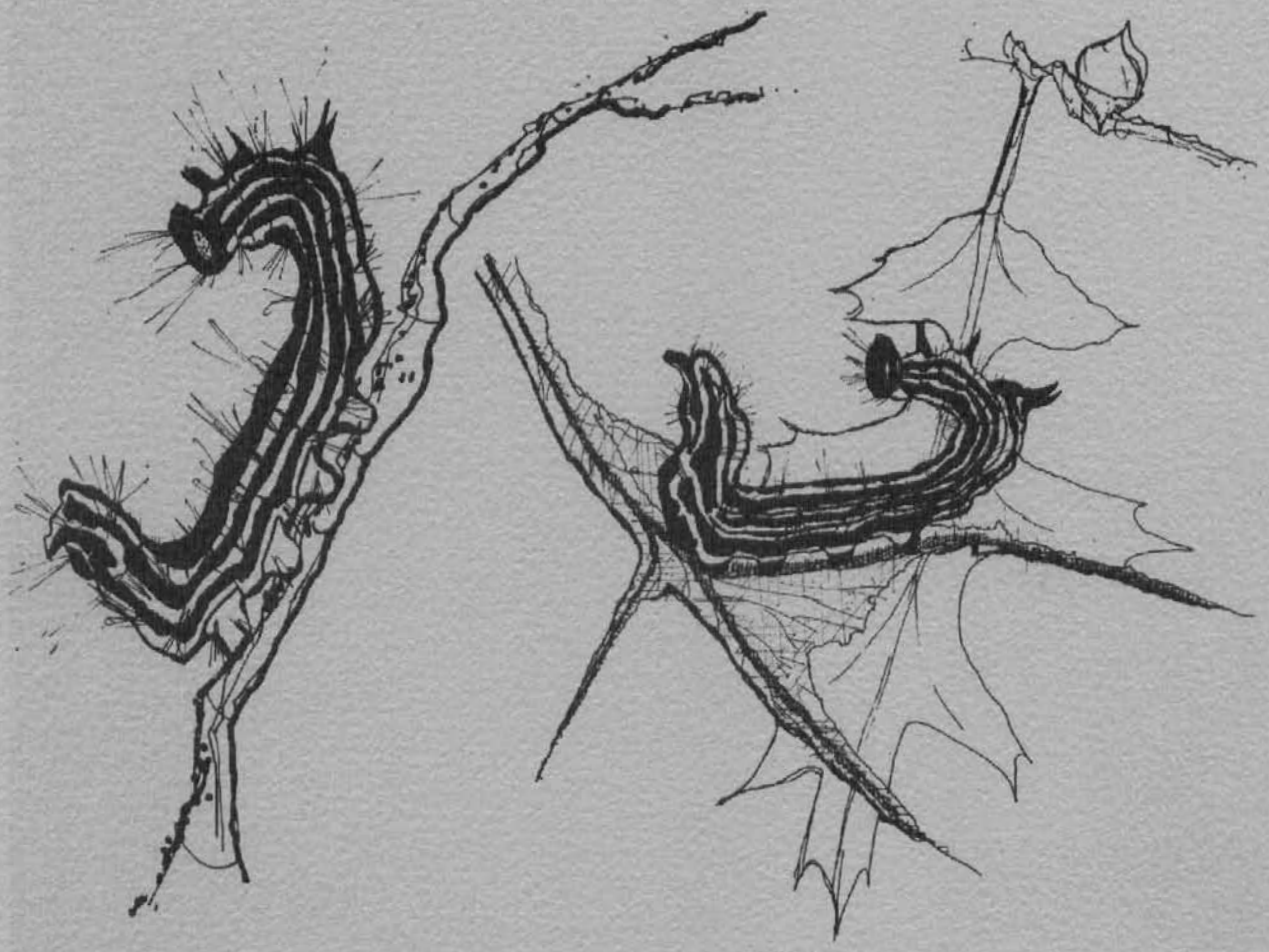
Forest Insect and Disease Report



1986

Minnesota Department of Natural Resources, Division of Forestry

1986 FOREST PEST REPORT

BY

The Forest Insect and Disease Unit

Minnesota Department of Natural Resources

Division of Forestry

March, 1987

St. Paul, Minnesota

PREFACE

The 1986 Annual Report represents a significant change in the method of reporting information. In attempt to make the document more "reader friendly", the contents have been reorganized. Reports on individual pests now begin with a brief introduction of statewide impacts and infestation status. This information is then followed by Regional Notes. These are meant to present highlights or pertinent information by region on the individual pests. Coverage of Special Projects will complete the document. The historical recording of phenology, survey types and results, etc. will now be in a separate appendices. In the future these appendices will be printed separately and made available on a request basis.

It is hoped that these changes will help make this report more timely, readable and useful. The Forest Pest Unit would appreciate receiving any comments on this approach.

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INTRODUCTION

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 MN-DNR Forestry Division. Field activities within this division have been regionalized into six regional administrative units. The insect and disease unit consist of a Forest Insect and Disease Supervisor, one statewide Pesticide Use coordinator, four Regional Forest Insect and Disease Specialists and five seasonal Plant Health Specialists. The four Specialists and the five seasonal Plant Health Specialists have regional responsibilities.

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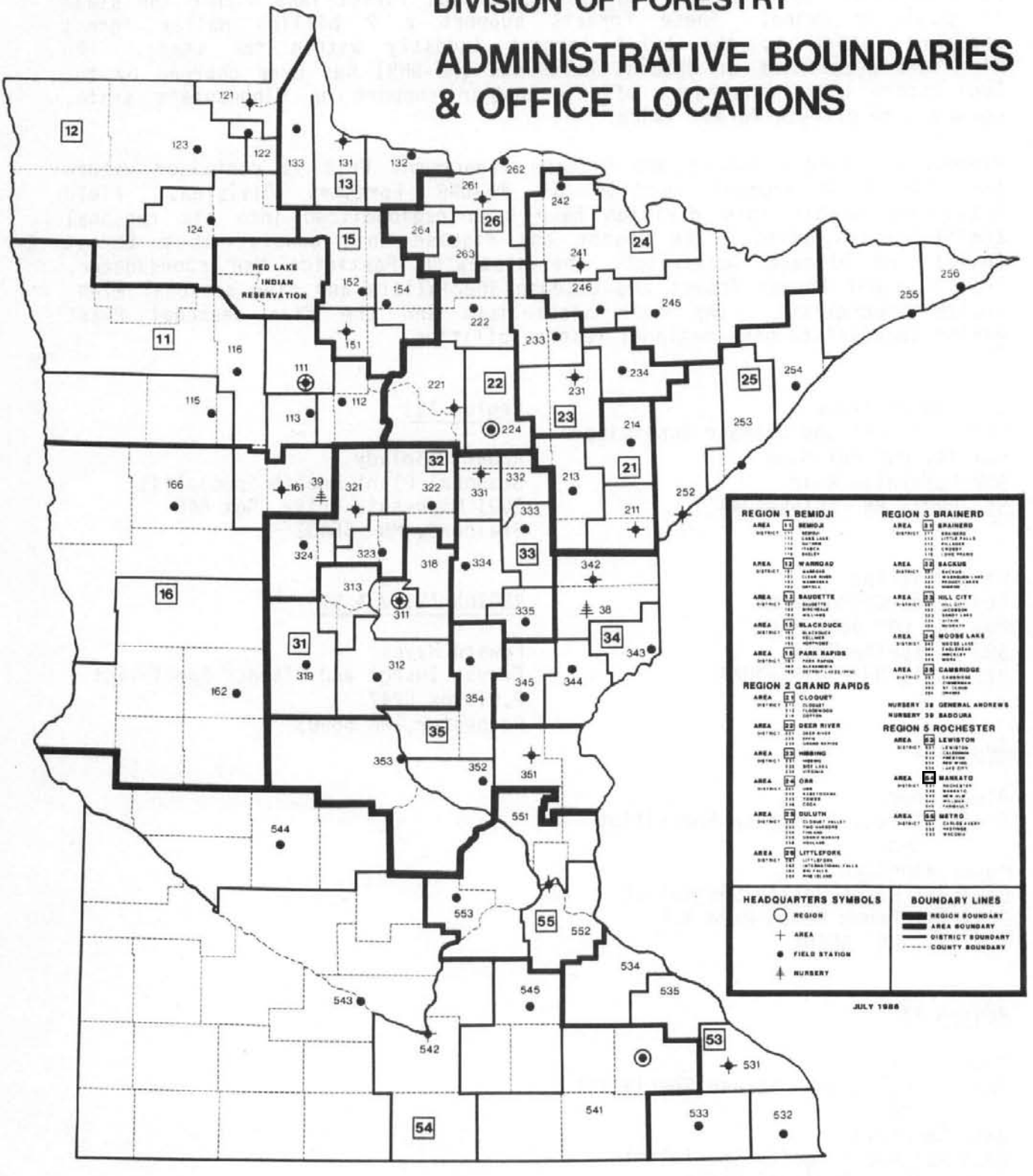
DIVISION OF FORESTRY

ADMINISTRATIVE BOUNDARIES & OFFICE LOCATIONS



JULY 1988

PEST CONDITIONS REPORT: INSECTS

JACK PINE BUDWORM
Choristoneura pinus Freeman

ACREAGE: 146,350 acres

SEVERITY: DEFOLIATION
Light (1-20% needle loss) - 63,750 acres
Moderate (21-50% needle loss) - 55,800 acres
Heavy (50% needle loss) - 26,800 acres

RECENT HISTORY: Budworm populations in the northeastern and central parts of the state are declining while populations remain stable in the northwest.

PREDICTION: Small, localized pockets of light to moderate defoliation may occur in the Dentabow area in Koochiching County and near Wolf Lake in northeastern Itasca County. Moderate to heavy defoliation may occur in eastern Roseau, western Lake of the Woods, southern Beltrami, and central Hubbard Counties.

