FOREST INSECT & DISEASE REPORT 1988-1989

Minnesota Department of Natural Resources
Division of Forestry

FOREST PEST REPORT
1988 - 1989

BY

The Forest Insect and Disease Unit

Minnesota Department of Natural Resources

Division of Forestry

September, 1990

Page Number

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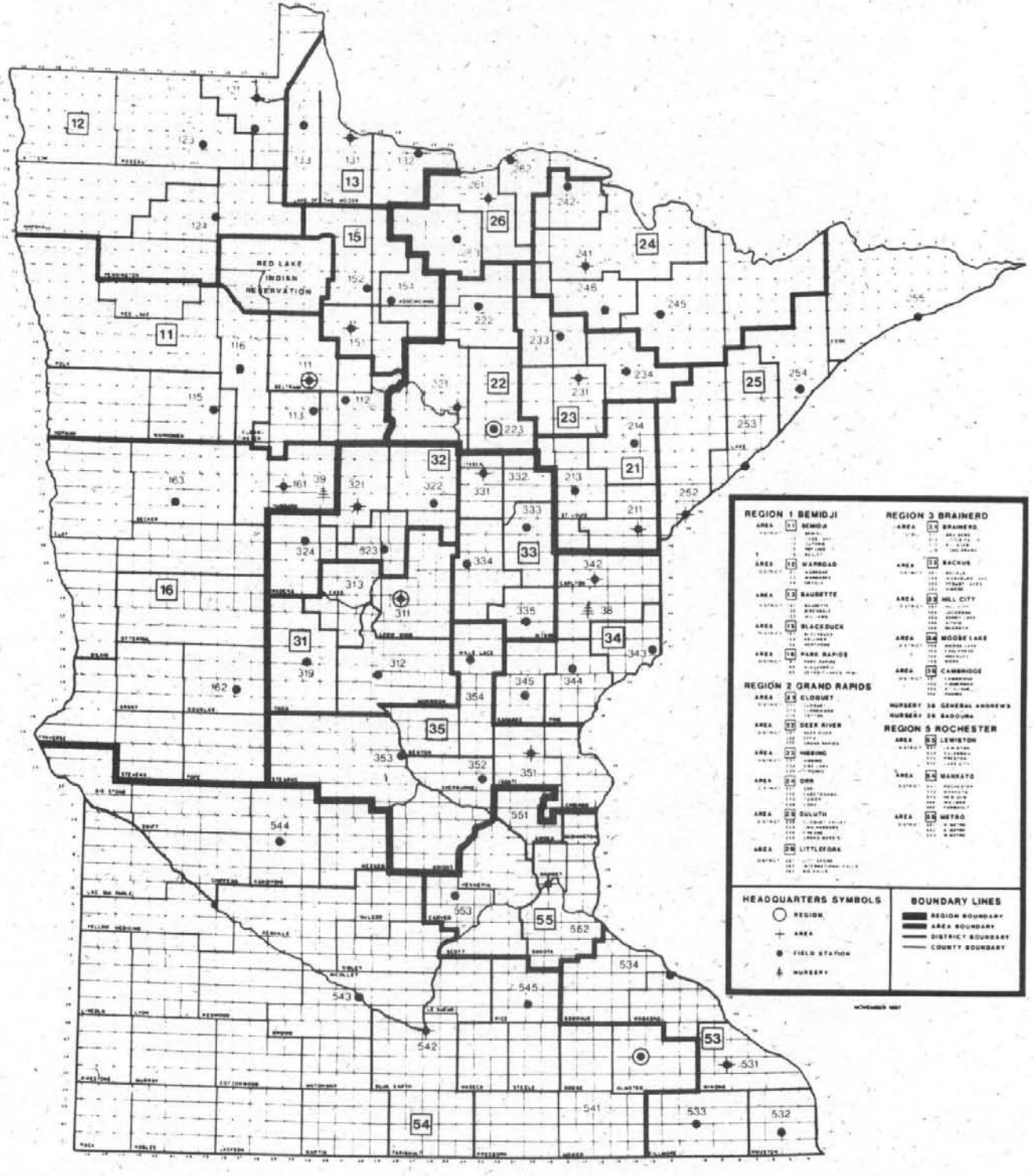

MINNESOTA FOREST INSECT AND DISEASE MANAGEMENT PROGRAM

There are approximately 16.5 million acres of forest land within the State of Minnesota. Over one-half of the commercial forest land within the state is publicly owned. These forests support a 2 billion dollar forest industry, which is the third largest industry within the state. The Minnesota Department of Natural Resources (MN-DNR) has been charged by the legislature with management efforts and/or support on Minnesota's state, county, and private forest lands.

Minnesota's Forest Insect and Disease Management Unit is contained within the Forest Management Section of the MN-DNR Forestry Division. Field activities within this division have been regionalized into six regional administrative units. The insect and disease unit consists of a Forest Insect and Disease Supervisor, one statewide Pesticide Use Coordinator, five regional Forest Insect and Disease Specialists, and two seasonal Plant Health Specialists. The five Specialists and the two Seasonal Specialists have regional responsibilities.

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LIST OF MAPS

HIGHLIGHTS and OUTLOOKS

-1988-

Drought in Minnesota during 1988 may well turn out to be the worst ever recorded. Having been called a one hundred and fifty year drought, conditions were severe across western and central Minnesota and severe to moderate in the southeast.

By far the most serious losses occurred in red pine as a bark beetle outbreak caused by *Ips pini* became widespread. In many areas of the state there were 4 generations of bark beetles during 1988. The most affected counties were Sterns, Benton, Sherburne, Kanabec and Anoka counties. Eighty percent of all pine plantations in these counties had active bark beetle pockets. The average mortality exceeded 10%. In Anoka county alone, the estimated loss was over 200,000 eight inch trees. The combined losses in all areas exceeded over a million trees. Red pine mortality in Washington county and across the southeast was at a lower level and widely scattered. Across the southeast, scattered old growth Scots pines found in many towns were killed. In Fillmore and Houston counties, native eastern white pine growing on bluff sites were killed individually and in pockets.

In the hardwood forests, oak mortality in the red oak group was also the result of a bark boring beetle, the two-lined chestnut borer, *Agrilus bilineatus*. Oak mortality caused by the two-lined chestnut borer first became evident during the last week in July across the drought affected oak range. Rates of mortality ranged from less than 1% to as high as 20% in some limited areas. Across the southeast, hardwood forests with widely scattered individual northern red oak mortality was very common. The first trees to die were those found along logging roads, on the edges of clearcuts, and on slow growing sites.

The highest mortality rates occurred on poor sites in the southeast and on good sites in northern Kandiyohi County where spring defoliation by forest tent caterpillar, *Malacosoma disstria,* preceded the drought. During field visits made in mid-August, red oak killed by the borer did not yet have *Armillaria* root rot present on the root flares of the dead red oak. *Armillaria* root rot is expected to be more noticeable in 1990 on the dead and dying oaks.

There was no significant two-lined chestnut borer activity found on bur oak. There was, however, widespread leaf scorch on bur oak that occurred during the first week in August. On August 3rd and 4th temperatures

reached 100 degrees F and winds exceeded 20 mph. The injury occurred on exposed sites and extended from the southwest along the Minnesota river, through the southeast and into Metro area. Some limited attempts at refoliation were seen in Wabasha County in early September. Bur oak is expected to recover without long term impact.

Numerous other insect pests were in very high numbers throughout the season. The oak twig pruner, *Elaphidionides villosas*, damaged branches in red oak species all across the red oak range.

Defoliation by the birch leaf miner, *Fenusa pusilla*, on white birch was serious and widespread in central and portions of the southeast by early summer. Later top kill and mortality caused by the bronze birch borer, *Agrilus anxius*, was common in all drought affected areas. The likely severe stress to root systems of this sensitive species will likely lead to continued attacks for the next few years.

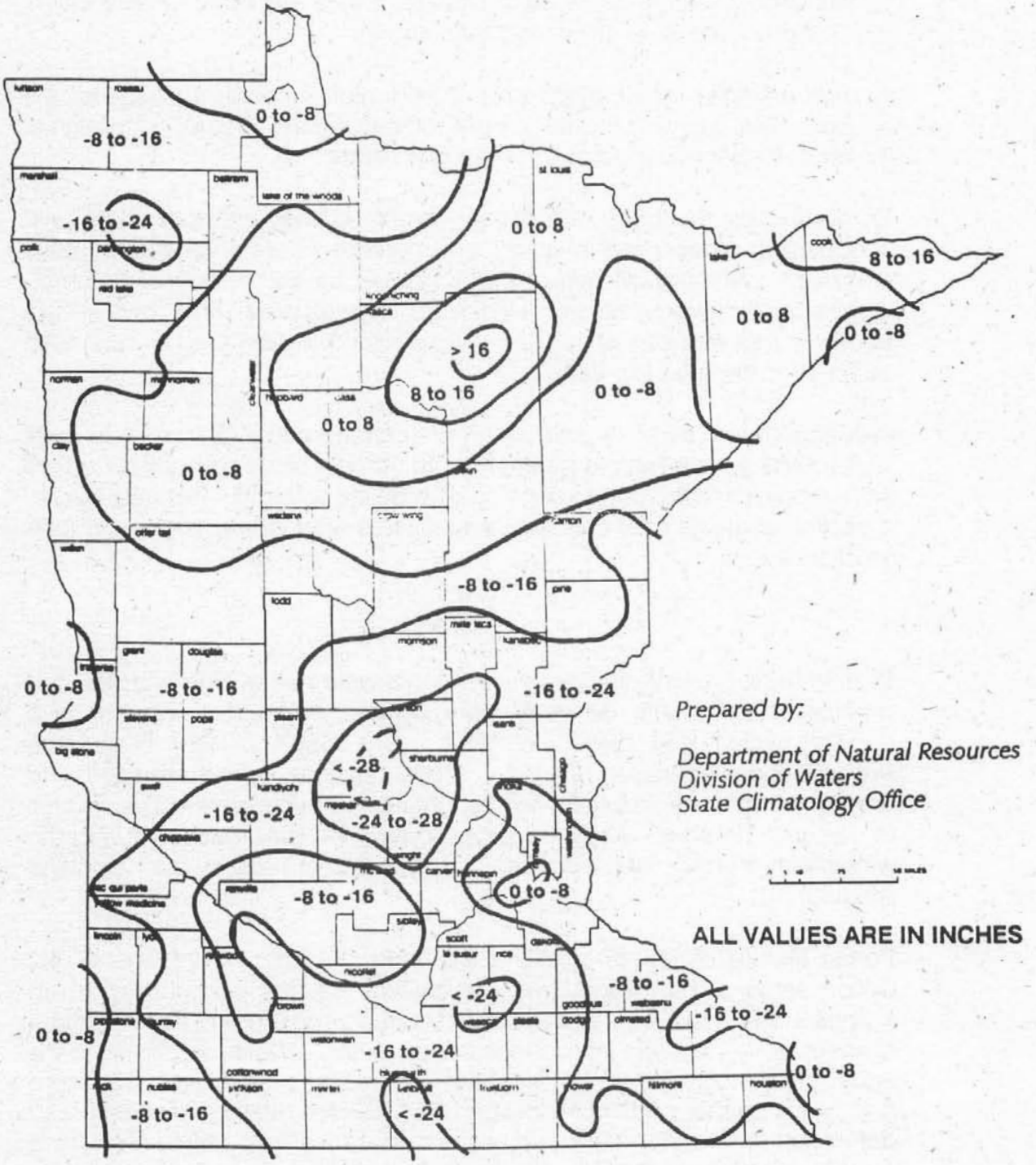
Leaf scorch and early fall coloration were common on sugar maple in most areas. Many trees with large areas of the crown showing early fall colors were responding to root damage caused by the drought. This may lead to a decline of maple over the next several years within the severest drought-stricken areas.

-1989-

During 1989, growing season temperatures were not as high as 1988, and precipitation amounts generally were higher. Minnesota was still in a drought which had begun in 1987. See "1987 - 1989 Cumulative Precipitation Departure," Map 1. Trees continue to be stressed and weakened from the drought, and drought related pests were still very much in evidence. In some areas red pine mortality became evident during the winter with mortality reaching measurable levels of 1-2% by the beginning of 1990.

Forest tent caterpillar populations exploded in 1989. Approximately 4.2 million acres of hardwoods were defoliated. During previous cyclic up swings in FTC populations, defoliation is usually most dramatic in northern Minnesota in the large contiguous aspen areas. While defoliation once again made an impact in northern Minnesota, defoliation was also significant in other parts of Minnesota. FTC caused heavy and widespread defoliation to basswood and red oak stands throughout central Minnesota and southward to the Minnesota River. Aerial spraying with Bt by lakeowner associations was undertaken during 1989, and during 1990 the amount of aerial spraying will increase significantly.

MAP 1: 1987 - 1989 CUMULATIVE PRECIPITATION DEPARTURE



Populations of the bark beetle declined in 1989 due to a cool spring and normal fall. Only two beetle generations were produced. Two-lined chestnut borer populations and activity increased significantly. This insect was able to build up populations in oaks weakened by drought and/or defoliation by the forest tent caterpillar. Oak mortality from the two-lined chestnut borer reached as high as 70% in some stands in central Minnesota.

The widespread leaf scorch reported on bur oak in 1988 did not lead to any serious losses during 1989. Individual trees which had been tagged and rated for leaf scorch severity, showed no damage in 1989.

PEST CONDITIONS REPORT: INSECTS

BARK BEETLES
Ips spp.

-1988-

ACREAGE: Not determined. Infestations occurred in variably-sized pockets which did not exceed 1 acre in size. See Map 2: Bark Beetles, 1988.

SEVERITY: Very severe; tree mortality as high as 80% of the stands and windbreaks in central and southern Minnesota

-1989-

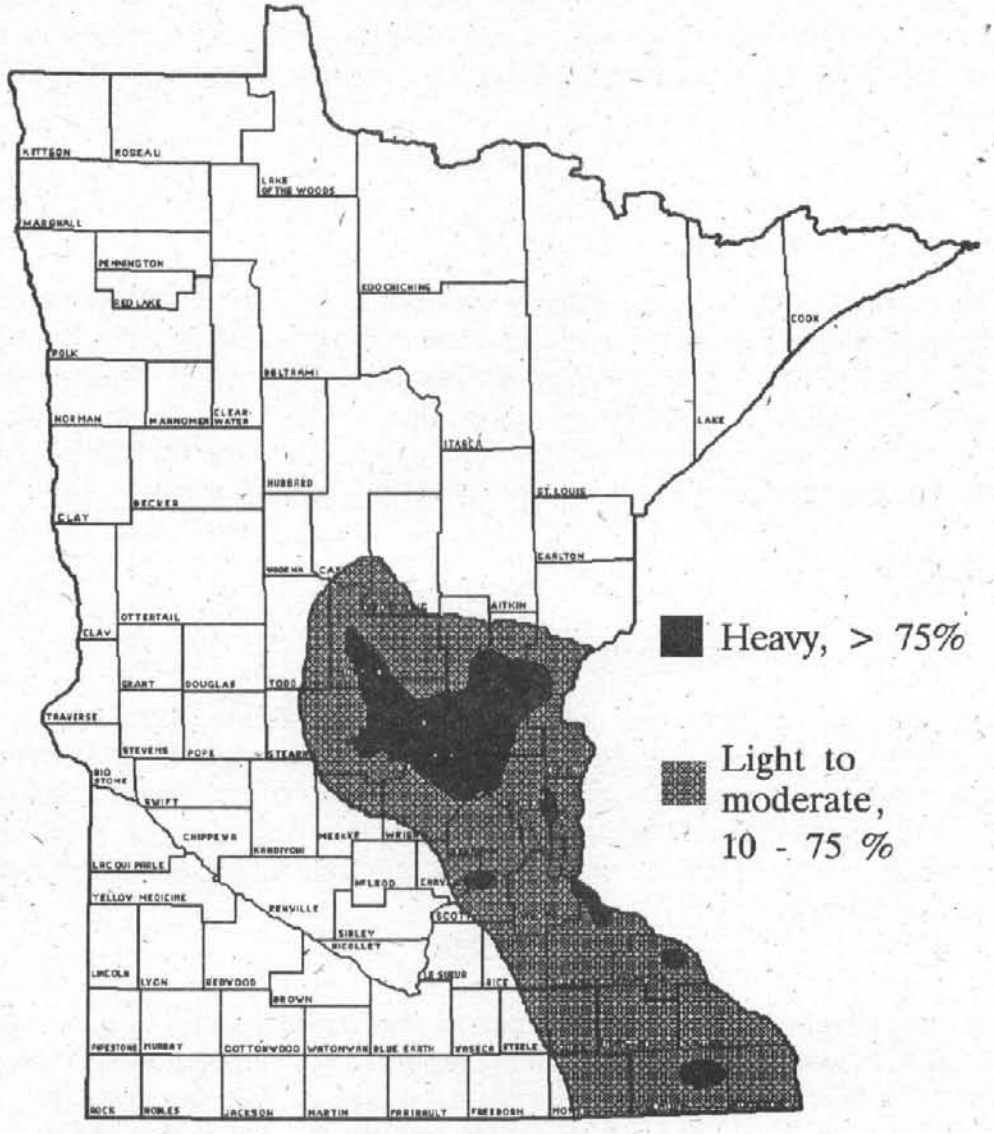
ACREAGE: Approximately 150 acres in Region 2; undetermined elsewhere. Infestation remained in all areas affected in 1988, but at a significantly lower level.

SEVERITY: Very light

HISTORY: The early warm spring weather and the drought of 1987 and 1988 favored development of large populations of bark beetles in both years. Mortality of red pine was common in 1988. Mortality continued in 1989 but was much reduced from 1988 levels.

PREDICTIONS: Due to the large numbers of overwintering beetles and continued dry conditions through the winter and spring of 1990, existing pockets may enlarge, and additional infestations may occur.

MAP 2: BARK BEETLES, 1988



REGIONAL NOTES

REGION 1

-1988-

The drought conditions in the pine areas in this region were not severe for a long enough period to allow bark beetles to build up. Even in stands where high water conditions the previous years killed rims of pine around potholes, little additional bark beetle kill was associated with these dead trees.

-1989-

Little additional bark beetle activity was noted in this region during 1989. Although drought conditions returned late in the growing season, there was adequate moisture early in the growing season. This early season moisture help to prevent a bark beetle build up in May and June. Summer temperatures were not as high as those occurring during 1988. These weather patterns helped keep bark beetle damage to a minimum.

REGION 2

-1988-

The early warm spring and hot summer of 1988 allowed the development of 3 to 4 generations of bark beetles in this Region. The large number of bark beetles produced in combination with the drought stress resulted in many pine trees being killed in 1988. Most bark beetle pockets, however, were established in stands where thinning and/or pruning extended into the growing season.

-1989-

Very large populations of beetles overwintered and emerged in the spring of 1989. However, in Region 2 the spring and summer weather in 1989 was closer to normal and limited the bark beetles to two generations. The reduced number of bark beetles and the normal rains resulted in fewer pines dying in 1989 than in 1988.

Some examples of bark beetle problems in this Region included:

Sec. 21-T58-R24W: 30 acre, 27 year old red pine plantation. This site was pre-commercial thinned from 1/88 - 3/88. Approximately

15% of the red pine were killed by bark beetles in 1988. This site was set up as a study using bark beetle pheromone traps. (See Special Projects.)

Sec. 21-T59-R24W: 20 year old red pine; pre-commercial thinned early in 1988. Scattered pockets of 10 - 20 trees were killed by bark beetles throughout the plantation in 1988.

Sec. 16-T60-R24W - Lost Lake: 40 acres of red pine were pre-commercial thinned in 2-3/88. Scattered pockets of 2 to 15 trees were killed throughout the plantation. This plantation was used to study the effectiveness of spraying baited trap trees with Sevin SL in controlling bark beetles. (See Special Projects.)

Sec. 34-T61-R26W - Private land: Mortality of approximately 40-50 thirty year old red pine occurred around a home building site.

Sec. 23-T60-R21W: Five acres of red pine plantation were pre-commercial thinned, 1/88. Large populations of bark beetle developed in slash in 1988 and 1989. Slash was removed and burned on June 6, 1989.

Sec. 23-T60-R21W: 5 pockets of 5 - 10 trees each were killed by bark beetles in 1988. Pheromone baited traps were hung in the pockets on 5/89 to reduce the bark beetle population and prevent further mortality.

Sec. 36-T61-R22W: 8 acre red and jack pine plantation which was pre-commercial thinned 12/87 and 1/88. Large populations of bark beetles developed in 1988. There was concern that the beetles would emerge in the spring of 1989 and kill trees. 2.6 acres were pheromone trapped at 5 traps/acre using C-flex lures. 2.6 acres had 5 trap trees per acre baited with C-flex lures and sprayed with Sevin SL. 2.6 acres were left untreated as a control. (See Special Projects.) Some trees cut during December 1987 and January 1988 were still being attacked by adult bark beetles on July 20, 1989.

Many other pockets of bark beetle killed trees were found during aerial and ground surveys. Dozens of people requested information about bark beetle control.

REGION 3

-1988-

The drought and the building bark beetle population conspired to produce a devastating year in Region 3. While we had expected 1988 to be a banner year for bark beetles, the degree and depth of the drought permitted the situation to get completely out of hand in most of Sherburne, Stearns, Isanti, Mille Lac, Benton, and Morrison Counties. Ninety percent of the red pine stands were infested; the damage level averaged 12%. Damage in some stands reached 100% near Rice in Benton County.

