MINNESOTA FOREST HEALTH REPORT

1996

Department of Natural Resources
Division of Forestry - Forest Ecosystem 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 insects.

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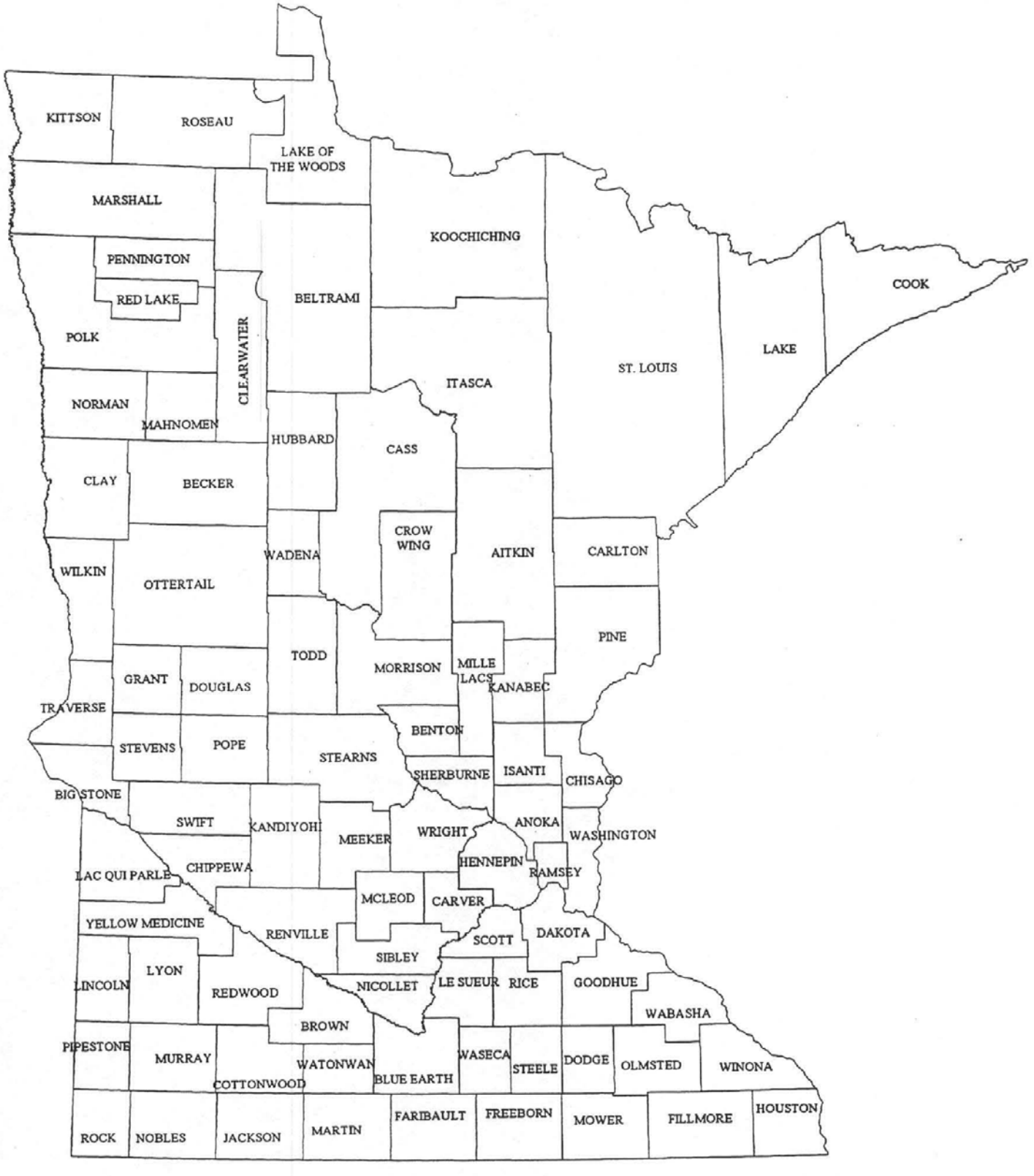
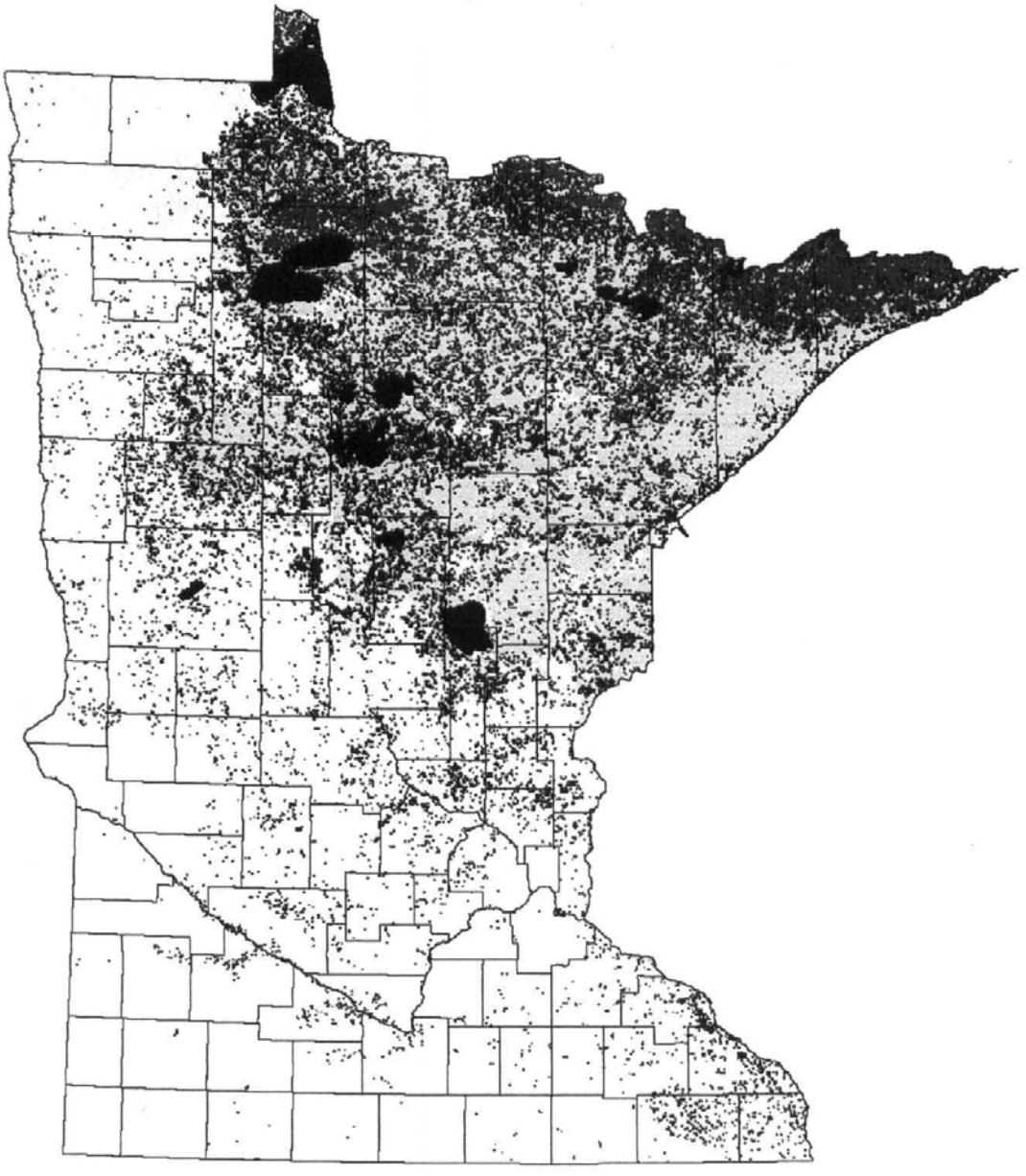

KITTSON
ROSEAU
LAKE OF THE WOODS
MARSHALL
KOOCHICHING
PENNINGTON
RED LAKE
BELTRAMI
COOK
POLK
CLEARWATER
LAKE
ST. LOUIS
ITASCA
NORMAN
MAHNOMEN
HUBBARD
CASS
CLAY
BECKER
CROW WING
AITKIN
CARLTON
WILKIN
OTTERTAIL
WADENA
PINE
TODD
MORRISON
MILLE LACS
KANABEC
GRANT
DOUGLAS
TRAVERSE
BENTON
STEVENS
POPE
STEARNS
SHERBURNE
ISANTI
CHISAGO
BIG STONE
SWIFT
KANDIYOHI
MEEKER
WRIGHT
ANOKA
WASHINGTON
CHIPPEWA
HENNEPIN
RAMSEY
LAC QUI PARLE
MCLEOD
CARVER
YELLOW MEDICINE
RENVILLE
SCOTT
DAKOTA
SIBLEY
LYON
LINCOLN
REDWOOD
NICOLLET
LE SUEUR
RICE
GOODHUE
WABASHA
BROWN
PIPESTONE
MURRAY
WATONWAN
WASECA
STEELE
DODGE
OLMSTED
WINONA
COTTONWOOD
BLUE EARTH
FARIBAULT
FREEBORN
MOWER
FILLMORE
HOUSTON
ROCK
NOBLES
JACKSON
MARTIN

Forest Cover Type, 1993
Resource Planning Act AVHRR Version



- Pines
- Spruce - fir
- Oaks
- Elm - ash -cottonwood
- Maple - basswood
- Aspen - birch

- Non-forest area
- Water

Scale: 0 — 50 mi — 100 mi

Source: AVHRR Satellite and FIA data, analysis by USFS Starkville, MS. See USFS GTR-RM-??, 1992.
Map production and analysis by EPIC
Minnesota Department of Natural Resources
Division of Forestry, Forest Health Unit

4/3/1997

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PROGRAM ACCOMPLISHMENTS

FOREST HEALTH MONITORING

A. DETECTION SURVEYS

Target ..... 10.3 million acres

Accomplishment ..... 13.9 MILLION ACRES

Summary of aerial damage detection survey - 1996				
Damage	**Total**	**Light**	**Mod**	**Heavy**
Spruce budworm defoliation & mortality	207,900	93,200	5,100	109,600
Oak wilt mortality (outside Metro)	7,200	---	---	---
Oak defoliation - walkingsticks	120	---	---	120
Aspen defoliation & mortality	73,200	8,500	64,200	500
Hardwood defoliation & discoloration	15,100	10,600	1,900	2,600
Hardwood dieback and mortality	31,800	5,200	25,500	1,100
Jack pine discoloration & mortality	74,800	70,200	4,600	---
Red/white pine discoloration & mortality	3,500	2,800	---	700
Redcedar discoloration & mortality	130	---	---	---
Herbicide injury - hardwoods	2,500	---	---	2,500
Chlorotic oak syndrome - urban	1,500	1,500	---	---
Winter burn and kill	1,000,000	---	---	---
Winter kill - windbreaks	1,860	1,700	90	70
Low temperature injury - walnut	200	---	---	---
Flooding	3,300	---	---	---

Damage	Total	Light	Mod	Heavy
Wind	150	---	---	---
TOTAL	1,423,260			

B. EVALUATION ACTIVITIES

Target ..... 1.5 million acres
Accomplishment ..... 1.2 MILLION ACRES

Findings

✔Spruce budworm: 41 egg mass plots and 23 larval plots were established to evaluate populations and tree conditions on 750,000 acres of the spruce-fir type. Populations were declining.

✔Jack pine budworm: 49 larval plots and 49 egg mass plots were established to evaluated population dynamics on 220,000 acres of jack pine in central and northwestern Minnesota. Populations were nearly non-existent.

✔ Pine tussock moth: Trap catches from 22 pheromone traps indicated population declines except in Wadena and Hubbard Counties where trap catches indicate increasing populations.

C. EPIC

Target ..... Release of Version 2.0
Accomplishment ..... RELEASED VERSION 3.0.
Target ..... Digitize 25 historic maps
Accomplishment ..... DIGITIZED 12 MAPS TO ADD TO THE 350 THEMATIC LAYERS

D. FOREST HEALTH MONITORING

Target ..... Measure 40 forested plots
Accomplishments ..... 120 FORESTED PLOTS

PREVENTION AND SUPPRESSION

A. PREVENTION

Activities focused on implementing the forest health mitigation strategies identified within the Generic Environmental Impact Statement on Expanded Timber Harvesting in Minnesota. Insect and disease implications and management considerations were included in discussion, review, and production of extended rotation issues and in best management practices developed for a variety of forestry and forestry related activities. Assistance was provided to communities in developing Oak Wilt Action Plans for addressing expanding losses in the rural-urban interface. Gypsy moth information and education efforts were continued in cooperation with Project Learning Tree activities. Education efforts continued in state recreation areas and in the urban arena in the mitigation and prevention of hazard trees.

Regional specialists provided input and direction to the development and review of Regional Plans, State Stewardship Work Planning, and Urban and Community Forestry Work Planning.

B. SUPPRESSION

Oak Wilt Suppression Program

Targets ..... See Cooperative Suppression Program Narrative
Accomplishment ..... REPORTED IN COOPERATIVE SUPPRESSION PROGRAM NARRATIVE

Spruce budworm
Target ..... 1,000 acres
Accomplishment ..... NO SUPPRESSION PROJECTS

Bark Beetles
Target ..... 1,200 traps
Accomplishment ..... 1,500 TRAPS

Forest tent caterpillar
Target ..... 500 acres
Accomplishment ..... NO SUPPRESSION PROJECTS

Vegetation management
Target ..... 1,500 acres
Accomplishment ..... 3,500 ACRES

C. ERADICATION
Target ..... Gypsy moth - 3 sites, 35-50 acres
Accomplishments
✔Sites treated for gypsy moth: 3
✔Acres treated for gypsy moth: 250
✔Gypsy moths trapped at sites in 1996: 7 on one site; 0 on the other two sites.

NORTH AMERICAN MAPLE PROJECT

Target ..... 8 clusters
Accomplishment ..... 8 CLUSTERS
Results
Number of years of measurement: 4
Number of clusters remeasured: 8
Dieback: Slight increase
Foliage transparency: Continued increased
Possible explanation: Response to severe weather conditions including a hard freeze in April of 1995, record low temperatures during the winter of 1995-96, and the extremely late spring in 1996.

TECHNOLOGY TRANSFER

A. TRAINING SESSIONS & MEETING PRESENTATIONS
Target ..... 20 events - 800 people
Accomplishment
Developed the training opportunity and delivered the training:
Hazard Tree Train-the Trainer Workshop - 11 states participated
Hazard Tree Training for Missouri foresters and recreation managers
Hazard Tree Training for Minnesota personnel - 3 events -75 people
Community Forest Workshop
FHM Crew Training
FIA Crew Training
Participated in the session as one of the trainers:
Shade Tree Short Course

Windbreak Renovation Workshop
GIS/LIS Annual Conference
EPPL Users Conference
Vermillion Community College
Proctor Planting Workshop
Legislative Commission on Minnesota Resources White Pine Tour
Itasca Community College Field Tour
White Pine Regeneration Strategies Work Group
White Pine Society of American Foresters Tour
DNR Northeast Region Area Forest Development Leaders Workshop
DNR Northeast Region Pesticide Workshop
Society of Municipal Arborists Annual Conference
Hinckley Area Field Tour
University of Minnesota Hardwood Management Workshop
Fire Ecology Workshop

B. REPORTS

Target ..... 4 Reports

Accomplishment ..... 2 REPORTS

Paper Birch Ecology and Management
Spruce Budworm and Balsam Fir: How Much is Enough

C. PUBLICATIONS

Target ..... 12 publications

Accomplishment

Forest Health Newsletters (6 editions)
1995 Minnesota Forest Health Report
How To Hazard Trees (in cooperation with USFS S&PF)
Hazard Tree Slide Set (also on CD-ROM)
How to Identify and Manage Needlecast Diseases of Balsam Fir (in cooperation with USFS, WI DNR, and Penn State Univ.)
Pest Alert: Rhizosphaera Needle Diseases of Fir (in cooperation with USFS, WI DNR, and Penn State Univ.)
Long-horned Wood Borers
White Trunk Rot of Aspen (co-authored with Mike Ostry, NCFES; submitted for publication in Northern Journal of Forestry)
12 fliers and fact sheets for various technical and lay audience
Gypsy moth cards - 4th printing (450,000 cards) - total printed, 1.5 million; distributed in 17 states

D. NEWS RELEASES

Target ..... None specified

Accomplishment 4

Minneapolis Tribune - Spruce budworm
Minneapolis Tribune - Effects of drought
KDLH radio (Duluth) - Fall webworm and gypsy moth
Statewide newspaper release - Winter burn
Grand Rapids Public Radio

E. SPECIAL EVENT

Target ..... None specified

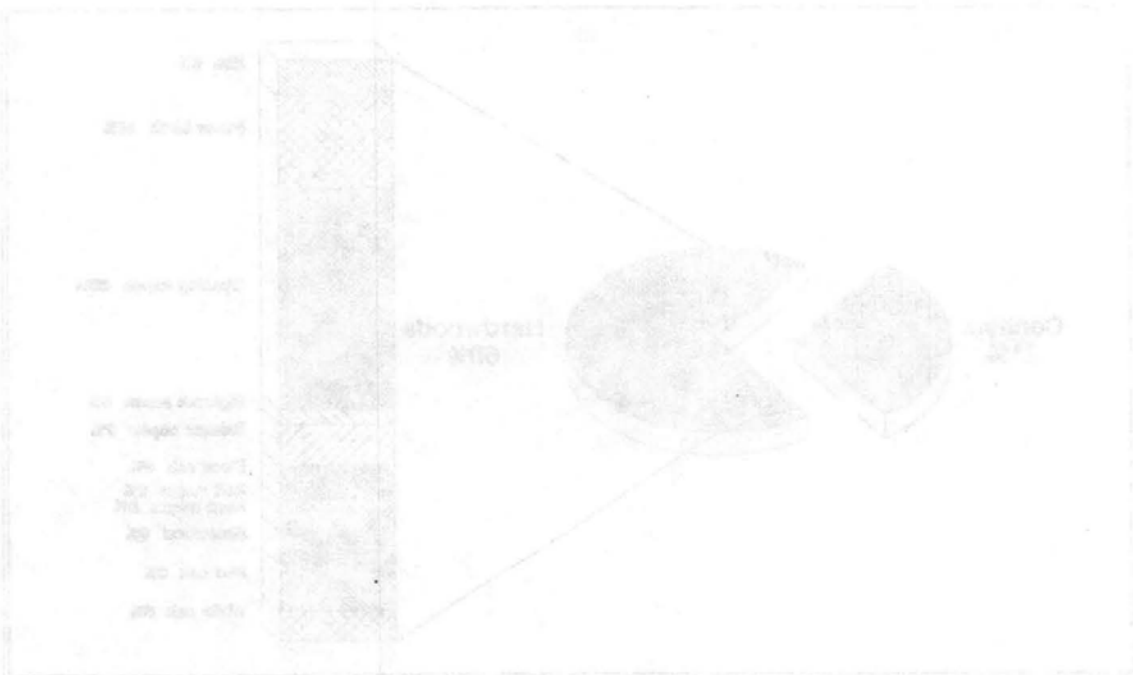
Accomplishment

On August 20, the DNR sponsored a media event to celebrate the plowing of the MILLIONTH

FOOT of vibratory plow line for oak wilt control. Over 150 people attended the event; 75% of the attendance were citizens and officials from the cooperating communities. Senator Paul Wellstone delivered the keynote address, and Sixth District Congressman Bill Luther plowed the millionth foot on an operational oak wilt site in the City of Blaine. Dr. Ann Bartuska, USFS, was on had to plant a ceremonial red oak to symbolize the success of the oak wilt suppression program. Two local TV stations carried an extended story on the program that evening, and numerous written stories appeared in Twin Cities and suburbs newspapers.

COMMITTEE & COORDINATION ACTIVITIES

Minnesota Gypsy Moth Technical Advisory Committee
Minnesota Shade Tree Advisory Committee (including Forest Health Sub-Committee)
FORNET Project Team
FEMA Risk and Mitigation Team
Minnesota Stewardship Committee
Forest Health Monitoring Northern Region Group
Forest Health Monitoring Off-Plot Group
North Central Forest Pest Workshop
North American Maple Project
North Central Forest Health Cooperators Meeting
Western International Forest Disease Work Conference
Annual Community Forestry workshop for NE MN (Cooperation with IRRRB, MN DOT, and Univ. Of MN)
Trees for Teens Committee (Grand Rapids High School)
Advisory Group to the White Pine Regeneration Strategies Working Group



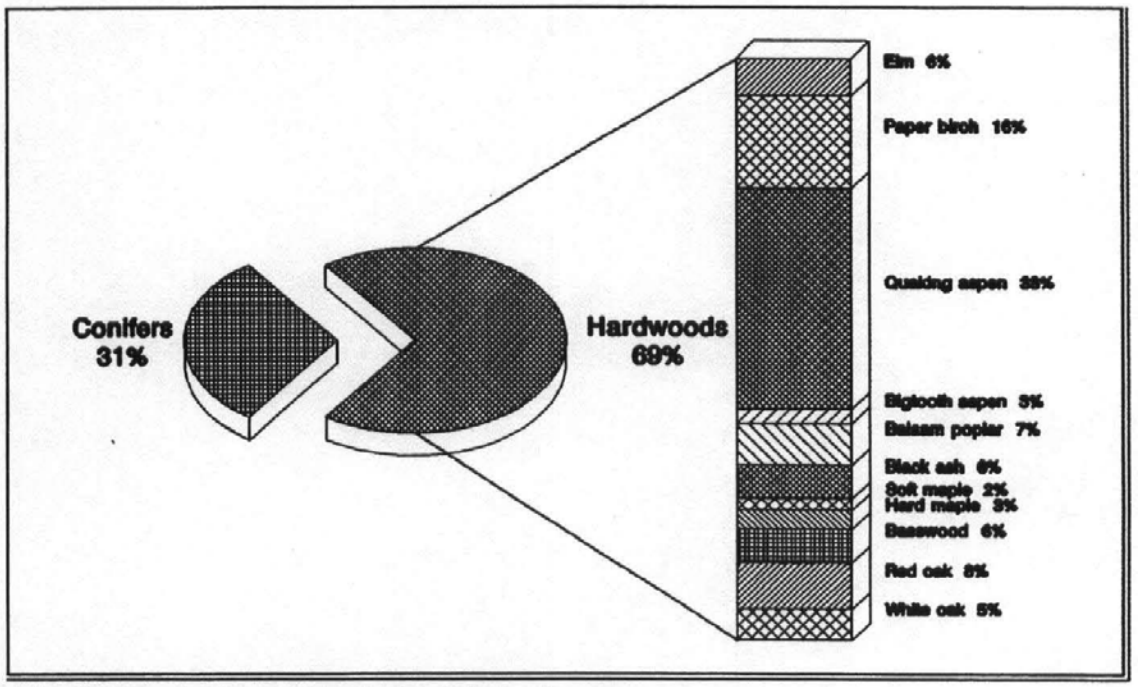
THE FOREST RESOURCE

Forest Inventory Analysis - 1990: The resource and mortality losses

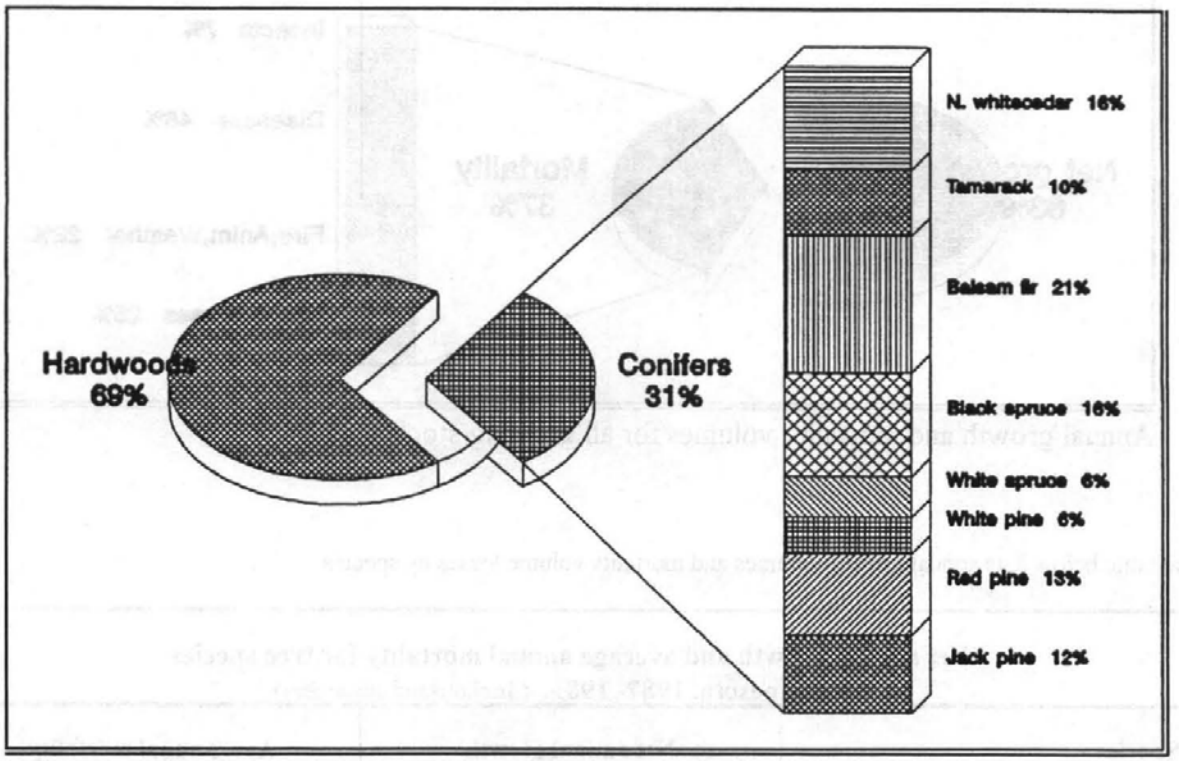
The latest Forest Inventory Analysis in Minnesota covered the period of 1977-1989. Acreages, volumes and other values found in this Report are based on data from the FIA and can be found in "Minnesota Forest Statistics, 1990" by Miles and Chen.