Regional Notes

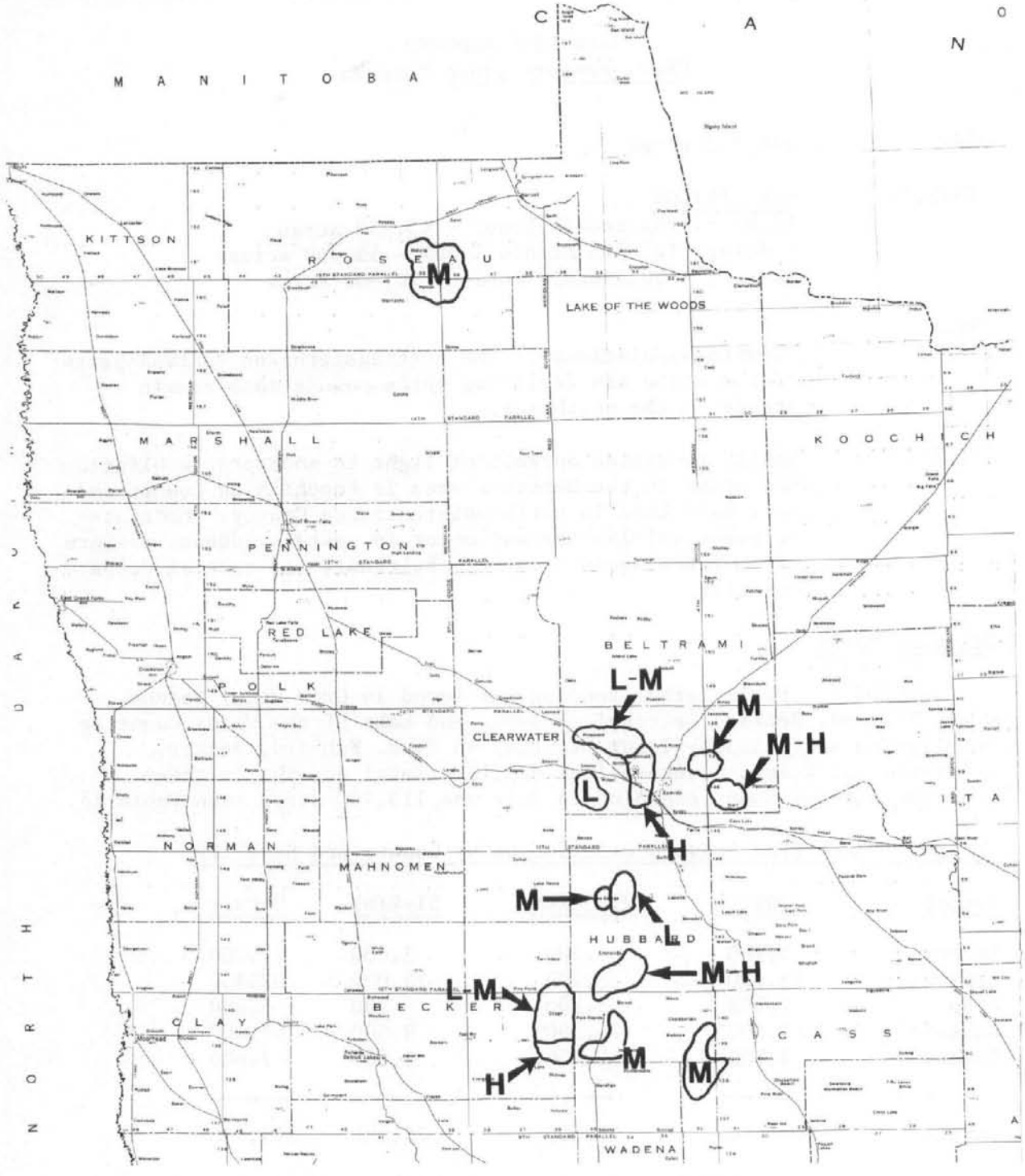
REGION 1: Early larval feeding was found in Crow Wing, Wadena, Cass, Hubbard, Becker, Beltrami, Roseau, and Lake of the Woods Counties. Defoliation and foliage-firing occurred in Cass, Hubbard, Becker, Beltrami, and Roseau Counties (see Map 1). Total acreage in these counties showing some reddening in July was 113,400 acres (see Table 1).

Table 1: Jack Pine Budworm Defoliation by County and Severity

County	1-20%(L)	21-50%(M)	51+%(H)	Totals
Becker	5,700	7,000	3,000	15,700
Beltrami	15,000	5,700	12,000	32,700
Cass	1,500	3,200	700	5,400
Hubbard	19,400	23,100	9,500	52,000
Roseau	3,800	2,800	1,000	7,600
Totals	45,400	41,800	26,200	113,400

Losses were confined to scattered top kill in stands heavily defoliated in 1985. Some salvaging occurred in Hubbard County during the winter of 1986-87. Salvaging was prompted by a positive jack pine market rather than trying to prevent further loss.

Map 1: Jack Pine Budworm Defoliation in Region 1 & 3



L Light (1-20% needle loss)

M Moderate (21-50% needle loss)

H Heavy (greater than 50% needle loss)

This present budworm outbreak began in 1984 when actively feeding larvae were found but little defoliation could be observed. In 1985, heavy defoliation occurred in southern Hubbard, Crow Wing, and Wadena Counties. In 1986, these areas had little additional defoliation, but some new areas experienced defoliation. Egg mass surveys predicted additional new areas of defoliation for 1987 with a reduction in defoliation severity in the stands defoliated in 1986. 1987 should be the last year for widespread defoliation in the Region.

REGION 2: Jack pine budworm was active in St. Louis, Lake, and Cook Counties (see Map 2). Acres defoliated and defoliation severity were both reduced compared to 1985 levels. During the aerial survey, budworm defoliated jack pine was detected on 13,750 acres which was a 93% reduction in acres compared to 1985. The regionwide level of severity was reduced from 15% in 1985 to less than 5% in 1986. Within the outbreak area, stands suffering defoliation were widely scattered. Within these stands, the majority of trees were not visibily defoliated.

Moderate defoliation (20-50% of the current needles consumed) was observed in two locations, near Moose River along the Echo Trail and in NW Lake County along Highway 1. Severe defoliation (90% or greater loss of current year needles) was reported near Lac LaCroix on the Canadian border in St. Louis County. The 70+ year old jack pine have had three consecutive years of defoliation, and some mortality has occurred.

Lifestage and defoliation surveys were conducted throughout the Region, and attention was focused on 19 permanent plots in 7 Districts.

In late May and early June, we observed that both the number of early larvae, and the number and size of staminate cones were reduced on jack pines growing in the outbreak areas. Historically, these two factors have indicated an abrupt population reduction, and that is what happened. By mid-June, the larvae that fed earlier and started webbing needles together had mostly died off. The major moth flight was July 7-14th from larvae that did survive and pupated. Regionwide, defoliation was less than 5% at the end of the growing season.

Jack pine stands near the Lake One access in northwest Lake County are representative of the effects of budworm defoliation in the northern part of the Region. In these stands, only a very few trees were killed by budworm defoliation, and 10-50% of the jack pine had top kill. Many of the trees that appeared top killed in the fall of 1985 produced a few new shoots and needles on their crowns during 1986. The budworm population collapsed in 1986, caused very little defoliation, and allowed the trees to begin recovery.

REGION 3: Aerial defoliation surveys conducted during July found no defoliation in Crow Wing County, but defoliation had occurred in Wadena and Cass Counties. Cass County acreage is included in the Region 1 summary. In Wadena County, 19,200 acres showed some defoliation. Light defoliation (1-20% needle loss) was evident on 4,600 acres, moderate defoliation (21-50% needle loss) on 14,000 acres, and heavy defoliation on only 600 acres. Jack pine with apparently dead tops in

Map 2: 1986 Jack Pine Budworm Defoliation

Note: shaded area presumed infested

northeastern Wadena County were climbed to closely inspect the tops. There were few live needles remaining on the tops, but live cambium was found and no bark beetle activity could be detected.

Because of inadequate staffing in the Region, early larval surveys were not conducted. Surveys starting on June 11 found many jack pines with 90% of the shoots with webbing, but few larvae could be found. Predators such as spiders and stinkbugs were seen, and evidences of disease and parasites in the larvae were observed during the following two weeks. Slow and abnormal movements in live budworms, small instar budworms, and dead budworms indicated a buildup of disease and parasites in the budworm population. These limiting biotic factors plus abiotic factors such as excess rain combined to reduce budworm numbers and needle feeding. The excess rain contributed to survival of the shoots and to the growth of the partially chewed and unchewed needles. During the last week in June, pupation was rapidly occurring; emerged moths were observed July 3, and many moths were seen flying from shaken pine branches in Pine County on July 7.

In summary, the jack pine budworm in Region 3 appears to be diminishing and should not result in whole tree mortality, top kill, or stress that will allow bark beetles to infest the trees.

PINE TUSSOCK MOTH
Dasychira pinicola Dyer

ACREAGE: No observable defoliation.

RECENT HISTORY: This insect is at minor levels statewide, and in Region 3 populations were less than during 1985. Only 1 larva was observed at all checkpoints in the Region, and no egg masses were found.

PREDICTION: Populations should remain low with no defoliation.

RED PINE TIP MOTH
Rhyacionia adana Heinrich

ACREAGE: 130 acres

SEVERITY: Upto 50% of the seedlings were damaged.

RECENT HISTORY: None

PREDICTION: None

Regional Notes

REGION 2: Containerized red pine on at least 4 industry-owned plantations in central St. Louis County have symptoms of attack by tip moth larvae. On one site, it is suspected that the seedlings' "cabbage" form and short height are due to past years' tip moth attacks. The red pine on this site are 5 years old, and many are still less than 1 foot in height.

SPRUCE BUDWORM
Choristoneura fumiferana (Clemens)

ACREAGE: 440,000 acres

SEVERITY: Defoliation ranged from very light (10%) to heavy (50% needle loss), but most defoliation was in the moderate category (21-50% needle loss).

RECENT HISTORY: Surveys indicate an increasing population.

PREDICTION: Spruce budworm activity will be confined to northeastern Minnesota, as follows:

Cook County: Increased feeding activity should occur in the southwestern townships. There is a likelihood of heavy defoliation occurring in the northern and northwestern townships. Defoliation should remain moderate to heavy along the Arrowhead Trail.

Lake County: Moderate to heavy defoliation should continue in the northwestern part of the county. The southwestern townships may see a decrease in defoliation intensity. Elsewhere in the county defoliation levels should be similar to 1986.

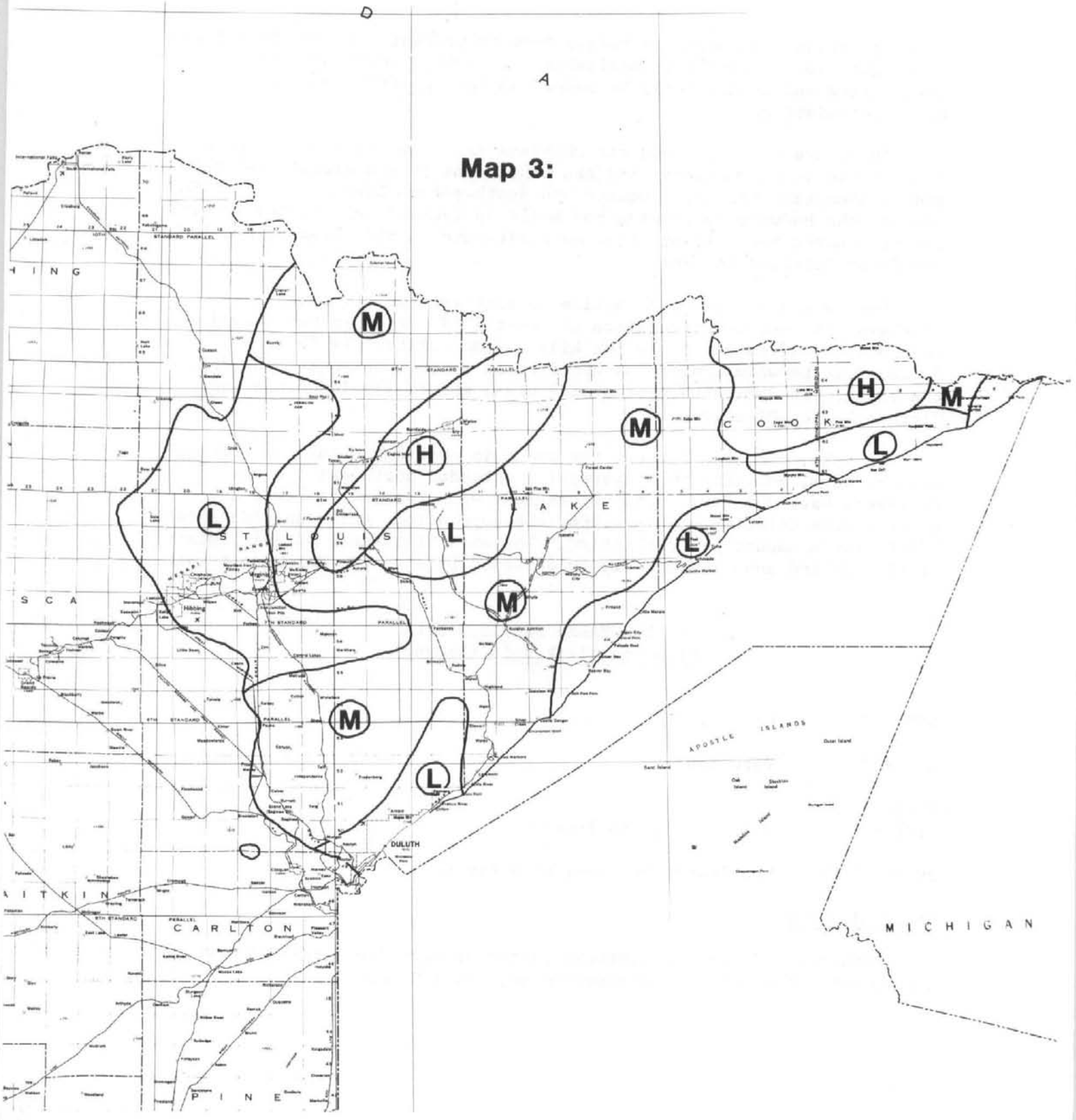
St. Louis County: In the northeastern townships, heavy and moderate defoliation is predicted. Defoliation may increase in the west central and northwestern townships. The south central townships might expect decreased defoliation, but top kill and tree mortality should continue to occur.