The beetle's biology went into high gear due to the high temperatures. The insect passed through 4 generations; the normal is 2. The first generation was completed by Memorial Day, the second by July 4, and the third by mid August. In September, with the shorter day lengths and the cooler nights, it is at this time that the beetles normally seek a place to hibernate in the duff. Temperatures were so high in 1988 that at least some of the beetles developed a fourth generation. Judging from the amount of damage, this fourth generation was not undertaken by the entire population, but a small proportion of the total, perhaps 20-25%.

Not normally seen until July, damage from the spring generation was becoming visual by the first week in June due to the high moisture stress on the trees. It is likely that the blue stain fungus that accompanies the beetle and actually kills the trees accelerated its development as well. Damage from the fourth generation appeared through the late fall and on into early spring. Since we flew our surveys in October and November, it is likely that the total damage for the year was underestimated in the southern parts of the region where the fourth generation occurred.

Control actions were few and far between and, in effect, the bark beetle owned most of the state in 1988. Trap trees processed in May on the Sand Dunes State Forest (Sherburne Co.) worked perfectly until the third generation of beetles ripped back into the stands. Aerial infrared photography taken in early June showed treated areas free from beetle activity. By mid-July these stands were seriously infested with 15% mortality.

One bright spot in the story was the initial use of pheromone traps for control. Six stands were treated in 1988. In all but one, treated stands did not receive serious, if any, damage. The work in 1988 was very preliminary and encouraging. On the poor side, one stand in Stearns County, was trapped at a very low density beginning in mid-June. Because there were

not enough traps to attract and capture a high percentage of beetles, this stand was very seriously damaged (25+%). Another stand near Mora in Kanabec County was trapped early in May at a higher density and suffered no mortality in 1988. The evaluation of this technology will continue in 1989, with the installation of a full, scientifically designed study co-sponsored by the U.S. Forest Service and the MN DNR.

-1989-

Bark beetle damage abated dramatically in 1989 due to the cool spring and mild summer which permitted only two generations of the beetle to develop. Damage began to pick up again in August as the drought once again deepened. Unfortunately, sparse fall rains, a lack of snow, and severely weakened trees created a potential that will permit the bark beetle to explode again in 1990. While the situation is expected to improve in the northern parts of the state, the bark beetle can be expected to continue to be a serious problem in the central part of the state including much of Anoka, Isanti, Sherburne, Stearns, Morrison, and Benton Counties. Adequate rainfall in the spring of 1990 should lessen the potential for bark beetle damage to occur. However, the outbreak is not expected to abate quickly due to the extremely weakened condition of the trees.

About 50 private individuals purchased approximately 600 pheromone traps during 1989. Private individuals were able to purchase these traps provided they agreed to work with the DNR in the evaluation of trapping technology. Three communities, Lino Lakes, Burnsville, and Plymouth, also purchased traps. There were about 1500 traps on state lands, including Camp Ripley in Morrison County, O'Brien State Park in Washington County, and Sand Dunes State Forest in Sherburne County. In total, about 2500 pheromone traps were used in Minnesota in 1989. Traps were placed by April 20 and were rebaited during the first week in June.

REGION 5

-1988-

The actual acreage has not been determined; however, of an estimated 2,000 acres in Anoka and Washington Counties, 80% of all plantations have at least one active bark beetle infestation. In Anoka County, the average is five bark beetle pockets per plantation and in Washington County, one pocket per plantation.

The average bark beetle mortality of red pine in county plantations in the Metro Region was 10%; the range was from none to 80% mortality. In southeastern Minnesota, bark beetle mortality in pine plantations is estimated to be 5% with 70% of the plantations infested.

In addition to the red pine mortality, eastern white pine and Scots pine were also affected. A small number of native eastern white pine on bluff sites were killed in Fillmore and Houston counties. Several large Scots pine found in small towns across southern Minnesota were also attacked and killed.

-1989-

Following serious bark beetle mortality in 1988, several control operations were attempted in southeastern Minnesota counties. Pheromone traps were used in three counties, Fillmore, Winona, and Houston; and trap trees were used on several sites in Winona, Fillmore, Wabasha, Goodhue, and Houston Counties. Large numbers of beetles were trapped by both methods; however, no new bark beetle mortality was observed or reported in untreated areas adjacent to and widely separated from the control areas. No further bark beetle mortality is expected until we return to the severe drought conditions of 1988.

PHENOLOGY

-1989-

April 16:	Bark beetle traps placed in Grand Rapids District plantation. Some frost still in the ground in the plantation. Itasca Co.
May 11:	A few bark beetles starting to make nuptial chambers and starting to lay eggs. Snow still on ground in spots in this plantation. Side Lake, St. Louis Co.
May 16:	Bark Beetle trap logs sprayed with Sevin SL and baited with pheromone. Lost Lake Plantation, Itasca Co.
May 22:	Some bark beetle eggs hatched and larvae feeding Link Lake, Itasca Co.
May 30:	Most egg laying galleries still pretty short. Side Lake, St. Louis Co.
June 14:	Bark Beetle trap logs sprayed with Sevin SL and baited with pheromone. Side Lake, St. Louis Co.

JACK PINE BUDWORM
Choristoneura pinus Freeman

-1988-

ACREAGE: None

SEVERITY: Very light

-1989-

ACREAGE: No significant budworm activity

HISTORY: From 1984 to 1987, budworm populations were in an outbreak status somewhere in the state of Minnesota. The peak year was 1986 when over 100,000 acres of jack pine were defoliated. Populations started to decline in l987 when 80,000 acres were infested, but 50% of the infested acreage sustained only light defoliation (1-20%).

PREDICTIONS: The population has collapsed, and little defoliation will be evident during the early '90's.

REGIONAL NOTES

REGION 1

-1988-

Most of the jack pine budworm experienced in Minnesota in 1986 and 1987 occurred in Region 1. There was a dramatic population decline in 1988. In 1987 80,500 acres were infested in this region; in 1988 less than 300 acres were rated as showing moderate defoliation (21-50% needle loss). The early larval survey conducted during June resulted in predictions of either no new defoliation or only light defoliation. The highest larval count was 3 on 30 shoots collected, and those collections were from southern Beltrami County. On only 20 out of 43 larval survey plots were larvae found.

As expected, the egg mass survey conducted in August resulted in the same picture. Egg masses were found only on 4 out of 51 plots, and all plots positive for egg masses only had 1 egg mass each. This would indicate very little noticeable defoliation from the jack pine budworm in 1989.

The jack pine in Lake of the Woods and Roseau Counties is separated from the pine in Hubbard, Becker and Beltrami Counties, but it also experienced budworm feeding during this current outbreak. In 1986 budworm caused noticeable defoliation in Roseau County, and life stage surveys found an active budworm population in Lake of the Woods County. However, in 1987 no noticeable defoliation was detected in Roseau County, and life stage surveys found little evidence of budworm in the rest of the Roseau County jack pine areas as well as in Lake of the Woods County.

This pattern of budworm occurrence in these two northern counties was similar to the previous outbreak during the 1970's. In 1976 parts of Roseau County had heavy defoliation from the budworm. In 1977 the budworm disappeared, and no damage was sustained.

Damage from this budworm infestation was much less than from the infestation during the late 70's. Total stand mortality was sustained in the 70's, particularly in Wadena County, but there was heavy enough damage in southern Hubbard County and in the Lake George area of central Hubbard County that stand salvaging was necessary during the 1970 outbreak. Losses from this latest budworm outbreak were limited to top kill. Some stand salvaging occurred in southern Hubbard County; however, the availability of markets rather than the condition of the stands prompted the salvage of the top killed, over mature jack pine stands.

In the '70's, heaviest losses occurred to older stands on droughty soils. The soils haven't changed, but stand age is generally younger. As management efforts help to bring about a regulation of age classes, the older stands that were stored on the stump in order to help bring about regulation should no longer be as prevalent as they were in the '70's. Management efforts should also reduce the numbers of open grown stands. Often open grown stands were created when markets were good for bolts but not for pulp; partial cuts were made. These stands were characterized by a larger proportion of wolf trees. These large crowned, limby wolf trees act as sinks for population survival and build up.

Managed stands will not reduce the occurrence of budworm, but long term permanent damage in the form of significant top kill and mortality should be reduced.

One major difference between the outbreak in the 70's and the present outbreak was the severe drought conditions leading into the budworm outbreak of 1977. The drought severely stressed the trees on the droughty soils of Wadena County, and with the added defoliation of the budworm outbreak, severe losses resulted. Drought conditions were experienced in

Region 1 during 1987 and 1988, but the severity was not nearly as great as during 1976 and 1977. Leading up to the droughty conditions in the 80's were 5 years of near record setting precipitation.

-1989-

Larval surveys conducted in widely spaced plots in southern Hubbard, Roseau, and Lake of the Woods Counties found neither larvae nor any evidence of feeding on any shoots collected. This follows the predicted pattern for this defoliator. The jack pine budworm seems to cause 2-3 years of moderate to heavy defoliation (30 - 50%+) separated by 6-8 years of no detectable feeding.

REGION 3

-1988-

At 12 sampling locations a total mix of 30 vegetative shoots and staminate cone clusters (6 from each of 5 jack pines) were checked for budworm. According to Stewarts' studies in Wisconsin, if 20 or more budworms are found at each location, moderate to heavy defoliation can result. At no location were such numbers found, and defoliation was absent or less than 5% except at a Pine County State plantation where jack pines had been planted in 1965. This was the only location in Region III where heavy defoliation was found (70 to 80% of the shoots and 1987 needles partly or completely eaten or cut off with pieces left webbed on the twigs). On June 28th, 90% of the budworm had pupated, but no adults (moths) were seen. Only 10 pupae were found, and 2 were dead from predators.

-1989-

An early larval survey was conducted at 9 locations throughout the Region. Two plots in Pine County located in SWNE 6-44-19 and SENW 36-45-20, and 1 plot in Wadena County located in NENE 3-138-33 were positive for larvae. The highest number of larvae were found in 36-45-20 of Pine County where 9 larvae were found in the staminate cone clusters. Since 20 or more larvae is the threshold for moderate to heavy defoliation, the low numbers of larvae found do not indicate a large enough population to cause any noticeable defoliation.

The results of the larval survey are expected at this stage in the budworm cycle. None to only a few larvae should be found during early larval surveys conducted for at least the next 5 years.

PHENOLOGY

-1988-

May 25:	Male cones shedding pollen and vegetative shoots at candle stage. Very large male cone crop throughout Itasca, Carlton and St. Louis Counties.
June 14:	Late instar larvae present: Lake of the Woods County.
June 23:	Both pupae and late instar larvae present: Beltrami County.

PINE TUSSOCK MOTH
Dasychira plagiata Dyer

-1988-

ACREAGE: None

-1989-

ACREAGE: None

PREDICTION: No new infestation for 1990

REGIONAL NOTES

REGION 3

-1988-

Since 1980, the numbers of pine tussock moth caterpillars and egg masses in Pine County have diminished. In 1986 only one caterpillar was observed in all Region III checkpoints, and in 1987 no caterpillars were observed. No egg masses were found in 1986 or 1987. In 1988 only 1 caterpillar, and no egg masses were found.

The trap data (as compared with trap data during years when the insect was present in great numbers), the caterpillars observed (only one), and lack of observed egg masses all indicate that the pine tussock moth population in Region III is minor.

-1989-

Larval surveys were conducted in Pine, Cass, and Wadena Counties. No larvae were found.

Ten pheromone traps were also placed in Cass, Wadena, Crow Wing, and Pine Counties. The results of this trapping indicate that the pine tussock moth populations remain at minor levels in the historical pine tussock moth areas. Northeastern Wadena County continues to be the location where the greatest number of moths were trapped. Traps located in sections 3 and 10 of 138-33, Wadena County trapped 55 and 57 moths. The range of trap catches at the other locations around the Region was between 29 and 38 with the exception of a trap located in section 30 of 45-19 in Pine County where the trap catch number totalled 54.

ADANA TIP MOTH
Rhyacionia adana Heinrich

-1988-

ACREAGE: Not determined; documented in 4 plantations in west central St. Louis Co. and 1 plantation in International Falls area

SEVERITY: In a study area in west central St. Louis Co., populations are greatly reduced (<2.5%).

HISTORY: Adana tip moth damaged shoots are occasionally found in young red pine plantations but generally occur at very low levels of incidence.

JACK PINE SAWFLY
Neodiprion pratti banksianae Rohwer

-1989-

ACREAGE: 30 - 40 acres

SEVERITY: Moderate defoliation

REGIONAL NOTES

REGION 2

Moderate defoliation occurred on 30+ foot tall jack pine in sec. 16, T.56, R.17W near Cotton in St. Louis County. Defoliation on understory trees was heavy with previous years as well as current years foliage being consumed.

BALSAM TWIG APHID
Mindarus abietinus (Koch)

-1989-

Region 2

Acreage: 30

SEVERITY: 25% of trees affected

This aphid became noticeable during 1988 and was treated with insecticides in the 30-acre plantation. Its occurrence is also common on roadside trees in this area. The numbers of trees affected and the severity of the infestation was reduced in 1989 compared to 1988 levels.

SPRUCE BUDWORM
Choristoneura fumiferana (Clemens)

-1988-

ACREAGE: 199,800 See Map 3: Spruce Budworm Defoliation, 1988.

SEVERITY:

Rating	Defoliation	# of Townships
Severe	> 90%	1.6
Heavy	50-90%	39.5
Moderate	20-50%	20.7
Light	1-20%	29.5

-1989-

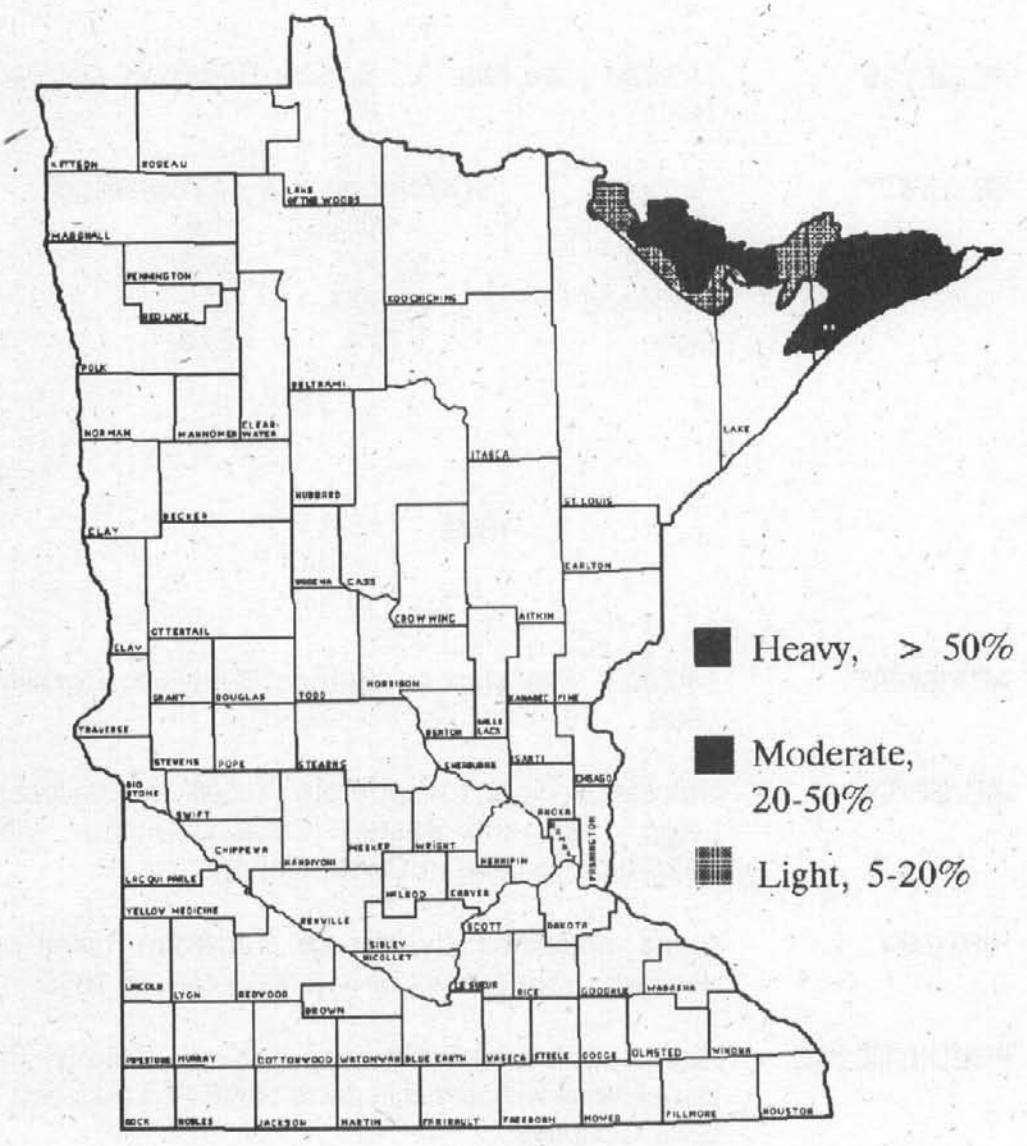
ACREAGE: 140,000 See Map 4: Spruce Budworm Defoliation, 1989.

SEVERITY: Defoliation: light to moderate (1 -50% needle loss) St. Louis, Lake, and western Cook Counties. Heavy defoliation (>50%) in Cook County.

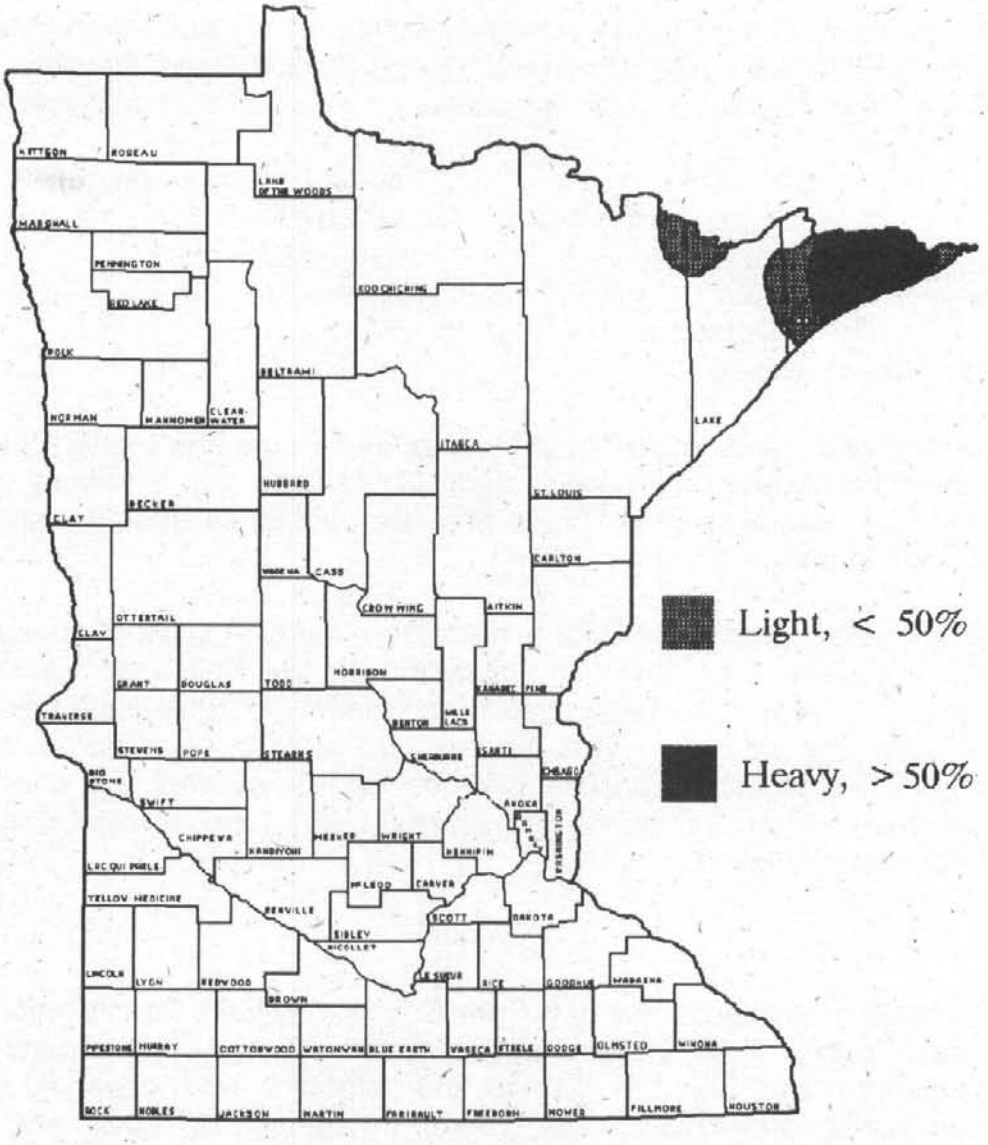
HISTORY: Acres defoliated by spruce budworm have been declining from a peak of 440,000 acres in 1986.

PREDICTIONS: High populations will persist in Cook County. Small populations will persist in parts of NE St. Louis and NW Lake Counties.

