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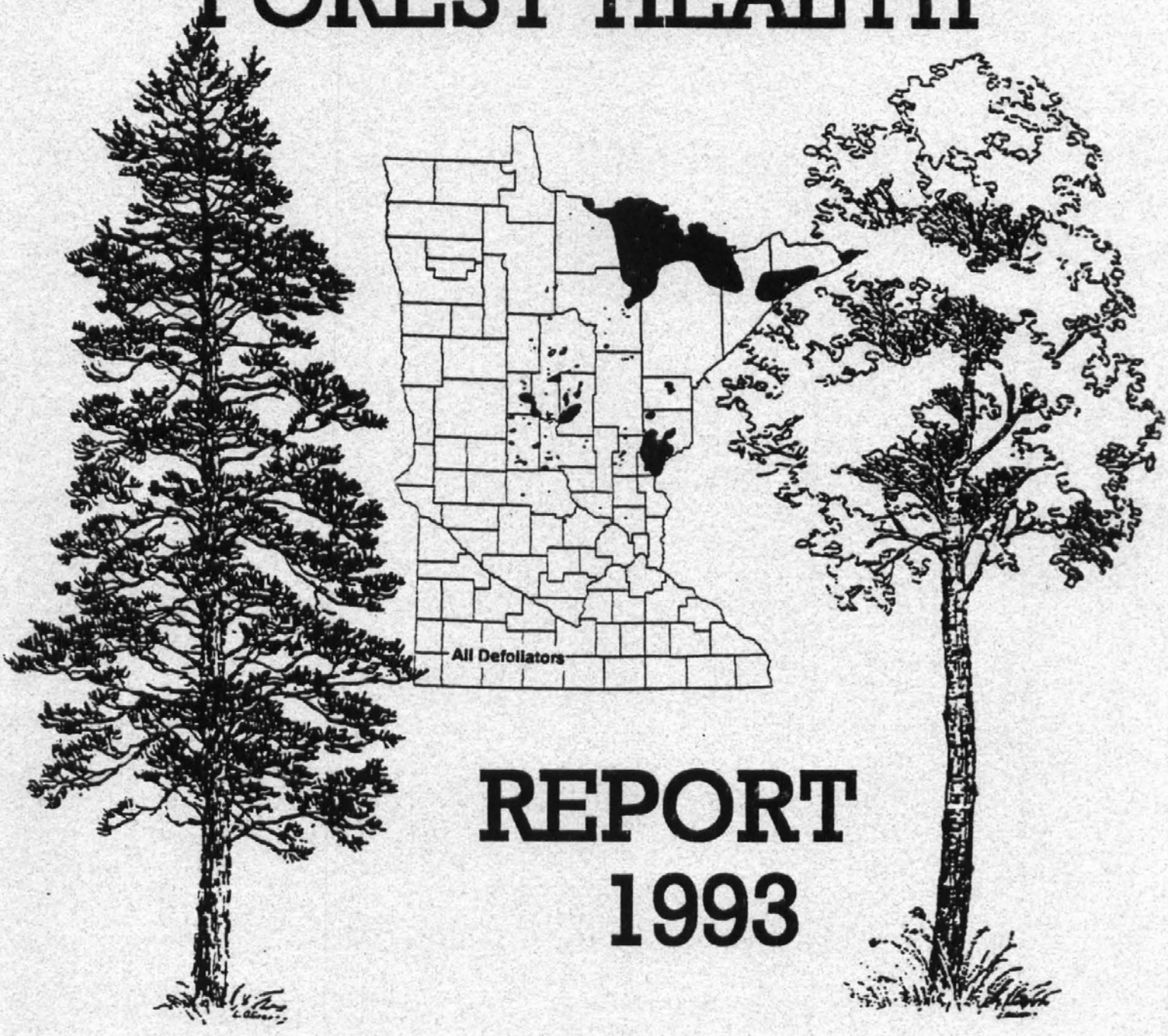
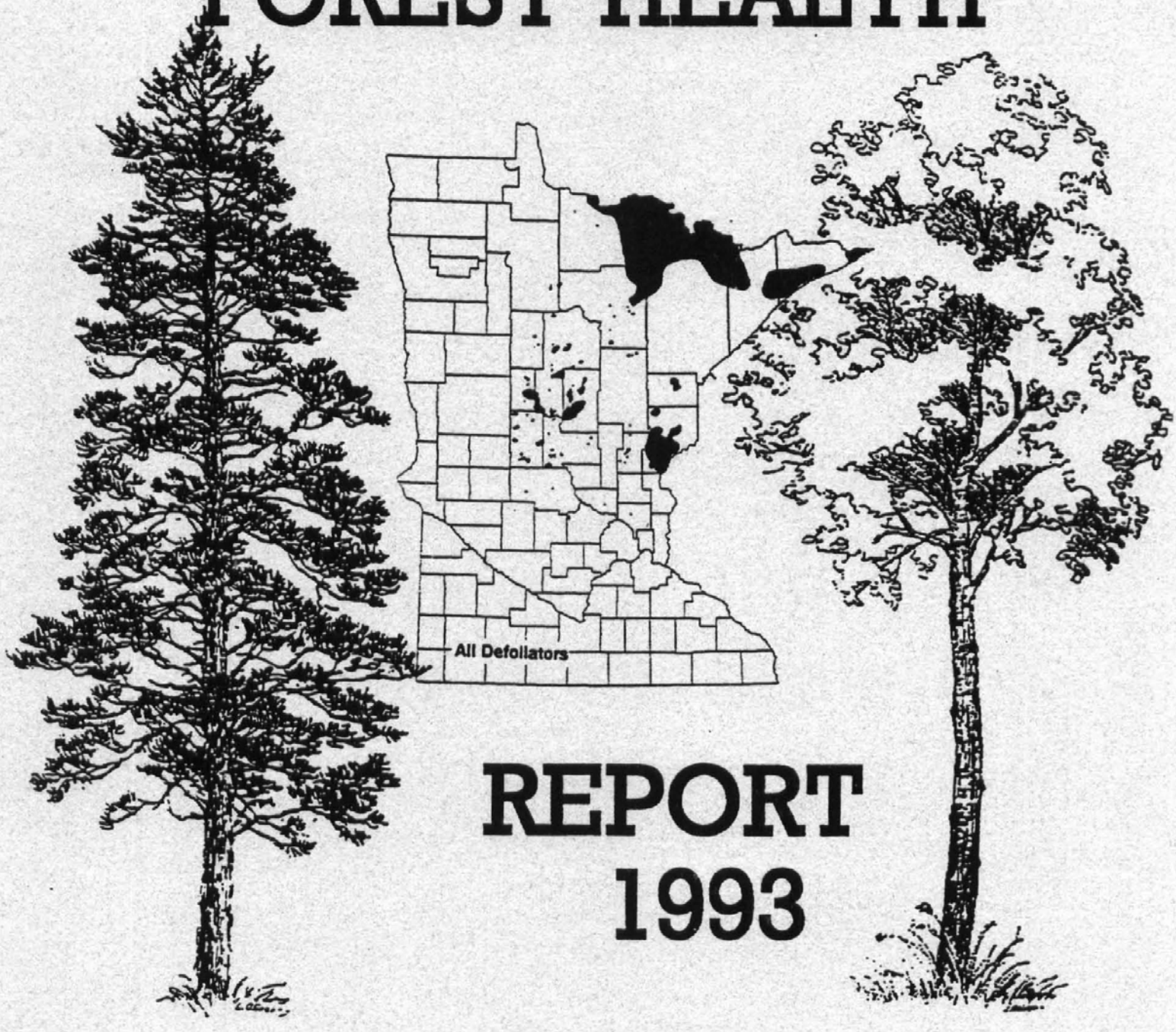
MINNESOTA FOREST HEALTH



REPORT 1993

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

MINNESOTA FOREST HEALTH



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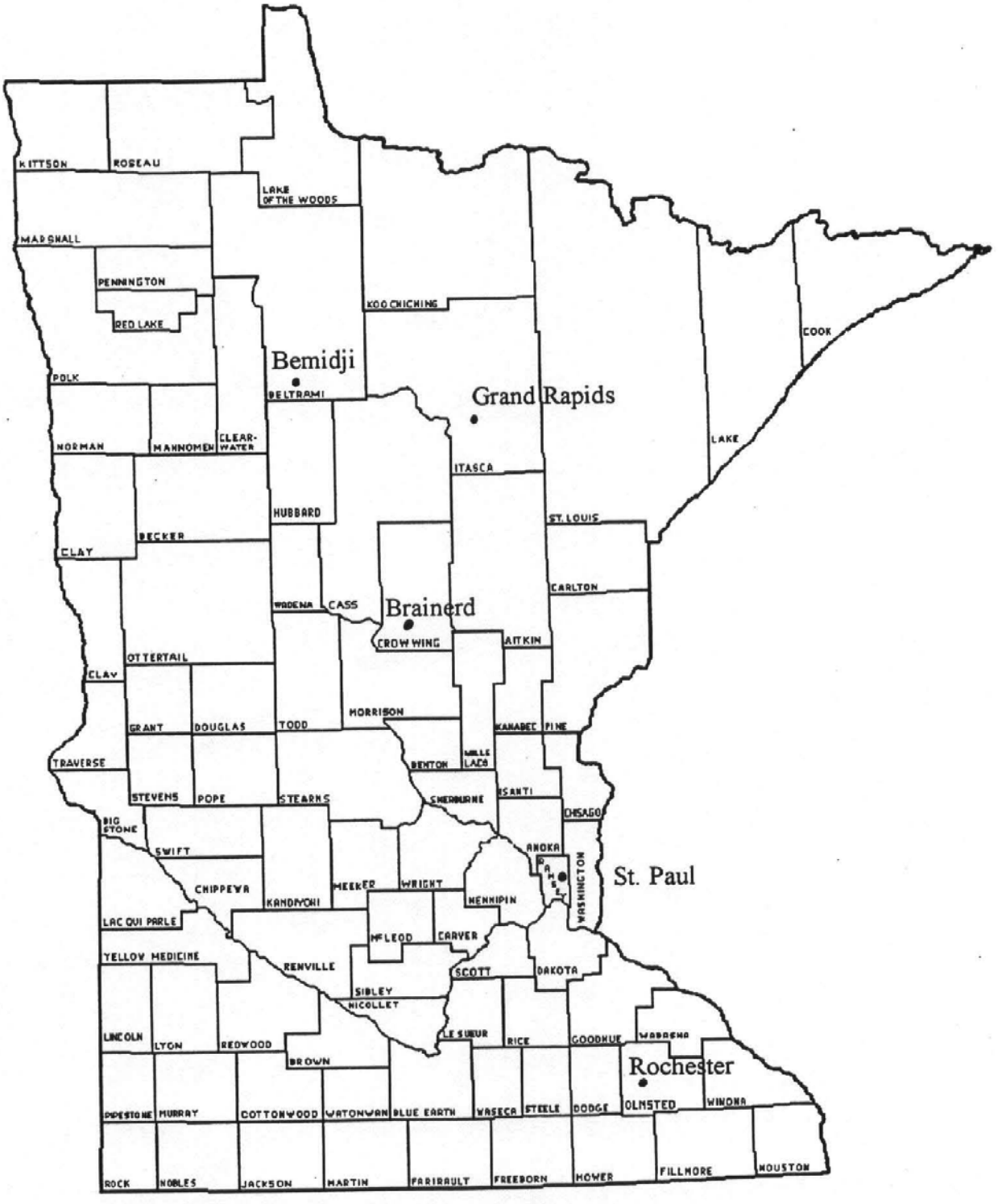

Minnesota counties and
DNR Regional Headquarters.

The Forest Health Report is an assessment of the overall health of Minnesota's forests as well as a summary of the insects, diseases and other pests which can lead to a reduction in forest health. There are 16.7 million acres of forest land in Minnesota and of those, 14.8 million acres are classified as timberland. Our forest ecosystems harbor 48 native tree, 176 bird, 60 mammal and 28 reptile species. Forests also provide opportunities for recreation and support the state's economy. The forest industry is valued at 7 billion dollars and is the state's fourth largest industry. Minnesota's forests enhance the environment and add to the quality of life for all Minnesotans.

The forest types in this report are a combination of the 14 forest types identified in the 1990 Forest Inventory. This report is organized into 7 covertypes: aspen-birch, spruce-fir, maple-basswood, elm-ash-soft maple, oak, pine and urban. " Urban forest " is included as a forest type since it involves a wide variety of tree species and occupies a unique ecological niche. Forest type definition, acreages, volumes and tree numbers are based on the publication, *Minnesota Forest Statistics, 1990* by Miles and Chen.

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

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Forest Health Program Highlights

In 1993, the Forest Health Unit was involved in the following activities:

Surveyed 14.2 million acres for pest occurrence. The most significant pest detection was spruce budworm found affecting more than 116,000 acres.

Placed, monitored, and retrieved 526 gypsy moth pheromone traps as part of the statewide interagency monitoring effort which included a total of 7,479 traps. 97 moths were caught in 64 traps.

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

Evaluated 500 new oak wilt infection centers during a pre-suppression survey in Dakota Co. in order to expand the treatment area in the Oak Wilt Cooperative Suppression Program.

Treated 677 oak wilt infection centers with 35.3 miles of vibratory plow line. Distributed approximately $650,000 to communities for oak wilt control through the federal-state Cooperative Suppression Program for Oak Wilt.

Installed 960 feet of vibratory plow line in a state-owned red oak seed orchard for oak wilt control.

Provided technical assistance to MN Department of Transportation for direct control of a yellow-headed spruce sawfly infestation on 25 miles of white spruce windbreaks along Interstate 35 south of the Twin Cities.

Continued development of the GIS-based Forest Health Information System. The system will make the access and analysis of forest health information user-friendly. The system will also be adaptable to other states and regions.

Completed an aerial photography study which evaluated film, camera, scale and season to best document crown conditions to supplement Forest Health Monitoring plot activities. A written report with color, stereo-paired photographs has been distributed.

Conducted growing season aerial photography of forested Forest Health Monitoring plots and the FIA plots within the hexagons. Photography is being catalogued and interpreted to establish baseline crown conditions of the plot areas.

Hazard tree training was expanded to include city foresters and tree inspectors. Approximately 250 urban forestry staff representing over 100 communities were trained during 1993. The one day training session has been awarded 4 continuing credits from the International Society of Arboriculture.

Conducted 11 forest insect and disease training sessions; 218 forestry related personnel were trained.

Conducted FIA forest insect and disease training in Wisconsin for 22 people.

Revised and printed 450,000 gypsy moth cards. This brings to just over 1 million cards in circulation. A total of 12 states now utilize the cards in their gypsy moth programs.

Produced an additional 9,500 copies of the Minnesota Hazard Tree manual for distribution through S&PF to other states in the Northeastern Area. Supplies of the first edition were depleted within one year of printing.

Produced 5 Insect and Disease Newsletters. The circulation is now over 700 and although the main audience is field foresters and urban forestry personnel, more and more people in the general public are requesting their free subscription.

A paper entitled "Management of Cone and Seed Insects and Diseases in a White Spruce Seed Orchard--A Ten Year History" was presented at the Northern Forest Genetics Association.

Division of Forestry hosted the Sixth National Urban Forest Conference in September. Some 950 delegates from around the world attended this four day meeting in Minneapolis. Significant number of hours of Forest Health personnel were involved in pre-conference planning and logistical support during the conference. One of the day-long field sessions featured preservation and protection of the urban forest.

Co-hosted the 1993 North Central Forest Pest Workshop in Rochester in October with State and Private Forestry-USFS. Approximately 110 people attended this two day workshop which focused on the role of insects and diseases in the forest ecosystem and on exotic pests and hazard trees.

Pest detection and evaluation highlights

The growing season was cool and moist, much like 1992. The precipitation map for the period April 1 to November 8 shows that all areas of the state received at least 100% of their normal rainfall amounts. See Map 1. With weather like this, insect development was delayed and foliar pathogens abounded. Anthracnoses of oaks and ashes were severe and occurred statewide in the spring and summer. Blights and scabs of leaves and needle rusts were also observed in abundance.

Although spruce budworm did not cause the most defoliation this year, it was the most widespread. Surprisingly, it was found well outside of its normal range (also the natural range of balsam fir and white spruce). The center of activity has moved from Cook Co. to northern Lake and St. Louis Cos. where mortality is now beginning in balsam fir and white spruce stands. On the southern and western edges of the outbreak area, only white spruce in plantations were defoliated this year. Nearby balsam firs were not touched or only had a trace of defoliation. An unusual situation! Egg mass surveys indicate that the populations are on the upswing and are moving south and west.

Jack pine budworm defoliation was heavy to severe in the central counties this year. Damage was moderated by weather conditions which kept the trees well supplied with water. With the fortunate combination of cool, wet weather, no bark beetle activity and some needles remaining on the new shoots, damage to the jack pines was minimal. Egg mass surveys indicate declining populations next year, with remnants perhaps causing noticeable defoliation in southeast Hubbard Co. and in southern Crow Wing Co. Populations will be increasing and causing defoliation at St. Croix State Park in Pine Co.

In the northern half of the state, Diplodia and Sirococcus shoot blights were very destructive in red pine plantations. These blights caused leader, shoot and branch death. In some instances the top half of the sapling was dead.

The acreage affected by aspen defoliators was less than last year. Large aspen tortrixes, leafminers, leaftiers and blotchminers were the main caterpillars involved. Forest tent caterpillars caused basswood and oak defoliation in isolated stands in Kandiyohi, Wright, Ottertail, Stearns and Todd Counties.

Over 76 miles of vibratory plow line have been installed in the Metropolitan area in order to control oak wilt in the past 3 years. Approximately 1000 infection centers have been treated. This effort accounts for 28% of the inventoried infection centers and already 6 communities have run out of oak wilt centers to treat.

A total of 97 gypsy moths were caught in 64 locations in the state. Of these, 88 were caught in the greater metropolitan area and the remainder as follows: 1 in Olmstead Co., 1 in Winona Co., 2 in Itasca Co., 2 in Carlton Co. and 3 in Stearns Co.

