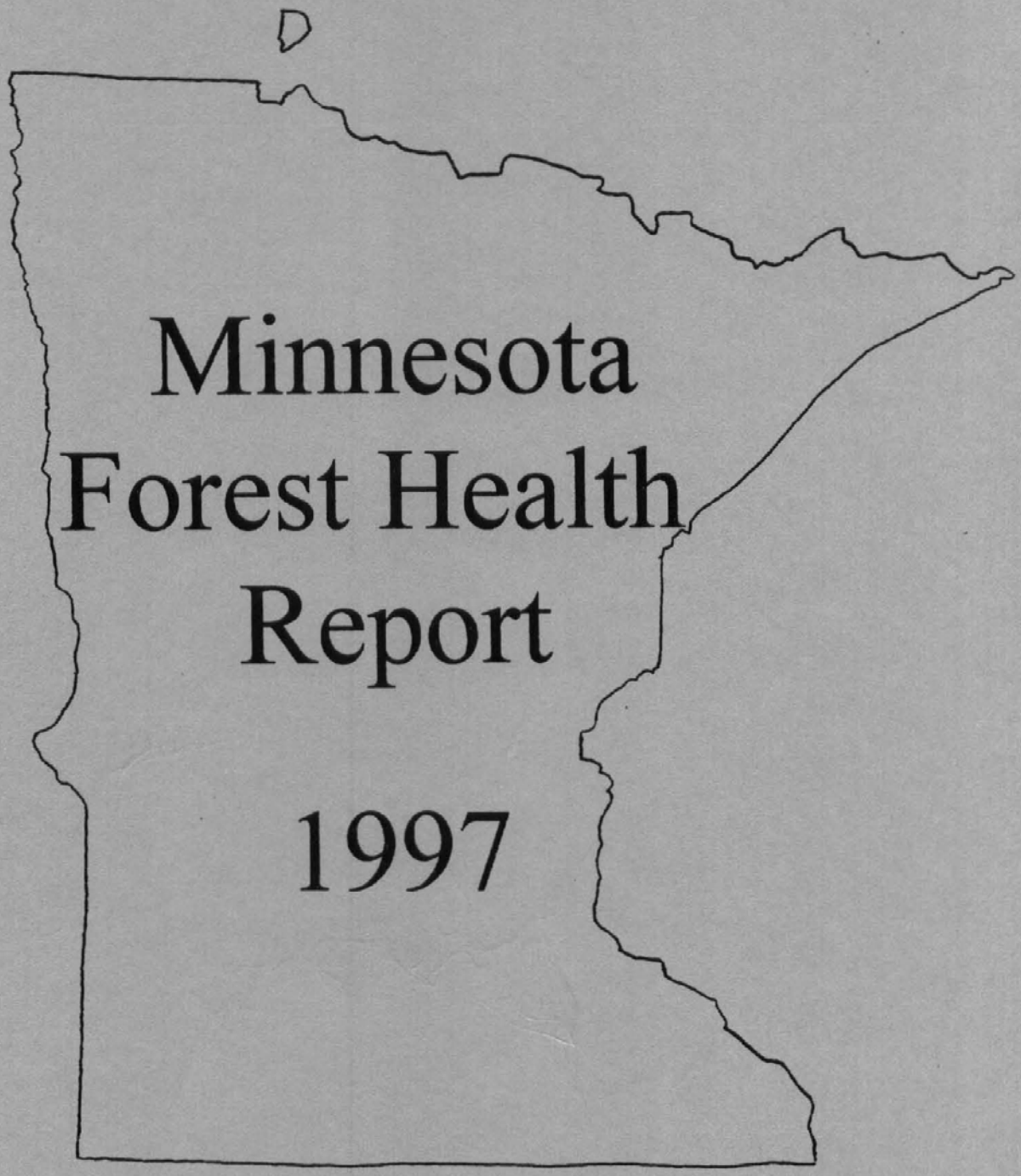
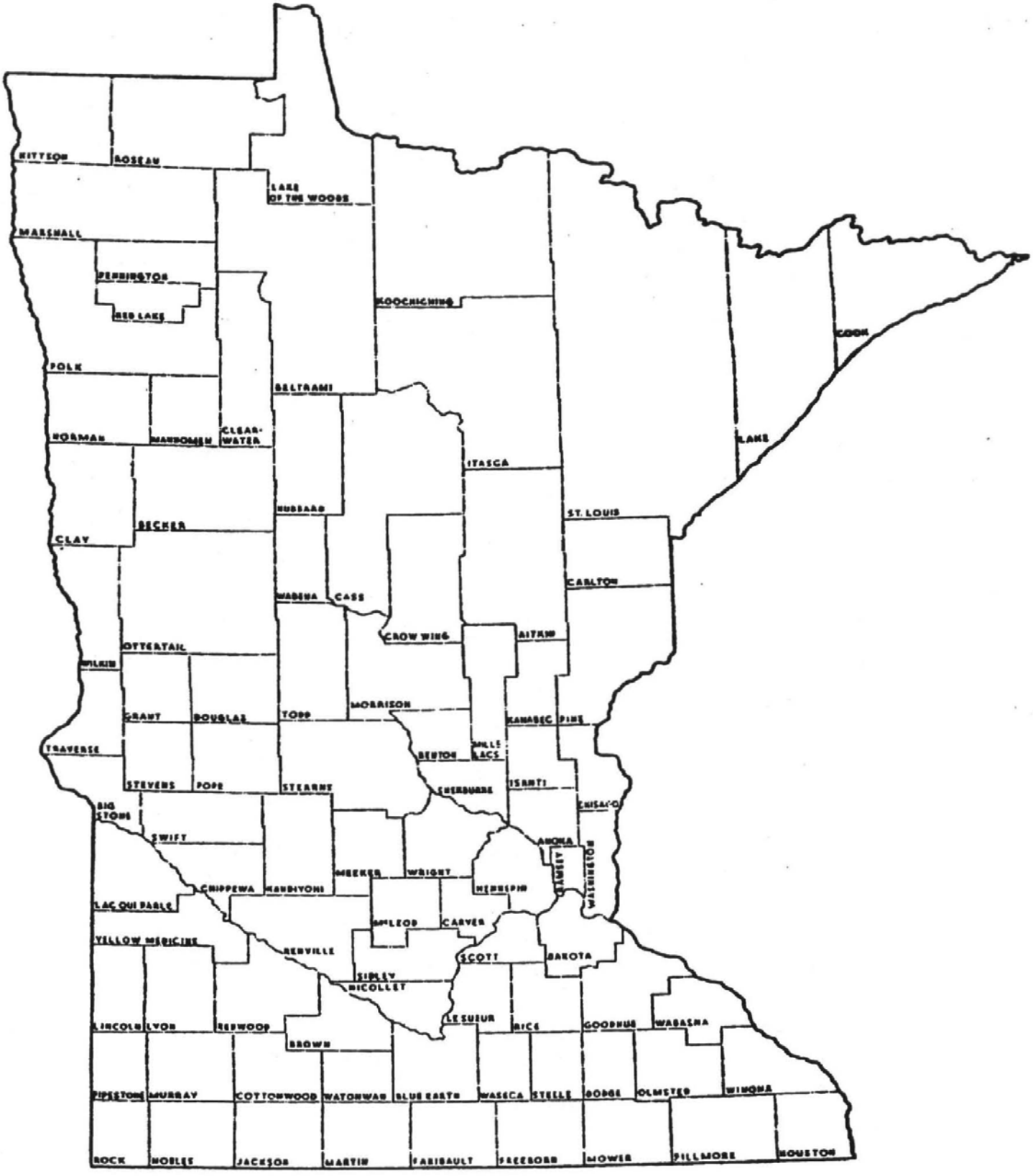


Minnesota Forest Health Report

1997

Department of Natural Resources
Division of Forestry
Forest Ecosystem Health Unit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CLEAR-WATER
LAKE
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HUBBARD
BECKER
ST. LOUIS
CLAY
CARLTON
WADENA
CASS
CROW WING
AITKIN
OTTERTAIL
WILKIN
GRANT
DOUGLAS
TODD
MORRISON
KANABEC
PINE
TRAVERSE
BENTON
MILLE LACS
STEVENS
POPE
STEARNS
SHERBURNE
ISANTI
CHISAGO
BIG STONE
SWIFT
ANOKA
RAMSEY
WASHINGTON
MEEKER
WRIGHT
CHIPPEWA
KANDIYOHI
HENNEPIN
LAC QUI PARLE
McLEOD
CARVER
YELLOW MEDICINE
RENVILLE
SCOTT
DAKOTA
SIBLEY
NICOLLET
LINCOLN
LYON
REDWOOD
LE SUEUR
RICE
GOODHUE
WABASHA
BROWN
PIPESTONE
MURRAY
COTTONWOOD
WATONWAN
BLUE EARTH
WASECA
STEELE
DODGE
OLMSTED
WINONA
ROCK
NOBLES
JACKSON
MARTIN
FARIBAULT
FREEBORN
MOWER
FILLMORE
HOUSTON

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 cover types: 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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FOREST HEALTH HIGHLIGHTS

Record flood

The 1997 spring flooding along the upper reaches of the Minnesota River and Red River of the North broke most existing flood records in Minnesota. In the post-settlement era, no sequence of extreme precipitation events has impacted these river basins as those experienced during the autumn of 1996 through the spring of 1997. The Federal Emergency Management Agency's estimate of public infrastructure damage was approximately $300 million. Before the water receded, 58 of 87 counties were declared federal disaster areas. The American Red Cross reported that 23,263 families were affected by the massive floods. Total flood damages and associated economic impacts were estimated to be as high as $2 billion. At the present, the impact on woodlots and shade trees is not known. Reports should be available in 1998.

Severe wind storms

A straight line wind and a tornado knocked thousands of acres of woodlands down this year. On the evening of July 1st, straight line wind cut a wide swath across central Minnesota that included Wright County east through Sherburne County, western Anoka County, and on into Wisconsin. It is estimated that a swath 5 to 10 miles wide by 40 miles long was affected.

The second notable storm was a tornado on September 18th that cut a sinuous path through Morrison, Mille Lacs and Kanabec Counties. Over 5000 acres were blown down or destroyed.

Gypsy moth

Minnesota produced 261 moths in the pheromone trapping grid. This was not even close to the record of 580 moths taken in 1984 or the "Breach Year" (1994) catch of 350 moths. We have actually seen a dramatic increase in the number of sites over the past three years: from 67 in 1995, to 117 in 1996, and to 154 in 1997. The increase in just the last year was 37 new sites. In the county department, we tied the record of 25 counties established in 1995.

The most significant increase in site numbers was produced in three key southeastern counties of Fillmore, Houston, and Winona. In 1994, this area was trapped and produced just four moths at four sites. This year's take was an astounding 65 moths from 49 sites.

Metro counties actually showed a decrease in sites to 68, down from 86 . One bright spot was the discovery of an infested cotoneaster shrub in the Apple Valley spray area from 1996. The shrub produced an astounding nine egg

masses and six pupae. The other "hot spot" this year was over in Eden Prairie where some "uncertified" blue spruce from Michigan were planted. These did not come through legitimate nursery channels and the USDA is investigating.

Fall defoliator complex

Since the early 1980's, the "bellwether" locations for fall defoliators have been quiet. In 1995, one location had noticeable feeding on oaks and by 1996, forty acres were defoliated there. This year orangestriped oakworms, *Anisota senatoria*, redhumped oakworms, *Symmerista canicosta*, yellownecked caterpillars, *Datana ministra*, and pinkstriped oakworms, *Anisota virginiensis*, defoliated about 1700 acres in central Minnesota. Walkingsticks defoliated about 200 acres there also. Defoliated sites ranged from five to 1500 acres in size. Caterpillars are predicted to increase in 1998 because their observed natural enemies (parasites, diseases, predators) were minimal. Walkingsticks won't be back until 1999 since they have a two year life cycle.

Analysis of Gypsy Moth Damage Potential in Minnesota

With the specter of gypsy moth knocking at our door, we need to take a deep breath, lean back, evaluate the situation, and earnestly begin to prepare for a forest ecosystem that includes an increased defoliation stress component.

A four layer, weighted model was created to assess the potential damage to forested stands in Minnesota due to the introduction and outbreak of the exotic gypsy moth, *Lymantria dispar*. In this analysis, the damage potential of the gypsy moth was identified relative to where defoliation is (1) likely to be heavy and sustained and (2) have the greatest chance of "contacting" additional environmental stress.

The damage potential model was created by combining four Minnesota data sets. These sets can be classified into two groups, biological and environmental, based on their general nature and dynamic state. Biological data sets consisted of land cover type and forest cover density. These describe the general vegetative cover of the land and are considered to be dynamic variables in the analysis, ie. they can change with time. The environmental variables of soil type and environmental stress, measured as Evapotranspirational Shortfall (*EVTS*), are generally considered to be fixed save major catastrophic events of geology or climate.

As the result of this analysis, we are able to predict that the introduction of gypsy moth into Minnesota's forest ecosystems is likely to have a major impact on the nature of the forest cover. If the pattern of damage holds from other states, this change will occur over a period of years, likely decades, as gypsy moth outbreaks wax and wane. Damage will likely occur in individual stands as mortality of preferred host species, oak and aspen, leads to stands with a higher component of nonpreferred species. Mortality will be highest in intermediate and suppressed trees and be worse on sandy or droughty soils. It is likely to accelerate dramatically in areas where drought and defoliation due to forest tent caterpillar occurs.

According to this model, the highest GMDP ratings are in these counties: Winona, Houston, Itasca, Kanabec, Wabasha, Fillmore, Cass, Crow Wing, Carlton, Pine, Todd and Morrison. The Twin Cities area will suffer some damage but will likely bear the brunt of the "nuisance damage factor" due to high public contact in the urban forest.

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
Red cedar 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	---	---	---

Damage	Total	Light	Mod	Heavy
Flooding	3,300	---	---	---
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
Woodland Owners and Users Workshop
Wabasha County Forestry Day
Minnesota PIE and ROW

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

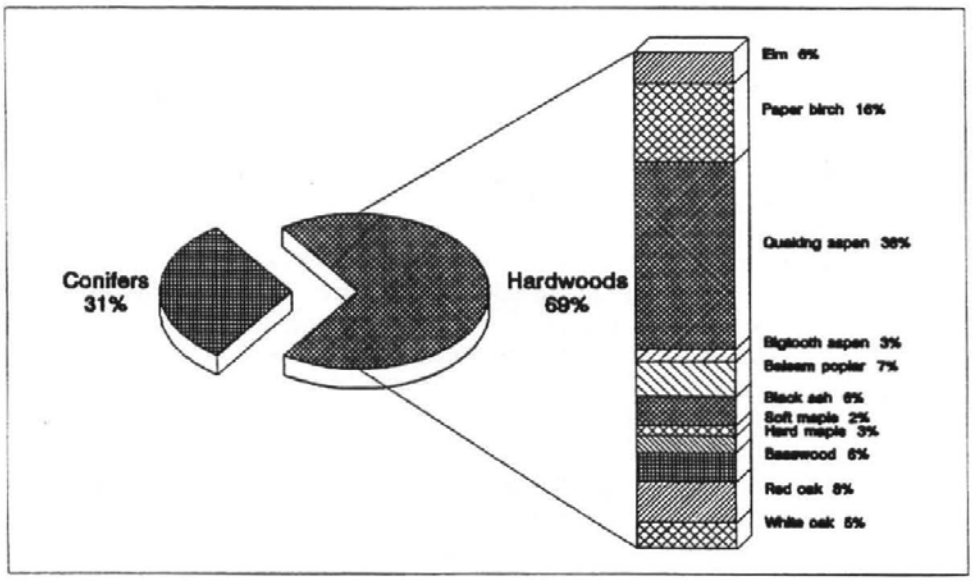
THE FOREST RESOURCE

Forest Inventory Analysis - 1990: The resource and mortality losses

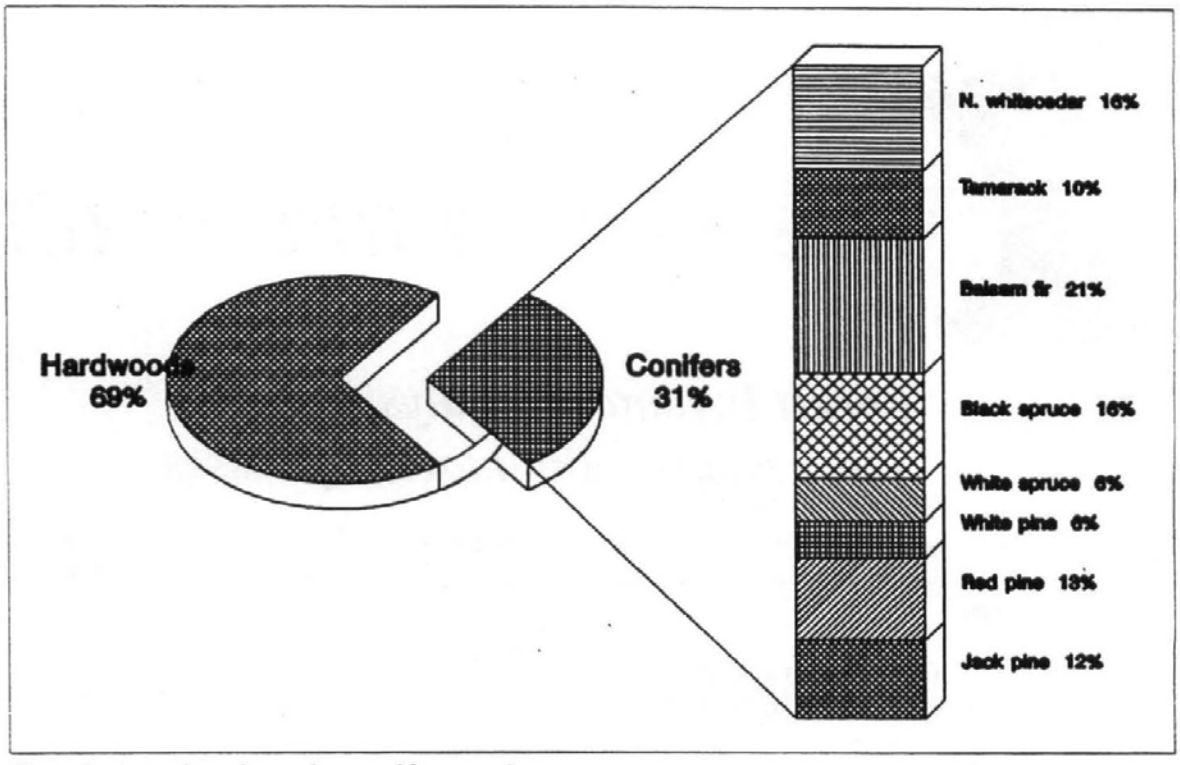
The latest Forest Inventory Analysis in Minnesota covered the period of 1977-1989. Acreages, volumes and other values found in this Report are based on data from the FIA and can be found in "Minnesota Forest Statistics, 1990" by Miles and Chen.