MAP 3: SPRUCE BUDWORM DEFOLIATION, 1988



MAP 4: SPRUCE BUDWORM DEFOLIATION, 1989



REGIONAL NOTES

REGION 2

-1988-

Nineteen pheromone trap plots were set out and egg mass counts were taken. The average moth catch per trap was 82.

There was a 60% decrease in overall acreage as the population collapsed from the Cloquet Valley Station north to the Orr and Tower Stations. There were a few detectable outlying populations in the area of collapse:

near Sand Lake	60-18 (township-range)
north of Chisholm	59-21
near Cotton	54-17,18
near Alborn	52-18
east of Bassett	57-11
near Isabella	59-8

In northwestern St. Louis Co., larvae and pupae were easily found but there was no detectable defoliation. Near Myrtle Lake (65-18) where spruce budworm was active, the spruce twig tips were straw-colored instead of being the normal brick-red color.

In Cook Co., spruce budworm defoliation intensified; black spruce and tamarack were even fed upon. Along the Gunflint Trail, a tamarack stand turned red due to the heavy level of defoliation. In general the balsam fir are declining or dead. They appear grey-white in color due to lichen-covered branches, branches with just a few needles left and dead branches. Budworm phenology in Cook Co. was about 1 week behind that in central St. Louis Co.

-1989-

Defoliation was concentrated in Cook County, NW Lake County and NE St. Louis County. Smaller scattered populations still exist in other parts of St. Louis and Lake Counties. Larvae and defoliation were observed during surveys conducted from the ground throughout St. Louis and Lake Counties, but they were much less common than in recent past years. Defoliation during aerial surveys was observed only in Cook, NW Lake and NE St. Louis Counties.

Five pheromone trap plots (3 traps per plot) were set out in 1989. Average moth catch per trap was 29 in St. Louis County and 97 in Cook County.

REGION 3

-1988-

On June 14, three pheromone traps were placed in the Nemadji State Forest at each of 7 permanent plot locations. Traps were collected July 19, spruce budworm moths counted, overall stand feeding on this year's balsam needles estimated, and egg masses counted on three 15-inch midcrown balsam branches (one branch cut from each of three trees at each plot).

Generally, spruce budworm activity in this area is very low. Maximum trap catch was 8 moths, and no egg masses or defoliation were detected.

PHENOLOGY

-1988-

May 31:	Second instar (1/4 inch long): Cook Co.
June 2:	Balsam fir shoots and needles 1/2 to 3/4 developed: South central St. Louis Co.
June 7:	40% pupation and very light defoliation: T59-R21, St. Louis Co.
June 10:	First of 57 pheromone traps set out: Reg.2
June 14:	Beginning pupation: Cook Co.
June 15:	50% pupation: Echo Trail, northeast St. Louis Co.
June 16:	Found single pupa and single late instar larva: Central Lake Co.
June 25:	90% emerged with L-M defoliation: Cotton, St. Louis Co.
June 28:	10% emerged, some pupae are 1/2 normal size: T60-R4W, Cook Co.
June 29:	10% emerged; many, many moths in flight: Gunflint Trail, Cook Co.

-1989-

June 6:	Spruce budworm ¼" long - Grand Marais, Cook Co.
June 8:	Larvae 3/8" to ½" long - Cotton, St. Louis Co.
June 10:	Dandelions have gone to seed - fluff. Spruce budworm in third instar - Twig, St. Louis Co.
June 13:	High bush cranberry in full bloom - Floodwood in St. Louis Co. Balsam Fir shoots 1½" to 3" long - Orr, St. Louis Co.

June 14:	Columbine, Mountain ash and yellow trout lilies in full bloom. Strawberries and yellow rocket in bloom. Sullivan Lake, St. Louis Co.
June 21:	Spruce budworm 50% pupated - Grand Rapids in Itasca Co.
June 29-July 3:	Aerial surveys for spruce budworm.

WHITE SPRUCE CONE INSECTS

-1989-

ACREAGE: 10 acre seed orchard

SEVERITY: 23% of cones damaged

HISTORY: In 1988, approximately 12% of the cones in the seed orchard were attacked by one or more insect.

REGIONAL NOTES

REGION 2

-1989-

Four hundred cones were harvested and dissected to assess insect incidence. Twenty cones from each of 20 trees representing 10 different clones were dissected and examined.

All insects	22.7%
Choristoneura fumiferana (Clemens)	2.7%
Dioryctria abietivorella (Grote)	1.5%
Laspeyresia youngana Kearfote	1.5%
Dasineura rachiphaga Tripp	7.5%
Hylemya anthracina Czerny	12.7%
Other insects	0.5%

Percentages are not additive since some cones were attacked by more than one species of insect. A seed chalcid was found in one cone; possibly, *Megastigmus ateduis.*

FOREST TENT CATERPILLAR
Malacosoma disstria Hubner

-1988-

ACREAGE: 1,314,000 See Map 5: Aspen Defoliation, 1988.

SEVERITY: Moderate to heavy defoliation

-1989-

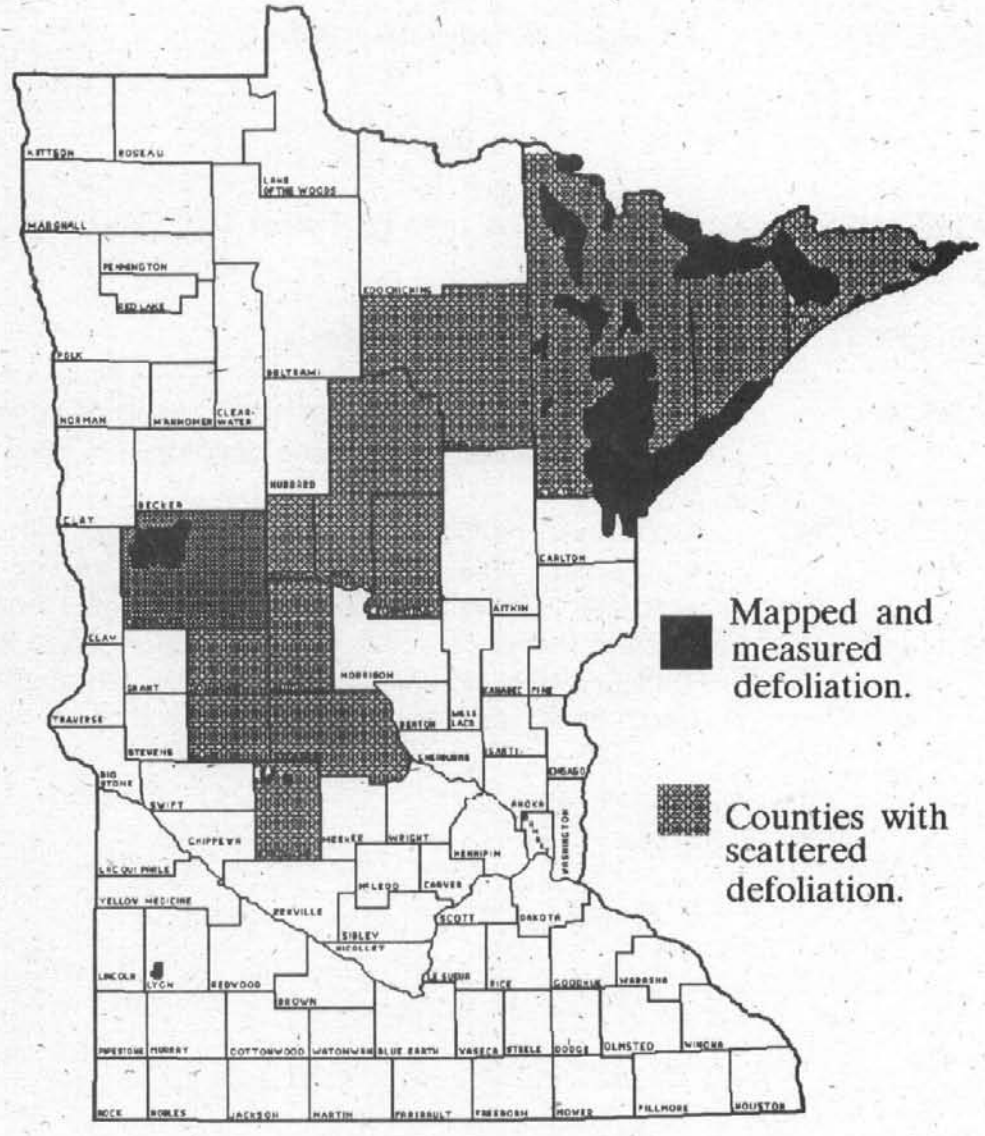
ACREAGE: 4,200,000 See map 6: Forest Tent Caterpillar Defoli ation, 1989.

SEVERITY: Moderate to heavy defoliation

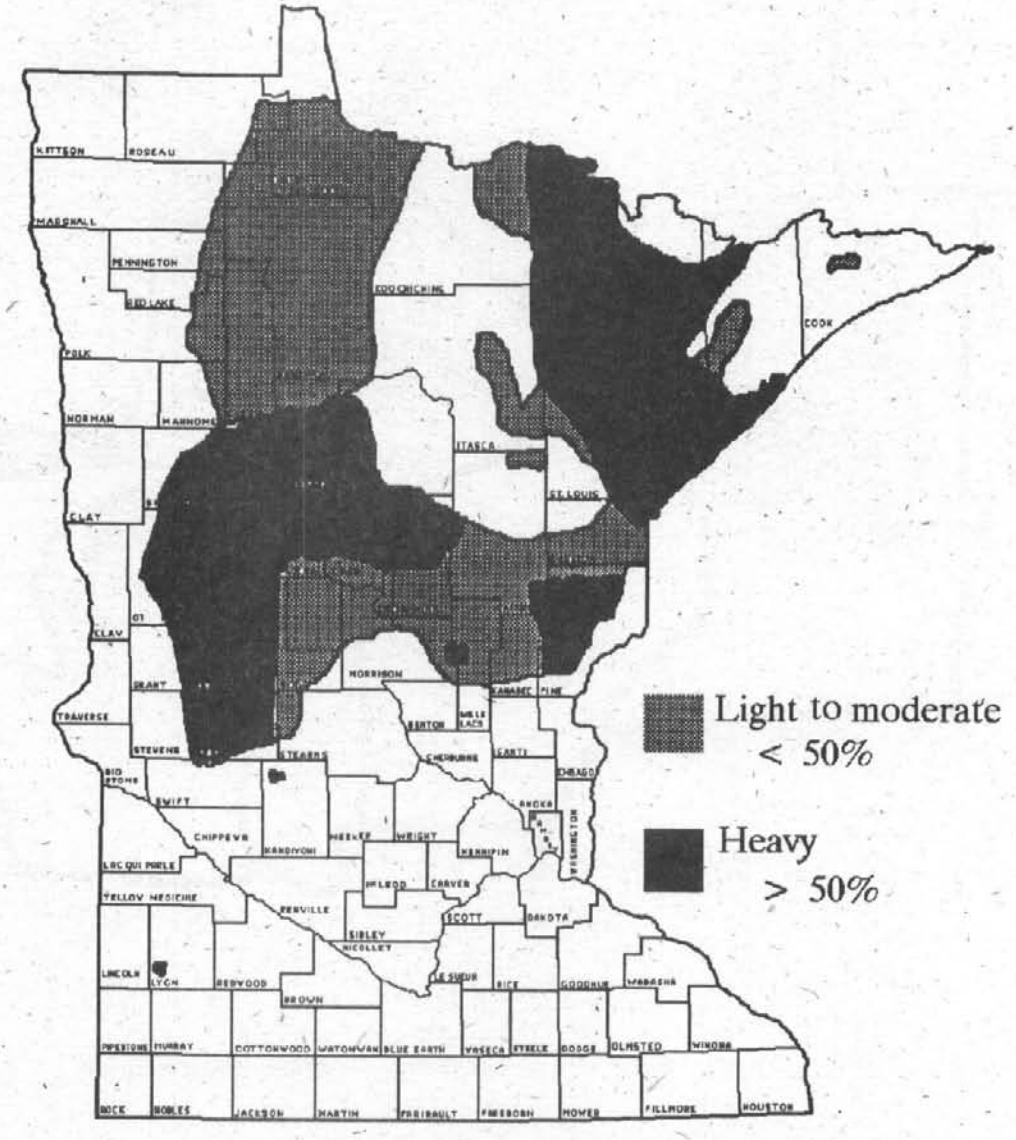
HISTORY: Defoliation during 1988 and 1989 is part of an infesta tion which started to become noticeable during 1987.

PREDICTIONS: Continued expansion of acres defoliated will occur statewide. This outbreak is part of a region wide outbreak involving all 3 of the lake States and the Ontario Provence. See Map 7: Region Wide Forest Tent Caterpillar Defoliation, 1989. Populations should begin to diminish during 1990.

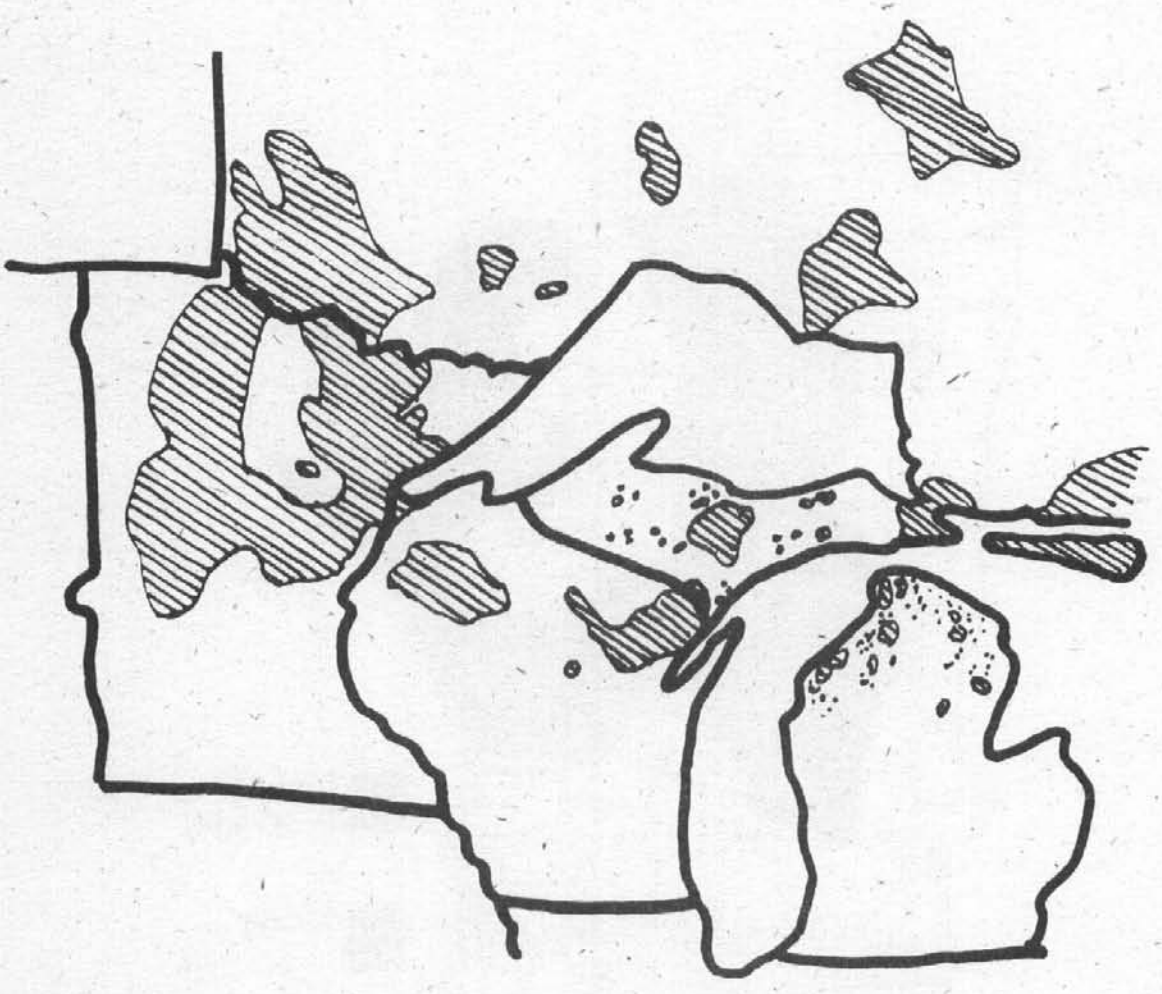
MAP 5: ASPEN DEFOLIATION, 1988



MAP 6: FOREST TENT CATERPILLAR DEFOLIATION, 1989



MAP 7: REGION WIDE FOREST TENT CATERPILLAR DEFOLIATION, 1989



= 20-100% defoliation

REGIONAL NOTES

REGION 1

-1988-

The forest tent caterpillar became obvious in this region during 1988. During 1987, reports were received of early season defoliation in Maplewood State Park in northern Ottertail County. The reports were not clear what defoliator was responsible. In 1988, forest tent caterpillar was the defoliator present, and the FTC did cause complete defoliation to 30,000 acres of basswood and oak in northern and central Ottertail County. Lighter defoliation also occurred in scattered locations throughout Grant and Douglas Counties. Basswood and oak were the preferred species, and aspen growing close to the basswood did not seem to be fed upon. Scattered, single caterpillars were noticed as far north as Bemidji (southern Beltrami County), and it appeared that populations were moving northward from Regions 3 and 5, and westward from Region 2.

-1989-

Heavy defoliation from the FTC in this Region was primarily confined to the part of the Region south of Bemidji. Hardest hit were the basswood and oak forests around lakes in Ottertail, Douglas and Pope Counties. Approximately 460,000 acres were heavily defoliated.

Northward from Bemidji, there was a band of moderate to heavy defoliation through southern Beltrami and Clearwater Counties accounting for approximately 6,500 acres. North of this band stretching to the Canadian border through Beltrami, Lake of the Woods, and Roseau Counties was a 65,000 acre area of mostly aspen showing light to moderate defoliation.

COUNTY	ACRES	SEVERITY
Pope	4,000	Heavy
Douglas	12,000	Heavy
Ottertail	127,000	Heavy
Becker	147,000	Heavy
Hubbard	170,000	Heavy
Beltrami/Clearwater	6,500	Moderate
Beltrami	46,000	Light
Lake of the Woods	17,000	Light
Roseau	2,000	Light

REGION 2

-1988-

The acreage infested in this region accounted for the majority of the total statewide defoliation. Estimated defoliated acres was 1,265,500. The severity of the defoliation ranged from very little detectable defoliation to 100% leaf loss by mid-June. This current defoliation is part of a building FTC population statewide. In 1987, only scattered pockets of defoliated aspen could be found throughout the Region, but in 1988 there was an 8-fold increase in the defoliated acres.

Aspen defoliation was caused by a variety of insects: forest tent caterpillar, large aspen tortrix, aspen leafrollers and tiers, leafmining beetles and possibly, bruce spanworm. Bruce spanworm may have been involved along the northern edge of Lake and Cook Counties. However, the forest tent caterpillar was the most prevalent and most important insect defoliator.

North of Cloquet, Carlton Co., FTC was observed feeding in the upper crowns of oaks. Aspen defoliation looked dramatic this year primarily because many trees did not refoliate due to the dry weather and so remained 'leafless" all season long.

In cooperation with the USFS-State and Private Forestry, the Division is conducting an aspen loss assessment to account for the mortality and growth losses caused by 11 continuous years of FTC defoliation. Losses will be derived from comparisons of Phase 1 data from 1977 and 1988 and from comparisons of aerial photography taken in 1972 and 1988. (See 'Brookston Study" in the Special Studies section.)

-1989-

Acreage:	3,500,000 acres in Region 2
Severity:	Ranged from 0-100%.
Recent History:	Defoliation has increased from 168,000 acres in Region 2 in 1987 to 3.5 million acres in 1989.

Forest tent caterpillar was the primary defoliator of aspen in 1989. Small widely scattered pockets of defoliation occurred throughout Itasca and Koochiching Counties. Woody understory vegetation was completely

defoliated through much of St. Louis County. No massive mortality of the caterpillars was observed due to either starvation or disease.

Forest tent caterpillar in combination with the drought of 1987 and 1988 put a lot of trees under severe stress. This showed up especially in oaks where pockets of dead and dying trees were evident. Two-lined chestnut borer was found in many of these stressed oaks.

A pupal parasitism survey was conducted near Meadowlands in St. Louis County. Of pupae examined, 78% were dead due to parasitism and disease.

Starlings, chipping sparrows and red winged black birds were observed feeding on forest tent caterpillars in Region 2.

REGION 3

-1988-

Forest tent caterpillar made several serious inroads into Region 3 in 1988. About 5,000 acres were defoliated in 1988, with the defoliation peaking by Memorial Day in the Brainerd area. One of the hardest hit areas was the recreational areas near Gull Lake where about 1500 acres were defoliated. Defoliation in Region 3 was most noticeable near larger lakes (>40 acres) and where basswood was present in significant amounts. This pattern was found from Paynesville in southern Stearns County to Gull Lake near Brainerd. This buildup near lakes may be attributed to protection from late spring frosts and/or the high spring temperatures that we have experienced recently. In addition, a number of small stands of aspen in Wadena, Cass, and Crow Wing Counties exhibited noticeable defoliation in widely scattered pockets.

-1989-

The cool spring slowed the development of the caterpillars so that defoliation in the Brainerd area peaked about June 10th. In 1988, defoliation peaked on Memorial Day.

