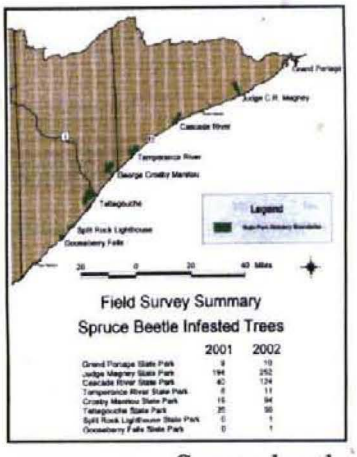
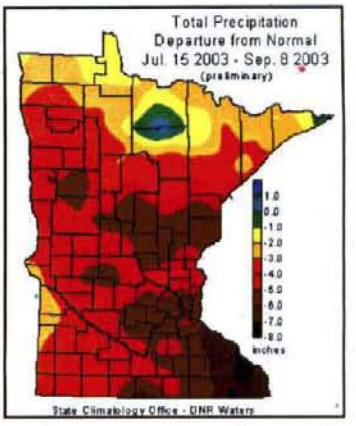
Minnesota Forest Health Annual Report 2003

Mn DNR-Forestry
Forest Health Unit

Winter injury

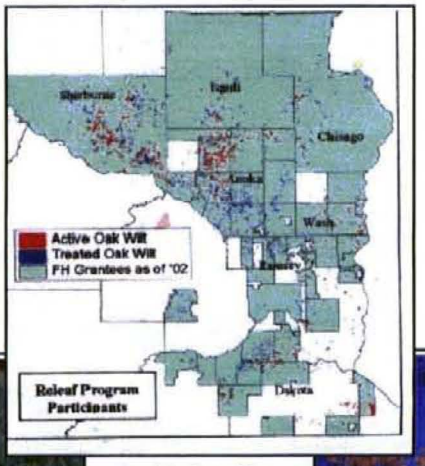


Spruce beetle



Drought

Jack pine budworm



Oak wilt

Sphaeropsis collar rot

Two-lined chestnut borer

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of forest land; 14.7 million acres are classified as "timberland" or lands capable of producing timber and are not withdrawn from timber utilization or associated with rural or urban development.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.

Coulee in southeastern Minnesota

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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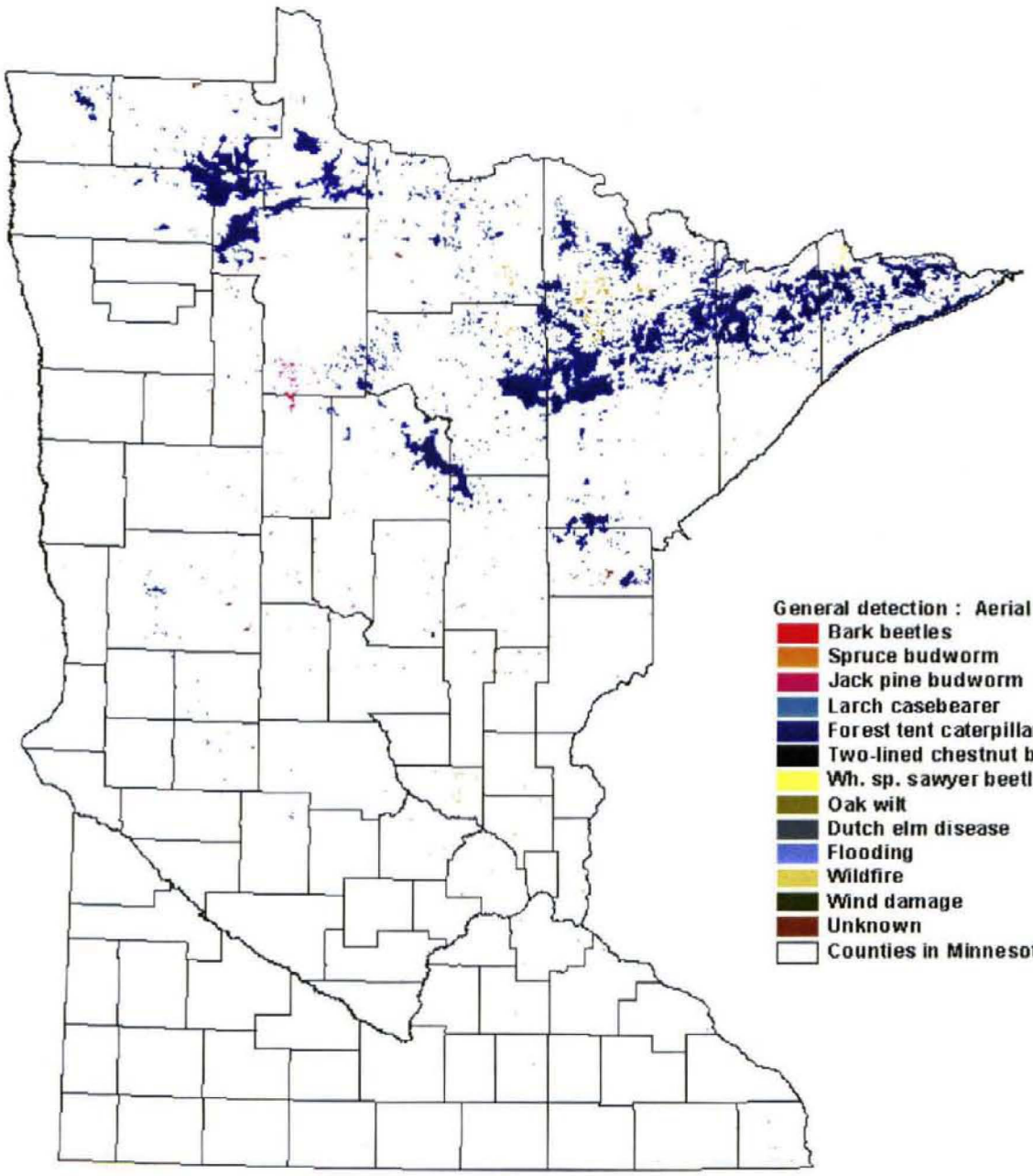
AERIAL SURVEY RESULTS

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 table and map.

Causal agent	Damage type	Acres detected	Trend
Bark beetles	Mortality	1,189	Up by 100%
Hickory bark beetles	Mortality	4	
Spruce budworm	Defoliation	34,601	Down by 60%
Jack pine budworm	Defoliation	18,546	NEW this year
Larch casebearer	Defoliation	1,660	Down by 40%
Forest tent caterpillar	Defoliation	2,254,050	Down by 70%
Two-lined chestnut borer	Mortality	12,557	Similar to last year
White spotted sawyer	Mortality	3,426	NEW this year
Decline (of Scots pine)	Mortality	136	
Oak wilt	Mortality	4,513	
Dutch elm disease	Mortality	74	
Porcupine	Mortality	1	
Domestic animal	Mortality	10	
Flooding	Mortality	7,986	Down by 30%
Wildfire	Mortality	168	
Wind/ tornado	Breakage	586	Down by 75%
Winter injury	Discoloration	17	
Herbicide	Discoloration	12	
Logging damage	Mortality	364	
Unknown:	Defoliation	5,174	
	Discoloration	7,375	
	Dieback	4,155	
Mortality of larch (likely larch beetle)	Mortality	6,079	Down by 50%
Mortality of all other host species	Mortality	11,145	
Total acres		**2,373,828**	

Aerial Survey 2003



INSECTS

Douglas-fir beetle

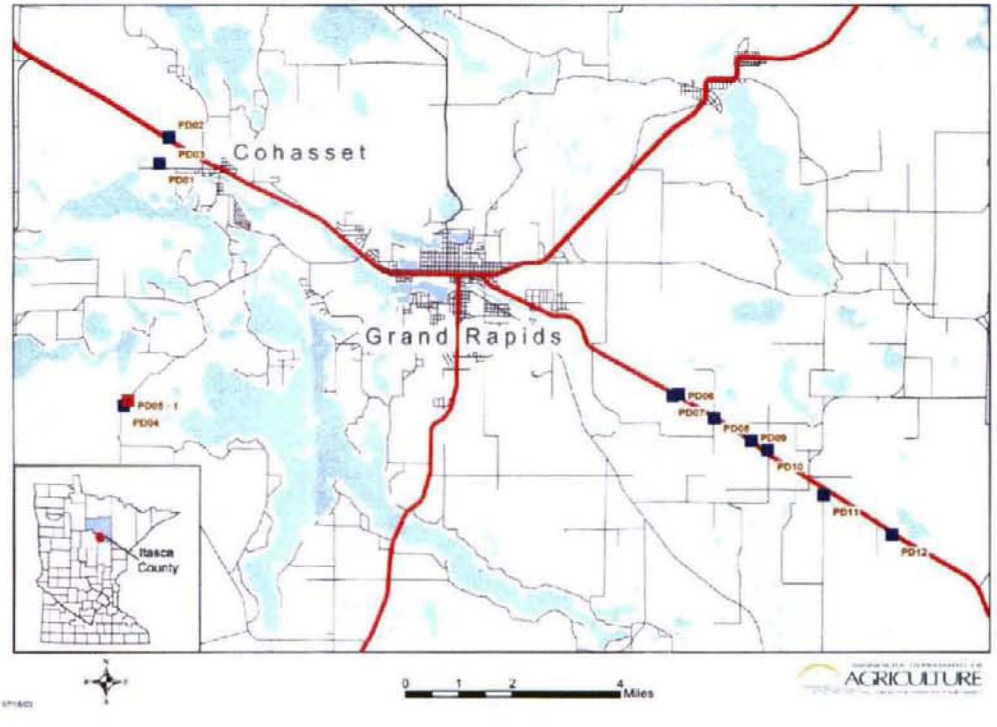
Dendroctonus pseudotsugae

Photo by Steve Seybold

Two funnel traps were set in Arbo township in Itasca County (sec 7-T56N-R25W) on April 30th for Douglas-fir beetles. This is the site where the beetles were originally found in Minnesota in 2001. One of the traps was baited with one ethanol pouch, one MCOL bubble cap and one frontalin tube. The other trap was baited with one ethanol pouch, two racemic seudenol bubble caps and three (-) frontalin tubes. Traps were emptied once a week through June 30th. Trap catches have not yet been sorted but no Douglas-fir beetles were seen in the catches while traps were being emptied. Trap catches were placed in plastic bags in a freezer.

MN Department of Agriculture placed 12 traps for Douglas-fir beetles as shown on the map below. One Douglas-fir beetle was caught in trap PD05. This trap was located approximately 4.5 miles south of the plant that imports western larch logs, the suspected source of the Douglas-fir beetles in Itasca County. The other eleven DOA traps were negative for the beetle.

Minnesota Department of Agriculture
Douglas Fir Beetle Trap Locations in 2003



A grant proposal was funded by the USDA Forest Service to provide funding for a study of the Douglas-fir beetle in Minnesota. A post-Doctorate candidate was hired to work under the direction of Dr. Dan Gilmore (U of MN) and Dr. Steve Seybold (USDA, FS, PSwRS). He will begin working on the study in January 2004.

Eastern larch beetle

Dendroctonus simplex

Hosts:	Tamarack
Damage:	Mortality
Area:	6079 acres statewide
Severity:	Variable
Trend:	Undetermined but likely declining

Eastern larch beetle continues to kill tamarack. Markets for tamarack have improved somewhat making it possible to harvest more of the heavily damaged stands. Mortality in some of the most severely damaged stands where the beetle has been active for a number of years, seems to be declining. The trend is difficult to determine since it is not possible to detect most of the current year larch beetle activity from the air during the aerial survey. This also results in under reporting of acres affected.

Larch beetle galleries

Eastern larch beetle killed a one acre stand of tamarack planted 50 years ago by the U of MN on the Itasca Community College Campus. It was also found in a planting of European X Japanese larch on the ICC campus as well as in larch in a U of MN breeding orchard near Wendigo Golf course along Harris Town Road south of Grand Rapids.

Larvae and pupae again survived overwintering . Three tamaracks near Meadowlands in St Louis County in Sec 18-T53-R18W were checked on May 29, 2003 for eastern larch beetle. All three trees had live pupae, larvae and a few callow adults under the bark at 4 feet above the ground. Since there was very little snow this past winter these larvae and pupae overwintered well about the snow line. The winter of 2002-2003 was another mild winter. This site is near the junction of Hwy 211 and Hwy 133.

Fall webworm

Hyphantria cunea

The late dry season conditions may have favored the fall webworm in southeast Minnesota. The large silk webs enclosing tips of branches are sure signs of fall webworms. It is common to see this insect defoliator in most years, but was particularly noticeable this year. This caterpillar constructs web nests in trees late in summer feeding on the enclosed foliage. Although the webs are unsightly, little if any damage is done to the trees.

Forest tent caterpillar

Malacosoma disstria

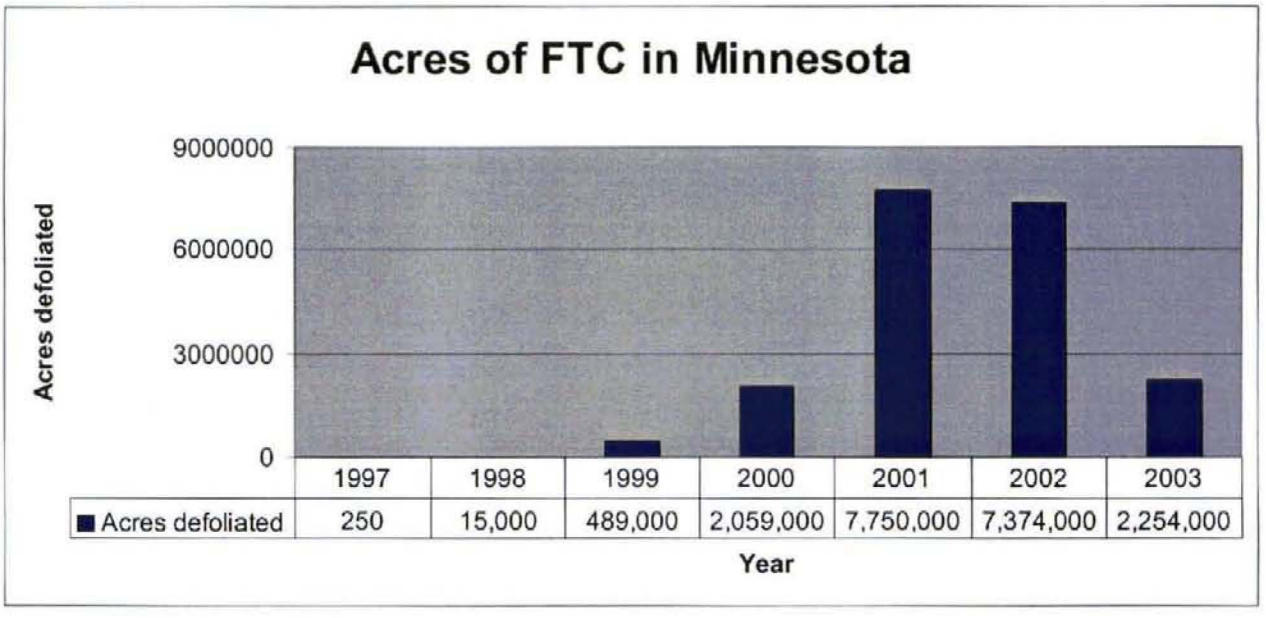
Hosts:	Aspen, oak, basswood and other hardwoods
Damage:	Defoliation
Area:	2,254,050 acres
Severity:	Variable across the northern half of the state
Trend:	Population is decreasing, collapse is imminent.

Although FTC populations were on the downswing in 2003, 2.25 million acres were defoliated in May and June. See chart and map. Acreage is down by 70% compared to last year. Defoliation was scattered or patchy except in the northeastern counties where it was continuous.

