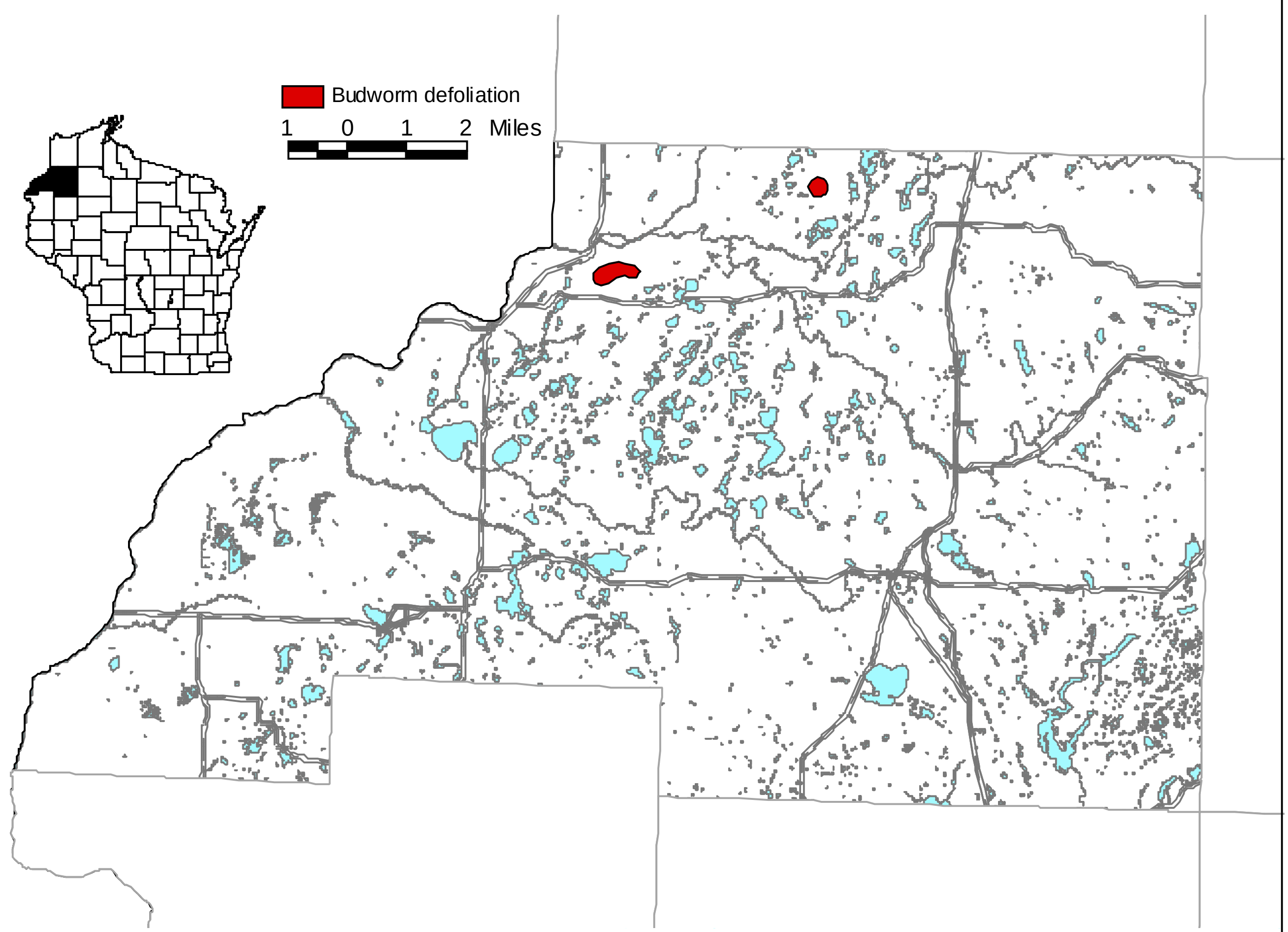
The drought is also beginning to impact white, red and jack pine. Seedlings and saplings on drier sites started to turn red-brown and orange in September and October followed by larger trees fading in October and November. Field examination revealed infestation by *Sphaeropsis sapinea* shoot blight and canker in the crowns of some of the declining trees. Bark beetle populations, often associated with drought-stressed conifers, have not reached outbreak levels but if dry conditions continue in 2004, populations are expected to build.

ó This summer, a moderate defoliation by the jack pine budworm was observed in the Northern Region. Approximately 1,500 acres were moderately defoliated in Burnett and Washburn Counties, and pockets of defoliation were seen in Lincoln, Oneida, and Vilas Counties. Larval and pupal surveys also detected a rapid increase in the jack pine budworm population in Bayfield and Douglas Counties as well as the counties that showed visible defoliation. If weather patterns favor the survival of this insect, we should expect a much more widespread defoliation in 2004 and a full-scale outbreak may be possible in 2005.

Jack pine budworm is native to North America and its population periodically reaches the outbreak level. The last major outbreak of the jack pine budworm in Wisconsin occurred in the early 1990ís. In 1993, the insect defoliated 400,000 acres of jack pine in northern and central Wisconsin, more than æ of the stateís jack pine.

Larval feeding of needles can cause growth loss, top kill, and tree mortality. Stands older than 45 years that are growing on very sandy sites under stressed conditions, due to over- or understocking or drought, are particularly vulnerable to damage.

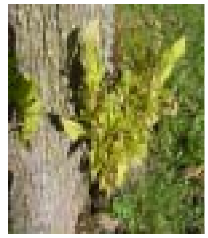
Jack Pine Budworm Defoliation in Burnett and Washburn Counties 2003



Minor Issues

Ash Yellows - Phytoplasma

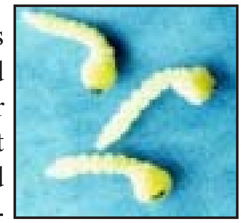
ó Ash yellows, caused by a phytoplasma, was confirmed in 2 new counties, Jefferson and Dodge, in 2003 (see map). Confirmation of infection was based on the presence of brooms along the lower portion of the infected treesí stems. Ash yellows has now been confirmed in 13 counties. This disease is typically more common in urban settings or in woodlots bordering agricultural fields.



Brooms are indicative of ash yellows which was confirmed for the first time in Jefferson and Dodge counties this year (shown in black on the map).