Defoliation expanded from about 5,000 acres in 1988 to 250,000 acres in 1989. The outbreak continues to be confined to lakeshore areas from Stearns County southwest of St. Cloud to Cass and Wadena Counties, but it has expanded to a generally moderate level of defoliation across much of Stearns, Morrison, Wadena, Cass, and Crow Wing Counties. Complete defoliation is present in significant sections of Pine, Mille Lacs, Aitkin, Cass, Wadena, and Carlton Counties.

Many private parties sprayed to protect the foliage in recreational areas near Gull Lake and Lincoln. Total area treated in these two locations was approximately 300 acres. In all cases where DNR Forestry staff provided technical assistance, DiPel 8L was applied at the rate of 8 BIU/acre. Applications were made with a helicopter. About half the area was treated with two sprays timed one week apart.

REGION 5

-1988-

In this Region, 14,000 acres of basswood, aspen, and northern hardwoods were defoliated in Kandiyohi and Lyon Counties. These populations have been active for at least 9 years.

Pupal parasitism surveys were conducted in both Sibley State Park in Kandiyohi County and in Camden State Park in Lyon County. In both parks, less than 15% of the pupae were parasitized.

FTC defoliation, drought, and two-lined chestnut borer caused 20% mortality to the northern red oak on a 800+ acre area of Sibley State Park. FTC has been in these hardwood areas since 1979.

-1989-

Oak mortality in Sibley State Park has been severe due to the combined effects of several years of FTC defoliation and the 1988 drought. Northern red oak mortality was greater that 50% in 1989. Mortality in bur oak increased in 1989 and is expected to continue during 1990.

To protect drought stressed trees, Bt was aerially applied between May 21 and May 25 to 1600 acres in Sibley (Kandiyohi County) and Camden (Lyon County) State Parks. Dipel 8L at the rate of 8 BIU per acre with the addition of 2% Plyac sticker was used. Total spray volume was one gallon per acre. At the time of treatment the caterpillars were in the third and fourth instars. A similar number of private acres was privately treated near the two state parks.

Foliage protection was achieved in all treated areas. In adjacent untreated areas there was some limited moderate to heavy defoliation. The areas treated in 1989 will be retreated in 1990. However, after 1990, no further control measures will be recommended in these two state parks. These areas will be observed to see what FTC will do in these diverse hardwood forests following two years of control.

PHENOLOGY

-1988-

April 7:	Aspen catkin bud break: Itasca and southern St. Louis, and northern Carlton Counties
May 1 & 2:	Aspen leaf bud break begins: Itasca Co.
May 7:	FTC hatch: Brookston, St. Louis Co.
May 25:	Most caterpillar 3/4 - 1&1/4 inch long; 1 colony noted with 1/2 inch long bodies and large head capsules: Brookston, St. Louis Co.
May 27:	FTC are 1&1/4 inches long: Nett Lake, northern St. Louis Co.
June 8:	5% pupated: Orr, St. Louis Co.
June 14:	90% pupated: Echo Trail, St. Louis Co. *Sarcophaga* flies seen on cocoons: St. Louis Co.
June 16:	95% pupated: T56-R17, St. Louis Co. 10% pupated: T57-R12, St. Louis Co. 0% pupated: T54-R13, St. Louis Co. 90% pupated: T50-R17, St. Louis Co.
June 24:	Moth flight begins; < 5% emerged: T50-R13, central St. Louis Co.
June 25:	0% emerged; abundant parasitism: north of Cotton, St. Louis Co.

-1989-

April 13:	About 50% of aspen catkins have emerged. Grand Rapids, Itasca County & Cloquet, Carlton Co.
May 7:	Green leaves show on black cherry and raspberry. Aspen catkins spent. Grand Rapids, Itasca Co.
May 11:	Less than 1% of aspen have leaves. No FTC have hatched yet. Brookston, St. Louis Co. Unhatched FTC egg masses and larvae both present. Side Lake, St. Louis Co.
May 20:	Bigtooth aspen leaves small grayish in color. Lilacs just beginning to bloom. *Trillium* in bloom. Grand Rapids, Itasca Co.
May 22:	FTC larvae 1" long. Itasca Co.
May 25:	Choke cherries and cotton grass in bloom. Tamarack mostly leafed out. Ash beginning to leaf out. Lots of aspen "cotton" in the air. Itasca Co. FTC larvae 1" long Brookston - St. Louis Co. Red wing black birds feeding on FTC larvae

June 10: Starlings feeding on FTC larvae.

June 14: Buttercups, daisies and goatsbeard in full bloom. *Ledum* in bloom. FTC larvae 1¼"-1½" long. Meadowlands, St. Louis Co. Columbine and mountain maple in bloom. Dandelions have gone to seed. Yellow trout lilies in full bloom. Choke cherries just finished blossoming. Strawberries and yellow rocket blooming. Sullivan Lake, St Louis Co. FTC larvae 1½"-2" long. Lilacs just fading. North of Two Harbors, St Louis Co.

June 18: FTC forming cocoons Hibbing - St. Louis Co.

June 21: FTC just starting to pupate Cotton - St. Louis Co.

June 25: 90% of FTC in cocoons Hibbing - St. Louis Co.

June 29-July 3: Aerial surveys for FTC flown.

First Observed FTC Activity in Past Years

YEAR	DATE	EVENT	COUNTY
1979	5/17	Eggs hatching	Southern Cass
	5/24	Eggs hatching	Hubbard
	5/29	1/4" long larvae	Lake of the Woods
1980	4/21	Eggs hatching	Carlton
	5/2	Eggs hatching	Becker
1981	5/1	Eggs hatching	Carlton
1982	4/26	Eggs hatching	Carlton
1983	5/17	First immature larvae	Carlton
1984	5/17	First immature larvae	Carlton
1985	5/6	Eggs hatched	Carlton
1987	4/18	Eggs hatched	St. Louis (Brookston)
1988	5/7	Eggs hatched	St. Louis (Brookston)
1989	5/11	Eggs hatching	St. Louis (Side Lake)

LARGE ASPEN TORTRIX
Choristoneura conflictana (Walker)

-1988-

ACREAGE: Not determined, but a significant portion of the aspen acres defoliated in eastern Cook Co. were defoliated by this insect.

SEVERITY: Generally, < 20% defoliation occurred. In eastern Cook County, complete defoliation in early spring occurred and the aspen looked like they did not leaf out.

HISTORY: In 1987, 200,000 acres were defoliated by the tortrix.

-1989-

ACREAGE: None due to forest tent caterpillar defoliation.

PREDICTIONS: This defoliator seems to be declining in numbers and impact. With the increase in forest tent caterpillar activity, very little tortrix should be detected during 1990.

REGIONAL NOTES

REGION 2

-1988-

The forest tent caterpillar and other aspen defoliators joined the tortrix in Cook County and obscured the exact location of their respective populations. Tortrix were the only aspen defoliators found on the eastern tip of Cook Co. Elsewhere in the Region, tortrix was rarely found.

PHENOLOGY

-1988-

June 15: Moths emerged in collections: Cook Co.

BIRCH LEAFMINER
Fenusa pusilla (Lepeletier)

-1988-

ACREAGE: Not determined

SEVERITY: Heavy (75%) crown infested

-1989-

ACREAGE: Not determined

HISTORY: Increasing due to dry year in '87 and drought of 1988

PREDICTIONS: Continued activity should occur, particularly if the weather remains dry.

REGIONAL NOTES

REGION 2

-1988-

In 1987, birch leaf miner defoliation was extremely heavy in all counties within the Region.

Similar to the report last year, our aerial survey found the birches along the North Shore to be completely tan due to the effects of the miners and the droughty weather.

REGION 5

-1988-

Leaf miner activity was very high throughout southern Minnesota because of the drought conditions. Similar to drought, the leaf miner infestation is another stress factor to the birch. Significant birch dieback and mortality from the bronze birch borer should start to become evident in 1989 on trees stressed by leaf miners and drought.

PHENOLOGY

-1988-

June 2: Noted first crown discoloration due to mining activity: Itasca Co.

ELM LEAFMINER
Fenusa ulmi Sund.

-1988-

ACREAGE: 100,000

SEVERITY: Complete infestation.

HISTORY: Continued higher level of infestation throughout the hardwood forest over '87 levels.

PREDICTIONS: Leaf miner activity will depend on conditions next spring. If dry cycle continues, expect high populations.

REGIONAL NOTES

REGION 5

Despite the Dutch elm disease there is still a sizeable population of American elm in southeastern Minnesota. These elms can be easily detected in early summer because they have been completely infested with leaf miners. During the drought of 1988, a second generation was apparent in mid-August.

ELM LEAF BEETLE
Pyrrhalta luteola (Muller)

-1988-

ACREAGE: Unknown

SEVERITY: Heavy infestation affecting 50-100% of the crowns

HISTORY: Little activity noted in the past

PREDICTIONS: High if dry cycle continues

REGIONAL NOTES

REGION 5

Elm leaf beetle populations were very heavy in south central Minnesota in August on Siberian elm in windbreaks and small towns. The infestation was most evident in Nicollet and Sibley Counties.

OAK TWIG PRUNER
Elaphidionoides villosus (F.)

-1988-

ACREAGE: Unknown

SEVERITY: Moderate: 40% of the crowns of infested trees were affected

HISTORY: Activity was first noted during 1987. In 1988 twig pruner activity was increased greatly.

REGIONAL NOTES

REGION 5

Northern red oak throughout its range south of St. Cloud was infested. The dry cycle has contributed to the buildup.

ALDER TUBEMAKER
Acrobasis rubrifasciella Packard

-1988-

ACREAGE: Not determined; widespread where alder is found in Itasca, St. Louis and Lake Counties

SEVERITY: Predominantly heavy defoliation (>50%).

-1989-

ACREAGE: Not determined.

SEVERITY: Defoliation was widespread in 1989. Areas which suffered heavy defoliation in 1988 commonly had extensive twig dieback in 1989.

REGIONAL NOTES

REGION 2

-1988-

Alder in much of the Region had rather sparse foliage and many bare branch tips due to the alder tubemaker. In the spring, tubemaker larvae mine buds and leaf petioles. As the larvae grow, they begin to feed on the leaves which they tie into clusters. Inside the leaf clusters, they build a tube-like shelter made of frass and lined with silk.

BASSWOOD THRIPS
Species undetermined

-1988-

ACREAGE: Not determined

SEVERITY: 90% defoliation in two new locations in St. Louis Co

-1989-

ACREAGE: Not determined

SEVERITY: In the southeastern counties, defoliation was widespread and heavy.

HISTORY: In 1987, defoliation was light. Both defoliation and mortality have been observed since 1983 in Carlton Co. and in the southeast.

PREDICTIONS: Unknown, but populations and defoliation seem to be present every year. Some mortality will probably occur in basswood due to the added stress of the drought.

REGIONAL NOTES

REGION 2

-1988-

Severe defoliation, topkill and mortality were observed in 2 locations in St. Louis Co.: 2-50-19 and 11-50-19.

Region 5

-1989-

In southeastern counties, defoliation has been widespread and heavy. In the past 8 to 9 years, basswood defoliation has varied from light to heavy with subsequent refoliation completed by mid-June. This year with the obvious higher numbers of thrips and the effects of the 1988 drought, refoliation did not occur until early July. In mid July basswood crowns still appeared weak and off-color. The basswood resource is under great stress; some mortality of the weaker trees is expected.

TWO-LINED CHESTNUT BORER
Agrilus bilineatus (Weber)

-1988-

ACREAGE: Unknown

SEVERITY: 1-2% mortality in red oak type statewide; some limited areas up to 20% mortality

-1989-

ACREAGE: Not determined, but greatly expanded from 1988

SEVERITY: 20% tree mortality was common, and there was up to 70% mortality and dieback in drought-stricken counties throughout central Minnesota.

HISTORY: This insect and the resultant oak dieback and mortality have been generally undetectable in most years. As a result of the hot, dry conditions during the 1988 growing season, early fall color in the oaks was noted. During the 1989 growing season, dead tops and trees were common through the central and southern parts of the state.

PREDICTIONS: Insect activity and oak mortality in association with *Armillaria* root rot should continue even with a return to favorable growing conditions. If the drought continues, oak mortality will increase. Highest mortality rates should occur in those oak stands that have sustained multiple years of defoliation by the forest tent caterpillar.

REGIONAL NOTES

REGION 1

-1988-

Little evidence of this insect and resultant oak mortality was evident in the Region during 1988. Both red oaks and bur oaks in Ottertail and Douglas Counties experienced early leaf coloration and drop. This was attributed to leaf scorch brought on by the abnormally high temperatures.

-1989-

By August, many red oaks from Bemidji south were undergoing leaf color changes. Leaf color was not the typical crimson of normal fall coloration, but a brown, dead color. And, although there was leaf drop, the affected oaks held onto a lot of the browned leaves even through the winter months. Lake Carlos State Park in Douglas County was particularly hard hit in one of their campgrounds. Recent underground utility work throughout the campground was also a contributing factor to stress on the trees which predisposed the trees to attacks by the two-lined chestnut borer.

Another area showing dramatic loss of oak due to stress and this borer was at Inspiration Peak in Ottertail County. A timber sale was set up in this area to salvage dead and dying oaks.

Heavy oak loss was also reported from Cass County, especially on droughty soils.

REGION 2

-1989-

The drought in combination with defoliation and two-lined chestnut borer has resulted in significant amounts of oak mortality and dieback in the southern portions of the Region. Heaviest mortality occurred on hills and ridge tops. The mortality and dieback began to show up in mid- to late-summer as wilting and discoloration of the leaves. *Armillaria* root rot is also likely involved in the mortality.

REGION 3

-1989-

This insect quickly became the major pest problem in the central part of the state. Red oaks were attacked and killed in significant quantities over most

of the area stricken by the drought during 1988. Two-lined chestnut borers attacked oak in pure and mixed stands killing as much as 70% of the trees in some areas. While damage has been high in some localities, most areas have been subjected to mortality in the 10 to 20% range.

Some of the highest mortality came in pole size stands that were thinned in 1987 and 1988 in Crow Wing County. Mortality to the residual stems exceeded 40% with serious damage to the remaining trees. Thinning reduces competition for moisture and in the long run the residual trees should be more vigorous and grow faster. The immediate response to thinning is stress on the residual trees. The increased stress is caused by the elevated temperatures and wind speeds found in thinned stands for several years until the crowns close. In addition, the water in the soil spaces vacated by the thinned trees does not become available to the residual trees until their root systems have expanded into the vacated zones.

Other areas suffering serious mortality included Stearns, Morrison, Benton, Sherburne, and Anoka Counties where the drought was most severe. Most sandy sites suffered increase mortality as well. TLCB mortality was also high in areas of southern Cass County that were defoliated by the forest tent caterpillar.

REGION 5

-1988-

Drought related mortality from the two-lined chestnut borer started showing up in the last week in July in the northern part of the Metro Region and the first week in August in the southeast hardwood forest. The first trees attacked were those on the edges of harvested areas or logging roads. In Sibley State Park in northern Kandiyohi County and in limited areas in the southeast, red oak mortality rates approached 20%. These included sandy sites where the northern red oak is slow growing and in one area that was selectively harvested three years ago. This drought related mortality was particularly dramatic because in most years the activity of TLCB is so low as to be undetectable.

-1989-

Losses due to this insect were two times greater in 1989 than the losses during 1988. The highest rates of mortality were found in stands that were poorly managed, stands on poor soils, stands defoliated by the forest tent caterpillar, or stands with a history of grazing.

GYPSY MOTH

Lymantria dispar (Linnaeus)

-1988-

ACREAGE: 87

SEVERITY: One isolated infestations; otherwise, single moths

-1989-

ACREAGE: No information

SEVERITY: Four isolated infestations (2 known and 2 unknown); otherwise single moths

HISTORY: Existing isolated infestations were treated; likely new infestations will be detected.

PREDICTIONS: No established populations of gypsy moth are expected to be found. Small numbers of male moths will continue to be recovered from existing infestations and from new introductions. Detected infestations will be controlled.

STATEWIDE MONITORING PROGRAM

-1988-

Statewide cooperative efforts between the state and federal Departments of Agriculture resulted in the placement of 6,995 traps within the Metro area and selected outstate counties. The Department of Natural Resources cooperated by placing an additional 529 traps on high use public lands throughout the state.

There were no male gypsy moths found in the traps placed by Division of Parks and Forestry personnel. The Minnesota Department of Agriculture recovered 64 moths taken from 19 traps statewide.

The catches by locations are as follows:

County	Location	#moths/trap
Anoka	Coon Rapids	2/2
Hennepin	Bloomington	1/1
	Deephaven	1/1
	Minnetonka	41/7
Ramsey	Roseville	2/1
	St. Paul	1/1
Sherburne	Elk River	13/3
Washington	Denmark	1/1
	Cottage Grove	1/1
Wright	Delano	1/1

-1989-

There were two areas with significant trap catches. These were located in Minnetonka and Elk River where approximately 60 moths were recovered. The trapping in these two areas was designed to delineate the areas which need control measures in 1990. Catches were also made in Rochester where delineation trapping will be used in 1990. Egg masses were collected at each site.

Three sites were mass trapped in 1989. Delano, treated in 1988, had no moths, but Elk River and Minnetonka sites had 70 and 69 moths, respectively. Twenty moths were taken in detection traps, all in the Metro except for one trap catch of 5 in Rochester. Only 3 traps caught more than 1 moth: 1 in Rochester and 2 in Minneapolis. Delimiting trapping will be under taken in 1990 by the Department of Agriculture (MDA).

REGIONAL NOTES

REGION 1

-1988-
152 traps; 0 catches

-1989-
152 traps; 0 catches

REGION 2

-1988-
140 traps; 0 catches

-1989-
140 traps; 0 catches

REGION 3 & 6

-1988-
115 traps; 0 catches

A two-acre infestation was found in 1987 in a Wright County farm yard near Delano and was treated in 1988. The area received two ground applications of Dimilin. One male moth was recovered in 1988.

The infestation found in Anoka county in 1987 was treated in May of 1988. The 87 acre area was treated with three aerial applications of Dipel (*Bacillus thuringiensis*) at weekly intervals beginning on May 13. A small core area centered around the point of introduction was also treated with Dimilin, an insect growth regulator. The treatments were successful as no male moths were recovered during the trapping season.

New possible infestations were discovered in Minnetonka and Elk River. Subsequent egg mass surveys did not recover any viable life stages so these areas will be mass trapped in 1989.

-1989-
132 traps; 0 catches

Egg searches at the Elk River site discovered 16 viable masses. Egg searches at the Minnetonka site discovered 6 viable egg masses. Both sites will be sprayed in May of 1990.

Two sites will be treated in 1990. The one area is a rural interface area of about 25 acres in Sherburne County at S.35 T.33 R.27. Five or six homes would be affected. The other is a heavily developed area of Minnetonka about 35 acres in size involving several dozen homes. Both areas will be sprayed with three aerial applications of Foray 48B at 16 BIU. Dimilin will not be used in 1990. MDA and USDA will operate the spray projects. DNR will provide aerial photography of the spray sites, communications overhead, and will actively participate in the operations.

REGION 5

-1988-
122 traps; 0 catches

-1989-
122 traps; 0 catches

There were two areas with significant trap catches. These were located in Minnetonka and Elk River where approximately 60 moths were recovered. The trapping in these two areas was designed to delineate the areas which need control measures in 1990. Catches were also made in Rochester where delineation trapping will be used in 1990.

PEST CONDITIONS REPORT: DISEASES

SHOOT BLIGHTS OF PINE
Sphaeropsis sapinea (Fr.) Dyko & Sutton
Sirococcus strobilihus Preuss

-1988-

ACREAGE: Not determined; common and widespread in Itasca, St. Louis and Lake Counties.

SEVERITY: Symptoms range from just a few current year twigs infected to thinning of entire crowns in mature pines.

-1989-

ACREAGE: Not determined

HISTORY: These diseases are endemic to Minnesota. Infections occur during wet weather, but symptom expression is greatest during droughty weather.

PREDICTIONS: *Diplodia* blight and canker (*S. sapinea*) should be more evident during 1990. Because of the drought of 1988 and 1989, it is likely that this disease will progress from killing shoots to killing branches, tops, and entire trees.

REGIONAL NOTES

REGION 2

-1988-

In Lake Co., shoot infestations were light (<20%) in mature, pole-sized and small plantation red pines. Mature pines growing along a 10 mile stretch of highway in central Lake Co. had very thin lower crowns due to heavy shoot blight infections.

In west central Itasca Co., pole-sized pines and understory regeneration showed light shoot blight.

SWEETFERN BLISTER RUST
Cronartium comptoniae Arth.

-1989-

ACREAGE: 80 acres; 2 plantations

SEVERITY: 25 - 45% bole infections

REGIONAL NOTES

REGION 2

Two plantations with a high incidence of sweetfern blister rust were surveyed.

A plantation in Sec. 36-61-22W was a mixture of red and jack pines and approximately 35 years old . This plantation had been thinned at least once. Forty-five percent of the remaining jack pine have sweetfern blister rust infections.

Another plantation in Sec. 25-61-22W was a 35 year old jack pine planting. It also had been thinned at least once. Twenty-five percent of the trees had sweetfern blister rust infections and 0.5% were infected with *Commandra* rust.