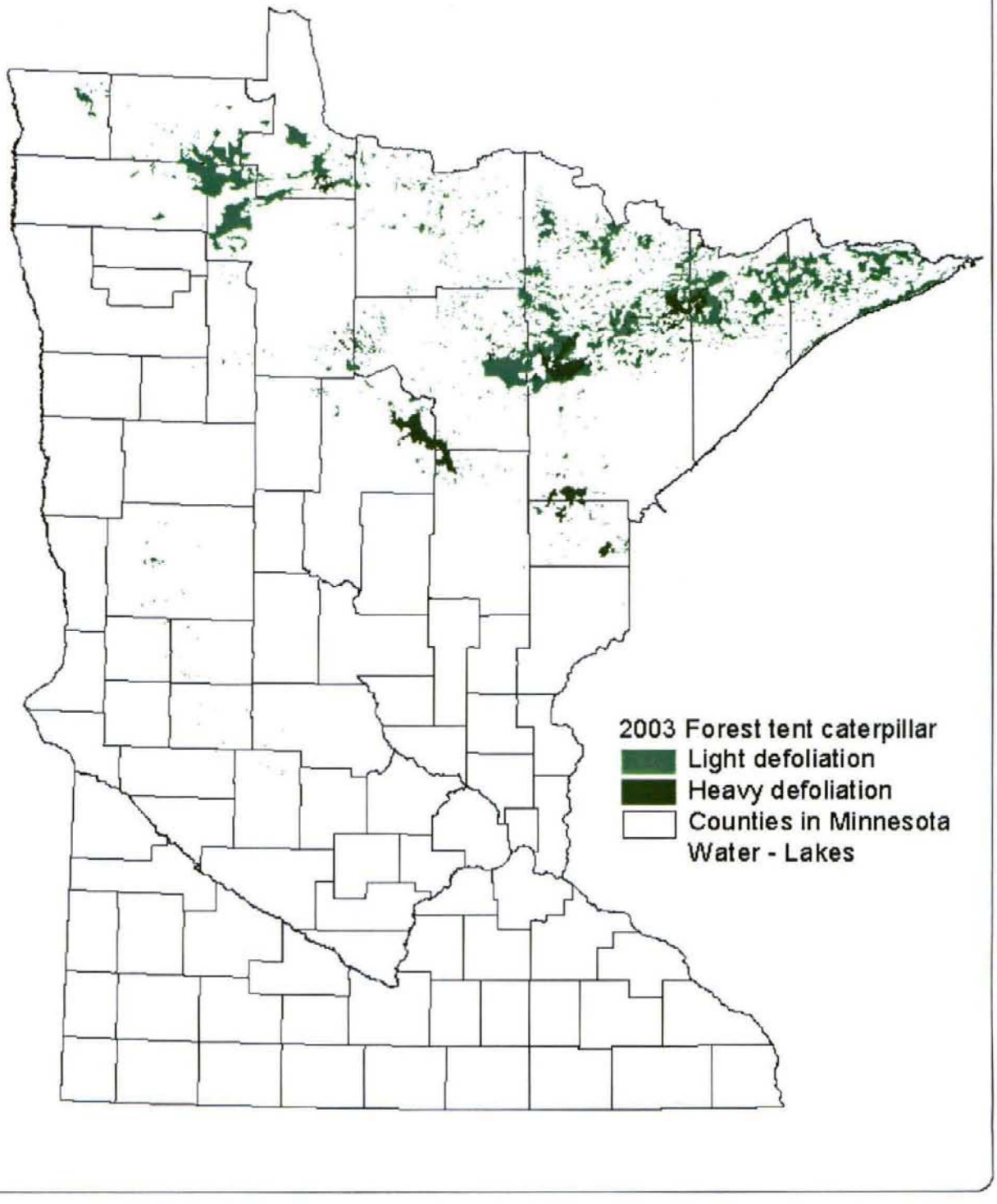
Defoliation was particularly severe across the Iron Range where much of the aspen were completely defoliated again this year. The crowns of many aspen trees looked thin by late summer. They were defoliated by forest tent caterpillar, refoliated and then suffered additional defoliation by the aspen webworm. This was noted especially around Grand Rapids, Cloquet, Hibbing and Virginia but likely occurred in other parts of the Region as well. Later season defoliation by aspen webworm has occurred the last couple of years following forest tent caterpillar defoliation.

Concomitant with the end of an FTC outbreak was a plague of friendly flies, *Sarcophaga aldrichi*. Friendly flies are parasites of FTC pupae and build up to astronomical numbers by the end of the FTC outbreak. Parasitic fly populations were high with many people calling to complain. Most people feel that the annoyance caused by the flies is worse than the nuisance caused by the caterpillars.

Forest tent caterpillar populations and acres defoliated are expected to continue to decrease next year although no egg mass surveys have been conducted. Some locations are still expected to have noticeable defoliation in 2004. Unfortunately, the friendly fly populations won't collapse until late next summer or the year after.



Forest tent caterpillar



Gypsy Moth

Cooperative Minnesota Gypsy Moth Program
2003 Season Summary
Taken from Minnesota Department of Agriculture Final Report

General survey program

The Minnesota Department of Agriculture (MDA) was the lead agency during the 2003 gypsy moth detection survey program. Other cooperators included USDA, APHIS, PPQ; USDA, FS; DNR and the Three Rivers Park District in the Twin Cities metro area. Staff in the cooperative program set approximately 17,790 delta traps across the state, and 535 male moths were recovered. See map. This was a 453 percent increase from 2002, when 118 male moths were recovered.

Gypsy moth trap catches for 2003	
Moth counts	**Type of trap**
317	Standard detection (1 trap/sq. mi)
25	Standard detection (1 trap/ 4 sq. mi)
94	Delimit (16-36 traps/sq. mi.)
55	Nursery
32	Nursery delimit
7	Mill
5	State Park
535	**TOTAL**

Traps were set at one trap per square mile (1/1) in areas considered high-risk for the introduction and establishment of gypsy moth due to human activity levels, preferred habitat for gypsy moth, and the advancing gypsy moth front from Wisconsin. Areas designated high-risk included the seven-county Twin Cities metro area, counties bordering Wisconsin in central and southeastern Minnesota, and along the shore of Lake Superior including the entire city of Duluth. The remainder of the state receives traps at one trap per four square miles (1/4) on a four-year rotation, with approximately one-third of the state receiving traps in any one year. The entire eastern half of Minnesota was trapped in 2003.

As in 2002, a seasonal trapper conducted "hike-in" trapping along a predetermined 1/1 grid (as opposed to using available roads) for all of the Grand Portage Reservation. Two hundred forty traps were set on the Grand Portage Reservation, and six moths were caught in five traps. Forty-nine traps were set on the Fond du Lac Reservation, and no moths were trapped. Nine hundred fifty traps were set in Superior National Forest, and three moths were caught in three traps.

Nursery and mill trapping

Nurseries either reporting stock sources from gypsy moth-quarantined areas or who are wholesale dealers are considered high-risk. Outside the standard detection grid, 34 high-risk nurseries were trapped and one moth was found.

Logging mills are considered high-risk if it is known or likely that they have out-of-state sources or if they are within 60 miles of Wisconsin counties trapping fifty or more moths. Outside the standard detection grid, 16 high risk mills were trapped and no gypsy moths were recovered at these mills. Three mills are under federal Compliance Agreements for gypsy moth. A Compliance Agreement is designed to decrease the risk of gypsy moth establishment and allows mills to transport logs from gypsy moth-quarantined areas for milling or pulpwood. Mills under compliance are trapped at 36 traps per square mile for one square mile. Sappi, Blandin and International Paper were trapped and no gypsy moths were found.

Egg mass surveys

Three egg mass surveys were conducted in the fall in response to relatively high trap catches at the sites. Two sites were within the Twin Cities metropolitan area (Edina and Hugo) and one was in rural southeastern Minnesota

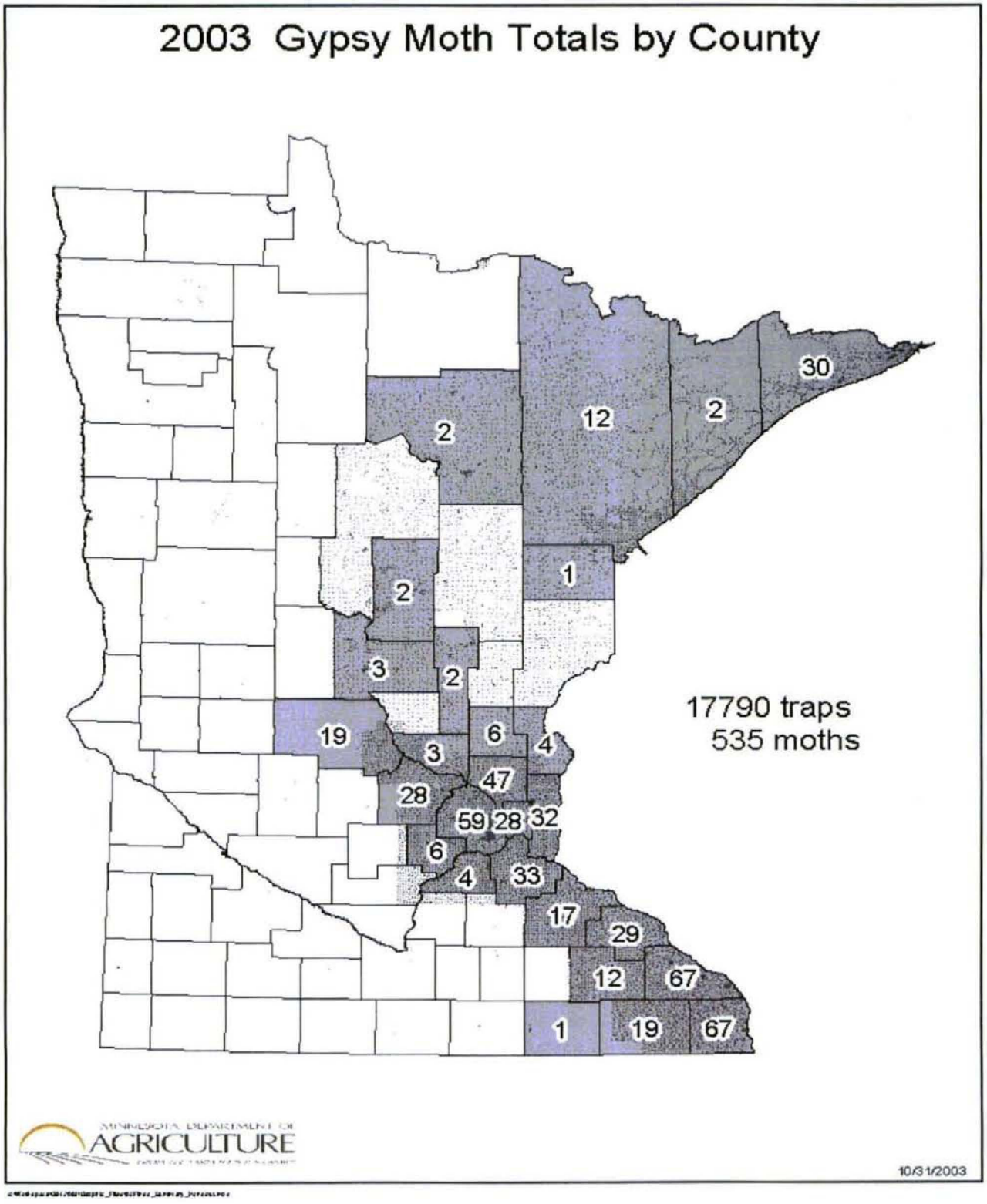
(Rollingstone). The Minneapolis site was part of the 2002 Lake Harriet treatment delimit area. Twenty-two moths were caught in seven traps at this site, the largest number of finds at a single site for the 2003. During the egg mass survey, more than a dozen egg masses were found on two large, isolated oak trees. This site will receive a treatment in the spring of 2004. No egg masses were found during the two other surveys.

Regulatory incidents – quarantine breaches

In early July, MDA was notified that Colorado blue spruce shipped from another Midwestern state to an Iowa nursery was infested with gypsy moth larvae and egg masses. One Minnesota nursery had received stock and when a site inspection was conducted, three spent egg masses were discovered. A Stop Sale Order was immediately issued until further inspection could be conducted, but was suspended the next day when no other life stages were located.

In late July, multiple males were caught in survey traps at four nurseries: two in the Minneapolis-Saint Paul metropolitan area (Blaine and South St. Paul) and two within 70 miles of the Twin Cities (Hanover and St.Cloud). All four businesses were immediately issued Stop Sale Orders. Inspections at the four sites revealed multiple gypsy moth life stages, and as a result, each of the nurseries entered into formal compliance agreements with MDA and USDA, APHIS. One provision of the compliance agreements was that the nurseries must treat for gypsy moth in the spring of 2004, and all conifer material must be held off-sale until treatments have been completed. Two of the businesses were unable to over-winter their conifers so those nurseries elected to burn potentially infested material. Further investigation into the source of the infested material at the four Minnesota nurseries revealed three separate nursery quarantine breaches from three different states within the federal gypsy moth quarantine. All material arrived in Minnesota with the proper gypsy moth certification paperwork.

Two of the Minnesota nurseries received infested stock several months before the quarantine breach was discovered, allowing for possible cross-contamination of other stock on site. The majority of the potentially infested stock had already been sold to other nursery dealers, landscape contractors, or homeowners across the state by the time MDA learned of the breach. Follow-up surveys are being conducted across Minnesota to determine if stock sold to secondary customers was indeed infested.


2003 Gypsy Moth Totals by County
30
2
12
2
2
1
2
3
2
19
6
4
3
47
28
59
28
32
6
4
33
17
29
12
67
1
19
67
17790 traps
535 moths
MINNESOTA DEPARTMENT OF
AGRICULTURE
10/31/2003

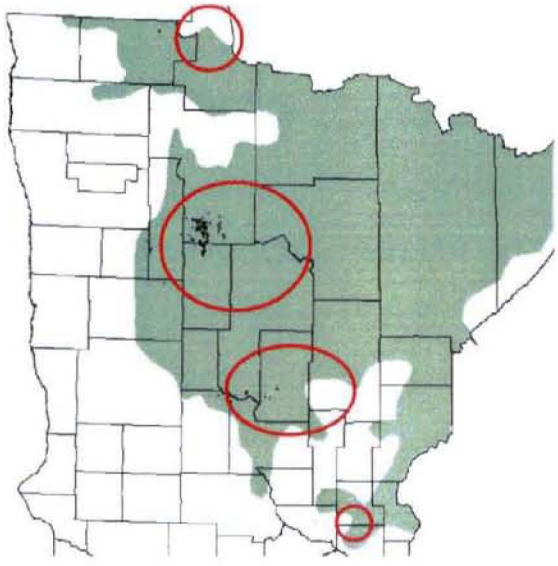
Jack pine budworm

Choristoneua pinus

Host:	Jack pine
Damage:	Defoliation, topkill, mortality
Area:	18,546 ac
Severity:	Predominantly heavy defoliation
Trend:	Population is building.

Larva on male cones

It's been several years since the last jack pine budworm outbreak in Minnesota and, frankly, this outbreak was way overdue. Since 1954, outbreaks in western counties have occurred at four to seven year intervals. The last JPBW outbreak ended in 1994, making it nine years since budworms were active here. For the last several years, early larval and egg mass surveys have been predicting very low (endemic) populations. The extent and magnitude of this year's outbreak was a surprise. We have four hot-spots in the state, from Roseau County reaching down to Sherburne County. See map and table.



Location	Acres defoliated
Bemidji and southwest	16,807
Brainerd and west	1,478
Roseau Co.	114
Sherburne Co. (on red pine)	147
Total	**18,546**

An interesting sign of budworm infestation occurred this spring in Beltrami County. Although there were very heavy pollen cone crops this year in Eckles (147-34), Buzzle (148-35) and Jones (146-35) Townships, there were no clouds of pollen. Recall that budworm larvae infest pollen cones and consume pollen. These townships also had heavy cone crops in 2002.

Jack pines near Bemidji and in most of Beltrami County are now showing signs of budworm heavy defoliation and some topkill. See local map and photo above. Unfortunately, most affected stands are more than 60 years old, have topkilled trees, are suffering the ill effects of a recent drought and are low vigor as evidenced by having only two years of needles on their shoots. According to recent studies by McCulough (1999), the amount of pre-outbreak topkill in a stand is a good predictor of the amount of post-outbreak mortality. This means that extensive negative impacts, topkill and mortality, are likely to occur in the next couple of years as the outbreak peaks. Bemidji Area rapidly mobilized its staff to assess damage, prepare pre-salvage operations and kept the public and cooperating agencies informed. Forest health staff participated and provided several news releases, handouts and presentations. See Publications section.