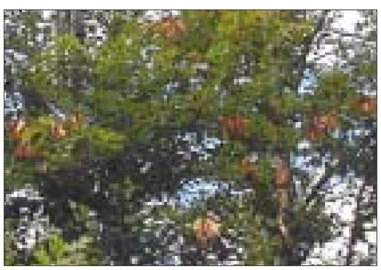
Flat Headed Apple Tree Borer on Ash

ó A declining ash tree was observed in Dane County with S-shaped galleries similar to those of emerald ash borer. The exit holes were more oval-shaped then the D-shaped emerald ash borer exit holes. A flatheaded appletree borer (*Chrysobothris femorata*) was reared from a branch of this tree. The host tree species of this insect include apple, hickory, walnut, oak, elm, maple and numerous others. Identification of the beetle was done by Phil Pellitteri, extension entomologist, at the University of Wisconsin-Madison.



A brief article on this borer is available at: http://www.ext.vt.edu/departments/entomology/factsheets/flatbore.html

Oak Tip Flagging

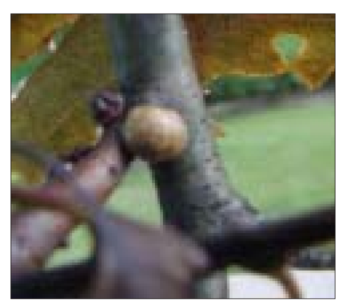


Oak trees with tip dieback create green & brown two-tone appearance on the crown

ó This summer you may have noticed that many northern red and pin oak trees had brown leaves at the tips of their branches. Though wilted and browned, the leaves were still attached to the tree. This tip flagging was observed scattered throughout the tree and usually within 12 inches of the tip of a twig.

Two common causes of this leaf flagging were identified: the fungus, *Botryosphaeria quercuum,* and one of several scale insects including Kermes species. Twigs infected with *Botryosphaeria quercuum* had blackened and cracked bark with dark streaks underneath. Damage caused by this fungus typically does not extend more than 6 inches down the twig, and should not cause serious harm to the health of a tree. This problem occurs cyclically, and usually lasts only a year or two.

Several different types of scale insects were found on affected twigs, but the Kermes scale (right) was most common. Female Kermes scales are light-brown and globular. Females are immobile and often clustered near buds of a twig or branch. These scales feed on sap causing a loss of plant vigor and growth, as well as twig dieback. While a heavy infestation may cause young trees to be stunted or deformed, natural enemies are usually plentiful and control is not necessary.



Kermes scale

Frost Related Oak Tatters Injury in Southern Wisconsin

In recent years, tattered leaf symptoms have been periodically showing up on oaks in the spring and early summer. This phenomenon is called ìoak tattersî and has been observed in many states in the Midwestern United States. The

Figure 1. Early frost injury to expanding oak leaves.

cause of damage has not been confirmed but three possible causes include bud or leaf-tissue damage due to low temperatures at time of leaf expansion, possible insect feeding, or herbicide injury. Observations made in the spring of 2003 in Dane County, Wisconsin, strongly concurs with the theory of low temperature related tissue damage to buds and expanding leaves.

On May 21st and 22nd , 2003, temperatures dropped into the low 30ís throughout Wisconsin. On May 24th frost injury was observed on newly expanding leaves on bur oak and other tree species in southern Dane County (Figure 1). Observations were made on the same trees over the next few weeks as the oak tatter symptoms started to appear (Figure 2). As previously observed by others, some trees developed more severe symptoms then other adjacent trees. This is likely due to differences in leaf phenology between these trees at the time of the frost event. Other tree species in the area also showed signs of frost injury and included ash, black locust, cherry, elm, mulberry, silver maple, and walnut.

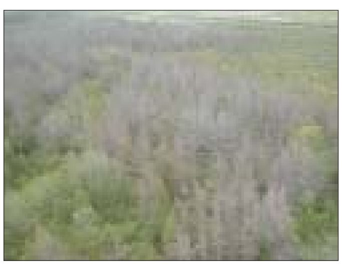
Figure 2. Different levels of symptoms on adjacent trees are often observed.

Additional information on oak tatters may be found at:

Forest service web site: http://www.na.fs.fed.us/spfo/pubs/pest_al/oaktatters/oaktatters.htm

Wisconsin DNR web site: http://www.dnr.state.wi.us/org/land/forestry/FH/fhissues/tatters.htm

Tamarack mortality



Tamarack defoliation in Sheboygan

ó Thousands of acres of dead 80 year-old tamarack were observed in the Sheboygan Marsh in northwest Sheboygan County. Eastern larch beetle, *Dendroctonus simplex*, was observed on the trees. Apparently healthy trees were scattered among dead ones. There was no evidence of bark beetles, needle feeders (including larch sawfly, larch casebearer, or gypsy moth), or fungal infection. Earlier in the year, the water level in the marsh had been lowered in order to manage weeds. Given the large area of tamarack death and decline, this may have been a key factor in tree mortality.