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



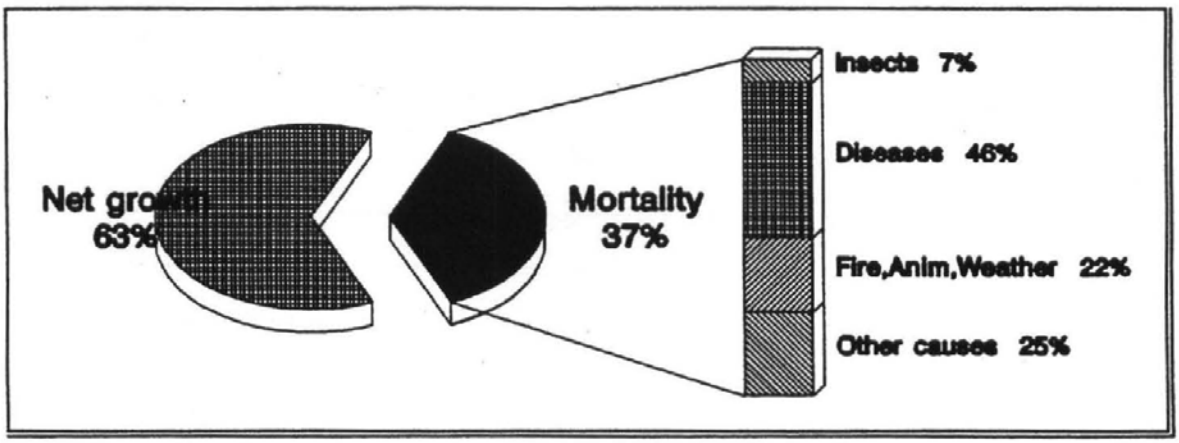
Growing stock volume by conifer species

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:

Forest tent caterpillar
Bronze birch borer
Dusky birch sawfly

Forest tent caterpillar

Malacosoma disstria (Hubner)

Host: Basswood and aspen
Damage: Defoliation
Area: 264 acres
Severity: Moderate to heavy defoliation
Trend: Increasing

On May 14th, tiny (1/32 of an inch) caterpillars were hatching and starting to munch away on basswood leaves

near Little Birch Lake in southeastern Todd County. The next day, hatchlings were found near northern Gull Lake in Crow Wing County. Small, isolated populations of this defoliator were located in central Minnesota on the south side of Lake Koronis in northeastern Meeker County, between Big and Little Birch Lakes in southeastern Todd County, on the northeastern side of Beauty Lake in eastern Todd County, on the eastern side of Bay Lake in Crow Wing County, on the northwestern side of Gull Lake in Cass County, and the southwestern side of Anne Lake in Kanabec County. By June 12th these caterpillars had grown to about 1 and 1/2 inches long. Defoliation was limited to basswood. A bacterial insecticide was applied to the Birch, Gull, and Koronis Lakes caterpillar populations by property owners associations.

Ground surveys for forest tent caterpillars were completed during the first week of June in Region I. No defoliation was observed as of June 13th. Hardwood stands with defoliation in 1995 have been revisited both in 1996 and this spring. It appears that FTC populations in Douglas and Ottertail Counties have collapsed since 1995.

Dusky birch sawfly

Croesus latitarsus Norton

Host:	Birches
Damage:	Defoliation
Area:	Not determined
Severity:	NA
Trend:	NA

Defoliation on white birch in the Blackduck area by the dusky-birch Larvae, when fully, developed are yellow-green with shades of dark black blotches in series along the sides. The larvae are gregarious and feed along the leaf margins toward the mid-ribs.

Bronze birch borer

Agrilus anxius Gory

Host:	Birches
Damage:	Topkill and mortality
Area:	Not determined
Severity:	Not determined
Trend:	Increasing

Bronze birch borer continues to cause extensive mortality of paper birch in Region I, especially over the past two years. Birch mortality from BBB increased sharply during the early 1980's, somewhat leveled out in the late 1980's only to become more active in the past few years.

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
Larch sawfly

Spruce budworm

Choristoneura fumiferana (Clemens)

Host:	White spruce and balsam fir
Damage:	Defoliation and topkill
Area:	256,949 acres
Severity:	See table below.
Trend:	In 1996, defoliation acreage (205,250) was down by fifty percent compared to previous years. In 1997, defoliation increased by about 50,000 acres to 256,949 acres.

Spruce budworm defoliation, aerial survey, 1997			
County	**Defoliation**		
	Light	**Moderate**	**Heavy**
Aitkin	130		56
Becker	163		
Beltrami		1593	
Benton	271		
Cass	884	1682	281
Clearwater	54		
Crow Wing	5		
Dakota	27		
Fillmore	192		
Goodhue	254		
Houston	32		
Hubbard	249		205
Isanti		34	
Itasca	2083	24189	222
Kanabec	61		
Koochiching	3340	73583	20519
Lake of the Woods	1282		
Mahnomen	76		
Mille Lacs		42	
Morrison	256		49
Olmsted	108		
Ottertail	212		
Pine	37		
Red Lake	84		
Roseau	128		
St. Louis	4558	119205	

Sherburne	37		
Stearns	130		
Todd	321		91
Wabasha	59		
Waseca	84		
Winona	64		
Totals	15,194	220,236	21,517

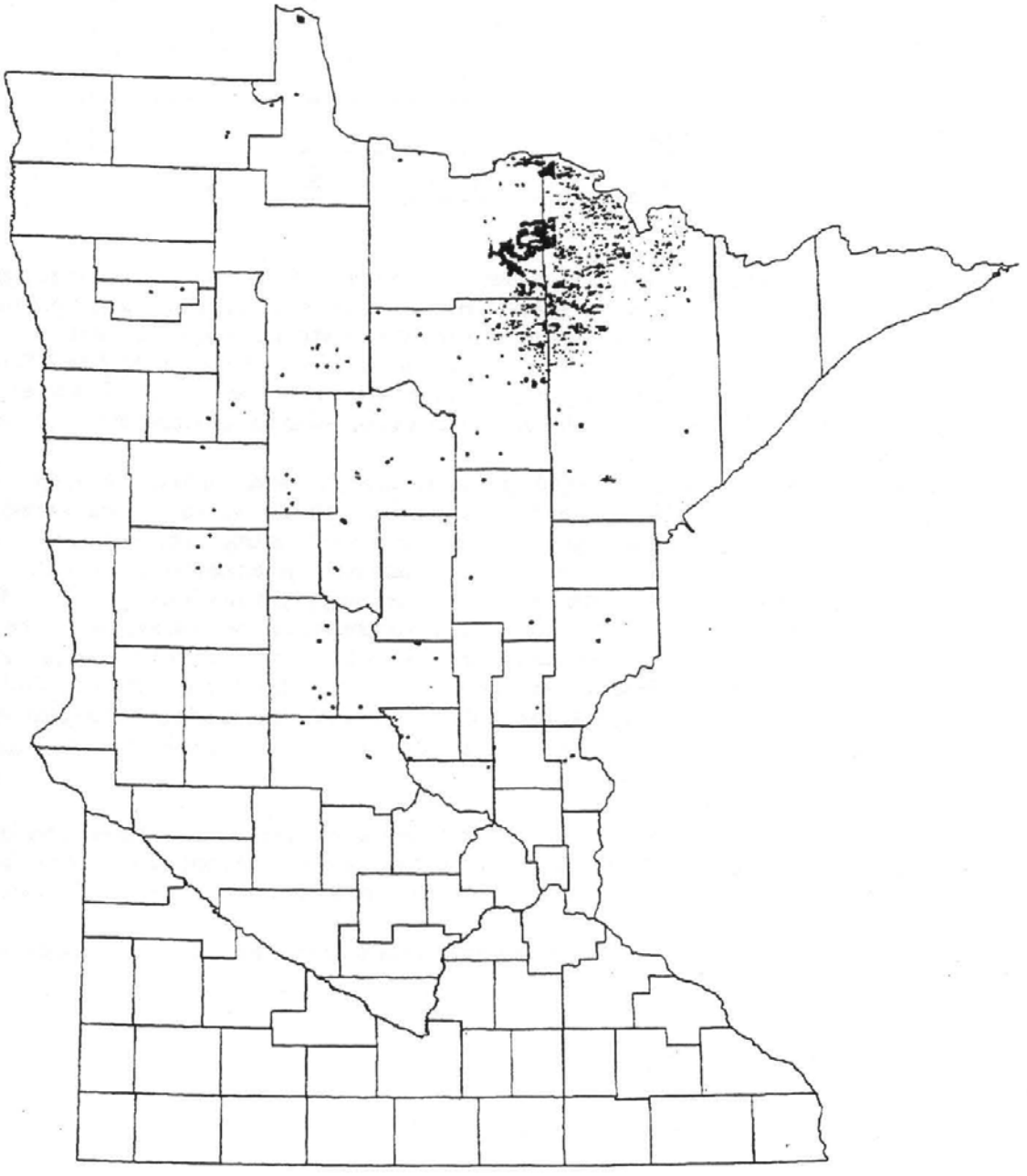
Defoliation of white spruce by spruce budworm larvae was a fact of life again this summer in Region I. Larval surveys of white spruce stands in Becker, Hubbard, Beltrami and Cass Counties were carried out and completed by June 26th. Stands defoliated for each of the past five to six years were fed on again this summer.
This defoliator of spruce and balsam continues to spread to plantations in Region 3. By June 25th, budworms had nearly completed feeding and causing damage to shoots, needles and next year's buds. Surveys earlier in June in northeastern and central Minnesota revealed that numbers of budworm had increased in several areas.

In Region 1, it appears that while we are finding more and more defoliated stands each year, the amount of defoliation in individual stands has leveled off or decreased over the past two years. Aerial surveys carried out in July of 1996 detected spruce defoliation in Cass County just east of Cass Lake. These stands were sampled for the first time and results confirm that new infestations have taken place on spruce plantations that are twenty to thirty years old. Results of surveys indicate that defoliation is increasing in geographical distribution in Region I. Populations are also moving into white spruce stands situated between Region I & Region II in the Chippewa National Forest. Defoliation on white spruce appears somewhat less than in 1996 with most plot sites having fewer or similar egg mass counts compared to 1996. However, one spruce plantation in Section 21, T145N-R31W on federal land experienced about 60% top-kill and 10% tree mortality. This stand has had defoliation for six or more years but was never identified until the 1996 aerial surveys found it. It was discovered this year during the routine ground checking of the aerial survey polygons.

In Region 2, the acreage of spruce budworm defoliation decreased, especially in the Superior National Forest. High populations continued in northeast Itasca, southeast Koochiching and northwest St. Louis Counties. Populations are expected to stay at high levels in these locations and increase in northwest St. Louis Co.

In Region 3, defoliation of white spruce is up slightly compared to last year and the egg mass counts are very slightly down.

Map of spruce budworm defoliation -1997



Yellow-headed spruce sawfly

Pikonema alaskensis (Rohwer)

Host:	White spruce
Damage:	Defoliation
Area:	Rice County and north central and north west counties
Severity:	Locally abundant, scarce elsewhere.
Trend:	Static.

Larch sawfly

Pristiphora erichsonii (Hartig)

Host:	Tamarack
Damage:	Defoliation
Area:	40 acres
Severity:	Severe
Trend:	First observation in this location; not noted elsewhere. In the past two to three decades larch sawfly populations have been very low and scattered in Minnesota. Occasionally a small area will be defoliated for one or two years before the population dies out.

Approximately forty acres of larch sawfly defoliation occurred in S 17- T 52N- R 21W just west of Floodwood along Highway #2. The larch (tamarack) trees, twelve to thirty feet tall were entirely defoliated by the sawfly larvae. Feeding was completed by the first week of August and the trees were beginning to refoliate. Many dead larvae were seen hanging from branches and shoots. This is characteristic of larvae killed by the parasitic fungus *Entomophthora.*

The larch sawfly is considered a very serious threat to larch and in the past it has been very destructive with large outbreaks across the US and Canada. Between 1910 and 1926, it is estimated that 1 billion board feet (2 million cords) of larch were killed by the sawfly in Minnesota. Another large outbreak started in Minnesota in 1939 and extended into the mid-1950's or later.

The origins of the larch sawfly has been debated but it is now thought that there are a number of strains in North America. Some are native and others introduced from Europe and Asia. The sawfly was thought to have only a few natural parasites in North America. So a parasite from Europe *Mesoleius tenthredinis* was released in Manitoba in 1913 and is credited with reducing outbreaks during the 1920's and 30's. However a resistant strain of the sawfly, developed leading to the large outbreaks in the 1940's and 50's. The resistant strain of the sawfly is able to encapsulate the egg of the parasite and is not killed by the parasite.

Two European ichneumon parasites of the larch sawfly and a Bavarian strain of *Mesoleius tenthredinis*, one that the sawfly is not able to encapsulate, were subsequently released in Manitoba. These same parasites were also released in Koochiching, Lake of the Woods, Beltrami and Itasca Counties in Minnesota in 1971 and 1972. The parasites have spread and become established throughout Minnesota and Manitoba.

Since there have been no large outbreaks after the introductions were made, it appears that the introduced parasites along with the native parasites, fungal diseases and flooding of cocoon sites have been effective in keeping larch sawfly populations in check. This doesn't mean that there will not be any outbreaks of the larch sawfly in the future, but hopefully, any outbreaks will continue to be of short duration and not as destructive as in the past.

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
Eastern tent caterpillar

Fall defoliator complex

Symmerista canicosta Franclemont	redhumped oakworm
S. leucitys Franclemont	orangehumped mapleworm
Anisota senatoria (JE Smith)	orangestriped oakworm
A. virginiensis (Drury)	pinkstriped oakworms
Dryocampa rubicunda (F.)	greenstriped mapleworm
Datana ministra (Drury)	yellownecked caterpillar
Diapheromera femorata (Say)	walkingstick

Host:	Oaks and other hardwoods
Damage:	Defoliation
Area:	1800
Severity:	Very light to heavy
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.

Fall defoliators, a diverse group of caterpillars and walkingsticks , 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, in 1996, the orange-striped and red-humped oakworms heavily defoliated about forty acres of burr and red oaks.

In 1997, pinkstriped oakworms, greenstriped mapleworms, orangestriped oakworms, yellownecked caterpillars and walkingsticks were found defoliating 1800 acres of hardwoods in Region 3. Late July, August, and early September are the months when fall defoliator insects eat leaves of various hardwoods. By September 30th , all the caterpillars had completed their defoliation and had dropped to the ground where they pupate, overwinter, and then emerge as moths next June. When natural enemies are scarce, populations of these pests build up and cause heavy localized defoliation for three or more years.

In late July large numbers of young orangestriped oakworms, *Anisota senatoria*, were observed in Morrison County southeast of Little Falls feeding on five acres of bur oak. Their empty egg cases were still nearby on the leaf undersides, and about five to ten percent of the eggs had been parasitized by natural enemies. In Todd County, north and east of Little Sauk, orangestriped oakworms moderately to heavily defoliated about 1500 acres of oaks. Another location of large numbers of the orangestriped oakworm was in Benton County, north of Sartel and just west of Watab in S27-T37-R31 where about ten acres of oaks were heavily defoliated. The orangestriped oakworm, *Anisota senatoria*, and the redhumped oakworm, *Symmerista canicosta*, defoliated about five acres of bur oaks in Morrison County just south of Little Falls.

Two-inch long, mature, pinkstriped oakworms, *Anisota virginiensis,* were observed July 28th lightly defoliating 140 acres of bur oaks near Brainerd on the southeast side of North Long Lake. This pest also feeds on white birch and other hardwoods. Natural enemies control this pest, but none were observed this July, so the caterpillars are predicted to increase in 1998 and 1999.

About 140 acres of scattered red maples in Crow Wing county on the southeast side of North Long Lake near Brainerd were heavily defoliated by the greenstriped mapleworm, *Dryocampa rubicunda*. By July 29th these caterpillars had grown to one and one-half inches long and one quarter inch wide, and they were dropping to the ground where they form overwintering pupae in the duff. Parasitized and diseased caterpillars were only rarely observed in July, and since this was the first year of an outbreak, defoliation by this pest in predicted to be heavy in 1998 and perhaps also heavy in 1999.

Smaller numbers of yellownecked caterpillar, *Datana ministra*, was reported defoliating oaks in Chisago County near North Branch. Acreages were not determined.

Walkingsticks defoliated about 200 acres of Birch Lake State Forest deciduous trees in northeastern Stearns County. This insect defoliates many species of deciduous trees but prefers oaks, basswood and cherry. Since they remove leaves in late July and August they cause minor stress on trees. Walkingsticks lay eggs until October when killing frosts occur. These eggs drop to the ground and remain dormant until late May or June of 1999 (a two-year cycle).

Eastern tent caterpillar

Malacosoma americanum (F.)

Host:	Wild cherry, apple, and crabapple
Damage:	Defoliation
Area:	Not determined, but widespread in state.
Severity:	Light to heavy
Trend:	Increased compared to last year.

Eastern tent caterpillars, *Malacosoma americanum*, were active this year in southern Minnesota. They are native defoliators, occurring from the Rockies to the east coast. Further east they are much more common than in southern Minnesota. Their favorite hosts are wild cherry, apple, and crabapple, but they occasionally feed on other deciduous trees.

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:

Fall webworm
Hardwood damage

Fall webworm

Hyphantria cunea (Drury)

Host:	Alder and other hardwoods
Damage:	Defoliation
Area:	Not determined, but across northern counties.
Severity:	Minor
Trend:	Much increased from 1996.

The tents that were obvious across northern Minnesota on alder, hazel, willow, oak, aspen, birch, etc. were made by the fall webworm. Fall webworms are unlikely to kill trees. Outbreaks only last for two to three years and most feeding damage is confined to the tents or webs. No controls are usually necessary. Braconid and ichneumonid wasps are effective natural controls but usually do not build up until webworms are quite abundant. On small trees and shrubs the best control is to clip off the branch with the tent and dispose of it or burn it.

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, 1997						
County	Discoloration	Defoliation	Dieback	Mortality		
				Light	Moderate	Heavy
Aitkin	390	44		111		
Becker		178		49		
Benton			79	59		
Chisago	66		212	2078		
Clearwater			118			
Crow Wing	234					
Dakota				98		
Dodge				145		
Fillmore			261	689		
Goodhue				882		
Houston			74	355		
Isanti	32		88			
Itasca	24					
Kanabec			1094	71		
Koochiching			98	210		
Lake of the Woods			190			
Morrison		81				
Nicollet			49			
Olmsted				632	106	
Pine			301	513		
Polk						27
Rice				123		

Roseau			395			
Scott				284		
Stearns			180			
Wabasha				432		
Wadena			140			
Waseca	64		22			
Washington				88		
Totals	810	303	3,301	6,820	106	27

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
Leaf miners
Oak webworm
Kermes scale
Two-lined chestnut borer
Phomopsis gall of hickory

Oak wilt

Ceratocystis fagacearum (TW Bretz) J.Hunt

Host:	Northern pin oak
Damage:	Mortality
Area:	5,532 acres.
Severity:	Scattered infection centers in central and southeastern counties. See table below.
Trend:	Decreasing on forestry managed lands in Sherburne Co. Elsewhere, increasing.

Oak wilt *, aerial survey, 1997	
County	**Acres**
Chisago	168
Dakota	724
Fillmore	180
Goodhue	281
Houston	553
Isanti	168
Olmsted	773
Sherburne	1381
Wabasha	207
Washington	237
Winona	422
Total	5094

* = Acres outside the Metropolitan area.

Cambridge Area let an oak wilt control project for three oak wilt infection centers on state land in Sherburne Co. These sites were on S24, 29-T34-R27W and S25-T34-R27W. On the latter site, a plow line was installed in 1994 and, in 1997, evidence of a "jump" was detected necessitating additional plowing. Vibratory plow line totaling 4600 feet was used to control root grafting . Potential spore producing trees were identified and will be disposed in the spring of 1998.

Southeast of Princeton in Sherburne County, wilting oaks were observed on three sites in late August. Lab tests were negative for oak wilt this year, so additional samples will be taken next year.

In another location in Sherburne County, a large oak stand suffered a serious fire in early May. Where the fire burned the strongest, bark was partially burned off the lower eight feet of the stem and these trees will obviously die. But in other areas, oaks were partially scorched and live sapwood exposed. Fresh scrapes and wounds to the oaks' sapwood were caused by falling trees and bulldozers. Will oak wilt get a foot hold in this stand because of all the wounding during the fire?

Not this year. In normal years this would have been a cause for concern and actions taken to prevent oak wilt infections. But spring this year was late and very cold, delaying the development of spore mats on infected oaks. According to Dr. Jennifer Juzwik, a North Central Forest Experiment Station researcher, oak wilt spore production was just about nil prior to May 12th in areas north of the Twin Cities. If you remember the jingle "Never prune is May or June", you realize that wounding an oak during this time frame can allow the overland spread of oak wilt by picnic beetles and other vectors. But if you don't have the spores, you won't get the disease even if the oaks are wounded.

On the day that the fire occurred and for 48 more hours, oak wilt spores were not present in the Sherburne County so the probability of overland spread was virtually nil. The oak wilt fungus is poor competitor on the surface of oak sapwood and if spores land on the sapwood 48 hours or more after the initial wound, the fungus is unable to infect the recent wound. Lucky for the landowner; oaks surviving the fire were not infected by oak wilt.

Leaf miners

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

Host:	Bur oak
Damage:	Discoloration caused by the mines
Area:	Not determined, but most noticeable in Becker, Ottertail, Mahnomen, Sherburne, Cass and Crow Wing Counties.
Severity:	Heavily infested trees.
Trend:	Incidence of these miners was sharply increased in 1996 and in 1997 incidence again increased and they were found in several more counties.