WHITE SPRUCE CONE DISEASES

American Spruce-Raspberry Rust: *Pucciniastrum americanum* (Farl.) Arth
Inland Spruce Cone Rust: *Chrysomyxa pirolata* Wint.

-1988-

ACREAGE: 10

SEVERITY: 2.8% of the cones infested

-1989-

ACREAGE: 10

SEVERITY: 16.8% of cones infected

HISTORY: Rust incidence in 1987 and 1988 was very low due to dry spring weather both years.

PREDICTIONS: A very small cone crop is expected in 1990. Rust incidence will depend on weather.

REGIONAL NOTES

REGION 2

-1989-

Cone production in the seed orchard was 122 bushels. The cones yielded 125 lbs. of seed or 16.5 oz./bushel. Five hundred unsprayed cones were examined for rust infection on June 28, 1989. Cones were rated as infected or not infected, and the number of infections on each infected cone was determined. Most infected cones had only one infection. Spruce-raspberry rust infections were observed on 16.8% of the cones. *C. pirolata* infected 1.2% of the cones.

AMERICAN CHESTNUT BLIGHT
Endothia parasitica (Murr.)

REGION 5

-1988-

In 1984, chestnut blight was reported for the first time in Minnesota. The site was in a windbreak grove 10 miles east of Rochester. In 1986, the merchantable trees were harvested and sawn on the site using a portable mill. In the last two years, chestnut sprouts continue to grow and be attacked by the canker disease. In both 1987 and 1988, a hypovirulent strain of the fungus was introduced for control evaluation.

In a separate event in 1988, fifty (50) American chestnut seed from an apparent disease free grove in Houston County were exported to New Zealand. The seeds traveled by airmail to a closed quarantine agricultural station in Auckland, New Zealand. There they will be stratified and later grown in quarantine for a year to make sure the chestnut blight does not enter the country.

OAK WILT DISEASE
Ceratocystis fagacerum (Bretz). Hunt

REGIONAL NOTES

REGION 5

-1988-

Surveys were conducted using both color infra red aerial photography and aerial sketch mapping techniques. Roughly 410 oak mortality centers were detected by aerial sketch mapping in an 18 county area in southeastern Minnesota. The majority of these areas are suspected to be oak wilt disease. The average size is estimated to be 1 to 3 acres. The disease was found as far west as Mankato.

-1989-

An additional eleven townships were photographed in 1989 in portions of Washington, Scott, Dakota, Olmstead, Wabasha, and Winona Counties. The results of the photo interpretation are yet to be reported.

In Olmstead County southeast of Rochester, a vibratory plow control demonstration was conducted on private land in August of 1989. The session was well attended and interest was high for an expanded program.

Additional oak wilt survey results and more detailed description of survey methodology are reported in the Special Reports section.

ASH YELLOWS
Mycoplasma-like Organism

ACREAGE: 10 acres

SEVERITY: 50% of the ash are affected; 30% mortality

HISTORY: This is the first confirmation of Ash Yellows in Minnesota. It is estimated that this disease has been in the woodlot for 3-5 years.

REGIONAL NOTES

REGION 5

-1988-

On a 10-acre farm woodlot in Olmsted County, Sec. 35, T107, R13W, 100 black ash (*Fraxinus nigra*) averaging 12 inches DBH were identified as showing ash yellows symptoms. The infestation was estimated to be 3 to 5 years old. The current mortality was 30% with an additional 20% in advanced stages of decline.

In Iowa and Wisconsin, this disease has been found on white ash. In New York and Indiana this disease has been reported in green ash. The infected woodlot in Olmstead County is the first report of the disease in Minnesota, and it is the first report of the disease occurring on black ash.

An additional seven sites were checked in 1988 for ash yellows. The sites were S28-T104-R7W, S11-T103-R7W, and S12-T102-R7W in Houston County; and S2-T103-R9W and S19-T102-R8W in Fillmore County. These areas of known ash stands were surveyed by the U.S. Forest Service using color infrared photography and ground checked by Division personnel. No additional ash yellows was found.

-1989-

In 1989 a salvage harvest was conducted in the 10 acre Olmstead County site. All merchantable timber was removed. When the sale was completed, the remaining ash trees >1 inch in diameter were chain saw girdled, and the girdles were treated with Tordon RTU. Ash less than 1 inch were pulled by hand and destroyed.

WINTER INJURY

Region 5

-1989-

Widespread winter injury to a number of conifer and hardwood species was evident in early 1989. Large Norway spruce found in shelterbelts across the southeast were damaged and some mortality occurred. This was the second time in ten years of observations that Norway spruce have been killed by winter conditions in this Region. Serious winter injury was also evident on balsam fir, red pine, and other conifers.

On hardwoods, Siberian elm initially produced only sparse foliage because many of the small branch tips had been killed. Several ornamental honeylocust in the Olmstead County area did not begin to leaf out until the first week in July. Foliage production occurred from dormant buds on older portions of branches. Most of the younger, branches with current year buds had been killed by the winter conditions.

SPECIAL PROJECTS

-1988-

HAZARD TREE EFFORTS

Hazard tree rating was an important project for the Insect and Disease Unit during the entire year. A hazard tree is any tree or part of a tree that poses a high risk upon failure or fracture for damage or injury to people or property (1). Both the Division of Forestry and Division of Parks recognized the need for developing a system to rate hazard trees and for training field personnel. Because of this need, the I&D Unit risk rated 4 recreation/public sites, held training sessions and workshops and started developing a hazard tree rating program.

Four recreation/public sites were rated for hazard trees. These included Sakatah Lake, Helmer Myre, and Nerstrand Woods State Parks; and Region 2 office site. These ratings served a dual purpose: (A) to actually rate the trees, and (B) to develop a rating system that had statewide applicability. This rating system would enable a person to decide if a tree's defects warrant an action such as removal or pruning. The decision to take action is based on its potential to fail in the next 1 year period.

Numbers of trees rated and actions taken:

Site	Evaluated	% Removed	%Pruned	% No Action
Sakatah Lake				
Campgrounds	239	44	35	21
Helmer Myre				
Campgrounds	340	30	20	50
Nerstrand Woods				
Campgrounds	667	31	30	39
Pioneer Camp	192	17	0	83
Picnic Grounds	356	4	4	92
Reg. 2	116	8	43	49

Contracts were let and the recommended actions were accomplished.

To begin fulfilling the need for training Department personnel, 3 formal training sessions were held. Dr. Alex Shigo and I&D Unit personnel conducted a seminar on "Assessment and Management of Hazard Trees" for 125 people from the Divisions of Forestry, Parks and Trails and Waterways, Dept. of Transportation and a few others. Dr. Shigo is a leading expert on hazard trees and is currently a private consultant. He worked as a forest pathologist for the U.S. Forest Service from 1959 to 1985. The day-long seminar focused on the basics:

tree biology
compartmentalization of decay in wood
structure and function of roots
identification of stem and branch defects
identification of root problems, and
application of hazard rating system

Dr. Shigo then conducted a smaller workshop for the I&D and Vegetation Management personnel. An action plan and a format for developing a hazard tree management program were devised.

The Division of Parks requested additional training for their personnel. The topics "How a tree grows" and "Backyard tree care" were presented by Pest Specialists in December.

Based on the preliminary work and upon input by Dr. Shigo, the Division of Forestry and Division of Parks decided to expand the rating system and develop a training package. Additional training will address specifics of the hazard tree rating system, identification of hazard trees in the field, and balancing the aspects of safety, funding, and aesthetics when rating a site.

(1) Adapted from Alex Shigo, "A New Tree Biology Dictionary". 1986. Shigo & Trees, Assoc. Publ. Durham, N. Hamp.

BROOKSTON ASPEN LOSS ASSESSMENT

A loss assessment survey is being conducted as a cooperative study by the MN-DNR Division of Forestry and the USFS - State & Private Forestry. The survey is to determine the volume of aspen lost due to continuous defoliation by the forest tent caterpillar in a five township area in southwestern St. Louis County.

Color infra-red 9X9 aerial photographs taken the summer of 1988 will be used to make an accurate determination of the acres of aspen with mortality and to rate the aspen stands according to level of mortality.

FIA permanent inventory plots were established in the study area during the 1977 inventory. Remeasurement of these plots will be completed by January, 1989. The data from these plots will be used to determine the number of trees killed and the volume of aspen lost due to continuous defoliation by the forest tent caterpillar since 1977. This study will also be used to test the accuracy of data derived from inventory plots in a small localized area.

WHITE SPRUCE SEED ORCHARD CONE PEST STUDIES - 1988

Insects, diseases, and other damage to white spruce cones were monitored and evaluated at the White Spruce Seed Orchard. For the past 3 years, the cone crop has been very low; usually less than 500 cones were produced in the entire orchard each year. In 1988, a large cone crop was produced. Approximately 2/3 of the trees were fruitful and the orchard produced 153 bushels of cones. The yield was 220 lbs. of improved seed, and which averages 23 oz. of seed per bushel.

391 cones were harvested on July 27 in order to assess pest incidence. Twenty cones from each of 20 trees representing 20 different clones were dissected and examined.

Damage	Incidence
All insects	**11.8%**
Dioryctria	0.5
Choristoneura	3.3
Dasineura	3.5
Hylema	1.7
Laspeyresia	2.8
Diseases	**2.8**
Pucciniastrum rust	2.8
Shrivelled cones	**2.0**
Seed empty or shrivelled	**14.0**

The cones were rated as either "good" or "no good" for seed production. Seed production in 66% of the cones was rated as "good" which is an increase from 1.1% in 1987.

Two new cone pests were found, spruce seedworms and spruce cone axis midges. Seedworms, *Laspeyresia youngana*, are major pests of spruce cones virtually across the continent. These insects leave no external evidence of damage. Infested cones have the cone axis hollowed out and seedworms move from seed to seed consuming their contents. Usually 1-3 seedworms infest a single cone. Seedworms overwinter inside cones which suggests a control measure, picking 100% of the cones to eliminate their winter habitat.

Cone axis midges, *Dasineura rachiphaga*, usually do not damage the seed. Like seedworms, there is no external evidence of infestation and they have a trans-continental distribution. The only damage the axis midges do is to hollow out the cone axis which sometimes disrupts water flow to the cone tip. Many midge larvae are active in a single cone, and they form tiny, white cocoons in the cone axis. Control of these insects is not necessary.

On June 25, 1,950 cones (representing 13 clones) were rated for cone rust incidence. Earlier in the year, the orchard was operationally sprayed with either mancozeb or chlorothalonil to prevent rust infection. One quarter of the orchard area was not treated and thus served as a control. Due to the extremely dry conditions during May and June, rust infection was only 1.7%. *Chrysomyxa pirolata* infections were observed in the orchard but did not appear in the samples or study cones.

Fifty cones in the mid and upper crown of each of 13 ramets were inspected and number of rust pustules were counted.

Number of rust pustules

Clone	Control	Mancozeb	Chlorothalonil
7222	2	1	0
7219	1	0	0
5229	0	2	0
7241	0	1	0
7241	0	0	0
3767	3	2	0
7171	2	0	0
7171	0	1	1
7223	1	1	1
7223	1	1	0
7233	0	0	0
7210	1	0	1
7170	0	0	1
Sum	11	9	4

= Significantly different from the controls at the 10% level as determined by the student's t-test for pairs.

Two clones, #7237 and #7233, were apparently rust free.

PHENOLOGICAL NOTES:

April 21: Spruce vegetative buds have lower row of bud scales starting to open, otherwise scales tight. *Pyrola* shedding seed, leaves green. No infection noted. Raspberry canes inactive, dark red in color. Maple floral buds just breaking. Lake is open. No grasses in orchard.

April 27: Noted many floral buds, uncertain as to gender. Vegetative buds scales starting to open. Mound ants active. Saw mourning cloak butterfly.

May 3: 2/3 of trees with female floral buds.

May 6,8,9: First rain in a month.

May 11: All male and female cones open, bud caps 95% off and a few starting to shed pollen. Female cone scales flared. Could not see any difference in development of cones on clone #7237 except they are a little smaller and are brighter red in color.

May 16,17: 3/4 of the orchard sprayed with fungicides, mancozeb or chlorothalonil. 90% of pollen shed.

May 25: Most cones partially pendant, scales closed. Cotton grass and dandelions in full bloom.

June 2: Cones 1 1/4 inch long. Noted spruce budworm feeding damage.

June 6,7: Second fungicide treatment.

June 10: Raspberry floral buds almost ready to bloom.

June 25: Rated cones for presence of rust pustules.

July 26: Identified rust infected raspberry plants.

July 27: Cones harvested.

SPECIAL PROJECTS

-1989-

WHITE SPRUCE SEED ORCHARD CONE PEST STUDIES - 1989

Insects, diseases, and other damage to white spruce cones from the white spruce seed orchard near Cotton have been monitored and evaluated since 1981. See Charts 1 and 2. In 1989, 42% of the cones were damaged. See Chart 3. Insects accounted for the majority of the damage; nearly 55% of the damaged cones were damaged by insects.

Despite the damage to 42% of the cone crop, 122 bushels of cones were harvested. The cones yielded 125 lbs. of seeds or 16.5 oz./bushel. In 1988, 153 bushels of cones were harvested yielding 220 lbs. of seed or 23 oz./bushel. By contrast, 1987, 1986, and 1985 were very poor cone production years; usually less than 500 cones were produced in the entire orchard each year.

Results

Cone Rust Incidence

On June 28, 500 unsprayed cones were examined for rust infection. Cones were rated as infected or not infected. The number of rust infections was also determined on infected cones.

Most infected cones had only one infection. Spruce-raspberry rust, *Pucciniastrum americanum*, infection was observed on 16.8% of the cones. Inland spruce cone rust, *Chrysomyxa pirolata*, infection was observed on 1.2% of the cones. This rust causes a systemic infection of the entire cone.

CHART 1: CONE PESTS WHITE SPRUCE SEED ORCHARD

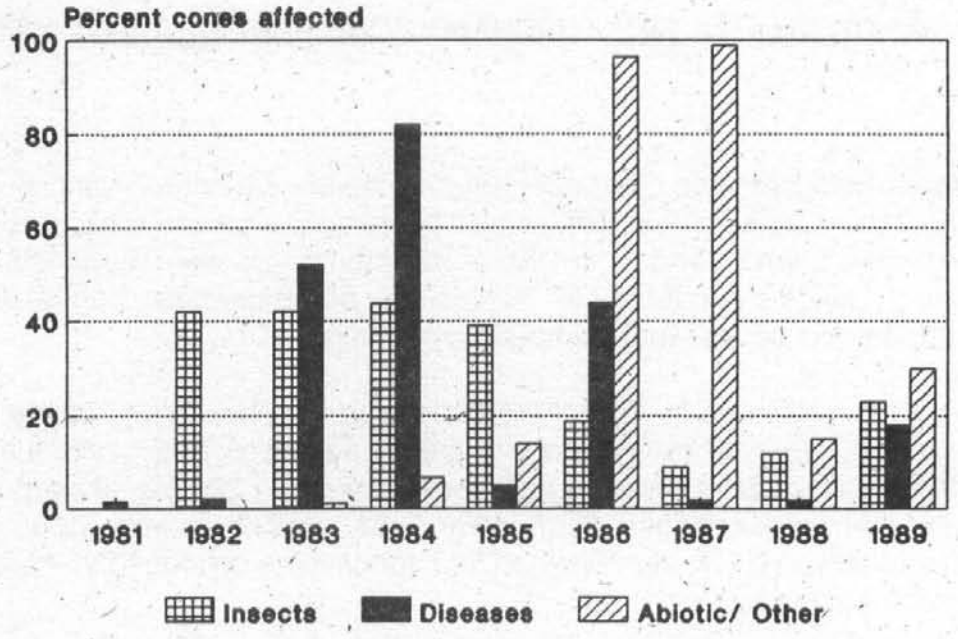


CHART 2: INSECT AND DISEASE INCIDENCE IN WHITE SPRUCE

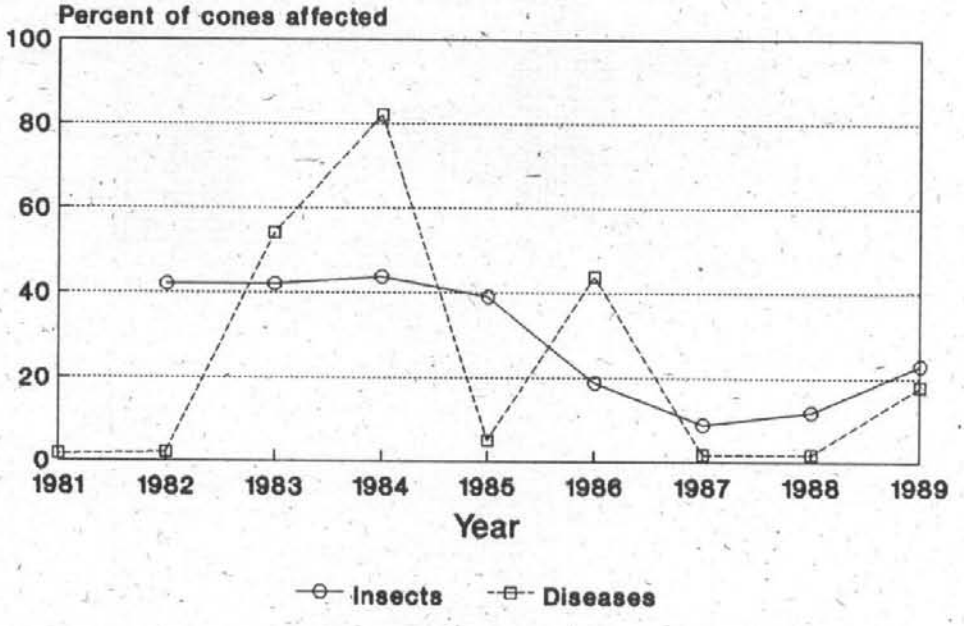
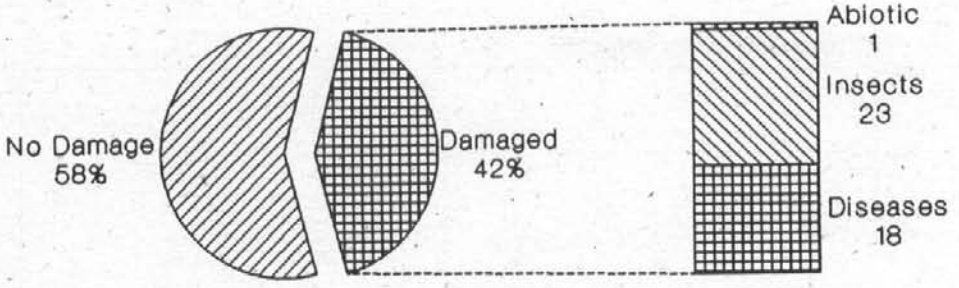


CHART 3: CONE DAMAGE - 1989



Cone Insect Incidence

At the time of harvest, 20 cones from each of 20 trees representing 10 different clones were dissected and examined for insect damage. Results are listed below:

PEST	INCIDENCE
All insects	22.7%
Choristoneura fumiferana (Clemens)	1.5%
Dioryctria abietivorella (Grote)	1.5%
Laspeyresia youngana Kearfott	1.5%
Dasineura rachiphaga Tripp	7.5%
Hylemya anthracina Czerny	12.7%
Other insects	0.5%

Percentages are not additive since some cones were attacked by more than one species of insect.

A seed chalcid was found for the first time in this seed orchard; this chalcid may possibly have been *Megastigmus atedius* Walker.

Overall Cone Rating

When cones were dissected and examined, the cones were also rated as "good" or "no good". To be rated as "good", more than 50% of the seeds must appear sound. Overall, 58% of the cones examined at the time of harvest were rated as "good".

Fungicide Trials

Two fungicides were tested for efficacy against cone rust. The fungicides tested were chlorothalonil (Bravo 500) and mancozeb (Dithane M-45). The plan was to make the first application when the conelets were fully upright with bracts open or extended. The second application was to be applied when the conelet bracts were closed and the cones pendant 2-3 weeks later. The first application was made as planned on May 22, 1989, but the second application was not made due to equipment and personnel problems.

PESTICIDE APPLICATIONS

Product	Rate	Total Product Applied	Location
Bravo 500	8 pints/ 100 gal.water	8 pints	Rows 10-13 & 20-24
Dithane M-45	4 lbs./ 100 gal. water	4 lbs.	Rows 1 - 4 & 25-29

The fungicides were applied using a tractor mounted mist blower. Rows 14-19 were unsprayed and used as controls.

On June 28, 500 cones from each fungicide treatment and 500 cones from unsprayed control rows were evaluated for rust infection. Cones were rated as infected or not infected. The number of infections per cone was also determined. Fifty cones per tree were examined. The same clones were sampled in each treatment.

NUMBER OF INFECTED CONES

Tree Clone Number	Mancozeb	Chlorothalonil	Control
7223	16	6	12
7223	6	6	8
7233	18	9	12
7171	13	9	9
7224	9	9	9
7174	12	6	9
7241	14	9	5
7241	10	3	7
7222	17	6	17
7227	6	6	2
	121	69	90

The rust infections were caused by both *P. americanum* and *C. pirolata*. In the mancozeb treatment, of the 121 infected cones, 10 were infected by *C. pirolata*. In the chlorothalonil treatment, 6 of the sampled cones were infected by *C. pirolata*, and in the control, 6 of the cones were infected by *C. pirolata*.