Other Pests Reported in 2003

Pest	Host	Damage	Location
Ash			
Anthracnose *(Gnomoniella fraxini)*	Green & white ash	Moderate levels of necrotic lesions with some premature leaf fall	All of northwest Wisconsin, Waukesha and Milwaukee counties
Ash plant bug (*Tropidosteptes amoenus*)	Green ash White ash	Leaf damage	Waukesha, Milwaukee, Washington Co. Counties
		Moderate to heavy stippling with some necrosis and leaf drop	Washburn and Sawyer counties
Ash leaf drop: cause unknown	Ash	Numerous reports of leaf drop in late May	Dane County and other parts of the state Brown, Einnebago, & Kewaunee counties
		Premature green leaf drop late summer	Scattered in West Central Region
Clearwing ash borer	Ash	Girdling	Outagamie County
Meadow vole *(Microtus pennsylvanicus)*	White ash planting	Chewing and girdling trees	Dane County
Woolly ash aphid *(Prociphilus fraxinifolii)*	Ash	Defoliation	Brown and Oconto counties
Mountain ash sawfly (*Pristiphora geniculata*)	Mountain ash	Partial defoliation	Milwaukee County
Aspen			
Aspen blotch miner *(Phyllonorycter spp.)*	Quaking aspen	Heavy mining conspicuous discoloration in small trees low in crowns of large trees.	Sawyer, Rice, Rusk, Ashland & Iron counties
Forest tent caterpillar *(Malacosoma disstria)*	Aspen	Moderate to heavy defoliation	Florence, Forest, Vilas & Marinette counties
		Complete population collapse	Northwest region
Poplar borer *(Saperda calcarata)*	Aspen	Branch dieback to tree mortality	Jackson County
Balsam Fir			
Armillaria/bark beetles	Balsam Fir	Elevated levels of mortality common	Washburn, Burnett and Douglas counties
Fir needle rust *(Uridinopsis spp.)*	Balsam Fir	Blisters on needles	Eau Claire County
Hail damage	Balsam fir	Flagging with wounds on upper twig surface	Florence Co.
Basswood			
Introduced basswood thrips *(Thrips calcaratus)*	Basswood	Light to moderate defoliation	Florence, Forest, and Oneida counties
Linden borer *(Seperda vestita)*	Basswood	Girdling	Brown County
Birch			
Bronze birch borer *(Agrilus anxius)*	White birch	Top dieback and tree mortality	Oneida,Vilas & Marinette counties
		Minor increase in mortality on sandy sites	Douglas & Bayfield counties
Drought	White birch	Premature leaf color & drop	S Washburn, Burnett, Polk, Barron counties
Dusky birch sawfly *(Croesus latitarsus)*	White birch	Localized heavy defoliation	Burnett County
Fall webworm *(Hyphantria cunea)*	White birch	Localized feeding damage by nests	Dane County

Pest	Host	Damage	Location
Cherry			
Black knot *(Apiosporina morbosa)*	Black cherry	Prevalent in ornamental Canadian cherry	Sawyer, Price and Washburn counties
Fall webworm *(Hyphantria cunea)*	Black cherry	Localized feeding damage by nests	Rock County
Eastern tent caterpillar *(Malacosoma americanum)*	Choke & Pin cherry Crabapple	Extremely high populations	N Washburn & sS Douglas counties
		Defoliation	Scattered throughout the West Central and Southeast regions
Green Pouch Galls *(Eriophid mite sp.)*	Black Cherry	Green Pouch Galls	Rock County
Christmas trees			
Rhizosphaera needlecast *(Rhizosphaera kalkhofii)*	Balsam & fraser fir	Needle discoloration and needle loss	Oneida Co.
Crab Apple			
Eastern tent caterpillar *(Malacosoma americanum)*	Flowering crab	Defoliation of the trees.	Scattered throughout the West Central and Southeast regions.
Winter injury	Flowering crab	Leaves curled & dropped in spring, trees did not reflush	Scattered throughout the West Central Region
Elm			
Dutch elm disease *(Ophiostoma ulmi)*	Elm	Tree death	Scattered throughout the West Central and Northeast regions
Fall webworm *(Hyphantria cunia)*	Elm, tag alder	Low prevalence, minor defoliation	Sawyer, Price, Rusk & Taylor counties
Hemlock			
Winter injury	Eastern hemlock	Moderate to severe discoloration of needles in lower crown & small trees	Sawyer & Price counties
Hickory			
Hickory bark beetle *(Scolytus quadrispinosus)*	Hickory sp.	Branch dieback and tree mortality	Dane County
Leafstem gall adelgid *(Phylloxera caryaecaulis)*	Shagbark hickory	Branch galls and branch dieback	Jefferson, Lafayette counties
Phomopsis gall *(Phomopsis spp)*	Hickory spp	Galls on branches causing some branch dieback	Crawford, Sheboygan and Racine counties
Maple			
Anthracnose	Red & sugar maple	Very heavy leaf spotting	Washburn, Polk & Burnett counties
Bruce Spanworm *(Operaphtera bruceata)*	Maple	defoliation	Shawano County
Fall webworm *(Hyphantria cunia)*	Many hardwoods	Webbing of branches and light defoliation	Scattered throughout the West Central region
Leaf blister *(Taphrina spp.)*	Maple	Black necrotic tissues on leaves	Throughout northeastern Northern Region

Pest	Host	Damage	Location

Pine (continued)

White Pine Weevil *(Pissodes strobi)*	Jack, Scotch, and White Pines	Terminal leader killed on open grown saplings. Open grown Jack Pine was preferred over white pine in the same area.	Scattered throughout the WCR.
	White pine	Terminal leader mortality in a young open grown stand	Waupaca County
Winterburn	Red, white & jack pine	Severe discoloration of 1-3 year old seedlings with excellent recovery	Scattered in Northwest region
Zimmerman Pine Moth *(Dioryctria zimmermani)*	Jack, red, scotch, white pine	Pitch flows & some decline in vigor	Scattered in West Central Region.

Spruce

Eastern spruce gall adelgid *(Adelgis abietis)*	White spruce	Galls	Door County
Pitch mass borer *(Vespamima pini)*	Norway spruce	Pitch masses on trunk, some deline in vigor	LaCrosse & Wood counties
Rhizosphaera needlecast *(Rhizosphaera kalkhoffii)*	Blue spruce	Needle browning	Brown, Oconto,& Marinette counties
Winterburn	White spruce	Severe discoloration of first year plantings with considerable mortality	Polk County
Yellowheaded spruce sawfly *(Pikonema alaskensis)*	White spruce	Light to heavy defoliation	Lincoln and Vilas Cos.

Tamarack

Larch bark beetle *(Dendroctonus simplex)*	Tamarack	Populations are declining but still producing elevated mortality	Price, Sawyer & Washburn counties
		Extensive death/decline	Sheboygan Marsh, Sheboygan, Waupaca, Brown, Fond du Lac& Langlade counties
Larch casebearer *(Coleophora laricella)*	Tamarack	Moderate defoliation	Oneida Co.
Larch needlecast *(Micosphaerella laricina)*	European larch	Present on only ~15% of trees with an average 30% defoliation	Polk County

Walnut

Fall webworm *(Hyphantria cunea)*	Black Walnut	Numerous nests present on many individual trees	Lafayette County
Pecan leaf casebearer *(Acrobasis juglandis)*	Walnut	Black cone-shaped cases on the leaf stem	Oneida Co.
Rose chafer *(Macrodactylus subspinosus)*	Black walnut	reported feeding on leaves	Richland County

Willow

Willow sawfly *(Nematus ventralis)*	Willow	Defoliation	Eau Claire County
Imported willow leaf beetles *(Plagiodera versicolora)*	Willow	Moderate defoliation	Oneida County

Abiotic factors

Hail damage	Red pine	Wounding of branches & bark scales knocked off of the trunk	Crawford County
Winter root injury	Pine, cedar, spruce, fir, yew	Brown needles, dieback, mortality	Throughout West Central Region

Jack Pine Budworm Survey Procedures and Results: 2003

Shane Weber, DNR Forest Entomologist
Dept of Natural Resources
Spooner, Wisconsin

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 shots are usually used. A count of 10 or more infested shoots and flowers is considered sufficient to cause moderate to severe defoliation.