Carlton County: No defoliation is predicted.

Regional Notes

REGION 2: Budworm was active in the majority of Cook County, all of Lake County, and in most of St. Louis County in 1986 (see Map 3). It's estimated that defoliation to balsam fir and white and black spruces occurred on 440,000 acres. This is an increase of 110,000 acres over that defoliated in 1985. In 1985, most of this 110,000-acre area

Map 3:



1986 Spruce Budworm Defoliation

of defoliation was mapped as having budworm present, but the impact was so slight that it wasn't quantifiable. In 1986, budworm impact intensified and stands could be mapped as having light, moderate or heavy defoliation.

There are two major budworm outbreak areas in the Region. One area is centered in Cook County, and the other area is centered in central and southeastern St. Louis County and southwestern Lake County. In Cook County, the budworm population has built up rapidly, maintained itself, and has caused top kill and tree mortality over a wide areas since it was first detected in 1983.

Spruce budworm has been active in southeastern St. Louis and southwestern Lake Counties since at least 1977. Budworm has caused and continues to cause extensive top kill and mortality. In 1985, a decrease in budworm impact was observed in a few locations. In 1986, the impact has decreased over a wide area, especially in Cotton and Cloquet Valley Districts.

In 1985, the area between the two main outbreak areas was infested with budworm, and this new infestation estended northwest towards Voyageurs National Park. The populations were too low to cause any quantifiable defoliation. In 1986, the populations built up and caused a detectable amount of defoliation. The area of intense activity starts at Biwabik and goes through Ely to Basswood Lake on the Canadian border.

YELLOWHEADED SPRUCE SAWFLY
Pikonema alaskensis (Rohwer)

ACREAGE: 0

SEVERITY: Very low

RECENT HISTORY: Maintaining low levels

PREDICTION: Continued low level of activity

Regional Notes

REGION 2: Sawfly populations remain at very low levels. A few larvae were observed in southwestern St. Louis County.

LARCH SAWFLY
Pristiophora erichsonii (Hartig)

ACREAGE: 50 acres

SEVERITY: Heavy

RECENT HISTORY: Increasing

PREDICTION: None

Regional Notes

REGION 2: Sawflies were active on native tamarack in section 32, T. 58N, R. 16W and in section 5, T. 57N, R. 16W in St. Louis County. The acreage and severity increased this year. On State land 20 acres were defoliated, and 30 acres of County land were defoliated.

GYPSY MOTH
Lymantria dispar (Linnaeus)

ACREAGE: 280 acres

SEVERITY: Isolated infestation with no observable defoliation.

RECENT HISTORY: A decreasing population seems to be present as evidenced by a decreasing total number of male moths recovered over the last two years.

PREDICTION: No outbreaks or major defoliation are predicted, but small numbers of male moths will continue to be trapped from new and existing introductions.

Statewide Monitoring Program

Statewide cooperative efforts between the Minnesota Department of Agriculture and the Department of Natural Resources resulted in the placement in 62 counties of 8,780 Delta traps baited with plus lure for the purposes of detection, deliniation, and control. Ten moths on 9 sites were recovered. This number is significantly down from 1984 when 509 moths were trapped and from 1985 when 126 moths were trapped.

Trap catches and locations are as follows:

COUNTY	LOCATION	# OF MOTHS
Anoka	Burns	1
Clearwater	Itasca State Park	1
Dakota	Burnsville	1
	Eureka Township	1
Hennepin	Minneapolis	1
	Deephaven	1
	Minnetonka	1
Olmstead	Marion	1
Scott	Shakopee	2

Regional Notes

REGION 1: One hundred and eight traps were placed throughout the Region to monitor for the gypsy moth. One male moth was trapped in the Bear Paw Campground in Itasca State Park. The closest known infestation is approximately 200 miles to the southeast. Itasca State Park has the most visitors of all the state parks, and this one trap catch probably indicates a "hitchhiker" from an out-of-state camper or one from the Twin Cities area. There were 7 other traps in the park, and they were all negative. This, too, indicates the trap catch was a single hitchhiking male moth. Plans, however, are being made to intensively trap the park in 1987 to make sure that a population has not been established.

REGION 2: One hundred and twenty-seven pheromone traps were placed in this Region by Division of Forestry and Division of Parks personnel. No gypsy moths were trapped. Plans call for continual trapping in the Region to watch for gypsy moth introductions.

REGION 5: Two sites in Apple Valley were treated for the second consecutive year. On May 14, 20, and 28 both sites were treated by helicopter using Dipel 8L at 16 BIU per acre. Plyac sticker was added at the rate of 2% by volume. Within this area, two separate sites were treated for a total of 280 acres. No male moths were subsequently recovered from the treated areas in 1986. There are now no known infestations in Minnesota.

FOREST TENT CATERPILLAR
Malacosoma disstria Hubner

ACREAGE: 61,800 acres

SEVERITY: Moderate (less than 50% leaf loss) defoliation occurred on 400 acres in Kandiyohi County while heavy defoliation (greater than 50% leaf loss) occurred on 61,400 acres in St. Louis County.

FOREST TENT CATERPILLAR

RECENT HISTORY: Increasing populations are occurring in both areas.

PREDICTIONS: Defoliation will continue to occur in both areas, and both populations should move into surrounding areas previously free of forest tent caterpillar activity.

Regional Notes

REGION 2: 1986 marked the tenth consecutive year of defoliation in the 15,000-acre "core area" of FTC defoliation near Brookston in St. Louis County (see Map 4). The area of defoliation expanded to 61,400 acres in 1986 which represents a four-fold increase in area defoliated (see Map 5). FTC larvae were found in scattered locations along the North Shore between Duluth and Two Harbors in Lake County. Pupal parasitism was assessed in two locations near Brookston in St. Louis County. The average parasitism was 81% which was not sufficient to limit the population.

REGION 5: This defoliator continues to be active in northern Kandiyohi County, and has been present in this area for several years. In 1986, 400 acres were defoliated in six seperate areas in the county.

LARGE ASPEN TORTRIX
Choristoneura conflictana Walker

ACREAGE: 225,600 acres

SEVERITY: Heavy defoliation (greater than 50% leaf loss) occurred over the infestation area.

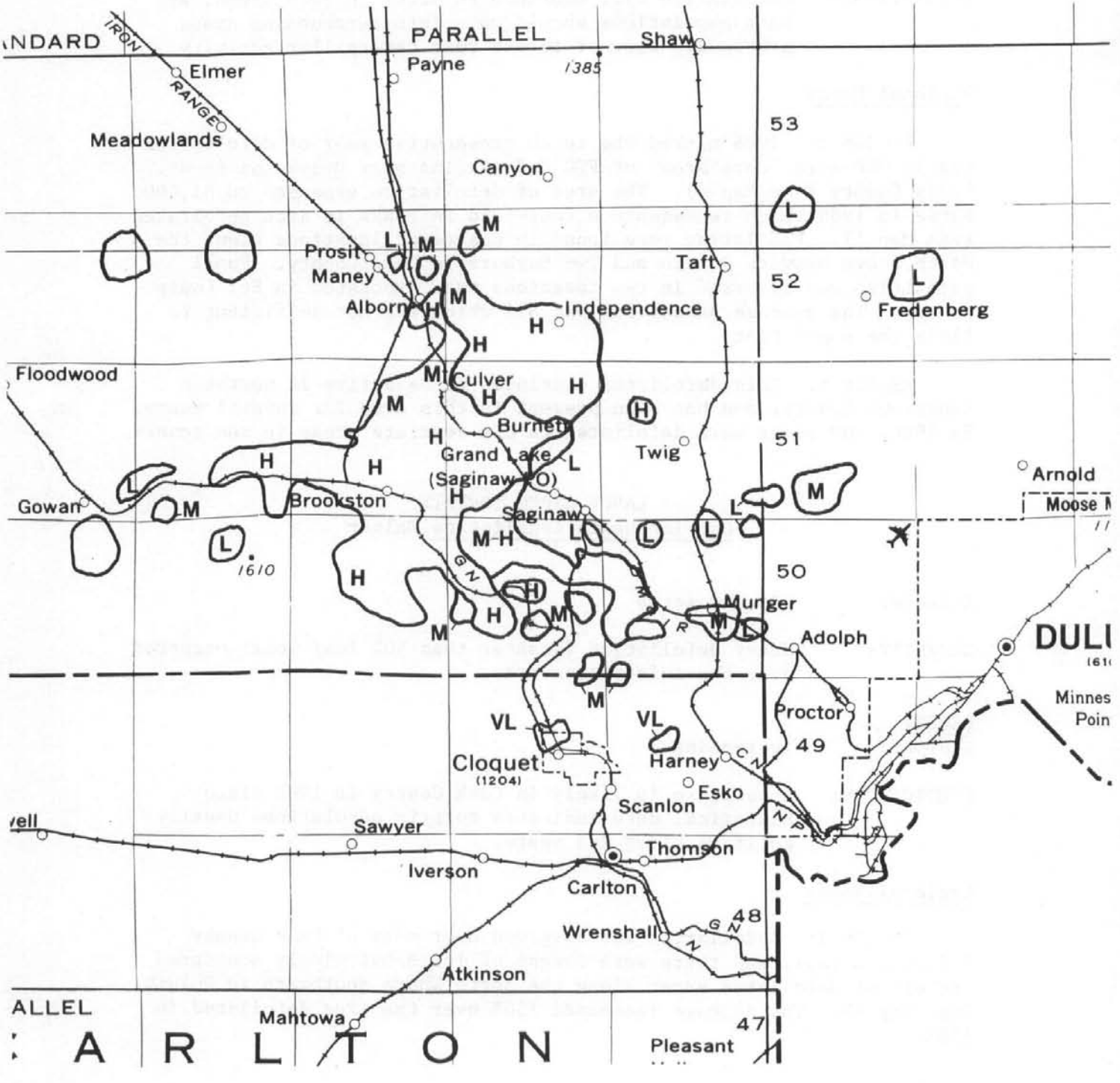
RECENT HISTORY: Increasing

PREDICTIONS: A collapse is likely in Cook County in 1987 since historical data indicates tortrix populations usually collapse after 2-3 years.

