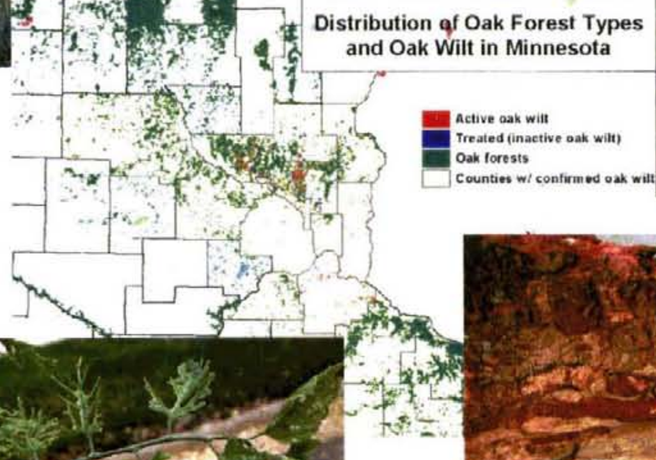
Minnesota Forest Health Annual Report 2002



Department of Natural Resources
Division of Forestry - Forest Health Unit

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Our Forest Resource

In Minnesota there are approximately 16.7 million acres of forest land; 14.7 million acres are classified as "timberland" or lands capable of producing timber and are not withdrawn from timber utilization or associated with rural or urban development. Forest land ownership includes 38% non-federal public lands, 36% NIPF, 17% federal and tribal lands, and 9% forest industry and other corporate lands.

Two major industries depend on Minnesota's forest lands: forest industry and tourism. The forest industry is Minnesota's second largest manufacturing industry employing more than 55,000 people. The value of the forest products manufactured in Minnesota exceeds $7 billion and accounts for 16% of all manufacturing dollars generated in Minnesota. The tourism industry is Minnesota's second largest employer employing over 140,000 people and accounting for a payroll in excess of $3 billion. Gross receipts from tourism exceed $6 billion. Over 70% of people who took at least 1 spring or summer trip in Minnesota rated "observing natural scenery" as the most important activity of their trip.

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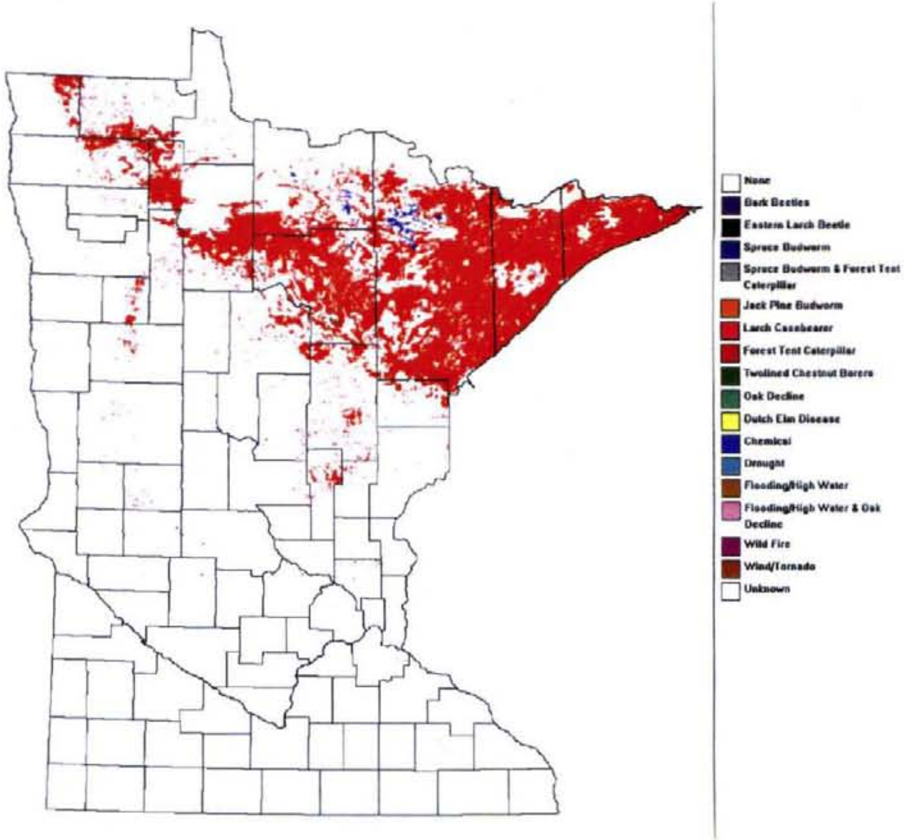
Aerial survey results

Aerial survey was conducted by Bill Befort and Steve Gallay from DNR Resource Assessment and by Marc Roberts from USFS S&PF. Again, this year was forest damage was dominated by forest tent caterpillar defoliation. See map and table.



General detection surveys - 2002		
Damage agent	*Damage*	*Acreage*
Forest tent caterpillar	Defoliation	7,374,057
Spruce budworm	Defoliation	90,689
Two-lined chestnut borer	Mortality	9,665
Larch casebearer	Defoliation	2,544
E. larch beetle	Mortality	1,279
Dutch elm disease	Mortality	2,528
Bark beetles	Mortality	658
Wind	Mortality	1,995
Flooding	Mortality	10,781
Jack pine budworm	Defoliation	845
Tamarack - unknown	Defoliation	17,072
Tamarack - unknown	Mortality	15,966
Total		**7,528,079**

Insects

Fall defoliator complex

Dryocampa rubicunda	Greenstriped mapleworm
Anisota senatoria	Orangestriped oakworm
Symmerista canicosta	Redhumped oakworm

Host:	Oaks, maples, other hardwoods
Damage:	Defoliation
Area:	Not determined; primarily in northwestern counties
Severity:	Locally important, variable severity
Trend:	Redhumped oakworm populations widespread in Region 1 and increasing. Others declining.

The orangestriped oakworm, *Anisota senatoria*, is a defoliator of all species of oaks, although it prefers white oaks. It had increased to high numbers in central Minnesota in the past few years, but a large number of parasites and predators helped terminate the outbreaks. This year a disease killed all the caterpillars before they had grown to 1 inch long in an outbreak area in Morrison County, 5 miles south of Little Falls. Many dead caterpillars were still attached to leaf veins or twigs. This insect has periodic outbreaks in this area.

Defoliation of bur oaks and other oak species was reported in Hubbard, Beltrami, Becker, Cass,Crow Wing, Morrison, and Itasca Counties during late August and September. Redhumped oakworms, *Symmerista canicosta*, consume all of the leaf tissue except the major veins. See photo above. This was the third year defoliation was noticed, and, interestingly enough, different stands are affected each year. Many reports of defoliated woodlots and stands in fall of 2002. Populations expected to be noticeable in 2003.

Forest tent caterpillar

Malacosoma disstria

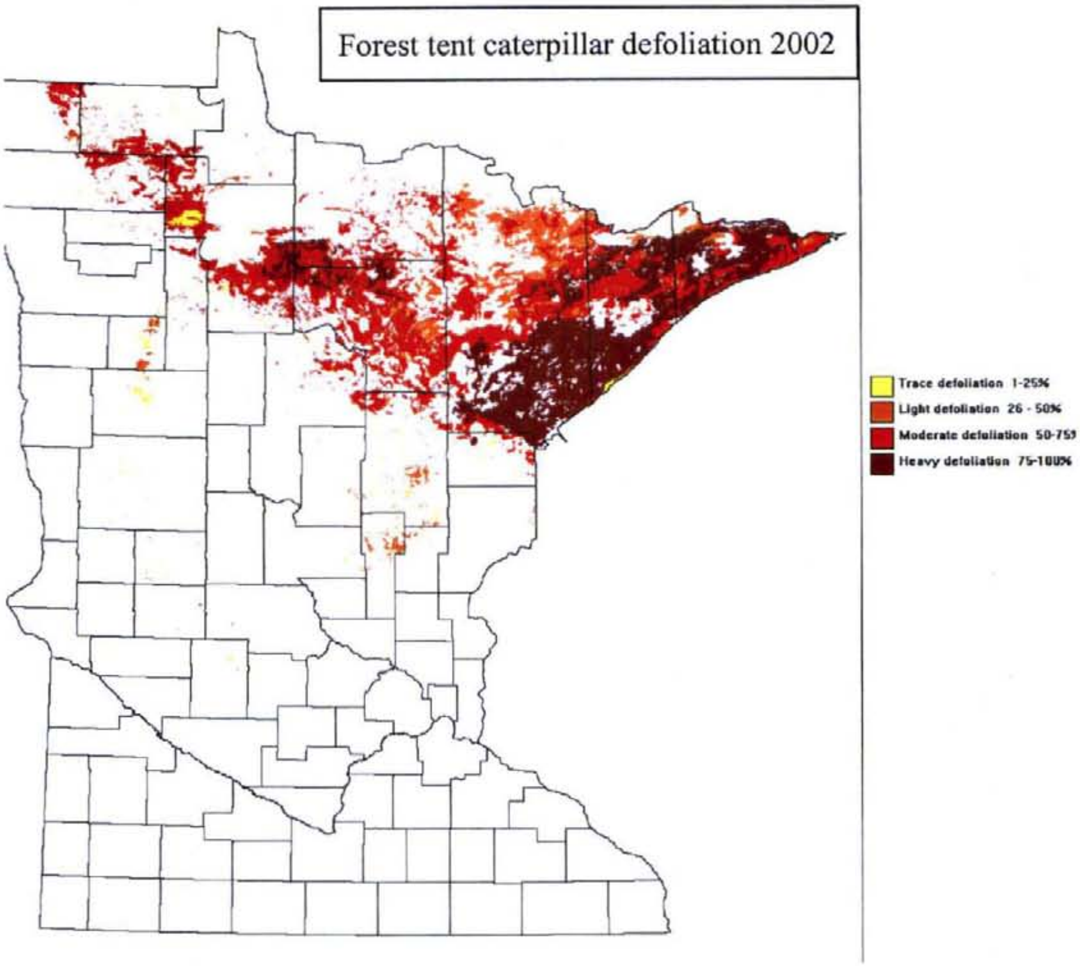
Host:	Aspen, oak, basswood and hardwoods
Damage:	Defoliation
Area:	7,374,057 acres
Severity:	Variable across the state
Trend:	Decreasing

Following a record year for number of acres defoliated, forest tent caterpillars again reached levels far above those found in previous outbreaks. 7,374,000 acres were defoliated in 2002. See map. Surveys of forest tent caterpillar egg masses in central and northeastern Minnesota completed in this summer predict a sharp drop in next year's caterpillars in all sampled areas except near Deer River, Hibbing, Virginia, Finland, and Gooseberry Falls State Park where populations will be high.

Besides the egg mass survey results, there are other clues that forest tent caterpillars will decline next year. First, a comparison of larval surveys in 2001 and 2002 found many more dead caterpillars, killed by diseases, hanging from branches and trunks in an increasing number of locations in 2002. Second, there was a great increase in numbers of the parasitic flies that attack pupae this year. Historically, they mark "the beginning of the end".

Caterpillar-to-moth success in 2002

Location	Moths emerged
Hibbing	2 %
Deer River	10
Grand Rapids	9
Fr. Hennepin S Park	2
Bay Lake, Aitkin Co.	3
Floodwood	7
Two Harbors	4
Cloquet	5
NE Duluth	3
Gooseberry Falls S Park	5
Average	**5**



An early July collection of 100-plus cocoons from each of ten areas in central and northeastern Minnesota indicated a great increase in parasitized cocoons, as shown by the almost zero noise of fluttering moth wings in the rearing containers. This was borne out in August when the moths were counted and numbers of parasitic fly puparia, adult wasps, and disease-killed caterpillars were tallied. The table above shows some of the results of this study. A similar study last year found that on twelve sites, an average of 24% of the moths emerged.

We feel that the outbreak is nearly over and there will be a sharp drop in the overall population of this forest insect in 2003. However, there will be some areas where forest tent caterpillars will survive in bothersome numbers, especially where they expanded into new areas this year and where their natural enemies (disease pathogens, parasitic flies, etc.) are minimal. Another type of situation where FTC could remain a problem is where night lights attracted egg-laying moths from surrounding areas, concentrating them on nearby trees and shrubs.

To determine the effects of temperature and dormant oil on FTC hatching, an experiment was set up April 4th in Brainerd on 40 egg masses collected last summer. Sixteen egg masses were sprayed with a dormant oil labeled for use on FTC egg masses. All others were not sprayed. Each egg mass was placed in a window-pane envelope. Then the egg masses were either kept at room temperature or kept outdoors in the shade. This study found that dormant oil spray is useful in preventing FTC from hatching and can kill most of the caterpillars that do hatch.

Numbers of caterpillars that hatched* and lived
* = There are more than 300 eggs per egg mass.

	Not sprayed with oil	*Sprayed with oil*
Indoors	All lived	None lived
Outdoors	All lived	5 Larvae lived (much less than 1%)

Gypsy moth

Lymantria dispar

Host:	Hardwoods
Damage:	Defoliation
Area:	None
Severity:	NA
Trend:	Decreasing

The APPD unit and communication team of MN Dept. of Agriculture (MDA) put together a very success program for 2002. While there were a number of partners involved, along with some outside funding, MDA deserves to be congratulated for their efforts. Nearly 16,000 traps were hung, a record number of acres were treated and a massive PR campaign was launched, all with positive results.

Statewide trap catch numbers are down considerably. At this time, a total of 119 male moths have been caught statewide. See map. This is the lowest number since 1993, when 93 male moths were caught. Of the 52 state parks that were trapped, only 2 male moths were recovered in one state park, Charles A. Lindbergh near Little Falls, Minnesota. A total of 7 moths were trapped at nursery locations within the MDA trapping grid. Nurseries outside the standard trapping grid and all large-scale timber mills were trapped by USDA-APHIS, with no additional moths found.

2002 treatments:

Minneapolis near Lake Harriet: Trapping following the 425 acre treatment found zero moths in spite of signs of early defoliation prior to the treatments and the recovery of two caterpillars found after the treatments were completed. Ten single and one multiple trap of five were caught outside the treatment boundary. None of these finds appear to be related to the treatment site. The treatment boundary and the positive finds outside the treatment boundary will again be delimit trapped during the 2003.

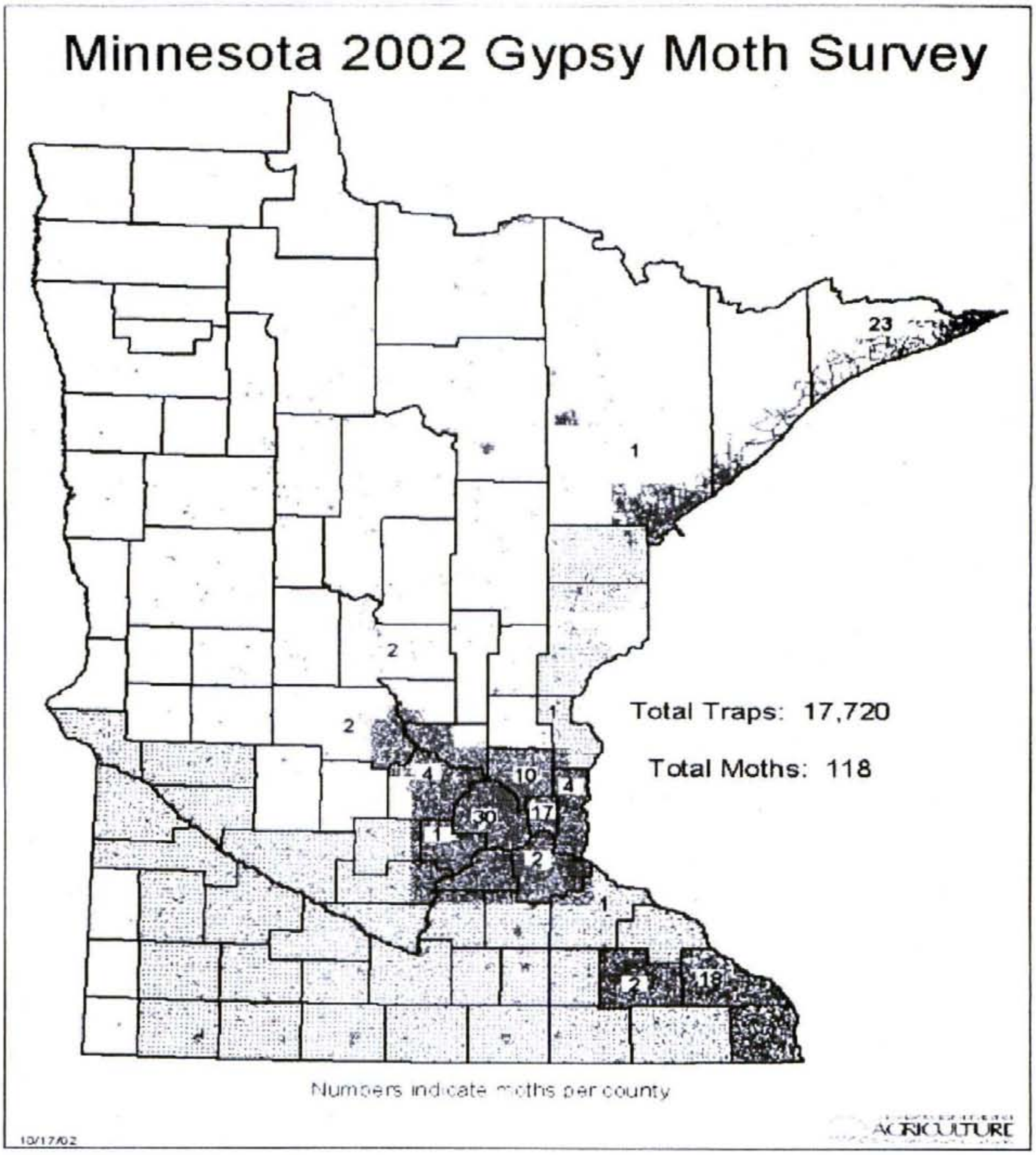
Golden Valley near Theodore Wirth Park: 1836 acres were aerially treated with Bt. Burlap bands were also used to monitor caterpillar survival at this site, but none were found. Six male moths were recovered, 1 within the mass trapping core, 2 within the treatment boundary, and 3 within the delimit boundary outside the treatment block. The catches were spread out geographically; suggesting the presence of a reproducing population is not likely.

Crooked Creek site in Houston County: A 650 acre site, straddling part of the Dorr State Forest was treated with Disparlure (Disrupt II). The use of pheromone flakes is new to Minnesota but is becoming a common occurrence within the national Slow-the-Spread program. The primary advantage over Bt is the increased specificity. Disadvantages include the inorganic plastic chads used as a carrier and the one to two year residual that limits trapping following pheromone treatments. Pheromone flakes work by saturating an area with GM pheromone thus masking the presence of any female moths present (limiting, if not prohibiting mating). However, the flakes also mask the presence of any detection traps, which utilize the same pheromone to attract male moths. Although the area was intensively trapped this year (with no moths found) it will need to be trapped again next year before treatment results can be assessed. Catch history and limiting site factors made this an ideal candidate for the treatment. If the treatment is shown to be effective under MN conditions, it may prove useful in other situations.

North Shore Temperature Study:

With federal funding, support from the OTIS lab of USDA APHIS, and field help from a number of local partners, NRRI, affiliated with the U of MN, placed traps in three 1 square mile plots at varying grid densities as a pilot project to assess the effect of temperature on moth flight and capture rates. At the center of each plot, sterile male moths were released on a weekly basis between July 18 and September 26. Colored external dyes were used to separate moths by release date. An internal dye (incorporated in the food on which the caterpillars were reared) was used to separate wild from reared moths (no wild moths were caught within the study area). Traps were checked regularly and the dye color recorded.

Moth emergence rates ranged between 5 and 78 % per release based on spent pupal cases. Recapture rates ranged between 4 and 7%. However, the largest challenge of the project (besides finding the traps among the alder bogs) was out-witting the chickadees. The birds quickly discovered the release cages and sat there picking the moths off as they emerged to dry their wings. Researchers had to devise mess bags to protect the moths until they were dry and strong enough to fly. Even then, the chickadees snagged a large number of the young male moths. The effect on moth recapture rates per plot won't be known until the data is analyzed this winter.



Jack pine budworm

Choristoneura pinus

Host:	Jack pine
Damage:	None observed
Area:	None — 400 ac
Severity:	~~NA~~ 4
Trend:	Expecting a population increase soon.

No significant defoliation was observed in the major jack pine stands in Region 1 where outbreaks have occurred in the recent past. Twenty nine stands were checked for the presence of larvae on June 25th and July 2nd. See Results Section for data.

Twelve larvae were found. A few very minor populations were found; they caused no observable defoliation from the ground or from the air. Although no egg masses were collected, little defoliation is predicted for 2003.

Larch beetle

Dendroctonus simplex

Host:	Eastern larch
Damage:	Mortality
Area:	17,245 acres
Severity:	Variable, see table below.
Trend:	Increased for last 3 years; likely increasing.

In the early 1970's and 1980's, this insect caused the loss of 593 million board feet of tamarack in eastern Canada. Around the same time, Alaska experienced mortality on more than eight million acres. To make matters worse, in some areas, 50 percent of the mortality occurred in just over two years. Minnesota has not been isolated from this beetle. Notable outbreaks were documented as early as 1938 and again in the 1980's but nothing like in Canada or Alaska. But in 2000 and 2001, the population exploded in some locations, most noticeably in the Deer River, Cloquet, and Hibbing, Hill City and Aitkin Areas

Larch beetles have been a part of the Minnesota landscape for decades, but the attacks have usually been associated with tamaracks predisposed to attack due to stress from drought, flooding, or defoliation. The size of the areas involved in an attack has usually been small. Mortality is usually confined to individual trees or small pockets of trees. In the last two years though, both the amount of mortality and the size of the areas affected has increased. Much of the mortality has still been confined to small pockets. However, some stands of 30 to 40 acres and larger have experienced over 75 percent mortality. Most attacks have occurred in northeastern Minnesota, but it is thought the mortality can be found throughout the natural range of tamarack in Minnesota.

What makes the larch beetle a bit more insidious is the fact that it's not discriminatory in its eating habits. Mortality has been found in stands ranging from 40 to 160 years in age; on lowland and upland sites; and in pure stands as well as mixed component stands. The damage is quite visible on the ground. As the beetles feast on the trees, woodpeckers feast on the beetles, leaving behind telltale signs that include mounds of bark chips at the base of trees and reddish or white boles, depending on how much bark a woodpecker flakes off as it searches for food. In late summer, needles of the affected trees begin to turn yellow, then brown, before falling off. The dieback begins at the bottom of the crown and works upward, leaving the green tops for last. This progression of mortality makes it difficult to see new damage from the air.

Larch beetle attacks have usually been associated with stressed trees. Although stress is likely a factor in some stands, it is thought the current pockets of mortality have more to do with the mild winter weather the past four years than with stress. Larch beetles normally overwinter as adults underneath the bark of host trees. In the spring, the adults emerge and fly to new host trees, laying eggs. Most adults remain in the new host tree for the remainder of the summer. Those insects caught in the pupae or larval stages when winter sets in normally have a poor chance at survival. The mild winter conditions we've experienced since 1998 has increased the probability of non-adults successfully overwintering , thus creating higher populations in the spring, which cause higher than normal mortality.

A couple of stands that experienced high amounts of mortality in 2000 and 2001 were examined in March of 2002. Larch beetle populations appear to be much smaller in these stands than they were at this time last year. Cocoons of parasitic wasps were found in galleries under the bark and may be reducing populations of the larch beetle. Larch beetles will likely kill additional trees in these stands this summer but it appears that, at least in these stands, the population of beetles is declining.

There is really no way to predict the amount of additional damage the larch beetle will cause. However, when out checking stands, keep an eye on tamarack sites. Look for evidence of beetles and/or mortality. If beetle infestations are discovered, consider setting up a salvage sale. Since the market for tamarack is not very good, concentrate on salvaging older, larger diameter trees in purer stands. Utilize trees to at least a 4-inch top and if possible, whole tree skid and burn the slash the same year cutting takes place to decrease the emergence of adults the following spring.

Since some adults move to new host trees to overwinter rather than staying in the original host tree, consider adding a buffer strip to the sale approximately 1 chain wide. If the sale won't be harvested for a few years, the buffer may need to be increased to capture further dispersal of the beetles. If seed trees are left on the site, it is not likely that they will add significantly to the problem. However, most seed trees will likely be dead within a year of the harvest on sites where beetles are active. If seed has been dispersed, the seedlings will not be affected by the beetles.

Studies: Larvae, pupae as well as adult larch beetles survived the winter in tree the winter of 2001-2002 at the Arbo site in Itasca County as well as at the Zim site in St Louis County. Survival was not checked at the Carlton County site along the Ditch Banks Road.

Trapping for eastern larch beetle started in 2001 was continued in a study with Dr. Steve Seybold during 2002. The same three sites used in 2001 were used in 2002. These were Arbo township near Grand Rapids in SWNW sec 7-T56N-R25W; Zim in St Louis County in NWNW sec 2-T55N -R18W; and the Ditch Banks site near Cloquet in Carlton County in Sec 18-T49N - R19W. Funnel traps (16 funnel) baited with a variety of baits were emptied once a week. Traps were randomized once a week.

Experiment I was set out on April 17th and ran through July 17th, 2002. Below are listed the treatment used at each of the three sites:

Treatment A = blank trap
Treatment B = alpha-pinene
Treatment C = seudenol
Treatment D = alpha-pinene + racemic seudenol
Treatmtne E = alpha-pinene + (-) -seudenol
Treatment F = ethanol +racemic seudenol +frontalin (this trap was baited for Douglas-fir beetle)

Experiment II was set out July 17 and ran though August 28th, 2002. Listed below are the treatments used at each of the three sites:

Treatment A = blank trap;
Treatment B = alpha-pinene + racemic seudenol + seudenone;
Treatment C = alpha-pinene + seudenone;
Treatemtn D = alpha-pinene + racemic seudenol

All collections were placed in plastic bags, labeled and placed in a freezer. Dr Steve Seybold has the collections and will be having them sorted and analyzed.