A number of tiny insects in the genera *Cameraria* and *Profenusa*, as well as others, mine the leaves of oaks. 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. Another closely related species is the gregarious oak leafminer, *C. cincinnatiella.* As the name suggests, several caterpillars feed together inside a single, large mine. *Profenusa* species are not caterpillars at all, but are leafmining sawflies.

Last year, oak leafminer activity was observed from Sherburne County north into Cass and Crow Wing Counties on bur and red oaks. This year, most counties in central Minnesota have bur oaks with leafminer activity. 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 .

Defoliation of white and bur oaks over large areas of Region I by the gregarious oak leaf miner, *Cameraria cincinnatiella* , were reported during the months of August and September and were common in Otter Tail, Becker and Mahnomen Counties.

Oak webworm

Archips fervidana (Clemens)

Host:	Red and bur oaks
Damage:	Defoliation
Area:	Not determined, in central counties.
Severity:	Very light
Trend:	Increased from last year.

In June and July, oak webworms were found on red and bur oaks in central Minnesota. The webs of these caterpillars enlarge to three or four inches wide and nearly two feet long. Webs contain feeding caterpillars, excrement, and bits of leaves.

Kermes scale

Host:	Bur oak
Damage:	Defoliation
Area:	Not determined, in northwestern counties.
Severity:	Not determined
Trend:	NA

Defoliation of bur oak in northwestern Minnesota counties by Kermes scale insects. Members of one family, the Kermesidae, or gall scales, are distinct for their feeding on oaks. Most scale insects are small, 10mm or less, and may be found on only certain parts of the host plant. Scales usually become numerous during periods of wet conditions preceded by droughty times. Natural enemies generally provide necessary controls unless the trees have been severely stressed by drought or flooding prior to becoming infested.

Two-lined chestnut borer

Agrilus bilineatus (Weber)

Host:	Bur and pin oaks
Damage:	Topkill and mortality
Area:	Not determined, reported from Lake of the Woods and Beltrami Counties.
Severity:	Moderate to heavy damage
Trend:	Continuing and expected to increase in the wake of the Red River flood damage.

The on-going saga of drought, mature trees, and flathead borers continues in Region I, especially in the northern part of the region. For example, the bur oak in an area of housing development and wooded lots on the shore of Lake of the Woods a few miles north of Baudette have been hard hit by two-lined chestnut borer, *Agrilus bilineatus*, along with associated Armillaria root rot. More than fifty percent of the oaks have thirty percent or more crown die-back with numerous dead trees around the housing development. Pin oaks that were planted around the campground by the golf course nearby are also affected. Although bur oaks can withstand drought very well, they are particularly sensitive to changes in their environment, such as, fluctuating water tables. Mortality and crown die-back were also reported around Kelliher in Beltrami County in 1997.

Phomopsis gall of hickory

Phomopsis spp.

Host:	Pignut hickory
Damage:	Dieback
Area:	Throughout range of hickory in state.
Severity:	Light to severe
Trend:	Endemic

Phomopsis galls of hickory are caused by one or more species of *Phomopsis*. The galls appear as a cluster of nodules tightly pressed together. When cut open they consist of woody tissue that is a bit disorganized in comparison to the normal wood. Phomopsis galls can be found not only on hickory but also on oak, maple and elm.

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 cover type 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 cover type. 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
Introduced pine sawfly
Pine root collar weevil
Red turpentine beetles
Red pine shoot moth
Red pine needle midge
Cone insects
Pine mortality

Bark beetles

Ips pini (Say)

Host:	All pines
Damage:	Discoloration and mortality
Area:	274 acres
Severity:	Mainly small, less than one acre pockets of branch kill or tree mortality.
Trend:	Static

Bark beetles were not a problem this year, although small pockets of infestation were observed during the aerial survey.

Jack pine budworm

Choristoneura pinus Freeman

Host:	Jack pine
Damage:	Defoliation
Area:	111 acres
Severity:	Light to moderate defoliation. Budworm activity was very rare and was very minor.
Trend:	Last year was the lowest population observed in the last thirty years and this year was very low also.

Ground surveys of jack pine budworm in northwestern and north central Minnesota during the summer of 1996 and early May of this year, combined with aerial mapping in July of 1996, confirmed that this forest pest was at very low population numbers except in small pocket east of Menahga in Wadena County. Moderate to heavy defoliation by this pest occurred in 1994, followed by less defoliation in 1995. Ground checking after aerial mapping in 1996 improved data collection on budworm populations and it added locations not found by 1996 summer ground checks.

During the third week in June, jack pine budworms started forming pupae. Feeding of the budworms this year was confined mainly to the pollen cone clusters so defoliation was minimal. Numbers of this pest remained low in central and northwestern Minnesota. See Survey Section.

Twenty-four egg mass plots were taken throughout the major jack pine stands in Region I that have had defoliation outbreaks periodically over the past thirty years. No egg masses were found on any of the twenty-four plots. In Region 3, no egg masses were found on twelve plots in Crow Wing, Pine and Wadena Counties. Surveys indicated that JPBW is inactive at present and that populations will remain low statewide in 1998.

Pine tussock moth

Dasychira pinicola (Dyar)

Host:	Jack pine
Damage:	None
Area:	Pine, Crow Wing, Wadena and Hubbard Counties
Severity:	NA
Trend:	Since 1980 the numbers of Pine Tussock Moth caterpillars in Pine and Crow Wing counties have diminished or remained low. In 1996 and 1997 trapped moths in northeastern Wadena and southeastern Hubbard counties increased sharply.

There is 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. In early June, 26 traps were set out and then monitored until late August or early September. See Survey Results.

Increased monitoring should be done based on this year's trap catches. Larval surveys and defoliation assessments should be undertaken in northeastern Wadena and southeastern Hubbard Counties in 1998, especially in those sections of Hubbard County, townships 139, range 32 and township 139, range 33 where more than 20 moths were collected in a single trap check period. Such assessments should also be done in Wadena County, sections 7 thru 10 and 27 of township 138, range 33. Pheromone trapping should be expanded in Wadena and Hubbard Counties in 1998. A limited number of traps should be placed in Cass County adjacent to northeastern Wadena and southeastern Hubbard Counties.

Introduced pine sawfly

Diprion similis (Hartig)

Host:	White and Scots pine
Damage:	Defoliation
Area:	Not determined, but widely scattered in central counties.
Severity:	Low to moderate
Trend:	Increased compared to last year.

Introduced pine sawfly larvae were widely scattered in central Minnesota and had increased in August to such large numbers that moderate to heavy defoliation of pines had occurred. In early September, large numbers of introduced pine sawfly larvae were reported from the Walker area in Cass County and throughout central and southern Hubbard County. Defoliation in the fall can be severe enough to cause top-kill or entire tree mortality in one season. On the sites inspected, none of the trees had defoliation severe enough to warrant insecticidal control.

Pine root collar weevil

Hylobius radicis Buchanan

Host:	Jack pine and Scots pine
Damage:	Stem girdling and mortality
Area:	6.5 acres investigated in two jack pine seed orchards; 5 acres in one Scots pine seed orchard
Severity:	70 and 75% of stems infested; more than 15 % mortality.
Trend:	For jack pine: In 1996, all stems infested and after cultural treatments, infestation decreased to above levels. In 1997, insecticide treatment applied and effects will be checked in 1998. For Scots pine: Abandoned seed orchard adjacent to highly valuable white pine seed orchard.

Both Nickerson and Little Falls jack pine seed orchards are infested with pine root collar weevil. Pine root collar weevils are hard to notice until tree mortality starts showing up. The usual targets are pines in widely spaced plantations (like 20' x 20'), plantations with more than one species of pine growing in them and any type of site with Scots pines planted on them. Damage occurs to planted pines, not naturally-seeded pines, because seedlings are often planted too deep, giving the trees a larger root collar area for the insect to attack. Injury to the pines is caused by weevil larvae feeding in the inner bark and wood below ground in the root collar and between the major roots. The soil and bark near the root collar becomes blackened and soaked with pine pitch. Larvae can be found in tunnels in the bark and pitchy soil. Trees are weakened and girdled at the ground level and may fall over or die or both. The canopy fades to pale green to yellow then red.

Weevils are sensitive to light and temperature; they like it dark, cool and humid. Management recommendations therefore try to create conditions that thwart their environmental needs.

1. When planting trees, minimize the size of the root collar area by matching the dirt line at the root collar with the soil level in the planting hole.
2. Allow more light and heat to reach the root collar area by pruning away the lower whorls of branches. You only need to prune up three feet.
3. Create a drier and hotter root collar area by raking away the duff and scraping away surface soil (down one or two inches) in a circle about one foot around the base of the tree.
4. Avoid mulching as this creates a dark, cool and humid environment.
5. Avoid planting mixed pine species because the risk of damage is greater if you do so. Scots pine is most susceptible and white pine is least susceptible.
6. Plant at closer densities so that crown closure occurs as soon as possible in the plantation.
7. As a last resort, use an insecticide to kill adult weevils in the soil and root collar area. The threshold for this treatment is finding fifty to seventy percent of the trees with one or more weevil larvae.

Larval surveys were conducted in late June and early July and the results are as follows:

	Little Falls	**Nickerson**
Current infestation = percent of trees infested	75%	70%
Evidence of old infestation	100%	100%
Number of larvae per tree	5-10	1-2
Number of dead trees	2	0
Number of trees sampled	17	10

The pine root collar weevil literature recommends that the treatment threshold is 70% current infestation. Cultural treatments had some positive effect on weevil incidence in just one growing season. Look at the old infestation data. The first step (basal pruning) of the three step program has reduced infestations at both orchards down to 70 to 75%. The second and third steps (duff removal then insecticide treatment) were recommended given the high investment and value of these orchards.

The second step is to rake away duff and excavate soil two inches deep around each tree stem. This further disrupts/ destroys larval and adult habitat. This step was accomplished in July. Insecticide application was the third step and was accomplished in August. Dursban 4E at 5.3 ounces per gallon of water was applied to the lower trunk and exposed root collars. One pint to one quart of spray solution was sprayed on each tree.

These three steps disrupt habitat and decimate existing populations and should not need to be repeated for five to six years, IF at all. Again, surveys for insect life stages and or damage should be completed before any retreatment is planned.

At the St. Francis Seed Orchard in the Sand Dunes State Forest in Sherburne County, the Scots pine seed orchard was abandoned a few years ago. In 1997, more than ten percent of the trees are already dead and another ten percent are either fading or tipping over due to pine root collar weevil. Unfortunately, this planting is immediately adjacent to a highly valuable white pine seed orchard. Total destruction of the Scots pine seed orchard was recommended using a bull dozer to raze the site followed by burning the slash piles and finally treating the root holes with Dursban 4E next year.

Red turpentine beetle

Dendroctonus valens Le Conte

Host:	Red pine
Damage:	Mortality
Area:	2 acres at Region 2 Headquarters Bldg.
Severity:	Moderate
Trend:	Increasing

Although *Dendroctonus valens* are the largest and most widely distributed bark beetles on the continent, outbreaks are rare and quite localized. They are primarily attracted to stressed pines here in Minnesota and commonly build up in trees already infested with other species of bark beetles, like *Ips pini*, another species that attacks stressed pines. Unfortunately, red turpentine beetles seem to prefer the large, old red and white pines.

Similar to other bark beetles, red turpentine beetles attack trees wounded or stressed by construction activities, like paving, regrading, trenching or root smothering. So, damage can be prevented by avoiding these activities within forty to fifty feet of the large pines. Beetle activities can be mitigated by a series of management practices; watering, fertilizing, trapping out the beetles (using pheromone traps) and insecticide treatment of the attacked stems. Probably the most important practice is to water the trees to keep them healthier so bark beetles, of any species, aren't successful in either attacking the tree or in laying eggs inside the tree. Watering is especially important this year after the droughty and very stressful spring and early summer weather.

Red pine shoot moth

Dioryctria resinosella Mutuura

Host:	Red pine
Damage:	Branch tip death
Area:	Not determined
Severity:	Locally heavy.
Trend:	1996 saw an increase in incidence and severity and, in 1997, both increased again.

Red pines at scattered locations in central and east central Minnesota have had up to twenty percent of their shoots killed by the red pine shoot moth. Caterpillars of this insect bore into shoots in late May and feed there until July in central Minnesota (the second week of July in 1997) when they transformed into nonfeeding pupae and then moths.

Red pine trees in plantations, along roadsides in parts of Region I are displaying brown tips due to hollowing out of new shoots by the red pine shoot moth (borer). Flagging is most noticeable in Hubbard, Becker, and northwestern Cass Counties. Trees ten to twenty feet tall appear the most affected. One large red pine plantation in Becker County, just south of Osage, had enough flagged shoots that it was mapped by aerial survey flights during first part of July. By July 21st no moth larvae were found in the affected shoots.

Red pine needle midge

Thecodiplosis piniresinosae Kearby

Host:	Red pine
Damage:	Needle distortion and defoliation
Area:	Not determined
Severity:	Light
Trend:	NA

Defoliation of the current year's needles of pole size red pine near Lake George in Hubbard County was attributed to the red pine needle midge. This is the first report of red pine needle midge in Region 1 that we are aware of. These insects prefer trees that are slow growing with low vigor and are open grown. Growth loss can last up to four years.

Pine cone insects

Host:	Red and white pines
Damage:	Cone abortion
Area:	Throughout northern and central counties
Severity:	Heavy to severe
Trend:	Increased incidence compared to 1996.

Many areas of the state last year had bumper crops of white pine, white spruce and red pine cones. With such an abundant food source, numerous seed and cone insects successfully reproduced and increased in numbers. These increased "cone predator" populations are now attacking this year's limited cone crop. Since cone crops following a bumper yield are normally smaller, a larger percentage of this year's cones may be hollowed out or aborted early by insect feeding. Seed bugs, coneworms and cone beetles are at high levels.

Pine mortality

Variable causes

Host:	Jack, red and white pines
Damage:	Mortality
Area:	28,433 acres
Severity:	Light
Trend:	Decreased by half compared to 1996.

As determined by ground survey, jack pine mortality was due to the combination of jack pine budworm defoliation and bark beetle attack. Red and white pine mortality was caused by a number of agents including white pine blister rust, fluctuating water tables, bark beetles and severe thinning or pruning.

Jack, red and white pine mortality Aerial survey, 1997		
County	**Jack pine acreage**	**Red and white pine acreage**
Aitkin	81	281
Becker	5717	127
Benton		44
Carlton		98
Cass	6093	
Chisago		32
Clearwater	812	64
Crow Wing	5453	32
Houston		42
Hubbard	4769	449
Itasca		177
Mahnomen	145	
Morrison	444	318
Pine	1727	355
Roseau	29	
St. Louis	190	
Sherburne		19
Todd	126	
Wadena	809	
Totals	26,395	2,038

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
Spruce budworm

Oak wilt

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

Host:	Oaks, primarily red oaks
Damage:	Mortality
Area:	8,387 infection centers in a 79 township area in the Twin Cities area
Severity:	Severe
Trend:	Decreasing due to the Cooperative Suppression Program that ended this year.

There have been many ways to measure the accomplishments of the Oak Wilt Program that have evolved throughout the program. They have evolved for many reasons, but the most important of these are the quality of the data available and the analytical tools, particularly the EPIC GIS System. In the original pre-CSP inventory, we identified 3,006 infection centers in a 44 township area. At the end of the project, we track 8,387 centers in a 79 township area. The number of centers has also increased because of the more accurate on-ground survey used by the communities. New areas have also become infected.

During the CSP, 5164 infection centers (61.5%) were treated. The original goal of the program was to lower the incidence of centers to 1.00 per square mile. We now know that the pre-CSP density was actually 2.97, almost 50% more than originally thought. The final density across the entire area was lowered to 1.58. Originally, the goal was to have 75% of the area at this density by the end of the project. The final data identifies this percentage as 53%. In retrospect, 1.5 centers per square mile was a more obtainable goal and, in fact, 64% of the project area attained this level of suppression.

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.

The Minnesota Department of Agriculture coordinates an annual detection trapping program in Minnesota. In 1997, this program placed 12,965 traps in the state. The distribution of traps placed by all cooperating agencies and the trapping results is summarized in the following two tables.

Minnesota Gypsy Moth Trapping Program, 1997

Agency	Number of traps
Minnesota Dept. of Agriculture	8,446
USDA APHIS	3,240
Minnesota Dept. of Natural Resources	700
USDA Forest Service (federal lands)	250
County Agricultural Inspectors	200
Hennepin County Parks	109
City of Duluth	20
Total	**12,965**

Gypsy Moth Catch Summary by County, 1997	
County	**Moths/ Sites**
Aitkin	1 / 1
Anoka	10 / 6
Beltrami	1 / 1
Carver	3 / 3
Dakota	44 / 11
Dodge	2 / 2
Fairbault	1 / 1
Fillmore	15 / 14
Freeborn	2 / 2
Goodhue	4 / 4
Hennepin	65 / 28
Houston	23 / 13
Itasca	6 / 1
Lake	1 / 1
Mower	2 / 2
Nicollet	1 / 1
Olmsted	8 / 7
Polk	1 / 1
Ramsey	16 / 10
Sherburne	1 / 1
Steele	1 / 1
Wabasha	9 / 9
Waseca	2 / 2
Washington	15 / 10
Winona	27 / 22
Total	**261 / 154**

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.

While manual, mechanical and chemical weed control remains the major pest management program in our Nursery operations, the following impacts were recorded in the 1997 growing season.

State Nursery Pest Summary - 1997

Agent	Host	Impact	Action
Pine root collar weevil *Hylobius radicis*	Seed orchard - Scots and jack pines	Lodging and tree mortality	Elimination of Scots pine orchard in Zimmerman. Sanitation and sprays in remaining orchards.
Leaf hoppers Aphids Grasshoppers	Conifers and hardwoods	Needle an leaf damage	Malathion sprays at Badoura Diazinon sprays at General Andrews
Jack pine gall-rust *Cronartium quercum* and *Endocronartium harknessii*	2-0 jack pine	2-3 % cull in bed lifting	Hand sorting to discard during lifting. Sowing of improved seed.
Tip blight of red pine *Sphaeropsis sapinea*	1-0, 2-0 red pine	Scattered tip and seedling mortality in beds next to red pine windbreaks.	No sprays and loss accepted at Badoura. Daconil spray schedule at General Andrews.
Foliage blight of red cedar *Phomopsis juniperovora*	2-0, 3-0 red cedar	1-2% foliage and twig loss	No sprays and loss accepted at Badoura. Daconil and Clearys spray schedule at GA.
Pocket mortality Standing water	1-0, 2-0 balsam fir and white spruce	Tree mortality	Bed shaping to drain away water at Badoura.
Hardwood leaf spots and anthracnose	Oak, walnut	Foliage blight and leaf loss	Clearys spray schedule at General Andrews.

WEATHER-RELATED

Winter injury

Pine species showing symptoms of winter injury or winter burn were observed in Beltrami, Hubbard and Becker Counties this spring. Hardest hit were Scots, red, white and ponderosa pines growing along roadsides, windbreaks and in boulevards. Plantations of small trees whose tops were exposed above the snowline were also affected. From early November through January this year, the average temperatures were considerably lower that during the same time period in last year. However, the period from late January through April was much warmer in 1997 than in 1996. By January 20th of 1997 we were 100 degree days colder than in 1996, but by mid-March we were 300 degree days warmer than the same period last year.

Seems that we had another severe winter, especially in southwestern Minnesota. The injury is especially evident in Siberian elm and hard maples. Some of this injury in the maples is related to the previous severe winter of 1995-96! The dramatically cool spring resulted in very late foliage development across much of the south and west parts of the state.

Spring hardiness?

1997 will not go into the history books as being a good year for green ash. The mild winter and this past spring with its up and down temperatures has clearly left its mark. All over the Metropolitan Region, green ash, medium to large size, never broke bud and have now died. Trees show external symptoms ranging from lion's tailing (a cluster of leaves at the end of a branch), to death of a section of the crown (right vs. left, top vs. bottom, etc), to total tree mortality (total toast). We have seen trees up to 20" DBH die for no immediately discernable reason.