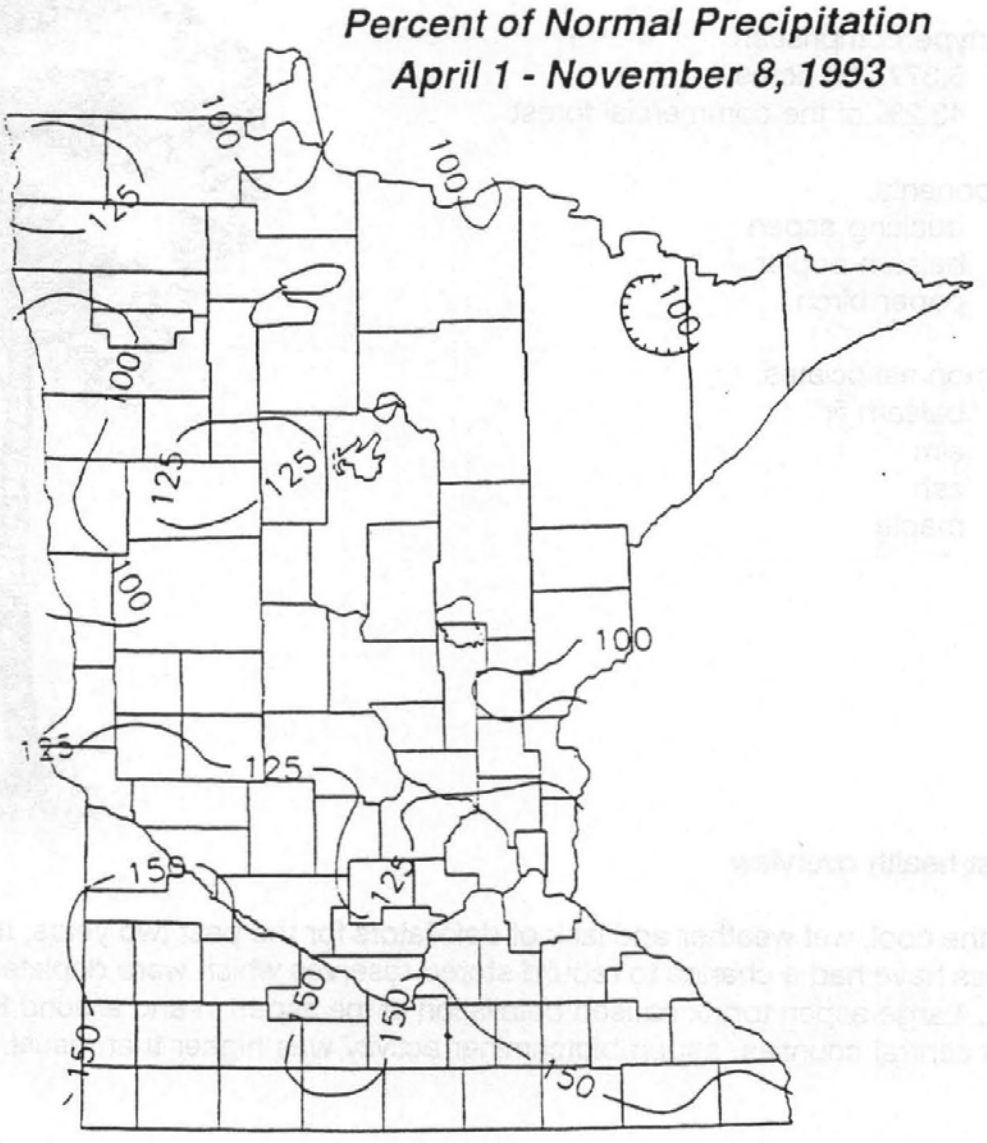
Unless otherwise noted, the acreages reported are based on the 1990 FIA database. An outbreak area was aerially sketch-mapped, digitized and then layered onto the FIA covertype database. This generated an acreage figure which represents all the affected covertype(s) within the sketch-mapped area.

Defoliation ratings are based on this scheme:

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

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

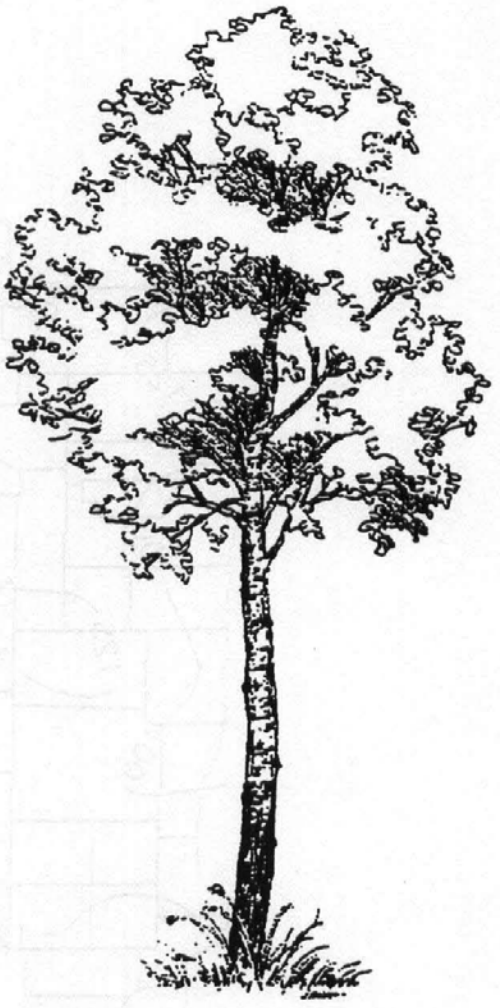
Map 1. Percent of Normal Precipitation.



Precipitation data gathered by:
Department of Natural Resources
National Weather Service
Minnesota Extension Service

Prepared by:
State Climatology Office
D.N.R. - Waters

ASPEN - BIRCH FORESTS



Covertype comprises:
- 6,377,700 acres
- 43.2% of the commercial forest

Components:
- quaking aspen
- balsam poplar
- paper birch

Common associates:
- balsam fir
- elm
- ash
- maple

Forest health overview

With the cool, wet weather and lack of defoliators for the past two years, the aspens and birches have had a chance to rebuild stored reserves which were depleted during 1988-1991. Large aspen tortrix caused defoliation of the aspen in and around Pine Co. In the north central counties, aspen blotchminer activity was higher than usual.

Pests included in this report:

Large aspen tortrix
Aspen blotchminer
Birch leafminer

Large aspen tortrix

Choristoneura conflictana (Walker)

Host: Aspen
Damage: Defoliation
Area: 221,440 acres
Severity: Moderate to heavy defoliation of aspen.
Trend: Leaf rollers and tiers were reported last year in Hubbard, Beltrami, Cass, Becker and Clearwater Counties.

In Pine Co., defoliation by large aspen tortrix was the most severe and most widespread. Seventy percent of the leaves were tied and rolled but most of the leaves were still green. Elsewhere, defoliation was less severe. See Map 2.

Phenology:

Date	Event	Location
6/ 25	Both pupae and larvae found.	Pine Co.

Aspen blotchminer

Phyllonorycter tremuloidiella (Braun)

Host: Aspen
Damage: Defoliation
Area: Not determined
Severity: Light to moderate defoliation of aspen
Trend: Some blotchminer activity is reported every year. This year, blotchminer activity was particularly notable in Itasca, Koochiching and Cass Cos.

Aspen blotch miner was common throughout the northeast and north central counties. Despite the wet weather this year, blotchminers seemed to be at higher population levels.

In parts of Itasca and Koochiching Counties almost every leaf was mined. Damage was most common on understory trees along roadsides. Leaves remained green and attached to the trees into late August even though they were heavily infested. It was common to find 4 mines per leaf.

Phenology:

Date	Event	Location
7/ 30	Mines turning brown and becoming more visible.	Crow Wing Co.
8/ 2	Pupae in mines. Mines are ¼ by ½ inches. Extensive on aspen.	Mission Tnsp., Crow Wing Co.
8/ 4	Leaves starting to look chlorotic due to leaf mining.	Koochiching Co.
8/ 17	Adults have emerged from pupal cases which stick out from the underside of the mined area in the leaf.	Cass Co.

Birch leaf miner

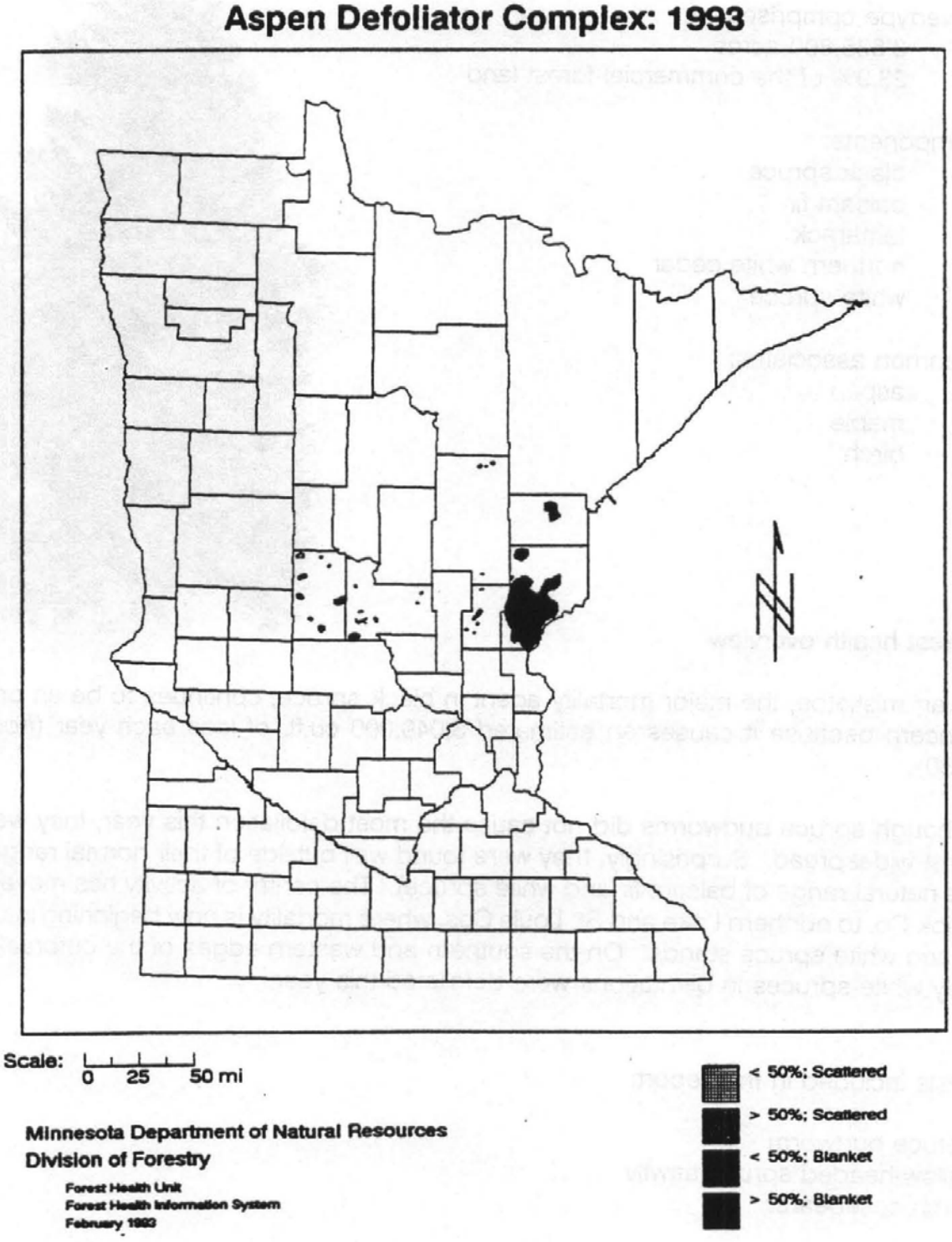
Fenusa pusilla (Lepeletier)

Host: Birch
Damage: Defoliation
Area: Not determined
Severity: Minor
Trend: Distribution and damage was much reduced from past years' levels.

Birch leafminer populations in forested areas were reduced to the point where it was not obvious on most birch trees. Birches that have had heavy leafminer activity for many years had little or no leafminer activity this year.

In urban forests of the Metropolitan area, the 2 generations of leafminer blended into a single continuous attack. It is theorized that the cool, wet summer caused the generations to overlap.

Map 2. Aspen defoliator complex: 1993



SPRUCE - FIR FORESTS

Covertype comprises:
- 3,535,800 acres
- 23.9% of the commercial forest land

Components:
- black spruce
- balsam fir
- tamarack
- northern white cedar
- white spruce

Common associates:
- aspen
- maple
- birch

Forest health overview

Dwarf mistletoe, the major mortality agent in black spruce, continues to be an ongoing concern because it causes an estimated 3,049,000 cu.ft. of loss each year (from FIA, 1990).

Although spruce budworms did not cause the most defoliation this year, they were the most widespread. Surprisingly, they were found well outside of their normal range (also the natural range of balsam fir and white spruce). The center of activity has moved from Cook Co. to northern Lake and St. Louis Cos. where mortality is now beginning in balsam fir and white spruce stands. On the southern and western edges of the outbreak area, only white spruces in plantations were defoliated this year.

Pests included in this report:

Spruce budworm
Yellow-headed spruce sawfly
Larch casebearer

Spruce budworm

Choristoneura fumiferana (Clemens)

Hosts: Balsam fir, white spruce
Damage: Defoliation
Area: 116,165 acres
Severity: See Table below.
Trend: Populations and acreage increased slightly in 1993. Populations and defoliation continued a 1992 trend of increasing and spreading to the west and south with defoliation being reported in very scattered locations and extending even into the Metropolitan area. Budworm activity in these locations was reported primarily in white spruce plantations.

Acres and severity of budworm defoliation by county

	Light and scattered	Moderate and contiguous	Heavy and scattered	Heavy and contiguous
Aitkin			80	
Hubbard		50		
Beltrami		820		
Cass		695	700	
Wadena			40	
Sherburne			80	
Anoka			40	
Cook		6,300	14,600	
Lake			7,060	53,000
St Louis	3,300		2,900	22,000
Koochiching	2,200		1,000	
Itasca	100		1,200	
Totals	5,600	7,865	27,700	75,000

Acreage of defoliation reported for 1993 was only slightly higher than that reported in 1992 although budworm continued to expand westward and southward and gross acreage involved was greater than in 1992. For the northeastern counties, acres of defoliation are reported only for white spruce and balsam fir covertypes based on the 1990 FIA acreage. It should be noted that defoliation also occurred in other covertypes that contain white spruce and balsam fir components however these were not included in the defoliation acreage. Defoliation was detected by aerial and ground surveys. See Map 3.

Populations declined significantly in Cook County where budworm has been in outbreak status for the past 10 years or so. Budworms are still active in Cook Co. but at reduced acreage and severity. Near Ely, populations have been building for several years and are starting to cause detectable mortality. Population levels and gross acreage affected increased in St. Louis, Lake, Koochiching, and Itasca Counties. In parts of eastern Koochiching and eastern Itasca Counties, where spruce budworms were just beginning their attack, defoliation occurred primarily in white spruce plantations. Nearby balsam fir often showed only a trace of activity or no sign of activity at all.

Aerial surveys in late June revealed the presence of spruce budworm defoliation in a number of white spruce plantations in Beltrami, Cass, Wadena and Hubbard Counties. Heavy budworm feeding on white spruce plantations was observed from the ground in Aitkin, and Cass Counties. Surrounding mixed stands of balsam fir, white spruce and aspen were not infested with this defoliator to the point of showing discoloration. Only the white spruce plantations were discolored. The plantations were generally older plantations with trees at least 20 feet tall. The occurrence of spruce budworm in Aitkin, Beltrami, Cass, Hubbard and Wadena Counties is very unusual.

Spruce budworm is rarely found as far south as Anoka and Sherburne Cos., being out of the natural range of both balsam fir and white spruce. In Anoka Co. the area under attack is an abandoned Christmas tree farm which has become a residential development. In Sherburne Co., a 30'tall white spruce wind fence was heavily defoliated.

It is likely that spruce budworm has been able to increase its populations on white spruce to damaging levels in the state due to the cool, wet growing seasons which have kept white spruce foliage tender and succulent longer than normal for two growing seasons.

Several private industry white spruce plantations were aerially sprayed in Itasca and Aitkin Counties with Bt on June 11, 1993. Foliage was protected. It is likely that additional private plantations will be sprayed in 1994.

An extensive egg mass survey was completed by DNR, Koochiching County and private industry foresters. Survey results indicate that populations of spruce budworm may intensify in 1994 in Kabetogama, Littlefork and Side Lake Districts in St.Louis, Koochiching and Itasca Counties. In Cass, Crow Wing and Aitkin Cos., populations are expected to

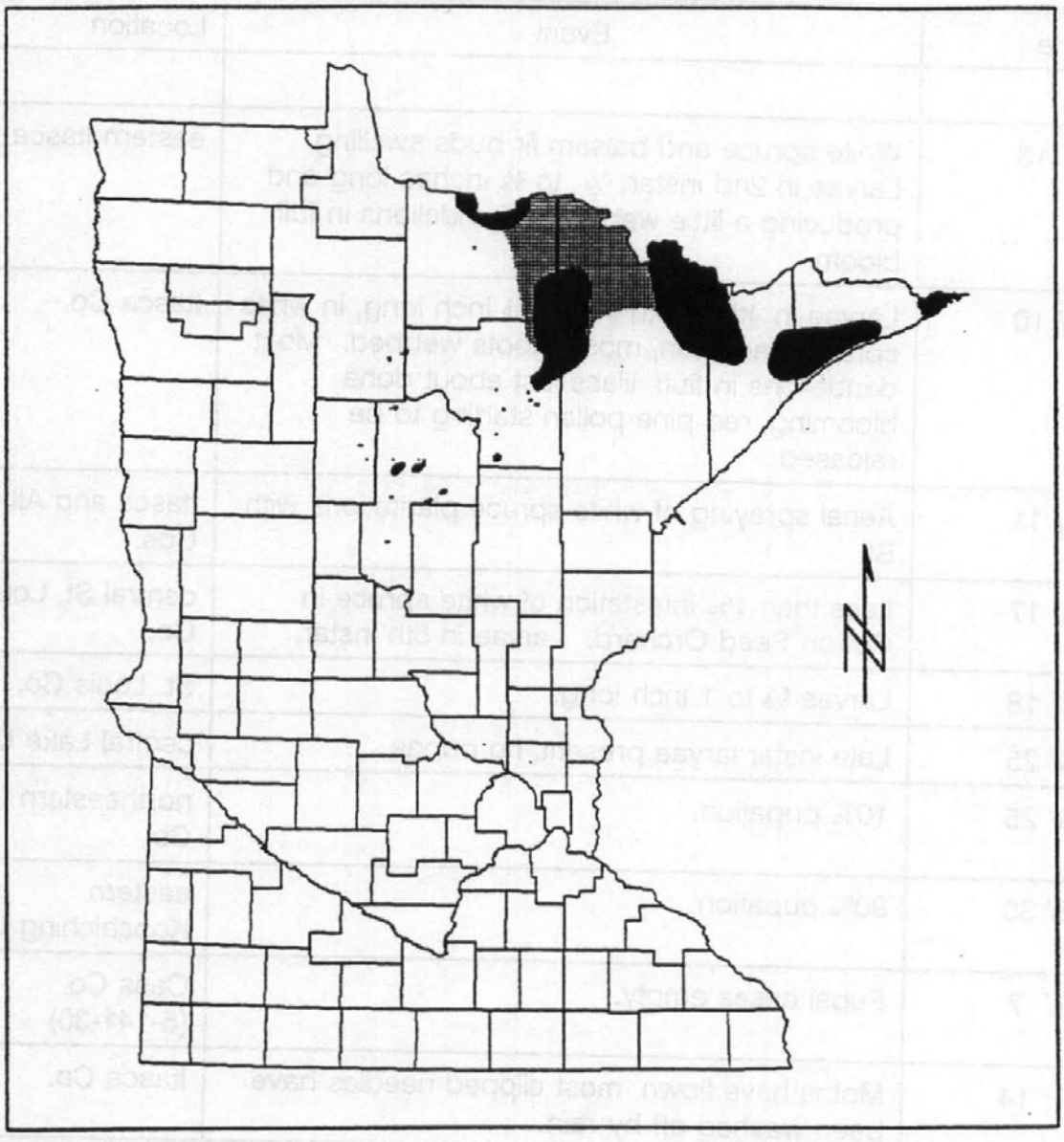
increase, causing more widespread, but very scattered, defoliation. In Anoka and Sherburne Cos., the populations will decrease and cause, at most, light defoliation in 1994.