Larch casebearer

Coleophora laricella

Hosts:	Tamarack
Damage:	Discoloration, defoliation
Area:	2544 acres
Severity:	Moderate to heavy
Trend:	Declining

The aerial survey recorded 1850 acres of larch casebearer in Koochiching County and the remainder in St Louis County. The acreage affected is declining and is expected to continue to decline.

Pine tussock moth

Dasychira pinicola

Host:	Jack pine
Damage:	No defoliation observed
Area:	West central counties.
Severity:	NA
Trend:	Stable at very low levels.

Since 1981, the numbers of pine tussock moths caught in pheromone traps in Pine and Crow Wing Counties have diminished or remained extremely low, but since 1996, they have increased in northeastern Wadena and southeastern Hubbard Counties. During 2002, 9 trap locations were established in Wadena and Hubbard Counties. Fewer than31 male moths were trapped in each two week period of trapping which indicates an insignificant population. Drop-cloth sampling for caterpillars on these nine sites yielded no tussock caterpillars.

Trapping in Mission Township in Crow Wing County resumed in 2002 at 2 sites and at one site north of Brainerd at the Paul Bunyan Nature Learning Center. Again, less than 31 male moths were trapped in each two week period, indicating that populations remain insignificant.

Spruce beetle

Dendroctonus rufipennis

Hosts:	White spruce
Damage:	Mortality
Area:	None reported
Severity:	Heavy in pockets along the North Shore
Trend:	Unknown

Spruce beetle continues to kill white spruce along the shore of Lake Superior. A concentration of mortality was found in Crosby Manitou State Park. The southern most location of spruce beetle along the north shore is a single white spruce killed this year in Gooseberry Fall State Park. The farthest inland that mortality has been observed is 8 miles with the majority of the mortality being within 3 miles of the lake shore. Spruce beetle killed trees were found in Sec23-T63N-R4E near Jackson Lake Road, in Sec10-T63N-R3E north of Tom Lake and in Sec10-T61N-R3W off cook County # 4 , near Holly Lake.

As part of a Coastal Zone Management Grant, the Division of Parks and Dr. Steve Seybold tested the attractiveness of various pheromone baits to spruce beetle. Funnel traps baited with materials listed above plus blank traps for controls were placed in 8 locations along the shore of Lake Superior. Baits tested are listed below:

1. Commercial spruce beetle bait (SBB)= alpha-pinene, frontalin, (+/-) -MCOL
2. SBB and verbenene
3. Alpha-pinene, frontalin, and(+)-MCOL,
4. Alpha-pinene, frontalin, (+)-MCOL, and verbenene
5. Alpha-pinene, frontalin, and verbenene
6. SBB, and cis-verbenol
7. SBB, and trans-verbenol
8. SBB, and verbenone
9. SBB, and exobrevicomin
10. SBB, and endo-brevicomin
11, SBB, and trans-pityol
12. SBB, and seudenol
13. SBB, and ethanol
14. White spruce stem monoterpenes, frontalin, and (+/_)-MCOL
15. White spruce foliage monoterpenes, frontalin, and (+/_)-MCOL
16. Alpha-pinene and trans-pityol

18. 3-methyl-3-buten-1-ol (large Eppendorf Tube, 1ml load)

None of the materials tested, including the commercial spruce beetle bait, appeared to have any attraction to the spruce beetle at all.

Spruce budworm

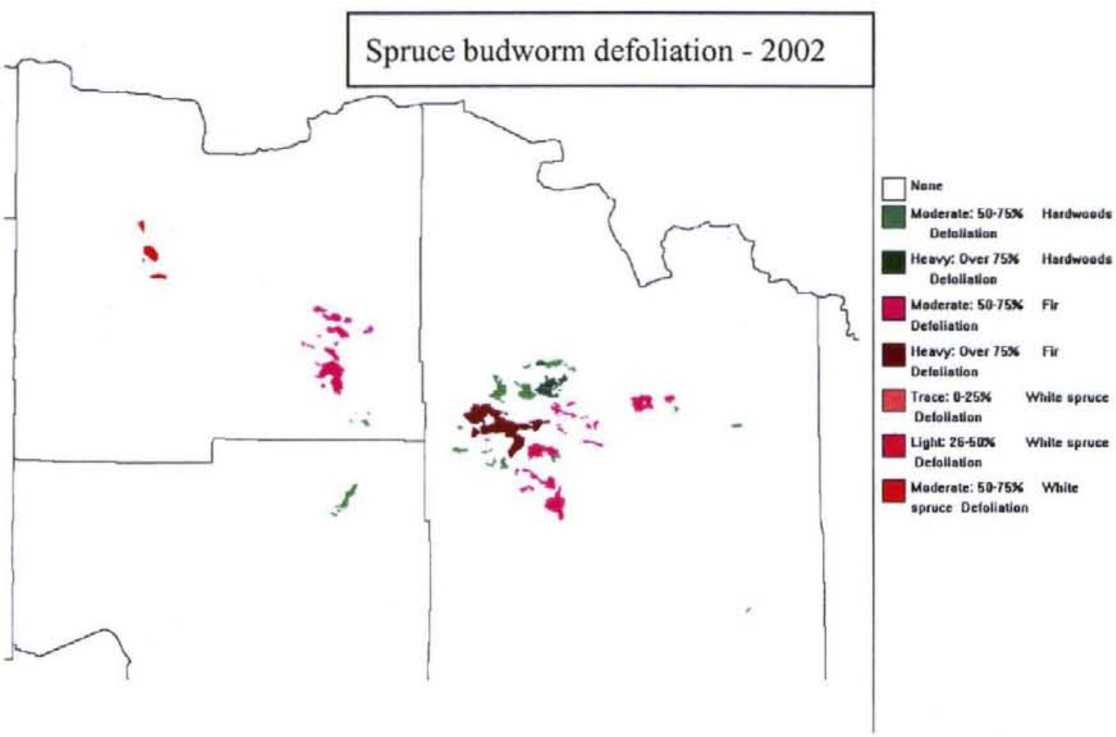
Choristoneura fumiferana

Host:	Balsam fir and white spruce
Damage:	Defoliation, topkill and mortality
Area:	90,689 acres aerially mapped in Koochiching, Itasca and St. Louis Counties.
Severity:	Light to heavy
Trend:	Increasing in northeastern counties, decreasing elsewhere.

In Region 1, white spruce plantations and stands that have experienced spruce budworm defoliations during the past eight to ten years were not defoliated in 2002, except in two locations. Defoliation was not detectable from the air. At Two Inlets State Forest (21-141-36 in Becker Co.), defoliation was light and no egg masses were found. At Itasca State Park (along Wilderness Drive, Clearwater Co.), defoliation was moderate to heavy and is expected to be light to moderate next year. These areas of defoliation were not detected during the general aerial survey.

In Region 2, population levels through most of the northeast remain low; unchanged from last year. In northwestern St Louis and eastern Koochiching Counties, aerial surveys showed a significant increase in acres of defoliation. See map. Limited egg mass surveys indicate moderate to heavy defoliation is expected in these same areas in 2003.

In former Region 3, spruce budworm populations are also down. There is only one known location where budworms can be found doing damage in a white spruce plantation, south of Jacobson in Aitkin County. Here defoliation was moderate to heavy in 2002 and is predicted to be moderate in 2003 based on egg mass studies.



Two-lined chestnut borer

Agrilis bilineatus

Host:	Oaks
Damage:	Mortality and topkill
Area:	13,489 acres
Severity:	Variable, see table below.
Trend:	Likely increasing

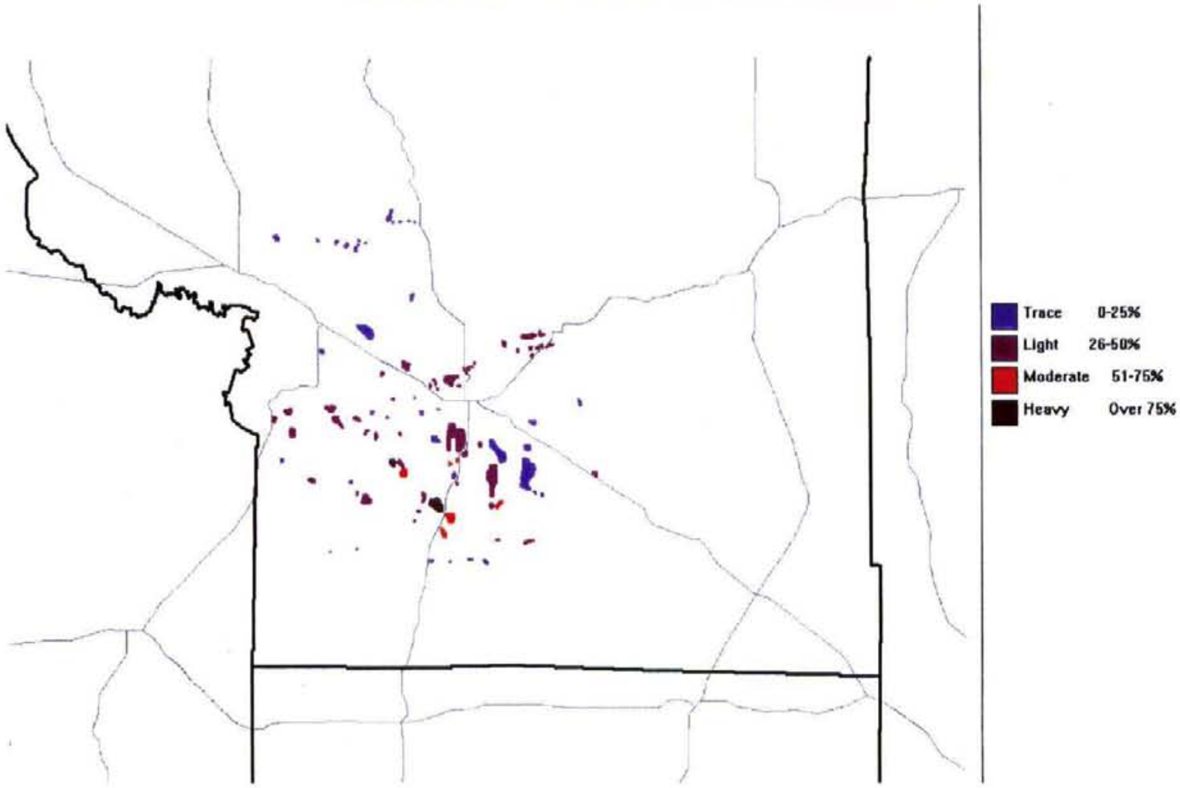
In late July, two-lined chestnut borer (TLCB) damage began to show up in Itasca County. By mid-August, dieback, topkill and whole tree mortality were widespread in northern Minnesota. Some oaks that did not appear to have been attacked by TLCB in 2001 were entirely brown and looked dead by the end of August 2002. Borer galleries could be found in the trunks of these trees down to the soil line. A few pockets of TLCB were seen in the fall of 2001 but the amount of topkill and mortality seen in 2002 was unexpected. A very dry April, May and June just as the trees were leafing out coupled with two or more years of forest tent caterpillar defoliation were likely the stress factors contributing to the success of the borers.

Aerial survey was flown in late August over 84 townships in parts of Clearwater, Beltrami, Cass, Itasca, Mille Lacs, Aitkin and Crow Wing Counties. See map and table below. Approximately 13,500 acres with oak mortality and top kill were mapped. Scattered damage occurred throughout northern Minnesota but the worst damage was in Itasca County. Over 8,000 acres of oak stands with mortality were mapped within a 10 mile radius of Grand Rapids. Additional damage continued to become evident through September. In some stands, over 75% of the oaks suffered top kill or mortality. Severe damage occurred in stands that had been recently thinned or in areas where road construction or building construction had recently occurred.

A red oak tree attacked by two lined chestnut in 2001, near St Joseph's Church in Grand Rapids, was cut and placed in an emergence box at the U of MN by Dr Steve Seybold. Below is a list of insects that emerged from the oak in the emergence box between 12/31/01 and 1/25/02.

Number of insects	Identity of emerged insects
77	*Agrilus bilineatus*
8	Unknown smaller *Agrilus* spp.(possibly *bilineatus* also)
9	*Atanycolus rugosiventris* (Asmead),(Hymenoptera) det. J.Luhman
2	*Atanycolus simplex* Westwood, (Hymenoptera) det. J Luhman
8	*Phasgonophora sulcata* Westwood,(Hymenoptera) det. J Luhman
6	*Pseudopityophthorus minutissimus*
6	*Heterspilus* spp., (Hymenoptera) det. J. Luhman
1	*Urographis despectus* (LeConte) (Coleoptera: Cerambycidae), det. P.J. Clausen
6	Buprestids large bronze/copper colored
2	Unknown parasitic wasps
1	Unknown tiny wasp

Southern Itasca County with TLCB - 2002



Yellow-headed spruce sawfly

Pikonea alaskensis

Hosts:	Spruce
Damage:	Defoliation, mortality
Area:	None mapped
Severity:	NA
Trend:	Appears to be increasing

Defoliation by yellow-headed spruce sawfly appears to be increasing. There has been an increase in questions about the sawfly as well as reports of defoliation. Most defoliation is still occurring on individual trees and small groups of trees. Yellow-headed spruce sawfly has been at a very low level for many years but should be watched more closely the next few years.

Diseases

Jack pine gall rust at Badoura State Nursery

Evaluation of 2-0 jack pine in compartment E6 for incidence of galls on April 17, 2002. For each seed source, inspected 500 seedlings in groups of 50 seedlings along length of bed and in all rows. If all samples are pooled, then the overall gall rust incidence is 12.5 %. For each seed source, the incidence of gall rust is:

Bemidji	(# 104)	16.4 %
Crow Wing Seed Orchard	(#285)	11.4%
Long Prairie Seed Orchard	(# 240)	9.8%
Itasca State Park	(#803) 1	2.4%

Oak tatters

Unknown cause

Host:	Oaks and hackberries
Damage:	Defoliation
Area:	Not determined
Severity:	NA
Trend:	Unknown

Oak tatters symptoms advanced north into central Minnesota in 2002. For the first time, scattered pockets of oaks were affected in Stearns and Morrison Counties. Much of the area in southern Minnesota affected last year was free of tatters in 2002, including six counties where hackberry tatters occurred last year.

Tatters primarily affects the bur oaks but has also been observed in Minnesota on swamp white oak, eastern white oak, a few red oaks and on hackberry. Newly emerging leaves of affected trees have missing leaf tissue between the veins, which gives the leaves a lacy or tattered appearance. In some years large areas of the landscape have been affected in southern Minnesota. The current trend has seen a decline of affected oaks in the southeast and an increasing occurrence on hackberry in the southwest. Within a few weeks a new flush of leaves will appear and be free of the tatters symptoms and will remain unaffected throughout the season. The long-term impact remains low. Early spring defoliation in deciduous trees is a recoverable stress given the opportunity for re-foliation and enough time to rebuild food reserves. The cause of tatters remains unknown.

Oak: Tabakia leaf disease

Tubakia dryina

Host:	Oaks
Damage:	Defoliation
Area:	Not determined
Severity:	Not determined
Trend:	None

Across southern Minnesota, a late season leaf disease can be seen on bur oaks, usually after August 1st. The causal fungus, *Actinopelte dryina*, has had a recent name change to *Tubakia dryina*. This year in August, the University of Minnesota Lab examined samples and confirmed that *Tubakia* is the main leaf spot fungus causing the foliage symptoms.

The appearance can be very dramatic as the entire crown turns brown except a few leaves at the very top. Defoliation can reach 90% in a few short weeks and affected trees look nearly dead. Late season defoliation has minimal impact on the tree's health. However, several consecutive years of defoliation of this nature could long-term impacts.

Sphaeropsis collar rot: Sampling at Badoura State Nursery.

On April 17, 2002, 2-0 red pine were sampled from 2 compartments. Five different beds were sampled in each compartment. In each bed, a single 1 meter length of a seedling row was inspected for the presence of symptomatic seedlings (live or dead) and asymptomatic seedlings. Numbers of each were tallied. Dead and symptomatic seedlings were collected for further examination by Dr. Stanosz, University of Wisconsin.

Investigations of 2-0 red pine for Sphaeropsis symptoms at Badoura Nursery, 2002

Compartment B 11:

Furthest away from red pine windbreaks and manager indicates that this is the compartment with the least amount of disease. * = It looked like these died due to desiccation.

Bed number	Live asymptomatic	Dead Asymptomatic *	Live symptomatic	Dead symptomatic
22	110	3	1	0
21	92	9	1	0
19	110	0	1	0
18	100	2	0	4
17	77	4	1	0
Average values	97.5	3.6	0.8	0.8

Investigations of 2-0 red pine for Sphaeropsis symptoms at Badoura Nursery, 2002

Compartment A 3:

Closest to red pine windbreaks and manager indicates that this is the compartment with the most disease. As 1-0's the beds looked orange due to Sphaeropsis infection.

Bed number	Live asymptomatic	Dead asymptomatic	Live symptomatic	Dead symptomatic
22	33	0	5	32
21	28	0	14	27
19	28	0	7	47
18	33	0	11	53
17	23	0	10	46
Average values	29	0	9.4	41

There was clearly a difference in the incidence of symptomatic seedlings between the 2 compartments. In A3, 63% of all seedlings were symptomatic whereas, in B11, only 1.5% of all seedlings were symptomatic. As a result, the beds in A3 are only producing 30% of what the beds in B11 are producing because of Sphaeropsis shoot blight and mortality.
Note: There may be additional losses in A3 due to asymptomatic collar rot infections.

Sphaeropsis collar rot survey in red pine plantations - 2002

In October, a request was sent to all Forestry Areas for samples of red pine seedlings that died since planting this year. This is part of the continuing effort to document the presence and effects of *Sphaeropsis* infection on our Nursery seedlings. There were several respondents from Region 1, 2 and 3. Seedlings came from PFM and state-owned plantations. Unless otherwise noted, only 5 seedlings per plantation were used for this study because of the lab time involved in verification. The seedlings were examined for symptoms of collar rot and then for the presence of *Sphaeropsis* pycnidia.

Red pines growing in 28 plantations (18 were documented) averaged 67 % mortality.
Other species in the same plantations (only 7 were documented numerically) averaged 12 % mortality.
160 seedlings were examined in the lab.
Five dead seedlings from a non-DNR source had no trace of *Sphaeropsis* infection.
Examination of 155 DNR -source seedlings revealed the following:

- 3 seedlings (1.9%) died from other causes,
- 12 seedlings (7.7%) had symptoms of collar rot but no fruiting bodies were found, and,
- the remaining 140 seedlings (90.4%) all had symptoms and fruiting bodies of *Sphaeropsis*.

So, from DNR-sources, 98% of the sampled red pines had symptoms of *Sphaeropsis* infections and 90% of the sampled red pines had abundant fruiting bodies on their stems.

Incidental Pests

Insects and Mites	Host	County	Comments
Ant -thatching ant *Formica obscuripes*	Oaks	Itasca	Widespread in MN
Ash bark beetle		Itasca	In bark beetle traps baited for *Temnochila*
Aspen leaf-blotch miner	Aspen	Widespread in R2, Hubbard, Becker, Cass	Most dead from parasites and diseases
Aspen webworm	Aspen	Itasca & several counties in central & NE MN counties	In old FTC cocoon 2002
Balsam twig aphids	Balsam fir	Cass, Crow Wing	
Bronze birch borer	White birch	Crow Wing, Morrison	
Buffalo tree hoppers	White oaks	Morrison	On tattered leaves
Cinara aphids	White spruce	Crow Wing	
Eastern ash bark beetle *Hylesinus aculeatus*	Ash	Cass	
Eastern spruce gall adelgid	White spruce	Cass, Crow Wing	
Elm leaf miner	Slippery elm	Aitkin	West and North sides of Mille Lacs Lake
Engraver beetle	Pine	Hubbard	Used trap trees to control
European fruit lecanium scale *Parthenolocancium corni*	Oaks	Crow Wing	
Flat leaf tiers	Oaks	Crow Wing, Cass	
Gall wasp *Diplolepis tuberculatrix*	Rugosa rose	Crow Wing	
Geometrid caterpillar *Stenoporpia polygrammaria*	White oak	Morrison	Tattered leaves
Greenstriped mapleworm	Red maple	Crow Wing	Only 1, 1 ¼ " mapleworm
Hickory gall phylloxera *Phylloxera caryaecaulis*	pignut hickory	Itasca	
Hickory tussock moth *Lophocampa caryae*	Oaks	Crow Wing	Only a few caterpillars found
Introduced pine sawfly	White pine	Morrison, Hubbard	Very low population this year
Kermes scale	Oak	Becker	
Larch casebearer	Larch	Aitkin, Cass	Population greatly reduced this year; only 1 site found in R1
Maple webworm *Tetralopha asperatella*	sugar maple	Itasca	
Mites *Eriophyes caulis*	Black walnut	Crow Wing	
Northern pine weevil	Pine plantation	Hubbard	Attracted to mulching materials
Oak webworms	Oaks	Crow Wing	
Oak sawfly *Periclista albicallis*	White oak	Morrison	Tattered leaves
Pale tussock moth *Halisidota tessillaris*	Deciduous trees	Crow Wing	found Nside Mollie Lake
Pine tortoise scale	Scotch pine	Crow Wing	
Pine tortoise scale	Jack pine	Lake of the Woods, Roseau	Severe infestations. Also sooty mold associated
Pine webworm	Jack pine	Crow Wing	
Pine bark beetles	Pines	Central MN	Stressed trees
Poplar leaf petiole gall aphid *Pemphligus populicaulis*	Cottonwood	Crow Wing	
Powder-post beetles	Boards	Crow Wing	Garage ceiling boards
Red-headed ash borer *Neoclytus acuminatus*	broom handle	Koochiching	broom purchased in Tennessee
Red-headed pine sawfly	Jack pine, Red pine	Hubbard	Pole-sized trees with very thin crowns; mapped from the air.
Red pine sawfly	Red pine	Crow Wing	Few leaves present

Insects and Mites	Host	County	Comments
Red turpentine beetle	Red pine	Sherburne, Morrison, Crow Wing	On stressed red pines
Red pine cone beetle *Conophthorus resinosae*	Red pine	Crow Wing	Never seen before 2002
Root collar weevil	Red pine	Cass, Crow Wing	
Rose chafer beetles	Trees, shrubs	Crow Wing	
Sawyer beetle *Monochamus notatus*	White pines	Cass	An ALB look-alike.
Spruce needle rust	blue spruce	St Louis	Meadowland
Spruce needle rust	blue spruce	Koochiching	International Falls
Striped alder sawfly *Hemichroa chocea*	Alder	Crow Wing	
Two lined chestnut borer	Red oaks	Widespread R2&3	
Wasps: *Itoplectis conquisetor* and *Gambrus canadensis*	FTC	R2 & R3	Parasitic wasps, only 2 from FTC cocoon study
Whitegrubs	White pine	Crow Wing	Root damage to 3 to 4 ' trees transplanted last year
Wooly alder aphid	Maple	Crow Wing	
Yellowheaded spruce sawfly	White spruce	Cass, Crow Wing Widespread in R1	Tree farm, yards. More than in 2001.
Zimmerman pine moth	White spruce	Cass	

Diseases	Host	County	Comments
Anthracnose	Red oaks	Crow Wing	Light infection this year in R2 & R3
Armillaria root disease	Red pine, White pine	Pine, Crow Wing, Hubbard	10 to 12" red pine planted in furrows stressed by 2001 and 2002 drought
Black knot	Cherries, plums	Pine, Crow Wing	
Cytospora canker	Blue spruce	Crow Wing	Yard trees
Diplodia tip blight	Red pine		
Dothistrom needle blight	Austrian pine	Stearns	
Dutch elm disease	Am. Elm	Morrison	
Fireblight	Mt. Ash	Stearns	
Fomes officinalis	western larch	Itasca	logs from Montana
Laetiporus conifericola	western larch	Itasca	logs form Montana
Maple leaf blister *Taphrina dearnessii*	Red maple	Crow Wing	Yard trees
Neolentinus lepideus	western larch	Itasca	logs from Montana
Purple eye *Phyllosticta minima*	Red maple	Crow Wing	
Rhizosphaera needlecast	Blue spruce	Crow Wing, Wadena, Hubbard, Beltrami	Yard trees
Spruce needle rust	Black & blue spruce	Aitkin, Koochiching, All of northwest	Epidemic in R1.
White pine blister rust	White pine	Crow Wing, Hubbard	Top kill
Yellow witches broom *Chrysomyxa arctostaphyli*	white spruce	St Louis	east side of Hwy 53 a few miles south of Kabetogama DNR

Animal or abiotics	Host	County	Comments
Deer browse damage	Pines, spruce, cedars, etc	Crow Wing, Beltrami, Hubbard, Clearwater, Becker, Wadena	Widespread in R1andR3
Drought & winter injury	Red pine	Sherburne	
Drought	White pine	Stearns, Morrison	
Flooding	All species	Lake of the Woods	10 - 11 inches of rain fell on June 11th
Gopher root mortality	Red and scotch pine	Crow Wing	Browse on roots
Hail	Blue spruce	Hubbard	
Herbicide kill	Poplar seedlings	Crow Wing	
High water table	All species	Northwestern counties	Fourth consecutive year of very wet soil conditions
Lightening	Am. Elm	Crow Wing	
Root suffocation	Red pine	Crow Wing	High water
Root suffocation	Red oak	Crow Wing	Asphalt and concrete close to tree
Salt dehydration and needle death	Red pine	Cass	Nisswa Sewage Treatment water sprayed on Grandview Lodge golf course pine
Sewage field effluent	White spruce	Aitkin	Roots in contact with septic tank effluent
Sewage fields effluent killed oaks	Red oaks	Pine	Tank not pumped in 5+ years
Shading dieback	Balsam, spruce	Crow Wing	6 foot trees grown in sun and planted last year in shade
Soil mineral deficiencies causing yellowing of needles	White spruce	Cass	Trees growing in white sand
Squirrels chewing off bark	Maple	Cass	Yard tree
Squirrels removal of twigs (cutoff)	White spruce and red pine	Crow Wing	Several twigs on the ground
Tattered leaves	Oaks	Morrison	
Winter drying of needles	White pine	Crow Wing	
Yellow bellied sapsucker damage	Mt. Ash	Crow Wing	

