MINNESOTA FOREST HEALTH REPORT

1995

Department of Natural Resources
Division of Forestry - Forest Health Unit

Preface

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 fourteen 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.

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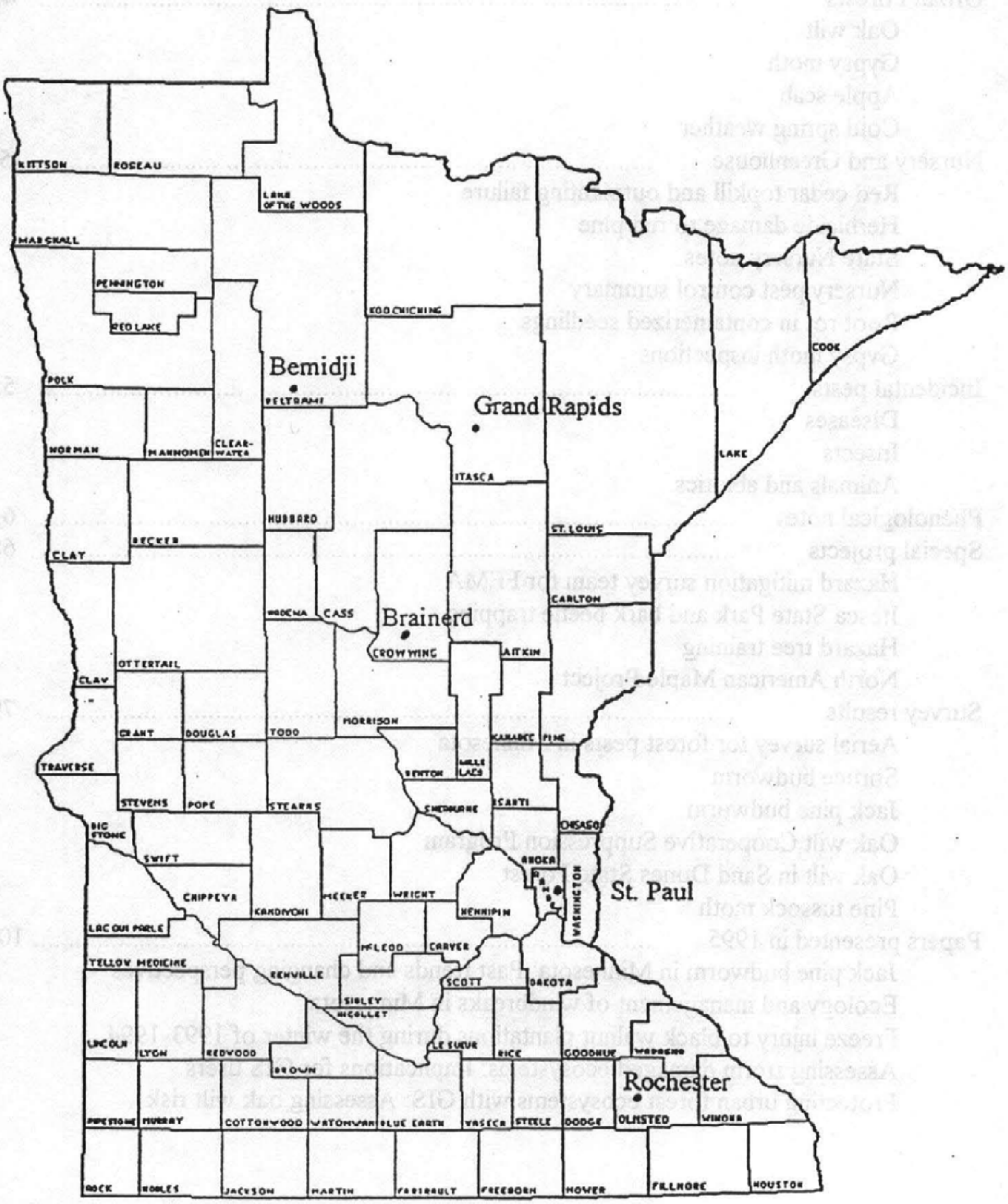
MAP OF MINNESOTA COUNTIES



THE FOREST RESOURCE

***Items in this section include*:**

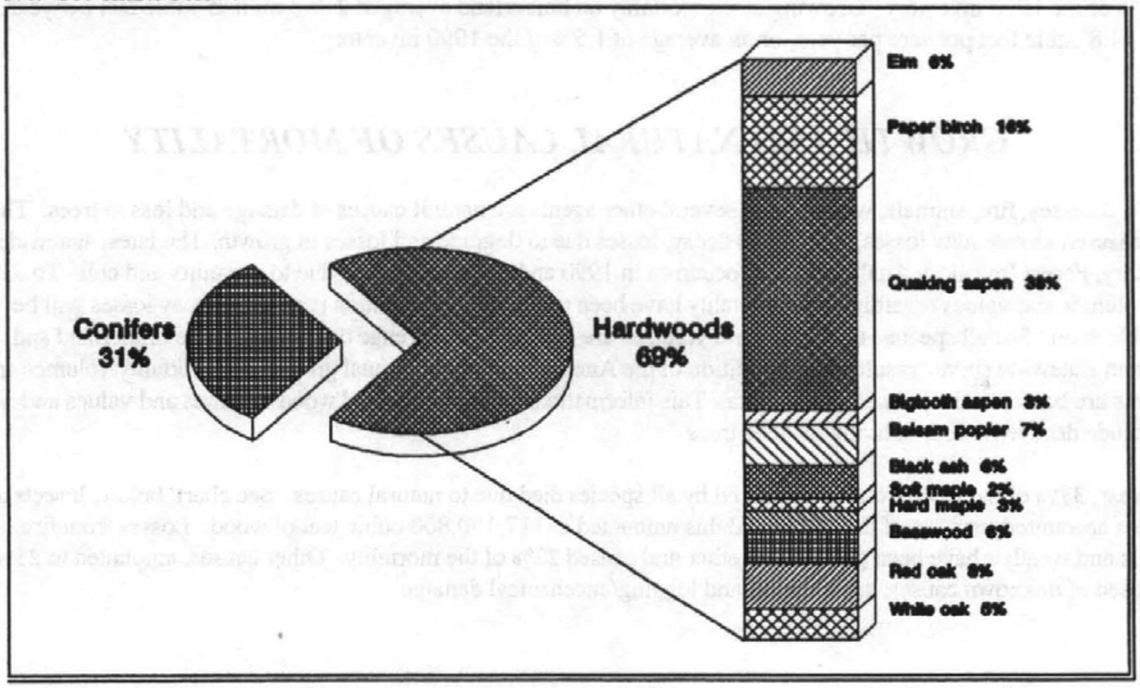
Forest Inventory Analysis - 1990: The resource and mortality losses
Forest Health Monitoring - 1994: Results Analyzed

Forest Inventory Analysis - 1990: The resource and mortality losses

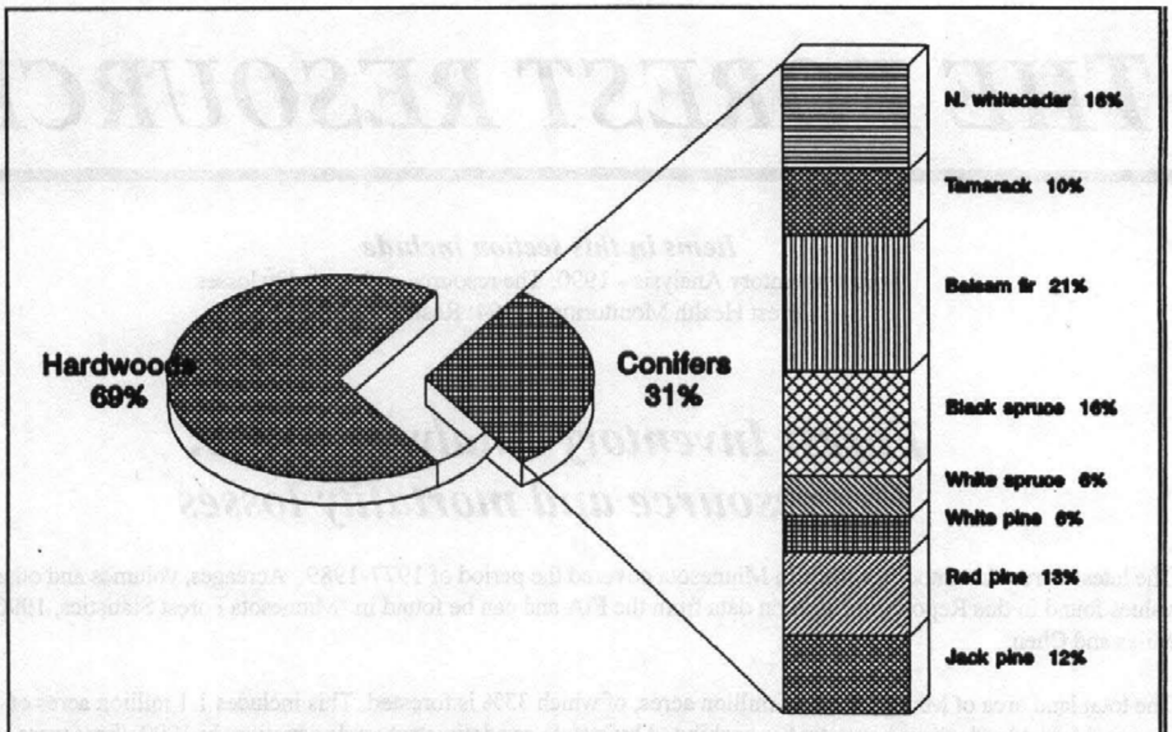
The latest Forest Inventory Analysis in Minnesota covered the period of 1977-1989. Acreages, volumes and other values found in this Report are based on data from the FIA and can be found in "Minnesota Forest Statistics, 1990" by Miles and Chen.

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



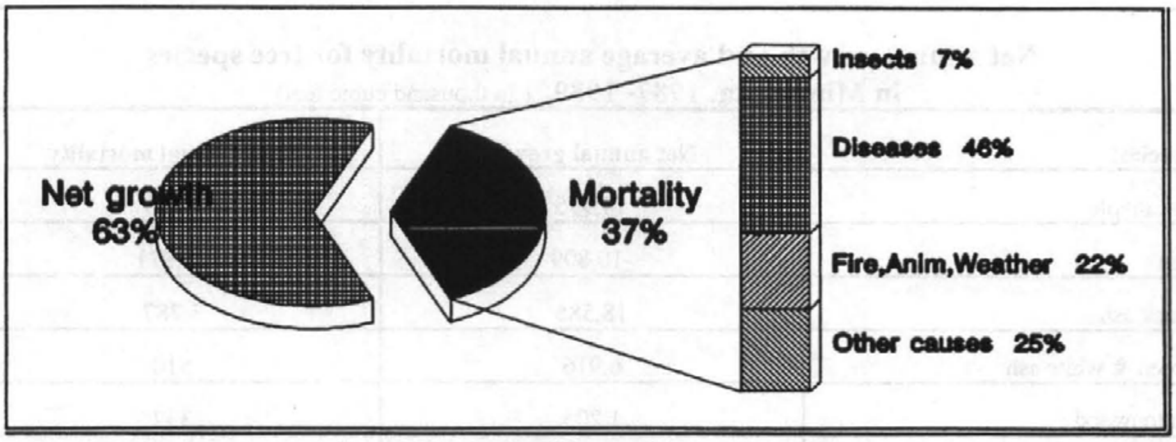
Growing stock volume by conifer species

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
Yellow birch	104	278
Hard maple	12,365	1,071

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**
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 Monitoring - 1994: Results Analyzed

OBJECTIVES

The Northern Forest Health Monitoring Program was initiated in 1990 to provide for a long-term, systematic collection of scientifically sound information on the condition of forested ecosystems. This program in the Northeast is a continuing, cooperative effort among the USDA Forest Service, U.S. Environmental Protection Agency, and the various state departments and agencies which deal with forested ecosystems. The Northeastern Forest Experiment Station has overall responsibility for activities on the plots and is assisted by the Northeastern Area, State and Private Forestry, Forest Health Protection staff. The EPA Environmental Monitoring and Assessment Program for forests (EMAP-Forests) provides specific assistance in sampling design, training and quality assurance activities, electronic data collection procedures, and research on additional indicators of forest health and condition. The State foresters in cooperating states provide the services of their staffs to cooperate in developing and managing the program, and in collecting data.

The objectives of the program relating to the plot network are to:

1. Estimate the current status, extent, changes, and trends in forest ecosystem health with known confidence;
2. Monitor indicators of forest tree and ecosystem condition and identify associations between natural and human-caused stresses and ecological condition;
3. Provide periodic statistical summaries and interpretative reports on the ecological status and trends to resource managers and the public.

In 1994, 360 plots were established in Minnesota. This will be the baseline data set for future comparisons. Of these plots, approximately 120 are forested. Each plot is made up of a cluster of four subplots with a fixed radius of 24 feet. All live and dead trees larger than five inches d.b.h. are tallied and several measurements, including crown parameters, are taken on each tree. Seedlings, saplings and other vegetation are surveyed on smaller plots within each subplot.

2392 trees were assessed on the plots. For statistical reasons, only data from 2201 trees will be considered. In order to statistically address a tree species' population, it has to have at least 30 trees in the FHM data set. Seventeen tree species met this criterion in Minnesota.

TREE CROWN MEASUREMENTS

Three different measurements, foliage transparency, crown dieback and crown density, were collected for trees greater than five inches in diameter.

Foliage transparency is an estimate of the amount of skylight visible through the foliated portion of a tree crown. The amount of foliage transparency differs by species and depends on the branching pattern plus the type and orientation of leaves. Foliage transparency serves as an estimator of defoliation caused by insect damage, pathogens, or environmental stress. See table below. 98.8% of the trees were classified as having normal foliage. Departing from the norm were black ash and tamarack. 17.3% of the black ash trees and 6.9% of the tamarack trees had moderate to severe transparency.

Foliage transparency

Species	Number of trees (n > 30)	Percent of sampled trees		
		Normal 0-30%	Moderate 31-50%	Severe 51-100%
aspen	494	97.9	0.6	1.4
birch	231	97.4	2.6	0
black ash	121	82.6	16.5	0.8
basswood	118	98.3	1.7	0
burr oak	109	100	0	0
red oak	93	98.9	0	1.1
red maple	93	100	0	0
sugar maple	57	100	0	0
balsam poplar	52	98.1	1.9	0
American elm	43	100	0	0
balsam fir	217	97.2	0	2.8
black spruce	208	98.6	0	1.4
white cedar	150	98.7	0	1.3
tamarack	73	93.1	1.4	5.5
red pine	69	100	0	0
jack pine	48	100	0	0
white pine	35	97.1	0	2.9

Crown dieback is defined as recent branch mortality that begins at the terminal portion of branches and proceeds toward the trunk. Dead branches in the center and lower crown or below the live crown are assumed to have died from competition of shading and are not included. Crown dieback is caused by severe stress, frequently to the root system of the tree, though some species exhibit light levels of dieback as part of their normal growth and development. See table below. 98.5% of the trees were classified as having no or light dieback. All hardwoods had a fraction of a percentage in the moderate dieback category. Balsam fir and black spruce were the only conifers with any dieback above the light category. Black ash had 19.9% of the trees with moderate to severe dieback; balsam fir had 9.6% and American elm had 6.1%

Crown dieback

Species	Number of trees (n > 30)	Percent of trees sampled			
		None 0-5%	Light 6-20%	Moderate 21-50%	Severe 51-100%
aspen	494	88.9	10.3	0.6	0.2
birch	231	87.0	9.5	0.4	3.1
black ash	121	65.3	14.9	2.5	17.4
basswood	118	93.2	3.4	0.8	2.5
burr oak	109	96.3	3.7	0	0
red oak	93	89.3	9.7	1.1	0
red maple	93	90.3	9.7	0	0
sugar maple	57	94.7	5.3	0	0
balsam poplar	52	73.1	23.1	1.9	1.9
American elm	43	90.7	2.3	2.3	4.7
balsam fir	217	77.0	13.4	6.9	2.7
black spruce	208	87.5	9.6	1.9	1.0
white cedar	150	90.7	9.3	0	0
tamarack	73	98.6	1.4	0	0
red pine	69	97.1	2.9	0	0
jack pine	48	77.1	22.9	0	0
white pine	35	100	0	0	0

Crown density represents the amount of foliage, reproductive structures (e.g., seeds or cones), and branches that obstruct skylight visibility through the crown. A normal, healthy, forest-grown tree is used as the standard. A dead top is included but dead lower branches are excluded. Estimates of low crown density have been correlated with reduced tree growth for several species. See table below. 97.7% of the trees were classified as having average of better crown density. Most tree species had a fraction of a percentage in the poor density class. Black ash had 17.4% of its trees in the poor category and American elm had 4.6% of the trees in the poor category.

Crown density				
Species	Number of trees (n > 30)	Percent of trees sampled		
		Good 51-100%	Average 21-50%	Poor 0-20%
aspen	494	59.1	39.3	1.6
birch	231	68.8	27.7	3.5
black ash	121	57.8	24.8	17.4
basswood	118	59.3	38.1	2.5
burr oak	109	74.3	25.6	0
red oak	93	64.5	35.5	0
red maple	93	62.4	35.5	2.1
sugar maple	57	75.4	24.6	0
balsam poplar	52	61.5	36.5	2.0
American elm	43	60.5	34.9	4.6
balsam fir	217	57.1	42.4	0.5
black spruce	208	74.0	26.0	0
white cedar	150	60.0	38.7	1.3
tamarack	73	72.6	26.0	1.4
red pine	69	91.3	8.7	0
jack pine	48	41.7	56.2	2.1
white pine	35	60.0	40.0	0

TREE DAMAGE MEASUREMENTS

Damage caused by pathogens, insects, weather extremes, or other agents can adversely affect tree health, either by killing trees or by reducing the growth or development. Information is collected on up to three types of damage per tree, limiting observations to certain types of damage which may potentially either kill the tree or adversely affect long-term survival. For each damage the location of where it occurs is also recorded, along with an assessment of the degree of severity.

A certain amount of damage in the population of trees is expected and even desirable. For example, openings in trees are used as shelters by wildlife, and decaying wood harbors insects which are a critical part of the ecosystem food chain. The purpose of collecting data on tree damages is to establish a baseline of expected damage levels, against which future trends may be measured, and to provide tree-specific data useful in determining potential causes of decline based on measurements of other variables.

Although it was possible to record three damage codes per tree, only 5.5% of the trees had two or three damaging agents recorded. In all analyses, only the first damaging agent was used. This will facilitate comparison of the FHM and FIA databases.

The table below summarizes the first damage code recorded for each tree on all the FHM plots. 78.5% of the trees did not show any sign of measurable damage. The decay and crown damage categories had the highest incidence, 9.5% and 4.6%, respectively. These findings are surprisingly consistent with those recorded for 1993 in New England and the Mid-Atlantic Regions. Decay is the leading damage agent and the remainder occur in less than 5% of the trees.

Comparison of Minnesota to two other Regions

		Percent of trees in damage categories				
	Number of trees	No damage	Canker	Decay	Open wound	Crown damage
Minnesota	2201	78.5	1.0	9.5	2.4	4.6
New England *	5848	78.6	1.1	11.6	4.0	1.2
Mid-Atlantic*	719	78.7	1.9	14.0	1.3	1.0

* = From Twardus and Miller-Weeks, 1995, Forest Health Assessment for the Northeastern Area- 1993, USDA, USFS and EPA and NASF, NA-TP-01-95.

The 1994 FHM database will serve as the baseline for comparison for future FHM survey efforts. Since they are scheduled to occur annually, the FHM data should closely reflect the change in forest health due to small disturbances, such as annual defoliation or short-lived drought.

1994 damage incidence								
Species	Number of trees (n > 30)	Percent of trees sampled						
		No damage	Canker	Decay	Open wound	Broken bole	Loss of terminal	Crown damage
basswood	117	83	0	9	3	0	3	3
elm	43	86	0	7	0	0	2	5
balsam poplar	51	61	2	22	2	0	6	8
black ash	121	87	1	2	0	0	2	9
bur oak	109	87	0	8	1	0	1	3
red oak	93	66	4	15	3	0	4	8
birch	231	71	3	14	3	0	5	3
aspen	486	66	3	25	2	0	1	2
red maple	93	69	5	16	4	0	2	3
sugar maple	57	77	9	11	4	0	0	0
balsam fir	217	81	0	2	1	0	2	14
black spruce	208	86	0	1	2	0	7	4
white pine	35	91	3	0	6	0	0	0
jack pine	48	65	4	8	4	0	10	8
white cedar	150	79	1	11	1	0	3	5
red pine	69	96	0	3	0	0	0	1
tamarack	73	85	0	7	5	0	0	3

COMPARISON WITH FOREST INVENTORY ANALYSIS (FIA) DATABASE

In Minnesota, the FHM plots were installed in the prescribed manner onto an existing FIA plot. This FIA plot was the plot closest to the center of the FHM hexagon. This created a linkage between the FHM and FIA databases, namely that the FHM plots are nearly a subset of the FIA plots. In terms of plot numbers, the FHM database is about 1/100th the size of the FIA database. It is beyond the scope of this report to do a plot by plot comparison, instead, the entire FIA database will be compared to the FHM database.

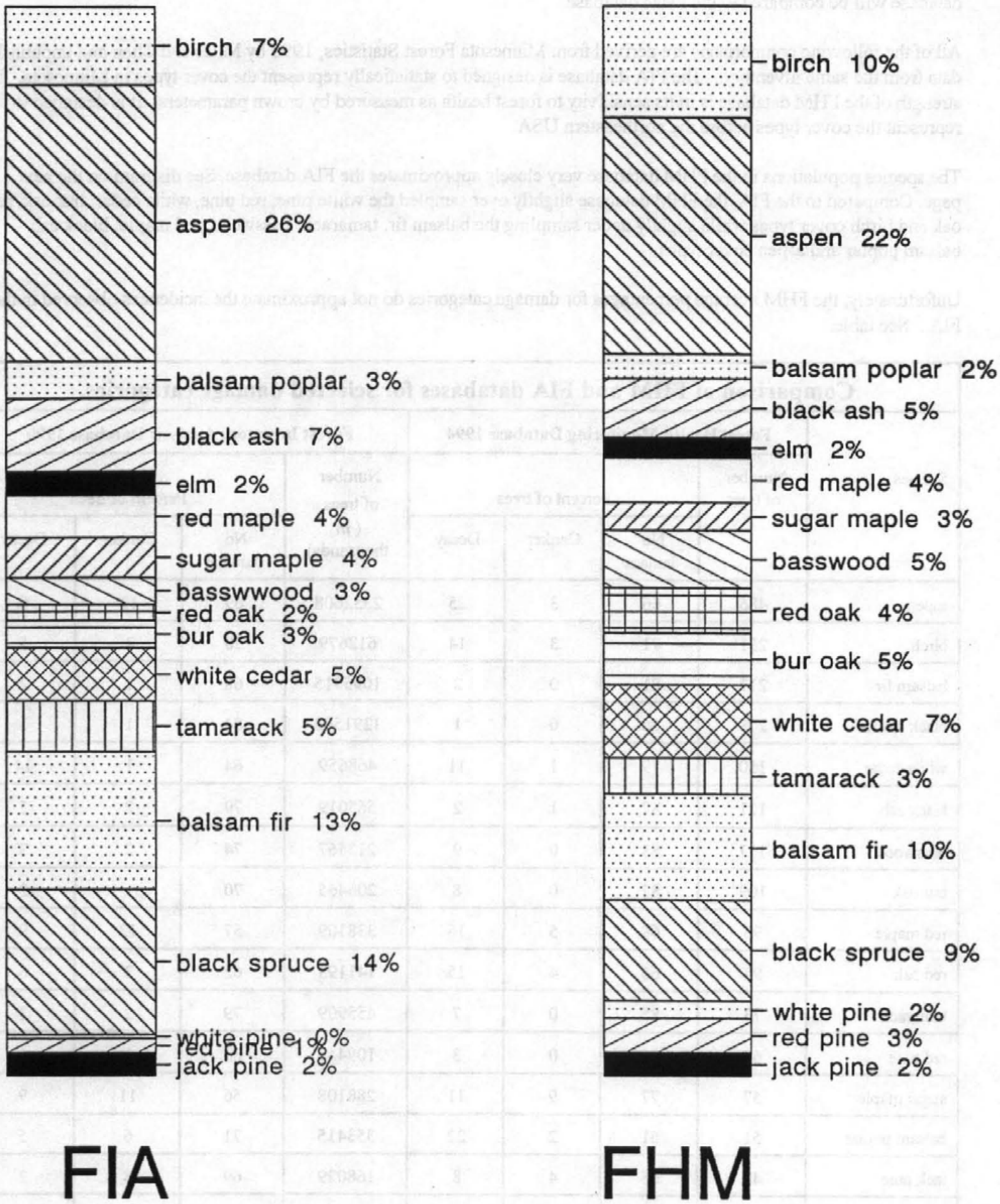
All of the following comparisons are derived from Minnesota Forest Statistics, 1990 by Miles and Chen and unpublished data from the same inventory. The FIA database is designed to statistically represent the cover types in Minnesota. The strength of the FHM database is in its sensitivity to forest health as measured by crown parameters. It is designed to represent the cover types across the northeastern USA.

