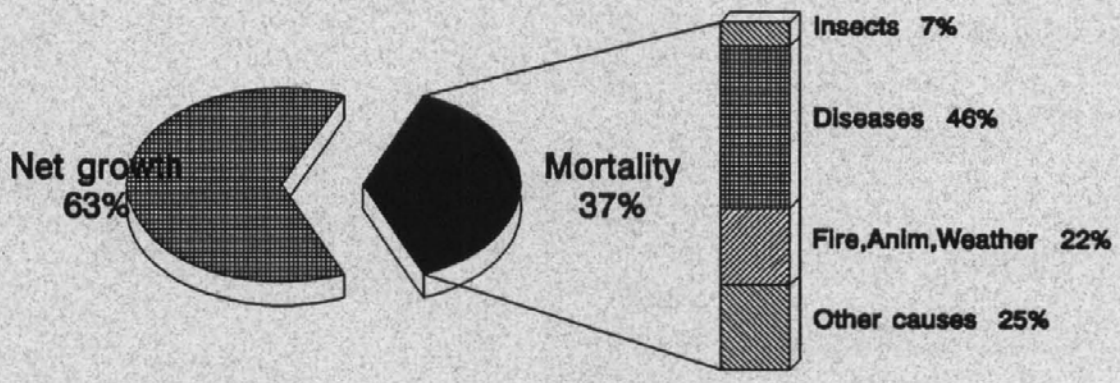
MINNESOTA FOREST HEALTH REPORT

1994



Minnesota Department of Natural Resources
Division of Forestry - Forest Health Unit

FOREWORD

The Forest Health Report is an assessment of the overall health of Minnesota's forest trees and summarizes the insects, diseases and other pests which damage trees, primarily in the forest, but also in the urban environment. Our main purpose in publishing this Report is to record and interpret forest pest diagnosis, damage and trends. Secondarily, it is to inform readers about special project results and accomplishments in the Forest Health Program.

The forest types in this report are a combination of the 14 forest types identified in the 1990 Forest Inventory. This report is organized into seven covertypes: aspen-birch, spruce-fir, maple-basswood, elm-ash-soft maple, oak, pine and urban. " Urban forest " is included as a forest type since it involves a wide variety of tree species and occupies a unique ecological niche. Forest type definition, acreages, volumes and tree numbers are based on the publication, *Minnesota Forest Statistics, 1990* by Miles and Chen.

Because of the difficulty in aerially detecting visible symptoms, detection and monitoring of most forest diseases is accomplished via ground surveys. Diseases are reported only in general terms because of the sporadic and short duration of most foliar diseases and the relatively static nature of root, stem and branch diseases and the difficulty of assessing change. Since this report reflects the change in pest status from year to year, disease information is frequently omitted unless a significant change has occurred. It should not be construed that forest diseases are absent or unimportant within the state. In fact, diseases cause more direct mortality and likely cause more growth loss than do insect pests.

The Department of Natural Resources, Division of Forestry, Forest Health Unit is charged with managing Minnesota's forest and tree resources to reduce the impacts of biotic and abiotic pests so that the health of the forests is improved. The Forest Health Unit personnel are:

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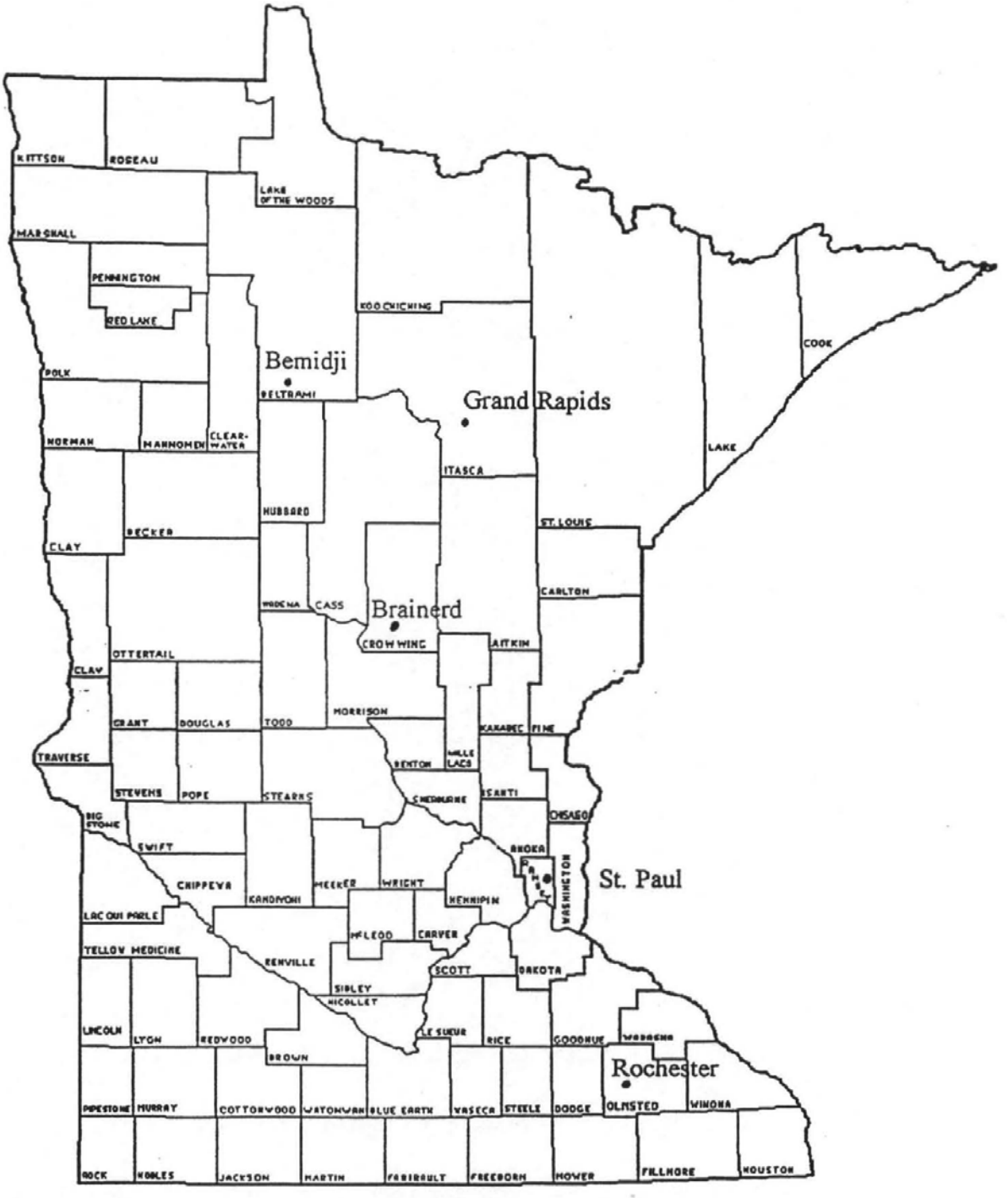
MAP OF MINNESOTA COUNTIES



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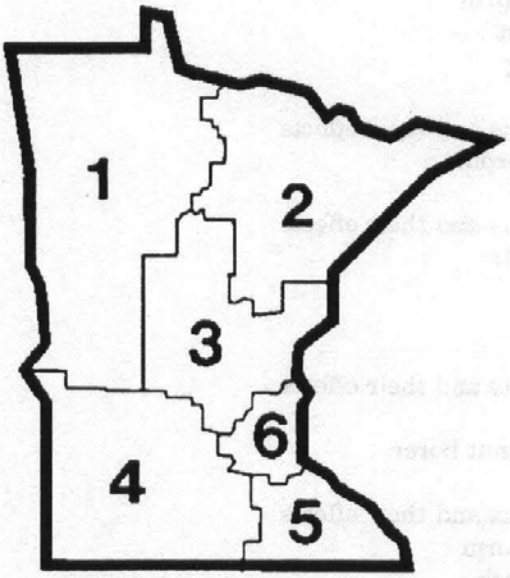


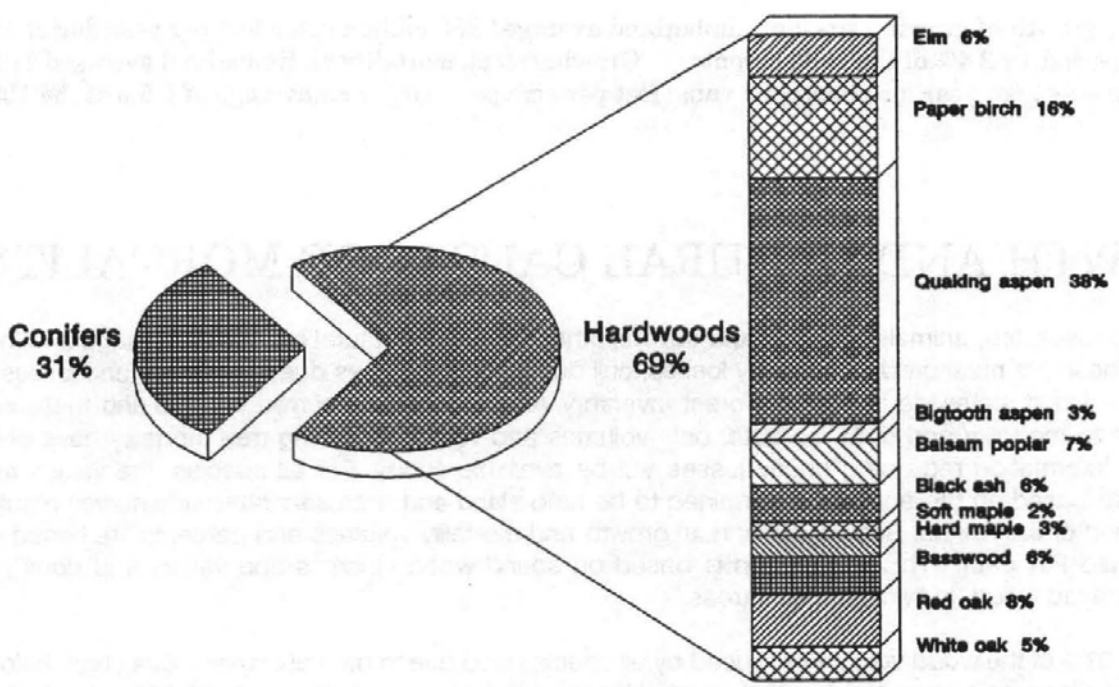
DNR Forestry Regions

THE FOREST RESOURCE

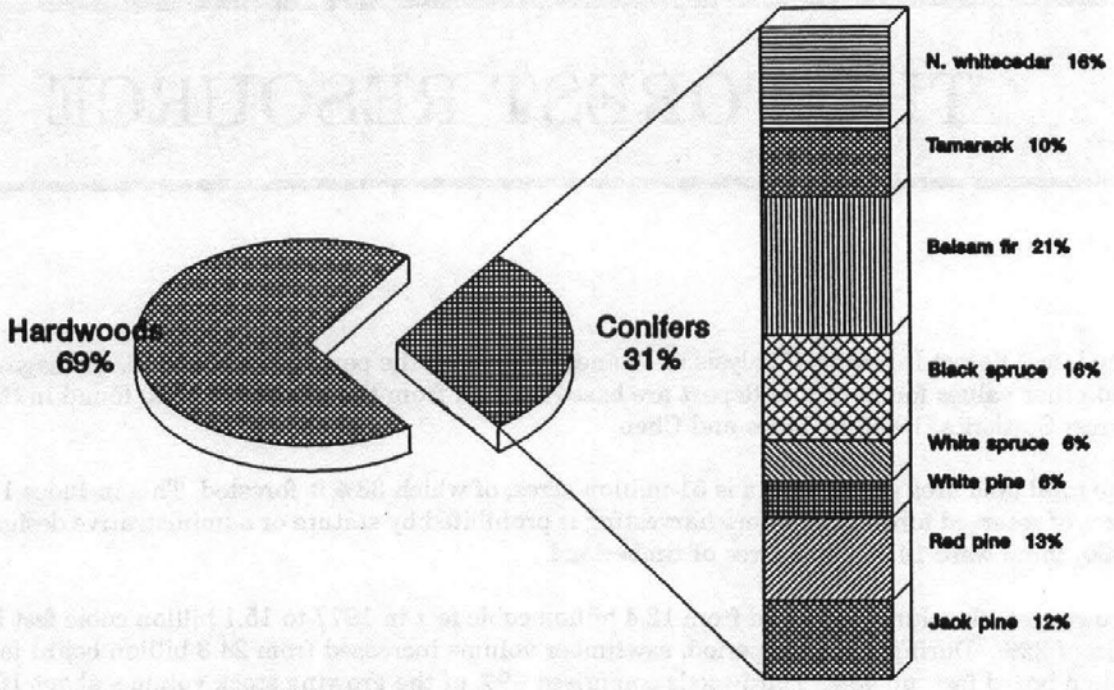
The latest Forest Inventory Analysis in Minnesota covered the period of 1977-1989. Acreages, volumes and other values found in this Report are based on data from the FIA and can be found in "Minnesota Forest Statistics, 1990" by Miles and Chen.

The total land area of Minnesota is 51 million acres, of which 33% is forested. This includes 1.1 million acres of reserved forest land where harvesting is prohibited by statute or administrative designation. In 1990, there were 14,773,400 acres of timberland.

Growing stock volume increased from 12.4 billion cubic feet in 1977 to 15.1 billion cubic feet in 1990, a gain of 22%. During the same period, sawtimber volume increased from 24.3 billion board feet to 34.8 billion board feet, up 43%. Hardwoods comprised 69% of the growing stock volume, about 10.5 billion cubic feet and softwoods accounted for the other 31%. See charts below.



Growing stock volume by hardwood species



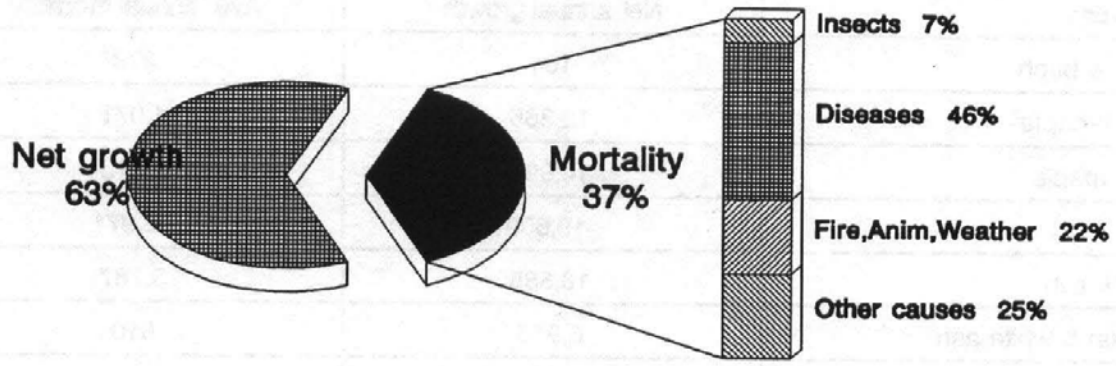
Growing stock volume by conifer species

Net annual growth of growing stock on timberland averaged 368 million cubic feet per year during the inventory period, or 2.4% of the 1990 inventory. Growing stock mortality on timberland averaged 219.2 million cubic feet per year, or about 14.8 cubic feet per acre per year, or an average of 1.5% of the 1990 inventory.

GROWTH AND NATURAL CAUSES OF MORTALITY

Insects, diseases, fire, animals, weather and several other agents are natural causes of damage and loss in trees. These are measured as mortality losses, cull due to decay, losses due to degrade and losses in growth. The latest statewide inventory, Forest Inventory Analysis (FIA), occurred in 1990 and measured losses due to mortality and cull. To date, only volumes and values regarding tree mortality have been published; information regarding decay losses will be available soon. For all species, the values and volumes are based on the acreage determined to be timberland and represent statewide survey results. In this edition of the Annual Report, the annual growth and mortality volumes and percents are based on the published FIA data. This information is based on sound wood volumes and values and does not include decayed wood, in living or dead trees.

Each year, 37% of the wood volume produced by all species died due to natural causes. See chart below. Insects and diseases accounted for 53% of the losses and this amounted to 117,190,800 cubic feet of wood. Losses from fire, animals and weather have been grouped together and caused 22% of the mortality. Other causes, amounted to 25%, is composed of unknown causes, suppression and logging/ mechanical damage.



Annual growth and mortality volumes for all growing stock species

The table below lists annual growth volumes and mortality volume losses by species.

Net annual growth and average annual mortality for tree species in Minnesota, 1987- 1989.
(In thousand cubic feet)

Species	Net annual growth	Ave. annual mortality
Jack pine	11,012	10,308
Red pine	23,687	386
White pine	8,767	873
White spruce	12,800	2,048
Black spruce	11,515	14,076
Balsam fir	17,030	32,234
Tamarack	12,328	4,452
E. red cedar	649	30
N. white-cedar	14,700	1,828
Other conifers	213	NA
White oak	14,845	993
Red oak	17,864	6,990
Hickory	879	75
Basswood	17,576	3,091

Species	Net annual growth	Ave. annual mortality
Yellow birch	104	278
Hard maple	12,365	1,071
Soft maple	14,995	2,219
Elm	-10,809	25,971
Black ash	18,585	3,787
Green & white ash	6,916	510
Cottonwood	1,205	332
Willow	506	351
Hackberry	406	92
Balsam poplar	9,292	14,937
Bigtooth aspen	8,359	2,600
Quaking aspen	114,996	67,100
Paper birch	23,388	20,984
Black cherry	408	132
Black walnut	465	20
Butternut	689	104
Other hardwoods	1,814	NA
Total	367,969	219,228

FIA Glossary

Mortality = The volume of sound wood in growing stock trees that die annually.

Growing stock volume = Net volume of growing stock trees greater than 5 inches dbh., from 1 foot above the ground to a 4 inch top diameter. This does not include decayed wood, rotten or dead trees.

Net growth = The annual change in volume of sound wood in live trees and the total volume entering these classes through ingrowth, less volume losses resulting from natural causes.

Timberland = Forest land that produces 20 cubic feet per acre per year of wood and that is not withdrawn due to urban or rural development or in reserve (ie: national park, scientific and natural area, etc.).

FOREST HEALTH HIGHLIGHTS

FOREST CONDITIONS AND PEST HIGHLIGHTS

Oak Wilt Suppression

The oak wilt suppression program that began in 1991 continued to make significant progress towards its stated goal of one (or less) infection centers per square mile in the treatment area by 1994. The total number of treated sites is approximately 1700. Between 1991 and 1994, over 130 miles of vibratory plow line have been installed and 5,000 spore producing trees have been removed.

At least four communities have virtually eliminated their oak wilt problem as of December, 1994.

Data on treatment effectiveness is becoming more available since three field seasons have passed on sites treated early in the program. Treatments are 88% effective in eliminating infection centers with just a single treatment with a 60" vibratory plow. Even where the disease breached the plow line, breakovers are very minor and easily retreated.

In addition to the treatments, DNR-Forestry staff, community foresters, and private consultants are cooperating to report activities and track accomplishments using GIS technology. Using the models and maps generated by this activity, communities and the state are able to accurately assess the program's accomplishments.

Gypsy Moth Attempts An Invasion

Due to a quarantine breach involving commercial nursery stock, Minnesota has been dealt a major blow in its battle to keep gypsy moth out of the state. Infested nursery stock was shipped to approximately 200 nursery outlets around the state before the incident was discovered in late May. Despite a major effort to locate, inspect, and treat the stock, many infested trees were sold and planted. Additional trees in the nurseries became infested when eggs hatched and young larvae migrated to preferred host material in the nurseries.

The breach lead to an increase in the number of male moths captured in pheromone traps in 1994. Trapping in 1994 produced 349 moths from 178 sites in 24 counties; whereas, 1993 produced only 97 moths from 64 sites in 15 counties. In addition, follow up surveys and intensive ground searches discovered fresh, Minnesota grown egg masses at seven sites.

Most of the egg mass "finds" were confined to very small areas, but two sites produced egg masses a distance away from the infested stock. On one site, a viable egg mass was found about 1500 feet away from the original nursery stock. All areas with egg mass finds will be sprayed, mass trapped and monitored.

Butternut Canker

Butternut canker, caused by *Sirococcus clavigignenti-julandacearum*, is rapidly killing off butternut trees as the disease spreads throughout its range. In 1994, cankered trees were found in four additional counties, enlarging the known range of the disease. The incidence of cankering on butternut trees ranged from 10-70% with cankering severity ranging from 10-60%. Cankers predominated on trees larger than 10" dbh.

Walnut Winter Kill

The winter of 1993-1994 caused dramatic and serious injury to black walnut trees in southeastern Minnesota. The type of walnut sites that sustained the most injury were either valley sites with steep adjacent side slopes or bottomland sites where the walnut was planted in the lowest part of a broader landscape. Ten percent of the walnut resource in plantations and natural stands may have been lost.

The vast majority of these plantations have no past history of any winterkill problems. In Wabasha and Goodhue Counties, 36 state plantations on upland and bottomland sites have been surveyed. Eight plantations (20%) had winter injury. The level of injury was either light or severe; there were no moderately injured plantations found. Lightly injured plantations had 10% to 15% of the trees with less than 25% crown dieback. Of the eight injured state land plantations in this survey, three were severely damaged. All three were located in valley positions with steep adjacent side slopes and had 75% to 100% of trees with crown dieback of more than 50%.

Spruce Budworm

In central Minnesota counties, spruce budworm concentrated defoliation on white spruce plantations 20-40 years old. It did not cause notable defoliation in balsam fir. This was anomalous behaviour in terms of the Minnesota experience. The last time budworm was active in these counties was 1954, when a one year outbreak occurred in the Chippewa National Forest.

Most of the ground surveyed plantations had two or three years of heavy defoliation causing enough shoot mortality to cause a massive proliferation of buds which in turn causes tufting of the branches. In addition, this is the approximate time when diameter growth losses occur and height growth ceases. In the next one or two years, these trees will become top-killed if there is continued heavy feeding damage.

Currently, the budworm population is not utilizing all the new-growth needles so there's enough food for the population to intensify. The outbreak could collapse next year, but it is more likely that it will run its course, anywhere from four to twelve more years of defoliation.

Health of the maple resource

For the third field season, Minnesota participated in the North American Maple Project and eight plots were remeasured. This year only crown ratings and tree vigor were remeasured. Each tree crown is evaluated for branch dieback, foliage transparency, foliage discoloration, dwarfed foliage and insect defoliation. Any new insect or disease injury and seed production was also recorded.

The trees all looked good this year. Since there has been little disturbance, (drought or insect defoliation), there was little dieback and the crown transparencies were low. There was some branch mortality caused by squirrels peeling off the bark. For the second year of collecting seed data there was no seed production in there stands.

Forest Health Monitoring

From June 13 to September 1, 1994, crews travelled throughout Minnesota installing plots to begin monitoring the health of the forests. This is a new effort in Minnesota and is part of a nationwide program called "Forest Health Monitoring" (FHM). The motivation to begin monitoring the health of our forested

ecosystems grew out of the observed effects of air pollutants, insects, diseases, and other stressors as well as the concern over the potential effects of global climate changes to the composition and stability of our forests. The FHM Program began in 1990 in the northeastern states and is a partnership between the Environmental Protection Agency (EPA) and state and federal agencies involved in managing forests. In Minnesota, there are 360 permanent FHM plots and approximately 120 of them are forested. Each plot is made up of a cluster of 4 subplots with a fixed radius of 24 feet. Within each subplot are smaller plots for sampling seedlings, saplings, and other vegetation.

PROGRAM HIGHLIGHTS

❧ Surveyed 14.2 million acres of forest land for damage, pest occurrence and life stages. The three major defoliators were aspen defoliator complex, 599,000 acres; spruce budworm, 194,000 acres; and, jack pine budworm, 46,800 acres. Winterkill of hardwoods, particularly black walnut, was the main abiotic problem. This prompted a revision of the black walnut management guidelines.

❧ Placed, monitored and retrieved 516 gypsy moth pheromone traps as part of the statewide, interagency monitoring effort which totalled 6,048 traps. 349 moths were taken in 24 counties. This was a significant increase over the past few years and was due to the quarantine breach in May.

❧ Cooperated with APHIS on trapping common pine shoot beetles and other exotic bark beetles. The tentative identification of the beetles caught indicate that only native beetles were trapped.

❧ Continued participation in the North American Maple Project which evaluates long term change in managed and unmanaged sugar maple stands. Eight plots were remeasured during the growing season.

❧ Began on-plot Forest Health Monitoring in Minnesota. FIA plots were installed over the top of the new FHM plots so that FIA and FHM could be more closely linked.

❧ Treated over 700 oak wilt infection centers under the auspices of the Cooperative Oak Wilt Suppression Program. This brings the project to a total of over 1700 infection centers treated. To date, over 131 miles of vibratory plow line have been installed. The total value of the program now exceeds $3,100,000.

❧ Released a PC-based, high resolution, high performance GIS data access system, called EPIC. It was cooperatively developed by the Forest Health Unit with several other state agencies. It permits Forest Health professionals to bring together soil, climate, cover, administrative, insect and disease and other data layers for analysis.

❧ Drafted "Gypsy moth hardwood silviculture guidelines" for use in our managed stands to prepare for the inevitable outbreak of gypsy moth. Two Forest Health Specialists and two Regional Silviculturists developed this draft guideline. The goals are to reduce susceptibility and vulnerability of hardwood stands by maximizing tree growth and vigor and by altering stand composition. As the threat of gypsy moth defoliation becomes imminent, additional cultural practices will be implemented.

❧ Participated in the interagency "Gypsy moth SWAT team" handling the aftermath of the gypsy moth quarantine breach.

❧ Trained the FIA/FHM crews to identify forest pests and damage.

❧ Educated 544 people during insect and disease training sessions. An additional 140 people were trained during a Burning Workshop.

❧ Held a one day workshop for field foresters on the management of spruce budworm. Emphasis was placed on shared concerns for the white spruce plantations in the central counties, where budworm occurs now, but has not been an historic pest.

❧ Expanded hazard tree training to include outstate training. In Michigan, a "train the trainers" session was held for Michigan DNR Parks, Forestry, Urban and Community and private consultants. At home in Minnesota, 308 city foresters and tree inspectors were trained; this represents 125 communities.

❧ Produced the second gypsy moth poster, "Metamorphosis", with a press run of 7,500. The poster is targeted at biology classes at the secondary level. It features a full color front illustrating the gypsy moth's life stages and the back is full of details on biology and ecology.

❧ Produced 10,000 copies of a poster, "How to Identify Hazard Trees". This full color poster is a synopsis of the Hazard Tree Manual. The seven hazard categories are illustrated on the front side. Methods for detecting, assessing and correcting hazard trees are presented on the back side. The poster can be used for urban or recreational purposes.