Early Larval Populations

County	No. Plots	No. Infected Shoots	Infected Shoots/ Plots	No. High Plots	% High Plots
Polk	15	2	0.13	0	0
Burnett	24	17	0.71	1	4.2
Washburn	21	4	0.19	0	0
Douglas	54	26	0.48	0	0
Bayfield	32	19	0.59	0	0
District	**146**	**68**	**0.47**	**1**	**0.7**

Early Larval Population Trends

	No. Infested Shoots/Plot						% High Plots				
County	1999	2000	2001	2002	2003	%Change 2002-2003	1999	2000	2001	2002	2003
Polk	2.60	2.47	6.00	0.60	0.13	**-78**	13.3	6.7	26.7	0	0
Burnett	1.29	1.08	0.83	0.63	0.71	**+13**	4.2	0	0	0	4.2
Washburn	6.57	0.24	0.52	0.52	0.19	**-63**	28.6	0	0	0	0
Douglas	4.17	0.36	0.28	0.35	0.48	**+37**	9.3	0	0	0	0
Bayfield	1.63	0.09	0.13	0.16	0.59	**+269**	0	0	0	0	0
District	**3.32**	**0.62**	**0.97**	**0.40**	**0.47**	**+18**	**9.6**	**0.7**	**2.8**	**0**	**0.7**

Jack Pine Budworm 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 yearís 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 5 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.

2003 Pupal Survey

				Moths		Parasites		Not Emerged	
County	**Total Pupae**	**Total Minutes**	**Pupae/ Min**	**No.**	**%**	**No.**	**%**	**No.**	**%**
Polk	8	75	0.11	4	50.0	4	50.0	0	0
Burnett	72	135	0.53	49	68.1	14	16.4	9	12.5
Washburn	70	135	0.52	44	62.9	21	30.0	5	7.1
Douglas	168	330	0.51	109	64.9	50	29.8	9	8.3
Bayfield	94	190	0.49	72	76.6	19	20.2	3	3.2
District	**412**	**865**	**0.48**	**278**	**67.5**	**108**	**26.2**	**26**	**6.3**

Pupal Population Trends

County	2000 Pupae/min	2001 Pupae/min	2002 Pupae/min	2003 Pupae/min	%Change 2002-2003
Polk	0.74	0.57	0.28	0.11	-61
Burnett	0.21	0.31	0.30	0.53	+77
Washburn	0.07	0.13	0.11	0.52	+373
Douglas	0.05	0.13	0.23	0.51	+122
Bayfield	0.01	0.03	0.08	0.49	+513
District	**0.15**	**0.19**	**0.20**	**0.48**	**+140**

Jack Pine Budworm 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 the University of Wisconsin for identification. Pupal cases from which nothing emerges are dissected to ascertain the cause of failure.

Parasite/ Predators	Polk	Burnett	Washburn	Douglas	Bayfield	Total	% of Parasitized	% of Total
Itoplectes	2	4	7	21	8	42	38.9	10.2
Scambus	0	1	1	2	0	4	3.7	1.0
Phaogenes	0	0	1	2	0	3	2.8	0.7
Pteromalids	0	0	3	5	1	9	8.3	2.2
Tachinids	2	6	4	10	3	25	23.1	6.1
Predators	0	3	5	10	7	25	23.1	6.1
Total	**4**	**14**	**21**	**50**	**19**	**108**	**100**	**26.3**

Survey Results for Entomophaga miamiaga , NPV and Parasitic Flies

Affecting Gypsy Moth Populations in Portage, Waupaca, and Waushara Counties- 2003

Mark Guthmiller
Microbiologist Sr.
(former Regional Gypsy Moth Suppression Coordinator)
Wisconsin Dept. of Natural Resources

Introduction

The gypsy moth population has been on the increase the past few years in the central sands area of Portage, Waupaca, and Waushara Counties. Approximately 20,000 acres of moderate to heavy defoliation occurred in these three counties in 2003. As the late instar larval development was reached by the gypsy moth, numerous calls from landowners were received with reports of caterpillar mortality. The reports were coming in from both areas with high gypsy moth populations as well as areas thought to have low populations. A survey was conducted on July 15^{th} and 16^{th} to determine the cause of larval mortality in these areas.

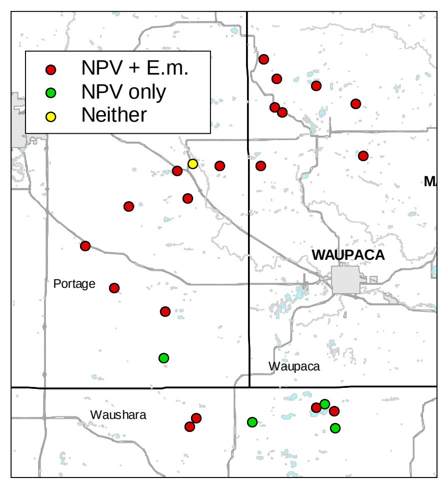
Methods

A roadside survey was conducted using both aerial survey location data showing areas of defoliation as well as random stops in the three county area. Twenty-four locations were sampled for the presence of the fungal disease, *Entomophaga maimaiga,* and the viral disease NPV (Nucleopolyhedrosis Virus). In addition, notes were taken on the presence of parasitic flies and adult male and female gypsy moths. The results are presented in table 1 below and on the map provided.

The presence of *E. maimaiga* was confirmed from dead larvae. The larvae were microscopically examined for the presence of conidia or the over-wintering azygospores of *E. maimaiga*. NPV was confirmed based on the condition of dead larvae. If the larvae died hanging head down and were of a liquid consistency or dried up with a ìmilky coral likeî pattern on the back of the larva, it was considered positive for NPV.