The species populations in the FHM database very closely approximates the FIA database. See diagram on the next page. Compared to the FIA, the FHM database slightly over sampled the white pine, red pine, white cedar, bur oak, red oak and birch cover types while slightly under sampling the balsam fir, tamarack, basswood, red maple, black ash, balsam poplar and aspen cover types.

Unfortunately, the FHM average percentages for damage categories do not approximate the incidences observed in the FIA. See table.

Comparison of FHM and FIA databases for selected damage categories.

Species	Forest Health Monitoring Database 1994				Forest Inventory Analysis Database 1990			
	Number of trees	Percent of trees			Number of trees (in thousands)	Percent of trees		
		No damage	Canker	Decay		No damage	Canker	Decay
aspen	486	66	3	25	2352608	69	12	6
birch	231	71	3	14	612679	70	4	5
balsam fir	217	81	0	2	1095915	68	1	2
black spruce	208	86	0	1	1291508	84	1	1
white cedar	150	79	1	11	468659	64	1	14
black ash	121	87	1	2	565019	79	2	2
basswood	117	83	0	9	213467	74	2	3
bur oak	109	87	0	8	206465	70	1	2
red maple	93	69	5	16	338109	57	12	9
red oak	93	66	4	15	141193	62	3	6
tamarack	73	85	0	7	455909	79	2	3
red pine	69	96	0	3	109441	83	1	1
sugar maple	57	77	9	11	288108	56	11	9
balsam poplar	51	61	2	22	353415	71	6	5
jack pine	48	65	4	8	168029	69	8	2
elm	43	86	0	7	192449	71	2	1
white pine	35	91	3	0	21494	64	9	5

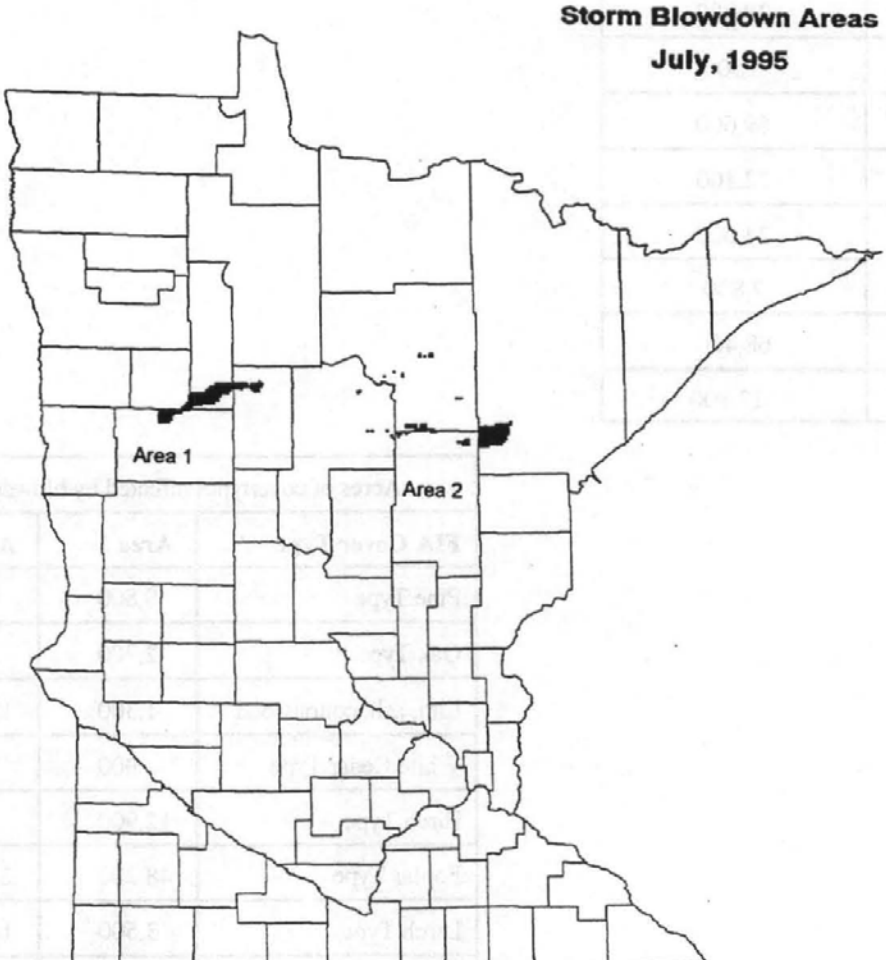

birch 7%
aspen 26%
balsam poplar 3%
black ash 7%
elm 2%
red maple 4%
sugar maple 4%
basswwood 3%
red oak 2%
bur oak 3%
white cedar 5%
tamarack 5%
balsam fir 13%
black spruce 14%
white pine 0%
red pine 1%
jack pine 2%
FIA
birch 10%
aspen 22%
balsam poplar 2%
black ash 5%
elm 2%
red maple 4%
sugar maple 3%
basswood 5%
red oak 4%
bur oak 5%
white cedar 7%
tamarack 3%
balsam fir 10%
black spruce 9%
white pine 2%
red pine 3%
jack pine 2%
FHM

BLOWDOWN 1995

Severe thunderstorms moved across northern Minnesota early on three consecutive mornings, July 12th, 13th and 14th. These storms produced strong straight-line winds (up to 129 mph) for long periods of time (more than 20 minutes in a given location). These storms are termed "derechos". The strongest storm occurred on July 13th in the Grand Rapids area.

Damage occurred in two categories; forests and power distribution systems. Fortunately, there were no fatalities and structural damage was minimal. Eight counties took the brunt of the storms. See map and table below.

Storm Blowdown Areas
July, 1995



Map production and analysis by EPIC
Minnesota Department of Natural Resources
Division of Forestry, Forest Health Unit

The DNR estimated that 6.5 million trees toppled in the wind storms increasing the fuel loads from 10-20 tons/acre to 80-100 tons/acre which will increase the risk of catastrophic wildfire in years to come. Salvage activities may only recover 50% of the downed trees. In addition, dead and dying trees may provide the substrate for the development of high populations of insects and diseases, such as, pine bark beetles, two-lined chestnut borers and Armillaria root disease.

Area of counties affected by blowdown	
County	**Acres**
Aitkin	14,600
Becker	29,800
Cass	5,500
Clearwater	69,600
Hubbard	22,100
Itasca	24,000
Mahnomen	7,800
St. Louis	68,400
Total Area	217,800

Area 1 was considered to severe blowdown and Area 2 was considered scattered blowdown.. According to estimates made using FIA plot data, the acres for each of the following covertypes are listed in the table below. One caution as you look at these data. Blowdown varied dramatically within the area affected by the storm. It was complete in some areas and very scattered in others; Area 1 tended to be much more severely affected than Area 2.

Acres of covertypes affected by blowdown		
FIA Cover Type	**Area 1**	**Area 2**
Pine Type	8,800	1,300
Oak Type	2,700	500
Elm, ash, cottonwood	1,300	12,200
White Cedar Type	900	7,400
Birch Type	12,900	1,900
Poplar Type	48,200	23,000
Larch Type	3,500	14,000
Spruce/Fir Type	3,900	26,400
Non-Stocked Forest	0	1,300
Totals	82,200	88,000

A full report of weather conditions, damage caused and the Presidential declaration of the affected area as a "disaster area" can be found in the Special Projects section as the "Hazard mitigation survey team report, FEMA-1064-DR-MN".

In Itasca State Park

Straight line winds in the range of 55 to 129 mph caused extensive blowdown in the old growth conifer strands of Itasca State Park. While the monumental task of reopening the park was complete with the cooperation of local foresters and loggers, ongoing concerns over remaining hazard trees and the potential loss of additional trees due to pine bark beetle outbreaks continue.

In August and September, stand checks were made in the Park to monitor clean-up efforts (slash burning) and bark beetle activity. These checks verified high bark beetle activity in damaged and stressed pine stands. Due to these existing population centers and the extensive amounts of down and damaged material in the park that would not be removed due to wilderness designation or lack of access, park managers began to analyze methods to protect the remaining monarch pines in areas of high public use and historic value.

By law, the Park is charged with protecting sites of historical significance within its boundaries. While numerous blowdown areas will be left untouched and have interpretive trails developed through them, the areas of Douglas Lodge, Preachers Grove, the Burial Mounds and key campgrounds were designated protection zones. Traditional trap tree and direct spray operations were deferred to a program using Lindgren funnel traps with PheroTech Lanerone lures to mass trap bark beetles. Traps were concentrated at three to four per acre in these protection zones surrounded by non-host buffers, mostly lowland hardwoods, spruce and balsam fir. The management choice was made based on the sensitivity of the high use areas and experience gained from bark beetle trapping tests conducted in Minnesota during the drought years in the late 1990's and early 1990's.

The trapping efforts were part of an interpretive program for park visitors. Activities and locations were signed, special programs on old growth management and beetle biology were conducted during the visitor season and handout materials were developed and distributed.

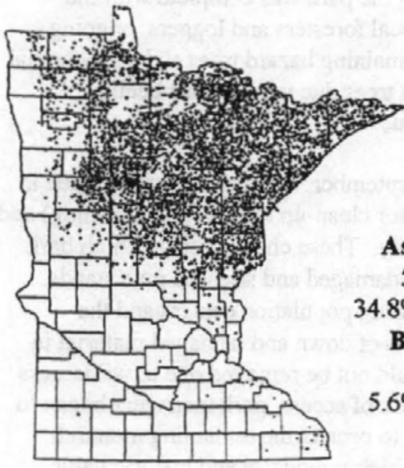
Itasca State Park offers an ideal test of this developing management tool with abundant control areas for comparison. The Park is committed to a three to five year trial, if necessary. Funding is being sought from the Federal Emergency Management Agency (FEMA) and North Central Forest Experiment Station. It is hoped that diligent trap collections and close monitoring of beetle activity will decrease tree mortality rates in trapped stands. Directed tree removal will continue where possible. Weather patterns will be an important factor for success or failure. Whatever the outcome, tree mortality in trapped and non-trapped areas will be documented.

ASPEN-BIRCH FORESTS

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. Insects accounted for less than one percent of the volume losses due to mortality (FIA, 1990).

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). 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.

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, at least 37% of the volume of birch wood produced is lost due to insect and disease agents (FIA, 1990). Various decay causing organisms, notably, *Inonotus obliquus*, lowers stem quality through decay and discoloration.



Aspen covertype
5,114,200 acres
34.8% of timberland
Birch covertype
835,800 acres
5.6% of timberland

Pests included in this report:

Aspen blotch miner
Aspen leaf rollers and leaf tiers
Birch leaf miner
Birch skeletonizers
Pale green weevil

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:	While some blotch miner activity is reported every year, populations and damage were high in 1993, 1994, and 1995.

Quaking aspen and balsam poplar blotch miners caused the leaves on many trees in northeast Minnesota to turn tan in color in 1995. See map. Blotch miners were very heavy on small roadside trees but in some locations aspen and balsam poplar of all sizes had heavy damage. Aspen blotch miners overwinter as small tan colored moths that seek out sheltered locations to overwinter, such as, under bark flaps but are sometimes also found in large numbers in protected locations such as under trim boards on houses and garages etc.

During the years with high blotch miner populations, many people observed jack pine trees with most of the outer dead flakes of bark removed and lying in a pile at the base of the tree. It is speculated that large numbers of blotch miner moths tried to overwinter under the loose bark flaps or scales. Birds, like wood peckers and nuthatches, remove the bark flaps while trying to locate and eat the overwintering insects. This activity does not harm the tree since the birds only remove the dead outer bark flaps.

Collections of blotch miner infested leaves were made in the summer of 1995. Few moths emerged from the leaves indicating that perhaps the population has collapsed and there may be much less damage in 1996. During an outbreak the number of miners in each leaf increases to 10 or more. Due to larval competition for food and to an increase in parasites, outbreak populations of this pest tend to be short-lived.

Aspen leaf rollers and leaf tiers

Undetermined insects

Hosts:	Aspen
Damage:	Defoliation
Area:	Not determined
Severity:	Light
Trend:	None

Aspen in scattered locations in northeastern Minnesota had aspen leaf rollers and leaf tiers feeding on their leaves. This caused light defoliation in a number of locations that were detected during aerial surveys. Locations noted included:

Sec 19-T61N-R10W	Lake Co
Sec 4,5-T51N-R20W	St Louis Co
Sec 19,20-T52N-R19W	St Louis Co
Sec 29,30-T52N-R19W	St Louis Co

Birch leaf miner

Fenusa pusilla (Lepeletier)

Host:	Birch
Damage:	Leaf mining
Acreage:	Not determined
Severity:	Heavy
Trend:	Similar to 1994 levels which were up significantly from 1993 levels.

Small mines caused by the birch leaf miner began to be evident in Grand Rapids by May 29th and foliage on trees with heavy birch leaf miner damage began to turn brown by June 21st.

Most birch trees showed little or no damage however heavy birch leaf miner activity was common throughout northeast Minnesota in 1995 both on urban and on forest sites. Heavily damaged trees take on an overall tan or brown appearance by late June. The amount of damage was similar to 1994 levels. In 1993 birch leaf miner populations and damage were at very low levels and the miner damage was observed on only a few trees.

Birch skeletonizer

Bucculatrix canadensisella Chambers

Host:	White birch.
Damage:	Defoliation.
Area:	300 acres
Severity:	Moderate to heavy.
Trend:	None.

The birch skeletonizer defoliated two to three hundred acres of birch in southern Winona County and central Houston County centered around Money Creek. Larvae feed on the under side of the leaves and remove the foliage between the veins.

Pale green weevils

Polydrusus impressifrons (Gyllenhal)

Hosts:	Aspen and other broadleaf trees and shrubs
Damage:	Defoliation
Area:	Not determined
Severity:	Very light defoliation
Trend:	The weevil has been commonly reported for the past 6 years.

High populations of *Polydrusus impressifrons* were observed in northeast Minnesota especially in Carlton, St Louis, Lake and Itasca Counties. The pale green weevils are most abundant in June and July and die by early August at which time masses of dead bodies can be found in rain gutters, on window sills, etc. The most common complaint about the weevils is that they crawl on walls and ceilings insides houses and also on people and their clothes.

The adult weevils feed on most broadleaf trees and shrubs but seem to prefer birch and poplars. They feed on the edge of leaves and cause a characteristic scalloped look to the edge of the leaves. The weevil larvae likely feed on plant roots. At the present, no damage has been attributed to root feeding by the high populations of this weevil.

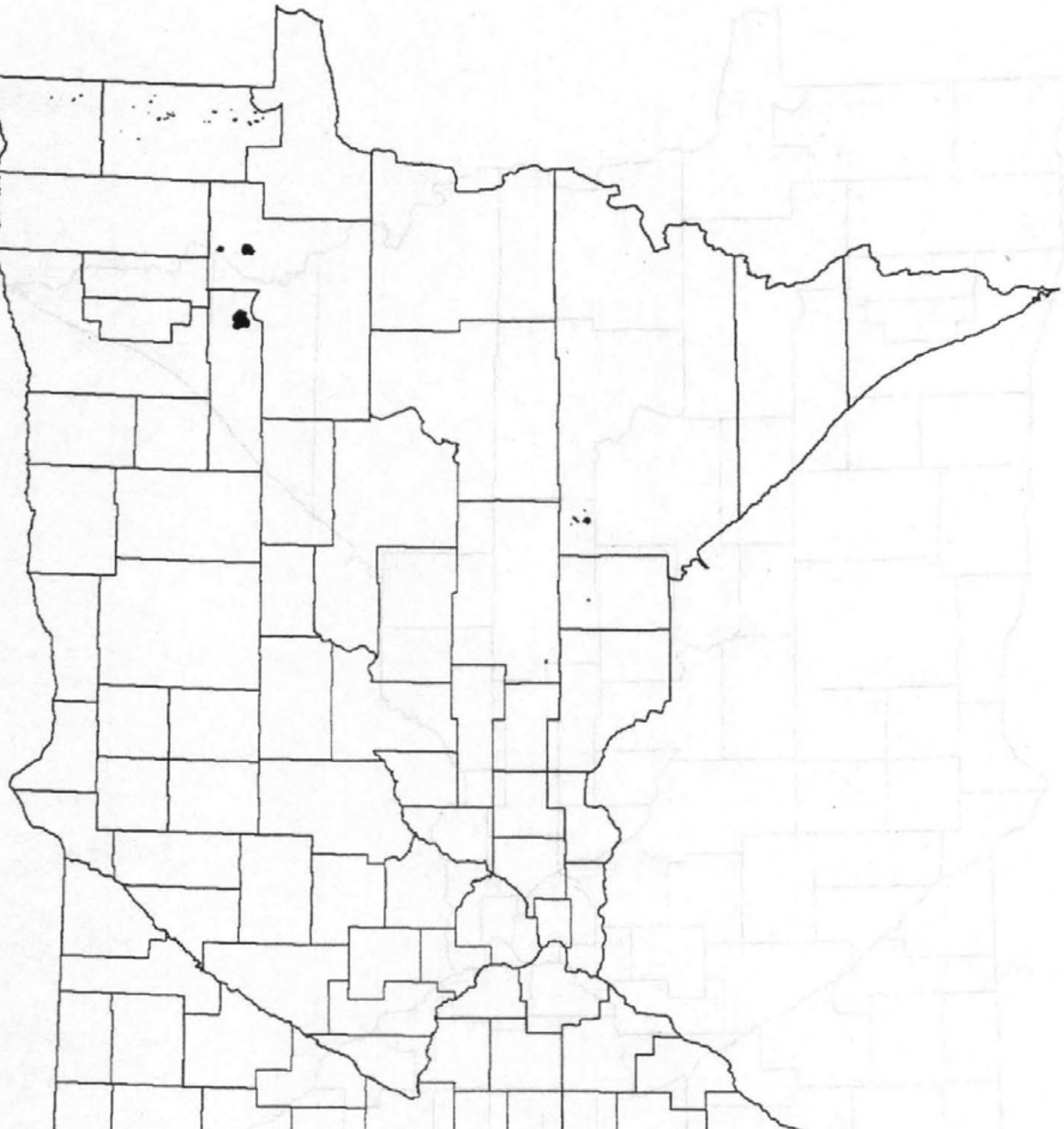
Balsam Poplar Blotch Leaf Miner
1995

Source: FHU aerial sketch mapping.

Map production and analysis by EPIC
Minnesota Department of Natural Resources
Division of Forestry, Forest Health Unit
6/20/1996

Aspen Defoliator Complex

1995



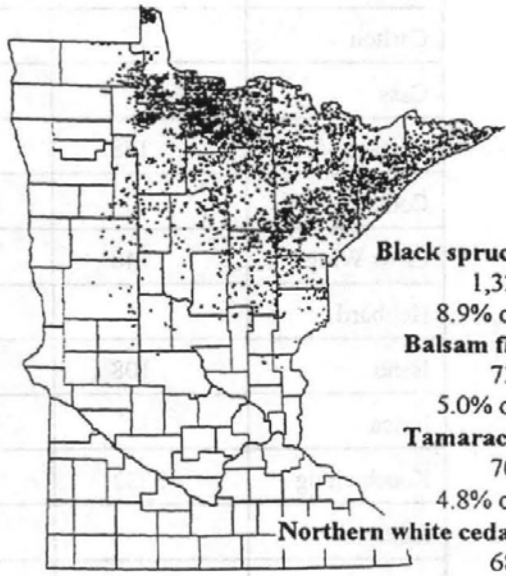
Source: FHU aerial sketch mapping.

Map production and analysis by EPIC
Minnesota Department of Natural Resources
Division of Forestry, Forest Health Unit

6/20/1996

SPRUCE- FIR FORESTS

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). 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.



Black spruce covertype
1,322,100 acres
8.9% of timberland
Balsam fir covertype
734,300 acres
5.0% of timberland
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

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 mortality losses during the latest inventory period. Fire, animals and weather events also caused 32% losses. 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.

Pests included in this report:
Spruce budworm
Balsam fir needlecasts
Rhizosphaera needle blight
Yellow-headed spruce sawfly
Hail damage

Spruce budworm

Choristoneura fumiferana (Clemens)

Hosts: Balsam fir, white spruce
Damage: Defoliation, topkill, mortality
Area: Gross area = 4,990,000 acres
Net Area = 506,000 acres (host type)

Severity: See table below.
Trend: Population levels, defoliation intensities, and distribution were similar to 1994.

Spruce budworm acres of defoliation by county for 1996				
County	**Light**	**Moderate**	**Heavy & Scattered**	**Heavy & Continuous**
Beltrami		617		
Carlton		190		
Cass		1213	615	
Chisago	168			
Cook			58,382	65,323
Crow Wing	748			
Hubbard		763		442
Isanti	108			
Itasca		2989	4494	22,174
Koochiching	3232			21,905
Lake			54,035	54,908
Lake of the Woods	1146			
Pine		195		
St. Louis			104,503	107,147
Stearns		360		
Wadena		353		
Totals	5,402	6,680	222,029	271,899

For more than forty years, spruce budworm populations have been defoliating balsam firs and white spruces at varying locations in Minnesota. The pest, it's name and the damage are the same, only the locations change. In 1995, 506,00 acres were defoliated.

Spruce budworm continued its usual feeding on balsam fir with most of the damage occurring in northeastern Minnesota. See map. However, budworm populations are widespread, occurring in scattered locations to the west past Bemidji and south to Anoka County. Budworm defoliation did occur in balsam fir stands in Pine and Crow Wing Counties. As in the past couple of years, spruce budworms continued to feed on white spruce plantations more heavily than they have historically done in Minnesota. Approximately 1700 acres of privately owned white spruce plantations in Itasca County and 67 acres in Cass County were sprayed to prevent budworm defoliation.

Spruce budworm also played a role in the 14,000 acre Sag-Corridor fire in Cook County in 1995. The fire was fanned by 50 mile per hour winds and fueled by balsam fir killed by spruce budworm since the outbreak started there in 1983.

Weather conditions made aerial survey difficult this year. High winds and storms in mid-June knocked damaged needles off trees so they never developed the 'fired-up' appearance typical of budworm damaged trees. It was very difficult to see the damage from the air .

FH, Spruce Budworm, 1995

Map production and analysis by EPIC
Minnesota Department of Natural Resources
Division of Forestry, Forest Health Unit
6/20/1996

There has been much speculation about why the budworm is damaging white spruce plantations to such an extent, when historically, there has been fairly light damage to white spruce plantations. One theory is that weather conditions in the spring have caused the new needles on the spruce to remain palatable and not harden off for a longer time than normal. This would provide more food over a longer time period to support a larger, healthier population of budworm allowing them to build up to more damaging levels.

Mattson and Haack have proposed that drought stress increases the nutritional suitability of white spruce as budworm food. Therefore budworm are more prolific on stressed spruce. Under normal (non-outbreak) conditions budworm populations are kept at a low level by natural mortality factors such as diseases, parasites, and predators. Once an outbreak starts the natural mortality factors are not enough to reduce the populations to a non-outbreak state and outbreaks usually end only after most mature host trees have been killed in an area. Mattson and Haack suggest that drought stress causes more favorable biochemical, physiological and environmental conditions for the budworm on white spruce. These changes act synergistically causing the natural enemies to be less effective allowing the budworm population to build to outbreak levels. Perhaps the drought of 1988-1989 and the occurrence of budworm in spruce in the 1990's support this theory.

In a few white spruce plantations, in northern St. Louis County, the budworm did not do as much damage as might be expected based on population levels and the past couple years of experience. The larvae did not cause as much defoliation as expected and produced pupae that were only ⅛ to ½ normal size. In these plantations it appeared that the white spruce flushed early and the new shoots developed rapidly and may have hardened off and become unpalatable to the budworm before they could complete feeding. This may have caused them to pupate early resulting in small pupae. However in white spruce plantations in the rest of the state the budworm continued to cause considerable damage and they appear to have completed their normal development.