Phenology :

Date	Event	Location
5/ 13	White spruce and balsam fir buds swelling. Larvae in 2nd instar, ¼ to ⅜ inches long and producing a little webbing. Dandelions in full bloom.	eastern Itasca Co.
6/ 10	Larvae in 4th to 5th instar, ⅝ inch long, in white spruce plantation, most shoots webbed. Most dandelions in fluff, lilacs just about done blooming, red pine pollen starting to be released.	Itasca Co.
6/ 11	Aerial spraying of white spruce plantations with Bt.	Itasca and Aitkin Cos.
6/ 17	Less than 1% infestation of white spruce in Cotton Seed Orchard. Larvae in 5th instar.	central St. Louis Co.
6/ 18	Larvae ⅝ to 1 inch long.	St. Louis Co.
6/ 25	Late instar larvae present, no pupae.	central Lake Co.
6/ 25	10% pupation.	northeastern Lake Co.
6/ 30	90% pupation.	eastern Koochiching Co.
7/ 7	Pupal cases empty.	Cass Co. (5-141-30)
7/ 14	Moths have flown, most clipped needles have been washed off by rain.	Itasca Co.
7/ 15	100% pupation, no moth flight, 30% of pupae are still green. Pupae are only about ⅓ normal size.	Cook. Co.

Map 3. Spruce budworm: 1993

Spruce Budworm: 1993



Scale: 0 25 50 mi

Minnesota Department of Natural Resources
Division of Forestry

Forest Health Unit
Forest Health Information System
February 1993

< 50%; Scattered
> 50%; Scattered
< 50%; Blanket
> 50%; Blanket

Yellow-headed spruce sawfly

Pikonema alaskensis (Rohwer)

Host: White spruce
Damage: Defoliation
Area: Approximately 35 acres, along Interstate Highway # 35 in Steele County and on ornamental trees in the Metropolitan area.
Severity: Light to severe defoliation.
Trend: Unknown

In March, the Department of Transportation requested an evaluation of the infestation along Interstate Highway #35 in Steele Co. Two to three rows of white spruce form a living snow fence that stretches for 25 miles. The DNR recommended control actions and timed the treatment and the DOT supplied the contractor. On June 10, just after most larvae had hatched, the infestation was treated with an aerial application of esfenvalerate. Additional control is not anticipated.

In the Metropolitan area, larvae attacked ornamental spruces. Some trees in exposed windbreaks and highway plantings had severe defoliation.

Phenology:

Date	Event	Location
5/ 25	Adult emergence.	Steele Co.
5/ 27	Lilacs in full bloom.	Steele Co.
6/ 2	10% hatch. Weather has cooled.	Steele Co.
6/ 4	20% hatch.	Steele Co.
6/ 6	General hatch.	Steele Co.

Larch casebearer

Coleophora laricella (Huber)

Host: Tamarack
Damage: Defoliation
Area: Not determined
Severity: Very light to light defoliation was obvserved in widely scattered locations.
Trend: Unknown, however, casebearer was not reported in 1992.

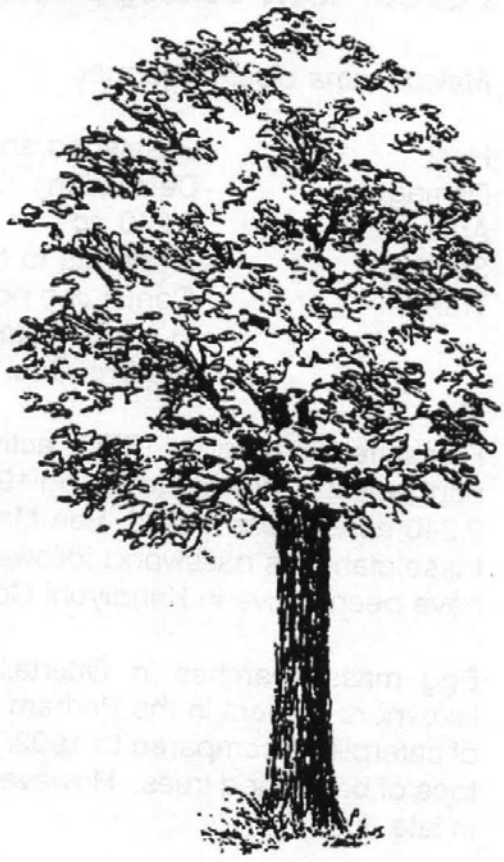
Larch casebearer was observed in a few scattered locations in St. Louis and Itasca Counties. It was most abundant on a site in S29-T57-R18 where it caused light defoliation by mining needles.

Larch casebearer is a introduced pest that now occurs throughout the range of tamarack. It is one of the most serious defoliators of tamarack with outbreaks occurring in eastern Canada on 8 year cycles. Two introduced parasites are considered helpful in controlling the severity of outbreaks.

Phenology:

Date	Event	Location
5/ 18	Cases ⅛ to ¼ inches long.	St. Louis Co.

MAPLE - BASSWOOD FORESTS



Covertype comprises:
1,402,900 acres
9.5% of the commercial forest land

Components:
sugar maple
red maple
basswood
yellow birch
American elm

Common associates:
white pine

Forest health overview

The overall health of this forest type continues to improve. Introduced basswood thrips have not been a major problem since 1988 and forest tent caterpillar defoliation is almost negligible. FTC activity is confined to isolated basswood stands usually along lakeshores in the west central counties.

Early fall coloration was displayed again this year by sugar and red maples, particularly across the southern counties. It has been theorized that the unusually cool summer temperatures and the water-saturated soils led to this display.

A complete remeasurement of the North American Maple plots was done in 1993. See the write up on NAMP in the Special Projects section of this report.

Pest covered in this report:

Forest tent caterpillar

Forest tent caterpillar

Malacosoma disstria Hubner

Host:	Basswood and oak
Damage:	Defoliation
Area:	2,240 ac
Severity:	Moderate to heavy defoliation
Trend:	Continuing population decline after collapse in 1990. Now persisting in small, isolated locations in Ottertail, Kandiyohi, Todd, Wright and Stearns Cos.

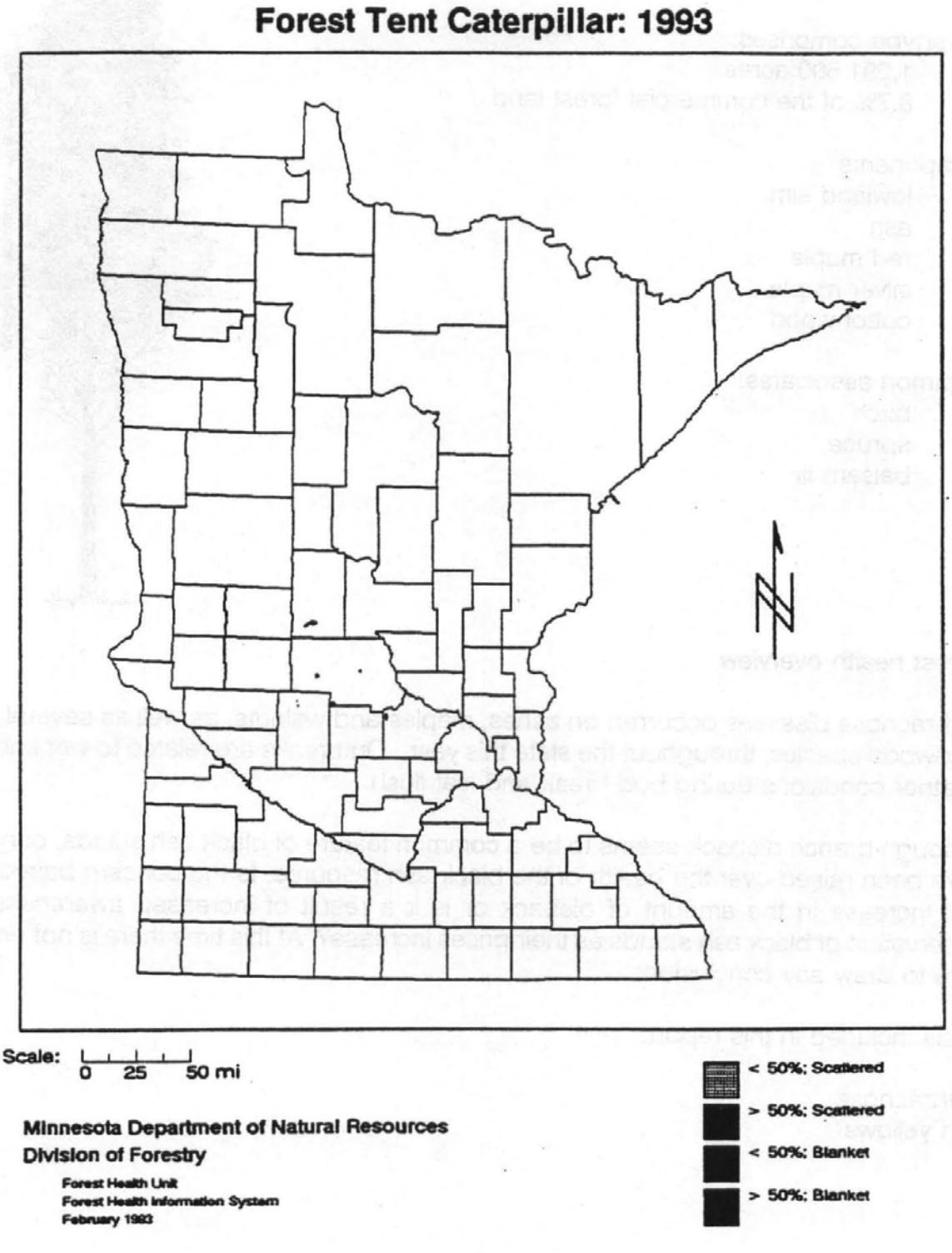
Forest tent caterpillar (FTC) activity was nearly undetectable in western, central and northwestern Minnesota during 1993. However, seven separate defoliated areas totalling 2,240 acres were found. See Map 4. The preferred host of the forest tent caterpillar in these stands is basswood followed by oaks. This is the 14th consecutive year that FTC have been active in Kandiyohi Co.

Egg mass searches in Ottertail County during May were unsuccessful. However, lakeshore owners in the Perham area reported seeing a 10-fold increase in the number of caterpillars compared to 1992. By June 8th some light defoliation was seen in the very tops of basswood trees. However, no defoliation could be detected during aerial surveys in late June.

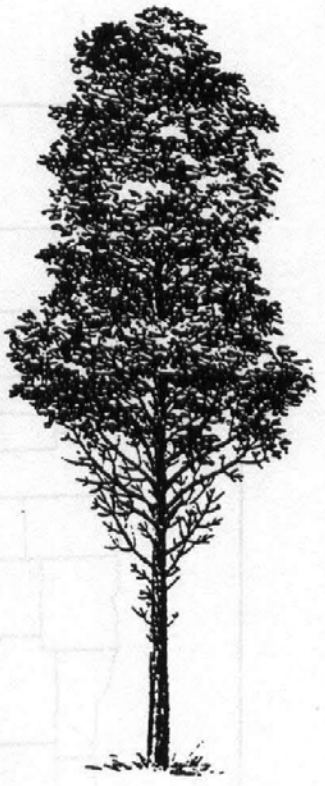
Phenology:

Date	Event	Location
5/ 28	Found a single FTC which was 1¼ inch long. No aspen defoliation visible.	Brainerd, Crow Wing Co.
5/ 28	In 3 separate locations, caterpillars are ⅜ , ⅝ and ½ to ⅞ inches long. On basswood.	Todd Co.
6/ 2	Two caterpillars found in aspen stand.	Gull Lake, Crow Wing Co.
6/ 9	Caterpillars are 1¼ to 1¾ inches long. Basswood defoliation evident.	Todd Co.
6/ 30	Ultimate instars and pupae present.	Todd and Stearns Co.

Map 4. Forest tent caterpillar: 1993



ELM - ASH - SOFT MAPLE FORESTS



Covertype comprises:
- 1,291,500 acres
- 8.7% of the commercial forest land

Components:
- lowland elm
- ash
- red maple
- silver maple
- cottonwood

Common associates:
- birch
- spruce
- balsam fir

Forest health overview

Anthracnose diseases occurred on ashes, maples and walnuts, as well as several other hardwood species, throughout the state this year. Outbreaks are related to wet and cool weather conditions during bud break and leaf flush.

Although branch dieback seems to be a common feature of black ash stands, concerns have been raised over the health of the black ash resource. Is the concern based on a real increase in the amount of dieback or is it a result of increased awareness and observation of black ash stands as their prices increase? At this time there is not enough data to draw any conclusions.

Pests included in this report:

Anthracnose
Ash yellows

Anthracnose

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

Hosts:	Ashes, oaks, maples and walnut
Damage:	Defoliation, twig dieback
Area:	Not determined, but statewide occurrence
Severity:	Heavy to severe defoliation of several hardwood species, twig infection common in ash.
Trend:	Infection and severity levels increased over levels experienced in 1992.

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

Phenology:

Ash was affected first with most of the damage occurring in mid to late May. White oak symptoms became evident in early June, but most damage expression occurred in early July. Walnut damage was observed in early to mid June.

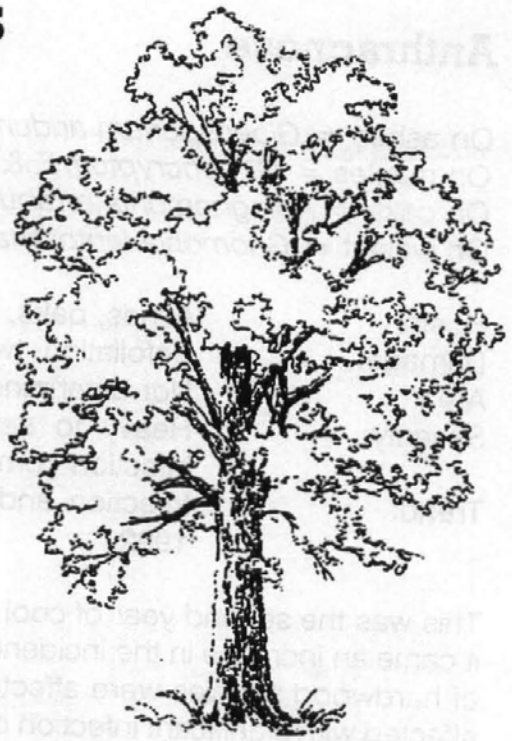
Ash Yellows

Mycoplasma-like organism

Host:	Ashes
Damage:	Decline
Severity:	Unknown
Trend:	Unknown

In 1993 three new counties were added to the list of counties with confirmed cases of ash yellows. They are Washington, Carver, and McLeod Counties. As additional surveys and tests are conducted, confirmed cases will probably increase the distribution of ash yellows in the state. The impact of this disease in Minnesota has yet to be determined.

OAK FORESTS



Covertype comprises:
- 1,184,300 acres
- 8% of the commercial forest

Components:
- northern red oak
- white oak
- bur oak
- hickories

Common associates:
- jack pine
- elm
- maple

Forest health overview

The overall health of the oak forests is improving and, in fact, very little oak mortality occurred during 1993.

Due to the cool, wet conditions of 1993, oak anthracnose occurred statewide, as did many other foliage diseases. This was the second year of severe defoliation of white oaks by antracnose in the southeastern counties.

Oak wilt continues to be a major problem in the oak type and has become a significant problem in urban areas. A more detailed report of the Federal Oak Wilt Suppression Project can be found in the Urban Forests section.

In southeast Minnesota, a limited amount of oak wilt occurs in forested areas where extensive stands of northern pin oaks grow on sand with rural or urban development nearby. In 1993, two control projects were conducted with a vibratory plow. One project was on state land in the red oak seed orchard (S26-T106-R8) and the other was on private land in Olmstead Co.

Pest included in this report:

Two-lined chestnut borer

Two-lined chestnut borer

Agrilus bilineatus (Weber)

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

Two-lined chestnut borer is still causing the death of individual oaks weakened during the 1987-1989 drought. Most of the borer attacks are concentrated in an area of sandy soils in the northern part of the Metropolitan area where oak mortality reached 25% in 1989. Above normal growing season precipitation for the past two seasons has hastened the decline of this insect.

Usually, mortality from two-lined chestnut borer attacks is most evident in August. With the cool, wet weather conditions in 1993, evapotranspirational stress on trees was minimal throughout the summer. This lack of stress delayed symptom expression by one to two weeks in trees with lethal attacks and likely suppressed symptoms completely in trees with sub-lethal attacks.

PINE FORESTS

Covertype comprises:
- 812,300 acres
- 5.5% of the commercial forest land

Components:
- jack pine
- red pine
- white pine

Common associates:
- aspen
- birch
- maple

Forest health overview

The health of the pine forests is improving. Jack pine budworm populations peaked in the west central counties in 1992 and in the east central counties in 1993. In both instances, damage was moderated by weather conditions which kept the trees well supplied with water. Only remnant populations will exist in Badoura Tnsp. in Hubbard Co., in the Brainerd-Baxter area of Crow Wing Co. and in St. Croix State Park in Pine Co.

Seedling red pines were plagued by shoot and tip blights for the past two years. Again, this was blamed on the weather which favored disease infection and spread. In many cases it was also a result of mature, overstory red pines being left on sites regenerated to pine.

White pines in the central counties experienced moderate to heavy defoliation in 1991 and 1992 by the introduced pine sawfly. The population collapsed in 1993 and recovery undoubtably began for the defoliated pines.

Pests included in this report:

Jack pine budworm
Pine tussock moth
Introduced pine sawfly
Diplodia and Sirococcus shoot blights

Jack pine budworm

Choristoneura pinus Freeman

Host:	Jack pine
Damage:	Defoliation
Area:	121,120 acres
Severity:	Light to heavy defoliation, topkill was very rare
Trend:	Budworm populations were significantly less in 1993 in Hubbard and Beltrami Counties than the 1992 population levels. In contrast to those counties, the budworm populations in Wadena, Cass, Pine, Crow Wing and Morrison Counties increased and expanded this year. The last major budworm infestation peaked in 1988 with 100,000 acres of jack pine defoliation. In 1990, populations started building in Beltrami and Hubbard Counties. Defoliated acreage remained low (560 acres) in 1991 with Pine County being added to the list of afflicted counties. In 1992, a total of 17,000 acres were defoliated in Hubbard, Beltrami, Wadena, Crow Wing, Cass and Pine Counties.

Early larval surveys were conducted on 84 sites in central and northern Minnesota. On 50 of the sites, no larvae were found. To show significant defoliation and reddening of trees, larval counts need to average more than 20 per plot. Only one plot in Crow Wing Co.(T45-R30) had more than 20 larvae, the remaining plots ranged from 1 to 18 larvae found. See Survey Results section for individual plot locations and findings.

The development of budworm larvae was slowed by the cool, wet weather conditions. Normally by mid-June larvae are well developed, have finished feeding on the new shoots and have moved onto the older foliage to feed. In 1993 by mid-June, larvae were still feeding on the new shoots, and some larvae were still found in the dried up masses of staminate cones. While very heavy staminate cone crops were common throughout the northeast, pollen cones were rarely found and were often limited to trees along the edges of the stands in the central counties.

Aerial surveys during late June and early July over Beltrami and Hubbard Cos. revealed no discolored jack pine from heavy budworm feeding.

The aerial surveys over Wadena, Cass, Crow Wing and northern Morrison Counties found large acreages of jack pine whose foliage turned bright red as a result of defoliation in June and July. See Map 5. Defoliation was many times more severe than expected based on the early larval surveys and preliminary observations. The stands in Mission Township (T136-R27) and stands in and around the town of Baxter (T133-R29, T133-R28)

and the city of Brainerd (T134-R28, T46-R30, T45-R30) were heavily defoliated. The jack pines were silvery from budworm webbing and suffered some shoot mortality and some topkill.

The outbreak in central Pine Co. collapsed in 1993 but a new outbreak was observed in St. Croix State Park (T40-R18) in the eastern part of the same county. See the Special Report section for further discussion of this developing outbreak.