Results

Both *E. maimaiga* and NPV were present together at 19 of 24 survey sites (see map on the right). At four sites *E. maimaiga* was not confirmed but NPV was present. Two of the ìNPV onlyî sites had a very low-level gypsy moth populations. *E. maimaiga* or NPV were not detected at only one site (site #15). This particular site had heavy defoliation and many flying male moths. Five of the 24sites had adult male moths present and only one site had a single female moth present. Flies and/or maggots were observed on gypsy moths at 10 of 24 sites. Flies clustering on dead larvae from one collection site were identified as a *Sarcophagidae* in the genus *Sarothromyia*. This family of flies is considered parasitic on burrowing hymenoptera, turtles, and lizards. These flies may be secondary parasites of the gypsy moth larvae[1] . A more extensive survey, identification, and study of these flies may be of value. The role these flies are playing may be useful in future control efforts of gypsy moth.



Discussion

The widespread heavy mortality of gypsy moth in Portage, Waushara, and Waupaca Counties appears to be the result of a combination of the fungal disease *E. maimaiga* and the viral disease, NPV. The role of the parasitic flies

[1] Identification and comment from Steve Krauth, Distinguished Academic Curator, Insect Research Collection, Dept. of Entomology, University of Wisconsin, Madison.

Table 1. Results of survey for the presence of *E. maimaiga*, NPV, parasitic flies, adult male and female gypsy moths. The survey was conducted July 15-16, 2003.

Site	E. maimaiga only	NPV only	Both E.m & NPV	Flies or maggots	Adult Males	Adult Females	Comments
1		X					Low population, no live larvae
2			X	X			No live larvae or pupae
3		X		X			No live larvae or pupae
4			X				No live larvae or pupae
5		X					Low population, no live larvae
6			X	X			No live larvae or pupae
7			X	X			Some live larvae and pupae
8		X					A few live larvae
9			X	X			Wolf Lake treatment site, Sarothromyia fly collected here, some live larvae, no noticeable defoliation
10			X				No live larvae, no pupae present
11			X				No live larvae or pupae
12			X	X			Standing Rock Co. Park treatment site, some live larvae
13			X	X			No live larvae or pupae
14			X	X			No live larvae or pupae
15					Many		Heavy defoliation with many male moths flying, no larval mortality in center of infestation
16			X				No live larvae or pupae
17			X				Some live larvae and pupae, no males flying
18			X	X			Some live larvae and pupae, no adult males flying
19			X		Many		No females present
20			X				A few live larvae, no moths flying
21			X		Many		No live larvae
22			X	X	Many		Some live pupae and larvae
23			X		Many	1	Some live pupae
24			X				Some live pupae, no live larvae, no flying males

is uncertain and may be worth more investigations into the role it plays in the gypsy moth population.

NPV is most often associated with very high gypsy moth populations. The fact that NPV was also present in areas with relatively low populations may indicate that *E. maimaiga* is the primary factor reducing the health of the gypsy moth population and allowing for the virus to attack. In a few instances both the virus and fungus were present on the same larva. The absence of *E. maimaiga* at four sites that did show NPV may have been the result of a small sample size or may simply have been missed. If *E. maimaiga* was not actually attacking larvae at these four sites, the micro-climatic conditions of the site may not have been conducive for fungal growth or the fungus was not yet present.

Although large numbers of male moths were flying at five of the sites, only one female was found at one of the 24 sites. The timing of the survey may have played a role in the lack of adult females observed. It is also possible that many of the late instar larvae observed dead were females that, due to the extra required molt, were more at risk for disease infection and unable to complete growth to the adult stage.

Sample sites 9 and 12 were taken at the 2003 gypsy moth suppression treatment locations. The Wolf Lake County Park (site # 9) site did not have any noticeable defoliation. Standing Rock County Park (site #12), based on aerial survey had a small area of approximately 30 acres with light defoliation on the north end of the spray block. The lack of defoliation or only minor defoliation may or may not indicate a successful aerial treatment program. It is hard to separate out affects of Gypchek treatment with those of naturally occurring biological control organisms, *E. maimaiga* and NPV at these sites. Based on the number of larger late instar larvae that were dead or still alive brings into question the efficacy of the Gypchek[1] aerial treatments.

This survey indicates a major crash in the gypsy moth population in Portage, Waupaca, and Waushara Counties. *Entomophaga maimaiga* is well established in these areas and will continue to play a major role in reducing gypsy moth populations, especially in years with wet cool spring weather. Isolated high populations of gypsy moth appear to still exist based on male moth flight. A better predictor of potential defoliation next year would require egg mass surveys to detect currently viable populations in this area.

[1] Gypchek is an insecticide containing the gypsy moth NPV virus and is produced by the Forest Service.

Results from the Third Sampling of on the Sauk County Forest 2002 Stump Treatment Trial

MarkGuthmiller
Microbiologist Sr.
Wisconsin Dept. of Natural Resources

Introduction

The Sauk County Forest has been the site of on going research related to the control of annosum root disease (*Hetrobasidion annosum*). Freshly cut stumps just outside the perimeter of known annosum infections were treated with the bio-control fungus, *Phlebiopsis gigantea,* to create a barrier to prevent root to root spread of annosum root rot from infected stumps to adjacent healthy stumps and trees (see photo on the right). Detailed methods and results of previous work can be found in the masters thesis by Crystal Floyd, ìBiological Control of Root Rots in Forests Using Fungiî, University of Minnesota, December 2002. Additional information on the Sauk County Forest research can be found in the previous ìForest Health Conditions in Wisconsinî (WI DNR 2000, 2001, 2002).

Methods

For the third sampling, four stumps from each of 15 infection centers (or group of infection centers) were sampled in approximately the north, south, east, and west quadrant of the infection center. A large piece of wood (~10cm x 5cm x 3cm) was cut from each of the 60 designated monitoring stumps using a chainsaw (see photo on the left). Fourteen infection centers were in red pine (*Pinus resinosa*) and one infection center in white pine (*Pinus Strobus*). Samples were collected July 2nd, 2003.