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, saw timber 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



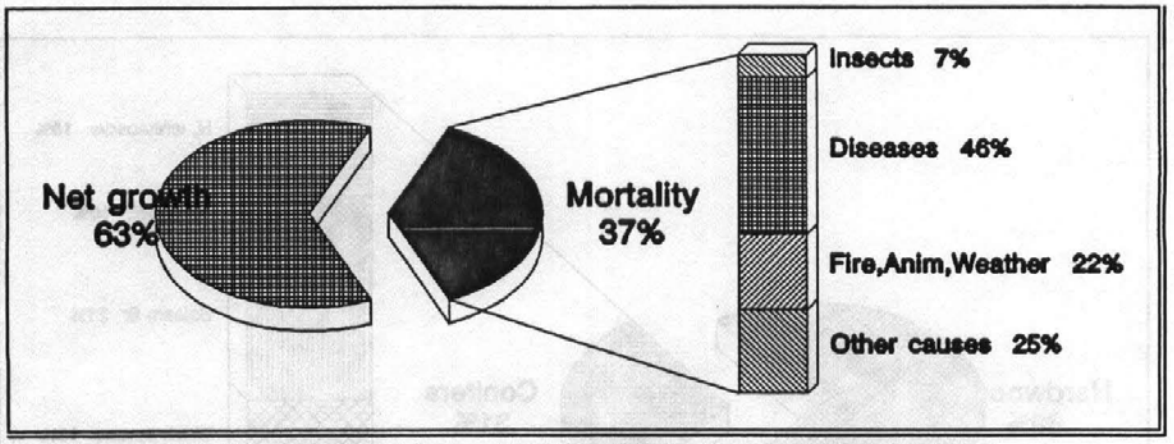
Growing stock volume by conifer species

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.).

ASPEN-BIRCH FOREST

Aspen birch forests comprises 6,377,700 acres or 43.2% of the commercial forest in Minnesota. The main tree species are quaking aspen, balsam poplar and paper birch. Tree species commonly associated with the aspen-birch forest are balsam fir, elm, ash and maple.

Damaging agents and their effects

Defoliators and wood boring beetles are the major insect pests of aspen. The forest tent caterpillar, *Malacosoma disstria*, and the large aspen tortrix, *Choristoneura conflictana*, occasionally defoliate areas of several thousand square miles. Severe defoliation reduces growth but rarely causes mortality unless coupled with other stresses. Wood boring beetles of the genus *Saperda* cause increased wind breakage and lumber and veneer degrade. 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 47% 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.

Insects and diseases included in this report:

Aspen defoliator complex
Aspen blotch miner
Forest tent caterpillar
Birch leaf miner
Pale green weevils

Aspen defoliator complex

Archips purpurana (Clemenns)	Omnivorous leaf roller
Choristoneura conflictana (Walker)	Large aspen tortrix
Choristoneura rosaceana (Harris)	Obliquebanded leaf roller
Orthotaenia undulana (Dyar & Smith)	Dusky leaf roller
Pseudosciaphila duplex (Walsingham)	Spotted aspen leaf roller

Host: Aspen
Damage: Defoliation, leaf rolling and leaf tieing
Area: Not determined
Severity: Very light
Trend: Decreasing.

This complex continued its decline observed in 1995 and only minor defoliation occurred in 1996. A check along Interstate 35 between Sandstone and Pine City on June 6th found only a very few caterpillars belonging to this complex.

Aspen blotch miner

On quaking aspen, *Phyllonorycter nr. salicifoliella* (Chambers)

Host: Aspen and balsam poplar
Damage: Discoloration due to leaf mining
Area: 60 acres
Severity: Heavy infestation
Trend: Collapsing. This pest has sharply declined in 1996 except in a small area in Pine County.

In Pine County near Willow River, aspen leaf blotch miners were still mining aspen leaves on July 31st and causing leaf browning. During the previous three growing seasons, this miner had caused extensive leaf damage to various aspen species in northern and central Minnesota. Field studies in August of 1995 revealed that few larvae had survived, probably due to large larval numbers (ten or more) competing for food in mines of each leaf and to parasite buildup. Surveys in 1996 discovered very few locations where this insect could be found on aspen, except in Pine County, where extensive leaf mining is occurring. Moths started emerging on August 10th.

Forest tent caterpillar

Malacosoma disstria (Hubner)

Host: Basswood and aspen
Damage: Defoliation
Area: 73,147 acres
Severity: Light and moderate defoliation, primarily in northwestern counties.
Trend: Increasing.

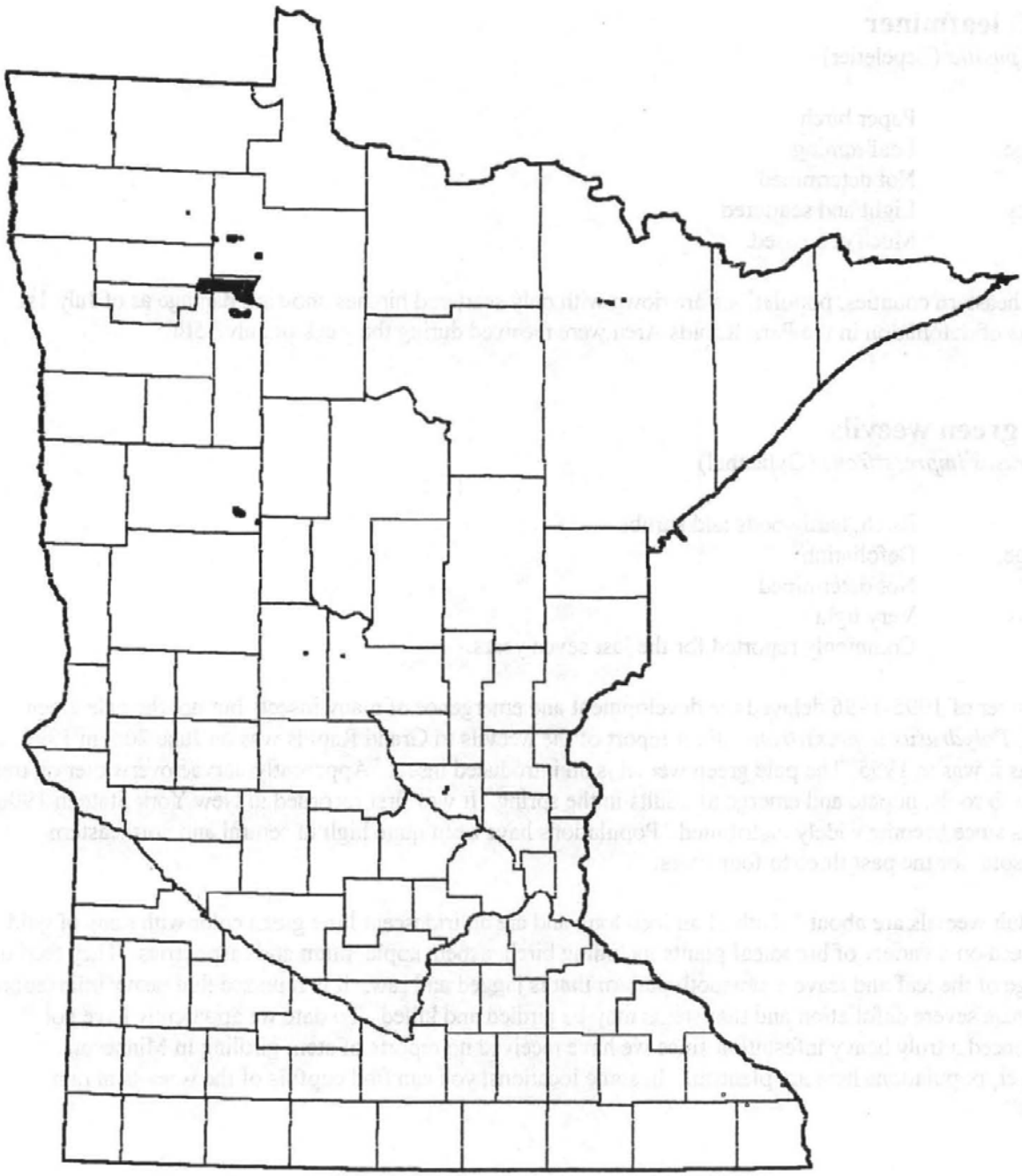
Aspen defoliation and mortality, aerial survey, 1996				
County	Defoliation			Mortality
	Light	Moderate	Heavy	Light
Becker	3753	341		
Beltrami	4200			
Clearwater		50,447		
Houston				32
Marshall	22			
Morrison	32			
Pennington		13,363		
Polk		17		
St. Louis			489	
Sherburne	284			
Todd	135			
Winona	64			
Totals	8490	64,168	489	32

A June 4th survey around five lakes in central Minnesota where the forest tent caterpillar caused extensive defoliation in 1995 revealed surprising changes. In Douglas County on the north side of Lake Carlos no caterpillars were found in the State Park where heavy defoliation occurred in 1995. In Kandiyohi County on the north side of Green Lake, and in Meeker County on the southwest side of Lake Koronis, no caterpillars were seen. In Todd County, between Big and Little Birch Lakes, one basswood tree had hundreds of 1 and 1/4 inch long caterpillars clustered along the shaded side of the trunk, but heavy defoliation had not yet occurred. In this same county on the northeast side of Beauty Lake only 5 clusters of ½ to 1 inch long caterpillars were found on basswood trunks or leaves. At both locations in Todd County there were extensive numbers of caterpillars and heavy defoliation in 1995.

The cold winter may have caused extensive mortality of this pest, as temperatures of -28 to -32°F tends to kill egg embryos. On May 7th about fifty twigs with egg masses were collected from the tops of basswood trees between Big and Little Birch Lakes. Only about 30% of the egg masses hatched but almost every egg produced a caterpillar. The other 70% of the egg masses had no or very little hatching.

Increasingly, there are reports of forest tent caterpillar populations feeding on basswood trees along lake shores. The notable reports in 1996 were in White Pine Township (T45-R32), near Ann Lake in Kanabec Co. and on the north side of Gull Lake in Cass County. Minor defoliation occurred, but populations of this insect have increased over that of 1995 and increased numbers are predicted in 1997. Exceptions to the increase

Aspen defoliation, Aerial Survey, 1996



Scale: 0 — 50 mi — 100 mi

Source: DNR Forest Ecosystem and Resource Assessment Units
Aerial Survey to National (USFS) standards or better.
Map production and analysis by EPIC
Minnesota Department of Natural Resources
Division of Forestry, Forest Health Unit

3/26/1997

occurred in Todd County near lakes, where minor defoliation and only a few groups of caterpillars found during surveys. Here, forest tent caterpillars are at sharply lower levels than in 1995.

Aerial survey reports of FTC defoliation to aspen on the west side of Lower Red Lake in Clearwater County and to mixed hardwoods in the Wolf Lake area of Becker County.

Birch leafminer

Fenus pusilla (Lepeletier)

Host:	Paper birch
Damage:	Leaf mining
Area:	Not determined
Severity:	Light and scattered
Trend:	Much decreased.

In northeastern counties, populations are down with only scattered birches showing damage as of July 1st. Reports of defoliation in the Park Rapids Area were received during the week of July 15th.

Pale green weevils

Polydrusus impressifrons (Gyllenhal)

Host:	Birch, hardwoods and shrubs
Damage:	Defoliation
Area:	Not determined
Severity:	Very light
Trend:	Commonly reported for the last seven years.

The winter of 1995-1996 delayed the development and emergence of many insects but not the pale green weevil, *Polydrusus impressifrons*. First report of the weevils in Grand Rapids was on June 20th in 1996, the same as it was in 1995. The pale green weevil is an introduced insect. Apparently, larvae overwinter on tree and shrub roots, pupate and emerge as adults in the spring. It was first recorded in New York State in 1906, and has since become widely distributed. Populations have been quite high in central and northeastern Minnesota for the past three to four years.

The adult weevils are about 3\16th of an inch long and are an iridescent lime green color with hints of gold. They feed on a variety of broadleaf plants including birch, aspen, apple, plum and raspberries. They feed on the edge of the leaf and leave a sawtooth pattern that is jagged and raw. It is reported that heavy infestations may cause severe defoliation and that stems may be girdled and killed. To date we apparently have not experienced a truly heavy infestation since we have received no reports of stem girdling in Minnesota. However, populations here are plentiful. In some locations, you can find cupfuls of the weevils in rain gutters.

SPRUCE-FIR FOREST

The spruce-fir forests comprises 3,535,800 acres or 23.9% of the commercial forest land in Minnesota. Black spruce, balsam fir, tamarack, northern white cedar and white spruce are the main components and associated species are aspen, maple and paper birch.

Damaging agents and their effects

The major disease problems on black spruce are dwarf mistletoe, *Arceuthobium pusillum*, and root and butt rots. Black spruce is attacked and killed in all stages of its development by dwarf mistletoe. On an annual basis, 55% of the volume of black spruce wood produced is lost due to natural causes (FIA, 1990). Losses in black spruce were due primarily to blow down and beaver flooding, although dwarf mistletoe accounted for 22% of the losses. Root and butt rots caused by *Armillaria* spp. and *Inonotus tomentosus* are present in most stands over 30 years of age. Losses from root and butt rots may range up to 40% of the merchantable volume of the stand. Root rots are the major contributing factor to wind damage.

The spruce budworm, *Choristoneura fumiferana*, is the most destructive insect in Minnesota forests and causes the greatest mortality volume loss. It attacks, injures and kills all age classes of balsam fir. The spruce budworm outbreak in northeast Minnesota has been continuous since at least 1954, when aerial mapping started. Budworm caused 32% of the 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.

Insects and diseases included in this report:

Spruce budworm
Yellow-headed spruce sawfly

Spruce budworm

Choristoneura fumiferana (Clemens)

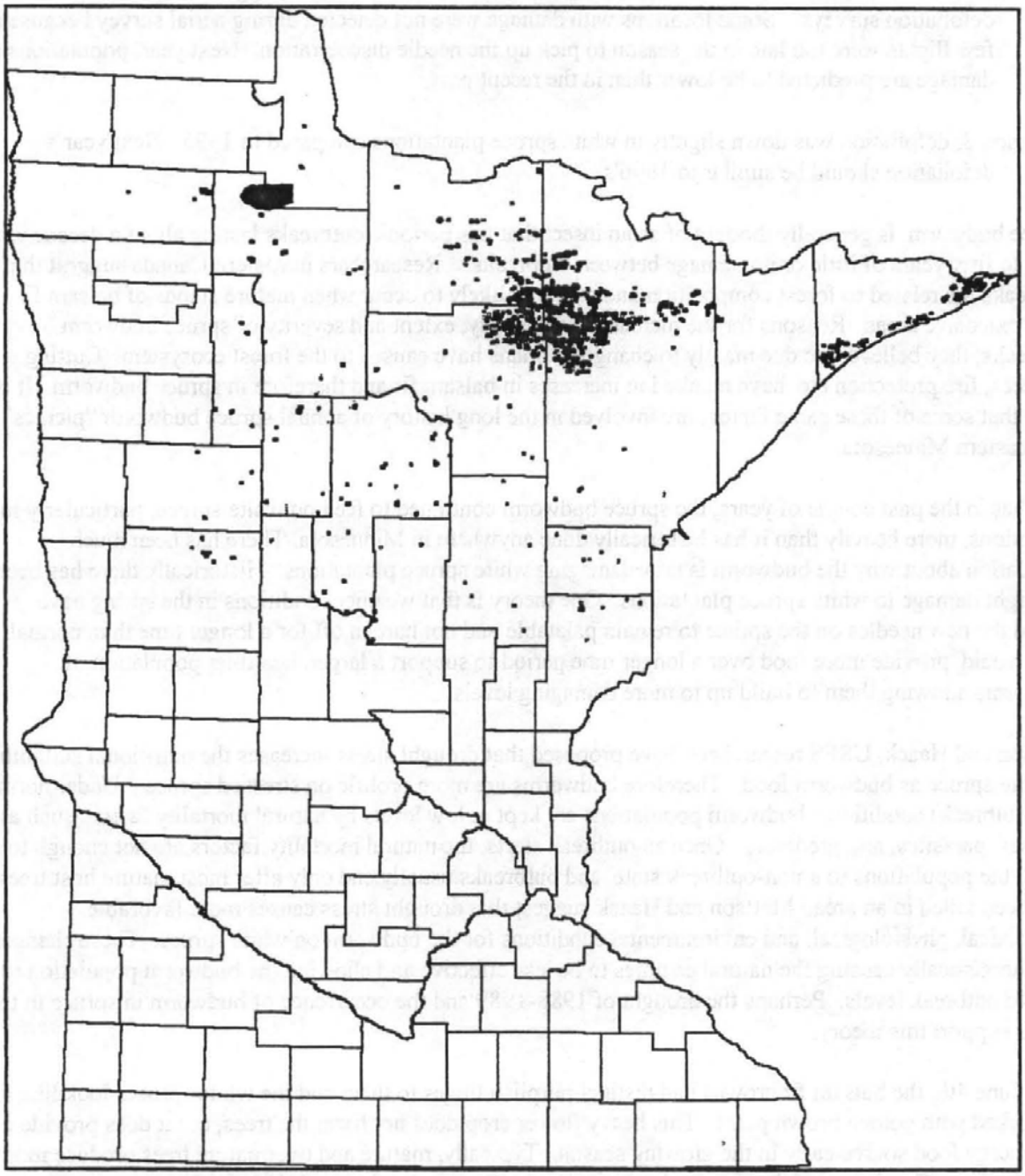
Host:	White spruce and balsam fir
Damage:	Defoliation and topkill
Area:	Defoliation = 205,250 acres and mortality = 2,572; see table below.
Severity:	See table below.
Trend:	As detected in aerial survey, the acreage was down by fifty percent.

Spruce budworm defoliation and mortality, aerial survey, 1996						
County	Defoliation			Mortality		
	Light	Moderate	Heavy	Light	Moderate	Heavy
Aitkin	513					
Becker		210	224	210		
Beltrami	30,232	1,060		253		
Carlton	341					
Cass	2,485	1,069	182		513	76
Clearwater				705	397	
Cook			15,520			
Crow Wing	931					
Hubbard		1,504	170		219	
Itasca	563	108	19,982			
Kanabec	42					
Koochiching	9,201		10,052			
Lake			983			
Lake of the Woods	42,764					
Marshall	2,500			86		
Ottertail	467		121	113		
Pine	714					
St. Louis	1,349		61,883			
Wadena			88			
Totals	92,102	3,951	109,205	1,367	1,129	76

In 1996, spruce budworm populations and their defoliation dropped drastically. See map. Perhaps it was caused by extreme cold, pressure from natural parasites/ predators, other population factors or a combination of them all.

In Region 1, defoliation by spruce budworms on white spruce intensified and expanded in 1996 compared to the damage done in 1995. Damage was observed in the Leech Lake watershed near Brevik,

Spruce budworm damage, Aerial Survey, 1996



Scale: 0 — 50 mi — 100 mi

Source: DNR Forest Ecosystem and Resource Assessment Units
Aerial Survey to National (USFS) standards or better.
Map production and analysis by EPIC
Minnesota Department of Natural Resources
Division of Forestry, Forest Health Unit

3/26/1997

Strawberry Lake, Lake Plantagenet and in the Buena Vista State Forest. Egg mass based predictions for next year's defoliation are for moderate to heavy feeding damage. Budworm moths appear to be successful in locating and maintaining populations in white spruce stands that are isolated from each other throughout Region 1.

In Region 2, overall populations and feeding damage on balsam fir and white spruce were considerably down from 1995 levels. This was evident from all surveys done; early larval, egg mass and aerial defoliation surveys. Some locations with damage were not detected during aerial survey because a few flights were too late in the season to pick up the needle discoloration. Next year, populations and damage are predicted to be lower than in the recent past.

In Region 3, defoliation was down slightly in white spruce plantations compared to 1995. Next year's defoliation should be similar to 1996's.

Spruce budworm is generally thought of as an insect that has periodic outbreaks lasting about a decade with thirty to fifty years of little or no damage between outbreaks. Researchers in eastern Canada suggest that outbreaks are related to forest composition and are most likely to occur when mature stands of balsam fir cover extensive areas. Reasons for the increase in frequency, extent and severity of spruce budworm outbreaks, they believe, are due mainly to changes humans have caused to the forest ecosystem. Cutting practices, fire protection etc. have resulted in increases in balsam fir and therefore in spruce budworm. It is likely that some of these same factors are involved in the long history of annual spruce budworm "picnics" in northeastern Minnesota.

As it has in the past couple of years, the spruce budworm continued to feed on white spruce, particularly in plantations, more heavily than it has historically done anywhere in Minnesota. There has been much speculation about why the budworm is now damaging white spruce plantations. Historically there has been only 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 budworms allowing them to build up to more damaging levels.

Mattson and Haack, USFS researchers, have proposed that drought stress increases the nutritional suitability of white spruce as budworm food. Therefore budworms are more prolific on stressed spruce. Under normal (non-outbreak) conditions, budworm populations are kept at low levels 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 and 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.

As of June 4th, the balsam fir crowns had distinct purplish tinges to them and the white spruces look like they are flocked with golden brown paint. This heavy flower crop does not harm the trees, but it does provide a high energy food source early in the growing season. Typically, mature and overmature trees produce more male flowers. This is one of the reasons having lots of mature and overmature balsam firs encourages spruce budworm outbreaks.

Two white spruce stands in Hubbard County were checked for feeding activity on May 20th. At that time, buds were only starting to swell. On May 23rd, a white spruce stand south of Brainerd in Morrison County was inspected. Less than one fourth of the new buds had shed their caps, starting to flush. Some of the new buds had tiny caterpillars present but no quantitative data was collected. All the sampled stands had recent spruce budworm defoliation over at least the past two years.

On June 5th north of Grand Rapids in Itasca County, spruce budworm caterpillars on white spruce were mostly in the third instar with very few of them in the fourth instar. Caterpillars were mostly 1/4 inch long. Compared to last year, they are about one week late in their development. White spruce shoots were ½ to two inches in length.

Several spruce budworm moths were observed June 24th in a stand of twenty to thirty foot white and blue spruce just south of Brainerd in Crow Wing Co. Pupae were still present among the webbed and chewed shoots, but many other shoots were not damaged. No branch mortality is predicted, and reduction of trunk diameter growth should be minimal. As of July 3rd, the moth flight was finished in Chisago and Sherburne Counties. Black birds were observed feeding on spruce budworm moths in Morrison County.

As of July 2nd, 80% of the spruce budworm caterpillars had pupated near Ely. In Itasca County on the same date, all of the budworm had pupated and 30% of them had already emerged as adult moths.

Isolated white spruce stands in northwestern counties continue to be damaged by spruce budworm in 1996.This is the fifth year these stands have been damaged. Of the surveyed stands, only one is expected to experience light defoliation, all others will have moderate to heavy feeding. Budworm moths are successful in locating white spruce stands that are isolated from each other and in intensifying defoliation once the population is established.

The small infestation in Anoka County decreased substantially in 1996. So aerial spraying was undertaken, but approximately ten landowners used ground spraying with acephate to control defoliation.

Yellow-headed spruce sawfly

Pikonema alaskensis (Rohwer)

Host:	White spruce
Damage:	Defoliation
Area:	Rice County and north central and north west counties
Severity:	Very low
Trend:	Decreasing.

Few calls received about this pest and field observations noted a few infested spruces. Light defoliation was seen on scattered individual trees in Rice Co. The population is markedly less than in 1995 and development was about ten days to two weeks behind schedule compared to 1995.

MAPLE-BASSWOOD FOREST

Maple basswood comprises 1,402,900 acres or 9.5% of the commercial forest in Minnesota. The main tree species are sugar maple, red maple, basswood, yellow birch and American elm. An associated species is white pine.

Damaging agents and their effects

The greatest volume losses in northern hardwood species are the result of disease organisms which discolor, decay, or deform standing timber. Occasional tree mortality can be caused by shoestring root rot fungus, *Armillaria* spp., and sapstreak disease, caused by *Ceratocystis coerulescens*, in wounded or stressed trees. Mortality in the northern hardwood type is not common. On an annual basis, 7% of the volume of basswood and maple wood produced is lost to natural causes (FIA, 1990). This does not include harvest removals. There were no outstanding causes of mortality as identified by the Inventory. 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.