Egg masses were searched for in July and August in 83 locations in Hubbard, Beltrami, Lake of the Woods, Roseau, Todd, Wadena, Cass, Crow Wing, Morrison and Pine Counties. Three egg masses per plot indicate a potential for a significant budworm population next year. Three locations have that potential; Hubbard Co. (T139-R32), Crow Wing Co. (T133-R29) and Pine Co. (T40-R18). Elsewhere, egg mass surveys predict little or no defoliation in 1994. See Survey Results.

Phenology :

Date	Event	Location
5/ 24	Jack pine pollen shed starting.	Crow Wing Co.
6/ 4	Second instar, ⅛ - 3/16 inch long. Feeding in pollen cones.	Crow Wing Co.
6/ 8	Second and third instars, ¼ - ⅜ inch long.	Crow Wing Co.
6/ 10	Jack pine pollen shedding about complete, gall rust sporulating.	Itasca Co.
6/ 10	Jack pine pollen 80-90% shed.	Koochiching Co.
6/ 17	Third instars, ⅜ inch long. Found in empty pollen cones.	Wadena Co.
6/ 17	Third and fourth instars, ¼ - ⅜ inch long. Feeding on shoots, very little damage.	Crow Wing Co.
6/ 18	Larvae ¼ to ½ inches long.	northern St. Louis Co.
6/ 24	80% of larvae are 6th and 7th instars. Ten percent dead from predators. Minor defoliation. 1 pupa found.	Crow Wing Co.

6/ 25	Sixth instars. Just a few stand edge pines showing heavy infestation and browned shoots.	Crow Wing Co.
6/ 28	A few 4th and 5th instars but predominantly 6th and 7th instars. Many are undersized! Concentrated along stand edges. Light to moderate defoliation. Few pupae found.	Crow Wing Co.
6/ 29	Damage to understory red and white pines noted.	Crow Wing Co.
7/ 1	Ultimate instars are very small and now spinning up. Trees silvery from webbing, some topkill noted.	Cass and Crow Wing Cos.
7/ 6	About 30 % pupated. Observed stink bug predation and 1 diseased larva.	Mission Tnsp, Crow Wing Co.
7/ 6	Only pupae found; no larvae.	Pine Co.
7/ 12	Only pupae found. A few moths observed.	Crow Wing Co.

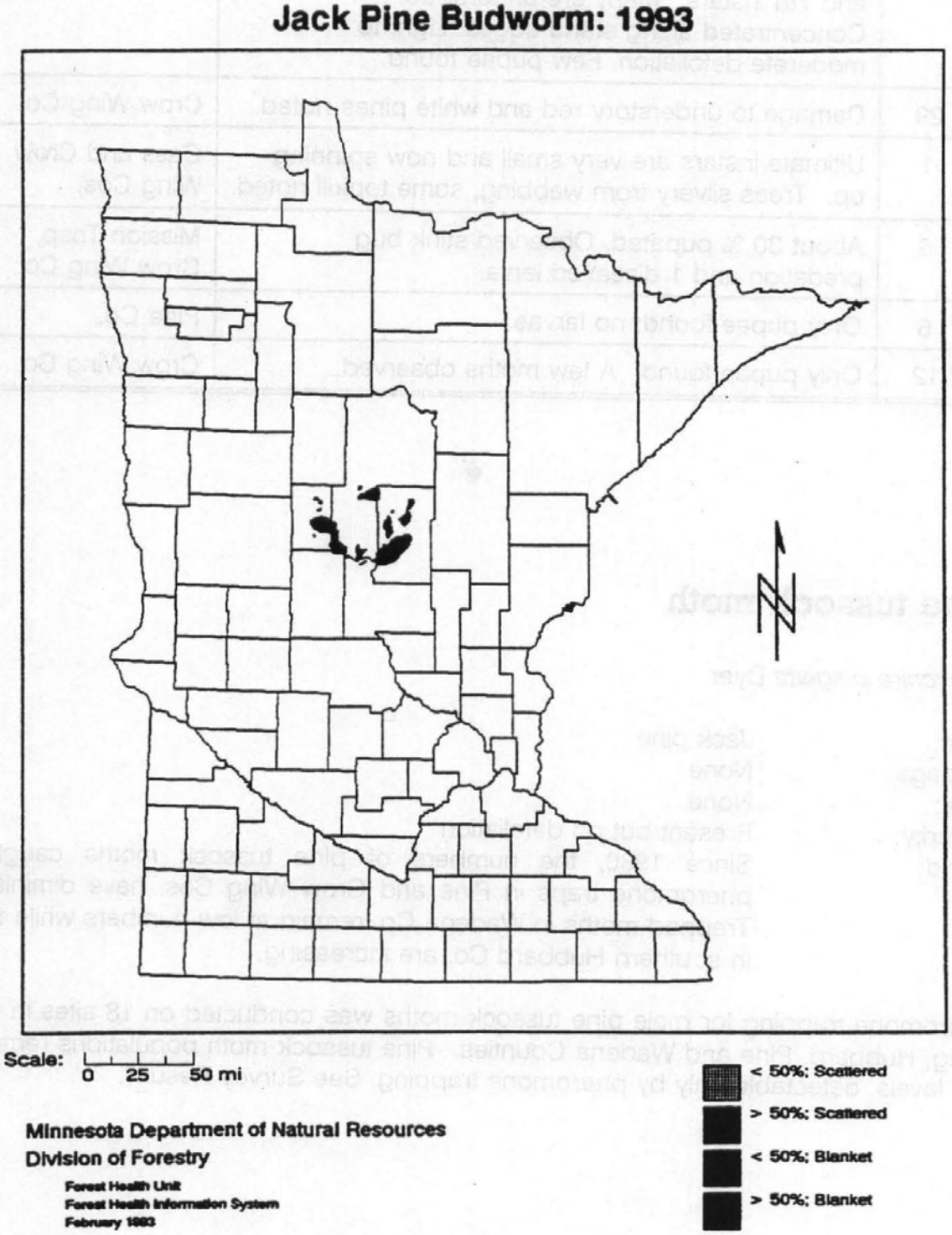
Pine tussock moth

Dasychira plagiata Dyer

Host: Jack pine
Damage: None
Area: None
Severity: Present but no defoliation
Trend: Since 1980, the numbers of pine tussock moths caught in pheromone traps in Pine and Crow Wing Cos. have diminished. Trapped moths in Wadena Co. remain at low numbers while those in southern Hubbard Co. are increasing.

Pheromone trapping for male pine tussock moths was conducted on 18 sites in Crow Wing, Hubbard, Pine and Wadena Counties. Pine tussock moth populations remain at low levels, detectable only by pheromone trapping. See Survey Results.

Map 5. Jack pine budworm: 1993



Introduced pine sawfly

Diprion similis (Hartig)

Host: White pine
Damage: Defoliation
Area: Not determined
Severity: No noticeable current year defoliation in 1993.
Trend: Population collapsed this year.

White pines were defoliated during July and August of 1992 by introduced pine sawfly larvae. Thin white pine crowns were still visible during aerial surveys in June of 1993 in an area extending from Mission Township in Crow Wing Co. to Lake Alex in Morrison Co. to Skunk Lake in Morrison Co. There was no new defoliation of white pines in 1993.

Phenology:

Date	Event	Location
6/ 22	First generation larvae are ⅛ to ½ inch long. No cocoons found.	Crow Wing Co.
7/ 19	First generation feeding almost complete. Forming cocoons. No noticeable defoliation on jack pine.	Crow Wing Co.
7/ 28	2 open cocoons found. Only 1 larvae observed.	Crow Wing Co.
8/ 18	Found I larvae, no cocoons found.	Morrison Co.

Diplodia and Sirococcus shoot and tip blights

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

Host:	Pines
Damage:	Shoot and branch dieback
Area:	Not determined, but damage was observed in red pine plantations scattered across the northern counties. Also in Stearns, Isanti and Winona Counties.
Severity:	Damage ranged from dead current year shoots to dead branches to trees with the upper one-third to one-half of the tree dead.
Trend:	There was an explosive increase in the amount of shoot blights observed on red pines.

Shoot blights were common in red pine plantations in Cook, Lake, St. Louis, Itasca and Koochiching Counties. Infection levels varied from 5% to 50% and most of the infections appeared to have been initiated in 1992. Red pine hardest hit were plantation trees, 3 to 8 feet tall. Infection and damage were also noted on pole size and mature trees. Both *Sphaeropsis* and *Sirococcus* fruiting bodies and spores were found on trees symptomatic for Diplodia shoot blight

Damage was greatest on trees closest to overstory red pines. However, in some of the plantations, infection and damage occurred across the entire plantation and was not limited to edges or proximity to overstory red pines. Apparently weather conditions were conducive to the long distance spread of these fungal spores.

None of the volunteer jack pine in the plantations examined appeared to be infected.

URBAN FORESTS

Covertype:

A wide range of native and exotic species which grow within and are influenced by the urban environment.

An urban forest stand can be as small as a single shade tree or as large as a multiple acre grove of trees.

Forest health overview

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.

Oak wilt continued to be a major problem in the oak urban forests particularly north of the Twin Cities. An aggressive oak wilt control program has made significant headway in controlling this fatal disease.

Gypsy moth continued to be monitored statewide and, in 1993, there were several new locations where gypsy moths were trapped for the first time.

Two consecutive, cool and rainy summers brought on many and different kinds of foliage blights. Most noticeable among them was apple scab on ornamental crabapples.

Pests included in this report:

Oak wilt
Gypsy moth
Apple scab
Winter sunscald
Maple decline

Oak wilt

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

Hosts:	Oaks
Damage:	Tree death
Area:	3,000 infection centers averaging 1.6 acres in size in 7 Metropolitan counties
Severity:	Seven counties in central Minnesota seriously affected including:

Anoka County	1200 infection centers active
Chisago County	295 infection centers active
Dakota County	500 infection centers active
Ramsey County	200 infection centers active
Sherburne County	300 infection centers active
Washington County	400 infection centers active

Trend: The number of active oak wilt infection centers has been decreasing over the past three years due to the successful actions of the Oak Wilt Cooperative Suppression Program.

In 1993, 677 infection centers were treated by installing over 186,000 feet of vibratory plow line and by removing 2398 potential spore producing trees. This brings the total to 1013 centers treated, which is control of 28 % of the known infection centers in the Metropolitan area. By the time this program ends in 1995, it is estimated that 65 % of the oak wilt centers will have been treated. A complete description of the annual accomplishments of the Oak Wilt Cooperative Suppression Program can be found in the Special Projects section.

Phenology:

Expression of wilt symptoms was delayed and minimized in 1993 due to the cool, wet summer weather.

Gypsy moth

Lymantria dispar (Linneaus)

Host: Oaks and other hardwoods
Damage: None
Area: None
Severity: None
Trend: There was a slight increase in the number of moths caught statewide in the pheromone trap detection survey.

Gypsy moth trapping in Minnesota is an interagency cooperative program with the majority of the work being undertaken and coordinated by USDA-APHIS and Minnesota Dept. of Agriculture (MDA). The following tables summarize statewide trapping in 1993. Map 6 depicts the Detection Trap Catches. A summary of DNR-placed trap locations can be found in the Survey Results section.

Trapping Agency	Number of Traps
MDA & USDA-APHIS	6444
Mn-DNR	526
USDA-USFS	176
Community Cooperators	333
TOTAL	7479

1993 Gypsy Moth Catches

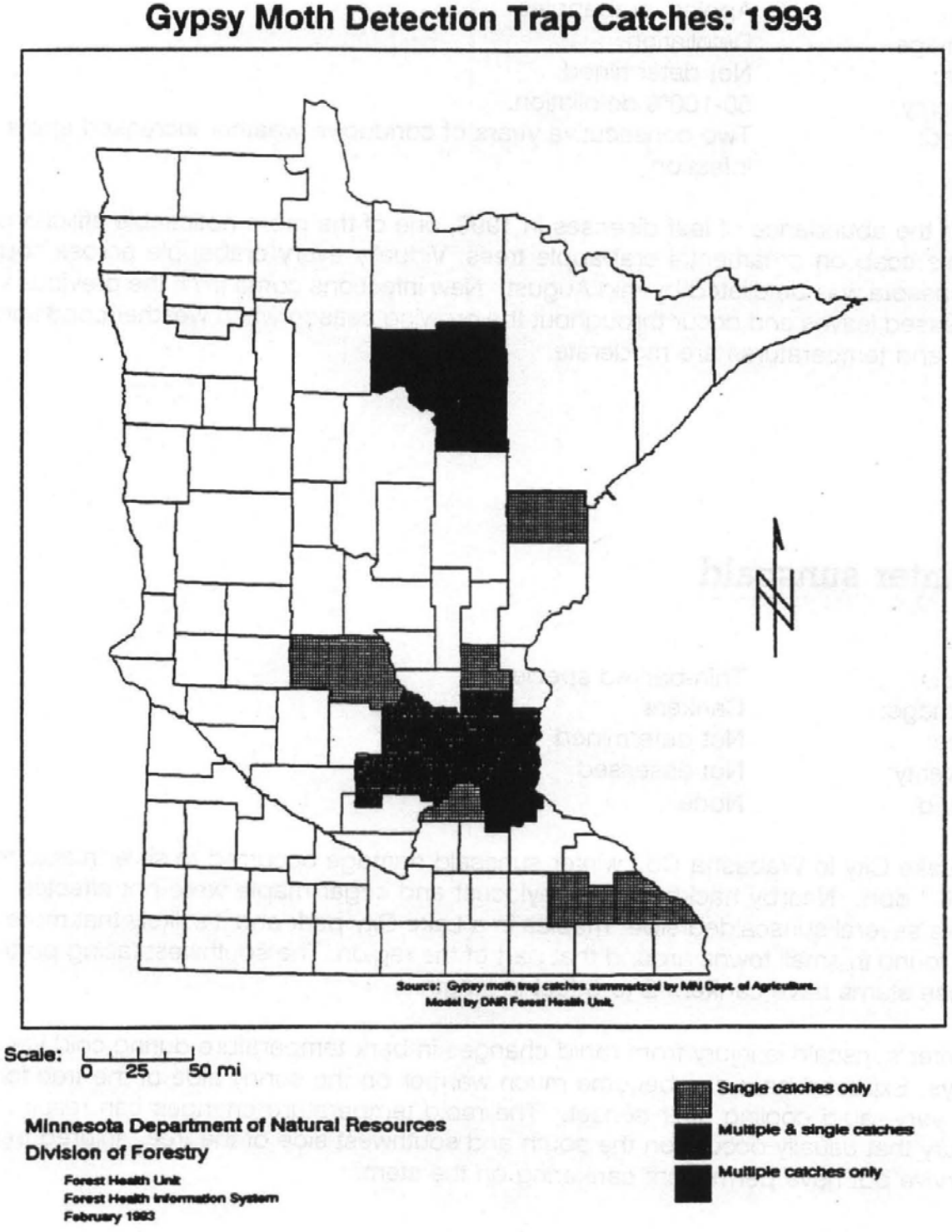
COUNTY	Number of Moths	Number of Sites
Anoka	8	5
Carlton	2	2
Carver	3	2
Dakota	7	2
Hennipen	29	24
Isanti	1	1

Itasca	2	1
McLeod	4	2
Olmsted	1	1
Ramsey	20	10
Scott	3	3
Stearns	3	3
Washington	5	4
Winona	1	1
Wright	8	3
Total	97	64

In total, 97 moths were taken at 64 sites in 15 counties. This is up from 1992 when 84 moths were taken from 59 sites in 16 counties. Of the 1993 catches, 48 were single moths in a single trap and 16 traps had multiple moths per trap. Only 10 moths were taken outside the 11 county Metropolitan Area. Next year, all locations with multiple moth catches will have detection grid trapping patterns around them.

The MDA placed delimiting trap grids in International Falls, Roseau, Red Lake Falls and in a KOA campground in Carlton Co. where multiple moths were caught in 1992. No moths were caught in the International Falls, Roseau or Red Lake Falls grids. Two male moths were caught in the Carlton grid. The MDA still does not consider this a resident population. They feel the moths are coming in on vehicles from outside the area. However, this is the third consecutive year moths have been trapped in or near the campground. The MDA will place delimiting grids around the Carlton site again next year.

Map 6. Gypsy moth detection trap catches: 1993



Apple scab

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

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

With the abundance of leaf diseases in 1993, one of the more noticeable afflictions was apple scab on ornamental crabapple trees. Virtually every crabapple across southern Minnesota was defoliated by mid August. New infections come from the previous year's diseased leaves and occur throughout the growing season when weather conditions are wet and temperatures are moderate.

Winter sunscald

Hosts:	Thin-barked species
Damage:	Cankers
Area:	Not determined
Severity:	Not assessed
Trend:	None

In Lake City in Wabasha Co., winter sunscald damage occurred to silver maple trees 4 to 6 " dbh. Nearby hackberry, honeylocust and sugar maple were not affected. There were several sunscalded silver maples in a Lake City park and it's likely that more could be found in small towns around that part of the region. The southwest facing portions of these stems have cankers 2 to 3 feet in length.

Winter sunscald is injury from rapid changes in bark temperature during cold yet sunny days. Exposed bark can become much warmer on the sunny side of the tree followed by very rapid cooling after sunset. The rapid temperature changes can result in bark injury that usually occurs on the south and southwest side of the tree. Injured trees will survive but have permanent cankering on the stem.

Maple Decline

Multiple causes, etiology unknown

Host:	Maples
Damage:	Early fall coloration, defoliation and dieback of branches
Area:	Communities in southeastern counties
Severity:	Scattered locations, but locally heavy
Trend:	Maple decline continues to progress in symptomatic trees. There are new reports of maple decline from both urban and rural areas.

Sugar maple trees across the southern counties continue to express symptoms of decline in spite of and, in some cases, due to the abundant rain fall. Symptoms of maple decline include early fall coloration, leaf defoliation and branch dieback. By mid-July boulevard maples were again expressing decline symptoms. Many of these trees continue to decline and die back from damage done to root systems as distant as the 1988 drought.

In other instances, early fall coloration appeared on boulevard maples where there were no previous symptoms of decline. The trigger for this decline symptom may be saturated soils and lack of oxygen as higher than normal rainfall was experienced this year. A city park lost several small, established trees after local flooding covered the root systems for just 5 days.

INCIDENTAL PESTS

Insects

Pest	Host	County	Notes
Aphids Undetermined	Maple Hardwoods	Dakota Ramsey Washington	Scattered ornamental trees, some with heavy attack causing leaf fall.
Pine bark adelgid *Pineus strobi*	Red pine White pine	Crow Wing	On 1' tall red pine seedlings. Stunting white pines. May 10.
Spider mites *Oligonychus ununguis*	Balsam fir	Gen. Andrews Nursery	On 2-0 seedlings. May 17.
Wooly pine needle aphids *Schizolachnus piniradiatae*	Red pine	Gen. Andrews Nursery	June 17.
Cottony aphids *Cinara pini*	3-0 pines	Cass	June 16.
Jack pine sawfly *Neodiprion pratti banksianae*	Jack pine	Pine	Populations much decreased, no damage. July 19.
Eastern pine shoot borer *Eucosma gloriola*	Red pines	Sherburne	Christmas trees. Owner sheared 2-3 weeks later than usual which probably allowed larvae to become established.
Oak webworm *Archips fervidanus*	Red oaks	Crow Wing	On basal sprouts.
White pine weevil *Pissodes strobi*	White pine	Pine	Also, root collar weevil. May 3.
Bark beetles *Ips pini*	Jack pines	Carlton	On 200+ pole-sized pines.
Lace bugs *Corythuca arcuata*	Bur oak	Crow Wing Cass	May 19 and Aug. 17.
Aphids Undetermined	White pine	Kanabec	And sooty mold.