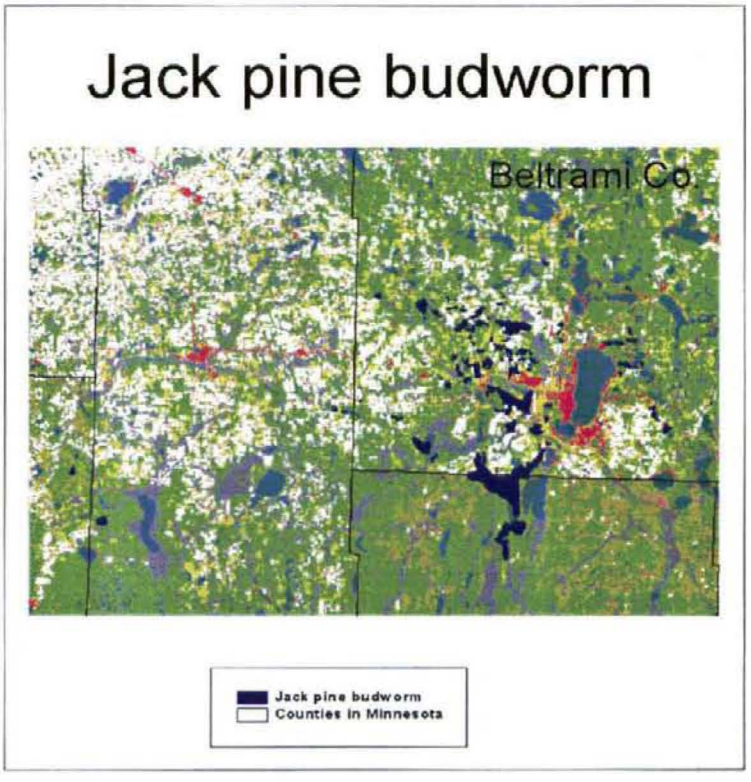
The damage produced by these outbreak populations can range from moderate defoliation producing minor growth loss to severe, multi-year defoliation producing topkill and mortality. Budworm populations and activity are expected to increase in at least the three northern locations and "spread out" to stands between Bemidji and Brainerd. In fact, some of these stands already had a slight tinge of defoliation this year. And, factoring in the hot, dry summer weather,

it's a good bet that we'll see defoliated jack pine stands in Cass, Wadena, Hubbard, Becker and Clearwater Counties next year. In Sherburne County, budworms have defoliated a few red pine stands totaling 147 acres. See the next article.

Where Jack pine budworm outbreaks commonly start in Region 1

These are locations/ townships where jack pine budworm populations first build up during a jack pine budworm outbreak. These were identified by Roger Hannigan, who worked as a Forest Health Specialist for over 25 years.

Jack pine budworm outbreaks: Where they first build up	
Becker Co.	Shipman Lakes Two Inlets (town and forest road)
Beltrami Co.	Eckles Tnshp Lammen Tnshp
Hubbard Co.	Crow Wing Tnshp Straight River, sect 35 near Badoura near Nevis
Mahnomen Co.	Roy Lake



Jack pine budworm in red pine

Choristoneura pinus

This summer, DNR staff discovered foliar damage in a 147-acre portion of the Sand Dunes State Forest. When the site was inspected, both red pine shoot moth and jack pine budworm (JPBW) were found damage the stand. JPBW had defoliated 79 acres, some of which was already showing top kill. There are only a few scattered jack pines in the area and for the most part, they looked better than the red pine.

It is fairly unusual to see extensive defoliation of red pine by JPBW, particularly when there is little if any jack pine in the area. The nearest noticeable JPBW defoliation of jack pine this year was near the town of Motley in Todd Co. The only other record on red pine in MN that we could find was in 1956 & 1957 near Cloquet, Pequot Lake and Bemidji. So how this infestation became established is not known.

It is also not known which factors contributed to the heavy defoliation. In the first year of defoliation, damage ranged from 30-90% in the core area. While stand vigor and other stress agents can determine mortality, top kill occurred in the 1957 event after 80% defoliation. However, in that event, the population had begun earlier and the adjacent jack pine was also heavily damaged. In this case, the population is relatively isolated and apparently exploded in one year's time.

That leaves a number of management questions open to discussion. Can JPBW thrive on red pine alone and then survive the winter? Given the level of defoliation already, will there be enough foliage to support another year of defoliation on the same trees? What is the impact of the tipmoth? How did JPBW get here and can they spread to the adjacent red pine stands, of which there many. Has the stress been sufficient to initiate a bark beetle attack?

At this point the most reasonable options include harvesting the trees to avoid a bark beetle infestation and to avoid further spread of the JPBW; spraying the stand with Bt to control JPBW and hoping the stand recovers before bark beetles move in; or taking a wait and see approach, hoping the JPBW doesn't survive the winter, which is a relatively common occurrence in jack pine. JPBW overwinters in the 2nd instar larval stage. When they first emerge in the spring, they begin to feed on the new needles or on the staminate cones. If the young larval were less than vigorous going into the winter due to improper nutrition, or if there isn't enough cones or young needles to feed on in the spring, the larvae are not able to survive to complete their life cycle. If either occurs, a second year of defoliation is unlikely. But there isn't any way to know that until next spring and then there isn't enough time to act before July moth flight.

To help determine the likelihood of defoliation next year, an eggmass survey will take place this winter. The extent of the population and the likelihood of it moving to adjacent stands will also be assessed.

Larch casebearer

Coleophora laricella

Hosts:	Tamarack
Damage:	Discoloration, defoliation
Area:	1660 statewide
Severity:	Moderate to heavy
Trend:	probably declining

Aerial survey recorded 1660 acres of larch casebearer statewide this year. The most obvious casebearer activity in Region 2 was in Aitkin County. Entire stands of tamarack looked yellow and brown in late June. The aerial survey acreage reported is an underestimate because a number of stands, with casebearer damage observed on the ground, were not mapped during the aerial survey. Larch case bearer was especially noticeable in late June, south of Hill city in NENE S22-T50N-R26W and SESE S15-T50N-R26W as well as between McGregor and Aitkin at NENE S36-T48N-R25W and north of McGregor along Hwy 65.

Multi-colored Asian lady beetles

Harmonia axyridis

These exotic ladybeetles were very abundant resulting in many calls from homeowners for information about control, management, and avoidance or sometimes just to complain. The warm, dry summer appears to have been favorable to a population buildup. Complaints started coming in on Oct 6 th and 7th as the beetles started entering houses. Apparently, a cooler than normal end of September and hard frost followed by sunny days with temperatures in the 70's and 80's, in early October, triggered an instinct to seek shelter for the winter.

Complaints about the beetles were high in 2000, the first year the beetles reached Grand Rapids and the rest of northern Minnesota. Few complaints were received in 2001 and 2002.

Northern spruce engraver beetle

Ips perturbatus

Hosts:	white spruce
Damage:	mortality

The northern spruce engraver is a bark beetle reported as abundant in northern coniferous forests with white spruce being the primary host. It commonly breeds in logging slash but apparently sometimes attacks and kills live trees as well. It has been found a number of times in the past year killing white spruce in Region 2. It was found killing white spruce in Sec 2-T62N-T21W in St Louis County. The trees were 10-12 inch in diameter and had full healthy green crowns even though the trunks of the trees were covered with boring dust and the cambium was entirely destroyed by bark beetle feeding. A single white spruce along the Ash River Trail (NWSE S12-T68N-R21W) had similarity been attacked while the crown was still green and healthy looking. A single large (over 2 foot diameter) spruce in Jay Cooke State Park in Carlton County, was infested with the beetle. This tree likely was being stressed by a number of factors contributing to beetle attack. Dr Steve Seybold reared *Dryocoetes* (probably) *affaber* and *Cypturgus borealis* in addition to *Ips perturbatus* from the bark of this tree.

I perturbatus was also reported in dying white spruce in Grand Marais, Cook County where it may be attacking trees in association with spruce beetle. These were identified by Jeff Hahn, U of MN Extension Service. *I perturbatus* was also found in a dying Norway spruce in a U of MN seed orchard at Itasca Comunity College.

Red turpentine beetle

Dendroctonus valens

Historical trap catch dates for red turpentine beetle are as follows:

2003 - May 15 - *valens* flight period starts Brainerd, Crow Wing Co.
2002 - May 22 - thirty six *valens* in 3 bark beetle traps in north Crow Wing Co.
2001 - May 11 - *valens* in bark beetle traps north Crow Wing Co.
2000 - May 7 - *valens* in bark beetle traps north Crow Wing Co.
1998 - May 7 - seventeen *valens* in bark beetle traps Grand Rapids DNR Region Office (720 DD using base 32)

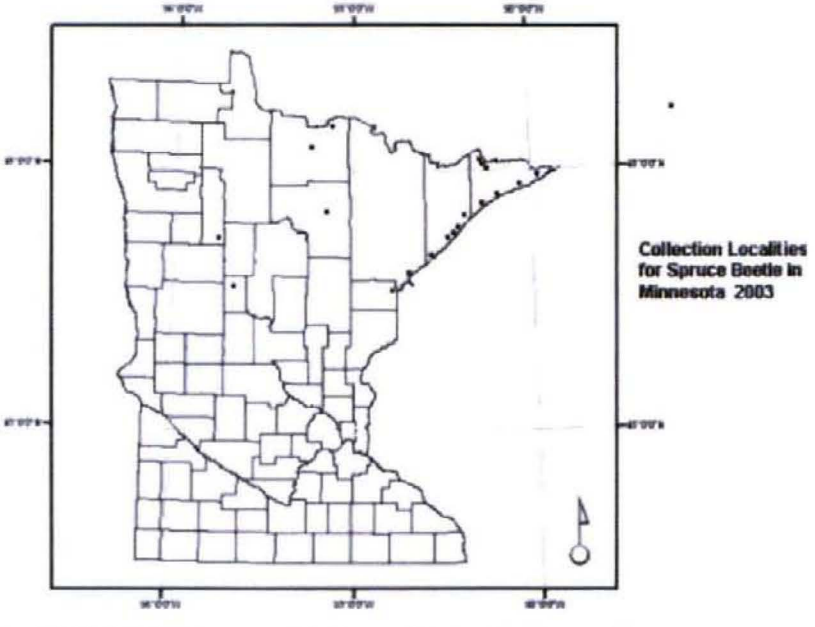
Red turpentine beetles were trapped in Crow Wing township in Crow Wing County as part of a study with Dr Steve Seybold (USDA Forest Service Research) The study is designed to develop a better bait for trapping this beetle. Trapping was done on three locations: NENE Sec 9-T44N-R31, NENW Sec 10-T44N-R31W, and NWSE Sec 10-T44-R31. Six 12-funnel bark beetle traps were set at each location. Traps were baited on May 12th as shown below. Traps were emptied daily and their location on each site re-randomized by moving the entire trap and its baits. Trap contents were placed in plastic bags and stored in a freezer. Traps were emptied and removed on June 18th. Trap catches have not yet been sorted.

A = blank
B = (-) -alpha-pinene
C = (+) - alpha-pinene
D = (racemic) - alpha-pinene
E = (-)-beta-pinene (3 baits in each trap)
F = commercial bait for *D. valens*

Spruce beetle

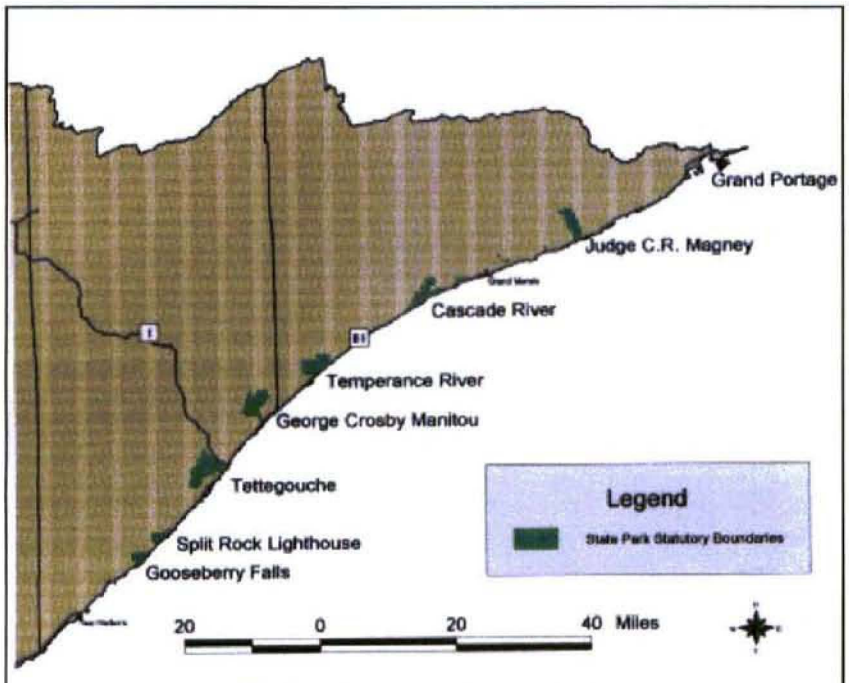
Dendroctonus rufipennis

Hosts:	White spruce
Damage:	Mortality
Area:	None reported
Severity:	Heavy in pockets
Trend:	Unknown



Spruce beetle a native bark beetle infrequently found in Minnesota has been killing large diameter white spruce trees along the shore of Lake Superior the past few years. The amount of mortality has been increasing and expanding as new infestations continue to be found. The problem was first noticed in Judge Magney State Park in Cook County. Dying trees have now been found in state parks as far south as Gooseberry Falls State Park. Individual dead trees with pitch tubes have also been found in Lake County just north of Two Harbors in Sec 30-T54-R10W and in Sec 31-T52-R11W near Knife River. Spruce beetle mortality was also found in three stands in Koochiching County in the Pine Island State Forest. Stand 20 in Sec 20-T156-R25W is 13 acres of 118 years old white spruce that had about 20% mortality of 18-24 inch DBH white spruce. It looked like some mortality had been occurring for at least two to three years. There was some blow down in the stand which may have started the problem. Stand 9 (14 acres) in Sec 20-T156-R25W also had mortality in 145 year old white spruce. Mortality from spruce beetle was also occurring in stand 20 Sec 19-T156-R25W. Pitch tubes were also found in a dying spruce windbreak in Wadena County. The beetle is likely present in other locations and will be found as more people learn to look for and identify it.

Results of the North Shore State Parks Spruce Beetle survey funded by a Coastal Zone Management Grant are presented in the tables below. The survey showed an increase in infested trees between 2001 and 2002. Some of this increase was due to the increase in acres surveyed but also indicated continued activity by the spruce beetle along the North Shore.



Field Survey Summary
Spruce Beetle Infested Trees

	2001	2002
Grand Portage State Park	9	10
Judge Magney State Park	194	252
Cascade River State Park	40	124
Temperance River State Park	6	11
Crosby Manitou State Park	19	94
Tettegouche State Park	25	59
Split Rock Lighthouse State Park	0	1
Gooseberry Falls State Park	0	1

Field Survey Overview

2001

	Inspected Trees	Infested Trees	Acres Inspected
Grand Portage State Park	177	9	26
Judge Magney State Park	2328	194	146
Cascade River State Park	915	40	99
Temperance River State Park	156	6	40
Crosby Manitou State Park	487	19	120
Tettegouche State Park	484	25	187
Split Rock Lighthouse State Park	308	0	68
Gooseberry Falls State Park	364	0	58
Totals	5219	293	744

2002

	Inspected Trees	Infested Trees	Acres Inspected
Grand Portage State Park	186	10	30
Judge Magney State Park	2232	252	182
Cascade River State Park	1457	124	118
Temperance River State Park	334	11	52
Crosby Manitou State Park	1006	94	169
Tettegouche State Park	653	59	309
Split Rock Lighthouse State Park	473	1	82
Gooseberry Falls State Park	512	1	87
Totals	6853	552	1029