At the suggestion of the Forest Health Unit, a private, non-industrial white spruce plantation in Cass County was sprayed for budworm suppression. When first visited in the fall of 1993, budworms had already caused heavy defoliation in the upper crowns and the landowner wanted to keep the spruces green and growing. See Table below. In 1994, defoliation was again heavy, in fact, an average of 35% of the expanding shoots and buds had been destroyed by budworm feeding. 1994 was also the first year that bud proliferation was observed. The decision to spray in 1995 was based on the cumulative effect of defoliation of the trees, severity of bud destruction and abundance of egg masses. On June 2, 1995, 67 acres were sprayed with Bt. The larvae were in the fourth and fifth instars (50% in each instar) and bud caps were 90-100% off of the expanding needles. Unfortunately, due to a faulty nozzle, there were many skips in coverage of the plantation. Subsequent observations showed that the skips had moderate to heavy defoliation. New growth was 2 1\2 inches to 4 inches long in the treated areas and only 1 to 2 inches long in the skipped areas. However, populations were suppressed as shown by pupal and egg mass surveys post-treatment. See table below.

Spruce budworm continued to be a locally important pest in the northern portions of Region 6 in 1995. Infestations have been continuing for several years in white spruce 20-40' tall. Most of the areas affected are abandoned Christmas tree plantations dating from the 1950's which have been developed for residential areas as the Twin Cities urbanization fringe moves north through Anoka County. Most of the areas are 40 acre or smaller sites in the northern portions of the City of Andover.

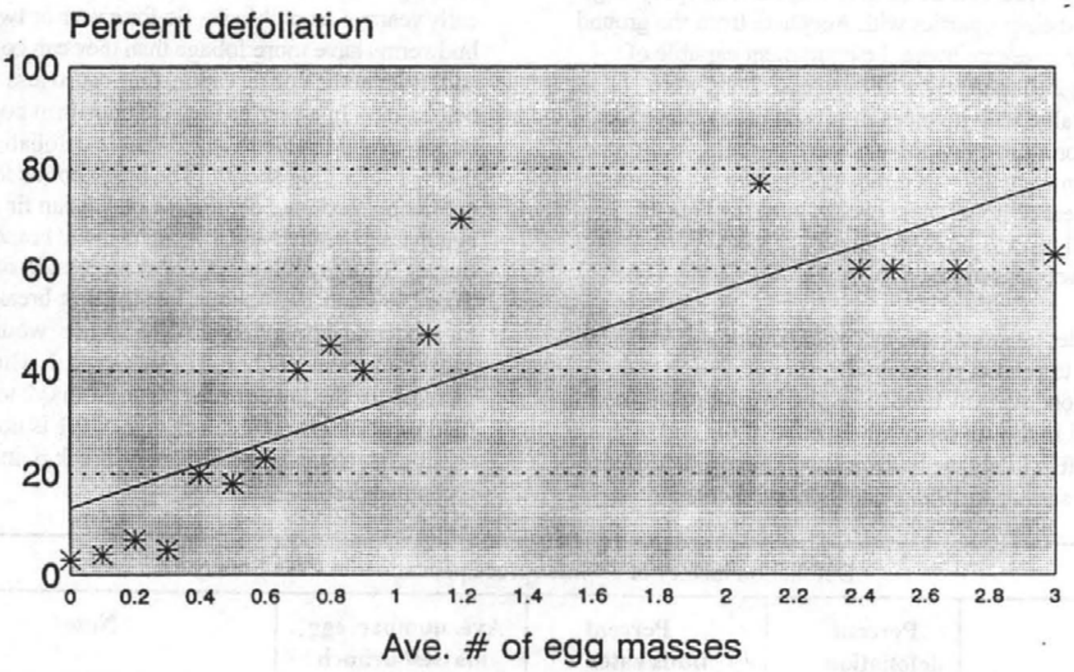
Spraying has become common place in the developed areas, particularly near homes, where homeowner toleration of damage is poor. Defoliation levels have consistently been at 20-40% over most of the areas involved and have not shown visual signs of negative impacts on tree health. Leader length continues good and the trees carry more than sufficient foliage to maintain good growth the following year. Although residents of the area claim to want to preserve tree health, most of the spraying undertaken relates to protection of the visual and nuisance aspects of the problem. Homeowner sprayed trees tend to be nearest the house, commonly being those at the front or immediately surrounding a backyard deck.

One group of homeowners in an area just west of the 1994 spray area chose to spray Bt in 1995. A commercial helicopter (Scott's Spray Service, LeSeuer, MN) was contracted to spray 20 BIU/acre of Bt at two applications. Cost was approximately $40 / acre for the spray, both applications including the material. The spray clearly reduced populations visually and

Defoliation of white spruce

by spruce budworm, 1993-1994 egg masses.

32 locations in north central and central Minnesota.



Graph 1

protected the foliage. Tree health remains good. A number of homeowners, however, we not satisfied with the results and complained that they could still "find worms" after the operation. This was similar to the results of the 1994 spray in the same area. When "worms" were detected after the helicopter operation, several residents applied heavy doses of Acephate themselves, virtually sterilizing their trees.

Residents of the 1994 spray area did not repeat aerial operations in 1995. Most did nothing or applied "home remedy" sprays themselves to selected trees near their homes. Several homeowners, however, sought the ultimate solution and contacted a commercial arborist (Rainbow Treecare, St. Louis Park, MN) to spray large areas of their properties with Acephate from the ground with high pressure hydraulic equipment capable of reaching into the crowns of the trees. Costs were considerable with invoices in several cases exceeding $1000 for a property. Results were impressive. Spruce budworm virtually was removed from the spray areas for the year although field checks in the fall clearly indicated reinvasion from unsprayed areas. Formal egg counts were not made.

Statewide, egg mass surveys were conducted in the fall of 1995 to predict spruce budworm population and defoliation levels in 1996. The plot by plot results can be found in the survey results section at the end of this report. It is likely the budworm will have a distribution in 1996 similar to 1995. The plots predict heavy defoliation in 1996 will occur in fewer locations than in 1995. However while quite a few plots were surveyed it is still a small sample and should not be looked at as an accurate prediction of the amount of defoliation to expect in 1996. Unfortunately a collapse of the budworm outbreak is not being suggested. The budworm should be alive and well here in Minnesota for yet another year.

An analysis of egg mass survey results over the past two years revealed that the sampling and rating systems used for predicting defoliation in balsam fir could be used for white spruce, at least in the early phases of an outbreak. White spruce trees respond to defoliation by forming many more shoots; ie: more needles, in the early years of an outbreak. So for a year or two, the budworms have more foliage than they can consume and, from human observation, they cause less defoliation. In a year or two, the budworm population builds up and is able to cause visible defoliation on these proliferating shoots. The break points for predicting moderate defoliation on balsam fir are 0.2 egg masses/ branch and 1.7 egg masses/ branch. See Survey Results section. A linear regression of the data from 1993 and 1994 shows that the best break points for moderate defoliation of white spruce would be 0.3 and 1.7 egg masses/ branch. See Graph 1. This is an increase for the lower break point, from 0.2 to 0.3. For field work of this nature, a change of 0.1 is not significant, so using the balsam fir break points is recommended.

Defoliation history of a white spruce plantation in Cass County				
Year	**Percent defoliation**	**Percent buds eaten**	**Ave. number egg masses/ branch**	**Notes**
1993	60	-	0.88	Normal foliage.
1994	80	35	0.88	Bud proliferation and tufting of branches noted in August.
	55	75	0.55	
	55	50	0.88	
	35	10	0.44	
	50	15	0.22	
1995	10	<1	0.44*	Treated area
	45	7	0.66	Skip in treated area.

* = Apparent influx of egg-laying moths from skipped areas into fully treated areas.

Balsam fir needlecasts

Lirula nervata (Darker) Darker
Lirula mirabilis (Darker) Darker

Hosts:	Balsam fir
Damage:	Needle discoloration and needle loss
Area:	Not determined
Severity:	Heavy
Trend:	Static at moderate levels.

In late May to early June, second, third and fourth year needles were observed to be turning a bright brown tan color and on some trees needles were starting to fall off balsam fir twigs. This was occurring in Christmas tree plantations as well as on scattered balsam fir in forests throughout northeastern Minnesota. By late June needles would rain from the trees when the tree was shaken.Fungi involved were *Lirula nervata* and *Lirula mirabilis*. Other fungi found on the fir trees included *Rhizosphaera pini, Leptosphaeria faulii* and *Lophodermiun lacerum*. *L. faulii* is considered a saprophyte often associated with other needlecasts,especially *Isthmiella faulii* and is suspected of having a biocontrol effects on needlecasts. It invades dead and dying needles and competes for the nutrients. The needlecasts then fail to develop sexual fruiting bodies thus preventing needlecast spores from developing.

Rhizosphaera needle blight

Rhizosphaera pini (Chorda)Maubl.

Host:	Balsam fir
Damage:	Needle blight
Area:	Not determined
Severity	Moderate to heavy damage on affected trees.
Trend:	This disease has likely been fairly common in the past but went unidentified until this year.

Rhizosphaera needle blight could be found fairly commonly on balsam fir needles throughout northeastern Minnesota. It caused significant damage in several Christmas tree plantations where it damaged up to 50% of the needles on some trees. Most damage occurred on the lower part of the tree but some went up to about four feet on the trees. In these Christmas tree plantations, there was some evidence that damage occurred in 1994 but there was much more damage in 1995.

In the Christmas plantations, damage was first noticed in March and April. The color of the infected needles had faded to a light tannish gray and the needles were very limp, drooping and soft. All years of needles were affected. Black pycnidia, typical of *Rhizosphaera* species, were found poking out through stomates on the needles.

In a Christmas tree plantation in northern St. Louis County, pycnidia were found but no spores were present in the pycnidia on May 24th. On June 6th the pycnidia were full of spores. Spores were still present in some pycnidia on July 6th while some pycnidia appeared to be empty.

Infection probably starts in June and may extend through most of the summer during wet periods. Apparently any year needle can become infected. Symptoms become most apparent early the next spring. Infection is most severe on the bottom of trees but can extend up to four feet or more. Infections often appear as dead patches on the trees where most or all of the needles on individual branches are infected.

Rhizosphaera pini is reported as circumpolar in distribution on *Abies* species. In Canada it is reported occurring on fir and spruce. It was not determined if *Rhizosphaera pini* has previously been reported in Minnesota however it appears to be very widespread and can be found most locations. It is likely that the fungus and the disease have been here a long time but were not identified prior to this.

Yellow-headed spruce sawfly

Pikonema alaskensis (Rohwer)

Host:	White spruce
Damage:	Defoliation
Area:	Approximately 35 acres
Severity:	Light to moderate
Trend:	Declining

Larvae were in general hatch on June 12th along Highway #35 in Rice County. The Department of Transportation was advised and they sprayed the spruce along I-35 in Rice County on June 14th.

Hail damage

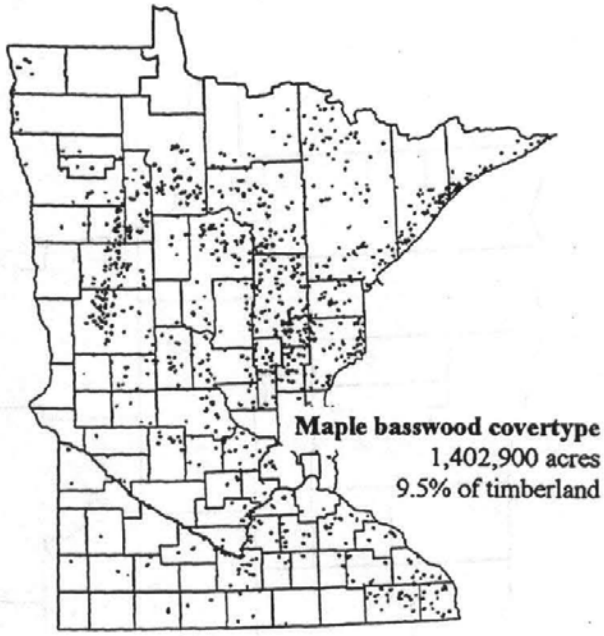
Hosts:	All species
Damage:	Branch flagging, dieback, cankers
Area:	Not determined
Severity:	Heavy
Trend:	None

Hail damage on balsam fir, white pine and red pine was observed in T53N - R14W in southeastern St. Louis Co. The hail caused branch flagging and branch dieback as well as impact cankers to branches and stems.

Severe hail damage was obvious in T51N-R12W and T52N- R12W on all species of trees. Heavy branch flagging was obvious on the conifers especially the balsam fir. The aspen had sparse foliage and clumps of foliage with a lot of dead branches. The hail storm occurred in August of 1994. Hail stones were reported as being from golf ball- to fist-sized. Many people in the area had to reshingle their homes as well as replace windows in homes and cars.

MAPLE-BASSWOOD FORESTS

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. 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.



Pests included in this report:
Forest tent caterpillar
Introduced basswood thrips
Venturia blight of maple
Maple mortality

Forest tent caterpillar

Malacosoma disstria (Hubner)

Host:	Basswood and oak
Damage:	Defoliation
Area:	Isolated small areas
Severity:	Light to moderate
Trend:	Still finding small, isolated infestations in Kandiyohi, Meeker, and Wright Counties.

FTC was active this year in Region 4 and defoliation was mapped on June 13th. There were several areas of defoliation in Kandiyohi County. The areas included several lakes; Green, Nest, Norway, and Lake Andrew. There was some spraying that went on in these areas against our recommendations since it was too late to be effective.

Forest Tent Caterpillar
1995

Source: FHU aerial sketch mapping.

Map production and analysis by EPIC
Minnesota Department of Natural Resources
Division of Forestry, Forest Health Unit

6/20/1996

Minnesota
DEPARTMENT OF NATURAL RESOURCES

Introduced basswood thrips

Thrips calcaratus (Uzel)

Hosts:	Basswood
Damage:	Defoliation, holes in leaves
Area:	Not determined
Severity:	Light to heavy
Trend:	Thrips damage increased in some locations after 5 to 6 years of very low levels of damage.

Defoliation in northeast Minnesota was heavy in scattered locations from 1982 to 1988. From 1989 through 1994 very little leaf damage was observed. In 1995 leaf damage was again observed in locations in Carlton County that have been surveyed for years for the presence of thrips. Damage from thrips increased to a much more noticeable level in several locations in Itasca County. In S5-T54N-R25W, foliage was sparse especially in the lower crowns on May 29th. In S35-T55N-R26W, trees averaged 50% defoliation with some mature basswood having up to 90% defoliation The thrips were not actually identified to species this year but were assumed to be the introduced basswood thrips based on the results of a study in 1990 which showed that the introduced basswood thrips was the most abundant thrips present on damaged foliage in Minnesota.

The adult thrips feed in the opening buds and leaves. They damage trees when they feed by puncturing leaf cells and suck the sap out of the leaf. Leaves darken, curl, dry and fall prematurely. Leaves that don't drop prematurely from the tree are often small, cupped and may have small holes. Apparently thrips do some feeding on buds since some of the buds on heavily damaged branches fail to leaf out in the spring. Damage resembles frost injury occurring early in the spring.

Venturia leaf blight of maple

Venturia acerina Plakidas ex Barr

Host:	*Acer* species
Damage:	Leaf spots and leaf deformity
Area:	Not determined
Severity:	Not determined
Trend:	While common in 1995 it is not commonly found other years.

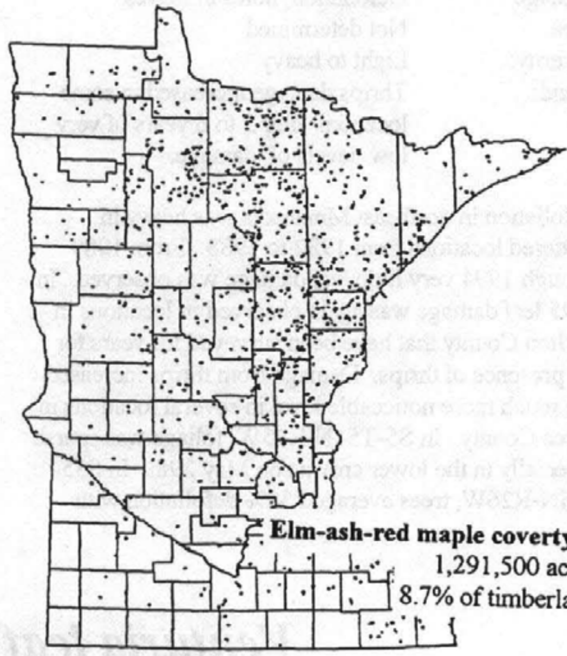
Red maples from Carlton County to Crow Wing County were found to have Venturia leaf blight in 1995. It is a close relative to the apple scab fungus, *Venturia inequalis.*

Venturia leaf blight of maple causes black spots up to 3\4 inch in diameter to form on the upper surface of the leaves. The spots are olive green to brown on the lower surface of the leaf. The spots dry out and tend to split or tear. One leaf may have numerous spots. The disease usually does no serious or permanent damage to the tree. Raking and destroying the fallen leaves reduces the inoculumn for the next spring.

ELM-ASH-RED MAPLE FORESTS

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.

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 covertype
1,291,500 acres
8.7% of timberland

Pests included in this report:
Black ash dieback
Dutch elm disease
Cankerworms
Scab and black canker of willow

Black ash dieback

Unknown

Host:	Black ash
Damage:	Dieback, decline, death
Area:	Not determined but scattered throughout most of the range of black ash.
Severity:	Ranges from none to heavy
Trend:	Widespread for the past few years but the health of the black ash appears to have stabilized or started to improve in 1995.

For the past several years, symptoms of dieback have been observed in black ash stands in northern Minnesota. Symptoms include dieback of twigs and major branches, epicormic sprouting on trees with severe dieback, and a general unthrifty appearance when looking at the stand as a whole. Dieback, the progressive death of twigs and branches from the top of the tree down and from the branch tips into the crown, can be viewed as a survival mechanism. A stressed tree has less energy and a smaller tree, as a result of dieback, requires less energy. In the absence of successful attack by secondary organisms, trees suffering dieback due to stress often recover after the stress abates. If stress continues and other factors including secondary organisms and other stress factors put additional stress on a tree, the tree may decline and eventually die.

In the past twenty years, northern Minnesota has experienced two periods of extreme drought, 1976 - 1977 and 1988-1989. In the intervening years, there was also a period of record high water levels. The wettest five year period on record occurred between 1980 and 1985. This fluctuation puts more stress on trees in or near potholes and wet depressions. We observed this same type of pattern with red pine during the droughts. Trees growing in and near the wet depressions and potholes often showed the first and most severe dieback and mortality. Trees growing in potholes and wet depressions are used to growing in fairly wet conditions and so suffer more stress during drought. These same sites tend to hold water during high water years because of the lack of an outlet and so the trees tend to suffer more stress due to flooding.

Also during this 20 years, there were two outbreaks of forest tent caterpillar which defoliated black ash as well as most other hardwoods. This undoubtably was a contributing stressor.

Thirty seven black ash stands between Hill City and Floodwood were inspected in 1995. No witches brooms, which would be diagnostic for ash yellows, were found in declining stands. Four stands were scrutinized in much more detail than the others. Results are still preliminary and more research needs to be done to fully answer the questions. However based on these investigations it appears that the weather and forest tent caterpillar undoubtedly stressed these trees and contributed to the dieback,but were not the primary cause. Dieback appears to be site related. Dieback symptoms were not observed in stands on mineral soils or in stands with wet organic soils where there is rolling topography. In general ash stands with evidence of water flow across the site at some time during the year did not have evidence of dieback while ash on sites without water flow, i.e. ash growing in potholes or depressions, had varying degrees of dieback. Ash on sites where water flows through the site after a rain were healthy while ash on sites where water stands or puddles after a rain had evidence of dieback. In our investigations we found healthy stands near stands with dieback. The difference appeared to be the site itself. The presence of roads or beaver activity also appear to play a role in ash dieback on some sites. Where they caused flooding or altered drainage patterns there was more dieback.

In general the ash dieback problem across northern Minnesota appears to have been caused by a combination of site and weather factors. Other factors such as forest tent caterpillar, frost, or anthracnose likely also played a role in adding stress to these trees.

For the last year or so, some of the trees with dieback have been rebuilding their crowns. It seems that in most of the affected stands, the trees were at least holding their own. The dieback was not progressing or getting worse and some of the trees seem to be improving. However annual growth ring size has not noticeably improved in the last 2 years. Hopefully the trees will continue to recover.

Current recommendations are to avoid activities such as logging in stands with symptoms of dieback. Trees in these stands are stressed and logging will only add more stress to the trees. If the trees recover and start to rebuild crowns in the next few years cutting could resume. Some products may be lost with this approach but hopefully the ash covertype on these sites will be saved.

The MN DNR, Division of Forestry, Forest Development Manual, recommends all aged selection as the only safe cutting method on wet sites. Clearcutting on wet sites causes a decrease in evapotranspiration on on the site and can lead to higher water tables and loss of the site. Higher water tables inhibit seedling establishment, growth of sprouts and favors grass and brush or even cattails. According to Erdman et. al. the best way to obtain favorable black ash regeneration is through single tree selection cutting on organic sites and through shelterwood cuts on wet mineral soils.

Erdmann,G.G.; Crow,T.R.; Peterson, R.M.; Wilson,C.D. 1987. Managing black ash in the Lake States. Gen. Tech. Rep. NC-115. St Paul, MN USDA, FS, NCFES. 10p.

Ash anthracnose

Gloeosporium aridum Ell.& Holw.

Hosts:	Ashes
Damage:	Defoliation, twig dieback
Area:	Not determined, across southern Minnesota.
Severity:	Moderate to heavy defoliation of several hardwood species.
Trend:	Severity levels vary from year to year depending on weather conditions.

Green ash defoliation from anthracnose started in the last week of May in southern Minnesota. Continuous outbreaks occurred throughout May and June when ever it rained, several other hardwood species were affected.

Dutch elm disease

Ophiostoma ulmi (Buisman) Nanf.

Host:	Elms
Damage:	Mortality
Area:	Very widespread across southern Minnesota
Severity:	Light
Trend:	Minor losses continue in most years.

There was a higher incidence of Dutch elm disease through the season. The elm bark beetles were possibly in higher numbers this year due to the mild winter. The difference this year was that several individual large old trees that had survived many years isolated in small towns were lost.

Cankerworms

Fall cankerworm, *Alsophila pometaria* (Harris),
Spring cankerworm, *Paleacrita vernata* (Peck)

Host:	Elm, maple, and oak
Damage:	Defoliation
Area:	Individual pockets in stands
Severity:	Locally heavy where it occurs
Trend:	Periodic in early spring

Cankerworms were active n scattered locations around the southeast in early June this year. Defoliation was locally heavy in some locations. The spring and fall cankerworms are two of the more common and injurious of the many species of loopers, spanworms, and inchworms that attack ornamental trees. The common names of these two insects indicate the respective seasons during which their eggs are laid. The fall cankerworm lays its eggs in late November and early December, and the spring cankerworm in late February and early March. Eggs of both species hatch as soon as buds begin to open in the spring, and they occur together in mixed populations. They have a wide host range but are important pests primarily of elm, apple, oak, linden, and beech.

Scab and black canker of willow

Venturia saliciperda Nüesch
Glomerella cingulata (Stonem.) Spauld. & Schrenk

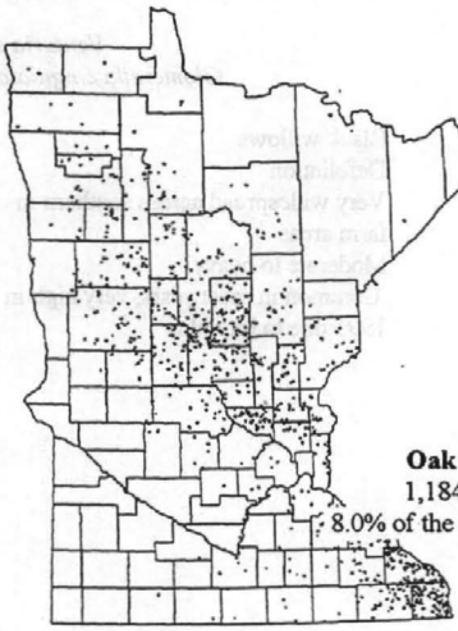
Host:	Black willows
Damage:	Defoliation
Area:	Very widespread across southern in farm areas
Severity:	Moderate to heavy
Trend:	Common in most years, very high in 1995 due to humidity

In August, symptoms of scab and black canker were evident and widespread across southern Minnesota. Symptoms included: blighted leaves that turned black, shriveled and fell; dark cankers that formed on twigs, and; entire branches that blackened and died back. A lasting impact could be made on individual infected trees if there are two or three more years of heavy disease severity.

OAK FORESTS

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). 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.



Pests included in this report:
Oak wilt
Hickory bark beetles

Oak wilt

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

Host:	Oaks
Damage:	Mortality
Area:	8 acres in Sherburne Co. and a single infection center in Brown Co.
Severity:	Very low incidence of new infections.
Trend:	General trend is smaller control sites in Sherburne Co. See table below.