Regional Notes

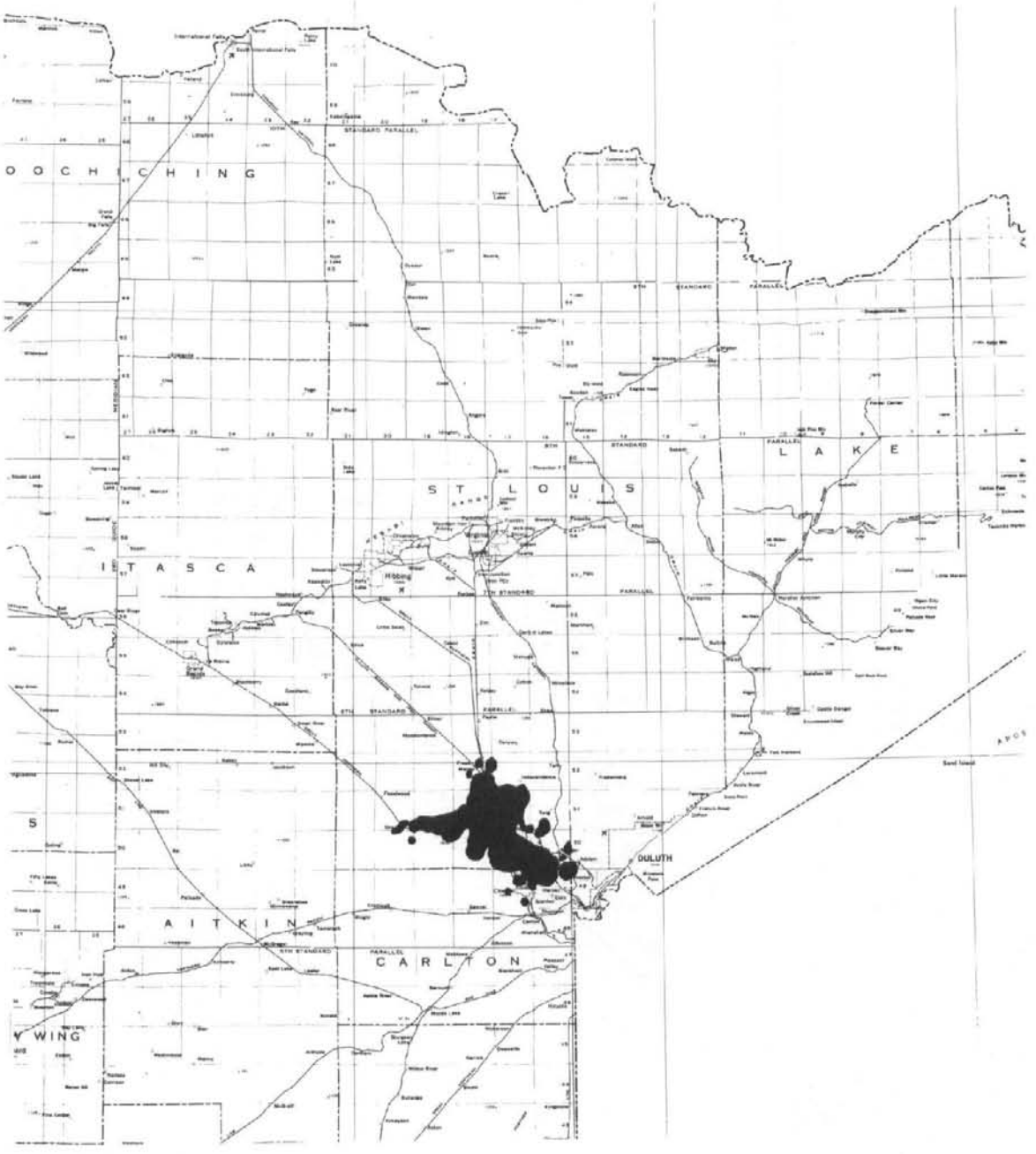
REGION 2: Defoliation was observed over most of Cook County (178,000 acres), and there were dozens of large but widely scattered pockets of defoliated aspen along the North Shore southward to Duluth (see Map 6). The acreage increased 150% over the area defoliated in 1985.

Map 4: 1986 Forest Tent Caterpillar Defoliation of Aspen

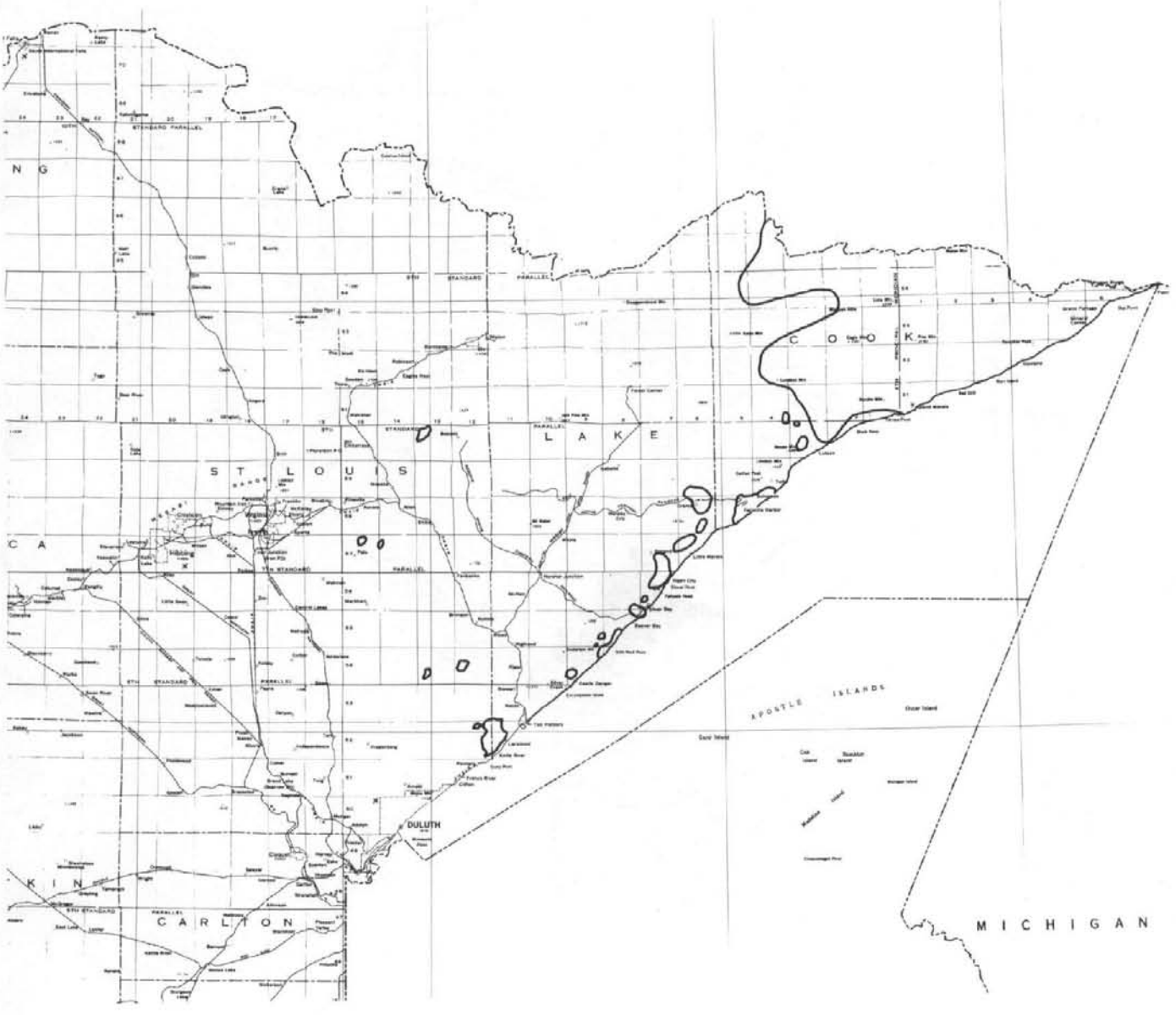


Aerial Survey: June 26 D.N.R. 61,400 acres

Map 5: 1986 Forest Tent Caterpillar Defoliation



Map 6: 1986 Large Aspen Tortrix Defoliation



BALSAM POPLAR BORER
Unknown Species

ACREAGE: Unknown

SEVERITY: Pockets of mortality have been observed.

RECENT HISTORY: Unknown

PREDICTIONS: Unknown

Regional Notes

REGION 2: Scattered pockets of dying balsam poplar were observed in the Two Harbors District in Lake County. The poplars have died over the past 4 to 6 years. Quaking and bigtooth aspen growing in close association have not been affected.

The dying poplars have abundant, large diameter bore holes scoring the surface of the wood immediately under the bark and in 2 to 3 growth rings below that. Often, the bark splits over the areas where borer activity occurred. A close inspection of a felled balsam poplar showed borer tunneling activity along its entire stem length. Sap was bleeding from some of the tunnels, and other tunnels were infected by a canker forming fungus. Cankers were 4 to 5 inches in diameter.

No current year activity could be found. It appeared that the peak of tunneling occurred 2 to 3 years ago.

BASSWOOD THRIPS
Seriocothrips tilae (Hood)

ACREAGE: 100,000 acres

SEVERITY: Generally, damage has been very minor.

RECENT HISTORY: Decreasing

PREDICTIONS: Light defoliation should be observable in 1987 throughout the general basswood range in southern Minnesota.

Regional Notes

REGION 2: Thrips were observed in two locations in 1986 in Carlton County in section 23, T. 48N, R. 16W and section 21, T. 49N, R. 18W. These two areas totalled about 100 acres in size. The upper crown foliage looked healthy, but the lower crown leaves were deformed. On June 3rd, thrips were actively feeding. Buds opened on trees where the thrips were feeding, but the leaves were small, dry and brown.

Many basswood trees on both sites have dead branches and are in poor condition or dead from the cumulative effects of thrip feeding over the past few years.

REGION 5: Thrips infested about 100,000 acres and caused light to moderate defoliation throughout much of the basswood range in southern Minnesota. This is a continuation of an infestation which started a few years ago.

A BASSWOOD LEAF SKELETONIZER
Anchylopera sp.

ACREAGE: 200 acres

SEVERITY: Trees heavily infested shed their leaves in August.

RECENT HISTORY: Unknown

PREDICTIONS: Unknown

Regional Notes

REGION 1: Basswood in an area from the north end of Lake Bemidji in Beltrami County to Cass Lake in Cass County showed brown leaves and thin crowns in August. Because this corresponded to the area that was heavily defoliated by the variable oakleaf caterpillar (Heterocampa manteo (Doubleday)) in 1984, there was a concern that this defoliator was once again present after it had collapsed in 1985. Closer inspection showed leaf damage very different from that caused by leaf chewing defoliators. Feeding was confined to the undersides of the leaves and occurred only along the main veins of the leaves. Larvae spin webs along both sides of the veins folding the leaf along the veins and then skeletonizing the leaf tissue. The leaves turn brown on top where feeding has occurred, and many of the leaves had two and three folds in them. The leaves drop prematurely, and the larvae pupate in the folded leaves.