Insects and diseases included in this report:

Fall defoliator complex
Herbicide injury
Hardwood damage table

Fall defoliator complex

Symmerista canicosta Franclemont	redhumped oakworm
S. leucitys Franclemont	orangehumped mapleworm
Anisota senatoria (JE Smith)	orangestriped oakworm

Host: Oaks and other hardwoods
Damage: Defoliation
Area: 40 acres
Severity: Moderate defoliation
Trend: Since the early 1980's, the "bellwether" locations for fall defoliators have been quiet. At one of these locations in 1995, one or two acres were defoliated and by 1996, the populations caused about 40 acres of leaflessness. Uncharacteristically, the orange-striped oakworms were hit by disease early in the outbreak. Considerably larger acreages of heavily defoliated oaks and other trees are predicted for 1997 in Morrison County.

Fall defoliators, a diverse group of caterpillars and other insects, go into outbreak status every fifteen years or so. The last outbreak occurred in the early 1980's and continued for three or four years. They concentrate their feeding on oak, elm, basswood, aspen, birch and maple trees. In central Minnesota, there are two locations where these insects seem to build up first, thus being the "bellwethers" for the next outbreak. One location is close to Hardy Lake near Brainerd.

The other is in Morrison County about six miles south of Little Falls and about one mile east of the Mississippi River (NENE S20-T39-R32). Here, orange-striped and red-humped oakworms heavily defoliated about forty acres of burr and red oaks These caterpillars had grown to two inches long by Sept. 12th. By mid-September over 70% of these oakworms had completed their feeding, dropped to the ground and spun cocoons. Oakworms were first noted at this location in August of 1995 but, at that time, their numbers were extremely low and they occupied less than a two acre area. They've been observed for two years now in their bellwether locations and the populations seem to be building.

The presence of orange-humped mapleworms on the under sides of burr oak leaves was reported in a homeowner's yard north of Bagley in Clearwater County on August 22nd. No feeding activity was observed. There were masses of young larvae milling about, not quite seeming to know what to do. This hardwood defoliator has not been reported in this vicinity since 1983.

Herbicide injury

Clomazone

Host:	Hardwoods
Damage:	Discoloration
Area:	Thirty square miles of herbicide injury
Severity:	Light to moderate
Trend:	None.

In most years, herbicide injury is part of the southern Minnesota landscape. Although pesticide drift is neither desired nor approved, it can be fairly common in farming communities. Usually the injury is localized and, fortunately, in most cases the injured forests and woodlots recover quickly.

We expect that to be true for the trees in southern Fillmore County. In mid-June, herbicide injury was evident extending from the small community of Newburg ten miles to Harmony and one half mile north and south of that line. Drift damage was observed both on the ground and during aerial survey. The herbicide used was clomazome, a common product used in soybean fields. Clomazome is a photosynthesis inhibitor and its drift can be seen in most years turning the edges of the fields white after its application. Clomazome must be incorporated into the soil after application. It seems that this year, the soils in the area were too wet to get right back in to incorporate the herbicide. That situation combined with a localized weather event resulted in some significant volatilization of the product throughout the farms and woods of the area. The drift problem was investigated by the Minnesota Dept. of Agriculture.

Symptoms were most prominent on trees near the edges of fields. The veins remained green but the chlorophyll in the leaf blade "bleached out". Several species were affected: sugar maple, northern red oak, basswood, ironwood and green ash, to name a few.

The effect was supposed to be temporary. That was not the outcome. Field checks in late July did not find any change in the hardwood leaves, everything that was chlorotic or mottled remained that way. This event may or may not be significant in terms of stressing the trees. It depends on the tree condition at the time of the disturbance and which additional stress events occur in the near future, particularly winter weather and decline initiation by secondary pests.

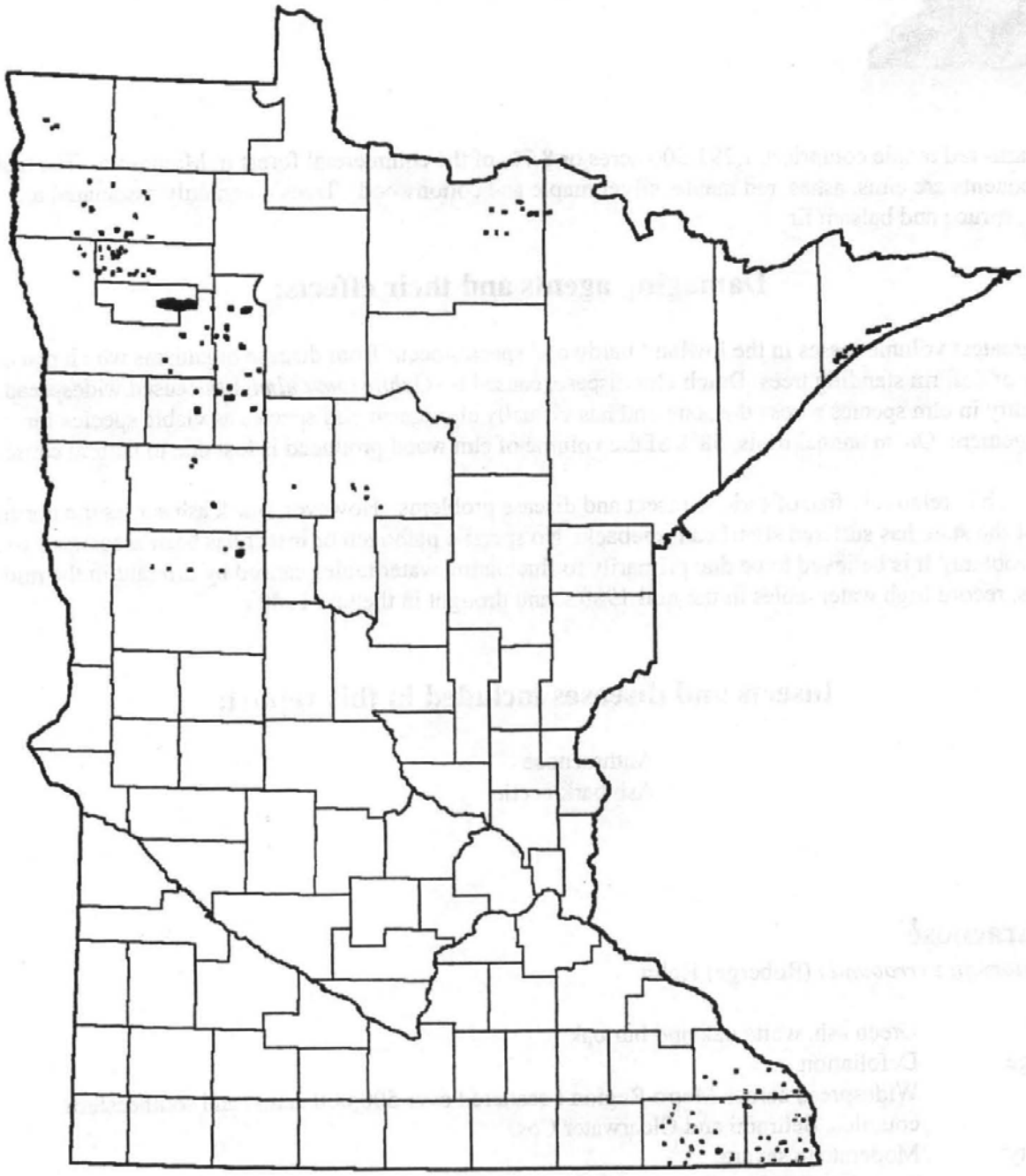
Hardwood damage

Acres of hardwood damage based on aerial survey is summarized by county. Damage could be discoloration, defoliation, dieback or mortality. It does not include any of the other damaging agents discussed in this report. See map.

Hardwood damage, aerial survey, 1996

County	Discoloration	Defoliation	Dieback	Mortality		
				Light	Moderate	Heavy
Becker	452				402	
Cass					172	
Clearwater	3,202	1,437			3,615	84
Cook		2,552		254		
Fillmore	148		66	1,045		123
Houston	242	56		588		
Hubbard				86		
Kittson				232		98
Koochiching		1,699				
Mahnomen	1,235			1,704		
Marshall	185	1,337			499	126
Olmsted				14		
Ottertail	1,314	239	330	47		
Pennington				605	1,084	237
Polk	66	1,063		116	528	130
Red Lake					19,204	
St. Louis		326				
Winona	392	148		355		
Totals	7,236	8,857	396	5,046	25,504	798

Hardwood damage, Aerial Survey, 1996



Scale: 0 — 50 mi — 100 mi

Source: DNR Forest Ecosystem and Resource Assessment Units
Aerial Survey to National (USFS) standards or better.
Map production and analysis by EPIC
Minnesota Department of Natural Resources
Division of Forestry, Forest Health Unit

3/26/1997

ELM-ASH-RED MAPLE FOREST

Elm-ash- red maple comprises 1,291,500 acres or 8.7% of the commercial forest in Minnesota. The main components are elms, ashes, red maple, silver maple and cottonwood. Trees commonly associated are birch, spruce and balsam fir.

Damaging agents and their effects:

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

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.

Insects and diseases included in this report:

Anthracnose
Ash bark beetle

Anthracnose

Apiognomonia errabunda (Roberge) Hohn

Host:	Green ash, white oak and bur oak
Damage:	Defoliation
Area:	Widespread across Metro Region (scattered over 500,000 acres) and southeastern counties, Beltrami and Clearwater Cos.
Severity:	Moderate to severe
Trend:	Associated with cool, wet spring weather. Increasing in Metro Region.

The cool, cloudy weather and slow developing foliage triggered the worst outbreak of anthracnose that the Metro Region has seen in recent history. As usual, green ash was most affected with oak, particularly white oak, in second. One noteworthy observation is that the damage seems to be spotty, almost completely defoliating some areas while other areas are relatively unaffected.

Similar outbreaks occurred in green ash across the southeastern counties in late May and into June during periods of wet weather. An extensive outbreak of bur oak anthracnose occurred in late May. At that time, the leaf development of bur oak was at least three weeks late and all the foliage was infected and completely destroyed. The bur oaks refoliated in late June. In Beltrami and Clearwater Counties, bur oaks and maples developed symptoms of anthracnose in late June into mid-July.

Ash bark beetle

Hylesinus aculeatus (Say)

Host:	Green ash
Damage:	Mortality
Area:	Rice Co.
Severity:	Light
Trend:	Associated with severe winter and cool, late spring.

Found this year in Rice County, eastern ash bark beetles were causing mortality in green ash weakened by the severe winter. The trees in question leafed out and were likely so weak that they were easily infested and killed by these bark beetles. It turns out that there are a number of species of ash bark beetles that occur in North America, with this species being the most common on ash species.

OAK FOREST

The oak forest is comprised of 1,184,300 acres or 8% of the commercial forest in Minnesota. The main components are northern red oak, white oak, bur oak and, in the southeast, hickories. Trees commonly associated with oaks are jack pine, elm and maple.

Damaging agents and their effects:

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

Insects and diseases included in this report:

Oak wilt
Flat leaf tiers
Leaf miners
Iron chlorosis
Two-lined chestnut borer

Oak wilt

Ceratocystis fagacearum (TW Bretz) J.Hunt

Host:	Northern pin oak
Damage:	Mortality
Area:	7200 acres in southeastern counties and eleven sites totaling about 1/10 of a square mile in Sherburne Co. See tables below.
Severity:	Scattered infection centers
Trend:	Decreasing on forestry managed lands in Sherburne Co. Elsewhere, increasing.

Oak wilt in southeastern counties - Aerial survey, 1996	
County	**Acres of mortality**
Dakota	914
Dodge	106
Goodhue	2,221
Olmsted	1,435
Wabasha	1,242
Washington	593
Winona	686
Total	7200

In Sherburne County, all sites outside of the Scientific and Natural Area have been treated by vibratory plow except site 96-1. See table below. The plow contractor ran into frost and was unable to complete site 96-1 on December 3rd. Nothing was done in 1996 on the SNA oak wilt sites.

Oak wilt in Sherburne County - 1996
Sites discovered during aerial survey by Area personnel in July and August 1996

SITE	# TREES TO CHECK LATE WINTER	EST PERIM	FIREWOOD VOLUME CORDS	LOCATION NARRATIVE
95-4	4 14" Pin Oak	300'	3.3 cords PO	S of 233rd Ave near Hammers
96-1 Trust	vib plow not done fall 96	300'	vib plow not done	Camp site 12
96-2 Trust	check	300'	firewood for rec	Across form 4-H
96-3	no potential for spore production 12-96	500'	4 cords PO	FR 247 to FT 145 5 chains w of Ft 145 at pink flag
96-4 SNA	SNA personnel will do	1400'	"	SNA 3 ch n of FT 171 orange flag
96-5 SNA	SNA personnel will do	400'	"	SNA 3 ch n of 96-4 orange flag
96-6 SNA	SNA personnel will do	1000'	"	SNA 5 ch w of 96-4 on FT 171 n&s of clearing
96-7 SNA	SNA personnel will do	500'	"	SNA s of gate in heavy oak regen e of FT 170
96-8 SNA	SNA personnel will do	600'	"	SNA end of FT 171 steep and logs
96-9	no potential for spore production 12-96	300'	cruise about 3 cords	166th St n of 231st Ave 3 ch e of Volhabers orange flag heavy brush
96-10 Trust	check late winter	300'	cruise about 3 cords for rec?	ski trail s of FR 257
SUMMARY		AQU 1100' TRUST 900' SNA 3800' TOT 4800'		LINE COST SUPV COST TOTAL $1200 $100 $1300 674 100 774 2900 100 3000 $1874 $300 $1874**

Flat leaf tiers on oak

Psilocorsis reflexiella Clemens

Host:	Bur oak
Damage:	Defoliation
Area:	Three locations less than 80 acres each in Aitkin, Chisago and Morrison Cos.
Severity:	Heavy defoliation
Trend:	Probably static. These sites will be checked in mid-May of 1997 and caterpillars will be collected to confirm the continued presence of the flat leaftier and to identify any other caterpillar species that participate in this early season but short duration defoliation.

In mid-May and into early-June, heavy defoliation of red and burr oaks occurred in Aitkin County just southwest of Big Sandy Lake, in southeastern Morrison County near Buchman and north of Pierz, and in northwestern Chisago County. The flat leaftier, *Psilocorsis reflexella*, was tentatively identified as one of the defoliators. Another defoliator present was the obliquebanded leaf roller, *Choristoneura rosaceana*. This was at least the second year of such defoliation for these sites.

Flat leaftier moths emerge from pupae in the early spring and lay eggs on twigs. Larvae consume the newly expanding leaves as the buds break. By June 4th at the Chisago Co. site, the insects had dropped to the ground and had pupated in the litter. Refoliation of these oaks started in June. Leaftiers are normally kept in check by parasites which prevent them from increasing and causing noticeable defoliation.

Leaf miners on bur oak

Cameraria hamadryadella (Clemens)
C. cincinnatiella (Chambers)
Profenusa spp.

Host:	Bur oak
Damage:	Discoloration caused by mining of leaves
Area:	Sherburne, Cass and Crow Wing Cos.
Severity:	Heavily infested leaves
Trend:	Up sharply compared to 1995.

A number of tiny insects in the genera *Cameraria* and *Profenusa*, as well as others, mine the leaves of oaks. This year, oak leafminer activity has been observed from Sherburne County north into Cass and Crow Wing Counties on bur and red oaks. Conspicuous infestations occur occasionally, however, they tend to be short-lived and have very little impact on tree health. Leafminer activity causes discoloration of the foliage and, during heavy infestations, may cause premature defoliation .

The caterpillars of the solitary oak leafminer, *C. hamadryadella*, feed singly in each mine, but tend to merge when a number of mines occur on the same leaf. Caterpillars are flattened, have only rudimentary legs and when full-grown are about five millimeters long. There are two generations each year with the second generation overwintering as caterpillars in the leaf mines on the ground. They change to pupae in the spring. Another closely related species is the gregarious oak leafminer, *C. cincinnatiella*. As the name suggests, several caterpillars feed together inside a single, large mine.

The *Profenusa* spp. are not caterpillars at all, but are leafmining sawflies. Larvae produce large, blister shaped mines then drop to the ground to overwinter as prepupae.

Iron chlorosis

Lime-induced chlorosis

Host: Red oak
Damage: Dieback in upper crowns
Area: Scattered in Winona and Houston Counties
Severity: Light
Trend: Ongoing.

Iron chlorosis is evident this year on the bluffs of the hardwood forests in the southeastern counties. Iron in alkaline soils (soils with a high pH) is often in a form too tightly bound to other molecules to be available for tree roots. This problem occurs most frequently in high calcium soils and is referred to as lime-induced iron chlorosis. It's common to see a line of red oaks or scattered red oaks along the side slope associated with a limestone outcropping.

Two-lined chestnut borer

Agrilus bilineatus (Weber)

Host: Red oak, bur oak
Damage: Mortality
Area: Not determined, in south central and western counties
Severity: Scattered individual trees
Trend: Unknown.

Reports of two-lined chestnut borer from Park Rapids, Detroit Lakes, Mankato and Fairbault Areas were received during mid-July. Oaks are the primary host trees of this borer with red oak being more frequently attacked. Borers only successfully attack stressed trees; drought stress being the most common. Across south central Minnesota, several large, 130 year old bur oaks died from two-lined chestnut borer attack. Recent predisposing stresses to these trees included drought, severe winter and late leaf-out in 1996. Two-lined chestnut borers were also active in severely chlorotic oaks in the Metropolitan Region where their activity was considered opportunistic.

PINE FOREST

The pine forest is comprised of 812,300 acres or 5.5% of the commercial forest in Minnesota. The main species are jack pine, red pine and white pine. Associated species are aspen, birch and maple.

Damaging agents and their effects:

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

White pine blister rust, *Cronartium ribicola*, and white pine weevil, *Pissodes strobi*, are the major insect and disease problems of 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.

Insects and diseases included in this report:

Bark beetles
Jack pine budworm
Pine tussock moth
Common pine shoot beetle
Introduced pine sawfly
Eastern pine shoot borer
Grasshoppers

Bark beetles

Ips pini (Say)

Host: Jack pines in west-central counties and Pine County,
Red and white pines in central counties and in Itasca State Park,
Red and white pines on the Region 2 Office site.
Damage: Discoloration and mortality
Area: 78,310 acres (aerial survey). See table below.
Severity: Light to moderate
Trend: Rapid build-up on jack pine budworm defoliated jack pines.

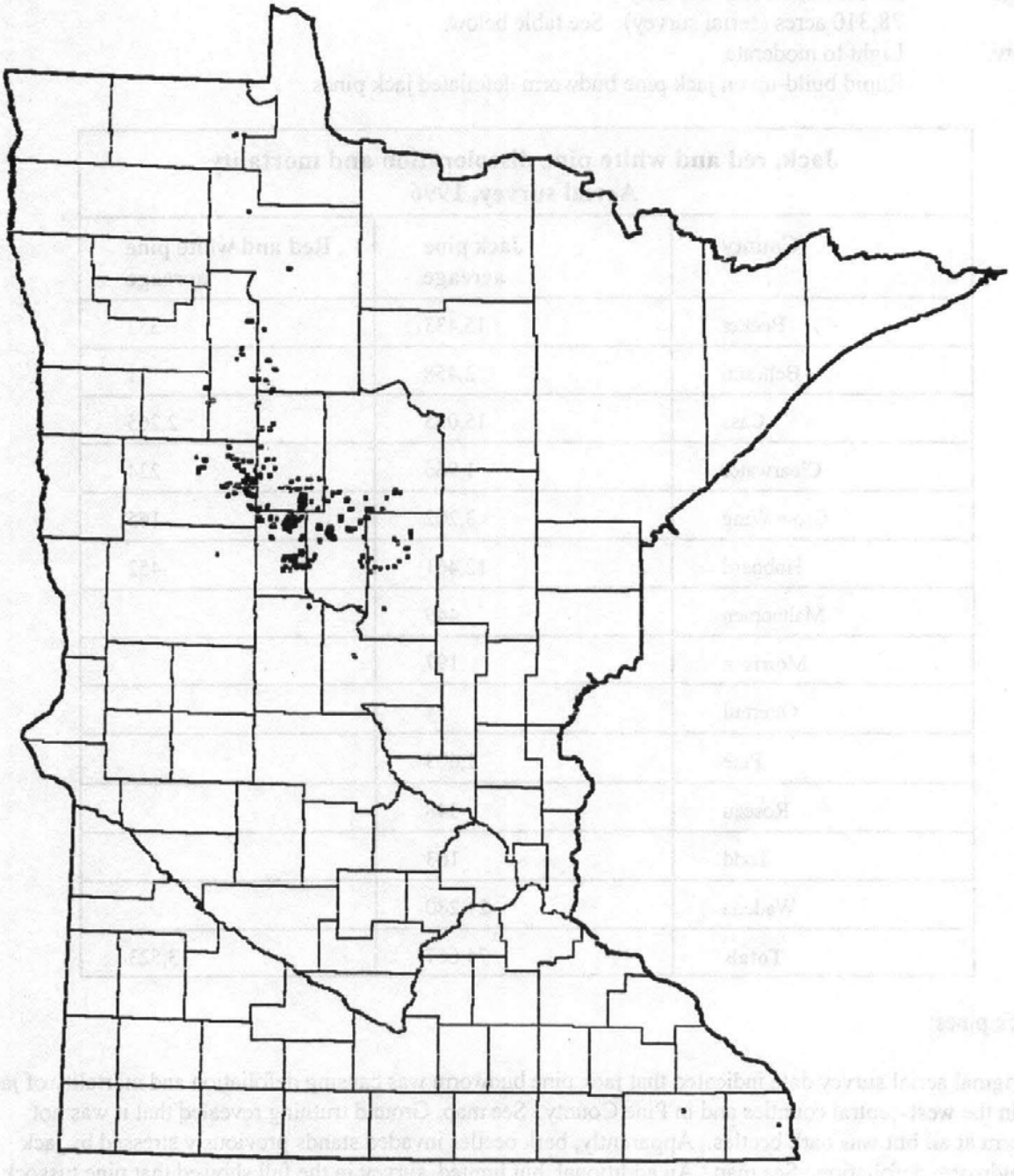
Jack, red and white pine discoloration and mortality
Aerial survey, 1996

County	Jack pine acreage	Red and white pine acreage
Becker	15,433	333
Beltrami	2,458	71
Cass	15,055	2,265
Clearwater	1,966	234
Crow Wing	3,202	165
Hubbard	12,461	452
Mahnomen	449	
Morrison	197	
Ottertail	54	
Pine	1,603	
Roseau	348	
Todd	163	
Wadena	21,280	
Totals	74,667	3,523

For jack pines:

The original aerial survey data indicated that jack pine budworm was causing defoliation and mortality of jack pines in the west-central counties and in Pine County. See map. Ground truthing revealed that it was not budworm at all but was bark beetles. Apparently, bark beetles invaded stands previously stressed by jack pine budworm defoliation. See map. An additional, but limited, survey in the fall showed that pine tussock moths were not the cause of the damage to jack pines noted during aerial survey.

Jack pine damage, Aerial survey, 1996



Scale: 0 — 50 mi — 100 mi

Source: DNR Forest Ecosystem and Resource Assessment Units
Aerial Survey to National (USFS) standards or better.
Map production and analysis by EPIC
Minnesota Department of Natural Resources
Division of Forestry, Forest Health Unit

3/26/1997

Red and White pine damage, Aerial Survey, 1996

Scale: 0 — 50 mi — 100 mi

Source: DNR Forest Ecosystem and Resource Assessment Units
Aerial Survey to National (USFS) standards or better.
Map production and analysis by EPIC
Minnesota Department of Natural Resources
Division of Forestry, Forest Health Unit

3/26/1997

For red and white pines:

Fourteen stands had red or white pine discoloration or mortality as detected during aerial survey. See map. None of these stands were systematically ground checked. Bark beetles are just one of a number of possible causal agents, but are often a consequence of fluctuating or changed water table, severe thinning or pruning or drought.

For red and white pines at the Region II Office site:

In April, nine pheromone traps and five sets of trap logs were placed among the pines on the Region II Office grounds in order to mass trap the stand and help prevent further infestation and decline of the pines. Trap logs were set out at the end of April, removed and replaced in late May and again in the first part of July.

The largest *Ips pini* catch occurred from May 10th to the 12th. A few *I. pini* adults were seen each week during the growing season, but no second flight was seen. Traps were checked each week for bark beetles and all other insects were released. *Dendroconus valens* was trapped in low numbers, the last one trapped on August 6th. Only one trap log was colonized (a single nuptial chamber) in May.

Jack pine budworm

Choristoneura pinus Freeman

Host:	Jack pine
Damage:	Defoliation
Area:	Less than 1000 acres of current year defoliation.
Severity:	Budworm activity was very rare and was very minor.
Trend:	The nadir. This insect is at its lowest population level in 30 years according to Bob Tiplady and Roger Hannigan.