The Areas's management tactic is to catch them early and save control line cost. As Jerry Lewis once said, "You've gotta hit 'em hard, you gotta hit 'em low, and you gotta hit 'em fast. You've got to play *guts* football!"

Oak wilt control activities continued in the Sand Dunes State Forest in Sherburne County. In 1994, fifteen sites were treated by vibratory plowing and eighty one potential spore-producing trees were cut and tarped. Salvage of the cut wood, as firewood, from the plowed sites was planned for one year after harvest.

Oak wilt summary for Sand Dunes State Forest				
Year	**Number of sites/ number of acres***	**Number of wilt trees removed****		**Control line (estimate)**
1993 & before	12 sites/ 21 ac	13 Pin Oak 2 Bur Oak		10,100 ft
1994	13 sites/ 11.5 ac	56 PO	2 BO	11,200 ft
1995	12 sites/ 8 ac	35 PO	6 BO	9,100 ft
Total	33 sites/ 40 acres	104PO	10 BO	30,400 ft.

* 4 sites have been retreated for line jumps.

** Potential spore mat producing trees. Small stump sprouts not included.

During July and August of 1995, aerial and ground surveys by Area personnel found fifteen sites with actively wilting oak trees. See table in Survey Results section. Ground surveys confirmed the presence of oak wilt disease on all sites. Although the number of sites did not decrease as anticipated, the size of the diseased site did decrease. Disease sites having one to three wilting trees were readily and reliably detected. See table below. Approximately 9,400 feet of primary vibratory plow line were established from Nov. 10, 1995 to April 20, 1996. Seventy three trees were deemed capable of producing *Ceratocystis* spores during the summer survey. In March of 1996, only thirty six of these trees still had suitable inner bark environments for sprore production so they were cut and tarped.

In Brown County, an isolated infection center was located. In southeast Minnesota, a limited amount of oak wilt occurs in forested areas where stands of northern pin oaks grow on sand or where oaks are disturbed by urban development.

Hickory bark beetles

Scolytus quadrispinosus (Say)

Host:	Hickory
Damage:	Mortality
Area:	Individual pockets in stands
Severity:	Locally severe.
Trend:	Related to dry weather.

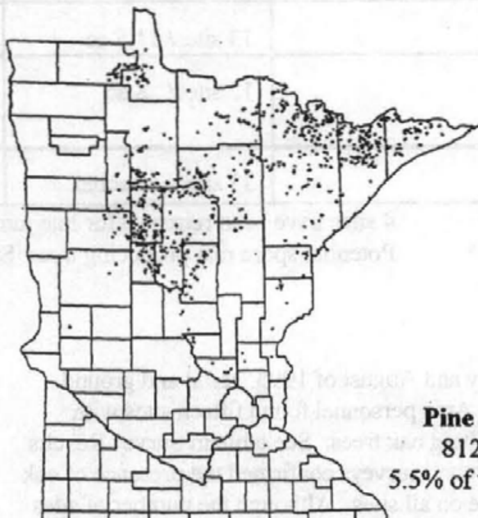
The hickory bark beetles have been active in Goodhue County causing pockets of mortality in hickory stands in S34-T112-R16. Over the years there has been scattered hickory mortality throughout the Region whenever the season turns dry. This is probably one of the best examples in the southeast of what can happen to a species in the northern part of its natural range. Sites are, of course, a big factor. The mortality occurs on the drier sites, which is where most of the hickory is found. The hickory bark beetle is considered to be the most destructive insect attacking the species. These bark beetles feed both externally and internally on a tree, and if a significant number attack, they may damage the tree past its ability to recover. Symptoms in the usual order of appearance are wilted leaves, dead twigs and limbs, premature dropping of leaves, broken but not severed twigs in the crown, and quantities of fine boring dust on bark flaps and at the base of the tree. The centipede-shaped gallery that is etched on the interface of sapwood is so characteristic that the hickory bark beetle can be identified by this sign alone.

PINE FORESTS

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 the white pine covertype. 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). 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). 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.



Pine covertype
812,300 acres
5.5% of timberland

Pests included in this report:

Jack pine budworm
Pine tussock moth
Pine bark beetles
Common pine shoot beetles
Spruce budworm on pines
Diplodia and Sirococcus shoot blights

Jack pine budworm

Choristoneura pinus Freeman

Host:	Jack pine
Damage:	Defoliation
Area:	66,500 ac.
Severity:	See table below.
Trend:	Jack pine budworm in central Minnesota is cyclic. Populations peaked in 1993 with 121,100 acres of heavy and continuous defoliation.

In 1994, defoliation occurred in isolated pockets in Wadena, Morrison, Cass and Pine Counties with the exception of a large, contiguous area of light defoliation in Crow Wing County (34,000). In total, 46,800 acres were defoliated in 1994.

Severity of jack pine budworm defoliation by county.			
Location	**Light defoliation**	**Moderate defoliation**	**Heavy defoliation**
Becker	2,117	1,210	22,285
Cass	4,623		
Crow Wing	4,435		
Hubbard	2,881	1,910	5,621
Lake of the Woods	392		
Morrison	709		
Pine	3,708		
Roseau	568		
Todd	605		
Wadena	13,061	2,369	
Subtotals	33,103	5,490	27,907
Total		66,500	

A continuing decline in acres defoliated was anticipated for the 1995 growing season. Instead, the incidence of defoliation increased by 40% for a statewide total of 66,500 acres. See Map. The populations did not intensify in the same areas where budworms were found in 1994. In 1995, the location of the defoliating populations shifted north and west into Cass, Wadena, Becker and Hubbard Counties. See Map. Last year's egg mass and this year's early larval surveys focused on areas where budworm populations were found in 1994 and consequently under-sampled areas where budworms would be abundant in 1995.

Mature jack pine stands from Two Inlets State Forest south to Osage and the southeast to Menahga supported moderate to high larval populations in June. When early dry spring weather was replaced by winds and heavy storms from July 12 -14, however, the visible damage was removed. Moderate defoliation was observed in northwestern Wadena County and all other locations had light and scattered defoliation. By July 7th, webbed needles had turned brick red which gave the affected pines a very noticeable discoloration which lasted well into September.

Ground checks in August verified the aerial survey designation of moderate to heavy defoliation. Extremely thin crowns were detected by timber cruisers in October and November. No direct control plans are forthcoming. Mature stands with thin crowns and preexisting bark beetle mortality will be added to harvest lists where possible.

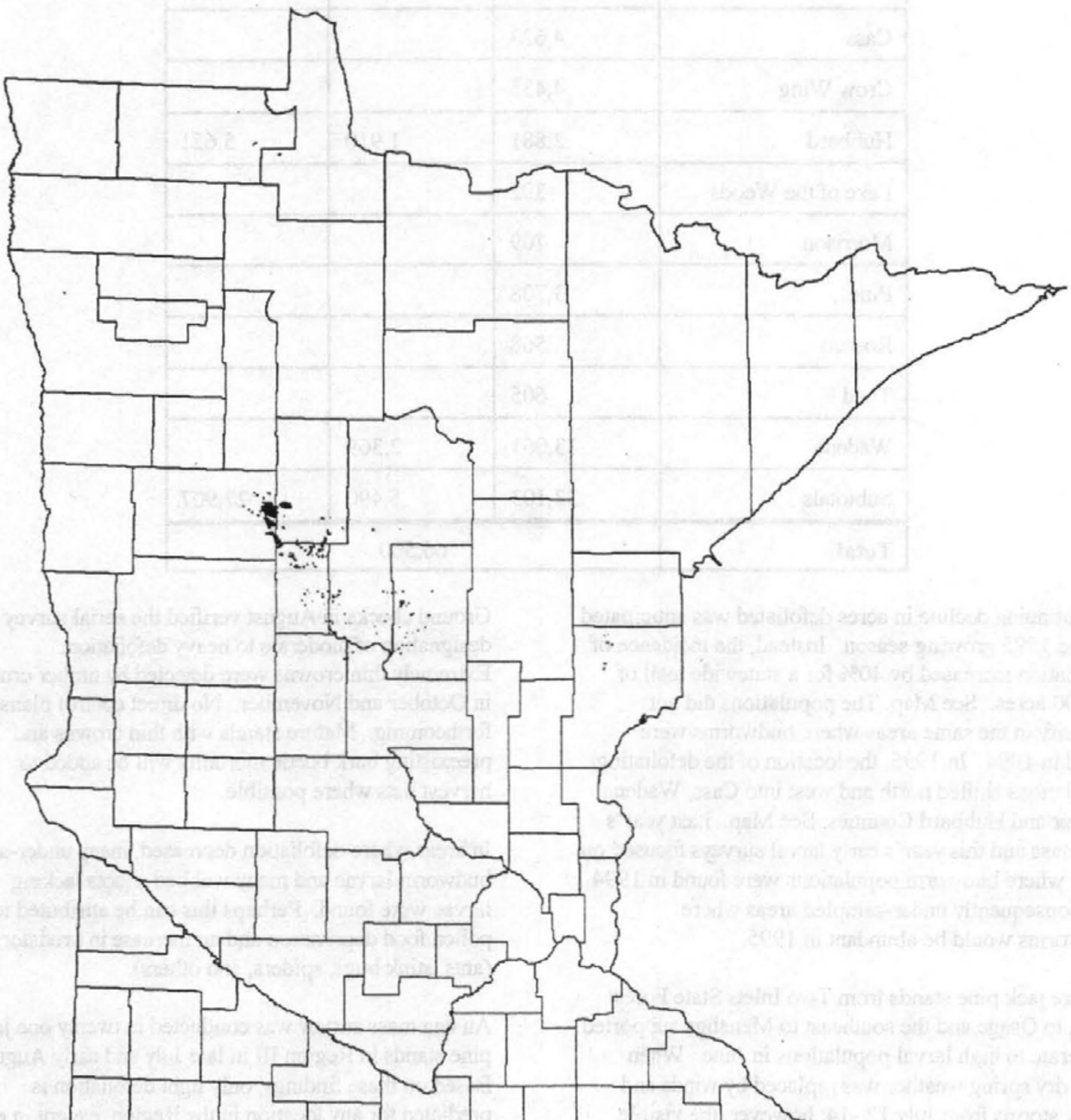
In areas where defoliation decreased, many under-sized budworm larvae and many webbed shoots lacking larvae were found. Perhaps this can be attributed to pollen food deprivation and an increase in predators (ants, stink bugs, spiders, and others).

An egg mass survey was conducted in twenty one jack pine stands in Region III in late July and early August. Based on these findings, only light defoliation is predicted for any location in the Region except in east central Wadena County where pockets of light to moderate defoliation may occur.

Abundant fall and winter moisture should promote excellent tree growth in spring of 1996. The effect of severe winter cold (-54°F) will be unknown until June when larval surveys are conducted.

Jack Pine Budworm

1995



Source: FHU aerial sketch mapping.

Map production and analysis by EPIC
Minnesota Department of Natural Resources
Division of Forestry, Forest Health Unit

6/20/1996

Pine tussock moth

Dasychira plagiata Dyer

Host:	Jack pine
Damage:	None
Acre:	None
Severity:	Defoliation not visible, but pheromone trap catches increased in Hubbard County while decreasing in Pine and Crow Wing Counties.
Trend:	Since 1980 the numbers of pine tussock moths trapped in Pine and Crow Wing Counties have diminished or remained low. The 1995 trapping indicates that the populations remain at minor levels in Pine and Crow Wing Counties but ares increasing in Hubbard County.

Pheromone traps were set out in the large jack pine areas in Pine, Crow Wing, Wadena and Hubbard Counties to monitor pine tussock moth populations. In 1995 trapped moths in Wadena County decreased slightly, as compared to 1994, and in southern Hubbard County, just north of Wadena County, trapped moths significantly increased. See Survey Results section. In one location, on one date, the moth catch met the threshold for serious damage next year. A 1996 June survey for caterpillars should be completed in Wadena and Hubbard Counties to determine the severity and extent of the building infestation.

Pine bark beetles

Ips pini (Say)

Host:	Pines
Damage:	Mortality
Area:	Individual trees across the southeast
Severity:	Light to moderate
Trend:	Related to the season

Due to the heat and humidity over the summer months and the fact that we experienced a moderate drought, bark beetle activity became noticeable on several species. *Ips pini* were active throughout the southeast killing individual white, Scots, and red pines which were already under stress. An example was a red pine from Lewiston. Red pines do not thrive on fine textured soils in the southeast, so this tree was under stress from being planted "offsite" and ultimately became victim to bark beetle attack.

Common pine shoot beetles

Tomicus piniperda (L.)

Host:	Red pine and other conifers
Area:	None
Severity:	None
Trend:	None

In cooperation with APHIS-Plant Protection, a survey for pine shoot beetles was conducted in Pine County east of Hinckley. Three fresh red pine logs cut in three foot lengths served as bait and trap logs. Logs were set out on March 14th, the fourth day in 1995 with temperatures greater than 32° F for the entire day. This should have been correct timing for trapping the overwintering adults. Traps were monitored and beetles reared out. No common pine shoot beetles were found, although many other species were trapped. See table below.

Pine shoot beetle survey in Pine County.			
Trap number	**Date**	**Location**	**Insect found**
1	8/3/95	Forestry office	*Polygraphis rufipennis* - 43
2	8/3/95	Forestry office	*Orthotomicus caelatus* - 45 *Ips grandicollis* - 9
3	8/3/95	Forest plantation	*Hylurgops rugipennis pinifex* - 3 *Orthotomicus caelatus* - 6
4	8/3/95	Forest plantation	*Orthotomicus caelatus* - 21 *Ips pini* - 13
5	8/3/95	Forest plantation	*Ips pini* - 81 *Hylurgops rugipennis pinifex* -1
6	6/22/95 8/3/95	State trust land	*Orthotomicus caelatus* -2 *Orthotomicus caelatus* -35 *Ips grandicollis* - 9
7	8/3/95	Natural area	*Orthotomicus caelatus* - 22
8	8/3/95	St. Croix St. Park	*Ips grandicollis* - 2 *Ips pini* - 2
9	6/22/95 8/3/95	St. Croix St. Park	*Ips pini* *Ips pini*
10	6/22/95 8/3/95	St. Croix St. Park	*Ips pini* - 2 *Ips pini*
11	6/22/95 8/3/95	St. Croix St. Park	*Ips pini* *Ips pini* -31 *Ips grandicollis* - 12
12	8/3/95	St. Croix St. Park	*Ips grandicollis* -10 *Orthotomicus caelatus* - 6 *Hylurgops rugipennis pinifex* -1
13	8/3/95	State Forest	*Ips pini* - 28
14	8/3/95	State Forest	*Ips grandicollis* -28 *Orthotomicus caelatus* -22

Spruce budworm on pines

Choristoneura fumiferana (Clemens)

Host:	White pine
Damage:	Bud mortality and shoot damage
Area:	Observed in two plantations
Severity:	Up to 70% of the terminal leaders affected
Trend:	None

Spruce budworm is suspected as the cause of damage to the terminal buds and shoots in two white pine plantations in the Littlefork Area. The plantations were bud capped for protection from deer browse in the fall of 1994. During the summer of 1995 it was observed that quite a few of the seedlings did not develop good terminal shoots. The bud cap did not deteriorate as expected and was still present on quite a few trees at the end of September 1995. Evidence of aphid feeding damage was seen under the bud cap on some of the trees. On other trees there was evidence of Lepidoptera larvae having been present. Frass and a head capsule or two were found. It is speculated that spruce budworm was the pest. The larvae fed on the bud and killed it and in other case, larvae fed on the tender bark of the shoot, deforming it.

The bud cap should normally deteriorate through the winter and not be intact the next spring. In these two plantations the bud caps did not deteriorate as normally expected. It was felt this may have been due at least in part to the drought experienced in this part of the state in the spring and summer of 1995. With the lack of rain the bud cap paper did not soften and deteriorate adequately. The bud caps appear to have served as protected feeding sites and maybe also as protected overwintering sites for the spruce budworm.

Diplodia and Sirococcus shoot blights

Sphaeropsis sapinea (Fr.:Fr.)Dyko & Sutton
Sirococcus conigenus (DC.)P. Cannon & Minter

Hosts:	Pines
Damage:	Shoot blights
Area:	Not determined
Severity:	Up to 100% of current year shoots
Trend:	None

The observed damage was mainly on understory pines and appeared to be primarily cause by *Sirococcus* based on symptoms. In a few locations most of the understory red pine seedlings and saplings had close to 100% of their current year shoots killed.

Shoots blights were observed throughout northeast Minnesota. Some of the more heavily damaged areas are listed below.

Sec28-T59N-R23W	Itasca Co.
Sec25-R59N-R23W	Itasca Co.
Sec4-T60-R23W	Itasca Co.
Sec9-T60N-R23W	Itasca Co.
Sec35-T62N-R23W	Itasca Co.
Sec2-T64N-R22W	Koochiching Co.
Sec8-T65N-R23W	Koochiching Co.
Sec21-T58N-R13W	St Louis co.

Diplodia tip blight was common on pole sized red pine in a fairly large area in Lake County infecting much of the red pine in the following townships:

Most of	T60N-R10W
South part of	T61-R10W
South part of	T61-R9W
Southwest part of	T60-R8W

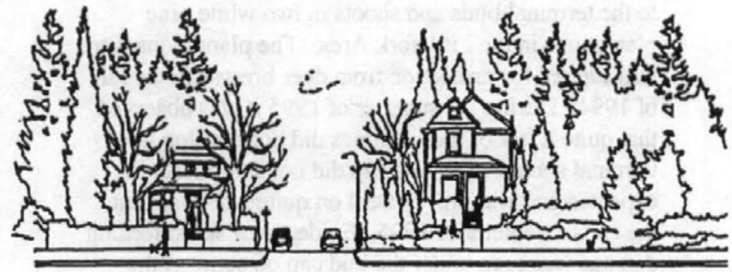
Diplodia tip blight has been commonly observed in this large area for quite a few years.

URBAN FORESTS

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.



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.

Pests included in this report:

Oak wilt
Gypsy moth
Apple scab
Cold spring weather

Oak wilt

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

Host:	Oaks
Damage:	Mortality
Area:	Seven county metropolitan area
Severity:	194 active oak wilt sites per square mile or 4711 active sites remaining from a total of 7254 sites.
Trend:	Decreasing due to the Cooperative Suppression Program.

The Cooperative Suppression Program (CSP) program for Oak Wilt, begun in 1991, continued in 1995. It is currently approved to run through 1997 with funding already approved for 1996. Progress continues to be made across the seven counties of the CSP (Anoka, Chisago, Dakota, Isanti, Ramsey, Sherburne, and Washington Counties). See community data in the Survey Results section. The federal program is expected to sunset when the Environmental

Assessment and Decision Notice expires at the end of 1997.

Funding history of the CSP, see table below, has been largely federal, with the state's commitment being largely limited to support services, both administrative and technical. The cash match, required for use of the federal funds, has been largely met by commitments at the local level. Local level match has been comprised of (in descending order) private landowner cash, local governmental unit cash, local governmental unit "in-kind", and private volunteers in the estimated ratios of 50% landowner, 30% local unit cash, 15% local unit "in-kind", and 5% volunteer. The program has typically been overmatched by local effort by about 75%.

Funding history for the Oak Wilt Cooperative Suppression Program						
Year	**Federal Cost Share Cash**	**State Cash**	**State "In-kind" support**	**Local Cost Share Match**	**Local "In-kind" & Volunteer Overmatch**	**Total Value of Project**
1991	$50,000	$25,000	$75,000	$75,000		$225,000
1992	$150,000		$85,000	$150,000	$50,000	$435,000
1993	$750,000		$90,000	$750,000	$300,000	$1,890,000
1994	$494,000		$90,000	$494,000	$300,000	$1,378,000
1995	$150,000		$90,000	$150,000	$300,000	$690,000
Total	$1,594,000	$25,000	$430,000	$1,594,000	$950,000	$4,618,000

Accomplishment history of the Oak Wilt C. S. P.				
Year	**Infection CentersTreated (number)**	**Plow Line Installed (feet)**	**Spore Trees Removed (number)**	**Communities Involved (number)**
1991	115	50,000	25	23
1992	303	150,763	200	70
1993	611	279,245	1,100	95
1994	614	280,000	2004	111
1995	876	212,992	2,358	111
Total	2,519	973,000	5,687	-----

Modeling Oak Wilt Risk From New Construction

The risk of developing a new oak wilt infection center as the result of construction damage was modeled for the 1995 field season. Using the EPPL7 GIS to combine basic soil type and the distance from a known active infection center (greater or less than 1500'), oak wilt risk was modeled into three classes. High risk was defined as those areas within 1500' of an active center on sand-based soil. Low risk was defined as areas more than 1500' from an active center and on any soil type other than sand. Moderate risk areas were defined as either within 1500' on non-sand soil or more than 1500' from an active center on sand soil, ie. one of the two risk factors present. The modeled data layer was imported into EPIC and then a map and summary was prepared for each community with and active program. A sample of this risk map for the city of Blaine (Anoka County) is attached. The results of this work were also presented at the Minnesota LIS/GIS Consortium Meeting in September of 1995. An abstract of that paper follows in the appendix.

Gypsy moth

Lymantria dispar (Linneaus)

Host: Hardwoods
Damage: None
Acres: None
Severity: None
Trend: Trap catches decreased.

The trapping results are in for the year and, while they clearly indicate that we still have significant challenges ahead, it is clear that we have dodged the majority of the attack. First, the number of traps placed this year was up dramatically from 1994 (6,988 traps in 1994). Moths were taken in 25 counties. This was up from 24 in 1994. Despite the increased trapping effort, moth catches dropped this year to 201, down from 349 in 1994.

For DNR cooperators, the good news was particularly sweet this year. Only one moth was taken in a DNR trap in 1995. We wish any surviving moths, still in Scenic State Park, a cold, cold winter.

Gypsy moth pheromone trapping - 1995	
Trapping Agency	**Number of Traps**
USDA & Minnesota Dept. Of Agriculture	15,033
Minnesota DNR	499
USDA Forest Service	384
Hennepin County Parks	76
Total	16,002

Trapping in 1995 was almost encouraging. Here are the county results with a few notable communities. As usual, the bulk of the moths were taken from the Metropolitan Region. Gypsy moth pressures continue to relate largely to movement of household articles and nursery stock, but the continually increasing number of counties capturing moths each year clearly illuminates the continually increasing pressure that we will feel as the infestation draws ever closer.

Gypsy moth trapping results - 1995		
County / Community	**Moths taken**	**Sites**
Anoka	7	3
Blue Earth	6	1
Carver	4	2
Chisago	15	1
Crow Wing	1	1
Dakota	95	10
Apple Valley	69	
Eagan	20	
Goodhue	8	4
Hennepin	29	10
Richfield	10	
Isanti	1	1
Itasca	1	1
Mille Lacs	1	1
Mower	1	1
Nicollet	2	1
Olmsted	3	3
Pipestone	1	1
Ramsey	4	3
Rice	1	1
St. Louis	3	2
Scott	7	3
Sherburne	1	1
Stearns	1	1
Wabasha	1	1
Washington	3	2
Winona	1	1
Wright	4	2
Total	201	67

Apple scab

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

Host: Apples, crabapple
Damage: Defoliation.
Area: Not determined.
Severity: 50-100% defoliation.
Trend: Very common in most years.

By mid August virtually every susceptible crabapple tree across southern Minnesota was completely defoliated. Apple scab is one of the most common defoliators of crabapple and we seen to be seeing this fairly extensively in most years. Of more than 30 species of Venturia fungi recognized in North America, about 12 are pathogens of woody plants and about 6 are economically or aesthetically important. The most famous and economically important pathogen in this group is Venturia inaequalis, the cause of apple scab.

Apple scab causes necrotic spots on leaves shoots on susceptible apple and crabapple species. These fungi over winter as mycelium on currently diseased leaves and twigs. Primary infections are initiated whenever the weather is conducive during the growing season. Epidemics occur whenever humidity is high and temperatures are moderate during the spring and through the summer, and continue as long as immature host tissue is available, the conditions were more than ideal this year. Pathogens in this group are generally host specific. Host plants include nearly all commercial cultivars of apple, most crabapple and many other species of Malus. Some species and cultivars of Malus are resistant to Apple scab and should be researched for use in future plantings.

Cold spring weather

Host: Hardwood species
Damage: Late leaf-out, reduced blooming, dieback
Area: Metropolitan area
Severity: Not determined
Trend: An uncommon event.

The winter of 1994-1995 was quite mild, in fact one of the mildest winters on record. In addition, March temperatures were well above average. As a result, dormancy was poorly developed over the winter and ended early and by the end of March many trees had begun spring activity. Of particular interest were many silver maples that were in full flower on April 1. During the first week of April, 1995, an exceptional arctic airmass move south from Canada and blanketed the state. On April 4, the morning temperatures were absolute record setters. The Metropolitan Region had reported temperatures that ran from -4 in northern Anoka County to +4 in the core of the urban heat island.