Spruce budworm

Choristoneura fumiferana

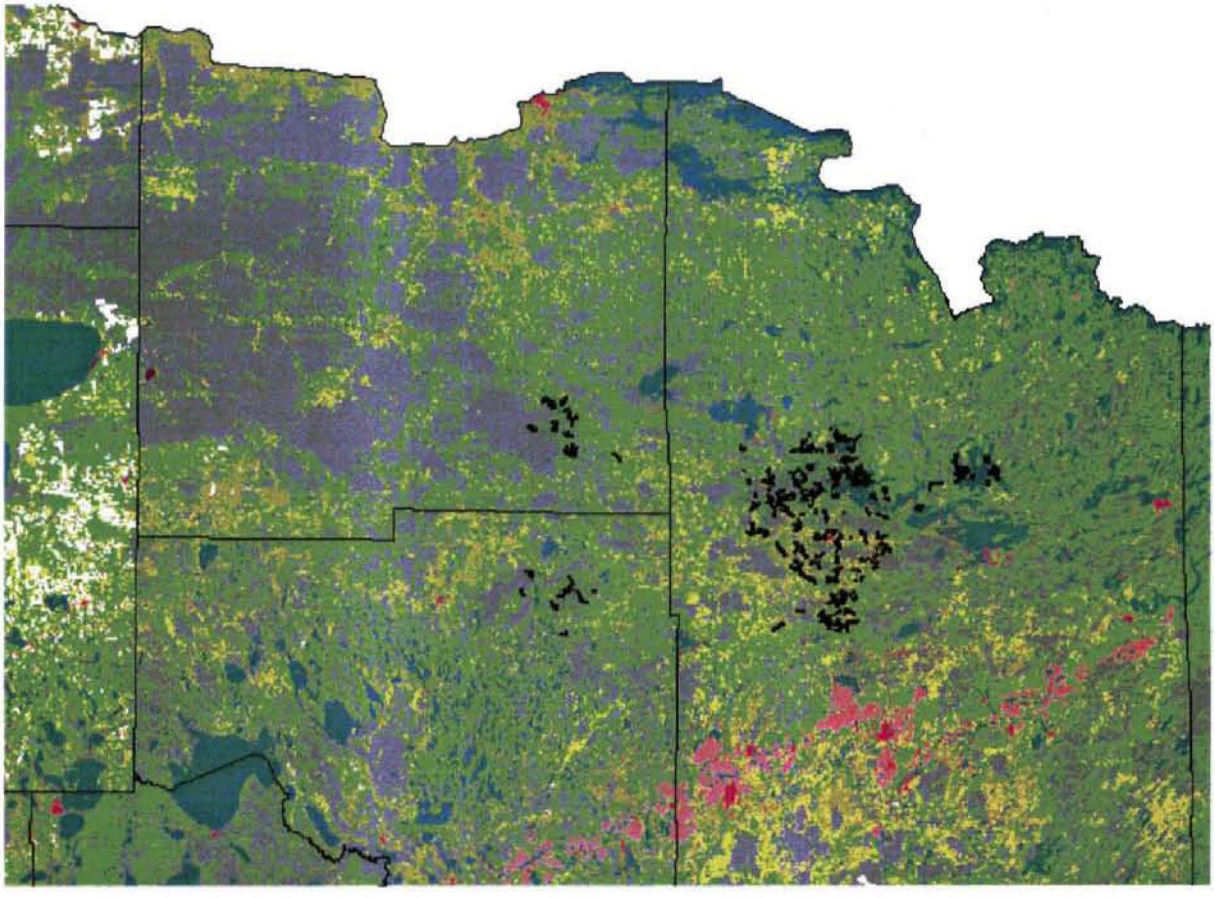
Host:	Balsam fir and white spruce
Damage:	Defoliation, topkill and mortallity
Area:	34,601
Severity:	Trace to heavy
Trend:	**This is the 50th consecutive year of continuous spruce budworm defoliation in Minnesota.**

Acres of defoliation mapped this year declined by 60% from 2002 levels. See map. Budworm activity remains centered in northwestern St. Louis, northeastern Itasca and eastern Koochiching Counties. A few scattered pockets of defoliation occurred in additional locations such as central Koochiching and southern Itasca Counties but were not mapped during the aerial survey. No egg mass or larval surveys were conducted because of the layoff of the seasonal Plant Health Specialists.

White spruce plantations included in the white spruce thinning study were ground surveyed in the fall of 2003 for defoliation levels. Balkan Township, Taconite Trail, and O'Leary Lake sites were not surveyed. Results are presented below:

Plantation name	Location	Defoliation
White spruce alley	S21-T64-R21,ST Louis	0 defoliation on plots R1, T1, T2, T3 Trace defoliation on plots R2, R3
Warba	S23-T54-R23 Itasca	0 defoliation on all plots
Power line	S36-T155-R25, Koochiching	0 defoliation on plots R1, R2, R3, T1, T2 Trace defoliation on plot T3
Johnson Landing	S28-T65-R26, Koochiching	0 defoliation on all plots
Plantation Road	S24-T149-R27, Itasca	0 defoliation on all plots
Larson Lake Salvage	S16-T61-R24, Itasca	Trace defoliation on plots R3, R4 Light defoliation on plots R1, R2, T4 Moderate defoliation on plots T1, T2, T3
Sam Welches Corner	S12-T147-R30, Beltrami	0 defoliation on all plots
White Township	S36-T57-R15, St Louis	0 defoliation on all plots
Smith Creek	S12-T53-R26, Itasca	Light defoliation on plots R3, T1, T3 Moderate defoliation on plots R1, R2, T2
Aitkin County	S8-T52-R25, Aitkin	0 defoliation on all plots

Spruce budworm



2003 spruce budworm
Light defoliation
Heavy defoliation
Counties in Minnesota

Two-lined chestnut borer

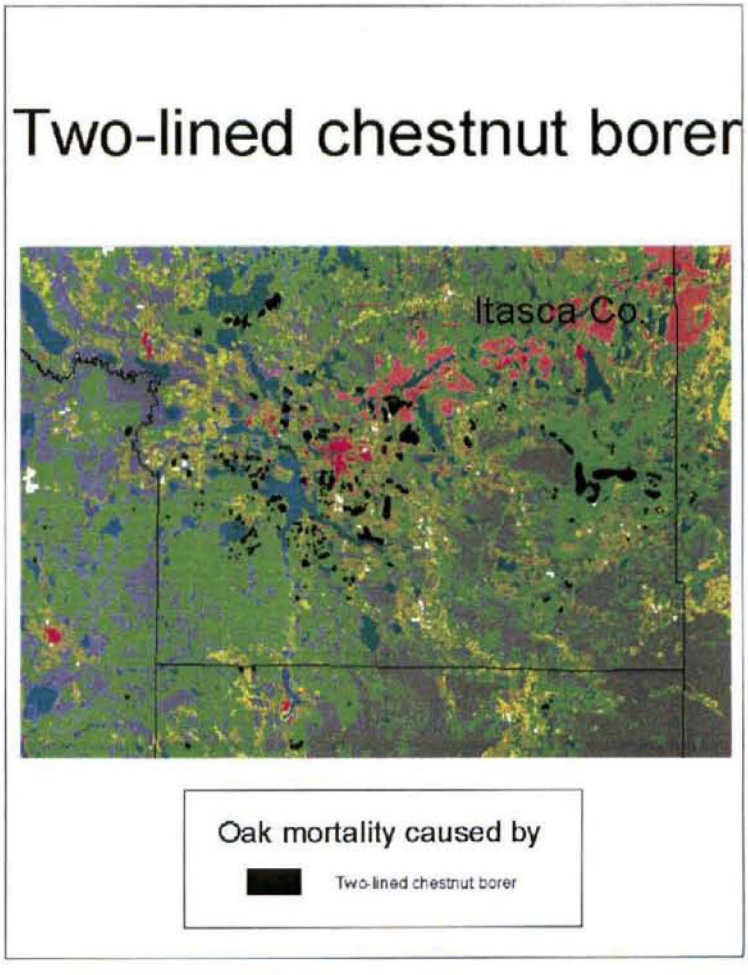
Agrilus bilineatus

Hosts: Oaks
Damage: Mortality and topkill
Area: 12,557 acres from aerial survey
Severity: Variable
Trend: Depends on the weather. Likely to stay high if drought continues.

The aerial survey flown in September detected oak mortality on 12,557 acres of stands in Itasca, Cass, northern Aitkin, northern Crow Wing, and southeastern Beltrami Counties. See table and map. Most of the mortality occurred within a radius of 15 miles of Grand Rapids. In many stands, 80 to 90% of the oaks are now dead. Many stands thinned in the last year or two now have nearly complete mortality of the residual oaks. Damage appeared to be more severe in thinned portions of stands than unthinned portions. Leaves on trees attacked by TLCB began to turn brown the first week of August. Entire trees seemed to turn brown overnight. Most of the oaks that have been killed are northern red oak but a few burr oaks have also died.

The oaks were attacked and killed by two-lined chestnut borer because they were stressed by forest tent caterpillar defoliation and drought. Armillaria root disease is also active on the dead and dying oaks and no doubt has contributed to the mortality

Acres of hardwood stands with TLCB-caused oak mortality, August, 2003	
Aitkin County	473 ac
Cass	459
Itasca	11,525
St. Louis	100
Total	**12557**



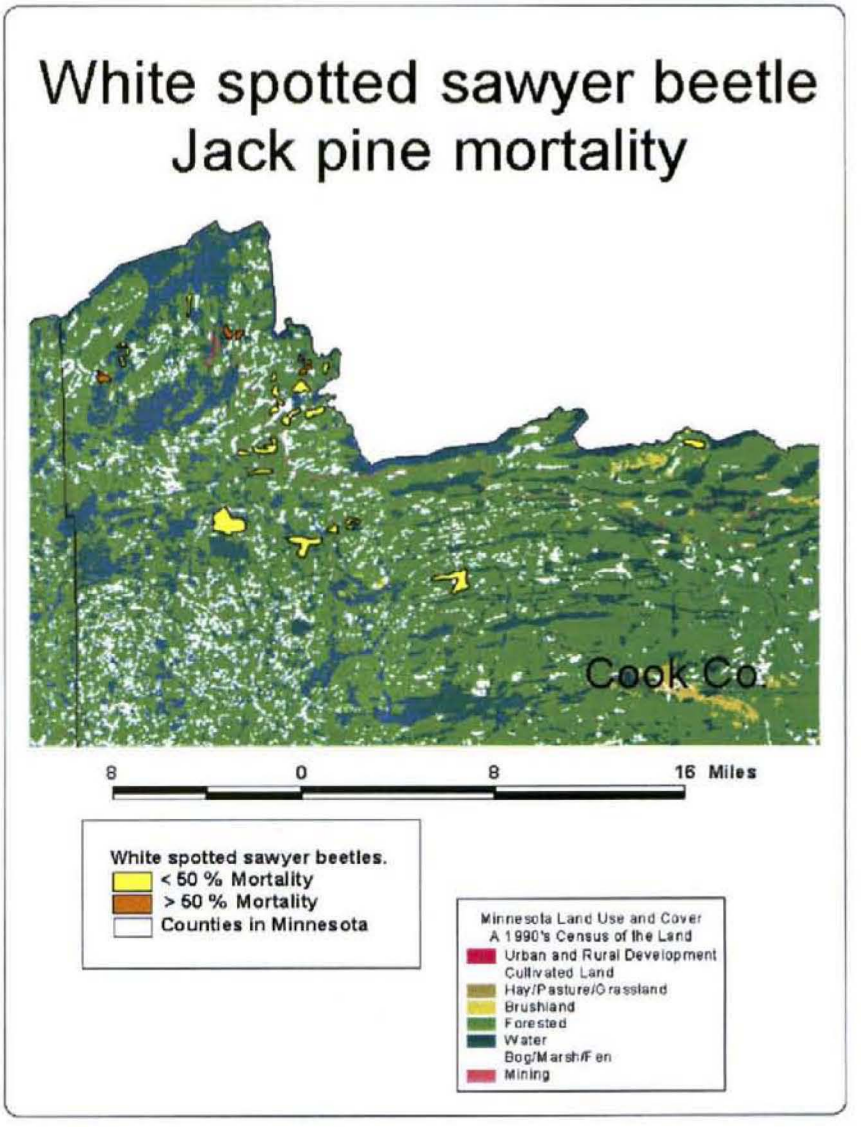
White-spotted sawyer beetles

Monochamus spp.

Host:	Jack pine
Damage:	Mortality
Area:	3,426 acres
Severity:	Heavy
Trend:	Populations and damage are expected to decrease as 1999 blow down trees deteriorate

During the aerial survey flown in the summer of 2003, jack pine mortality was mapped on 3426 acres around the Gunflint trail corridor in Cook County. See map. Kamal Gandhi, a University of Minnesota graduate student studying insects following the 1999 blow down in the BWCA, found wood borers killing the trees. She observed large numbers of female wood borers, primarily *Monochamus* spp., ovipositing on standing live jack pine in blow down areas. In 2001, she tagged live standing trees with borer attack. By 2003, 100% of the trees with borer attack were dead.

Sawyer beetles are usually considered secondary colonizers because they bore into trees that have already been damaged and killed by something else, such as bark beetles. But in this case, they appear to be the primary colonizers and primary cause of death. Apparently, the sawyer populations built up in the blow-downed pines and were then able to mass attack and kill standing live jack pine. We would normally expect this kind of result from bark beetles but not from sawyers.



DISEASES

Anthracnose

Various fungal species

The cool, wet weather (at least in central MN) has added to the slowed leaf development and produced environments favorable to anthracnose diseases. Ash in particular, are showing symptoms of infection. Leaf drop involves green leaves as well as discolored leaves. Anthracnose infection causes brown to black blotches on leaf blades and petioles. This year, severe anthracnose may add to the stress caused by the winter injury and may thus lead to decline.

In most years across southern Minnesota, a late season anthracnose can be seen on individual bur oaks, usually after August 1st. The causal fungus, *Actinopelte dryina,* has had a recent name change to *Tubakia dryina*. In 2003 the amount and severity of affected oaks varied greatly. The range was from light to very evident disease development. The mid-season developing drought complicated the symptoms on bur oak foliage, as leaf scorch was apparent in early September in many very dry areas. In some years, the appearance of the leaf spot can be very dramatic as the entire tree turns brown except a few leaves in the very upper crown. The defoliation can reach 90% in a few short weeks. Affected oaks refoliate the following year. Generally, late season defoliation has little long-term effect.

Apple scab

Venturia inaequalis

The cool wet weather during April, May and early June this year have contributed to abundant apple scab infections, and numerous calls from concerned landowners in central Minnesota and the Twin Cities. Susceptible tree crowns are thin with withering leaves rapidly dropping to the ground. Unlike the fungi involved in most other leaf spot diseases, the apply scab fungus remains active through out the season. So long as there is sufficient moisture, new infections can multiple exponentially, creating an epidemic of among susceptible hosts. Affected tree species include apple, crabapple, hawthorn and mountain ash.

Dying sugar maples

Stegonsporium spp. plus other causes

Many reports of sugar maples dying in yards were received this summer in eastern Carlton and southeastern St Louis counties. A variety of causes were involved on the different sites including hail, ice storm, drought, defoliation, lawn mower injuries, winter without snow cover, etc. In most cases the mortality was likely due to a combination of factors that weakened the maples. Often these weakened maples were then attacked by *Stegonosporium* spp., an opportunistic fungal pathogen. The fungus was found on many of the dead or dying maples where it looked like a black tarry substance on the surface of the bark on the trunk or branches. The stress or stresses were likely the real problem and the fungus is killing off the already stressed trees.

Jack pine gall rust

Cronartium quercuum

The incidence of jack pine gall rust on 2-0 jack pine was evaluated at Badoura Nursery on May 1, 2003. For each of two seed sources, 7 replicates of 100 seedlings were inspected for gall rust. Stems and root collars were inspected. Beds 104 and 240 were immediately adjacent to each other.

Bemidji source (#104)	3.42 % infections
Improved, Long Prairie source (#240)	3.23 %

In 2002, several hundred 2-0 jack pine seedlings were established in a plantation near Huntersville (S12-T138-R34) to continue the study of jack pine seedling mortality in Wadena County. Gall rust infected only 0.2% of the live and dead seedlings; very low incidence. See table below.

Percent damage found on jack pine seedlings from Huntersville plantation			
Damage	**Live and dead seedlings combined**	**Live seedlings**	**Dead seedlings**
None	19%	19%	NA
Browse	69.5	62.0*	7.5
Gall rust	0.2	0.1	0.1
Dead due to other causes: Poor planting, no roots, insect, *Sphaeropsis*, etc.	17.7**	NA	17.7

* = Browse on live seedlings was severe, usually only 2 or 3 green needles were left on a 4" stub.
** = *Sphaeropsis* incidence was 3.3% , verified by lab examination.

Notes on plantation
established in 2002, two seed sources: Bemidji and Improved from Long Prairie (couldn't distinguish where they were planted), 401 seedlings examined on May 8 and 13, 2003, used pink flagged metal pin to mark where we sampled JP for lab analysis.

Oak wilt

Ceratocystis fagacearum

Fifteen infection pockets were identified on the Sand Dunes State Forest. Ten of those sites (9.2 acres) were treated in 2003, installing a total of 5600 feet of plow line for $6785.00. On all ten sites, a system of double primary plow lines was used to ensure complete root graft disruption and to minimizing future regrafting. Potential spore producing trees were cut and destroyed. Remaining live oaks within the plow line were cut on nine of the ten sites using firewood permit sales. On the tenth site, live oaks inside the plow line were frill girdled using Tordon and left standing to protect advanced pine regeneration standing on the site.

Forty two active infection pockets, covering a total of 44.7 acres, were identified on the Carlos Avery Wildlife Management Area. Because of limited funds, the sites were prioritized for future treatment, placing those sites most at risk of spreading off state land and those along major transportation routes at the top of the list. No treatments were implemented in 2003, but the plan is to address all of those top priority sites in 2004. A combination of treatment options will be utilized including a treat-to-the-line approach without plowing to protect areas with sensitive cultural features.