Is this an indication that green ash is not winter hardy in Minnesota? Not exactly. Effectively all of these trees meet two criteria: (1) they are urban ornamentals suffering a variety of urban environmental stresses ranging from road salt, to lawn care chemicals, to high pH and (2) they are planted, nursery raised stock from unknown seed source (most green ash planted are grown from seed). It seems that the main replacement for the elms in many of our communities, green ash, is not aging very gracefully.

Not winter hardy? Most of the trees showing problems this year came through the record cold of the two previous winters just fine. It's hard to believe that a tree that has taken minus 30 or colder in two successive winters can be seriously affected by minus 15. On the other hand, we almost expect to see this type of problem from green ash following the up and downs of a funky Minnesota spring like 1997. Is it possible to not be "spring hardy"?

Severe wind storms

A straight line wind and a tornado knocked thousands of acres of woodlands down this year. On the evening of July 1st, straight line wind cut a wide swath across central Minnesota that included Wright County east through Sherburne County, western Anoka County, and on into Wisconsin. It is estimated that a swath 5 to 10 miles wide by 40 miles long was affected. The second notable storm was a tornado on September 18th that cut a sinuous path through Morrison, Mille Lacs and Kanabec Counties. Over 5000 acres were blown down or destroyed.

Climate Update -- Spring and Summer, 1997

prepared August 15 by the State Climatology Office, DNR - Division of Waters

Sharp contrasts marked the 1997 growing season. Following the heavy snows of Winter, the Spring weather suddenly turned dry. This climatic flip-flop led to one of the driest Springs ever recorded in some areas. With concern growing for an imminent drought; northwestern, central and southern sections of Minnesota were abruptly soaked by one of the wettest Julys ever experienced. Only northeastern Minnesota missed the July deluge, and the continued dryness reduced that region's streams to a trickle and enhanced forest fire potential.

After the early Spring rain and blizzard of April 5 and 6, the weather was cold and dry for the remainder of the Spring season. From early-April to late-June, much of Minnesota experienced below normal precipitation. The driest areas were east central, and central Minnesota. Precipitation totals were less than four inches in many counties for the period. Those counties received less than 50 percent of their normal 10 inches of precipitation. In some Minnesota communities, April 1 - June 23 precipitation totals were near or below all-time low precipitation records. A precipitation ranking map shows that roughly one quarter of Minnesota was at or below the 5th percentile. A community at the 5th percentile indicates that precipitation totals for this period were this low or lower in only 5 of the last one hundred years. Cool weather mitigated the extreme dryness somewhat by reducing evaporation demand. Another alleviating factor was the wet late-Autumn of 1996. The Autumn precipitation was especially heavy in those eastern sections of the State where the 1997 Spring dryness was most intense.

The dry spell ended abruptly in the Northwest when heavy rains drenched many counties on June 22-24. A slow moving storm system passing through northern Minnesota brought intense rains to that area. Two to three inches of rain fell in portions of Clay and Becker counties during the first wave of storms. The rains resumed in earnest just hours later, dousing portions of Norman, Polk, Red Lake, Clearwater, and Beltrami counties with three to six inches of additional rain. The deluge led to flooded basements and closed roads.

Heavy rains returned to Minnesota on June 28-29 when a complex of thunderstorms brought downpours to portions of northwestern, central, and southwestern Minnesota. The storms dropped a band of five inches or more inches of rain through Kandiyohi, Meeker, and Mcleod counties.

On July 1, for the third time in roughly a week, heavy rains fell across portions of northwestern and central Minnesota. The northwestern counties of Red Lake, Pennington, Marshall, and Kittson reported rainfall amounts of one to four inches. Rainfall totals of one to four inches also stretched across central Minnesota from Lac Qui Parle and Yellow Medicine counties through the Twin Cities metropolitan area. The heavy rains fell on the already drenched soils of central Minnesota. Portions of Kandiyohi, Mcleod, and Meeker counties recorded weekly totals of over eight inches. The July 1 event was notable not only for its volume, but also its intensity. The St. Paul campus of the University of Minnesota received three inches of rain in less than one hour. The intense rainfall rate exceeded the 100-year storm total for the area. The torrent led to numerous occurrences of urban and small stream flooding as well as countless wet basements. The severe thunderstorms that brought about the intense rains also caused extensive wind damage throughout central and east central Minnesota. The high winds downed many trees and damaged numerous buildings. Hail-damaged fields, particularly in western Minnesota, became an increasingly common sight throughout late June and into July.

The first week of July was one of the coldest July weeks in State history. Temperatures averaged 10 degrees below normal. International Falls recorded a low temperature of 34 degrees F on July 7, the coldest July temperature in their history. On the same morning, the observer 3 miles south of Tower recorded a low temperature of 24 degrees F, tying the state record for the lowest July temperature. In contrast to the cold weather in early July, the second half of the month was warm and very humid. Numerous communities around the state broke high dew point temperature records. Dew points in the high 70s, and even 80 degrees F were common during the second half of the month.

On July 22, heavy rains once again doused the Twin Cities. This was the third significant rainfall event in the month of July for the area. Rainfall amounts ranged from one to five inches. The deluge fell upon already saturated ground, again leading to numerous reports of urban and small stream flooding and wet basements.

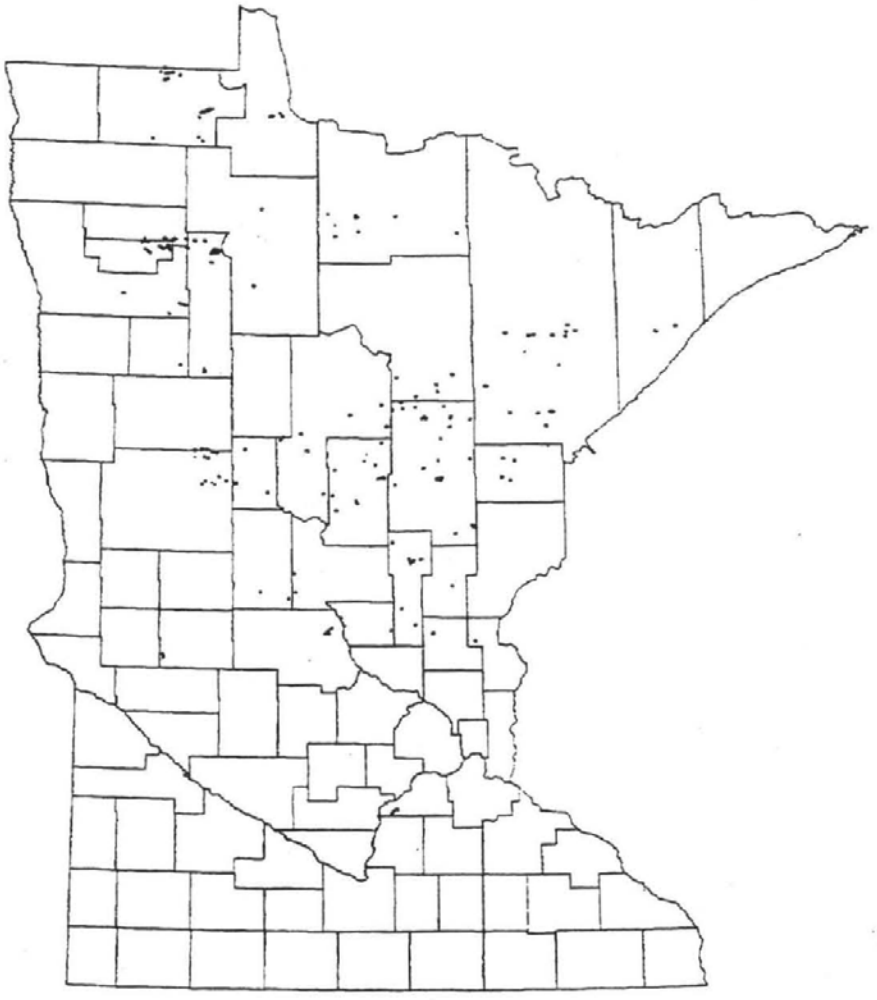
Extremely heavy rains plagued southern and central Minnesota on July 24-25. The event began in the evening hours of July 24 in southwestern Minnesota and continued into the morning hours of July 25 in eastern counties. Some of the rains fell upon relatively dry areas in Minnesota's southwestern counties. However, much of the rain in central and southeastern counties fell upon already moist ground leading to the flooding of roadways and other difficulties. The heaviest reported rainfall totals were

four to five inches in northern Lincoln and Lyon counties, portions of Sibley and Mcleod counties, and a portion of Goodhue county.

Yet another intense rainfall event hammered the St. Cloud area on August 2, dropping over three inches of rain in just a few hours. On August 14 and 15, a small area of Rice and Steele counties was soaked with over six inches of rain. The Medford area of Steele county received a whopping 24 hour total of 8.2 inches

How wet was the Summer of 1997? For the period June 24 to August 4, large areas of northwest, north central, central, and east central Minnesota were at the 99th percentile for precipitation. (See map of flooded forest lands.) The 99th percentile indicates that these locations were near or above all-time high precipitation records. Numerous communities recorded over 12 inches of rain in this six week period. Twelve inches of rain is two to three times the historical average. For many areas, the mid-Summer of 1997 will be remembered as one of the wettest periods ever.

Map of flooded forest lands - 1997.



INCIDENTAL PESTS

INSECTS

Insect	Host	County	Comments
Aspen leaf blotch miner *Phyllonorycter tremuloidiella*	Aspen	Kanabec	
Basswood thrips *Thrips calcaratus*	Basswood	Stearns	
Birch leafminer *Fenusa pusilla*	Paper birch	Crow Wing	
Blackheaded ash sawfly *Tethida cordigera*	Green ash	Crow Wing	Yard tree. Associated with spiny ash sawflies.
Bronze birch borer *Agrilus anxius*	White birch	statewide	
Cecropia moth *Hyalophora cecropia*	Silver maple	Crow Wing	
Cottony maple scale *Pulvinaria innumerabilis*	Maple	Pine	
Cottony maple leaf scale *Pulvinaria acericola*	Maple	Pine	
Crimson erineum mite *Eriophyes spp.*	Silver maple	Crow Wing	
Eastern pine shoot borer *Eucosma gloriola*	Scots, white and red pine	Sherburne	Associated with spittlebugs, root collar weevil in overgrown Christmas tree plantations.
Fall webworm *Hyphantria cunea*	Alder, elm, birch, cherry	R1, 2 & 3	Widely scattered yet very abundant this year.
Great ash sphinx moth *Sphinx chersis*	Black ash	Aitkin	Associated with spicebush silk moth.

Insect	Host	County	Comments
Lace bugs *Corythuca spp.*	Oaks, butternut	Region 3	
Mealy bugs *Phenacoccus acericola*	Maple	Pine	
Northern pine weevil *Pissodes approximatus*	Red pine	Todd	Yard trees.
Oak apple gall wasp *Amphibolips confluenta*	Red oak	Crow Wing	
Poplar petiole gall aphid *Mordwilkoja vagabunda*	Aspen	Morrison	Yard trees.
Redheaded pine sawfly *Neodiprion lecontei*	Larch	Kanabec, Pine	Larch is secondary host.
Red pine cone beetle *Conophthorus resinosae*	Red pine	Sherburne	Extremely abundant in lateral shoots this year likely due to the high populations developed last year in the cone crop and lack of cones this year.
Saperda borer *Saperda calcarata*	Aspen	statewide	
Spicebush silk moth *Promethia* spp.	Black ash	Aitkin	Also found ash sphinx and a few other small caterpillars causing defoliation.
Spruce gall adelgid *Adelges abietis*	Spruce	Pine	
Willow leaf beetle *Plagiodera versicolor*	Willow	Crow Wing, Cass	
Wood borers Various species	Hardwood species	statewide	
Wool sower gall wasp Callirhytis seminator	White oak	Washington	
Wooly alder aphids *Prociphilus tessellatus*	Maple	Crow Wing, Morrison	Yard trees.
Yellow-headed spruce sawfly *Pikonema alaskensis*	White spruce	Regions 2 & 3	
Zimmerman pine moth *Dioryctria zimmermanni*	Jack pine, white pine	Wadena, St. Louis	Associated with gall rust in young plantation trees. Problems in pruned white pine plantation.

DISEASES

Organism	Host	County	Comments
Anthracnose *Apiognomonia quercina*	Bur oaks	Region 3	Widespread
Armillaria root disease *Armillaria sp.*	Spruce, Balsam fir	statewide	
Black knot *Apiosporina morbosa*	Canadian red cherry	statewide	
Cyclaneusma needlecast *Naemacyclus minor*	Scots pine	Benton, Pine	Christmas tree plantations.
Diplodia blight and canker *Sphaeropsis sapinea*	Jack and red pines	Crow Wing	Heavy infections on hail wounds.
Dutch elm disease *Ceratocystis ulmi*	American elm	Region 3	A few scattered infections.
Fire blight *Erwinia amylovora*	Crabapple, Apple	Itasca, Pine	Ornamentals
Hypoxylon canker-rot *Hypoxylon atropunctatum*	Oak	Olmsted, Blue Earth	Minor incidence and associated with oak decline.
Inonotus canker *Inonotus obliquus*	White birch	statewide	
Needlecast *Lirula spp.*	Balsam fir	Crow Wing	Christmas tree plantation.
Phomopsis gall *Phomopsis* spp.	Bur oak	Morrison	Yard tree.
Pine-pine gall rust *Endocronartium harknessii*	Jack pine	Wadena	Associated with Zimmerman pine moth and mouse damage in young plantations.
Rhizosphaera needle cast *Rhizosphaera kalkhoffii*	White spruce, Blue spruce	Crow Wing, Pine	Widespread on older spruce trees.
Rhizosphaera needle cast *Rhizosphaera pini*	Balsam fir	Itasca, Cass, Crow Wing	In Christmas tree plantations.
Scleroderris canker *Gremmeniella abietina*	Red pine	Lake	Two plantations in T59R7 and one plantation in T58R7 were identified as having this disease.
Septoria leaf blight *Septoria musiva*	Balm of gilead	statewide	
Spruce needle rust *Chrysomyxa* spp.	Spruce	Pine	Christmas tree plantation.
Venturia shoot blight *Venturia tremulae*	Aspen	Pine	On regenerating aspen in understory.

ABIOTIC AND ANIMAL DAMAGE

Damage	Host	Location	Comments
Fertilizer	Blue spruce	Morrison	Excessive use.
Flooding	Red pine	Morrison	Mortality due to flooding for several years.
Gopher	Pines, fir spruce	Benton	Christmas tree plantation.
Grading	Red and white pines	Crow Wing	Stress initiated by adding soil to grade allowed bark beetle infestation and subsequent mortality of pines.
Hail	Jack and red pines	Crow Wing	Greer Lake Campground.
Maple decline	Sugar maple	Region 5	
Mice	Nanking cherry	Morrison	Girdled from ground level up 2 feet.
Sapsucker	Scots pine	Morrison	Christmas tree plantation.
Winter injury	Scots pine, ash, maple	Region 1 & 3; Kanabec	
Winter injury	Scots pine, Fraser fir, blue spruce	Benton	Winterburn on needles.

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: Grand Rapids, Brainerd, St. Cloud, Hinckley, Duluth, Park Rapids, Aitkin, Little Falls, Hibbing and Intl. Falls.

Phenology - 1997			
Date	**Event**	**Accumulated degree days**	**County**
Winter	The winter of 1996-1997 was long with lots of snow. Not quite as cold as the previous winter, but similar, near record amounts of snow.	0	Itasca
4/ 23	Snow is gone in the woods and grass is green in pastures. Aspen catkins are out in Itasca Co. = 10%, Cass = 50% and Crow Wing = 100%. Silver maple buds are broken and pasque flowers blooming in Crow Wing Co.	225, 228	Itasca, Cass, Crow Wing
4/ 25	Spruce buds still dormant.	335	Morrison
4/ 26	Ice went out on Lake Pokegama.	273	Itasca
4/ 28	Red and silver maples flowering and insects are active. Concolor fir and plum buds swelling in Brainerd.	306, 316	Itasca, Crow Wing
5/ 02	A few aspen clones with green leaves	341	Kanabec
5/ 02	Tamarack stands are starting to look green. 10% of swamp willows have catkins.	335	Aitkin
5/ 05	Apple trees and dandelions blooming.	427	Crow Wing
5/ 06	Maples and birches in flower, aspen leafing out and red pine buds elongating	446	Crow Wing
5/ 06	A few aspen clones with 1 inch leaves, basswood buds about 1 inch. Trillium and marsh marigolds blooming. No bark beetle grubs or FTC larvae found.	408	Kanabec

Phenology - 1997			
Date	**Event**	**Accumulated degree days**	**County**
5/ 06	Late spring and very dry in R2 and R3. Lots of trees "on hold" in terms of bud break. Red maples flowering. Placed 4 bark beetle traps at R2 HQ baited with ipsdienol, b-pinene and ethanol.	420	Itasca
5/ 08	Last of the snow melts in the overnight rain.	449	Itasca
5/ 09	Oaks starting to leaf out.	498	Crow Wing
5/ 09	Larch buds broken. Large bellwort and *Hepatica* are blooming.	466	Itasca
5/ 09	Trilliums and march marigolds blooming.	455	Mille Lacs
5/ 09	Larch needles just visible. Elms in flower and in small leaf.	458	Aitkin
5/ 10	Aspen leaves present, some clones still at bud break.	485	Itasca
5/ 11	First day of aspen clones with leaves. Bloodwort and marsh marigold beginning to bloom.	501	Itasca
5/ 12	Oak buds breaking, boxelder leaves 3/4 to 1 inch, hazel leaves ½ to 1 inch and *Amelachier* is blooming. Choke and pin cherries will bloom very soon.	572	Sherburne
5/ 12	White spruce shedding pollen, birch with catkins and *Trillium* in bloom.(first day).	497	Aitkin
5/ 13	First *Ips pini* trapped in R2HQ traps.	507	Itasca
5/ 13	Red maple and paper birch are flowering, aspen leaves about 1 inch long.	511	Cass
5/ 13	Bark beetle adults main flight (into pheromone traps).	512	Kanabec
5/ 15	Spruce buds just swelling, no SBW, yet.	564	Crow Wing
5/ 15	Forest tent caterpillars just emerging from egg cases = 1/32 of an inch long. Aspen leaves up to 1 inch.	696	Todd
5/ 16	Forest tent caterpillars hatched and feeding on basswood leaves.	547	Cass
5/ 16	Juneberries blooming.	589	Crow Wing
5/ 19	Blood root and *Trillium* in bloom.	595	Itasca
5/ 21	Hoary puccoon blooming.	634	Crow Wing

Phenology - 1997			
Date	**Event**	**Accumulated degree days**	**County**
5/ 27	Bark beetle larvae filling up trap logs.	755	Kanabec
5/27	Jack pine starting to shed pollen. Pin cherries in bloom.	819	Crow Wing
5/ 28	Spruce budworm second instars present.	845	Crow Wing
6/ 01	44 *Dendroctonus* beetles trapped at R2HQ.	903	Itasca
6/ 02	Choke cherries and blue lupines blooming.	1002	Crow Wing
6/ 02	2nd instar spruce budworm larvae (Jay Cooke). Birch leaf miner mines just visible, about 1/16 inch. White spruce bud caps still attached, shoots 1 inch long in sun, in shade, ½ inch. Lilac just starting to bloom.	698	Carlton, St Louis
6/ 02	Bark beetles laying eggs in red pine. Jack pine pollen shed beginning; candles are >2 inches. Oaks with catkins. Red pine candles > 3 inches. Pine cherries full bloom. Ohio buckeye blooming. Elderberry, wild columbine, *Kalmia*, cottongrass and lilacs in full bloom.. Understory ash starting to leaf out, overstory still quiet. Amelanchier past peak bloom. Bigtooth leaves are 1-2 inches.	941	Cass, Itasca
6/ 03	Leafy spurge blooming.	1037	Crow Wing
6/ 05	Spores being shed from jack pine gall rusts and heavy pollen shed from jack pine.	1021	Pine
6/ 05	Red pine shedding pollen.	1154	Benton
6/ 05	Forest tent caterpillars variable on basswood, ½ to 1 ½ inches. Lilacs blooming. *Trillium* just done and wild geranium starting to bloom.	1044	Cass
6/ 06	Spruce budworm pupae found	1186	Sherburne
6/ 07	Scots and red pines starting to shed pollen.	1103	Itasca
6/ 09	Mt. ash starting to bloom.	1171	Itasca
6/ 09	Spruce budworm larvae 1/8 inch long.	1175	Cass
6/ 10	Spruce budworm in 6th instar.	1268	Crow Wing
6/ 10	Wild geranium and leafy spurge blooming.	1461	Todd
6/ 11	Jack pine budworm in 2nd instar, very tiny.	1243	Wadena, Becker
6/ 11	Forest tent caterpillar in bur oaks, 1 ½ -2 inches long. Early coloration/ symptoms of oak wilt.	1357	Sherburne