Jack pine budworm was at unusually low population numbers in Minnesota this year. Don't worry, the budworms did not pack their cocoons and leave the state. One June 10th, a few caterpillars were collected in Buzzle Township in Beltrami County, Two Inlets Tnsp. in Becker Co. and in Straight River Tnsp. in Hubbard Co. Only one plot (S26-T139-R35) had four caterpillars, which is well below the threshold for heavy defoliation for the current year. Larval counts in parts of southwestern Beltrami County also showed only a small population that has remained about the same level as in 1995. Larval surveys in southeastern Becker County indicate that the population collapsed during the winter of 1995-96. These stands experienced moderate to heavy defoliation in 1995. In Hubbard County, sampling indicates that a small population, similar to 1995, is still active in Straight River Township. All other parts of Hubbard County showed little or no jack pine budworm activity in 1996. On June 20th, a single jack pine budworm caterpillar was found in Morrison County (NENE 6-132-30).

A few jack pine budworm moths were caught in pine tussock moth pheromone traps set out in Crow Wing and Pine Counties. This happens every season to some extent because the budworm moths are slightly attracted to the tussock moth pheromone and they were detected by this method again this year.

Jack pine stands in and around Osage, Menahga and Park Rapids, among other areas, have thin crowns from last year's budworm defoliation. Aerial survey detected discoloration and mortality in jack pine stands in

many counties. Field checks indicated high bark beetle activity in these stands. Active bark beetle populations are killing off the overmature, damaged and stressed trees. However, these stands, and others, will be rechecked in 1997 to determine if budworm or pine tussock moth populations are rebounding.

Zero egg masses were found on forty-nine plots in Pine, Crow Wing, Wadena, Hubbard, Beltrami and Becker Counties. See data in Survey Results section. Needless to say, budworm populations should be very, very low next summer.

Pine tussock moth

Dasychira pinicola (Dyar)

Host:	Jack pine
Damage:	None
Area:	Pine, Crow Wing, Wadena and Hubbard Counties
Severity:	NA
Trend:	Pheromone trap catch increasing in Hubbard and Wadena Counties, elsewhere static or decreasing.

Pheromone trapping has been conducted every year since the pheromone was available, starting with experimental trials in 1980. Populations in Pine and Crow Wing Counties remained at very low levels again this year. See trapping data in Survey Results section.

Pine tussock moth populations are building in northeastern Wadena and southeastern Hubbard Counties. 703 moths were caught in seven pheromone trapping locations. The action threshold, based on moth catch, is thirty per trap in a two week period. In 1996, the catch averaged twenty-six per trap. Early larval surveys will be scheduled for 1997 to further monitor this population.

Common pine shoot beetle

Tomicus piniperda (L.)

Host:	Pines
Damage:	None, pheromone trapping for detection.
Area:	Traps located in St. Louis, Hennepin, Ramsey, Dakota and Goodhue
Severity:	No common pine shoot beetles were trapped and no other exotic bark beetles were trapped .
Trend:	NA

USDA, APHIS, Plant Protection and Quarantine surveyed fifty-five locations in five counties for the presence of adult, exotic bark beetles. A synthetic lure containing pinene was used to bait the common pine shoot beetle pheromone traps. A three component lure was used to bait the exotic bark beetle pheromone traps. Fresh pine longs were also used in St. Louis Co. See tables below. No exotic bark beetles were found.

Pheromone trapping for exotic bark beetles - 1996, by APHIS-PPQ			
County	**Number of locations with pinene lure**	**Number of locations with 3 component lure**	**Number of locations with fresh pine logs**
Ramsey	11	1	0
Goodhue	10	0	0
Dakota	11	1	0
Hennepin	10	3	0
St. Louis	4	4	5

Bark beetle species caught in pheromone traps - 1996, by APHIS, PPQ		
Insect species	**In pinene lure trap**	**In 3 component lure**
Ips grandicollis	Yes	
Ips pini	Yes	Yes
Hylurgops rugipennis pinifex	Yes	
Orthotomicus caelatus	Yes	Yes
Hylastes porculus	Yes	Yes
Dendroctonus valens		Yes

Introduced pine sawfly

Diprion similis (Hartig)

Host: White and Scots pine
Damage: Defoliation
Area: Plantations and ornamental trees in Crow Wing, Morrison and Benton Cos.
Severity: Light to moderate
Trend: Increasing.

Large numbers of introduced pine sawfly larvae had significantly defoliated Scots and white pines in a few plantations and yards in southeastern Crow Wing, northeastern Morrison, and northwestern Benton Counties by early September.

Eastern pine shoot borer

Eucosma gloriola Heinrich

Host:	Jack pine
Damage:	Current shoot and leader killed
Area:	A single plantation
Severity:	High incidence
Trend:	Unknown.

Damage on a young jack pine plantation in the Baudette area (S8-T160-R33), caused by the eastern pine shoot borer, *Eucosma gloriola*, was observed on September 6th. Almost every tree had new shoots that were bored, bent or broken off during 1996. It was too late to find the critters because after tunneling in the shoots, the caterpillars dropped to the ground in July and formed cocoons in the litter below the tree. However, their feeding damage is diagnostic: young caterpillars bore into the new shoots and mine their way to the base of the shoot. These tunnels are one-half to one and a half inches long. Mature caterpillars then reverse directions tunneling upward for an inch or so before girdling the new shoot. Oval holes at the base of the injury are created so they can leave the shoot. Both lateral and terminal shoots are attacked.

Grasshoppers

Melanoplus spp.

Host:	Containerized conifer seedlings
Damage:	Mortality
Area:	Not determined
Severity:	Very severe, nearly 100% affected
Trend:	If conditions remain dry, expect grasshoppers to reappear.

A forester from Red Lake reports that grass hoppers are so hungry, so many, and so bold that containerized tree planting plans had to be put on hold until later in the growing season or into the fall when grasshopper populations diminish. The planters told him that it is difficult to make any progress from day to day. The grass hoppers eat off all the seedlings planted the day before, and it is difficult to know where to start planting again the next day.

These grass hoppers are not just nibblers, either. Instead of just eating the green needles, they eat the entire seedlings down to the ground line. All that's left are the roots, and that's a pretty tough way to grow a tree.

URBAN FOREST

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

Damaging agents and their effects:

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

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

Insects and diseases included in this report:

Oak wilt
Gypsy moth
Chlorotic oaks
Diplodia shoot blight

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 (CSP).

The Cooperative Suppression Program program for Oak Wilt, begun in 1991, continued in 1996. It is currently approved to run through 1997. Progress continues across the seven counties of the CSP

(Anoka, Chisago, Dakota, Isanti, Ramsey, Sherburne, and Washington Counties). 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 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%. This year, federal expenditures were $125,000 and the total Program value was estimated to be $300,000.

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
1996	549 (est.)	210,000 (est.)	1,100 (est.)	123
Total*	3068	1,183,000	6787	-----

* = Totals are based on estimated values for 1996.

Millionth Foot celebration

On August 20, the DNR sponsored a media event to celebrate the Plowing of the Millionth Foot of vibratory plow line. Over 150 people attended the event, 75% of which were citizens and officials from the cooperating communities. During the event, ten local communities were honored for their excellent programs. These communities were nominated by the Minnesota Shade Tree Advisory Committee's Forest Health Task Force. They received a plaque and a commemorative oak tree to be planted in their community. Senator Paul Wellstone delivered the keynote address to a packed tent. Sixth District Congressman Bill Luther was on hand to plow the millionth foot on an operational oak wilt site in Pioneer Park in the City of Blaine. Dr. Ann Bartuska, USFS, was also on hand to plant a ceremonial red oak to symbolize the success of the program. Two local TV stations carried an extended story on the program that evening, plus numerous written stories in local newspapers. Additional information can be found in the Special Projects section.

Gypsy moth

Lymantria dispar (Linneaus)

Hosts: Primarily hardwoods
Damage: None
Area: None
Severity: NA
Trend: Disturbingly upward.

Gypsy moth is a quarantined insect in Minnesota. As such, most of the activity relating to this insect is regulatory in nature. This effort is lead at the federal USDA's Animal and Plant Health Inspection Service (APHIS) and Plant Protection and Quarantine (PPQ) working in cooperation with the Minnesota Department of Agriculture's Agronomy Services Division. The Minnesota Department of Natural Resources Division of Forestry works in direct, close collaboration with these agencies to detect and eradicate gypsy moth in Minnesota.

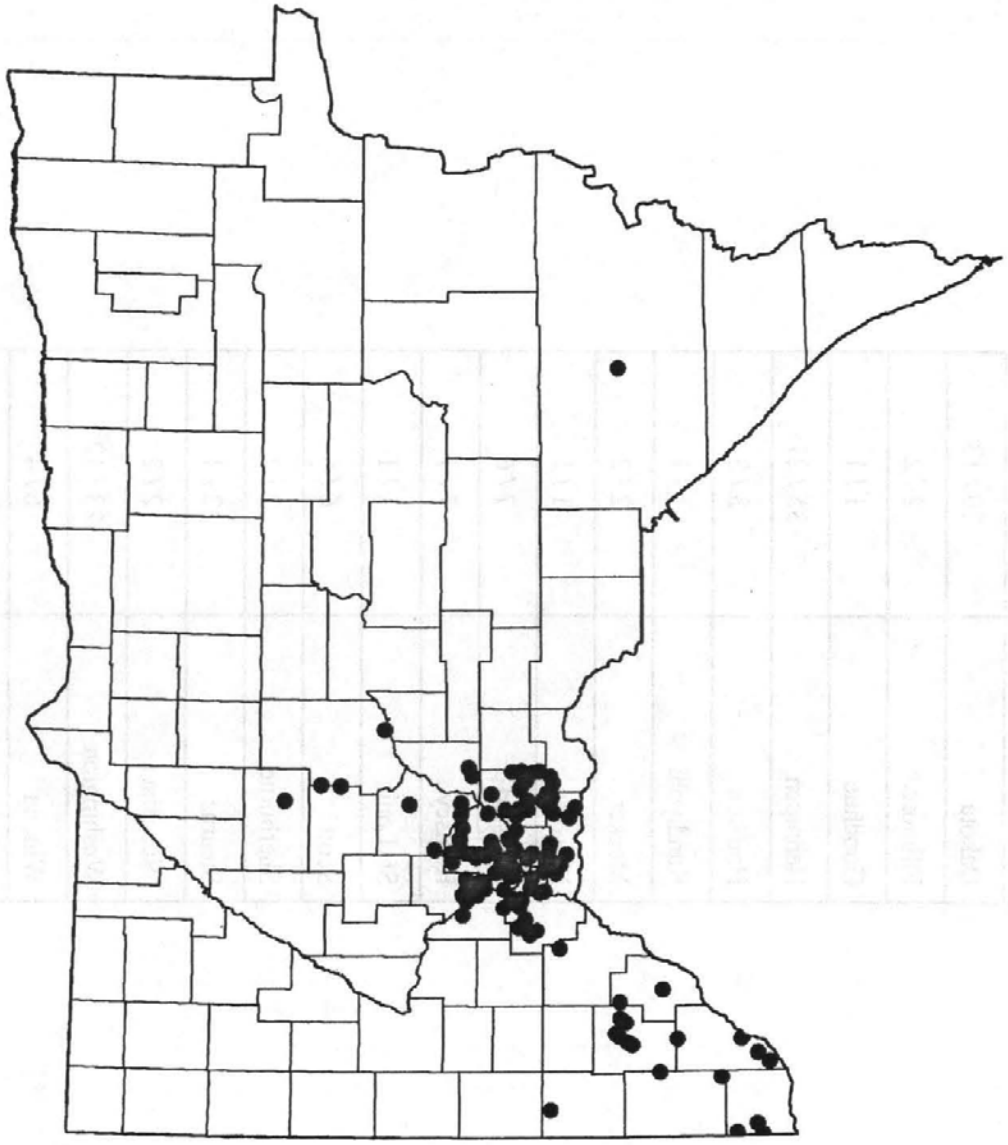
Gypsy moth is not yet established in Minnesota, however there are several areas in the Metropolitan Region that likely have very small, localized populations. These are heavily trapped each year for delimiting purposes as well as ground searched for alternate life stages. When populations are located by ground searching, they will be treated for eradication.

Gypsy Moth Trapping Program

The Minnesota Department of Agriculture coordinates an annual detection trapping program in Minnesota. In 1996, this program placed 9,668 traps over most of the state. In 1996, 155 male gypsy moths were taken in the Minnesota trapping grid. These moths were taken at 117 sites in 21 counties. This figure is down slightly from the 1995 catch of 202 moths in 25 counties. This difference is likely due to weather related reductions in the massive distribution of moths caused by a quarantine breach-related introduction in 1994. The distribution of traps placed by all cooperating agencies and the trapping results is summarized in the following two tables.

Gypsy moth trapping by agency	
Trapping Agency	**Number of Traps Placed**
Minnesota and US Department of Agriculture	8,681
Minnesota DNR	548
US Forest Service	314
Hennepin County Parks	91
Various local cooperators	34
Total	9,668

Gypsy Moth Male Catch, 1996



Scale: 0 — 50 mi — 100 mi

Source: MDA database automated by MN-DNR.
Note: Catch locations enlarged for visual clearity.
Map production and analysis by EPIC
Minnesota Department of Natural Resources
Division of Forestry, Forest Ecosystem Health Unit
3/17/1997

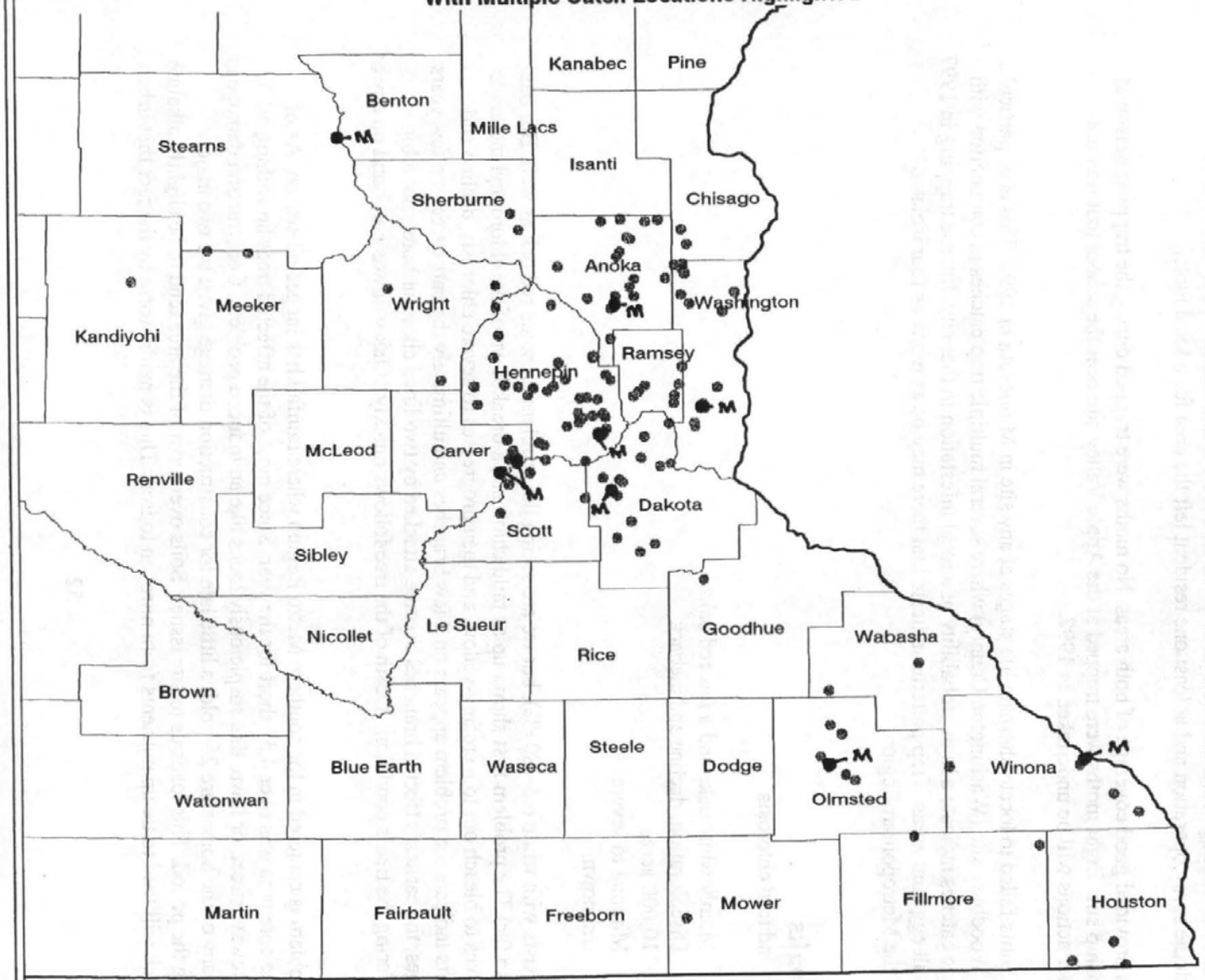
FH, Gypsy Moth Multiple, 1996, 5000m buffer

Minnesota
DEPARTMENT OF NATURAL RESOURCES

Gypsy moth trap catches by county	
County	**Moths / site**
Anoka	21 / 17
Carver	8 / 5
Chisago	2 / 2
Dakota	20 / 13
Fillmore	2 / 2
Goodhue	1 / 1
Hennipen	35 / 27
Houston	3 / 3
Kandiyohi	1 / 1
Meeker	2 / 2
Mower	1 / 1
Olmsted	7 / 6
Ramsey	7 / 7
St. Louis	1 / 1
Scott	6 / 5
Sherburne	2 / 2
Stearns	2 / 1
Wabasha	2 / 2
Washington	23 / 12
Winona	6 / 4
Wright	3 / 3
Total	155 / 117

Catches were located in the EPIC GIS for the first time in 1996. See map of moth catch distribution in the Twin Cities area. This figure only shows the moths taken in the southeastern portion of the state. Only one moth was taken outside of this range, that from St. Louis County approximately 50 miles north of Duluth.

Gypsy Moth Male Catch In 1996
With Multiple Catch Locations Highlighted



Gypsy Moth Male Catch

No Gypsy Moth Catch

Scale: 0 — 25 mi — 50 mi

Source: Data from MDA & APHIS, processed by DNR.

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

12/12/1996

FH, Gypsy Moth Multiple, 1996, 5000m buffer

Minnesota Department of Natural Resources

Eradication Sprays

Two areas were sprayed for eradication in 1996. The larger of the two areas, in Apple Valley (Dakota County), was approximately 240 acres in size in an urban setting involving several hundred homes. The other spray area in Lent Township (Chisago County) was only ten acres and was largely wooded with only five homes in the spray block. Both areas were sprayed twice with helicopter applications of 24 BIU of Bt Insecticide (Foray AF) one week apart on May 29 and June 5.

Spraying was delayed this year due to delayed phenology of the insects and host leaves. The Apple Valley site contained a school. Due to public concern for safety, the school grounds were not sprayed. Neither site contained any specific heritage concerns, natural or cultural. Several residents in Apple Valley were displeased with the spray operation and at least one resident left the area for a local motel.

Spray patterns provided good coverage of both areas. No moths were trapped during the trapping season at the Lent Township site. Eight moths were trapped at the Apple Valley site near the school that was not sprayed. Further actions will be undertaken in 1997.

Fall egg mass hunts failed to locate alternate life stages at any site in Minnesota in 1996. This is of particular concern at the Woodbury site (Washington County) where several multiple trap catches in conjunction with additional single catches indicate a high probability of a local infestation in that city. Intense trapping in 1997 will follow up all egg hunt areas. Trap patterns indicate that there may be as many as four isolated infestations in the Metropolitan Region.

Chlorotic oaks

Alkaline water induced chlorosis

Host:	Mainly white oaks and a few red oaks
Damage:	Discoloration, decline and dieback
Area:	10,000 acres
Severity:	Minimal to severe
Trend:	Unknown.

The problem exists with white oak (80+%), but we are seeing the problem on some red oak as well. Bur oak is unaffected (so far).The problem first shows up as mild chlorosis, a breakdown of the chlorophyl molecule causing the leaves to bleach out to a creamy-yellow, and then progresses to severe chlorosis, decline and dieback. Reports indicate the problem appears on a few branches and ultimately the entire tree in a few years. In its final stages, the earliest affected branches become attacked by two lined chestnut borer, not a big surprise considering the tree's condition. Death of the tree follows quickly. Oak wilt was not found on any of the trees.

Most of the problem is centered in the southern Metro Region where rainfall has lagged all season. As of mid-August, the core area was over 4.5" short for the year. Since most of the affected trees lie withing 50-75' of a house, driveway, street, or lawn, this suspiciously looks like an induced problem. Construction damage is not an issue, many of the homes are 25+ old, a little late for construction damage given the two major droughts during the period. This leads us to site issues. Soils over most of the area tend to be slightly alkaline (pH > 7.0) which will tend to tie up nutrients from nitrogen to iron. This is made worse by the fact that urban

soils tend to have a pH that rises over time due to lawn care practices such as leaf raking, grass clipping collection, liming, and watering.

Watering may be implicated as part of the problem. For example, the pH of city water commonly runs > 7.0 with 7.5 being typical. One city in the center of this problem, Bloomington, has a water supply AT THE TAP of approximately 8.5; St. Paul's water runs close to 9.0. Limited soil sampling showed chlorotic trees with soil in the 7.8 pH range while nearby healthy trees were in the order of 7.0 to 7.5. More investigations will be undertaken in 1997.

Diplodia shoot blight

Sphaeropsis sapinea (FR.:Fr.) Dyko and Sutton

Host:	Red, jack, ponderosa and Austrian pines
Damage:	Discoloration and dieback
Area:	Not determined
Severity:	Minimal to causing tree death
Trend:	Secondary to drought stress.

Normally confined to seriously stressed trees, Diplodia shoot blight is rather ubiquitous on stressed pines (ie: exposed windbreak trees, residuals left for wildlife habitat in harvest areas and compacted urban sites). Diplodia is common in the hard pines including native jack and red pines and ornamentals like Austrian and ponderosa pines. Normally appearing as a shoot blight, Diplodia kills the tips of individual branches. Damage is usually scattered about the tree giving the crown a peppered appearance of dead tips. As the disease develops, the killed tips increase in number and size until 30-40% of the crown is affected. By this time the tree has been so seriously weakened that pine bark beetles drop by for the kill.

This is much the scenario in the southern part of the Metro region where the stresses of urban life (ie. soil compaction, needle raking, lawn liming, poor thinning, just to mention a few) have increased Diplodia to the point where the *Ips* bark beetle is starting to work the pine trees. Add the stress of the "moisture shortfall" and you will find, now and into next year, dead pines.

FOREST NURSERIES

The two DNR tree nurseries provide forest tree planting stock for public and private use. The General Andrews and Badoura Nurseries have production capabilities of over forty million seedlings per year on their 270 acres of seedbeds. One, two, three and four year old trees are produced. Seedlings are sold for afforestation, reforestation, wildlife habitat, windbreaks, shelterbelts, erosion control and soil and water conservation. Since the beginning of operations in 1931, state nurseries have grown and shipped over 815 million seedlings for planting in Minnesota.

Insects and diseases included in this report:

Shoot blights of pine
White pine pocket mortality
Additional pest control operations

Shoot blights of pine

Sphaeropsis sapinea (FR.:Fr.) Dyko and Sutton

Host:	Red pine seedlings
Damage:	Shoot dieback
Area:	Windbreak "shadows"
Severity:	Light to moderate
Trend:	Reduction due to protectant sprays during budbreak and shoot elongation.

Shoot blight killed the tops of rising 2-0 red pine in both state nurseries where the seedling beds are adjacent to mature red pine windbreaks. Spring weather conditions were ideal for spore dispersal to newly elongating shoots in these windbreak "shadows". Protectant fungicide (chlorothalonil) spray operations were applied at both sites.

White pine pocket mortality

Secondary root rotting fungi (*Fusarium*) in association with standing water and poor nursery bed drainage.

Host:	White pine seedlings
Damage:	Moderate to severe in pockets
Area:	Proximal to irrigation lines and equipment paths
Severity:	Light to heavy
Trend:	Reduction due to avoidance of poorly drained bed locations and destruction of hard pans in nursery beds.

Studies are underway in cooperation with the USFS North Central Experiment Station and State and Private Forestry to study the effects of field cultivations techniques, irrigation line placement, cover crop management and soil compaction on white pine root rot fungi. See report in Special Projects section.

Additional pest control operations included:

1. The use Daconil drench treatments to control Diplodia in 3-0 red pines and foliar diseases on rising 1-0 and 2-0 choke cherry seedlings.
2. Malathion drench of hardwood and shrub seedling beds that were defoliated by grasshoppers and leaf hoppers.

WEATHER-RELATED DAMAGE

Water on the Northwestern Plains

Flooding

Host:	All species
Damage:	Discoloration and dieback
Area:	Acreage not determined ; occurring in Kittson, Marshall, Pennington and Polk Counties
Severity:	Not recorded
Trend:	None.