Phenology

Date	Event	County
3-28	Conifers change to spring green color	Ramsey
4-15	Aspen catkins showing.	Cass
4-16	Aspen catkins 10% out.	Itasca
4-16	Aspen catkins 40-50% out. Red maples blooming	Aitkin
4-16	Red oak buds breaking, silver maple flowers out.	Ramsey
4-17	Quaking aspen with catkins, pussy willows blooming, red maples starting to flower	Hubbard, Crow Wing
4-18	Lilac leaves showing from buds	Crow Wing
4-29	American elm blooming	Crow Wing
5-1	Spruce budworm 2nd larvae starting to drop from trees	Itasca
5-2	Larch needles showing	Crow Wing
5-13	FTC starting to hatch in woods	Itasca
5-14	Extra-ordinarily late and cold spring. In Grand Rapids since mid-April, freezing temperatures at night, usually overcast and plenty of rain.	Itasca
5-14	One aspen clone with green leaves < 1 inch long.	Aitkin
5-14	FTC hatching. Buds breaking on northern hardwoods, few red maples are blooming.	W side of Mille Lacs, Crow Wing
5-14	Basswood buds showing green leaves	W side of Mille Lacs, Crow Wing
5-14	Carpet of *Hepatica* in bloom.	Central Mille Lacs
5-14	Siberian elm leaves size of mouse ears, dandelions just starting to bloom, box-elder leaflets are 3/4 inch	Sherburne
5-20	Red pine candles < 1 inch, Mt maple blooming, boxelders with small fruit, lilacs just starting to bloom, ash in small leaf, crabapples in bud stage, elderberry blooming, spruce bud caps 90% off, oaks, willows, poplars in small leaf stage, maples with fruit, dandelions in town blooming, marsh marigolds blooming.	Sherburne
5-20	Yellow rocket, Dutchman's breeches, *Trillium* blooming.	Mille Lacs
5-21	Bark beetle females depositing eggs	NW Wright
5-22	June berries blooming	Crow Wing
5-22	Ash buds with 1" leaves and small flowers	Crow Wing
5-22	Basswood leaves to ¾" long	Crow Wing
5-22	FTC first instars (3-4 millimeters) starting to feed on basswood buds	Crow Wing
5-22	Red elderberry blooming	Crow Wing
5-22	Trembling aspen leaf blades to 1 ¼ " wide	Crow Wing
5-22	Birch leaves just showing from buds	Crow Wing
5-22	Birch in flower, wood anemone, Dutchmans, breeches, adders tongue, white trout lily, Heptatica and large bellwort blooming	Crow Wing
5-22	FTC ¼" long (hatched 3 days ago) and basswood leaf blades to 1 ½ " wide	Crow Wing
5-22	Basswood leaf blades to 1 ½ " wide and FTC in first instar. White birch leaves up to 1"long and ¾" wide	Southern Todd
5-22	Juneberries blooming and ed and white oak leaves to 1 ½" long	Southern Todd
5-22	Red turpentine beetle (36) in 3 pheromone traps	N Crow Wing
5-23	Sugar maples, serviceberry blooming. Most aspen and birch are leafless. Pin cherries beginning, *Trillium grandiflora*, lily pads on ponds.	Itasca, Cass
5-23	Pine bark beetles in nuptial chambers, a few eggs present	Wright
5-28	Red and white oaks done pollinating and leaf blades 1 ½" long, Big-tooth aspen leaf blades 1" long. Pin cherries blooming, quaking aspen dropping seeds (dry fruit) flowering crabs blooming. Lilacs blooming.	Crow Wing
5-28	Basswood leaf blades 2 ½" wide and 3" long	Cass
5-13	FTC 1/4 to 3/8 inches long	Itasca
5-31	Chokecherries blooming	Crow Wing
6-3	FTC 3rd instar ¾" long	St Louis, Duluth area

6-5	Spruce budworm in 3rd instar according to Darren Blackford	Itasca
6-5	Lilacs in full bloom in grand Rapids	Itasca
6-6	FTC 1 to 1 1/4 inches long along 169 between GR and Nashwauk	Itasca
6-6	FTC 11/4 to 11/2 inches long in Grand Rapids	Itasca
6-7	FTC > 1 inch, 3rd instars with some 4ths. Not much defoliation.	Southern Todd
6-9	Ironwood flowering, basswood still in bud, mt. maple seeds are red. Blooming: black-eyed Susans, St. John's wort, bitter nightshade, parsnip, tall meadow rue.	Itasca
6-10	Lots of Sarcophagid flies near Side Lake	St Louis
6-10	FTC defoliating oaks and ashes	Grand Rapids
6-10	White spruce and jack pine releasing pollen	Itasca
6-10	Columbine and cotton grass blooming	Mille Lacs, Morrison
6-12	Blooming: wild geranium, black locust, false Solomon's seal	Mille Lacs
6-13	FTC larvae about 11/2 inches long near Meadowlands	St Louis
6-13	Hoary puccoon blooming	Crow Wing
6-13	Indian parent brush blooming	Cass, Wadena
6/17	Spruce budworm approximately 3/8 to 1/4 inches long	St Louis
6/17	spruce budworm approximately ½ inches long near Cook	St Louis
6-18	Catching ash bark beetle in trap baited for *Temnochila*	Itasca
6-20	FTC 11/4 inches long along North shore	Lake, Cook
6-20	Spruce beetle egg galleries 2 to 5 inches long with lots of eggs, Cascade River and Judge Magney State Park	Cook
6-20	FTC 2" long	Itasca
6-20	1 FTC cocoon east and 1 west of Grand Rapids	Itasca
6-20	Friendly flies (parasite of FTC) mating	Itasca
6-20	Many FTC cocoons on red maple	Itasca
6-22	FTC starting to cocoon in Grand Rapids	Itasca
6-24	FTC pupating. Blooming: Oxeye daisy, Canada mayflower, pagoda dogwood, goat's beard, tick trefoil, dogbane, yellow sweet clover, wild rose, blue flag iris, white water lily	Cass, Itasca
6-24	Blooming: Indian paintbrush, blue flag iris, beard's tongue, white milkweed.	Wadena
6-25	Lupine and hawkweed blooming	St Louis- Duluth area
6-28	FTC about 50-75% pupated in Grand Rapids Lots of Sarcoohagid flies in Demo forest	Itasca, StLouis
7-2	Wild rose, butterfly weed, blackeyed Susan, white campion, harebell, yellow sweet clover, tall sunflower, water hemlock, butter and eggs, meadow rue, vetch, common milkweed blooming	Sherburne
7-2	New oak leaves not tattered	Morrison
7-5	FTC moths in Cohasset but some still in cocoons	Itasca
7-5	Common and swamp milkweed, blackeyed susan and fireweed blooming	Cass
7-5	Many FTC cocoons at gas station lights	Itasca
7-8	98% of FTC still feeding larvae, lots of dead FTC and a few cocoons in Goosebery Falls State Park	Lake
7-9	Blooming: Rudbeckia, white sweet clover, basswoods, orange butterfly weed.	Isanti
7-9	Larch casebearer-caused discoloration is very visible	Aitkin
7-9	Many FTC moths around night lights	Crow Wing
7-15	Most Spruce budworm eggmasses have hatched according to D Blackford	Itasca
7-22	Common milkweed, sweet clover, blackeyed susan, lead plants, white sage, prairie clover, mullein, golden rod, soapwort, tangy spotted knapweed blooming	Crow Wing, Morrison
7-22	Giant hyssop blooming	Todd
7-23	Yellow headed spruce sawfly larvae done feeding and in duff	Crow Wing
7-23	Found only 1 greens striped mapleworm, 1 ¼"	Crow Wing
7-23	Aspen webworms defoliating aspen around Grand Rapids	Itasca
7-29	Spruce needlerust near International Falls	Koochiching
	spruce needlerust showing near Floodwood	St Louis
8-9	Sunflower, showy tick trefoil, goldenrod, purple prairie coneflower, and *Monarda* blooming	Chiscago
8-21	Lots of two-lined chestnut borer damage showing up	Itasca
9-3	Wild plums ripe. Black currants starting to ripen	Crow Wing
9-20	Red humped oakworm pupating in duff	Crow Wing

Impacts of drought and bark beetles on red pine forests of the Anoka Plains

By Dr.Matthew Ayres, Bruce Ayres, Mike Peltier and Jana Albers
(Excerpted to discuss only objective 3.)

Red pine has been widely propagated since the late 1950s and has proven itself to be an excellent silvicultural option. Since it is only now that the first rotation of plantings are maturing into 2nd growth forests, which are destined to one day become our only old growth, foresters and landowners have surprisingly limited experience on which to base some important management decisions. For example, there is little basis for knowing when or where there will be consequential mortality of adult trees from drought and bark beetles. If some soil types or regions have predictably higher mortality rates for trees, the expected half life for a cohort of trees will be reduced, which, among other things, influences the successional trajectory of a forest managed for wildlife, and changes the optimum harvest schedule of a forest managed for economic returns. There is also little basis for evaluating the costs and benefits of pest control efforts in mature stands of red pine. One of the most significant pests of mature pines in the Great Lakes region is the pine engraver beetle, *Ips pini*. *I. pini* is regarded by many forest entomologists as an occasionally eruptive species that normally has little impact on healthy trees, but which can produce sustained outbreaks when environmental conditions such as a drought or windthrow allow the development of large populations that then become self-sustaining through continued successful mass-attacks on otherwise healthy trees. Such populations are excellent candidates for cost-effective control because occasional efforts can suppress eruptions back to low (endemic) populations levels where they then tend to be regulated by natural forces. Based on this theoretical principle, rather extensive control programs (mass-trapping) were conducted in the Sand Dunes State Forest following the drought of 1988-89 and in Itasca State Park following the windstorms of 1996-97. However, the underlying theory has not been tested for *I. pini*. If it does not hold, then bark beetle control efforts such as mass-trapping or sanitation logging would have less benefit, no benefit, or even make matters worse by delaying the onset of natural controls from predators.

Objectives

There is limited ability to know when, or where, there will be consequential mortality of adult trees from drought and bark beetles, and what, if anything, can be done to mitigate the undesirable impacts. Motivated by the most recent drought, we conducted studies during 2002 to address the following questions:

1. Why is tree mortality associated with bark beetles more common in the Anoka plains than in superficially similar regions, e.g., west central Wisconsin?
2. Are there predictable patterns in tree mortality within a region that are related to soil type?
3. Do bark beetle infestations tend to become self-perpetuating eruptions following a drought?

Background for Objective 3: Are *I. pini* populations eruptive on the Anoka Plains?

During July 2001, more than 50 patches of red pine mortality were detected in Sherburne and Isanti Counties during aerial surveys by Minnesota Forest Health personnel. This was thought to be the result of a drought during 2000, which had ended by 2002. The eruption hypothesis assumes that populations are regulated around one of two equilibria, at endemic or epidemic levels (Fig. 1). Under this model, populations can undergo a state change from endemic to epidemic if some exogenous factor (e.g., a drought that kills some trees and produces a pulse of high quality food resources) permits populations to exceed an escape threshold beyond which further resource limitations are relaxed because they are able to employ mass-attacks to kill additional trees. In the case of bark beetles, resource limitations that regulate populations around the endemic equilibrium are expected to produce a pattern of increasing colonization density in suitable host material (fresh logs and recently killed trees) with increasing abundance of colonizing adults within the forest stand. When local abundance of colonizing adults exceed the hypothetical escape threshold, colonization density in logs is predicted to decline as some adults participate in attacks of nearby live trees. We tested these predictions (Fig. 2) with studies of multiple infestations in and around the Sand Dunes State Forest, a putative epidemic population, and multiple stands of red pine on the Colfax Plains, a putative endemic population.

Methods Objective 3. Test for eruptive behavior in populations of *Ips pini.*

We used 12-unit Lindgren funnel traps to estimate the abundance of *Ips* bark beetles at each study site during the early summer flight period in 2002 (4 weeks of sampling from 26 May to 25 June). This sampling was timed to capture beetles that had successfully overwintered and were destined to reproduce during the summer. At each site, we deployed an array of four funnel traps, configured as an approximate square of ~ 20 x 20 m. Two traps per site were baited with the pheromone signal of *Ips pini*, ipsdienol + Lanierone, one was baited with the pheromone signal of *I. grandicollis*, ipsenol, and one was baited with the pheromone signal of I. *perroti*, ipsenol and ipsdienol (Ayres et al. 2001). Pheromone lures were bubblecaps purchased from PheroTech: elution rates of 0.2 mg / d for ipsdienol (racemic) and ipsenol, and 0.01 mg / d for Lanierone. Traps were emptied weekly and, at the same time, lures were rotated among traps to guard against spurious effects from trap position. Later, trap captures were counted and identified.

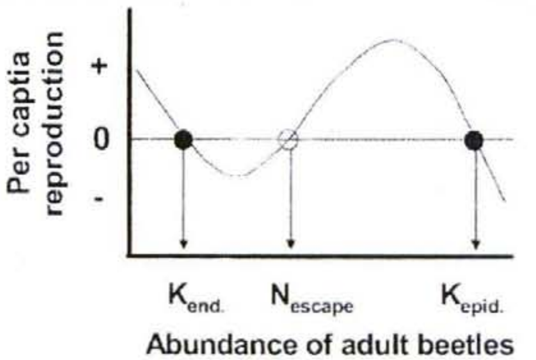


Fig. 1. Theoretical model of an eruptive forest insect. Per capita population growth rate is a complex function of abundance. When abundance is less than N_{escape}, populations tend to be regulated around an endemic equilibrium ($K_{endemic}$). However, if exogenous forces permit the population to exceed an unstable equilibrium or escape threshold (N_{escape}), populations will tend to grow to a much higher epidemic equilibrium ($K_{epidemic}$). We tested whether this model applies to the pine engraver beetle, *Ips pini*, by testing some predictions derived from this model (Fig. 2)

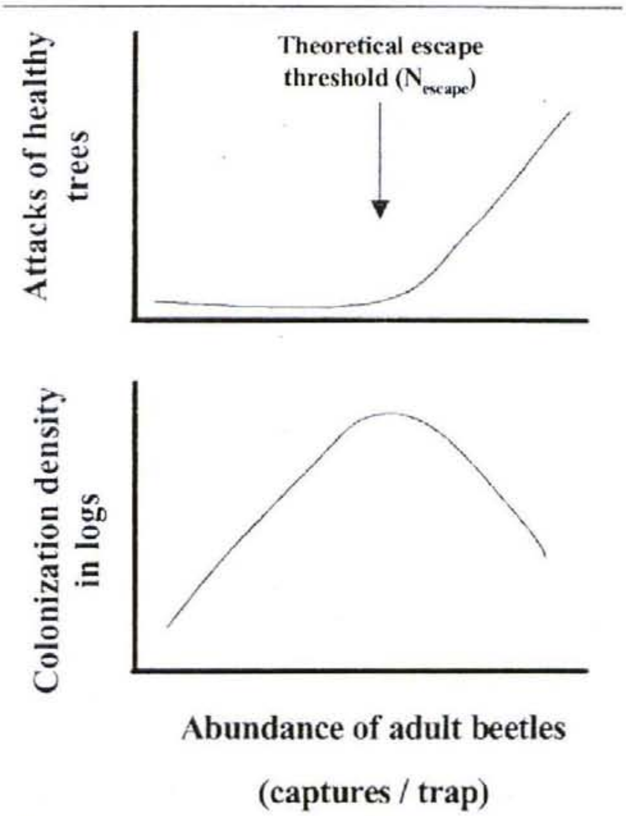


Fig. 2. Predictions derived from Fig. 1 for *Ips pini*. As local population abundance increases, the colonization density in logs (ovipositing females / dm^2) is predicted to increase (generating the initially negative relationship in Fig. 1 between adult density and per capita reproduction), until populations reach a threshold where they begin to attack live trees, at which point competition for food resources is theoretically alleviated and colonization density is predicted to decline.

At each site, we also measured beetle colonization densities in logs. In late May, two trees were felled at each site, and 5, 50-cm long logs were removed from the mid-bole of each tree. At this time, 5 logs (2 or 3 from each source tree) were spread over each site (one log near each funnel trap, and one in the center of the trapping area). The other five logs were covered with a tarp, to prevent beetle colonization, until 15-20 July, when they were placed in the same locations as the first set of logs to provide a resource for colonization by the 2nd generation of *I. pini*. At this time, the first set of logs were consolidated and covered with a tarp to prevent further colonization by beetles. On 22-27 August, we measured the colonization density by *Ips* of each trap log. We carefully removed a 40 x 22 cm section of bark from the upper surface of each log and counted the number of oviposition galleries, each representing one adult female that entered the log and began laying eggs. For each site, we calculated average experienced attack density. This calculates the density experienced by an average ovipositing female within each site, which is more appropriate than the average density per log for estimating effects of intraspecific competition on population growth rate. It turned out that by the time of our measurements in late August, the logs colonized during June were too damaged by wood borers and other phloem-feeding insects to measure *Ips* colonization densities. Hence, our subsequent analyses were restricted to logs colonized after 15 July. When we examined the logs in late August, we collected samples of adult *Ips* from the trap logs for identification. Not all of these have been examined yet, but it appeared that most, or all, were *I. pini*, which is as expected since the *I. pini* always has multiple generations per year in this region, while *I. grandicollis* and *I. perroti* typically just have a single generation.

Results and Discussion

Objective 3a: Abundance, species composition, and pheromone preferences of the bark beetle community

As expected, *I. pini* were more abundant in the Anoka Plains compared to the Colfax region (Table 4). With the same trapping protocol, captures of *I. pini* from late May to late June (the flight time of the overwintering generation) averaged about 8-fold higher in Anoka vs. Colfax (826 / site vs. 111 / site; Table 4). *I. grandicollis* were also more abundant in Anoka, but less so (only about 50% higher). Surprisingly, *I. perroti* were actually less abundant in Anoka than Colfax (Table 4). The two most abundant predators, *Thanasimus dubius* (Coleoptera: Cleridae) and *Playtsoma cylindrica* (Coleoptera: Histeridae) were both about 7-fold more abundant in Anoka than Colfax. The abundance of predators relative to prey, (*T. dubius* + *P. cylindrica*) / total *Ips*, was about 2.5x higher in Anoka compared to Colfax. This is consistent with the hypothesis that these specialist predators increase in their abundance after a year or two of high prey abundance. Presumably, this generates some negative feedback (with a delay) on the population growth rates of bark beetles (as has been reported for some other bark beetle systems; Turchin et al. 1999). It is not known whether or not this negative feedback is sufficient to eventually drive bark beetle populations back to an endemic equilibrium, or whether it is merely sufficient to regulate abundance around an epidemic equilibrium (see Fig. 1)

Bark beetle pheromone preferences in both regions matched those reported in earlier studies conducted near Colfax, WI and Itasca State Park, MN (Table 5): 95 -96% of *I. pini* were captured in traps baited with ipsdienol + Lanierone; and 73 - 94% of *I. grandicollis* were captured in traps baited with ipsenol by itself. The two most abundant predators were captured with all three pheromone signals, but were most attracted to the signal that is produced and preferred by *I. perroti* (ipsenol + ipsdienol). This suggests a hypothesis for why *I. perroti* were relatively rare in the forests where *I. pini* were very abundant.

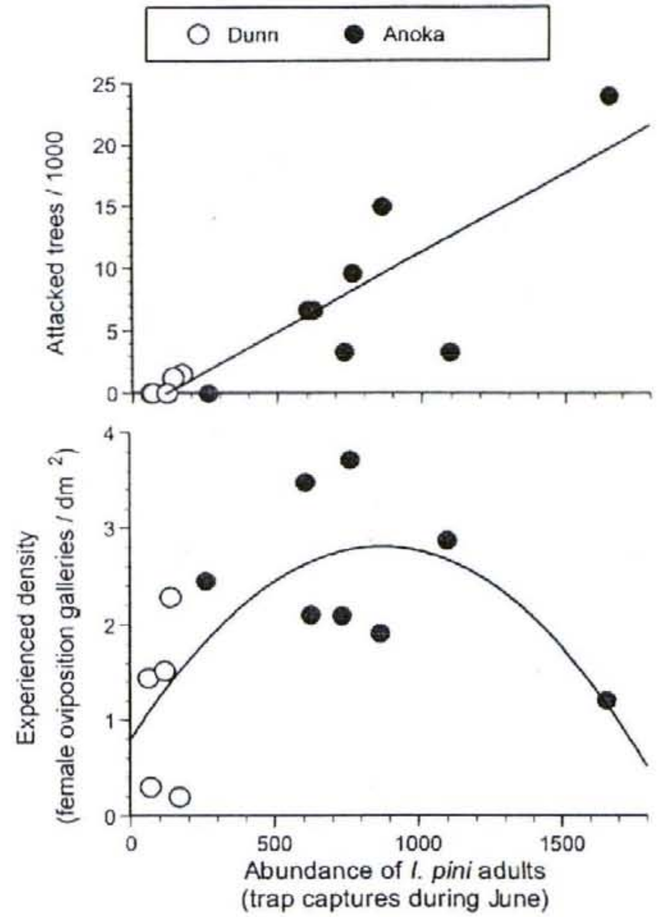


Fig. 17. Trees attacked by Ips pini during summer 2002 as a function of I. pini trap captures during early summer (upper) and I. pini colonization density in logs as a function of trap captures (lower). Best fit function for upper: $Y = -1.5 + 0.013 \cdot X$ ($P = 0.0002$). Best fit function for lower: $Y = 0.79 + 4.63E\text{-}3 \cdot X - 2.66E\text{-}6 \cdot X^2$ ($P = 0.035$ for full model, $P < 0.02$ for both coefficients). Compare these empirical data to theoretical predictions in Fig. 2 for an eruptive population (Fig. 1).

Objective 3b: Test for eruptive behavior in populations of *Ips pini*

As expected, beetle-attacked trees were common in the Anoka Plains and very rare in the Colfax region: average tree mortality rates during the three years from 2000-2002 were 15.8 vs. 0.5 tree deaths per 1000 trees per year for Anoka and Colfax, respectively (Table 3). Across 8 red pine stands on the Anoka Plains, average tree deaths per 1000 were 6.4 in 2000, 24.7 in 2001, and 6.9 in 2002. In all but one Anoka site, tree deaths peaked in 2001. Tree attacks during 2002 were positively related to abundance of *I. pini* during early summer (Fig. 17 , upper). There was a suggestion of a threshold for tree attacks, as predicted by the theoretical model for eruptive population dynamics. Tree attacks became relatively common when early summer trap captures of *I. pini* exceeded about 500 per two traps per month (Fig. 17, upper).

Colonization densities of logs by *I. pini* were also higher in Anoka than Colfax: mean experienced density + SE = 2.5 + 0.1 vs. 1.1 + 0.2 ovipositing females / dm^2, respectively. Across all 13 red pine stands that were studied, the density of *I. pini* in logs colonized during August was related to trap captures of overwintering *I. pini* adults during June (Table 2). However, this relationship was nonlinear, with a peak when trap captures were intermediate (Fig. 17 , lower). There was strong statistical support for the nonlinearity of this relationships (AIC for 2nd order polynomial vs. linear model = 5.57). The form of this relationship, and the match between a threshold for tree attacks and the peak in colonization density, were as predicted by the theoretical model for eruptive population dynamics (compare Figs. 2 and 17). The support for this model, although based on only a single year of data, is strengthened by the fact that the test involved rather specific predictions about the interrelations among three independent variables (local abundance as measured by trap captures, colonization densities in logs, and the number of live trees attacked during the summer). Presumably, beetle colonization densities in logs started to decline after trap captures exceeded about 800 because some beetles were participating in successful attacks of live trees, which increased the resource base for ovipositing females, and eased competition for phloem. Results suggest that the escape threshold for *I. pini* (N_{escape} in Fig. 1) is at 600 - 800 captures per two funnel traps per month.

Conclusions

Regional differences in tree growth, tree mortality, and beetle outbreaks

Tree mortality rates are clearly much higher on the Anoka Plains than areas within 90 miles that experience similar climates and have similar sandy soils. This was obvious not only from the counts of mortality events during the last 3 years, but also from dramatic differences between the regions in the numbers of downed trees from earlier deaths; such logs were abundant throughout pine stands in the Anoka Plains but were rare or absent in pine stands near Colfax. The differences in tree mortality are difficult to explain based on the modest (6%) difference in average annual precipitation. Apparently there is a strong effect from the Anoka Plains being made up of soils that drain more rapidly than those near Colfax. Still, the direct effects on red pine forests of lower and more variable soil water would probably be modest were it not for the presence of bark beetles that can apparently be triggered by drought episodes to switch from endemic populations that rarely kill trees to epidemic populations that commonly kill trees. Thus the explanation for differences between red pine forests near Anoka and Colfax appear to involve strong interactions between climate, soils, and beetle population dynamics. The regional difference in tree mortality rates is surely enough to influence optimal harvest schedules, and is also surely enough to warrant careful consideration of bark beetle management on the Anoka Plains, even while forest managers near Colfax can generally ignore them without consequence.