% INFECTION

Control = 18%
Chlorothalonil = 13.8%
Mancozeb = 24.2%

Statistics have not yet been done on these numbers; however, one application of chlorothalonil did appear to reduce the level of infection. The high level of infection in the mancozeb treatment complicates the picture and doesn't seem to make sense. No explanation has been found for this result. It almost would appear that either a mix up occurred at the time of application and the wrong rows were sprayed or that the rust infection did not occur randomly across the seed orchard.

Insecticide Trials

Plans were made to spray a portion of the seed orchard with acephate. The wind speed was too high when the spray equipment was available in the seed orchard and the spraying was not done.

X-Ray Analysis of 1988 Seed

A sample of seed from the 1988 crop from the Cotton seed orchard was sent to the National Tree Seed Laboratory. The sample was taken before gravity separation. The x-ray photographs showed that 55% of the seeds were full. One percent of the seed was not properly developed and had a slight shriveling of the female gametophyte.

The cause of the empty seed could be seed bug feeding, poor pollination, genetic lethals or infertile ovules. In spruce, an infertile ovule can form an empty seed coat. The cause of the empty seed was not determined, but poor pollination is thought to be the major cause.

Raspberry Control

Windrows along the sides of the seed orchard were treated with triclopyr to control raspberries. Raspberry is the alternate host for *P. americanum* rust. Spraying was done on 9/12/89 using backpack sprayers.

PHENOLOGICAL NOTES

Cotton White Spruce Seed Orchard

-1989-

May 11	Male cone buds plump, but scales tight. Female cone bud scales tight. Vegetative buds tight. Raspberry leaves 0 to ½" long. No growth on *Pyrola*. Aspen catkins spent. No leaves on aspen yet.
May 22	Seed orchard sprayed for rust control using Bravo 500 and Dithane M-45.
May 25	Female conelets upright; bracts have closed. Spruce vegetative buds have elongated - up to 2" long. Bud caps still adhere to shoots. Raspberry leaves are fully expanded.
June 28	Cones rated for rust infection.

BARK BEETLES
PHEROMONE TRAP EVALUATION

Bark beetle pheromones were just being discovered twenty years ago and are just now finding their way into insect management activities. First used in Minnesota and South Dakota in 1988 in a few scattered trials, the results were very encouraging. Based on these results, the Department of Natural Resources in 1989 undertook a two year field evaluation in cooperation with the U.S. Forest Service, State and Private Forestry Section, to determine the potential use of pheromone traps in the management of *Ips* bark beetles.

The study utilizes a complete block design. Each study area is approximately 25 acres in size and consists of two 12.5 acre treatment blocks. Each block in a study area received either one treatment of 6 traps per acre or no traps per acre. There are ten study areas.

In all stands, traps were placed in a grid pattern at a density of 6 traps per acre. Trap spacing was 85' on center with rows 85' apart. Traps were hung

on standard rod hangers so that they were at least 5' from a tree and were placed in small openings or flightways where possible. This placement wasw done to prevent visual and chemotactal confusion by the insect, and to help in maximizing beetle catches. Where possible, traps were placed so they would remain in the shade for as much of the day as possible. Where necessary, traps were placed so that morning sun strikes the trap rather than the hot afternoon sun. This helped minimize the thermal and UV degradation of the Ipsdienol in the lure.

The lures were of the C-flex (24 degree C) type purchased from PheroTech Inc. They were loaded with 16 mg. of 50/50 (+/-) Ipsdienol diluted 50/50 with ethanol to retard degradation. The release rate of this encapsulation is .2 mg per day. Since the useful life of a lure is only 45-60 days, the lures on the traps were changed during the first or second week of June.

Traps were either a 16 or 12 unit Lindgren funnel trap manufactured by PheroTech Inc. of Delta, British Columbia. These traps are a proprietary design and carry a US Patent (#4471563).

Evaluations of trapping effectiveness will be made by aerially photographing both the trapped areas and the control areas using 35mm color or IR photography. Ground checking will also follow aerial photography when dead trees are found. The ground checks will verify whether or not the mortality was due to *Ips*.

BARK BEETLES
BAITED TRAP LOGS SPRAYED WITH SEVIN SL

The purpose of this study was to determine if spraying pheromone baited logs with an insecticide would be an effective control technique in pine stands showing an established bark beetle infestation. This control technique is used in the Western States, but it had never been tried in the Midwest. If it proved successful under conditions where rainfall amounts during the growing season are greater than in the West, then this technique could be another useful tool in managing bark beetles under a variety of moisture situations.

Two plantations in Region 2 were included in this study. The first plantation was located in Itasca County, S16-T60-R24W. This forty acre red pine plantation was pre-commercially thinned in February and March of 1988. During the spring of 1988 bark beetles built up in the slash and in

porcupine damaged trees. Beetle killed trees in scattered pockets of 2 to 15 trees each. There was also a pocket of mature jack pine where 40-50 trees were killed. In the spring of 1989, bark beetles began attacking standing dead trees and trees on the ground that had been cut.

On May 16, 1989 two or three live trees were felled and cut into 8 foot lengths. They were then placed in each pocket of bark beetle killed trees. The trap logs were sprayed with Sevin SL using a backpack sprayer. Logs were rolled to ensure that all sides were treated. Sevin SL was mixed at a rate of 1 pint in 3 gallons of water. Approximately 1 gallon of spray mix was applied per 50 sq. ft. of trap log. These trap logs were then baited with either 2 C-flex lures or 1 pouch lure. The lures contained the synthetic pheromone Ipsdienol. C-flex lures contained 16 mg of pheromone and released it at a rate of 0.2 mg/day at 24°C. Pouch lures contained 50 mg of pheromone and released the pheromone at the rate of 0.5 mg to 1.0 mg/day. No baited trap logs were left unsprayed as controls.

The trap logs were examined in late July for effectiveness. The trap logs were covered with bark beetle galleries. Both living and apparently healthy larvae and emerging adults were present. Eight to ten entrance holes per 1 sq. ft. of bark were found on the sprayed trap logs. The application of Sevin SL did not prevent the bark beetles from attacking and completing their life cycles in the trap logs. No additional standing trees appeared to have been killed by bark beetles in the plantation in 1989. Even though many other plantations had large populations of bark beetles in the spring of 1989, little tree mortality occurred in 1989.

The second plantation was near Side Lake, S36-T61-R22W. It was eight acres in size and was a mixture of red and jack pines. The plantation was pre-commercially thinned from December 1987 through January 1988. Large populations of beetles developed in the slash during 1988. A few of the overwintering beetles had emerged by May 11, 1989, and started to make nuptial chambers and lay eggs. On this date patches of snow were still common in the plantation. By May 30 many more adults were active in this plantation; however, most of the egg laying galleries were still short and being extended. The large number of beetles in the slash caused concern that tree mortality would occur in 1989.

On June 14, pheromone traps were placed on 2.6 acres of the plantation at the rate of 5 Lindgren Funnel traps per acre. The traps were baited with C-flex lures containing the synthetic pheromone Ipsdienol. On another 2.6 acres of the plantation 5 trees per acre were cut down sprayed with Sevin SL and baited with pouch lures containing Ipsdienol. An additional 2.6 acres were left untreated as a control. By late July, one generation of bark

beetles had developed in the sprayed trap logs, and the logs were being attacked by adults a second time. It was also evident that trees cut down in December 1987 and January 1988 were still being attacked and utilized by bark beetles in late July 1989. No live trees were found to be attacked and killed by bark beetles in either of the treatments or the controls in this plantation.

Conclusions

One application of Sevin SL to baited trap logs in these two plantations did not prevent bark beetles from attacking or successfully completing a new generation of bark beetles in the sprayed logs.

Trees cut down and left on the ground in plantations in December of 1987 and January of 1988 were still usable by bark beetles in July 1989. The winters of 1987-88 and 1988-89 both had heavy snow cover which may have helped prevent the logs from drying out.

Large populations of bark beetles developed during 1988 and killed many trees. 1987 and 1988 were very dry years with warm early springs. In 1988, the early spring, above average summer temperatures, and the late fall allowed 3 - 4 generations of bark beetles to develop. Normal rains started in Region 2 in late summer of 1988 helping trees recover from the drought. Large populations of bark beetles overwintered the winter of 1988-89 and emerged in the spring of 1989; however, only a few trees were killed in 1989 as compared to 1988.

There were three factors which seemed to be different between 1988 and 1989: the return of normal soil moisture, the length of the growing season, and lower temperatures during the growing season. These may have been important in influencing bark beetle activity and the resultant damage. Lower temperatures may have had two effects. The lower temperatures were less of a stress on the trees, and the lower temperatures helped reduce the number of bark beetle generations. In 1989, only two generations of bark beetles developed.

Rather than only considering weather effects on the pine, one also has to consider the weather effects on the bark beetles. Perhaps the number of generations able to make an attack during a single growing season is as important as rainfall amounts and temperature stresses in explaining the significant difference in pine mortality between 1988 and 1989 despite populations and brood material being present during both years.

OAK WILT SURVEY

Introduction

Oak wilt, caused by the fungus *Ceratocystis fagacearum* (Bretz) Hunt, is the primary cause of oak mortality in Minnesota despite being confined to east central and southeastern Minnesota. See Map 8. The oak type, made up of 6 major species of oak, occupies approximately 650,000 acres in Minnesota. Harvesting oak for wood products adds approximately $1 billion to the state economy, and oaks in residential settings are our most valuable shade trees. In addition, landowners and resource administrators have long recognized the effects this disease can have on their woodland resources and associated wildlife species. Squirrels, white-tailed deer, and other species of wildlife use acorns as a primary food source.

Oak wilt has become a serious and costly problem in central Minnesota. In order to develop interest and funding for a major oak wilt control program in Minnesota, a survey was undertaken to document the severity of oak wilt. The following is a description of those survey procedures and results. A more detailed treatment of this subject can be found in the publication entitled "Oak Wilt in Minnesota" by D.W. French and T. Eiber, March, 1990. MN Department of Natural Resources, Division of Forestry. St. Paul, MN.

AERIAL PHOTOGRAPHY

Between July 5 and July 27, 1988, a 1,620 square mile area east and northwest of Minneapolis/St. Paul was aerially photographed. Film used was Kodak 2443 color infrared film, and the scale of the photos was 1:15,840. The photos were interpreted with the objective of locating every oak wilt infection center consisting of three or more trees. Infection centers were then characterized by location, size, and number of dead and dying trees. 35 mm slides with suspected infection centers were projected on USGS topographic maps so that the image from the slide was the same scale as the map. Infection centers were plotted on the maps. Ground

Map 8: Oak Wilt Distribution in Minnesota

truthing was then carried out between October 22, 1988 to March 30, 1989. After all interpretation and ground truthing were completed, the information was digitized using Arc Info software.

The survey identified a total of 3,012 oak wilt infection centers on 5,006 acres containing 91,821 trees (Table 1). Of the total infection centers, 1,055 (approximately 35% of the total) were over 1.0 acre in size (21% of a township). In this case, mortality currently equals .48% of the *total surveyed area*. The remaining 1,957 infection centers were less than 1.0 acre, and their sizes were not recorded or included in the acreage totals. The largest identified infection center was 99.4 acres (near Long Lake in Bradford Township, Isanti County).

Table 1. Oak wilt statistics by county from the 1988 Aerial Survey.

COUNTY	INFECTION CENTERS	TOTAL ACREAGE	NO. OF TREES
ANOKA	1,351	2,816.0	62,357
CHISAGO	257	253.2	4,265
ISANTI	258	448.8	7,288
RAMSEY	87	38.4	783
SHERBURNE	508	980.0	11,309
WASHINGTON	551	469.8	5,819
WRIGHT	0	0.0	0
TOTALS	3,012	5,006.2	91,821

Among counties, Anoka has the most infection centers (1,351) as well as having the greatest number of diseased trees (62,327) and the largest affected total area, 2,816 acres. No infection centers were found in Wright County where a relatively small area, <3 townships, was included in the survey. Infection centers also were not detected in 3 of the 4 townships along the northern tier of the surveyed area in Isanti and Chisago Counties.

Among units of local government including cities, villages, and townships, Oak Grove Township in Anoka County led in all oak wilt categories. This township had the most infection centers (381), the greatest number of diseased trees (27,230), and the largest affected area (1,306 acres.) (See Tables 2 & 3).

TABLE 2. Oak Wilt Statistics by Municipality or Political Township from the 1988 Minnesota Aerial Photo Survey.

LOCALE	CENTERS	ACRES	TREES
Anoka County			
Andover	257	457.3	9,734
Anoka	3	0.0	33
Bethel	1	1.5	25
Blaine	76	53.8	2,026
Burnsville Twp	20	33.6	881
Centerville	0	0.0	0
Circle Pines	1	0.0	10
Columbus Twp	39	21.2	769
East Bethel	152	288.3	4,269
Ham Lake	84	77.6	2,069
Lexington	0	0.0	0
Lino Lakes	28	19.7	741
Linwood Twp	105	127.6	2,231
Oak Grove Twp	381	1,306.0	27,230
Ramsey	118	193.7	6,004
St. Francis	86	235.7	6,335
Chisago County			
Branch	103	128.9	2,510
Center City	0	0.0	0
Chisago City	0	0.0	0
Chisago Lake Twp	14	9.9	152
Fish Lake	0	0.0	0
Franconia Twp.	4	0.0	14
Lent Twp.	79	61.3	984
North Branch	0	0.0	0
Stacy	0	0.0	0
Wyoming	9	0.0	62
Wyoming Twp.	48	53.1	543
Isanti County			
Athens Twp	58	43.6	1,668
Bradford Twp	72	160.2	1,766
Cambridge	0	0.0	0
Cambridge Twp	0	0.0	0
Isanti	0	0.0	0
Isanti Twp	7	15.7	410
North Branch Twp	20	23.0	437

TABLE 2. Oak Wilt Statistics by Municipality or Political Township from the 1988 Minnesota Aerial Photo Survey (continued).

LOCALE	CENTERS	ACRES	TREES
Isanti County (Cont.)			
Oxford Twp	11	15.1	185
Spencer Brook Twp	6	73.8	170
Springvale Twp	4	1.1	60
Stanford Twp	80	116.3	2,592
Ramsey County			
Arden Hills	8	15.2	122
Little Canada	1	0.0	5
Mounds View	3	0.0	18
New Brighton	3	0.0	23
North Oaks	35	14.2	277
Shoreview	13	2.3	95
Vadnais Heights	12	1.7	138
White Bear Lake	5	1.5	39
White Bear Twp	2	0.0	13
Sherburne County			
Becker	0	0.0	0
Becker Twp	1	1.1	20
Big Lake Twp	175	410.0	4,409
Elk River	207	326.2	3,523
Livonia Twp	35	24.6	470
Orrock Twp	86	217.6	2,859
Zimmerman	2	0.0	13
Washington County			
Afton	18	18.0	233
Bayport	0	0.0	0
Bayport Twp	14	5.5	144
Dellwood	5	0.0	19
Forest Lake	1	0.0	5
Forest Lake Twp	24	41.2	367
Grant Twp	68	22.4	521
Hugo	55	39.5	657
Lake Elmo	41	34.3	407
Lakeland	0	0.0	0
Lakeland Shores	0	0.0	0
Lake St. Croix Beach	2	1.3	30

TABLE 2. Oak Wilt Statistics by Municipality or Political Township from the 1988 Minnesota Aerial Photo Survey (continued).

LOCALE	CENTERS	ACRES	TREES
Washington County (Cont.)			
Mahtomedi	19	13.4	170
Marine on St. Croix	12	6.3	76
May Twp	134	168.0	1,753
New Scandia Twp	42	22.0	302
Oakdale	5	1.0	30
Oak Park Heights	1	0.0	5
Pine Springs	5	1.6	32
Stillwater	1	0.0	4
Stillwater Twp	52	73.3	595
West Lakeland Twp	16	9.1	134
Willernie	1	0.0	3
Woodbury	35	12.9	332
Wright County			
Clearwater Twp	0	0.0	0
Monticello	0	0.0	0
Monticello Twp	0	0.0	0
Silver Creek Twp	0	0.0	0

TABLE 3. Distribution of oak wilt infection centers among the 44 geographical townships (ordered according to number of infection centers).

Location	Number of Infection Centers	Total Acreage	Number of Trees
T.33N., R.24W. (Oak Grove Twp.)	381	1,306.0	27,230
T.32N., R.24W. (Andover Twp.)	249	449.2	9,425
T.33N., R.26W. (Elk River)	207	326.2	3,523
T.34N., R.24W. (St. Francis/Standford Twp./ Athens Twp.)	195	350.2	9,501
T.3IN., R.2OW. (May Twp.)	144	172.2	1,809
T.33N., R.27W (Big Lake Twp.)	140	360.1	3,396
T.32N., R.25W. (Ramsey)	129	201.8	6,346
T.33N., R.23W. (East Bethel)	116	145.2	3,065
T.35N., R.2IW. (Branch Twp.)	103	128.9	2,510
T.3ON., R.2IW (Grant Twp.)	96	37.4	734
T.34N., R.27W. (Orrock Twp.)	86	217.6	2,859
T.32N., R.23W. (Ham Lake)	84	77.6	2,069

TABLE 3. Distribution of oak wilt infection centers among the 44 geographical townships (ordered according to number of infection centers) (continued).

Location	Number of Infection Centers	Total Acreage	Number of Trees
T.34N., R.21W. (Lent Twp.)	79	61.3	984
T.34N., R.22W. (Linwood/Oxford Twps.)	77	116.9	1,901
T.31N., R.23W. (Blaine)	77	53.8	2,036
T.35N., R.24W. (Bradford Twp.)	72	160.2	1,766
T.34N., R.23W. (East Bethel/Athens Twp.)	59	157.1	1,780
T.33N, R.21W. (Wyoming Twp.)	57	53.1	605
T.31N., R.21W. (Hugo)	55	39.5	657
T.30N., R.20W. (Stillwater)	54	73.3	604
T.30N., R22W. (NW Ramsey Co.)	49	15.4	430
T.29N., R21W. (Lake Elmo)	48	35.3	448
T.32N., R.20W (New Scandia Twp.)	44	24.1	322
T.33N., R.22W. (Linwood Twp./Columbus Twp.)	41	25.8	535

TABLE 3. Distribution of oak wilt infection centers among the 44 geographical townships (ordered according to number of infection centers) (continued).

Location	Number of Infection Centers	Total Acreage	Number of Trees
T.33N., R.28W. (Becker Twp., Monticello, Monticello Twp.)	38	51.5	1,048
T.3ON., R.23W. (NE Ramsey Co.)	38	23.0	353
T.34N., R.26W. (Livonia Twp.)	37	24.6	483
T.32N., R.22W. (Columbus Twp.)	37	21.2	749
T.28N., R.2lW. (Woodbury)	35	12.9	332
T.29N., R.2OW. (Baytown Twp./ W. Lakeland Twp.)	30	14.6	278
T.3lN., R.22W (Lino Lakes)	28	19.7	741
T.32N., R.2lW. (Forest Lake Twp.)	25	41.2	372
T.33N., R.25W (Burns Twp.)	20	33.6	881
T.35N., R.22W. (North Branch Twp.)	20	23.0	437
T.28N., R.2OW. (Afton)	20	19.3	263
T.34N., R.2OW (Chisago Lake Twp.- No.)	9	6.2	87

TABLE 3. Distribution of oak wilt infection centers among the 44 geographical townships (ordered according to number of infection centers) (continued).

Location	Number of Infection Centers	Total Acreage	Number of Trees
T.33N., R.2OW. (Chisago Lake - South/ Franconia Twps.)	9	3.7	79
T.34N., R.25W. (St. Francis/Stanford Twp.)	7	32.9	543
T.35N., R.23W. (Isanti Twp.)	7	15.7	410
T.35., R.25W. (Spencer Brook Twp.)	6	73.8	170
T.36N., R.24W. (Springvale Twp.)	4	1.1	60
T.33N., R.29W. (Becker, Silver Creek, Clearwater Twps.)	0	0	0
T.36N., R.25W. (Wyanett Twp.)	0	0	0
T.36N., R.23W. (Cambridge Twp.)	0	0	0
T.36N., R.22W. (Fish Lake Twp.)	0	0	0

AERIAL SKETCH MAPPING

In 1987 and 1988, much of southeastern Minnesota was sketch mapped for oak wilt. In 1987, the southeast counties of Olmsted, Fillmore, Houston, Winona and Wabasha were mapped. In 1988, most of the 1987 lines flown over the Doer Memorial Hardwood forest in the five southeastern counties were rechecked and the remaining counties in the region were surveyed. The additional counties added in the 1988 survey were Mower, Dodge, Steele, Goodhue, Rice, LeSueur, Dakota, Scott, Carver, Hennepin, Wright, southern Washington, and the eastern wooded areas of Nicollet, Sibley, McLeod, and Meeker counties. See Map 8.

The survey was conducted during the third and part of the fourth weeks in July. U.S. Geological Survey planimetric cover type maps on a scale of 1:100,000 were used. The flight lines were three miles apart, and the plane maintained an elevation of 1500 feet above the ground.

The total number of oak wilt infection centers across the southeastern region is estimated to be 400-550. See Table 4. This is an estimate since not every mortality center mapped is expected to be oak wilt nor was every existing center detected. In Dakota County where the estimate is from 50 to 150 centers, the area mapped did not include Burnsville, Eagan, Apple Valley, and Inver Grove Heights since commercial air traffic limited access. Oak wilt is known to be common in these areas.