Phenology - 1997			
Date	**Event**	**Accumulated degree days**	**County**
6/ 15	Pale green weevils are out and about.	1381	Itasca
6/ 18	Spruce budworm 3/4 to 1 inch long; 1-20% pupated. Red osier dogwood and daisy in bloom.	1294	St. Louis
6/ 20	Along the shore, these are blooming: crab apples, lilacs, Juneberries, *Acer spicatum*, and Oriental poppies. Up in the hills, these are blooming: thimble berry, red osier dogwood and wild roses; dandelions in "fluff".	Not available	Cook
6/ 23	In bloom: wild iris, common buttercup, oxeye daisy, Indian paintbrush, blue vetch.	1534	Aitkin
6/ 24	Maple, birch and apple trees are losing leaves as a drought response. 7 inches below normal since snow melt.	1831	Sherburne
6/ 24	Jack pine budworm in 5th and 6th instars.	1688	Cass
6/ 24	Jack pine budworm starting to pupate.	1704	Wadena
6/ 25	Rose chafer beetles on roses and peonies	1797	Crow Wing
6/ 26	Yellow headed spruce sawflies are ½ to 1 inch long.	1570	St. Louis
7/ 01	Fresh wilting of elms due to Dutch elm disease. Catalpas are blooming	2294	Todd, Morrison
7/ 07	Butterfly weed blooming.	2190	Crow Wing
7/ 08	First pine tussock moths trapped in pheromone traps.	2161	Hubbard, Wadena
7/ 08	Fireweed and milkweed just beginning to bloom; *Thalictrum* and dogbane just past.	2141	Cass
7/ 09	First pine tussock moths trapped in pheromone traps.	2161	Pine
7/ 14	Oak anthracnose observed on bur oak. Lecanium scale and *Cameraria* spp. on oak. Noted maple spindle galls.	2369	Itasca
7/ 15	Oak anthracnose; lots of late infections.	1995	Carlton
7/ 17	First pine tussock moths trapped in pheromone traps.	2578	Crow Wing
7/ 21	In bloom: Canada thistle, cow vetch, water hemlock, common evening primrose.	2533, 2645	Aitkin, Pine

Phenology - 1997			
Date	**Event**	**Accumulated degree days**	**County**
7/ 21	In bloom: Spotted knapweed, harebell, early goldenrod, wild bergamot, common milkweed, smooth aster, birdsfoot trefoil and hoary alyssum.	2645	Pine
7/ 23	Showy aster and small white aster blooming.	NA	Region 3
7/ 23	Tansy and sunflowers blooming.	2790	Crow Wing
7/ 30	*Anisota senatoria* in first to third instars.	3439	Todd
8/ 04	Jerusalem artichoke blooming.	3140	Pine
8/ 05	Gypsy moth (3) collected from trap at Ann Lake Cmgrd. in Sand Dunes State Forest.	3396	Sherburne
8/ 11	Larch sawfly larvae still feeding.	3128	St. Louis
8/ 11	Lots of fall webworm, caterpillars are 3/4 inch long. Heavy basswood flowering this year. Heavy cone crop in white pine (second year in a row).	3402	Itasca
9/ 08	Goldenrods and sunflowers blooming.	4249	Itasca

SPECIAL PROJECTS

An analysis of gypsy moth damage potential in Minnesota
Oak wilt aerial survey and photo interpretation
Forest health grants for communities
Wind and tree failures
Itasca State Park: Old growth pine and bark beetle hazard assessment projects
Hosted:

- Northeastern Area Forest Nursery Conference and Workshop
- North Central Forest Pest Workshop

Crow Wing County Forest Management Plan: Insects and diseases
Hazard tree training sessions
Christmas tree growers meeting
Fliers:

- Why conifers turn red in the spring
- Webworms, tent caterpillars and other web-making insects
- Gypsy moth: At the crossroads in Minnesota
- Land cover assessment using multi-temporal satellite analysis
- Forest health in Minnesota

An Analysis of Gypsy Moth Damage Potential in Minnesota

By Dr. Thomas Eiber

Introduction

With the specter of gypsy moth knocking at our door, we need to take a deep breath, lean back, evaluate the situation, and earnestly begin to prepare for a forest ecosystem that includes an increased defoliation stress component. Over the next few issues, we will engage in several important discussions relating to this pending, inevitable "invasion". In this issue, we will discuss the damage potential to Minnesota's forests caused by gypsy moth. In subsequent issues, we will discuss the specifics of predicted damage and some approaches to modified silvicultural practices that can minimize the impacts, both economic and ecological, to our forested systems.

An Primer of Gypsy Moth Damage Potential In Minnesota

Defoliation is easy to predict while damage potential, ie. impact, is much more difficult. It is safe to assume that effectively all forested systems in Minnesota will feel the bite (no pun intended) of gypsy moth defoliation. Oaks and aspen, along with birch and maple, are all devoured with varying degrees of vigor. With gypsy moth established in the Sudbury area in Ontario and central Maine, it is unwise, perhaps downright foolish for us to assume that Minnesota's "legendary" winter will provide anything like immunity from the pest. There is little evidence that indicates that we will NOT be completely infested within the next ten to fifteen years.

Defoliation is not damage, at least not in any serious sense other than visual and aesthetic. Real? Yes, but limited. True damage will occur when trees loose vigor and begin to die. As we have progressed through the *maxi-drought* in 1988 and localized *mini-droughts* in the 1990's, we have come to understand that the ultimate impact of stress is tree death, a.k.a. mortality. We have also learned that tree mortality is not as easy to understand as it is to say. Trees die from stress, more specifically, from too much stress. We also know that stress is cumulative and that it comes from many sources.

As a result, we clearly must understand that damage from gypsy moth will occur NOT just in areas that are defoliated, but will occur in areas where trees are stressed from other causes and are defoliated. One of these "other causes" is the competition caused by normal stand structure and overcrowding. Silviculturists have long called small, understory trees in a forest "suppressed" for good reason. Gypsy moth will add another stress, but that is a story for another day.

Environmental Stress Plays an Important Role

Minnesota lies astride one of the most dramatic ecological boundaries in North America. The divide between the grassy plains in the central continent and the blanket of forest to the east. We clearly understand the issues of the edge. Climate, particularly rainfall patterns, plays a major role in the health of forests over a great proportion of the state, particularly the hardwood band swiping from northwest to southeast called the hardwood forest. This is a zone of ecological tension. Wet years and dry years. Rainfall, largely expressed by shortfalls in evapotranspiration, drives forest ecology in this zone back and forth, prairie to forest to prairie to forest and so forth.

Soils play an important role in this tug-of-war by effectively buffering short and medium term shortfall events. We have long since thought of sandy soils as "droughty". Actually, there is no evidence that it rains less on sandy soils. Simply, sandy soils have a poor ability to hold rainfall and to effectively store moisture. Loamy soils do a really good job. Clay soils do an even better job of holding soil moisture, but

are totally miserable at releasing it. Banded soils, where sands and silts (loam) form layers, act as water storage devices and tend to be our most productive soils.

Structure of the Damage Potential Model

A four layer, weighted model was created to assess the potential damage to forested stands in Minnesota due to the introduction and outbreak of the exotic gypsy moth, *Lymantria dispar*. In this analysis, the damage potential of the gypsy moth was identified relative to where defoliation is (1) likely to be heavy and sustained and (2) have the greatest chance of "contacting" additional environmental stress.

The damage potential model was created by combining four Minnesota data sets. These sets can be classified into two groups, biological and environmental, based on their general nature and dynamic state. Biological data sets consisted of land cover type and forest cover density. These describe the general vegetative cover of the land and are considered to be dynamic variables in the analysis, ie. they can change with time. The Environmental variables of Soil Type and Environmental Stress, measured as Evapotranspirational Shortfall (*EVTS*), are generally considered to be fixed save major catastrophic events of geology or climate.

The analysis model was created by combining the two biological factors into a sub-model and the two environmental factors into a second sub-model each with separate weighting factors. As a result of this weighting, each sub-model contained scale values of relative damage potential. Operating at the landscape level, these models evaluate the relative damage potential for locations based on the individual factors. In a second phase, the sub-models were added together to derive a damage potential value for the entire state. While no specific research has been applied in the overall model, effectively all components are known to affect damage potential. The structure and weighting of the model was derived with this considerable body of research in mind.

Biological Component: Forest Cover Type

Forest cover type for all lands within the state is surprisingly elusive. The only available statewide cover type information was derived from a 1990 USGS study which used AVHRR (weather) satellite data to generate a national cover type map. This data was minorly adjusted based on our current knowledge of ECS, FIA, and land cover into the modified AVHRR Land Cover layer found in the MGC100 data set in EPIC (see attached map).

This layer was given the heaviest weighting of all model elements at 60%. A maximum of 60 rating units (points) were assigned to areas that had a high proportion of aspen or oak. Nonpreferred hosts were assigned 5 or fewer units.

Biological Component: Forest Cover Type Density

Forest cover type density is derived from another AVHRR study. Forest density was considered to be useful in appraising damage potential since areas with fewer trees have fewer trees to damage. With a weighting of only 5%, a maximum of 5 rating units could be assigned to a given area. The areas with the highest forest density are almost exclusively located in the Laurentian Forest Province in the northeastern part of the state.

Environmental Component: Soil Type

Soil data from the Minnesota Soil Atlas has been available in automated, fully registered format for many years. Currently part of EPIC's MGC100 data set, it is easily the best statewide soil information. Scoring soils was based on a general understanding of soil to site quality relationships. Soil quality was assigned a 20% weighting in the model with a maximum score of 20 being assigned to sandy soils. In effect this component estimates a soil unit's LACK of productive capacity. Better quality soil units received lower scores.

Environmental Component: Climatic Stress

Climatic stress, as measured by the evapotranspiration shortfall (summer rainfall minus water needed by the vegetation) has been understood for several years in Minnesota. It has been used in various work ranging from windbreak management to Ecological Classification Systems work. It is effectively a measure of the stress created by our "normal" shortfall of growing season precipitation. This "shortfall" fails to provide an optimum photosynthetic environment even in normal years. It is particularly important in Minnesota in understanding the west to east, prairie to forest transition that occurs in Minnesota.

The Climatic Stress component was given a weighting of 15%. While important in predicting general stand vigor over time, it is probably somewhat less important than soil, which tends to "buffer" its effect. A maximum unit score of 15

was assigned to areas with a EVTS shortfall greater than 8". These areas show a clear tendency to occur in the western Prairie Province. An area of low EVTS shortfall (1-2") occurring near Lake Superior was given a minimal score of 1 effectively showing minimal stress caused by a lack of rainfall.

A Technical Note

All spatial modeling was accomplished with the EPIC GIS using the MGC100 data set. Two 2-way reclass models were applied to the primary thematic layers to generate the two sub-models of Biological and Environmental Components. These were additively combined using EPPL's EVLAUATE command. All component and sub-models are available in EPIC as MGC100 data layers. The final results were a run of damage potential values from a low of 7 to a high of 96. These values were simplified to the three basic class illustrated on the attached map.

Results

The attached color map is a first in two ways. First, it is the first full color map page in this newsletter. Perhaps the sign of things to come. Second, it graphically shows the final result of the Damage Potential model simplified into the three classes we know so well, low, medium, and high. Several things are immediately apparent. First, most areas of the state can expect to see damage caused by gypsy moth to some degree. Two, there are significant areas of high damage potential in the northern parts of the state. This is largely due to the large expanses of highly-favored aspen in these areas.

How do the forests in your area fare? The list below is the average danger class by county. The numeric score for each county is based on Minimal = 1, Moderate = 2, and High = 3. The counties are ordered from greatest to least damage potential. For example, Winona County has the highest average score of 2.09, indicating that ***on average*** we expect somewhat more than moderate damage. Hint: This is not a nice list on which to score high. We will be using this damage prediction model for various purposes over the next few years as we prepare for establishment of the gypsy moth. By using it, we can focus our attention and efforts into those areas of the state most likely to be damaged by gypsy moth defoliation. We expect gypsy moth to be everywhere, but damage to be concentrated in more specific areas.

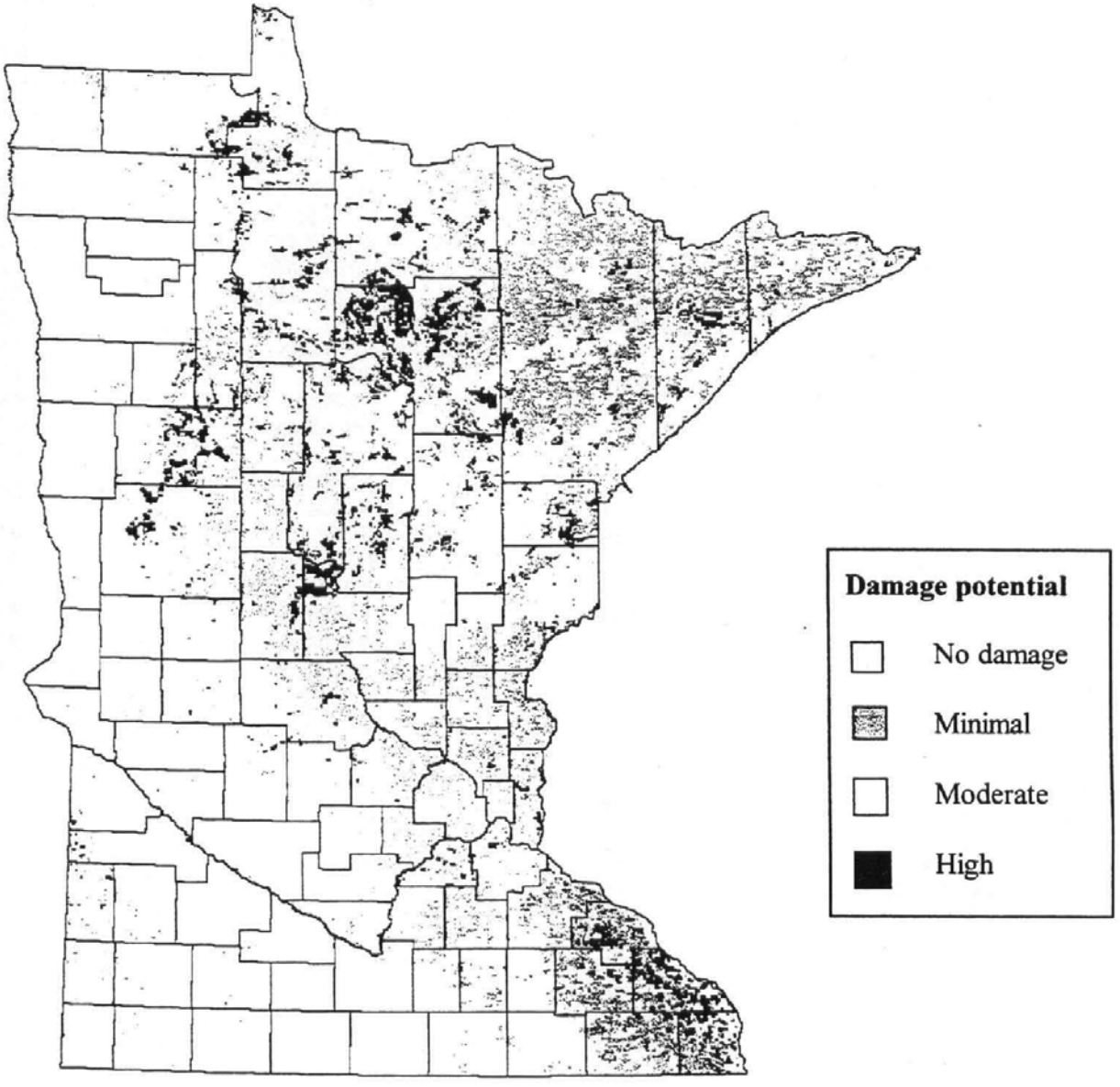
Summary

As the result of this analysis, we are able to predict that the introduction of gypsy moth into Minnesota's forest ecosystems is likely to have a major impact on the nature of the forest cover. If the pattern of damage holds from other states, this change will occur over a period of years, likely decades, as gypsy moth outbreaks wax and wane. Damage will likely occur in individual stands as mortality of preferred host species, oak and aspen, leads to stands with a higher component of nonpreferred species. Mortality will be highest in intermediate and suppressed trees and be worse on sandy or droughty soils. It is likely to accelerate dramatically in areas where drought and defoliation due to forest tent caterpillar occurs.

Damage will concentrate in the southeast (DNR Areas 531 and 533). Regions 2 and 3 will also feel a significant sting in several areas (Areas 221 and 222 in Region 2 and Areas 323 and 351 in Region 3). Regions 1 and 4 will be relatively little damaged. Region 6 will suffer some damage but will likely bear the brunt of the "nuisance damage factor" due to high public contact in the urban forest.

Rank	County	Average Damage Potential Score
1	WINONA	2.09
2	HOUSTON	1.96
3	ITASCA	1.84
4	KANABEC	1.72
5	WABASHA	1.69
6	FILLMORE	1.63
7	CASS	1.63
8	CROW WING	1.61
9	CARLTON	1.59
10	PINE	1.58
11	TODD	1.58
12	MORRISON	1.53
13	HUBBARD	1.49
14	ANOKA	1.45
15	CLEARWATER	1.43
16	STEARNS	1.36
17	WASHINGTON	1.32
18	CHISAGO	1.31
19	BECKER	1.28
20	MILLE LACS	1.25
21	LAKE	1.21
22	OLMSTED	1.18
23	CARVER	1.17
24	AITKIN	1.16
25	COOK	1.14
26	BENTON	1.13
27	ST. LOUIS	1.08
28	WADENA	1.06
29	ISANTI	1.03
30	SCOTT	1.01
31	OTTERTAIL	0.96
32	BELTRAMI	0.96
33	WRIGHT	0.94
34	SHERBURNE	0.91
35	GOODHUE	0.91
36	KOOCHICHING	0.91
37	HENNEPIN	0.90
38	DOUGLAS	0.83
39	RICE	0.79
40	MAHNOMEN	0.74
41	LAKE OF THE WOODS	0.71
42	POPE	0.63
43	RAMSEY	0.62
44	LE SUEUR	0.62
45	KANDIYOHI	0.57
46	LINCOLN	0.49
47	DAKOTA	0.48
48	MEEKER	0.41
49	ROSEAU	0.36
50	MCLEOD	0.35
51	STEELE	0.28
52	SIBLEY	0.27
53	NICOLLET	0.24
54	WASECA	0.23
55	DODGE	0.20
56	YELLOW MEDICINE	0.19
57	CHIPPEWA	0.17
58	SWIFT	0.17
59	FREEBORN	0.14
60	BROWN	0.13
61	PIPESTONE	0.13
62	LAC QUI PARLE	0.12
63	MOWER	0.12
64	LYON	0.12
65	KITTSON	0.12
66	BLUE EARTH	0.11
67	MARSHALL	0.09
68	RENVILLE	0.08
69	REDWOOD	0.07
70	BIG STONE	0.07
71	COTTONWOOD	0.06
72	CLAY	0.05
73	STEVENS	0.04
74	POLK	0.04
75	MURRAY	0.04
76	JACKSON	0.03
77	FAIRBAULT	0.02
78	NOBLES	0.02
79	NORMAN	0.02
80	ROCK	0.02
81	MARTIN	0.02
82	GRANT	0.02
83	WATONWAN	0.02
84	WILKIN	0.02
85	RED LAKE	0.01
86	PENNINGTON	0.01
87	TRAVERSE	0.00

Map: Damage potential to Minnesota's forest ecosystems due to infestation and defoliation by gypsy moth



Modeled in EPIC by Tom Eiber. FHU, Oct. 1997.