With constant annual mortality rates of 0.5 / 1000, such as we observed at Colfax, and other things being equal, a red pine stand would experience 48 deaths / 1000 trees over 100 years. Since 1930, there appear to have been about six significant droughts on the Anoka Plains. We estimated that the 2001 drought resulted in mortality of 15.8 trees / 1000. If there is one drought per 12 years that results in the death of 15.8 trees / 1000, on top of a background annual mortality rate of 0.5 / 1000, a red pine stand would experience 175 deaths / 1000 trees over 100 years. These calculations are very simplistic. In particular, they fail to account for: (1) the risks of catastrophic losses associated with droughts more severe than that of 2001; (2) mortality risks associated with fire, blowdown, fungal pathogens, and ice damage; (3) potential for minimizing risks through selective harvesting. Nonetheless, these calculations suggest that there would be value in developing more sophisticated projections to aid in the development of long term management plans for red pine stands that account for regional differences in tree growth and mortality rates on timber yield and stand structure over 50 - 100 year time frames. Our sense is that it is realistic to manage red pine stands near Colfax for a time frame of >100 years, while reasonable rotation times for red pine stands near Anoka may be substantially less. These calculations also suggest that the expected lifespan for red pine stands near Anoka may be extremely sensitive to consideration of bark beetle risks in site selection and management.

In addition to modifying red pine management strategies on the Anoka plains, it may make sense to consider other tree species for future reforestation. Because tree/bark beetle interactions can be quite species-specific, and because tree species differ in moisture requirements and drought response, planting other conifers instead of red pine, may make sense. Mixed species plantings in some areas have shown promise for managing pest/tree interactions, and offer the additional benefit of providing a more diverse ecosystem. Our work offers no insight as to the suitability of alternate tree species, but could help establish parameters for comparisons.

Application of USGS hydrological discharge data

Analyses of river discharge data suggest that there would be value in monitoring USGS discharge data to recognize potential droughts in the early stages and implement appropriate, cost-effective responses (e.g., minimizing log decks that could permit buildups of bark beetles, and conducting aerial and ground surveys for early signs of tree deaths and beetle activity). This would also facilitate studies of tree water status and resin defenses during the time of presumed maximal water deficits. Such studies are needed to understand how drought influences the defenses of trees that would survive in the absence of beetles. Available data suggest that resin defenses of pines are actually increased by moderate water deficits, but patterns at Anoka are also consistent with the alternative hypothesis that drought stress compromises tree defenses. Resolution of these competing hypotheses will aid in understanding how beetle control efforts and stand management can mitigate risks of tree mortality.

USGS river discharge data may have broader applicability for: (1) objectively identifying regions that are generally susceptible to consequential droughts; and (2) monitoring entire states for local or regional droughts. This broader applicability depends upon the unvalidated proposition that patterns identified here based on four rivers in two county-sized regions can be extended to a broader spatial scale. However, it would cheap and easy to begin evaluating the generality of, for example, the 30% drought threshold suggested here. Among other benefits, results would likely enhance our ability to anticipate the consequences for forests of changes in temperature and precipitation that have already occurred and are likely to accelerate. We can expect climate changes to continue to alter patterns of soil water availability in Minnesota, and the effects on forests, whether positive or negative, are likely to be the largest and most immediate in regions like the Anoka. Plains.

Correlations within a region between local soil types, average tree growth, and stand susceptibility to droughts

We were unable to resolve what, if any, are the patterns between local soil types, tree growth, and stand susceptibility to drought and beetles. However, the question is important and deserves further study. We suggest that a subsequent study include replicate pine stands selected at random from within different mapped soil types. Within these stands, one could measure: (1) soil moisture profiles as in Figs. 15-16, replicated within each stand and across the season; (2) tree mortality via surveys for dead trees and downed logs; (3) historical patterns in height and diameter growth; and (4) depth of roots. Results would aid forest managers and landowners in selecting sites for red pine propagation, and customizing management of red pine stands for site-specific characters (e.g., harvesting schedules, tree selection during harvesting, pest monitoring, and pest control).

Implications for understanding effects of climate on tree mortality and beetle populations

Results indicate that there are potential benefits to monitoring populations and treating those that have exceeded the escape threshold that separates endemic populations from eruptions. Apparently, climate and beetles interact to determine tree mortality rates and forest disturbance regimes. Direct death of trees from drought may be less important than drought as a factor that triggers state changes of bark beetles from endemic to epidemic. If it were otherwise, the impacts of beetles would be restricted to times when trees are dying, or have compromised defenses, as a result of climatic stress. As it appears to be, beetle mortality may continue for years after a drought abates. Potential control strategies for *Ips* in red pine forests include mass-trapping with pheromone-baited funnel traps, deployment and destruction of trap logs, and aggressive sanitation. In our judgement, it remains to be established that these control strategies can be effective and practical for pine systems in Minnesota, but if *I. pini* populations tend to have endemic and epidemic states (Fig. 1), there is potential value in pest control. The correlation among stands between trap captures in early summer and tree attacks during the summer, suggests that control might be effective at the stand level (not necessarily requiring expensive regional efforts). We recommend that a plan be devised for implementing pest control efforts in some stands that are above the estimated escape threshold (Fig. 17) and leaving other such stands as controls. This would permit the evaluation of different possible control strategies, the continued testing and refinement of models to predict bark beetle population dynamics, careful assessment of possible undesirable side effects (e.g., removal of natural controls by predators) and, hopefully, the mitigation of expensive beetle impacts within treated stands.

Table 3. Stand characteristics, beetle captures in pheromone-baited funnel traps, *Ips* colonization densities in traps logs, and beetle-attacked trees in red pine stands near Anoka, MN and Colfax, WI.

		Stand characteristics							Trap captures (per 4-trap array during June 2002)						*I. pini* in logs[d]	Attacked trees / 1000		
Region	Site	Soil.ID	Age.2002[a]	Age.2002[b]	Height(ft)	Site.Index[c]	DBH(in)	BasalArea	*I.pini*	*I.grand*	*I.perrot*	*T.dubius*	*P.cylind*	Ips/Predator	Attacks/dm2	2002	2001	2000
Anoka.MN	1	1256 lfs	49	52	63	61	10.1	107	624	346	33	430	452	1.1	2.11	7	60	0
Anoka.MN	2	1256 lfs	51	53	59	56	10.5	137	1096	206	1	221	95	4.1	2.88	3	10	7
Anoka.MN	4	1258 fs	57	51	52	51	8.7	230	606	252	12	244	217	1.9	3.48	7	84	31
Anoka.MN	5	158A fs	57	55	66	61	10.9	90	866	297	16	363	121	2.4	1.91	15	28	2
Anoka.MN	6	158A fs	48	43	66	75	8.2	180	1657	331	34	1443	304	1.2	1.20	24	52	24
Anoka.MN	8	158A fs	40	45	52	57	9.5	207	261	177	28	1123	143	0.4	2.45	0	10	0
Anoka.MN	9	1258 fs	45	46	64	68	7.7	183	733	269	205	721	216	1.3	2.10	3	3	0
Anoka.MN	10	Sp fsl	35		39	53	8.0	177	762	162	2	153	22	5.3	3.72	10	0	0
		Mean	**48**	**49**	**58**	**60**	**9.2**	**164**	**826**	**255**	**42**	**587**	**196**	**2.2**	**2.5**	**9**	**31**	**8**
		SE	**1.0**	**0.7**	**1.2**	**1.0**	**0.2**	**6**	**51**	**9**	**8**	**59**	**17**	**0.2**	**0.1**	**1**	**4**	**2**
Colfax.WI	ChamN	Pdb	39	39	72	89	10.6	183	62	156	56	65	34	2.8	1.44	0	0	0
Colfax.WI	ChamW	EmB	39	39	67	83	11.0	147	169	189	202	130	38	3.3	0.20	2	0	0
Colfax.WI	Dickin	PfA	43	42	72	83	10.2	133	139	145	176	68	25	4.9	2.29	1	5	0
Colfax.WI	ScoreN	PdB	42	41	68	80	10.1	160	69	86	8	45	10	3.0	0.30	0	0	0
Colfax.WI	ScoreS	UnB	42	41	71	84	8.6	230	118	242	224	110	37	4.0	1.52	0	0	0
		Mean	**41**	**40**	**70**	**84**	**10.1**	**171**	**111**	**164**	**133**	**84**	**29**	**3.6**	**1.1**	**1**	**1**	**0**
		SE	**0.4**	**0.3**	**0.5**	**0.6**	**0.2**	**8**	**9**	**11**	**19**	**7**	**2**	**0.2**	**0.2**	**0**	**0**	**0**

[a] Age based on planting records. Age.2002.b – age at 1 m (from cores) + 5. Site indices calculated from Age.2002.b

Table 4. Average captures per site (in 4 Lindgren funnel traps) of three species of *Ips* bark beetles and two species of bark beetle predators during early summer 2002 in 8 red pine stands on Anoka Plains, MN and 5 red pine stands near Colfax, WI.

~Mid-date	*Ips pini*		*Ips grandicollis*		*Ips perroti*		*Thanasimus dubius*		*Playtsoma cylindrica*	
of collection	Anoka	Colfax	Anoka	Colfax	Anoka	Colfax	Anoka	Colfax	Anoka	Colfax
27-May		23		136		101		11		4
3-Jun	675	20	229	15	37	20	313	23	98	6
13-Jun	60	10	11	6	4	7	120	14	36	6
20-Jun	91	58	15	6	1	5	155	36	62	13
29-Jun		441*		6		40		30		17

* Presumed to be the 2nd generation.

Table 5. Percent of captures by species and region in Lindgren funnel traps baited with either of three sets of pheromone lures, designed to match the pheromone production of *I. pini* (ipsdienol + Lanierone), *I. grandicollis* (ipsenol), or *I. perroti* (ipsdienol + ipsenol). Bark beetle preferences in both regions matched expectations based on previous studies near Colfax and Itasca (Ayres et al. 1999, 2001). Both of the two most common predators responded to all pheromone signals, but were most attracted to ipsdienol + ipsenol. This, plus the generally high abundance of predators near Anoka, might explain the relative rarity of *I. perroti* near Anoka (Table 4).

Pheromone	*Ips pini*		*Ips grandicollis*		*Ips perroti*		*Thanasimus dubius*		*Playtsoma cylindrica*	
lure(s)	Anoka	Colfax	Anoka	Colfax	Anoka	Colfax	Anoka	Colfax	Anoka	Colfax
Ipsdienol + L*	95	96	3	0	4	2	35	29	34	38
Ipsenol	2	0	73	94	0	0	24	23	19	12
Ipsdien. + Ipsenol	3	4	23	6	95	98	41	48	47	50

* Lanierone, = pheromone synergist of ipsdienol for *Ips pini*

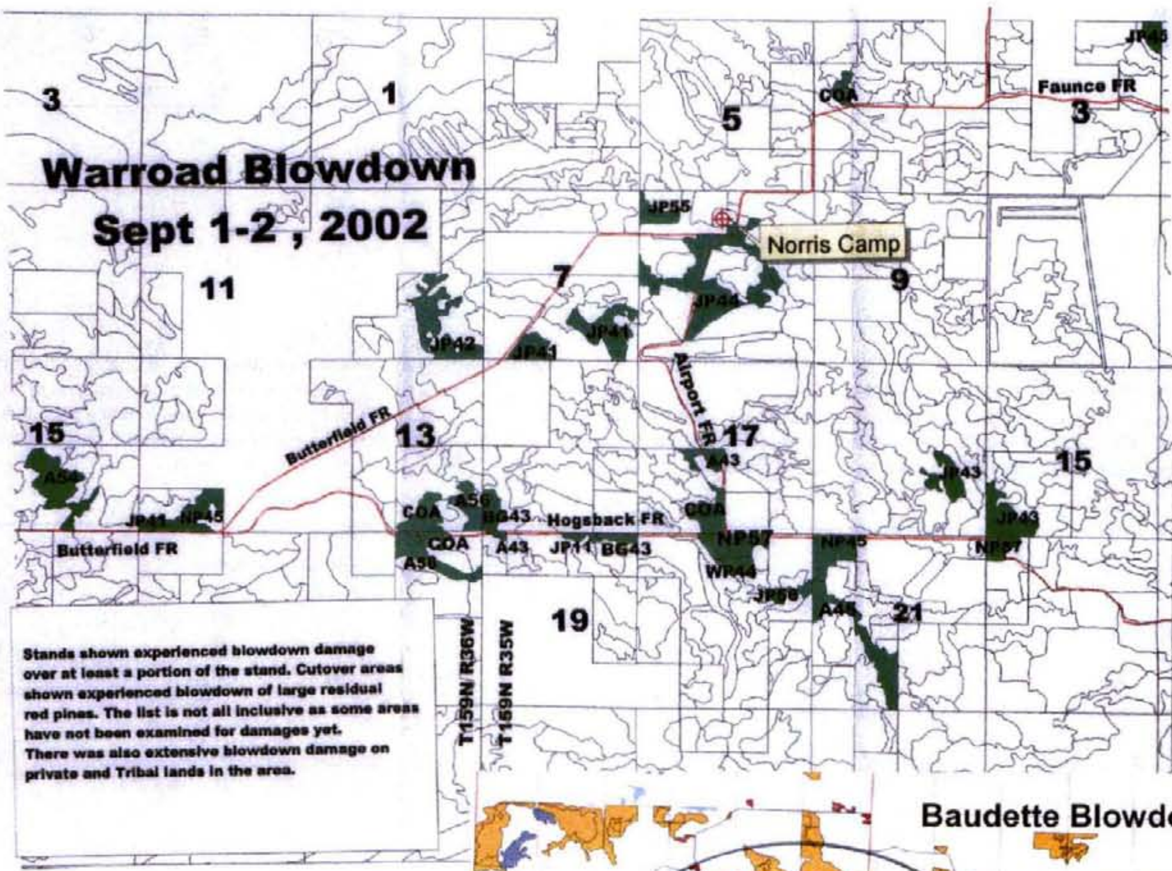
From the preliminary report, Impacts of drought and bark beetles on red pine forests of the Anoka Plains, MN. March 9, 2003.

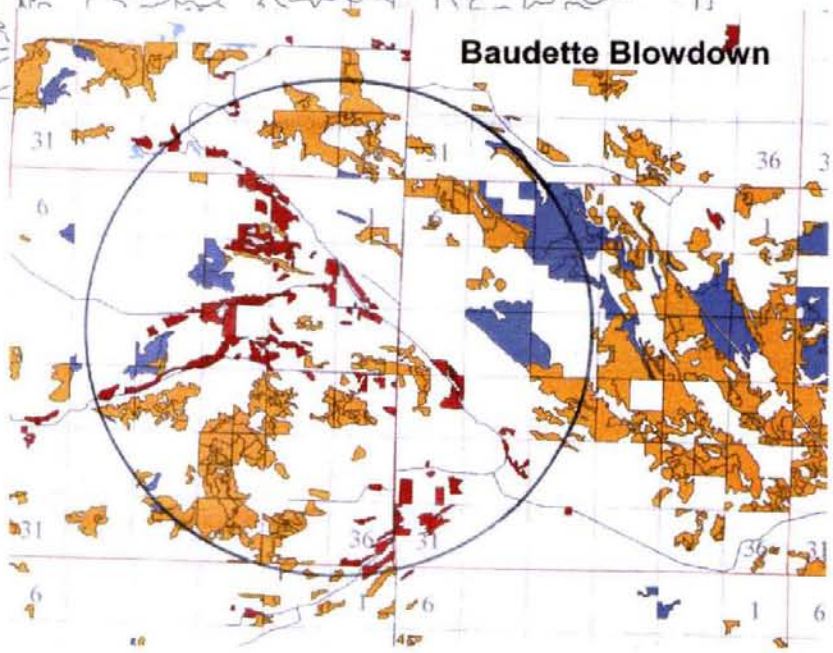
Dr. Matthew Ayres is Assoc. Professor of Biology at Dartmouth College.
Bruce Ayres is Director of the Great Lakes Institute of Pine Ecosystem Research in Colfax, Wisconsin.

Blowdown and bark beetles:
Natural disturbances in " very rare" red pine age classes

By Jana Albers

138 acres of mature, natural red pines were blown down in a windstorm on September 1st on DNR-managed lands near Baudette and Williams. See attached maps. There is a concern that losing more acres of this age class will make mature, natural-origin red pines vulnerable to extirpation in this landscape. The immediate concern, and one which could hasten their demise, is that a pine bark beetle outbreak might occur. Pine bark beetles could infest the snags, snap-offs and tip-overs during the next 2 to 3 growing seasons, build-up their populations and then spread to nearby, standing mature red pines and kill them.





Blow-down and other natural disturbances in red pine stands occur from time to time. These are "natural" events and the decision whether to actively manage the affected lands depends on several factors. Among these factors is the demography of the affected resource. Management response should take into account the rarity of species affected and, in the case of long-lived trees, its age class. As a species becomes more rare in its landscape, the effect of disturbances becomes increasingly magnified and the species can become vulnerable to extirpation.

In Baudette and Warroad Areas, red pine is a "rare" covertype comprising 1.8% of all forested lands. See table below. Large and old red pine lands. See table below. Large and old red pine are "very rare", being found on 550 acres, 0.06% of the forested land. Blowdown affected 138 acres of older, red pine stands which leaves 412 acres. DNR-Wildlife manages 96% of the older, red pine acres with blowdown on them.

Acres and (Percentages) of covertypes.				
Management unit	**Forested area All covertypes**	**Red pine All size classes**	**Red pine Either > 70 yrs or > 9" dbh**	**Blowdown In red pine stands**
LUP	25,951	1,836 (7.1)	240 (13.1)	132
Baudette	363,630	3,278 (0.9)	259 (7.9)	6
Warroad	463,935	10,779 (2.3)	51 (0.5)	0
Totals	853,516	15,893 (1.8)	550 (0.06)	138

It is the purview of DNR-Wildlife to use passive management on the blowdown acres since they occur on LUP lands. However, it may be unwise given the history of bark beetle outbreaks in the vicinity and the increasing danger of loosing the remaining acres of older age classes of red pine. DNR management activities may want to focus on perpetuating the remaining older red pine stands by not allowing the situation to degenerate further due to losses by either fire or bark beetles.

Background

Pine bark beetle outbreaks do occur in Lake of the Woods County. In the last 25 years, several bark beetle pockets developed in red pines along the same sand ridge and were removed before they caused serious losses. For example, in 1975, about ¼ mile east of the current blowdown, bark beetles killed 50 mature trees before the pocket was found, harvested and the infested materials burned.

In 1985, bark beetles built up in freshly felled trees in a large pine thinning operation. The logger was unable to remove the logs until mid-June. Fortunately, bark beetles did not have time to mature, leave the logs and infest the nearby residuals by mid-June. Bark beetle losses were prevented. In 1986, flooding killed 50% of a red pine plantation which was subsequently infested with bark beetles. The plantation was salvaged and the slash piles burned by DNR-Forestry. This year, bark beetles killed a small group of 6 mature trees on LUP lands. The pocket is within ½ mile of all the blowdown areas and within 100 feet of one of them. The bark beetle pocket was not cleaned up and remains a potential threat; the potential primarily dependent on next year's weather.

Pine bark beetles also infest jack pines. Populations of bark beetles can spread from one pine species to another.

Ayres et al found that bark beetles had a meaningful impact on old, mature red pine demography after blow-down events in Itasca State Park in 1995 and 1996. They found:

1. *Ips pini* has the greatest capacity for rapid increases in population size following blowdowns.
2. Downed red, white and jack pines can all provide excellent habitat for bark beetles.
3. Blowdowns can lead to rapid dramatic increases in the abundance of bark beetles. A local population can increase 1000-fold over the summer.
4. A single downed tree (10" dbh) could produce 80,000 bark beetles in one summer.
5. Bark beetles are able to attack and kill apparently healthy, vigorous trees.
6. The annual probability of any pine tree becoming attacked is about 1%. About half of the attacked trees died in 1 year. Another 25% died in 2 years and the remaining 25% of the attacked trees lived.
7. By 1997, local populations of bark beetles 200-300 meters away from the blowdown areas were no higher than the background levels.
8. The mortality rate (due to bark beetles, fire, other causes) in the red pine population exceeded 1% for a number of years after the blow-down event.
   Note: In temperate forests, annual mortality rates are usually less than 1% (Runkel 1985, Twardus et al,1993). Rates > 1% indicate that the current seral stage is not being perpetuated; it is succeeding to something else.

It has been suggested that black backed woodpeckers (BBWp) rely on bark beetles found in red pines, such as might develop after this blowdown event. BBWp are insectivores, permanent residents, and are very rare in Minnesota. They are found in boreal habitats of spruces and firs. Tamarack is also an important tree species for them. BBWp are an irruptive species that forages opportunistically on outbreaks of wood-boring beetles and bark beetles.

Across northern Minnesota, an outbreak of larch bark beetles on tamarack has been ongoing for the last 3 years (Forest Health Annual Report, 2001) and accounts for the loss of 7500 acres of tamarack in Baudette and Warroad Areas. Larch bark beetle grubs are present year-round and can be found under the bark in all months of the year. Local birders near Zim, MN have noted that BBWp have been observed feeding on larch trees infested with larch bark beetles and that populations of BBWp have increased. Infested tamaracks are locally abundant and larch beetle grubs represent a year-round food source for BBWp. In contrast, pine bark beetle grubs can be found infesting pines from late May to early August. Otherwise, these bark beetles, in the adult stage, are buried in the duff. Pine bark beetles would not supply a food source for BBWp for 9-10 months of the year.

Bark beetle management

Since this blow down event occurred late in the growing season, experience has shown that bark beetle populations are likely to be small in 2003 with beetles infesting the freshly downed wood and live stubs. If a bark beetle population develops, it would spread to live, standing red pines in 2004 or 2005. At this point, I expect that the numbers of bark beetles coming from the blowdow material to be minimal and I think that the risk of significant pine mortality is unlikely unless the residual pines are physiologically stressed by drought or flooding during the next two years. The spread of beetles from the existing pocket cannot be predicted and would also constitute another risk.

Bark beetle management is preventative; once they build up to outbreak phase, there are no good management options. The Division of Forestry suggests using active management to keep bark beetle populations below the threshold where they could cause damage to nearby jack and red pines. Options are:

1. Prevent BB population build-ups in slash, downed trees and stubs caused by the blowdown event so that subsequent bark beetle movement to live pines does not occur.
    a. Clean-up or harvest all pine stubs, tip-ups, bent or broken trees by May 1, 2003. Use all woody material down to 2- 3" in diameter. Scatter small slash over site. Non-pines or pines that died prior to 2002 can be left untreated on the sites.
    b. Destroy bark beetle habitat yet retain coarse (pine) woody debris by debarking all the stubs, tip-ups, bent or broken trees before May 1, 2003. Scatter bark debris on site.
    (Note: In "Voluntary Site-Level Management Guidelines", the removal of pine snags and pine leave-trees is allowed if pine bark beetles are a threat to existing pine stands or to adjacent pine stands.)
2. If option 1 is not chosen and an outbreak develops, prevent bark beetles from moving off LUP management areas into jack or red pine stands managed or owned by others.
    a. Use the "bark beetle trap tree" technique. Sacrifice 1 or 2 living red pines per acre to serve as the trap trees. Trap trees are felled in late winter and must be debarked, chipped, piled and burned or removed from the site by June 1st. Repeat as needed throughout the growing season; for one or more growing seasons.
    b. Use sanitation method described in 1a above except that an additional buffer strip (1/2 chain wide) needs to be clearcut if harvested during the growing season.
3. Prevent fire in these stands. Do not prescribe fire in these blowdown stands. Control wildfires. Ayres (at Itasca State Park) and Gandhi (in BWCA) have shown that fires kill mature red pines due to scorch and due to post-fire effects of bark beetles on injured trees.

Likely ecological outcomes with bark beetle management implemented:

1. Bark beetle populations do not buildup to damaging levels and do not spread to live, nearby pines.
2. Some of the pine coarse woody debris is retained on site. Pine materials will not have bark on them.
3. Harvest activities scarify soil and sever woody competition which creates a seed bed for natural red pine regeneration that is free-to-grow. Red pines follow red pines as canopy trees on these sites.

Likely ecological outcomes without active bark beetle management or only partial removal of bark beetle habitat :

1. Bark beetles may build up in downed and moribund trees in the next 2 years.
2. Most of the future coarse woody debris is retained on site. If the cambium is alive or fresh (recently died), it will support 1 or more generations of bark beetles. Wood borers will build up in these materials, too.
3. Significant mortality of residual pines due to pine bark beetles will not occur unless there is a significant drought or prolonged flooding occurs when bark beetle populations are also high.
4. Advanced reproduction, aspen and balsam fir, will predominate and out-compete existing pines on the sites. Red pines will not reappear as canopy trees for several decades.

Indigenous exotics found: Douglas-fir beetles and others

By Mike Albers and Dr. Steve Seybold, Univ. of Minnesota

In May, 2001 while trapping larch beetles, 3 Douglas-fir beetles, *Dendroctonus pseudotsugae*, were trapped in Arbo Township just north of Grand Rapids. These were sent to Dr Donald Bright (Canadian National Collection, Ottawa) for confirmation. These beetles were trapped in funnel traps baited for eastern larch beetle with alpha-pinene and seudenol. No Douglas-fir beetles were trapped in either the Zim or Ditch banks sites. Further investigation revealed that Larex Inc. in Cohasset MN ships approximately 2000 tons (800 cords) of raw western larch logs from western Montana into Minnesota by rail annually. They extract a long-chain polysaccharide from the logs to be used in dietary supplements and human health care products. Galleries as well as cadavers of Douglas-fir beetles were found under the bark of the western larch logs at the Larex woodyard.