Report: After ten years of oak wilt management, where are we?

The year 2002 marked 10 years of active oak wilt (OW) management within the Minnesota Department of Natural Resources (MN DNR). Active management began with a federal pest suppression grant in 1992. In 1998, the effort was incorporated into a community assistance program called Minnesota Releaf. The Releaf Program broadened its scope in 2003, to include other forest health practices in an attempt to integrate traditional urban forestry with ecosystem management at the community level.

In the meantime, the status of oak wilt across the state had evolved as well. Early in the program, aggressive outreach enrolled a large number of communities. Their involvement increased legislative support, while at the same time decreasing the incidence of OW, in spite of continued pressure from urban development. In 1997 and 1998, a series of spring windstorms across central Minnesota damaged large numbers of oaks at the height of the oak wilt infection period. As a result, numerous new OW infection centers sprang up across the area.

In response to increasing disease pressures, requests for community OW funding exceeded available grant dollars for the first time in 2001-2002. As a result, a system of prioritization was needed to determine the level of community funding. However, developing one that would withstand close scrutiny from the state legislature, participating communities and partner organizations proved to be a difficult task.

On the program's tenth anniversary, the change in program goals and the increasing need to upgrade the technologies used to collect, manage and interpret treatment data, prompted an evaluation of the Minnesota oak wilt program. A preliminary analysis of the existing data was completed in 2002. In 2003, a formal assessment of the status of OW in Minnesota was initiated with the support of both state and federal funds.

The Federal Suppression Project

While the Minnesota effort began in the 1970's with the research of Dr. David French, it reached program status in the late 1980's with the a formal survey done in 1988. Color infrared photography (CIR) was taken of Anoka, Ramsey and Washington Counties plus parts of Isanti, Sherburne and Chisago Counties. Scattered areas in southeastern Minnesota were flown in 1989. Dr. French worked with a local contractor, to develop the protocol to interpret and digitize the photography back before anyone else had done anything similar. A massive outreach effort was launched by a coalition of the University, government agencies, industry professionals and concerned individuals to inform landowners and garner public and legislative support for disease management. The slogan 'Don't Prune in April, May and June' was advertised across the state and soon most Minnesota residents in the affected area had heard of oak wilt and its potential to kill trees. The MN DNR then presented the CIR data to the US Forest Service in a grant request for oak wilt suppression. The out-reach effort paid off and a $500,000.00 grant was awarded. Thus the first federal cost-share program (CSP) was launched.

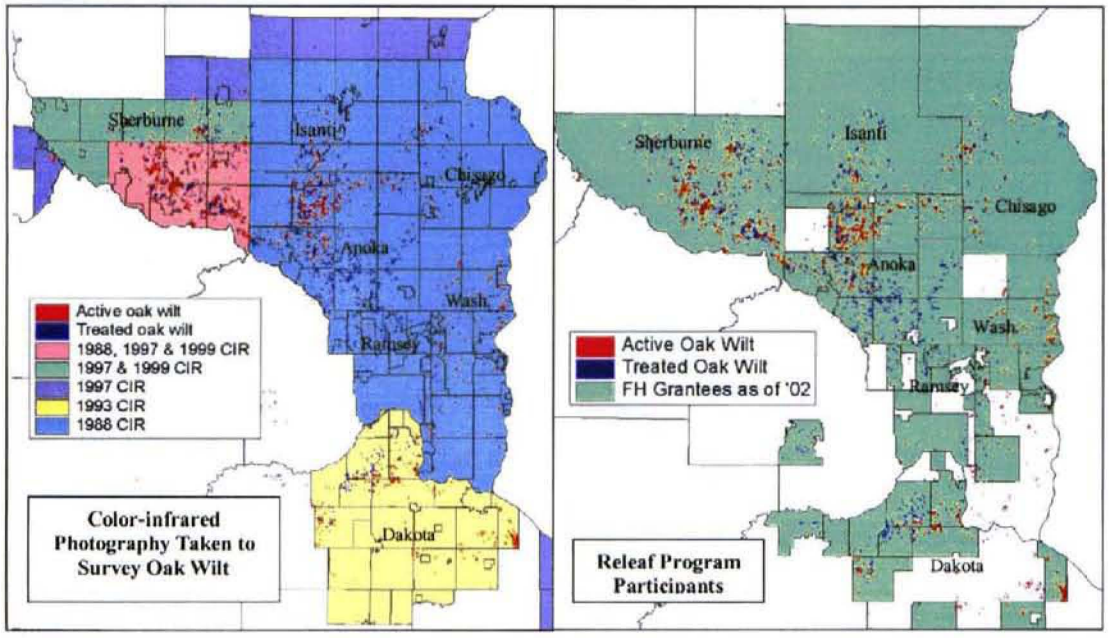
The overall goal was to lower the incidence of oak wilt to levels manageable by local units of government and thus build local capacity to sustain long-term community forest health. Based on research that described the average rate

of spread and satellite infection development, the density of oak wilt manageable by local government was determined to be one infection pocket per square mile. The control zone or focus area was defined as the six county area known to contain the most oak wilt. Dakota County was added to the list the following year. The original project objectives were to reduce the incidence of oak wilt within 75% of this control zone to one active infection center per square mile and to do so within five years through active community assistance.

Program and Data Management

One of the driving forces in the suppression project was outreach and citizen involvement and that focus influenced the way the program was designed, what data was collected and how it was managed. Public involvement required a better understanding of oak wilt and the factors that influenced disease incidence. Public support required a system to track program accomplishments across a wide area. These needs provided the impetus to develop new user-friendly, inexpensive GIS software that would allow program managers and participating communities to view and assess management activities in their particular area. EPIC, a raster-based GIS system was developed as a joint venture between thee MN DNR and the MN Land Management Information Center (LMIC) to serve program objectives.

The original CIR data was interpreted using a stereoscope and transferred to 1:24,000 quad maps, by projecting the maps over photographic prints and matching key features. Later on, additional CIR was taken and added to the data (see CIR map).

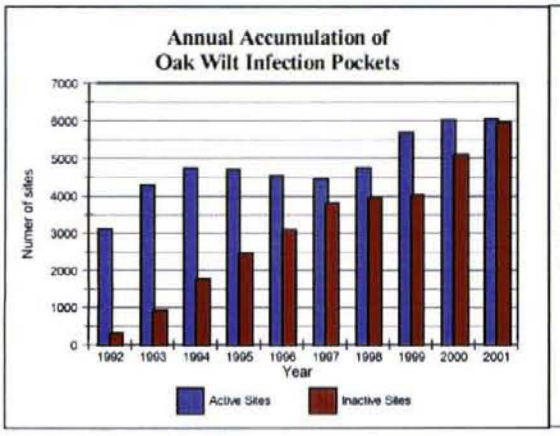


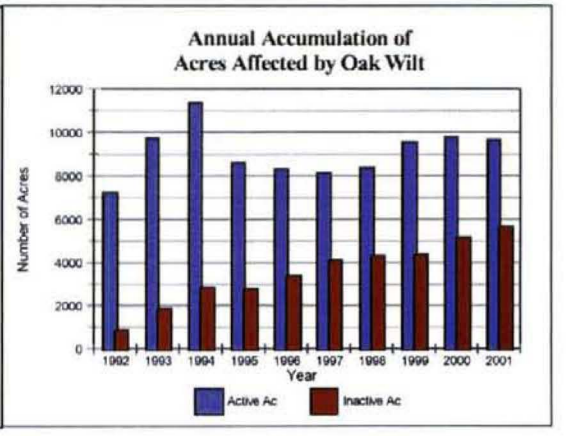
Once the infection pockets were drawn in, they were digitized in Arc/Info. Macros were developed in Arc/Info to produce community maps of all known infection pockets and their current status. These maps were printed and distributed to participating communities. The communities did any ground truthing necessary and updated the maps on an annual basis by hand drawing in any corrections and/or additions to the known infection pockets (see above map of CSP & Releaf participants). These data were generalized into treated versus active infection pockets and exported into EPIC. Raster analysis in EPIC allowed rapid assessment of oak wilt density, spore loading and the acres of oak forests at risk of future infection. The information facilitated reporting and furthered on-going outreach.

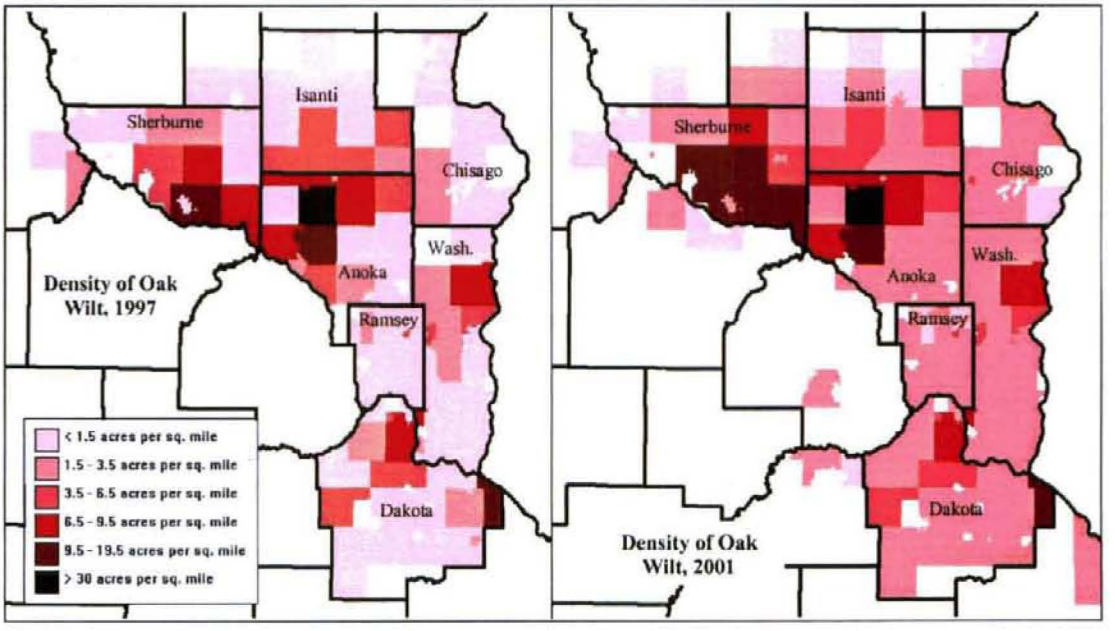
In the initial inventory, 3006 infection pockets were identified in 44 townships. By 1997, 8387 infections centers had been identified across an expanded control zone of 79 townships. Participating communities had treated 5164 infection pockets or 61.5% of the known pockets. Even though the combined survey data indicated that the density was nearly twice as high as expected, the cost-share program lowered the density of oak wilt from 2.97 centers per square mile to 1.58. Within 53% of the control zone, the density was lowered to one infection center or less (see annual charts below). Given the high initial density, this is a significant accomplishment. The other significant program accomplishment was the high level of public awareness and involvement achieved. During the five years of the first federal suppression project ('92-97), communities and private citizens spent $3,043,294.00 to match $1,950,000.00 in federal funds, for a project total of $4,993,294.00!!

The federal suppression project ended in 1997 and the state incorporated oak wilt management into the Minnesota Releaf program. Since then funding has been uncertain with funds available some years and not others. Intermittent and/or delayed funding has impacted the level of management activities and in a few cases, community participation. Yet public support has remained high as demonstrated by the number of letters and testimonies given in support of state budget requests during the '02-03 legislative session.

During this same period, the incidence of oak wilt began to increase. Factors included funding levels for community programs, increased urban development and a series of severe spring windstorms that whipped the north metropolitan area in 1997 and 1998. The storms damaged trees over a wide area at the height of the oak wilt infection period. By 1999, the incidence of oak wilt had reversed previous gains in several areas, particularly in Sherburne County; hit the hardest by the storm events, and the numbers have continued to climb since then (See 1997 and 2001 maps).





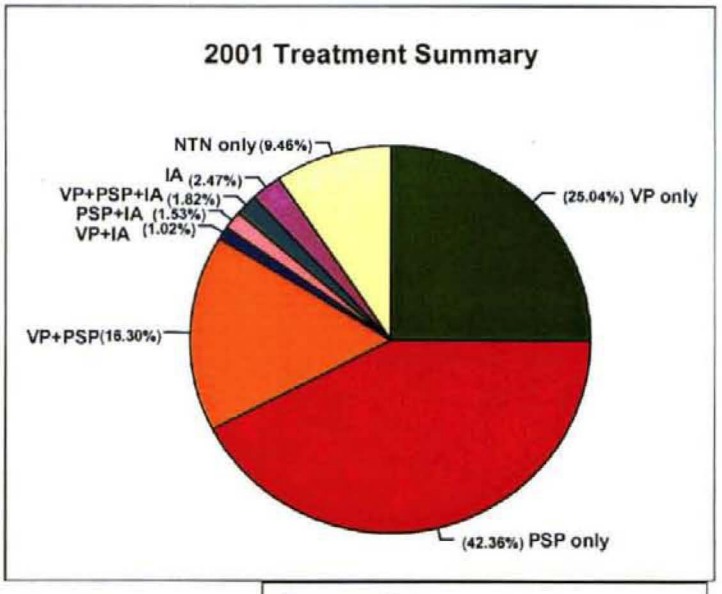


In response to increasing questions about program accomplishments and necessary funding, the data was exported to Arc/View and for the first time the treatment histories were assessed. The fact that this was the first time the treatment data was evaluated may seem odd unless you understand the nature of raster data and the original program design. Rasters or pixels can contain only one set of attributes, for instance forested or not. The attribute could be the species, such as oak, elm or ash, but not pole-sized maple, versus mature basswood, unless you create a large number of categories for the one attribute possible to cover all possible size/species combinations - something that is not usually feasible. In this example, the size data would be put in one data layer or file, while the species data would be put in a different data layer. Any number of data layers can be laid one on top of the other. Because each layer shares

the same geographical reference, i.e. the raster or pixel, each data layer can be compared to the others to determine patterns and correlations between data sets. Although file sizes are small, the power in spatial analysis is huge. And EPIC was designed to provide that kind of power to participating communities at no charge. But in the process, it took the treatment data and generalized it down to treated versus not treated. When an individual pocket was treated, how it was treated or how often was not known until the data was moved to a different platform. In response to increasing questions about program accomplishments, necessary funding and the increasing incidence of disease, the data was exported to Arc/View and for the first time the treatment histories were assessed.

Treatment Summary

Sites were considered 'treated' if they had received any combination of treatments or if it were determined (by the community) that no treatment was necessary (i.e. the pocket was no longer active). Communities reported VP treatments alone on 25% of the treated sites and PSP alone on 42% of the sites. Only 16% of the sites received both VP and PSP treatments. Fungicide injections were becoming more common. Data collected for the first time in 2001 indicated 4.37% of the sites received fungicide injections in combination with other treatments and 2.47% received fungicide injections alone (see treatment charts).

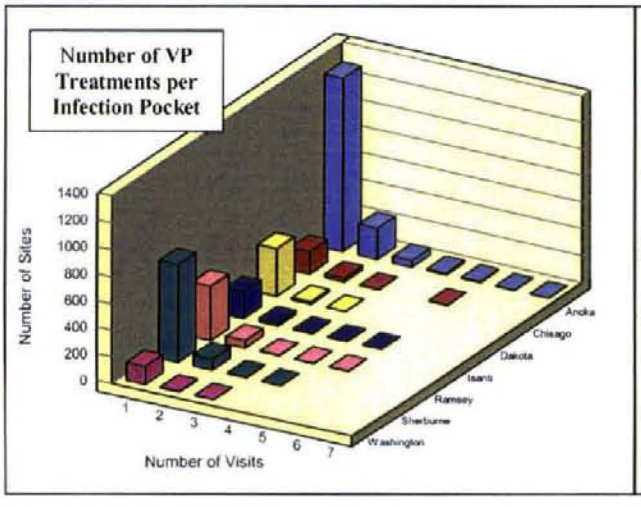


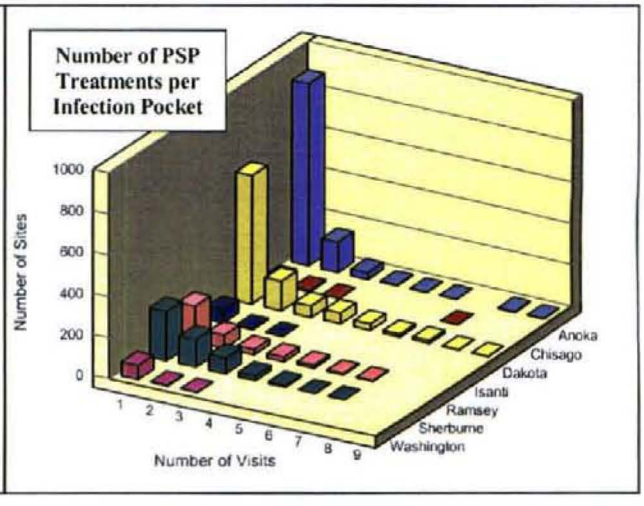
Once the treatment data became available, a number of new questions arose. Correlations between disease incidence and differences in local program implementation began to become apparent. How annual treatment data was obtained (which varied by community) determined the level of detail provided. The size of the paper maps relative to community size seemed to influence the reported acreage. And the codes used to denote treatment methods were being confused at times and not corrected.