Incidental pests

Erineum mite *Eriophyes elongatus*	Sugar maple	Cass Crow Wing	Heavy infestation.
Spruce tip moth Unidentified	White spruce	Crow Wing	In plantation.
Fire fly *Ellychnis corrusca*	-	Crow Wing	Larvae.
Cooley spruce gall aphids *Adelges cooleyi*	White spruce	Crow Wing	Private nursery.
Arborvitae leaf miner *Argyresthia thuiella*	Arborvitae	Crow Wing	Private nursery.
Midge *Cricotopus* spp.	-	Aitkin	Abundant around Mille Lacs on June 2.
Root collar weevil *Hylobius radicis*	White pine	Pine	June 7.
Sawflies and aphids *Neodiprion* spp. and *Pineus strobi*	Red pine	Crow Wing	Ornamental.
Carpenter ants *Camponotus pennsylvanicus*	In dwelling	Crow Wing	June 11.
Oak gall wasps *Callirhytis cornigera*	Red oak	Morrison	June 21.
Eriophyid mites *Eriophyes betulae*	Birch	Crow Wing	June 21.
Pine spittlebug *Aphrohpora parallela*	Jack pine	Crow Wing	July 6 & 7.
Adana moth *Rhycionia adana*	Red pine	Sherburne	In plantation.
Mt. ash sawfly *Pristiophora geniculata*	Mt. ash	Crow Wing	Ornamental.
Poplar petiole gall aphid *Pemphigus populicaulis*	Aspen	Crow Wing	Urban.
Bronze birch borer *Agrilus anxius*	Birch	Cass	Urban.
Hermit flower beetle *Osmaderma eremicula*	Garden	Crow Wing	Ornamental.
Walking sticks *Diapheromera femorata*	Raspberry	Crow Wing	Mating season. Aug. 18.

Incidental pests

Butternut wooly sawfly *Eriocampa juglandis*	Black walnut	Pine	Larvae present. Aug. 23.
Red-humped caterpillar *Schizura concinna*	Apple	Crow Wing	Sept. 2.
Oak twig pruner *Elaphidionoides villosus*	Oak	Aitkin	Sept. 27.

Diseases

Pest	Host	County	Notes
Rhizosphaera needle cast *Rhizosphaera kalkhoffii*	Spruces	Crow Wing	Ornamental spruces.
Pine/oak gall rust *Cronartium quercuum*	Jack pines	Crow Wing	Aeciospores being shed. June 3.
Elm wetwood bacterial species	Elm	Crow Wing	Urban. June 14.
Scab and black canker *Venturia saliciperda* and *Glomerella miyabeana*	Willow	Crow Wing Dakota Ramsey Washington Carlton Itasca Aitkin	June 18.
Armillaria root rot *Armillaria* spp.	Red pine	Pine	Also root collar weevil and porcupine damage to 7' plantation saplings.
White pine blister rust *Cronartium ribicola*	White pine	Crow Wing	Yard tree, July 7.
Dutch elm disease *Ceratocystis ulmi*	Elm	Crow Wing	July 19 and 30.
Verticillium wilt *Verticillium* spp.	Maples	Morrison Isanti	In cemetary.

Incidental pests

Needle rust *Chrysomyxa ledicola*	Colorado blue spruce	Aitkin	100+ trees 30' tall. Only 1993 needles. Aug. 6.
Needlecasts *Lirula nervata* and *Ishmiella faulli*, Hyperparasite *Phacidium balsamae*	Balsam fir	Isanti	15 trees in a plantation. The hyperparasite inhibits the complete fruiting of the needlecast fungi.
Pine needle rust *Coleosprorium asterum*	Red pine Scots pine	Anoka Washington Fillmore	
Needle cast *Mycosphaerella laricina*	European larch	Winona Fillmore	In 10 yr. old plantation. Highly susceptible seed source.
Armillaria root disease *Armillaria* spp.	Red oak Aspen Red pine	Anoka Carver Dakota Hennipen Ramsey Scott Washington	Commonly misdiagnosed as oak wilt in red oak in oak wilt prone areas. Purple-turning, oxidized sugars in root flair were diagnostic.
Cedar-apple gall rust *Gymnosporangium juniperi-virginianae*	Ornamental junipers including varieties based on *J. communis, J. virginiana, & J. scopulorum*	Anoka Carver Dakota Hennipen Ramsey Scott Washington	Increasing for the past three years.
Fire blight *Erwinia amylovora*	Crabapples Mt. ash	Anoka Hennipen Ramsey Washington	

Abiotic agents

Problem	Host	Location	Notes
Weed Whip Trimus the-grassus	Conifer seedings	Anoka Dakota Ramsey Washington	Many homeowners still think that weed whips do not damage trees.
Sapsucker damage	Black walnut	Wabasha	Unusual damage to small sawtimber stand.
Fertilizer burn	Blue spruce	Kanabec	Seedlings 2 feet tall.
Construction damage	Maples	Crow Wing	Dieback due to root damage.
High water damage	Red pines River birches	Crow Wing	Planted trees.
Poor planting and tree care	Spruce Balsam fir	Crow Wing	Roadside trees
Construction damage and root smothering	Red pines	Kanabec	Damage evident now-after 10 years. Also bark beetles and Diplodia blight.
Poor planting and bark damage	Red pines	Isanti	Trees 9 feet tall.
Fertilizer damage	White spruce	Todd	10 feet tall. Used concentrated liquid.
Herbicide damage	Conifers	Stearns	1-4 feet tall.
Chlorosis	Chokecherry	Badoura Nursery	Aug. 6.
High water damage	Tamarack	Morrison	In S6-T133-R30.
Herbicide damage	Balsam fir White pine	Wadena	2-4 feet tall.
J-rooting Toofasta plantae	Conifer seedings	Anoka Dakota Washington	

PHENOLOGICAL NOTES

Date	Event	Location
4/ 20	Buds swelling on birch, red oak and maple. Some green showing on birch buds.	Cass Co.
4/ 21	Jack pine buds still dormant.	Crow Wing Co.
4/ 22	Domestic plum buds swelling.	Crow Wing Co.
4/ 22	Pine bark adelgid on red pine seedlings.	Crow Wing Co.
4/ 22	White pine buds showing very thin green lines and some swelling.	Morrison Co.
4/ 28	Red maple blooming.	Itasca, Crow Wing and Aitkin Cos.
5/ 3	Tamarack needle buds green and open ¼".	Aitkin Co.
5/ 5	80% of quaking aspen are leafed out. Light green and beautiful.	Itasca Co.
5/ 19	Spider mites on 2-0 balsam seedlings.	Pine Co.
5/ 19	Bur oak flowers open. Leaves 2" long.	Crow Wing Co.
5/ 19	Staminate jack pine beginning to shed pollen.	Crow Wing Co.
5/ 19	Blooming: water cress, hoary puccoon, blueberries, wood anemone.	Crow Wing Co.
5/ 24	Some staminate cones shedding pollen in jack pine.	Cass Co.
5/ 24	Elms in flower.	Cass Co.
5/ 28	White pines still not shedding pollen.	Morrison Co.
5/ 28	Pine spittlebug nymphs present.	Crow Wing Co.
6/ 1	Blooming: Large flowered Trillium, winter cress	Mille Lacs
6/ 3	Jack pine pollen shed heavy but flowering trees rare, only on suppressed or edge trees.	Pine
6/ 3	Blooming: wild geranium	Mille Lacs, Kanabec and Aitkin Cos.
6/ 3	Red pine sawfly larvae on jack pine are 1/4" long.	Crow Wing Co.
6/ 10	Blooming: Indian paintbrush	Todd Co.
6/ 11	Red pine sawfly larvae are 7/16" long.	Crow Wing Co.

Phenological notes

6/ 15	Yellow-headed spruce sawfly larvae are 5 mm long. No noticeable defoliation.	Crow Wing and Pine Cos.
6/ 15	Blooming: orange hawkweed	Pine Co.
6/ 17	Red pine sawfly larvae are 10-13 mm long on older needles. 20%of them have black stripes.	Crow Wing Co.
6/ 17	Pine spittlebug on jack pine, in nymph stage. 1 or 2 per 15' branch. Past year's flagging is moderate to heavy.	Pine Co.
6/ 17	Blooming: smooth phlox, goat's beard	Crow Wing, Cass, Wadena and Pine Cos.
6/ 22	Heavy catch of cutworm moths in light trap.	Crow Wing Co.
6/ 22	Blooming: large flowered beard's tongue.	Crow Wing Co.
6/ 24	Yellow-headed spruce sawfly larvae are ½" long. Causing moderate defoliation.	Crow Wing Co.
6/ 25	Red pine sawfly larvae are ¾" long. Causing about 30% defoliation of jack pines.	Crow Wing Co.
6/ 25	Red pine sawfly larvae are 3/16" long.	Pine Co.
6/ 25	Blooming: tufted vetch, oxeye daisy, and common buttercup	Crow Wing and Aitkin Cos.
7/ 6	Blooming: spiderwort	Crow Wing Co.
7/ 9	Blooming: yarrow and Virginia bluebells	Aitkin and Crow Wing Cos.
7/ 16	Jack pine sawfly larvae are ⅝ to ¾" long. Causing defoliation 16" back from the branch tip. Populations are down compared to 1991 and 1992.	Pine Co.
7/ 16	Blooming: evening lychnis, white yarrow, tufted vetch, harebells, wood lily and wild rose.	Crow Wing and Pine Cos.
7/ 16	Blooming: Turk's cap lily, purple meadow rue, common milkweed, fireweed and common thistle.	Pine and Aitkin Cos.
7/ 28	Blooming: tansy	Morrison
7/ 30	Blueberries are ripe.	Crow Wing Co.
8/ 6	Two red maples have turned red. Roadside trees.	Pine Co.
8/ 6	Blooming: spotted knapweed, wild bergamot and blazing star	Pine Co.
8/ 6	Blooming: black-eyed Susan, asters, goldenrod and evening primrose	Pine and Aitkin Cos.

Phenological notes

8/ 18	Blooming: tall thistle and spotted joe-pye-weed	Cass, Pine and Morrison Cos.
8/ 20	Blooming: giant sunflower	Crow Wing, Pine and Aitkin Cos.
8/ 26	Spruce gall aphids have emerged.	Crow Wing Co.
8/ 26	Oak gall wasp larvae are present.	Crow Wing Co.
9/ 2	Second generation mt. ash sawfly larvae are present.	Crow Wing Co.
9/ 8	Maples changing color = yellow, pink. orange and red. Elms turning yellow. 90% of the remaining tree species are still green.	Cass and Crow Wing Cos.

SPECIAL PROJECT REPORTS

Oak Wilt Cooperative Suppression Project

Active oak wilt control revolves around two activities: (1) suppression of the disease at active infection centers, and, (2) elimination of spores likely to generate new infection centers outside of existing infection centers. The oak wilt cost share program includes two practices that are intended to deal with oak wilt by (1) lowering the incidence of disease by mechanically severing root grafts, and, (2) preventing the disease from forming new infection centers by eliminating spore producing trees.

In general, the cost share program is designed to assist property owners through their local community, with priority being given to communities with approved oak wilt suppression plans.

1993 was the third year for the cooperative suppression project for oak wilt. Available cost share funding was $750,000 for FFY93, of which $650,000 was allocated by September 31. Thirty six cooperating units in two states and 7 Minnesota counties were allocated funding. The figures reported below are for 1992 and 1993 program accomplishments in Minnesota.

County	Number of infection centers in 1988	Number of infection centers treated	Feet of plow line installed	Number of spore trees removed
Anoka	1,351	602	217,708	2275
Chisago	257	21	11,500	0
Dakota	813	99	12,342	271
Isanti	258	73	39,223	381
Ramsey	87	78	19,376	243
Sherburne	508	146	104,011	162
Washington	551	11	3,564	14
Totals	3,825	1,029	410,755	3,346

Jack Pine Budworm at St. Croix State Park

Most of St. Croix State Park was an island in the St. Croix River during the last period of glaciation and now is a dry, outwash plain very similar to the adjacent landmass in Burnett Co., Wisconsin. In terms of habitat, it is a forest-prairie transition that has jack pines and scrub oaks as the covertype. Early surveyors called it pine barrens. Even today, about 5000 acres of jack pines remain on what was once the island.

In 1993, while most of the other jack pine budworm populations in the state were on the decline, a small but noticeable population was building in this portion of Pine County. Defoliation ranged from a trace to severe in these stands. It should also be noted that similar budworm activity began at the same time just across the river in Burnett Co., Wisconsin. Egg mass plots indicate that the population will increase next year causing similar or increased defoliation.

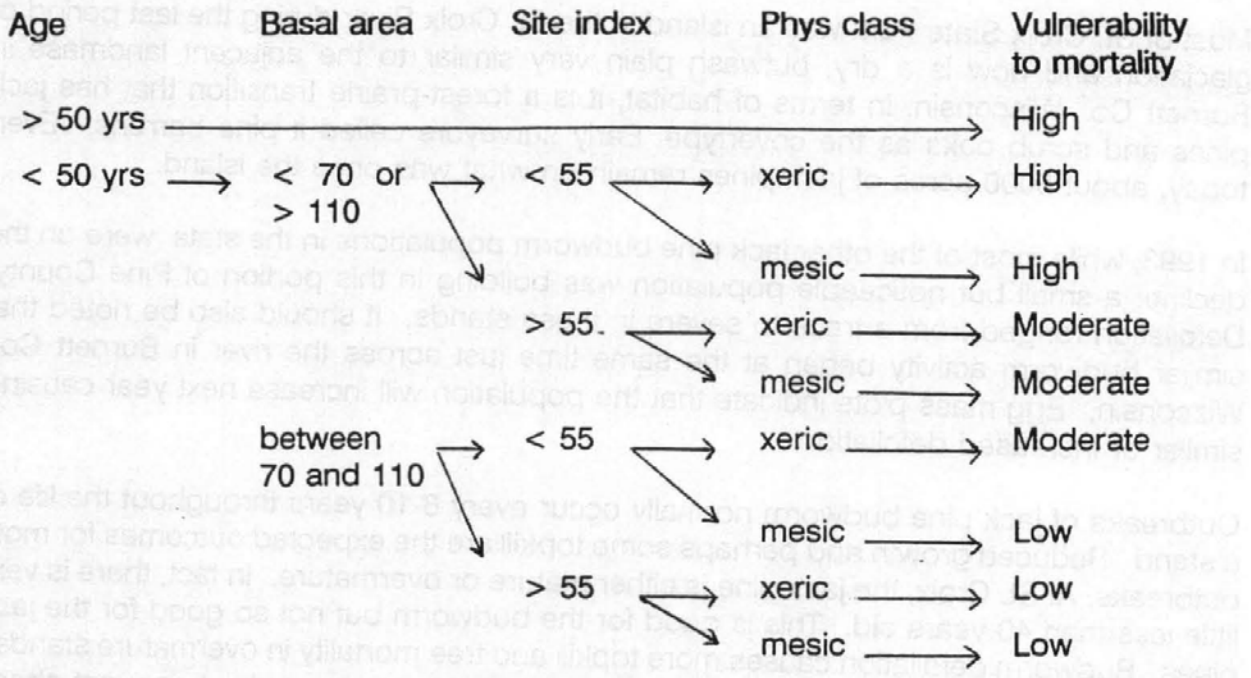
Outbreaks of jack pine budworm normally occur every 6-10 years throughout the life of a stand. Reduced growth and perhaps some topkill are the expected outcomes for most outbreaks. At St. Croix, the jack pine is either mature or overmature. In fact, there is very little less than 40 years old. This is good for the budworm but not so good for the jack pines. Budworm defoliation causes more topkill and tree mortality in overmature stands. When outbreaks occur during droughty years, the lack of water and subsequent attack by pine bark beetles accelerate the rate of tree death. Then, wildfire can sweep through these stands killing trees. At St. Croix, most of the jack pine stands are of fire origin.

The good news is that these stands have withstood budworm defoliation 3 or 4 times in the last 25 years. Unless there is a drought coupled with the outbreak or a prolonged outbreak, most of the trees will survive with little damage.

Park Managers and Vegetation Specialists knew there was a tremendous age imbalance in the jack pine and are using the occurrence of the budworm outbreak as a catalyst in renewing efforts to manage these stands. The advice and services of the Division of Forestry was sought by Parks personnel. At several meetings, these topics were discussed: Park's objectives and concerns, Forestry's role and workload, the potential impact of budworm defoliation and bark beetle build-up, the role of prescribed fire, management options including the use of Bt, regeneration methods and hazard tree concerns.

Stands were risk rated for their vulnerability to budworm with the hopes of working in the high risk stands during the winter of 1993-1994. Knowing that the Inventory data was old (CSA from 1981) and that the rating is based on two variables which can change rapidly, it was suspected that the ratings might not mean much. So all the stands were risk rated based on the old information and then a subsample of the stands was taken and they were reinventoried to see if their rating changed.

All the stands were risk rated based on the following scheme:



All jack pine stands in the Park were rated; 36 were high, 23 were moderate and 8 were low. Since there were so many stands in the high risk category based on age alone, the old stands (>50 yrs) were then triaged based on basal area, site index and physiologic class as if they were less than 50 years old. Using this scheme, young vulnerable stands and old stands with poor basal area or site index and xeric phys class were rated as high. The goal was to have a significant number of acres to reinventory and rate during December 1993. 25 stands were chosen from township 40-18, where most of the jack pine occurs. Foresters from Gen. Andrews Nursery did the field work. The following Table summarizes their work:

CHARACTERISTICS OF SELECTED STANDS

Stand # in Section	Age	Basal area	Site index	Acres	Cords per acre	Number stems reprod. per acre	Percent JPBW defol.	Percent mortal. by bark beetles
14 in 18	45	55	62	65	12.2	928	10	1
9 in 17 1 in 18	43	95	71	276	22.9	1025	30	1.5

7 in 17	76	77	70	14	24.9	166	10	2
15 in 16	45	83	75	11	15.5	625	35	2
8 in 10 11 in 15 2 in 14 10 in 11	76	87	54	230	21.2 plus 135bf/ a	695	30	0-4
14 in 16	45	125	77	96	28.5	1384	44	2
8 in 15 4 in 16	74	60	57	21	15.6	1500	70	4
11 in 10	44	65	62	16	14.2	500	43	2
11 in 17	92	103	50	96	22.8	1333	35	1
4 in 15 5 in 15	81	75	68	131	20.1	1250	27	3
8 in 16 6 in 21 11 in 21	36	110	75	26	23.0	874	30	1
3 in 11 3 in 14	88	132	57	19	22 plus 5620 bf/a	500	22	2.2
2 in 16	68	70	65	190	18.4	1175	21	2.6
2 in 21	48	73	70	64	16.6	1450	21	2.3
12 in 16 2 in 17	55	104	65	187	23.2	831	48	2.2

Having current data and knowledge of budworm damage allowed the risk ratings to be reduced as seen in the table below. The data from the subsample shows that the stand characteristics probably have changed enough so that a reinventory should be done for each of the remaining jack pine stands in the Park.

	Number of stands		
	High risk	Moderate risk	Low risk
Data from 1981	21	4	0
Data from 1993	10	10	5

The 10 high risk stands recommended for harvest in 1994 or 1995 are:

Stand 14 in Section 18	Stand 14 in Section 16
" 8 " 15	" 11 " 10
" 4 " 16	" 11 " 17
" 3 " 11	" 12 " 16
" 2 " 17	" 3 " 14.