Logs of western larch were collected and placed in emergence boxes. Insects that emerged are listed below.
List 1:Preliminary List of Insect Specimens from *Larix occidentalis*, collected April 18, 2002, Larex Plant Site, Cohasset, MN

1. Carpenter ants, *Camponotus novaeboracensis* (thousands of specimens)
2. Flatheaded woodborer, Buprestidae, *Chrysobothris trinervia* (Kirby), 10 specimens. Occurs in western states including Alaska and western Canadian provinces; hosts include *Pinus ponderosa*, *Pinus flexilis*, *Pinus edulis*, and *3. Pseudotsuga menziesii*. From Western Forest Insects, Furniss and Carolin. Also, listed on white pine and spruce in Insects of Eastern Forests. Five specimens deposited in UMN collection; 5 given to C.L. Bellamy, CDFA Plant Pests Diagnostics Lab.
4. Roundheaded woodborer, *Neoclytus muricatulus muricatulus* (Kirby), 4 specimens, occurs in northeastern US and ranges into the Rockies (deposited in UMN collection).
5. Roundheaded woodborer, *Phymatodes dimidiatus* (Kirby), 1 specimen, occurs in northeastern US and ranges into western North America (deposited in UMN collection)
6. Roundheaded woodborer, *Tetropium velutinum* LeConte, 2 specimens, occurs in northeastern US, but is more common in northwestern North America (deposited in UMN collection).
7. False powderpost beetle, Bostrichidae, one unidentified species, 3 specimens.
8. Rove beetle, Staphylinidae, unidentified species, 5 specimens (Species 1).
9. Rove beetle, Staphylinidae, unidentified species, 8 specimens (Species 2).
10. Weevil, Curculionidae, unidentified species, 4 specimens (Species 1).
11. Ground beetle, Carabidae, unidentified species, 1 specimen, given to Kamal Gandhi.
12. Miscellaneous Coleoptera/Hymenoptera, 5 specimens.

List 2:Preliminary List of Insect Specimens from *Larix occidentalis*,collected May 30, 2002, Larex Plant Site, Cohasset, MN

13. Bark beetle, Scolytidae, *Scolytus laricis*, 39 specimens, 16 males, 23 females.
14. Bark beetle, Scolytidae, *Dendroctonus pseudotsugae*, 1 female specimen.
15. Bark beetle, Scolytidae, *Polygraphus rufipennis*, 2 specimens.
16. Flatheaded woodborer, Buprestidae, *Phaenops drummondi* (Kirby) (=*Melanophila drummondi*, 65 specimens. Occurs extensively in the western states and provinces including Alaska; hosts include Douglas-fir, true firs, spruce, western hemlock, and western larch. Sometimes attacks and kills apparently healthy trees, especially on dry sites (Western Forest Insects, Furniss and Carolin). Also occurs in eastern forests on fir, larch, spruce, and hemlock (Insects of Eastern Forests). All specimens deposited in UMN collection.
17. Roundheaded woodborer, *Pygoleptura nigrella* (Say), 1 specimen, reddish elytra. Specimen deposited in UMN collection.
18. Roundheaded woodborer, *Phymatodes dimidiatus* (Kirby), 12 specimens, occurs in northeastern US and ranges into western North America. All specimens deposited in UMN collection.
19. Roundheaded woodborer, *Xylotrechus longitarsus* Casey, 1 specimen. Specimen deposited in UMN collection.
20. Roundheaded woodborer, *Tetropium velutinum* LeConte, 34 specimens. All specimens deposited in UMN collection.
21. Roundheaded woodborer, *Tetropium velutinum* LeConte, 2 specimens, collected live at the Larex site on June 6, 2002. Both specimens deposited in UMN collection.
22. False powderpost beetle, Bostrichidae, one unidentified species, 3 specimens.
23. Blue-Green Trogositid, Trogositidae, 11 specimens, *Temnochila chlorodia*, predator of bark beetles, does not occur in eastern North America. The specimens emerged between early and mid-August and after all bark beetles and woodborers had emerged. They take a long time to complete development relative to the herbivores. Could reside in older barked wood pieces.

24. Rove beetle, Staphylinidae, unidentified species 3, 1 specimen (Species 3)
25. Ground beetle, Carabidae, unidentified species, 1 specimen (Species 2).
26. Weevil, Curculionidae, unidentified species, 1 specimen (Species 1).
27. Weevil, Curculionidae, unidentified species, perhaps *Rhyncolus* spp., 1 specimen (Species 2).
28. Miscellaneous Coleoptera/Hymenoptera/Lepidoptera, 12 specimens.

Lists updated July 22, 2002 by Dr. Steve Seybold

The Douglas-fir beetle and larch engraver identification was confirmed by Dr Donald E. Bright, Agriculture Canada, Ottawa, Ontario. The flatheaded borers were confirmed by Dr. Charles Bellamy, California Department of Agriculture, Sacramento, California. The roundheaded borers were confirmed by Dr. John A Shemsak, University of California at Berkeley, California.

The Douglas-fir beetle, the larch engraver, and the *Temnochila chlorodia* are all exotic to Minnesota. The other insects occur in Minnesota, but these logs are likely harboring different populations of these species and the implication of this introduction of new genotypes into Minnesota on the pest status of the insects is unknown. *Phaenops drummondi* and *Tretopium velutinum* have been noted in the western literature to be particularly aggressive wood borers.

Field studies

In April, 2002 tamarack logs infested with bark beetles were cut on the Arbo site and placed in emergence boxes. Lots of eastern larch beetles emerged and were collected. No Douglas-fir beetles emerged from the tamarack logs.

Trapping on the Arbo site in May and June of 2002 caught 5 additional Douglas-fir beetles with none caught at the Zim or Ditch Banks site. One trap on each of the three sites were baited for Douglas-fir beetle with alpha-pinene, seudenol, frontalin, and ethanol.

Twenty eight funnel traps baited with alpha-pinene, seudenol, frontalin and ethanol were placed in three trap lines to the northwest, southeast and south of the Larex site starting 2 to 3 miles from the woodyard and extending 10 to 11 miles out. See map below. Single traps were also placed at UMN ROC, and also in Arbo Township shown as N1 and N2 on the map below. Traps were initially set out and baited from May 16-18. Traps were emptied weekly and baits were replaced as needed. Traps were removed July 12th except W1 which was removed 8/7 and E1, E2 and W2 which were removed on 8/14. Trap collections are frozen and are being sorted by Dr Steve Seybold. Of the collections sorted to date, Douglas-fir beetles were trapped at the trap locations circled on the map.

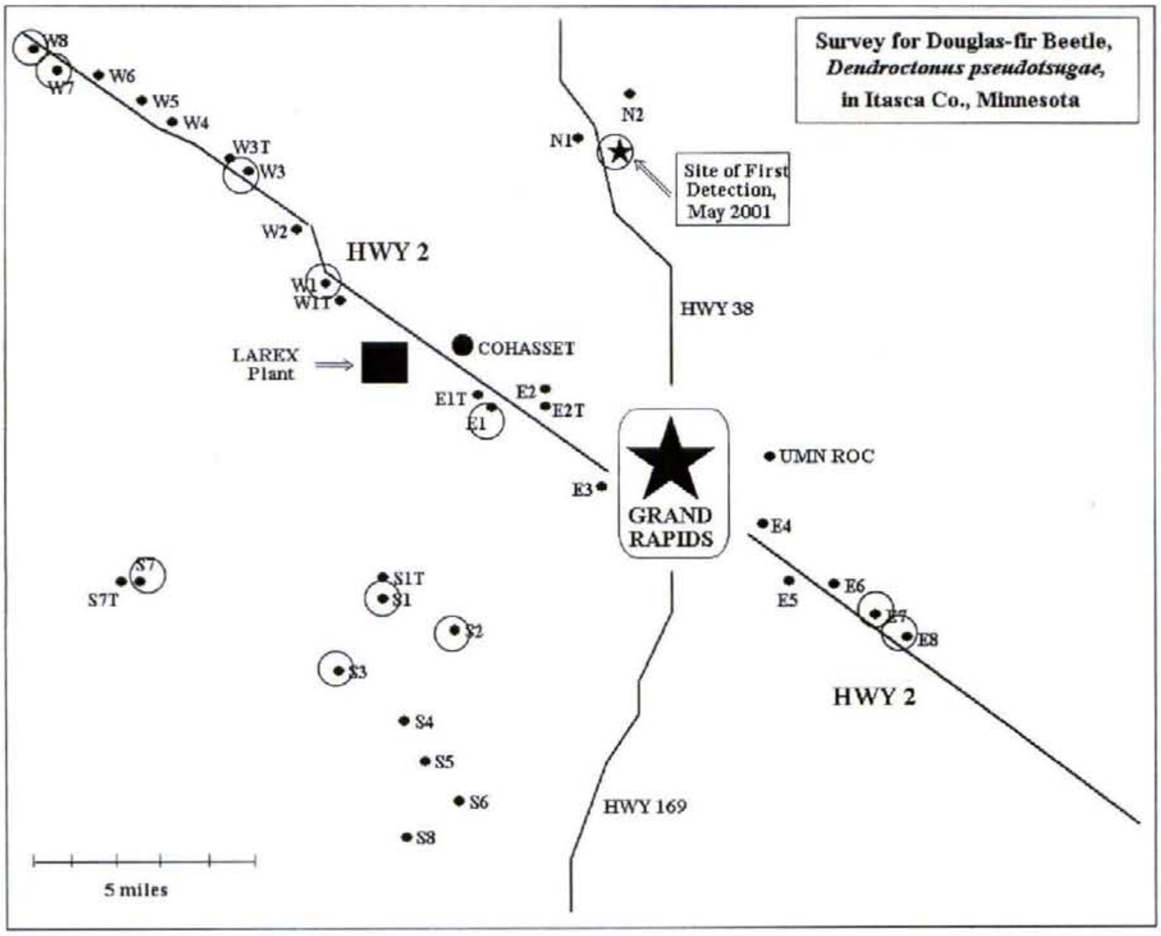
Six traps baited with exobrevicomin for the western bark beetle predator *Temnochila chlorodia* were set and baited between May 16-18. This predator emerged from western larch logs in emergence boxes. The trap locations were W1T, W3T, S1T, S7T, E1T, and E2T. These traps were emptied weekly and removed on Aug 29th. No *Temnochila chlorodia* were trapped.

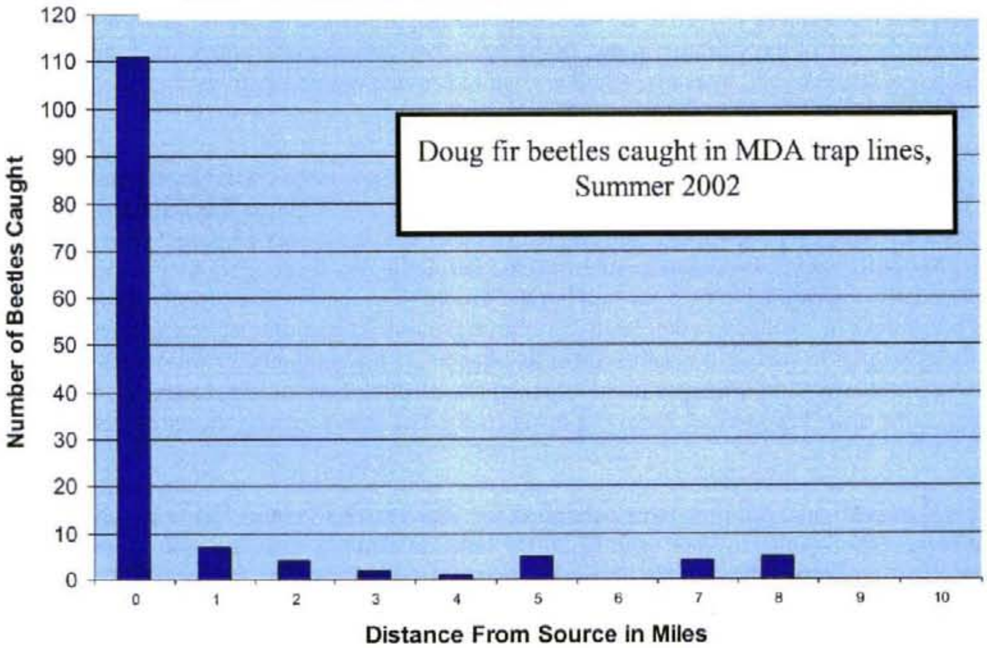
Fresh cut tamarack logs were felled in Arbo Township and at the Ditch Banks site and baited for eastern larch beetles. When these were colonized by larch beetles, Dr Robert Blanchette isolated blue stain fungi from the wood. He was unable to isolate the bluestain fungi from the beetles. The blue stain fungi were sent to Dr Tom Harrington at Iowa State University for identification. He identified an isolate as *Ophiostoma ips*. There was also a *Leptographium* isolated several times from the larch logs from the mill but the species could not be determined.

MN Dept of Agriculture also trapped for Douglas-fir beetles. Funnel traps (12 funnel) were baited with commercial Douglas-fir beetle baits which is a 3-component lure containing MCOL, frontalin and ethanol. Traps were placed in pairs starting next to the wood pile at Larex and extending out about 10 miles to the northeast. A pair of traps was placed approximately every mile. One hundred ten Douglas-fir beetles were caught next to the wood pile. See chart below. Douglas-fir beetles were caught out to 8 miles to the northeast from the woodyard in Cohassett. The commercial Douglas-fir beetle baits appear to have caught much fewer eastern larch beetles than the combination of frontalin, seudenol and ethanol used by Albers and Seybold making trap catch sorting easier.

Fungal fruiting bodies were collected from the western larch logs at the Larex woodyard a number of times in 2002. Fungi collected included *Fomitopsis officionalis*, which has not been reported in Minnesota, *Lentinus lepidius* (which may now be *Neolentinus* or *Lentinula lepidius*) which is reported as widespread throughout North America, and *Laetiporus conifericola* which has only been reported from western North America. *Laetiporus conifericola* has never been reported from western larch. *Laetiporus conifericola* was identified by Dr. Hal Burdsall, retired mycologist from the Center for Forest Mycology Research, Forest Products Lab, Madison, Wisconsin. Identity of *F. officionalis* and *L. lepidius* was confirmed by Dr. Hal Burdsall and Dr Robert Blanchette, University of Minnesota, St Paul, Minnesota.

Doug fir beetles caught in DNR/ Univ. trap lines, summer 2002





Oak Wilt Suppression: Using Herbicides

By Ed Hayes

The Issue. The vibratory plow has been the principal tool used to suppress oak wilt disease in southeast Minnesota in the recent past. The vibratory plow uses a five-foot vibrating knife blade that is pulled through the soil severing root grafts between susceptible oaks. It has been shown to be an effective tool in the isolation of active oak wilt centers. However, this method has not been universally appropriate in all instances particularly in the southeast. Problems exist with it's difficulty of use in limestone soils, site accessibility, the questionable use considering quality and value of the oaks protected, the potential overuse on sites of mixed species, and the durability of the root graft barriers over time. In addition, sanitation issues related to disposal of spore producing trees in the years following treatments are compounded with the need for follow-up site inspections and changes in property ownership. This leads to efficacy issues related to eventual failure by post wilting of secondary trees and possible reconnecting of root grafts.

The Disease. Oak wilt is a disease is primarily an underground disease with the most efficient mode of spread occurring below ground through root graft transmission between susceptible oak species. Overland spread does occur but fortunately is inefficient and on average preventable with properly timed cultural practices, sanitation, and education of the public. The disease is caused by the fungus *Ceratocystis fagacearum* and is currently active in all southeastern Minnesota counties. All species of oak are susceptible to oak wilt, but susceptibility varies. The most susceptible species are the red oak group, northern pin oak, *Quercus ellipsoidalis* and northern red oak, *Quercus rubra*. Infected trees may die within a few days after symptoms first appear. Bur oak (*Quercus macrocarpa*), which also occurs throughout the region is intermediate in susceptibility. White oak (*Quercus alba*), which occurs on a limited number of sites, is the least susceptible. Infected white oak and bur oak may survive for several years and may occasionally recover.

Belowground spread of the disease occurs when fungal spores are moved within the vascular system through root grafts between infected and healthy trees. Oak wilt spreads this way through root grafts an average of 25 feet per year (depending on tree size and root spread), spreading in a radial pattern throughout susceptible oaks. Above ground or overland spread occurs when species of sap feeding beetles carry spores from diseased trees to wounded trees. Overland spread by insect vectors can average 1500 feet per year. Oaks are most susceptible to overland spread during the months of April, May, and June. This is when the fungus produces sweet smelling fungus mats just under the bark attracting the insects. These two modes of disease spread result in larger pockets of oak wilt surrounded by smaller satellite infection centers that can coalesce to kill entire stands of susceptible oak.

Using Herbicides to Stop Oak Wilt. For years foresters have been interested in researching the feasibility of using herbicides to effectively treat this disease. Previous attempts in Minnesota over the recent years have lead to limited success primarily due to inadequate above ground mortality of treated oaks. Sprouting was the issue. Without mortality above and below ground it would seem that the use of herbicides would have little success as a method to stop the spread of oak wilt. However, if better products and methods could be tested and observed or proved to be successful the use of herbicides would provide a practical and relatively inexpensive alternative to the use of the vibratory plow. In the late 1990's discussions with trade industry professionals determined that trichlopyr (Garlon 4) and imazapyr (Stalker) would provide the best activity on oaks. These two products were combined with the penetrating oil Riverside Diluent XLT.

Field Studies: In the fall of 1998 and 1999 herbicide treatment plots were established in active oak wilt centers on both state and private land with cooperating landowners. The first plots used a modified Hack and Low Volume Basal Bark method. A hatchet was used to make cuts through the bark every few inches around the stems at approximately 18 inches above ground. The cut surface and the lower 18 inches of the stems were then treated with the herbicide mix thoroughly treating the bark surface. The stem treatment was eventually determined to be a success but the timing of success was a concern. On some sites oaks above 12 inches dbh took several weeks or months to completely die above ground. Larger diameter oaks proved more difficult to kill but did eventually die taking up to two field seasons. Oaks as large as 25 inches diameter were treated. The ability of basal stem treatments such as trichlopyr and imazapyr in oil to penetrate the thick bark of large diameter was observed to be successful it just took some time. For obvious reasons a faster method of above ground mortality needed to be used.

Annual observations on the above six treated oak wilt sites have continued for four seasons (years) following applications of herbicides to stop the oak wilt disease. The results to date (winter 2003) indicate that no new oak wilt disease has been observed to move out of the former infection centers through the herbicide treated dead oak barriers into nearby susceptible red oaks. Should the barriers hold for at least one more year, the method would seem to have a high level of confidence for success. If over the next few years should the plots begin to generally fail, we would abandon this approach.

In September 2000, five new sites were added on state land in Wabasha County. To obtain a faster rate of above ground mortality, the treatment method was changed to a single chain saw girdle using the same herbicide mix and treating only the cut surface opening created by the chain saw. Fifty-five, 10-inch average dbh oaks were treated using the single chain saw girdle method around the five new oak wilt infections. All five sites originated on singletree new infections, by field diagnosis and subsequent sporulation of the fungus the following April on four of the plot center oaks. The following spring two branches on two of the 55 trees were observed to form undersized leaves which died within a few weeks. Johann Bruhn's TTC (tetrazolium stain) method was used to determine when the below grade roots actually died. Sampling took place every six months for two years. Major buttress roots were excavated and sampled just below the root collar. At the end of the second field season, and 2 years after treatment these roots were determined to have finally died. No additional oak wilt disease has been observed to move out of the former infection centers following two years of observations (winter 2003). Three quarts of actual herbicide mix was used to treat the 55 oaks on the recent plots.

Virtually no sprouting has been observed on well over 100 treated oaks on all of the multiple year plots. Two sprouts were seen to have formed and died on one of the oaks on the year 2000 plots. We observed that oaks treated in August using the single chain saw girdle and herbicide treatments wilt and die above ground within a few days. In these same oaks 2-lined chestnut borer was seen to be active under the bark and through the root flares within three weeks.

Herbicide treatment recommended for oak wilt suppression.

Locating Treatment Lines. Line locations can be estimated using Bruhn's model, and field experience. The model works well in pin oak on sand. It varies depending on stem size. It may under estimate for small diameter stems and over estimate for larger diameter stems. The best recommendation may be to use local experience. All oaks within the primary line are treated.

Timing. Avoid the spring peak sap flow period. The best time appears to be after mid summer into fall. There is further agreement that herbicides can be effectively applied in the dormant season also. Periods of drought should be avoided.

Herbicide Mix: 1quart trichlopyr (Garlon 4), 5 ounces imazapyr (Stalker), and 3 quarts of Riverside Diluent XLT.

Treatment Alternative A. For all trees cut a single continuous chain saw girdle at approximately 12 inches above ground or just above the root flares. Care must be taken to be sure the stem is completely girdled. Without a complete the treatment will fail. Flood the chainsaw cut opening to run off using a sprayer equipped with a cone or fan nozzle.

Treatment Alternative B. Fell or harvest trees to be killed for the barrier. Flood the cut surfaces to run off using a sprayer equipped with a cone or fan nozzle. Treat the cut stump surface and bark to the ground line.

Caution: It is possible for whole trees to fail at the moment the stem is girdled if extensive undetectable brown rot is present. Follow all safety precautions and use all safety equipment. Again, a potential safer alternative is to fell oaks to be treated then apply the herbicide mix to the stump cut stem surface and bark to ground line.

Sphaeropsis and red pine seedling mortality

By Jana Albers

This report will discuss the effects of a pathogenic fungus, *Sphaeropsis sapinea*, on red pine seedlings in DNR nurseries and plantations . *Sphaeropsis sapinea* used to be named *Diplodia pinea*. *Sphaeropsis* is a native species and is endemic in our pine nurseries and forests as shoot blights and cankers. We can now add another phase, collar rot, which was recognized just this year occurring in our DNR nurseries and plantations.

Sphaeropsis infections can cause symptoms of shoot blight or collar rot in pine seedlings depending on which tissues are infected. If needles and shoots are infected, then the disease is expressed as shoot blights. If stems and root collars are infected, then the disease is expressed as collar rots.

What is collar rot?

Collar rot is an infection of the bark, cortical and wood tissues right at the root collar by *Sphaeropsis*. The infections can kill the seedlings by girdling them at the root collar. Infected 1-0's almost always die whether infected at the root collar or higher up the stem.

Symptoms of collar rot on older seedlings are: blackened cortical tissues at the root collar, dark staining of underlying wood, dark resinosus of wood and cortex only if the tissues died slowly and had enough time to produce resin, and, fruiting bodies may or may not be present. Fruiting bodies are usually found up to three inches above the root collar.

We are fortunate we know a lot of the particulars about *Sphaeropsis* infection process, incidence and shoot blight control courtesy of three USFS researchers who worked in Lake States nurseries in the 1980's, including General Andrews State Nursery. They found that the typical incidence of shoot blight was less than 1%, but could range as high as 50% in bad years. Red pine seedlings can become infected as 1-0's, 2-0's,3 -0's or as transplants.

One source of infection is the windbreak pines. Spores can be produced in fruiting bodies on cones and on blighted shoots. Then, wind-driven raindrops spread the spores down onto the adjacent seed beds. Data from the early 80's shows that seedlings more than 600 feet away can still get a heavy dose of spores and develop disease. Windbreaks are the only source of infection for 1-0 seedlings.

Another source of infection is right in the seedbeds. Fruiting bodies on dead or infected seedlings produce spores which are rain-splashed or spread in irrigation water onto adjacent healthy seedlings. This is the main source of infections for 2-0's and 3-0's. Nearby dead seedlings supply 10,000 times more spores than nearby windbreaks. So the real trick to disease control is to prevent 1-0 infection by removing pine windbreaks.

Recent findings
During the 1990's, Dr. Stanosz (Univ. of Wisc.) surveyed Wisconsin state nurseries and forests for shoot blight and collar rot and did further work to clarify the mode of action and impacts of *Sphaeropsis*. He was drawn into this work in 1991 when Wisconsin DNR had heavy losses in some RP plantations after a drought. Losses due to collar rot were high, from 14-95% of newly planted seedlings and up to 30% of established seedlings died.

Stanosz also recently discovered that *Sphaeropsis* is a "latent" pathogen. This means that some seedlings do not show symptoms of collar rot even though they are infected.

1. The fungus can persist in the live seedling without producing any disease symptoms. In Wisconsin Nurseries, Dr. Stanosz found that 15-40% of the green, healthy seedlings are latently - infected. It passively exists in the bark of the root collar. Fungicides don't completely prevent infection and systemic fungicides don't reach the infections because the chemicals are carried in the xylem and phloem, not the bark tissues where the fungus lives.
2. The fungus has a prolonged, host-induced quiescence. As long as the host is vigorous, the fungus can not produce the disease or the symptoms. The fungus can passively inhabit seedlings for a few years and still cause disease.
3. The fungus can produce collar rot when there is a change in host physiology. Only when pines are drought stressed does the fungus cause disease. Disease incidence is directly related to the severity of the stress.

Do we have a collar rot problem in nursery seedlings?
Last fall, Stanosz alerted the pest specialists from the Lake States to the destructive potential of collar rot in nurseries and plantations. In the spring of 2002, we developed a handout so that Pest Specialists, Nursery Managers and Foresters could watch for the occurrence of this disease. We also began detection/ incidence studies starting with the our nurseries.
3 studies with red pines. We thought we did not have a problem!

Study 1. Is *Sphaeropsis* incidence greater near pine wind breaks?
We surveyed both Nurseries for the presence symptomatic seedlings (either shoot blight or collar rot) in rising 3-0 seed beds. Just showing results from Badoura. We purposely looked for what was "worst" and for what was "best" so this was not a statistical representation of the whole nursery.

Presence of symptomatic seedlings in nursery beds				
	Number of seedlings in 1 meter samples			
	Live		*Dead*	
	No symptoms	*Symptoms*	*No symptoms*	*Symptoms*
B11 = Far from windbreak	97.5	0.8	3.6	0.8
A3 = Near windbreak	29.0	9.4	0	41.0

A. It was what we expected: most seedlings far from windbreaks live because they are rarely infected.
B. Many seedlings near windbreaks become infected, develop symptoms and die. The nursery manager had noticed a distinctive discoloration of these seedlings as 1-0's.
C. Looking at all symptomatic seedlings, over 60% of the seedlings in A3 were affected whereas less than 2% in B11 were affected.
D. The practical upshot is that seedbeds in A3 produced only about 1/3 the number of live seedlings that B11 did because of disease losses.