The effects of the cold were dramatic. Trees with foliage or flowers had those succulent tissues frozen off the tree. Many homeowners ultimately remarked that the maples (silver) did not produce seed that year. Gutters and downspouts, normally packed with silver maple's "helicopters", remained totally clear. Some of the worst damage in this respect was found on some of the hardiest trees. For example, the Kelsey Crabapple, a Canadian variety developed by the Morden (Manitoba) Research Station for use in the prairie provinces, was already in flower when the cold hit. Not only did these trees loose their flowers, but subsequent foliage development was very poor. (Authors note: In contrast, the winter of 1995-1996 contained extreme overwinter, all-time record setting cold. Kelsey crabapples flowered beautifully in the spring of 1996.)

Damage was not, however, limited to trees that had broken dormancy. Many trees that had begun activity, but had not yet broken bud and begun to develop foliage, were severely retarded in their growth. White oak were severely set back by the cold snap. Although they were not expanding buds at the time, they were apparently well out of deep dormancy and had begun significant physiological activity for the year. White oak ultimately did develop foliage in 1995, but did not make a serious budbreak until the first week in June. Many trees initially developed clusters of leaves only at branch tips initially, giving the trees a "lion's tail" appearance that lasted through early July when oak commonly has a second growth flush.

Exotic species, commonly considered marginally hardy in the Metropolitan Region, fared variably in thespring. Of the numerous varieties of Norway maples (*Acer platanoides*) found in the region, few had difficulties with the spring freeze. Apparently they had not broken dormancy to any serious degree when the cold hit. Black locust (*Robinia pseudo-acacia*), on the other hand, took the cold very poorly. Budbreak was ultimately delayed until mid-June for many black locust, in fact, a number of trees under observation did not break bud until the first week in July. Twig and branch dieback was common and the crowns of most trees remained sparse all summer.

Green ash was almost predictable in its reaction. Scattered trees, particularly exposed urban specimens along streets, died to varying degrees. Green ash typically has problems with abnormal winter conditions and typically responds by dieing back in peculiar ways. Rather than showing twig or tip dieback, green ash in urban situations typically shows dieback as dead sections of the crown, usually resulting from the death of a major branch or section of the tree. In some cases the tree dies completely for no apparent cause. In a few isolated cases, the crown section remains dormant until July and then begins to grow. In one case, a major scaffolding branch remained dormant for an entire year, only to resume growth the following year.

NURSERY AND GREENHOUSE

Items included in this report:

Red cedar topkill and outplanting failures
Herbicide damage to red pine
State Nursery notes
Nursery pest control summary
Root rot in containerized seedlings
Gypsy moth inspections

Red cedar topkill and outplanting failures

Weather damage

Host:	Red cedar
Damage:	Topkill and mortality
Area:	Not documented
Severity:	Topkill on 40-85%, mortality of <20% of seedlings.
Trend:	None

Severe weather in the winter of 1994-95 (fluctuating temperatures and periods of no snow cover) caused extensive damage (shoot lodging and top desiccation) to red cedar stock *Juniperus virginiana* in private and public nurseries in the midwest.

In July and August of 1995 the State Forest Nurseries began receiving calls on red cedar outplanting failures. Field checks verified survival rates of 60 to 15%. Close inspection of "failed" seedlings verified dead tops but better than 80% had live lower branches. Other species planted at the same time had traditional 85 to 95% survival rates. Dead and damaged cedar stock was replaced or credited for next year.

Checks for Phomopsis blight, root rot and stem cankers did not confirm a prime causal agent. Top desiccation was determined to be the probable cause. Whether it was winter burn, lifting shock or heat scorch after planting could not be determined. Soil temperatures in relation to juniper root initiation needs could not be documented. Seedlings remaining under irrigation in the nursery exhibited no top kill. Additional checks are needed to see if damage varied in relation to the seed sources (purchased seed, central Minnesota and southwest Minnesota).

Herbicide damage to red pine

Oxyfluorfen

Host:	Rising 2-0 red pine
Area:	Eight nursery beds
Severity:	Approximately 50% of the seedlings were dead and the remaingin seedlings were at least 75% dead.
Trend:	None

Oxyfluorfen was applied at labelled rates in August to 1-0 red pines prior to hardening off. This was one month earlier than normal. Needle browning was noted during the autumn, but extensive topkill and mortality was first observed as the snow melted. On topkilled seedlings, new buds were set. Volunteer jack pines were not affected.

State Nursery notes

Paper birch: New find: scale insect on paper birch. Identification pending. Spring survey for crawler and control timing.

Sugar maple: The State Forest Nursery program was anticipating a bumper hard maple seed crop in 1995. Early stand checks documented heavy seed set on sugar maples from Walker to Grand Rapids. This crop aborted in July of 1995 with little good seed found in the fall.

Nuts scarce: Seed crops for red oak, bur oak and butternut were light to nonexistent in north central Minnesota.

Nursery pest control summary

Direct control operations	
Pest	**Action**
Leafspot and anthracnose on chokecherry, paper birch and ash	Daconil sprays
Cottony aphid, cutworms and leafhoppers	Malathion and diazinon sprays
Grasshoppers in hybrid cottonwood	Malathion sprays

Root rot in containerized seedlings

Fusarium and *Pythium* spp.

Host: Red pine containerized stock
Area: All containers
Severity : Mortality of one third of crop, root mortality on every seedling examined.
Trend: None

About 50 % of the crop was still green and growing and 35% was dead with the remaining fraction being chlorotic and dwarfed. In live seedlings, the root systems were alived one to two inches below the root collar and dead down to the bottom of the container. This was due to a combination of cultural factors, increased watering frequency, heavier potting mixture, low greenhouse temperatures and increased nitrogen fertilizer and root rot infection. Root rots were caused by *Fusarium* and *Pythium* species.

Recommendations for the this crop were to encourage root growth into the entire depth of the cavity by: warming up the greenhouse, drying out the cavity, applying a fungicide (etridiazole and thiophanate-methyl) to prevent new infections, and, applying phosphorus and potassium fertilizers. For the next crop, use fungicides in this scheme as a preventative treatment. Apply a fungicide (etridiazole and thiophanate-methyl) at sowing. One month later, apply another fungicide (benomyl). Wait one month and reapply the first fungicide. Regularly monitor root growth and development for the presence of root rot. If root rot occurs, continue with fungicide scheme as outlined above.

Region II foresters contacted Badoura SFN in May of 1995 to replace refused container red pine with fresh lifted 2-0, 6 row grown bareroot red pine stock. Trees were shipped to sites in the Tower area. Stock was inspected, deemed acceptable and planted by contract crews. Comments back were positive and formal survival and growth evaluations are scheduled for the summer of 1996.

Gypsy moth inspections

Lymantria dispar (Linneaus)

Host:	Containerized red pine seedlings
Damage:	None
Area:	None
Severity:	None
Trend:	None

Ten percent of the red pine containerized seedlings from Mead Paper Greenhous in Escanaba, Michingan were inspected for the presence of gypsy moth life stages. None were found.

In another instance, a shipment of containerized seedling from a firm located in a gypsy moth infested county in Michigan was ordered. A contigency plan for gypsy moth inspection and pallet disposal was developed. The order was cancelled and the plan was not used.

INCIDENTAL PESTS

Diseases

Disease - common name ***Causal agent***	**Host**	**Location**	**Notes**
Apple scab *Venturia inaequalis*	Apple	southeastern counties	
Anthracnose *Apiognomonia errabunda*	Oaks elm maples	Ottertail Beltrami Morrison Pine Crow Wing	Late summer following wet period. Minor infections.
Cyclaneusma needlecast *Cyclaneusma minus*	Red pine	Benton	Windbreak , trees 3-4" tall.
Cytospora canker *Cytospora kunzei*	Blue spruce white spruce balsam fir	Beltrami Isanti St. Louis	Yard trees. Damage from lawn mowing associated with injuries.
Diplodia tip blight *Sphaeropsis sapinea*	Ponderosa, red, Scots pine	Polk Itasca Beltrami Kanabec	Farm yard windbreak trees. Plantations associated with overstory pines. Ornamentals.
Dutch elm disease *Ceratocystis ulmi*	American elm	Beltrami Ottertail most of Region I	Higher incidence in 1995 than previous year.
Fir broom rust *Melampsorella caryophyllacearum*	Balsam fir	Carlton	
Fire blight *Erwinia amylovora*	Mt. ash	Beltrami	Ornamental mountain ash seriously affected.
Leaf blister *Taphrina sacchari*	Maple	Crow Wing	A rare find.
Nectria canker *Nectria galligena*	Elm	Pine	On ornamentals.
Pine needle rust *Coleosporium asterum*	Red pine	Crow Wing	Plantations.

Disease - common name *Causal agent*	**Host**	**Location**	**Notes**
Rhizosphaera needlecast *Rhizosphaera pini*	Balsam fir	Itasca St. Louis	Understory trees along roadside in low, swampy areas.
Rhizosphaera needlecast *Rhizosphaera kalkhoffii*	Blue spruce white spruce	Polk Beltrami Crow Wing Morrison	Farmyard windbreak common in Region I. Ornamental plantings.
Sirococcus tip blight *Sirococcus conigenus*	Red pine	Itasca Beltrami Pine Lake	High incidence and common along highway 46 on understory trees. Also at Net Lake Campground.
Smooth patch *Aleurodiscus oakšeii*	White, burr oak	Beltrami	Prevalent in Bemidji. Non-pathogenic bark disease.
Willow scab *Venturia saliciperda*	Willow	southern counties	

Insects

Insect - Common name *Latin name*	**Host**	**Location**	**Notes**
Adana shoot moth *Rhyacionia adana*	Red pine	Morrison	Windbreak planting.
Aphids Not identified	Walnut black locust	Metro	Curling leaves and leaf fall.
Aspen blotch miner *Phyllonorycter tremuloidiella*	Trembling aspen	Wide-spread in Region I	Roadsides, yards.
Basswood leafroller *Pantographa limata*	Basswood	Cass	Minor defoliation.
Birch skeletonizer *Bucculatrix candensiella*	White birch	Winona Houston	
Bladder mite galls *Vasates quadripedes*	Maple	Aitkin Pine Crow Wing	
Cankerworms *Alsophila pomentaria* *Paleacrita vernata*	Elm apple oak basswood	souteastern counties	Heavy defoliation in some locations.

Insect - Common name *Latin name*	**Host**	**Location**	**Notes**
Cooley spruce gall adelgid *Adelges cooleyi*	Blue spruce	Crow Wing	Ornamental plantings.
Crimson erineum mites *Eriophyes* spp.	Silver maple	Pine Aitkin	
Cynipid gall wasp *Callirhytis quercuspunctata*	Oak	Itasca	
Eastern pine shoot borer *Eucosma gloriosa*	White pine	Kanabec	Ornamental planting.
Eastern tent caterpillar *Malacosoma disstria*	Wild cherry apple crabapple	southern counties	Tents and defoliation of infested trees.
Elm leaf beetle *Pyrrhalta luteola*	Siberian elm	west central counties	Causing leaves to turn brown.
European pine sawfly *Neodiprion serifer*	Red, Scots, mugho, Jack pine	Metro	
Fall webworm *Hyphantria cunea*	Alder box elder other species	Scattered through-out Region I	Appears to be higher incidence in 1995.
Forest tent caterpillar *Malacosoma disstria*	Aspen ash basswood birch	Lake Carlos State Park	Moderate defoliation of the picnic area and west edge of Lake Carlos.
Grasshoppers Not identified	Hardwoods and conifers	Hubbard Ottertail Stearns Beltrami	Defoliation of windbreak trees.
Hickory bark beetles *Scolytus qadrispinosus*		Goodhue	
Imported willow leaf beetle *Plagiodera versicolora*	Willow	Crow Wing	Skeletonizing leaves.
Lacebugs *Corythuca* spp.	Oaks	Benton Aitkin Morrison Stearns Crow Wing Pine	Leaf bronzing in July.
Leaf hoppers Not identified	Burr oak	Gen. Andrews Nursery	On seedlings.

Insect - Common name *Latin name*	**Host**	**Location**	**Notes**
Mites *Acalitus phloeocotes*	Wild plum	Crow Wing	Leaf galls.
Mountain ash sawfly *Pristiphora geniculata*	Mt. ash	Scattered areas in Region I	Some trees stripped twice during summer.
Northern pitch twig moth *Petrova albicapitana*	Jack pine	Hubbard Becker	Commonly found when doing Jack pine budworm surveys.
Oscellate gall midge *Cecidomyia ocellaris*	Red maple	Morrison	
Pale green weevil *Polydrussus impressifrons*	Hardwoods	Itasca Cass Crow Wing	Leaf edge feeding weevils.
Pear sawfly *Caliroa cerasi*	Mt. ash	Becker	Slug sawfly that skeletonizes leaves.
Pine spittlebug *Aphrophora parallela*	Jack pine	Pine	Sooty mold also present.
Pine bark adelgid *Pineus strobi*	White pine	Crow Wing	Roadsides and ornamentals
Pine bark beetles *Ips pini*	Jack pine	Beltrami	Site near old sawmill that had a history of bark beetle infestations.
Pine pitch midge *Cecidomyia reeksi*	Jack pine	Hubbard Becker	
Pine tortoise scale *Toumeyella parvicornis*	Jack pine	Hubbard Becker Pine	Heavy infestation in late summer. Sooty mold also present.
Pine root collar weevil *Hylobius radicis*	Red pine Scots pine	Hubbard Crow Wing	Leaning trees in windbreak and plantation.
Pitch mass borer *Synanthedon pini*	White spruce	Pine	
Rear-humped caterpillar *Amphipyra pyramidoides*	Basswood	Cass	A few caterpillars found on ornamental tree.
Red pine cone beetle *Conophthora resinosa*	Red pine	Morrison	Windbreak planting.
Red-humped oakworm *Symmerista canicosta*	Burr oak	Morrison	Light defoliation of a few oaks.
Rose chafer *Macrodactylus subspinosus*	Hardwoods	Crow Wing	

Insect - Common name *Latin name*	**Host**	**Location**	**Notes**
Saratoga spittlebug *Aphrophora saratogensis*	Jack pine Red pine	Hubbard, Wadena	In plantation where heat caps were used. In plantation frost pocket where infestation last occurred in 1981.
Sawyer beetle *Monochamus* spp.	Balsam fir	Carlton	Feeding on balsam fir Christmas trees.
Speckled green fruitworm *Orthosia hibisci*	Basswood	Cass	Few caterpillars present.
Spider mites *Oligonychus ununguis*	Balsam fir white cedar	Pine Crow Wing	Causing chlorotic needles.
Spiny elm caterpillar *Nymphalis antiopa*	Elm	Morrison	On ornamental planting.
Spruce gall adelgid *Pineus similis*	Spruce	Pine Morrison Crow Wing	Clustered galls at needle bases.
Spruce needle miners *Endothenia albaineara*	Blue spruce	Morrison	
Spruce gall midge *Mayetiola piceae*	White spruce	Carlton Itasca	On ornamentals.
Spruce gall aphids Unidentified species	White spruce	Roseau Becker	On ornamentals. Irregularly formed galls.
Tarnished plant bug *Lygus lineolaris*	White birch	Crow Wing	
Walking stick *Diapheromera femorata*	Oaks	Stearns	Causing noticable defoliation on 80 acres.
Wooly elm aphids *Eriosoma americanum*	Elm	Crow Wing	
Wooly alder aphid *Prociphilus tessellatus*	Silver maple	Beltrami Pine Crow Wing	Scattered yard trees. Some trees with heavy infestations.
Yellow headed spruce sawfly *Pikonema alaskensis*	White spruce	Becker Hubbard Beltrami Rice	Greatly decreased reports in 1995.
Yellow-headed spruce sawfly *Pikonema alaskensis*	White spruce	Cass Crow Wing Lake	2-4' tall trees in plantations and ornamental settings.

Animals and Abiotics

Symptom or damage ***Causal agent***	**Host**	**Location**	**Notes**
Constrution damage	Red pine oaks other species	Crow Wing	Due to root severing and piling of fill dirt.
Crown dieback	White oak	Beltrami	Yard trees. Root damage and crown dieback due to soil flooding from storm water run-off.
Dieback of crowns Construction damage	Oak spruce ash basswood	Clearwater Beltrami	Due to soil storage over root system and filling, sodding and over-watering of sod.
Fertilizer damage	White spruce blue spruce	Beltrami	Reddened tips of new growth along driveway. Homeowner encouraging growth during hot dry weather.
Gopher	Jack pine	Crow Wing	Roots severed.
Herbicide damage	White pine red pine white birch burr oak	Clearwater Beltrami	Homeowner spraying weeds and brush during hot breezy conditions.
Lammas growth	Red pine white spruce	central and northeastern counties	
Leaf reddening Unknown	White pine	Throughout Region I	First noticed in 1994. New shoots turned red in June.
Mice	White pine white spruce	Kanabec	Winter girdling of 2' seedlings in back yard.
Pocket gophers	White spruce Jack pine	Becker Hubbard	Plantation and yard trees.
Seedling death and chlorosis Water-logged soils	Red pine	Pine	Planted in 1994.
Socket pull Winter snow weighs down branch	Jack pine	Crow Wing	In Seed Orchard. 12-15' tall trees.
Winter damage	Ash maples oaks	Beltrami Clearwater Becker Lake of the Woods	Mild winter November - January. Then very cold. Possibly trees never reached complete dormancy.

PHENOLOGICAL NOTES

Accumulated degree days are calculations based on daily 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 readings from one of the following locations: Fergus Falls, Baudette, Bemidji, Grand Rapids, International Falls, Winton, Hibbing, Duluth, Park Rapids, Hinckley, Brainerd, St. Cloud, St. Paul, Winona or Rochester.

The spring of 1995 was cold and wet with very little sunshine.

Phenology for 1995

Date	Accumulated degree days	Event	Location
4/17	180	Aspen catkins are breaking bud.	Itasca
4/18	191	Aspen buds breaking.	Itasca, Aitkin
4/24	259	Maples in flower.	Cass, Crow Wing
4/27	273	Aspen catkins pendant.	Itasca
5/ 1	342	Birch catkins well formed, but closed. 20-30% of aspens with catkins opened.	Crow Wing
5/3	378	40% of aspen clones with catkins in north and 90% in south. Bumble bees are out.	Crow Wing
5/ 3	352	Aspens still dormant. Catkins on hazelnut. 50% of red maples blooming. Swamp pussy willows showing green.	Cass
5/ 3	307	Red maple buds swelling, not flowering	St. Louis
5/ 3	355	Red maples are flowering.	Itasca
5/ 6	411	First time in 1995 that temperature reaches 70 F.	Itasca
5/ 8	479	Red pine shoots still dormant. Jack pine shoots to 1/2" long and resin-covered. Spring growth starting. Elms are in flower. Birch catkins open.	Crow Wing
5/ 8	463	Maple flowers dropping off. Bloodroot flowering.	Itasca
5/11	747	Spruce budworm larvae in second instar and feeding in spruce buds. White spruce buds swollen. Marsh marigolds in bloom. Aspen crowns faintly green.	Chisago, Isanti

Phenology for 1995			
Date	**Accumulated degree days**	**Event**	**Location**
5/ 11	537	Aspen tops faintly green. Marsh marigolds in bloom.	Kanabec
5/ 12	552	Dandelions blooming.	Crow Wing
5/ 12	538	5% of aspen clones with leaves 1" long, remainder are far behind. Red maple flowering. Birch catkins fully out. Larches appear green. Marsh marigolds just beginning to bloom.	Cass
5/ 13	560	Aspen leaves about the size of nickels.	Itasca
5/ 14	579	Large bellwort in full bloom. *Maianthemum* just emerging. Bloodroot in full bloom or just past peak.	Itasca
5/15	603	Marsh marigolds in bloom.	Aitkin
5/ 15	619	Bud caps still on most white spruce and balsam fir. Aspen 80-90% leafed out. Tamarack needles to 1/4" long. *Trilliums* blooming.	Crow Wing
5/ 15	505	Basswood thrips adults active in buds. Most aspen leafed out.	Carlton
5/ 16	627	Spruce budworm in second instar.	Cass Itasca
5/ 16	659	Spruce bud caps off. No spruce budworm.	Pine
5/ 16	619	*Amelanchier* blooming.	Pine Crow Wing
5/ 16	632	Jack pine buds are ½ " to 3/4" long.	Wadena
5/ 16	632	Aspen leaves ½ " long. Larch needles ½ " long, female cones with scales open, terminal buds to 1/4" long. Red maple leaves ½ " long. *Amenlanchier* buds broken, shoots to ½ " long and leaves 3/4 " long.	Cass Wadena
5/ 16	632	Spruce budworm second instar larvae in spruce buds which are tight or slightly expanded. Jack pine sapling candles 1-3 " long; on mature trees, ½ to 1" long. Marsh marigolds in full bloom. Aspens are all leafing out. Black ash buds swollen. Boxelder leaves out.. Blueberry plants 3" .	Cass
5/ 17	683	Larvae found on/ in aspen leaves and buds: spotted aspen leafroller, dusky leafroller, birch-aspen leafroller and two-lined aspen looper.	Pine Kanabec
5/ 17	683	Oaks starting to leaf out.	Kanabec
5/ 17	683	Basswood, aspens, elms, maples and birch leafed out. White spruce bud caps falling off.	Mille Lacs

Phenology for 1995			
Date	**Accumulated degree days**	**Event**	**Location**
5/18	666	Second instar spruce budworms found in sunny location on white spruce; bud caps on these trees have broken loose at the base of the new shoot. Wild strawberry beginning to bloom. No mosquitos , yet. *Trillium* just starting to bloom.	Itasca
5/20	721	*Amelanchier* starting to bloom.	Itasca
5/22	792	Jack pine cones shedding pollen.	Pine
5/22	766	In bloom: marsh marigolds, *Trilliums*, dandelions, *Amelanchier*.	Aitkin
5/22	766	Mostly seconds and some third instar spruce budworm larvae. White spruce pollen being shed. Red oak leaf buds expanding to 1" long. Amelanchier peak bloom is spectacular this year. Dandelions in full bloom. Pin cherries starting to bloom. Trillium flower buds not open.	Itasca
5/23	789	White spruce bud caps beginning to detach at base but remain on and cover new needles. Jack pine candles 1-3" long. Male cones turning yellow-green and ready to open. Trilliums blooming. Aspen leaves are "spring green". Bigtooth aspen leaves <1" long. Pin cherry blossoms just evident.	Aitkin
5/23	682	In bloom: Yellow rocket and *Trilliums*.	Carlton
5/23	789	Second instar spruce budworm larvae on balsam firs. Elm leaves <1" long. Cottongrass blooming.	Itasca
5/24	814	Introduced pine sawfly larvae 1/4" long.	Crow Wing
5/26	858	Spruce budworm larvae in second and third instars. Jack pine cones shedding pollen. In bloom: chokecherry, hoary puccoon.	Crow Wing
5/26	835	Spruce budworm larvae in second instar. Spruce bud caps are 70% still on the buds.	Cass
5/27	866	Small mines evident caused by birch leaf miner. A few June bugs flying. Crab apples starting to bloom.	Itasca
5/28	887	Forest tent caterpillars 3/4" long.	Todd
5/28	891	*Trillium* still blooming. Just beginning to flower: false Solomon's seal, yellow violet , *Viola pubescens* and crab apples. Wood anemone peak bloom.	Itasca
5/30	967	Yellow-headed spruce sawfly adults present. Oak catkins present, leaves to 2" long. Big tooth aspen leaves turning green. Jack pine cones yellow with pollen.	Crow Wing
5/30	967	Basswood is in full leaf.	Stearns