In the lab, two samples were taken from each stump piece using a sterile scalpel. All samples were taken just below the inoculation site (just below stump surface). Each of these pieces were divided into three parts (~1mm x 1mm x 5mm) and plated on BSA media. Approximately one week later, any fungi that grew out from these pieces were transferred to MYA media and incubated for one more week. The MYA cultures were then confirmed for the presence of *P. gigantea* by fungal morphology and presence of spores.

Results

In the third sampling (~50weeks), the percent of stump colonization (table 1) by *P. gigantea* was 29% (103 of 360 pieces plated). Although the percent colonized was 29%, the incidence of *P. gigantea* occurring on a stump was 45% (27 of 60 stumps).

Table 1*. Percent stump colonization by *Phlebiopsis gigantea* in three biocontol trials.

Sites	6-8 weeks	12-13 weeks	50 weeks
West Arena	10%	43%	77%
Sauk County Forest (SCF1)	6%	44%	23%
Sauk County Forest (SCF2)	16%	49%	**29%****

*Data summary from Crystal Marie Floyd, Biological Control of Root Rots in Forests Using Fungi, December 2002 M.S. Thesis, University of Minnesota, Plant Pathology Department.
**** Data added to this summary from results of this third sampling**

Based on recovery results, this third sampling had significantly more stump colonization in the south, east and west quadrants then the north quadrant (table 2). Recovery results from the 2nd sampling (SCF2) also indicated (personal communication, Crystal Floyd) better recovery from south, east and west aspects.

Table 2. Percent recovery of *P. gigantea* from the 103 positive samples (by quadrant).

South	East	West	North
40%	33%	21%	6%

Discussion

The percent recovery of *P. gigantea* from this third sampling was consistent with the third sampling of a previous trial (SCF1) a year prior. After one winter (~38weeks) the percent recovery dropped from 49% to 29% in SCF2 and 44% to 23% in SCF1. A number of factors could cause this decrease in recovery over time. Secondary organisms could be displacing *P. gigantea.* Weather conditions through the winter could have an affect on fungi survival. Geographic location (micro-climate) of the stump within a treatment center could play a role in successful colonization of *P. gigantea*.

Although the recovery rate of the third sampling decreased in two of three trials conducted, the more critical time for colonization of *P. gigantea* to prevent annosum root rot, is immediately after harvest when stump conditions are most favorable for annosum. Future work that would increase recovery rate of *P. gigantea* at the 6-8 week and 12-13 week sampling would be beneficial in establishing a successful biocontrol program. As indicated in table 2, location of a stump within a treatment area appears to greatly affect success of *P. gigantea* to colonize the stump. Once the infection center and perimeter trees are harvested, stumps with a northern aspect, in relation to an infection center, receive the most sunlight and have the driest conditions making it hard for *P. gigantea* to survive. The larger the infection center and subsequent harvest the drier the site is likely to become, making it harder for *P gigantea* to colonize a stump. Early detection and treatment of annosum root rot when infection centers are small, will increase the success of this method of control. Also adding an anti-desiccant compound to the spray inoculum may offer greater survival of *P. gigantea* in the early stages of stump colonization. *P. gigantea* is not currently available for commercial use in the United States.

National Science Foundation Project on Red Pine Pocket Mortality

Professor Ken Raffa
Dept. of Entomology
University of Wisconsin, Madison

Introduction

Interactions between below- and above- ground processes

One of the least understood sets of ecological relationships involves interactions between below- and above- ground processes. The relatively few investigations into such interactions have identified important links affecting biodiversity and symbioses, ecological processes such as nutrient cycling and litter accumulation, and plant community architecture such as canopy thinning and gap formation. One factor that strongly affects interactions between below- and above- ground processes is herbivory. Previous studies have indicated that root herbivory can exert important feedback at several levels of scale, but mechanistic links between underlying processes and community-level impacts are poorly understood, especially over long time frames. We propose to build on previous work on the subcortical root- and stem- colonizing guilds in conifers. This multidisciplinary approach involves three entomologists with expertise in plant-insect interactions, predator-prey modeling, & systematics, a plant pathologist experienced with conifer root fungi and management, three statisticians with various areas of expertise including spatially explicit analysis, and a landscape ecologist with expertise in Geographic Information Systems.

The Root Colonizing Guild of Red Pine, *Pinus resinosa*, in the Great Lakes Region

Red pines are colonized by a complex of root feeding beetles. Six species show pronounced niche partitioning based on microhabitat, preferred condition of the host, and mode of oviposition. All can co-occur in the same host, except for *Hylobius pales* and *Pachylobius picivorus* which appear to engage in scramble competition . This niche partitioning is mediated in part by semiochemistry. These root feeders vector *Leptographium* spp. fungi, predominantly *L. terebrantis* by bark beetles and *L. procerum* by weevils.

The Stem Colonizing Subcortical Guild of Red Pine in the Great Lakes Region

Several species of subcortical insects colonize the main stems of red pine in this region (). The bark beetles *Ips pini* and *I. grandicollis* emerge from brood trees, disperse, enter susceptible trees, and oviposit. Larvae complete development within the host.

Predators of the Stem Colonizing Subcortical Guild of Red Pine

Unlike root colonizers, bark beetles experience high predation. These predators locate their cryptic prey by exploiting beetle pheromones as kairomones and can show higher attraction than the herbivore to its own signal. They strongly reduce *Ips* reproduction in laboratory assays, and are correlated with prey abundance in the field

Description of the Disease Syndrome and Model System

Numerous red pine plantations (30-50 yr-old) throughout the Great Lakes region show a characteristic progression of decline, in which a zone of tree mortality spreads from an epicenter. No or very few living red pines remain in this epicenter, and the resulting gap is colonized by early successional plants. Trees along the margin show reduced radial and crown growth, but trees further into the stand show no symptoms. As the epicenter expands, more trees die and trees along the new margin begin to show the above symptoms.