Study 2. Are there any latent infections in our nursery stock?
Small samples of the live, healthy-looking seedlings were taken from the "best" and the "worst" areas for *Sphaeropsis* infection and they were tested for latency by Dr. Stanosz. He sampled other Lake States nurseries, too.

Symptomless seedlings from state nurseries		
	Spore load from windbreaks	*No symptoms but infected with Sphaeropsis*
Gen. Andrews Nursery	Low	20 %
	Low	26
Badoura Nursery	Low	19
	High	88

A. "Spore load from windbreaks": High = visual evidence that there were abundant spore sources from the windbreaks. Low = no shoot blight evident in windbreak.

B. At GASN, Stanosz found that 20 to 26% of the seedlings had latent infections in spite of having a "low" rating.

C. At Badoura, seedbeds near windbreaks had 88% latent infections while seedbeds far from windbreaks had 19% latent infections.

D. Stanosz sampled other Mid-Western nurseries.
Toumey Nursery carries 0% latent infections and Wisconsin nurseries average around 30%.
Toumey has only white cedar windbreaks and Wisc.nurseries have pine windbreaks.

E. From this study, we can see
(1) The proportion of latent infections is higher near windbreak trees.
(2) the importance of removing the pine windbreaks for disease prevention.

NOTE: Badoura is not going to lift and ship seedlings from A3 next year. We plan to outplant some infected seedlings and continue testing for the presence and incidence of *Sphaeropsis* infections and mortality levels.

Study 3. Do we have collar rot in our plantations?

This fall, the FH Unit put out a call to Area Offices requesting samples of dead red pine seedlings from this year's plantings. Most of the state suffered a dry spell right at planting time which lasted for five weeks; lots of drought stress which should induce *Sphaeropsis*-caused mortality.

NOTE: These are NOT the same seedlings that we checked in the spring.

Presence of *Sphaeropsis* in dead seedlings from new plantations					
	Plantation data			**Seedling data**	
	Other species planted	*Mortality of other species*	*Mortality of red pines*	*Symptoms of collar rot*	*Lab verification*
DNR source (n = 27)	JP, WP, WS, WO, GA, Wcedar	12 %	67 %	98 %	90 %
Non-DNR source (n = 1)	WS, WP, Tam	20	50	0	0

A. Here are the results for 11 of the 12 plantations:
Red pines suffered proportionally more mortality than did the other species planted side by side in these plantations.
98% of the DEAD red pines had collar rot symptoms and 90% had tons of fruiting bodies on them.

B. Here is data for the 28th plantation, the only non-DNR source of seedlings:

Non-DNR source red pines had neither collar rot symptoms nor fruiting bodies.

But here is the interesting part; even though they were not infected, red pines died in high numbers relative to the other species on the same site.

C. So what killed these seedlings? Was it drought alone or *Sphaeropsis* induced by drought stress?

I can't give you a definitive answer because I really can't tell you if the 50% mortality level is significantly different than the 67% level because our samples were too small and we did not look at infection of live seedlings, too.

Conclusions

The main conclusion is that collar rot was a contributing factor to the higher red pine seedling mortality that occurred this year due to drought. We had a *Sphaeropsis* epidemic this year due to the convergence of several factors over a period of years:

- In the nurseries, red pines were planted near pine windbreaks for the past several years.
- Seed bug infestations were high in pine windbreaks. These insects are the vectors of *Sphaeropsis*.
- Weather was conducive for heavy infections.
- Rising 3-0's and lifted 3-0's were heavily infected.
- There was extreme stress on red pines due to drought (5 week duration) in the plantations.
- Heavy mortality of infected red pines occurred, which are more prone to succumb when stressed.

I think 2002 can be seen as a "blip" in the survival of red pine plantations because of the convergence of these factors. Collar rot was a contributing factor in the overall amount of mortality that was suffered this year.

What can be done to prevent *Sphaeropsis* infections?

To control *Sphaeropsis* shoot blight and collar rot, we need to prevent infection of seedlings in the nursery and to maintain seedling vigor during handling and planting.

In the Nurseries:

- plant red pines far away from pine windbreaks,
- or better still, remove pine windbreaks,
- harvest as 2-0's until windbreaks are gone,
- spray with systemic fungicides (alternate Benlate, Domain and Bravo),
- decrease seedbed density,
- cull dead and infected seedlings,
- avoid heavy nitrogen fertilization, and,
- avoid bringing in stock from other nurseries.

In planting sites:

- properly transport, store and handle seedlings,
- avoid drought-prone sites for red pine plantations,
- supervise planting so J-rooting is not a problem,
- reduce weed and grass competition, and,
- document our work and plantation survival.

As you can see, collar rot management is going to be a team effort.

Management of Spruce Beetle in Minnesota: Guidelines for Professional Land Managers

By M.A. Albers, and Dr. S.J. Seybold (Univ. Of Minnesota)

Spruce beetles are bark beetles native to Minnesota that attack white spruce trees. In Minnesota, they prefer trees 12 inches in diameter and larger. They will, however, occasionally attack smaller diameter trees. Spruce beetles have been found attacking and killing spruce trees predominately along the northern half of the North Shore of Lake Superior and within several miles of the lakeshore.

To minimize spruce beetle damage you must learn to identify the signs of spruce beetle attack. The best evidence of attack includes reddish boring dust at the base of the tree, and secretions of resin (pitch tubes) on the bark surface of the tree stem. Fallen trees or trees that have more advanced infestations may only have boring dust, but no pitch tubes. Removal of a small piece of bark will reveal the galleries and mines of the adult and larval beetles. The needles of heavily attacked trees will eventually become tan or red and the tree will die. However, it may take 6 to 12 months or longer for the needles to turn color. A tree with just a few attacks may not die during the first year, but it may continue to be attacked and eventually die in the following year or years. Infested trees are a source of more beetles that are likely to threaten nearby healthy trees.

Management of spruce beetles is based on three key strategies:

- Maintain healthy and vigorous trees
- Remove or destroy fallen trees and tree parts (i.e. high tree stumps) capable of producing large numbers of adult beetles
- Manage and control spruce beetle populations

The first strategy is to make your trees as healthy and vigorous as possible. This will make them less attractive to the beetles and better able to defend themselves if they are attacked by beetles. The second strategy involves sanitation and removal of breeding material to prevent large populations of spruce beetles from developing on the property that you manage. These small ($3/16^{th}$ – $1/4^{th}$ inch) beetles must attack trees in large numbers to successfully kill the trees. Removal of material in which they can breed and develop reduces the available habitat capable of producing large numbers of adult beetles that can attack nearby healthy trees. Fresh windthrown trees can produce 5X to 10X the number of beetles that a standing spruce tree can produce. The third strategy, managing and controlling spruce beetle populations, involves removing or destroying infested trees to reduce the size of local beetle populations and/or protecting your uninfested trees from future attack.

Listed below are suggestions for reducing damage and mortality to white spruce by spruce beetles.

1. Improve and maintain the health and vigor of your trees. Fast growing, healthy trees are more resistant to spruce beetle attacks than slow growing, unhealthy trees. Spruce beetles prefer trees weakened by factors such as defoliation, drought, disease, root and stem wounds, and overcrowding (high stand density). Weakened trees are more susceptible and not as capable of defending themselves against spruce beetle attacks as are healthy trees.
   A. Water trees during periods of drought. Large trees require substantial amounts of water. Place a hose on the ground under the trees and allow water to soak the area under the crown out to the edge of the drip line. Do not use sprinklers because moisture sprayed on the needles increases the risk for some needle diseases.
   B. Maintain a 3-4 inch thick layer of mulch over the root zone of the tree using wood chips, shredded bark or other organic material. This minimizes competition, moderates soil temperature and maintains soil moisture.
   C. Avoid wounding the tree stem. This weakens the tree and releases volatile resins from the wounds that may attract beetles.
   D. Avoid injuring tree roots and compacting soil, particularly during construction, telephone line installation, etc.
   E. Protect trees from defoliation by other insects. Insects such as spruce budworm or sawflies that feed on needles may reduce tree vigor making a tree more susceptible to attack by spruce beetle. An insecticide treatment to prevent defoliation may be necessary if populations of defoliating insects are present on spruce.

1. Sanitation and removal of breeding material helps prevent the buildup of large populations of spruce beetles. Spruce beetles need to attack trees in large numbers in order to successfully enter, colonize, and kill a healthy tree.

   A. White spruce trees that have tipped over or are damaged during storms should be removed before May 1st. Trees that are damaged during the summer should be removed promptly, or at least before August 31^{st}. If these trees are not removed promptly (within several weeks of falling or being damaged) spruce beetles may colonize and reproduce beneath the bark resulting in the development of large numbers of beetles that emerge and may attack nearby healthy white spruces. These trees should be burned, debarked, or removed from the site.

B. In northern Minnesota, spruce beetles appear to readily colonize the stump remaining from trees that have broken or fallen during winter and spring storms. Cut off white spruce stumps as close to the ground as possible before May 1st. Debarking the remainder of the stump including the portion down to 6 inches below ground, is suggested for complete removal of breeding material.

C. Do not store infested or recently cut (fresh) white spruce firewood in your yard unless it is either debarked or at least ¼ mile from the nearest susceptible spruce. Spruce firewood that is dry (dead more than 1 year), and not infested with spruce beetle can be safely stored in your yard.

D. Standing, or fallen white spruce trees or tree parts that have been dead for 3 or more seasons do not have to be removed because they will no longer attract or produce spruce beetles. However, standing dead trees near houses are hazardous and should be removed before they decay and potentially harm people or property.

1. Management and control of an existing spruce beetle population is necessary if a large population has already developed on or near your property and is already attacking or killing trees.

A. Examine the white spruce trees on your property in August, looking for evidence of recent spruce beetle attack. A tree heavily attacked during the summer should be removed before August 31st, if possible. (Heavily attacked trees will have reddish brown boring dust on more than 50 percent of the trees circumference at ground level.) The tree should be cut down and burned, debarked, or removed from the site. The stump should be treated as described above. Burning or debarking kills all beetle life stages under the bark and prevents them from emerging and attacking nearby trees. All outer bark must be burned or removed from the tree to ensure that all life stages of the insect are killed. Beetles may emerge from dead trees for a period of two years following attacks. Spruce beetle is generally not found in trees that have been dead 3 or more years.

The two suggestions listed below have not been tested or applied in Minnesota for spruce beetle control, but have proven effective elsewhere.

B. Trap logs are green trees that are felled before the beginning of the initial beetle flight (usually around May 1st). They are very attractive to spruce beetles. The logs must be removed or destroyed before the beetles complete their life cycle and emerge through the bark of the logs. Trap logs are often used in western North America to trap beetles, and thereby reduce or prevent attacks on living trees growing near an active spruce beetle infestation. Spruce beetles prefer downed trees to standing live trees, and according to the Canadian Forest Service, trap logs attract 10 times the number of beetles that are attracted to standing trees. Large diameter trees (> 16"diameter) make the best trap logs. Branches should be left on the trap logs because spruce beetles prefer to attack shaded portions of the tree stem or bole. Improper use of trap logs may exacerbate a spruce beetle problem. Trap logs should be at least 100 feet from live white spruce trees. If a trap log is adjacent to a live white spruce tree, the standing tree may also be attacked. All trap logs and attacked standing trees must be removed before August 31st to ensure the effectiveness of this strategy. If trap logs and infested standing trees are not removed or destroyed, beetle populations will increase significantly, attacking nearby healthy spruce during the following spring or summer.

C. Registered insecticides for spruce beetle (such as Carbaryl 4L, Sevin SL or Astro) can be applied to the stem of uninfested trees to kill beetles as they arrive on the bark surface. These insecticides will not soak through the bark and kill beetles already in the tree. If possible, all of the main stem should be treated. On larger trees, (>16") the stem must be treated to a height of at least 45-50 feet. All bark surfaces must be thoroughly treated up to this height including the base or root collar on the tree. Applications where only a portion of the bark surface on the main stem is treated or the base of the tree is missed are often ineffective. The material should be applied so that the bark surface is dripping during the application. In the western United States, the insecticides mentioned above are effective for one to two years, if the application is properly applied. Fall pruning the lower limbs on the main stem up to a height of 15-20 feet will improve application success. Spring pruning can increase the risk of attack. A licensed commercial applicator with the proper equipment (hydraulic sprayer with 250-300 psi equipped with a #5 or #7 nozzle orifice) will be required to meet the spray height objectives. The insecticide must be handled and applied properly to avoid injury to humans, animals and aquatic habitats. The insecticides are **not** selective for the spruce beetles; other insects (including beneficial species) will also be killed if the insecticide is ingested or is contacted. Remember, if applying pesticides, the **Label is the Law**.

Spruce beetle management for homeowners

By Mike Albers and Dr. Steve Seybold

Spruce beetles are bark beetles native to Minnesota that attack white spruce trees. They prefer trees 10 inches in diameter and larger, however they will occasionally attack smaller diameter trees. In Minnesota, spruce beetles have been found attacking and killing spruce trees predominately along the northern half of the North Shore and within several miles of Lake Superior.

To manage spruce beetles you must learn to identify the signs of spruce beetle attack. The best evidence of attack includes reddish boring dust, at the base of the tree, and secretions of resin (pitch tubes) on the bark surface of the tree stem. Removal of a small piece of bark will reveal the galleries and mines of the adult and larval beetles. The needles of heavily attacked trees will eventually become tan or red and the tree will die. However it may take a year or more for the needles to turn color. A tree with just a few attacks may not die during the first year, but it may continue to be attacked and eventually die in the following year or years. Infested trees are a source of more beetles that will likely threaten nearby healthy trees.

Management of spruce beetles is based on three key strategies. The first strategy is to make your trees as healthy and vigorous as possible. This will make them less attractive to the beetles and better able to defend themselves against beetle attacks. The second strategy is based on sanitation and removal of breeding material to prevent large populations of spruce beetles from developing on your property. These small (3/16th – 1/4th inch) beetles must attack trees in large numbers to successful kill the tree. Removal of material in which they can breed and develop reduces the chances of them producing large enough populations to harm nearby healthy trees. The third strategy involves spruce beetle population management and control. This involves removing or destroying infested trees in order to reduce the size of a beetle population that has already developed and/or protecting your other trees from attack.

Listed below are suggestions for reducing damage and mortality of white spruce due to spruce beetles.

1. Improve and maintain the health and vigor of your trees.

Fast growing, healthy trees are more resistant to spruce beetle attacks than slow growing unhealthy trees. Spruce beetles prefer trees weakened by factors such as defoliation, drought, root decay, root and stem wounds, and overcrowding (high stand density). Weakened trees are not as able to defend themselves against spruce beetle attacks as are healthy trees.

A. Water trees during periods of drought. Large trees require substantial amounts of water. Place a hose on the ground under the trees and allow water to soak the area out to the edge of the drip line. Do not use sprinklers because moisture sprayed on the needles increases the risk for some needle diseases.

B. Maintain a 3-4 inch thick layer of mulch over the root zone of the tree using wood chips, shredded bark or other organic material. This minimizes competition, moderates soil temperature and maintains soil moisture.

C. Avoid wounding the tree stem. This weakens the tree and releases volatile resins from the wounds that attract beetles.

D. Avoid injuring trees roots and compacting soil, particularly during construction, telephone line installation, etc.

E. Protect trees from defoliation by other insects. Insects such as spruce budworm or sawflies that feed on needles may reduce tree vigor making it more susceptible to attack by spruce beetle. An insecticide treatment to prevent defoliation by these insects may be necessary.

2. Sanitation and removal of breeding material

These actions help prevent the buildup of large populations of spruce beetles. Spruce beetles need to attack trees in large numbers in order to successfully enter, colonize, and kill a healthy tree.

A. White spruce trees tipped over or damaged during storms should be removed before May 1st. Trees that are damaged during the summer should be removed promptly, or at least before August 30th. These trees should be burned, debarked or removed from the site. Spruce beetles are attracted to storm damaged trees, where they reproduce beneath the bark resulting in the development of large numbers of beetles that emerge and may attack nearby healthy spruces.

B. Cut off white spruce stumps as close to the ground as possible. Any remaining stump as well as the portion of the stump below ground should be debarked down to 6 inches below the soil line before May 1st.

C. Don't store white spruce firewood in your yard unless it is debarked or unless it is dry and you are sure it is not infested with spruce beetles.

D. Trees that have been dead for 3 or more seasons do not have to be removed. These trees will no longer produce spruce beetles. However, if near houses, they should be removed before they decay and become hazardous to people or property.

3. Management and control of an existing spruce beetle population

This is necessary if a large population has already developed on or near your property and is already attacking or killing trees.

A. Examine the white spruce trees on your property in mid to late summer looking for evidence of recent spruce beetle attack. A tree heavily attacked during the summer should be removed before August 30^{th}, if possible. If not it should be removed before the following May. The tree should be cut down, burned, debarked or removed from the site and the stump treated as described above. Burning or debarking kills all beetle life stages under the bark and prevents them from emerging and attacking nearby trees. Beetles may emerge from dead trees for 1 or 2 years. A tree that has been dead long enough for its needles to fall off will no longer be inhabited by spruce beetles.

B. Other management techniques using insecticides or trap logs are sometimes used in the western United States and Canada. These techniques have not been tested or used in Minnesota and if done improperly have the potential to create additional problems. Please consult someone familiar with their use such as an Extension Agent, Forester, or professional pest control specialist.

Oak Wilt Analysis

By Susan Burks

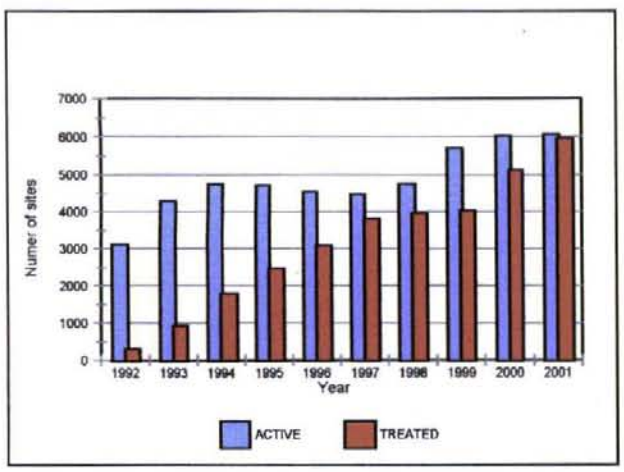
Community maps for 2002 are being digitized in preparation for the up-coming treatment season. As of the spring 2002, the number of active infection pockets was 6055, with 5959 treated sites (map 1). Sherburne County has the largest number of active infection pockets and the most acreage affected.

Following the storms of 1997 and 1998, the number of infection pockets dramatically increased in those areas affected by the storms. As a result, the oak wilt epicenter shifted northwestward into Sherburne County, where storm damage and increased development have put a large number of oaks at risk (map 1). The spread increases the risk of oak wilt moving into heavily forested counties further north that do not yet have oak wilt. If oak wilt is allowed to spread into these counties, the loss of trees and the cost of disease control could be substantial.

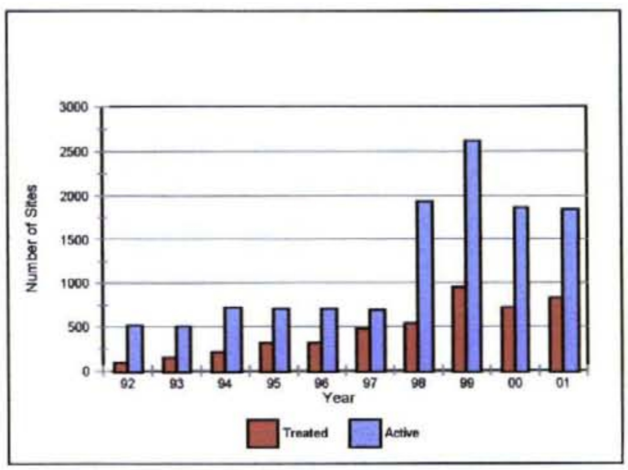
In 2003 and 2004, funding for oak wilt management will be provided through the MN Releaf under an expanded forest health program. The new progrm will provide funding for a number of other forest health issues, which may reduce overall funding levels for oak wilt management.

The incidence of oak wilt in areas under active management since 1992, the continued spread outward from the Twin Cities area and reduced state funding suggest a need to reevaluate state's management strategy. The state's approach has been to suppress the incidence of oak wilt to within levels manageable by local government. However, program delivery and community success has varied dramatically. To make the best use of state funding, a stratified approach is in order. To determine where and how to focus state management activities, an evaluation will be initiated in 2003, pending budget approval. The study, scheduled for completion in 2005, will include an analysis of hange detection as well as ground and community surveys

MN Oak Wilt Sites
Annual Accumulation by Year



Sherburne Co. Oak Wilt Sites
Annual Accumulation by Year

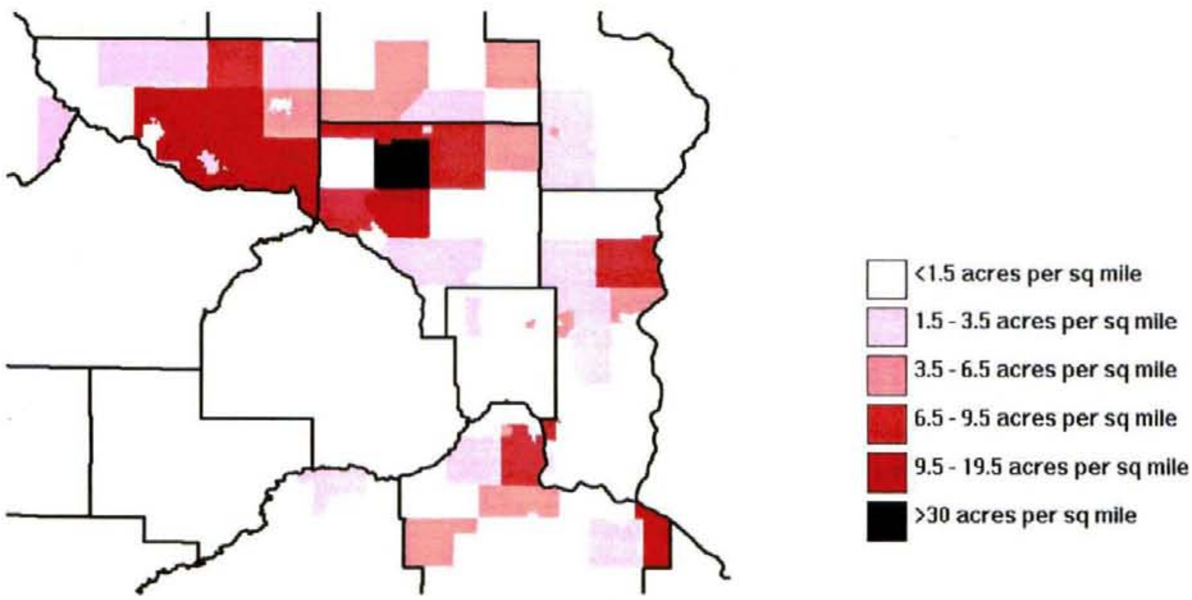


SITES	Active	Treated	Total	% Active
Anoka	1530	2247	3777	41%
Benton	1		1	100%
Chisago	303	195	498	61%
Dakota	851	1195	2046	42%
Fillmore	16		16	100%
Goodhue	52		52	100%
Hennepin	33	165	198	17%
Houston	5		5	100%
Isanti	365	246	611	60%
Mille Lacs	22	7	29	76%
Olmsted	119	12	131	91%
Pine		2	2	100%
Ramsey	148	698	846	17%
Scott	26	27	53	49%
Sherburne	1837	828	2665	69%
Stearns	13	2	15	87%
Wabasha	85		85	100%
Washington	763	216	979	78%
Winona	37		37	100%
Wright	5		5	100%
	6211	5840	12051	52%

ACRES	Active	Treated	Total	% Active
Anoka	2974.26	2161.36	5135.62	58%
Benton	1		1	100%
Chisago	388.88	273.53	662.41	59%
Dakota	1403.55	572.64	1976.19	71%
Fillmore	19.94		19.94	100%
Goodhue	54.26		54.26	100%
Hennepin	22.4	70.78	93.18	24%
Houston	7.03		7.03	100%
Isanti	565.35	398.54	963.89	59%
Mille Lacs	15.97	7.6	23.57	68%
Olmsted	122.76	13.36	136.12	90%
Pine			0	100%
Ramsey	105.19	3.65	108.84	97%
Scott	61.38	285.31	346.69	18%
Sherburne	3015.14	18.6	3033.74	99%
Stearns	45.75	1555.09	1600.84	3%
Wabasha	72.1	0.72	72.82	99%
Washington	866.49	134.86	1001.35	87%
Winona	32.24		32.24	100%
Wright	10.86		10.86	100%
	9784.55	5496.04	15280.59	64%

SITE #	Both	VP only	PSP only	NTN only	Other only	TOTAL	% no VP	% no PSP	% w/ revisits
Anoka	680	923	395	248	1	2247	28.7%	30.7%	18.1%
Chisago	35	157	1	2		195	1.5%	44.8%	16.4%
Dakota	263	109	675	132	16	1195	68.9%	12.1%	26.9%
Hennepin	13	1	144	7		165	91.5%	2.5%	17.0%
Isanti	61	168	8	9		246	6.9%	41.1%	14.6%
Mille Lacs	1	5		1		7	14.3%	46.2%	0.0%
Olmsted		12				12	0.0%	50.0%	0.0%
Pine		2				2	0.0%	50.0%	0.0%
Ramsey	186	285	129	80	18	698	32.5%	31.7%	24.1%
Scott	1	17	6	2	1	27	33.3%	37.7%	3.7%
Sherburne	487	338	2	1		828	0.4%	29.0%	33.0%
Stearns		2				2	0.0%	50.0%	0.0%
Washington	35	110	41	24	6	216	32.9%	35.3%	6.0%
TOTAL	1762	2129	1401	506	42	5840	33.4%	27.0%	21.9%

2001 Oak Wilt Density
(i.e. Infected Acres per Square Mile)



Gypsy moth and oak wilt posters

By Susan Burks

Two posters were developed in cooperation with USDA Forest Service, State and Private Forestry, Forest Health Protection personnel (see below). Both were developed in Power Point so MN DNR foresters and their partners could print the posters and use them as needed for workshops and presentations. The posters were distributed to all MN DNR regional offices and to forest health cooperators in the seven Midwest state region.