WILLOW LEAF BEETLE
Plagiodera versicolora (Laicharting)

ACREAGE: 200,000 acres

SEVERITY: Visible browning and premature defoliation occurred to most willows infested.

RECENT HISTORY: This is the second year of noticeable feeding, but the area over which the feeding damage has been observed has been reduced over 1985 levels.

PREDICTIONS: Populations seem to be declining, and feeding damage should be less in 1987.

Regional Notes (Willow Leaf Beetle)

REGION 1: Feeding damage was once again widespread and noticeable and accounted for most of the 200,000 acres which were infested. Most of the feeding dmage was confined to Roseau, Lake of the Woods, and Beltrami Counties.

REGION 2: Feeding damage was reduced from the 1985 levels, and damage occurred only in scattered pockets throughout the Region.

PEST CONDITIONS REPORT: DISEASES

TARSPOT NEEDLECAST OF JACK PINE
Davisomycella ampla (Dar.) Darker

ACREAGE: Common and widespread through the jack pine areas

SEVERITY: This disease does cause some moderate defoliation, and when this defoliation is combined with defoliation due to the jack pine budworm, tree mortality can occur.

RECENT HISTORY: Unknown

PREDICTIONS: Unknown

Regional Notes

REGION 2: This needlecast disease occurred at a moderate level in St. Louis County. By May 28th, fruiting bodies were abundant, and infected needles were turning brown.

NEEDLE DROOP OF RED PINE
Physiological

ACREAGE: 60 acres

SEVERITY: 20% to 40% of the plantation trees affected

RECENT HISTORY: Unknown

PREDICTIONS: Unknown

Regional Notes (Needle Droop)

REGION 2: This condition was diagnosed on 2 county-owned red pine plantations in southeastern St. Louis County. One plantation had been planted to bare root stock, and the other plantation was established with containerized stock. Both sites are characterized by a gravelly, sandy soil texture and little competition. On the bare root planted site, J-rooting was very common.

Symptoms included a drooping of some of the current year needles and the death of proleptic shoots before the needles had elongated to 1 inch. However, most terminal buds were still viable. Lab examinations revealed no evidence of insect activity or fungal pathogens. About 40% of the bare root seedlings were affected by needle droop in 1986. Many of these were previously affected in 1984 and 1985 as evidenced by their form and dead shoot remnants. The containerized stock was planted in 1985, and only 20% of the seedlings were affected in 1986.

SPRUCE NEEDLE RUST
Chrysomyxa ledi deBary

ACREAGE: Common

SEVERITY: Moderate to heavy

RECENT HISTORY: Unknown

PREDICTIONS: Unknown: Disease incidence is related to wet weather.

Regional Notes

REGION 1: Incidence of this disease was greatly reduced over the high infection levels experienced in 1985.

REGION 2: Spruce needle rust was very common in late summer throughout much of the Region. The level of infection varied greatly from location to location and from tree to tree. Some blue spruce in urban plantings were so covered with aeciospore production that the entire tree looked orange from a distance. The tree species involved included white, black, and blue spruces.

AMERICAN SPRUCE-RASPBERRY RUST
Pucciniastrum americanum (Farl.) Arth.

ACREAGE: 10 acres

SEVERITY: Moderate

RECENT HISTORY: Increasing

PREDICTIONS: Unknown

Regional Notes

REGION 2: The aeciospores of this rust are produced on cones and also on current year needles. The rust is reported in the literature as rarely occurring on cone scales, but in the white spruce seed orchard at Cotton, the rust occurs mainly on the cones. In 1986, 43.6% of the cones were infected by this rust fungus (see Special Projects). The rust has not been a significant problem on the needles with less than 5% of the needles infected in 1986. Aecia were found on needles on June 6th.

WILLOW BLIGHT COMPLEX
Venturia saliciperda Nuesch
Glomerella cingulata (Stonem.) Spauld & Schrenk

ACREAGE: Widespread throughout Region 2, except in Cook County.

SEVERITY: Heavy to severe defoliation

RECENT HISTORY: Increasing

PREDICTIONS: Unknown

Regional Notes

REGION 2: This disease complex was very common on willows throughout the Region, except it could not be found in Cook County. Early in the summer many willows looked as if they had been scorched by fire. Many of these willows suffered upto 100% destruction of their leaves due to infections by *Venturia*. As the summer progressed, cankers caused by *Glomerella* developed on small branches throughout the crown. Many of the infected branches were girdled by the cankers. The blight occurred on native as well as ornamental willows. A number of infected trees in the Grand Rapids area were rated for damage and will be evaluated in 1987. This blight complex is likely the cause of death of mature trees often seen in yards and windbreak situations. Additional work remains to be done on a positive identification of the fungi involved.

ANTHRACNOSE
Gnomonia spp.

ACREAGE: Southern one-third of the state

SEVERITY: High

RECENT HISTORY: It was a rare outbreak due to an abundance of early growing season moisture.

PREDICTIONS: Unknown because it is closely associated with weather conditions; however, it is not expected to approach the 1986 levels.

Regional Notes

REGION 5: In 1986 there was a widespread outbreak of early season oak anthracnose. There was extensive disease development across the southern one-third of the state in late May. Complete defoliation was common on single trees and in groups. Record early season rainfall was thought to have contributed to what is viewed as a rare occurence.

OAK WILT
Ceratocystis fagacerum (Bretz.) Hunt

ACREAGE: Unknown

SEVERITY: There is low disease occurence in southeastern Minnesota, but there is moderate to high occurence in a four-county area north of St. Paul and Minneapolis.

RECENT HISTORY: Increasing

PREDICTIONS: This disease should continue at the same levels.

Regional Notes

REGION 5: Oak wilt is epidemic in a four-county area north of the Twin Cities where losses have been severe. Scattered epicenters exist within areas in the central and southeastern parts of the state.

OAK DECLINE
Armillaria mellea (Vahl. ex Fr.) Karst
and other unknown factors

ACREAGE: 500 acres

SEVERITY: Between 20% and 40% of the oaks in the 500-acre area are affected.

RECENT HISTORY: Increasing

PREDICTIONS: Unknown

Regional Notes

REGION 2: Oak decline was observed in 1985 in Itasca County in red oaks growing on an upland site in a mixed hardwood stand. Mycelial fans of Armellaria mellea were observed on the majority of declining trees that were sampled. In 1986, mushrooms of the fungus were abundant around the bases of the declining oaks. The stand is in the process of being harvested. Some stumps have produced sprouts while others have not. The difference is likely due to the difference in the vigor of the trees at the time of cutting and also differences in the amount of Armillaria root rot in the root systems. The managing agency hopes to have the site regenerate back to oak. If the oak stumps sprout, the sprouts will be susceptible to Armillaria infections. Regeneration success will be monitored.

A large tract of private land north of Grand Rapids in Itasca County is in the same situation. At this time the impact of Armillaria on the living and declining oaks is unknown and will be assessed during the spring of 1987. If oak stump sprouting is not adequate to restock the stand, then the landowner may plant seedlings to ensure oak regneration.

MINOR & INCIDENTAL PESTS
DISEASES

PEST	HOST	DISTRIBUTION	COMMENTS
Needlecast *Lirula macrospora*	White spruce	Roseau, Itasca, Pine, St. Louis	ornamental spruce
Chestnut canker *Cytospora* sp.	chest-nut	Region 5	
Needlecast *Isthmiella faullii*	Balsam fir	St. Louis	1984's needles
"Strap" disease 2,4-D damage	Willow	St. Louis	stem swelling, urban problem
Needlecast *Lophodermium seditiosum*	Red pine	Crow Wing	Christmas trees
Chorosis/dieback *Cylindrocarpon* spp.	Scots pine		grafted/contain-erized seedlings
Dessication/root rot *Fusarium* spp.	J.pine Larch	Cass	containerized seedlings
Winter burn	Red pine	Crow Wing	Christmas trees
Leaf blight *Venuria populina*	Balsam poplar	St. Louis	widespread in Duluth
Physiological	Black spruce	Koochiching	poor planting conditions
Puffballs	Red pine	Pine	on peeled logs
Leaf spot *Xanthomonas* sp.	Plum	Itasca	Urban
Winter burn & *Lophodermium pinastri*	Red pine	Mahnomen	Urban
Physiological	Red pine	G.A. State Nursery	nitrogen burn on seedlings
Herbicide damage	W.Spruce, Scots pine	Pine	private nursery seedlings
Herbicide & *Fusarium* sp.	W.pine, B.fir	Carlton	private nursery seedlings
Dessication	Scots pine	Aitkin	Christmas trees

PEST	HOST	DISTRIBUTION	COMMENTS
Needle rust *Chrysomyxa* spp.	Black spruce	Koochiching	common
Needle rust *Coleosporium* spp.	Red pine	Itasca, Beltrami Clearwater	plantations
Root rot *Armillaria mellea*	Red & jack pines	Koochiching	plantation
Surface mold *Penicillium* spp.	Tamarack	Koochiching	containerized seedlings
Pinewood nematode *Bursaphelenchus xylophilus*	Red pine	Crow Wing	mature tree
Root rot *Fusarium* & *Pythium* spp.	Black spruce	Itasca	containerized seedlings
Root rot *Fusarium* sp.	Jack & Scots pines	Itasca	containerized seedlings
Physiological Stem crook	Walnut	Badoura Nursery	cold temp damage to seedlings
Shoot blight *Diplodia pinea*	Red pine	Aitkin	seedlings
Needlecast *Rhizosphaera kalkhoffii*	White spruce	Koochiching	urban
Needle rust *Davisomycella ampla*	Jack pine	St. Louis	abundant
Birch dieback	Birch	St. Louis	native birch
Ash dieback	Black ash	St. Louis	native ash
High water	Jack pine	Hubbard, Becker Koochiching	all sizes of trees dying
Ash anthracnose *Gloesporium* spp.	Green ash	Southern MN	moderate
Black knot *Apiosporum morbosa*	*Prunus* spp.	Southeast MN	increasing on ornamentals
Cytospora canker *Cytospora kunzei*	Blue Spruce	Southern MN	major urban problem
Maple anthracnose *Gleosporium* spp.	Sugar maple	Southeast MN	increased in 1986

PEST	HOST	DISTRIBUTION	COMMENTS
Walnut canker *Fusarium sporotrichioides*	Walnut	Southeast MN	dormant season prune to control
Walnut shoot dieback *Phyllosticta* spp.	Walnut	Southeast MN	pockets of mortality
Frost damage	White spruce	Becker, Hubbard	minor damage
Dessication	Jack pine Tamarack	Roseau	containerized seedlings
Animal damage Squirrels	Walnut	Wabasha	bark stripped on 6 acres of pole size walnut

MINOR & INCIDENTAL PESTS

INSECTS

Bud gall mites *Aceria rudis*	Birch	Cass	urban
White grubs *Phyllophaga* spp.	White spruce	St. Louis	
Spruce gall midge *Mayetiola piceae*	White spruce	St. Louis Todd	Urban
Pine bark aphid *Pineus strobi*	White pine	Hubbard	shoot death
Wood borer (Unknown spp.)	Balsam poplar	St. Louis	dieback
Sawfly *Neodiprion abietis*	Balsam fir	Itasca	
White pine weevil *Pissodes strobi*	Jack pine	Koochiching	private plantation
Bark beetles *Ips pini*	Red pine	St. Louis	urban
Long horned borer (Unknown spp.)	Red pine	Carlton	adult feeding on new shoots
Spruce spider mites *Oligonychus ununguis*	Cedar	Crow Wing	urban