Treatment Codes:

VP = vibratory plow
PSP = potential spore producing tree removal
NTN = no treatment needed
IA = fungicide injections

These issues created doubts about the reliability of the data. While the trends described help program managers understand where problems may exist in state program delivery, they couldn't be used to redesign the program to meet changing needs. Yet, the increase in disease incidence (and decreasing resources with which to control it) meant program adaptations were needed. But based on what?





2003-2005 Oak Wilt Assessment

A formal reassessment of the status of oak wilt in the state was initiated in 2002. New CIR photography was taken of 33 townships with another 76 townships flown in 2003. The data will be used to establish a baseline for the current federal CSP and to analyze the change in disease incidence based on a variety of factors. The primary goal is to evaluate our current management strategy; is it working at a program level and if not, why not. A secondary goal is to describe factors outside our control (like urban development and storm damage) and the influence they are having on disease incidence so we can incorporate that information into the way we prioritize treatments (and cost-sharing).

While the details are still being discussed, the assessment project will be divided into three phases. The first involves interpretation and digitization of all new CIR to establish a baseline. Digital ortho-rectified quad (DOQ) maps will replace the 1:24,000 K maps as the base layer. That will allow finer detail in the interpretations. The work will be done in Arc/View to avoid data distorts that can occur during translation to other formats.

The second phase will take data from the new CIR from a 20-township subset of the total and run a comparison against earlier CIR data to describe the change in disease incidence, i.e. density per square mile. Noted changes will be assessed by three factors; type of Releaf program, change in urban development and presence/absence of storm damage resulting from the 1997 or 1998 storms. The three categories of Releaf program will be 1) non-participant, 2) full-service, including a formal survey of the entire community, and 3) partial service, informal service or treatment by request only.

The third phase will use an additional subset of 12 townships. The older existing CIR will be reinterpreted using the latest technology. Both the new and old sets of CIR will be rectified. Then the two sets of data will be compared to describe the change in disease incidence. The same three factors will be used to assess any changes in the density of oak wilt, but this time individual pockets will be traced to explore the affect of various treatment practices.

The fourth phase of the project will be to compare the cost and the results of the two methods of change detection to determine the potential for future applications.

All of the new CIR photography was taken in 2003. Photo interpretation will happen this winter. A minimum of 10% of the mapped pockets will be ground truthed by the state, i.e. field checked, during 2004 to establish the level of accuracy. Change detection and analysis will occur during the winter of '04-05. The final results will be available in 2005, at which time Releaf management strategies will be reevaluated and modified as needed.

For those participating in the Releaf program, that means that the management strategies, mapping protocols and the system of prioritization for funding will stay the same for the next two years. That timing should work well since 2005 marks the end of the current Releaf grant period and the beginning of the new biennium.

In the meantime . . .

With the continuing increase in disease incidence, one of the biggest questions we face is whether or not it is possible to stay ahead of the spread of oak wilt. While some communities are doing an excellent job of staying current, others are falling behind. Modifying the means of program delivery and enhancing resident outreach may be all that's needed in some cases. Better enforcement of PSP removal for instance is one area where improvements can be made. But in other areas, disease incidence seems to be increasing in spite of well-run, full-service programs. Whether or not our strategies are inadequate, or outside factors are having a stronger influence, these areas serve as a source of continued disease pressure that may eventually overwhelm those that currently have oak wilt under control.

The situation resembles that seen in the gypsy moth slow-the-spread (STS) program. Those with the worst problem are tempted to throw up their hands because of the effort and expense involved in slowing the spread of oak wilt. However, continued management is critical to the well being of the oak resource as a whole. If those with the worst problem quit now, neighboring areas will be overrun. It is easy to focus only on those trees in your own back yard. But if we are to succeed, it is important that we all work together to preserve Minnesota's oak resource. Hopefully, the assessment project will provide the answers we need to regain lost ground and build on earlier accomplishments.

2003 Oak Wilt Suppression under Minnesota Releaf

ORGANIZATION	LCMR AWARD	USFS GRANT	COMBINED
Anoka Co. Parks	$3,000.00		$3,000.00
Baldwin Twp.	$1,350.00	$11,000.00	$12,350.00
Big Lake Twp.	$1,350.00	$13,000.00	$14,350.00
Braham School Dist. # 314	$10,000.00		$10,000.00
Chisago County		$28,000.00	$28,000.00
City of Aitkin	$4,500.00		$4,500.00
City of Andover	$3,000.00	$11,000.00	$14,000.00
City of Apple Valley			$0.00
City of Blackduck	$5,000.00		$5,000.00
City of Blaine		$7,500.00	$7,500.00
City of Chanhassen	$6,000.00		$6,000.00
City of Clarkfield	$8,000.00		$8,000.00
City of Coon Rapids		$5,000.00	$5,000.00
City of Cottage Grove	$7,500.00		$7,500.00
City of Crystal	$12,000.00		$12,000.00
City of East Bethel	$5,000.00	$9,500.00	$14,500.00
City of Elk River	$1,350.00	$13,000.00	$14,350.00
City of Emily			$0.00
City of Erskine	$6,200.00		$6,200.00
City of Excelsior	$6,500.00		$6,500.00
City of Falcon Heights			$0.00
City of Grand Marais	$7,200.00		$7,200.00
City of Granite Falls	$14,000.00		$14,000.00
City of Ham Lake			$0.00
City of Hendricks	$12,500.00		$12,500.00
City of Hendrum	$4,000.00		$4,000.00
City of Inver Grove Heights	$2,500.00	$4,000.00	$6,500.00
City of Lakeville		$12,500.00	$12,500.00
City of LeCenter	$3,000.00		$3,000.00
City of Lewiston	$3,400.00		$3,400.00
City of Lino Lakes			$0.00
City of Lonsdale	$10,000.00		$10,000.00
City of Mahtomedi			$0.00
City of Moorhead	$2,500.00		$2,500.00
City of Mounds View	$5,000.00		$5,000.00
City of New Brighton	$3,500.00		$3,500.00
City of New Richland	$5,000.00		$5,000.00
City of Oak Grove		$14,500.00	$14,500.00
City of Oak Park Heights	$1,000.00		$1,000.00
City of Oakdale		$4,000.00	$4,000.00
City of Olivia	$6,000.00		$6,000.00
City of Prior Lake	$9,000.00		$9,000.00
City of Prior Lake	$10,000.00		$10,000.00

ORGANIZATION	LCMR AWARD	USFS GRANT	COMBINED
City of Proctor	$7,000.00		$7,000.00
City of Ramsey	$4,500.00	$9,500.00	$14,000.00
City of Robbinsdale	$12,000.00		$12,000.00
City of Shakopee	$500.00	$4,000.00	$4,500.00
City of St. Francis		$13,000.00	$13,000.00
City of St. Louis Park	$12,000.00		$12,000.00
City of Staples	$4,500.00		$4,500.00
City of Stillwater			$0.00
City of Waubun	$2,500.00		$2,500.00
City of Woodbury			$0.00
Columbus Township			$0.00
Grand Rapids School Dist. # 818	$5,000.00		$5,000.00
Gustavus Adolphus College	$4,000.00		$4,000.00
Hennepin County	$14,000.00		$14,000.00
Hutchinson School Dist. # 423	$9,000.00		$9,000.00
Isanti County		$28,000.00	$28,000.00
Linwood Twp.		$12,500.00	$12,500.00
Livonia Twp.	$1,350.00	$11,000.00	$12,350.00
MPLS Folwell Neighborhood	$10,000.00		$10,000.00
MPLS Hale Community School	$4,300.00		$4,300.00
MPLS Lind-Bohanon Neighborhood.			$0.00
MPLS Little Earth			$0.00
MPLS Marcy-Holmes Neighborhood			$0.00
MPLS Northside Redevelopment			$0.00
MPLS Prospect Park Neighborhood			$0.00
MPLS Seward Neighborhood			$0.00
MPLS Webber-Camden	$10,000.00		$10,000.00
Mountain Lake Public School	$15,000.00		$15,000.00
Ogilvie School Dist. # 333	$4,000.00		$4,000.00
Olmstead SWCD		$7,000.00	$7,000.00
Ramsey Co. Public Works			$0.00
Rochester Park & Rec. Dept	$14,000.00		$14,000.00
Sherburne Co.	$2,200.00	$27,000.00	$29,200.00
St. Clair Public School Dist. # 75	$4,000.00		$4,000.00
Stearns Co. SWCD		$5,000.00	$5,000.00
Wadena Co. SWCD			$0.00
White Bear Twp.			$0.00
TOTAL	$319,200.00	$250,000.00	$569,200.00

Sphaeropsis collar rot

Sphaeropsis sapinea

Host:	Red pine and jack pine
Damage:	Shoot blight, collar rot, mortality
Area:	Nurseries and scattered localities statewide
Severity:	Variable
Trend:	Unknown

DNR Forestry has experienced two consecutive years of poor red pine plantation establishment due, in part, to a disease caused by *Sphaeropsis sapinea* (formerly known as *Diplodia pinea)*. This disease is best known as the cause of shoot blight on young red pines planted under older, overstory pines in the Lake States. In other parts of the world, *Sphaeropsis* causes other types of diseases, notably, collar rot. In any form, the most insidious aspect of this disease is that it can be carried in green, healthy looking planting stock and then cause the seedling to die once it's stressed on the planting site.

Collar rot is an infection of the bark, cortical and wood tissues of the root collar. Collar rot infections girdle the seedlings which results in the sudden death of the seedlings during the summer. It is common for infected seedlings not to candle out after they are planted. Symptoms at the root collar include: loose bark, blackened cortical tissues, black/dark blue staining of woody tissues, presence of dark resins and presence of fruiting bodies in bark above the root collar.

Red pine seedlings can become infected as 1-0, 2-0 or 3-0 seedlings while still in the nursery. The main sources of infection in the nursery are pine windbreaks. (Cones on windbreak trees become infected as insects carry spores from nearby infected pines.) *Sphaeropsis* spores are produced in infected cones and on blighted shoots. Then, wind-driven raindrops carry the spores down onto the bed of seedlings. Shoot blight data from the 1980's show that seedlings more than 600 feet away from a windbreak can become infected. Within the seedbed, dead or blighted seedlings produce spores that can be water-splashed onto adjacent seedlings. This is the main source of infection for a 2-0 and 3-0 seedlings. US Forest Service researchers, Palmer and Nichols, showed that nearby dead seedlings supplied 10,000 times more spores than windbreak pines.

Dr. Glen Stanosz, Univ. of Wisconsin-Madison, has been working on *Sphaeropsis* diseases of pines since 1991. He recently found that *Sphaeropsis* is a latent pathogen; it can persist in live, red pine seedlings without producing any disease symptoms. The fungus passively exists in the bark of the root collar. As long as the seedling is vigorous, the fungus cannot produce the disease symptoms. Latent infections are activated by the stresses due to internal water deficits. Internal water deficits could be instigated by poor stock handling or storage, transplant shock, J-rooting, drought or hail damage.

Before the DNR ships seedlings, they are inspected and sorted. Only live, healthy-looking seedlings make it out of the Nurseries. Unfortunately, latent infections cause no symptoms so latently infected seedlings cannot be detected and discarded prior to shipment.

2002

In the spring of 2002, Dr. Stanosz conducted a survey to determine if latent infections were present in red pine nursery stock in several Mid-western nurseries. It was present at four of the six nurseries tested and latency ranged from 0 to 95% in the sampled seedlings. At Badoura and Gen. Andrews Nurseries, small samples were taken from rising 2-0 beds that had high or low inoculum pressure (symptoms of shoot blight/ seedling mortality). In August, Dr. Stanosz reported that GASN had 26% and 20% latent infections and that Badoura had 88% and 19% latent infections. We did not know how extensive the disease was nor did we know its average severity. In the meantime, reports of poor plantation survival were coming in from all over the state. Apparently the 3-0 red pines were similarly infected and latent infections were activated by droughty weather at planting time. Twenty seven new plantations were surveyed in the fall and a sample of dead seedlings were inspected in the lab for presence of *Sphaeropsis*. The average percent

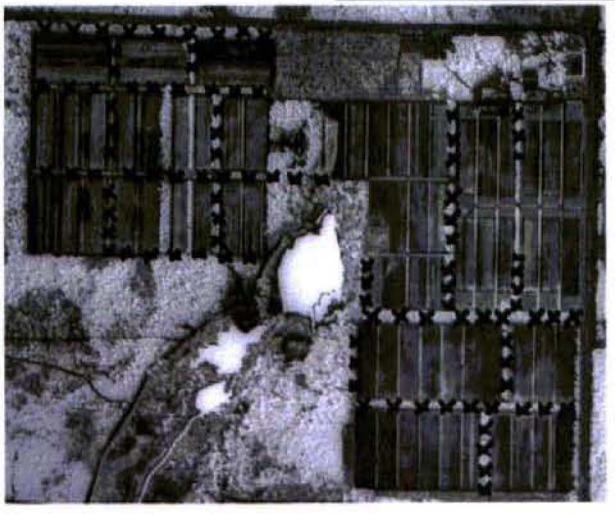
loss due to *Sphaeropsis* in those plantations was 55%. Of the dead seedlings that were examined in the lab, 98% were symptomatic for *Sphaeropsis*. Our Mid-western nurseries are in the midst of the *Sphaeropsis* epidemic, and in Minnesota, Badoura Nursery is hardest hit.

2003

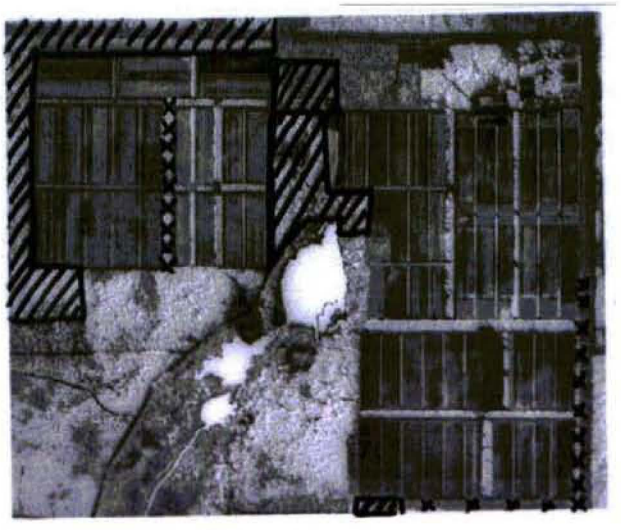
A. At state nurseries

To control the *Sphaeropsis* epidemic, seedling infection needs to be prevented in the nursery. The best course of action is to completely remove overstory pines in the nursery thus eliminating the possibility of disease spread from infected overstory pines down onto pine seedlings. That is exactly what the DNR Nurseries did last winter, at Badoura for example, 1270 cords of red pine were removed from the windbreaks stands bordering nursery beds. See maps. Red pine seed was sown in beds where there were no red pine windbreaks or stands (outside the fence) nearby. Jack pine windbreaks were retained pending further research.

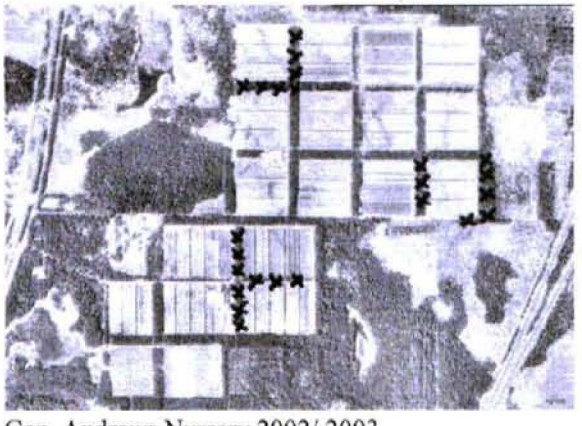
Removals of red pines from windbreaks, groves and areas bordering the state nurseries.
Cross hatched areas represent removals.