❧ Received an award for co-authoring "Woodland Stewardship; a Practical Guide for Midwestern Landowners". Published in 1993, it is a complete guide for private landowners wishing to create a plan for their land.

❧ Wrote or presented the following:

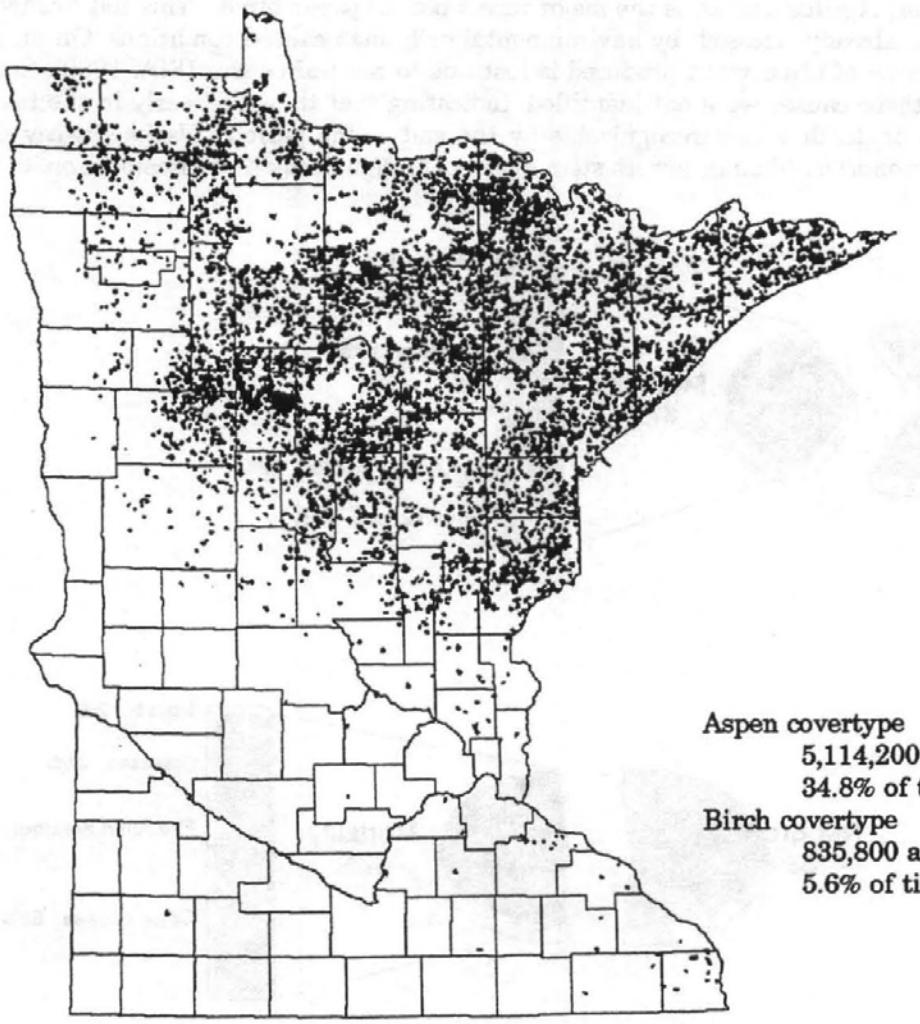
"Forest Health Monitoring" for Roots
"Five Favorite Fall Tours" for The Volunteer
"Winter kill of black walnut"
Birch Loss Assessment for the State Cooperators Meeting
EPIC demonstration for the State Cooperators Meeting
EPIC: A User's Manual
Insect and Disease Annual Report for 1993

❧ Produced six Insect and Disease Newsletters containing 61 articles. The circulation is now over 850, with the readership primarily state, urban and federal foresters yet an increasing number of people from the general public subscribe to the Newsletter.

❧ Attended these meetings:

Western Forest Disease Work Conference in Albuquerque, NM.
Annual Gypsy Moth Review in Portland,OR.
Hazard Trees: The Ultimate Session in Sturbridge, MA.

ASPEN - BIRCH FORESTS



Aspen covertype
5,114,200 acres
34.8% of timberland

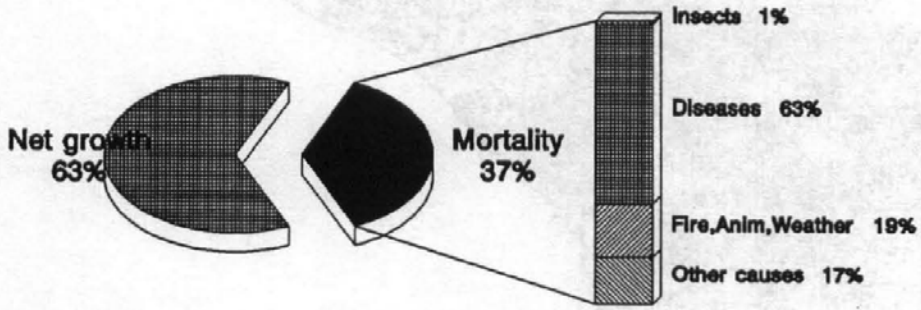
Birch covertype
835,800 acres
5.6% of timberland

DAMAGING AGENTS AND THEIR EFFECTS

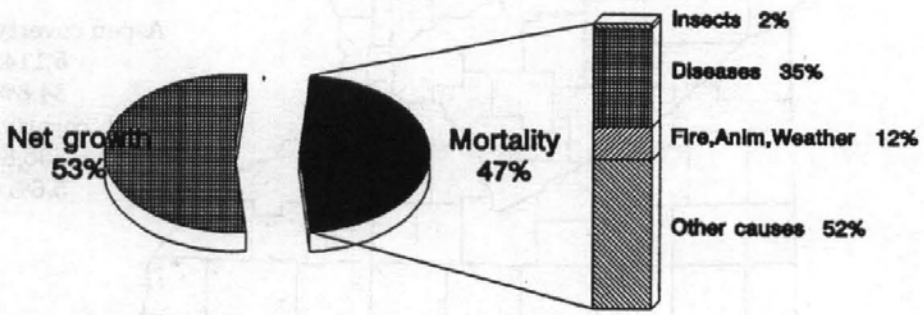
Defoliators and wood boring beetles are the major insect pests of aspen. The forest tent caterpillar, *Malacosoma disstria*, and the large aspen tortrix, *Choristoneura conflictana*, occasionally defoliate areas of several thousand square miles. Severe defoliation reduces growth but rarely causes mortality unless coupled with other stresses. Wood boring beetles of the genus *Saperda* cause increased wind breakage and lumber and veneer degrade. As much as 64% of all mature aspen in a stand may be attacked.

The major diseases of aspen are Hypoxylon canker, *Hypoxylon mammatum*, and white rot, *Phellinus tremulae*. Hypoxylon canker is a fatal disease and causes serious volume losses. On an annual basis, 37% of the volume of aspen wood produced is lost to natural causes (FIA, 1990). See chart below. Diseases accounted for 63% of these volume losses (with Hypoxylon canker being the likeliest cause). Losses from decay cannot be discerned from FIA data because the volumes already reflect deductions for decay, sweep, crook, etc.

The bronze birch borer, *Agrilus anxius*, is the major insect pest of paper birch. This flat-headed borer attacks and kills trees already stressed by environmental or human-caused conditions. On an annual basis, 47% of the volume of birch wood produced is lost due to natural causes (FIA, 1990). See chart below. Over half of these causes were not identified, indicating that they died early in the inventory period and the cause of death was unrecognizable by the end of the period. Various decay causing organisms, notably, *Inonotus obliquus*, lowers stem quality through decay and discoloration.



Aspen



Paper birch

Pests included in this report:

Aspen defoliator complex
Aspen blotchminer
Birch leaf miner
Birch mortality
Pale green weevils

Aspen defoliator complex

A collection of the aspen defoliators from central Minnesota during mid-May included:

Archips purpurana (Clemens)	(omnivorous leaf roller)
Choristoneura conflictana (Walker)	(large aspen tortrix)
Choristoneura rosaceana (Harris)	(obliquebanded leaf roller)
Orthotaenia undulana (Dyar & Smith)	(dusky leaf roller)
Pseudosciaphila duplex (Walsingham)	(spotted aspen leaf roller)
Agonopterix argillacea (Walsingham)	
Epinotia criddleana Kearfott	

Host: Aspen
Damage: Leaf rolling and leaf tieing
Area: 599,600 acres
Severity: Defoliation of individual trees within the mapped area was greater than 50% and the vast majority of trees were affected.
Trend: Acreage more than doubled since 1993 with two main centers in Pine County and in Cass/ Wadena Counties.

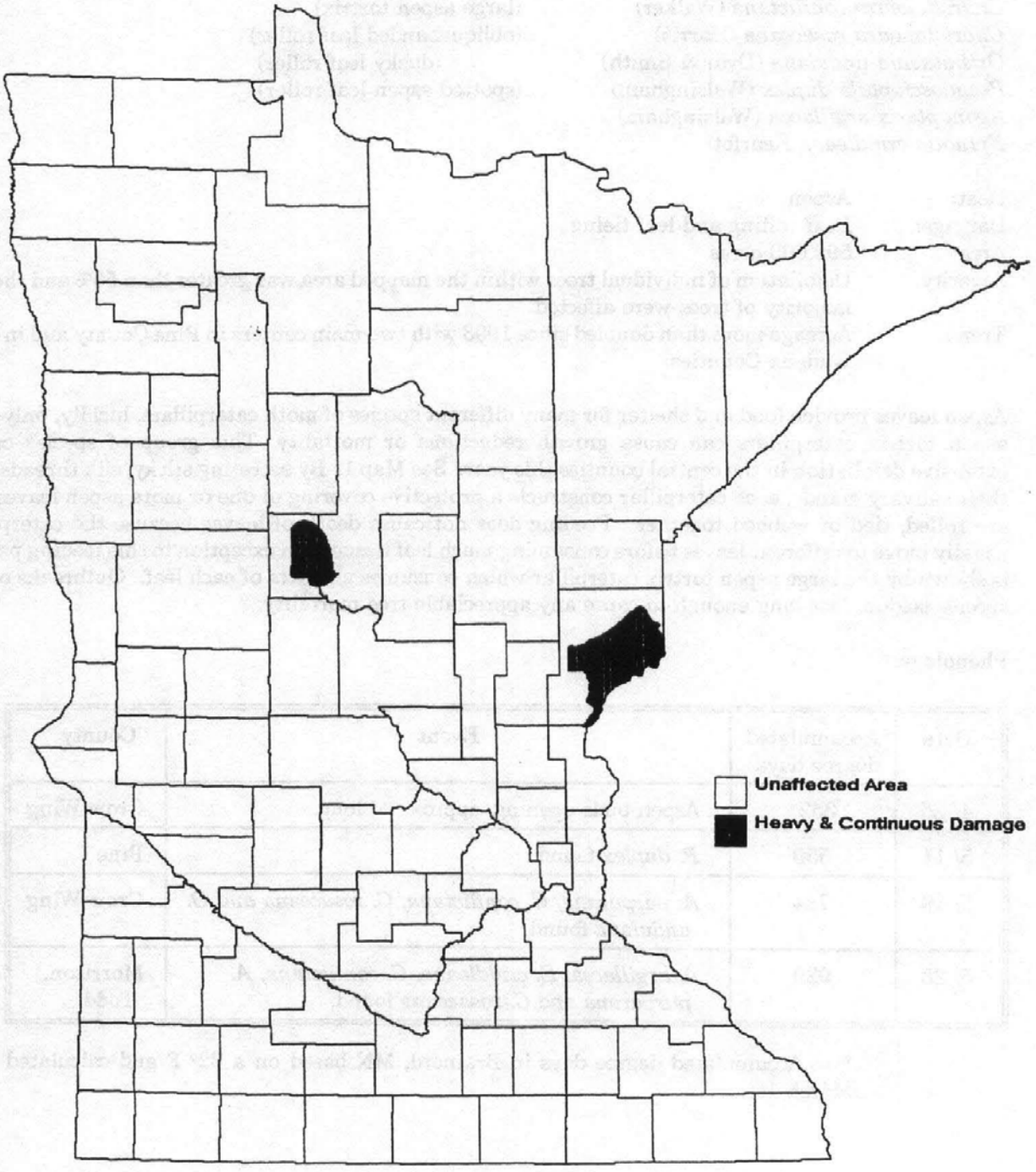
Aspen leaves provide food and shelter for many different species of moth caterpillars, luckily, only large aspen tortrix caterpillars can cause growth reductions or mortality. This group of species caused extensive defoliation in the central counties this year. See Map 1. By secreting sticky, silk threads from their salivary glands, each caterpillar constructs a protective covering of one or more aspen leaves that are rolled, tied or webbed together. Feeding does not cause death of leaves because the caterpillars usually move to different leaves before consuming much leaf tissue. An exception to this feeding pattern is shown by the large aspen tortrix caterpillar which consumes all parts of each leaf. Outbreaks of this species seldom last long enough to cause any appreciable tree mortality.

Phenology:

Date	Accumulated degree days	Event	County
4/ 25	352*	Aspen buds opening, approx. ¾" long.	Crow Wing
5/ 11	559	*P. duplex* found.	Pine
5/ 19	784	*A. purpurana, C. conflictana, C. rosaceana and O. undulana* found.	Crow Wing
5/ 23	929	*A. argillacea, E. criddleana, C. conflictana, A. purpurana and C. rosaceana* found.	Morrison, Todd

* = Accumulated degree days in Brainerd, MN based on a 32º F and calculated since March 1st.

Map 1. Aspen defoliator complex, 1994.



Aspen blotch miner

Phyllonorycter nr. salicifoliella (Chambers) on quaking aspen
Phyllonorycter nipigon (Freeman) on balsam poplar

Host: Quaking aspen, balsam poplar
Damage: Leaf mining
Area: Not determined
Severity: Heavy
Trend: Some blotch miner activity is reported every year. Blotch miner activity increased in 1993 and was particularly notable in Beltrami, Itasca, Koochiching and Cass Cos. In 1994 blotchminer activity increased again and caused early leaf fall across northeastern Minnesota.

The aspen leaf blotch miner caused many aspen trees in central and northern Minnesota to develop an overall tan leaf color. There can be ten or more of these insects in separate or conjoined mines in a single leaf. Last year the average was four mines per leaf. In most years blotchminers can be found on small roadside aspen. This year blotch miner activity was heavy on aspen trees of all sizes and on balsam poplar. Blotch miners were not limited to edge or roadside trees but occurred across entire stands. In some locations up to 75% of the leaf area was damaged. Leaves turned brown and dried up as early as late July. Buds for 1995 are well formed; so, tree and branch mortality are unlikely. A number of calls were received from people wondering if the damage was from the spraying of roadside herbicides or acid rain or some kind of pollution falling from the sky.

Phenology

Date	Event	Location
6/29	Blotchminer mines ⅛ to ¼ inches in diameter and not yet showing through the top of the leaf.	St. Louis Co.

Birch leaf miner

Fenusa pusilla (Lepeletier)

Host: Birch
Damage: Leaf mining
Area: Not determined
Severity: Heavy
Trend: Distribution and damage increased over 1993 levels.

Birch leaf miner is mainly a problem in urban areas but can also be abundant in forested parts of northeastern Minnesota. It is a common pest and in most years there are numerous reports of damage. Last year, 1993, was an exception with very few reports of birch leaf miner. Birch leaf miner activity resumed its normal occurrence in 1994. There were many reports of heavy leaf mining throughout the northeastern part of the state in the urban as well as the forest setting.

Birch mortality

Drought, Defoliation, Age, and Bronze birch borer

Host:	Birch
Damage:	Mortality and dieback
Area:	Not determined
Severity:	Light
Trend:	The amount of birch mortality has returned to a low level, probably the normal background level, from a high in 1991 and 1992.

A very high level of birch mortality occurred in 1991 and 1992. This mortality followed the drought of the late 1980's and was attributed to the combination of drought, defoliation, age, and bronze birch borer. It was estimated that 105,440,000 birch trees of all sizes died due to drought, defoliation, age, and bronze birch borer during a 4.3 year period. This loss is approximately 20% of the trees that were alive as of the last Forest Inventory Analysis in 1989 on a statewide basis.

Rainfall levels have returned to normal or above normal for the past couple of years and with it levels of birch mortality, in 1993 and 1994, have returned to more normal, or background, levels.

Pale green weevils

Polydrusus impressifrons (Gyllenhal)

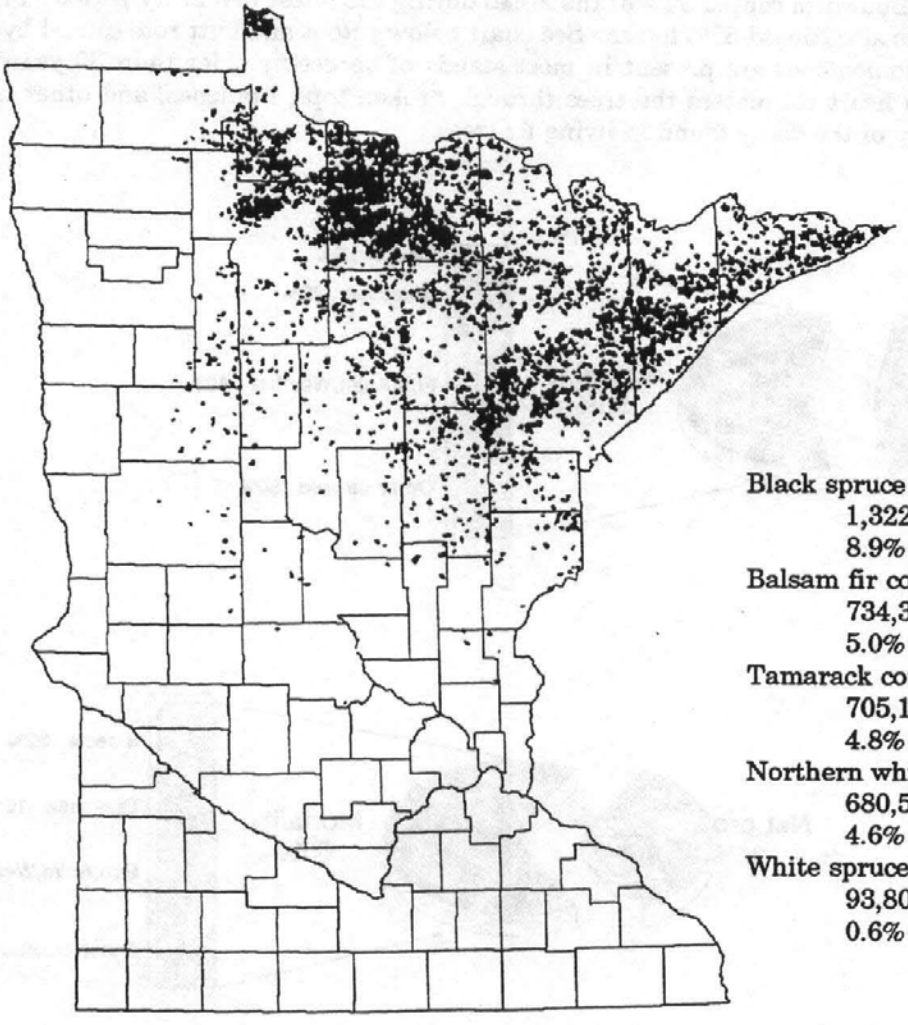
Host:	Aspens and other broad leaf trees and shrubs
Damage:	Defoliation
Acreage:	Not determined
Severity:	Very light defoliation
Trend:	It has been commonly reported in the past five years. Noted heavier populations than in 1993.

Heavy populations of *Polydrusus impressifrons* were observed in the north central counties during June and July yet damage to aspen leaves was minimal. The pale green weevils were almost completely gone by August 1st.

This insect is a snout beetle which is light metallic green and about 1/5th of a inch long. The adults feed by nibbling developing buds and chewing on the edges of leaves leaving a ragged margin on the leaf. Adults are present from late May to late July. The adults feed on most broad leaf trees and shrubs but seem to prefer birch and poplars. There was one report of weevils defoliating raspberries to the point that the grower wanted control recommendations. In addition to being present on plants, the adults were common in houses, on cars and on people. Most of the reports of the weevil were a result of people finding them on their clothing or in and about their houses.

The pale green weevil is an introduced species from Europe and was discovered in New York in 1906. It is not known how long the weevil has been present in Minnesota; however, in the past five years it has been commonly found in the northeastern part of the state.

SPRUCE-FIR FORESTS



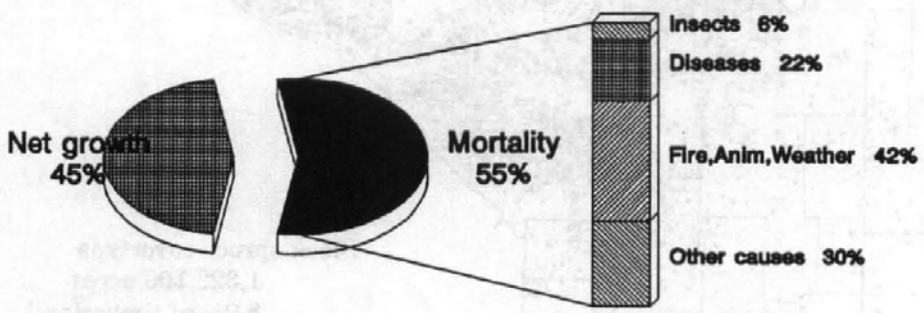
Black spruce covertype
1,322,100 acres
8.9% of timberland
Balsam fir covertype
734,300 acres
5.0% of timberlan
Tamarack covertype
705,100 acres
4.8% of timberland
Northern white cedar covertype
680,500 acres
4.6% of timberland
White spruce covertype
93,800 acres
0.6% of timberland

DAMAGING AGENTS AND THEIR EFFECTS

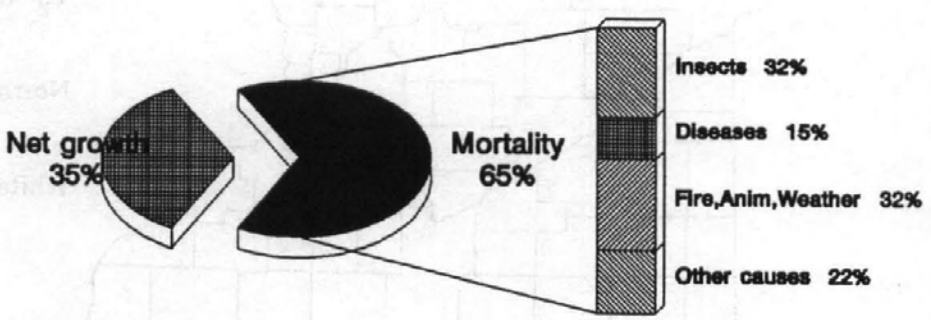
The major disease problems on black spruce are dwarf mistletoe, *Arceuthobium pusillum*, and root and butt rots. Black spruce is attacked and killed in all stages of its development by dwarf mistletoe. On an annual basis, 55% of the volume of black spruce wood produced is lost due to natural causes (FIA, 1990). See chart below. Losses in black spruce were due primarily to blow down and beaver flooding, although dwarf mistletoe accounted for 22% of the losses. Root and butt rots caused by *Armillaria* spp. and *Inonotus tomentosus* are present in most stands over 30 years of age. Losses from root and butt rots

may range up to 40% of the merchantable volume of the stand. Root rots are the major contributing factor to wind damage.

The spruce budworm, *Choristoneura fumiferana*, is the most destructive insect in Minnesota forests and causes the greatest mortality volume loss. It attacks, injures and kills all age classes of balsam fir. The spruce budworm outbreak in northeast Minnesota has been continuous since at least 1954, when aerial mapping started. Budworm caused 32% of the losses during the latest inventory period. Fire, animals and weather events also caused 32% losses. See chart below. Root and butt rots caused by *Armillaria* spp. or *Inonotus tomentosus* are present in most stands of spruce-fir older than 30 years. *Stereum sanguinolentum*, a heart rot, enters the trees through broken tops, branches, and other injuries and causes the majority of the decay found in living fir trees.



Black spruce



Balsam fir

Pests included in this report:

Spruce budworm
Yellow-headed spruce sawfly
Larch sawfly
W-marked cutworm
Larch needlecast
Cedar browning

Spruce budworm

Choristoneura fumiferana (Clemens)

Hosts: Balsam fir, white spruce
Damage Area: Defoliation, topkill, mortality
Severity: 198,000 acres of defoliation

Acres* and severity of budworm defoliation by county.

COUNTY	Defoliation < 50% and scattered	Defoliation >50% and scattered	Defoliation >50% and continuous	TOTAL ACRES
Carlton	0	0	0	0
Cook	0	0	48,943	48,943
Itasca	0	2,487	699	3,186
Koochiching	0	2,455	82	2,537
Lake	0	0	43,832	43,832
St Louis	0	42,277	41,379	83,656
Aitkin	1,015	0	473	1,488
Cass	9,060	908	1,363	11,331
Chisago	0	303	0	303
Crow Wing	2,430	0	0	2,430
Wadena	0	348	0	348
TOTAL ACRES	12,505	49,251	136,298	198,054

* = Acreage figures derived from Eppl7 comparison of 1990 FIA cover types and 1994 aerially sketched-mapped stands with spruce budworm defoliation. The FIA cover types include balsam fir and white spruce.

Trend:

Populations and acreage increased in northern Lake, St. Louis, and Cook Counties occurring in natural stands of balsam fir and white spruce as well as in plantations. Populations and acreage in Koochiching and Itasca Counties were similar to 1993 and again occurred primarily in 20+ year old white spruce plantations.

A one year outbreak of spruce budworm occurred in the Chippewa National Forest in 1954. Since then, budworm activity has not been noticed or documented. In 1992, defoliated white spruce plantations were observed in northern Aitkin County. In 1993

surveys were more extensive and defoliation was detected in 10 spruce plantations in northern Cass and Crow Wing Counties. There was no defoliation of nearby balsam firs.

Comparing 1993 acreage with 1994 acreage shows quite a large increase. However, the acreage figures are not directly comparable because acreage was determined by different methods in 1993 and 1994. Acreage in 1993 was based on white spruce and balsam fir covertypes using an average per township for each county from the 1990 FIA data. Acreage in 1994 was determined using EPIC and 1990 FIA covertypes. Only spruce - fir covertypes within the areas of defoliation were counted. In Region 2, only heavy defoliation (>50% defoliation) was recorded in 1994 and most of the areas of light and moderate defoliation were not recorded.

Both populations and acreage of defoliation increased somewhat in Lake, Cook and St. Louis Counties in 1994. See Map 2. Populations in Koochiching and Itasca Counties were similar to 1993 levels and noticeable defoliation was confined almost exclusively to 20+ year old white spruce plantations. Why the budworm has been occurring in the white spruce plantations and not in the natural balsam fir stands is not entirely understood, but is believed to be a result of the influx of moths from the northeast outbreak areas and also the weather the past couple of years. The cool springs and summers the past couple of years may have delayed hardening off of the spruce needles keeping them more palatable to the budworm than normal. This may have allowed larger populations to develop and survive on white spruce than normally would occur.