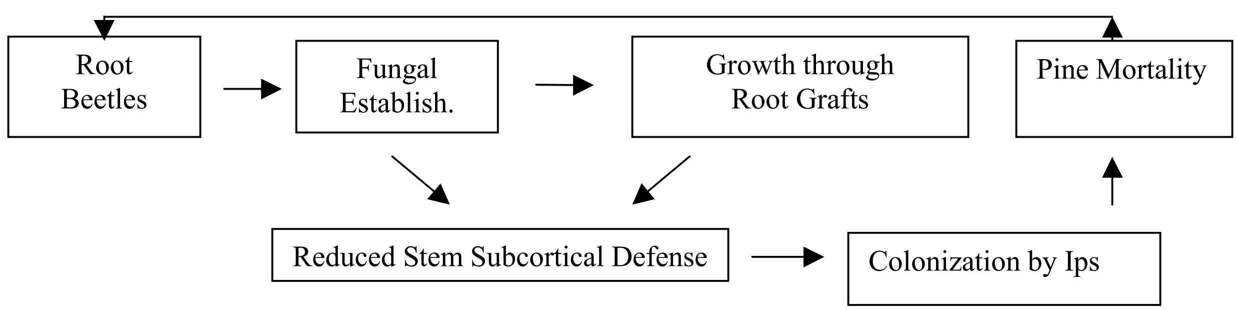
Our major findings are:

1. There are higher populations of root-colonizing beetles in declining than asymptomatic stands.
2. All dead trees contain *I. pini* and were alive at time of colonization. No live trees contain *I. pini*. Trees colonized by *I. pini* are more abundant in declining than asymptomatic stands.

3. Most trees colonized by *I. pini* are colonized first by root beetles, and are located along the margin of the epicenter.
4. There is high recovery and moderate vectoring of *Leptographium* spp. by root beetles.
5. There is extensive root grafting throughout these stands. *Leptographium* spp. can pass through root grafts, and infection occurs in advance of above-ground symptoms.
6. There are physiological differences between trees adjacent to and distant from the epicenter, some of which are associated with beetle behavior.
7. Complex spatial / temporal interactions are imbedded in the above patterns.

Proposed Model

Based on these observations, we propose the following model: Root colonizing beetles enter red pine stands, and vector *Leptographium* fungi. These organisms do not kill mature trees, but compromise physiological conductance between above- and below- ground tissues. This stress reduces treesí ability to resist *Ips-Ophiostoma* attacks in the stem, which are lethal. *Leptographium* spread through root grafts, leading to a radial pattern of decline and mortality. Dead trees are subsequently colonized by *H. pales* and *P. picivorus*, which introduce more *Leptographium*. Some within-stand transmission of *Leptographium* occurs by *D. valens, H. radicis* and *H. porculus*, but most trees can resist such attacks.



Several features of this interaction require further understanding before this model can be accepted. First, patterns of tree mortality are consistent with the above model, but high spatial autocorrelation among observations leaves open the possibility that some other factor is actually responsible and that meaningful relationships are being missed. Second, we have continual long-term observations for one stand only. Third, the observed physiological changes are consistent with our model, but again, we only have data for one stand and the spatial pattern introduces high autocorrelation. Also, these tests were conducted before relationships between fungal infection and distance from the margin were fully quantified, so we can now design more powerful experiments. Fourth, results of stand manipulation are consistent with the model, but lack both replication and detailed observations. Fifth, our presumption that colonization by *Ips* spp. is required for tree mortality is untested. Sixth, the statistical associations among *Ips* spp., *T. dubius*, and *P. cylindrica* are consistent with an important role of predators, but there is strong and multiple covariance in the data. Seventh, we lack the data to evaluate the relative importance of host predisposition vs. predation, which poses a classic bottom-up vs. top-down question.

Objectives

The overall purpose of this research is to explore the role of one ecosystem process, herbivory, in interactions between below- and above- ground functions. Specific objectives are to

1) Evaluate the role of below ground herbivory on susceptibility to above-ground herbivores, with particular emphasis on a) spatial / temporal patterns of colonization, tree mortality, & vegetation and b) physiological changes within trees over time, as related to their spatial position;
2) Evaluate the degree of connectedness among forests harboring common below- and above- ground feeding guilds by measuring movement of root beetles, bark beetles, and predators;

3) Conduct manipulative experiments to test relative importance of inciting agents, stem colonizing organisms, and predators in tree mortality and gap formation.

Objective 1. Evaluate the role of below ground herbivory on susceptibility to above-ground herbivores and gap formation

The working hypotheses to be tested are:

a) Colonization of red pine stems is more likely in trees whose roots have been previously colonized by root beetles and associated fungi;
b) The spatial spread of tree mortality reflects a relatively stereotypic sequence involving root, stem phloem, and stem sapwood colonization;
c) Colonization of root tissue compromises tree defenses against stem colonizing subcortical insects;
d) Interactions of below- and above- ground processes contribute to gap formation and altered vegetational pathways;
e) Predator - *Ips* spp. interactions show density dependent relationships;
f) *Ips pini* and *I. grandicollis* partition the stressed-tree resource at the tree and stand levels, but show scramble competition (Reeve et al. 1998) at the landscape level;
g) Weather conditions can affect dynamics when
   i) warm temperatures allow an extra generation of bark beetles without predators and
   ii) low precipitation increases the proportion of trees colonized by *Ips* that have not experienced previous root colonization

Objective 2. Evaluate connectedness of declining stands by quantifying dispersal of subcortical herbivores and their predators.

We will use mark-recapture experiments to quantify the dispersal behavior of root and stem colonizers and predators in the red pine system. One objective is to characterize the long-range dispersal abilities for members of each guild, using quantities like median dispersal distance and other dispersal quantiles. A second is to quantify movement in the vicinity of declining stands, and in particular determine the distance at which epicenters are attractive to different species. Given these two pieces of information, and the distance between epicenters, we can determine if dispersal processes are linking existing declining stands or contributing to incipient ones. Our methods draw from studies of related organisms (Turchin & Thoeny 1993, Turchin 1998), including one by a PI on this proposal (Cronin *et al*. 2000).

Objective 3. Use manipulative experiments to quantify the relative importance of top-down and bottom-up processes in population dynamics of subcortical insects.

The working hypotheses to be tested are:

a) Reduction of and interference with root beetles and fungi will reduce colonization by bark beetles and tree mortality;
b) Augmentation with predators will reduce colonization by bark beetles and tree mortality;
c) Root herbivory and infection predispose trees to colonization by *Ips*, but the latter are required for tree death.