Badoura Nursery 2002/ 2003



Badoura Nursery 2003/ 2004



Gen. Andrews Nursery 2002/ 2003

Additional courses of action to deal with the epidemic were implemented at both Nurseries: they used systemic fungicides every two weeks during the growing season to prevent new latent infections, decreased seedbed density, rogued dead and blighted seedlings in all the red pine beds, and, avoided heavy nitrogen fertilization of seedbeds. When lifting seedlings, the Nurseries culled all dead, blighted or wounded seedlings and then cooled-down seedlings prior to shipping. Nursery managers are also investigating the possibility of shipping 2-0 seedlings instead of 3-0 seedlings in the near future.

In May, nursery beds were surveyed for the presence of *Sphaeropsis* symptoms. See table below. (For more information, see tables in Survey Results section.) At GASN, symptomatic seedlings and transplants remained below 10%. At Badoura, symptomatic seedlings ranged from 31 to 60% and symptomatic transplants ranged from 11 to 55%. Jack pine at Badoura showed an overall low level of symptom expression.

***Sphaeropsis* survey: Percent symptomatic seedlings (dead or live) found in nursery beds, approximately 400 seedlings per sample.**		
Species and age	**At Badoura**	**At GASN**
Red pine		
rising 1-0	Not germinated	6.8
rising 2-0	50.6	6.3
rising 3-0	30.9 and 59.6	2.7
rising 2-1	11.0	2.8
rising 2-2	55.5	9.3
Jack pine		
rising 2-0	5.3	Not germinated

The spring and summer weather of 2003 were droughty, providing ample opportunity for the expression of latent infections in newly planted red pine plantations. This means that foresters and private landowners were hit two consecutive years with *Sphaeropsis* epidemics and serious losses in their plantations. By late July, Nursery Management was concerned about the seedlings destined for shipping in 2004 from Badoura Nursery. Dr. Stanosz visited Badoura and devised a sampling scheme that (a) determined percent latent infections in the red pine beds slated for shipping in 2004 (currently 2-0 and 2-1 age classes), and (b) sought to establish a relationship between the percent symptom occurrence and percent latency of seedlings in the same plots. 210 - one meter plots were established in 42 beds of 2-0 seedlings for both symptom detection and latency sampling. Additionally, ten beds of 2-1 transplants were evaluated and sampled. In all, over 26,000 seedlings were evaluated for symptoms and 575 seedlings were taken for the latency assay.

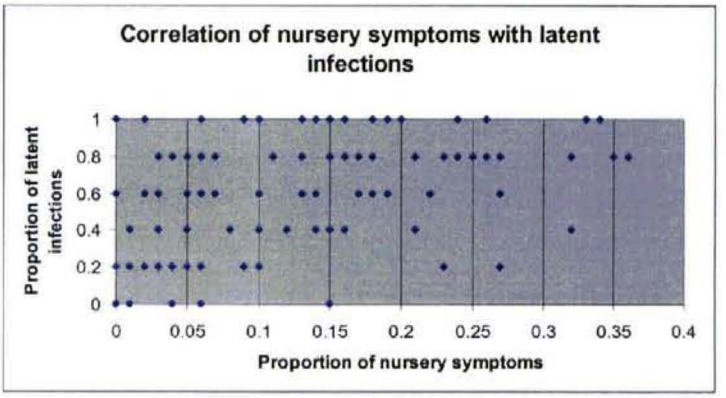
The 2-0 red pine averaged 12.5% symptomatic seedlings per plot (range = 0 to 74%; only 1 plot exceeded 36% symptomatic seedlings). The 2-1 transplants averaged 42.3% symptomatic individuals per bed (range = 32.4 to 49.0%). See Survey Results section for more details.

In late October, Dr. Stanosz supplied the results of both studies. (See " Report of results of assay for *Sphaeropsis sapinea* in asymptomatic red pine stock from MN DNR Badoura Nursery, fall 2003" in the Survey Results section for further details.) Latent infection of pine seedlings ranged from 0 to 100% in plots. Latent infections in fields ranged from 40 to 71% and strongly indicated that these seedlings would be very likely to die upon outplanting. See table below. The decision was made to not sell any of the 2-0 red pine stock from Badoura in 2004. This necessitated the purchase of red pine seedlings for new plantations and for replacement stock for state and private land owners.

Frequency of detection of *Sphaeropsis* latent infections and group A or B of that pathogen found in red pine seedlings and transplants from Badoura Nursery. Collected July 29, 30, 2003.
Data from G. Stanosz, Univ. of Wisc, Results received Oct. 22, 2003

Stock	Field	Latent infections			Group A or B determination		
		No. of plots	No. of trees	Mean percent of latent infections	No. of trees tested	No. of Group A	No. of Group B
3-0	B 1	31	155	68	28	26	2
	B 9	13	65	40	10	9	1
	B 10	17	85	47	16	14	2
	D 10	44	220	71	41	27	14
2-2	C 4	5	50	10	3	3	0

The second aspect of Stanosz's study was to determine if there was a correlation between the levels of detected symptoms with levels of latent infections. If there was a correlation, then nursery managers could predict how serious the latent *Sphaeropsis* infections were based on the observable symptoms in the nursery beds. Alas, no correlation was found. Plots with low symptoms could have low or high levels of latency. See graph to right.

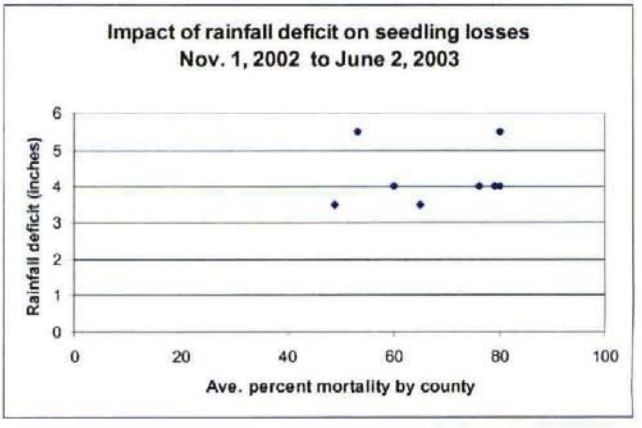


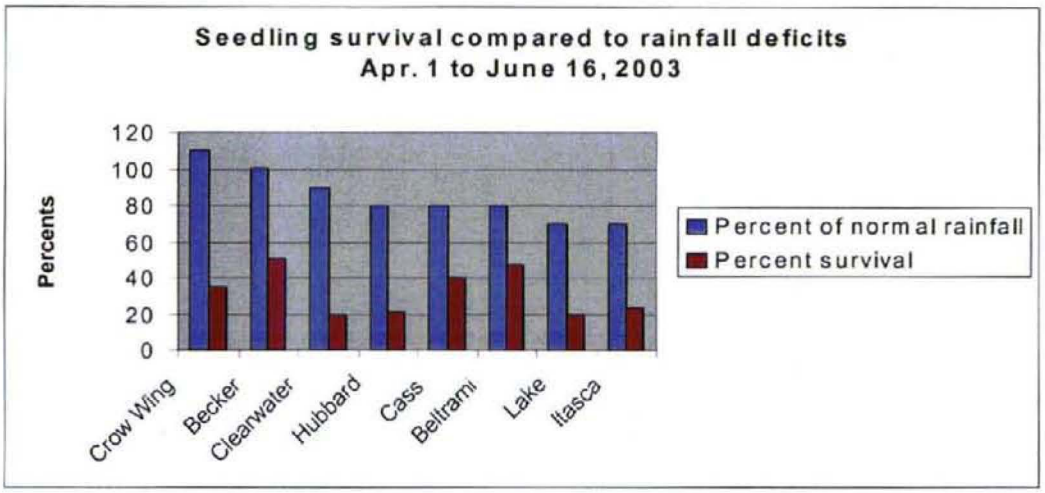
B. In new pine plantations

Most of northern Minnesota continued to be droughty in 2003, particularly during the critical planting and establishment time in May and June. Again losses were staggering. Counties that submitted their losses averaged 62% mortality. See table below. Drought, deer browse, latent *Sphaeropsis* and poor handling practices all took their toll. Only two of the eight counties tallied had 100% of normal precipitation during that time.

Percent survival of red pine seedlings planted in 2003		
County	**Number of seedlings planted**	**Percent survival**
Becker	48,000	51 %
Beltrami	235,000	47
Cass	182,000	40
Clearwater	36,000	20
Crow Wing	31,600	35
Hubbard	19,700	21
Itasca	49,500	24
Lake	70,000	20
Sums/ Averages	**672,300**	**38 %**

If the majority of the county plantation losses were due to latent *Sphaeropsis* infections activated by drought, then there should be a direct relationship between drought and mortality. Several weather data and loss correlations were investigated. There was no correlation between the level of drought and the level of mortality using percent of normal rainfall during planting time. Similarly, there was no correlation when using water deficits (7 month period ending June 2nd). See charts right and below. So, it is likely that there are additional causes of mortality not related to drought and latent infections, such as, the severity of deer browse.





Ten samples of dead red pine seedlings from state and private plantations were examined for the presence of *Sphaeropsis*. 78% of the seedlings were positive for the disease (which was down from 98% in 2002).

In Minnesota, we have long-standing records of establishment losses in our jack pine plantations in western counties. Some DNR Foresters will not plant jack pine because these losses are too great. Initial surveys of jack pine seedlings (May, 2003) at Badoura showed *Sphaeropsis* shoot blight/ mortality levels of 5% in 3-0 seedlings. See results in Survey Section. And, for the first time, *Sphaeropsis* has been documented as the cause of mortality in State and County jack pine plantations. A sample of newly planted, dead seedlings from Beltrami County had: 20% dead from *Sphaeropsis*, 20% dead due to gall rust, 30% dead due to herbicide damage and 30% dead due to insects and other causes. A small planting (401 seedlings found) in Wadena County (12-138-34) had very different results; only 3.3% of the seedlings succumbed to *Sphaeropsis*. See table below.

Cause of damage/ death by percent in Jack pine seedlings from a plantation, established 2002, in S12-T138-R34 near Huntersville, Wadena Co.

	Live	**Dead**
Healthy	19.0	NA
Browse	62.0	7.5
Gall rust	0	0.2
Sphaeropsis (lab verified)	0	3.3
Other (insect, poor planting, etc.)	0	8.0

Many agencies and private landowners are interested in replanting their plantations but were worried about the spread of the disease from old stock to new stock. The following information, as a handout, was made available to them:

Suggestions for replanting red pine seedlings in plantations where *Sphaeropsis*-caused mortality was a problem:

Background information about *Sphaeropsis*-caused mortality:

1. When *Sphaeropsis* collar rot causes high levels of mortality in young red pine plantations, the pathogen was probably already present as latent infections in the seedling at the time of outplanting.
2. *Sphaeropsis* spores are spread by splashing and wind driven rain, not by wind alone. Spores are more likely to spread long distances from the crowns of overstory trees than from small seedlings close to the ground. Typically, spores are rain-splashed a distance equal to 1 ½ times the height of the infected tree.

Conclusions:
Dead red pine seedlings spread out over a plantation have a relatively small chance of infecting nearby live red pine seedlings.
If you plan on replanting or interplanting with red pine seedlings, you can minimize the risk of spread of this disease by planting the new seedlings as far away from dead seedlings as is practical.

Suggestions:

1. Wait two or more years before replanting or interplanting, so that inoculum (spore) levels will have dropped.
2. If feasible, rogue out, collect and destroy the dead seedlings prior to replanting.
3. Where seedlings are planted in rows, create new rows of seedlings that are spaced in between existing rows in order to place the new seedlings at a maximum distance from the dead seedlings.
4. Where seedlings are planted in trenches or scalps, choose new planting sites as far from dead seedlings as possible. Additionally, you might consider one or both of these options as the planters work through the plantation:
    A. Rogue dead seedlings out of the trench/ scalp and drop them away from the trench or scalp.
    B. Step on the dead seedlings and crush them into the dirt. (When a dead seedling is crushed into the soil, decomposing fungi and bacteria can easily colonize and destroy the *Sphaeropsis* fruiting bodies.)

C. Research initiated in fall of 2003

Over the 2003-2004 winter, Dr. Stanosz will be working on the impact of *Sphaeropsis* on jack pine seedlings at Badoura Nursery. He will assay jack pine seedlings to determine (a) levels of latent infection, and, (b) if drought stress activates latent infections like it does in red pine seedlings. He will also identify candidate fungicides for preventing infections in the nursery. See attached grant proposal.

Jack pine cones from nursery windbreaks will be inspected for the presence of *Sphaeropsis* fruiting bodies. If *Sphaeropsis* is indeed a significant problem in our jack pine seedlings, Nursery managers would be encouraged to remove all jack pines from windbreaks, groves and borders.

D. Conclusions

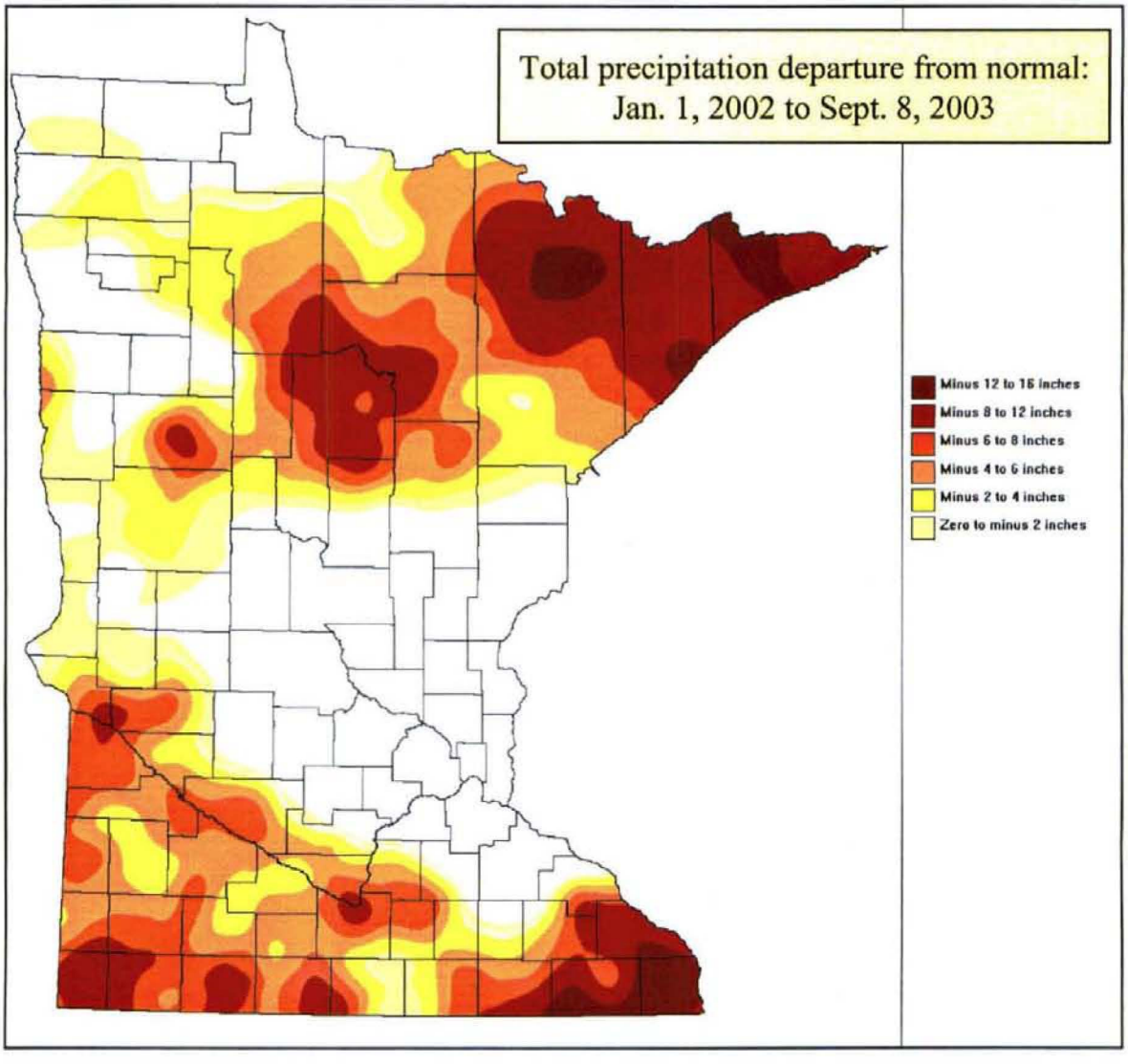
1. The *Sphaeropsis* epidemic continues at Badoura Nursery. The disease rarely causes losses at Gen. Andrews Nursery.
2. The source of the inoculum is the windbreak trees in the nurseries. Removal of red pine trees in and around the nurseries should greatly improve outplanting success beginning in 2005, when seed planted in 2003 is shippable.
3. Data from 2003 will be the baseline for future comparisons. We have values for percent symptoms and percent latency based on the examination of 21,000 red pine seedlings.