There were a lot of heavy rains in June and July. For example north of Virginia, 10.5 inches of rain fell one day in mid-June. This knocked a lot of the budworm damaged needles off trees and affected the apparent defoliation during the aerial survey. There were also several reports that the rains may have knocked larvae and pupae off trees.

During aerial detection flights in the north central counties, fifteen plantations and natural white spruce stands were discolored by budworm defoliation. See Map 2. Spruce budworm activity continued to concentrate in 20-40 year old plantations, some of which have had three consecutive years of defoliation. Most of the ground surveyed plantations had two or three years of heavy defoliation causing enough shoot mortality to cause a massive proliferation of buds which causes tufting of the branches. After two to three years of heavy defoliation, radial growth losses occur and height growth ceases. In the next one or two years, these trees will become top-killed if there is continued heavy feeding damage.

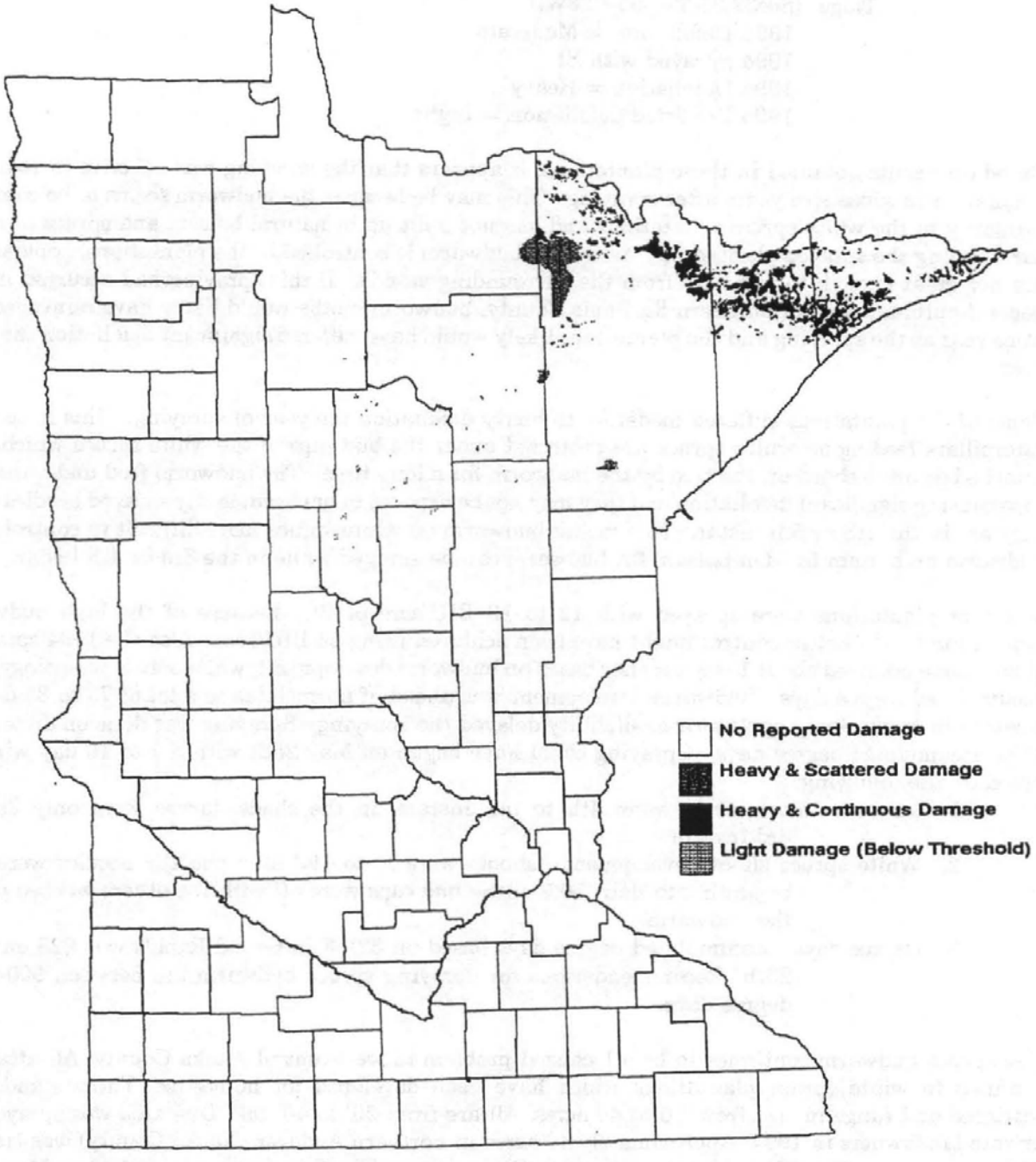
In northern Cass County, up to 50% of this year's needles were chewed off balsam firs in a few locations. Otherwise, balsam fir defoliation was minimal or non-existent in the north central counties.

A number of private white spruce plantations in Itasca and Aitkin County were sprayed in 1993 and 1994. Results are shown below:

Lawrence Lake (Sec35-Twp58N-R24W)
- 1992 Defoliation = moderate to heavy
- 1993 Sprayed with Bt
- 1993 Defoliation = Moderate
- 1994 Defoliation = Very Light
- 1995 Predicted defoliation = Moderate

Ball Bluff (Sec6&7-Twp51-R23W)
- 1993 Sprayed with Bt
- 1993 Defoliation = Moderate
- 1994 Defoliation = Very light
- 1995 Predicted defoliation = None

Map 2. Spruce budworm defoliation, 1994.



Big Smith Creek (Sec11,14,15-Twp53N-R26W)
1993 Defoliation = Heavy
1994 Sprayed with Bt
1994 Defoliation = Light
1995 Predicted defoliation = Light
Tioga (Sec32,33-Twp55-R26W)
1993 Defoliation = Moderate
1994 Sprayed with Bt
1994 Defoliation = Heavy
1995 Predicted defoliation = Light

Based on results obtained in these plantations, it appears that the spraying was effective in reducing defoliation in successive years after spraying. This may be because the budworm seems to be confined primarily to the white spruce plantations and has not built up in natural balsam and spruce in areas surrounding the sprayed plantations. When the budworm is controlled in the plantations, populations are not great enough to reinvade from the surrounding stands. If this spraying had occurred in the general outbreak area of northern St. Louis County, budworm moths would likely have reinvaded the same year as the spraying and the plantations likely would have suffered significant defoliation the next year.

Some of the plantations suffered moderate to heavy defoliation the year of spraying. This is because caterpillars feeding on white spruce are protected under the bud caps of the white spruce which stay attached or are webbed on the tree by the budworm for a long time. The budworm feed under the bud caps causing significant defoliation and they may not be exposed to or consume any sprayed needles until they are in the 4th or 5th instar. This makes budworm on white spruce more difficult to control than budworm on balsam fir. On balsam fir, budworm can be sprayed while in the 3rd or 4th instar.

The four plantations were sprayed with 12 to 13 BIU/acre of Bt. Because of the high budworm population levels, better control might have been achieved using 24 BIU/acre. Also the 1994 spraying should have occurred about 1 week earlier based on budworm development, white spruce phenology, and accumulated degree days. Budworm development was ahead of normal due to a lot of 70 to 85 degree weather in May. Spray applicator availability delayed the spraying. Spraying was done on June 1, at 1131 accumulated degree days. Spraying could have begun on May 25th with a 7 to 10 day window based on the following:

1. Larvae - most larvae were 4th to 5th instars; in the shade, larvae were only 2nd to 3rd instars.
2. White spruce shoot development - shoots were 1" to 1¼" long and the needles were just beginning to flair; 50% of the bud caps were off with the others webbed on by the budworm.
3. Degree days - accumulated degree days based on 32° F in Grand Rapids was 928 on May 25th. Recommendations for spraying spruce budworm are between 900-1100 degree days.

The spruce budworm continues to be a localized problem in west-central Anoka County. All attack is confined to white spruce plantations which have been developed for homesites. These stands are scattered and range in size from 20 to 40 acres. All are from 20' to 40' tall. One area was sprayed by private landowners in 1994. Approximately 40 acres in northern Andover (Anoka County) was treated with two sprays of Bt (Dipel AF) at a rate of 16 BIU per acre. The first spray was applied on May 25th and the second, a week later. The cost was approximately $45 per acre. DNR FHU staff provided technical support in spray timing and general advice. Results were good, but some landowners were disappointed when they could still find a few caterpillars a week after the spray. Several other areas received moderate to severe defoliation, but were not sprayed.

Egg mass survey results from 20 locations in the north central counties indicate that defoliation will intensify in three plantations and remain similar or decrease in the remainder. See Survey Results section. Currently, the budworm population is not utilizing the current year's needles. There's enough food for the population to intensify. The outbreak could collapse next year, but it is more likely that there will be an additional four to twelve more years of defoliation.

A one day field session to discuss the effects and impacts of an outbreak and options for managing the spruce stands was held on September 27th. A detailed report is included in the Special Projects section of this report. It is titled "Spruce Budworm Conclave".

Pheromone trapping was done in a number of white spruce plantations. See Survey Results section. There do not appear to be any good correlations between 1994 defoliation levels and trap catches or between trap catches and predicted 1995 defoliation levels based on the egg mass survey. There were a small number of trap locations but past years' trapping data have not shown any strong correlations either. Spruce budworm pheromone trapping does not appear to be very useful for forest managers at this time.

Phenology:

Date	Accumulated degree days	Event	Location
5/ 5	422	No larval activity in buds.	Cass (141-28)
5/ 13	854	20% of bud caps have fallen off white spruce shoots.	Anoka
5/ 18	1002	Second instar larvae noted in buds.	Anoka
5/ 18	678	White spruce shedding pollen.	Itasca
5/ 19	708	**Larvae in 2nd with a few 3rd instars feeding under bud caps.** Juneberry starting to drop flower petals,bigtooth aspen starting to leaf out. Pin cherry in bloom. Buds in sunny locations starting to enlarge, needles can be seen at base of bud. Temp 85 F.	Itasca Co.
5/ 20	746	Crab apple in bloom. Temp 85 F.	Itasca Co.
5/ 23	857	Jack pine beginning to shed pollen. Lilacs starting to bloom.	Itasca Co.

5/ 25	1258	Fifth and sixth instar larvae. SBW plot (34-17) where number of larvae = 14 on 9 twigs.	Sherburne Co.
5/ 25	928	Fifty to 200 buds per twig. Larvae 4th-5th instar in sun, mostly 2nd - 3rd instar in shade, 50% of white spruce bud caps are off, others are webbed on by budworm, white spruce shoots are 1-1 ¼" long and needles just beginning to flair.	Itasca Co.
5/ 27	1308	Fifty percent of shoots infested at private suppression area.	Anoka
6/ 1	1131	White spruce plantations sprayed with Bt.	Itasca
6/ 4	1585	Moths emerged from collections taken in Sherburne Co.	Sherburne
6/ 6	1663	Pheromone traps set up.	Sherburne
6/ 15	1405	Completely pupated.	Hubbard (141-32)
6/ 18	1641	75% pupation. Most damaged needles have been washed off trees by heavy rains.	northern St. Louis
6/ 24	1869	Most moths have emerged and some new egg masses are present.	northeastern Itasca
6/24		20% of moths have emerged.	southeastern Koochiching
6/ 27	2491	Egg masses hatched.	Sherburne
7/ 1	2109	Weather has been overcast with heavy rains during moth flight and egg laying.	northeastern counties
7/ 7	2311	Moths still flying	St. Louis
7/ 12	2483	A few moths are still flying, but the moth flight is over for the most part.	northern St. Louis

8/ 15		Balsam fir are still a bit discolored due to defoliation in wind-protected locations.	Cass (141-26)
8/ 16		Latest date pheromone traps were retrieved.	Aitkin (51-23)

Yellow-headed spruce sawfly

Pikonema alaskensis (Rohwer)

Host: White spruce
Damage: Defoliation
Acres: Approximately 40 acres in Rice and Freeborn Counties and scattered ornamentals trees in all Metropolitan Region counties.
Severity: Light to severe defoliation.
Trend: Increasing in Rice and Freeborn Cos., elsewhere static or decreasing.

Yellow-headed spruce sawfly activity was generally down in the northwestern counties during 1994. The sawfly populations remained low in Steele Co. in 1994. However, this year in Rice County, heavy defoliation occurred. Rice and additional areas of concern in Freeborn County will need egg surveys next spring.

Phenology:

Date	Accumulated degree days	Event	County
6/ 29	2047	Larvae are 1" long.	St. Louis

Larch sawfly

Pristiphora erichsonii (Hartig)

Host: Tamarack
Damage: Defoliation
Acres: 100 acres
Severity: Not determined
Trend: Unknown

Larch sawfly was observed in a number of scattered locations in southwestern St. Louis County in mid-July. The largest area of detected defoliation was less than 100 acres of moderate to heavy defoliation in Section 21, Township 53N, Range 18W. In addition to larch sawfly both the light and dark stages of the larch looper, *Semiothisa sexmaculata* (Packard), were also found. The larvae were ¾ inches long on 8/6/94. Reports of larch sawfly were also received from scattered locations in Region 1.

W-marked cutworm

Spaelotis clandestina (Harris)

Host: Balsam fir
Damage: Defoliation
Acres: 10-15 acres
Severity: Severe defoliation
Trend: Occurred in 1993 and in 1994. These cutworms were a problem again this year.

The w-marked cutworms made a return trip to a young conifer plantation west of Bemidji. They first appeared in the spring of 1993, severely stripping newly planted balsam fir. In 1994, the cutworms again were found feeding on balsam fir seedlings and chemical control was instituted.

Larch needlecasts

Mycosphaerella laricina (Hart.) Neg.
Meria laricis Vuill.

Host: European larch
Damage: None
Acres: None
Severity: None
Trend: None

In September, several young European larch plantations were surveyed for larch needlecast diseases. Needlecasts were not observed in the field. See table below. Samples were brought into the lab for identification of fungi on the needles. Neither needlecast fungus was found.

Larch needlecast.

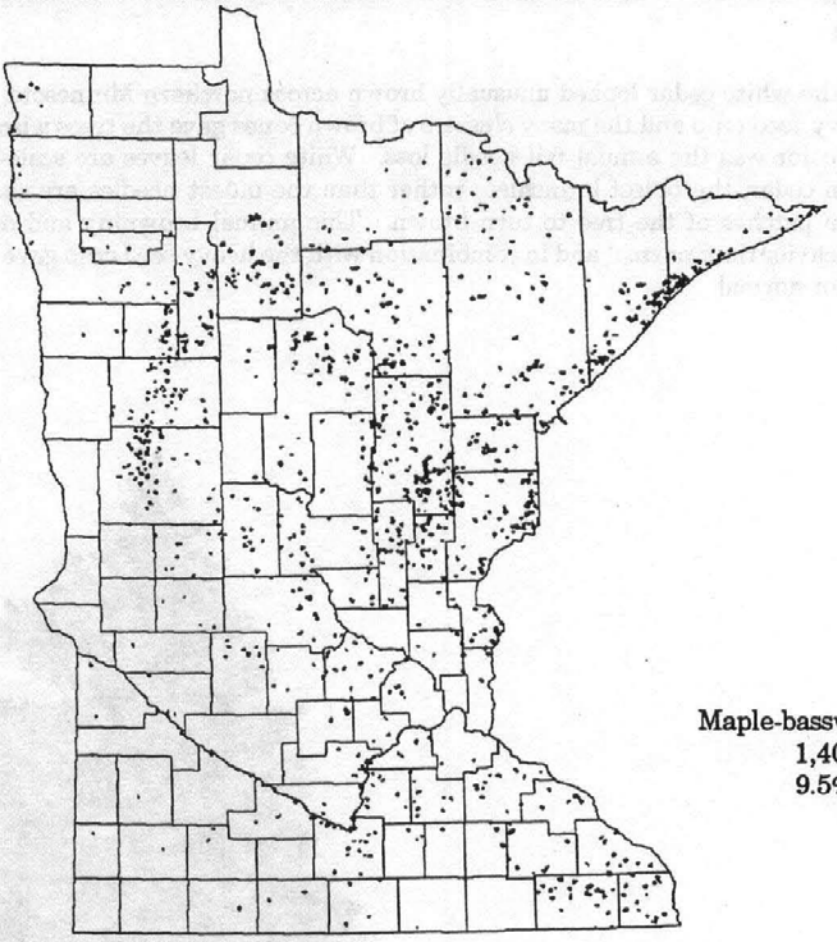
County	Legal description	Acres	Ownership	Needlecast
Carlton	18-48-18	12	State	None
Cass	NESW 23-145-29		State	None
	S½ of NE 25-145-28		State	None
Itasca	SE 16-56-25	2	Private	None
Lake	SE 17-59-8		State	None
	SESW,SWSE 16-55-11	10	State	None

Brown discoloration of white cedar

Host: White cedar
Damage: None
Area: None
Severity: None
Trend: None

In the fall of 1994, the white cedar looked unusually brown across northern Minnesota. White cedars produced a very heavy seed crop and the many clusters of brown cones gave the trees a brown cast. Also contributing to the color was the annual fall needle loss. White cedar leaves are scale-like and cover small branchlets. In cedar, the oldest branchlets rather than the oldest needles are shed in the fall. This can cause large patches of the tree to turn brown. This annual browning and dropping of old branchlets seemed heavier than normal and in combination with the heavy seed crop gave the trees more of a brown color than normal.

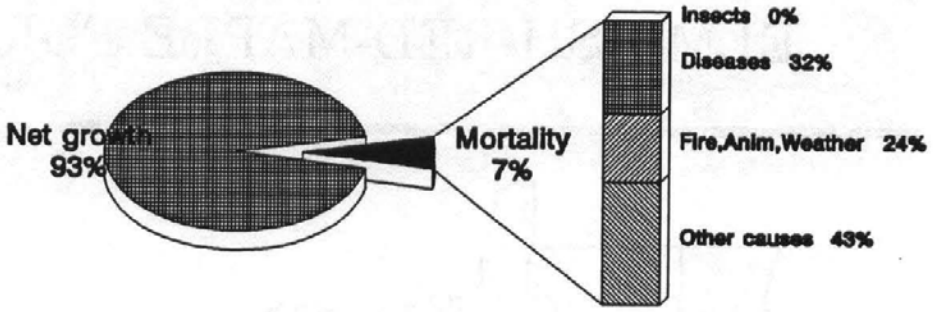
MAPLE-BASSWOOD FORESTS



Maple-basswood covertype
1,402,900 acres
9.5% of timberland

DAMAGING AGENTS AND THEIR EFFECTS

The greatest volume losses in northern hardwood species are the result of disease organisms which discolor, decay, or deform standing timber. Occasional tree mortality can be caused by shoestring root rot fungus, *Armillaria* spp., and sapstreak disease, caused by *Ceratocystis coerulescens*, in wounded or stressed trees. Mortality in the northern hardwood type is not common. On an annual basis, 7% of the volume of basswood and maple wood produced is lost to natural causes (FIA, 1990). This does not include harvest removals. There were no outstanding causes of mortality as identified by the Inventory. See chart below. Growth losses and periodic declines can occur following insect defoliation or adverse climatic conditions. Defoliators include basswood thrips, saddled prominent, orange-humped mapleworm, green-striped mapleworm and maple trumpet skeletonizer. Canker diseases caused by *Nectria galligena* and *Eutypella parasitica* can reduce yields, cause minor mortality in young trees and serve as openings for decay organisms.



Maple-basswood

Pests included in this report:

Forest tent caterpillar

Forest tent caterpillar

Malacosoma disstria Hubner

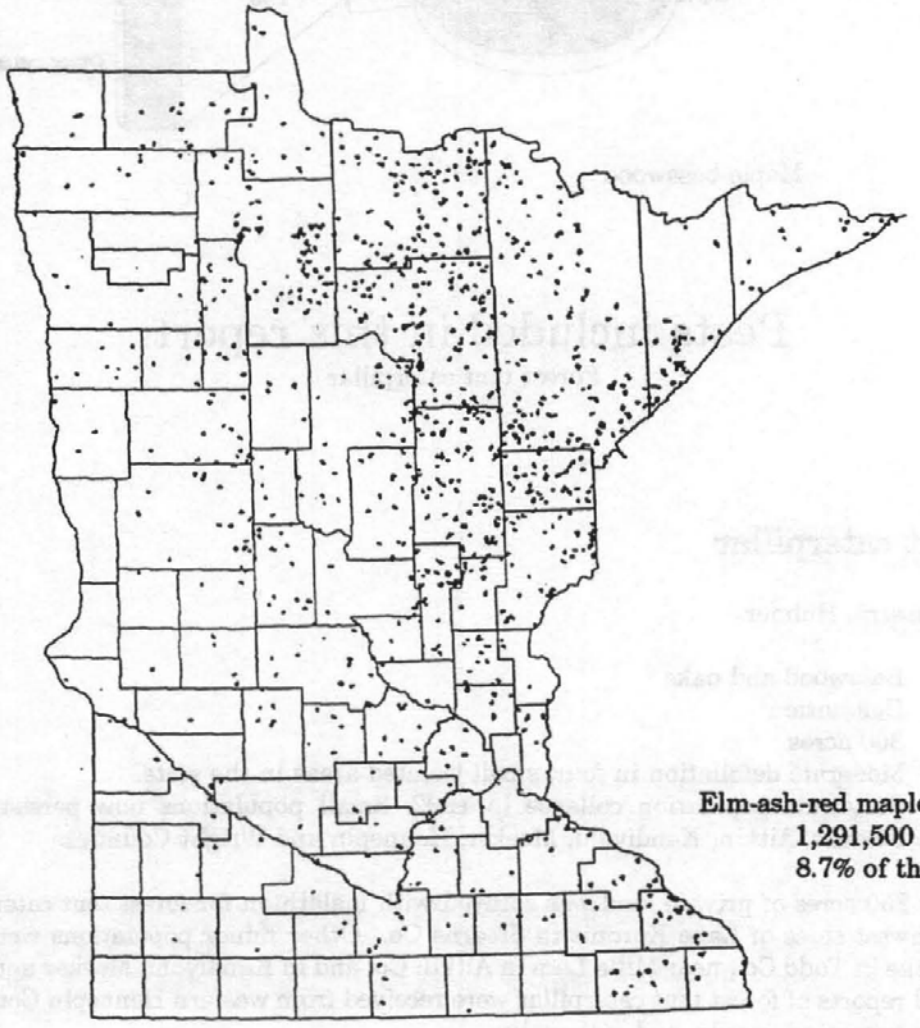
Host: Basswood and oaks
Damage: Defoliation
Acres: 300 acres
Severity: Moderate defoliation in four, small isolated areas in the state.
Trend: Statewide population collapse in 1992. Small populations now persisting in Todd, Stearns, Aitkin, Kandiyohi, Meeker, Hennepin and Wright Counties.

Approximately 250 acres of private land was sprayed with malathion for forest tent caterpillar on the west and southwest sides of Lake Koronis in Stearns Co. Other minor populations were found near Little Saulk Lake in Todd Co., near Mille Lacs in Aitkin Co. and in Kandiyohi, Meeker and Wright Cos. A few scattered reports of forest tent caterpillar were received from western Hennepin County and host plants included basswood, maple, and crabapples.

Phenology:

Date	Event	Location
5/ 23	Caterpillars ¼" long on NE side of Little Saulk Lake.	Todd Co.
5/ 25	Private spraying of resort acreage near Lake Koronis.	Stearns Co.

ELM-ASH-RED-MAPLE FORESTS

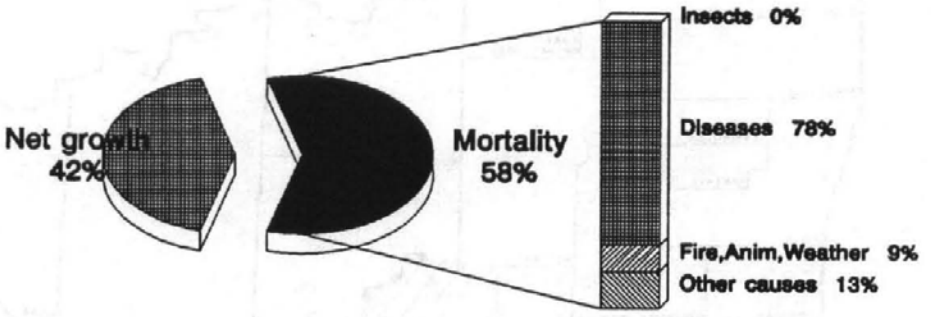


Elm-ash-red maple forests
1,291,500 acres
8.7% of the timberland

DAMAGING AGENTS AND THEIR EFFECTS

The greatest volume losses in the lowland hardwood species occur from disease organisms which discolor, decay or deform standing trees. Dutch elm disease, caused by *Ophiostoma ulmi*, has caused widespread mortality in elm species across the state and has virtually eliminated elm species as viable species for management. On an annual basis, 58% of the volume of elm wood produced is lost due to natural causes. See chart below.

Black ash is relatively free of serious insect and disease problems. However, black ash across the northern part of the state has suffered significant dieback. No specific pathogen or insect has been associated with this problem. It is believed to be due primarily to fluctuating water tables caused by drought in the mid 1970's, record high water tables in the mid 1980's, and drought in the late 1980's.