Table 4. Incidence of oak mortality centers in southeastern Minnesota Counties from 1988 aerial sketch mapping

COUNTY	# OAK MORTALITY CENTERS	
Wright	14	
Hennepin	19	From Lake Minnetonka west; does not include eastern Hennepin County
Carver	10	
Scott	17	
Dakota	50	Does not include Burnsville, Eagen, Apple Valley and Inver Grove Heights
Washington	18	Southern Washington County
Nicollet	3	
Le Sueur	6	
Rice	19	

Table 4. Incidence of oak mortality centers in southeastern Minnesota Counties from 1988 aerial sketch mapping (continued).

COUNTY	# OAK MORTALITY CENTERS
Goodhue	29
Wabasha	52
Steele	1
Dodge	3
Olmsted	62
Winona	50
Mower	6
Fillmore	19
Houston	32
TOTAL	410

Throughout the southeastern region, the highest concentrations of oak wilt were associated with northern pin oak forests on sandy sites with urban development. This was consistent with the photographic survey in the Metro Region. In Olmsted County where 62 centers were detected, the majority of which were located in the greater Rochester area. Just southeast of Rochester, in southern Marion township, over thirty tentative centers were identified. This is an area of extensive pin oak on sandy soils with a recent history of urban development. This area is very similar to small areas across the southeast where other active centers were found. The incidence of oak wilt appears low in the rural hardwood forested areas especially when compared to the urban and suburban forested areas.

DISCUSSION

Aerial photography was useful for detecting tree mortality. The primary errors were detecting mortality of tree species other than oak and identifying mortality caused by other diseases or insects. Many dead trees were located along ponds and lakes and related to flooding in 1986. A major problem in identifying single infected trees was deterioration; trees were infested with secondary diseases or insects, making detection of oak wilt difficult. Identification of oak wilt-infected trees in clusters was much easier because the trees were in all stages of decline. Deteriorating dead trees, recently killed trees, and wilted trees often were present in each cluster.

Both surveys clearly confirm that oak wilt is causing serious mortality in Minnesota. While ground checking the aerial sketch mapped areas will be under taken in 1990, preliminary ground truthing indicate that the analytical aspects of the aerial survey were accurate.

Although other mortality agents were detected during these surveys, the primary cause of tree mortality was the oak wilt fungus. Current mortality from oak wilt accounts for 93% of the oak mortality centers and accounts for 85% of the area. Already, losses from oak wilt in the Metro Region total .48% of the *total land area* (includes roads, homes, non-oak type, etc.). These losses greatly exceed the losses found in Wisconsin where less than 1 percent of the total volume of oak on the Necedah Wildlife Refuge was killed by oak wilt or the .3% of the oak type in a survey of central Wisconsin counties. (5)

Loss of timber volume over much of the area is of secondary importance, since the primary objective of many of the landowners is aesthetic management and wildlife habitat. Current losses of large oak trees significantly lower property values and reduce the mast crops. Oak wilt is of particular importance in areas where red oaks predominate on sandy soils. The red oak group is highly susceptible to oak wilt, and the mortality rate for infected trees is 100 percent.

Oak wilt will continue to spread from the large number of infection centers. Infection center spread rate studies conducted in the 1950's by Gerald Anderson and Ralph Anderson (1) found that the average radial spread was 2.6 to 4.4 feet per year. French and Bergdahl (2) found spread rates up to 25 feet per year. Given the large number of centers identified in the surveys and the numerous new spots too small to be identified, it can be expected that if oak wilt is allowed to continue to spread, red oaks will essentially be eliminated in many areas.

Where red oak is eliminated, oak wilt will probably die out from lack of suitable hosts. The length of time infection centers are active depends on the size of the center. Himelick and Fox (4) found that 1 percent of the infection centers with less than five trees were active after 5 years, while 82 percent of the centers with more than five trees still were active after 5 years.

Many factors affect the rate of spread, but shallow soils, availability of compatible oaks, and the number of dead and currently wilting trees in an infection center are important factors (3). Because most spread occurs by root contact between diseased and healthy trees, contiguous stands of red oak have the greatest potential for loss. Park-like open stands will have

less tree mortality and may be barriers to disease spread. Spread by insect vectors will be most effective in wounded trees.

There is little doubt that a major cause of the proliferation of oak wilt in portions of Anoka and Sherburne Counties, in particular is the continuing population increase in these areas. New infection centers result from oaks being wounded in May and June during home construction, clearance for utility lines, road construction, yard maintenance, and recreation activities.

In an attempt to evaluate the effects of home construction, efforts were made to determine the probable origins of infection centers in portions of Blaine, Ham Lake, and East Bethel. Of 190 centers, 74 (39%) were judged as having a reasonable likelihood of resulting from construction activity. This conclusion should be treated cautiously. It was reached by initially considering all infection centers that adjoined the boundary of a home or a yard.

In a number of these cases, other possibilities may explain the presence of oak wilt. These include tree pruning or wounding, the possibility that the home or development was built in an existing center and the possibility that a nearby infection center expanded to the property where the home was located. In such instances, a judgement had to be made, often with insufficient evidence, regarding the most likely explanation of how the center started. Some of the infection centers initially attributed to home construction were dropped from consideration and perhaps others should have been. On the other hand, it was difficult to identify infection centers around homes where most or all of the trees had been removed.

Conclusions

From both the aerial and ground surveys, it can be concluded:

In excess of 100,000 oak trees were dead or dying.

Oak wilt was confirmed as the primary mortality factor.

Aerial photography is an effective tool for locating active pockets and estimating their size.

Timber volume losses from oak wilt is significant.

The most costly losses are occurring in the urban forest.

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COOPERATIVE SURVEY OF BLACK WALNUT *FUSARIUM* CANKER

INTRODUCTION

Fusarium canker on walnut was first reported In 1974. The first incidence of *Fusarium* canker in Minnesota was recorded in 1979 in Fillmore county. In 1980 a policy was developed for state lands to help control this canker. That policy said that walnut should only be pruned during the dormant season. In 1983, MN DNR reported two walnut plantation surveys in which *Fusarium* canker incidence exceeded 50% of the stems surveyed. Many cankers encompassed lateral branch pruning scars which dated back to a mid-summer pruning that took place in July and August of 1976. Cankers were also associated with dead branches and other wounds.

The incidence and impact of *Fusarium* canker continues to be a concern. Planted and managed walnut is a significant and valuable hardwood resource in the 5 central states of Minnesota, Wisconsin, Iowa, Illinois, and Missouri. There is an estimated 15,000 acres of walnut plantations between

the ages of 5 and 20 years in this 5 state area. Because of the potential impact of this canker, a cooperative survey between these 5 states and the US Forest Service was undertaken in 1989 to determine the incidence of *Fusarium* stem canker.

OBJECTIVES

Determine the incidence of stem canker in each state.

Determine the species of *Fusarium* in each state.

Determine relationships between incidence of stem canker and site and/or cultural practices.

Evaluate management recommendations used to control the canker.

METHODS

A minimum of 30 plantations per state were randomly selected. An important criteria in selecting the 30 plantations was to select plantations so that they were uniformly spread throughout the geographic range of walnut in each state. Plantations were further stratified by selecting an equal number of upland and bottomland sites.

A minimum of 10 rows and 100 trees total were surveyed in each plantation. For plantations greater than 10 acres, 10 trees were surveyed per acre. Every tree had an equal chance of being surveyed.

Each tree was examined for stem cankers. When cankers were found, the following data were recorded:

Canker length and width

Canker height measured from the center of the canker to the ground

Azimuth from the center of the canker

If the canker was open or closed

Canker association with lateral pruning, dead branches, or other mechanical wounds

Three canker samples were collected from each plantation and sent to a lab in Wisconsin to identify the fungi involved.

RESULTS & DISCUSSION

In Minnesota there were 31 plantations surveyed. Sixteen plantations were found on upland sites and 15 found on bottomland sites. The data is summarized in Table 1 by plantation. The discussion of the results is based only on data collected in Minnesota.

A total of 3,558 walnut trees were examined. *Fusarium* type cankers were found in all plantations surveyed, and the fungus causing walnut stem cankers in Minnesota was *Fusarium solani*. This fungus was collected from 12 plantations on both upland and bottomland sites. Average canker size was 4.8 square inches.

Table 1. Summary of *Fusarium* canker survey, 1989.

LOCATION[1]	ACRES	AGE	PRUNED	% CANKER
FILLMORE CO.				
21-103-9 B	3	11	N	20
5-103-8 U	24	20	Y	1
5-103-8 B	5	6	N	2
GOODHUE CO.				
29-112-13 B	10	10	Y	30
13-112-15 B	10	18	Y	18
13-112-13 U	4	9	Y	3
24-112-14 U	7	16	N	3
4-112-16 B	3	10	Y	2

LOCATION[1]	ACRES	AGE	PRUNED	% CANKER
HOUSTON CO.				
14-103-7 U	3	9	N	3
15-102-5 U	12	20	N	3
34-101-4 U	8	7	Y	11
28-102-4 U	7	9	N	2
28-102-4 U	12	9	Y	4
26-102-4 U	8	19	Y	8
11-102-4 U	7	7	Y	7
11-102-4 B	3	17	Y	31
OLMSTEAD CO.				
8-107-13 B	10	8	N	2
3-105-15 U	5	6	Y	5
19-106-15 B	10	8	Y	11
34-107-13 B	4	17	Y	13
WABASHA CO.				
29-110-11 B	20	12	Y	20
26-110-12 B	8	17	Y	74
26-110-12 U	4	13	N	18
21-109-13 B	5	15	Y	34
18-110-11 U	1	16	Y	10

LOCATION[1]	ACRES	AGE	PRUNED	% CANKER
18-110-10 U	3	20	Y	5
10-109-10 B	6	6	N	7
WINONA CO.				
8-108-9 B	1	8	N	22
17-108-9 B	1	21	Y	31
23-107-8 U	3	18	N	7
27-105-9 U	2	17	N	6

[1]Location refers to plantations on bottomland (B) sites and plantations on upland (U) sites.

Plantations on the bottomlands had a much higher incidence of cankers.

LOCATION	# PLANT.	AVG INCIDENCE	RANGE
Upland	16	6.0%	1-18%
Bottomland	15	21.1%	2-74%

Plantations that had been pruned had a higher incidence of cankers than unpruned plantations. The difference in canker incidence was not as great as was the difference due to plantation location.

PRUNED	# PLANT.	AVG INCIDENCE	RANGE
YES	19	13.9%	1-74%
NO	12	7.9%	2-22%

When looking at the interaction of location and pruning, there was no difference in canker incidence on upland sites between pruned and non-pruned plantations. However, on bottomland sites there was a difference between the pruned and unpruned plantations. It is interesting to note that the greatest difference in location incidence occurred in pruned plantations. Also interesting is the observation that a majority of cankers originating since 1980 were associated with dead branch wounds.

	PRUNED			UNPRUNED		
LOCATION	#	AVG INC	RANGE	#	AVG INC	RANGE
Upland	9	6.0%	1-11%	7	6.0%	2-18%
Bottomland	10	26.4%	2-74%	5	10.6%	2-22%

The range of cankers on the pruned upland sites was 1-11%. These numbers included a few private land plantations where the practice of limiting pruning to the dormant season was not followed.

The range of cankers on the non-pruned upland sites was 2-18%. The plantation that reached 18% incidence was 13 years old and had been interplanted with green ash sometime after the walnut had become established. With the high stem density and the absence of any weed control the conditions were excellent for many diseases. The 18% canker incidence appeared to be the result of infections through dead branches. If this one site was removed the average for upland non-pruned plantations would decrease to 3.6%.

The range of cankers on the pruned bottomland sites was 2-74%. The plantation that reached 74% incidence was 17 years old, on private land, and was pruned during July and August of 1976. Since that time the plantation had been thinned twice, and many cankered stems had been removed. If this one site was removed from the survey the average for the bottomland pruned plantations would decrease to 19%.

In addition, 6 of the 10 plantations that make up the bottomland pruned sample pre-date the 1980 guideline recommending only dormant season pruning. The average canker incidence in these 6 plantations was 33%. The average canker incidence in the remaining 4 plantations in the sample that were managed under the 1980 guideline and have had only dormant season pruning was 15%. This rate of canker disease is probably a good

estimate of the amount of cankers that will be found in bottomland plantations that have not been pruned.

The range of cankers on the non-pruned bottomland sites was 2-22%. Two of these plantations reached a canker disease incidence of 20 and 22%. The observations from these two plantations were significant because canker infections were directly related to dead branch wounds.

It is not a practice in plantation management to laterally prune each year with a goal of removing every branch while still alive. It is a practice to sometime before the plantation reaches 8 to 10 years to do some lateral pruning on the best quality stems. This practice will result in the removal of both live and dead lateral branches. However, a 20% infection rate at age 10 in a plantation with 450 trees per acre is not high enough to cause significant damage to that plantation. Continued losses would be expected to decrease after pruning since the removal of the lower branches would change the microclimate within the plantation. Microclimatic changes would have an effect on the ability of *Fusarium* to sporulate, infect, and survive. However, if these plantations were pruned during the growing season, there could be a chance of suffering an 80% infection rate.

RECOMMENDATIONS

Continue the practice of confining pruning operations to the late dormant season.

Where intensive single tree walnut culture is the objective, start pruning when the trees are young, prune annually, and remove lateral branches while still alive.

BUTTERNUT CANKER DISEASE RESISTANT TREE SEARCH

Butternut, also called white walnut, is a highly valued lumber species and is the species of choice by wood carvers due to its beautiful grain and soft texture. However, a canker disease caused by the fungus, *Sirococcus clavigignenti-juglandacearum*, is causing significant mortality and threatens its very existence.

Widespread mortality of butternut was first reported in southwestern Wisconsin in 1967. In a butternut plantation in southwestern Wisconsin established in 1972, the rate of mortality increased from 5% to 76% during a 5 year period from 1978 to 1983. In the early 1970's the disease was first observed in southeastern Minnesota. During the 1970's and early 1980's butternut has nearly been eliminated from the southeastern Minnesota hardwood forest.

The most obvious symptoms an infected tree displays are dead branches in the crown and cankers on the stem. In the crown the lower branches die first as the disease progresses upwards. Usually there is at least one obvious basal canker on the main stem at the ground line. Trees die from the multiple effects of hundreds of non-girdling cankers that eventually destroy the entire growing surface of the tree. In the spring, an inky black, thin fluid exudes from cracks in the cankers. Cankers on young stems are sunken and originate at leaf scars, buds, and various wounds. Older stem and branch cankers are typically loosely covered with bark. Beneath the bark, the wood at the canker is dark brown or black. Under the outer bark of a canker, the fungus forms thin black structures that lift up the outermost layer of bark. Spores are then released and disseminated by rain.

For many years this disease was called butternut decline and was thought to be caused by the fungus *Melanconium oblongum*. It is more commonly known by its teleomorph stage, *Melanconis juglandis*. It was later discovered that this fungus was only weakly pathogenic on butternut and primarily infected trees under stress. In 1967 Dr. Jim Kuntz at the University of Wisconsin discovered a species of *Sirococcus* responsible for causing the multiple cankers characteristic of this disease. In 1979 Kuntz published a description of the disease naming the fungus *Sirococcus clavigignenti-juglandacearum*.

It is not known how long this canker disease has existed or even whether the fungus was brought here from outside the United States. However, its

effects on butternut are known and have been devastating. Today it is difficult to find trees without cankers.

Because of butternut's high value and the catastrophic nature of this disease, the U.S.Forest Service in cooperation with states within the natural range of butternut have embarked on a program to find natural resistance to butternut canker. This new program will be using both traditional tree breeding methods and relatively new biotechnology techniques. The use of biotechnology may make it possible to alter the genetic makeup of susceptible trees and produce trees which are disease resistant. The advantage of biotechnology is the real possibility that disease resistant trees can be produced within a few short years.

The technique being used is somaclonal variation which can produce genetic changes in plants without going through the lengthy process of the normal breeding cycle. Somaclonal variation is the variation exhibited by plants obtained from aseptic tissue culture. It involves screening for disease resistance without having to grow the tree. The first step will be to refine the technique so that butternut can be reproduced in tissue culture. At the same time cuttings from trees found in the field that appear to be resistant will be grafted onto black walnut stock. After plants are produced from both techniques they will be exposed to the butternut canker fungus. The resistant plants from this group will then be field tested over a wide geographic area.

A challenge in developing a butternut with resistance is that throughout the butternut range single butternut trees without cankers are hard to find. In central and northeastern Minnesota where butternut advances to the northern limits of its natural range, there are many uninfected trees. However, in the search for resistance these trees are not of great value at this time since they have not yet been exposed to the disease for an extended period. Therefore the most intense search in Minnesota is occurring in the southeast where butternut use to be a common component of the Central Hardwood stands. Four trees, one each in Wabasha, Houston, Fillmore, and Rice Counties have been located that appear to be canker free. Additionally, candidate trees have been found as far south as North Carolina.

Grafting was started during the spring of 1990. Butternut seed collected in the fall of 1989 has been stratified and will soon be placed in tissue culture. Grafted seedlings and plants produced in tissue culture will be tested in the fall of 1990. Field testing any resistant trees is scheduled for 1992.

FOREST INVENTORY and ANALYSIS
DAMAGE CODE STANDARDIZATION

Introduction

In cooperation with the USFS, states carry out a forest inventory approximately every 10 years. The inventory is known as Forest Inventory and Analysis (FIA). It consists of establishing permanent plots and remeasuring established plots. Part of the information collected is a damage incidence on each tree 1.0 inches and greater DBH, and a cull deduction from the damage incidence on each tree 5.0 inches and greater DBH.

Each state has the opportunity to tailor their damage codes to meet their needs. However, not all states rely on their Insect and Disease Specialists for input into the inventory system in their respective states. Because damage codes and rules for applying the codes may differ from state to state and the damage codes may not even meet the needs of the Insect and Disease Specialists in their states, the damage code assessment section of the FIA inventory process needed to be altered.

Regional assessments of damage and insect and disease occurrences also were not possible when states differed in the information being collected. Because the state of forest health is now being commonly discussed in many circles and there is a need to know state of health on more of a regional basis, a project was undertaken to try to standardize the FIA damage codes in the North Central region. This region includes the following states: Michigan, Wisconsin, Minnesota, North Dakota, South Dakota, Iowa, Illinois, Indiana, Missouri, Kansas, and Nebraska.

Methodology

In the fall of 1987, Insect and Disease Specialists from Minnesota, Michigan, North Dakota, South Dakota, Indiana, the USFS; and Forest Inventory personnel from Minnesota and USFS, North Central Forest Experiment Station met together at Brainerd, MN to begin the process of developing standardized damage codes and a system to use the codes uniformly across the Region.

That meeting set the stage for additional dialogue via letters, phone calls, and meetings. Finally, during the winter of 1990, a final version of the codes and system was sent out for review.

Results

A list of standardized damage codes were developed. This list includes both general damage categories and some specific insects and diseases. This standardized list would be reported on by all 11 states, and it would be the basis for region wide reports.

Included in the list of damage codes is a list of unknown or uncoded injury codes. These can be thought of as being unknown damage; that is, a significant damage is on the tree and the damaging agent is unknown or it is not included in the damage code list. The use of these codes is a recognition that often significant injuries exist on the trees, but we simply cannot identify the causal agent. The system, however, emphasizes the importance of trying to identify what caused the injury rather than on just reporting the occurrence of the injury.

Along with a standardized list, a host list for each damage code and a severity rating for each code were developed. The severity rating would be the minimum condition to be satisfied in order to be coded. The philosophy is that the damage condition or agent must be significant or be causing noticeable significant damage before it can be coded. For example, the presence of a *Nectria* canker on a limb would not be coded, but *Nectria* on the bole would cause more significant damage and would be recorded.

The standardized damage codes, hosts for each, and severity rating follow:

DAMAGE OR DEATH	HOSTS	SEVERITY
Healthy	All species	<20% crown affected No volume/degrade loss
Insect defoliators	All species	>20% defoliation
Gypsy moth	Hardwoods	Any occurrence
Shoot/branch insects	All species	Any occurrence on leader >20% shoots/branches affected
Branch gall insects	All species	>20% branches affected
Bole borers	All species	Any occurrence on bole
Bark beetles	Conifers	>20% crown dead/dying

DAMAGE OR DEATH	HOSTS	SEVERITY
Root/root collar insects	Conifers	Entire crown off color Dead tree
Foliage diseases	All species	>20% of foliage affected
Shoot blights	All species	Any occurrence on leader >20% shoots affected
Mistletoe	Black spruce White spruce Black Hills spruce Tamarack Jack pine Lodgepole pine	Any occurrence
Bole rusts	Pines	Any occurrence on bole
Bole cankers	Hardwoods	Any occurrence on bole
Eutypella canker	Maple	Any occurrence on bole
Hypoxylon canker	Aspens	Any occurrence on bole
Nectria canker	Hardwoods	Any occurrence on bole
Butternut canker	Butternut	Any occurrence on tree
Stem Decay (Heartrot)	All species	Any occurrence on bole
Ash yellows	Ash	Any occurrence
Dutch elm disease	Elms	Any occurrence
Oak wilt	Oaks	Any occurrence
Annosus root rot	Conifers	Any occurrence
Armillaria root rot	All species	>20% crown dieback

DAMAGE OR DEATH	HOSTS	SEVERITY
Weather	All species	>20% crown affected Any damage to leader Any damage to bole cambium
Animal	All species	>20% crown affected Any damage to leader Any damage to bole cambium
Fire	All species	>20% foliage affected Any damage to leader Any damage to bole cambium
Logging/TSI	All species	>20% crown affected Any damage to leader Any damage to bole cambium
Chemical	All species	>20% foliage affected
Unkn/uncd[1] dead	All species	Use on dead trees only
Unkn/uncd defoliation	All species	>20% foliage affected
Unkn/uncd discoloration	All species	>20% foliage affected
Unkn/uncd dec/dieback	All species	>20% crown affected
Unkn/uncd breakage	All species	>20% crown affected Any occurrence on bole
Unkn/uncd abnorm crwn	All species	>20% crown affected
Unkn/uncd canker	All species	Any occurrence on bole
Unkn/uncd cracks	All species	Any occurrence on bole
Unkn/uncd abnorm bole	All species	Bole: any volume loss

[1] Unkn/uncd = Unknown/Uncoded

In addition to the hosts and severity rating for each damage code, standardized procedures and coding rules were also developed:

To use a damage/death code, the pest or damage must:

A. Be identified using the coding criteria. If the pest/damage does not satisfy the coding criteria, it must be coded to a more general code i.e. the unknown/uncoded damage codes.