Aerial survey confirmed excessively wet conditions on the northwestern plains. During July flights, water was observed standing in fields and drainages were clogged with excess water. Two prevalent symptoms were discoloration and dieback in woodlots and shelterbelts. The severe winter of 1995-96 combined with continuing wet conditions throughout the summer contributed to the damage; but field checks in 1997 are needed to confirm causative and secondary agents of the symptoms observed in 1996.

Winter injury

Desiccation and low temperatures

Host:	All species
Damage:	Mortality, dieback and abnormal bud break
Area:	Scattered, but statewide
Severity:	Moderate to severe. The winter of 1995-96 led to some of the most spectacular and dramatic winter injury ever witnessed in Minnesota in the widespread injury to a large number of species.
Trend:	None.

During the winter of 1996 several new all time record low temperatures were recorded in areas across northern and southeastern Minnesota. Examples include Wadena, Staples, Thorhult, Littlefork, Gull Lake, Hibbing, Itasca, and Becker. In southeastern Minnesota new lows were recorded at the University of Minnesota in St. Paul, Winona, and Red Wing. In southeastern Minnesota where the topography can vary greatly, the temperatures are generally 10 to 15 degrees colder in the valley bottoms than the adjacent hill tops. During the February cold snap a tree farmer in Wabasha county recorded an unofficial -52F° degrees in a walnut plantation next to a stream in a valley bottom. A new official state record was recorded at Tower, Minnesota at -60F° degrees. The spring temperatures varied around the state in some areas and it was very late compared to normal years. In southeastern Minnesota the combined average April and May temperatures were the coolest recorded in thirty years.

The record cool spring resulted in very late emergence in a few species. By late May, the bur oak across wide areas of southeastern Minnesota had barely reached 40% leaf development. It appeared as if the bur oak was the only species that knew what was going on. Unfortunately most of this oak then experienced a widespread outbreak of anthracnose leaf disease, destroying the small leaves. By June 1st, much of this oak looked brown from a distance. It was late June before refoliation was complete. In urban communities, catalpa trees appeared dead until they began to expand their buds and produce foliage during the last week in June. There was some minor dieback in this species.

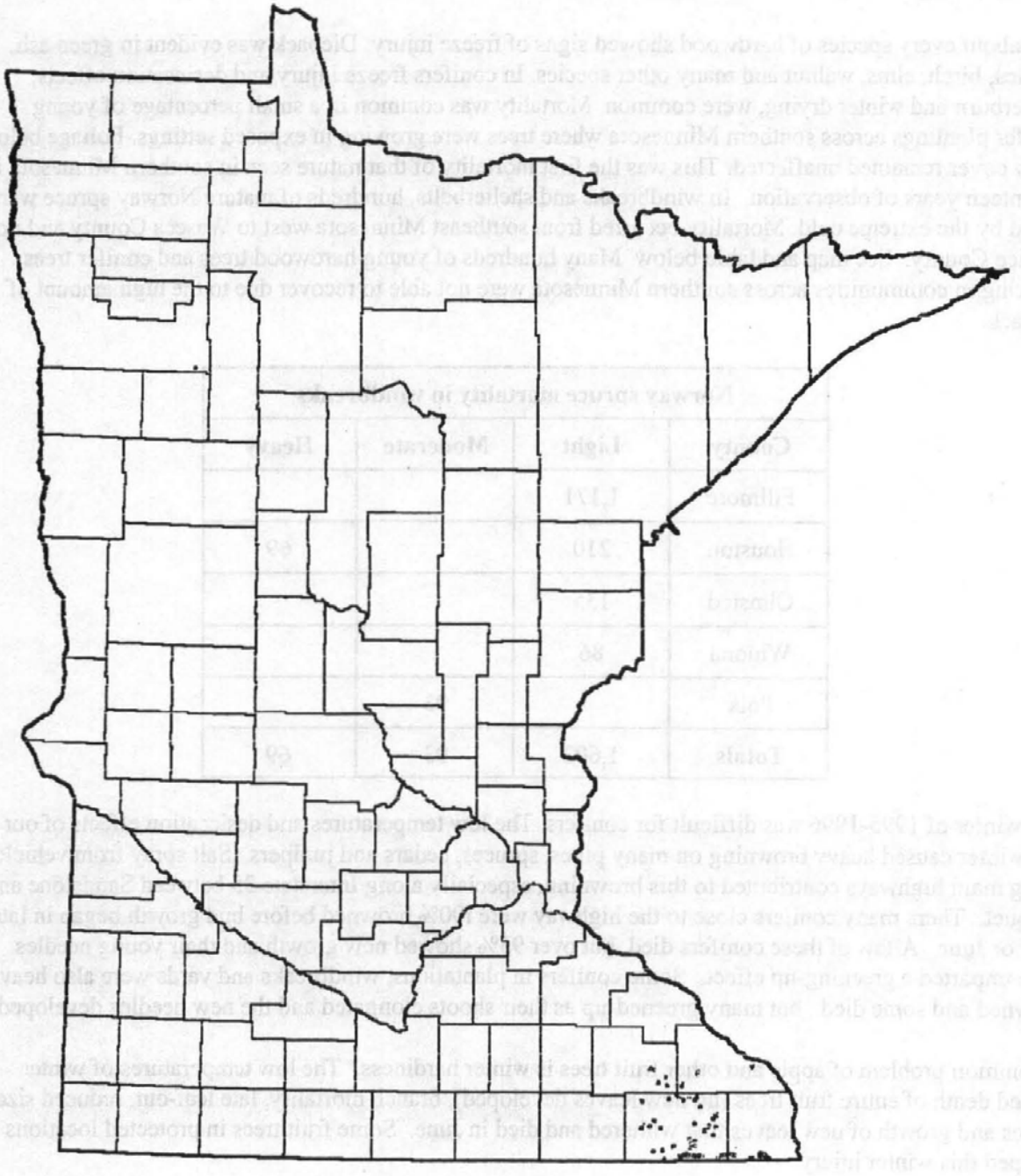
Just about every species of hardwood showed signs of freeze injury. Dieback was evident in green ash, maples, birch, elms, walnut and many other species. In conifers freeze injury and desiccation effects, winterburn and winter drying, were common. Mortality was common in a small percentage of young conifer plantings across southern Minnesota where trees were growing in exposed settings. Foliage below snow cover remained unaffected. This was the first mortality of that nature seen in southern Minnesota in seventeen years of observation. In windbreaks and shelterbelts, hundreds of mature Norway spruce were killed by the extreme cold. Mortality occurred from southeast Minnesota west to Waseca County and north to Rice County. See map and table below. Many hundreds of young hardwood trees and conifer trees growing in communities across southern Minnesota were not able to recover due to the high amount of dieback.

Norway spruce mortality in windbreaks			
County	**Light**	**Moderate**	**Heavy**
Fillmore	1,171		
Houston	210		69
Olmsted	135		
Winona	86		
Polk		93	
Totals	1,602	93	69

The winter of 1995-1996 was difficult for conifers. The low temperatures and desiccation effects of our last winter caused heavy browning on many pines, spruces, cedars and junipers. Salt spray from vehicles along main highways contributed to this browning, especially along Interstate 35 between Sandstone and Cloquet. There many conifers close to the highway were 100% browned before bud growth began in late May or June. A few of these conifers died, but over 95% showed new growth and their young needles have imparted a greening-up effect. Some conifers in plantations, windbreaks and yards were also heavily browned and some died , but many greened-up as their shoots elongated and the new needles developed.

A common problem of apple and other fruit trees is winter hardiness. The low temperatures of winter caused death of entire fruit trees (no new leaves developed), branch mortality, late leaf-out, reduced size of leaves and growth of new leaves that withered and died in June. Some fruit trees in protected locations escaped this winter injury.

Spruce Winterkill, Aerial Survey, 1996



Scale: 0 — 50 mi — 100 mi

Source: DNR Forest Ecosystem and Resource Assessment Units
Aerial Survey to National (USFS) standards or better.
Map production and analysis by EPIC
Minnesota Department of Natural Resources
Division of Forestry, Forest Health Unit

3/26/1997

INCIDENTAL PESTS

INSECTS

Insect	Host	County	Comments
Basswood thrips *Thrips calcaratus*	Basswood	Itasca	Sparse foliage on most basswoods in the county.
Birch leafminer *Fenusa pusilla*	White birch	Hubbard	Reported in mid June
Bladder gall mite Unknown	Plum	Beltrami	
Bronze birch borer *Agrilus anxius*	White birch	NW counties	Drought stressed yard birch
Bronze birch borer *Agrilus anxius*	Paper birch	Cass	
Crimson erineum mite *Eriophyes spp.*	Silver maple	Aitkin	Yard tree. Common on lower branch leaves of silver maple in central Minnesota.
Eastern pine shoot borer *Eucosma gloriola*	Jack pine	Lake of the Woods	Private plantation 95% of trees sapling size attacked
Fall webworm *Hyphantria cunea*	Apple, crabapple, elm, birch, cherry	Aitkin, Pine, NW counties	In August.
Flat leaftier of bur oak *Psilocorsis reflexella*	Red and burr oak	Aitkin, Chisago, Morrison	100% pupated in ground, 6/16, in Chisago county.
Lace bugs *Corythuca spp.*	Oaks, butternut	Crow Wing, Morrison	

Insect	Host	County	Comments
Linden twig gall midge *Cecidomyia citrina*	Basswood	Crow Wing	On a shade tree. Caused 95% bud blast. Later, refoliated.
Maple petiole borer *Caulocampus acericaulis*	Sugar maple	Aitkin, Crow Wing	Common on north shore of Mille Lacs.
Oak webworm *Archips fervidana*	Oak	Pine	
Oak spider mites *Oligonychus bicolor*	Bur oak	Crow Wing	
Orange spruce needle miner *Coleotechnites piceaella*	Blue spruce	Morrison	Yard tree
Pine leaf adelgid Not identified	Jack pine	Beltrami, Hubbard, Becker	White flecking on needles observed in August.
Pine bark adelgid *Pineus strobi*	Red pine, white pine	Crow Wing, Morrison	
Pine leaf aphid *Pineus pinifoliae*	Red pine	Pine	
Pine needle scale *Chionaspis pinifoliae*	White spruce	Beltrami, Hubbard, Koochiching	Mature white spruce plantation
Red pine cone beetle *Conophthorus resinosae*	Red pine	Sherburne	High populations inhabiting shoots, ranges from 1-20% of shoots on affected trees.
Saperda borer *Saperda calcarata*	Aspen	NW counties	Scattered trees
Spruce gall midge *Mayetiola piceae*	Spruce	Wadena	
Spruce mites Unknown species	White spruce	Roseau	Forming abnormal shoots on ornamental yard white spruce
Strawberry root weevil *Otiorhynchus ovatus*	Various shrubs	Crow Wing	
Two-lined chestnut borer *Agrilus bilineatus*	Red oaks	Becker, Hubbard	Yard trees
Webspinning sawfly *Cephalcia spp.*	Red oak	Crow Wing	.
White pine weevil *Pissodes strobi*	White pine	Lake of the Woods	Chip cocoons found in terminal leaders mid July

Insect	Host	County	Comments
Wood borers Various species	Hardwood species	Beltrami, Hubbard	Log homes and stored lumber
Wooly aphids Undetermined	Silver maple	Morrison	
Yellow-headed spruce sawfly *Pikonema alaskensis*	White spruce	Hubbard, Becker	Very light activity
Zimmerman pine moth *Dioryctria zimmermanni*	White pine, blue spruce	Crow Wing	

DISEASES

Organism	Host	County	Comments
Anthracnose *sp.*	Bur oaks, Maple	Beltrami, Clearwater	Late June mid July, Clearbrook - Nebish area
Armillaria root disease *Armillaria sp.*	Spruce, Balsam fir	Crow Wing, Beltrami	Yard trees.
Bark rot fungus *Perenniporia phloiophila*	Red oak	Crow Wing	
Black knot *Apiosporina morbosa*	Canadian red cherry	Aitkin	
Cytospora canker *Valsa kunzei*	White spruce	Roseau, Beltrami, Hubbard	Declining mature white spruce orchards windbreaks, yard trees. Increasing occurrence.
Diplodia blight and canker *Sphaeropsis sapinea*	Ponderosa pine	Pine	Ornamental trees.
Dutch elm disease *Ceratocystis ulmi*	American elm	Crow Wing	
Fire blight *Erwinia amylovora*	Apple	Hubbard, Beltrami	Showing up in early June.
Inonotus canker *Inonotus obliquus*	White birch	Roseau	Yard tree
Needlecast *Isthmiella faulli*	Balsam fir	Crow Wing	

Organism	Host	County	Comments
Phyllosticta leaf spot *Phyllosticta minima*	Maple	Hubbard	Reported in Park Rapids.
Pine needle rust *Coleosporium asterum*	Red pine	Crow Wing	Spores being shed 6/10.
Pine-pine gall rust *Endocronartium harknessii*	Scotch pine	Todd	Plantation 2 to 4foot tall trees.
Rhizosphaera needle cast	White spruce, Blue spruce	Roseau, Beltrami, Crow Wing, Isanti, Morrison	Common on yard trees.
Septoria leaf blight *Septoria musiva*	Balm of gilead	Cass	Locally heavy
Sulfur shelf fungus *Laetiporus sulfureus*	Oak	Crow Wing, Morrison	

ABIOTIC AND ANIMAL DAMAGE

Damage	Host	Location	Comments
Bird	White spruce Balsam fir	Beltrami, Hubbard, Lake of the Woods	Clipping off of previous seasons growth March-April possibly grouse feeding
Beaver	Birch, Aspen	Clearwater	Partial bark removal. Yard trees by stream
Maple decline	Sugar maple	Beltrami, Hubbard, Becker	
Winterkill	Ash, apple, balsam fir, juniper, maple, pear, pines, willow, and other thin-bark trees.	Central and northwestern counties	Effects included:sunscald, dieback and whole tree mortality.

PHENOLOGICAL NOTES

Accumulated degree days are calculations based on daily high an low temperature readings starting on March 1st of the year with the base temperature of 32F. For a given location, the degree days were calculated from readings at one of the following locations: Aitkin, Brainerd, Cloquet,Grand Rapids, Hinckley, Littlefork, Orr, Park Rapids, St. Cloud and Virginia.

Date	Event	Accumulated degree days	County
4/15	Snow cover up to 18 inches in shaded forest; some bare patches in forest openings.	51, 55	Aitkin, Kanabec, Isanti
4/16	Aspen buds swollen. East central counties are snow free.	62	Chisago, Pine
4/17	Pine bark beetle traps set out at the Region 2 office.	63	Itasca
4/28	Aspen catkins are out.	146	Itasca
5/ 6,7	Snow almost 2 feet deep. 20°F last night. Some forest roads near Ely still have too much snow for travel.		St. Louis
5/6	Willows and aspen in bloom	250	Aitkin, Carlton, Crow Wing
5/6	Elm, silver maple and sugar maple blooming	332	Crow Wing
5/6	10-25% of aspen have catkins	238	Itasca
5/6	<50% of aspen have catkins out. Caragena buds green and expanding.	277	Pine
5/6	Most maples and elms flowering.	277	Chisago
5/6	Willows showing green.		Ramsey

Date	Event	Accumulated degree days	County
5/7	Dandelions blooming	246	Todd
5/ 8	Red maple starting to flower. Last of the big patches of snow starting to melt.	272	Itasca
5/ 8	A few *Ribes* leafing out.	187	Koochiching
5/9	Forest tent caterpillars hatched from collected egg masses. Basswood buds 1/4 inch long.	285	Todd
5/18	First bark beetle caught in pheromone traps.	455	Itasca
5/18	Marsh marigold in bloom.	463, 455	Aitkin, Itasca
5/19	Sugar maple flowering. Arrowwood blooming.	493	Itasca
5/20	White pine blister rust aeciospores being produced. Found 1 second instar spruce budworm spinning down from a white spruce. White spruce buds just starting to swell.	523	Itasca
5/21	Spruce bud caps detached at base and still covering most of the buds which are ½ to 3/4 inches long. White oak, basswood and aspen leaves 1 ½ -2 inches. Elm and black ash leaves are ½ to 1 inch. Black cherries starting to bloom. Bellwort almost done. Marsh marigolds still in bloom. *Thalictrum* buds visible.	665	Stearns, Morrison
5/21	Juneberries and choke cherries starting to bloom.	549	Itasca
5/22	White pine blister rust shedding aeciospores.	706	Cass, southern
5/22	Hoary puccoon blooming. Red and white oak leaves ½ to 2 inches long.	706, 691	Crow Wing, Morrison
5/23	Marsh marigold blooming	716, 597	Morrison, Todd
5/23	Choke cherries and pin cherries starting to bloom. Juneberries blooming heavily.	724, 716	Crow Wing, Morrison

Date	Event	Accumulated degree days	County
5/24	Juneberries starting to flower.	615	Itasca
5/28	Red pine pollen being shed. Balsam fir buds ½ to 1 inch long, flaring slightly. Bigtooth aspen leaves are 1 inch long. Pin cherries starting to bloom, also Trillium and yellow rocket. First mosquitos out.	704	Itasca
5/29	*Ribes* in bloom in white pine plantation, also choke cherries. Black walnut starting to leaf out in town. Bark beetles still coming into traps. A few went into trap logs and are constructing galleries and laying eggs.	730	Itasca
5/29	Jack pine pollen starting to be shed.	875	Crow Wing
5/29	Trillium blooming	730, 864	Itasca, Morrison
5/29	White pine blister rust aeciospores being shed.	875, 730	Crow Wing, Cass, Itasca
5/29	Cotton grass blooming in wetlands	735, 707	Aitkin, Carlton
5/30	Bur oak leaves webbed together by *Psilocorsis reflexiella.*	891, 754, 794	Morrison, Aitkin, Chisago
5/30	Spruce budworm in 3rd instar.	908	Crow Wing
5/30	White spruce pollen nearly done and shoots about 1 inch; bud caps still on but needles visible. Aspen leaves nearly 2 inches. Bigtooth leaves ½ to 1 ½ inches. Ash buds breaking. Oak leaves less than 2 inches. Maple seeds pendant. Jack pine candles 1-3 inches. Red pine candles 2-3 inches, pollen present. Basswood leaves 2 inches. Wild strawberry, yellow rocket and hoary puccoon in full bloom. Trillium past peak. Large dragonflies are out.	750	Cass, northern
5/31	Aspen seed being shed profusely.	778	Itasca
6/2	Elderberry in bloom	839	Itasca

Date	Event	Accumulated degree days	County
6/3	Basswood thrips present; basswood leaves about ½ of full size. Black ash just starting to break bud. In bloom: Juneberry, elderberry, Trillium and cotton grass.	834	Carlton
6/3	Balsam fir buds 1/4 to ½ inch long, needles tight; shedding pollen. Lots of male cones this year; some trees look off-color.	834	St. Louis, southern
6/3	Lilacs (in towns) are blooming.	867	Itasca
6/4	Forest tent caterpillars ½ to 1 and 1/4 inches on basswoods.	901	Todd
6/4	Ohio buckeye in peak bloom. Heavy pine pollen release this year. Temps hitting 80° for last few days.	882	Itasca
6/4	Lots of needlecast in understory balsam fir. Aspen fluff is in the air. Wild strawberry in bloom. Juneberry done flowering, choke cherry almost ready to flower.	926	St. Louis, central
6/5	Spruce budworm 1/4 inch long = 3rd instar. White spruce shoots ½ to 2 inches long. Jack pine pollen shed starting. Mt. ash starting to bloom.	905	Itasca
6/5	Jack pine pollen about 100% shed	1066	Crow Wing
6/6	Spruce budworm in 4th instar. Spruce bud caps about 90% shed.	1096	Crow Wing
6/6	Very few caterpillars of aspen defoliator complex found.	972	Pine
6/6	Winter cress blooming	927, 785	Itasca, St. Louis
6/6	Red columbine blooming	1096, 927, 1079	Crow Wing, Itasca, Morrison
6/6	Wild lupine blooming	1096, 1079	Crow Wing, Sherburne
6/7	Spruce budworm in 5th instar.	1129, 1110	Crow Wing, Sherburne
6/10	Pine needle rust spores being shed.	1244	Crow Wing

Date	Event	Accumulated degree days	County
6/11	Painted cup and Indian paintbrush blooming	1085	Itasca
6/12	Air is thick with pine pollen. Spruce budworm mostly 4th and 5th instars. White spruce shoots 1 to 3 inches long. Balsam fir leaders are >6 inches and needles are flaring. Dandelion seed heads are fluffy. Choke cherry bloom is past. Columbine is blooming. Milkweed plants 1 ft. tall.	1126	Itasca
6/13	Callow adult bark beetles observed.	1205	Itasca State Park
6/13	*Mertensia* blooming		Cook, (along North Shore)
6/14	Spruce budworm 5% pupated and mainly last instars remaining.	1389	Crow Wing
6/14	Orange hawkweed blooming	1244	Pine
6/17	Spruce budworm 60% pupated . Downy phlox blooming	1484	Crow Wing
6/17	Forest tent caterpillars 1 and 1/4 to 2 inches long on basswood.	1484	Cass
6/17	Painted cup (yellow variety) blooming	1471	Morrison
6/18	Blue flag blooming	1325, 1363	Aitkin, Pine
6/20	Forest tent caterpillars 1 and 3/4 to 2 inches long on basswood.	1457	Todd
6/20	A single Jack pine budworm caterpillar found. 6th instar.	1567	Morrison
6/20	A few pale green weevils showing up in Grand Rapids.	1399	Itasca

Date	Event	Accumulated degree days	County
6/21	Red pine sawfly larvae are 1" long. Anthracnoseon green ash caused leaf drop. Heavy seed set on red maples. Raspberry-spruce cone rust starting to show symptoms. Two observations of single forest tent caterpillars, 1 and 1/4 inches long. Orange hawkweed just starting to bloom. Buttercup in full bloom.	1435, 1244	Itasca, St. Louis, central
6/21	Indian paintbrush and yellow hawkweed blooming.	1414	Aitkin
6/24	Spruce budworms 100% pupated and a few moths seen.	1697	Crow Wing
6/24	10% spruce budworm pupation, rest in 5th and 6th instars. A little birch leaf miner showing up.	1510	Itasca
6/24	Spruce budworm is 30% pupated. In bloom: wild rose, buttercup and Lab tea.	1510	Itasca, northern
6/24	Spruce budworm is 20% pupated. Not much defoliation this year.		St. Louis, northern
7/1	Yellow-headed spruce sawfly larvae are ½ to 1 inch.	1988	Crow Wing
7/1	Spruce budworm 90-100% pupated. Lots of dead birch along Echo Trail.		St. Louis, northern
7/1	Mountain ash sawfly larvae are ½ to 1 inch long.	1772	Itasca
7/1	Birch crowns showing damage from birch leaf miners.		Across NE counties
7/1	Butterfly-weed blooming	1988, 1991	Crow Wing, Sherburne
7/2	Saw 1 spruce budworm moth; About 80% pupation. In bloom: orange hawkweed, buttercup, dogwood.		St. Louis, northern
7/2	30% spruce budworm moth emergence.	1805	Itasca
7/3	Ox-eye daisy blooming. Hairy hawkweed blooming. Common buttercup blooming.	1871	Pine

Date	Event	Accumulated degree days	County
7/8	Bridal wreath blooming	2228,2034	Crow Wing, Cass
7/9	Red berried elder has red berries, now. Milkweed just starting to bloom.	2061	Itasca
7/17	Spotted knapweed starting to bloom. Wood lily and Turk's cap lily blooming.	2365	Pine
7/30	Black ash defoliated by unknown caterpillar. Aspen blotch miner is showing up, also on balm of gilead. Reports of FTC near Littlefork.	2558	Koochiching
7/31	Aspen blotch miner pupated inside mines. Sunflowers, tanzy, goldenrod and wild bergamot blooming	2844	Pine
8/1	Burr oak leafminer pupae present, *Cameraria* spp.	3089	Stearns
8/1	Wooly alder aphid on silver maple.	2714	Carlton
8/5	Mountain ash sawfly larvae (second generation).	3225	Crow Wing
8/6	Purple fringed orchis in full bloom	3011	Itasca
8/7	Wooly alder aphid on silver maple.		Lake
8/13	Fall webworm on alder.	3261, , 3153	Itasca, Lake, St. Louis, southern
8/13	Red headed pine sawfly larvae about 1 inch long on jack pine.	3261	Itasca
8/14	Aspen bronzing noted.	2976	St. Louis, central
8/23	Pearly everlasting and blue asters blooming		Cook, Lake (along North Shore)
8/27	White spruce trees have pinkish cast to them because of needle rust infection.	3750	Itasca
8/28	Blooming: joe-pye weed, Jerusalem artichokes, "plumose" goldenrod, sow thistle, purple aster, some black-eyed Susans and bluestem is ripening.	3780	Cass, northern

Date	Event	Accumulated degree days	County
9/2	A few black ash just starting to turn yellow for the autumn.	3969	Itasca
9/11	Fall coloration: dogbane, bracken fern.	3899, 4270	St. Louis, southern, Itasca
9/12	Fall defoliators on bur oak. Orangestriped oakworms were 2 inches long; redhumped oakworms were 1 and ½ inches long.	4588	Morrison
9/30	Still catching a few bark beetles in pheromone trap.	4645	Itasca
10/1	Good fall coloration, yet still many trees with green leaves. Have had spotty frosts in county, mostly low areas.	4661	Itasca
10/2	First widespread frost. Most black ash have lost their leaves.	4678	Itasca
10/4	Probably peak fall coloration.	4691	Itasca

SPECIAL PROJECTS

Project list

Hazard tree program accomplishment report: 1987-1996
National "Train-the-trainer" hazard tree session developed and held
EPIC GIS development
Aerial survey standards for the Lake States
Spruce budworm and balsam fir: How much is enough?
Field and lab studies of *Lirula* spp. on balsam fir needles
"HOW TO identify and manage needlecast diseases on balsam fir"
PEST ALERT "Rhizosphaera needle disease of fir"
Oak wilt suppression: Millionth foot celebration
Tours to Wisconsin highlighting hardwood poletimber management
Bark beetle infestation of old growth pines at Itasca State Park
White pine blister rust collections
White pine mortality at Gen. Andrews State Nursery
Cold hardiness study
Fungal surveys at the Nurseries
Aitkin Home Page
RX 340: Introduction to Fire Effects

Hazard Tree Program
Accomplishment Report: 1987-1996

(Presented to the Forestry - Division Management Team on November 25, 1996)

Our work formally began in September of 1987 when the FHU was invited to come down and rate Sakatah State Park for hazard trees after a "near miss". Existing systems did not work for us, so over a period of a few months , we put together a rating system that we thought would work in recreational areas. Subsequently, the rating system turned into a manual and Department training program and then the FHU set to work on hazard trees in the urban setting. Now the manual has a nationwide audience.