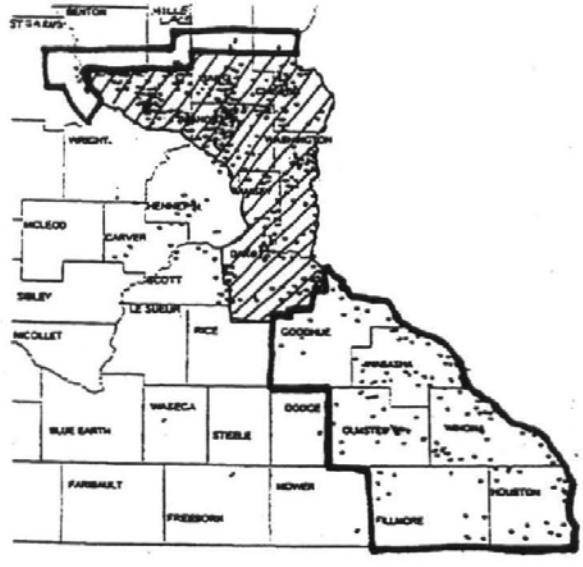
Oak wilt aerial survey and photo interpretation

The Federal Oak Wilt Cost Suppression Program, which began in 1991, ended in December 1997. In anticipation of continued state funding, counties with oak wilt outside the 79 township, CSP area were surveyed. See map. This new project followed the same methods and procedures established in the three earlier surveys to ensure data compatibility. Aerial survey, photo interpretation and digitization was used to pinpoint the infection centers. This will enable communities and counties to request state funding for cost-sharing practices.

In Region 3, the surveyed townships are immediately adjacent to the Federal CSP area and are on the Anoka Sand Plain which is extremely conducive to root graft spread of oak wilt. Townships in Wright County were not flown because a catastrophic wind storm occurred two weeks before the survey and discoloration and mortality blowdown and breakage could not be reliably distinguished from oak wilt. An area equaling ten townships was photo-interpreted. Very few infection centers were found. See table.

In Region 5, surveyed townships were scattered through five counties where oak wilt was known or suspected. An area equaling ten townships was also photo-interpreted. See table.

Oak wilt: aerial survey results - 1997		
Location	**County**	**Number of infection centers**
St. Augusta	Stearns	11
Rush City	Chisago	1
Maple Ridge	Isanti	3
Princeton	Mille Lacs	7
Rochester	Olmsted	124
Red Wing	Goodhue	59
Wabasha	Wabasha	107
Winona	"	27
St. Charles	"	17
Rushford	Fillmore	17
Houston	Houston	5
Brownsville	"	4
Caledonia	"	3
Total		**395**



Aerial survey 1997

Area of CSP

1998 - 2000

Forest Health Grants to Communities

The Minnesota State Legislature passed a spending bill during the last session that contains funds for forest health programs in Minnesota communities. Specifically, there are two grant programs that have been authorized. One, for oak wilt and the second for "forest health".

Oak Wilt Funding

The Legislative Commission of Minnesota Resources (LCMR) is providing $80,000 specifically earmarked of oak wilt control in Minnesota communities. These funds can be used in Regions 3, 4, 5, & 6. Priority for these funds is to be given to communities that did NOT have access to the federal oak wilt funding that was available from 1991 to 1997. These funds will be made available as "grants by reimbursement" to communities with organized programs.

Forest Health Grants

The general legislative session also provided $250,000 for general forest health grants earmarked to improve and maintain forest health in Minnesota communities. In general, grants can be obtained for programs that will take action on a specific, defined problem in a community. These problems can be insect or disease outbreaks (eg. oak wilt, gypsy moth, etc.) or other forest health issues. The funds are 50:50 match, "grant by reimbursement", and up to $10,000 per grant. These funds are part of the Minnesota ReLeaf Program and are administered through the ReLeaf Regional Committees.

Wind and tree failures

When we developed our hazard tree guidelines back in 1989, we felt we had a good understanding of tree defects and tree failures. Since that time, we have had to opportunity to visit four separate catastrophic storm events where trees have been severely damaged: tree failures a' la carte. The most recent storm "event" occurred during the evening of July 1st across the central part of the state cutting a wide swath that included Monticello east through Sherburne County, western Anoka County, and on into Wisconsin. This was the fourth "autopsy" since the hazard tree guidelines came into existence so we couldn't resist touring some of the hardest hit areas and assessing the damage with the guidelines firmly in mind. In particular, the questions asked were "What failed and why did it fail?" We tallied data on 187 trees. Here are some of the data and some conclusions.

Trees did not fail at random, but failed in regular, almost uniform, patterns. The number of trucks driving by us that day with silver maple branches and leaves hanging out prompted our assistant for the day, a forestry "intern", to comment that she would have a hard time ever looking at silver maple into future with anything other than a seriously skeptical eye. Our survey was not statistically designed and suffers from several fatal flaws in that sense. We only looked at what had failed, we did not evaluate the survivors.

1. We went into areas with serious damage, where trees had been pushed to and beyond their mechanical and structural capacities.
2. We only recorded data on trees that had failed in a major way. We did not record information for trees in the same areas that had NOT failed.
3. The areas we visited are typical of urban areas on the Anoka Sand Plain. The species composition is heavy to the urban intrusions of green ash, silver maple, and blue spruce and the native remnant of oak, largely northern pin with greatly reduced numbers of burr and red oaks. Clearly these trees failed most commonly because they are most common. Others failed less often because they are less common. The pattern of failure is, however, unmistakable.

Trees failed for one of two reasons. First, they failed because they had defects. Namely, "visible defects" that would have been detected in a basic hazard tree evaluation. Specifically, silver maple's failed due to weak unions with included bark (70%) and broken branches with decay (30%). This is a typical pattern with silver maple in storms. Northern pin oak failed due to the presence of decay columns in the main stem and branches. These were commonly complicated by old codominant stems with weak unions, included bark, and subsequent main stem decay in the "hot zone".

The second mode of failure was a fracture of the root plane causing the tree to tip over with root/soil mound that rarely

exceeded four feet from side to side. These trees were clearly improperly anchored. They simply did not have enough root mass to support the stem. Two species tipped over with a startling regularity: green ash and blue spruce. Arguably the two most commonly planted trees in the urban landscape, these two trees typically do not establish sufficient root structure relative to the tops they grow. Nicknamed the sail effect for good reason we found these two species failed with a pattern almost frightening in its regularity. The other noteworthy aspect was that these trees did NOT exhibit external, visible defects that would have been obvious during a hazard tree inspection.

In detail, we observed 18 green ash and 21 blue spruce that had failed. Of the Green ash, more than half (10/18) failed for visible cause, ie. Included bark with codominant stems. Blue spruce failed due to windthrow, one hundred percent! Both of these species exhibited a major portion of root plate failures on otherwise "defect-free" trees. It is worthy to note that only 3 of 79 oaks that failed did so as root plate failures and all three had root rot caused by construction damage. In addition, sugar maple (2/2), silver poplar (5/6), and black cherry (2/3) exhibited a high proportion of root plate failures.

Two additional observations bear repeating. Blue spruce is quite windfirm until it gets old enough to be tall enough to get 10-15' of crown above the general line of the roof tops in the neighborhood. This factor alone may help explain why large, old blue spruce are hard to come by except in older, better canopied neighborhoods with lots of two-storied houses. And here you thought they died from Cytospora canker or needle cast disease.

The other observation is the generally small size of the root/soil mass raised when green ash failed. These were quite consistent in size and commonly were reminiscent of the size of balled and burlaped root balls on transplanted trees. We can't help but wonder if this species is having a problem reestablishing the necessary five to seven large, woody, primary lateral roots after transplantation into the well watered, well watered urban landscape. After seeing this pattern for four wind events, we can't help but wonder if we are not growing these two species wrong: too much water, too much fertilizer, too fast of growth, too much top, TOO LITTLE root.

Itasca State Park - Old growth pine and bark beetle hazard assessment projects

Efforts to evaluate the impact of pine bark beetles and their ecological associates continue in Itasca State Park. The Forest Health unit will continue to monitor four areas within the Park, where tagged trees will be evaluated each year for visual crown status, vigor, decline or mortality. This will provide a simple baseline comparison of tree health in stands with:

A. Salvage and pheromone trapping
B. Control bum and pheromone trapping
C. No intervention
D. Salvage, burning and trapping

Far more detailed studies, carried out by researchers from Syracuse and Dartmouth, are as follows:

A. State University of New York, College of Environmental Science and Forestry

Project Overview

The research conducted in Itasca State Park by the SUNY, ESF will consist of two field experiments with separate but related goals. There will be substantial sharing of the work responsibilities with Dartmouth personnel.

Experiment 1.

This experiment will compare tree mortality in blow-down areas with high vs. low density beetle populations. All other aspects (i.e., stand structure and composition, soils, slope, aspect, etc.) of the paired sites will be kept constant to the extent possible. The high density populations will be untreated blow-down areas. In these areas, beetle populations are expected to increase as the insects reproduce in wind damaged trees. The low density populations will be blow-down areas in which the beetle populations are substantially reduced by salvage, burning, or manual debarking of fallen timber and mass trapping. Beetle populations in both treatment and control areas will be periodically monitored to verify the relative differences in the beetle populations. The response variable will be the percent mortality of each pine species in each site. The data will be analyzed primarily by t-test or a non-parametric equivalent.

Experiment 2.

This experiment will involve the deployment of pheromone traps to monitor *Ips* populations in widely scattered locations throughout the Park. The locations will be selected with heavy reliance on GIS data on the basis of soils, slope, aspect, and stand structure to ensure that most of the common conditions in the Park are represented. In addition, field assessments of variables not represented in the GIS sources will be made. The response variable will be 1997 tree mortality within a radius of approximately 100 meters from the center of the pheromone monitoring traps. The data will be analyzed by multiple regression to determine which variables, including number of beetles trapped, or combination of variables relate to tree mortality. These data can then be incorporated into a spatial model which can be used to forecast tree mortality.

Objectives

1. The purpose of the first experiment is to determine if *Ips* bark beetles are capable of killing pines when they occur at high population densities as typically seen following severe windthrow. Conventional wisdom asserts that bark beetles should be controlled to reduce beetle-induced tree mortality, but data does not exist to support this assertion in the upper Midwest and Lakes States.
2. An ancillary goal of the first experiment will be to determine if intensive management can successfully reduce bark beetle populations.
3. The purpose of the second experiment will be to determine quantitative relationships between tree mortality and various bark beetle population densities as well as other environmental variables such as soil type, slope, aspect, and stand composition and structure.
4. The results of the second experiment will be used to construct a computer model that will predict bark beetle damage as a function of these variables.

B. Dartmouth College

"The biology and management of bark beetles in old growth forests of Itasca State Park"

Project overview

In 1994-96, the old growth pine forests in Lake Itasca State Park sustained a sequence of heavy blowdowns from windstorms. The downed trees have provided abundant food resources for *Ips* bark beetles, leading to an apparent dramatic increase in the population size of *Ips*. Under some conditions, *Ips* are capable of attacking and killing trees that would otherwise survive. Limitations in soil water availability, such as characterize forests near the edge of the Great Plains in western Minnesota, have been hypothesized to exacerbate the risk of tree mortality from bark beetles. Thus, bark beetles pose a potentially severe risk for the remaining old growth forests of Lake Itasca State Park. The objective of this research is to assess that risk, evaluate

potential strategies to mitigate the risk, and develop biologically sound models to guide our management and understanding of this unique and ir-replaceable forest ecosystem. Research will be aided by a substantial existing knowledge base regarding interactions between pine trees and bark beetles. However, research will be unique in being the first scientific studies of bark beetles in old growth pine forests of the Great Lakes region. Because Lake Itasca represents one of the last remaining patches of primary forest from this once extensive forest type, results will also have great significance in advancing our understanding of the natural workings of unaltered forest ecosystems.

Objectives

Research will be conducted in close cooperation with researchers at the State University of New York at Syracuse. Our integrated research plan includes two large studies designed to test the hypothesis that bark beetles kill mature pine trees and to evaluate the efficacy of potential control measures. The Dartmouth research team will contribute to these studies, which are described in detail in the Syracuse work plan. In addition, the Dartmouth research team will conduct studies to address the following objectives.

1. The role of abiotic effects on bark beetle phenology and population dynamics. Climatic patterns are thought to exert strong effects on bark beetle population dynamics. We will develop models that predict the seasonal course of beetle development, the number of generations per year, and over-winter survival as a function of temperature. These models will allow an assessment of the climatic conditions that tend to increase and decrease beetle population growth and will provide a tool for scheduling beetle monitoring programs, beetle control programs, and blowdown salvage operations.

2. Effects of tree physiological status. The attack success and oviposition rate of bark beetles is inversely related to tree resin flow. The survival, growth, and fecundity of their offspring is influenced by the nutritional attributes of the phloem, especially nitrogen content. The availability of water and mineral nutrients has strong effects on tree growth, secondary metabolism (e.g., oleoresin synthesis), and phloem chemistry. Thus, site characteristics that influence tree growth (e.g., water availability, nutrient availability, and basal area) are expected to influence tree susceptibility to bark beetles and the reproductive rate of colonizing bark beetles. We will test for correlations between site characteristics and tree attributes that are of relevance to beetles. This research will allow identification of sites and trees that are relatively high and low risk from bark beetles. Studies will also provide comparisons of the relative suitability for bark beetles of the three pine species that occur in Itasca State Park and test for effects of tree size and age on host suitability.

3. Effects of community interactions. Natural enemies and competitors can be potent forces in limiting the abundance of forest insects to levels below that of significant economic or ecological damage. Management strategies that incorporate these natural control agents can be cost-effective as well as environmentally friendly. However, this approach requires improved understanding of the structure and function of bark beetle communities in Itasca State Park. We will conduct replicated quantitative sampling of the bark beetle community within the outside of the blowdown area to address the following questions. Under baseline conditions (in the absence of blowdowns), what is the abundance of *Ips* bark beetles and their natural enemies? What is the relative abundance of the three *Ips* species that occur in the park (I. pini, 1. grandicollis, and 1. perroti). How does the abundance and species composition of the bark beetle community change in the presence of blowdowns and how do these changes influence the probability of tree mortality? Which of the bark beetle species is the most likely to cause tree mortality and which of the natural enemies exerts the strongest control over that species of *Ips?* What are the interactions among *Ips* species? If *Ips* species compete, then reduction of one species (e.g., by mass trapping) would lead to an increase in the others. Alternatively, the *Ips* species may cooperate in locating and attacking trees, in which case the reduction of one *Ips* species would lead to a decrease in the other Ips species. These alternatives have strong implications for management strategies.

4. Bark beetle dispersal patterns. We will conduct mark-recapture studies to parameterize a diffusion model describing the dispersal patterns of *Ips pini* in Itasca State Park. This information is essential in developing management strategies to protect high priority sites and adjacent land owners.

Hosted the Northeastern Area Forest Nursery Conference and Workshop

The Badoura State Forest Nursery hosted the 1997 Northeastern Area Forest Nursery Conference and Workshop from August 11 to August 14. Eighty-five researchers, foresters and nursery managers from the US and southern Canada converged on the Northern Inn in Bemidji for a series of research talks, operations updates and field trips, focused on the theme: "Plant Propagation Systems in North Central Minnesota - Where Recreation, Agriculture and Forestry Collide". Presentations focused on forest regeneration efforts in Minnesota, seedling production systems and cooperative research and development projects.

Field tours included stops at Badoura Nursery, Round Bay Resort, Bolton's Family Farm, Eagle Bay Farms Nursery and Itasca State Park in the Park Rapids area; Pro-West and associates in Walker; the Red Lake Tribal Greenhouse, the Potlatch Sawmill and the Williams Seed Company in the Bemidji area.

Jointly sponsored by the Northeastern Area Forest Nursery Association and the North Central Forest Experiment Station, the Conference served as a technology update and information exchange forum for managers of public and private nurseries. Next year's conference will be hosted by Maryland.

Hosted the North Central Forest Pest Workshop

The 46th annual North Central Forest Pest workshop was held September 15- 19, 1997 at Ruttger's Sugar Lake Lodge in Grand Rapids, MN, The meeting was well attended with 115 people from across the US and Canada in attendance. Presentations, posters, field trip, banquet, ice cream sundae building contest, slide contest and fungal foray made up the schedule. Presentations were grouped under the following topic titles: White Pine Management is Pest Management, Do bark beetles pine for old growth, How's your aspen doing and Bug-n-stuff. The day long field trip included stops and presentations on aspen thinning, white pine management and red pine management. The field trip concluded with a step back in time with a tour of the Forest History Center in Grand Rapids for a historic perspective of forestry and logging in Minnesota.

Crow Wing County Forest Management Plan: Insects and Disease

Since the last Crow Wing County Plan was written, there has been a shift in resource management philosophy from sustained yield of products to ecosystem sustainability. The management focus is shifting to a more inclusive view of what remains in the forest after management activities, rather than on what goods and services are produced from those activities. Although some insects and disease effects may continue to interfere with some forest management goals, consideration of their potential role in maintaining forest health is essential to balanced assessments of their impacts and the need for their suppression.

Native forest insects and diseases have co-evolved with their host trees over thousands of years and alter forest composition, structure and succession by selectively affecting tree growth and mortality rates. They are undoubtably important components of forested ecosystems, functioning as agents of disturbance and regulators of productivity, diversity and density. Non-native pests, like Dutch elm disease, white pine blister rust and gypsy moth, do not have a "role" in our ecosystem and interfere with forest management goals. Non-native insects and diseases have historically caused intensive and severe disturbances over large areas. When management goals could be or are being impacted, preventative or control measures are warranted.

According to the latest Forest Inventory Analysis (1990), insects and diseases cause at least 65% of the annual growth and mortality losses in Minnesota forests. Forest insect and disease management guidelines and recommendations focus on silvicultural methods that either prevent pest occurrence or capture wood volumes prior to being lost.

The proper implementation of silvicultural guidelines can reduce the severity of insect and disease outbreaks. All stand manipulations affect the occurrence and severity of insects and disease. Once a stand is established many of the parameters governing insect and disease control are unalterable. In developing silvicultural prescriptions, species selection, regeneration methods, site characteristics, potential and historical pest problems, future stand manipulations, desired products, economics,

rotations, and harvesting techniques must be considered. Prevention or suppression of future pest problems by integrated pest management techniques must be a major goal in forest management.

Specific pest management guidelines must be developed for individual stands. However, some general integrated pest management guidelines exist:

1. Check all stands routinely for insects and disease. Promptly remove, destroy, or chemically treat infested material where economically feasible.
2. Utilize regeneration methods that reduce or eliminate insect and disease potential for attack of young seedlings. See specific recommendations by type.
3. Favor insect and/or disease resistant species or varieties.
4. Avoid replanting susceptible species in areas of historical insect and/or disease problems without an evaluation of cause.
5. Do not mix species which have common insect and disease problems.
6. Match tree species to the planting site.
7. All management practices must be aimed at promoting stand vigor.
   a. use proper planting techniques
   b. manipulate rotation age
   c. maintain proper stand density
8. Avoid planting in frost pockets.
9. Avoid wounding growing stock during thinning and/or harvesting operations.
10. Diversify species whenever possible.

The major forest cover types of Crow Wing County have historically supported certain forest insects and disease organisms for which guidelines have been developed (see the MN - DNR- Division of Forestry "Development Manual"). See Table below.

It is predicted that the introduction of gypsy moth, a non-native insect, into Crow Wing County's forests is likely to have a major impact on the nature of the forest cover. In fact, Crow Wing County ranked 7th out of the 87 counties in a recent Gypsy Moth Risk Analysis (Eiber, 1997). If the pattern of damage holds from other states, this change will occur over a period of years, likely decades, as gypsy moth outbreaks wax and wane. Damage will likely occur in individual stands as mortality of preferred host species, oak and aspen, leads to stands with a higher component of nonpreferred species. Mortality will be highest in intermediate and suppressed trees and be worse on sandy or droughty soils. It is likely to accelerate dramatically in areas where drought and defoliation due to forest tent caterpillar occurs.

For the present, pheromone trapping and local (spot) eradication projects continue under the direction of the Minnesota Dept. of Agriculture. Forest management guidelines for the years prior to actual defoliation are based on maximizing tree growth and vigor and, secondarily, on altering stand composition. Tree vigor has been shown to be the single most important factor in predicting tree mortality due to gypsy moth. Low vigor trees die first. Therefore, silvicultural objectives are to maintain optimal stocking levels and to remove suppressed, intermediate and poor crowned trees in susceptible stands.

Crow Wing Co. General pest management recommendations by cover type.