B. AND Must be causing at least as much damage as the severity rating for that particular damage code. For example, an insect defoliator is coded only when it is causing >20% defoliation. Another example, a *Hypoxylon* canker on a branch would not be coded since its severity rating is "any occurrence on the bole."

Use the most specific code possible; avoid general injury codes as much as possible. For example, *Eutypella* canker code has preference over bole canker code which has preference over unknown/uncoded canker.

When 2 or more pests occur on a tree, record the most significant and important pest. The following 3 situations will apply:

A. Record the causal agent causing the most severe damage. A causal agent which will cause death will take precedence over one causing volume loss which takes precedence over one causing growth or quality loss. For example, a canker low on the main bole takes precedence over decay higher on the stem, but decay low on the main bole takes precedence over a canker high in the crown.

B. Record permanent damage before temporary or seasonal damage. For example, decay or canker would take precedence over insect defoliation even if defoliation was 100% on a hardwood tree.

C. Record bole damage before branch damage.

Death codes are the same as damage codes, i.e., when coding the cause of tree death choose a code from the entire list of damage codes.

To Be Done

The final part of this project is to develop a training package for each state so that the FIA crews can be trained consistently in each state. This will help to better standardize the use of the damage codes. Standardization is the key to a more accurate region wide report. A slide set has been assembled and duplicated. The last item of the training package to be developed is documentation to be used with the slide set. This should be completed by the end of 1990.

ASPEN LOSS ASSESSMENT

Introduction

The aspen cover type in Minnesota accounts for 39% of the commercial forest acreage. Since 1977, there have been 10 major paper and composite board additions or expansions, all relying heavily on the supply of aspen. One-half of the aspen resource is over mature, and shortages of merchantable age classes of aspen are predicted to occur within 20 to 30 years. Industry is concerned over the long term supply of aspen.

Projections of available and future aspen supplies are based on data collected during the Forest Inventory and Analysis (FIA) statewide inventory. Methodology used to estimate losses due to insects and diseases during this inventory have never been evaluated, and the accuracy of the loss estimates is unknown. Since insect and disease losses play a large role in the amount of wood fiber available, industry needs an accurate loss projection. For example based on the 1977 FIA inventory, annual losses to the aspen growing stock from diseases alone amount to 572,000 cords, or enough volume to keep 3 waferboard plants in operation each year. Errors made in these kinds of projections can affect the very existence of the waferboard industry in Minnesota.

The objective of this project, then, was to develop a loss assessment methodology. It would be developed for and used in the aspen resource, but it would be a methodology which could be used for any species. The goal also was to develop a methodology that could be related to the FIA system since this inventory is crucial for statewide resource assessments and provides the potential for periodic structured updates of pest impact information since it is conducted every 10 years.

A pilot project was designed to:

*Evaluate the loss assessment methodology;

*Evaluate the variation of insect and disease incidence, volume loss, and mortality within plots in order to determine numbers of plots needed for future studies;

*Evaluate FIA procedures and results for collecting pest incidence and determining cull deductions; and

*Evaluate the influence of clones on the incidence and severity of aspen cankers.

Methods

Thirty aspen stands on state lands in St. Louis and Koochiching Counties were selected based on the following criteria:

-Typed as aspen on Phase II inventory
-10 acres or greater in size
-Undisturbed and not on the planned cut list for 1989
-Accessible

Stands were stratified according to site index and stand age. Site indices strata included 50-72 and >72. Age strata included 21-30, 31-40, and 41-50 years.

One FIA plot was established in each stand by an inventory contractor. Plots were added to a contract that was soon to be advertised for bidding. In this way the successful bidder would think that the 30 plots were no different than the real or normal plots. Plots were then established in May through July of 1989, and after plot establishment, Insect and Disease Specialists visited the plots.

When the plots were visited by the I&D Specialists, the following was done:

1. All trees 1.0 inch and greater DBH were rated for insect and disease incidence using the FIA damage codes. Rating was done "blind" without knowing what the contractor rated each tree. I&D Specialist's rating were then compared to contractor ratings, and trees showing differences were inspected to determine the cause of the differences.

2. Ten live merchantable (>4.9 inches DBH) aspen trees on each plot were randomly selected to be destructively sampled. The objective was to choose 1 tree per point. These trees were then felled.

3. Total length of the tree, total merchantable length to a 4 inch DOB or stopper, and total crown length measurements were made while the tree was laying on the ground.

4. The tree was then bucked into 2-foot segments until the merchantable top was reached. Each segment was rated for external indicators of internal injury, and the amount of advanced decay on the top face of each segment was traced onto acetate. Canker lengths and positions were measured, and the amount of decay associated with the cankers was recorded. *Saperda* galleries were also traced onto the acetate.

5. The tracings on the acetate were then measured using a planimeter. The areas of the tracings were converted into square feet. The volume of decay in each 2 foot segment was then calculated and summed to arrive at a total cubic foot loss for each tree.

Clonal differences were to be determined by differentiating clones using color aerial photography of each plot taken in the spring of the year when leaf flush was occurring. Since clones differ in the timing of leaf flush, this seemed to be the best way to try to differentiate clones on the ground.

Results

Data is still being summarized, and a full report will not be completed until 1991. However, some preliminary results follow:

The total number of trees evaluated for insect and disease incidence on the 30 plots was 1,561 trees. Of this total, 850 or 54% were aspen. Nineteen other species were also rated, but balsam fir (272 trees, 17%) and paper birch (127 trees, 8%) dominated the non-aspen species. 295 aspen trees were destructively sampled.

Looking at just the aspen trees, 278 or 33% were rated with a damage code other than healthy. Fifty-nine aspen had advanced decay caused by *Phellinus tremulae* as evidenced by the presence of conks. This amounted to only 7% of the total aspen included on the survey, and *P. tremulae* accounted for 21% of the damage codes on aspen. Forty-two or 5% of the

aspen had *Hypoxylon* cankers, and 44 or 5% of the aspen had been solely damaged by *Saperda*. *Saperda* was more common than this 5% figure, but occurred on aspen which had *Phellinus* or *Hypoxylon* and therefore did not show up on the inventory data sheets.

When comparing the insect and disease calls of the contractor with the calls of the specialists, an overall agreement average for all damage codes was 67.9% The contractors were most accurate in determining when a tree was healthy or did not need a damage code. Agreement for healthy trees reached nearly 80%. 61% of the *Phellinus* calls agreed which seems high, but *Phellinus* was identified strictly by the presence of a conk. Conks generally were fairly obvious making *Phellinus* one of the easier diseases to identify. 57% of the *Hypoxylon* calls agreed. The number of contractor calls of *Hypoxylon* were almost 4 times greater than the specialists' *Hypoxylon* calls. In other words only 29% of the contractors' *Hypoxylon* calls were correct. The contractors had the most difficulty with *Saperda* calls. Only 2 out of the 44 *Saperda* calls of the specialists' did the contractors correctly make.

295 trees were felled and destructively sampled. 214 of the trees had estimated lengths and cull deductions. The other 81 trees fell on point 11 which was a growth plot where lengths and cull were not estimated. Merchantable length measurements on the 214 trees agreed between the contractors' estimates and the actual measurements only 11 times or about 5%. 132 or 62% of the lengths were over estimated; over estimation of lengths ranged between 1 and 31 feet. Under estimation of lengths occurred 71 times or 33%. The range for under estimation ranged between 1 and 18 feet.

Tracings are still being measured, and therefore cull deductions have not been calculated. Without analyzing the data, it would appear that contractors generally over estimated the amount of cull.

Results from the aerial photography to differentiate clonal differences was disappointing. The photographs were taken too late in the spring to see the difference in leaf flush. Insect and disease incidence as well as cull deductions cannot be evaluated by clonal differences.

MINOR AND INCIDENTAL PESTS

1988

PEST	HOST	COUNTY	COMMENTS
INSECTS			
Gall mites *Eriophyes* spp.	Ash	St. Louis	
Aspen borer *Goes* spp.	Aspen	Koochiching	Mature aspen
Balsam fir sawfly *Neodiprion abietis*	Balsam fir	St. Louis	Small, scattered colonies
Balsam twig aphid *Mindarus abietinus*	Balsam fir	St. Louis	Heavy infestation; used insecticides
White grubs *Phyllophaga* spp.	Balsam fir	St. Louis	Lost 30% of new transplants
Luna moth caterpillars *Actias luna*	Birch	Itasca	
Larch casebearer *Coleophora laricella*	European larch	Itasca	Found 2 cases
Eastern tent caterpillar *Malacosoma americanum*	Hardwoods	St. Louis	
Pitch midge *Cecidomyia banksianae*	Jack pine	St. Louis	Some trees 50% infested
Pitch nodule maker *Petrova albicapitana*	Jack pine	St. Louis	Locally heavy
Jack pine sawflies *Neodiprion* spp.	Jack pine	Cook	Rare
Green climbing fruitworm *Othosia hibisci*	Maple	Itasca	Urban
Greenstripe mapleworm *Dryocampa rubicunda*	Maple	St. Louis	6 sections defoliated in T67-R19
Greenstripe mapleworm	Maple	Koochiching	Several locations
Maple petiole borer *Caulocampus acericaulis*	Maple	Itasca St. Louis	
Ocellate gall *Cecidomyia ocellaris*	Maple	St. Louis	

PEST	HOST	COUNTY	COMMENTS
Gall flies *Cincticornia* spp.	Oak	Itasca	
Shoot moth *Dioryctria* spp.	Red pine	Itasca	5 foot tall seedlings
Sawfly galls *Pontania* spp.	Willow	Itasca	
Spiny elm caterpillar *Nymphalis antiopa*	Willow	Itasca	
Powder Post beetles *Lyctus* spp.	Cabin logs	Itasca	Light infestation
Powder post beetles	Dwelling	St. Louis	In 2 beams
DISEASES			
Needle rusts *Coleosporium asterum*	Jack pine	St. Louis	100% infected seedlings in some plantations
Root rots *Fusarium* spp. *Cylindrocarpon* spp.	Red pine	Carlton	Containerized seedlings
Phomopsis canker *Phomopsis eleagni*	Russian olive	St. Louis	
ABIOTIC			
Scorch Abiotic	Maple	Cass	

MINOR AND INCIDENTAL PESTS

1989

PEST	HOST	COUNTY	COMMENTS
INSECTS			
Green striped mapleworm *Dryocampa rubicunda*	Maple	St. Louis	In northern part of county; few scattered trees
Red pine sawfly *Neodiprion nanulus*	Red pine	Itasca	Yard trees; very light defoliation
Dog tick nymphs *Dermacentor* sp.	Home	St. Louis	On furniture
DISEASES			
Anthracnose *Apiognomonia quercina*	White, bur oaks	St. Louis	Common; especially along lakeshores
Hypocotyl infection *Fusarium* spp.	White spruce	Pine	General Andrews State Nursery; associated with insect feeding and irrigation
ABIOTIC			
Herbicides	Ash	Clay	
Fertilizer burn	Red pine	Carlton	seedlings
Nitrogen burn	Red pine	Pine	General Andrews State Nursery; seedlings
Winter drying	Red pine	Carlton	

SURVEY RESULTS

JACK PINE BUDWORM

REGION 1 LARVAL SURVEY

COUNTY	DESCRIPTION	NO. SHOOTS W/LARVAE	DEFOLIATION PREDICTED	DEFOLIATION ACTUAL
Beltrami	2-147-34	1	O-L	O
	4-147-34	2	L	O
	7-147-34	1	O-L	M
	8-147-34	0	O	O
	9-147-34	3	L	L
	9-147-34	1	O-L	L
	11-147-34	3	L	M
	13-147-34	3	L	L
	26-147-34	0	O	O
	1-147-35	1	O-L	L-M
	2-147-35	1	O-L	M
	4-147-35	2	L	L
	11-147-35	2	L	O
	13-147-35	1	O-L	M
	19-148-35	1	O-L	O
	19-148-35	3	L	L
	28-148-35	0	O	L
	29-148-35	0	O	O
	30-148-35	2	L	L
	31-148-35	0	O	O
	32-148-35	1	O-L	L
L.O.W.	2-158-34	0	O	O
	30-159-33	2	L	O
	36-159-33	0	O	O
	10-159-34	0	O	O
	13-159-34	0	O	O
	1-159-35	0	O	O
	3-159-35	0	O	O
	15-159-36	0	O	O
	15-159-36	1	O	O

REGION 1 LARVAL SURVEY (CONTINUED)

COUNTY	DESCRIPTION	NO. SHOOTS W/LARVAE	DEFOLIATION PREDICTED	DEFOLIATION ACTUAL
Roseau	8-159-37	0	O	O
	8-159-37	0	O	O
	11-159-37	0	O	O
	3-159-38	0	O	O
	6-160-37	3	L	O
	31-160-37	0	O	O
	12-160-38	0	O	O
	25-160-38	0	O	O
	27-160-38	0	O	O
	12-161-36	0	O	O
	30-161-36	0	O	O
	26-161-37	1	O	O
	33-161-37	0	O	O

REGION 1 EGG MASS SURVEY

COUNTY	DESCRIPTION	NO. OF EGG MASSES	PREDICTED DEFOLIATION
Becker	14-139-36	0	0
	15-139-36	0	0
	22-139-36	0	0
	26-139-36	0	0
	27-141-36	0	0
	33-141-36	0	0
	34-141-36	0	0
Beltrami	22-146-35	0	0
	23-146-35	1	0
	33-146-35	0	0
	35-146-35	0	0
Hubbard	6-139-32	0	0
	9-139-32	0	0
	10-139-32	0	0

REGION 1 EGG MASS SURVEY (CONTINUED)

COUNTY	DESCRIPTION	NO. OF EGG MASSES	PREDICTED DEFOLIATION
Hubbard	11-139-32	0	0
	12-139-32	0	0
	30-139-32	0	0
	13-139-33	0	0
	25-139-33	0	0
	35-139-33	0	0
	35-139-33	0	0
	13-139-35	0	0
	19-139-35	0	0
	23-139-35	0	0
	35-139-35	0	0
	23-140-32	0	0
	24-140-32	0	0
	26-140-32	0	0
	30-140-32	0	0
	31-140-32	0	0
	35-140-33	0	0
	10-143-33	0	0
	12-143-33	0	0
	8-143-34	0	0
	8-143-34	0	0
	9-143-34	0	0
	10-143-34	0	0
	16-143-34	0	0
	2-143-35	0	0
	14-143-35	0	0
	4-144-35	0	0
	20-144-35	1	0
	32-144-34	0	0
	32-144-34	1	0
	2-145-34	0	0
	22-145-34	0	0
	23-145-34	0	0
	24-145-34	0	0
	34-145-34	0	0
	2-145-35	1	0
	4-145-35	0	0

REGION 3 JACK PINE BUDWORM LARVAL SURVEY

COUNTY	DESCRIPTION	BUDWORMS	DATE
Crow Wing	NWNE 16-144-31	0	6-24
	NESE 10-136-29	0	6-24
	NESW 9-136-27	0	6-24
	NENE 23-136-27	0	6-24
Pine	SESW 25-45-20	1+3 Pupae	6-28
	NWNW 1-44-20	10 Pupae	
	SESE 13-45-20	0	6-28
Wadena	NENE 3-138-33	3	6-13
	SWSW 7-138-33	6	6-13
	NWSW 20-135-33	0	6-27
	SESE 19-136-33	0	6-27
	NESE 35-136-33	0	6-27

PINE TUSSOCK MOTH PHEROMONE TRAPPING IN REGION III

TRAP LOCATION	DATE	MOTHS IN TRAP
Pine County (General Andrews Nursery vicinity) (placed 7-8-88)		
1. SWNE 6-45-19	7-18	12
	7-20	18
	8-5	5*
	8-17	0
2. SWNW 6-45-19	7-18	18
	7-20	13
	8-5	5
	8-17	2

PINE TUSSOCK MOTH TRAPPING (CONTINUED)

TRAP LOCATION	DATE	MOTHS IN TRAP
3. NWSE 20-45-19	7-17	15
	7-20	16
	8-5	6
	8-17	1
4. SWSE 25-45-20	7-18	22
	7-20	10*
	8-5	5*
	8-17	1
5. SWSE 26-45-20	7-18	5
	7-20	6
	8-5	5
	8-17	1
6. NENW 25-45-20	7-18	14
	7-20	7
	8-5	4
	8-17	1
7. NESE 13-45-20	7-18	21
	7-27	14
	8-5	6
	8-17	2
8. SWSE 18-45-19	7-18	9*
	7-27	5*
	8-5	2
	8-17	2
Crow Wing County (Mission Township) (placed 7-8-88)		
9. SWSW 11-136-27	7-20	12
	7-28	26
	8-9	9
	8-18	1

PINE TUSSOCK MOTH TRAPPING (CONTINUED)

TRAP LOCATION	DATE	MOTHS IN TRAP
10. SENE 10-136-27	7-20	13
	7-28	23
	8-9	9
	8-18	4
11. NESW 10-136-27	7-20	10
	7-28	11*
	8-9	4*
	8-18	2
12. NWSE 9-136-27	7-20	8
	7-28	13
	8-9	3
	8-18	1
13. SWNW 9-136-27	7-20	8
	7-28	17
	8-9	13
	8-13	8
14. NWSW 9-136-27	7-20	7
	7-28	13*
	8-9	7*
	8-18	3*
Cass County (Placed 8-12-88)		
15. SESW 25-138-32	7-20	9
	7-28	28
	8-9	9
	8-18	2

PINE TUSSOCK MOTH TRAPPING (CONTINUED)

TRAP LOCATION	DATE	MOTHS IN TRAP
Wadena County (Northeastern) (Placed 8-12-88)		
16. SENW 15-138-33	7-20	5
	7-28	5
	8-9	2
	8-18	2
17. SWNE 10-138-33	7-20	20
	7-28	18
	8-9	2
	8-18	6
18. NENE 3-138-33	7-20	21
	7-28	27
	8-9	18
	8-18	6

*Bird predation removed some moths

1988 SPRUCE BUDWORM PHEROMONE TRAPPING RESULTS

REGION II

PLOT LOCATION	TOTAL # MOTHS	DEFOLIATION RATING	TOTAL # LARVAE[1]	TOTAL # EGGMASS[1]
Carlton Co.				
7-49-18	20	L	--	0
Cook Co.				
32-64-3E	694	VH	--	--
11-63-4E	19	L	--	--
32-65-3W	310	VH	--	--
1-61-1W	1829	VH	--	--
Lake Co.				
9-58-6	10	0	--	--
9-63-9	756	H[2]	29	2
19-55-10	19	0-VL	1	2
36-55-12	63	0-VL	2	2
St. Louis Co.				
8-68-20	42	VL	--	1
14-65-14	414	L	7	0
16-65-17	308	L	4	0
8-65-20	100	0	1	0
24-64-13	478	L	4	10
13-59-20	258	VL	5	1
4-59-21	370	L	21	2
16-51-15	--	--	--	--
18-53-17	231	L	--	1
14-42-16	85	L	--	1
32-60-17	114	L	--	0

[1] = On each plot 9 - 15" branch samples were examined.

[2] = Noted budworm feeding on upland black spruce also.

SPRUCE BUDWORM PHEROMONE TRAPPING - 1988

REGION III

Trap No..	Plot Location	Moths Trapped	Defoliation of New Growth	Egg Masses
1	NWNW 45-46-16	2	Low[1]	0
2	SESW 2-24-17	6	Low	0
3	SESE 7-45-16	3	Low	0
4	NESE 6-45-16	4	Low	0
5	SWNE 10-45-17	0	Low	0
6	NENE 14-44-17	8	Low	0
	NWNW 13-44-17	8	Low	0
7	SESW 12-44-17	8	Low	0

[1]Low - 0 to 20% defoliation of new growth of all trees at plot. No defoliation was seen.

This year's trapped moths represents the third of several years planned study to relate number of spruce budworm moths, current growth defoliation and egg masses to the next year's defoliation on the balsam and spruce trees. When heavy to severe defoliation is thereby predictable, control can be planned before the budworm can spread and cause extensive balsam and spruce loss.