The rating system

The rating system is based on visual assessment; we are looking for external symptoms of internal structural weakness. Our task in hazard tree management is not to sanitize the recreation area/ urban setting but to provide for reasonable public safety. Trained people can probably find 80% plus or minus 10% of the hazard trees that are there. There is no such thing as "zero risk" in hazard tree management.

Trees fail in predictable patterns; as species, they are vulnerable to certain pests and as individuals, they have their own history of injuries and diseases. The rating system has seven categories for people to use to inspect trees. They are cracks, decay, canker, weak branch unions, dead branches or trees, root problems and poor tree architecture.

Early in the process of developing the rating system and writing the manual, we thought that the hazard tree program should have these attributes:

SIMPLE	easy to learn and use; not cumbersome in the field.
DOABLE	each Division has sufficient staff and funding to implement it.
SCIENTIFIC	system based on tree biomechanics, biology and pathology.
STANDARDIZED	inspected trees rated and treated similarly regardless of the owner or manager.
FOCUSED	increased attention paid to sites with high occupancy, long duration of occupancy and type of site (ie: wilderness trail versus handicap accessible campsite).
DOCUMENTED	inspections and ratings on paper; records kept at local manager's office.
EMPOWERED	local manager has both authority and responsibility for hazard tree management on the site.
PRESERVES	the system preserves the nature of the site and provides for reasonable human safety.
PREVENTS	the system suggests many ways to avoid creating hazardous trees.

In retrospect, another attribute could be added to this list, adaptable.

ADAPTABLE	system can be built upon, altered or adapted to local needs and uses.

We think this is why it has gained so much popularity and is spreading from recreational uses to urban uses. It also filled a need in the 1990's for a rating system that was neither complicated nor biased.

During the development of the system (and the Manual and Op order), we had training and guidance from Dr. Alex Shigo, a renowned forest pathologist.

The Manual

The manual defines basic set of standards for judging defective trees as hazards and defines schedules for rating sites by type and frequency of use. The Manual and Op order were written simultaneously. They were a Departmental effort; representatives from the Divisions of Forestry, Trails and Waterways, Parks and Fish and Wildlife were all on the committee. The technical portions were written solely by FHU. Other forest health specialists from State & Private Forestry, Wisconsin and Michigan reviewed and suggested some changes before it was finalized.

A good gauge of the success of the hazard tree program is in the distribution and use of the Manual. See list below. We originally printed 2000 copies and used them up in one year, revised and reprinted another 10,000 copies and are now running out. S&PF provided monies for the first two printings.

Organizations that have adopted or adapted the Manual		
State Agencies	**Universities**	**Federal and Others**
Minnesota DNR, DOT	Univ. of Minnesota	USFS - NE Area
Wisconsin DNR	Univ. of Wisconsin	FEMA
Michigan DNR	Penn State	TVA
Illinois DNR	Univ. of Maine	BIA (NE USA)
Iowa DNR	Delaware State Univ.	National Parks (NE USA)
Missouri DNR	Univ. of East Shore Maryland	National Institute of Health
Ohio	Univ. of Arizona	Army Corps of Engineers
Pennsylvania DNR, DOT		NE Plant Pathology Group
New Jersey Transit Authority		National Zoo
W. Virginia		Bartlett Tree Co.
Delaware		City of Philadelphia
Maryland		City of Washington, DC.
Maine		> 200 communities in Minnesota
Vermont		
New Hampshire Extension		
New York Dept. Env. Conserv.		

Organizations that have adopted or adapted the Manual		
State Agencies	**Universities**	**Federal and Others**
Massachusetts		
Connecticut		
Rhode Island		
Colorado		
Montana		
Washington		
Oregon		
California		
Alaska		
Georgia		

Operational order

Parks adopted the rating system in 1988 and the Division of Forestry suggested creating an Operational order so that the Divisions of Forestry and Parks would be standardized in their treatment of hazard trees in parks and campgrounds. Our policy goal was and is "to provide for public safety" first and then to preserve a natural setting in our recreation areas and administrative sites. Liability was not a driving force. The Op order codifies the manual and defines responsibilities for DNR personnel. Again, it was written by the Divisions with legal guidance by the Attorney General's office. The Op order was signed three years later by the Commissioner, primarily because we wanted to have the Manual and Op order to become official at the same time.

Training by the FHU

This is where the bulk of the effort and time has been spent, especially in the last five years. Back in 1988, the FHU put on a one day session for 125 Departmental personnel featuring Dr. Shigo who spoke about tree biology and hazardous trees. There was a hiatus of three years because the Attorney General's advice was to have both the Op order and manual in place before holding any more training.

The manual was written as half of the training package, the other half is the training session itself. Since 1992, the FHU has trained approximately 1000 people in Minnesota (350 = DNR) and has conducted four out-of-state HT training sessions for other state's DNRs. See table below. The purpose of training is to "calibrate the students eyes", that is, to show them what the categories mean in real life. For example, when does a cracked stem become dangerous?

Hazard tree training sessions - 1992 to 1996		
Location	**Date**	**Number trained**
Side Lake	3/9/92	22
Bemidji	3/10/92	38
Brainerd	3/11/92	31
Whitewater	3/92	33
New Ulm	3/26/92	25
Rosemont	2/23/93	47
New Ulm	3/26/93	20
Bunker Hills	4/15/93	26
Detroit Lakes	10/18/93	39
Redwood Falls	10/21/93	18
Rochester	10/26/93	32
Phalen Park, St. Paul	10/28/93	28
East Lansing, Michigan	1/27/94	9
East Lansing, Michigan	2/95	250
Burnsville	3/2/95	31
Baker Park Reserve	10/19/95	23
Bemidji *	10/25/95	25
Bemidji, Elec Coops	10/26/95	27
Cloquet *	10/27/95	30
Jefferson City, Missouri	2/21/96	29
Jefferson City, Missouri	2/22/96	27
Bloomington *	5/96	30
Cloquet	10/1/96	31
Bloomington	10/21/96	26
Minneapolis, Building Inspectors	11/13/96	17

* = An estimated class attendance.

The FHU received a federal grant from the USFS-Urban Tech Group in Chicago to host a national "Train-the-Trainer" session in May of 1996. See the following section for a complete report.

The educational aids we've created include: lecture slide sets, a poster, a CD of all the slides and lecture notes from the Train the Trainer Session and a pamphlet, "How To recognize Hazardous Defects in Trees" . The How To was funded by S&PF and we cooperated in writing this pamphlet which is aimed at the homeowner audience. First printing was 100,000 in January of this year. It can also be downloaded off the Internet.

Training by the USFS

State and Private Forestry has also been instrumental in promoting the rating system and using the Manual for their training sessions in the Northeast. Three offices (including St. Paul) have their own hazard tree training staff and, as of September, they've held 43 sessions for 1000 people.

Where are we going?

Rating	We continue self education for benefit of ourselves, our trainees and next edition of the Manual.
Manual	There is a definite need to reprint, hopefully, update it too.
Op order	We try to ensure that hazard tree inspections occur on Forestry recreation sites each year.
Training	We continue to train DNR personnel. In the spirit of interagency cooperation, we are including new faces as trainers in our training sessions because the demand for training is outstripping our ability to provide it.

National "Train-the -trainer" hazard tree session developed and held

On May 7-9, DNR-Forestry held a special three day workshop in cooperation with the Urban and Community Forestry Center for the Midwest and S&PF's Forest Health Protection Unit in Bloomington, Minnesota. The workshop was designed to provide lead professionals in each participating state with information fundamental to initiating a Hazard Tree Management Program with an urban focus. Eleven states participated, including nine Northeastern Area states plus Montana and Kentucky. Attendees tended to be Urban Forestry staff or foresters attached to state Highway Departments.

The session was designed as a series of lectures with copious amounts of discussion and interaction time. An afternoon field trip was held at nearby Ft. Snelling State Park providing a hands on experience. Lectures included a session on legal considerations presented by an attorney from the Minnesota Attorney General's Office who has specialized in tree-related cases.

As part of the program, several Hazard Tree Management products were prepared in addition to the Workshop Notebook. These included a 35 mm slide set (also provided on CD-ROM), a cooperatively produced "How To" publication for national distribution, and a Hazard Tree pin to be used as recognition in training programs.

EPIC GIS Development

DNR Forestry continued to develop a user friendly, desk top GIS product for Forest Health information access with the release of a 16-bit version to parallel the release of EPPL7 Version 3.0. The program is already being used to provide timely analytical, modeling, and mapping of forest health information ranging from aerial detection survey, to climatic data, to forest covertyping. In addition to supporting "access to information", the EPIC development has build partnerships with other state and federal agencies is build a rich data base including over 350 thematic layers including historical pest outbreaks since 1950, climatic averages, soil information, ecosystem information, FIA data, and pollution control. The 1997 work plan calls for the creation of a Windows-based version with even greater analytical and modeling capacities. Internet access is also being investigated.

Aerial survey standards for the Lake States

The Federal Forest Health Monitoring Program requested that the aerial survey standards be determined on a regional basis. To that end, Forest Health Specialists from the Lake States have been working together to draft regional standards. So far, it looks like Minnesota's standards (as published in last year's Annual Report) are the basis for the Lake States' standards along with a few modifications.

Spruce budworm and balsam fir: How much is enough?

Northeastern Minnesota is experiencing its forty-third consecutive year of spruce budworm outbreak. See table. While the budworm population and the number of acres affected have had their ups and downs and the locations affected have shifted around the area, the outbreak has persisted since 1954. See maps.

Forty three years seems like an awfully long time for an outbreak to persist. Is this normal? Is this a change from the past? Have other localities experienced a change in the duration and intensity of spruce budworm outbreaks? If the pattern of budworm outbreaks has changed, what might have allowed it or caused it? In this article I will look at these and other questions and suggest some possible answers.

Outbreaks

Native insects, such as spruce budworm, usually exist at low, endemic levels held in check by parasites, diseases, predators (including birds), weather and the amount of food they can find. It's likely that a spruce budworm outbreak begins when a restraining factor, such as weather or the amount of food, changes. This allows the budworm population to increase and the parasites and predators are not able to kill or eat enough of the budworms to bring the population under control. The population stays in an outbreak state until much of its food source, the mature and overmature balsam fir, is used up. As the food supply dwindles, the population starts to collapse and the parasites and predators are again able to hold it in check at low levels. White spruce is also a suitable food source for budworms.

The previous spruce budworm outbreak in Minnesota lasted from 1912 into the early 1920's. This fits the typical budworm outbreak pattern with outbreaks lasting from eight to ten years. However, since 1954, spruce budworms have been causing a long standing outbreak. What caused the change? According to Blais, a Canadian researcher, outbreaks are related to forest composition and are most likely to occur when mature stands of balsam fir cover extensive areas.

Outbreaks usually kill much of the balsam fir and some white spruce in the area. After that, the budworm population declines to a barely detectable, endemic level and another budworm outbreak may not develop for thirty to sixty years when much of the balsam fir would again be mature and overmature. The literature indicates that this type of a boom or bust population cycle of spruce budworm was probably typical over the past couple hundred years in Minnesota.

Increasing in duration and frequency

Researchers in other parts of eastern North America have also observed a change in frequency, intensity, and duration of spruce budworm outbreaks. According to Hardy (1985), spruce budworm outbreaks have been known to occur in eastern North America for at least the past 300 years. In the first 200 years of known budworm outbreaks, the outbreaks tended to be localized not spreading to adjacent forests and consecutive outbreaks were usually separated by at least 60 years. However, this pattern changed in the 20th century. In looking at outbreaks in eastern Canada, Blais (1983) found that twenty one outbreaks took place in the period of 1900 to 1980, compared to nine outbreaks in the preceding 100 years. Also while earlier outbreaks were restricted to specific regions, those in the 20th century coalesced and increased in size. Blais concluded that the recent outbreaks in eastern Canada have become longer, more frequent, more severe and covered more acreage.

According to Hardy, northern Minnesota is in a corridor of thermal preference which often has weather conditions favorable to the budworm. This corridor is based on mean summer and annual temperatures and extends from Minnesota to Maine in the US and from Manitoba to New Brunswick in southern Canada. In the past, this corridor was dominated by non-host forest covertypes. When weather conditions favorable to budworm developed, budworm outbreaks would erupt in localized areas of host trees and stands but would soon collapse because their host trees were not abundant. In this century, in eastern Canada, the corridor has been invaded by spruce and balsam fir and increases in the abundance of fir within the corridor have increased the amount of food available to the budworm. Now both climate and a favorable abundance of host trees exist most of the time in the corridor. Outside the corridor, in the boreal forests to the north, budworms are still forced to wait for favorable weather conditions to take advantage of the plentiful food source, causing sporadic and local outbreaks there.

Human alterations of the forest

Blais felt that in eastern Canada, humans have increased the frequency, extent and severity of spruce budworm outbreaks by changing the forest ecosystem. Humans have altered the forest composition primarily through cutting practices and fire protection which greatly increased the amount of balsam fir. These practices have rendered the forest more prone to budworm attack.

It is likely that humans have altered the forest ecosystem in Minnesota in much the same way and contributed to a change in the pattern of spruce budworm outbreaks. While there is currently inadequate data for comparing the amount of balsam fir in pre-European settlement times to now, we do know that portions of northeastern Minnesota have more balsam fir and older balsam fir than they did in the preceding century. According to Lee Frelich (1995), the unlogged areas in the Boundary Waters Canoe Area now contain twice as much spruce-fir-birch as was recorded in presettlement times but less than a third as much red/ white pine. This shift is to be expected because the relative lack of fires since 1910 has prevented establishment of new pine stands and has allowed spruce and fir to succeed in the existing pine stands. Balsam fir is a very fire sensitive species, and prior to 1910, the higher frequency of fires would have killed more of the balsam fir, reducing its abundance. In the Chippewa National Forest, Almendinger (1996) found that balsam fir had generally increased from 5.4 percent of the Public Land Survey bearing trees to 9.0 percent of the 1990 Forest Inventory Analysis trees. The Public Land Survey was conducted between 1864 and 1896.

Cutting practices in this century have also affected the abundance, geographic distribution and age class distribution of balsam fir in Minnesota. Until recently, balsam fir had very few markets resulting in little cutting of balsam fir stands. This perpetuated more mature and overmature balsam fir. In mixed-species stands, scattered balsam fir were often left standing while other species were cut around them. Also balsam fir is fairly shade tolerant and often comes in as an understory component in other covertypes, especially aspen and birch. As these hardwood stands age, the balsam fir

starts to poke through the canopy and these stands become mixed stands of aspen, spruce, balsam fir and birch.

Putting all this information together, it appears likely that the forty-three year spruce budworm outbreak in northeastern Minnesota is a result of the budworm adapting to an increase in the amount and age of balsam fir.

Symptom of overpopulation

Within the corridor of thermal preference, past budworm outbreaks were minimized because of the scarcity of balsam fir. Human alteration of the forests within the corridor has resulted in more and older balsam fir in a climate that favors spruce budworm. In the last half of this century, these changes have resulted in longer, more frequent and severe outbreaks in eastern Canada and a forty-three year outbreak in Minnesota. These outbreaks could be viewed as a symtom of overpopulation by balsam firs in northeastern Minnesota.

Spruce budworm and balsam fir have evolved together in North America. Outbreaks, as well as fire, are a natural part of the ecosystem where balsam fir occurs. Although balsam fir grows well within the corridor, budworm outbreaks along with fire usually kept the balsam fir populations at lower levels. Budworm plays a beneficial role in killing mature, overmature and deteriorating balsam fir stands and in rejuvenating young, healthy stands of balsam fir. Outbreaks also benefit the forest by reducing balsam fir populations and encouraging other species. Budworm is able to kill off vast acreages of balsam fir, making the landscape prone to stand replacement fires and reinvasion by pines and aspen. By altering the historical pattern of outbreaks, budworm may be maintaining a healthy ecosystem by partially replacing the role of fire.

"Since extensive stands of mature balsam fir are the main prerequisite for budworm outbreaks, any action that results in maintaining or increasing the balsam fir content of the forest is likely to contribute to rendering it more prone to budworm attack "(Blais). Management activities including planting balsam fir, extending the rotation age, leaving scattered overstory residual balsam fir in harvested areas, regenerating balsam fir using shelterwood or partial cuts during a budworm outbreak are all designed to maintain the balsam fir content and age of the forest. This should assure the budworm of an abundant food supply and may extend an already long outbreak. It also holds the promise of longer and more frequent outbreaks in the future.

Which brings us back to our original question. How much balsam fir is enough? Perhaps the continuous outbreak of spruce budworm could be viewed as evidence that there currently is more balsam fir than can be sustained in northeastern Minnesota.

Citations

Almendinger, J.C. 1996. Trees of the Chippewa Forest Then and Now. Roots, MN DNR-Forestry, June. p 1.

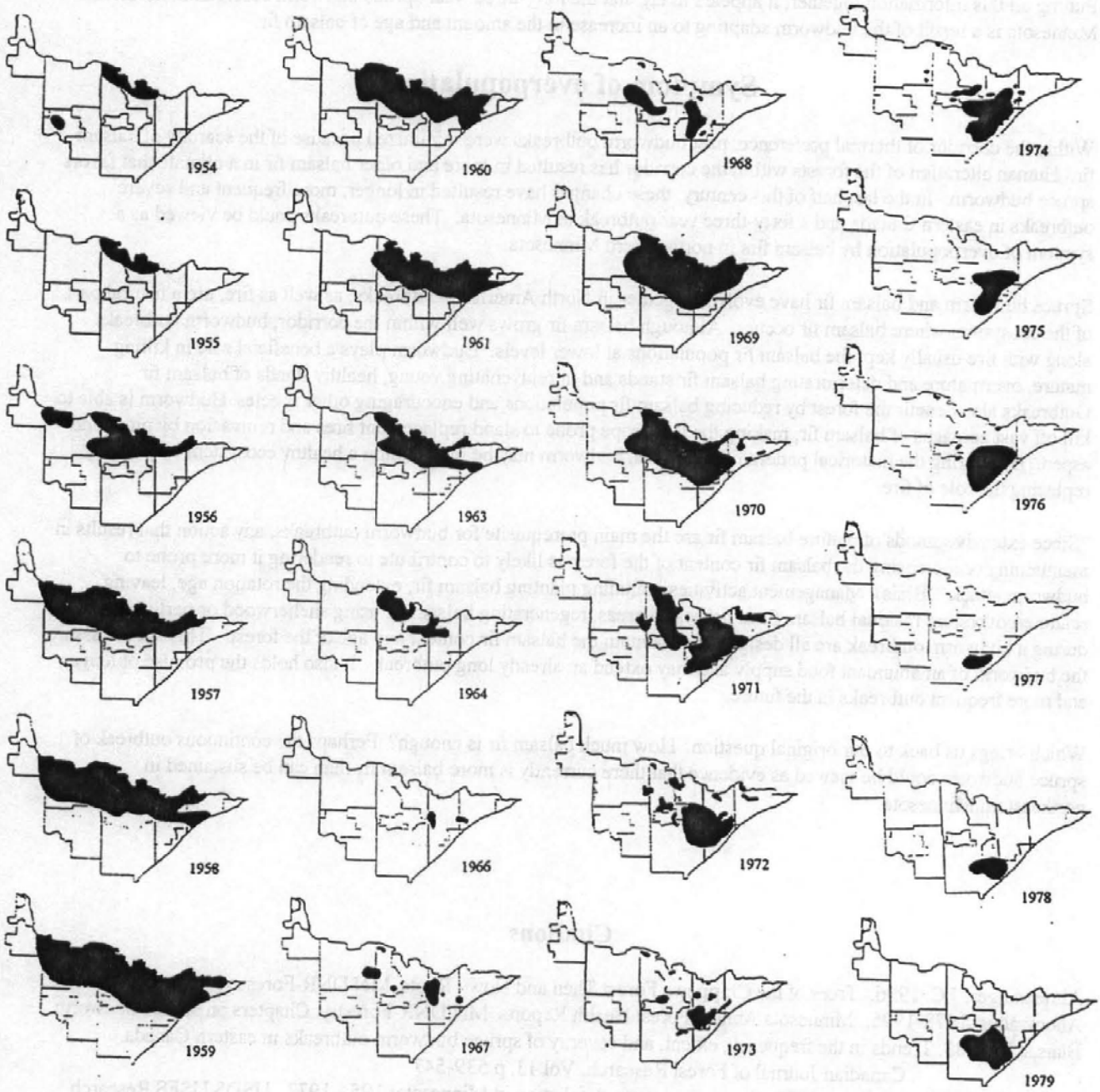
Anonymous. 1978-1995. Minnesota Annual Forest Health Reports. MN DNR-Forestry. Chapters on spruce budworm.

Blais, J.R. 1983. Trends in the frequency, extent, and severity of spruce budworm outbreaks in eastern Canada. Canadian Journal of Forest Research. Vol.13. p 539-547.

Erickson, G. and A. Hastings. 1978. Spruce budworm defoliation in Minnesota: 1954-1977. USDS,USFS Research Note NC-243.

Frelich, L.E. 1995. Old Forest in the Lake States Today and Before European Settlement. Natural Areas Journal. Vol 15(2) p 157-169.

Hardy, Y. 1985. Dynamics of Spruce Budworm Epidemics. In: Spruce-fir Management and Spruce Budworm, Proceedings of the Society of American Foresters Region VI Technical Conference. USDA U.S.F.S. NE FES, GTR-NE-99.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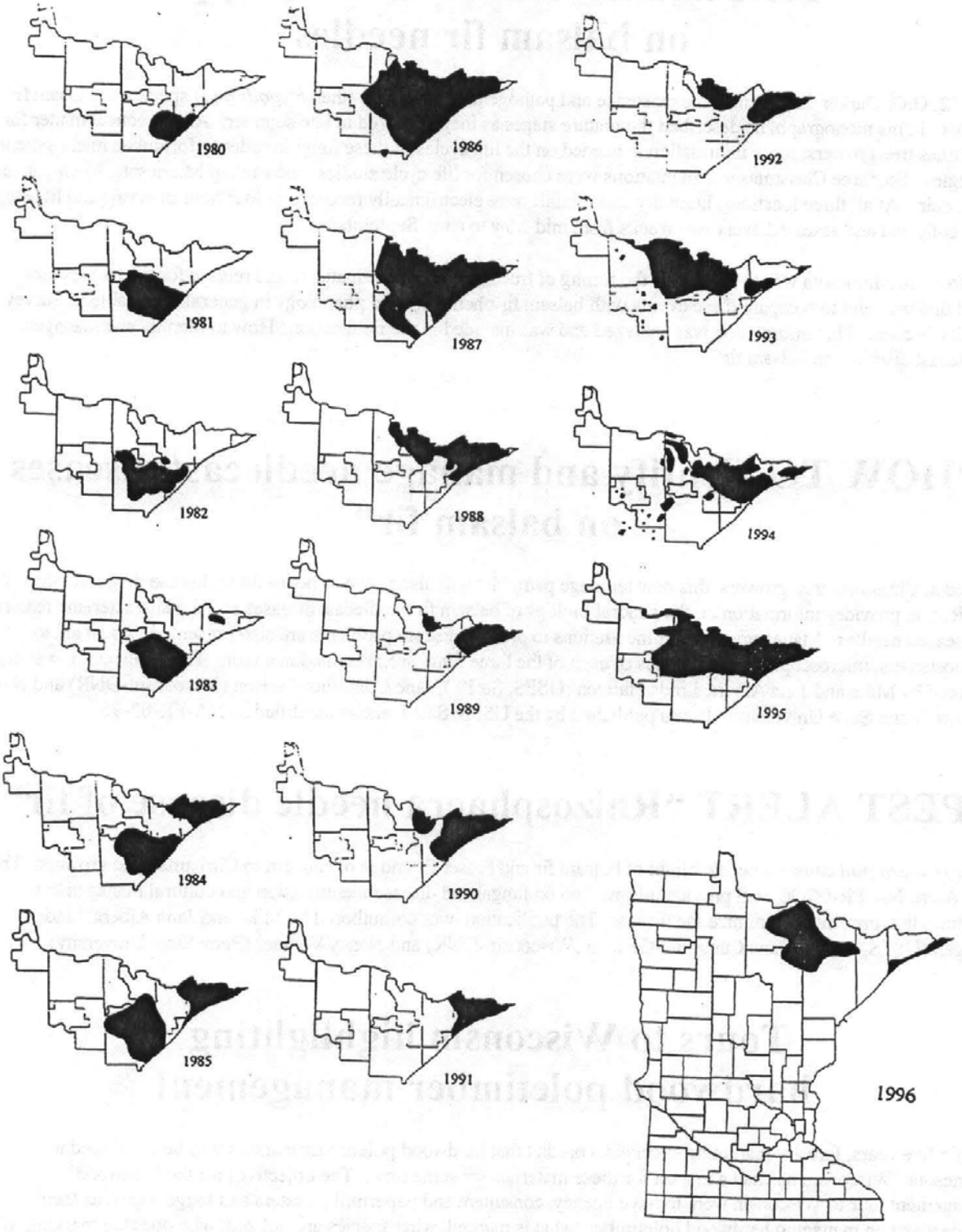
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Field and lab studies of *Lirula* spp. on balsam fir needles

In 1932, G.G. Darker documented the existence and pathogenicity of *Lirula* (then *Hypoderma*) species on balsam fir needles. In his monograph, he described the mature stages as they appeared in late summer. As a practical matter for Christmas tree growers, more information is needed on the life cycles of these fungi in order to formulate management strategies. So, three Christmas tree plantations were chosen for life cycle studies; one each in Minnesota, Michigan and Wisconsin. At all three locations, humidity and rainfall were electronically recorded at four hour intervals and life stages were collected and assessed every two weeks from mid-May to early September.