PEST	HOST	DISTRIBUTION	COMMENTS
Cedar tree borer *Semanotus ligneus*	Cedar	St. Louis Lake	feeds on dead and dying cedar
Bronze birch borer *Agrilus anxius*	Birch	St. Louis, Carlton	urban and parks
Leaf tierer (Unknown spp.)	Aspen	St. Louis	
Birch leaf miner *Fenusa pusilla*	Birch	Beltrami,Hubbard, Olmstead	common in urban settings
Ash flower gall mite *Eriophyes fraxiniflora*	Green Ash	Statewide	minor importance
Fall webworm *Hyphantria cunea*	Cherry Walnut	Southeast MN along MI River	minor importance
Walnut caterpillar *Datana integerrima*	Walnut	Southeast MN	common
Walking sticks *Diapheromera femorata*	White oak	Ottertail	some noticeable defoliation
Striped alder sawfly *Hemichroa crocea*	Birch	Cass	defoliation of a small acreage
Aspen blotch miner *Phyllonorycter tremuloidiella*	Aspen	Northern MN	common

SPECIAL PROJECTS

Risk Rating Minnesota Hardwood Forests

Edward M. Hayes

In 1985 a pilot study was initiated in cooperation with the University of Minnesota to develop a risk rating system for gypsy moth suitable for the basis of a long range management plan. Methods developed by Houston and Valentine (1) were field evaluated in 1985 and in 1986. Stands and individual plots within stands were risk rated based on diameter and density of preferred host, and the presence or absence of protective features such as bark flaps and fissures. Risk ratings will be compared to plot characters such as aspect and slope position and to Phase II Forest Inventory attribute data. Results will be modeled on a G.I.S. in combination with additional information available through the state planning agency.

(1) Houston, D.R., and H.T. Valentine. 1985. Classifying forest susceptibility to gypsy moth defoliation. U.S. Dept. Agric., For. Serv. Aric. Handbook No. 542. 19p.

White Spruce Cone Pests

Mike Albers and Jana Campbell

The cone crop at the white spruce seed orchard in Cotton District (central St. Louis County) was very small this year. Only 190 cones were produced. Pollination was also low; only 7 cones had viable seeds. All cones were dissected to detect cone pests and results are:

PEST	PERCENT AFFECTED*
Choristoneura fumiferana	18.4
Hylemya spp.	2.6
Dioryctria abietivorella	0.5
Pucciniastrum americanum	43.7
Chrysomyxa pirolata	0.0
Frost	1.6
Unknown	5.3
NO DAMAGE	32.6

* = A cone could have more than one pest.

Insect depredation decreased by 50% in comparison to the three previous years due primarily to the decrease in the number of cones infested with coneworms.

Two pheromones developed by Dr. G. DeBarr of the U.S Forest Service in Georgia were employed from early spring until late summer to attract Dioryctria moths. The lures were for two different species, D. amatella and D. disclusa. There was no cross species attraction, and no moths were trapped. In 1987, a lure recently developed for D. abietivorella will be tested in an attempt to define moth emergence periods so that spray schedules can be developed.

Again this year there were no Chrysomyxa rust infected cones. Pucciniastrum rust infected 5% of the cones in 1985 and 44% in 1986. This represents nearly a 9-fold increase in infection. The identification of the rust species as P. americanum was verified by Dr. Y. Hiratsuka of the Canadian Forestry Service in Edmonton, Alberta.

A herbicide treatment to control raspberries in the seed orchard was completed in the fall of 1986. Raspberries are the alternate host for Pucciniastrum cone rust.

FUNGI RECOVERED FROM FREEZER-STORED BLACK WALNUT SEEDLINGS

Jana Campbell

Studies at other state nurseries (1) have found that fungi living epiphytically on root surfaces can become pathogenic during freezer storage and cause root rot of black walnut. This disease has been termed the surface mold/root rot complex. In the recent past, walnut in freezer storage at the General Andrews Nursery have had surface molding problems. At the request of nursery personnel, the incidence and severity of surface mold and root rot, and the fungi causing them were studied.

METHODS

In 1985, 1-0 black walnut seedlings were undercut and lifted on two dates, October 11th and 21st. Those lifted on the 11th were heeled in and transferred to cold storage on October 22. Those lifted on the 21st were put in cold storage the next day. The temperature of the cooler was 29°F on October 22nd, and after two weeks the temperature was reduced to 26°F and maintained there. Seedlings were bundled in groups of 25 and placed in large storage crates lined with tarpaper and kraft paper. They remained frozen until January 22nd when one crate from each lifting date was opened, and two bundles near the bottom were removed from each crate.

Each seedling was visually rated for the incidence and severity of surface mold and root rot in the laboratory. Since there were no surface molds present and the extent of root rot was very limited, only 36 seedlings were selected for fungal isolations. The 36 seedlings were from 4 groups: 1. lifted October 11 with no root rot; 2. lifted October 11 and root rot was present; 3. lifted October 21 with no root rot; and 4. lifted October 21 with root rot present. In each group, half of the

seedlings were scrubbed with soapy water and rinsed with sterile water and the other half were scrubbed, rinsed, sterilized in a 1% solution of sodium hypochlorite, and then rinsed with sterile water.

Isolations from the root surface and the root interior were plated onto potato dextrose agar (PDA), and the PDA was amended with acid or antibiotics to inhibit bacterial growth. The growth media in the plates were PDA, PDA + lactic acid, PDA + streptomycin, PDA + pencillin + polymixin, and PDA + streptomycin + penicillin + polymyxin. Cultures were incubated at room temperatures for 4 to 15 days.

Both fungi and bacteria were recovered. Fungi were identified to genus when possible, and the unknown organisms were subcultured for further work.

Based on visual inspection of the 102 black walnut seedlings, there was no surface mold, and root rot was limited to some of the root tips. The rot in all cases involved less than 5% of the primary roots. Differences between lifting dates showed that those lifted first had less root rot (46%) compared to those lifted later (60%).

	NUMBER OF SEEDLINGS	
	NO SUFACE MOLD NO ROOT ROT	NO SURFACE MOLD 1-5% ROOT ROT
Lifted: Oct. 11	29	23
Lifted: Oct. 21	20	30

A total of 370 isolations were made from the 36 selected seedlings. Nine percent of the isolations yielded fungi; no Fusarium, Pythium, Phytophthora, or Cylindrocladium species were isolated.

	NUMBER OF ISOLATIONS	
	SURFACE	INTERNAL TISSUES
Trichoderma	1	0
Penicillium	4	12
Mucoraceae	4	5
Unknown	5	1

The isolate from the Mucoraceae family was as unidentified species.

DISCUSSION

Researchers in Indiana nurseries have defined the surface mold/root rot complex of black walnut seedlings and have isolated the causal agents. Fungal species belonging to the genera of Fusarium, Trichoderma, Cylindrocladium, Penicillium, Zygorhynchus, Pythium, and Phytophthora are associated with this disease complex (1,2). The surface mold phase of this disease is not a problem unless buyers find

the seedlings visually unsatisfactory. Seedlings covered with a surface mold survive and grow as well as mold-free seedlings after they are outplanted (1).

The root rot phase is caused by Fusarium, Pythium, or Phytophthora infection and is desribed as a soft, watery necrosis and decay of the fleshy primary roots (1). In planting studies in Indiana, seedlings with less than 25% of their primary root rotted survived as well as healthy seedlings (1).

In this study, we found only the fungi that can cause the surface mold phase of the disease and none that cause the root rot phase. In April of 1986 when all of the black walnut seedlings were taken out of cold storage, nursery personnel did not observe mold or note an increase in root rot compared to the level found in January.

Ten to fifteen years ago, the General Andrews Nursery experienced a surface molding problem on stored walnut seedlings (Czelusta, personal communication). Captan dipping was implemented for several years and then abandoned. Since that time, surface molding has not been a problem.

Even using the new machinery which undercuts at a greater depth, wounding of some of the walnut root tips occurred and these tips developed a limited amount of root rot. Between lifting dates, those lifted on October 11th had 14% less root rot than those lifted on Ocotber 21st. This could be explained either by different undercutting depths or by differences in the wound healing prior to freezer storage. The sample size and selection were too small to know for certain that differences found between the lifting dates were real or significant.

(1) Green, H.L. 1985. Fungi associated with the surface mold/root rot complex on black walnut seedlings stored in freezers before planting. Plant Disease Vol 75, No. 11. 214-217.

(2) Green, H.L., and P. Plourde. 1980. Root rot of stored black walnut seedlings. Tree Planters' Notes. Vol. XX, No. 6. 31-39.

Hebeloma arenosa Burdsall, MacFall and Albers

Mike Albers

Ectomycorrhiza is a symbiotic relationship between a fungus and a conifer short root. Establishment and growth of conifer seedlings are more successful when the roots are infected with ectomycorrhizae.

I published a paper this year based on my graduate work on ectomycorrhizal fungi. The paper's title is " Hebeloma arenosa (Agaricales, Cortinariaceae), a new species from Lake States Nurseries," ans it was published in Mycologia, Vol. XXIX, No. 8.

STURGEON LAKE RED PINE SEED PRODUCTION: CONE INSECTS AND CONTROL RECOMMENDATIONS

Robert Tiplady

Cone-bearing red pine branches from the top third of the crown were collected from four locations in the Sturgeon Lake Red Pine Seed Production Area on July 29, 1986. Several of the 1986 maturing cones were cut longitudinally and checked both micro-and macroscopically to identify infesting insects and other arthropods. Two insect species were identified that had been present in the cones earlier this year but had vacated the cones in July. These species were a webbing coneworm, Dioryctria disclusa and the red pine coneborer, Eucosma monitorana. A third insect which leaves the cones in early August was found in one cone, but its distinct damage and growth limiting effects were identified on several other cones. This species was the red pine cone beetle, Conophthorus resinosae. Other insects found in the 1986 cones included the eastern pine seedworm, Laspeyresia toreuta; a coneworm, Dioryctria abietella; and a mite in the genus, Rubsaamenia.

Mites were found in several cones damaged by insects, and some cones had resisted significant damage by causing death of the insects through pitch production or perhaps toxic chemical production. The eastern pine seedworm was the major cone insect in numbers or cones infested, and the red pine cone beetle and the Rubsaamenia midge were the two other insects causing significant cone infestation. Overall, 65% of the 1986 cone crop was infested.

CONTROL

Due to variations in the time of the year when the six insect species are present, it will be difficult to insure 100% control on all of the insect pests. To get the best control, the top third of the crowns should be sprayed with Orthene during the first week of July. Cones should then be dissected and inspected for insect activity during August to determine the effectiveness of Orthene cone infestations by insects from outside the treated area.

DUTCH ELM DISEASE INCIDENCE AND IMPACT IN THE RED RIVER VALLEY

Alan C. Jones

A survey of the forested lands immediately adjacent to the Red River of the North was undertaken to assess the impact of Dutch elm disease in this important forested resource. Both sides of the river were surveyed in a cooperative project between the Minnesota Department of Natural Resources and the North Dakota Forest Service. The survey area started at the southern border of Wilken County at Breckenridge in Minnesota and Richland County at Wahpeton in North Dakota, and it extended northward to the Canadian Border.