The first poster on gypsy moth management targets private forestland owners. The two key points made by the poster are 1) the moth is not permanently established in Minnesota as of yet, but will be soon, and 2) forest land managers can minimize future impacts of the gypsy moth on their lands through active forest management. A very brief overview is given of the two silvicultural strategies used to management the gypsy moth. These are to increase diversity to reduce the risk of defoliation, and to increase stand vigor to reduce the risk of tree mortality following defoliation.

The second poster on oak wilt management targets communities and their residents. Key messages here are 1) your trees are risk of infection and 2) oak wilt can be managed. In a general overview, the poster presents disease symptoms, means of spread, likely hosts and control methods. Prevention is stressed as the key to minimizing future tree loss.

Gypsy Moth and Forest Management

The Gypsy Moth is Coming. Are Your Forests Prepared?

The gypsy moth is the most important forest defoliator in North America.

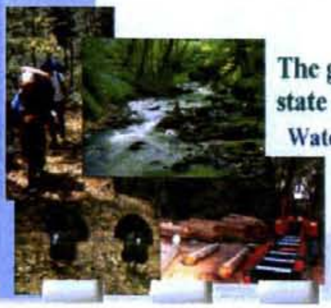
The larva (caterpillar) eats tree leaves and is the only damaging life stage.

The caterpillars can feed on over 500 plant hosts. But they prefer oaks and aspens, two of MN most important forest species.

The oaks were defoliated while the maples were avoided.

Trees die when gypsy moth defoliation is combined with other stressors such as:

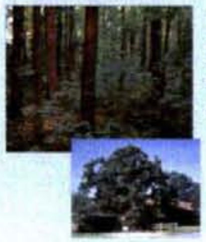
- drought
- root disease
- wood borers
- natural and human disturbances.



The gypsy moth will impact state resources:

Water quality, wildlife habitat, tourism and timber industries, human health and wellbeing.

Here's How You Can Prepare!



Forest management can help you meet your land use objectives and protect your resources.

The two gypsy moth strategies in forest management are:

- **limit future defoliation**
- **limit associated tree mortality**

To minimize future defoliation, encourage a mix of native tree species.

Gypsy Moth Hosts		
Preference	**Crown Position**	**Species**
Most Preferred	Overstory	Apple, basswood, bigtooth & quaking aspen, paper & river birch, tamarack, mountain ash, oak, willow
	Understory	Hawthorn, hazelnut, hophornbeam, hornbeam, serviceberry, witch-hazel
Less Preferred	Overstory	Yellow birch, boxelder, butternut, black walnut, chestnut, cottonwood, elm, hackberry, hemlock, hickory, maple, pear, pines, spruce
	Understory	Blueberry, cherry, sweetfern
Avoided	Overstory	Ash, redcedar, balsam fir, silver maple, red mulberry
	Understory	Dogwood, elderberry, grape, greenbrier, juniper, mountain & striped maple, raspberry, viburnum

Help is available: Contact the Department of Natural Resources information center for the forester nearest you:

1-888-MINNDNR (646-6367)

To limit future tree mortality, increase stand health.

Remove weakened trees so healthy trees can utilize the space. Healthy trees are better able to withstand defoliation.

Thin overly dense stands to reduce competition-related stress.

Encourage seedlings and sprouts in older stands.

Remember the needs of native wildlife

Leave snags, downed woody debris and brush for native fauna.

The Gypsy Moth is Coming...

Oak Wilt

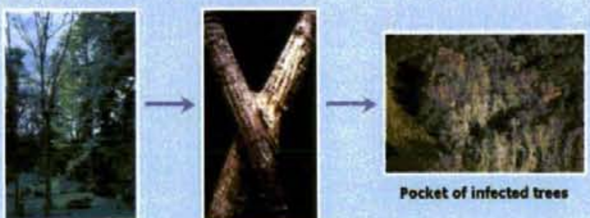
Problem

Your oak trees are at risk of dying from oak wilt.

Oak wilt symptoms include:

The disease restricts water movement, causing leaves to wilt. As water vessels become blocked, branches die one by one until entire trees are killed.

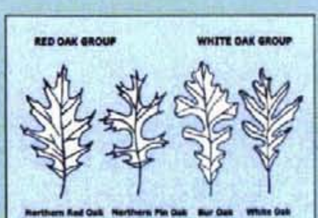
Oak wilt can spread to surrounding oak trees through grafted (interconnected) roots.



Single infected tree → Root graft transmission → Pocket of infected trees

Oak wilt can be lethal to all oak species, but susceptibility varies

- Red and pin oaks may die within as few as four weeks.
- Infected bur oaks can take several years to die.
- White oak branches are killed, but the trees often survive.



How do you know which oak you have?

Four oak species are common to Minnesota and easily distinguished by their leaf shape.

Prevention

Oak wilt prevention starts with understanding the biology of overland spread.

Three factors are involved:

- **Sporulating fungal mats:** The fungus produces spores mats just under the bark of infected trees.

- **Insect vectors (carriers):** Sap feeding insects carry spores from mats on diseased red oaks to fresh wounds on healthy oak trees.

- **Springtime wounding of oak trees:** Spring is the critical time period for the spread of oak wilt by insects. If spring wounding is unavoidable, paint the wound within minutes with water-based paint or shellac.

Planning a new home? Protect your investment.

Identify and control oak wilt before you start site work. Use fencing to protect trees from wounding. Avoid spring time construction near standing oaks.

"An ounce of prevention is worth a pound of cure."

Don't wound in April, May or June.

Control

Oak wilt can be controlled!

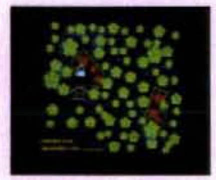
The cost to control oak wilt is often less expensive than:

- removing dead trees
- increased heating and cooling costs
- reduced property value
- tree replacements

Effective control involves a few steps:

Cut root grafts between diseased and healthy oaks with a vibratory plow.

Call Gopher State One before plowing
Statewide: 1-800-252-1166
Twin City Area: 1-651-454-0002



Remove infected trees before April 1st.

Remove red oaks likely to develop spore mats to keep the beetles from carrying spores from tree to tree.

Dispose of infected wood properly.

- Use approved disposal sites.
- Debark or tarp infected wood.
- Don't move infected wood to sites without oak wilt.

Help is Available: Contact your community and ask about cost-share programs.

To assist private land owners, many local governments have oak wilt suppression programs that match your investment. Check it out!

MINNESOTA DEPARTMENT OF AGRICULTURE

Two-Lined Chestnut Borer

By Mike and Jana Albers

This summer it is fairly common to see oaks that are dying due to infestation by two-lined chestnut borers (TLCB) from Bemidji to Grand Rapids to Mora. TLCB have attacked oak trees stressed by the recent forest tent caterpillar outbreaks, local droughts and/ or construction damage.

The two-lined chestnut borer, *Agrilus bilineatus,* is an opportunistic insect that attacks weakened oak trees. It is a native beetle known to attack all oak species found in Minnesota, red oak being its preferred host. When trees and stands are healthy, TLCB confines its attack to low-vigor trees or broken branches. When drought stress, construction and/or defoliation have reduced tree vigor, oaks are predisposed to TLCB attack. Under severe stress conditions, widespread outbreaks of TLCB can occur.

Adult beetles seek out and lay eggs on weakened oaks in late May and June. From June to August, larvae feed on the inner bark of live branches and stems which destroys nutrient and water conducting tissues causing the foliage to turn brown and hang on the branches. Larvae create meandering galleries on the surface of the wood which are visible if patches of bark are cut off infested branches or stems. Larvae are white with an enlarged head and slender segmented body, are about 1 and 1/4 inch long when fully grown, and have two spines at the tip of their abdomens. Larvae pupate under the bark where they overwinter. They emerge as adults through D-shaped exit holes in the bark the next May and June

In mid-July, the first visible symptoms of TLCB infestation occur. Infested oaks may be recognized by the sparse, small and discolored foliage which is followed by the dieback of branches. Leaves of infested branches turn uniformly red-brown. The leaves on non-infested branches remain green. Infested oaks have a distinctive pattern of dead and live leaves on them. Branches in the upper crown are dead and leafless; branches in the middle crown are dying and have red-brown wilted leaves; branches in the lower crown are alive and have green leaves. In other words, TLCB infested oaks have a "dead, red and green" pattern from the top of the tree down its branches.

By the time branch flagging becomes fully evident in August and September, the attack is finished for the year. The dead, brown leaves usually remain attached to the tree, even after normal leaf drop in the fall. When a tree is killed, surrounding oaks are often attacked by TLCB and Armillaria root disease and killed in the following year which creates a pocket of dead trees.

Management Options

There's a big difference in how you deal with the TLCB infestation depending on whether the trees are in your woodlot or whether they are in your back yard. In either case, we recommend replanting oaks to replace the ones that were lost.

Forested Stands

Oak stands that have been stressed by drought and defoliation are vulnerable to damage and mortality caused by two-lined chestnut borers and Armillaria root disease. Management options for these stressed stands should be limited to (1) postponement of any activities in the stand, or, (2) salvage of high-value, damaged trees to reduce economic impact. The choice of option to use depends on the potential for continuation of stress due to drought, defoliation or pest infestation and the volume and quality of wood in the stand.

Management activities should cease when oaks are under severe stress from drought and/ or defoliation since any stand disturbance will further open up the stand and cause additional stress on the trees. Management activities could begin during the winter after a growing season with more normal precipitation patterns. However, oaks would be vulnerable to TLCB for a few years after the drought and defoliation ended as the trees slowly regain their vigor.

Salvaging does not control borers in outbreak situations, but it does reduce the economic impact by recovering timber while it still has its greater value. Salvaging is an option if the dead oak and the oak with at least 50% dieback have a great enough volume to make a merchantable sale and the quality is high enough to produce veneer and grade lumber. Salvage the stand during the winter. Trees should be marked for salvaging during the leaf-on period since dead trees and trees with severe dieback will be impossible to identify during the dormant season. When salvaging, do not extend the harvest into areas of the stand untouched or lightly damaged by TLCB.

If the main product is firewood, delay any salvaging for at least a year after the oaks have died. Firewood quality will not deteriorate during this delayed period. This gives the borer larvae time to become adults and leave the tree and dead firewood will not be reinfested. If infested firewood is moved into backyards with oaks, the TLCB population will spread into the backyard oak trees.

Thinning will not control TLCB during an outbreak situation. In fact, thinning should be avoided during a TLCB outbreak, particularly if the outbreak has been triggered by drought. Thinning will open up the stand to drying winds which will increase the drought stress on the residual oaks. Thinning can also mechanically wound trees and cause serious damage to the tree roots. Even if thinning reduces stocking to optimum levels, the trees will not benefit from the reduced competition for a number of years until the roots and crowns are able to occupy the spaces created during thinning.

Thinning will also produce additional food supply for the Armillaria root disease organism. Fresh stumps and roots of cut trees will provide an additional food base for this fungal pathogen. It would be best to delay thinning for a few years until the oaks are more vigorous. Even at that time, thinnings should be kept light; do not remove more than 30% of the basal area.

Sanitation will not be effective in controlling damage during an outbreak. **A sanitation harvest simply cannot remove enough of the insect population to prevent future damage to the residual oak trees.** During an outbreak, there are vast numbers of low vigor, vulnerable oaks that will perpetuate the outbreak. The best practice is to postpone all management activities until the conditions that caused stress have ended.

Remember, **stump sprouting will be virtually non-existent in borer-infested stands.** In effect, the low vigor that created the TLCB problem will also decrease sprouting and enhance vulnerability to Armillaria root disease. To ensure future oak regeneration, count on advanced regeneration or oak planting stock, not stump sprouts.

Armillaria root disease, caused by an opportunistic soil borne fungus, attacks the root systems of weakened trees and will often lead to tree mortality. If Armillaria root rot is involved in damaging the root system, a white mat of fungal tissue growing between the bark and wood of the roots and root collar can be found. These white mats, however, may not be found until after the tree is completely dead.

Yard Trees

Yard trees are high value and additional measures are often possible with them. TLCB populations can be reduced by cutting and removing infested trees before the start of the next growing season. Infested oaks are those trees which died or show dieback this year. If you plan to remove oaks, mark infested trees now while the leaves are still on them so you can distinguish removals from trees that will not be cut.

Remove oaks that died this year or oaks with more than 50% dieback. TLCB populations can be reduced by cutting and removing infested trees before the start of the next growing season. Since TLCB larvae can survive in cut and split wood to emerge next spring, the complete removal of infested logs and branches should be done by May 1st of next year.

The preferred methods of wood and slash disposal are removal to an approved landfill or sale of tree for lumber. If <u>any</u> woody materials larger than 1 inch in diameter remain, pile and burn them before May 1st next year. If you want to keep the wood for firewood, cover the wood pile with a heavy plastic tarp and bury the edges of the tarp in the soil for an airtight covering. Keep the firewood covered until at least July 30th next year. Then the wood can be moved or burned as you like.

If droughty, water healthy and declining oaks on a regular basis during the growing season. Trees with less than 50% dieback may be saved by heavy watering during droughty weather. If rainfall is inadequate, make sure trees get at least 1½ inches of water per week in May and June and 1 inch per week in July and August. Water so that the entire root system receives this amount of moisture all at once. Remember the absorbing roots are at the dripline and beyond.

Strictly <u>avoid</u> using fertilizers and/or herbicides on lawns and gardens within 50 feet of an oak tree. Fertilizers will only hurt an ailing tree and herbicides kill tree roots too, leading to more root system loss.

Avoid practices which destroy or smother roots. Root loss will drastically affect tree vigor. Practices which damage roots include trenching or burying utility lines which sever the roots; compacting the soil around the roots by driving and parking of vehicles on roots systems; smothering roots by paving or temporarily storing excavated soil over the root system; or, by changing soil grade, either adding or removing soil.

Control other insects that cause defoliation before 60% of the foliage is lost. Once defoliation reaches this level, the trees may refoliate and this decreases tree vigor. Develop and implement spray plans if heavy defoliation is predicted to occur for the second or third consecutive year.

Avoid bringing fresh oak firewood into your yard. Bringing more infested wood into an area will only compound the problem.

Chemical insecticides are not useful against TLCB because of difficulties with timing and obtaining thorough coverage on large trees. However, certified arborists or commercial pesticide applicators may be able to treat high value shade trees.

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MINNESOTA DEPARTMENT OF NATURAL RESOURCES
FOREST ECOSYSTEM HEALTH PROGRAM
COOPERATIVE LANDS - FOREST HEALTH MANAGEMENT
FFY 2002 ACCOMPLISHMENTS INCLUDING
Forest Health Management
Forest Health Monitoring (Off-Plot, only)

Staffing and Organizational Changes

- In July 2002, MN DNR reduced its organizational structure to 3 regions from 6 regions. The Brainerd and Rochester Regions were eliminated. Currently there are 4 Regions:

  NW Region: Region Headquarters located in Bemidji
  NE Region: Regional headquarters located in Grand Rapids
  Central Region: Regional Headquarters located in St. Paul
  Southern Region: Regional Headquarters located in New Ulm

- MN FEHP staffing changes:

  The Program Supervisor and Coordinator positions were combined and located in St. Paul.
  Regional Forest Health Specialist located in Brainerd moved to Bemidji (NW MN).

Cooperative Forest Health Program

Oak Wilt Management	Target	Accomplished
Oak wilt infection centers treated	80	1,250
Townships analyzed for oak wilt	100	31

Training and Presentations	Target	Accomplished
Presentations and training events	15	44
People	800	1,800

Media Outreach	Target	Accomplished
Forest Health Newsletters	4	5
News releases	5	23
Brochures	3	5
TV/radio opportunities	3	18

Requests for Assistance	Target	Accomplished
Respond to requests for forest health assistance	750	1,400

Meeting Attendance (Target)	Accomplished
SPFO Cooperator's Meeting	YES
Gypsy Moth National Meeting	YES
Exotic Pest Workshop	YES
North Central Forest Pest Workshop	YES

Provide CFHP Forest Health Information	Target	Accomplished
Accomplishment and Expenditure Report	October 15	DONE

Forest Health Monitoring

Detection Surveys	Target	Accomplished
General pest detection (acres)	12,000,000	12,000,000
FHM plots aerially checked	300	300

Detection Survey Results			
HOST SPECIES	DAMAGE	AGENT	ACRES
Aspen & hardwoods	defoliation	Forest tent caterpillar	7,374,057
Balsam fir & white spruce	defoliation	Spruce budworm	90,689
Oak	mortality	Defoliation, weather, borers, disturbance	22,092
Tamarack	defoliation	Larch casebearer & unidentified	19,956
Tamarack	mortality	Larch beetle, weather, site activity	17,245
Oak	dieback	2-lined chestnut borer	13,493
Elms	mortality	Dutch elm disease	2,528
All types	breakage	Wind	1,999
Conifers	mortality	Bark beetles	658
All types	defoliation & discoloration	Unidentified causal agents	24,531
All types	All damages	All agents	7,567,248

Pest and Host Evaluations

Pest and Host Evaluations	Target	Accomplished
Area evaluated (acres)	750,000	~9,000,000
Life stage surveys	Jack pine budworm Spruce budworm Forest tent caterpillar Pine tussock moth	See results below.

Life Stage Surveys			
Pest	Survey Type	Acres	Trend
Jack pine budworm	Larval Egg mass	400,000	12 larvae found; no defoliation predicted in 2002 and 2003
Spruce budworm	Larval Egg mass	795,000	Population low; light defoliation in some locations
Forest tent caterpillar	Egg mass Cocoon Pupae	7,690,000	Population on decline and expected to collapse in some locations in 2003; 95% parasitized cocoons.
Pine tussock moth	Pheromone trapping	400,000	Insignificant populations
2-lined chestnut borer	Mortality evaluation survey	10,000	Mortality significant in some areas. Increase in mortality may be due to ftc defoliation effects.
Larch beetle	Pheromone trapping		Testing variety of baits
Bark beetles *(Ips* spp.)	Population studies; research plots	6,600	Increasing occurrence

Meeting Attendance (Target)	Accomplished
National Forest Health Monitoring Working Group	YES

Providing Forest Health Monitoring Off-Plot Information

FHM Information	Target	Accomplished
Pest detection survey results	Maps	Done
Pest conditions report	December 15	No [1]
Forest Health Highlights	January 15	February [2]

[1] Information for this report was gleaned from pest detection survey results.

[2] Report was late due to late delivery of pest detection survey results.

Survey Results

Jack pine budworm larval survey
Forest tent caterpillar
- Egg mass survey in April
- Parasite study
- Egg mass survey in summer and fall

Sphaeropsis collar rot survey
- At Badoura Nursery
- In plantations

Spruce budworm surveys

Jack pine budworm larval survey - June and July of 2002			
DESCRIPTION	**# LARVAE PER PLOT**	**STAMINATE FLOWERING (none, scarce, common, heavy)**	**DEFOLIATION (none, light, moderate, heavy, Vheavy)**
SENE 8-143-34	2	C.	None
NENW 16-143-34	1	C	None
SENE 4-143-34	1	C	None
SWSE 27-144-34	0	C	None
NWNW 22-140-32	0	C	None
SWSW 26-140-32	0	C	None
SWSW 23-140-32	0	C	None
SWSW 11-139-32	1	C	None
SWSW 12-139-32	0	C-H	None
SESW 28-139-32	0	H	None
SESW 30-139-32	0	C	None
SENW 26-139-33	0	C	None
NWNW 35-139-35	0	C	None
SWSE 26-139-35	0	C	None
SENE 35-147-34	0	C	None
NESE 26-147-34	2	H	None
SENE 10-147-34	1	H	None
SENE 3-147-34	0	C	None
NWNE 4-147-35	0	C	None
NENE 32-148-35	2	C-H	None
NWSE 19-148-35	1	C-H	None
SESE 11-147-35	0	C-H	None
NWSE 21-146-35	0	C-H	None
NESE 22-146-35	1	C-H	None
NESE 23-145-34	0	C	None
NENE 34-145-34	0	C	None
SESW 29-144-34	0	C	None
SWSE 5-143-34	0	S	None
SWSE 2-143-35	0	S	None

FTC Egg Mass Survey
Region 3
April 2002

Survey Date	County, Legal, GPS Location	Trees species and DBH	Number of FTC egg masses	Predicted Defoliation for 2002	Remarks
April 5	Crow Wing SWNE 13-43-28 E436823 N5117688	Average 4.6" basswood	Average 3.7	Light	Gen. Vessey's property
April 5	Mille Lacs SWSW 15-40-26 E454993 N5088845	2", 2", 1 ½, aspen	0,2,0	Very Light	Rum River S. For. (N side)
April 5	Mille Lacs NWSW 54-42-25 E455152 N5110591	1 ½", 2", 2" basswood	0,0,2	Very Light	Father Hennepin S park near swimming beach
April 7	Stearns NWNW 36-127-33 E361775 N5069692	4', 4', 1 ½ basswood	0,0,0	None	Birch Lake St Forest Campground 200 ft. into the road
April 7	Stearns NWSW 36-127-33 E361168 N5069512	2', 1 ½', 1 ½' basswood	0,0,0	None	Birch Lake St Forest Campground 200 ft. into the road
April 8	Pine SWNW ¼ 27-41-18 E529699 N5094973	3", 1 ½", 1 ¼" aspen	0,0,0	None	St Croix State Park about 200ft. S of entrance road. Found one FTC cocoon in leaf tent on 1 aspen
April 8	Pine SESW 26-43-16 E551305 N5113299	1 ½", 1 ¼", 1 ½" aspen	0,1,0	Very Light	W of Cloverton
April 8	Carlton NESW 28-46-19 E519860 N5142580	1 ¼", 1 ¾" aspen	0,1,0	Very Light	SE of Moose Lake
April 9	Carlton SWSE 16-46-19 E519257 N5145508	1 ¼", 1 ½", 1 ½" aspen	0,0,0	None	N of Moose Lake
April 10	Cass SWSE 6-141-25 E432318 N5211226	1 ¼", 3 ¼", 1 ½" aspen	0,5,0	Light	E of Remer
April 10	Aitkin SWSE 13-52-26 E455760 N5204047	2 ¼", 2". 2 ¼" aspen	2,2,0	Light	E of Hill City
March	Aitkin S12-T52-R22 E494888 N5205690	Average DBH-2.7" aspen?	Average FTC egg masses 18.5	Very Heavy	Corner 200 & 2 M. Albers data

April 12	Aitkin NENE 18-45-26 E448750 N5137232	2 ¼", 2", 4 ¼" aspen	0,0,0	None	Wealthwood State Forest
April 12	Aitkin NWNW 32-44-25 E458804 N5123103	Checked several large branches on several large basswood. Many FTC egg masses spotted. Lakeshore home yards will be sprayed. No small basswoods to sample		Heavy	Picard Point on Mille Lacs Lake Shore
April 12	Kanabec SWSW 13-41-23 E484423 N5097026	1 ¼", 1 ¼", 1" aspen	0,0,0	None	
April 12	Morrison SWSW 13-139-29 E439057 N5079448	1", 3", 2 ½" basswood	0,7,3	Moderate	
April 12	Crow Wing SESE 34-136-29 E399238 N5155691	1 ¼", 2", 2 ¼" aspen	0,0,0	None	Jonathon Jahn's area E Twin Lake
April	Crow Wing NWSE 7-137-27 E412549 N5171823	10+ basswood, 3" dbh	1,0,0,0,0 0,0,0,0,0	None – very light	Anchor Point N of Cross Lake
April 29	Cass SWNW 35-41-31 E379819 N5204885	¾", 1", ¾" aspen	2,2,3	Light	Ten Mile Lake searched for infested trees & sampled them
May 14	Mille Lacs NESE S7-43-27 E N	1 ¼", 2", 2 ¼"	1,5,4	Moderate	W side of lake FTC just hatching

A July 24th Study of Parasites of FTC in Northeastern and Central MN 2002

Date Cocoon Collected	Location	# FTC Cocoons collected	# moths emerged	% cocoons to moths	% cocoons pasteurized or diseased	Remarks
July 1	Hibbing, along Hwy 169	110	2	1.8%	98.2%	Many fly maggots and puparia
July 1	Deer River along Hwy 2 E and W of city	110	11	10%	90%	Many fly maggots and puparai and one wasp
July 1	Grand Rapids along Hwy 169 E and W	105	10	9%	91%	Many fly maggots and puparia and one wasp
July 3	Father Hennepin State Park	105	2	1.9%	98.1%	Few fly maggots
July 3	Bay Lake 0.4 mi. east of Ruttger's Lodge	36	1	3%	97%	Cocoons rare. A few fly maggots and puparia. Many dead FTC
July 7	Floodwood along Hwy 2 E and NW of city	112	8	7%	93%	Several fly maggots and puparai
July 8	Two Harbors NE and SW sides of city	117	5	4%	96%	Several fly puparia, many dead FTC at NE collection site , near water tower
July 8	Cloquet N side – 2 locations	103	5	4.8%	95.2%	Several fly maggots and puparia
July 8	Lakewood Township N side of Duluth (27 across from 53)	168	5	3%	97%	80 cocoons from S10, 28 from S6, and 30 from S18
July 8	Gooseberry Falls State Park	120	6	5%	95%	Many fly maggots and pupae. Collected mass from west side of hwy. Across from park entrance because 90% of FTC in park parking area not cocooned yet
Averages				**4.9%**	**95.1%**	