ABIOTICS

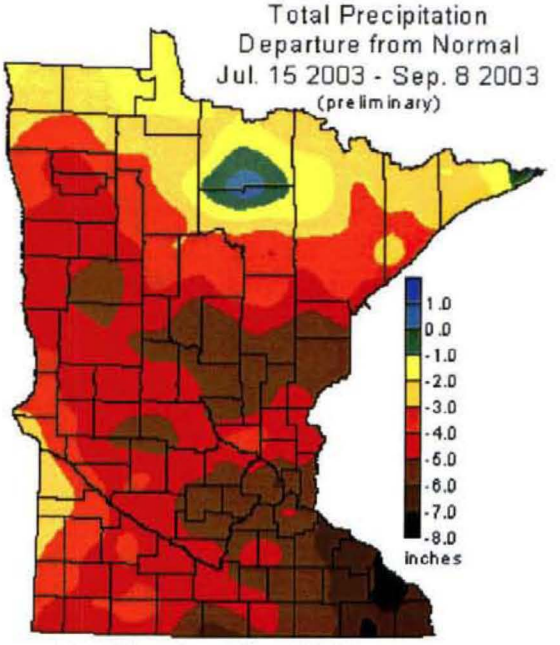
Twenty months of drought.... and counting

Since January of 2002, many areas in the state are short eight or more inches of rainfall. That's like taking the trees growing in Itasca County (down by twelve inches of rainfall) and moving them west to Jamestown, North Dakota. A few areas are down by as much as sixteen inches. Again, moving the trees in Cook County westward, it's as if the trees were living in Sioux Falls, South Dakota for the last twenty months.

Serious and long-term impacts to the affected forests are already being observed where additional stresses occur, such as two-lined chestnut borer in FTC-defoliated oaks in Itasca County and jack pine mortality in a single year due to jack pine budworm defoliation in Beltrami County.



Drought implications for trees



State Climatology Office - DNR Waters

Trees normally require an average of one inch of water per week. Many areas of the state have received less than one inch of water over the last two or three months. So trees in these areas are currently under severe drought stress. The primary effect of drought is damage and death of the roots. The feeder roots and root hairs are responsible for the uptake or water and nutrients. Because 99% of these roots occur in the top 3" of soil, they are the most at risk of damage as the soil dries. Damage to these fine roots creates a significant deficit in the entire plant, affecting a range of metabolic functions. These in turn, affect normal tree growth, maintenance and self-defense.

Between July 15th and Sept 8th, the precipitation received by most of the southern 2/3 of the state was 3" to 8" below normal, ranking the period among the worst in history (see maps). Trees most likely to show damage occur south of a line through Carlton County on the east, Wadena County in middle and Red Lake County in western Minnesota.

Effect on physiology

Plant growth occurs as a result of cell expansion, largely in response to water pressure, and cell thickening that occurs as cellulose (largely made up of water) is added to cell membranes. Available water, more than any other resource, determines the growth potential of individual trees, accounting for up to 80% of the size difference seen within tree species. Water deficits dramatically reduce both height and radial growth as well as bud production. Severe drought can limit future food production by reducing the number and vigor of leaf buds and thus the tree's ability to recover after the drought ends. Seed production may also drop for two to three years following a drought.

Water and nutrient uptake is driven by transpiration (the evaporation of water from plant leaves that pulls water through the plant from the soil, much like a soda straw). Stomates, pores in the leaves, control the amount of transpiration by opening or closing in response to heat, light and water loss. When closed, stomates reduce the amount of carbon dioxide available for photosynthesis and that reduces the amount of carbohydrates produced by the plant.

Besides plant growth and tissue maintenance, carbohydrates are used to form the basis of fats, proteins, growth regulators and many secondary metabolites. Secondary metabolites include tannins and alkaloids that are involved in defense. As the production of these compounds decrease, trees become susceptible to attack by opportunistic insects and disease organisms.

In a prolonged drought, there is a breakdown of the photosynthetic machinery itself. These tissues have to be repaired before normal processes can resume. In the meantime, carbohydrate reserves can be depleted. The result can be a downward spiral into decline and the eventual death of the tree.

The influence of secondary tree pests

For nearly all trees species, there are insect pests and disease organisms that have evolved to take advantage of weakened trees. Under normal conditions, these organisms act as recyclers, removing declining individuals, making room for others and releasing nutrients back into the ecosystem. However, during a stress event, populations of these pests can build to outbreak levels that can threaten stressed as well as healthy trees.

In pine, the two most common factors driving outbreaks of pine bark beetles are over-crowding and drought stress. Healthy pine trees produce enough pitch to push insects out or drown them in sap. Sap production in stressed pine is greatly reduced so beetles are able to successfully invade. All trees give off certain volatiles and bark beetles have evolved to pick up the change in volatiles given off by stressed pine. They flock to stressed trees in large numbers,

overwhelming natural defenses, quickly killing the trees.

For oaks the two most common opportunistic pests are two-lined chestnut borer and Armillaria root rot. They often attack stressed trees in concert, increasing the stress and quickly killing those overly compromised. A combination of environmental factors and these two organisms can cause oak decline. Last year, northern Minnesota saw an increase in the incidence of two-lined chestnut as a result of the dry weather. This year some of those same areas are being hit again as well as many areas further south. While Armillaria is more difficult to survey, reports of root rot are increasing as well.

Like the two-lined chestnut borer, many other woodborers prefer stressed trees. The bronze birch borer attacks stressed birch trees and the native ash borer attacks stressed ash. The incidence of spider mites, scale insects, lace bugs and other sucking insects can also increase during a drought event. Canker organisms can advance much more rapidly in stressed trees and may girdle infected stems and branches. Armillaria and other decay organisms can influence tree health as well; so different trees may show a range of symptoms, including tree death.

Because stored food reserves may last one or several years after a stress event, related damage may not become evident that year. That can make diagnosis of plant health problems very difficult. The drought this summer followed a dry open winter that produced symptoms of stress in many, many trees. So right now, there are a lot of trees out there in a weakened condition. If the weather is favorable next year, and the trees were healthy prior to the drought, they will likely recover with little long-term damage. If the weather is not favorable next year, or if the trees were already stressed prior to the drought, the trees may begin to decline. If the trees had been predisposed to stress because of poor growing conditions, site disturbance or a history of damage, they may die this year or next with little prior warning. Foresters and plant health specialists have to shift through the numerous pest organisms that may be present and the past history of the site to determine the likely cause of any damage.

Symptoms of drought stress

Leaves may curl, roll, wilt, yellow, or scorch (leaf browning, usually around the margins) depending on the level of stress and the tree species. Leaf loss may result when an abscission layer is formed and may thus resemble normal fall color change, or when the leaves lose turgor pressure, wilt and die. Different tree species have different mechanisms for coping with drought stress, so the initial symptoms may vary. But they are usually more pronounced in the more exposed areas of the tree (for instance the top or south-facing branches) and the more exposed trees within a planting (for instance those along the street or facing the sun). Growth lose is common among trees demonstrating leaf scorch. But if the stress event is temporary or if the drought event occurs late in the season, when most trees are shutting down for the winter anyway, trees may recover the following year with minimal long-term impact.

Severe scorch (greater than 60%) early in the season may force trees to put on a second flush of growth. That may further deplete food reserves and diminish natural defenses. Secondary pests become may become a problem. Under extreme drought conditions, existing buds may shrivel and fail to leaf out the following spring. Branches may dieback and the tree may begin to decline.

Effect on fall color

Obviously, if the leaves are already brown, there's little chance of seeing the pretty reds and yellows typical of the fall season. Although they may be still green, curled, folded or shriveled leaves are likely to drop this fall without turning color. In either case, areas under severe drought stress are unlikely to see many fall colors.

Under normal conditions, fall colors depend on a number of factors, only one of which is moisture. Other factors include light exposure, temperature, nutrient content of the leaves, tree vigor and timing of the first frost. The pigments that create typical fall colors are produced and stored in the chloroplasts. Production of these compounds is influenced by nutrient and carbohydrate availability. Production is also influenced by chloroplast integrity. Damaged chloroplasts and/or nutrient deficiencies induced by limited root uptake can lower the concentration of these compounds and thus color intensity. Temperature and the timing of first frost also influences fall color.

All of these factors are very site specific. So while fall colors in general may not be as intense this fall, there will be areas of the state with normal, if not, spectacular color. Check with local authorities before planning fall color tours.

Future Outlook

The future of your trees will depend on their health and vigor prior to the drought and the severity of the drought at your particular location. Growing conditions vary by individual site and micro-climatic. Variations in available resources can mean one tree thrives while another 50' away rapidly declines. So predicting future tree health on a broad scale is nearly impossible. However, we are likely to see a slight increase in the incidence of tree mortality across the entire area affected by the drought with isolated pockets of high mortality. Urban trees, recently disturbed or damaged trees, over-mature trees and those growing in sandy drought-prone soils are at more risk of mortality as a result of the current drought. In those cases, extra water is critical to tree survival.

Late bud break

The cold, dry weather this last winter has contributed to a number of issues in the spring. The ground froze to a much greater depth than usual, damaging sensitive roots. The damage has slowed bud break this spring in individual maple, ash, honey locust and elm trees in the Twin Cities. Some trees still have not produced any leaves, although the buds and bark appear healthy. Undersized leaves were eventually produced on the affected trees. That is good indication of stress and potential decline.

Seed Crops

In a forest setting, heavy seed crops are a blessing. In a residential setting, they are a curse. The elm this year produced a bumper crop of seed. When the seeds began to mature and turn brown, it gave the elms a yellow appearance that was alarming to many residents in the Twin Cities.

Winter injury

In 2003 winter injury was evident across much of southern Minnesota, more so than occurs in most years. Conifer discoloration, scattered dieback in hardwood branches, and late leaf emergence in some hardwood tree species was observed. Mortality of limited fall planted and fall transplanted small trees was also evident. Events that contribute to loss of moisture in plant material and/ or freezing of plant tissues and or greatly fluctuating winter temperatures can result in winter injury.

Several climatic factors may have contributed to the injury including;

1. An uncommon dry spell occurred from November 2002 through March 2003. This was among the driest five-month periods in Minnesota's climate history!
2. Warm temperatures on January 7th and 8th. High pressure and an unusual lack of snow cover contributed to a very warm January thaw. The warmest January 7th temperature found in Minnesota was 60 degrees at Fairmont. This 60 degrees is the warmest temperature ever recorded on January 7th in the state and the earliest 60-degree temperature ever recorded in January.
3. Record warm temperatures occurred on March 15-16. After a prolonged period of cold for the first half of March, the weather warmed up with southerly breezes that rapidly ate away at the snow pack over Minnesota. The mercury cracked 70 in a few places in southern Minnesota. Waseca reached 73 on the 15th and Preston reached 73 on the 16th.
4. All of the above on top of the deepest frost recorded in a decade.

Case of mistaken identity: Dutch elm disease versus winter injury

Dutch elm disease (DED), a devastating killer of elm trees, has been on the rise, in Central Minnesota, over the last several years. The cause is not completely understood, but involves an increase in the number and maturity of volunteer elm, weather patterns that have both stressed elm trees and favored beetle populations, and a slackening vigilance on the part of some community DED programs.

However, not all that goes wrong with elm is DED. With the damage caused this last winter, managers are having a difficult time distinguishing between causal agents. The result is a potential loss of elm that would not otherwise be lost. It is critically important for managers to verify DED before marking trees for removal. That can be difficult, because it means slowing down for a careful inspection in the midst of the rush to keep up with the number of trees that are infected with the DED fungus. Because DED can rapidly spread from tree to tree, any delay can mean more trees infected. So managers have to balance the need for a rapid response with the need to verify the cause.

Symptoms Observed

The most obvious symptom of winter injury seen early this year was the very late bud break and leaf expansion. By late May, many elms still had few if any leaves. Making the trees look even worse was a very heavy seed crop. As elm seed mature, they dry and brown and then drop during the month of June. The heavy seed crop combined with the lack of leaves, gave elm trees on overall brown appearance, as if rapidly wilting. Now that most of the seed has dropped and most of the trees have put on a crop of leaves, the trees still do not look particularly healthy. The leaves on many of the affected trees are considerably smaller than they ought to be. That gives the trees a thin appearance. The space on the stems, previously occupied by the seed, remain bare now the seed has dropped, adding to the thin appearance. In some cases, the seed has failed to drop, so twigs still have a brown cast to them.

Now add that to the early stages of DED disease development. Individual branches wilt and begin to yellow. Often it is just the tips of the branches that show symptoms at first, and these are scattered among branches with small undersized leaves and remnant seed crops that show brown among the leaves. It is nearly impossible to tell the two sets of symptoms apart during the typical drive-by inspection many cities use to detect DED.

Survey Methods

To get a better feel for the percent of trees being affected by DED and the percent being affected by winter injury, a survey was conducted in 4 neighborhoods within the north-central metropolitan area. Relatively speaking this is a very small survey, so cannot be used to make inferences across the state. But the numbers highlight the risk of misidentification (see Table 1.).

In the survey, trees that were symptomatic at the time of the inspection plus the few that had already been marked and removed this year were counted as DED trees. Trees removed during previous years were not counted. Trees with at least 80% of their normal leaf area were considered healthy. Winter injury (WI) was ranked in three categories, low (50-80% of "normal" leaf area), moderate (20-50% of "normal" leaf area) and high (less than 20% of their " normal" leaf area). Note the categories are based on leaf area and not number or percent of leaves. What is normal is difficult to define, but in this case was based on a combination of leaf size (1" average versus the more typical 3") and the number of live branches that had leaves on them. In general, most of the trees had put on a full complement of leaves. But in many cases, they were much smaller than normal. Trees that had neither WI nor DED, and showed signs of other kinds of damage were counted as Other. Trees showing signs of both DED and WI were counted as DED. Trees showing signs of either DED or WI and other kinds of damage were counted in either DED or WI.

Table 1. Tally of elm showing varying levels of damage from either Dutch elm disease (DED) or winter injury (WI).

# of Trees	Location 1	Location 2	Location 2	Location 4	Total	Percent
Healthy	63 (.40)	43	22	68	196	30
DED	12 (.08)	25	8	12	57	9
Low WI	57 (.36)	30	66	134	287	44
Mod. WI	22 (.14)	31	20	20	93	14
High WI	3 (.02)	2	6	2	13	2
Other		1			1	-
Total	157	132	122	236	647	100

Roughly 50% of location 1 consisted of Siberian elm. Elsewhere, Siberian elm made up less than 25% of the total number of trees. The rest were American elm. All of the Siberian elm and some of the American elm showed traces of damage from leaf miners. Otherwise there was no apparent difference in response to damage agents.

Survey Results and Discussions

The incidence of DED ranged from 5% to 19% across the four locations with 9% of all trees tallied showing signs of DED this year (see Table 2.). The incidence of moderate to severe winter injury ranged from 9% to 25% across the four locations with 16% of all trees tallied showing significant damage due to winter injury. So significant winter injury was much more common than DED, even though an annual loss of 9% due to DED is high. The sheer volume of winter injury increases the risk of confusion when diagnosing these two damage agents.

The good news is that 75% of the trees appeared healthy even after a severe winter. As long as communities do a reasonable job of getting the infected trees down and the wood destroyed, the winter injury is not likely to contribute to a significant increase in disease. A curious note is that many of the trees with moderate to severe winter injury had put on new growth that appeared nearly normal. So the leaves that emerged first were tiny in comparison to the second flush. Branch tips had larger, denser foliage, so had a "fox-tail" appearance. That suggests that at least some of the winter injury was confined to over-wintering tissue only. These trees will likely recover as the new growth makes up for the limited food production capabilities of the first flush. Another reason, to go slow when diagnosing DED among these trees.

Table 2. Summary of tree tally where "healthy" equals healthy trees plus those with minor WI, and "WI" includes those with moderate to severe winter injury, combining the two most severe damage categories.

Location	% Healthy	% w/ DED	% w/ WI	% w/ Other	Total
1	76	8	16		100
2	55	19	25	1	100
3	72	7	21		100
4	86	5	9		100
Percent of trees across all locations	75	9	16	*	100

* Less than 1%

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