Forestry management recommendations are summarized in the following table along with volume estimates.

FORESTRY RECOMMENDATIONS, ACRES AND VOLUMES

Recommendation	Number of stands	Total acres	Total cords	Pine board feet
Harvest 1994 or 1995	10	500	13,977	106,780
Harvest Later	10	841	17,674	31,050
No action at this time	5	101	1,831	0

Ultimately, the management action these stands undergo will be decided by Parks managers and Archeologist findings. St. Croix is a veritable treasure trove of prehistoric sites as well as last century logging and farming and Public Works-type activity from early this century. It is the goal of Parks management to develop a comprehensive plan for the perpetuation of jack pine at St. Croix before implementing any particular management strategy in the Park.

North American Maple Project

The North American Maple Project was formed in 1987 between Canada and the United States to monitor and evaluate sugar maple condition, particularly in relation to pollution and stand management intensity.

Currently, a total of 220 plot-clusters are distributed throughout North America from Minnesota and Ontario to Massachusetts and Nova Scotia. Each plot-cluster consists of five 66' x 66' plots located in sugar maple stands 50 to 150 years old. One-half of the plot-clusters within a state or province are in active sugarbushes and one-half are in unmanaged forests. Unmanaged forests are stands that have not had any disturbance caused by management activity since 1983. Minnesota has 8 plot clusters. Two are located in Wabasha County in the southeast, two in Itasca County in the northeast, two in Todd County in central portion of the state and two in Becker County in the northwest.

Sugar maple crowns are evaluated annually for branch dieback, foliage transparency, discoloration, dwarfed foliage, and insect defoliation. The incidence of these stress indicators fluctuate from year to year, probably as a result of individual tree response to changes in weather and site conditions. Continued monitoring will reveal long-term trends in forest health and possibly disclose the impact of disturbance such as effects of air pollution, defoliation, drought, or a combination of these.

Crown Dieback Ratings

Projectwide, the average level of dieback was 6% and about 95% of all trees were rated in the 0-20% classes. The average cluster dieback in Minnesota was 4.5%, up 1% from last year. Minnesota's average is 2 percentage points lower than the average for the project as a whole.

Crown Transparency Ratings

Crown transparency is thought to reflect general tree health in the current growing season and recent past. If this is so, then, the sugar maples can be said to be generally healthy. The range in ratings was 5 to 20%. In Minnesota, the average transparency rating was 7.5%, down 1% from last year. This average is 5 percentage points lower than the average for the project as a whole. Here, as in Wisconsin and Michigan, a severe drought had a significant impact on crown transparency that lasted for three years.

Hazard Tree Training

In 1993 the audience of the hazard tree training sessions changed from Department personnel to people in the public sector. During the year, 220 Tree Inspectors, public officials and private contractors were trained in one of seven sessions. They were held in New Ulm, Rosemont, Bunker Hills, Detroit Lakes, Redwood Falls, Rochester and St. Paul.

Minnesota Releaf

Thousands of trees were planted in Minnesota's communities in 1993. An August tour of several of these communities in southern Minnesota found the program to be a big success. At that time visits were made to the communities of Glenco, Winthrop, Lester Prairie, Hutchinson, Danube, Prinsburg, Clarkfield, Canby, Tracy, Chandler, Luverne, and Sherburn. Cultural problems, such as mulching and staking, were noticed and discussed with the community as well as their insect and disease problems.

PUBLICATIONS

Evaluating Airphoto Options for FHM Support

This nine page document was published in December by the Division of Forestry. The abstract follows.

Small format (35mm) and mid-format (645) aerial stereophotography was acquired in the summer and fall of 1992 on a test site in northern Minnesota to identify preferred format, film and scale combinations for use in an intensified Forest Health Monitoring system. Interpreters evaluated 1:2,000, 1:4,000, 1:6,000 and 1:8,000 scale color infrared, normal color negative and normal color reversal 8x10" prints made from 35mm and 645 originals. The 645 format normal color reversal prints at 1:4,000 were selected as optimal for the first round of FHM photo flights.

How to detect, assess and correct hazard trees in recreational areas

The manual is gaining considerable acceptance within the urban and recreational forest communities. The first printing of 2000 copies was distributed within the Department and sold in quantities to Vermont, New York, Michigan, Colorado and to the Bartlett Tree Company. In its second printing in 1993, 9500 copies were produced. It was distributed to Illinois, Indiana, Iowa, Missouri and Wisconsin, as well as, 3700 copies to the USFS-S&PF offices in Morgantown, WV, Durham, NH and Radnor, PA. More than 2,000 copies remain in stock to be sold at $5.00 each.

Management of cone and seed insects and diseases in a white spruce seed orchard - a 10 year history

By Michael Albers[1], Lawrence K. Miller[2], and Jana Albers[3]

ABSTRACT.--Cone and seed insect and disease incidence was tracked over a ten year period in a clonal white spruce seed orchard. The principal insects attacking cones and seeds were spruce budworm (*Choristoneura fumiferana*), coneworms (*Dioryctria* spp. and *Holcocera* spp.), spruce seed moth (*Cydia strobilella*), spruce cone maggot (*Hylemya anthracina*), and spruce cone axis midge (*Dasineura rachiphaga*). Two cone rusts are also present in the orchard, inland spruce cone rust (*Chrysomyxa pirolata*) and American spruce-raspberry rust (*Pucciniastrum americanum*). Small scale pesticide trials lead to the development of successful operational treatments. A tandem application of acephate and dimethoate gave good control of both early instar larvae and later stages feeding on developing conelets and seed. After raspberry rust inoculum levels were lowered by herbicidal control of raspberries in the orchard, a double application of chlorothalonil prevented *Pucciniastrum* rust infections. A single clone appeared to be completely resistant to both rusts. Although lack of pollination remains the primary cause of reduced seed yield, good insect and disease control have helped increase overall orchard production. Beginning at age 11, the orchard produced three good cone crops over a four year period.

INTRODUCTION

The Minnesota Department of Natural Resources-Division of Forestry began an applied tree improvement program in the mid-1970's with the establishment of a grafted white spruce orchard. A series of provenance trials planted in the late 1950's to early 1960's across eastern North America indicated that seed sources from southeastern Ontario were consistently superior across a wide range, from Maine to Minnesota. In Minnesota tests, the best sources produced as much as 40 % more volume than local sources at age 15 (Stellrecht, *et al*, 1974). The best individual trees from five superior Ontario sources were selected in provenance tests in Minnesota, Wisconsin, and Michigan, and grafted in the Minnesota State Forest Tree Nursery. Six clones from a superior Maine source were also grafted for the orchard. The orchard was planted in 1977-78 on a site north of Cotton, MN. Today, the seed orchard comprises 104 clones and 1300 ramets, and covers about ten acres.

The profitability of any tree improvement program is directly related to seed production (Porterfield, *et al*, 1975). Thus, most programs manage their orchards intensively to encourage early, frequent, and abundant flowering. For many forest tree species however, the potential of a good flower crop is often not realized because of cone and seed insects and diseases. Intensively managed orchards may attract and maintain higher populations of cone and seed insects because of the ready supply of flowers, cones, and seed. The seed orchard manager is challenged to maximize seed production in the face of an onslaught of insects and diseases. To implement an effective integrated pest management program knowledge of both

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the pests and host is required.

Fortunately for the DNR-Forestry Applied Tree Improvement Program, Regional Insect and Disease Specialists took an early interest in the orchard pest problems. The first field observations were made in 1981. Insect and disease monitoring continued through 1991, and several small scale pesticide trials were conducted. These studies resulted in the development of successful operational control treatments for the major cone and seed insects and diseases.

INSECT AND DISEASE STUDIES

1982

As is typical for grafted white spruce, the trees in the seed orchard began to produce megastrobili by three years after planting. These early "cone crops" were heavily attacked by the fir coneworm (*Dioryctria abietivorella* (Grote)) and the spruce budworm (*Choristoneura fumiferana* (Clemens)). In the early 1980's, the seed orchard was surrounded by balsam fir/black spruce stands that were heavily infested with spruce budworm. One of these stands was subsequently logged, but other infested stands remained as a ready source of spruce budworm.

A small scale pesticide trial using acephate (Orthene) was applied in late May to control coneworm and budworm feeding. Cones sampled from treated and untreated trees indicated that, although infestation was not reduced, treated cones were less severely damaged and larval development was arrested. Treated cones also had a significantly higher seed set than untreated cones.

1983

A very small number of cones were produced in 1983. Essentially all cones were picked and assessed for insect and disease damage. Coneworms and spruce budworm attacked about 20 % of the cones, and the seed destroyers *Hylemya anthracina* (Czerny) (spruce cone maggot) and *Mayetiola carpophaga* (Tripp) (spruce seed midge) were found. The most significant cone problem however, was cone rust. Identified as *Chrysomyxa pirolata* (Wint.) (inland spruce cone rust), 56 % of the cones were damaged. Inland spruce cone rust is a heteroecious rust, requiring an alternate, unrelated host. In this case, the alternate host was determined to be *Pyrola* spp. *Chrysomyxa pirolata* systemically infects the entire cone, destroying all seed production by massive production of mycelium and spores.

1984

The 1984 cone crop was the heaviest produced to-date, yielding 20 bushels of cones. However, seed set was very low (3.6 ounces/bu) due to ever increasing attacks by a variety of insects and diseases. Indeed, only 6.6% of the cones sampled were rated as "healthy". A second cone rust, *Pucciniastrum americanum* (Farl.) (American spruce-raspberry rust) damaged nearly 80 % of the cones. This rust is also heteroecious, requiring raspberry to complete it's life cycle. Unfortunately, raspberry was ubiquitous in and around the orchard, invading the disturbed sites and windrows around the perimeter. Rust infects single cone scales, and multiple infections can destroy all seed production.

Insects were also prevalent. The two main culprits were again, spruce budworm and coneworms. In addition to *Dioryctria*, a second species previously unreported in the upper midwest was discovered. *Holcocera* spp. contributed to the 17 % of cones attacked by coneworms. Other cones and seed insects such as cone maggots and seed midges remained at low levels.

Both fungicide and insecticide trials were conducted in 1984. Three fungicides, ferbam, chlorothalonil, and triadimefon were tested on 26 trees. Timing of the fungicide treatments was based on the phenology of the *Pyrola*, making it too late to be effective on the primary spruce-raspberry rust. Cones on 15 trees were treated with acephate for coneworm control. Four hundred cones were dissected in late July, with the following results:

	Average number of cones* infested per tree	Percent of cones infested per tree
Treated	2.2**	11
Untreated	4.2	21

* per 20 cone sample
** significant at the 5 % level

Acephate was efficacious in reducing coneworm infestation, but did not prevent it. There also appeared to be some conelet phytotoxicity from the chemical treatment.

1985

Following the excellent flower crop in 1984, the 1985 crop was predictably poor. Late spring frosts on May 21 and June 3 further reduced the small number of cones. All surviving cones were harvested in early August and assessed for pest damage. Only 42 % of the cones were rated as healthy. Insects (primarily spruce budworm) damaged about 40 %, spruce-raspberry cone rust took another 5 %, and frost damaged 14 %. Overall, 58 % of the cones were rated as "no good" for seed production.

Fungicide trials using ferbam, chlorothalonil, and triadimefon were conducted beginning May 6, concluding on May 26. Treatments were timed to coincide with megastrobili emergence through the pollination period. Although the background level of rust was low, there appeared to be some protection offered by the fungicides. Treated trees were completely protected from the cone rusts, while the control group exhibited 7 % infection. These results must be viewed with caution because of the very small sample size and low background level of rust, but there was at least an indication that the timing may have been correct.

1986

Another very poor cone crop occurred in 1986, yielding only 190 cones for analysis. Insects damaged 21 % of the cones and spruce-raspberry cone rust affected 44 %. Only 32 % were rated as healthy, and only seven cones produced sound seed. Very little could be deduced from these observations, other than the fact that *Puccinastrum americanum* was firmly established in the orchard. This rust would continue to be a problem until the alternate host was controlled. Triclopyr was used in the fall to treat raspberry growing along the east side of the orchard.

Pheromone trapping using *Dioryctria amatella* and *D. disclusa* lures was attempted. The traps were employed from early spring to late summer. There was apparently no cross species attraction as no moths were trapped.

1987

1987 was another very poor flowering year. Abiotic factors such as frost and lack of pollination essentially eliminated the few cones that were produced.

As part of a cooperative study, pheromone traps using a lure specific to *D. abietivorella* were set out on April 29, just prior to pollen shed. Four different synthetic formulations, a natural female pheromone, and controls tested. The traps were examined every 7-10 days through July. Unfortunately, no moths were caught in any of the traps, suggesting that the pheromone formulations were faulty.

Chlorothalonil was tested again to determine it's effectiveness in protecting cones from the rust diseases. A control treatment (no spray) was compared to a four-spray and a five-spray treatment. Probably because the weather during the typical inoculation period was very hot and dry (beginning of the record late-80's drought), the background rust infection level was practically zero. Chlorothalonil did reduce the number of infected cones, but no conclusions can be drawn from the results.

1988

Early in 1988, upper crown branch samples were collected and flushed in the greenhouse at General Andrews Nursery. These samples indicated the potential for a bumper cone crop. By this time, the orchard trees ranged from 10 to 20 feet tall, so a rather sizeable crop was possible. With this information and the knowledge gained from the small scale pesticide trials, pest control measures were planned.

By 1988, the spruce budworm populations in the surrounding stands had crashed. To this point, no other cone or seed insect had been more than a minor occurrence. Thus, operational pest control measures were concentrated on control of the cone rusts. Two fungicides were tested against a control (no spray) block; chlorothalonil and mancozeb. The fungicides were applied twice as shown below:

Product	Rate (amount product/100 gal water)	Date first	Date second
chlorothalonil	8 pints	May 16	June 9
mancozeb	4 lbs	May 17	June 9

Once again hot, dry weather inhibited the development of both cone rusts. Despite the presence of a huge cone crop, samples showed a background rust infection level of only 1.7 %. Cone samples taken from trees in the fungicide treatment blocks showed that mancozeb was apparently ineffective, but that chlorothalonil gave good protection. These results must be viewed in light of the very low level of infection present in the orchard.

As predicted, cone and seed insects were only a minor problem in the orchard. Two new pests were identified, the spruce seed moth (*Cydia strobilella* (L.)) and the spruce cone axis midge (*Dasineura rachiphaga* (Tripp)). About 12 % of sampled cones were attacked by one or more insects, including spruce budworm, coneworms, cone maggot, cone axis midge, and seed moth. It was more interesting that 14 % of sampled cones were damaged by abiotic agents, presumably late spring frost and pollination failure. Overall, 66 % of sampled cones were rated as "good" for seed production. The low levels of damaging agents in the orchard no doubt were responsible for the excellent seed yield - 23 ounces/bushel and a total of 153 pounds of improved seed.

1989

Following the bumper crop of 1988, the logical expectation for 1989 was a crop failure. However, flushed branch samples again indicated another good cone crop on the way. Because of the large crop in 1988 and the ever present threat of cone rust, pest control measures were directed toward both insects and diseases.

The chemical control strategy called for the operational application of acephate (two treatments) for cone and seed insects, and an operational trial of chlorothalonil and mancozeb (two treatments each) for the cone rusts. The first pair of fungicide treatments was made in mid-May, coinciding with the newly emergent megastrobili. Unfortunately the sprayer broke down, and subsequent treatments were missed, including the acephate applications.

Considering the buildup of insects from the 1988 crop, the return of higher levels of cone rust, and the lack of chemical controls, it was expected that seed yield would be reduced. The total harvested crop was 122 bushels and 125 pounds of seed, or 16.4 ounces/bushel. Overall, 42 % of the cones were damaged by either insects, cone rust, or both.

The usual cast of insects were present in the 1989 crop. With the exception of the cone maggot however, most were present in relatively small numbers. *Hylemya anthracina* infestation increased to nearly 13 %. Previously, the cone maggot had attacked only 1 - 3 % of cones.

Cone rust levels increased to 18 % in 1989, most likely due to a return to more "normal" spring rains and the continued presence of the alternate host. In the fall of the year, raspberry growing around the perimeter of the orchard was treated with triclopyr. Although the second fungicide treatment was missed, the data showed chlorothalonil again reduced cone rust infection. This fungicide has consistently reduced cone rust infection in white spruce, leading to it's recommendation for operational use.

1990

The crop failure in 1990 was predicted by branch samples, and totally expected because of the consecutive heavy crops in 1988-89. Also quite expectedly, insects ravaged the small number of cones produced. Almost 90 % of the sampled cones were attacked by insects. Leading the way were the cone maggot (50 %), coneworms (32 %), and the seed moth (28 %). Interestingly, most of the coneworm damage was caused by *Holcocera* spp. This was the second time this unexpected species was observed in the orchard.

Just over 14 % of sampled cones were damaged by the cone rusts, most of which was due to the spruce-raspberry cone rust. When combined with the insect damage, 97 % of the cones were rated as "no good" for seed production.

1991

The production of another good cone crop in 1991 (the third in four years) was quite unexpected. White spruce has the reputation of being a sporadic cone producer in natural stands, often going for many years between cone crops. Whether these cone crops were due to the drought, certain orchard management practices, or a combination of the two, 1991 offered an excellent opportunity to apply operational pest control methods developed over the past ten years of observations and trials.

Chlorothalonil had been shown to consistently reduce the incidence of cone rust in several previous tests. Most of the orchard (excluding a small control block) was sprayed twice using a tractor mounted mist blower, as follows:

Treatment 1: Conelets wide open and receptive, May 15

Treatment 2: Conelets closed and turning pendant, May 28

Cone samples collected on July 30 showed that once again, chlorothalonil had been effective. The rust incidence in the control block was 13.6 %. In the treatment block, rust incidence was only 4.2 %, a 69 % reduction.

The insect control strategy also involved a two-pronged attack. Two insecticides were used, dimethoate and acephate. The approval to use dimethoate was obtained in 1990 with the granting of a Special Local Need registration [24(c)]. Dimethoate has been labelled in Canada since 1985 for control of cone and seed insects of spruce. Canadian data was used in applying for the 24(c) label. The operational application of insecticides was made with a tractor mounted mist blower as follows:

Treatment 1: apply acephate at flower emergence to control early instar spruce budworm and coneworms, May 14

Treatment 2: apply dimethoate when conelets are closed and turning pendant to control coneworm, seed moth, cone maggot, and cone axis midge, May 28

Both of these pesticides have systemic properties, so should have provided some residual control. Analysis of cone samples collected on July 30 gave the following results:

pest	insecticide	control
spruce budworm %	3.7	4.2
coneworm %	0.5	4.7
cone maggot %	1.7	25.2
seed moth %	0.8	3.5
cone axis midge %	12.5	9.7

Except for the cone axis midge (not considered a major cone and seed destroyer), all major white spruce cone and seed insects were significantly reduced. Overall insect attack was reduced by 51 %. When cones were rated for seed production, 98% of the cones in the treatment block were rated "good", contrasted to 75 % in the control block.

A cone crop of 102 bushels was harvested during August, yielding 105 pounds of genetically improved seed. The yield of 16.5 ounces/bushel was somewhat surprising, but could be explained by the presence of poor quality cones. The cone harvesting contractor was paid a bonus for clean picking the orchard for sanitation purposes. This means all cones were picked, whether or not they were sound. Also, the unsprayed cones from the control block were mixed in with treated cones, without question bringing down the total yield.