Elm-ash-red maple

Pests included in this report:

Butternut canker
Anthracnose
Winter injury

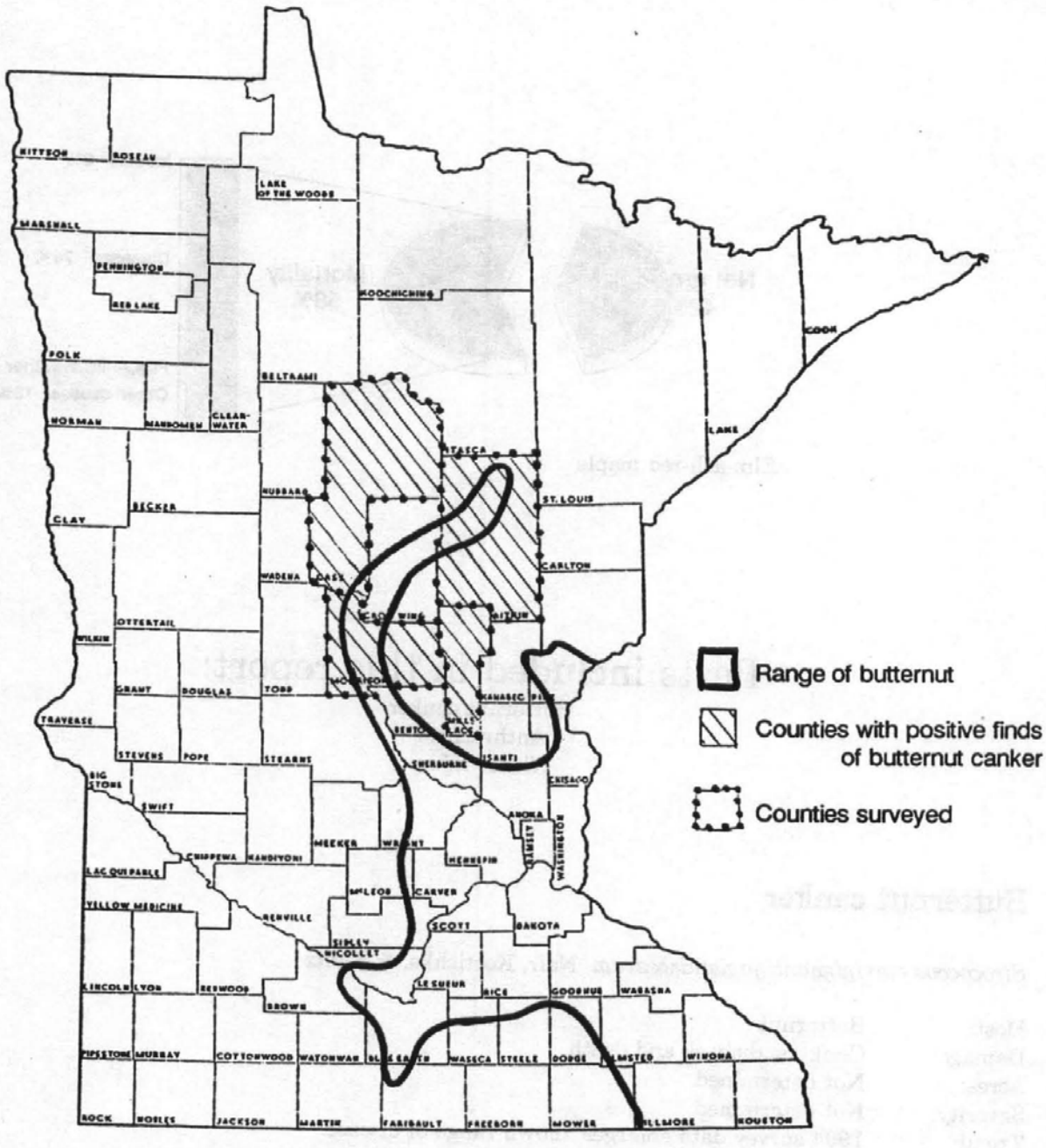
Butternut canker

Sirococcus clavigignenti-juglandacearum Nair, Kostichka, & Kuntz

Host:	Butternut
Damage:	Cankers, dieback and death
Acres:	Not determined
Severity:	Not determined
Trend:	1994 survey data enlarges known range of disease.

An incidence survey was conducted to determine if butternut canker had spread further north in the last ten years. See Map 3. Area personnel assisted in locating the stands with butternut and conducting the survey. See table below . New counties where butternut canker was documented include Aitkin, Cass, Mille Lacs and Morrison.

Map 3. Survey for butternut canker in north central Minnesota, 1994.



Butternut canker.

County	Legal description	Stand number	Forest covertype	Percent butternut in stand	Percent cankered butternut	Severity of cankers *
Aitkin	SWSW 16-46-27	9	Maple, basswood, aspen	1	0	0
	SENW 16-46-27	11	Maple, basswood, elm	1	50	10
	SWSW 12-45-27	21	Maple, basswood, oak	<1	30	25
Cass	NENW 36-134-30	10	Oak, birch	<1	0	0
	16-139-27	20	Maple, oak, basswood	<1	10	15
Crow Wing	36-136-28	43	Oak, birch, maple	1	0	0
	NESE 1-136-27	10	Oak, birch	0	0	0
Mille Lacs	32-40-26	13	Maple, oak, basswood	<1	70	60
Morrison	29-132-30	33	Oak, ash	<1	30	30
	32-132-30	37	Oak, ash, maple	1	25	20

* = Percent of trunk with cankers, from the base of the trunk upwards. Cankers predominated on the older trees, > 10 dbh.

Anthracnose

On ashes = *Gloeosporium aridum* Ell.& Holw.
On maples = *G. apocryptum* E.& E.
On oaks = *Apiognomonia errabunda* (Roberge) Hohn.
On walnut = *Gnomonia leptostyla* (Fr.) Ces. & de Not.

Hosts: Ashes, oaks, maples and walnut
Damage: Defoliation, twig dieback
Acres: Not determined, but in Twin Cities area and southeastern counties.
Severity: Moderate to heavy defoliation of several hardwood species.

Trend: Decreasing in the north central counties and the Twin Cities area and increasing in the southeastern counties.

The incidence and severity of anthracnose diseases decreased dramatically in the Twin Cities area and this may have been due to more normal weather patterns. 1992 and 1993 were characterized by cool temperatures and greater than normal rainfall. In the Twin Cities area, ash, white oak, and maple were the only species affected in 1994. Twig involvement was rare. Ash was affected first with most of the damage occurring in mid to late May. White oak symptoms became evident in early June. In the north central counties, black ash and green ash were infected, but at decreased levels of incidence and severity.

In southeastern Minnesota, 1994 was another year of cool temperatures and greater than normal rainfall in the southeast and with it came an increase in the incidence and severity of anthracnose diseases. A wide variety of hardwood species were affected. Ash, walnut and white oak were the most severely affected with significant infection of twigs. Red oak and maple were also affected, but twig involvement was rare. Birch, basswood, and elm leaf damage was common, however, no twig infection was observed.

Winter injury

Prolonged low temperatures and/or winter drying

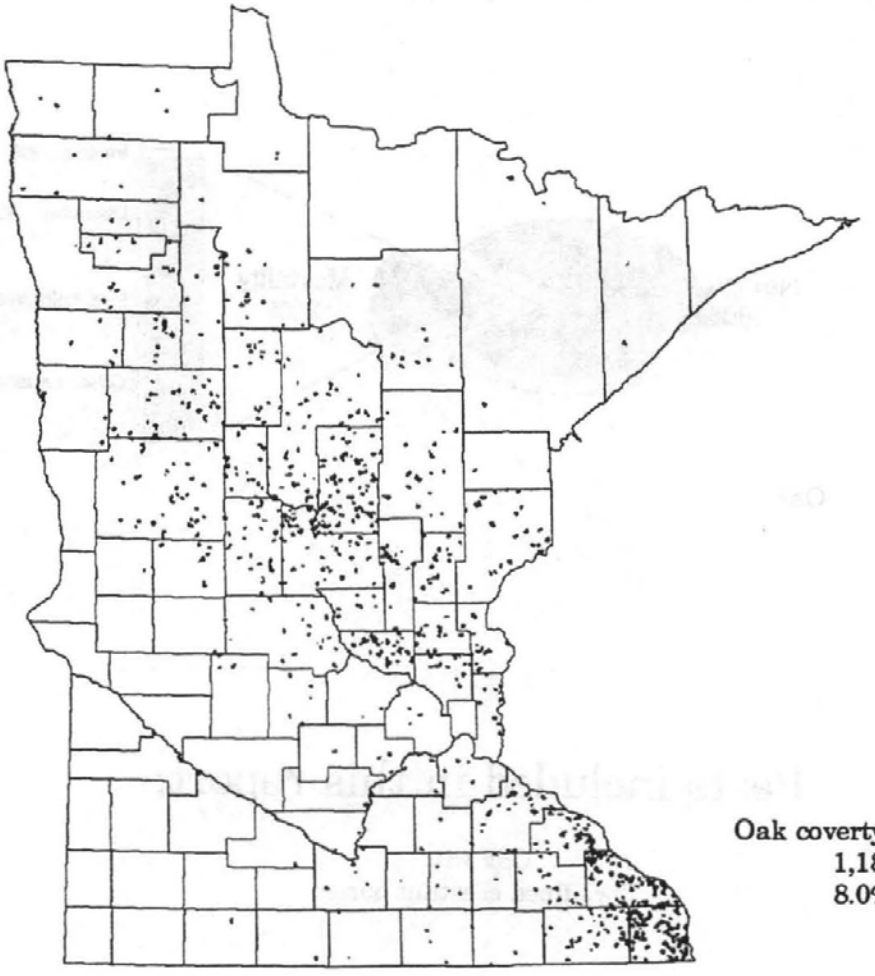
Hosts: Black walnut, honey locust, green ash, sugar maples and other hardwoods
Damage: Dieback and mortality
Acres: 30 walnut plantations in south east Minnesota and scattered trees throughout the state.
Severity: Variable
Trend: None

The first evidence of the winter injury was the failure of some walnut trees in plantations to leaf out. At the same time in mid May other hardwood species were slow to leaf out. By late May, there was a good pattern of winter injury all across southern Minnesota. The tops of the honey locust trees in yards and urban areas failed to leaf out. Green ash trees in the same areas were partially leafed out or, in some instances, dead. Dieback was evident in several hardwood species especially on stressed sites. At Nerstrand State Park, which has a history of disturbance, several sugar maples died-back or were killed. By far the greatest losses were suffered in black walnut plantations where the mortality was severe. See the Special Project section for a more complete report on walnut mortality. New management recommendations have been proposed.

The patterns of injury to individual trees caused by the winter injury was the same for all species whether it was maple, ash, or walnut. Only the severity varied. By mid August, early fall coloration was evident in sugar maple. The pattern was one of scattered individual branches adjacent to still green branches turning to fall color early. Those branches stressed by the winter temperatures were turning color early. This winter injury was caused by some of the coldest temperatures recorded here in several years.

Reports were received from Grygla and Bemidji of green ash trees leafing out very late in golf courses and parks. The trees remained bare long after all other trees had leaves. It was speculated that the extreme cold of the winter of 1993-94 altered the physiology of these trees and affected leaf out. Most trees did eventually leaf out, but some trees had dead crown portions and all of the affected trees had sparse leaf production.

OAK FORESTS

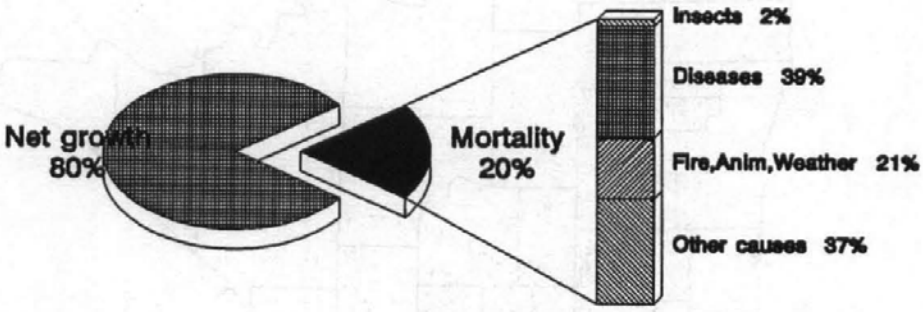


Oak covertype
1,184,300 acres
8.0% of the timberland

DAMAGING AGENTS AND THEIR EFFECTS

The greatest volume losses in oaks are the result of disease organisms which discolor, decay, or deform standing timber. Mortality within the oak type is caused by Armillaria root rot fungus, *Armillaria* spp., the two-lined chestnut borer, *Agrilus bilineatus,* and oak wilt disease, *Ceratocystis fagacearum.* Trees that become stressed by drought, insect and disease defoliation, overstocking, over maturity or other detrimental site conditions are attacked and killed by Armillaria root rot and the two-lined chestnut borer. Oak wilt disease causes mortality in individual trees and groups of trees root grafted together. Oak wilt is common in the Metropolitan Region and the southeastern counties.

On an annual basis, 20% of the volume of oak wood produced is lost due to natural causes (FIA, 1990). See chart below. Diseases accounted for 39% of the losses and this was primarily due Armillaria root rot. Insect losses probably account for more than the 2% tallied during inventory because two-lined chestnut borer symptoms often are higher on the bole and are difficult to see. In addition to this, Armillaria root rot and two-lined chestnut borer are commonly found on the same trees but only one pest can be coded for the FIA Inventory.



Oak

Pests included in this report:

Oak wilt
Two-lined chestnut borer

Oak wilt

Ceratocystis fagacearum (T.W.Bretz) J. Hunt

Hosts:	Oaks
Damage:	Tree mortality
Acres:	Where mapped in the Twin Cities area, there are 6,055 infection centers that average 1.6 acres each.
Severity:	Seven counties in central Minnesota are seriously affected. Counties include Anoka, Chisago, Dakota, Isanti, Ramsey, Sherburne, and Washington. In southeast Minnesota, a lesser amount of oak wilt occurs

	in forested areas, particularly where stands of northern pin oak grow adjacent to rural or urban development.
Trend:	The number of active oak wilt infection centers has been dramatically decreasing over the past three years due to the successful actions of the Oak Wilt Cooperative Suppression Program.

In 1994, 740 infection centers were treated by installing over 282,245 feet of vibratory plow line and by removing approximately 2,5000 potential spore producing trees. This brings the total to 1740 centers treated since the Program began in 1991. A more complete description of the annual accomplishments of the Oak Wilt Cooperative Suppression Program can be found in the Special Projects section.

Expression of wilt symptoms was normal in 1994. The first wilting tree was seen on June 10, but most of the active wilting occurred in mid-July.

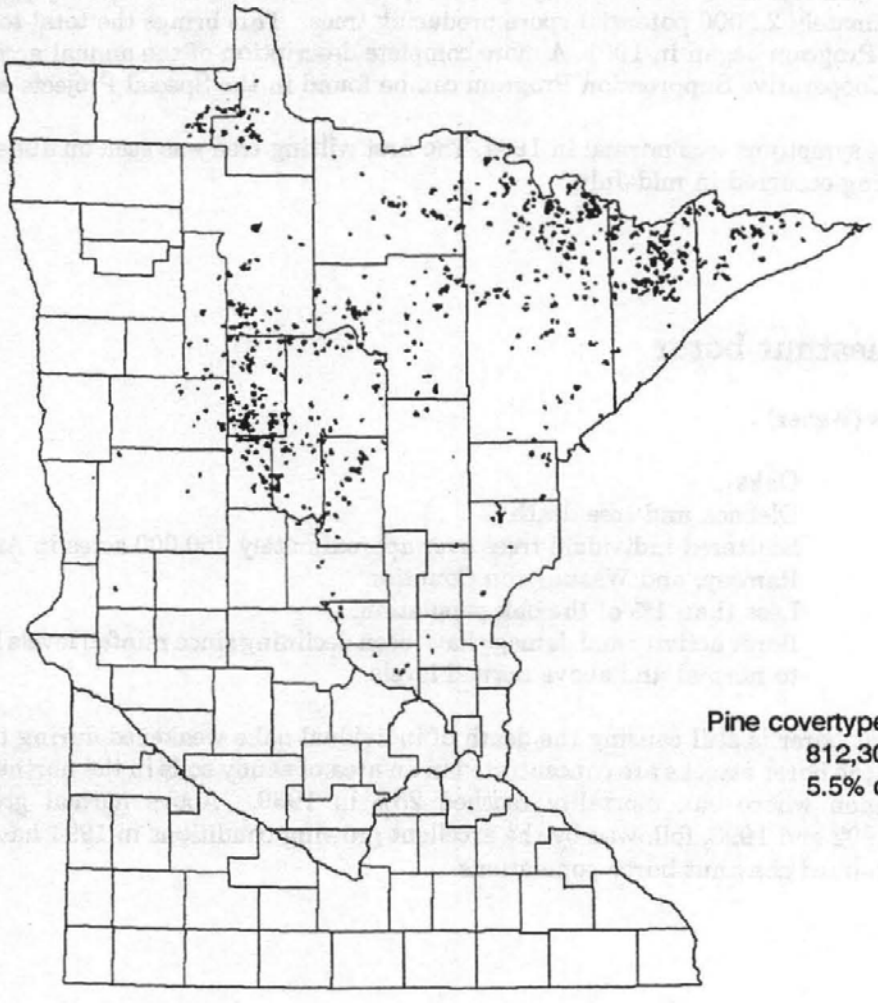
Two-lined chestnut borer

Agrilus bilineatus (Weber)

Host:	Oaks
Damage:	Dieback and tree death
Area:	Scattered individual trees over approximately 750,000 acres in Anoka, Dakota, Ramsey, and Washington Counties.
Severity:	Less than 1% of the oak population.
Trend:	Borer activity and damage have been declining since rainfall levels have returned to normal and above normal levels.

Two-lined chestnut borer is still causing the death of individual oaks weakened during the 1987-1989 drought. Most of the borer attacks are concentrated in an area of sandy soils in the northern part of the Metropolitan Region where oak mortality reached 25% in 1989. Above normal growing season precipitation in 1992 and 1993, followed by the excellent growing conditions in 1994 has hastened the decline of the two-lined chestnut borer populations.

PINE FORESTS



Pine covertype
812,300 acres
5.5% of timberland

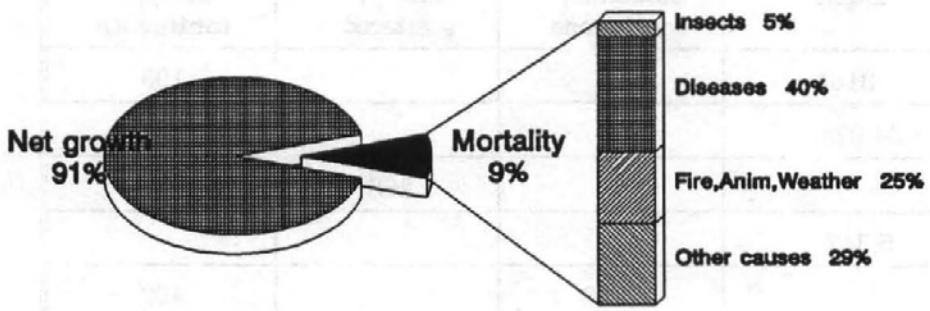
DAMAGING AGENTS AND THEIR EFFECTS

Mortality within the red pine covertype is caused by Armillaria root rot, *Armillaria* spp., Diplodia canker, *Sphaeropsis sapinea*, Sirococcus blight, *Sirococcus conigenus*, and several species of bark beetles.

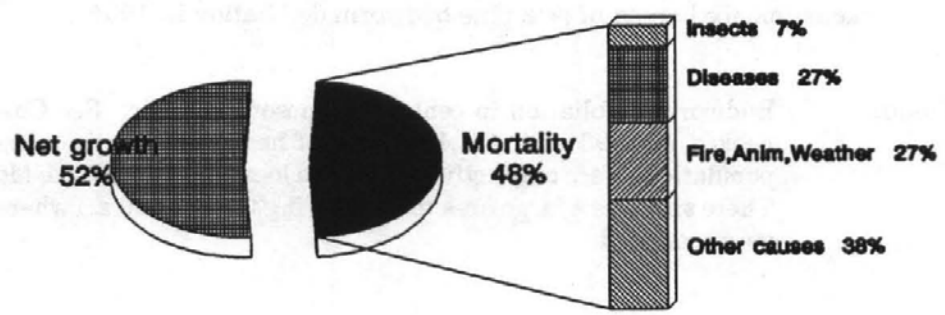
White pine blister rust, *Cronartium ribicola*, and white pine weevil, *Pissodes strobi*, are the major insect and disease problems of white pine. These problems have restricted new plantings and greatly reduced the existing commercial management of this species. On an annual basis, 9% of the volume of white pine

wood produced is lost due to natural causes (FIA, 1990). See chart below. White pine weevil, deer browse and white pine blister rust account for approximately 65% of those losses.

Phellinus pini causes about 90% of the decay in all ages of jack pine and it becomes more prevalent as the pines get older. The major pests causing mortality in jack pine are jack pine budworm, *Choristoneura pinus,* pine tussock moth, *Dasychira pinicola,* bark beetles, *Ips* spp., Armillaria root rot, *Armillaria* spp. and stem rusts, *Cronartium* and *Endocronartium* spp. On an annual basis, 48% of the volume of jack pine wood produced is lost due to natural causes (FIA, 1990). See chart below. Seven percent was lost to insects and additional surveys showed that jack pine budworm and bark beetles were the causal agents. Diseases, such as Armillaria root rot and stem rusts, caused 27% of the mortality losses.



White pine



Jack pine

Pests included in this report:

Jack pine budworm
Pine tussock moth
Common pine shoot beetle

Jack pine budworm

Choristoneura pinus Freeman

Host: Jack pine
Damage: Defoliation
Acres: 46,800 acres
Severity: Predominantly light defoliation.

Jack pine budworm acres of defoliation by county and severity.

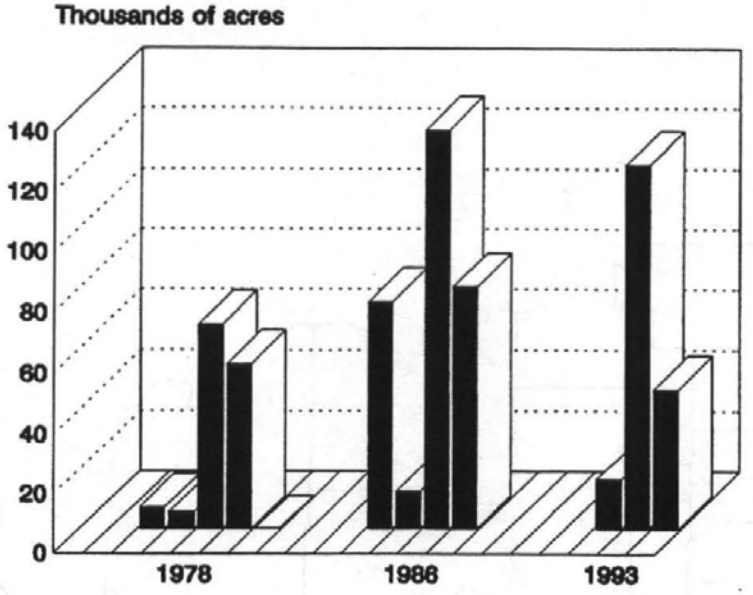
County	Light	Moderate, continuous	Heavy, scattered	Heavy, continuous
Cass	316*			193
Crow Wing	34,078			
Morrison			1,268	
Pine	5,347			
Wadena		5,098		492
TOTALS	39,741	5,098	1,268	685

* = Acreage figures based on the Eppl7 comparison of FIA cover types and the aerially sketch mapped areas of jack pine budworm defoliation in 1994.

Trend: Budworm defoliation in central Minnesota is cyclic. See Chart below. The population peaked in 1993 with 121,120 acres of heavy and continuous defoliation. By 1994 the populations were only active in isolated locations in Wadena, Morrison and Pine Counties. There still was a large area in Crow Wing Co. (34,000 ac) where defoliation was light and very scattered.

Jack pine budworm populations continued to decline in northwestern counties. In 1993 there was some noticeable defoliation north of the Badoura Nursery. In 1994, there was no observable defoliation. Early larvae surveys found larvae in both Hubbard and Beltrami Counties, but the counts were low. The highest counts were found in township 140 N, range 34 W in Hubbard County. The maximum number of larvae found on a plot was 9 on 30 shoots. This would indicate light defoliation at the most.

Twenty seven early larval plots were taken in the north central counties and larvae were found at all locations. Survey data can be found in the Survey Results section. In contrast to 1992 and 1993, the late spring weather in 1994 was warm. From a phenological viewpoint, budworm development was ten days ahead of last year's development. Many undersized larvae and webbed shoots with no larvae were observed and perhaps can be attributed to lack of pollen cone food source and/ or high levels of predation. Increased number of ants, spiders, stink bugs and other predators were noted. Based on this survey, four townships were expected to have noticeable defoliation; T44-R31 in Crow Wing Co., T40-R18 in Pine Co. and T136-R33 and T135-R33 in Wadena Co. Noticeable defoliation did occur in the townships predicted.



Jack pine budworm defoliation, 1974 to 1994.

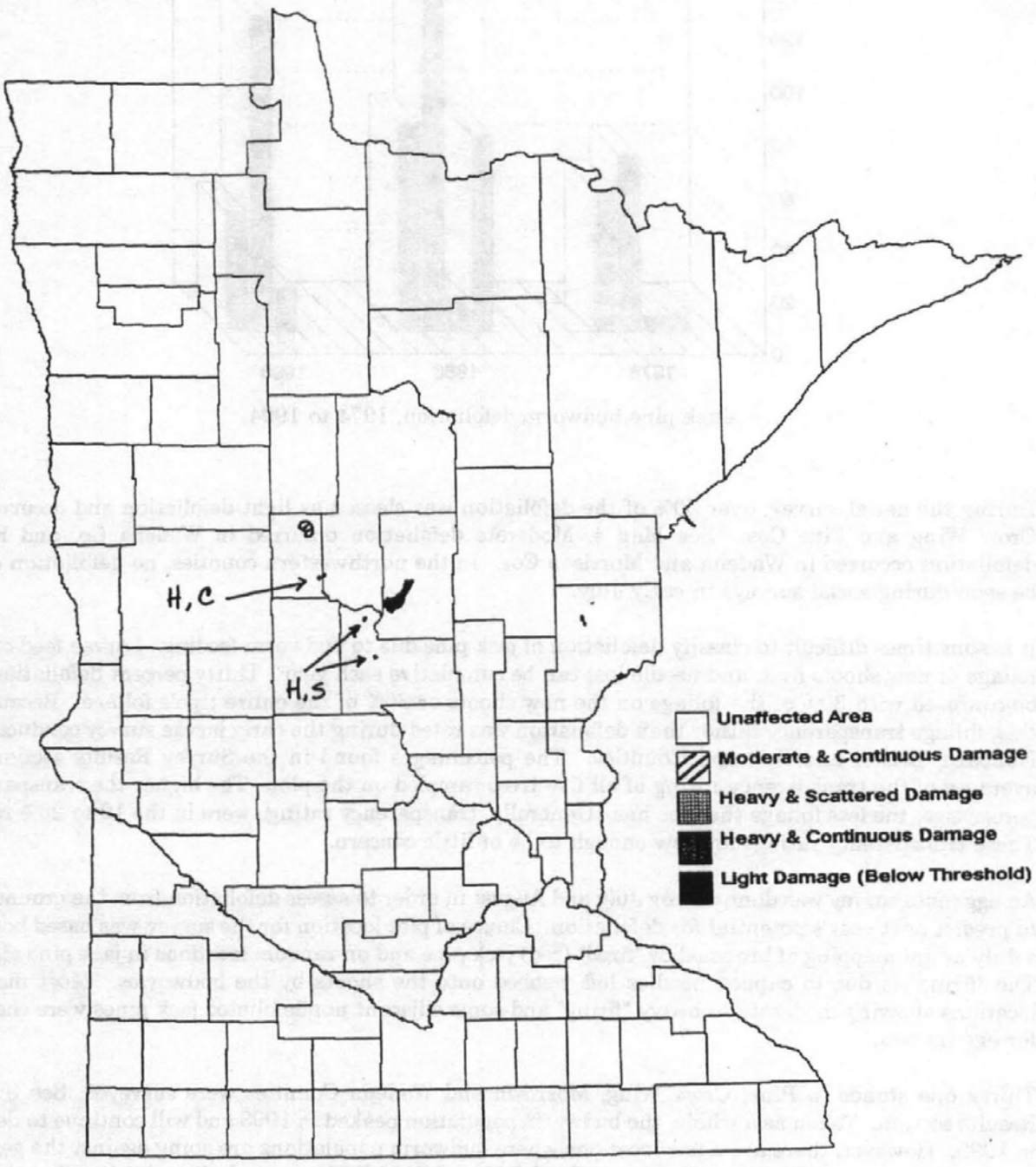
During the aerial survey, over 80% of the defoliation was classed as light defoliation and occurred in Crow Wing and Pine Cos. See Map 4. Moderate defoliation occurred in Wadena Co. and heavy defoliation occurred in Wadena and Morrison Cos. In the northwestern counties, no defoliation could be seen during aerial surveys in early July.