FTC Egg Mass Survey - 2002

Regions 2 and 3

Mark Platta and Bob Tiplady

Date	Location	DBH of Trembling aspen (inches)	# FTC egg masses	Predicted FTC Defoliation in 2003	Remarks
July 18	Todd NWNE 36-127-33	2 ¼, 1 ¾, 3 ¼ (basswood)	0, 0, 0	None	No noticeable 2002 defoliation in the area
July 23	Crow Wing SESW 3-45-28	3 ½, 2 basswood, 1 ½	0, 0, 0	None	Minor 2002 defoliation in this area
July 25	Aitkin NENW 23-52-26	5, 3 ½, 3	7, 2, 2	Light	
July 30	St Louis West side of Hibbing	3, 2 2 ¾	8, 2, 2	Moderate	
July 30	St Louis East side of Hibbing	2 ¼, 2 ½, 2 ½	3, 9, 5	Moderate	
July 30	St Louis W side of Virginia	2 ½, 1 ¾, 2	5, 14, 17	Heavy	
July 30	St Louis N side of Virginia	3, 3 ¼, 3 ¾	4, 2, 11	Moderate	Minor 2002 defoliation
July 30	St Louis S edge of Orr	3, 4, 1 3/4	1, 0, 1	Light	Very light 2002 defoliation and many dead FTC on trunks and branches
July 30	Itasca SESE 21-62-25 4 mi east of Effie.	2, 3, 2 ¾	3, 1, 0	Light	Heavy 2002 defoliation. Many FTC cocoons.
Aug 12	Carlton SWSE 25-149-16	2, 2, 3.5	1, 0, 0	Light	Moderate to heavy 2002 defoliation
Aug 12	St Louis SENW 23-51-13	3, 2, 2	4, 0, 0	Light	
Aug 12	St Louis NENE 34-56-13	2 ¾ , 3, 2 ¾	1, 2, 4	Light	
Aug 12	Lake N of Gooseberry Falls	2 ½, 2 ½, 2 1/2	2, 9, 14	Heavy	
Aug 12	Lake Two Harbors N of golf course	3, 31/4, 2 ½	2, 2, 4	Light	
Aug 13	Koochiching east of Northome	2 31/2, 3 ¾	1, 2, 4	Light	
Aug 13	Itasca Deer River area	2 ½, 3, 2	2, 5, 5	Moderate	
Aug 26	Mille Lacs SESE 31-41-27	1 ¾, 1 ¼, 2 1/2	0, 0, 0	None	Very minor 2002 defoliation and cocoons very rare
Aug 26	Mille Lacs SWSE 15-40-26 M L Wildlife Area	2 ¾, 1 ¼, 2 ½	0, 0, 0	None	No cocoons very minor 2002 defoliation. Lots of flies seen by locals
Aug 26	Kanabec NWSW 26-139-25 Northside of Oglive	3 ¼, 3 ½, 2	0, 0, 0	None	Minor 2002 defoliation, cocoons rare
Aug 26	Kanabec SESE 27-40-25 NW of Ann Lake	2 ¾, 3 ½, 2	0, 0, 0	None	Minor 2002 defoliation & cocoons rare
Aug 26	Kanabec NENW 24-41-23	1 ¾, 1 ½, 2	0, 0, 0	None	No 2002 defoliation or FTC cocoons
Aug 26	Aitkin SENW 12-46-26	2 ½, 2 ½, 2	0, 1, 0	Light	Minor 2002 defoliations but cocoons noticeable and several

	(+ 19 more in R2)				aspen welcome some cocoons
Oct 1	Aitkin NENE 33-45-27 NW Mille Lacs Lake	2, 1, 1 ¼	0, 0, 0	None	No 2002 defoliation
Oct 1	Aitkin SESW 26-45-27 Close to Mille Lacs	2, 2 ¼, 2 ¼	0, 0, 0	None	No 2002 defoliation
Oct 1	Pine SESW 23-43-18 East of Askov & Beron	2 ½, 2 ¼, 2 ½	0, 0, 0	None	No 2002 defoliation-
Oct 2	Aitkin NWSE 32-52-23 South of Ball Bluff	2, 1 ½, 1 ¼	0, 0, 0	None	
Oct 2	Aitkin SESW 13-52-26 East side of Hill City by public access	2, 1 ½, 1 1/2	0, 0, 0	None	Some dead FTC
Oct 2	Cass NWNE 34-14-28 Longville	2 ¼, 1 ¼, 2 ¾	1, 0, 0	Light	No 2002 observable defoliation
Oct 2	Cass NESW 140-30 S of Hackensack	3, 3 , 2 ¾	0, 1, 0	Light	No 2002 defoliation
Oct 2	Cass SENW 5-138-30 S of Backus	1 ½, 2, 3	0, 0, 0	None	No 2002 defoliation Scattered oaks
Oct 2	Cass SESE 11-145-31 E of Cass Lake	3, 3, 1 ¾	0, 0, 1	Light	Little 2002 defoliation. Dead FTC Scattered oaks
Oct 3	Crow Wing NWNE 7-137-27 Mission Tnsp.	3, 2 ½, 2 ¼	0, 0, 0	None	No 2002 defoliation

Sphaeropsis : Sampling at Badoura State Nursery. 2002

April 17, 2002 Albers and Tiplady

2-0 red pine were sampled from 2 compartments. Five different beds were sampled in each compartment. In each bed, a single 1 meter length of a seedling row was inspected for the presence of symptomatic seedlings (live or dead) and asymptomatic seedlings. Numbers of each were tallied. Dead and symptomatic seedlings were collected for further examination by Dr. Stanosz, University of Wisconsin.

Investigations of 2-0 red pine for *Sphaeropsis* symptoms at Badoura Nursery, 2002

Compartment **B 11**:

Furthest away from red pine windbreaks and manager indicates that this is the compartment with the least amount of disease.

Bed number	Live asymptomatic	Dead Asymptomatic *	Live symptomatic	Dead symptomatic
22	110	3	1	0
21	92	9	1	0
19	110	0	1	0
18	100	2	0	4
17	77	4	1	0
Average values	97.5	3.6	0.8	0.8

* = It looked like these died due to desiccation.

Investigations of 2-0 red pine for *Sphaeropsis* symptoms at Badoura Nursery, 2002

Compartment **A 3**:

Closest to red pine windbreaks and manager indicates that this is the compartment with the most disease. As 1-0's the beds looked orange due to *Sphaeropsis* infection.

Bed number	Live asymptomatic	Dead asymptomatic	Live symptomatic	Dead symptomatic
22	33	0	5	32
21	28	0	14	27
19	28	0	7	47
18	33	0	11	53
17	23	0	10	46
Average values	29	0	9.4	41

There was clearly a difference in the incidence of symptomatic seedlings between the 2 compartments. In A3, 63% of all seedlings were symptomatic whereas, in B11, only 1.5% of all seedlings were symptomatic. As a result, the beds in A3 are only producing 30% of what the beds in B11 are producing because of *Sphaeropsis* shoot blight and mortality.

Note: There may be additional losses in A3 due to asymptomatic collar rot infections.

Sphaeropsis collar rot survey in plantations - 2002

In October, a request was sent to all Forestry Areas for samples of red pine seedlings that died since planting this year. This is part of the continuing effort to document the presence and effects of *Sphaeropsis* infection on our Nursery seedlings. There were several respondents from Region 1, 2 and 3. Seedlings came from PFM and state-owned plantations. Unless otherwise noted, only 5 seedlings per plantation were used for this study because of the lab time involved in verification. The seedlings were examined for symptoms of collar rot and then for the presence of *Sphaeropsis* pycnidia.

Statewide Results:

Red pines growing in 28 plantations (18 were documented) averaged 67 % mortality.
Other species in the same plantations (only 7 were documented numerically) averaged 12 % mortality.

160 seedlings were examined in the lab.
Five dead seedlings from a non-DNR source had no trace of *Sphaeropsis* infection.
Examination of 155 DNR -source seedlings revealed the following:
3 seedlings (1.9%) died from other causes,
12 seedlings (7.7%) had symptoms of collar rot but no fruiting bodies were found, and,
the remaining 140 seedlings (90.4%) all had symptoms and fruiting bodies of *Sphaeropsis*.
So, from DNR-sources, 98% of the sampled red pines had *Sphaeropsis* infections.

Plantation Results:

The table below presents information by plantation. From 3 to 14 seedlings were examined for each plantation, the typical number being 5 seedlings per plantation.

Sphaeropsis collar rot of red pine seedlings - 2002						
	Plantation data			*Red pine seedling data*		
Area Location	**Plantation composition**	**Mortality of other species %**	**Mortality of red pines %**	**Symptomatic of collar rot %**	**Verified by lab %**	**Notes**
Park Rapids						
Spur 1 Trail	45% RP 50% JP 5% WP	5 %	55%	100%	100%	
Parkway Rd	90 RP 10 WP	5	70	100	100	
Steamboat	90 RP 10 WP	5	75	100	100	
Detroit Lakes						
Hofland	RP, WP			100	100	
Bicknell	RP, W cedar	46	74	100	100	
Hartig	BO, WS, RP, GA, WP	good	poor	100	100	

Sphaeropsis collar rot of red pine seedlings - 2002						
	Plantation data			*Red pine seedling data*		
Dombeck	RP, WP, WS, Tam	20	50	**0**	**0**	*** Non-DNR source**
Alexandria						
Riedel			50	100	90	
Obowa			77	100	80	
Musely			91	100	100	
Hendrickson			40	100	100	
Volkman			52	100	100	
Dykhoff			63	100	100	
McGowan			89	**80**	60	1 dead was unknown
Greg Johnson			73	100	100	
Myers			66	100	100	
John Olston			53	100	100	
Brandt				**80**	60	1 dead was insect caused
Hibbing						
16-60-19	RP, WP	good	poor	100	100	
36-57-14				100	100	
17-61-22	RP, WP	5	75	100	80	
3-59-21	interplant RP		75	100	100	
3, 16-61-20				100	67	3 seedlings
1, 21–60-21				100	100	
7, 35-62-23				**84**	50	1 of 6 dead due to insects
26-62-23				100	58	7 seedlings
Cambridge						
no location given				100	93	14 seedlings
Sandstone						
26-38-20	RP WP	0	70	100	100	*** Not droughty at all!**

Spruce budworm survey - 2002

Location	Species	1999		2000			2001					2002			
		Egg mass survey			Egg mass survey		Larval survey		Eggmass survey			Eggmass survey			Notes
		Actual defoliation	Ave # egg masses	Ave # of larvae on twig	Actual defol.	Ave # egg masses	% of buds on twigs infested	Ave # of larvae on twig	Actual Defol.	Ave # egg masses	Predicted defol. for 2002	Actual Defol.	Ave # egg masses	Predicted defol. for 2003	
Aitkin Co.															
NWSW 8-52-25Thinned Blandin	WS				0	0			0	0	0	0	0	0	
NWSW 8-52-25 Unthinned Blandin	WS				0	0			0	0	0	0	0	0	
NWNE 7-51-23	WS				L	1.8	> 50%	8.9	M	4.1	H	H	1.0	M	No topkill, fairly vigorous
Becker Co.															
NWNE 21-141-36	WS														
SESE 21-141-36	WS	MH	1.11		M	0.66						VL	0	VL	Improved vigor since thinning
SESE 21-141-36	WS	--	--		MH	0.66									
Beltrami Co.															
NWSW 12-147-30 Thinned Sam Welch's Cornor	WS				VL	0			0	0	0	0	0	0	
NWSW 12-147-30 Unthinned Sam Welch's cornor	WS	L	0.1		L	0			0-VL	0	0	0	0	0	
NESE 26-149-30	WS														
NENE 26-149-30	WS														
SESE 2-147-31	WS														
	"														

Spruce budworm survey - 2002

Location	Species	1999		2000			2001					2002			
		Egg mass survey			Egg mass survey		Larval survey		Eggmass survey			Eggmass survey			Notes
		Actual defoliation	Ave # egg masses	Ave # of larvae on twig	Actual defol.	Ave # egg masses	% of buds on twigs infested	Ave # of larvae on twig	Actual Defol.	Ave # egg masses	Predicted defol. for 2002	Actual Defol.	Ave # egg masses	Predicted defol. for 2003	
NESW 1-148-31	WS														
NW NW 12-147-30	WS	LM	0		VL	0									
SWSW 12-147-30	WS	VL	0		VL	0									
SESW 2-147-31	WS	MH	0.55		L	0.11									
Cass Co.															
NENE 1-139-26	WS														
NWNE 1-139-26	WS	0	0												
NWNW 11-139-26	BF														
NENE17-140-27	BF														
SENW 21-145-30 unthinned	WS	M	0.11		VL	0						VL	0	VL	sooty mold in canopy
NWSE 9-145-30 unthinned	WS											VL	0	VL	good vigor
SWSE13-136-31	WS				0	0	< 10%	0.1				0	0	0	
SWSE 22-138-31	BF														
NENW 1-139-25					0	0									
SWNE 30-139-25	WS														
NWNE 30-139-25	WS														
NWSE 8-145-30	WS														
SWSW 9-145-30	WS	LM	0		VL	0									
Chisago Co.															
SESE 36-36-21	WS				0	0	0	0				0	0	0	

Spruce budworm survey - 2002

Location	Species	1999		2000			2001					2002			
		Egg mass survey			Egg mass survey		Larval survey		Eggmass survey			Eggmass survey			Notes
		Actual defoliation	Ave # egg masses	Ave # of larvae on twig	Actual defol.	Ave # egg masses	% of buds on twigs infested	Ave # of larvae on twig	Actual Defol.	Ave # egg masses	Predicted defol. for 2002	Actual Defol.	Ave # egg masses	Predicted defol. for 2003	
Clearwater Co.															
Itasca State Park, 1.9 mi east	WS,BF											H	0.1	L-M	BF with virtually no defoliation
Itasca State Park, Wilderness Dr. parking lot	BF,WS											VL	0	0	
Itasca State Park, 0.9 mi est	WS											VL	0	0	
Cook Co.															
NWNW 33-63-4E	WS,BF														
NESW 35-64-3E	BF														
NWSE 3-61-1E	BF														
SWNE 22-63-1E	BF														
NESW 10-64-1W	BF														
SENE 4-61-1E	BF,WS														
Crow Wing Co.															
SENE 19-44-31	WS	0	0				< 10%	1.1				0	0	0	
SWNW 20-44-31	WS								0	0	0				
Hubbard Co.															
SE 13-141-32	WS														
SWSE 13-141-32	WS														

Spruce budworm survey - 2002

Location	Species	1999		2000			2001					2002			
		Egg mass survey			Egg mass survey		Larval survey		Eggmass survey			Eggmass survey			Notes
		Actual defoliation	Ave # egg masses	Ave # of larvae on twig	Actual defol.	Ave # egg masses	% of buds on twigs infested	Ave # of larvae on twig	Actual Defol.	Ave # egg masses	Predicted defol. for 2002	Actual Defol.	Ave # egg masses	Predicted defol. for 2003	
SESE 1-142-33	WS														
SE 1-142-33	WS														
NWSE 23-145-33	WS														
NENE 24-139-34	WS														
NWNE 21-141-36	WS														
SESE 1-142-30	WS	VL	0.55		VL	0						VL	0	VL	thinned 3 yrs ago
SESE 13-141-32	WS	VL	0.11		VL	0									
Itasca Co.															
NWNE 16-61-24 thinned Larson L	WS				L	0.44			VL	1.0	M	M	0.8	M	
NWNE 16-61-24 Unthinned Larson L	WS				L	0.11			VL	0.55	M	L	1.0	M	
NENW 12-53-26 Thinned Smith Creek	WS	L	0		VL	0			L	1.4	M	H	0.9	M	
12-53-26 Unthinned Smith Creek	WS	L-M	0.1		L	0.1			L-M	0.55	M	M	0.8	M	

Spruce budworm survey - 2002															
Location	Species	1999		2000			2001					2002			
		Egg mass survey			Egg mass survey		Larval survey		Eggmass survey			Eggmass survey			Notes
		Actual defoliation	Ave # egg masses	Ave # of larvae on twig	Actual defol.	Ave # egg masses	% of buds on twigs infested	Ave # of larvae on twig	Actual Defol.	Ave # egg masses	Predicted defol. for 2002	Actual Defol.	Ave # egg masses	Predicted defol. for 2003	
SENE 24-149-27 Thinned Dora Lake	WS	L-M	0		L	0			0	0	0	0	0	0	
SENE 24-149-27 Unthinned Dora Lake	WS	H	0.8		L	0			0-VL	0	0	0	0	0	
NESE 2-61-23	BF	L-M	0.2												
NENW 34-62-22	BF														
NWSE 26-62-23	BF														
NWSW 3-58-24	WS														
SWNE 3-58-24	WS	0	0	0	0	0	<10 %	0	1	0	0				
NWSW 35-58-24	WS								L	1.7	M				
NENW 23-59-24	BF														
SWSE 36-62-24	WS														
NENE 17-53-25	WS														
NWSW 35-58-24	WS	H	0.1	26	M	0.8	>10 %	10.3							

Spruce budworm survey - 2002

Location	Species	1999		2000			2001					2002			
		Egg mass survey			Egg mass survey		Larval survey		Eggmass survey			Eggmass survey			Notes
		Actual defoliation	Ave # egg masses	Ave # of larvae on twig	Actual defol.	Ave # egg masses	% of buds on twigs infested	Ave # of larvae on twig	Actual Defol.	Ave # egg masses	Predicted defol. for 2002	Actual Defol.	Ave # egg masses	Predicted defol. for 2003	
NWNE 7-60-25	WS														
NW 9-56-25	WS														
NWNE 4-60-26	WS														
SENW 12-53-26	WS														
SESW 11-53-26	WS	M	0.44	18.7											
SWSE 17-60-26	BF														
Koochiching County															
SESE 28-65-26 Thinned, Big Falls, Johnson Landing	WS				L	0.11			0	0	0	0	0	0	
SESE 28-65-26 Unthinned, Big Falls, Johnson Landing	WS	H	1.0		M	0.33			0-VL	0.1	L	0	0	0	
36-155-25 Thinned, Big Falls, Power line	WS				L	0			0	0	0	0	0	0	

Spruce budworm survey - 2002

Location	Species	1999		2000			2001					2002			
		Egg mass survey			Egg mass survey		Larval survey		Eggmass survey			Eggmass survey			Notes
		Actual defoliation	Ave # egg masses	Ave # of larvae on twig	Actual defol.	Ave # egg masses	% of buds on twigs infested	Ave # of larvae on twig	Actual Defol.	Ave # egg masses	Predicted defol. for 2002	Actual Defol.	Ave # egg masses	Predicted defol. for 2003	
36-155-25 Unthinned, Big Falls, Power line	WS	L	0		L	0			0	0	0	0	0	0	
NWNW 4-65-22	BF	L-H	0	0.8	L	0	<10 %	0	0	0	0				
NWNW 19-65-22	WS,BF														
NESE 36-65-23	BF											0	0	0	
10-67-22	WS														
SENE 23-67-22	BF														
NESW 31-70-26	WS	L	0												
SENW 4-71-22	BFWS	L	0												
SESE 35-71-24	WS														
SESE 8-69-23	BF	L	0												
SESE 16-69-23	BF														
NWNE 22-65-23	BF	L-M	0												

Spruce budworm survey - 2002															
Location	**Species**	**1999**		**2000**			**2001**					**2002**			
		Egg mass survey			**Egg mass survey**		**Larval survey**		**Eggmass survey**			**Eggmass survey**			**Notes**
		Actual defoliation	**Ave # egg masses**	**Ave # of larvae on twig**	**Actual defol.**	**Ave # egg masses**	**% of buds on twigs infested**	**Ave # of larvae on twig**	**Actual Defol.**	**Ave # egg masses**	**Predicted defol. for 2002**	**Actual Defol.**	**Ave # egg masses**	**Predicted defol. for 2003**	
SWSW 25-69-23	WS														
NWSE 5-70-23	BF														
SWSE 36-62-24	BF WS														
SENE 27-70-25	WS	L	0												
NWNE 27-158-26	WS														
Lake Co.															
SWNE 11-55-8	BF														
SWSE 5-59-8	BFWS				0										
SENE 11-61-11	WS,BF														
SENW 31-62-11	WS,BF														
Mille Lacs															
SWSE 1-35-27															
Morrison Co.															

Spruce budworm survey - 2002

Location	Species	1999		2000			2001					2002			
		Egg mass survey			Egg mass survey		Larval survey		Eggmass survey			Eggmass survey			Notes
		Actual defoliation	Ave # egg masses	Ave # of larvae on twig	Actual defol.	Ave # egg masses	% of buds on twigs infested	Ave # of larvae on twig	Actual Defol.	Ave # egg masses	Predicted defol. for 2002	Actual Defol.	Ave # egg masses	Predicted defol. for 2003	
NENE 1-41-29	WS	O-VL	0				< 10%	0.88	0	0	0	0	0	0	
SESE 1-42-30	WS				0	0									
NESW 11-42-32	WS														
Sherburne Co.															
NWNW 33-34-27	WS	L	0				< 10%	0.22							
SWSW 21-35-27	WS						< 10%	0.88	0	0	0	0	0	0	
NENE 29-35-27	WS	Trace	0		< 1 %	0									
St. Louis Co.															
NESE 22-62-12	BF				0	0	<10 %	0.11	VL	0	0				
NWNE 6-63-12	BF														
SESE 31-58-13	WS,BF														
NWNE 4-62-13	BF														
NESE 6-63-17	BFWS	L	0	2.7	VL	0	<10 %	0.4	O	0.11	L				

Spruce budworm survey - 2002															
Location	Species	1999		2000			2001					2002			
		Egg mass survey			Egg mass survey		Larval survey		Eggmass survey			Eggmass survey			Notes
		Actual defoliation	Ave # egg masses	Ave # of larvae on twig	Actual defol.	Ave # egg masses	% of buds on twigs infested	Ave # of larvae on twig	Actual Defol.	Ave # egg masses	Predicted defol. for 2002	Actual Defol.	Ave # egg masses	Predicted defol. for 2003	
SWNW 2-64-17	BF														
NENE 8-51-18	WS														
SWSW 33-61-18	WS,BF	H	0.8	10	H	2.2	>10 %	10.7	M	1.55	M	M-Spruce H-BF	2.4	H	
SENW 8-63-18												H	1.3	M	
NWNW 33-65-18	BF	M	0.44	8.7	M	0.55	>10 %	8.3	M	2.2	H	M	1.3	M	½ stand is dead
SWSW 26-61-20	WS														
NWNE 25-63-20	BF	H	0.66	6	M	0.4	>10 %	7.6	H	0.33	M	H	6.3	H	
NENE 12-68-20	WS,BF														
SWNW 33-60-21	WS														
SWSW 3-60-21	WSBF	L	0.2	1.7	VL	0	<10 %	0	0	0	0				
NWSW 12-64-21	BF														
NESW 12-64-21	BF	L-M	0.01	1.2	L	0	<10 %	0.3	0	0	0	0	0	0	

Spruce budworm survey - 2002

Location	Species	1999		2000			2001					2002			
		Egg mass survey			Egg mass survey		Larval survey		Eggmass survey			Eggmass survey			Notes
		Actual defoliation	Ave # egg masses	Ave # of larvae on twig	Actual defol.	Ave # egg masses	% of buds on twigs infested	Ave # of larvae on twig	Actual Defol.	Ave # egg masses	Predicted defol. for 2002	Actual Defol.	Ave # egg masses	Predicted defol. for 2003	
NWSW 15-67-21 Thinned 1998	WS thinned 1998	M	O												
NWSW 15-67-21 Planted 1978	WS	L	O												
16-67-21	WS	L	O												
NWNW 30-67-21	WS	L	0.3												
NWNW 30-67-21	WS	L	0.3												
SESW 12-68-21	WS	L	0												
SESE 13-64-21	BF														
5-68-19 Ash River Campground	WS	L	0	0.33	0	0	<10 %	0							
10-67-22 Velpar Short trees	WS	L	0.6												
SENW 10-67-22	BF, WS			0	0	0									

Pine tussock moth: Pheromone trap results

A count of 30 or more moths in a trap during a 14 day period could indicate population buildup and possible need for chemical control of PTM caterpillars during the next year.

Pine Tussock Moth pheromone traps where placed on 6/4/2002

Trap	County	Legal Description	GPS Coordinates		6/13	7/1	7/15	7/26	8/11	8/23	Total
1	Hubbard	SESE 9-139-32	N 46° 51.747'	W 094° 43.427'	0	21	22	10	4	0	57
*2	Hubbard	SESE 10-139-32	N 46° 51.745'	W 094° 42.157'	0	25	21	14	16	6	82
3	Hubbard	NWNW 33-139-32	N 46° 49.111'	W 094° 44.555'	0	14	12	8	1	0	35
*4	Hubbard	SWSW 29-139-32	N 46° 49.122'	W 094° 45.911'	0	23	24	23	12	5	87
5	Hubbard	NESE 26-139-32	N 46° 49.545'	W 094° 48.511'	0	25	20	9	4	0	58
6	Hubbard	SESE 34-139-33	N 46° 48.262'	W 094° 49.764'	0	30	22	5	12	** 19	88
*7	Wadena	SWSW 10-138-33	N 46° 46.558'	W 094° 51.045'	0	16	16	5	7	3	47
8	Wadena	SWSW 19-136-33	N 46° 34.378'	W 094° 53.123'	0	15	18	10	2	0	45
*9	Wadena	NWNW 5-135-30	N 46° 32.453'	W 094° 53.073'	0	17	17	9	9	1	53
10	Crow Wing	NWSW 9-136-27	N 46° 36.602'	W 094° 05.980'	2	18	14	6	16	4	60
*11	Crow Wing	NWSW 11-136-27	N 46° 36.540'	W 094° 03.474'	0	15	14	11	13	0	53
12	Crow Wing	SWSE 30-134-28	N 46° 23' 07.2"	W 094° 15' 04.5"	0	0	1	3	2	0	6

* denotes 3 trees ground cloth sampled on 6/4/2002, no PTM caterpillars where observed.

**Since 19 moths were trapped Aug. 23, trap 6 was left out until Sept. 20. Seven moths were found in this trap Sept. 20th.