Our focus in Minnesota was to determine the timing of fructification, spore maturity and release for the two species found this year and to compare these events with balsam fir phenology and phenology in general. See table in Survey Results Section. This information was analyzed and was included in the publication "How to identify and manage needlecast diseases on balsam fir".

"HOW TO identify and manage needlecast diseases on balsam fir"

Aimed at Christmas tree growers, this new ten page pamphlet will also prove to be useful to disease diagnosticians. The publication provides information on the general biology of balsam fir needlecast diseases and the characteristic features of diseased needles. Management recommendations to prevent disease problems are also presented. As an aid to diagnosticians, microscopic characteristics of each of the three fungi are presented in a table. The publication was co-authored by Mike and Jana Albers, Linda Haugen (USFS, S&PF), Jane Cummins-Carlson (Wisconsin-DNR) and Nancy Wenner (Penn State University). It was published by the USFS, S&PF and is identified as NA-FR-02-96.

PEST ALERT "Rhizosphaera needle disease of fir"

Rhizosphaera pini causes a needle blight of balsam fir and Fraser fir and is of concern to Christmas tree growers. This Pest Alert, NA-PR-06-96, will provide information on fungal and disease identification and cultural management practices that prevent or minimize the disease. The publication was co-authored by Mike and Jana Albers, Linda Haugen (USFS, S&PF), Jane Cummins-Carlson (Wisconsin-DNR) and Nancy Wenner (Penn State University).

Tours to Wisconsin highlighting hardwood poletimber management

Within five years, forestry marketing specialists predict that hardwood poletimber markets will be developed in Minnesota. Wisconsin has had a market for these materials for some time. The objectives for the hardwood management tour to Wisconsin were to have agency, consultant and papermill foresters and loggers give us their perspectives on managing hardwood poletimber; what is marked, what species are utilized, who does the marking, what types of equipment works best, etc. Also included as discussion topics were what doesn't work and why they've abandoned those ideas and methods.

Three tours were taken. The first was from January 16-18th and it featured stands near Rhinelander, WI and Neopit, WI (at the Menominee Indian Reservation). The second and third tours were taken in Hayward and Ladysmith, WI on October 3rd and November 6th.

Some key points were:

- All the foresters interviewed eagerly shared their philosophies, guidelines, rules of thumb and advice on how to mark and market these stands in great and numerical detail.
- Marking hardwoods is a challenge and is pure silviculture. Don't compromise your silviculture because of poor markets.
- It takes two to three YEARS experience to be a good marker.
- There is a strong adherence to research results from the Midwest by Kotar, Arbogast, Erdmann, etc.
- Marking is slow work; maximum output is three to seven acres per day.
- When USFS contracts for hardwood marking, they don't use low bid. They use proposal contracts and all contracting foresters are degreed foresters.
- Private consultants and agency foresters that we interviewed mark the "leave" trees; not the trees to be cut.
- Never get involved with "chopper's choice" sales. That is, never let the logger mark and cut the trees on a sale.
- To be economical, the operator should be able to produce 10 cds/person/day.
- Operator (logger) ability is important. Impact on residuals and site damage is operator dependent. If the site can't be logged without damaging the residuals, then wait until better operators and equipment are developed. Rusk County has "zero tolerance" to residual damage in their contracts.
- A forester should check the sale two times per week. Sale administration is that important.

Oak wilt suppression: Millionth foot celebration

It's hard to say exactly who celebrated a milestone in the Oak Wilt Cooperative Suppression Program on August 20, 1996. It wasn't just Metro Region, because the program includes parts of Region III, and representatives from that region were on hand to help celebrate. It wasn't just the Division of Forestry or the DNR, because the USDA Forest Service and over sixty communities in seven counties have been involved in the program. We can't say just government agencies because both private citizens and federal politicians joined in the celebration. Let's just say that on August 20, 1996, more than 150 people who truly care about Minnesota's oak resource gathered at Pioneer Park in the City of Blaine to celebrate.

They came to celebrate a milestone. The milestone was the One Millionth Foot of vibratory plow line being installed to control the spread of oak wilt in Minnesota. They also came to celebrate a partnership, a far-reaching partnership. This partnership stretches from the Senate floor in Washington, D.C. to twenty-five hundred backyards in suburban Minnesota, like that of Elk River resident Betty Belanger. This partnership includes the USDA Forest Service providing grant money and the DNR Division of Forestry to administer and provide technical assistance to the program. However, the local communities have done all the work.

Attending the event were Minnesota's senior senator, Paul Wellstone, and 6th District Congressman, Bill Luther. The celebration included live music; speakers including Wellstone, Betty Belanger, and two city mayors; the plowing of the millionth foot by Congressman Luther; a ceremonial tree planting of an oak tree; and even formal invitations and a banner.

More than 150 people attended the celebration, along with two TV stations, a major daily newspaper, and five local weekly papers. Mayors Elwyn Tinklenberg and Bill Nelson of Blaine and Ham Lake respectively, told of how the program enabled them to control a seemingly insurmountable problem in their communities. Eleven communities were honored for controlling oak wilt and developing a comprehensive community resource program. Betty Belanger, an Elk River resident that had benefitted from the program, told her story of years of frustration followed by success from the program. Senator Wellstone gave the keynote address, explaining how community partnerships, such as the Oak Wilt Cooperative Suppression Program, are the type of activity that government should be involved in.

A short walk from the speaking site, Congressman Luther plowed the millionth foot and a bit more. Then, a ceremonial planting of a red oak tree wrapped up the celebration. Dr. Ann Bartuska, Director of Plant Protection for the USDA Forest Service from Washington, D.C, planted the red oak. She said that planting the tree (the most susceptible species to oak wilt) literally in the face of the disease, signifies the confidence and commitment communities have in their ability to control oak wilt.

Bark beetle infestation of old growth pines at Itasca State Park

Itasca State Park contains the largest remnant of Minnesota's old growth pine forest ecosystem. Coincident with the wind events of 1994, 95 and 96 and the resultant salvage and pheromone trapping activities; the Park and its Resource Planning Committee are updating the Park's overall management plan. Area Forestry and Forest Health staff will continue to cooperate in this project.

One of the central themes of the Park plan is to extend the life of large red and white pines throughout the Park until restoration efforts can reestablish younger pines and multi-age and multi-level pine forests. The park is zoned into three management regimes. The road corridor is actively managed for high visitor use with both artificial regeneration and hazard tree removal practices. The outback has less intensive management and use. The wilderness zone is a reserve for natural processes and research.

Management decisions to promote forest health (as defined by extending the life of existing large pine trees and establishing younger ones) are complicated by this zoning in combination with missing pine age classes due to past practices, recent wind events and the endemic population of bark beetles. The old declining jack pines are reservoirs for bark beetle populations. All actions are further complicated by trying to maintain the delicate balance of providing visitor enjoyment without damage to a threatened resource.

In an effort to bring order to and properly record the impact of current bark beetle management efforts in the Park, a contract was proposed with researchers from New York, New Hampshire and Wisconsin to formally study beetle activity and related natural agents in old growth pine stands affected by blow down. Federal Emergency Management Agency grant money will be used to document:

- which species make up the bark beetle complex,
- what threat do bark beetles pose to the remaining old growth trees and under what conditions,
- how can pheromone trapping techniques then be refined to reduce damaging populations,
- what other agents are active in wind-affected stands, and,
- what stand manipulation techniques can be developed to extend the life of old growth pines.

Detailed information

A meeting was held at Itasca State Park on April 15, 1996 to plan one of the strategies to minimize the impact and development of bark beetle populations in the pine blowdown areas in Itasca State Park. The strategy is to use Lindgren funnel traps baited with bark beetle pheromone. Present at this meeting were Park Managers, the Park Naturalist, the MCC Crew Foreman, and Forest Health Specialists.

The use of Lindgren pheromone lure traps are not designed to eliminate bark beetle populations, but to minimize their impact and help cut tree losses to acceptable and manageable levels. Unlike other bark beetle situations in which populations exploded following some natural disaster, this project will be ahead of the bark beetle population development. Hopefully, this will allow managers to keep tabs on the situation and help it from becoming unmanageable from the start.

The size of the area affected by the blowdown is so great that it was decided to prioritize the pine stands most heavily used by the public to begin with, then to expand the trapping to include other stands later as more traps become available. Approximately 1500 traps were placed by MCC crews around May 1st. Traps were checked twice weekly during the growing season by volunteers. They were trained by Park personnel to identify bark beetles and release the other insects caught in the traps, especially the predacious beetles.

On May 16, 1996, pheromone traps in the Park detected the first appreciable flight of pine bark beetle adults. On the evening of May 17th, however, another big wind swept through the Park knocking down more old growth pine (and numerous bark beetle traps) in the Mary Lake, South Entrance, Preacher's Grove and East Entrance areas. Unfortunately, the storm added insult to the injury by downing more trees thereby providing more bark beetle breeding habitat. Sounds like Murphy's Law "if anything can go wrong, it will". Apparently the fresh downed cambium is more attractive to the beetles that the trap lures with nuptial galleries being constructed at a rapid rate in pines knocked down last July and in pines blown down last month. Park and Bagley Forestry personnel did a damage delineation survey by helicopter on May 22nd. On May 23rd, Forest Ecosystem Health staff confirmed new bark beetle nuptial chambers in the freshly downed material. The onslaught had begun!

A cooperative Park-Forestry plan was put together to map, appraise and contract the removal of the newly downed material. Loggers and tree care contractors were asked to chip or remove all pine material down to a two inch diameter. Trapping continued during this directed thirty day salvage operation.

On Thursday, August 1, 1996, staff from Itasca Park, Region I Parks and the Forest Health Unit met to review a plan put together by Jeff Haas and Tom Romaine. Developed while on a fire center assignment to the Park, the plan outlined how the Park should organize and staff to coordinate the trapping, clean-up and public relations efforts related to blowdown and bark beetle management.

Outside of the Park, foresters from Gutherie and Bagley were busy dealing with bark beetle infestations in scattered, remote areas with difficult access. One site in particular, in the Gutherie area, appears as though a tank regiment has been on maneuvers for a month of training. A person could walk across the whole La Salle Lake valley just on the trunks of downed trees. This site was inspected for bark beetles in early June with little activity detected. However, on July 24th, bark beetle galleries were abundant on most of the pine logs being salvaged.

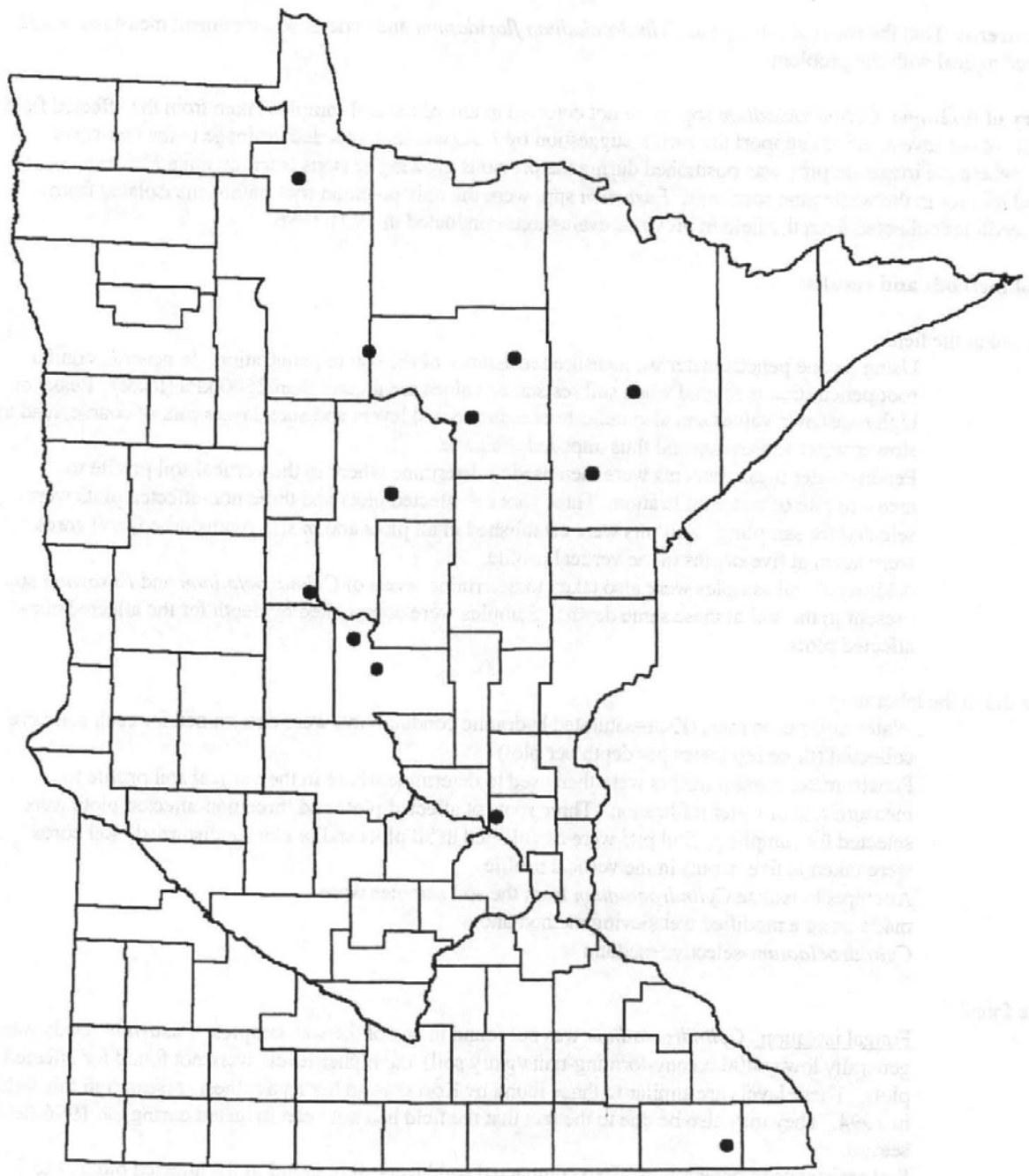
The storm blowdown not only created a bark beetle "challenge", but also left many large, residual red and white pines with large scrapes and openings in the bark which very efficiently opened them up to decay causing fungi. Foresters decided to leave the severely damaged and debarked trees to be used as "swing" or "pivot" trees as the loggers move the salvaged logs out. These trees will be removed last, just before the timber sale is closed on that site.

White pine blister rust collections

In cooperation with Dr. Zambino, a rust geneticist with the USFS Forestry Sciences Lab in Rhinelander, WI, blister rust cankers were collected during aeciospore dissemination. Three to ten sporulating cankers were collected at each of the twelve sites across the state . See map. Dr. Zambino is trying to discern the genotypic range of white pine blister rust across the Midwest and to determine if there is local variation in the rust fungus in single stands.

Blister rust collections - 1996					
Sample	**County**	**Location**	**Stand type**	**Number of cankers**	**Infections per tree**
MN 12	Morrison	SENE S31-T132-R30	White pine	5	<6
MN 13	Itasca	S33-T33-R25	WP, Scots pine	6	<3
MN 14	Itasca	S36-T60-R24	Paper birch	7	1
MN 15	Morrison	SESE S11-T41-R32	Oak, WP	7	<6
MN 16	Lake of Woods	S2-T158-R 34	Jack, white and red pines	10	<6
MN 17	Beltrami	NE S1-T148-R 30	Red, jack and white pines	8	<3
MN 18	Fillmore	W1/2 of NE1/4 S19-T 102-R8	WP	6	<6
MN 19	Itasca	NENW S16-T 56-R26	WP, aspen	3	1
MN 20	Cass	NE1/4 S17-T140-R 28	White, red and jack pines	8	<4
MN 22	St. Louis	SESE S28-T53-R 19	WP and white spruce	8	<3
MN 23	Wadena	S10-T134-R33	Oak	7	1
MN 24	St. Louis	S36-T58-R17	Birch, maples, fir and WP	7	1

White pine blister rust collection sites



Scale: 0 — 50 mi — 100 mi

Map production and analysis by EPIC
Minnesota Department of Natural Resources
Division of Forestry, Forest Health Unit
3/26/1997

White pine mortality at Gen. Andrews State Nursery

By Jennifer Juzwik, USFS-NCFES and Jill Pokorny, USFS-S&PF

The Problem: Root Rot in 3+0 white pine in E-8, General Andrews Forest Nursery, summer 1996

Main Concern: That the root rot was due to *Cylindrocladium floridanum* and serious soil treatment measures would be required to deal with the problem

Summary of findings: *Cylindrocladium* spp. were not detected in any of the soil samples taken from the affected field. The results of our investigations support the earlier suggestion by J. Juzwik that impeded drainage in the bed-rows closest to where the irrigation pipe was positioned during the previous growing seasons is triggering a *Fusarium*-associated root rot in the white pine seedlings. *Fusarium* spp. were the only potential root pathogens isolated from affected seedlings collected from the field in previous evaluations conducted in 1994-1996.

Details of methods and results:

What we did in the field -

1. Using a cone penetrometer we measured resistance of the soil to penetration. In general, conifer root penetration is limited when soil resistance values are greater than 2500 kPa (force). Peaks in high resistance values can also indicate compacted soil layers and such layers can, of course, lead to slower water infiltration and thus impeded drainage.
2. Penetrometer measurements were then used to determine where in the vertical soil profile to measure rate of water infiltration. Three root rot affected plots and three non-affected plots were selected for sampling. Soil pits were established in all plots and *in situ* (undisturbed) soil cores were taken at five depths in the vertical profile.
3. Additional soil samples were also taken to determine levels of *Cylindrocladium* and *Fusarium* spp. present in the soil at these same depths. Samples were composited by depth for the affected non-affected plots.

What we did in the laboratory --

1. Water infiltration rates (Ksat=saturated hydraulic conductivity) were determined for each soil core collected (three replicates per depth per plot).
2. Penetrometer measurements were then used to determine where in the vertical soil profile to measure rate of water infiltration. Three root rot affected plots and three non-affected plots were selected for sampling. Soil pits were established in all plots and *in situ* (undisturbed) soil cores were taken at five depths in the vertical profile.
3. Attempts to isolate *Cylindrocladium* from the soil samples were made using a modified wet sieving method and a *Cylindrocladium*-selective medium.

What we found -

1. Fungal isolation. *Cylindrocladium* was not found in any of the soil samples. *Fusarium* levels were generally low (<400 colony-forming-units/g dry soil) and higher levels were not found for affected plots. These levels are similar to those found by Kori Gust in her M.Sc. thesis research in this field in 1994. They may also be due to the fact that the field had not been irrigated during the 1996 field season.
2. Soil resistance to penetration. Two compacted soil layers were found in the affected plots (4 to 7 inches deep and 10 to 12 inches deep), while only the lower compacted zone was found in the non-affected plots.

3. Water infiltration. Water moved at a significantly slower rate through the soil profile in root rot affected plots compared to the non-affected ones (see table below).

What we concluded-
The problem was diagnosed as Fusarium root rot with development and severity of the disease being related to wetter soil conditions in bed-rows closest to where an irrigation line was placed compared to other areas of the field. The rotary tiller induced compacted layer at 4 to 7 inches deep may be a major contributor; however, the impeded drainage that we found throughout the measured profile would indicate a more general drainage problem in the affected plots.

What can be done in the future to avoid recurrence of the problem -

1. Soil management practices. If possible, alter practices that may be contributing to a more shallow compacted soil layer, e.g. don't run rotary tiller in beds when soil is fairly wet and/or use tiller with greater tine angles (>120 degrees). Modification of sub-soiling practices could be considered, e.g. sub-soiling in two perpendicular directions to break-up compacted layers. Vary the plowing depths when incorporating cover crops.
2. Irrigation. Routinely check for leaks or breaks along the pipe line during the growing season. Check for and replace worn nozzles on sprinkler heads. Do not over-water.
3. Avoidance. Consider not sowing white pine in bed-rows that will be on either side of where irrigation pipe will be placed during the growing season. Alternatively, consider not placing irrigation pipe beside or in between bed-rows of white pine seedlings.

Rate of water infiltration through undisturbed soil cores collected from root rot affected and non-affected plots in E-8, General Andrews Nursery, July 1996.

Soil depth (in inches)	**Water infiltration rate** (in cm/hr)	
	Non-affected	**Affected**
0 to 2	20.93	14.30
2 to 4	19.86	14.84
5 to 7	20.14	13.85
7 to 9	18.85	11.61
9 to 11	18.91	11.72

Cold Hardiness Study

Two seed sources of white spruce and one each of Norway pine and white pine are being tested for cold hardiness to determine the best time to begin fall lifting for freezer storage. This study is being conducted at the state nurseries by Dr. Richard Tinus and Dr. Karen Burr of the USFS through the North Central Forest Experiment Station.

Fungal Survey at the Nurseries

An ongoing survey of mushrooms and mycorrhizae that occur in operational seed beds is conducted by Neal Anderson and Cindy Buschena at the University of Minnesota Department of Plant Pathology. Both state nurseries apply metamsodium in August as a soil injected liquid that is then water capped for fumigation.

Aitkin Home Page

Aitkin Area Forestry developed a State Land Management Home Page on the Internet in 1996. The project was under the umbrella of ForNet (a University of Minnesota and NASA grant). The intended audience is the general public.

Two articles were written at the request of the Aitkin Area Forest Supervisor. The first article centered around timber harvesting beginning with stand management from an ecosystem perspective working through timber as a forest benefit and then focusing in on DNR Unit Planning and culminating in stand prescriptions and timber sales. The second article compared wood volume and timber harvest to different types and uses of bank accounts, recognizing that trees, unlike money, are perishable.

RX-340: Introduction to Fire Effects

This fire course, Introduction to Fire Effects, was offered for the first time in the Midwest at the Minnesota Interagency Fire Center in Grand Rapids from March 25-29th. A ninety minute lecture was presented on "Forest insects and diseases and their relationships to fire ecology".

PAPERS PRESENTED

Ecological Implications of Weather in Tree Health: Landscape Scale Considerations

by Thomas G. Eiber

Abstract:

Tree health is largely determined by the growing environment of the tree which can be characterized into three categories: biological, site, and climatological. This paper investigates the role that climate plays in tree and forest health at the landscape level. It investigates the stress placed on trees as a result of an annual moisture shortage that occurs even in normal years as the result of need exceeding actual rainfall. The argument is developed that total annual rainfall, a common measurement of drought, does not adequately reflect tree needs. While growing season rainfall (May - September) is better, tree need, ie. potential use, is best estimated by the Thornthwaite Water Balance, a common hydrological index. By subtracting Thornthwaite's potential usage from the measured growing season rainfall, we can estimate the average "shortfall" for a given area.

The resulting index, the "Average Annual Shortfall", is an excellent measure of the likelihood of "climatic resistance" to healthy trees in a landscape region. Typically, areas with less than 4" Average Annual Shortfall tend to have healthy trees and forests. Areas with more than 7" Average Annual Shortfall tend to have unhealthy trees and forests, in fact, they are commonly prairie ecosystems. Areas with 4" to 7" of shortfall tend to be "ecological tension zones" where trees and forests occur, but suffer serious "stress" related problems. This zone is marginally useful for trees and tends to suffer greatly during drought periods when precipitation is below average.