It is sometimes difficult to classify defoliation of jack pine due to budworm feeding. Larvae feed on the foliage of new shoots first, and needle loss can be cumulative each year. Thirty percent defoliation can be confused with 30% of the foliage on the new shoots or 30% of the entire tree's foliage. Because of this, foliage transparency rather than defoliation was rated during the early larvae survey conducted in Hubbard, Becker and Beltrami Counties. The percentages found in the Survey Results section are averages of the transparency rating of all five trees sampled on the plot. The higher the transparency percentage, the less foliage the tree has. Generally, transparency ratings were in the 10 to 20% range. These transparency ratings are low enough to be of little concern.

An egg mass survey was done during July and August in order to assess defoliation from the ground and to predict next year's potential for defoliation. Choice of plot location for the survey was based both on a July aerial mapping of browned or "fired" (red) jack pine and on random locations in jack pine stands. The "firing" is due to clipped needles left webbed onto the shoots by the budworms. Most mapped locations showing moderate to heavy "firing" and some adjacent nondefoliated jack pines were checked for egg masses.

Thirty one stands in Pine, Crow Wing, Morrison and Wadena Counties were surveyed. See Survey Results section. Taken as a whole, the budworm population peaked in 1993 and will continue to decline in 1995. However, there are a few locations where budworm populations are going against the general trend. Two stands in Morrison County, in T132-R30 and T130-R30, may be lightly defoliated next year. Four out of nine stands surveyed in Wadena County showed a potential for detectable defoliation, indicating that these stands should be closely monitored next year. The remaining stands in Pine and Crow Wing Counties have little or no potential for detectable defoliation next year based on this predictive tool.

Map 4. Jack pine budworm defoliation, 1994.



Egg mass survey results in the northwestern counties further corroborated a declining population. There were not any plots that met or exceeded the threshold for damaging defoliation. Three egg masses per plot is the threshold for becoming concerned. Only 2 plots with 2 egg masses were found: section 22 of township 139 N, range 36 W in Becker County; and in section 24 of township 140 N, range 32 W. See Survey Results. A continued decline in budworm activity for the northwestern counties is predicted for 1995.

Phenology:

Date	Accumulated degree days	Event	Location
5/ 13	612 *	Jack pine shoots elongated 2" and cones still green. Red oaks starting to leaf out.	Crow Wing
5/ 20	820	Jack pine shedding pollen.	Crow Wing
5/ 23	929	Hoary pucoon blooming.	Crow Wing, Cass
5/ 24	962	Gall rust aeciospores being produced.	Cass
5/ 26	1010	Jack pine budworm in staminate cones. 2nd instar.	Crow Wing
6/ 9	1431	3rd and 4th instars.	Crow Wing
6/ 13		3rd instars with a few 4th and 5th instars present.	Pine, St. Croix State Park (SCSP)
6/ 14	1611	5th and 6th instars.	Crow Wing
6/ 14		Mostly 6th and 7th instars. 1 pupa noted.	Pine, SCSP
6/ 15	1646	6th and 7th instars.	Crow Wing, Cass
6/ 20	1828	7th instars and pupae observed.	Crow Wing
6/ 24	1979	50% pupated.	Wadena
6/ 28	2123	90% pupated.	Crow Wing

* = Accumulated degree days based on 32°F; taken in Brainerd.

Pine tussock moth

Dasyschira plagiata Dyer

Host:	Jack pine
Damage:	None
Area:	None
Severity:	None
Trend:	Since 1980 the numbers of pine tussock moth caterpillars in Pine and Crow Wing Counties have diminished. Moths trapped in Wadena County have increased slightly, as compared to 1993. In southern Hubbard County, fewer moths were trapped in 1994 than in 1993.

Pheromone trapping of male moths indicates that the pine tussock moth population remains at minor levels in the central counties. Trap catch data is in Survey Results section.

Common pine shoot beetle

Tomicus piniperda (L.)

Host:	Pines
Damage:	None
Area:	None
Severity:	None

DNR-Forestry cooperated with USDA-APHIS- Plant Protection and Quarantine and two private forest industries in conducting a survey for common pine shoot beetles and spruce bark beetles. Traps were placed in Itasca, St. Louis and Carlton Counties. None were trapped. The collection of insects is still being analyzed for the presence of other exotic or imported insects.

URBAN FORESTS

Covertype:
A wide range of native and exotic species which grow within and are influenced by the urban environment. An urban forest can be as small as a few shade trees or as large as a multiple acre grove of trees.

DAMAGING AGENTS AND THEIR EFFECTS

Many of the problems that shorten the lives of urban trees are related to physiological stress and are caused by human damage or indifference. Mechanical and chemical damage, flooding or drought, poor nutrition, root compaction and poor planting practices are just a few of the things that cause physiological stress in trees. Stressed trees are easily attacked by a myriad of opportunistic insects and diseases.

Urbanization has created some difficulties in maintaining proper forest management practices. Many homeowners are maintaining pine plantations in an over dense condition for privacy and to mimic a dense forest. In addition, a number of communities have enacted tree protection ordinances so restrictive that a city permit is required to remove any tree, even for disease control, hazard tree abatement, or thinning.

In general, the health of the urban forest continues to improve as the effects of the drought in 1988 continue to fade. Problems related to construction damage and the general abuse of trees by homeowners continue. Dutch elm disease continues much as it has for the past decade. Ash yellows has failed to materialize as the grave problem some forest health workers felt it would a few years ago. Oak wilt continues to be a major problem in the oak urban forests particularly north and east of the Twin Cities. An aggressive oak wilt control program continues to make significant headway in controlling this fatal disease. Gypsy moth egg masses were found in seven new locations, all in urban settings.

Pests included in this report:

Gypsy moth
Mountain ash sawfly
Apple scab
Maple decline

Gypsy moth

Lymantria dispar (Linneaus)

Host: Oaks and other hardwoods
Damage: None
Acres: None
Severity: None
Trend: Increasing. Following the introduction of gypsy moth infested stock into Minnesota there was a three-fold increase in the number of moths trapped. There are seven known breeding populations.

Gypsy moth infested stock was shipped to 200+ commercial nurseries in Minnesota this past year. Egg masses were found by MDA Nursery Inspectors at many sites, however, a great many trees had been sold to the general public by the time the situation was discovered. It is generally assumed that most of the infested material was planted in the Twin Cities area, but moth catches indicate that Rochester and St. Cloud received infested stock as well.

Most of the problem stemmed from nursery stock shipped by Bork Tree Farms (Hinckley, MN) under phytosanitary certificates indicating Minnesota grown stock. The stock actually came from Michigan and was shipped to several other states as well as Minnesota. Infested stock was all blue spruce and Austrian pine. Nursery Inspectors (MDA) ultimately found gypsy moth in various life stages in 26 nurseries. Moth catches increased dramatically in 1994 both in the number of moths and in the number of counties.

Ground checks located seven viable breeding populations now in Minnesota. All sites are related to the quarantine incident and all have produced healthy, viable egg masses. These egg masses are in Chisago, Dakota, Hennepin, Pine, Ramsey, and Stearns Counties. All seven sites will be sprayed in 1995. Infestations at five of the sites are confined to the nursery grounds or local area. Two of the sites, Edina in Hennepin County and Maplewood in Ramsey County, produced egg masses away from the primary property. At the Edina site, an egg mass was found 1500 feet away from the point of introduction.

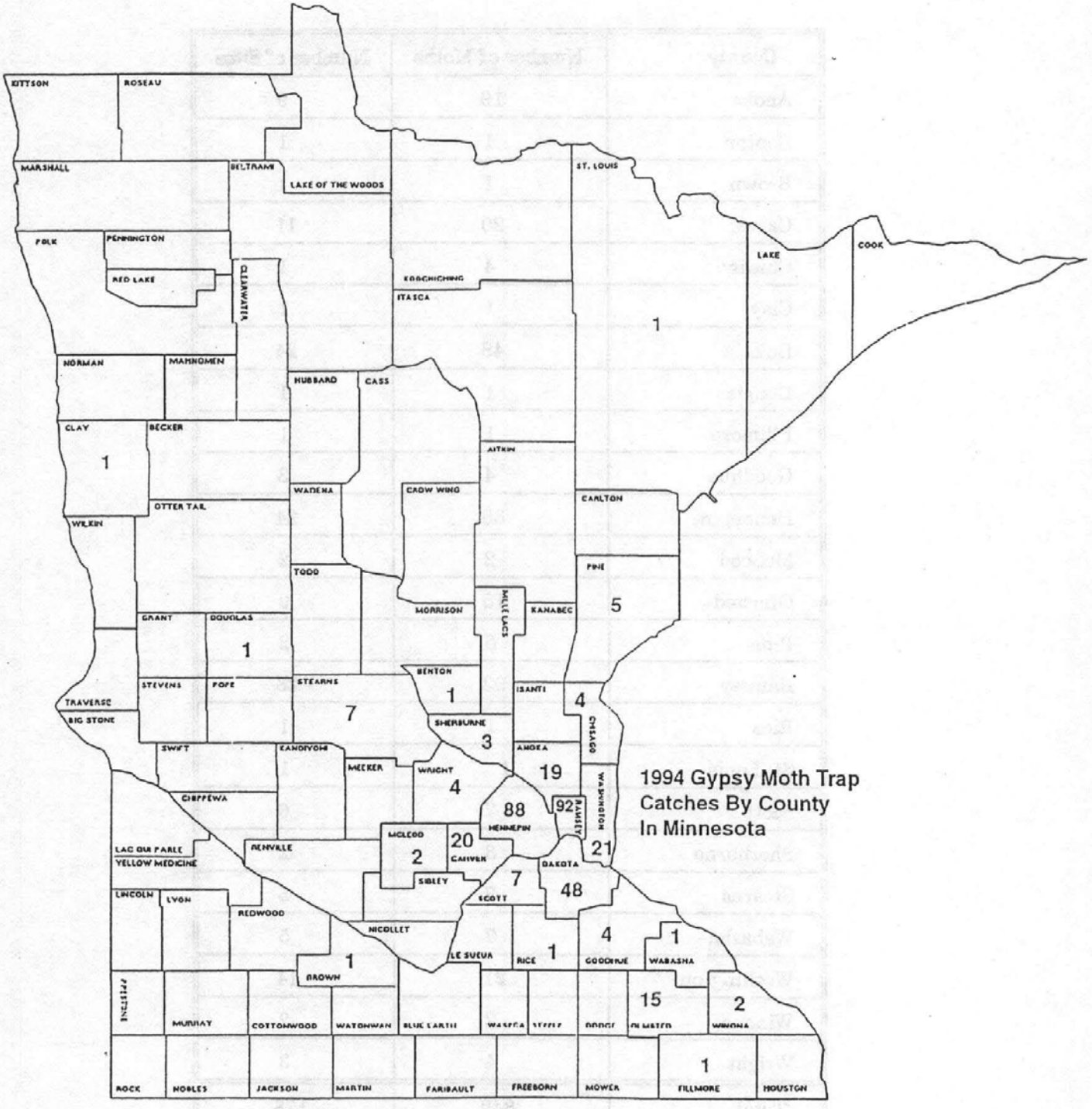
Gypsy moth trapping in Minnesota is an interagency cooperative program with the majority of the work being undertaken and coordinated by USDA-APHIS and Minnesota Dept. of Agriculture (MDA). The following tables summarize statewide trapping in 1994. Map 5 depicts the Detection Trap Catches.

Trapping Agency	Number of Traps
MDA & USDA-APHIS	6048
Mn-DNR	516
USDA-USFS	297
Community Cooperators	127
TOTAL	6988

In total, 349 moths were taken at 178 sites in 24 counties. This is up from 1993 when 97 moths were taken from 64 sites in 15 counties. Next year, all locations with single or multiple moth catches will have detection grid trapping patterns around them.

County	Number of Moths	Number of Sites
Anoka	19	9
Benton	1	1
Brown	1	1
Carver	20	11
Chisago	4	1
Clay	1	1
Dakota	48	24
Douglas	1	1
Fillmore	1	1
Goodhue	4	3
Hennepin	88	24
McLeod	2	2
Olmsted	15	9
Pine	5	2
Ramsey	92	28
Rice	1	1
St. Louis	1	1
Scott	7	6
Sherburne	3	2
Stearns	7	5
Wabasha	7	5
Washington	21	14
Winona	2	2
Wright	4	3
Total	349	178

Map 5. Gypsy moth detection trap catches, 1994.



Mountain ash sawfly

Pristiophora geniculata (Hartig)

Host:	Mt. ash
Damage:	Defoliation.
Acres:	Not determined.
Severity:	Heavy defoliation.
Trend:	Much increased compared to last year.

Mountain ash sawfly populations exploded in the Bemidji area and were also abundant in St. Louis and Itasca Counties. Many ornamental trees in towns and cities were stripped twice.

Apple scab

Venturia inequalis (Cke.) Wint. ap. Thum.

Host:	Apples, crabapple
Damage:	Defoliation.
Area:	Not determined.
Severity:	50-100% defoliation.
Trend:	Three consecutive years of conducive weather increased apple scab infection.

In 1994, one of the more noticeable foliage afflictions was apple scab on ornamental crabapple trees. Most ornamental crabapple across southern Minnesota were defoliated by mid August. This has been very common the last three years. New infections come from spores produced on the previous year's diseased leaves and subsequent infections occur throughout the growing season when weather conditions are wet and temperatures are moderate.

Maple decline

Host:	Maples
Damage:	Early fall coloration, defoliation and dieback of branches
Acres:	Not determined.
Severity:	Scattered locations, but locally heavy.
Trend:	Maple decline continues to progress in symptomatic trees. New maple decline was evident in both urban and rural areas in the southern counties.

Sugar maple trees in communities across the southern counties expressed symptoms of decline due to the severe cold during the 1993-1994 winter. Maple decline symptoms include early fall coloration, leaf defoliation and branch dieback. Decline symptoms in boulevard maples began to show in early August.

NURSERY PEST CONTROL SUMMARY

The major pest problem in the nurseries this year was weeds. Chemical control had limited effect due to moisture and temperature patterns. Hand labor budgets were also limited, so it was a good year for weeds. Control operations directed at insect and disease pests are listed in the following tables.

Direct control operations.

Pest	Action
Leaf spot and anthracnose on chokecherry, paper birch and white ash.	Daconil sprays
Cottony aphids, cutworms and leafhoppers.	Malathion and diazinon sprays
Grasshoppers in mt. ash and Juneberry.	Malathion sprays

Incidental occurrences.

Host	Pest
Paper birch	Dusky sawfly
Mt. ash	Mt. ash sawfly
Red pine	Jack pine budworm
Black spruce	Spruce budworm

The reintroduction of certain trees and shrubs into the nursery product line resulted in our "reaquaintance" with several pests and resulting management actions. See table below.

Host	Pest	Management action
Juneberry	Stem, leaf and fruit rust	Isolation from cedar stock.
Mt. ash	Fire blight	Dormant season pruning in seed production areas, plan to spray with Phyton if blight is verified in seedbeds.
Highbush cranberry	Powdery mildew	Lower bed densities. Preventative sprays with lime sulfur or manzate are planned.
Nannyberry	Cottony stem aphid	Malathion spray.

INCIDENTAL PESTS

INSECTS

Pest	Host	Location	Notes
Introduced pine sawflies *Diprion similis*	White pine	north central counties; Washington, Ramsey	At much lower levels than in 1992 or 1993. On ornamental trees.
Pine bark adelgid *Pineus strobi*	Red pine, White pine	Beltrami, Morrison	
Turpentine beetles and pine bark beetles *Dendroctonus valens* *Ips pini*	Red pine	Sherburne	Infesting red pines stressed by high water tables, Sand Dunes State Forest.
Pine bark beetles *Ips pini*	Red pines	Aitkin; Dakota, Washington	Infesting mature pines and causing branch mortality and some tree death.
Northern pitch twig moth *Petrova albicapitana*	Jack pine	north central counties	Incidence is higher than usual.
Pine spittlebug *Aphrophora parallela*	Jack pine	Crow Wing, Cass, Pine, Morrison; Washington	Christmas tree farm.
Rose chafer *Macrodactylus subspinosus*	Various trees and shrubs; Green ash	Crow Wing; Anoka	Fewer than in 1993. Populations seem to be declining for past four years; Windbreak trees.
Imported willow leaf beetle *Plagiodera versicolora*	Willow	Crow Wing, Olmstead	
Red headed pine sawfly *Neodiprion lecontei*	Jack pine	Sherburne	

Pest	Host	Location	Notes
Lace bugs *Corythuca arcuata*	Elm, oak, plums, choke-cherry	north central counties	Lower numbers observed compared to 1993.
Cutworm moths Undetermined		St. Louis	Hundreds of moths found in cabins.
Cottony maple scale *Pulvinaria innumerabilis*	Silver maple	Beltrami	
Ash plant bug *Tropidosteptes amoenus*	Green ash	Beltrami Becker	Common and doing noticeable damage, particularly in communities.
Pales weevil *Hylobius pales*	White pine Scots pine	Goodhue	
Introduced basswood thrips *Thrips calcaratus*	Basswood	Winona	
Red-humped caterpillar *Schizura concinna*	Apple	Pine, Crow Wing	A "fall defoliator".
Pine web spinning sawfly *Cephalcia* sp.	White pine	Hennepin	Ornamental planting
Aphids Undetermined	Maple hardwoods	Dakota Ramsey Washington	Scattered ornamental trees, some with heavy attack causing leaf fall.
Pine root collar weevil *Hylobius radicis*	Scotch pine	Washington	
Zimmermann pine moth *Dioryctria zimmermanni*	Pine	Ramsey	Ornamental planting
June beetle *Phyllophaga* spp.	Oak, basswood, cotton-wood	Dakota	Night feeding
Eastern pine shoot borer *Eucosma gloriola*	Jack pine	Anoka	Ornamental planting
Elm leafminer *Fenusa ulmi*	American elm	Ramsey	Ornamental tree
White pine weevil *Pissodes strobi*	White pine	Anoka	Ornamental planting

Pest	Host	Location	Notes
Birch leafminer *Fenusa pusilla* and Birch leafminning sawfly *Heterarthrus nemoratus*	Paper birch	Anoka Dakota Hennepin Ramsey Washington	Ornamental planting
Spiny elm caterpillar *Nymphalis antiopa*	Hardwood	Hennepin	Ornamental planting
Cooley spruce gall aphids *Adelges cooleyi*	White spruce	Hennepin	Ornamental planting
Bronze birch borer *Agrilus anxius*	Paper birch	Ramsey	Ornamental planting

DISEASES

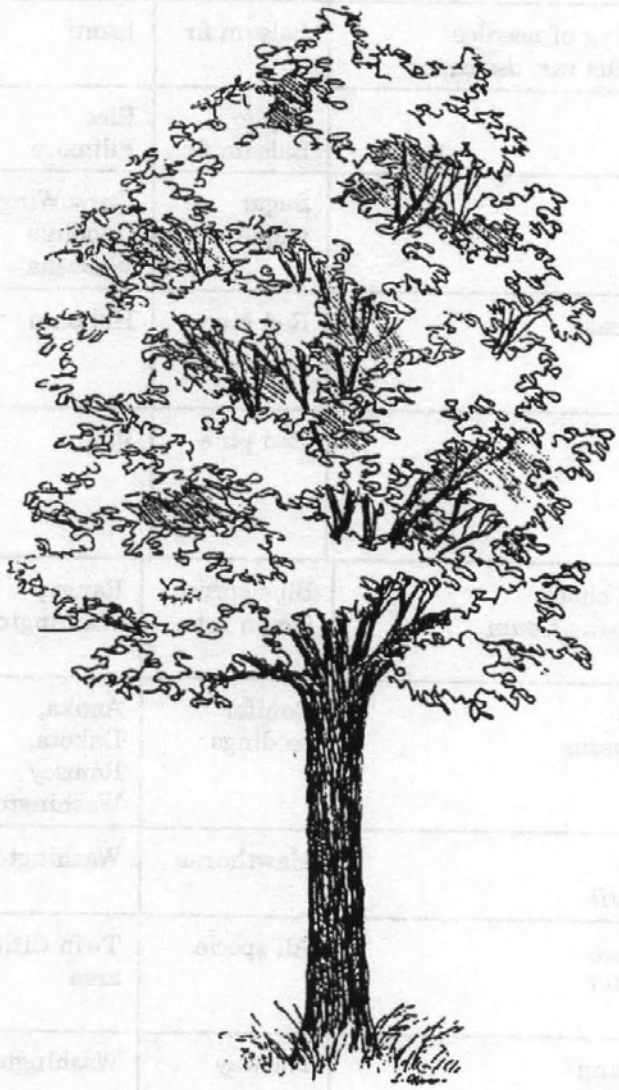
Pest	Host	County	Notes
Diplodia tip blight *Sphaeropsis sapinea*	Red pine	St. Louis	Scattered roadside trees along Hwy 53 from Hwy 37 to Cook
Needle rust *Coleosporium asterum*	Red pine	St. Louis	Pustules still present 6/29
Needle rust *Chrysomyxa sp.*	White spruce Black spruce	Koochiching St. Louis Itasca Region 1	Heavy in scattered locations 8/24
Scirococcus tip blight *Sirococcus conigenus*	Red pine	Itasca Cass	Roadside trees in sec 4,10,14,23-T147N-R27W and Sec33-T148N-R27W; low incidence in Cass Co.
Lirula needlecast *Lirula macrospora*	Blue spruce	St Louis	
Sirococcus tip blight *Sirococcus conigenus*	Blue spruces	Carlton	Ornamental tree
Willow blight *Venturia saliciperda* *Glomerella miyabeana*	Willow	None	Perhaps due to the dry spring in the north, blight was not observed this year.

Pest	Host	County	Notes
Pest	**Host**	**County**	**Notes**
Maple wetwood Unidentified bacteria	Red maple	Crow Wing	
Decay *Phellinus robustus*	Red oak	Itasca	
Nectria canker *Nectria* sp.	Honey locust	Washington	Ornamental planting
Rhizosphaera needle cast *Rhizosphaera kalkhoffii*	Blue and black spruce	Ramsey Washington	Ornamental planting
Fire blight *Erwinia amylovora*	Mt. ash	Dakota	Ornamental planting
Elm wetwood Bacterial species	Elm	Hennepin Ramsey	Urban street trees
Cytospora canker *Cytospora kunzei*	Blue spruce	Hennepin Ramsey Washington	Ornamental planting
White pine blister rust *Cronartium ribicola*	White pine	Ramsey Washington	Ornamental planting
Dutch elm disease *Ceratocystis ulmi*	American elm	Carver Dakota Ramsey Scott Washington	Urban street trees
Verticillium wilt *Verticillium* spp.	Sugar maples	Ramsey Washington	Urban ornamentals
Armillaria root disease *Armillaria* spp.	Red oak Aspen Red pine	Anoka Carver Dakota Hennepin Ramsey Scott Washington	Commonly misdiagnosed as oak wilt in red oak in oak wilt prone areas. Purple-turning, oxidized sugars in root flair were diagnostic.
Cedar-apple gall rust *Gymnosporangium juniperi-virginianae*	Ornamental junipers including varieties based on *J. communis, J. virginiana, & J. scopulorum*	Anoka Carver Dakota Hennepin Ramsey Scott Washington	Increasing for the past three years.

ABIOTIC AND ANIMAL DAMAGE

Pest	Host	Location	Notes
Lightning injury *Voltus gigantea*	Red pine	Gen. Andrews Nursery	About 30 trees killed or dying.
Winter damage *Damni coldus*	Apple, maple, cedar	north central counties	
Water damage *Blub-blub blubii*	Balsam fir, red pine, jack pine oaks	Cass, Crow Wing, Morrison, Todd	Poor crown and leaf color on edges of swamps or pockets of high water.
Winter drying of needles *Damni coldus var. desicatus*	Balsam fir	Isanti	
Mice	Apple Balsam fir	Rice Fillmore	Girdling of bark.
Squirrels	Sugar maple	Crow Wing Goodhue Wabasha	100% of bark stripped from base of tree out to ½" branches.
Pine grosbeaks	Red pine	Hubbard	15 acres had >50% of trees with terminal and lateral bud damage.
Chickens	Red pine	Pine	Root zone damage and fertilizer burn inside chicken pen. Also *Sphaeropsis* present.
Transplant shock *Dedumb novae-treum*	Blue spruce Green ash	Ramsey Washington	Late season planting in 1993, stock held too long at nursery
Weed whip *Trimus grassus*	Conifer seedings	Anoka, Dakota, Ramsey Washington	Many homeowners still think that weed whips do not damage trees.
Winterkill *Folius frostii*	Hawthorne	Washington	Suspect non-hardy cultivar
Deer damage *Bambi nibbli*	All species	Twin Cities area	Browse up to 5'. Antler rub especially heavy in 1994
Overcrowding *Densa densa*	Norway spruce	Washington	Windbreak trees

Pest	Host	Location	Notes
High water damage *Blub-blub blubii*	All species	Carver Dakota Hennepin Scott	Summer floods in 1993, areas covered for several weeks, especially along Minnesota River.
Construction damage *Compactus bulldozerus*	Oak Most other species	Anoka Carver Dakota Hennepin Scott Ramsey Washington	Mainly root damage by compaction, raised grade, and soil removal.



PHENOLOGICAL NOTES

Accumulated degree days are calculations based on high and low temperature readings starting on March 1st of the year with the base temperature of 32°F. For a given location, the degree days were calculated from temperature readings from either Brainerd, Crow Wing Co. or Grand Rapids, Itasca Co.