Cover Type	Acres *	Major Pests	General Management Recommendations **
Aspen-birch	171.1	White trunk rot Hypoxylon canker Saperda borers	If more than 15% of stems have decay conks, harvest at 35 to 40 years. If stand has more than 25% Hypoxylon cankered stems, then harvest early and convert the site. Remove and destroy Saperda borer brood trees.
Oak	77.9	Two-lined chestnut borer Armillaria root disease Oak wilt	Following periods of drought, monitor oaks for mortality and implement salvage. Do not prune or wound oaks between April 15 and July 1.

Pine	46.4	Jack pine budworm Pine bark beetles Heart rot White pine blister rust White pine weevil	Maintain jack pine stands between 70 and 100 sq. ft., remove wolf trees and harvest at 45-55 years. Following periods of drought or defoliation, monitor for bark beetles and implement salvage. Thin from Sept. 1 to March 1. Never thin and prune during the same year. Avoid micro-climatic conditions favoring white pine blister rust when selecting planting sites. Plant below and understory and start basal pruning when trees are 2 ft. tall. If weevil damaged, correctively prune leaders.
Elm-ash	38.1	Dutch elm disease	Salvage where possible.
Spruce-fir	26.8	Spruce budworm Dwarf mistletoe Yellow-headed spruce sawfly	Rotation age of balsam fir should not exceed 50 years and fell or harvest all balsam fir and white spruce in the stand. On harvested sites, kill all live black spruce 5 st. tall and taller by burning, shearing or using herbicides. Do not release white spruce plantations until they are 10 to 12 ft. tall.
Maple-birch	23.6	Stem cankers Bronze birch borer	Manage on all-age system and fell deformed stems. Harvest birches between 60 and 80 years. Following drought or prolonged defoliation, monitor birch for mortality and salvage.

* = based on FIA data (1990).
** = These are brief summaries, for a lengthier version, please see the MN DNR- Forestry " Forest Development Manual".

Hazard Tree Training Sessions

Five training sessions were held this year in Marshall, Fairbault, Duluth, Thief River Falls and Alexandria. 135 people received the latest information on hazard trees, policy making and field methods.

Christmas Tree Growers Meeting

A presentation on "Christmas Tree Pest Identification" was made at the 1997 Winter Convention and Trade Show of the Minnesota Christmas Tree Grower's Association. Approximately 75 people were in attendance. The workshop was held at the Sheraton Inn Midway in St Paul, MN on February 21 and 22, 1997.

Flier: Why conifer needles turn red in the spring

This winter has taken its toll on people, deer herds and on trees, as well. By this time you have probably noticed all the red needles on white pines and other conifers that are growing along highways. Although the needles look terrible, the buds, twigs and trees are not dead. The needles had a rough winter and they were discolored by winter injuries, but resist the urge to prune them away or remove discolored trees. Chances are very good that these trees are live and healthy beneath their mask of red needles. Buds are well protected during the winter and will grow once spring arrives. Winter injury was enhanced by strong, dry winds, many days of bright sunshine and by low relative humidity. Humans also added to the injury equation by applying road de-icing salts which are toxic to plants.

Salt toxicity

Undoubtably the most evident damage occurred on white pines growing along highways and was caused by the application of de-icing salts. Earlier in the winter, each passing car sent up clouds of water with a little salt dissolved in it. This salty water settled on nearby objects, including the pines. Salt was absorbed into individual needles, accumulated to toxic levels in the needle tips and killed the needles back, starting at the tips. Trees within 150 feet of a highway can be easily reached by salt spray. De-icing salt damage usually occurs on the side of the tree closest to the road. Spring rains will rinse off accumulated salts, new shoots will develop in May and June and the dead needles will be shed so that by summer these trees will look reasonably healthy. Trees with thick wax layers on needles, large resinous buds and/ or with thick, robust needles are more resistant to salt spray damage. White and red pines are very susceptible to salt spray damage; Scots pine, Norway spruce, juniper and eastern red cedar are moderately susceptible and jack pine, Austrian pine, larch and black spruce are tolerant to salt spray damage.

Needle dehydration

Even during the dormancy of winter, tree needles need and use liquid water. When water, stored in twigs and needles, is gone, cells and tissues become progressively more dehydrated and start dying. Water is lost faster when the relative humidity is low, when dry winds are blowing and when warm, sunny days occur. Affected needles, turn red or brown from the tip down and, often have dark bands or a mottled appearance. In late winter, the needle discoloration intensifies and becomes more noticeable. Buds are usually not killed. Normally, snow cover prevents winter injury of young conifers by providing shelter from drying winds and from the glare of the sun. In some years it is common to see young conifers with a strong line of demarcation separating the brown, desiccated tops from the healthy, green branches that were covered by snow.

Needles loose their internal water three ways:

- through evaporation from tiny ruptures in the needle's surface which are caused by wind and ice crystal abrasion.
- through the rupturing of cells and tissues due to rapid freezing. After slowly warming up and becoming metabolically active on sunny days, the needles quickly refreeze when the sun sets and water inside the cells and cell walls freeze which ruptures and kill's them.
- through transpiration on sunny, warm winter days. Water stored in needles was lost during the few (very few) days when temperatures were above freezing because cells were actively using water.

In our climate, water uptake and resupply, to replace water the needles have lost, is prevented by the continuous freezing of roots and stems.

Some trees or groups of trees seem to get winter injury every year. In these situations, it is likely that the trees are under stress and do not have the resources to tolerate any internal desiccation and therefore suffer winter injury every year. For example, some clumps of roadside red pines show winter injury symptoms every year because they are growing offsite, either in soils that are too wet or in soils that restrict rooting depth. This stress predisposes the trees to needle desiccation and ultimately to repeated winter injury.

Winter injury is the most important factor limiting the northern range of conifer species. Temperate species, such as red and white pines, are much more vulnerable to injury than are the boreal species, such as black spruce and jack pine. Native tree populations are adapted to their locality. Moving them (seeds or seedlings) 100 miles north or south of their site of origin can result in damage due to winter injury. Exotic species, like Austrian or Scots pine, should be planted in climatic zones similar to their site of origin in Europe.

Prevention techniques

Is there anything people can do to prevent winter injury? Here are some suggestions.

1. When selecting trees to plant, choose species and cultivars that are adapted to your local growing conditions.
2. Avoid planting white and red pines, balsam fir and white spruce within 150 feet of a highway to prevent salt damage.
3. Avoid planting yew and arbor vitae on south or southwest sides of buildings or in sunny and windy locations.
4. Erect temporary barriers around conifers susceptible to winter burn. They can be made of plywood, burlap, tar paper or plastics. Recycle your Christmas boughs and tree by propping them up on susceptible conifers. They will act as a barrier and also hold snow for more natural insulation and protection.
5. Just after the snow melts and prior to bud break, rinse de-icing salts off both conifers and hardwoods.
6. Reduce or eliminate the use of de-icing salts.
7. Replace trees that have severe winter injury year after year. They are not in the right location and will only decline due to needle and twig loss over a period of many years.
8. Keep conifers properly watered throughout the growing season and fall. Decrease the watering slightly in September to encourage hardening off, then water thoroughly in October until freeze-up. Watering only in late October does not help reduce winter injury.

Conifers growing in Minnesota have had a long, long winter with plenty of opportunities for winter injury. But in spite of their appearance, chances are good that your trees are live and healthy beneath their mask of red needles. Buds were well protected during the winter and will grow once spring arrives.

Webworms, tent caterpillars and other web-making insects

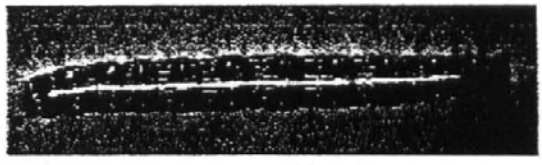
Several species of caterpillars and sawflies create conspicuous silken webs on the branches of shrubs and small trees that they feed on. Inside the webs, insect colonies feed and rest and are protected from birds and other predators. As the season progresses, the webs are enlarged by the growing insects and begin to fill with their frass and shed skins.

Larger webs and their caterpillars can be removed by hand and destroyed. Caterpillars in smaller and numerous webs may require application of a systemic chemical such as acephate or dimethoate. Fortunately, many parasites, predators (such as chickadees and nuthatches) and disease organisms eventually cause sharp declines in these insect pests, thereby making chemical control unnecessary.

Eastern tent caterpillars

Time: April, May and June
Trees: apples, cherries and plums

Silken tents are constructed on branches of apples, cherries or plums beginning in late April or early May. They are enlarged as these caterpillars feed on leaves elsewhere on the tree and return to their tents when not feeding. Caterpillars spin white or yellowish parchment-like cocoons on tree trunks, fences, and other available objects in late May and June. Adult moths emerge from these cocoons in about three weeks. Eggs masses overwinter on twigs.



Caterpillars are black-headed and black-bodied with a white stripe along their backs and many brownish diagonal marks on their sides. A row of pale blue spots are also present on each side of their bodies. Fine, long, light brown hairs cover their bodies. Full grown caterpillars are 2 and 1/4 inches long.

Forest tent caterpillars

Time: May and June
Trees: aspen, basswood, birch, ash, oak

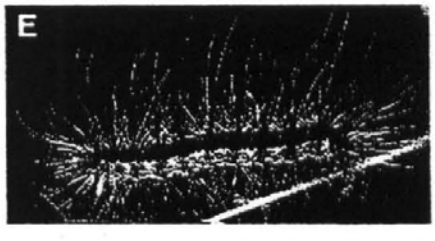
Inaccurately named, forest tent caterpillars do not form a tent or web to house the colony of caterpillars. Instead, this species constructs silken mats on the stems of host trees where the colony rests. FTC commonly feed during May and June on trembling aspen, basswood, birch, ash, and oak but shun red maple. This insect becomes very common during outbreaks which occur at ten year intervals and last three to four years. Cottony, white cocoons are spun in late June and moths emerge two to three weeks later. Egg masses overwinter on twigs.

Caterpillars are light blue and black with white spots down their backs that look like footprints or keyholes. Long brown hairs sparsely cover their bodies. Full grown larvae are 2 and ½ inches long.

Fall webworms

Time: July and August
Trees: All, except conifers

Webs are constructed in July and August by this species and they gradually are enlarged by the colony. All shade, fruit and ornamental trees, except conifers, serve as hosts for fall webworms. In early fall, caterpillars spin thin cocoons in the duff and overwinter as pupae. Adult moths emerge in spring and lay eggs. All larval stages feed within the web.



Caterpillars have pale yellow bodies with a row of dark red or black spots along their backs. Long white or yellow hairs cover their bodies. Full grown larvae are 1 and ½ inches long.

Oak webworms

Time: June and July
Trees: Oaks

The webs of these caterpillars are commonly three or four inches wide and nearly two feet long by July. Red and black oaks are favored hosts in our area. Webs fill with feeding caterpillars, excrement and bits of leaves, and are the locations where pupation and moth emergence occurs in August and September. Overwintering eggs are attached to stems and trunks.

Caterpillars are grayish green. Their heads and prominent neck shields are black. Full grown larvae are 3/4 of an inch long.

Ugly-nest caterpillars

Time: May through August
Trees: Cherries, hawthorn and more

These caterpillars spin a dense web around the feeding site that becomes filled with pieces of leaves and their frass. Favored hosts are roses, cherries and hawthorns. Eggs hatch in May and June and caterpillars immediately begin building the web where the colony enlarges the web during July and August until they emerge as adults in late summer. Egg masses overwinter on stems.

Caterpillars are yellowish-green with shiny black heads. When fully grown, they are 3/4 of an inch long.

Pine webworm

Time: June and July
Trees: Pines

These caterpillars form conspicuous webs on terminal twigs which are heavily laden with brown excrement particles and needles. Webs are found in late June and July on jack, red, white and Scots pine. At maturity, pine webworms drop to the ground and overwinter there as pupae. Adult moths emerge in the spring and lay eggs.

Caterpillars have yellowish heads and thoracic shields with brown markings, and their bodies are yellowish brown with dark brown longitudinal stripes. Full grown larvae are 5/8 of an inch long.

Pine false webworm

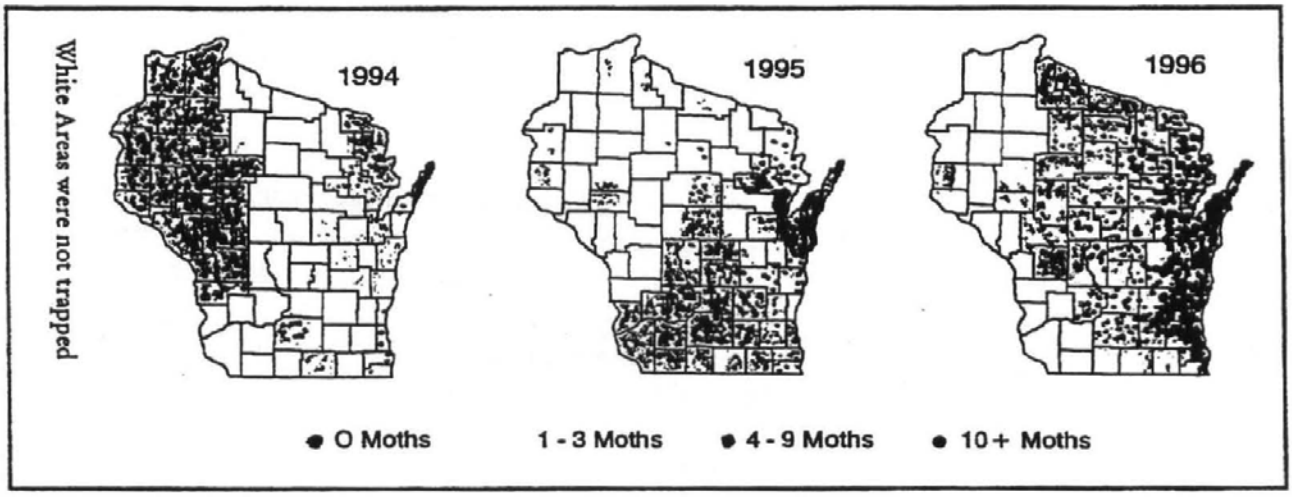
Time: May, June and July
Trees: Pines

This introduced species of sawfly is very common. Favored host trees are white pines and red pines; other ornamental pines are also hosts. Sawfly larvae are active in May, June and into July. Defoliated twigs, stems and branches are coated with unsightly webbing to which much frass is attached. Older needles are stripped and the current year's growth extends prominently beyond the colony's web. Larvae have vacated webs found in mid-summer and overwinter as pupae.

Sawfly larvae have clay-yellow heads with densse, small dark brown spots. Their bodies are green with purple-reddish stripes. Full-grown larvae are ½ to 3/4 of an inch long.

Gypsy Moth:
At The Crossroads in Minnesota

The Gypsy Moth is an exotic species of leaf-eating caterpillar that was introduced into the United States in the 1800's. Initially, it spread very slowly, but the post-WWII economy brought an increased movement of people, nursery stock, and recreational vehicles. Michigan became infested in the 1950's, but the onset of defoliation was delayed until the late 1970's. Defoliation exploded in the 1980's and, by 1990, Michigan was experiencing "First Pass" mortality. Around 1988, Wisconsin and northern Ontario became infested. Today, defoliation occurs as far north as Sudbury, Ontario, and as near as Michigan's Upper Peninsula. In just the last three years, moth catches have raced across Wisconsin with major infestations being discovered in Eau Claire and Madison.



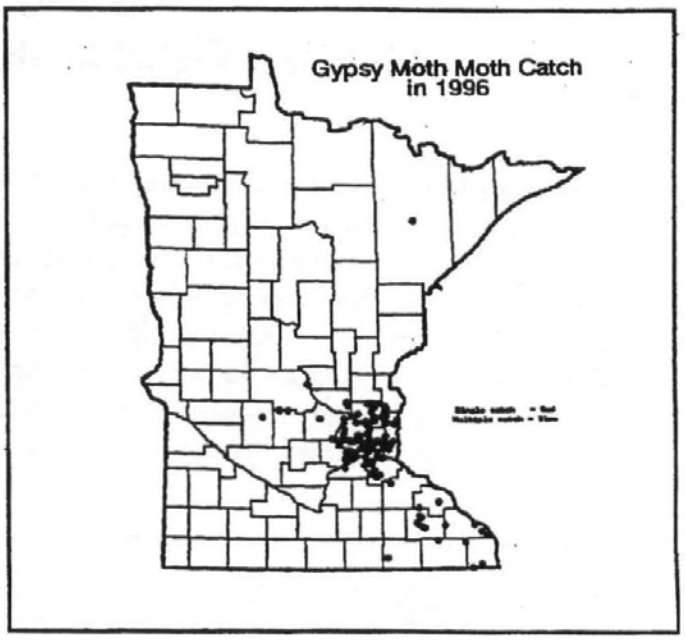
The Gypsy Moth

The Gypsy Moth eats leaves from over 200 species of trees and shrubs. In Minnesota, it will find lots of oak and aspen, two of its favorite hosts. As the caterpillars feed in the spring, they rob the tree of its ability to undertake photosynthesis, effectively stealing the tree's energy reserves and slowing growth. As an exotic species, it invades native ecosystems, competes with native species, and trashes visual resources. As a quarantined species, it adds layers of cost and paperwork to businesses as diverse as movers, timber industry, recreation, and landscape nurseries.

In government agencies, the gypsy moth causes chaos by cutting across jurisdictions creating overlapping authorities, programs, and activities. As states become infested, the gypsy moth causes even greater confusion as each state's activities move through a "Grey Zone" transitioning from quarantine and eradication programs to management programs. In Minnesota, we will enter this "Grey Zone" of transition in just a few years.

Where do we stand?

Over the past few years, Minnesota has come under increasing pressure of introduction as our neighboring states become infested. Michigan became "infested" during the 1980's and Wisconsin is now rapidly becoming infested. Each year in Minnesota, we catch more moths in more counties. The 1996 catch was 155 moths, *already over twice the catch in Wisconsin just ten years ago!* We need to understand that Gypsy Moth is coming.



What Impact Will The Gypsy Moth Have In Minnesota?

Problems occur in stages, beginning long before the gypsy moth causes defoliation.

- In the first stage, eradication programs in populated areas begin to meet with an increase in public resistance years before visual and biological damage begin. *Minnesota is still in this first stage.*
- In the second stage, quarantine and other regulatory issues cause disruption and nuisance.
- In the third stage after the moth is established, but defoliation is not yet visible, eradication sprays are sometimes stopped. At this time, the population explodes generating a great nuisance. *Now in this stage, Wisconsin moth catches jumped from 13 to 104,000 in just 11 years and they have NOT YET SEEN any defoliation.*
- In the forth stage, defoliation has gone on long enough that the "first pass" mortality wave, typically 15%, sweeps the area.
- In the fifth stage, there is a public outcry for relief from the nuisance and tree mortality. *To our east, lower Michigan is now beginning this stage.*

What needs to happen in Minnesota now?

Minnesota needs to take action now. Priority should be given to strong coordination by state and federal agencies. Active programs must focus on:

1) ***Strong, effective detection and monitoring programs.***
2) ***Resource partner awareness and support.***
3) ***A plan and program to slow the introduction and spread.***

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

March, 1997

Land Cover Assessment
Using Multitemporal Satellite Analysis

Land cover assessment is a fundamental layer of information for regional planning in forest resources management. When the DNR Division of Forestry undertook its regional plan in 1992, resource managers only had a Level I Forest Resource assessment available. Within that assessment, forest cover information was limited to the basic classifications of hardwood and conifer covertype. This information was developed from an analysis of a 1988 LandSat satellite image originally purchased by the Metropolitan Council for its Land Use Study in 1990. That image was reanalyzed by the University of Minnesota's Remote Sensing Laboratory (*RSL*) under contract to DNR-Forestry to obtain the Level I assessment that has been used for many years.

In 1993, the *RSL*, again under contract with DNR-Forestry, utilized ground truth information to "train" the image processing system in the northern third of Washington County. The results of this project clearly indicated the feasibility of obtaining more detailed forest cover information from satellite imagery. In 1994, the *RSL* under another research & development grant, undertook a project to classify the forest cover for the entire Metropolitan Region, approximately 1.9 million acres. The analysis procedure was to use a newly developed multitemporal technique using data from two separate images, one early and one late, from the 1991 growing season.