METHOD

The survey consisted of aerial photography of the entire river portion in the survey, and ground checking selected stands. The entire project area was photographed on 3 days: August 14, August 20, and September 6, 1985. Thirty-five millimeter color infrared photography was used, and a scale of 1:7920 (8" = 1 mile) was chosen. Color prints were made only of the stands selected to be ground checked. Photo intrepretation was made from slides projected on a screen. The photographs were used to update and verify the forested portions on USGS topographic quadrangle maps, and stand acreages were then measured on the topographic maps.

Photo interpretation involved rating each stand for Dutch elm disease occurrence and past logging activities. Stands were subjectively rated "major" or "minor" for Dutch elm disease occurrence. Major occurrence was obvious evidence of disease and appeared to cover at least 30% of the elm areas of the stand. If the stand had to be studied or inspected closely to find Dutch elm disease, then it was rated minor. Dutch elm disease was identified primarily by dead crowns but crowns which showed color other than the typical red of healthy foliage were also rated as Dutch elm disease infected. There was some early season cankerworm defoliation of elm, but by August refoliation had occurred. Any appearance of elm crowns that did not appear "normal" was assumed to be Dutch elm disease. There were 4 people rating the stands, and all 4 had to agree to the rating before going onto the next stand.

Past logging practices were identified by slash on the ground and holes in the canopy. Since high-grading was a common practice in which only the large, veneer quality elms were havested, stands could be rated both logged and positive for disease occurrence.

Not all wooded areas were rated. Only wooded areas which were at least 5 acres in size, at least 330 feet wide, and had no evidences of heavy grazing and heavy urban use were included in the survey. The interpretation and acreage determination were done on a stand basis since discrete wooded areas separated by agriculture land was the general pattern along the river.

The ground survey consisted of a 10 BAF variable radius plot cruise of selected stands. Information collected on the "in" trees included species; tree condition: healthy, infected, or dead; years since death; diameter; merchantable height in logs or sticks; grade; and age, growth, and height for selected trees to determine site index. Tree reproduction (all trees less than 5" DBH) was recorded on a 1/100th acre circular plot, and species and percent ground cover of herbaceous plants were also recorded on the reproduction plot. One stand in each township was selected to be surveyed. Stand selection criteria was the first 20+ acre stand north of the south line of the township. This selection process resulted in 18 Minnesota and 14 North Dakota stands being selected to be ground checked.

RESULTS

Dutch elm disease incidence and impact is greatest in the southern part of the river valley and almost non-existant toward the Canadian Border. This pattern is evident in both the ground and aerial surveys. From Table 1, there are less than 10% of the stands in the southern-most counties of Wilkin-Richland that are free of DED. In the northern-most counties of Kittson-Pembina, greater than 90% of the stands were free of DED.

TABLE 1: SUMMARY OF DED-INFECTED STANDS AND ACRES BY COUNTIES

	NO DED		TOTAL DED		MAJOR DED		MINOR DED	
COUNTY	NO. (%)	ACRES	NO. (%)	ACRES	NO. (%)	ACRES	NO. (%)	ACRES
Wilkin, MN	2 (5)	60	35 (95)	721	14 (38)	304	21 (57)	417
Richland,ND	4 (9)	59	40 (91)	893	16 (36)	340	24 (55)	553
Clay, MN	13 (23)	315	43 (77)	1580	3 (5)	98	40 (71)	1482
Cass, ND	9 (18)	240	40 (82)	1171	9 (18)	214	31 (63)	957
Norman, MN	20 (69)	525	9 (31)	494	1 (3)	94	8 (28)	400
Trail, ND	20 (59)	631	14 (41)	765	-	--	14 (41)	765
Polk, MN	45 (87)	1763	7 (13)	330	-	--	7 (13)	330
G. Forks,ND	16 (67)	638	8 (33)	462	-	--	8 (33)	462
Marshall,MN	30 (88)	1187	4 (12)	327	-	--	4 (12)	327
Walsh, ND	32 (94)	1170	2 (6)	121	-	--	2 (6)	121
Kittson,MN	35 (92)	1983	3 (8)	347	3 (8)	347	-	--
Pembina,ND	30(100)	1567	-	--	-	--	-	--

Tables 2 and 3 attempt to show disease progression starting from both ends of the river. One has to travel north 20 miles from Breckenridge-Wahpeton to encounter a stand without DED. Starting from the north, the first stand in Minnesota with DED is 14 miles south of the border, and in North Dakota it is 38 miles. However, the first major DED is 128 miles from the border on the North Dakota side.

TABLE 2: DISEASE PROGRESSION NORTHWARD FROM BRECKENRIDGE-WAHPETON

	Number of Miles[1]		Number of Stands	
	MN	ND	MN	ND
First stand	1	1	1	1
First DED	1	1	1	1
Next DED	2	4	2	2
First major DED	2	4	2	2
First non-DED stand	20	20	24	28

[1] Miles were calculated by legal description, not river miles. Miles were rounded to full miles.

TABLE 3: DISEASE PROGRESSION SOUTHWARD FROM THE CANADIAN BORDER

	Number of Miles[1]		Number of Stands	
	MN	ND	MN	ND
First stand	0	0	1	1
First DED	14	38	15	37
Next DED	22	45	22	41
First major DED	14	128[2]	15	129
First Non-DED stand	0	0	1	1

[1] See footnote for Table 2.

[2] This stand is located only 17 miles north of Fargo-Moorehead.

The ground survey also shows this same pattern. In Table 4, uninfected elms account for only 1/3rd of the elms in the sample in Wilkin and Richland Counties, but non-infected elms made up over 95% of the elms sampled in Kittson-Pembina Counties. The volumes summarized in Table 5 also range from 34% infected in Wilkin-Richland Counties to only 3% infected in Kittson-Pembina Counties.

TABLE 4: SUMMARY OF TREE CONDITIONS FROM THE GROUND SURVEY

County	No. of Stands	No. of Elms (%)[1]	Healthy (%)	Infected (%)	Dead (%)	Avg YSD[2]
Wilkin	2	51 (42)	19 (37)	23 (45)	9 (18)	1.0
Richland	2	74 (19)	24 (32)	12 (16)	38 (51)	2.5
Clay	4	75 (19)	47 (63)	21 (28)	7 (9)	1.2
Cass	2	76 (23)	69 (91)	3 (4)	4 (5)	1.0
Norman	2	40 (25)	22 (55)	15 (38)	3 (7)	5.0+
Trail	2	89 (35)	82 (92)	5 (6)	2 (2)	2.0
Polk	6	245 (48)	213 (87)	20 (8)	12 (5)	3.0
G. Forks	2	127 (60)	114 (90)	6 (5)	7 (5)	2.0
Marshall	1	38 (56)	34 (89)	-- -	4 (11)	5.0
Walsh	3	169 (50)	159 (94)	2 (1)	8 (5)	2.0
Kittson	3	132 (47)	130 (98)	-- -	2 (2)	2.0
Pembina	3	373 (52)	359 (97)	5 (1)	9 (2)	2.5
MN	18	581 (38)	465 (80)	79 (14)	37 (6)	2.9
ND	14	908 (40)	807 (89)	33 (4)	68 (7)	2.0

[1]The percentage is the number of elms compared to the total number of trees of all species counted as "in" trees on the cruise.

[2]YSD = Years Since Death

TABLE 5: VOLUMES OF HEALTHY AND INFECTED ELMS BY PAIRED COUNTIES

COUNTY	BOARD FOOT VOLUMES - SCRIBNER HEALTHY (%)	LIVE INFECTED (%)
Wilkin/Richland	817,976 (66)	494,772 (34)
Clay/Cass	2,021,940 (79)	552,090 (21)
Norman/Trail	1,726,304 (70)	636,560 (30)
Polk/Grand Forks	6,686,096 (92)	587,423 (8)
Marshall/Walsh	3,809,088 (99)	22,032 (1)
Kittson/Pembina	5,268,744 (97)	140,292 (3)
TOTAL: MN/ND	20,330,148 (89)	2,433,169 (11)

From the aerial survey, there seems to be a dramatic change in the percentage of infected stands between Clay-Cass Counties and Norman-Trail Counties. In Clay-Cass Counties, 77% and 82% of the stands have DED present (see Table 1). In Norman and Trail Counties, only 31% and 41% of the stands are infected. There seems to be another dramatic change between Norman and Polk Counties in Minnesota with the infected stands ranging from 31% in Norman County to 13% in Polk County. The change on the other side of the river is not as dramatic. Trail County has 41% of the stands infected; whereas, Grand Forks County has 33% infected stands. The dramatic change occurs between Grand Forks County and Walsh County. There is a difference of 27% between those two counties.

From the ground survey, a slightly different pattern emerges. Using healthy and live-infected volumes for the paired counties in Table 5, there is an increase in the live-infected volume in Norman-Trail Counties (30%) over Clay-Cass Counties (21%). Going north the similar pattern of decreasing DED northward again emerges with a 22% reduction in live-infected volume between Norman-Trail and Polk-Grand Forks Counties. Looking at the tree conditions in Table 4, on the North Dakota side of the river, Cass and Trail Counties are similar in percentage of healthy trees: 91% and 92%. The healthy tree percentage drops between Clay and Norman Counties in Minnesota, 63% to 55%. Again, the dramatic change is between the southern counties, Wilkin-Richland, and Clay-Cass Counties immediately to the north.

The average years since death estimation in Table 4 indicates relatively recently mortality all along the river. In one stand in Norman County, there was 1 dead elm, and it was estimated that it had been dead 10+ years. Years since death in the other stand in Norman County was only 1 year. There was only one stand sampled in Marshall County, and the average years since death estimation for the 4 dead elms in this county was 5 years.

Harvesting has been active from both ends of the river, but harvesting is reduced in the middle portion of the river (see Table 6). Thirty-two and 52% of the stands in Wilkin-Richland Counties have been harvested, and 29% and 33% of the stands in Kittson-Pembina Counties have been harvested. Except for Walsh County in North Dakota where 26% of the stands showed harvesting activities, all the other counties have less than 20% of their stands harvested. The extreme is Marshall County where some evidence of harvesting could be identified on the aerial photographs in only 3% of the stands.

TABLE 6: SUMMARY OF HARVESTING FROM AERIAL PHOTO INTERPRETATION

COUNTY	# STANDS HARVESTED	# HARVESTED STANDS W/DED	# HARVESTED STANDS W/O DED	# DED STANDS W/O HARVEST
Wilkin, MN	12 (32%)	12 (32%)	0	23 (62%)
Richland, ND	23 (52%)	23 (52%)	0	17 (39%)
Clay, MN	5 (9%)	5 (9%)	0	38 (68%)
Cass, ND	4 (8%)	2 (4%)	2 (4%)	38 (78%)
Norman, MN	4 (14%)	1 (3%)	3 (10%)	8 (28%)
Trail, ND	4 (12%)	2 (6%)	2 (6%)	12 (35%)
Polk, MN	4 (8%)	0	4 (8%)	7 (13%)
Grand Forks, ND	4 (17%)	2 (8%)	2 (8%)	6 (25%)
Marshall, MN	1 (3%)	0	1 (3%)	4 (12%)
Walsh, ND	9 (26%)	1 (3%)	8 (24%)	1 (3%)
Kittson, MN	11 (29%)	2 (5%)	9 (24%)	1 (3%)
Pembina, ND	10 (33%)	0	10 (33%)	0

Harvesting does not seem to reduce the incidence of DED. Only Polk, Marshall, and Pembina Counties had harvested stands where no DED could be detected. In Wilkin, Richland, and Clay Counties, all harvested stands still had evidence of DED. Cass, Norman, Trail, Grand Forks, Walsh, and Kittson Counties had both infected and non-infected harvested stands.