Date	Event	Accumulated degree days	County
3/ 28	First pussy willows showing.	50	Aitkin
4/ 12	50% of quaking aspen buds open. Silver maple in bloom. Loon sighted in open water.	127	Kanabec
4/ 19	Pussy willows and other willows blooming.	250	Crow Wing, Mille Lacs, Kanabec, Pine
4/ 20	Red, silver and sugar maples blooming. Aspen blooming.	259	Crow Wing
4/ 25	Red pine buds 1" long, but still brown. White pine buds swelling, ¼" long. Poplar buds opening, ¾" long.	352	Crow Wing
5/ 2	Pine bark beetles forming nuptial chambers and laying eggs. Marsh marigolds blooming.	399	Crow Wing
5/ 5	*Hepatica* just starting to bloom.	422	Itasca
5/ 6	White pine blister rust aeciospores released.	449	Crow Wing
5/ 7	A few aspen trees breaking buds. Marsh marigolds in bloom.		Carlton
5/ 9	Basswood leaves 20% of full size. A few aspens breaking bud. Marsh marigolds in bloom.	478	Stearns Itasca
5/ 11	Bellwort (*Uvularia*) in bloom.	515	Itasca

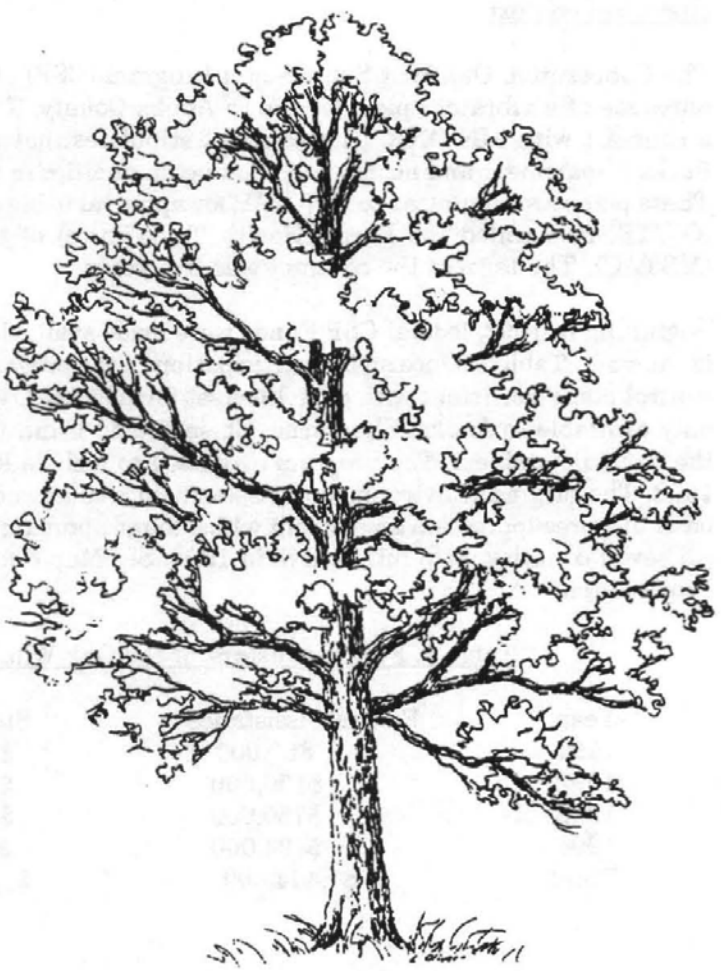
Date	Event	Accumulated degree days	County
5/ 12	Noted aspen leafrollers. First generation of bark beetle present (eggs, larvae and pupae).		Pine
5/ 13	Red oaks starting to leaf out. Jack pine shoots up to 2" long and staminate cones green. Larch needles about ½" long.	612	Crow Wing, Cass
5/ 17	*Trilliums* blooming.	716	Mille Lacs
5/ 18	Red and burr oaks blooming and leaves small. Wild plum and pin cherry blooming. Second instar spruce budworm. White spruce shedding pollen.	749 678	Cass, Crow Wing Anoka Itasca
5/ 19	Spruce budworm larvae in 2nd instar with a few 3rd instars feeding under bud caps. Buds in sun starting to enlarge, needles can be seen at base of bud. Red berried elder starting to bloom. Juneberry starting to drop flower petals, bigtooth aspen starting to leaf out. Pin cherry in bloom. Trillium in bloom. Temp 85 F.	708	Itasca
5/ 20	Jack pine shedding pollen. Crab apple in bloom.	820 746	Itasca Crow Wing
5/ 23	Hoary puccoon blooming. Jack pine beginning to shed pollen. Lilacs starting to bloom.	929 857	Cass, Crow Wing Itasca
5/ 24	Gall rust aeciospores released on pines.	962	Crow Wing, Cass
5/ 25	Spruce budworm larvae 4th-5th instar in sun, mostly 2nd - 3rd instar in shade, 50% of white spruce budcaps are off, others are webbed on by budworm, white spruce shoots are 1-1 ¼" long and needles just beginning to flair.	928	Itasca
5/ 26	Jack pine budworms ⅜" long, occurring in staminate cones. White pine blister rust aeciospores released.	1010	Crow Wing Crow Wing, Cass, Aitkin
5/ 28	Lilacs in full bloom.	998	Itasca

Date	Event	Accumulated degree days	County
5/ 31	Red and Scots pine pollen being shed. Some white spruce shoots up to 3" long. Red osier dogwood starting to bloom. Cotton grass and bog laurel in full bloom. Nodding trillium in bloom.	1103	Itasca
6/ 1	White spruce plantations sprayed with Bt (see Spruce Budworm).	1131	Itasca
6/ 7	Yellow-headed spruce sawflies are ½" long. Wild geranium and Virginia waterleaf blooming.	1378	Crow Wing
6/ 13	Wild rose blooming.	1561	Crow Wing and south.
6/ 15	Red pine sawfly larvae are ¾" long and feeding is completed. Mt. ash sawfly larvae are ½" long.	1646	Crow Wing
6/ 18	Spruce budworm is 75% pupated. Most damaged needles have been washed off by heavy rains. Orange and yellow hawkweed in bloom. Mt. ash in bloom.		northern St. Louis St. Louis
6/ 20	Bluebells and black-eyed Susans blooming.	1828	Crow Wing
6/ 24	Most spruce budworm moths have emerged and some new egg masses are present. 20% of spruce budworm moths have emerged.		northeast Itasca southeast Koochiching
6/ 23	Smooth hawkweed, oxeye daisy and wild lily of the valley blooming.		Pine
6/ 28	Yellow-headed spruce sawfly larvae are ¾" long.	2123	
6/ 29	Yarrow, Canada thistle and bird's foot trefoil blooming. Yellow headed spruce sawfly larvae are 1" long. Aspen blotch miner mines are ⅛ to ¼ inches in diameter. Needle rust pustules on red pine.	2156	Crow Wing St. Louis

Date	Event	Accumulated degree days	County
7/ 1	Weather has been overcast with heavy rains during spruce budworm moth flight and egg laying.		Region 2
7/ 7	Wood lily and Turk's cap lily blooming. Spruce budworm moths still flying.	2436	Crow Wing St. Louis
7/ 12	A few spruce budworm moths still flying, but the moth flight is mostly over.		northern St. Louis
7/ 15	Red headed pine sawfly larvae on scrub jack pine.		Sherburne
7/ 20	Adult pine spittlebugs observed.	2885	Crow Wing
7/ 22	Boneset blooming. Common sow thistle, spotted knapweed, wild bergamot, common mullein, evening primrose, goldenrod, turkeyfoot grass and asters blooming. Wintergreen fruits ripe. Common tansy blooming.	 2955	Aitkin Pine Crow Wing
7/ 29	Willow Sphinx caterpillar (*Smerinthus cerisyi*) found in BWCAW.		Lake
8/ 8	Aspen leaf blotch miner adults have emerged from pupae. Blazing star blooming.	3411	Pine, Crow Wing, Todd, Morrison
8/ 9	Joe-pye-weed blooming.		Carlton
8/ 24	*Chrysomyxa* rust pustules starting to show up on black spruce. Yellow-necked caterpillar (*Datana ministra*) found in Old Mill State Park.		Koochiching Marshall
10/ 11	71 degrees F.		International Falls, Koochiching Co.
11/ 21	First snow to stay on the ground.		Itasca

SPECIAL PROJECTS

Index



OAK WILT COOPERATIVE SUPPRESSION PROJECT

Introduction

Oak wilt, caused by the fungus *Ceratocystis fagacearum* (Bretz) Hunt, continues to be the primary cause of oak mortality in Minnesota. The oak type, made up of six species of oak, occupies 650,000 acres in Minnesota. Harvesting oak for wood products adds approximately $1 billion to the state economy while oaks in residential settings are our most valuable energy saving, shade trees. In addition, oaks are important for wildlife, from squirrels to white-tailed deer, and oak wilt can have a detrimental effect on these wildlife resources.

A 1988 photographic survey of the northern Metropolitan Region identified a total of 3,012 oak wilt infection centers on 5006 acres containing 91,821 trees. A second photographic survey of Dakota County in 1993 found additional centers. An aerial survey in 1989 found another 600 centers scattered over the southeast part of the state. In addition, oak wilt programs have identified new centers and additional centers too small to detect in the aerial survey. Today, approximately 6,000 infection centers are being tracked in Minnesota.

There is little doubt that a major cause of oak wilt in most areas has been development. Infection centers result from wounding trees during home construction, clearance for utility lines, road construction, yard maintenance, and recreation activities particularly in areas with existing infection centers.

Historical context

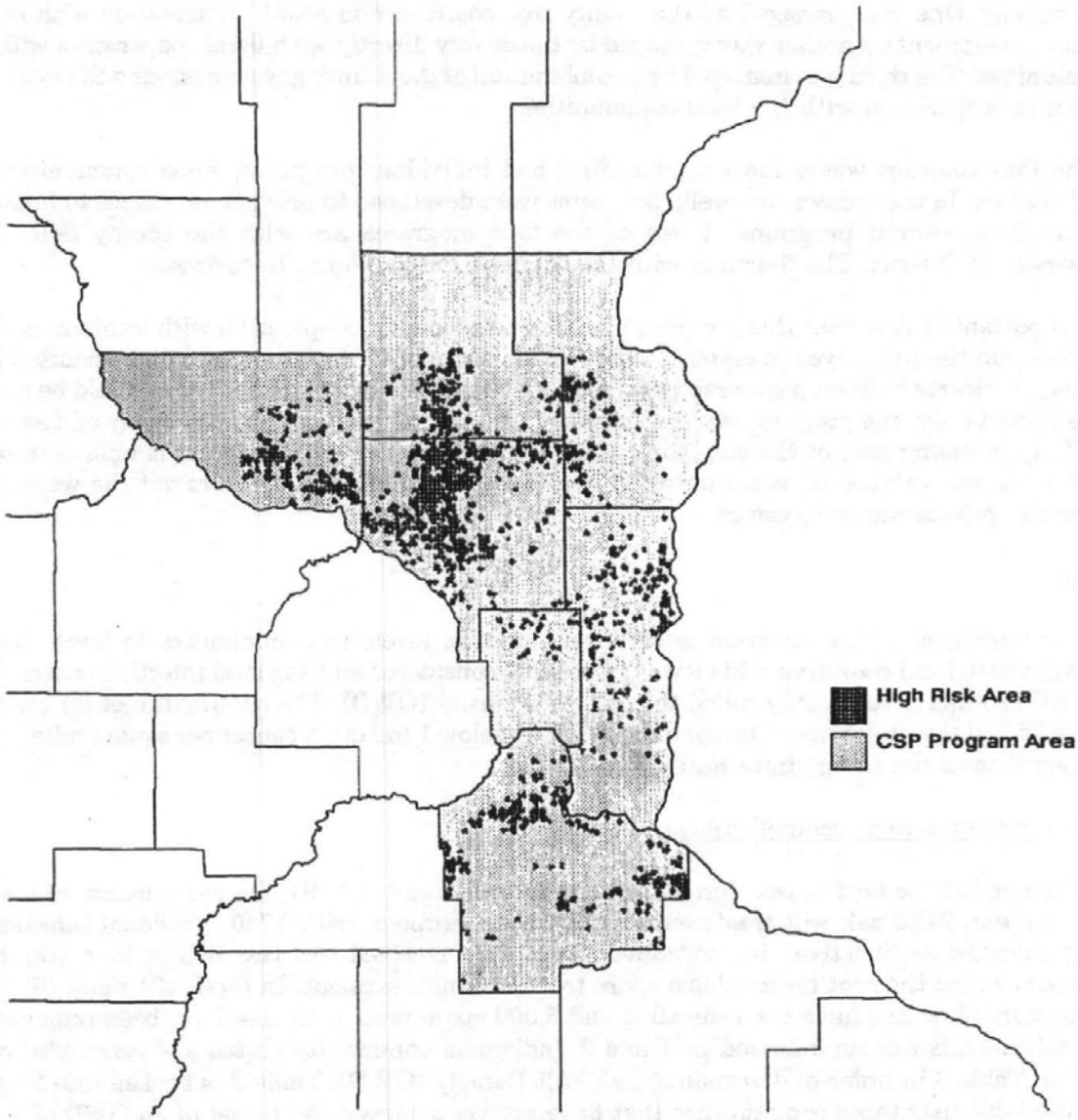
The Cooperative Oak Wilt Suppression Program (CSP) effectively began in 1991 with the cooperative purchase of a vibratory plow for use in Anoka County. This equipment was titled to the county under a contract with MN-DNR. This contract stipulates that the plow will be maintained by the county's Parks Department and made available to communities in the county that have Oak Wilt Control Plans. These plans are submitted to MN-DNR for approval using criteria developed by the Oak Wilt Task Force (OWTF, now called the Forest Health Task Force) of the Minnesota Shade Tree Advisory Council (MSTAC). The term of the contract was five years.

Beginning in 1992, federal CSP Funds were made available to communities. The history of that funding is shown in Table 1. Once again, participation in the program was dependent on communities developing control plans consistent with guidelines set forth by the OWTF. In the first year (1992), the program was only available to Anoka, Sherburne, Chisago, and Isanti Counties. These areas constituted the bulk of the oak wilt problem. The program expanded to include Ramsey, Washington, and Dakota Counties in 1993. The original Environmental Assessment was amended in 1993 to include Dakota County on the basis of a presuppression assessment which found approximately 800 infection centers in Dakota County. All seven counties were fully active in 1994. See Map 6 for Oak Wilt High Risk Areas within the CSP Project area.

Table 1. Funding history of the Oak Wilt CSP in Minnesota.

Year	Federal Assistance	State/Local Effort	Total Effort
1991	$50,000	$120,000	$170,000
1992	$150,000	$185,000	$235,000
1993	$750,000	$845,000	$1,595,000
1994	$494,000	$563,400	$1,057,400
Total	$1,444,000	$1,713,400	$3,147,400

Map 6. Oak wilt high risk areas within the Cooperative Suppression Project.



Scale: 0 5 10 mi

Note: CSP data as of June 1994. This map also illustrates the CSP project area.
Map production and analysis by EPIC
Minnesota Department of Natural Resources
Division of Forestry, Forest Health Unit

The first priority for servicing a community's needs for cost-share assistance was best served by developing a direct grant agreement with the community in which a block of funds, in effect a grant, was placed at the discretionary use of the community. Limited to a maximum of $35,000, 42 communities in four of the seven counties signed on. The other three counties developed unified county programs in various way. One was managed by the county tree board (a non-profit organization with links to the county government). Another was managed by the county directly with fiscal cooperation with the local communities. The third was managed by a combination of the county government and the local extension service in cooperation with the local communities.

In the four counties where local communities had individual programs, some communities declined participation. In these cases, umbrella programs were developed to provide assistance to landowners in communities without programs. Three of the four programs are with the county Soil and Water Conservation District. The fourth is with the county's Public Works Department.

It is important to note that this program has been developed in cooperation with local units. Currently, 131 communities are served in seven counties under terms of 42 separate grant agreements. The overall program is clearly built on partnerships, in fact, without those partnerships, there would be no program. More importantly, the program was designed to flow into the local community's way of doing business, in effect, becoming part of the community services. As a result, each program is unique in some way. Some cities use volunteers, some have full time foresters, and some contract out the work to various degrees to private sector foresters.

Goals

The primary goal of the program is to lower infection levels in communities to levels that can be managed with local resources. This level is generally considered as 1 (or less) infection center per square mile (IC/M^2) and is commonly called the oak wilt density (OWD). The specific target for the CSP is to a have 75% of the project area (by community) at or below 1 infection center per square mile. This figure is referred to as the Community Ratio (CR).

Current situation and accomplishments

As of the end of the field season (ground freeze-up) in December 1994, the performance of the program was excellent. 2493 oak wilt treatments had been undertaken, with 1740 individual infection centers being classified as "inactive", ie. controlled. Some sites received two treatments, ie. a vibratory plow treatment to cut the root grafts plus a spore tree removal treatment. In total, 131 miles (693,000 feet) of vibratory plow line have been installed and 5,000 spore producing tree have been removed. Annual accomplishments are summarized in Table 2. Individual community status and accomplishments are listed in Table 3 in order of descending Oak Wilt Density (OWD). Table 3 is broken into 2 parts. Part A of the table lists those communities that have not yet achieved the target of an OWD of 1.0. Part B of the table lists those communities that have achieved this level by the end of the 1994 field season.

Table 2. Minnesota's Oak Wilt CSP Accomplishments

Year	Infection Centers Treated	Vibratory Plow Line Installed	Spore Trees Removed
1991	n/a	n/a	n/a
1992	303	209,992	943
1993	726	200,763	2,403
1994	740	282,245	2,500**
1995*	700*	250,000*	2,000*

* Target; ** Estimated.

Currently, the oak wilt density in the project area has been reduced from 2.9 infection centers per square mile (IC/M²) to 1.8 IC/M² over the entire area. The Community Ratio (CR) was approximately 25% at the start and has already improved to 51% of the area.

Table 3. Oak Wilt Cooperative Suppression Program

Part A, Communities Above Target Threshold. After 1994 Treatments Listed in descending order of oak wilt density (Infection Centers Per Square Mile (MI/M²). MCD = Minor civil divisions.

City	Acres of Oak Wilt	Oak Wilt Treatment	Inactive Centers	Active in MCD	Total in MCD	MCD MI² as IC/MI2	IC/MI²	Cum Area
Oak Grove city	1475	57	40	376	416	35.0	10.7	0.01
Wyoming city	9	0	0	28	28	2.6	10.6	0.02
Andover city	741	60	52	342	394	35.0	9.8	0.04
Willernie city	0	0	0	1	1	0.1	7.5	0.04
Coon Rapids city	187	97	95	156	251	23.5	6.6	n/c
Marine on St. Croix	35	0	0	25	25	4.2	6.0	0.04
Dellwood city	5	0	0	13	13	2.7	4.8	0.04
Ravenna township	351	0	0	104	104	21.8	4.8	0.05
Ramsey city	347	100	65	140	205	29.7	4.7	0.07
Gem Lake city	6	0	0	5	5	1.1	4.4	0.07
Pine Springs city	2	1	1	4	5	0.9	4.3	0.07
Elk River city	533	129	83	183	266	43.8	4.2	0.09
North Oaks city	40	48	48	36	84	8.7	4.2	0.09
Inver Grove Heights	273	47	34	123	157	30.1	4.1	0.10
North Branch city	3	0	0	6	6	1.5	3.9	0.10
Big Lake township	547	92	53	170	223	45.3	3.8	0.12
Mahtomedi city	23	3	2	19	21	5.0	3.8	0.12
St. Francis city	279	19	16	85	101	23.7	3.6	0.13
Branch city	217	12	11	120	131	34.4	3.5	0.15
Ham Lake city	198	177	136	122	258	35.6	3.4	0.16
Lakeville city	185	25	22	126	148	37.5	3.4	0.18
May township	206	3	3	122	125	37.6	3.2	0.20
Bradford township	302	18	14	112	126	35.9	3.1	0.21
East Bethel city	434	61	40	148	188	48.0	3.1	0.23
Stacy city	4	0	0	3	3	1.0	3.0	0.23
Linwood township	177	28	18	104	122	35.9	2.9	0.25
Stillwater township	97	3	3	54	57	18.7	2.9	0.25
Cambridge city	11	16	11	10	21	3.8	2.6	0.26
Rosemount city	220	2	2	90	92	35.1	2.6	0.27
Grant township	55	0	0	68	68	27.1	2.5	0.28
Orrock township	283	38	20	89	109	36.2	2.5	0.30
Eagan city	191	182	132	79	211	33.3	2.4	0.31
Stanford township	263	46	39	93	132	39.4	2.4	0.33
Sunfish Lake city	5	0	0	4	4	1.7	2.4	0.33
Anoka city	13	1	1	16	17	7.1	2.3	0.33
Athens township	130	11	8	69	77	31.7	2.2	0.35
Bethel city	2	0	0	2	2	0.9	2.2	0.35
Lent township	117	18	17	74	91	35.6	2.1	0.36
Apple Valley city	83	322	196	33	229	17.7	1.9	0.37
Marshan township	100	0	0	65	65	34.8	1.9	0.38
Burnsville city	36	65	61	45	106	26.7	1.7	0.39
Lake Elmo city	57	1	1	43	44	25.2	1.7	0.41
Hugo city	62	0	0	55	55	36.0	1.5	0.42
Big Lake city	2	0	1	4	5	2.8	1.4	0.42
Miesville city	3	0	0	3	3	2.2	1.4	0.42
Vadnais Heights city	9	0	0	12	12	8.3	1.4	0.43
Wyoming township	94	9	8	47	55	32.7	1.4	0.44
Zimmermann city	3	0	0	3	3	2.2	1.4	0.44
Baytown township	14	2	2	14	16	11.0	1.3	0.45
Douglas township	50	0	0	43	43	33.5	1.3	0.46
West Lakeland township	17	0	0	16	16	12.6	1.3	0.47
Hampton township	42	0	0	37	37	34.3	1.1	0.48
New Scandia township	42	1	1	42	43	39.8	1.1	0.50
Oxford township	38	3	2	26	28	23.7	1.1	0.51

Table 3 (continued). Oak Wilt Cooperative Suppression Program.

Part B, Communities At or Below Target Threshold. After 1994 Treatments Listed in descending order of oak wilt density (Infection Centers Per Square Mile (MI/M^2).

City	Acres of Oak Wilt	Oak Wilt Treatment	Inactive Centers	Active Centers	Total Centers	MCD MI^2 in MCD	IC/MI^2 in MCD	Cum Area as IC/MI2
Hastings city	7	0	0	10	10	10.2	1.0	0.51
Lake St. Croix Beach	1	4	3	1	4	1.0	1.0	0.51
North Branch township	56	6	7	35	42	35.0	1.0	0.53
Oakdale city	31	32	32	10	42	10.1	1.0	0.53
Woodbury city	33	7	6	35	41	35.6	1.0	0.55
Livonia township	53	31	18	31	49	33.4	0.9	0.56
Afton city	26	0	0	20	20	26.4	0.8	0.57
Arden Hills city	18	10	5	8	13	9.6	0.8	0.58
Blaine city	212	183	148	28	176	34.0	0.8	0.59
Isanti city	1	0	0	1	1	1.3	0.8	0.59
Bayport city	0	0	0	1	1	1.5	0.7	0.59
Forest Lake township	51	0	0	24	24	32.7	0.7	0.60
South St. Paul city	1	0	0	4	4	6.1	0.7	0.61
Burns township	55	21	17	20	37	35.2	0.6	0.62
Columbus township	88	106	71	28	99	47.8	0.6	0.64
Mendota Heights city	5	0	0	6	6	10.1	0.6	0.65
Nininger township	11	0	0	10	10	17.7	0.6	0.65
Circle Pines city	12	38	22	1	23	1.9	0.5	0.66
Eureka township	20	0	0	18	18	35.8	0.5	0.67
Stillwater city	1	0	0	3	3	6.1	0.5	0.67
Forest Lake city	0	0	0	1	1	2.8	0.4	0.67
Isanti township	31	10	6	15	21	33.6	0.4	0.69
New Brighton city	17	54	22	3	25	7.1	0.4	0.69
Oak Park Heights cit	0	0	0	1	1	2.3	0.4	0.69
Vermillion township	23	0	0	14	14	34.1	0.4	0.71
White Bear township	11	13	8	4	12	9.1	0.4	0.71
Castle Rock township	25	0	0	12	12	35.8	0.3	0.73
Chisago Lake townshi	13	0	0	14	14	55.3	0.3	0.75
Empire township	8	0	0	10	10	34.4	0.3	0.76
Lino Lakes city	68	114	72	10	82	33.2	0.3	0.78
Shoreview city	49	122	57	4	61	12.7	0.3	0.78
Spencer Brook townsh	11	0	0	12	12	35.4	0.3	0.80
White Bear Lake city	2	0	0	3	3	10.4	0.3	0.80
Mounds View city	32	33	14	1	15	4.1	0.2	0.80
Springvale township	16	7	6	6	12	35.4	0.2	0.82
Baldwin township	52	27	14	3	17	35.5	0.1	0.83
Becker township	207	25	13	3	16	55.7	0.1	0.86
Blue Hill township	41	18	13	3	16	36.4	0.1	0.87
Cottage Grove city	3	1	1	5	6	37.9	0.1	0.89
Franconia township	2	0	0	4	4	31.9	0.1	0.90
Greenvale township	6	0	0	4	4	29.9	0.1	0.92
Clear Lake township	15	1	1	0	1	37.1	0.0	0.93
Maplewood city	6	8	8	0	8	18.0	0.0	0.94
Palmer township	7	1	1	0	1	36.5	0.0	0.95
Roseville city	0	0	1	0	1	13.8	0.0	0.96
Santiago township	8	4	3	0	3	36.3	0.0	0.98
St. Paul city	9	6	17	0	17	56.1	0.0	1.00
Totals and Averages For All Communities (Part A & B)	9956	2493	1740	4315	6055	2357.1	1.8	---

FOREST HEALTH MONITORING

From June 13 to September 1, 1994, crews travelled throughout Minnesota installing plots to begin monitoring the health of the forests. This was a new effort in Minnesota and is part of a nationwide program called "Forest Health Monitoring" (FHM). The motivation to begin monitoring the health of our forested ecosystems grew out of the observed effects of air pollutants, insects, diseases, and other stressors as well as the concern over the potential effects of global climate changes to the composition and stability of our forests. The FHM Program began in 1990 in the northeastern states and is a partnership between the Environmental Protection Agency (EPA) and state and federal agencies involved in managing forests.

The goals and objectives of Forest Health Monitoring are to:

- determine the present health of the forest ecosystem,
- detect changes and trends in forest conditions,
- analyze changes and determine causes, and,
- provide information to guide management and protection.

FHM is made up of 3 components, detection monitoring, evaluation monitoring and intensive site ecosystem monitoring. Detection monitoring is where most effort will be expended in Minnesota. Detection Monitoring determines annual differences from baseline conditions and trends. There are two types of fieldwork, surveys of forest pests and other stressors and a network of permanent FHM plots.

Annually, the Forest Health Specialists conduct the survey portion of this component. The entire forested area is surveyed for damage by air and ground. Larval and egg mass surveys for jack pine and spruce budworms as well as pheromone trapping surveys for pine tussock moths and gypsy moth are also carried out.