Phenology for 1995			
Date	**Accumulated degree days**	**Event**	**Location**
5/ 30	953	Forest tent caterpillars 3/4" long.	Todd
5/ 30	947	Black ash beginning to leaf out. Leaflets are about 1" long. Elms loaded with seed.	Cass Itasca
5/30	947	In bloom: red elderberry, choke cherry, pin cherry.	Aitkin
5/ 30	947	Predominantly third instar spruce budworm larvae. White spruce shoots up to 1 ½ " long and some just barely expanding. Balsam fir shoots are 1 ½ " long and some are starting to flare.	Itasca
5/ 30	953	Spruce budworm larvae are 50% in second instar and 50% in third instar. Lilac blossoms just about to open. *Amelanchier* petals are still hanging on to the flower.	Cass
5/ 31	983	In bloom: Lilacs, Jack in the pulpit, wild strawberries, star flower, columbine and fringed Polygala.	Itasca
6/ 1	1035	Mountain ash blooming.	Crow Wing
6/ 1	1022	Spruce budworm mostly fouth instars. White spruce shoots ½ to 3" long. Black spruce buds just swelling now. Jack pine pollen starting to be released. Scots pine pollen release. In bloom: bastard toadflax, golden Alexander and blue-eyed grass.	Itasca
6/ 1	1022	Mt. ash flower buds not open. *Ribes* in peak bloom. Also blooming: white crab apples, lilacs, *Trillium*, choke cherry and *Caragana*.	Aitkin
6/ 2	1058	Spruce budworm larvae in fourth and fifth instars. Bud caps 90-100% off, exposing the new needles.	Cass
6/ 5	972	Spruce budworm: 25% third instar and 75% fourth instar.	St. Louis, near Orr
6/ 5	878	Spruce budworm: 50% third instar and 50% fouth instar. Columbine in bloom.	St. Louis, near Ely
6/ 5	1064	Jack pine shedding pollen. Heavy cone crop near Virginia and Tower.	St. Louis
6/ 5	1084	Rhizosphaera pine have mature spores inside pycnidia on last year's balsam fir needles.	St. Louis
6/ 5	1166	Red pine pollen release.	Itasca
6/ 8	1252	Seed dispersal by willow species in wetlands.	Cass
6/ 9	1265	Predominantly fifth instar spruce budworm, fourths are moribund.	Itasca

Phenology for 1995			
Date	**Accumulated degree days**	**Event**	**Location**
6/ 9	1281	Anthracnose on urban sugar maples and ashes.	Morrison
6/ 13	1367	Jack pine early larval survey starts: Third instar larvae present. Cottongrass blooming.	Pine
6/ 13	1226	Cotton grass blooming in wetlands.	Pine Carlton
6/ 14	1438	Jack pine budworm second to fourth instars present. Downy phlox blooming.	Crow Wing
6/ 15	1481	In bloom: grass-leafed golden aster and leafy spurge.	Crow Wing Cass
6/ 16	1520	Forest tent caterpillars 1 3/4" long.	Todd
6/ 19	1638	Blue iris in bloom.	Aitkin
6/ 19	1515	In bloom: buttercup, daisy and orange hawkweed.	Itasca St. Louis
6/ 19	1674	Yello-headed spruce sawfly larvae are 1/2" long.	Crow Wing
6/ 20	1711	Jack pine budworm third instar to pupae present; majority in fifth to seventh instars. Jack pine budworm starting to pupate. Jack pine shoots beginning to appear brown.	Wadena
6/ 20	1686	Pale green weevil adults noted for first time this year.	Itasca
6/ 21	1553	Spruce budworm is 40% pupated. Mountain ash starting to bloom.	Lake
6/ 21	1601	Callow bark beetle adults present. Birch trees are starting to turn brown from leaf miner activity.	Itasca St. Louis
6/ 21	1660	Spruce budworm is 60 - 100% pupated. Wild rose in bloom.	St. Louis, near Orr
6/ 21	1758	Spruce budworm moths abundant and flying. In bloom: rose, oxeye daisy, basswood, wood anemone and *Diervilla*.	Cass
6/ 21	1767	Spruce budworm moths are flying.	Crow Wing Morrison So. Itasca
6/ 21	1424	Spruce budworm: 70% sixth instars and 30% pupated. Nearby, 25% pupated.	St. Louis, near Ely

Phenology for 1995			
Date	**Accumulated degree days**	**Event**	**Location**
6/22	1816	Jack pine budworm fifth to seventh instars present.. Red pine sawfly larvae 3/4" long. Yarrow and black-eyed Susans in bloom.	Crow Wing
6/22	1631	Pine tortoise scale crawlers present on jack pine shoots.	Beltrami
6/27	1990 1847 1660 1903	Spruce budworm moths are flying.	No. Itasca St. Louis Lake Koochiching
6/28	1887	Spruce budworm moths flying.	St. Louis
6/30	1868	Aspen leaf blotch miner mines about 1/8" in diameter. Black locust in bloom. Also lilacs along Lake Superior.	Carlton St. Louis
7/ 5	2268	Red pine sawfly now cocooned in duff. In bloom: bluebells, bird's foot trefoil.	Crow Wing
7/ 6	2232	Wild strawberries ripe; fireweed in bloom.	Pine Aitkin
7/ 6	2275	Fireweed starting to bloom.	Itasca
7/ 7	2322	Jack pines appear brick red due to discoloration of webbed needles.	Wadena
7/10	2446	Butterflyweed in bloom.	Crow Wing
7/21	2792	In bloom: Common evening primrose, spotted knapweed, orange hawkweed and wild bergamot.	Pine
7/21	2872	Turk's cap lily in bloom. Also, common sow thistle, Canada thistle and tansy.	Crow Wing
7/25	3014	White-marked tussock moths common.	Morrison
8/ 3	3267	Some black berries ripe. In bloom: goldenrods, giant fall sunflower, pearly everlasting, blue aster.	Pine
8/ 3	3343	Flat-topped white aster in bloom.	Crow Wing
8/ 4	3317	Fall webworms 7/8" long.	Itasca
8/ 4	3379	Fall thistle and peppermint in bloom.	Morrison
8/ 5	-	Leaf beetles skeletonizing balsam poplars. Pale green weevil adults present.	Lake Cook
8/ 7	3475	In bloom: *Liatris*, giant sunflower, white aster, wild licorice and Solidago spp.	Cass

Phenology for 1995			
Date	**Accumulated degree days**	**Event**	**Location**
8/18	3676	Fall webworm feeding on alder leaves.	St. Louis
9/ 8	4834	Walkingsticks abundant south of Birch Lake Campground. On oaks and hardwoods, not on alder and bigtooth aspen.	Stearns
9/12	4687	Sumac is turning burgundy red. Silver maples are yellowing. Few, scattered red maples turning color. Most black ash leaves yellow, some leaf fall noted.	Aitkin
9/24	4892	Peak fall coloration of hardwood leaves.	Itasca
10/20	5449 5344	Leaf fall almost complete. A few aspen clones are still golden. Tamarack needles yellow. Some urban silver maples still green.	Aitkin, Itasca Crow Wing

SPECIAL PROJECTS

Projects included in this report:

Hazard Mitigation Survey Team For FEMA-1064-GR-MN
Itasca State Park and bark beetle trapping
Hazard tree training
North American Maple Project

Hazard Mitigation Survey Team For FEMA-1064-GR-MN

On August 18, 1995 the President of the United States issued a federal disaster declaration for the Great Wind Storm of 1995 in North central Minnesota. This was the most significant Forest Health event in Minnesota in 1995. A Hazard Mitigation Survey Team convened on August 28, 1995 to identify hazard mitigation opportunities for the affected parks, forests, municipalities, counties, reservations and rural electric cooperatives. A Forest Health specialist was the DNR Forestry representative on the team that produced a report (HMST Report September 8, 1995) describing damage and recommending follow up actions. Exerpts of the report follow.

FEMA-1064-DR-MN

EXECUTIVE SUMMARY

The period from July 9 through July 14, 1995 will long be known as the Great Wind Storm of 1995. Northern Minnesota has experienced occasional tornado and high wind conditions before but never a disaster of this magnitude. While no lives were lost and injuries and property damage were minimal, extensive loss to the State's timber resources will be felt for many years.

The unusual duration of high, straight line winds (20 to 40 minutes at 129 miles per hour on July 12, 13, and 14) snapped trees at varying heights from ground level up to 40 feet. The winds completely leveled or bent large expanses of trees in isolated areas. Similar damage to trees and utility lines occurred on a more scattered basis throughout the declared area.

Foresters have estimated that the government logging allowance for the next 17 years lies on the ground in the disaster area. This unexpected surplus of timber (6.5 million trees) has lowered its market value. Future logging allowances may be reduced to encourage maximum harvesting of downed timber. Employment in the logging industry is expected to decline.

Clean up of the damage will be a challenge for many years. Timber which is salvageable must be harvested before winter weather. Tree stumps must be cut to ground level. Slash must be removed to reduce insect, disease and fire potential. New and additional fuel breaks must be introduced to gain access to damaged areas. Burning, if included in the clean up process, must be closely supervised. Finally, the clearing of areas anticipated for reforestation must be especially monitored.

The Hazard Mitigation Survey Team convened on August 28, 1995 to identify hazard mitigation opportunities for the affected parks, forests, municipalities, counties, reservation and rural electric cooperatives. The Team spent four days touring damaged areas and discussing mitigation strategy and opportunities with relevant officials. Following the site visits, the Team reconvened to discuss recommendations.

This report was developed utilizing the expertise and input of representatives from Federal, State, county and other units of local government, rural electric cooperatives, and the White Earth Indian Reservation.

II. DESCRIPTION OF THE DISASTER AREA

On August 18, 1995 the President declared a major disaster for Becker, Beltrami, Clay, Clearwater, Crow Wing, Hubbard, Itasca, Kittson, Mahnomen, Otter Tail, St. Louis, and Wadena counties, and the White Earth Indian Reservation in north central Minnesota. On August 23, 1995, Aitkin, Cass, and Wilkin counties were added to the declaration for a total of fifteen counties. The counties and reservation were made eligible for the Infrastructure (Public Assistance) Program.

III. DESCRIPTION OF THE EVENT

Beginning with a tornado in Kittson County on Sunday, July 9, northern Minnesota experienced extremely volatile weather through Friday, July 14. Strong to severe thunderstorms moved across northern Minnesota early on three successive mornings—July 12, 13, and 14. Having developed in eastern Montana and the western Dakotas on each previous evening, these storms produced high winds of extended duration. The strongest storm occurred on July 13 in the Grand Rapids area.

Meteorologically, thunderstorms accompanied by extended periods of high, straight line winds are called *derechos* which means "straight" in Spanish. As the name implies, extreme and damaging straight line winds occur with a derecho. Derechos as far north as northern Minnesota are rare. They are more common in South Dakota, Nebraska, southern Minnesota, Iowa and Illinois.

Pressure Areas

At the surface, the weather maps depicted an area of low pressure in the northern plains that slowly moved east into Minnesota by July 14. Southerly low level winds, enhanced by that low pressure area, brought increasingly warm and humid air into the region. These parameters, heat and moisture, are two surface level ingredients needed for thunderstorms.

A large and strong area of high pressure dominated the upper level weather pattern throughout the week. At the beginning of the week, the high was centered over the southern plains. By Friday, the high moved east-northeast to Illinois and Indiana. Strong west winds circulating around this high pressure area passed over the northern plains and northern Minnesota. Winds at altitudes of 18,000 feet and 25,000 feet were measured at 50 to 55 knots.

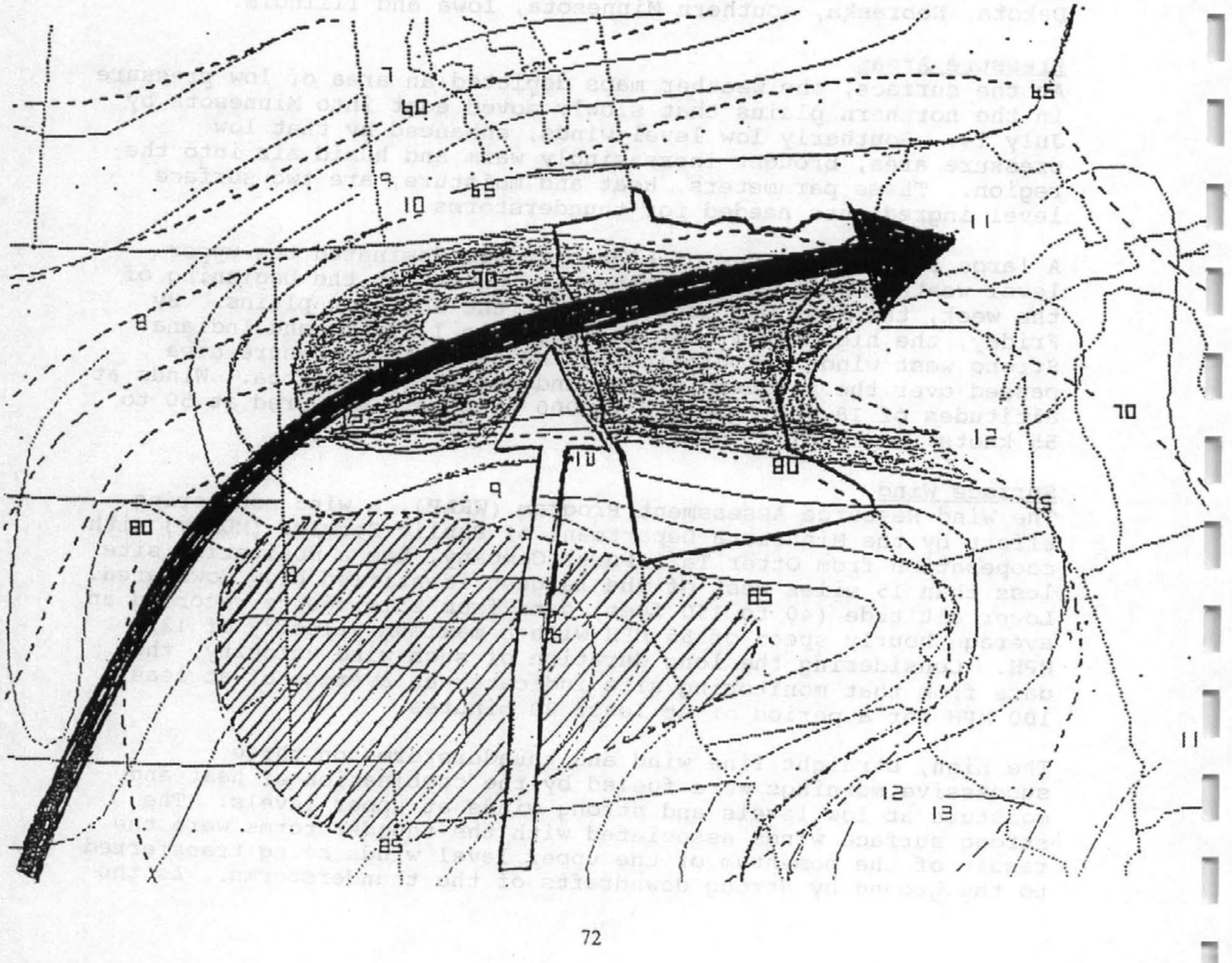
Surface Wind

The Wind Resource Assessment Program (WRAP), a wind monitoring effort by the Minnesota Department of Public Service (MDPSv) with cooperation from Otter Tail Power Company, has a monitoring site less than 15 miles west of the largest identified blow down area. Lower altitude (40 to 150 feet) data from this source recorded an average hourly speed of 55 MPH with a maximum velocity of 129 MPH. Considering the long duration of such wind velocity, the data from that monitoring site indicates an average of at least 100 MPH for a period of at least 20 minutes.

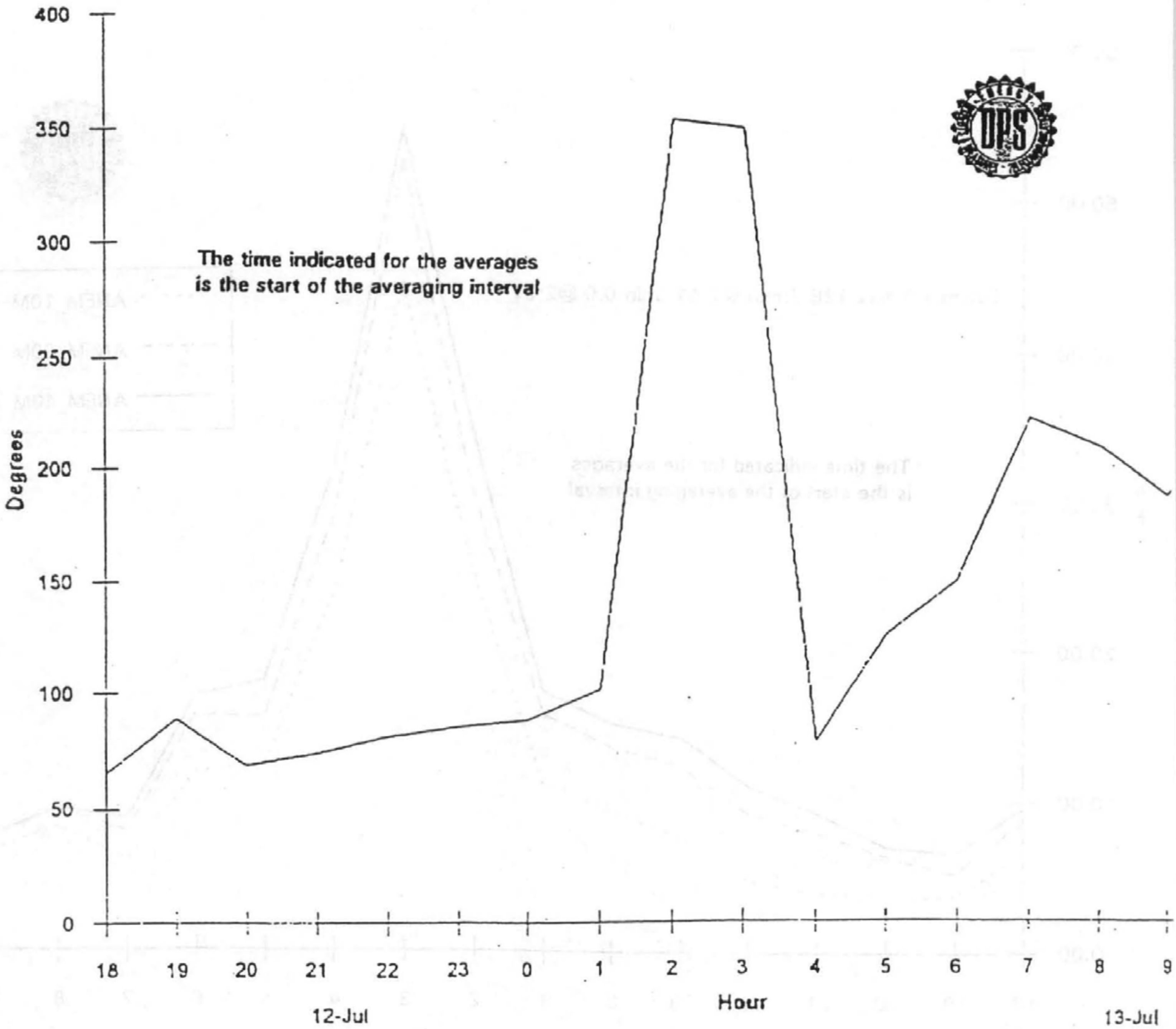
The high, straight line wind and thunderstorms on three successive mornings were fueled by the combination of heat and moisture at low levels and strong winds at upper levels. The strong surface winds associated with the thunderstorms were the result of the momentum of the upper level winds being transferred to the ground by strong downdrafts of the thunderstorms. As the storms approached, the preceding front brought high winds. Then the core of each storm contributed high winds. Finally, as the storms moved away, a rear downdraft may have added to the very strong winds.

Composite of wind, heat and moisture at 1:00am on July 13, 1995

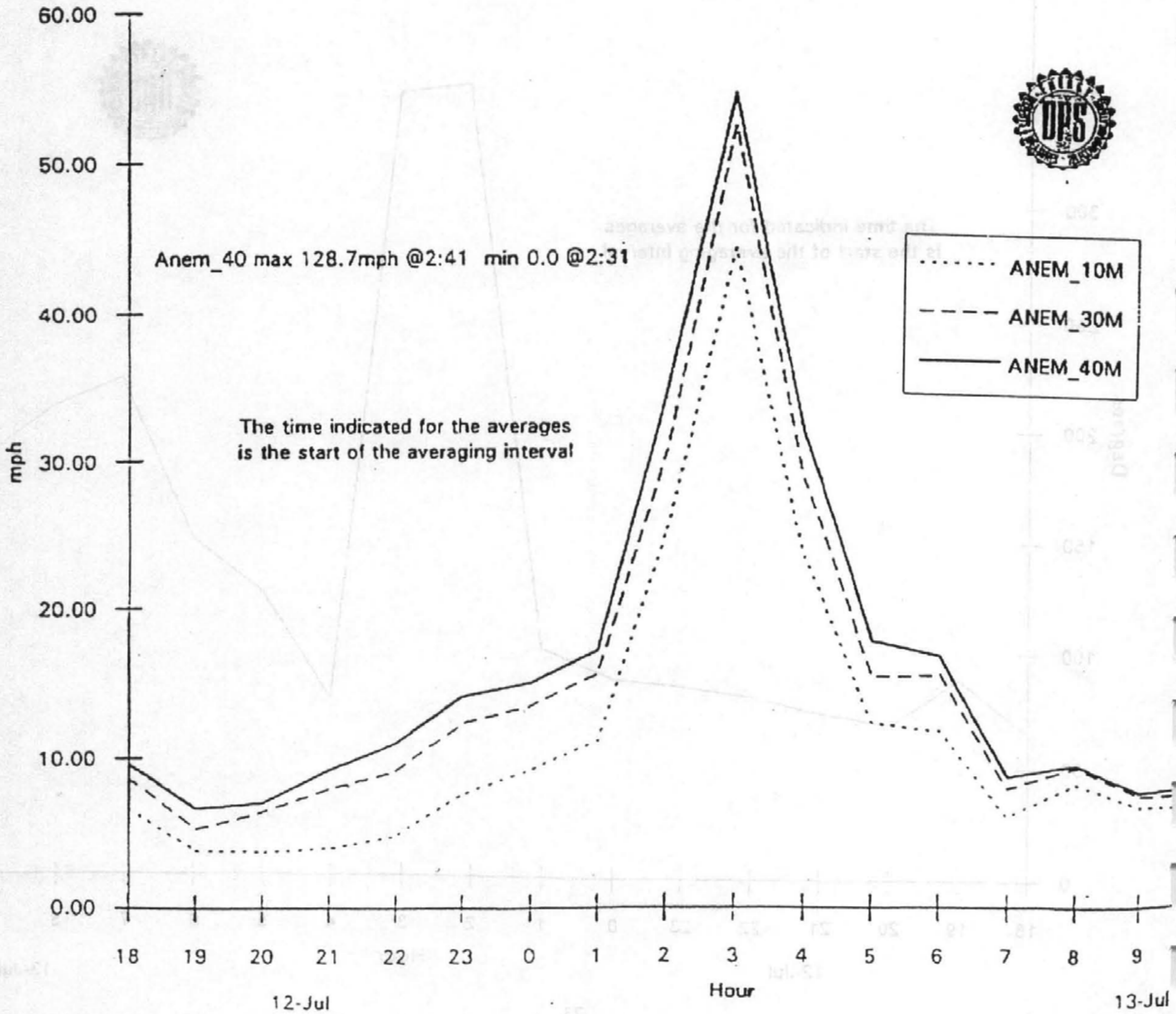
Diagram Key
-- Shaded area is high moisture at 3,000 feet
-- Hatched area is 85 to 90 degree heat at 3,000 feet
-- Dark arrow is general wind direction at 3,000 feet with speeds of 25 to 35 knots
-- Open arrow is general wind direction at 25,000 feet with speeds of 50 to 60 knots



Wind Direction
This is a graph of the wind direction for the period from 1800 hours on July 12 to 1200 hours on July 13. The degrees indicate the compass heading of the wind. A 90 degree reading indicates that the wind is blowing from the east. A 180 degree reading would indicate a south wind. From 1800 hours on July 12 until 0100 hours on July 13, the wind was generally from the east. At 0100 hours, however, the wind shifted to the north for the next two hours. After the storm, the wind shifted back to the east.



Wind Speed
This is a graph of wind speed for the period from 1800 hours on July 12 to 1200 hours on July 13. The WRAP monitoring station, within 15 miles of the largest blowdown area, has anemometers mounted at 10, 30 and 40 meters above the ground (32.8, 98.4 and 131.2 feet respectively). The solid line represents the average hourly wind speed in miles per hour as measured by the anemometer mounted 131.2 feet above the ground. The reading shown at 2:00am is the average wind speed for the hour between 2:00 and 3:00am.



IV. DESCRIPTION OF DAMAGES

Most of the damage from the straight line winds on July 12, 13, and 14 resulted from blown down trees and/or branches. Damage occurred in two primary categories: forests and power distribution systems. In addition, the millions of downed trees have increased the risk of a catastrophic wild fire in northern Minnesota. Minimal damage to structures was reported.

Economic Impact

The northern forests of Minnesota are important as a logging asset and as a destination for tourism. The July 1995 storms created problems for these and many other elements of the State's economy. Itasca State Park and other recreational areas were closed for days after the storm. For most people, masses of downed trees will continue to detract from the beauty of northern Minnesota parks. The market value of timber has been significantly reduced and will affect employment potential in the logging industry for many years.