The following figures summarize the cone and seed insects and diseases in the DNR White Spruce Seed Orchard over the period 1982-1991. Figure 1 tracks the level of total insect and cone rust damage. During the early-to-mid 1980's, insect damage was caused primarily by spruce budworm. When the local populations crashed, so did the cone damage in the orchard. Crop failures in 1985-87 basically purged

the orchard of most insect pests, while the consecutive bumper crops of 1988-89 resulted in the infestation spike in 1990. The combination of 1990 crop failure and good insect control resulted in the significant drop in affected cones in the good crop of 1991. Control of the alternate host (raspberry) in the fall of 1986 and again in 1989 no doubt contributed to the reduction in rust infection in the subsequent years.

Figure 2 illustrates the changes in insect populations. Again, spruce budworm was dominant early in the study period. Epidemic populations in stands surrounding the orchard were responsible for this damage. As the budworm populations crashed and more cones started to be produced, the more typical spruce cone and seed insects became more common. The huge increase in insects in 1990 was due to the consecutive bumper crops in 1988-89.

Figure 3 shows the importance of abiotic factors on cone damage. Late spring frost severely damaged cones in 1986 and 1987. These frosts occur close to the ground, so that by 1988 late frost caused very little damage because the trees had grown out of the frost zone.

Figure 1. Pest damage to white spruce cones.

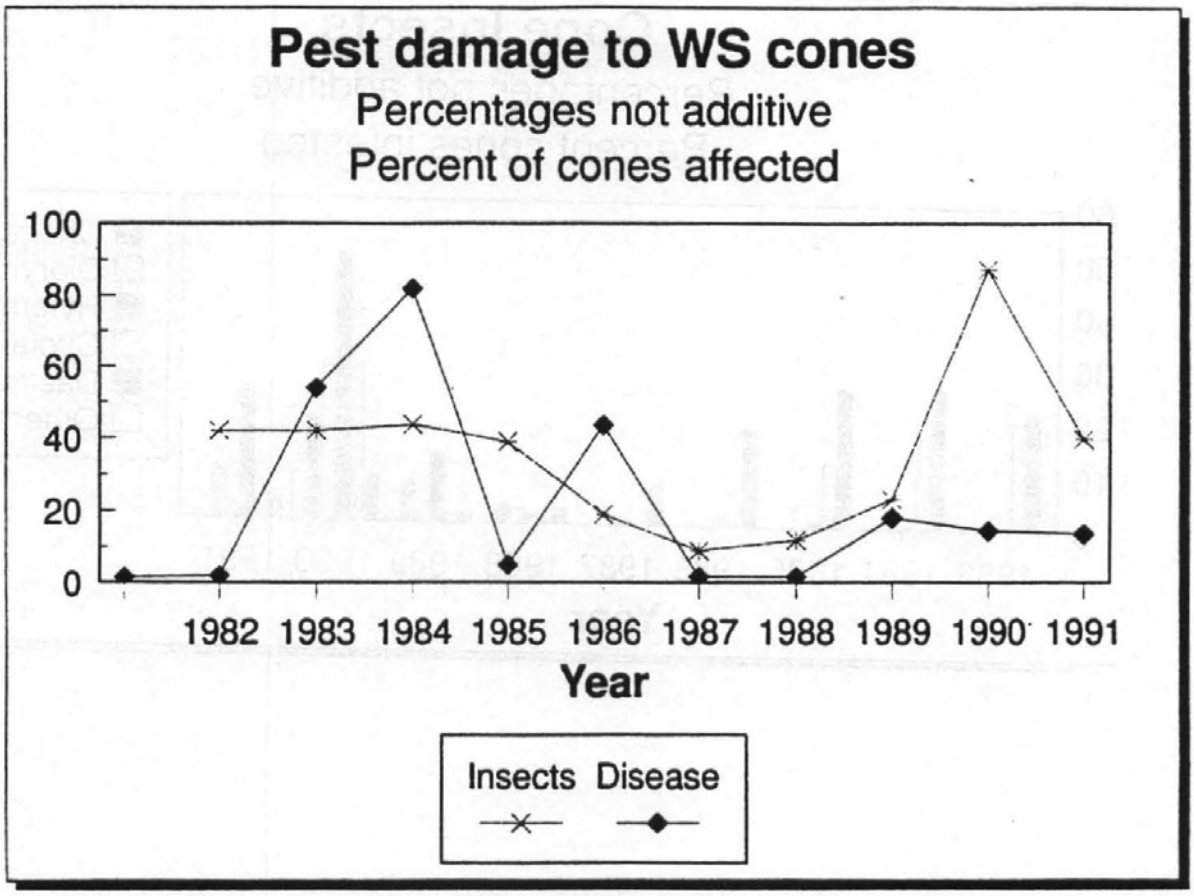


Figure 2. Cone insects.

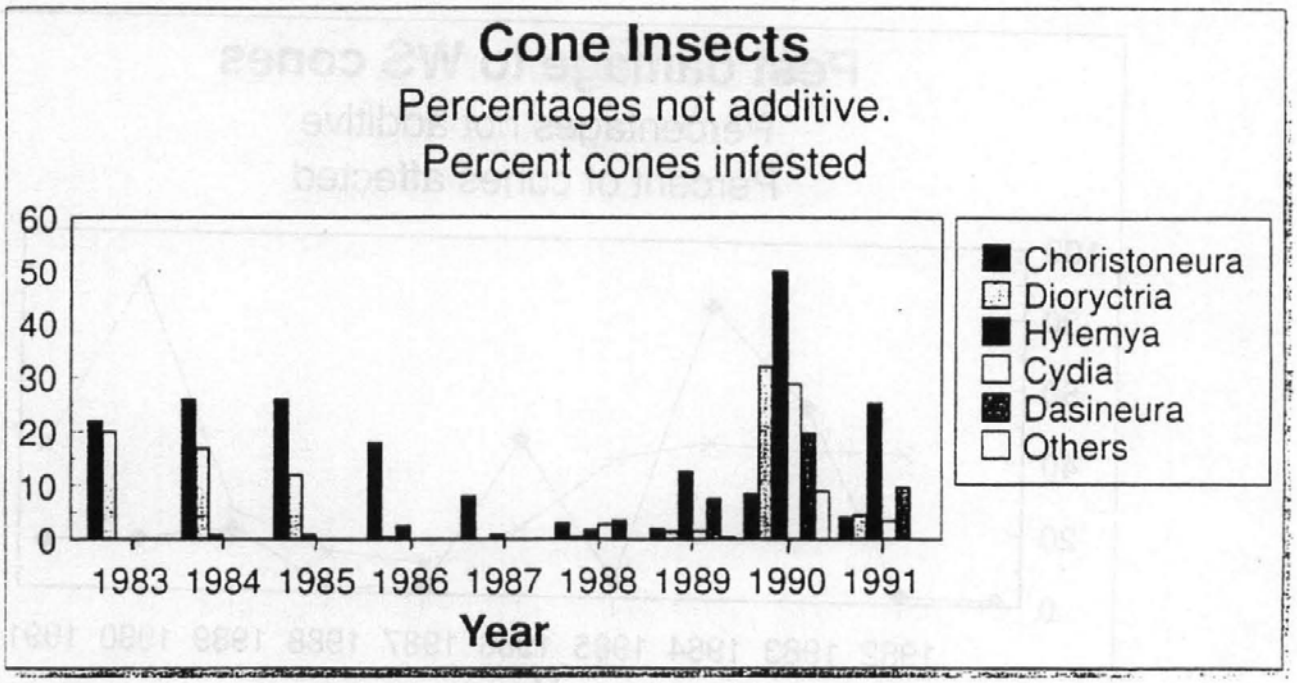
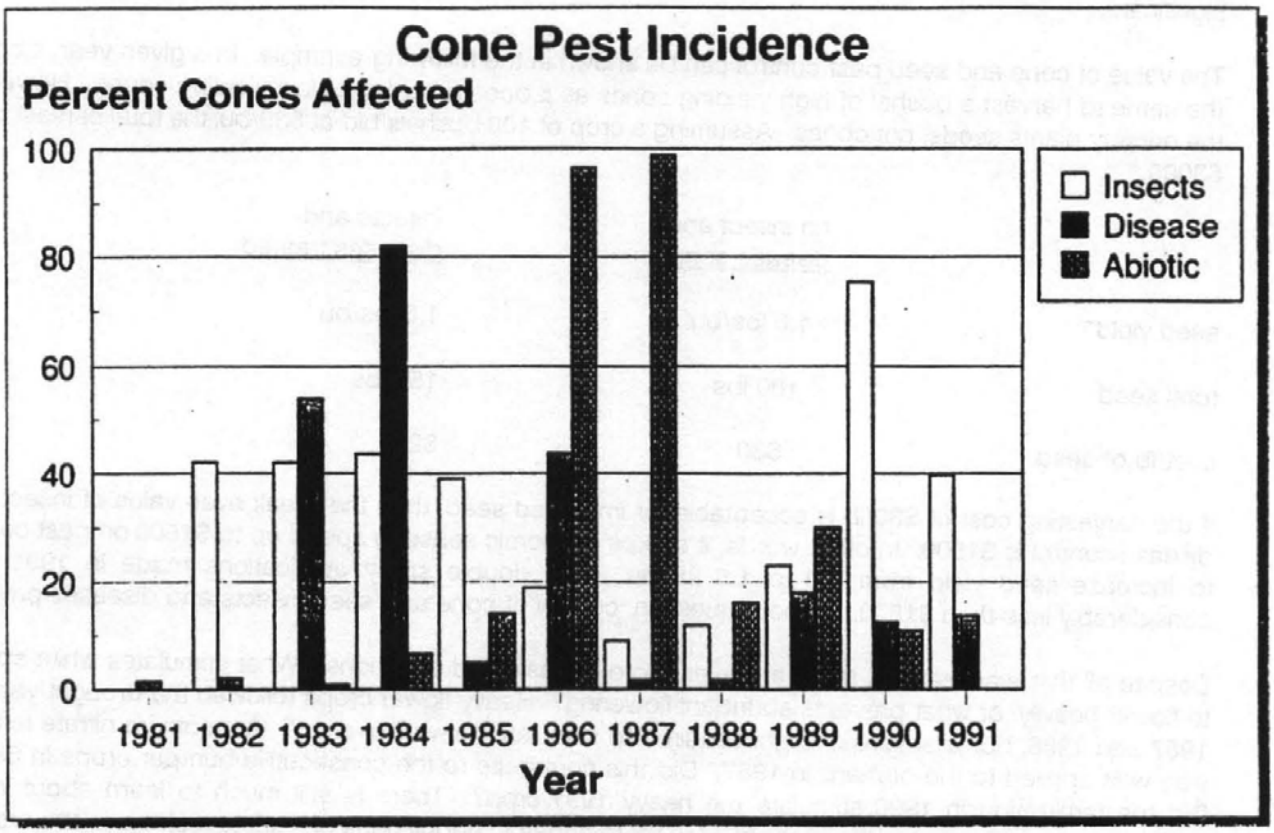


Figure 3. Cone pest incidence.



DISCUSSION

The investigation of white spruce cone and seed insects and disease reported here is an invaluable contribution to the Minnesota DNR Applied Tree Improvement Program. As has been demonstrated in other species, intensively managed orchards produce abundant seed crops, which usually leads to a buildup of high insect populations. This was certainly the case with the consecutive 1988-89 cone crops. There had been no crop to speak of for the three years leading up to the bumper 1988 crop, and insect damage was very low at 12 %. Insect damage in the 1989 crop more than doubled, rising to 26 %. Coupled with a dramatic increase in cone rust, seed yield
dropped from 23 oz/bu to 16 oz/bu. Clearly, the insect and disease impacts on seed production were quite significant.

The value of cone and seed pest control can be shown in the following example. In a given year, it costs the same to harvest a bushel of high yielding cones as it does a bushel of low yielding cones. However, the nursery plants seeds, not cones. Assuming a crop of 100 bushels bid at $30/bu, the total harvest cost $3000.

	no insect and disease control	insects and diseases treated
seed yield	1.0 lbs/bu	1.5 lbs/bu
total seed	100 lbs	150 lbs
cost/lb of seed	$30	$20

If the harvesting cost of $30/lb is acceptable for improved seed, then the break even value of insect and disease control is $1500. In other words, it makes economic sense to spend up to $1500 on pest control to increase seed yield from 1.0 to 1.5 lbs/bu. The double spray applications made in 1991 cost considerably less than $1500. Without question, control of cone and seed insects and diseases pays.

Despite all that was learned, there are even more unanswered questions. What stimulates white spruce to flower heavily, or what prevents abundant flowering? Heavy flower crops followed the drought years of 1987 and 1988, but is severe drought required to stimulate heavy flowering? Ammonium nitrate fertilizer also was applied to the orchard in 1987. Did this contribute to the consecutive bumper crops in 88-89? Did the fertilization in 1990 stimulate the heavy 1991 crop? There is still much to learn about insect population dynamics within the orchard. Are there endemic populations of insects resident in the orchard that buildup on heavy cone crops, or do populations increase by in-flight of insects drawn in by the heavy flower and cone crops? Are any of the clones resistant to any of the insects or the cone rusts? Over the years one clone that flowered regularly apparently was completely resistant to both cone rusts. What then is the mechanism(s) for this resistance? Can the development of cone and seed insects be linked to an easily measured factor such as heat sum? Similarly, what effect do differences in white spruce phenology have on susceptibility to one or another of the identified pests? What can be done to increase the effectiveness of the pollen produced in the orchard?

These and many other questions need to be addressed before seed yield can be increased much further. However, there is considerable potential to significantly increase the seed yield per bushel. Cone analysis indicates that the cone potential of white spruce is 90-100 seeds/cone. If all this seed were produced, the potential seed yield could be as high as 3.5 to 4.0 pounds per bushel. At this point 2.0 to 2.5 pounds per bushel are being lost, to a combination of lack of pollination, cold injury, insects, and diseases. Of these four factors, three can be ameliorated.

Lack of pollination is most likely due to inadequate mixing of the available pollen during the peak of female receptivity. Male flowering in the orchard is not the problem; pollen cones are produced in great abundance. Inadequate pollen mixing might be improved by running a mist blower down the rows, directed toward the male flowers. This technique increased seed set in a loblolly pine orchard by 48 % over the 11 crop year average (Brown, 1987). Both cone and seed insects and diseases can be significantly reduced by the effective chemical treatments previously outlined. It would seem likely then, that a target of increasing seed yield to at least 2.0 pounds per bushel is reasonable.

SUMMARY

Over a ten year period (1982-1991), cone and seed insects and diseases were monitored and studied in a clonal white spruce seed orchard. The primary insect pests identified were spruce budworm, coneworms, cone maggot, seed moth, and cone axis midge. With the exception of spruce budworm, insect populations rose and fell in response to cone crops. Two or more consecutive barren years essentially eliminates most cone and seed insects; a bumper crop following thereafter is usually not seriously affected. Insects do build up on heavy cone crops, and can wipe out a small crop following a bumper crop. Spruce budworm seems to be endemic in the orchard, although populations were much higher in the early to mid-1980's because of heavily infested natural stands nearby. When budworm populations in the area crashed, so did the level of cone damage in the orchard. Cone and seed insects were effectively controlled by tandem applications of acephate and dimethoate.

Two cone rust species were identified in the orchard, the American spruce-raspberry rust and the inland spruce cone rust. Inland spruce cone rust incidence was low during the period, usually 5 % or less. American spruce-raspberry rust was predominant, with a peak of 78 % infection in 1984. The spread of wild raspberry around the orchard and weather favorable to infection were the most likely causes of the increase in this rust. Infection rates were highly dependent on spring weather conditions. Cool, damp weather in May and June invariably resulted in increased rust infection. During the very hot and dry weather of the late 1980's, cone rust was practically non-existent. Control of raspberry certainly also helped reduce infection rates. Chemical control treatments using chlorothalonil were very effective in reducing cone rust infection.

ACKNOWLEDGMENT

A special thank you is extended to Raymond Dolan. He initiated the insect and disease work in the seed orchard and performed most of the insect identification.

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SURVEY RESULTS

Large aspen tortrix defoliation levels by township

Large aspen tortrix defoliation

County	Township	Legal	Defoliation
Aitkin	Idun	43-24	Light
	Rabey	52-24	L
	Ball Bluff	52-23	L
Carlton	Skelton	47-19	Moderate
	Fond du Lac I.R.	48-19	M
	"	49-19	M
	"	49-18	Moderate to heavy
	Atkinson	48-18	M - H
	Mahtowa	47-18	M - H
Kanabec	Hillman	41-24	Light
	Ann Lake	40-25	L
	Knife Lake	40-24	L
	Kanabec	39-25	L
	Arthur	39-24	L
	Pomroy	41-22	L
	Whited	40-23	L
	Comfort	39-23	L
	Grass Lake	38-23	L
Morrison	Little Falls	40-32	L
	Richards	42-28	L
	Granite	41-29	L
	Motley	133-31	L
	Scandia Valley	132-31	L
	Cushing	131-31	L
	Pike Creek	129-30	L

Large aspen tortrix defoliation levels by township

	Swanville	128-31	L
	Swan River	128-30	L
	Elmdale	127-31	L
Pine	Hinckley	41-21	Heavy
	Barry	41-20	H
	Arlone	41-19	H
	Clover	41-18	H
	Ogema	41-17	H
	Munch	40-20	H
	Brook Park	40-22	H
	Mission Creek	40-21	H
	Crosby	40-18	H
	Pokegama	39-22	H
	Chengwatana	39-20	H
	Royalton	38-22	H
	Pine City	38-21	H
	Pine Lake	43-21	Light to Moderate
	Dell Grove	42-21	L - M
	Finlayson	43-20	L - M
	Partridge	43-19	L - M
	Fleming	43-18	L - M
	Sandstone	42-19	L - M
	Danforth	42-18	L - M
Cass	McKinley	138-32	Light
Todd	Stowe Prairie	133-35	L
	Bertha	132-35	L
	Wykeham	131-35	L
	Burleene	130-35	L
	Leslie	129-35	L

Large aspen tortrix defoliation levels by township

Hubbard	Badoura	139-32	L

Spruce budworm egg mass survey results by legal description

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

Predicted defoliation	Average number of eggmasses/branch
None to Light	0 - 0.1
Moderate	0.1 - 1.7
Heavy	1.8+

Description	Species	1993 defoliation	EMs/branch	1994 defoliation
ITASCA				
S26-T57-R24	WS	L-M	2	HEAVY
S10-T53-R26	WS	H	0	0
S31-T57-R25	WS BF	0	0	0
S11-T53-R26	WS	H	0.33	MODERATE
S6-T56-R25	WS	H	2.7	HEAVY
S33-T55-R26	WS	L-H	2.5	HEAVY
S35-T58-R24	WS	L-H	0	0
S10-T60-R22	BF	0	0.1	LIGHT
AITKIN				
S6-T51-R23	WS	L-H	0.1	LIGHT
ST LOUIS				
S16-T65-R19	WS	M	0.2	MODERATE
S34-T67-R19	BF	H	0.2	MODERATE
S10-T65-R13	BF	H	1.1	MODERATE