In addition to an analysis using two dates, DNR-Forestry staff mapped the land cover including forest type on 40 one square mile random sample plots scattered about the region. This analysis was undertaken by the three Area Foresters attached to the Region using a combination of (1) air photo interpretation, (2) local experience, and (3) ground truth data. These 40 plots were mapped on acetate sheets and subsequently digitized into GIS format for analysis. The analysis utilized ARC/INFO, ERDAS, and EPIC for applications of data capture, analysis, visualization, and reporting. Completed in 1996, the thematic layer created by this project resides on the region file server and is available to everyone.

The data presented in the map on the reverse is an assessment of the forested areas in the region. This analysis has the advantages of completeness, uniformity, and spatial referencing necessary for forest resource planning and operations in the region. It constitutes the first DNR Region to have such an assessment. Areas of non-forest were also assessed and classified. These classifications include high and low density urban, three types of agriculture, grassy areas, wetlands, and lakes. The data are available as a fully georeferenced EPIC thematic layer.

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

March, 1997

Forest Health in Minnesota

Trees and forests are important to Minnesota. Trees in our urban communities provide energy saving shade for our homes. Water released from leaves during photosynthesis helps cool us on a hot day. In the winter, shelterbelt trees blunt the force of the wind and stop the snow from drifting. In forested areas, many species of animals, including deer, squirrels, and blue jays, eat acorns. Others use the trees for nests, dens, and shelter. In our economy, trees add billions of dollars in wood products and jobs. In our cities, trees help soften harsh environments and make them more livable. Not only are they more beautiful, they are safer. Recent studies show that crime rates go down in "forested" neighborhoods. Few would argue that trees are good.

Forest ***health*** issues are also important to Minnesota. From oak wilt in most communities in the southeast corner of the state, to forest tent caterpillar in Wilmar, Alexandria, Brainerd and Duluth, to bark beetles in Woodbury and Rice, to the specter of gypsy moth just about everywhere, Minnesota's communities and people struggle to maintain the health of trees near their homes, in woodlots, and parks. Management of forest insect and disease problems affects thousands of people in hundreds of communities every year.

How serious is the problem?

Trees growing in Minnesota face a variety of problems. Our climate is challenging, cold winters, hot and dry summers, late spring frost, insect and disease problems, construction damage, "urban syndrome", and neglect to mention a few. The State, counties, and local communities undertake a variety of remedial treatments to keep their trees healthy. In recent years, Minnesota trees have seen injections for Dutch Elm Disease, sprays for gypsy moth, spruce sawfly, and tent caterpillars, pheromone traps for bark beetle control, and parasite release against the pending gypsy moth invasion from the east.

Each year, the DNR's Forest Ecosystem Health Unit maps and assesses the problems facing the state's trees. During just the past two years, a relatively quiet period, we have mapped tree and forest damage on 1,222,000 acres in 51 Minnesota counties. Areas affected are as large as St. Louis's 275,000 acres (mostly spruce budworm) and as small as 10 acres in Rice, Sibley, and Wright counties. Looking at it in a different way, 76 legislative districts have seen forest damage in just the last two years.

The Answer: Community Based Assistance

We believe that one of the best ways to address these forest health problems is by working in partnership with local communities. These partners are individual counties, incorporated cities, townships, lakeshore associations, and non-profit tree boards where concerned people are ready to take action. In the federally assisted oak wilt program, DNR's partners include over 125 communities: townships, cities, counties, Soil and Water Conservation Districts, and non-profit tree boards. This program has treated over 3,500 infection centers. We believe that State support for Forest Health Programs that work with communities would be extremely valuable in improving the health of Minnesota's forests.

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

March, 1997

PAPERS PRESENTED

Hazard Tree Management: A Roadside View

By Thomas Eiber

Synopsis:

Years ago, when DNR was developing our Hazard Tree Policy, we met several times with staff from the State Attorney General's office. The concept of a policy, reasonable, prudent, published, and implemented was highly desirable. It would be dangerous to say that the details of the policy were not relevant, but it was every bit as important, perhaps more so, that there was a policy. That policy needs to be reasonable. That policy needs to be "published" and generally known. That policy needs to be systematically and uniformly implemented. When looking to the liability issues, it seems clear that perfection in the "standard of care" is not what is at issue in liability cases, rather was the policy and subsequent program "reasonable and prudent". I think you are more likely to get into trouble for not having a policy (or not following your policy) rather than for having a program "not as good as" someone else. Programs can, perhaps must differ. There are at least two issues here.

Keep in mind that defects are mechanical defects that can be identified and evaluated, to a large degree, in a methodical manner. Targets are largely determined by policy, use and, indirectly I suspect, budgets. Any discussion of "targets" quickly degenerates into a policy discussion. For example, DNR does not consider a trail to be a target, but one community here in the Twin Cities paves its trails for handicap access.

The second issue gets much more complex. "Roadside" vegetation likely can not be managed to the same level that a small, discrete park like area can. Minnesota has 12,000 miles of funk highways, many of which are in heavily wooded areas. If the target is the road itself the issue is one thing, but if the definition of target includes the "clear zone" (a recovery zone for vehicles that wander off the highway) the issue becomes significantly enlarged.

Presented at the 13th Annual National Roadside Vegetation Management Association Meeting held at the St. Paul Airport Hilton, Oct. 1619, 1996.

SURVEY RESULTS

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

Aerial survey methods
Spruce budworm
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 cover type 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 cover type 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 acquired 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 survey 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 multiplied by 100.

Egg mass survey

For each plot, three branches are clipped from the mid-crown of each of three co-dominant trees. The number of egg masses per 15 inch branch tip is tallied. The following scheme is used 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 - 1997								
Location	**Species**	**1996**	**1997**				**1998**	**Notes**
			Larval survey		**Egg mass survey**			
		Ave. # egg masses	**# of buds on twig**	**# of larvae on twig (percent infested)**	**Percent defoliation**	**Ave. # egg masses**	**Predicted defoliation**	
Aitkin Co.								
NENE 7-51-23	WS	0.1			54%	0..55	Moderate	
NENE17-52-24	WS	0.1			5	0.11	Light	Numbers decreased.
Becker Co.								
NWNE 21-141-36	WS	2.0			73	1.33	M	Slightly less than in 1996
Beltrami Co.								
NWSW 12-147-30	WS				7	1.58	M	Good vigor.
SWSW 12-147-30	WS				3	0.33	L-M	Good vigor.
NESE 26-149-30	WS	1.5						
	"	1.1			61	1.0	M	Slightly less than in 1996
NESW 1-148-31	WS	0.33						
Cass Co.								
NENE 1-139-26	WS				<1	0	0	
NWNE 1-139-26	WS				81	0.66	M-H	No topkill.
NWNW 11-139-26	BF	0.2			33	0.44	M	Vigorous, no topkill.
NENE17-140-27	BF	0						
21-145-30	WS				45	0.77	M	30% trees with topkill, 10-15% mortality
NWSW 9-145-30	WS				23	3.0	H	Plantation. 2nd year of defoliation
SWSE13-136-31	WS	1.3			37	0.33	L-M	Thinning in progress.
	"	0.5						
SWSE 22-138-31	BF	0						

Spruce budworm survey - 1997								
Location	Species	1996	1997				1998	Notes
			Larval survey		Egg mass survey			
		Ave. # egg masses	# of buds on twig	# of larvae on twig (percent infested)	Percent defoliation	Ave. # egg masses	Predicted defoliation	
NWSE 8-145-30	WS		465	98 (17.4)				
Chisago Co.								
SESE 36-36-21	WS	0						
Cook Co.								
NWNW 33-63-4E	WS,BF	0.22						
NESW 35-64-3E	BF	0						
NWSE 3-61-1E	BF	0	729	11 (1.5%)	5	0	Very Light	Good vigor.
SWNE 22-63-1E	BF	0						
NESW 10-64-1W	BF	0						
Crow Wing Co.								
SENE 19-44-31	WS	0.8			30	0.33	M	Fairly vigorous.
Hubbard Co.								
SWSE 13-141-32	WS	0.55			14	0.33	L-M	Good vigor
SE 1-142-33	WS	1.66						
SESE 1-143-33	WS	1.9			15	0.44	M	Less defol. than in 1996.
NWSE 23-145-33	WS	1.66						
NWNE 21-141-36	WS	2.1						
Itasca Co.								
NESE 2-61-22	BF				36	0.33	M	Camp-ground.
NENW 34-62-22	BF	0.44			3	0.77	M	
NESW 26-62-23	BF	0	568	41 (7.2)	4	0.55	M	Good vigor.
NWSW 3-58-24	WS	0	705	0 (0)	0	0	0	
SWNE 3-58-24	WS	0	685	1 (0)	0	0	0	
SWSW 35-58-24	WS		462	93 (20)	48	1.22	M-H	10% of trees heavily defoliated.
NENW 23-59-24	BF		328	0 (0)				Mixed stand.
SESE 29-62-24	WS		591	50 (8.4)				
SWSE 36-62-24	WS	0.77						
NENE 17-53-25	WS				30	1.99	H	No topkill

Spruce budworm survey - 1997								
Location	Species	1996	1997				1998	Notes
			Larval survey		Egg mass survey			
		Ave. # egg masses	# of buds on twig	# of larvae on twig (percent infested)	Percent defoliation	Ave. # egg masses	Predicted defoliation	
NWSW 35-58-24	WS	1.1						
NWNE 7-60-25	WS	0						
NW 9-56-25	WS	0.44						
NWNE 4-60-26	WS	0						
SENW 12-53-26	WS	0.1	420	13 (3)	1	0.11	VL	
SWNE 11-53-26	WS	0.1	339	38 (11.3)	2	0.55	M	
SWSE 17-60-27	BF	0	230	0 (0)				
Koochiching Co.								
NWNW 4-65-22	BF				70	1.22	M	Poor vigor
NWNW 19-65-22	WS,BF	2.0			15	1.11	M	Good vigor
NENE 24-65-23	BF		255	65 (25.5)	28	0.55	M	
SENE 23-67-22	BF	1.2						
NESW 31-70-26	WS		1047	70 (6.67)	63	0.11	L	20% of trees are M-H defol
SENW 4-71-22	BF, WS				14	0.44	M	Poor vigor
SESE 35-71-24	WS	0.11						
SESE 8-69-23	BF				3	0.11	L	Mixed forest
SESE 16-69-23	BF	0						
SWSW 25-69-23	WS, BF		889	5 (0.45)				
NWNE 27-158-26	WS	0	583	0 (0)				
Lake Co.								
SWNE 11-55-8	BF	0	442	0 (0)	0	0	0	Conifers <10%
SWSE 5-59-8	BF	0	649	12 (1.9)	0	0	0	
NESE 28-61-10	WS	0						
SENE 11-61-11	WS,BF	0						
SENW 31-62-11	WS,BF	0.1						
Mille Lacs								
SWSE 1-35-27					58	1.0	M	Vigorous.
Morrison Co.								

Spruce budworm survey - 1997								
Location	Species	1996	1997				1998	Notes
			Larval survey		Egg mass survey			
		Ave. # egg masses	# of buds on twig	# of larvae on twig (percent infested)	Percent defoliation	Ave. # egg masses	Predicted defoliation	
NENE 1-41-29	WS	1.6			70	0.33	M	Dead trees along S edge.
NESW 11-42-32	WS	0			70	0.44	M	Vigorous.
Sherburne Co.								
NWNW 33-34-27	WS	0.55			52	0.22	L-M	Vigorous.
St. Louis Co.								
NESE 22-62-12	WS,BF	0.55	540	67 (12.4)	16	0.33	M	Many dead fir
NWNE 6-63-12	BF	0.1						
SESE 31-58-13	WS,BF	0	950	0 (0)	0	0	0	Vigorous
NWNE 4-62-13	BF	0.22						
SWNW 6-63-17	BF	0.1	627	81 (13)	50	1.55	M	10% topkill
SWNW 2-64-17	BF	0						
NENE 8-51-18	WS	0						
SWSW 33-61-18	WS,BF	1.3	640	161 (25)	14	2.11	M	Vigorous
NWNW 33-65-18	BF	2.5	731	133 (18)	70	3.33	Severe	Few dead tops, mixed forest
NWNW 18-64-20	BF		105	89 (84.7)				
NENE 12-68-20	WS,BF	0.33						
SWNW 33-60-21	WS				45	1.66	M-H	
SWSW 2-60-21	WS	0.88	501	119 (23)	27	2.77	H	
NWSW 12-64-21	BF	0.22			17	0.66	M	Vigor OK
SESW 12-68-21	WS	0.77	634	136 (21.5)	51	1.55	M-H	No topkill

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		
Number of 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%

Jack pine budworm egg mass survey in Region 3			
Plot location	**Date**	**Egg masses**	**Comments**
Crow Wing County			
NWSE 4-45-27	9/ 22	0	No '97 defoliation.
NENE 34-135-28	9/ 22	0	No '97 defoliation.
NENE 19-44-31	9/ 22	0	No '97 defoliation.
SWSE 17-44-31	9/ 22	0	No '97 defoliation.
Pine County			
NESE 13-40-19	9/ 23	0	No '96 or '97 defoliation.
NWNE 15-40-18	9/ 23	0	No '97 defoliation St. Croix State Park
SWNE 6-44-19	9/ 23	0	No '97 defoliation
SESW 30-45-19	9/ 23	0	No '96 or '97 defoliation
Wadena County		0	
SESE 23-138-35	9/ 25		No '97 defoliation Medium to heavy 95' and '96 defoliation.
SWNW 17-137-33	9/ 25	0	Very light '97 defoliation

Jack pine budworm egg mass survey in Region 3			
Plot location	**Date**	**Egg masses**	**Comments**
NWNW 29-136-33	9/ 25	0	Very light '97 defoliation
NWNE 10-135-33	9/ 25	0	Very light '97 defoliation

Jack pine budworm larval and egg mass surveys in Region 1			
Location	**Larval count**	**Egg mass count**	**1998 predicted defoliation**
NESE 24-141-36	0		
NWNW 2-140-26	0		
NWNW 35-139-35	0		
NENW 16-143-34	0		
NENW 16-143-34	1		
SWNE 24-138-35	2		
SWSE 23-138-35	1		
NENE 9-147-34	0		
NWNW 7-147-34	0		
SESE 3-147-35	0		
SWSW 18-145-35	1		
NESE 26-147-34	0	0	0
SESE 11-147-34		0	0
SENE 10-147-34	0	0	0
SENW 16-147-34		0	0
NENE 2-147-35	2	0	0
SESE 11-147-35	0	0	0
NWSW 25-147-35	0	0	0
NESE 21-146-35		0	0
NWNE 4-147-35	0	0	0

Jack pine budworm larval and egg mass surveys in Region 1			
Location	**Larval count**	**Egg mass count**	**1998 predicted defoliation**
NENE 32-148-35	5	0	0
SESE 19-148-35	0	0	0
NWSW 25-145-34		0	0
NENW 4-144-34		0	0
NWNE 8-143-34		0	0
SESE 9-143-34		0	0
NWNW 35-141-36	0	0	0
NWNW 2-139-36		0	0
SWNW 23-139-36		0	0
NESE 34-140-32		0	0
NENE 10-139-32		0	0
NESE 15-139-32		0	0
SWSW 29-139-32		0	0
NENE 24-139-33		0	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.

COUNTY	LOCATION	DATE TRAP PLACED	TRAP NO. OR NAME	DATE TRAP CHECKED	MALE P.T. MOTHS IN TRAP	COMMENTS
Crow Wing	SWSE 30-134-28	6-24		7-30 9-9	5 0	Trap at Paul Bunyan Nature Learning Center
Crow Wing	SWNW 9-136-27	6-24	5	7-17 7-29 8-6 8-25 9-5	3 7 17 19 1	
Crow Wing	NWSE 9-136-27	6-24	6	7-17 7-29 8-6 8-25 9-5	2 0 14 18 0	
Crow Wing	NWSE 10-136-27	6-24	7	7-17 7-29 8-6 8-25 9-5	4 0 0 9 0	Bird predation.
Crow Wing	SWSW 11-136-27	6-24	8	7-17 7-29 8-6 8-25 9-5	3 10 7 13 3	
Crow Wing	NWNW 14-136-27	6-24	9	7-17 7-29 8-6 8-25 9-5	0 4 11 6 1	
Hubbard	16-139-32		Nursery	7-16 7-24 8-7 8-16 8-26 9-8	19 7 8 6 0 0	

COUNTY	LOCATION	DATE TRAP PLACED	TRAP NO. OR NAME	DATE TRAP CHECKED	MALE P.T. MOTHS IN TRAP	COMMENTS
Hubbard	16-139-32		Nursery	7-8 7-16 7-24 7-30 8-7 8-16 8-26	20 2 17 11 11 10 1	
Hubbard	9-139-32		Woodland Tour	7-8 7-16 7-24 7-30	21 17 11 14	
Hubbard	15-139-32		Cutoff Road	7-8 7-16 7-24 7-30 8-7 8-16 8-26 9-8	21 21 16 16 22 24 5 2	
Hubbard	15-139-32		Potlatch Landing	7-16 7-24 7-30 8-7 8-16 8-26 9-8	10 16 9 10 12 2 0	
Hubbard	17-139-32		Tripp Lake Rd. N	7-8 7-16 7-24 7-30 8-7 8-16 8-26	14 12 11 11 6 1 0	
Hubbard	20-139-32		110-109 Jct.	7-8 7-16 7-24 7-30 8-7 8-16 8-26	31 28 22 14 15 7 0	

COUNTY	LOCATION	DATE TRAP PLACED	TRAP NO. OR NAME	DATE TRAP CHECKED	MALE P.T. MOTHS IN TRAP	COMMENTS
Hubbard	30-139-32		109 East	7-8 7-16 7-24 7-30 8-7 8-16 8-26	30 27 10 16 9 9 0	
Hubbard	25-139-33		109 Landing	7-8 7-16 7-24 7-30 8-7 8-16 8-26	28 22 10 8 7 8 1	
Hubbard	26-139-33		109 Side Road	7-8 7-16 7-24 7-30 8-7 8-16 8-26	36 26 20 14 9 15 1	
Hubbard	35-139-33		Game Farm	7-8 7-16 7-24 7-30 8-7 8-16 8-26 9-8	23 27 19 16 7 8 5 2	
Pine	NESE 13-45-20	6-23	4	7-9 7-21 8-4 8-20 9-8	0 0 2 0 0	
Pine	SESW 30-45-19	6-23	2	7-9 7-21 8-4 8-20 9-8	2 0 2 17 0	
Pine	SWSE 25-45-20	6-23	1	7-9 7-21 8-4 8-20 9-8	0 0 2 4 0	

COUNTY	LOCATION	DATE TRAP PLACED	TRAP NO. OR NAME	DATE TRAP CHECKED	MALE P.T. MOTHS IN TRAP	COMMENTS
Pine	NESW 26-45-20	6-23	3	7-9 7-21 8-4 8-20 9-8	0 1 4 11 0	NE side of G.A. Nursery
Wadena	19-138-33		Huntersville Imp.	7-8 7-16 7-30 8-7 8-16 8-26 9-8	20 12 5 7 5 1 0	
Wadena	10-138-33		Roadside I	7-9 7-16 7-24 7-30 8-7 8-16 8-26	34 27 8 5 7 5 1	
Wadena	9-138-33		Roadside II	7-8 7-16 7-24 7-30 8-7 8-16 8-26	36 18 4 2 2 4 0	
Wadena	3-138-33		Mid Road HSC	7-8 7-16 7-24 7-30 8-7 8-16 8-26 9-8	24 13 0 2 2 4 0 0	
Wadena	22-138-33		Nimrod North	7-8 7-16 7-24 7-30 8-7 8-16 8-26	25 8 3 1 2 2 0	

COUNTY	LOCATION	DATE TRAP PLACED	TRAP NO. OR NAME	DATE TRAP CHECKED	MALE P.T. MOTHS IN TRAP	COMMENTS
Wadena	27-138-33		Nimrod 115	7-8 7-16 7-24 7-30 8-7 8-16 8-26	18 16 5 4 3 6 2	
Wadena	7-138-33		Shell River	7-16 7-24 7-30 8-7 8-16 8-26 9-8	15 6 6 8 11 0 0	
Wadena	8-138-33		Huntersville Tree Farm	7-8 7-16 7-24 7-30 8-7 8-16 8-26 9-8	34 24 15 8 5 11 0 0	