Power Distribution Systems

Northern Minnesota's power distribution systems were mainly damaged by trees and branches falling on power lines and poles. A small proportion of the poles and lines were blown down directly by the wind. Transformers were damaged when either poles collapsed or the transformers were struck directly by trees. In addition, power restoration crews were hindered by downed trees in power line rights-of-way.

The HMST visited two rural electric cooperatives and two municipal utilities. Managers reported that 65 to 90 percent of customers were affected by the wind storm with outage times ranging from a few hours to ten days.

Roads and Trails

In many areas, downed trees covered roads and trails. Itasca State Park was closed for two days while crews cleared roadways and trails. Several park visitors were trapped in the park while crews cleared roads. State, county, city and township roads were also closed after the wind storm. In some cases, blocked roads delayed utility restoration crews.

Hiking, bicycle, cross-country ski and snowmobile trails criss-cross northern Minnesota's parks and forests. Downed trees have made some of these trails impassable. Effects of the storm have had a negative impact on tourism which is expected to continue.

Fire Hazard

The Minnesota Department of Natural Resources (MDNR) estimates that 6.5 million trees toppled in the wind storms. The MDNR believes that at least 50% of the downed trees will remain in the forest, as salvage will be impossible or impractical in many areas. According to U.S. Department of Agriculture/Forest Service (USDA/FS) and MDNR estimates, fuel loads in affected forest areas increased from 10-20 tons per acre before the storm to 80-100 tons per acre afterwards.

The downed trees will pose a significant fire risk for the next two years as the smaller trees and branches dry and become flammable. Risk will increase again approximately five years from the event as the heavier trunks dry and provide fire fuel. The level of risk is dependent on weather. Personnel at the Minnesota Interagency Fire Center (MIFC) will monitor the affected areas very closely and will increase suppression activities as necessary.

Another area of concern involves the large proportion of downed timber and debris on county and private forest lands. The MDNR believes that fire mitigation and salvage activities may be less vigorous on these parcels due to financial constraints.

<u>Insects and Disease</u>
Dead and dying trees may provide the substrate for high populations of insects and disease. These vectors may spread to undamaged pockets, new plantings and adjacent timber stands, thereby reducing future timber yields. If insects and diseases become established, they will increase the risk of wild fire as more trees die and become flammable.

<u>Other Damages</u>
Officials at the White Earth Indian Reservation reported that tribal burial sites were impacted by the wind storm. Before debris can be removed at burial sites, a cultural assessment must be completed.

Official reports across the declared counties showed limited structural damage. Detroit Lakes Public Utility reported one wood frame storage building destroyed. White Earth Indian Reservation reported two destroyed buildings.

Itasca State Park and bark beetle trapping

Straight line winds in the range of 55 to 129 mph on July 12 to 14 caused extensive blowdown in the old growth conifer stands of Itasca Park. While the monumental task of reopening the park was completed with the cooperation of local foresters and loggers, ongoing concerns over remaining hazard trees and the potential loss of additional trees due to bark beetle outbreaks prompted the continued involvement of the Minnesota Forest Health Unit.

On August 9th Forest Health staff toured high use areas in the park with local managers to conduct hazard tree evaluations and identify additional trees for removal. Park staff were invited to attend a hazard tree training sessions held in Bemidji in October.

In August and September additional stand checks were made in the park to monitor clean up efforts (slash burning) and bark beetle activity. These checks verified high bark beetle activity in damaged and stressed pine stands in the park. Due to these existing population centers and the extensive amount of down and damaged material in the park that would not be removed due to wilderness designation or lack of access, Park managers began to analyze methods to protect the remaining monarch pines in areas of high public use and historical value.

By law, the park is charged to protect sites of historical significance within its boundaries. While numerous blowdown areas will be left untouched and have interpretive trails developed through them, the areas of Douglas Lodge, Preachers Grove, the Burial Mounds and key campgrounds were designated protection zones. Traditional trap tree and direct spray operations were deferred to a program using Lindgren Funnel Traps with PheroTech Lanerone lures to mass trap bark beetles. Traps will be concentrated 3 to 4 per acre in these protection zones surrounded by non-host (mostly lowland hardwoods, spruce and balsam) buffers. The management choice was made based on the sensitivity of the high use areas, information from trapping tests in Minnesota, and information from the General Technical Report INT-GTR-318. Application of Semiochemicals for Management of Bark Beetle Infestations - Proceedings of an Informal Conference, April 1995.

The park situation offers an ideal test of this developing management tool with abundant control areas for comparison. The park is committed to a long term trial (three to five years if necessary).

It is hoped diligent trap collections and close monitoring of beetle activity will decrease tree mortality rates in trapped stands. Directed tree removal will continue where possible. Time and weather patterns will tell of success or failure. Tree mortality in trapped and non-trapped areas will be documented.

The trapping efforts will be part of an interpretive program for park visitors. Activities and locations will be signed, special programs on old growth management and beetle biology will be conducted during the visitor season and handout materials will be developed and distributed.

Hazard Tree Training

Six full day Hazard Tree Training Sessions were conducted in 1995;
Bloomington, MN. in March-45 people.
East Lansing, Michigan, March-200 people.
Minneapolis, Baker Park Reserve, October-30 people.
Bemidji (2-sessions) and Cloquet, October-85 people.

The North American Maple Project

NAMP is a eight year old special project designed to evaluate and monitor the condition of sugar maple stands in relation to any forest health problems. NAMP is a cooperative 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 Data analysis and annual updates are provided by the College of Environmental Science and Forestry, Syracuse, New York.

The objectives of the project are to determine:

1. The rate of annual change in sugar maple tree condition ratings.
2. If the rate of change in sugar maple tree condition ratings are different among:
   a. various levels of sulfate and nitrate wet deposition.
   b. sugarbush and undisturbed forest.
   c. 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 are located in Wabasha county in the southeast, and two each near Grand Rapids, Long Prairie, and Detroit Lakes. One-half of the plot-clusters are in active sugarbush and one-half are in unmanaged forests.

Each plot-cluster consists of five 20- x 20-m subplots (66- x 66-ft) located in a sugar maple stands 50 to 150 years old. Throughout the north American project area data is collected on about 15,000 trees, of which approximately 70% or 11,000 are sugar maples. In Minnesota there are approximately 875 trees on the 40 subplots within the 8 Minnesota plots.

This year only crown ratings and tree vigor were remeasured. Each tree crown is evaluated for branch dieback, foliage transparency, discoloration or , dwarfed foliage, and insect defoliation. Ratings are recorded in 10% classes. Any new insect and disease injury, and seed production is also recorded.

Project-wide, the annual changes in the dieback and transparency classes have been less than 2% for the period of 1988 to 1994. In Minnesota, through 1994 the average dieback and transparency ratings were several percentage points lower than the project as a whole, indicating healthier stands than for the project as a whole.

In Minnesota in 1995, the dieback classes were similar to past years, however there was a noticeable increase in the transparency classes. See attached charts. This noticeable shift in the increase in the transparencies to the 10% and 20% classes over past years is likely due to the effects of the March warm-up followed be the April low temperatures. These transparencies are within what is considered to be the normal range of crown transparencies. We will expect to see transparencies to fall back to the past years levels in 1996.

SURVEY RESULTS

Items included in this report:
Aerial survey for forest pests and their damage
Spruce budworm
Jack pine budworm
Oak wilt suppression program
Oak wilt in the Sand Dunes State Forest
Pine tussock moth

Aerial survey for forest pests and their damage

Good communications are essential between the appropriate Region Forest Health Specialists and the aerial survey mappers before and during the survey period because it is not possible to completely describe survey methods and also needs, timing, and methods change due to weather, current pest problems, current projects.

Pre-flight meeting:

On an annual basis, the mappers from Resource Assessment and Region Forest Health Specialists should meet to discuss expected pest locations, ground check results and other topics of concern.

Preferred flight parameters:

1500 feet above ground level
3 mile flight lines
east-west flight lines

Timing:

In general, the main window is the last 2 weeks in June and the first 3 weeks in July. Since every year is just a bit different due to insect and tree phenologies, surveys should not start until the Region Forest Health Specialist (RFHS) gives the go ahead. The RFHS will be doing some pre-flight ground checks of insect phenology and damage to determine survey windows in each Region.

In addition, we may want surveys to be flown at other times, for example, fall defoliators in mid-August. This will be determined on an annual basis. We don't expect any "extras" in 1995.

The windows for specific pests are different temporally and geographically. Depending on the problems we're likely to encounter in a given year, the RFHS could indicate which pests are best viewed at which times. For example, spruce budworm is most visible during the last week of June and first week of July. There are additional limitations on flying for SBW; need to look for the color change in webbed needles before wind and rain knock them off the tree, low haze and shadows from clouds interfere with seeing the discolored needles. Since SBW has such a small window, it may be advisable to use more than one airplane in order to accomplish the acreage on a timely basis. Also, if clouds or haze occur in Reg 2 or 3, interfering with SBW detection, then use that day to survey elsewhere.

For 1995, we suggest starting in the south (Rochester) in early to mid-June to pick up early defoliators which show up in the south first. Because of the short window for optimun viewing of spruce budworm damage, northern Region 2 should be mapped during the last week of june and/or first week of July. Finish the remainder of the state by the 3rd week of July.

Time of day:

Generally, mapping can begin around 9 am and continue until haze, clouds, rain, etc. limit detection. For budworm, because the sun angle may limit the ability to pick up the slight color change we have historically surveyed from about 10 am to about 3 pm.

Weather:

Optimum = clear, blue sky, sunny days. Can't survey with a general overcast. As a rule, it is difficult to pick up color changes due to budworm feeding in both jack pine and spruce-fir in the shadow of a cloud. If cloud cover is patchy, you may be able to fly aspen defoliation detection as long as you can reliably distinguish covertype and defoliation.

If there's a question, fly over a ground checked area and be sure you can see the damage. Don't go into unknown territory under questionable conditions.

Maps:

1:100,000 scale. Use purchased maps in the plane, not photocopied maps.

On the maps:

1. Draw polygons delimiting the damage.
2. Make notations as to what type of damage it is (defoliation, mortality, stem breakage,etc.).
3. Make notations as to what tree species or covertype is affected OR if known, the causal agent.
4. Determine damage class. It is here that we can come up with many differing ways of describing damage. Yet, it's best to have as few "rules" as possible. We feel we can meet Federal standards and satisfy our own needs with these rules.

a. Map any damage type in stands surrounding FHM plots. The observer should judge how large an area to include. The ideal would be a 1,000 acre polygon (oligon) around the plot.

b. Do not map water-killed trees (beaver flooding) not associated with FHM plots (oligons).

c. **Defoliation alternative 1.** For defoliation, class 5 is NOT optional. Use classes 3,4 and 5 on the maps.

General definitions:
Class 3 = Heavy defoliation, scattered
Class 4 = Heavy defoliation, more or less contiguous
Class 5 = Light or moderate defoliation, scattered or contiguous.

Heavy = > 50% defoliation. Light and moderate = < 50%

Defoliation alternative 2. Map defoliation as light, moderate, or heavy and as scattered or contiguous and forget about classes during maping. When the maps are prepared for digitizing we would then add the classes. Light = 1 to 24%, moderate = 26 to 49%, heavy =>50% defoliation.

d. Map any occurrence of damage; there is no minimum size of damage. If you fly over something and it looks significant to you, then map it. Make any other notations, descriptions that you want directly on the map.

Exception to d. Map broad polygons (with appropriate damage classes noted) for pests that cover many thousands of acres. Do not map individual stands in these situations:

SBW in northern ST. Louis, Lake or Cook Cos.

aspen defoliation that covers many thousands of acres (FTC or LAT)

Post flight meeting:

As soon as the aerial survey is finished or better yet as parts of it are finished the mapper should meet with the appropriate RFHS to review the map and together prepare the final version of the map. This will allow the RFHS to augment the aerial survey with knowledge aquired in ground surveys and also try to clear up any questions the mapper may have, etc. The RFHS will send the final version of the map to be digitized.

Coop agreements:

The USFS will fly Superior Natl. Forest, Chippewa Natl. Forest, Voyageur Natl. Forest and the Grand Portage Indian Reservation, and the Red Lake Indian Reservation. See map prepared by Bill Befort. (Resource Assessment will make final agreement with USFS regarding areas of curvey coverage). The USFS should send us a digital file for the areas they survey in the state for merging with the state data.

Spruce budworm

Egg mass survey

For each plot, three branches are clipped from the mid-crown of each of three co-dominanat trees. The number of egg masses per fifteen inch branch tip is tallied. The following scheme is ued to predict next year's defoliation by spruce budworm.

Spruce budworm defoliation prediction		
Expected defoliation	**Defoliation percentages**	**Average number of egg masses per branch (AEM)**
None to light	0 - 20 %	0 - 0.1
Moderate	21 - 50 %	0.2 - 1.7
Heavy	51 - 100 %	> 1.7

Spruce budworm egg mass survey - 1995

Location	Species	Planted	1994 defol. %	1994 AEM	1995 defol. %	1995 AEM	Buds eaten %	1996 defol.	Comments
Aitkin Co.									
NENE 7-51-23	WS	Y	VL	0	2	0.11	<1	0-L	Vigorous.
NENE17-52-24	WS	Y	-	-	60	0.99	20	M	Lammas growth.
Beltrami Co.									
NESE 26-149-30	WS	Y	-	-	25	1.00	25	M	
	"	N	-	-	20	1.44	8	M	Trees near plantation edge.
NWNW 19-147-31	BF	N	-	-	15	0.33	20	M	
	"	"	-	-	30	0.22	20	M	
Cass Co.									
NWNW11-140-26	WS,BF	N	-	-	30	1.22	10	M	Patchy defol. in the stand.
NENE17-140-27	BF	N	L	0.44	20	0.22	1	M	In mixed stand.
SWSE13-136-31	WS	Y	H	0.88	10	0.44	<1	M	Sprayed with Bt. New growth 2½ to 4 inches.
	"	"	"	"	45	0.66	7	M	Skip in sprayed area. New growth 1-2 inches.
SWSE 22-138-31	BF	N	0	0	1	0.11	<1	0-L	
Chisago Co.									

Spruce budworm egg mass survey - 1995									
Location	**Species**	**Planted**	**1994 defol. %**	**1994 AEM**	**1995 defol. %**	**1995 AEM**	**Buds eaten %**	**1996 defol.**	**Comments**
SESE 36-36-21	WS	N	-	-	10	0.11	1	0-L	Small egg mass.
Cook Co.									
SWNE 34-62-1E	WS,BF	N	H	0.22	20	0	10	0-L	5% of spruce with dead tops. Apparent collapse of budworms in this stand.
NENE 32-63-4E	WS	Y	-	-	45	3.7	10	H	Defol. greater than last year according to B.Petz.
Crow Wing Co.									
SWSW 25-46-28	WS	N	-	-	85	0.88	40	M	2-5% dead tops and thin tops on 10%. Lammas growth noted.
SENE 19-44-31	WS	Y	30	-	20	1.55	5	M	Less damage than 1994.
Hubbard Co.									
SWSW 9-139-32	WS	Y	-	-	5	0	2	0-L	
NE 9-139-32	WS,BF	N	L	1.55	<1	0	<1	0-L	Partial harvest in 1995.
SE 13-141-32	WS	Y	H	3.0	65	0.33	30	M	Scattered trees with heavy defol. Overall moderate defol.
SE 1-142-33	WS	Y	H	1.11	35	1.66	25	M	
Itasca Co.									
NESE 2-60-22	WS,BF	N	-	-	65	0.66	25	M	
NESW 26-62-23	BF	N	-	-	4	0	1	0-L	Mixed stand with pines.
NENW 23-59-24	BF	N	-	-	<1	0	<1	0-L	
SWSW 36-62-24	WS,BF	Y	-	-	75	0.55	30	M	
NENE 11-53-26	WS	Y	VL	0.11	6	0	<1	0-L	Sprayed with Bt. Defol. Barely visible on few scattered spruces.
"	"	"	"	"	<1	0	0	0-L	"
SWSE 17-60-26	BF	N	-	-	1	0	<1	0-L	Mixed stand.
Koochiching Co.									
NWSW 25-64-22	WS	Y	VL	0	<1	0	<1	0-L	
SENW 16-65-23	WS,BF	N	-	-	8	0	<1	0-L	Mixed stand.
SENE 24-65-23	BF	N	H	0.99	75	0.44	35	M	
SESE 16-69-23	BF	N	VL	0.11	35	0.22	20	M	Mixed with aspen and birch.
NWNE 4-65-24	BF	N	-	-	7	0.44	1	M	Mixed with aspen and birch.

Spruce budworm egg mass survey - 1995									
Location	**Species**	**Planted**	**1994 defol. %**	**1994 AEM**	**1995 defol. %**	**1995 AEM**	**Buds eaten %**	**1996 defol.**	**Comments**
NWNE 27-158-26	WS	Y	L	0.55	<1	0	<1	0-L	Little sign of current year's defoliation.
Lake Co.									
NENW 9-63-9	WS	N	-	-	60	0.55	35	M	20-30% thin or dead tops on spruces.
SENW 27-60-10	WS	N	VL	0.1	1	0.11	<1	0-L	Defol. less than last year.
NWNE 11-63-10	BF	N	-	-	85	0.66	65	M	90% dead tops. One egg mass parasitized.
Morrison Co.									
NENE 1-41-29	WS	Y	H	0.88	45	0.88	20	M	Damage less than 1994.
Sherburne Co.									
NWNW 33-34-27	WS	N	VL	0.66	15	0	<1	0-L	
St. Louis Co.									
NENE 3-62-12	BF	N	-	-	80	0.11	15	M	80% with dead tops. The single EM was heavily parasitized.
NESE 22-62-12	WS,BF	N	-	-	55	0.11	15	0-L	10% with thin or dead tops. Spruces with very light defoliation.
NWNE 30-64-12	WS,BF	N	-	-	85	0.44	45	M	Several balsams have 50% corwn death. Lammas growth on spruces.
SESE 31-58-13	WS,BF	N	-	-	<1	0	0	0	No sign of budworms.
NWNE 4-62-13	BF	N	-	-	40	1.22	3	M	20% have thin tops.
NWNW 19-65-13	WS	N	-	-	75	0.11	30	0-L	Lammas growth.
SWNE-2-65-15	BF	N	-	-	95	0.55	70	M	80-90% with dead tops.
NENW-9-62-16	BF	N	-	-	15	0.33	1	M	
SWSW 33-61-18	WS,BF	N	-	-	30	0.88	3	M	Patchy defoliation.
NWNW 33-65-18	BF	N	-	-	55	0.77	15	M	Defoliation is patchy.
SWSW 7-64-20	BF	N	-	-	75	2.77	30	H	"
SENW 10-68-20	WS	Y	H	1.22	70	0.88	30	M	15% of trees are dead. Growth is only 1 1/4 inch.
SWSW 2-60-21	WS	N	M	0.99	40	1.33	25	M	Heavy bud proliferation.
SWSW 34-60-21	WS,BF	N	-	-	40	0.44	25	M	
NWNW 7-66-21	WS,BF	N	-	-	70	0	10	0-L	Understory trees left after harvest.

Spruce budworm egg mass survey - 1995									
Location	**Species**	**Planted**	**1994 defol. %**	**1994 AEM**	**1995 defol. %**	**1995 AEM**	**Buds eaten %**	**1996 defol.**	**Comments**
NWSE 15-67-21	WS	Y	VL	0.22	7	0.11	4	L	
NWSE 13-68-21	WS	Y	M	0.55	50	0.11	30	M	5% are dead and many trees with foliage only near tops. Growth was <1 1/4 inch.
	"	"	"	"	65	0.22	15	M	"
	"	"	"	"	50	0.55	35	M	"
SWSE 12-68-21	WS	Y	H	2.11	65	1.11	30	M	Lammas growth.
	"	"	"	"	90	0.88	30	M	"
	"	"	"	"	75	0.22	10	M	"
NENW 26-68-21	BF	N	VL	0.11	30	0	-	0-L	Open grown trees.

Jack pine budworm

Early larval survey

At each of the following locations staminate cone clusters and/or shoots (6 from each of 5 jack pines) were checked for budworm larvae. If 20 or more budworms are found at each location, moderate to heavy defoliation can result during this growing season.

Jack pine budworm early larval survey - 1995

Location	Number of budworms	Date	Comments
Crow Wing Co.			
NENE 38-134-28	4	6-14	Third and fourth instars.
SWNE 16-44-31	4	6-14	Second to fourth instars.
SWNE 10-44-31	1	6-14	Third instars.
NESE 17-44-31	6	6-14	Third instars.
SWNW 23-134-28	3	6-22	Fifth instars.
NESE 8-136-27	1	6-22	Sixth and seventh instars.
NENE 23-136-27	2	6-22	Sixth instars.
SESW 27-135-28	1	6-22	One pupa.
SESE 33-135-27	0	6-22	
NESE 11-134-28	0	6-22	
Pine Co.			
SESW 13-45-20	1	6-13	Third instar.
SWSE 25-45-20	2	6-13	Third instars.
NESW 30-45-19	9	6-13	Third instars.
SWSE 36-45-20	3	6-13	Third instars.
SESE 13-45-20	1	6-13	Third instars.
NENE 25-45-20	13	6-13	Few second but mostly third instars.
Wadena Co.			
NENE 12-134-33	23	6-20	Four pupae. Many sixth and seventh instars. Small pocket of budworm.
SENE 24-135-33	6	6-20	Third to fifth instars. No staminate cone clusters.
NENE 2-135-33	19	6-20	Sixth and seventh instars.
NWSW 3-135-33	5	6-20	Third to fifth instars. Light 94 defoliation.

Jack pine budworm early larval survey - 1995			
Location	**Number of budworms**	**Date**	**Comments**
NWNW 29-136-33	8	6-20	Fifth and sixth instars. One pupa. Many shoots with clipped, webbed and uneaten needles but no budworms. Light 94 defoliation.
SESW 19-136-33	19	6-20	Fourth to seventh instars. Light 94 defoliation.
SESW 13-138-33	9	6-20	Seventh instars.
SESE 36-138-34	4	6-20	Third to seventh instars.
SWSE 11-137-34	17	6-20	Mostly seventh instars.
SWSW 31-137-33	14	6-20	Mostly sixth and seventh instars.
SWSW 2-136-33	6	6-20	Fourth to seventh instars. One pupa.
Becker Co.			
139-36	8	6-9	Larval count ranged from 4 to 11 larvae per sample in this township.
141-36	12	6-9	Range 3-30 larvae.
140-36	16	6-9	
Hubbard Co.			
139-32	2	6-22	Range was 0-8.
140-32	1	6-22	Range was 0-8
139-33	12	6-22	Range was 0-22.
139-34	14	6-22	
139-35	12	6-22	Range was 10-14.
143-34	1	6-22	Range was 0-1.
144-34	0	6-22	
Beltrami Co.			
147-34	1	6-22	Range was 1-2.
147-35	3	6-22	Range was 1-12.
148-35	2	6-22	Range was 0-3.
146-35	1	6-22	Range was 0-1.

Wadena County jack pines showed light yelllow browning of shoots on June 20th from clipped and webbed but uneaten needles at spotty locations from east of Menahga in Shell River township, in Meadow township, North Germany township, and southeast to Thomastown township (Section 12).

The low production of pollen food and an increase of predators (ants, spiders, stink bugs, others)s may have caused decreased numbers of budworms in 1995 in ground surveyed sites of Region III. There may be other pockets of higher numbers of budworms in Region III not discovered during ground surveys. Many undersized budworms and many webbed shoots with no budworms and little needle damage were observed and perhaps can be attributed to budworms that were deprived of pollen food and died or were eaten by predators. Needle feeding by budworms was nearly completed by July 1st. No 1995 heavy defoliation is expected in Region III except in a very few scattered locations in southeastern and mid-eastern Wadena County.

In Hubbard, Becker and Beltrami Counties, little or no defoliation was visible during the week of June 12th. The majority of larvae were still in the second and third instars and feeding in and around the staminant cone clusters. However, by June 22nd, surveys in Beltrami County showed larvae in the 6th and 7th instars, which indicates rapid development during the week of June 19-23rd.

Defoliation and egg mass survey

This survey consists of counting the number of egg masses on jack pine needles and basing the prediction for next year's defoliation on the number of egg masses found. Two branches are cut from the mid-crown of four co-dominant jack pines and 18 inches of needle bearing twigs are examined on each of the eight samples. When more than three egg masses are found, then moderate to severe defoliation is predicted for the next year in that stand.