Spruce budworm egg mass survey results by legal description

S6-T64-R12	WS BF	H	3.1	HEAVY
S22-T63-R12	WS BF	H	3.2	HEAVY
S10-T68-R20	WS	L-M	2.4	HEAVY
S12-T68-R21	WS	L-H	1.1	MODERATE
S4-T59-R21	WS	H	0.8	MODERATE
S36-T63-R12	BF	H	2.4	HEAVY
S23-T61-R14	WS	0	0	0
S23-T61-R14	WS	0-L	0	0
S29-T68-R20	WS	0-L	0	0
S15-T67-R21	WS	L	0.2	MODERATE
S6-T68-R21	BS	0-L	0	0
S13-T68-21	WS	L-H	0.7	MODERATE
S4-T68-R21	BF	0-L	0.1	LIGHT
S26-T68-R21	WS	0-L	0	0
KOOCHICHING				
S26-T67-R22	WS BF	L	0	0
S5-T68-R22	WS	0	0	0
S19-T68-R22	WS	0	0	0
S10-T67-R22	WS BF	0	0	0
S7-T69-R26	WS	L	0.2	MODERATE
S27-T156-R25	WS	L	0.5	MODERATE
S10-T68-R24	WS	0	0	0
S11-T69-R24	WS	L	0.2	MODERATE
S16-T69-R23	WS	L-H	0.6	MODERATE
S30-T67-R26	WS	0	0	0
S28-T156-R27	WS	0	0	0
S28-T65-R26	WS	0	0	0
S29-T155-R26	WS	0	0	0

Spruce budworm egg mass survey results by legal description

S28-T158-R29	WS	L	0	0
S9-T159-R28	WS	L	0	0
S36-T158-R28	WS	L-M	1.4	MODERATE
S6-T66-R24	WS	0-L	0.1	LIGHT
S27-T155-R27	WS	0	0	0
S19-T65-R22	WS	L	4.7	HEAVY
S11-T156-R25	WS	M-H	1.3	MODERATE
S11-T156-R25	WS	L-M	0.8	MODERATE
S5-T153-R26	WS	VL	1.88	HEAVY
-S6-T66-R24	WS	L	0.11	MODERATE
S4-T154-R25	WS	LIGHT	0.77	MODERATE
S30-T66-R24	WS	VL	2	HEAVY
S5-T69-R26	WS	L-M	1.11	MODERATE
S7-T69-R22	WS	VL	0	0
S21-T67-R25	WS	M	1.0	MODERATE
S35-T63-R22	WS	L	3.22	HEAVY
S19-T65-R22	WS	L	4.77	HEAVY
S27-T155-R27	WS	0	0	0
S11-T156-R25	WS	M-H	1.33	MODERATE
S11-T156-R25	WS	L-M	0.88	MODERATE
S1-T63-R25	WS	0-L	0.1	LIGHT
S35-T152-R28	WS	0-L	0	0
S26-T64-R22	WS	L	0.88	MODERATE
S8-T67-R22	WS	0-L	1.0	MODERATE
S11-T66-R23	WS	0-L	0.67	MODERATE
S13-T68-R25	WS	0	0	0
S28-T68-R25	WS	L-M	19.9	HEAVY
S27-T158-R26	WS	L-H	12.8	HEAVY
S15-T159-R26	WS	0-L	0.4	MODERATE

Spruce budworm egg mass survey results by legal description

COOK				
S1-T61-R1W	BF	VL	0.1	LIGHT
S31-T61-R4W	BF	M-H	0.7	MODERATE
S34-T61-R3W	WS BF	0-H	0.4	MODERATE
S8-T65-R4W	BF	0	0	0
S32-T65-R3W	BF	0-VL	0	0
S4-T62-R1W	BF	L	0	0
LAKE				
S21-T63-R11	BF	H	1.1	MODERATE
S9-T63-R9	BF	M-H	0.2	MODERATE
S11-T61-R11	BF	L-H	0.3	MODERATE
S27-T61-R10	BF	0-VL	0	0
S26-T60-R10	BF	0-VL	0	0
CASS				
S8-T145-R30	WS	L-H	2.0	HEAVY
S3-T141-R28	WS	L-H	0.5	MODERATE
S21-T145-R30	WS	L-H	1.0	MODERATE
AITKIN				
S6 & 7-T51-R23	WS	Uneven defoliation, pockets of heavy. Sprayed with Bt in June. Minor bud death.	0.11	LIGHT
CASS				

Spruce budworm egg mass survey results by legal description

S5-T141-R30	WS	Heavy to severe defoliation of current needles.Light backfeeding and moderate bud death.	3.00	HEAVY
S3-T-141-R28	WS	Moderate defoliation with a trace of bud death.	0.55	MODERATE
13,24-136-31	WS	Heavy defol	0.88	Severe
ANOKA				
S3-T32-R24	WS	Light defoliation. Stand is mixed species.	0.00	0
SHERBURNE				
S33-T34-R27	WS	Light defoliation.	0.14	LIGHT

Jack Pine Budworm Early Larval Survey

In this early larval survey, 6 current year shoots on 5 trees (a total of 30 shoots) are examined at each site. Heavy defoliation is predicted when 20 or more shoots have larvae on them or when more than 25 larvae are found per plot.

County	Location	# of Larvae	Notes and defoliation
Cass	NWNE 26-136-29	0	Not defoliated in 1991 and 1992.
	NENE 1-139-29	0	Moderate to heavy, patchy defoliation ion 1992. Few trees with cone clusters. No dead tops.
	NENW 36-138-30	0	

Jack pine budworm life stage survey results by legal description

	SESW 32-139-30	0	Patchy light defoliation in 1992.
	NENE 22-138-32	2	Fourth instar larvae. No 1991 or 1992 defoliation.
Crow Wing	NENE 10-136-29	0	Pollen not shed yet.
	SENE 14-137-29	0	Pollen shed starting.
	NWSE 17-139-30	0	
	NESW 12-134-28	0	Few cone clusters.
	SESW 2-44-31	0	
	NESW 8-136-27	0	Little 1992 defoliation.
	SENW 10-136-27	2	Second instar. Patchy, heavy 1992 defoliation.
	NENE 23-136-27	11	Second instar. Patchy, heavy 1992 defoliation. Few pollen cones and only on edge trees.
	SESE 28-135-28	18	Second instar. Ditto above.
	SE 4-45-30	21	Second and third instars. Heavy 1992 defoliation. Pollen cones rare and few on edge trees.
	NW 9-45-30	7	Little 1992 defoliation.
	NENW 20-44-31	17	Third instars. Few in shoots. Little 1992 defoliation here but more 1/8 mi. south.
	SESE 33-135-27	18	Light to moderate 1992 defoliation. Second and third instars.
	NESE 10-134-28	2	Heavy 1993 defoliation and pollen cones rare.
	SESW 28-135-28	8	Third and fourth instars. Heavy 1992 defoliation. Budworms in shoots but little damage yet.

Jack pine budworm life stage survey results by legal description

Pine	SWNW 5-45-19	0	Heavy pollen shed from a few cones on taller trees.
	SWSE 25-45-20	0	Heavy pollen shed from a few cones on taller trees.
	SWSE 36-45-20	0	Trees heavily defoliated in 1992. Very few pollen cones.
	NESW 30-45-19	0	Trees heavily defoliated in 1992. Very few pollen cones.
	SESW 13-45-20	0	Little 1992 defoliation.
	NENW 36-45-20	4	Third instars in shoots. Pollen cones on edge trees.
	SWSW 36-45-20	9	Second instars mostly in pollen cones. Pollen cones rare.
Wadena	NESE 30-136-33	6	Third instars in nearly empty pollen cones. No 1991 or 1992 defoliation.
	SESW 12-138-34	4	No 1991 or 1992 defoliation.
	SESE 3-138-33	1	No 1991 or 1992 defoliation.
St. Louis	S1-T60-R13	0	
	S20-T58-R16	0	
	S28-T58-R16	0	
	S33-T58-R16	0	
	S35-T58-R16	0	
	S33-T54-R14	0	
	S15-T55-R12	0	
	S34-T61-R12	0	
	S4-T59-R20	0	
	S7-T65-R15	0	
	S15-T65-R14	1	
	S19-T64-R12	1	

Jack pine budworm life stage survey results by legal description

Itasca	S14-T147-R25				0	
	S1-T147-R25				0	
Koochiching	S36-T66-R27				0	
	S1-T66-R27				0	
	S4-T65-R24				1	
	S12-T65-R24				0	
	S19-T61-R22				0	
Lake	S21-T60-R10				0	
		S	T	R		
Beltrami	SESE	4	147	34	0	0
	SESW	8	147	34	--	0
	NWNW	9	147	34	0	0
	SESW	9	147	34	--	L
	SENE	10	147	34	--	0
	NENE	11	147	34	1	0
	NENW	11	147	34	--	0
	NWNW	11	147	34	3	--
	SWNW	15	147	34	--	0
	NWNE	21	147	34	--	0
	NESE	26	147	34	--	0
	SESE	26	147	34	2	--
	SENE	35	147	34	0	0
	NENE	1	147	35	0	0
	NWNE	2	147	35	0	--
	SENW	2	147	35	--	0
	SWNE	3	147	35	0	0
	SENE	3	147	35	1	--
	SESE	11	147	35	0	0
	NWNW	19	148	35	0	--

Jack pine budworm life stage survey results by legal description

	SESE	19	148	35	0	--
Hubbard	SENE	9	139	32	--	H
	SWSW	9	139	32	2	--
	SWSW	10	139	32	3	--
	SESW	10	139	32	--	M
	SESE	10	139	32	--	L
	NWNW	11	139	32	6	M
	SWSW	12	139	32	--	H
	NENE	13	139	32	--	M
	SENW	14	139	32	--	L
	SWSW	29	139	32	0	--
	NENW	30	139	32	1	--
	NESE	13	139	33	1	--
	NWSE	26	139	33	0	--
	SWSW	35	139	33	1	--
	SWSE	26	139	35	--	0
	NENW	35	139	35	--	0
	SWSW	35	139	35	--	0
	SWSW	14	140	32	--	0
	SWSE	14	140	32	--	0
	NWNW	22	140	32	--	0
	NWNW	23	140	32	5	--
	SWSW	23	140	32	--	L
	NENE	24	140	32	--	0
	SWSW	26	140	32	2	0
	NENW	34	140	32	--	L
	NWNW	34	140	32	2	--
	SESE	34	140	32	--	M
	NWNW	36	140	32	--	0

Jack pine budworm life stage survey results by legal description

	NWNE	5	143	34	--	0
	NWNE	8	143	34	0	--
	SWSE	8	143	34	0	0
	SESW	9	143	34	--	0
	NENE	9	143	34	--	0
	NWSW	10	143	34	--	0
	NENE	16	143	34	--	0
	NENW	16	143	34	0	--
	SENE	3	144	34	--	L
	NESE	10	144	34	--	0
	NWSE	15	144	34	--	0
	SWSE	22	144	34	--	0
	NWNE	32	144	34	0	--
	NENW	32	144	34	--	0
	SESW	34	144	34	--	L
	NENE	2	145	34	0	--
	NENW	3	145	34	--	0
	SESE	22	145	34	0	0
	NESE	23	145	34	--	L
	SWNW	24	145	34	8	--
	NWSE	27	145	34	--	0
	NESW	27	145	34	3	--
	SESE	33	145	34	--	0
Lake of the Woods	NWSW	32	161	32	--	0
Roseau	NWNE	6	160	37	--	0
	NENE	19	161	36	--	0
	NESW	30	161	37	--	0

Jack pine budworm life stage survey results by legal description

Jack Pine Budworm Egg Mass Survey

When the number of egg masses on a plot is 3 or more, next year's defoliation could be moderate to heavy. At a plot, 2 branches are cut from the mid-crown,near the trunk, of 3 jack pines. Fifteen inches of needle-bearing twigs are examined from each of the 6 branches.

County	Location	# of Egg masses	Notes
Crow Wing	NENE 13-137-29	0	All shoots with some green needles. Very few dead jack pine that were heavily defoliated in 1992.
	SESE 28-135-28	0	No dead shoots
	NENE 11-134-28	2	Trees all green.
	NWNE 4-45-30	0	Trees all green.
	SENE 10-44-31	0	A few trees light brown, rest green.
	SENE 19-44-31	0	About 40% of trees brown, but a few green needles on most shoots.
	NENE 23-136-27	1	Two tall jack pines with topkill.
	NWSW 11-136-27	2	
	SWNE 24-44-32	0	Most trees brown, heavily defoliated but some green needles on most shoots.
	NWSE 17-133-28	2	
	SENW 13-133-29	1	
	SESW 15-133-29	3	
Cass	36-134-32	0	Trees red with webbed needles.
Hubbard	9-139-32	1	Over 60% of new needles gone.
Morrison	19-133-31	0	Some green needles on most shoots.
	30-133-30	0	
Pine	SWSE 18-45-19	0	

Jack pine budworm life stage survey results by legal description

	SWSW 36-45-20				0	
	NESE 15-40-18				3	St. Croix State Park
	NWNE 21-40-18				2	"
	SWNW 20-40-18				3	"
	NWSW 11-40-18				0	"
	SENW 16-40-18				2	"
	NWSW 16-40-18				4	"
	SWSW 9-40-18				1	"
	NESW 30-45-19				0	
Wadena	10-135-33				2	Crowns still red.
	35-136-33				0	Over 80% of new needles lost.
	10-136-34				0	Light defoliation in 1993.
		S	T	R		
Beltrami	SESE	4	147	34	0	0
	SESW	8	147	34	1	0
	NWNW	9	147	34	0	0
	SESW	9	147	34	1	L
	SENE	10	147	34	0	0
	NENE	11	147	34	0	0
	NENW	11	147	34	0	0
	NWNW	11	147	34	--	--
	SWNW	15	147	34	0	0
	NWNE	21	147	34	0	0
	NESE	26	147	34	0	0
	SESE	26	147	34	--	--
	SENE	35	147	34	0	0
	NENE	1	147	35	0	0
	NWNE	2	147	35	--	--
	SENW	2	147	35	0	0

Jack pine budworm life stage survey results by legal description

	SWNE	3	147	35	0	0
	SENE	3	147	35	--	--
	SESE	11	147	35	0	0
	NWNW	19	148	35	--	--
	SESE	19	148	35	--	--
Hubbard	SENE	9	139	32	4	H
	SWSW	9	139	32	--	--
	SWSW	10	139	32	--	--
	SESW	10	139	32	0	M
	SESE	10	139	32	0	L
	NWNW	11	139	32	0	M
	SWSW	12	139	32	0	H
	NENE	13	139	32	1	M
	SENW	14	139	32	1	L
	SWSW	29	139	32	--	--
	NENW	30	139	32	--	--
	NESE	13	139	33	--	--
	NWSE	26	139	33	--	--
	SWSW	35	139	33	--	--
	SWSE	26	139	35	0	0
	NENW	35	139	35	1	0
	SWSW	35	139	35	0	0
	SWSW	14	140	32	0	0
	SWSE	14	140	32	0	0
	NWNW	22	140	32	0	0
	NWNW	23	140	32	--	--
	SWSW	23	140	32	0	L
	NENE	24	140	32	0	0
	SWSW	26	140	32	0	0

Jack pine budworm life stage survey results by legal description

	NENW	34	140	32	0	L
	NWNW	34	140	32	--	--
	SESE	34	140	32	1	M
	NWNW	36	140	32	1	0
	NWNE	5	143	34	0	0
	NWNE	8	143	34	--	--
	SWSE	8	143	34	0	0
	SESW	9	143	34	0	0
	NENE	9	143	34	0	0
	NWSW	10	143	34	0	0
	NENE	16	143	34	0	0
	NENW	16	143	34	--	--
	SENE	3	144	34	0	L
	NESE	10	144	34	0	0
	NWSE	15	144	34	0	0
	SWSE	22	144	34	0	0
	NWNE	32	144	34	--	--
	NENW	32	144	34	0	0
	SESW	34	144	34	0	L
	NENE	2	145	34	--	--
	NENW	3	145	34	0	0
	SESE	22	145	34	0	0
	NESE	23	145	34	1	L
	SWNW	24	145	34	--	--
	NWSE	27	145	34	0	0
	NESW	27	145	34	--	--
	SESE	33	145	34	0	0
Lake of the Woods	NWSW	32	161	32	0	0

Jack pine budworm life stage survey results by legal description

Roseau	NWNE	6	160	37	0	0
	NENE	19	161	36	0	0
	NESW	30	161	37	0	0

Pine tussock moth pheromone trap catches by legal description

A count of 30 or more male moths in a trap over a 10-14 day period would indicate probable need for control in the next year. (Or more than 120 moths over the trapping season.)

County	Location	Date trap placed	Date trap checked	Number of male moths in trap
Crow Wing	SWSW 9-136-27	7-6	7-16	6
			8-2	3
			8-20	4
Crow Wing	NWSE 9-136-27	7-6	7-16	2
			8-2	2
			8-20	11
Crow Wing	NWSW 11-136-27	7-6	7-16	3
			8-2	5
			8-20	3
Crow Wing	NENE 23-136-27	7-6	7-16	2
			8-2	0
			8-20	1
Crow Wing	NWNW 30-124-28	7-6	7-30	0
			8-16	2
			8-25	0
Hubbard	16-139-32		7-8	11

Pine tussock moth pheromone trap catches by legal description and date

County	Location	Date trap placed	Date trap checked	Number of male moths in trap
			7-13	8
			7-23	11
			7-29	6
			8-17	11
Hubbard	10-139-32		7-8	21
			7-13	15
			7-23	11
			7-29	4
			8-17	4
Hubbard	35-139-33		7-8	9
			7-13	7
			7-23	13
			7-29	8
			8-17	9
Pine	NESE 13-45-20	7-6	7-16	1
			8-6	0
			8-20	0
Pine	SWSE 18-45-19	7-6	7-16	0
			8-5	0
			8-20	1
Pine	SWSW 36-45-20	7-6	7-16	9
			8-6	5
			8-20	4
Pine	NWNW 6-44-19	7-6	7-16	0
			8-6	5
			8-20	3
Pine	SWSE 25-45-20	7-6	7-16	5

Pine tussock moth pheromone trap catches by legal description and date

County	Location	Date trap placed	Date trap checked	Number of male moths in trap
			8-6	2
			8-20	2
Pine	SESW 30-45-19	7-6	7-16	9
			8-6	0
			8-20	2
Pine	NESW 30-45-20	7-6	7-16	2
			8-6	3
			8-20	3
Pine	NESE 26-45-20	7-6	7-16	6
			8-6	4
			8-20	1
Wadena	15-138-33		7-8	9
			7-13	9
			7-23	5
			7-29	7
			8-17	6
Wadena	10-138-33		7-8	8
			7-13	12
			7-23	6
			7-29	3
			8-17	4

Gypsy moth trap locations summarized by county for DNR placed traps and (#) moths caught.

Gypsy moth pheromone trap locations

County	Traps	County	Traps
Aitkin	25	Lake of the Woods	18
Becker	12	Lyon	3
Beltrami	24	Mahnomen	3
Big Stone	3	Marshall	6
Blue Earth	3	Mille Lacs	10
Brown	6	Morrison	28
Carlton	9	Mower	3
Cass	1	Murray	3
Chisago	12	Nicollet	3
Clay	4	Olmstead	3
Clearwater	9	Ottertail	11
Cook	12	Pennington	2
Crow Wing	19	Pine	26
Douglas	11	Pipestone	3
Filmore	6	Polk	3
Freeborn	3	Pope	7
Goodhue	3	Rice	6
Houston	3	Rock	3
Hubbard	12	Roseau	10
Isanti	1	Sherburne	10
Itasca	32	St. Louis	50
Jackson	3	Stearns	2
Kanabec	6	Todd	6
Kandiyohi	6	Wabasha	6
Kittson	4	Wadena	3
Koochiching	16	Winona	12 (1)

Gypsy moth trap locations summarized by county for DNR placed traps and (#) moths caught.

Lac Qui Parle	3	Wright	6
Lake	29	Yellow Medicine	3