In Minnesota, there are 360 permanent FHM plots, and approximately 120 of them are forested. Each plot is made up of a cluster of 4 subplots with a fixed radius of 24 feet. Within each subplot are smaller plots for sampling seedlings, saplings, and other vegetation.

Detection Monitoring is continually evolving so that the ENTIRE forested ecosystem is monitored, not just the tree component of the ecosystem. Other indicators of forest health have been tested in various locations. Here in Minnesota, we will be looking for ozone sensitive plants, lichens, vegetation structure to measure plant diversity and the amount of sunlight reaching the surface under the tree canopy.

The permanent plot network in Detection Monitoring will not be intensive enough to definitively determine changes in the health of a forested area or a forest type within a state or county. The plots in a state will be part of a multi-state region which is part of the nationwide network of plots. Detection Monitoring will be useful to look at changes at a region-wide and nationwide scale. In the future, plot numbers in Minnesota may be increased so that more specific information can be gained about Minnesota's conditions. Combining plot measurements with survey information will also make plot information more useful in determining the changes in the health of Minnesota's forests.

FOREST HEALTH GEOGRAPHIC INFORMATION SYSTEM DEVELOPMENT PROJECT

Introduction

GIS technology is one of the most useful tools that natural resource managers have today, but difficulty in its use has kept most resource oriented professionals from using the tools in daily work. To date, most GIS work has concentrated on mapping projects or special analysis in defined project areas. GIS technology has become synonymous with costly hardware, specialized GIS staff, and long data entry periods. This project had two primary objectives, (1) to develop an intuitively operated user interface requiring little user training and (2) gather natural resource data into a single system in a standard format.

The standard state-wide data set will use 1 hectare cell size and is called MGC100. Each data layer will contain approximately 21 million cells. While the database was still being developed at the end of 1994, there were already over 100 thematic layers. These layers include information about forest health issues, climatology, soils, physiography, forest assessment, and administrative areas. These layers are currently available on Bernoulli Disks (150 multi-disk format and should be available on CD-ROM by mid-1995). This data set will be augmented in 1995 with ranges of native Minnesota trees, forest health information from 1949 to 1988, National Wetlands and state Protected wetlands, and additional administrative layers. As part of this project, all forest health map have been produced in digital form since 1990. Beginning in 1994, DNR-Forestry and the US Forest Service began interchanging map data in digital form.

EPIC is a user interface for PC class computers operating under MS-DOS. It utilizes EPPL7 software which permits data transfer to and from many GIS systems including ARC and ERDAS. It has been developed as part of the Forest Health Program in Minnesota in cooperation with the US Forest Service (FHM, S&PF, St.Paul). Version 1.0 went into general release in November, 1994.

The following briefly outlines the operational features of the program as of Version 1.0. Features indicated in *Italics* are in development, but will not be included until release 2.0 in 1995. Additional features being investigated include integration of data from DATANET (economic, census, social, etc.) and CD-ROM stored photos.

SELECT: choose the map area
- AREA: select the work area, ie. state, region, county, etc.
- LAYER: select the primary data layer for study, ie. rainfall, insect pest, drought, soil characteristic, forest covertype, etc. Over 100 are currently available.

DRAW: display on the computer monitor
- BEGIN: display the selected layer as defined
- OVERLAY: overlay the primary layer with line features like county lines, highways, climate zones, labels, etc. Manage overlays and their appearance.
- BACKGROUND: add hidden layers behind the primary data to permit spatial viewing of multiple layers.
- COLORS: edit and manage the color palette of the current layer
- OPTIONS: manage the DRAW default settings for personal preferences

PRINT: make a printed map
- CREATE: create the first copy of the map

PRINT: print copies of the map
ARCHIVE: save the current map for future use or save disk space
MAPQUEUE: set up a queue to print maps unattended
COLORS: manage the color palette used in the map
DOTSHELL[1]: use EPPL7's DOTSHELL program to make a custom map

ANALYSIS: develop new layers from existing data
BUFFERS: generate a new layer out a distance from defined features, ie. 100 meters from streams, roads, pine stands, or eagle nests
RECLASS: build a new layer by generalizing an existing layer
MODEL[2]: build a new layer from two existing layers and do time series work

REPORT: make summary reports of existing layers to the screen, printer, or file
FREQUENCY: make a frequency count of the current layer with acres
CROSS TAB: make a two way count of two layers summarizing all unique combinations with acres
THREE WAY: make a three way analysis of three layers
FOUR WAY: make a four way analysis of four layers

PEDIGREE: investigate the lineage and specifications of your data
LIST: display basic information on the screen
UPDATE: edit all the metadata (data about the data) for the current layer
PRINT: print a copy of the metadata for the current layer

UTILITY: useful routines gathered in one place
LOAD: load new AREA or LAYER
DELETE: erase AREA or LAYER
ARCHIVE: save AREA or LAYER for future use
BUILD SUB AREA: build new AREA from existing area including clipping of all LAYERS into the new sub area
PLS LOAD[3]: load PLS data (TRS) into a new point layer

GPS LOAD: load data from UTM labeled file from a GPS recorder into a new point layer
EXIT: leave the UTILITY menu

Map 7 is an EPIC produced map entitled "Risk Zones for Building Near Oaks Due to Oak Wilt in Dakota County in 1995." It was created in approximately 10 minutes on a 486-66 class PC. The data was derived from the Cooperative Oak Wilt Suppression Program database as modified by the cooperating communities. The model is based on distance to an active infection center (1500' is considered a critical threshold) and soil type. These maps will be produced for each cooperating community and distributed in time for the 1995 field season.

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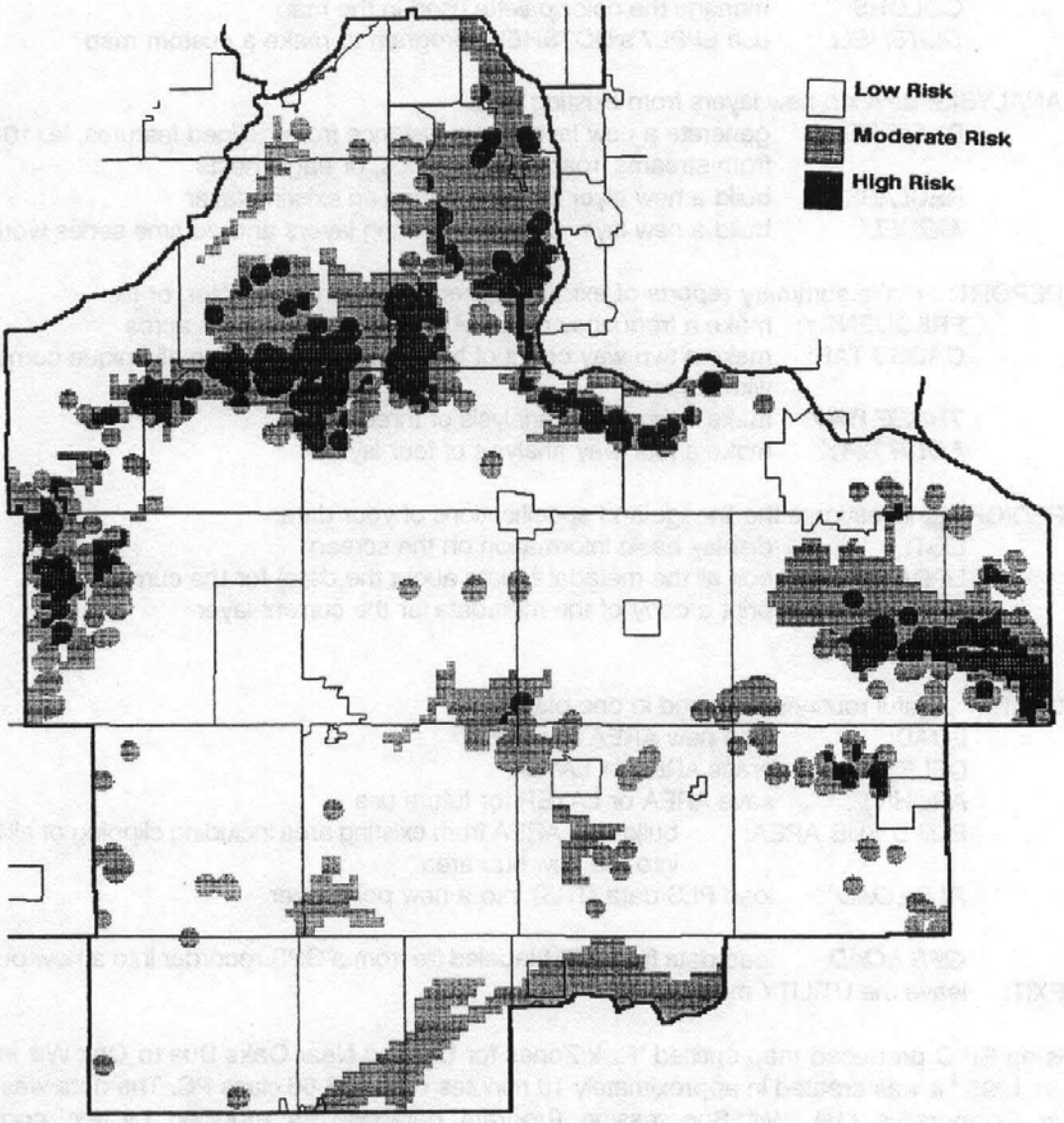
[1] currently a stand alone EPPL7 sub program

[2] currently being programmed at LMIC

[3] *already exists as a stand-alone routine, PLS2MAP.*

Map 7. Risk zone for building near oaks due to oak wilt in Dakota Co. in 1995.



Risk of New Oak Wilt Infections Arising From Construction During May and June In Dakota County

Scale: 0 5.00 mi 10 mi

Model depicts risk of developing a new oak wilt infection center. It is based on distance to an active infection center and soil type.
Minnesota Department of Natural Resources
Division of Forestry, Forest Health Unit

NORTH AMERICAN MAPLE PROJECT

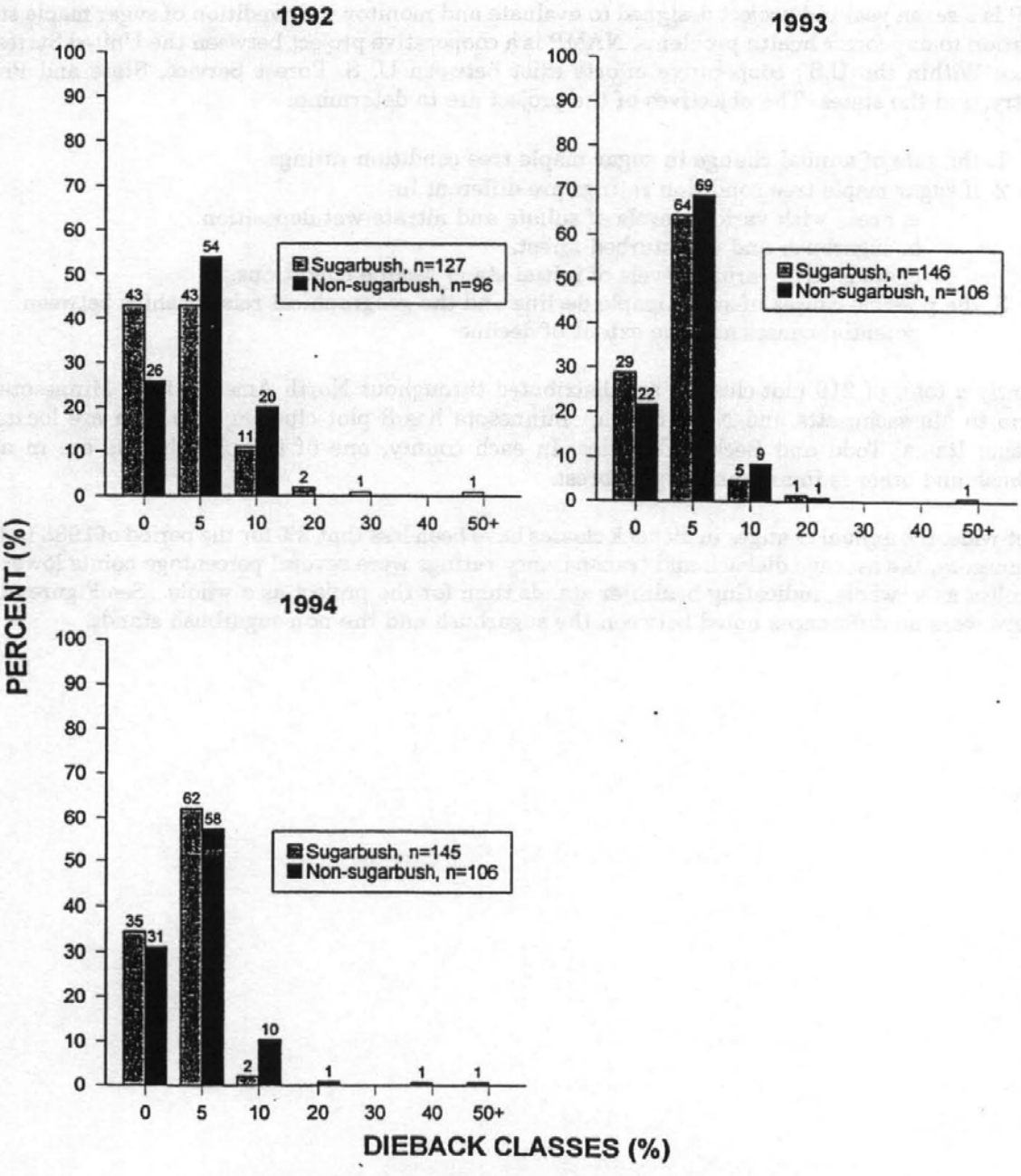
NAMP is a seven year old project designed to evaluate and monitor the condition of sugar maple stands in relation to any forest health problems. NAMP is a cooperative project between the United States and Canada. Within the U.S., cooperative efforts exist between U. S. Forest Service, State and Private Forestry, and the states. The objectives of the project are to determine:

1. the rate of annual change in sugar maple tree condition ratings.
2. if sugar maple tree condition ratings are different in:
    a. areas with various levels of sulfate and nitrate wet deposition.
    b. sugarbush and undisturbed forest.
    c. areas with various levels of initial stand decline conditions.
3. the possible causes of sugar maple decline and the geographical relationships between potential causes and the extent of decline.

Currently a total of 219 plot-clusters are distributed throughout North America from Minnesota and Ontario to Massachusetts and Nova Scotia. Minnesota has 8 plot clusters; two each are located in Wabasha, Itasca, Todd and Becker Counties. In each county, one of the plot-clusters are in active sugarbush and other is in an unmanaged forest.

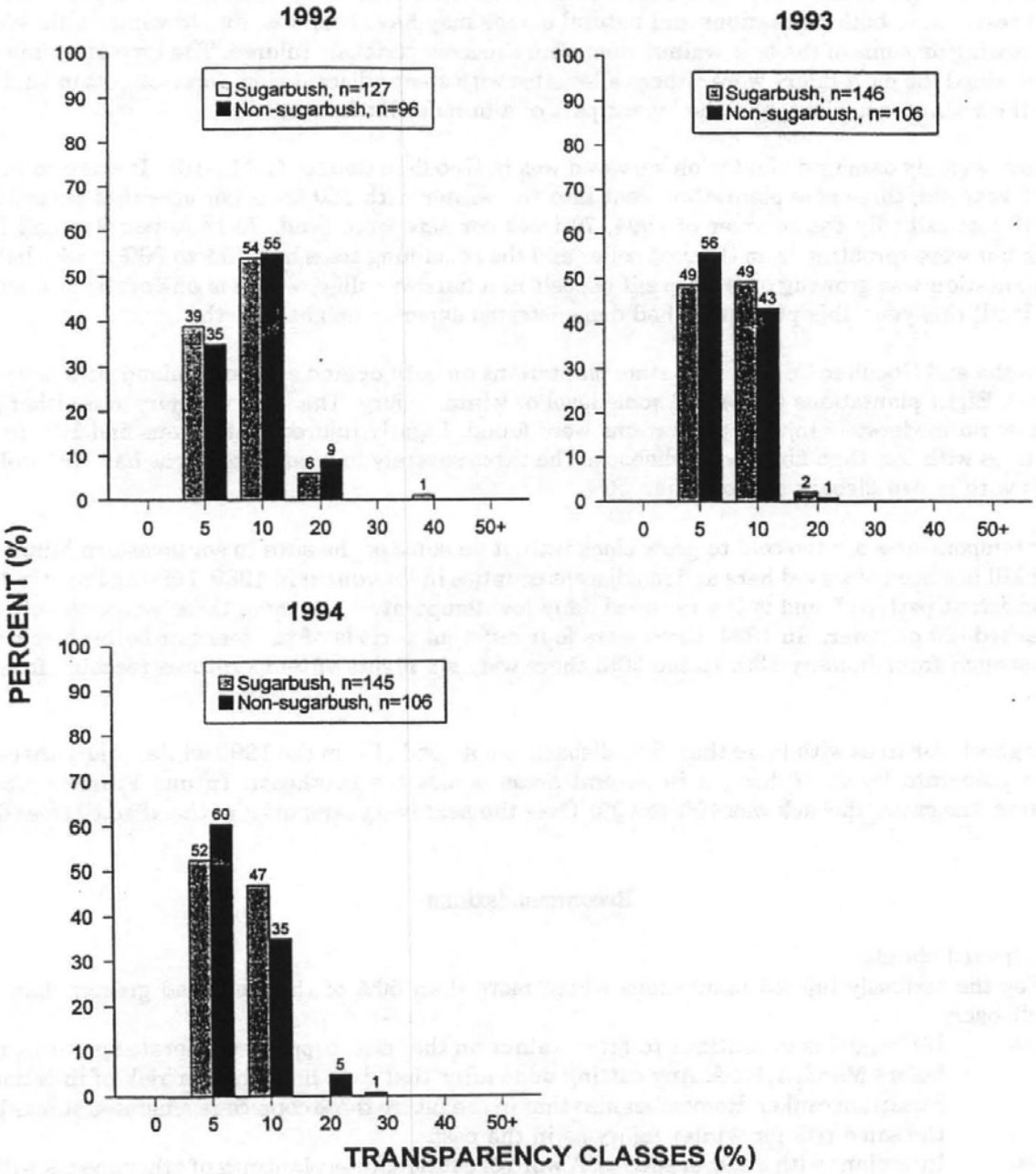
Project-wide, the annual changes in dieback classes have been less that 2% for the period of 1988 to 1994. In Minnesota, the average dieback and transparency ratings were several percentage points lower that the project as a whole, indicating healthier stands than for the project as a whole. See Figures 1 and 2. There were no differences noted between the sugarbush and the non-sugarbush stands.

Figure 1. Frequency distributions of crown dieback by management category in Minnesota.



Three-year frequency distributions of crown dieback by management category for live, dominant/codominant sugar maple, 1992-1994, in sugarbushes (SB) andnon-sugarbushes (NSB) in Minnesota.

Figure 2. Frequency distributions of crown transparency by management category in Minnesota.



Three-year frequency distributions of crown transparency by management category for live, dominant/codominant sugar maple, 1992-1994, in sugarbushes (SB) and non-sugarbushes (NSB) in **Minnesota.**

WINTER KILL OF BLACK WALNUT

The winter of 1993-1994 caused dramatic and serious injury to hardwood trees. Five or six black walnut plantations in each of the five southeastern counties have been severely damaged. Ten percent of the walnut resource in both plantations and natural stands may have been lost due to winter kill. Walnut trees growing on some of the best walnut sites were the most seriously injured. The type of walnut sites that sustained the most injury were either valley sites with steep adjacent side slopes or bottomland sites where the walnut was planted in the lowest part of a broader landscape.

The most severely damaged plantation surveyed was in Goodhue County (1-112-16). It was a total loss. This 18 year old, three acre plantation went into the winter with 250 trees per acre that ranged from 30 to 40 feet tall. By the summer of 1994, 70 trees per acre were dead, 70 trees per acre had 100% dieback but were sprouting from the root collar and the remaining trees had 76% to 99% crown dieback. This plantation was growing on a deep silt deposit in a narrow valley, which is one of the best walnut sites. Until this year, this plantation had demonstrated superior height growth.

In Wabasha and Goodhue Counties, 36 state plantations on both upland and bottomland sites have been surveyed. Eight plantations (20%) had some level of winter injury. The level of injury was either light or severe; no moderately injured plantations were found. Lightly injured plantations had 10% to 15% of the trees with less than 25% crown dieback. The three severely injured plantations had 75% to 100% of trees with crown dieback of more than 50%.

Winter temperatures are too cold to grow black walnut on some of the sites in southeastern Minnesota. Winter kill has been observed here and in adjacent counties in Wisconsin in 1989, 1990 and now in 1994. The consistent pattern found is the recorded daily low temperature. In these three years, the ultimate low reached -20 or lower. In 1994, there were four different periods of the teens or better below zero. In one stretch from January 13th to the 20th there were six nights of temperatures reaching from -21 to -29.

The prognosis for trees with more than 50% dieback is not good. From the 1990 winter injury there was light to moderate levels of dieback in several areas across the southeast. In one Fillmore County plantation, the crown dieback was 40% to 60%. Over the next two years, most of the affected trees died.

Recommendations

1. For affected stands:
   - A. For the seriously injured plantations where more than 50% of the trees had greater than 50% dieback:
     - If the goal is to continue to grow walnut on that site, coppice regenerate sprouting trees before March 1,1995. Any cutting done after that date has a higher risk of infection by Fusarium canker. Remember also that in the future these coppice regenerated stands have the same risk for winter injury as in the past.
     - Interplant with another species. A word of caution, interplantings of other species will not moderate the effect of cold temperatures on the surviving walnut.
     - If walnut is not a desired part of the site's future, contact your local forester for suggestions for alternative species. Otherwise Mother Nature will fill in the site herself.
   - B. For lightly injured plantations where less than 10% of the trees have less than 25% crown dieback:
     - Expect Fusarium cankers to develop in the crowns at the point of the dieback. Trees with dieback in the main leader will develop internal decay. In any case, if the plantation is

young enough and there are fewer stems per acre than desired, consider regenerating the injured trees by coppice.

Note: Removing dead branches and dead trees from plantations is not likely to have an impact on the amount of Fusarium canker in the plantation in the future. *Fusarium* seems to be found where ever wounding occurs be it from winter injury, dead branches, or lateral pruning wounds made during the growing season.

2. Restrict future plantations to sites where walnut grows naturally or where they survived the 1994 winter.

3. Avoid planting walnut in either narrow valley bottoms with steep side slopes or in broad valleys that form the lowest elevation in the landscape.

4. Consider interplantings with all walnut plantations. Continue to plant interplantings of walnut and other species on first bench or upland sites. Upland interplantings of walnut and white pine continue to be successful.

HAZARD TREE POSTER

"How to identify hazard trees" is a full color poster that is suitable for use in recreation areas. If only the front side is displayed, it could be used in urban situations. There are nine photos on the front depicting the seven hazard categories and ten diagrams on the reverse side depicting parts of the tree to inspect and what to look for. The text, a synopsis of the hazard tree manual, defines a hazardous tree, how to evaluate trees, the defects and their hazard level, how to correct the hazardous situation, preventing future hazards and how to improve a hazard tree program.

10,000 copies were printed and are available at no cost to agency personnel or low cost to private individuals. Contact a Regional Forest Health Specialist for more information. Graphic layout and design were done by the DNR, Information and Education Bureau, Graphics Design artist, Jean Miller.

HAZARD TREE TRAINING

A hazard tree training session, " Train the Trainers", was requested and conducted in Michigan by the Minnesota Forest Health Unit. An additional session was conducted in Minnesota for urban forestry personnel. These one day sessions are awarded 4 continuing credits from the International Society of Arboriculture.

SPRUCE BUDWORM CONCLAVE

A one day field session was held on September 27th to discuss the effects and impacts of a spruce budworm outbreak and options for managing white spruce plantations. Particular emphasis was placed on shared concerns for our white spruce plantations because budworms were targeting spruce rather than balsam fir in the central and north central counties. More than 30 foresters met at Badoura Nursery and another 25 joined the group at the first field stop.

Right now, budworm is concentrating defoliation in white spruce plantations 20-40 years old. It is not causing notable defoliation of balsam fir in nearby stands. This is anomalous behaviour in terms of the Minnesota experience. The last time budworm was active in these counties was 1954, when a 1 year outbreak occurred in the Chippewa National Forest. Could this be a short-lived and low intensity outbreak? No way to know. For now, we are monitoring life stages and defoliation severity in selected spruce plantations to see if something should be done in the managed areas.

Because white spruce holds its needles for seven to eight years, it can probably handle about two more years of heavy defoliation before topkill begins to appear. Potentially, spruces could accommodate defoliation for six more years before being killed. Balsam fir only holds its needles for five to seven years so it succumbs more quickly to budworm.

The value of thinning spruce plantations during a budworm outbreak was questioned. Thinning encourages optimum stand growth and tree vigor. Trees with a high growth rate, proper density and full crowns can handle defoliation for more years than suppressed or crowded trees. Yet, budworms prefer abundant new foliage, so thinning during a heavy outbreak may increase populations and accelerate defoliation of that stand.Leaving non-host trees in spruce plantations is a good practice because it reduces the in-stand survival of larvae. As the young larvae spin down, they are blown onto adjacent non-host trees and are unable to survive.

Harvest a merchantable, mature, white spruce stand if it has experienced severe defoliation and is getting topkill rather than spraying it to "hold over" until the outbreak is over. Spraying, at best, maintains green foliage but the trees do not add an appreciable amount of wood during the treatment.

It is worthwhile to spray isolated and well-managed plantations that have already had 3-4 years of heavy defoliation. Mature and overmature stands as well as unmanaged plantations probably are not worth the time, effort and expense of spraying. If spraying is planned, be aware that it is not always successful for two main reasons. Timing is important. Bt should be sprayed when the larvae are in the 4th or 5th instar (900-1100 degree days). Bt works better on balsam fir than on white spruce because of the shape of the spruce needles and the persistence of the spruce bud cap.

The economics of spraying is debatable. Current costs are $40/ acre and may have to be repeated about four times over a 10-12 year outbreak to prevent growth losses. Success is not guaranteed.

SURVEY RESULTS

AERIAL SURVEY RATING SYSTEM

Sketch mappers endeavored to follow the new, federal aerial survey guidelines during the 1994 season. The defoliation ratings for the traditional system is comparable to the new system as follows:

Traditional defoliation ratings are based on this scheme:

Low ..... 1 - 20 % of the foliage missing on the tree
Moderate..... 21 - 50 % of the foliage missing on the tree
High..... ..... 51 - 100 % of the foliage missing on the tree.

The new ratings add two parameters to the ratings, distribution and incidence.

Distribution:
Scattered.....More than 250 acres between affected areas
Contiguous or blanket.....Less than 250 acres between affected areas.