DNA-based identification of *Leptographium* species associated with red pine pocket mortality

Professor Glen Stanosz
Dept. of Plant Pathology
University of Wisconsin, Madison

PROBLEM STATEMENT:

Dying of red pines in radially expanding ìpocketsî of mortality in Wisconsin plantations has been attributed to activity of complex of insects and pathogenic fungi. Root- and lower-stem colonizing stain fungi vectored by insects of this complex include the closely related species *Leptographium procerum* and *L. terrebrantis*. Each of these species is known to be pathogenic to conifers, producing symptoms that result from colonization of vascular tissues. After infection through wounds, including those created by their insect vectors, tree to tree spread through interconnected root systems can result in the pattern of aggregated mortality observed in field.

Identification of *Leptographium* species can be problematic. Both species mentioned above and numerous others have been isolated from many different pine species and various insects. Thus, these associations cannot be definitive in determining identify. Morphological distinctions between species may seem small or subtle to the inexpert, and morphology may vary with medium or incubation conditions. Further, determination of the frequency with which a particular species is present or absent by cultural methods could be biased by the relative rapidity with which one species or the other grows on the culture medium or interfered with by the presence of other microorganisms. The tedious and time-consuming nature of cultural methods also is a barrier to intensive or large-scale studies of distribution, vector associations, and pathological ecology.

Use of molecular genetic methods have offered solutions to such limitations in detection and identification of numerous plant pathogenic fungi. In numerous instances, comparison of genetic material has allowed discovery of unique nucleotide sequences that differ in even closely related species. Primers designed on the basis of such differences are used to amplify DNA segments or ìmarkersî specific to a particular species or member of a species complex. For example, any given isolate of the pine shoot blight and canker pathogen *Sphaeropsis sapinea*, can be determined to belong to the A (more aggressive) or B (less aggressive) group and separated from similar, related fungi on the basis of molecular genetic markers studied in our laboratory. Similarly, in collaboration with Louis Bernier at Universite Laval, we can differentiate the poplar leafspot pathogen *Septoria populicola* from the more damaging leafspot and canker pathogen *S. musiva*. In addition, with sufficient resources, molecular methods can often be adapted to allow very sensitive and direct detection (i.e., without culture) from sample materials including stained or decayed wood, insects, and soil.

OBJECTIVES:

1) Obtain sequences of portions of the DNA of *L. procerum*, *L. terrebrantis* and other closely related pine-colonizing *Leptographium* species
2) Compare sequences for areas of difference and if found, develop primers for amplification of useful markers
3) Test the efficiency and specificity of primers using cultures of known isolates.

SCIENTIFIC METHODS TO BE EMPLOYED:

<u>Objectives 1 and 2</u>

Known cultures of *L. procerum* and *L. terebrantis* will be obtained from cooperators or culture collections for sequencing of the nuclear rDNA internal transcribed spacers (ITS) and 5.8S sequences (ITS region). Procedures, materials, and equipment for genomic DNA extraction will be similar to those previously described and used in our laboratory. Sequences will be manually compared to determine areas of difference that would likely be useful for primer design. If sufficient differences are found, primers for amplification of markers specific to each species will be designed.

Objective 3

Primers will be tested using cultures of known isolates and other nontarget fungi. Total genomic DNA will be extracted and for use as a template in polymerase chain reaction (PCR) amplification. PCR conditions will be modified from those used with other fungi in our lab as necessary to attempt amplification of species-specific markers that are diagnostic for *L. procerum* or *L. terebrantis*. PCR products (i.e., markers) will be separated by electrophoresis on agarose gels. Gels will be stained with ethidium bromide and photographed under UV light to allow visualization of markers.

In the course of completing work directed toward achievement of these objectives, known isolates of *L. procerum* and *L. terebrantis* also will be carefully examined for presence of traditional cultural or morphological characters that might aid in identification.

Proposal for further study of Red Pine Pocket Mortality

Sally Dahir
Forest Health Technician
Dept. of Natural Resources
Fitchburg, Wisconsin

The incidence of red pine pocket decline observed in the 2002 survey was fairly high. Over two-thirds (109) of 157 surveyed stands had at least 1 pocket. However, the number of pockets per stand was small in most cases and most pockets had few symptomatic trees, over one-third having fewer than 6. On the other hand, there were several stands with a large number of pockets, over 1 pocket for every 2 acres surveyed and where pockets were fairly large, averaging between 1 and 2 percent of all red pine in these stands. This wide variation suggests either that pocket decline is worse on some sites and self-limiting on others or that it is just beginning to show up in many red pine stands throughout the state and that these small pockets may expand rapidly in the near future.

One of the most significant observations of this survey was the high frequency of occurrence of the bark beetle, *Dendrotonus valens,* together with the fungus, *Leptographium terebrantis,*and their possible role in pocket initiation and expansion. A primary feeding site for these beetles is freshly cut stumps as well as healthy trees nearby. We noticed in the survey that pockets were almost nonexistent in unthinned stands, i.e. where no stumps were present. We also observed very high numbers of *D. valens* in very recently thinned stands surveyed during the period of beetle flight in late spring. In addition, the number of pockets decreased significantly as tree density increased. This may be due to the cooler and darker microclimate in dense stands, which would be much less conducive to beetle activity.

These observations point to the possible role in pocket formation of thinning and specifically the time of year in which a stand is thinned. Interestingly, there was no mortality in the 6 unthinned stands in their study. Time of year of thinning may also be correlated with pocket initiation in that stumps which are allowed to dry out for long periods prior to spring beetle flight may be less attractive as brood sites. In studies of Douglas fir in the western United States, mortality was negatively correlated with residual tree density and was much lower in stands thinned in the summer months.

Two major unresolved issues were raised by the results of this study. These included:

1) How fast are pockets expanding and does the rate of expansion vary with site attributes, location in the state, or weather (specifically drought or mild winter temperatures)

2) Does the time of year when a stand is thinned affect vector populations, specifically *Dendroctonus valens*, and the probability of pocket initiation

During the summer of 2003, we selected stands from the 2002 survey which had several small pockets. Pocket centers were located using global positioning equipment and symptomatic trees were mapped. Each mapped tree was rated as to the degree of symptomatology: ranging from healthy trees which had signs of turpentine beetle attack to snags in advanced stages of decay. These stands will then be visited annually through 2008 to determine the rate of pocket expansion. To address the second question, we will select red pine stands which were thinned either during the summer and fall of 2003 and stands that were thinned from late winter through the spring of 2004. Turpentine beetle traps will be placed in these stands during the spring flight period in order to monitor insect numbers. In addition, the stands will be surveyed annually through 2008 for newly formed pockets.