Jack pine budworm defoliation

Defoliation rating	Percent of current needles defoliated
Light	0-20%
Moderate	21-50%
Heavy	50-100%

Jack pine budworm egg mass survey - 1995

Location	Number of egg masses	Observed defoliation	Predicted defoliation	Comments
Becker Co.				
35-141-36	0	H	-	
27-141-36	0	H	-	
8-140-36	2	M	-	
28-140-36	0	VL	-	
5-140-36	0	L	-	
17-140-36	0	VL	-	
34-140-36	0	L	-	
2-139-36	0	L	-	
15-139-36	0	VL	-	

Jack pine budworm egg mass survey - 1995				
Location	**Number of egg masses**	**Observed defoliation**	**Predicted defoliation**	**Comments**
22-139-36	0	VL	-	
14-139-36	0	VL	-	
10-139-36	0	L	-	
Beltrami Co.				
35-147-34	0	0	-	
26-147-34	0	VL	-	
25-147-34	1	VL	-	
11-147-34	1	VL	-	
10-147-34	0	0	-	
4-147-34	0	0	-	
1-147-35	0	0	-	
2-147-35	0	0	-	
3-147-35	0	0	-	
4-147-35	0	L	-	
11-147-35	0	VL	-	
28-148-35	0	0	-	
32-148-35	0	0	-	
29-148-35	0	0	-	
Crow Wing Co.				
NWNE 9-45-30	0	L	-	No older needles eaten.
SWSE 17-44-31	0	0-L	-	Of '94 and '95 needles.
NESW 25-44-32	0	0	-	
SESW 25-44-32	0	0	-	
NWNE 12-134-28	0	M	-	No older needles eaten.
NWNW 34-135-28	0	L	-	"
SESE 7-44-31	0	0-L	-	Of '94 and '95 needles.
Hubbard Co.				
3-145-34	0	0	-	
2-145-34	0	0	-	
23-145-34	0	0	-	
22-145-34	0	0	-	

Jack pine budworm egg mass survey - 1995				
Location	**Number of egg masses**	**Observed defoliation**	**Predicted defoliation**	**Comments**
27-145-34	0	0	-	
4-144-34	0	0	-	
34-144-34	0	0	-	
5-143-34	0	0	-	
8-143-34	0	0	-	
16-143-34	0	0	-	
4-143-34	0	0	-	
2-143-35	0	0	-	
14-139-35	0	VL	-	
34-139-35	2	VL	-	
35-139-35	0	VL	-	
26-139-35	1	VL	-	
10-139-32	0	0	-	
11-139-32	0	0	-	
12-139-32	0	0	-	
9-139-32	0	0	-	
34-140-32	0	0	-	
23-140-32	0	0	-	
24-140-32	0	0	-	
22-140-33	0	0	-	Tortoise scale present.
35-140-33	0	0	-	
27-140-33	0	0	-	
5-139-32	0	0	-	Pine pitch midge present.
17-139-32	0	0	-	Heavy needle aphid population.
30-139-32	0	0	-	
31-139-32	0	0	-	
Morrison Co.				
SESE 32-133-30	1	L-M	-	No defoliation of older needles.
Pine Co.				
SENE 29-40-18	0	0	-	St. Croix State Park.
NWSE 16-40-18	0	0-VL	-	"

Jack pine budworm egg mass survey - 1995				
Location	**Number of egg masses**	**Observed defoliation**	**Predicted defoliation**	**Comments**
SWSW 21-40-19	0	L-M	-	"
NWSE 18-40-18	0	L	-	"
NESE 9-40-18	0	0	-	"
NWNW 11-40-18	0	0	-	"
SWSW 36-41-18	0	0-VL	-	"
Wadena Co.				
15-138-32	2	-	-	
15-128-33	0	-	-	
7-138-33	2	-	-	
NESE 27-136-33	0	L-M	-	
SWSE 21-136-33	0	L	-	
NESE 12-134-33	0	L	-	

Oak Wilt Cooperative Suppression Program

Community	Oak wilt Acres	Site tmts	Sites Inactive	Sites Active	Total Sites	Community Acres	Community Sq. Miles	Active OW /Sq. Mi.
Afton city	31.416	2	1	20	21	16864.685	26.351	0.8
Amador township	27.440	25	10	7	17	19558.096	30.560	0.2
Andover city	822.976	83	75	342	417	22388.251	34.982	9.8
Anoka city	13.196	1	1	16	17	4,546.037	7.103	2.3
Apple Valley city	91.896	462	241	36	277	11332.874	17.708	2.0
Arden Hills city	18.983	11	5	8	13	6,137.931	9.591	0.8
Athens township	129.929	12	9	66	75	20304.799	31.726	2.1
Baldwin township	90.145	47	27	20	47	22736.520	35.526	0.6
Baytown township	16.644	4	3	15	18	7,047.600	11.012	1.4
Becker township	567.744	41	16	116	132	35671.009	55.736	2.1
Big Lake township	584.564	144	73	168	241	29010.073	45.328	3.7
Blaine city	291.612	312	215	49	264	21756.607	33.995	1.4
Blue Hill township	150.800	28	16	54	70	23294.399	36.397	1.5
Bradford township	303.685	19	15	112	127	23006.133	35.947	3.1
Branch city	220.861	18	11	122	133	22038.061	34.434	3.5
Burns township	55.090	21	17	21	38	22499.405	35.155	0.6
Burnsville city	50.970	100	103	50	153	17097.796	26.715	1.9
Cambridge city	11.494	19	12	9	21	2,444.531	3.820	2.4
Castle Rock township	26.691	1	1	11	12	22919.229	35.811	0.3
Chisago Lake township	13.502	0	0	14	14	35376.509	55.276	0.3
Circle Pines city	12.332	38	22	1	23	1,245.018	1.945	0.5
Clear Lake township	28.356	2	1	5	6	23725.137	37.071	0.1
Columbus township	92.476	131	81	25	106	30573.177	47.771	0.5
Coon Rapids city	185.502	126	146	106	252	15061.907	23.534	4.5
Cottage Grove city	38.819	1	1	55	56	24229.517	37.859	1.5
Dellwood city	5.037	0	0	11	11	1,743.412	2.724	4.0
Denmark township	15.457	0	0	21	21	19461.901	30.409	0.7
Douglas township	53.810	0	1	43	44	21426.005	33.478	1.3
Eagan city	224.875	352	225	84	309	21337.789	33.340	2.5
East Bethel city	438.854	90	51	147	198	30728.076	48.013	3.1
Elk River city	564.109	175	94	181	275	28027.430	43.793	4.1
Empire township	8.725	0	0	10	10	21999.566	34.374	0.3
Eureka township	20.302	0	0	18	18	22934.406	35.835	0.5
Forest Lake township	52.621	0	0	25	25	20900.202	32.65	0.8
Franconia township	2.440	0	0	4	4	20434.419	31.929	0.1
Gem Lake city	6.193	0	0	5	5	726.642	1.135	4.4
Grant township	55.404	0	0	68	68	17356.875	27.120	2.5
Greenvale township	6.699	0	0	4	4	19117.908	29.872	0.1
Grey Cloud Island tnship	8.614	0	0	11	11	2,482.707	3.879	2.8
Ham Lake city	216.542	238	176	113	289	22800.188	35.625	3.2
Hampton township	42.148	0	0	37	37	21920.756	34.251	1.1
Harris city	2.962	0	0	2	2	12696.624	19.838	0.1
Hastings city	7.120	0	0	9	9	6,523.916	10.194	0.9
Haven township	0.688	0	0	1	1	23502.373	36.722	0.0
Hugo city	62.316	1	1	55	56	23027.978	35.981	1.5
Inver Grove Heights city	273.095	47	34	123	157	19266.059	30.103	4.1
Isanti township	33.355	11	7	14	21	21474.926	33.555	0.4
Lake Elmo city	57.401	1	1	43	44	16122.180	25.191	1.7
Lakeville city	200.747	60	50	128	178	24001.183	37.502	3.4
Lent township	123.898	30	22	77	99	22755.950	35.556	2.2

Lino Lakes city	71.868	139	87	8	95	21238.264	33.185	0.2
Linwood township	180.249	48	24	105	129	22959.104	35.874	2.9
Little Canada city	4.288	0	0	4	4	2,853.397	4.458	0.9
Livonia township	64.716	45	22	32	54	21378.806	33.404	1.0
Lake St. Croix Beach city	1.939	4	3	1	4	635.879	0.994	1.0
Mahtomedi city	25.140	4	3	20	23	3,212.801	5.020	4.0
Maplewood city	40.570	28	15	35	50	11495.086	17.961	1.9
Marine on St. Croix city	39.959	0	0	34	34	2,668.094	4.169	8.2
Marshan township	100.030	0	0	65	65	22255.814	34.775	1.9
May township	255.570	3	3	169	172	24052.864	37.583	4.5
Mendota Heights city	5.680	0	0	6	6	6,476.655	10.120	0.6
Mounds View city	34.536	51	18	1	19	2,647.899	4.137	0.2
New Brighton city	20.732	70	27	3	30	4,536.892	7.089	0.4
Newport city	25.477	0	0	37	37	2,500.362	3.907	9.5
New Scandia township	58.234	6	5	47	52	25458.910	39.780	1.2
Nininger township	11.458	0	0	8	8	11318.945	17.686	0.5
North Branch township	59.821	8	8	35	43	22373.805	34.959	1.0
North Oaks city	44.362	70	73	34	107	5,537.897	8.653	3.9
North St. Paul city	1.619	1	1	4	5	1,917.564	2.996	1.3
Oakdale city	31.610	32	32	10	42	6,434.422	10.054	1.0
Oak Grove tnship	1,479.80	90	56	375	431	22388.591	34.982	10.7
Oak Park Heights city	0.560	0	0	1	1	1,453.637	2.271	0.4
Orrock township	326.996	97	66	87	153	23181.642	36.221	2.4
Oxford township	38.276	4	2	26	28	15173.268	23.708	1.1
Palmer township	36.564	3	2	23	25	23350.290	36.485	0.6
Pine Springs city	2.724	1	1	4	5	600.173	0.938	4.3
Ramsey city	406.769	168	101	139	240	19015.607	29.712	4.7
Ravenna township	356.306	2	2	104	106	13979.685	21.843	4.8
Rosemount city	283.290	10	9	97	106	22468.829	35.108	2.8
Roseville city	7.778	5	2	11	13	8,848.094	13.825	0.8
Santiago township	80.370	11	7	18	25	23226.561	36.292	0.5
Shoreview city	54.759	183	74	3	77	8,146.772	12.729	0.2
South St. Paul city	1.649	0	0	4	4	3,921.586	6.127	0.7
Spencer Brook township	14.459	2	2	12	14	22654.591	35.398	0.3
Springvale township	16.652	8	6	6	12	22662.183	35.410	0.2
Stanford township	263.153	49	41	96	137	25206.358	39.385	2.4
St. Francis city	282.416	28	16	95	111	15181.401	23.721	4.0
Stillwater township	107.775	5	5	56	61	11986.583	18.729	3.0
St. Paul city	36.951	51	29	29	58	35923.084	56.130	0.5
Sunfish Lake city	6.830	2	2	4	6	1,085.236	1.696	2.4
Sunrise township	49.303	4	2	26	28	29373.652	45.896	0.6
Taylors Falls city	0.781	2	1	0	1	2,578.531	4.029	0.0
Vadnais Heights city	9.034	0	0	12	12	5,301.849	8.284	1.4
Vermillion township	23.599	0	0	14	14	21819.033	34.092	0.4
White Bear township	20.699	31	15	7	22	5,835.587	9.118	0.8
West Lakeland township	17.714	0	0	16	16	8,074.966	12.617	1.3
Woodbury city	33.691	7	6	35	41	22776.031	35.588	1.0
West St. Paul city	0.522	1	1	0	1	3,217.398	5.027	0.0
Wyoming township	104.373	14	10	71	81	20947.295	32.730	2.2
TOTALS	11502.2	3940	2543	4711	7254	1,605,966.7	2509.3	194.3

Oak wilt in the Sand Dunes State Forest

Oak wilt 1995 in Sand Dunes State Forest				
SITE	**DATE**	**NUMBER OF WILTED TREES THIS YEAR/ CORDS OF FIREWOOD**	**ESTIMATED PERIMETER**	**LOCATION NARRATIVE**
95-2 TRUST	7-13	1 CLUMP/3 STEMS. 1 CLUMP/4 STEMS 1 SINGLE TREE ALL PO 4 cords	200'	SENW SEC 36 E OF SOUTH SDSF S OF SOUTH INFO PARKING ALONG ROAD ALSO SE OF THERE 2 CH ANOTHER SITE
95-3 part Fed	7-28	5 STEMS SINGLE ALL PO 1 cord State 4 cords Fed	200' SF 400' FED	NWNE SEC 26 PART ON FED LAND 6 CH N OF PROP POST N OF FR 239 N OF LARSON SLOUGH
95-5	7-28	1 CLUMP/4 STEMS 1 CLUMP/2 STEMS ALL LG BO	500'	SENW SEC 35 15 CH N OF 233RD AVE FROM E EDGE OF JP COA SAMPLE POSITIVE
95-7 TRUST	8-8	2 LG PO 3 cords	200'	SESE SEC 16 ON DAY USE ROAD E OF 4H CAMP
95-8	8-8	1 CLUMP/2 STEMS 1 TREE ALL PO 10 cords	700'	NWNW SEC 21 ALONG SKI TR S OF 4H CAMP 180° 1 TALLY FROM RED BLDG
95-9 SNA	8-9	2 LG PO JULY 3 SM PO AUG	600'	SWNE SEC 29 SNA N OF COA START AT NNW OF UG 228° 5 CH THEN 310° 5 CH FOLLOW PINK FLAG. SNA
95-10 SNA	8-9	19 PO 50% SPROUTS & SINGLE STEMS	1000' ? LINK TO PO TO W ?	SWNE SEC 29 W SIDE OF COA NNW OF UG @ PINK FLAG FOLLOW OLD TR 3 CH THEN PINK FLAG TO W. SNA
95-11 SNA	8-10	1 SPROUT/5 SINGLE TREE 8 TO 14" JUL-AUG	400'	NWSE SEC 29 N OF TAM SWAMP FOLLOW RD PINK FLAG THRU OLD OAK/ASPEN CC FROM NORTH THEN 4 CH S. SNA
95-12 SNA	8-10	2 12" PO JUL-AUG	400'	NWSE SEC 29 N EDGE TAM SWAMP 4 CH SSE OF 95-11 PINK FLAG. WATCH ISO BO 6 CH NNE ALONG TAM SWAMP. SNA
95-13 SNA	8-10	1 7" PO	300'	NWSE SEC 29 215° 2 CH FROM 95-11 PINK FLAGGING. SNA
95-14	9-6	3 5" PO 2 18" PO JUL-AUG	500'	SWSW SEC 35 N OF 22805 160TH ST PARTIALLY ON PVT LAND. OLD FIRE 1993.

Oak wilt 1995 in Sand Dunes State Forest				
SITE	**DATE**	**NUMBER OF WILTED TREES THIS YEAR/ <u>CORDS OF FIREWOOD</u>**	**ESTIMATED PERIMETER**	**LOCATION NARRATIVE**
95-16 SNA	10-18	1 20" SINGLE 1 CLUMP 4 20" ALL PO JULY	300'	NENW SEC 28 E OF FT 172 AT FT 245
		FOREST LAND + 400' FED TRUST SNA TOTALS	2300 400' 3000' 5700'	LINE COST SUPV COST TOTAL $2760 $150 $2810 480 50 630 3600 250 3850 $6840 $450 $7290

Pine tussock moth

Moth survey

A count of thirty or more male moths in a trap over a ten to fourteen day period would indicate probable need for chemical control the next year. Such numbers and decision to apply chemical control should be combined with egg mass surveys and defoliation evaluations of the infested jack pines. Several previous spray operations, starting in 1960, are described in Region III files.

The 1995 pheromone trapping of male moths indicates that the pine tussock moth population remains at minor levels in Region III but is increasing in Hubbard County of Region 1.

Pine tussock moth survey -1995

County	Location	Date trap placed	Trap number or name	Date trap checked	Number of male moths in trap
Crow Wing	NESW 10-136-27	6-22	10	7-5 7-21 8-3 8-14 8-31 9-15	0 0 3 3 0 0
Crow Wing	NWSW 9-136-27	6-22	8	7-5 7-21 8-3 8-14 8-31 9-15	4 0 1 9 0 0
Crow Wing	SWSE 9-136-27	6-22	9	7-5 7-21 8-3 8-14 8-31 9-15	3 0 5 2 1 0
Crow Wing	NWSW 11-136-27	6-22	11	7-5 7-21 8-3 8-14 8-31 9-15	4 2 15 9 0 0
Crow Wing	SWNW 14-136-27	6-22	12	7-5 7-21 8-3 8-14 8-31 9-15	3 0 1 7 2 0

Pine tussock moth survey -1995					
County	**Location**	**Date trap placed**	**Trap number or name**	**Date trap checked**	**Number of male moths in trap**
Crow Wing	NENE 23-136-27	6-22	13	7-5 7-21 8-3 8-14 8-31 9-15	5 2 0 2 0 0
Hubbard	16-139-32		Nursery	7-17 7-28 8-10 8-24 9-7	9 6 26 3 1
Hubbard	9-139-32		Woodland Tour	7-17 7-28 8-10 8-24 9-7	11 2 19 5 0
Hubbard	10-139-32		Cutover Rd	7-17 7-28 8-10 8-24 9-7	15 2 30 0 0
Hubbard	34-139-33		Game Farm	7-17 7-28 8-10 8-24 9-7	25 5 19 5 0
Pine	NESW 13-45-20	6-19	1	7-6 7-21 8-3 8-14 8-30 9-15	0 0 0 0 0 0
Pine	SESE 18-45-19	6-19	2	7-6 7-21` 8-3 8-14 8-30 9-15	0 0 0 0 0 0

Pine tussock moth survey -1995					
County	**Location**	**Date trap placed**	**Trap number or name**	**Date trap checked**	**Number of male moths in trap**
Pine	SWSW 36-45-20	6-19	3	7-6 7-21 8-3 8-14 8-30 9-15	0 0 0 0 0 0
Pine	SWSW 6-44-19	6-19	4	7-6 7-21 8-3 8-14 8-30 9-15	1 0 0 1 0 0
Pine	SESW 30-45-19	6-19	6	7-6 7-21 8-3 8-14 8-30 9-15	2 1 0 0 0 0
Pine	SWSE 25-45-20	6-19	5	7-6 7-21 8-3 8-14 8-30 9-15	6 0 0 0 0 0
Pine	NESE 26-45-20	6-19	7	7-6 7-21 8-3 8-14 8-30 9-15	1 0 0 0 0 0
Wadena	15-138-33		Huntersville Imp.	7-17 7-28 8-10 8-24 9-7	23 15 0 1 0
Wadena	10-138-33		Roadside I	7-17 7-28 8-10 8-24 9-7	24 6 29 1 0

Pine tussock moth survey -1995					
County	**Location**	**Date trap placed**	**Trap number or name**	**Date trap checked**	**Number of male moths in trap**
Wadena	9-138-33		Roadside I	7-17 7-28 8-10 8-24 9-7	17 3 16 0 0
Wadena	9-138-33		Huntersville Store	7-17 7-28 8-10 8-24 9-7	19 1 9 0 0

PAPERS PRESENTED

Abstracts for the following papers are provided:

J.Albers, M.Carroll and A.Jones. 1995. Jack pine budworm in Minnesota: Past trends and changing perspectives. In proceedings: Jack pine budworm symposium, Jack pine budworm biology and management. Winnepeg, Manitoba. January 24-26, 1995. Natural Resources Canada, Canadian Forest Service,Information Report NOR-X-342, p.11-18.

T.Eiber. 1995. The ecology and management of windbreaks in Minnesota. Windbreak Renovation Workshop. Wilmar, MN. Aug. 10, 1995.

E.Hayes. 1995. Freeze injury to black walnut plantations during the winter of 1993-1994. In proceedings: 86th Annual Meeting of the Northern Nut Growers Association. River Falls, WI. Aug. 15, 1995.

T.Eiber and W.Befort. 1995. Assessing storm damaged ecosystems: Implications for GIS users. 1995 Second Annual EPPL& Users Conference, St. Paul, MN, September 20, 1995.

T.Eiber. 1995. Protecting urban forest ecosystems with GIS: Assessing oak wilt risk. Fifth Annual Conf. Of the Minnesota LIS/GIS Consortium. St. Louis Park, MN. Sept. 27-29, 1995.

Jack pine budworm in Minnesota: Past trends and changing perspectives

Abstract

Between 1976 and 1990, inventories of growing-stock volume losses due to insects increased 38-fold and doubled for sawtimber in Minnesota. Most of these losses are attributable to jack pine budworm. Since 1969, four jack pine budworm (*Choristoneura pinus* Freeman) outbreaks have occurred. In managing for budworm, the Minnesota Department of Natural Resources promotes the use of indirect control methods through integration of budworm management strategies into forest management activities. Strategies are aimed at minimizing pollen production and maintaining tree vigor. In forestry today, there are emerging issues which will form, perhaps reshape, our perspectives of forest and forest health, the way we manage lands and who influences our actions. Some of these issues are based on the resource itself while others are predicated on public sentiment and non-forestry influences. Nineteen issues are discussed. The 1993-1994 outbreak at St. Croix State Park is presented as a "real life" example of some of the emerging issues. Authors put forth a series of questions aimed at challenging the audience to review their own perspectives.

The ecology and management of windbreaks in Minnesota.

Abstract

Windbreaks have been considered desirable in agricultural areas for many centuries. They provide a respite from the winds, snow, and rains that typically sweep unhindered across open fields. The ecology of the typical windbreak is very different from that of the forest where trees developed their characteristics. If we are to use trees effectively in windbreaks, we will need to mimic, as much as practical, many of the ecological features of forested areas if we expect trees to perform well. This paper examines some of the more important ecological factors that affect trees in windbreak settings, such as, rainfall and evapotranspiration and soil alkalinity, and makes some suggestions as to how these factors can be made more forest-like in a typically non-forest area.

Freeze Injury To Black Walnut Plantations In Minnesota During The Winter Of 1993-94.

Abstract

The winter of 1993-1994 caused some of the most dramatic and serious injury to southeast Minnesota black walnut plantations ever witnessed here by forest managers. It was estimated that 5 to 6 walnut plantations in each of the 5 southeast Minnesota counties were severely injured. Severe injury was 75% to 100% of plantation with more than 50% dieback. Landscape position appears to be the most important factor influencing the walnut injury. The type of sites that sustained the most injury were those valley sites with steep adjacent side slopes and bottomland sites where the walnut was planted in the lowest part of a broader landscape. Injury occurred in both plantations and natural stands.

Protecting urban forest ecosystems with GIS: Assessing oak wilt risk

Abstract

Oak wilt is a catastrophic fungal disease of oak trees in urban forest ecosystems in the eastern US. It kills trees in a few weeks by causing the water conducting tissues to become plugged in June and July. It is spread mainly by root grafts, but new infection centers must be initiated when a wounded tree is visited by a spore carrying beetle. Once established, the disease will spread throughout the stand, effectively removing mature oak from the ecosystem. The great majority of infection centers occur on specific soil types and ecosystem landscape units. There is an 6-fold increase of oak wilt on sandy soils and a 3-fold increase within 1500' of an existing infection center. During the course of the federally-assisted Oak Wilt Suppression Program, all surveys and suppression activity over the 2 million acre project area have been captured in GIS format since 1988.

The GIS system provides three products now considered integral to the suppression program. First, large scale (4"/mile) maps are provided to each participating community with the location and status of each infection center. Over 6,000 centers in 100+ communities are being tracked. Two, the success of the program is evaluated using two GIS generated indices. The first index is the Oak Wilt Density (OWD) which is the number of active (untreated) infection centers per square mile. The second is the Resource Exposure Index (REI). The REI is computed as the percentage of the susceptible forest cover type that lies within 1500' of an active center. This is determined by comparing a LandSat forest cover against a buffer around active centers. The third product is new in 1995. Using the GIS, the risk of generating a new infection center from construction damage during May and June, the primary season of infection, has been assessed. This risk model combines the 8:1 risk of oak wilt associated with sandy soils and the 3:1 risk associated with a 1500' risk zone. All participating communities received this assessment in map form before the spring construction season began.

Assessing storm damaged ecosystems: Implications for GIS users.

Abstract

In July 1995, high winds severely damaged forests on almost 200,000 acres in eight counties of northern Minnesota. A rapid assessment was needed before salvage logging, forest health, and fire protection measures could begin.

PLS sections affected by blowdown were first delineated by aerial sketch mapping. The damaged area was then stratified by county, DNR Area, ecological type, forest cover type, land use, ownership, and legislative district using GIS technology. Once the damaged area had been identified, multiple analyses became simple. GIS provided damage estimates as accurately as manual methods, but with a faster turn around time. Some attributes of a Rapid Response GIS are discussed.