This paper presented at the Shade Tree Short Course held March 19-20, 1996, in St. Paul, Minnesota. The workshop was sponsored by the University of Minnesota Extension Service.

Identifying and Modeling Ecosystem Patterns at the Landscape Level Using GIS

By Thomas G. Eiber

Abstract:

Patterns of climate dramatically affect the health and configuration of the plants and animals that comprise ecosystems. Ecosystems are commonly defined over large areas based on general vegetation and soils patterns with only a basic understanding of large scale processes. Particularly true of climatology, these factors dramatically affect the character and health of ecosystems at the landscape level. These are complex adaptive systems in which biologists and ecologists attempt to evaluate a wide variety of factors, adaptations, and organism requirements to manage environmental changes from local-scale, man-caused events to landscape and global level changes such as those that might be caused by global warming.

GIS systems can be effectively used to model ecological parameters such as moisture shortfall from a variety of measurable factors including growing season rainfall, evapotranspiration, and "runoff". In their simplest applications, we can clearly see many of the landscape scale patterns of ecological zones such as the ECS Provinces. With relatively simple GIS modeling techniques, we can project the potential effects of a small rise (2°) in the boundaries of these ecological zones in Minnesota.

This paper presented at the 1996 Minnesota GIS/LIS Conference held September 25-27, 1996 in St. Louis Park, MN. The Minnesota GIS/LIS Consortium supports the use of GIS and geospatial data in Minnesota. They maintain an Internet site at *http://www.lmic.state.mn.us/gislis/conf.htm.*

Assessing the Impact of Urbanization on Forested Ecosystems: Integration of LandSat, Demography, and Urban Planning with GIS

By Thomas G. Eiber

Abstract:

Regional planning was greatly assisted by a GIS-based model which merged land use (1990), population density (1995), proposed regional development boundaries (MUSA 2040), and current building activity. The DNR was able to identify three community assistance zones: Developed, Developing, and Rural. Each of these zones will have Community-based Management (CBM) assistance available to help dealing with natural resource issues within the community. Once established, these zones can be used as a thematic layer in the GIS to analyze other data such as population change, natural resources, or dangers to specific resources such as the oak wilt risk in developing communities.

This paper was presented at the 3rd Annual EPPL7 Users Conference held November 26 in St. Paul, Minnesota. The workshop was sponsored by the Minnesota Land Management Information Center (LMIC).

MGC100: Revisiting MLMIS40 Raster Data In 16-bit

By Thomas G. Eiber, Les Maki and Ken Pekarek

Abstract:

The earliest GIS system in Minnesota was a raster based system that operated on a Control Data Cyber 6600 computer at the University of Minnesota. Digitizing as we know it today did not exist and spatial data was encoded using punch cards. This created a row and column representation of the state. Each square, or raster, represented a 40 acre parcel creating a database of about 1.4 million cells. Widely used for many years, thematic layers created this way became the first standardized data set used on a statewide basis. LMIC still maintains a data catalog with around 100 layers in this format and many of these layers still contain the most up to date data on specific themes. Other older data sets provide a historic perspective. In subsequent years, the drive for more detailed data for local applications created the need for a new data standard with a finer resolution. The MLMIS100 data standard created a geocorrected, raster data set with a 100 metre resolution on a county basis in the late 1980's.

With the coming of high capacity hard drives and CPU's, plus a new version of the raster GIS system EPPL7, the concept of the statewide data-base could be revisited. In 1993, as part of the EPIC development project, a new data standard was created for use with raster GIS systems. MGC100, for MLMIS geocorrect 100 metre, was created by appending all the MLMIS100 county data sets together. This first effort created about 75 state-wide data layers, all in 8-bit. The main advantages of MGC100 over MLMIS40 are: (1) a higher resolving capacity permitting better detail to be captured and used for statewide analysis, (2) a geocorrected format that permits the easy transfer of data between today's raster and vector systems, and (3) alternate coordinates in Zone 15 UTM coordinates.

In 1995, LMIC's venerable EPPL7 software went to 16-bit thereby permitting class values to over 65,535 as opposed to the 8-bit's limitation of 255 classes. MGC100 data sets are now being developed using the new 16-bit classification. For example, there is now a statewide ZIP Code layer in which the class value is the actual ZIP Code. In addition, a statewide layer of Minor Civil Divisions would permit the creation of various economic and social data layers. The MGC100 data set is now comprised of over 350 data layers covering topics including Ecosystem Based Management, Forest Ecosystem Health, Soils, Native Species Ranges, Political & Administrative Jurisdictions, and Climatology. Data is available on CD-ROM in EPIC/EPPL7 format through LMIC. Currently in NAD27, the MGC100 data set will be converted to NAD83 in the near future.

This paper presented at the 1996 Minnesota GIS/LIS Conference held September 25-27, 1996 in St. Louis Park, MN. The Minnesota GIS/LIS Consortium supports the use of Geographic Information Systems and geospatial data in Minnesota.

Minnesota Supplement To The Guide For Plant Appraisal with Regional Tree Appraisal Factors

Published by the Minnesota Society of Arboriculture

Abstract:

The Tree Valuation Committee was comprised of a variety of shade tree professionals that rated a wide variety of trees and shrubs for Minnesota based on experience and published research. In addition to the tree ratings, the guide presents the MSA Tree Rating Zones based on a combination of ECS Provinces and USDA Hardiness Zones.

Available from MSA, 110 Green Hall, University of Minnesota, 1530 N. Cleveland Ave. St. Paul, MN 55103.

Freeze injury and Fusarium canker of black walnut

By Edward Hayes and Cynthia Ocamb

Abstract:

The winter of 1993-1994 caused some of the most serious injury ever witnessed by forest managers to southeast Minnesota and southwest Wisconsin black walnut plantations . It was estimated that 5 to 6 walnut plantations in each of 5 southeast Minnesota counties were severely injured. Severe injury was 75% to 100% of walnut in plantation sustained more than 50% dieback. Topographic 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. Walnut trees wounded by the freeze injury were invaded by the fungus *Fusarium* spp. Adjacent noninjured walnut were not infected with *Fusarium* spp. *Fusarium* spp. were found to be opportunistic on walnut; entering wounds created by the freeze injury.

E.Hayes and C. Ocamb. 1996. Freeze injury and Fusarium canker of black walnut. In: Knowledge For The Future Of Black Walnut: Proceedings Of The Fifth Black Walnut Symposium. USDA Forest Service. General Technical Report. NC(# To be assigned). Springfield, Missouri, July 28-31, 1996.

SURVEY RESULTS

Methodology and survey data for the following insects are included in this report:

Aerial survey methods
Spruce budworm
Balsam fir needle casts
Jack pine budworm
Pine tussock moth

Aerial survey methods

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 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 flight 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, surveys may be flown at other times, for example, fall defoliators in mid-August. This will be determined on an annual basis.

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 Region 2 or 3, interfering with SBW detection, then use that day to survey elsewhere.

For 1996, we suggested 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 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

Larval survey and defoliation estimates

Percent buds infested is derived from a 15 inch branch sample. The number of larvae found is divided by the number of buds on the sample and the resulting number is multiplied by 100. If the number is greater than 10 percent, heavy defoliation can be expected.

Actual defoliation is the average value for nine 15 inch branch samples per plot. Actual defoliation is a visual estimate of the percentage of needles consumed during the feeding period.

Percent buds eaten is the average value computed for nine 15 inch branch samples per plot. The number of consumed buds is divided by the number of remaining buds plus the number of buds eaten and the resulting number is multipled by 100.

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 15 inch branch tip is tallied. The following scheme is ued to predict next year's defoliation by spruce budworm.

Spruce budworm defoliation prediction		
Average number of egg masses per branch	**Expected defoliation next year**	**Expected percentages of new foliage consumed**
0 - 0.1	None to light	0 - 20 %
0.2 - 1.7	Moderate	21 - 50 %
1.8 or more	Heavy	51 - 100 %

Spruce budworm survey - 1996								
Location	**Species**	**1995 Ave. # egg mase**	**1996 Buds infested %**	**1996 Actual defol. %**	**1996 Ave. # egg masses**	**1996 Buds eaten %**	**1997 Defol. Predicted**	**Comments**
Aitkin Co.								
NENE 7-51-23	WS	0.11		<1	0.1	<1	VL	Vigorous.
NENE17-52-24	WS	0.99		3	0.1	<1	L	In 94=mod. In 95= heavy.
Beltrami Co.								
NESE 26-149-30	WS	1.00		43	1.5	18	M	Repeatedly defoliated for last 6 years.
	"	1.44						
NESW 1-148-31	WS			6	0.33	5	M	
Cass Co.								
NWNW11-139-26	BF	1.22		30	0.2	3	L-M	Terminals tufing. Patchy defoliation.
NENE17-140-27	BF	0.22		36	0	5	L	Tufted terminals for 3 years. Vigorous.

Spruce budworm survey - 1996								
Location	**Species**	**1995 Ave. # egg mase**	**1996 Buds infested %**	**1996 Actual defol. %**	**1996 Ave. # egg masses**	**1996 Buds eaten %**	**1997 Defol. Predicted**	**Comments**
SWSE13-136-31	WS	0.44		8	1.3	3	M	Vigorous. Sprayed in 1995.
	"	0.66		7	0.5	4	L-M	"
SWSE 22-138-31	BF	0.11		1	0	<1	0-VL	Vigorous and stately.
Chisago Co.								
SESE 36-36-21	WS	0.11		<1	0	<1	0-VL	Vigorous.
Cook Co.								
NWNW 33-63-4E	WS,BF			36	0.22	<5	M	
NESW 35-64-3E	BF			0	0	0	0	
NWSE 3-61-1E	BF		2.6	6	0	<1	0	
SWNE 22-63-1E	BF			<1	0	0	0	
NESW 10-64-1W	BF			0	0	0	0	
Crow Wing Co.								
SENE 19-44-31	WS	1.55		40	0.8	5	M	Vigorous.
Hubbard Co.								
SE 13-141-32	WS	0.33		4	0.55	3	M	
SE 1-142-33	WS	1.66		50	1.66	43	H	
NWSE 23-145-33	WS			50	1.66	16	M-H	Good vigor.
NWNE 21-141-36	WS			37	2.1	30	H	
Itasca Co.								
NENW 34-62-22	BF			13	0.44	<5	M	

Spruce budworm survey - 1996								
Location	**Species**	**1995 Ave. # egg mase**	**1996 Buds infested %**	**1996 Actual defol. %**	**1996 Ave. # egg masses**	**1996 Buds eaten %**	**1997 Defol. Predicted**	**Comments**
NESW 26-62-23	BF	0		<5	0	<5	M	
NWSW 3-58-24	WS		1.7	<1	0	<1	0	Thinned plantation
SWNE 3-58-24	WS		1.6	0	0	0	0	Thinned plantation
SWSE 36-62-24	WS			82	0.77	40	M	
NWSW 35-58-24	WS		10.6	25	1.1	<5	M	
NWNE 7-60-25	WS			0	0	0	0	
NW 9-56-25	WS			5	0.44	<5	M	Unthinned plantation
NWNE 4-60-26	WS			0	0	0	0	
SENW 12-53-26	WS		3.4	<1	0.1	0	L	Unthinned plantation
SWNE 11-53-26	WS	0		<1	0.1	<1	VL	
SWSE 17-60-27	BF			<1	0	<1	0	
Koochi-ching Co.								
NWNW 19-65-22	WS,BF			46	2.0	16	H	
SENE 23-67-22	BF			15	1.2	8	M	
SESE 35-71-24	WS			15	0.11	8	L	
SESE 16-69-23	BF	0.22	4.5	6	0	4	0	
NWNE 27-158-26	WS	0	2.3	0	0	<1	0	
Lake Co.								
SWNE 11-55-8	BF		0.3	<1	0	0	0	
SWSE 5-59-8	BF		0	<2	0	<1	0	

Spruce budworm survey - 1996								
Location	**Species**	**1995 Ave. # egg mase**	**1996 Buds infested %**	**1996 Actual defol. %**	**1996 Ave. # egg masses**	**1996 Buds eaten %**	**1997 Defol. Predicted**	**Comments**
NESE 28-61-10	WS			4	0	1	VL	
SENE 11-61-11	WS,BF			7	0	<5	VL	
SENW 31-62-11	WS,BF			50	0.1	30	L	heaverd def. on fir
Morrison Co.								
NENE 1-41-29	WS	0.88		72	1.6	50	M-H	10% dead tops in a pocket. Rest of stand had less than 40% defoliation.
NESW 11-42-32	WS			5	0	3	0-VL	Vigorous.
Sherburne Co.								
NWNW 33-34-27	WS	0		15	0.55	4	M	Vigorous.
St. Louis Co.								
NESE 22-62-12	WS,BF	0.11	5.8	60	0.55	15	M	H on Fir, L on spruce
NWNE 6-63-12	BF			63	0.1	25	L	
SESE 31-58-13	WS,BF	0	0	0	0	0	0	
NWNE 4-62-13	BF	1.22		40	0.22	5	M	
SWNW 6-63-17	BF		9	10	0.1	<1	L	**
SWNW 2-64-17	BF			1	0	<1	0	
NENE 8-51-18	WS			0	0	0	0	
SWSW 33-61-18	WS,BF	0.88	15	12	1.3	3	M	
NWNW 33-65-18	BF	0.77	9.7	80	2.5	5	H	

Spruce budworm survey - 1996								
Location	**Species**	**1995 Ave. # egg mase**	**1996 Buds infested %**	**1996 Actual defol. %**	**1996 Ave. # egg masses**	**1996 Buds eaten %**	**1997 Defol. Predicted**	**Comments**
SWSW 2-60-21	WS	1.33	15.7	1	0.88	3	M	
NWSW 12-64-21	BF			66	0.22	20	M	
SESW 12-68-21	WS	0.88	16.9	76	0.77	38	M	
NENE 12-68-20	WS,BF	0.22		4	0.33	3	M	

Balsam fir needlecasts - 1996 report - Grand Rapids, MN

Date	*Lirula mirabilis*		*Lirula nervata*		Balsam fir	Phenology notes
	2 year needles*	3 year needles	2 year needles	3 year needles		
May 14		Ascoma closed, only paraphyses, no asci. Ascoma beginning to color along edges.		None in sample.	Buds like "winter", yet	Red maple flowering, some aspens with catkins
May 28		Ascoma coloration along center of midrib beginning to appear. No asci.		Ascoma fully colored, asci present with spores differentiated.	New terminal shoots are 1 cm, needles starting to flare. Laterals up to 1" long.	Juneberry in bloom. Bigtooth aspen leafing out. Red pine pollen being shed.
June 12	Entire length of needle is turning greenish-tan.	Either no line of dehiscence is visible or a slight yellow line is apparent. Asci present; some with plain cytoplasm others have spores with gel sheaths.	Entire length of needle is turning greenish-tan.	Line of dehiscence is forming/ formed. No evidence of spore release.	Terminals > 6" and laterals are 1.5 to 2.5" long. No terminal bud formed. Many new needles are "full-grown".	Dandelion heads are full with seeds. Pine pollen still thick. Coulumbine, yellow violets, *Thalictrum* in bloom. Few petals hanging on choke cherry. Milkweed 1' tall.
June 25		Almost all ascomata found at same phase of development. Ascoma dehiscence line is forming or just opened. Infected needles are golden in color with red-brown coloration along the midrib due to the ascomata. Ascospore well-formed, inside asci.		Only 4 needles found in sample. Dehiscence line of ascoma in various stages; forming, opened and closed. Needles are golden with jet black coloration along midrib due to ascomata. Ascospores well-formed, but not even pushed out of asci in process of squash mounts.	Lateral shoots 3.5" long, very limp. Bud forming at the tip. Terminals starting to lignify and grow upwards.	Blooming: goat's beard, purple vetch, campion, alfalfa, white clover. Milkweed has green flower buds.
July 9	Discolored needles are golden brown with a tinge of orange. 19/32 are identifiable as being infected by *L.mirabilis*.	Ascoma line of dehiscence is open and inrolled. Most hymenial layers colonized by fungus and deteriorating. Surviving ascomata had asci with spores inside them.	Discolored needles are golden brown with a tinge of orange. 7/32 are identifiable as being infected by *L.nervata*.	Only 6 needles. Ascoma slit has opened and is curled shut. Asci present with contained spores in 1 sample. All rest had hymenial layer colonized by another fungus and it was gone.	Laterals > 6" long. Twig color is sap green. Buds appear as single structure and are 5 m in diameter. Twig still quite flexible.	Fireweed and dandelions blooming. Milkweed just starting to bloom.

July 23	Pycnidia appear whitish, raised and water-soaked. No discoloration of lower midrib.	Ascomata varies from black to dark red-brown. 20% of ascomata with good ascospores remaining. Remainder were colonized. Found 1 needle with asci still discharging spores (a late bloomer).	Pycnidia are various from blackened to changing from tan/ water-soaked to black coloration. Ascoma development on lower midrib showing either no discoloration or dark pigments.	Ascomata jet black. 20% with good spores remaining; remainder colonized and deliquescent. Only a few asci with ascospores left in them.	Shoots are lignified, buds set and needles are spring green in color. 3 separate buds are discernable on twig tips. Twigs are starting to turn beige from sap green.	Blooming: wild licorice, black-eyed Susans, milkweed, tansy, Queen Anne's lace, fireweed and 4 o'clocks.
August 5	19/19 pycnidia are this species.	Mostly empty asci; some with spores. Noted effect during sectioning=hymenium separated/pulled out of ascomata in a layer leaving a base of plant tissue.	None found in sample.	None in sample.	Freshly sheared- so lost a lot of infected twigs. 3 winter buds set and large.	In bloom: goldenrod, *Liatris*, tall pussytoes, bluebells. Milkweed done. Still blooming: tansy, black-eyed Susans, fireweed, alfalfa and campion.
August 21	Needle coloration is predominantly buff; otherwise, tan with pycnidial ridges not pronounced and still water-soaked. Majority have pycnidial ridges that are topographically pronounced. Lower midrib not colored.	Buff colored needles is inrolled. Often wit. Found only 2 ascospores in an ascus. Ascomata opening h hymenium missing.	Pycnidia may be fully pigmented or lighter brown and spotty with tan areas, yet. Ascomata fully pigmented and jet black but without the dehiscence line. Hymenium very apparent, but only paraphyses present.	Ascomata with opening inrolled and appearing dry. Often hymenium not present.	Shoots with tan colored bark so they look identical to older twigs. Needle bases still sap-green.	Blooming: Joe-pye weed, big leaf aster, pearly everlasting, goldenrod and black-eyed Susans.
September 6	Pycnidial lines well-formed and range from water soaked and slightly raised to pigmented sharp ridges. Hymenial layer not even formed, yet.	Mostly shed (presumably due to needle cast infection).	Needle turgid, orangish-tan. Most not completely pigmented. Ascomata lines black. Paraphyses present, ascus initials are about 40 um = largest.	Mostly shed (presumably due to needle cast infection). Larger proportion of needles with *L. nervata* on them. Ascomata breaking apart at opening.	Needles increasingly waxy.	

* = Age of needles by fall of 1996.

Jack pine budworm

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		
No egg masses per plot	**Defoliation predicted**	**Percent of current needles expected to be consumed**
1-3	Light	0-20%
4 or more	Moderate	21-50%
4 or more	Heavy	50-100%

Plot location	Date	Egg masses	Comments
Crow Wing County			
SESE28-135-28	9/6	0	No defoliation in 1996.
NESW 4-134-27	9/6	0	"
SWSE 17-44-31	9/10	0	"
Pine County			
NENW 2-40-18	9/4	0	St. Croix State Park; no defoliation in 1996.
SWNE 10-40-18	9/4	0	"
SENW 17-40-18	9/4	0	"
NENE 29-40-19	9/4	0	"
SWSE 17-40-18	9/4	0	"
SWSE 25-45-20	9/5	0	No defoliation in 1996.
Wadena County			
SESW 29-138-33	9/6	0	0-5% defol. in 1996; in 1995 M to H defol.
NENE 30-136-33	9/6	0	No defoliation in 1996.
NWSE 3-135-33	9/6	0	"

Pine Tussock Moth

Pheromone trapping

The following data represents an annual effort to monitor the populations of the pine tussock moth, an insect that has, in years past, increased in such great numbers that it caused heavy mortality of pines in Mission Township of Crow Wing County and in Pine County around General Andrews Nursery. Since 1980, the numbers of pine tussock moth caterpillars in Pine and Crow Wing Counties have diminished or remained low. In 1996, trapped moths in northeastern Wadena and southeastern Hubbard Counties increased sharply. Larval surveys and defoliation assessments should be undertaken in northeastern Wadena and southeastern Hubbard Counties in 1997. Pheromone trapping should be continued in Crow Wing, Wadena, and Hubbard Counties in 1997.

A count of 30 or more male moths in a trap over a 7-14 day period would indicate possible need for chemical or other control the next year. Such numbers and decision to apply controls should be combined with larval surveys and defoliation assessments of the infested jack pines.

Pine tussock moth pheromone trap catches - 1996

COUNTY	LOCATION	DATE TRAP PLACED	TRAP NAME	DATE TRAP CHECKED	NO. MALE MOTHS IN TRAP	COMMENTS
Crow Wing	SWSE 30-134-28	6-21		7-17 8-1 8-19 9-8 9-27	0 7 2 0 0	Trap at Paul Bunyan Nature Learning Center
Crow Wing	SWNW 9-136-27	6-21	1	7-8 7-17 7-31 8-19 9-5 9-27	4 1 6 16 1 0	
Crow Wing	NWSE 9-136-27	6-21	2	7-8 7-17 7-31 8-19 9-5 9-27	3 5 6 20 1 0	
Crow Wing	NWSW 11-136-27	6-21	3	7-8 7-17 7-31 8-19 9-5 9-27	11 3 2 8 16 0	

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COUNTY	**LOCATION**	**DATE TRAP PLACED**	**TRAP NAME**	**DATE TRAP CHECKED**	**NO. MALE MOTHS IN TRAP**	**COMMENTS**
Crow Wing	NWNW 14-136-27	6-21	4	7-8 7-17 7-31 8-19 9-5 9-27	4 11 11 26 4 0	
Crow Wing	NENE 23-136-27	6-21	5	7-8 7-17 7-31 8-19 9-5 9-27	7 1 5 12 0 0	
Crow Wing	NWSW 9-136-27	7-31	A	8-19 9-27	15 0	Dry trap (Multipher, with Vaportape)
Crow Wing	10-136-27	7-31	C	8-19 9-27	27 0	Dry trap
Crow Wing	SWNW 10-136-27	7-31	B	8-19 9-27	1 0	Dry trap
Hubbard	16-139-32		Nursery	7-9 7-16 7-22 7-29 8-14 8-26 9-4	22 10 12 6 14 7 0	
Hubbard	9-139-32		Wood-land Tour	7-9 7-16 7-22 7-29 8-14 8-26 9-4	27 16 18 7 16 2 0	

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COUNTY	**LOCATION**	**DATE TRAP PLACED**	**TRAP NAME**	**DATE TRAP CHECKED**	**NO. MALE MOTHS IN TRAP**	**COMMENTS**
Hubbard	10-139-32		Cutover Road	7-9 7-16 7-22 7-29 8-14 8-26 9-4	23 13 15 2 18 0 0	
Hubbard	34-139-33		Game Farm	7-9 7-16 7-22 7-29 8-14 8-26 9-4	21 18 20 18 20 18 0	
Pine	NESW 13-45-20	6-21	6	7-3 7-17 7-30 8-21 9-5 9-27	0 6 1 0 0 0	
Pine	NESE 18-45-19	6-21	7	7-3 7-17 7-30 8-21 9-5 9-27	0 3 0 0 0 0	
Pine	SESW 30-45-19	6-21	10	7-3 7-17 7-31 8-21 9-5 9-27	0 0 1 3 0 0	
Pine	SWSE 25-45-20	6-21	9	7-3 7-17 7-31 8-21 9-5 9-27	0 1 0 2 0 0	

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COUNTY	**LOCATION**	**DATE TRAP PLACED**	**TRAP NAME**	**DATE TRAP CHECKED**	**NO. MALE MOTHS IN TRAP**	**COMMENTS**
Pine	NESW 26-45-20	6-21	8	7-3 7-17 7-31 8-21 9-5 9-27	0 0 2 4 0 0	NE side of G.A. Nursery
Wadena	15-138-33		Hunters-ville Imp.	7-9 7-16 7-22 7-29 8-14 8-26 9-4	24 20 22 1 11 2 0	
Wadena	10-138-33		Road-side I	7-9 7-16 7-22 7-29 8-14 8-26 9-4	27 17 19 20 24 11 0	
Wadena	9-138-33		Road side II	7-9 7-16 7-22 7-29 8-14 8-26 9-4	27 9 11 2 20 5 0	
Wadena	9-138-33		Hunters-ville Store	7-9 7-16 7-22 7-29 8-14 8-26 9-4	29 13 15 8 15 2 0	