Incidence:
Threshold of damage on canopy area based on 50% damage and affected trees occupying 30% of the canopy area.

So that the resulting new rating system looks like this:

Class 1.....> 50% damage on 30-50% of canopy area with scattered distribution.
Class 2.....> 50% damage on 30-50% of canopy area with contiguous distribution.
Class 3.....> 50% damage on > 50% of canopy area with scattered distribution.
Class 4.....> 50% damage on > 50% of canopy area with contiguous distribution.
Class 5.....Below threshold, either < 50% damage on > 30% of canopy area or
> 50% damage on < 30% of canopy area.

Spruce Budworm

Spruce budworm early larvae surveys

The likely impact of budworm in a stand can be assessed by sampling L3 and L4 instars in late May and early to mid-June. This survey consists of collecting 3 twigs from the midcrowns of 3 trees. The number of larvae and the number of current buds are counted on the 15 inch branch. If there is one larvae for each 10 buds on the branch defoliation is predicted to be heavy.

Survey dates May 31 - June 2, 1994

Legal description	Quarter	Tree Species	Total # of larvae	Total # of buds	Remarks	Predicted 1994 heavy defoliation	Actual 94 defoliation
S23-T61-R14	NWSE	BF	2	714	BF shoots 2-3",3rd & 4th instars	-	
S6-T64-R12	NWNW	BF	358	780	2nd & 3rd instars	+	
S22-T63-R12	NENW	BF	131	388	2nd & 3 rd instars	+	Heavy
S8-T65-R15		BF	74	503	2nd & 3rd	+	
S34-T66-R17	NENE	BF	199	406	2nd & 3rd and a few 4th instars	+	
S10-T68-R20		BF	268	988		+	Heavy
S12-T68-R21	SWSW	BF&WS	277	557	2nd to 5th instars	+	Heavy
S26-T68-R21		BF	20	448		-	Very light
S15-T67-R21	SWNE		25	487		-	Very light

Legal description	Quarter	Tree Species	Total # of larvae	Total # of buds	Remarks	Predicted 1994 heavy defolia-tion	Actual 94 defoli-ation
S19-T65-R22	NWSW	BF	67	361	3rd & 4th instars	+	
S16-T69-R23		BF	8	401		-	Modera te
S10-T68-R24	SENW	BF&WS	3	451	Shoots 2.5-3.5" long 3rd & 4th instars	-	none
S10-T67-R22		BF	12	513		-	
S19-T68-R22	NWSE	WS	1	570	Budcaps still on Shoots 1" long	-	Very light
S26-T64-R22	SENE	BF	2	391	Shoots 2" long 4th & 5th instars	-	

Spruce budworm pheromone traps

Purpose: To develop baseline data which may be used as a predictive tool as budworm populations build up, peak and decline in the state.

Method: At each location, three pheromone traps were deployed inside the stand in a triangular pattern 40 meters apart and 40 meters from the stand edge. Traps were set out as early as June 6th (Sherburne Co.) and retrieved as late as August 16th (Aitkin Co.). The number of moths are counted.

Analysis: Poor correlations ($r^2 = 0.2797$) with number of egg masses found on each site, perhaps next year's defoliation would be better. See tables below.

Legal Description	Average # of moths per trap	1993 Defoliation	1994 Defoliation	Predicted 1995 defoliation based on egg masses
S36-T52-R12	84		0	
S19-T55-R10	90		0	
S16-T69-R23	364	Moderate	Moderate	Heavy
S28-T68-R25	55	Moderate	Light	Moderate
S27-T158-R26	59	Light	Light	Moderate
S27-T156-R25	37	Light	Light	Heavy
S32-T55-R26	174	Heavy	Heavy	Light
S9-T56-R25	230	Heavy	Heavy	Moderate

County	Location	Species	Number of moths	Defoliation in 1994	Number of egg masses (1995 prediction)
Aitkin	6,7-51-23	WS	213	Very light	0.00 (0)
Carlton	7-45-16	BF	904	None	0
	27-46-16	BF	870	Trace	0
	13-44-17	BF	790	None	0
	2-45-17	BF	695	None	0
	10-45-17	BF	562	None	0
Cass	5-141-30	WS	2116	Heavy	4.66 (S)
	13,24-136-31	WS	2454	Heavy	0.88 (M)
Hubbard	9-139-32	WS	2549	Very light	1.55 (M)
	13-141-32	WS	5087	Heavy	3.00 (S)
Sherburne	33-34-27	WS	4790	Very light	0.66 (M)

Spruce budworm egg mass surveys

This survey consists of counting the number of egg masses on needles of white spruce or balsam fir. Three 15 inch branches are clipped from the mid-crown of 3 dominant or codominant trees. A total of 9 branches are collected at each site. The next year's defoliation is predicted as follows:

Predicted defoliation		Average number of egg masses/branch
none to light	=L	0 - 0.1
moderate	=M	0.1 - 1.7
heavy	=H	1.8 +

Legal Description	Quarter	Host	1993 Defol.	1993 Egg masses per branch	Predict. 1994 defol.	1994 Actual defol.	1994 Egg masses per branch	Pred. 1995 defol.
Itasca Co.								
S10-T53-R26	SWSW	WS	H	0	0	L	0	0
S11-T53-R26	SESW	WS	H	0.33	M	VL	0	0
S6-T56-R25	SWNE	WS	H	2.7	H	H	0.9	M
S33-T55-R26	NWSW	WS	L-H	2.5	H	H	0.1	L
S35-T58-R24	NWSW	WS	L-H	0	0	VL	0.4	M
S9-T56-R25	SENW	WS				H	0.7	M
S11-T53-R26	NENE	WS				VL	0.1	L
St Louis Co.								
S16-T65-R19	NWNE	WS	M	0.2	M	L	0.5	M
S26-T65-R18	NENE	BF				M	0.6	M
S35-T66-R17	NWNW	BF, WS				M	0.4	M
S35-T67-R17	SESE	BF				M	1.3	M
S8-T66-R18	NENE	BF				M	0.8	M
S2-T60-R21 RD		WS				M	1.0	M
S33-T60-R21	ROAD EDGE	WS				M	1.22	M
S33-T60-R21	INTERIOR OF STAND	WS				L	1.0	M
S4-T65-R20	NWNE					H	0.55	M

Legal Description	Quarter	Host	1993 Defol.	1993 Egg masses per branch	Predict. 1994 defol.	1994 Actual defol.	1994 Egg masses per branch	Pred. 1995 defol.
S6-T66-R20	NENW					VL	0	0
S24-T65-R14	SWNE					H	0.8	M
S22-T63-R12	NENW	WS BF	H	3.2	H	H	1.2	M
S10-T68-R20	SESW	WS	L-M	2.4	H	H	1.2	M
S12-T68-R21	SWSW	WS	L-H	1.1	M	H	2.1	H
S36-T63-R12	SENW	BF	H	2.4	H	H	0.55	M
S15-T67-R21	NWSE	WS	L	0.2	M	VL	0.2	M
S13-T68-21	NWSW	WS	L-H	0.7	M	M	0.6	M
S26-T68-R21	NENW	WS	0-L	0	0	VL	0.1	VL
S2-T64-R13	SENE	WS				H	1.3	M
S7-T65-R15	SENE	WS				VL	0.3	M
Koochiching Co.								
S19-T68-R22	SENE	WS	0	0	0	VL	0.1	VL
S27-T156-R25	SWSE	WS	L	0.5	M	L	2.56	H
S10-T68-R24	SENW	WS	0	0	0	0	0	0
S16-T69-R23	NENE	WS	L-H	0.6	M	M	1.88	H
S16-R69-R23	NWSE	BF				VL	0.1	VL
S12-T67-R22	SWSE	WS, BF				VL	0.1	VL
S24-T65-R23	SENE	BF, WS				H	0.9	M
S25-T64-R22	NWSW	WS, BF				VL	0	0
S28-T68-R25	SWSE	WS	L-M	19.9	H	L	0.78	M
S27-T158-R26	NWNE	WS	L-H	12.8	H	L	0.55	M
Cook Co.								

Legal Description	Quarter	Host	1993 Defol.	1993 Egg masses per branch	Predict. 1994 defol.	1994 Actual defol.	1994 Egg masses per branch	Pred. 1995 defol.
S1-T61-R1W	SESE	BF	VL	0.1	L	VL	0.1	VL
S34-T61-R3W	SWNE	WS BF	0-H	0.4	M	H	0.1	L
S8-T65-R4W	SWSE	BF	0	0	0	VL	0	0
S32-T65-R3W	SWNE	BF	0-VL	0	0	VL	0	0
S4-T62-R1W	NENE	BF	L	0	0	VL	0.1	L
S34-T62-R1E	NESW	BF				H	0.2	M
S19-R61-R4W	NWSW	BF				M	0.2	M
Lake Co.								
S21-T63-R11	NWNW	BF	H	1.1	M	H	1.2	M
S9-T63-R9	SENW	BF	M-H	0.2	M	H	1.7	M
S31-T55-R10	SWSW	BF, WS				0	0	0
S7-T57-R10	SWNE	BF				0	0	0
S27-T60-R10	SENW	WS				VL	0.1	L
S27-T61-R10	NESE	BF				L	0.1	L
S3-T61-R11	NESE	BF				H	0.7	M
S31-T62-R11	NWNW	BF				H	1.4	M
Carlton Co.								
S33-T61-R14	SWSE	BF				0	0	0
S25-T49-R19	SWNW	BF				0	0	0

Location	Tree species	Current defoliation	Percent dead buds	Average # of egg masses	Pred. 1995 defoliation
Aitkin County					
6 & 7-51-23	WS	Very light	0	0	0
16-52-24	WS	Severe	35	1.22	Moderate

Location	Tree species	Current defoliation	Percent dead buds	Average # of egg masses	Pred. 1995 defoliation
Carlton County					
7-45-16	BF	None	0	0	0
Cass County					
13,24-136-31	WS	Severe	35	0.88	Moderate
36-137-32	WS	Heavy	55	1.00	Moderate
22-138-31	BF	None	0	0	None
36-139-28	WS	Very light	5	0.11	Light
34-140-26	BF,WS	Heavy	45	1.00	Moderate
17-140-27	BF	Light	-	0.44	Moderate
32-140-28	BF	None	0	0	None
5-141-30	WS	Heavy	50	4.77	Severe
Crow Wing County					
17-44-31	WS	Moderate	15	1.77	Heavy
15-138-26	BF	None	0	0	None
Hubbard County					
9-139-32	WS	Light	25	1.55	Moderate
13-141-32	WS	Heavy	45	3.00	Severe
1-142-33	WS	Heavy	40	1.11	Moderate
Morrison County					
1-41-29	WS	Heavy	10	0.88	Moderate
Pine County					
13-44-17	BF	None	0	0	None
7-45-16	BF	None	0	0	None
2-45-17	BF	None	0	0	None
10-45-17	BF	None	0	0	None
Sherburne County					
3-34-27	WS	Very light	5	0.66	Moderate

JACK PINE BUDWORM

Survey results for Region 1.

It is sometimes difficult to classify defoliation of jack pine due to budworm feeding. Larvae feed on the foliage of new shoots first, and needle loss can be accumulative each year. Thirty percent defoliation can be confused with 30% of the foliage on the new shoots or 30% of the entire tree's foliage. Because of this, foliage transparency rather than defoliation was rated during the early larvae survey. The percentages in the table are averages of the transparency rating of all 5 trees sampled on the plot. The higher the transparency percentage, the less foliage the tree has. Generally, transparency ratings were in the 10 to 20% range. These transparency ratings are low enough to be of little concern.

Location	# of Shoots with larvae (30 total)	Average Percent Transparency	Number of Egg Masses
Becker			
138-36-1-nwnw	--	--	0
139-36-9-swnw	--	--	1
139-36-14-nene	--	--	0
139-36-14-swsw	--	--	1
139-36-15-nenw	--	--	0
139-36-22-nenw	--	--	2
139-36-24-nene	--	--	0
139-36-26-swnw	--	--	0
141-36-1-sesw	--	--	0
141-36-24-nenw	--	--	0
141-36-34-nene	--	--	0
Beltrami			
146-34-16-nwnw	--	--	0
147-34-4-sese	0	10	0
147-34-8-sesw	2	10	0
147-34-9-nwnw	7	20	0
147-34-9-sesw	3	20	0
147-34-10-sene	2	20	0
147-34-11-nene	4	20	0
147-34-11-nenw	4	20	0
147-34-15-swnw	4	20	0
147-34-21-nwne	0	30	1
147-34-26-nese	2	30	0
147-34-26-sene	--	--	1
147-34-35-sene	2	10	0
147-35-1-nene	1	20	0
147-35-2-senw	1	20	0
147-35-3-swne	4	10	0
147-35-11-sese	1	10	0
147-35-26-nwne	0	20	--
148-35-13-nene	--	--	0
148-35-20-swsw	0	20	--
148-35-28-sese	--	--	0
148-35-28-swsw	--	--	0

Location	# of Shoots with larvae (30 total)	Average Percent Transparency	Number of Egg Masses
148-35-29-sesw	2	30	--
148-35-29-senw	--	--	0
148-35-29-sese	--	--	0
148-35-29-swne	--	--	0
Hubbard			
139-32-9-nesw	7	10	0
139-32-9-sene	1	30	0
139-32-10-sese	4	20	0
139-32-10-sesw	1	20	0
139-32-11-nwnw	8	30	0
139-32-12-swsw	0	20	0
139-32-13-nene	6	20	0
139-32-14-senw	3	20	0
139-33-5-swse	--	--	0
139-33-13-nene	--	--	1
139-33-14-swne	--	--	0
139-33-26-senw	--	--	1
139-33-27-nese	--	--	1
139-33-35-nwnw	--	--	0
139-35-26-swse	6	20	0
139-35-35-nenw	2	20	0
139-35-35-swsw	4	20	0
140-32-14-swse	4	20	1
140-32-17-swsw	--	--	0
140-32-21-nwnw	--	--	0
140-32-22-nwnw	7	20	0
140-32-23-nwnw	8	20	0
140-32-23-swsw	9	20	0
140-32-23-swsw	--	--	0
140-32-24-nene	4	30	2
140-32-26-swsw	9	20	0
140-32-29-sesw	--	--	0
140-32-34-sese	1	20	1
140-32-34-nenw	4	20	0
140-32-36-nwnw	5	20	0
143-34-5-nwne	0	10	0
143-34-8-nwne	--	--	0
143-34-8-swse	0	10	1
143-34-9-nene	0	10	0
143-34-9-sesw	0	10	0
143-34-10-nwsw	0	10	0
143-34-16-nwne	0	10	0
143-35-2-swse	--	--	0
144-34-3-sene	0	10	0
144-34-10-nese	2	20	0
144-34-15-nwse	0	10	0
144-34-22-swse	0	10	0
144-34-32-nenw	1	10	0

Location	# of shoots with larvae (30 total)	Average percent transparency	Number of egg masses
144-34-34-swse	0	10	0
145-34-2-nene	0	20	0
145-34-4-nenw	--	--	0
145-34-22-sese	1	20	0
145-34-23-nese	0	20	0
145-34-27-nesw	--	--	0
145-34-27-nwse	0	20	--
145-34-33-sese	2	20	0
Lake of the Woods			
159-33-29-senw	--	--	0
159-33-35-sese	--	--	0
159-34-7-sese	--	--	0
159-34-13-nwnw	--	--	0
159-34-16-nene	--	--	0
159-35-2-nesw	--	--	0
159-36-13-swne	--	--	0
Roseau			
160-37-6-nwne	0	10	
161-36-19-sene	0	10	
161-36-30-nesw	0	20	

Jack pine early larval survey for Region 3.

County	Location	Number of budworms	Date	Remarks
Cass	SWSE 15-138-32	2	6-15	6th instars present. No 1993 defoliation.
Crow Wing	NESE 17-44-31	27	6-14	Many 5th and 6th instars but undersized. Medium shoot damage. Few pollen cones.
	SWNE 10-44-31	9	6-9	3rd and 4th instars. No pollen cones. Moderate 1993 defoliation.
	NWNE 10-44-31	21	6-14	Many 5th and 6th instars, a few 7th instars. Little current shoot damage.
	8,9,17,18-44-31	20 plus	6-28	Light defoliation in 1994. Budworms about 90% pupated. Heavy 1993 defoliation. 50% dead tops due to defoliation and winter kill of weak buds.

County	Location	Number of budworms	Date	Remarks
	SESW 9-137-29	3	6-15	6th and 7th instars.
	SWNE 3-136-29	11	6-15	7th instars.
	SESE 28-135-28	5	6-20	Two pupae and 5 7th instars. One dead budworm and 2 parasite cocoons in 2 webbed shoots. Heavy 1993 defoliation. In 1994, many webbed shoots without larvae and little needle damage. Pollen cones rare.
	NESW 11-134-28	4	6-20	6th and 7th instars. Pollen cones rare. Heavy 1993 defoliation.
	SWSE 30-134-28	8	6-20	7th instars and 2 pupae.
	NENE 32-134-28	3	6-20	One pupae.
	SENE 8-133-28	9	6-20	Most 6th and 7th instars. Little shoot damage. Many pine spittlebugs.
	NESW 11-136-27	14	6-21	Many 6th and 7th instars.
	NWSW 9-136-27	6	6-21	Many 6th and 7th instars. One pupa.
	SESE 33-135-27	1	6-20	One pupa. No pollen cones. No 1993 defoliation.
Hubbard	SESE 8-138-33	6	6-15	Many 6th instars. No 1993 defoliation.
Pine	NESE 13-45-20	3	6-13	2nd instars. Pollen cones rare.
	SWSE 25-45-20	1	6-13	3rd instars. Pollen cones rare.
	SENW 36-45-19	3	6-13	A few 5th instars. Pollen cones rare. Heavy spittlebug flagging of shoots.
	NESW 36-45-20	3	6-13	A few 4th instars. Pollen cones rare.
	St. Croix State Park			
	SENE 8-40-18 2.8 mi south of entrance	9	6-14	Most 6th instars. 1 pupa. All in pollen cone clusters with almost no needle feeding.
	SESE 8-40-18 3.6 mi south of entrance	26	6-14	Many 6th and 7th instars. 90-100% of new shoots heavily chewed, but no topkill.

County	Location	Number of budworms	Date	Remarks
	SWSE 10-40-18	3	6-14	5th and 6th instars. No pollen cones. Trees with 10% dead tops. Light 1993 defoliation.
	NENE 17-40-18 3.9 mi south of entrance	20	6-14	Many 2nd and 3rd instars; none larger. No discolored shoots.
	NESW 17-40-18	10	6-14	5th instars with little needle chewing. No pollen cones. Almost 50% of trees with dead tops from 1993 defoliation and winter kill of weakened buds. *
	SENE 21-40-18	17	6-14	Many 7th instars. Little needle feeding. Few or no pollen cones. 10% of trees with dead tops.
Wadena	19,22,30-35 of 136-33	20 plus	6-24	Lyon State Forest. About 50% pupated. Nearly 30% of trees with 90% of buds chewed, but only about 40% of shoots dead. No dead tops. Discoloration worse than last year. Many spittlebugs.
	3-6,8-10,15 and 22 of 135-33	20 plus	6-24	Lyon State Forest. Ditto.

* = On June 14th, a single jack pine, typical for the Park, was felled and dissected. There was four feet of topkill, the top two feet were dead and dry. The next lower two feet had wet sapwood although the lateral branches were dead. No bark beetles were found infesting the tree. Many spittle bugs were noted sucking sap of the felled tree.

Jack pine budworm egg mass survey

More than 3 egg masses or egg case clusters found at a plot location (2 branches cut from mid crown of 4 trees, and 18 inches of needle-bearing twigs examined from each of the 8 branches) could result in moderate to severe jack pine defoliation the next summer

PLOT LOCATION	DATE	EGG MASSES	COMMENTS
CROW WING COUNTY			
SENE 10-44-31	8-1	0	Medium (21-50%) defoliation of '93 needles. No defoliation of '94 needles.

PLOT LOCATION	DATE	EGG MASSES	COMMENTS
NESE 17-44-31	8-1	0	Light defol. of 93 and 94 needles
NESE 11-134-28	8-1	0	Light defol. of 93 needles and medium defol. of 94 needles.
NWNE 15-133-29	8-1	0	No 94 defoliation. Light to medium 93 needles eaten in 94.
SENE 8-133-28	8-1	0	Heavy (50+% of 93 needles eaten, but very light light (5 to 10%) defol. of 94 needles.
MORRISON COUNTY			
NESE 5-132-30	8-9	5	Medium to heavy defol. of 93 and 94 needles. Most buds alive.
NENW 14-130-30	8-9	4	Light defol. of 94 needles. Medium to heavy defol. of of 93 needles in 94.
NWSE 13-130-30	8-9	0	Very light defol. of 94 needles, but light to heavy defol. of 93 needles in 94.
PINE COUNTY			
SESE 8-40-18	7-21	1	St. Croix State Park. Heavy (70%) defol., but shoots and buds 90% alive.
SWSW 16-40-18	7-21	1	SCSP. Light (10%) defol. of 94 needles. Heavy defol. of 93 needles on 1/3 of branches.
SENW 17-40-18	7-21	1	SCSP. Zero to light defol. of 94 needles. Five % of eggs parasitized.
NESE 20-40-19	7-21	2	SCSP. Light defol. of 94 needles. No 93 needles defoliated.

PLOT LOCATION	DATE	EGG MASSES	COMMENTS
SWNW 15-40-18	7-21	0	SCSP. No 94 needles eaten.
NWSW 11-40-18	7-21	0	SCSP. No 94 needles eaten.
NESE 15-40-18	7-21	0	SCSP. No 94 needles eaten.
SWSE 25-45-20	7-22	0	Light (5 to 10%) 94 needle defol..
SENW 30-45-19	7-22	1	Dago Lake. Light 94 needle defol..
SESW 36-45-20	7-22	1	Light 94 needle defol..
SWNE 6-44-18	8-11	0	Very light 94 defol. of 93 and 94 needles.
SESW 27-44-20	8-11	0	Very light 94 defol. of 93 and 94 needles.
NENE 4-43-20	8-11	0	Very light 94 defol. of 93 and 94 needles.
NENW 14-43-20	8-11	0	Very light 94 defol. of 93 and 94 needles.
WADENA COUNTY			
SWSE 31-137-33	8-12	2	Heavy backfeeding of 93 needles in 94, and 0 to very light defol. of 94 needles.
SWNW 17-137-33	8-12	3	Light to medium defol. of 94 needles, but medium to heavy backfeeding of 93 needles in 94.
SESE 8-137-33	8-12	2	Light to medium defol. of 94 needles, and light to heavy backfeeding of 93 needles.
NENW 12-137-34	8-12	5	Light to heavy defol. of 93 and 94 needles.
SESW 36-136-34	8-12	0	Zero to light 93 and 94 needle defoliation.

PLOT LOCATION	DATE	EGG MASSES	COMMENTS
NWNW 29-136-33	8-12	2	Medium to severe (8l + %) defol. of 93 and 94 needles.
SWNW 5-135-33	8-12	4	Medium to severe defol. of 93 and 94 needles.
NWSE 3-135-33	8-12	7	Light to severe defol. of 94 needles. Medium to severe defol. of 93 needles.
NWNW 35-136-33	8-12	4	Medium to severe defol. of 94 needles, and light to medium (21 to 50%) defol. of 93 needles.

PINE TUSSOCK MOTH

Trap catches of pine tussock moths in pheromone traps

A count of 30 or more male moths in a trap over a 10-14 day period would indicate probable need for chemical control the next year. Such numbers and decision to apply chemical control should be combined with defoliation evaluations of the infested jack pines.

COUNTY	LOCATION	DATE TRAP PLACED	TRAP NO. OR NAME	DATE TRAP CHECKED	MALE P.T. MOTHS IN TRAP
Crow Wing	SWSE 30-136-28	6-15	1	7-20	0
	Paul Bunyan Nature Learning Center			8-23	0
				9-1	0
Crow Wing	NWSW 9-136-27	6-21	2	7-7	4
				7-20	0
				8-8	1
				8-23	0
				9-1	0
Crow Wing	NWSE 9-136-27	6-21	3	7-7	2
				7-20	2
				8-8	4
				8-23	1
				9-1	0
Crow Wing	NWSW 11-136-27	6-21	4	7-7	4
				7-20	0
				8-8	5
				8-23	4
				9-1	0
Crow Wing	NWNW 24-136-27	6-21	5	7-7	2
				7-20	0

COUNTY	LOCATION	DATE TRAP PLACED	TRAP NO. OR NAME	DATE TRAP CHECKED	MALE P.T. MOTHS IN TRAP
				8-8	2
				8-23	0
				9-1	0
Hubbard	16-139-32		Nursery	7-8	12
				7-21	4
				7-28	13
				8-5	2
				8-18	9
				9-1	0
Hubbard	9-139-32		Woodland Tour	7-8	6
				7-21	0
				7-28	1
				8-5	4
				8-18	9
				9-1	1
Hubbard	10-139-32		Cutover Rd	7-8	13
				7-21	5
				7-28	6
				8-5	8
				8-18	7
				9-1	0
Hubbard	34-139-33		Game Farm	7-8	16
				7-21	1
				7-28	10
				8-5	14
				8-18	20
				9-1	1

COUNTY	LOCATION	DATE TRAP PLACED	TRAP NO. OR NAME	DATE TRAP CHECKED	MALE P.T. MOTHS IN TRAP
Pine	NESE 13-45-20	6-23	6	7-7	3
				7-22	0
				8-9	0
				8-24	0
Pine	SESE 18-45-19	6-23	7	7-7	3
				7-22	2
				8-9	1
				8-24	0
Pine	SWSW 36-45-20	6-23	8	7-7	11
				7-22	0
				8-8	2
				8-24	0
Pine	SESW 30-45-19	6-23	9	7-7	10
				7-22	1
				8-8	0
				8-24	1
Pine	NESW 30-45-19	6-23	10	7-7	4
				7-22	0
				8-8	2
				8-24	0
Pine	SWSE 25-45-20	6-23	11	7-7	15
				7-22	2
				8-8	2
				8-24	0
Pine	NESW 26-45-20	6-23	12	7-7	6
	NE side of G.A. Nursery			7-22	1

COUNTY	LOCATION	DATE TRAP PLACED	TRAP NO. OR NAME	DATE TRAP CHECKED	MALE P.T. MOTHS IN TRAP
				8-8	0
				8-24	0
Wadena	15-138-33		Huntersville Imp.	7-8	19
				7-21	16
				7-28	21
				8-5	3
				8-18	5
				9-1	1
Wadena	10-138-33		Huntersville Rd	7-8	16
				7-21	13
				7-28	15
				8-5	7
				8-18	4
				9-1	0
Wadena	9-138-33		Huntersville Rd Extra	7-8	13
				7-21	2
				7-28	2
				8-5	6
				8-18	8
				9-1	0