DISCUSSION

Dutch elm disease came into the Red River Valley in the early 1970's. The first documented urban infection was in Fargo in 1973, and the first rural infection was documented in 1977 in Cass County, North Dakota (3). Based on these observations, disease spread through North Dakota was calculated at about 30 miles per year (3). After studying the data generated from this present survey, Stack (2) concluded that "the levels of disease found in the southern valley are close to those projected for an epidemic 12-15 years underway."

From the data, it would seem that rural DED infections were present south of Fargo-Moorehead long before the 1977 documentation. The southern-most paired counties of Wilkin-Richland have a much higher incidence of DED than the counties where Fargo-Moorehead are located. If DED incidence is related to time, then DED moved into the Fargo-Moorehead area from the Breckenridge-Wahpeton area and probably followed the river northward. Even though there is not a contiguous band of elm woodland linking the two urban areas, woodlands are close enough together that disease spread through beetle migration is very possible.

Despite the length of time that the disease has been present in the southern valley, there are still 674 acres or 13% of the woodlands in the 4 county area (Wilkin, Richalnd, Clay, and Cass) without evidences of DED, and 3,409 acres or 68% of the woodlands with only minor DED occurrence. Uninfected elm volumes in this 4 county area amount to nearly 3,000,000 board feet. In Cass-Clay Counties, 79% of the elm volume is uninfected, and in Wilkin-Richland Counties which have the highest infection, 60% of the elm volume is healthy.

DED has been present in the southern valley since 1973, and only 81% of the stands have a minor DED occurence (less than 30% of the elms in a stand infected) or no evidences at all of DED. The infection rates found in the middle and northern parts of the valley would indicate that the disease is just beginning to move into and become important in these parts of the river. If the disease spread follows what happened in the southern valley, then a conservative estimate of time until the middle and northern valley would match the southern valley for disease occurrence would be at least another 10 years.

The only evidence challenging this 10-year prediction is the similarity of years-since-death (YSD) estimations. In the 4-county area in the southern part of the valley, the average YSD is 1.4, and for the rest of the valley it is 2.9. However, if the one stand in Norman County is not included, the average is 2.4. The recent mortality all along the river may substantiate the observation that DED occurrence has increased over the past 3 to 5 years due to the mild winters allowing better beetle survival (1). If this in fact is the trend, then the 10-year estimation may have to be revised.

This survey was prompted because of a perception that DED was causing heavy losses. The timber industry was concerned over the potential loss of a resource which was vital to their existence. Elm is the most valuable species on the river, and the elm that is there apparently is unique in quality, size, and concentration (4). It would seem, however, that both the aerial and ground survey show that the elm resource is still a viable resource despite the presence of documented DED for 10 to 14 years.

The amount of harvested stands with DED present does indicate that high-grading dominated logging practices. One of the main markets for the elm is the overseas furniture market. Only large, high quality trees are selected for this type of market. There is still 20,000,000 board feet of elm left on the river, but the average size and quality may have been reduced due to higrading and DED. Even though the conservative projection of at least 10 years left on the elm resource before DED makes serious inroads against it in the middle and northern parts of the valley, the resource may not have the size and quality of elm left to sustain an export market. New product development may have to be stimulated to utilize the elm resource before it is loss to DED.

The aerial survey did show a high percentage of the stands in the 4-county southern valley protion with no harvesting but with DED present. Since this 4-county area has the greatest risk of losing elms because the disease is so well entrenched, efforts should first be

concentrated in this area to accelerate the harvest to capture the resource. Harvesting should be done with professional assistance to help reduce the amount of higrading.

There are minor conflicts between the two surveys in the pattern of disease progression. The aerial photography probably is a more accurate survey. The ground survey was a very limited sample with only one stand per township included in the sample. This small of a sample was necessary because of limited manpower and funding. Much of the ground survey had to be sandwiched between the normal duties and responsibilities of the foresters on both sides of the river. Consequently, most of the ground survey north of the Fargo-Moorehead area was done in October and November. The stands in Norman County in Minnesota were surveyed in early October when the leaves were dropping. Rating tree condition for live-infected trees could have been misleading based on leaf symptoms. Ground surveys north of Norman County were done when leaves were completely off of the trees. DED was identified by tree mortality, only. Current year infections would have been impossible to identify under these conditions.

Photo interpretation was very accurate in 2 stands south of the Fargo-Moorehead area used in a pilot project earlier in the summer of 1985 to test the survey methods. Individual dead and diseased elms could be identified on the ground from the aerial photographs. Confidence in interpretation was gained through this experience. It was felt by all that the subjective rating of the entire river was a fairly accurate assessment of the DED situation along the Red River.

(1) Anonymous. 1984. Forest insect and disease report 1984. MN Dep. of Nat. Res. St. Paul, MN. 54p.

(2) Stack, R.W., A.C. Jones, and R. Harsel. 1987. Impact of Dutch elm disease on the forest resource of the Red River valley in North Dakota and Minnesota. Proc. ND Acad. Sci.

(3) Stack, R.W., and H.A. Lamey. 1982. Dutch elm disease in North Dakota after the first decade. Proc. ND Acad. Sci. 36:45.

(4) Westigard, G. 1985. Personal communication. Transatlantic Hardwoods Inc. Frederic, WI.

BUDWORM PHEROMONE TRAPPING

I & D Staff Report

Division of Forestry personnel have been cooperating with the U.S. Forest Service in evaluating spruce and jack pine budworm pheromones which will help monitor populations and predict when and where heavy infestations will occur.

METHODS

Multi-pher plastic traps with a small plastic rod impregnated with a certain concentration of pheromone are used in this study. The lure is situated in the top of the trap, and a Vapona no-pest strip is placed the bottom reservoir of the trap. The male moths are attracted to the pheromone, and then are overcome by the volatile fumes from the Vapona strip. The dead moths fall into the bucket reservoir and can be counted at a later date.

A pheromone trapping plot consists of three traps placed in the stand in a triangular configuration. Each leg of the triangle is 40 meters in length so that the individual traps are spaced 40 meters apart. Traps are placed in jack pine stands for trapping the jack pine budworm, and in balsam types for the spruce budworm. The trapping plot is located at least 20 feet from the edges of roads, fields or cutover areas. The trap is hung at a height 2-3 meters above the ground and 0.7 - 1 meter away from the trunk. Traps are positioned by the last week of June and are in place throughout the moth flight period. The traps are retreived by about mid-August. At the time the traps are placed and retreived, stand defoliation is rated. If possible, life stage surveys are also conducted at each trapping location to relate trap catches to defoliation and insect numbers.

So far more evaluation has been done with a spruce budworm pheromone than with a jack pine budworm pheromone. It is often difficult to develop the proper chemical compound at the proper concentration to have it substitute for the naturally produced phermone that the female moths emit. Because the spruce budworm pheromone is more "accurate", one concentration is used in all three traps on a trapping plot. For the jack pine budworm, however, three different conentrations of pheromone lure are used: 0.003%, 0.03%, and 0.3%. Trap catches are recorded separately for each concentration.

RESULTS

Thirty-two spruce budworm trapping plots and 33 jack pine budworm trapping plots were established in the 1986 study. The results of the study are tabulated below including defoliation ratings. When additional life stage surveys were done on or close to the trapping plot, those results are presented.

TABLE 1: 1986 SPRUCE BUDWORM PHEROMONE TRAPPING RESULTS

Plot Location	1986 Trap Catches=Total	1986 Defoliation	1986 Early Larva	1986 Eggmass
ST. LOUIS COUNTY				
36-69-19	259-360- - = 619	0-VL	13	2
1-68-20	655-133-402 = 1190	0-VL	9	0
8-68-20	193-119-85 = 397	0	7	0
14-65-14	522-660-825 = 2007	M-H	11	8
7-65-15	145-198-155 = 498	M	40	12
16-65-17	325-490-421 = 1236	M	34	21
24-64-13	580-626-1195 = 2401	M	-	12
8-60-14	522-819-369 = 1710	H	-	12
32-60-17	186-307-206 = 699	M	-	1
4-59-21	1174-525-995 = 2694	M-H	16	6
13-59-20	606-919-436 = 1961	M	65	0
36-52-12	1792-829-1016 = 3637	L	8	6
18-53-17	189-145-33 = 367	M	69	6
14-52-16	230-8-213 = 451	M-H	166	3
3-53-16	236-193-244 = 673	M	68	13
CARLTON COUNTY				
12-49-19	20-21-21 = 62	VL	4	0
14-49-19	5-3-25 = 33	VL	1	0
LAKE COUNTY				
7-63-9	999-729-810 = 2538	H	-	19
9-58-9	209-312-256 = 777	L	82	4
19-55-10	357-345-357 = 1059	M	86	13
36-59-11	600-997-1040 = 2637	H	45	7

TABLE 2: 1986 SPRUCE BUDWORM PHEROMONE TRAPPING RESULTS (Continued)

Plot Location	1986 Trap Catches=Total	1986 Defoliation	1986 Early Larvae	1986 Eggmass
COOK COUNTY				
22-63-3E	1, 3, 0 = 4	M	39	5
11-63-4E	0, 7,234 = 241	L	58	1
32-64-3E	2, 4, 14 = 20	H	51	26
2-63-4E	1343-29-2513 = 3885	L	-	0
32-65-3W	464-891-941 = 2296	H	23	5
1-61-1W	685-1199-1359 = 3243	H	45	31
25-61-4W	665-278-379 = 1322	H	60	19
ITASCA COUNTY				
1-59-22	0 - 0 - 0 = 0	0	12	0
KOOCHICHING COUNTY				
Birchdale	215-232-330 = 777	0	-	-
Northome	45-58-60 = 163	0	-	-
LAKE OF THE WOODS COUNTY				
NW Angle	762-591-600 = 1953	0	-	-

TABLE 2: 1986 JACK PINE BUDWORM PHEROMONE TRAPPING RESULTS

Plot Location	Trap Catches 0.3	0.03	0.003	Total Catch	1986 Defol.	E. Larvae Survey	Eggmass Survey
ST.LOUIS COUNTY							
14-65-14	9	12	5	26	0	7/30	0
7-65-15	1	0	0	1	0	13/30	0
30-67-17	2	0	2	5	0	1/30	0
25-61-13	1	2	2	5	0	7/30	0

TABLE 2: 1986 JACK PINE BUDWORM PHEROMONE TRAPPING RESULTS (Continued)

Plot Location	Trap Catches 0.3	0.03	0.003	Total Catch	1986 Defol.	E. Larvae Survey	Eggmass Survey
ST. LOUIS COUNTY							
24-64-13	4	4	2	10	0	7/30	0
35-58-15	2	1	0	3	0	1/30	1
9-57-16	0	0	0	0	0	3/30	0
4-57-16	3	0	0	3	0	2/30	0
26-60-18	7	1	3	11	L	6/30	0
23-60-21	4	0	0	4	0	0/30	0
LAKE COUNTY							
9-63-9	4	3	16	23	VL	14/30	0
34-56-12	2	3	2	7	0	2/30	0
COOK COUNTY							
28-62-4W	2	2	0	4	0	0/30	0
16-65-4W	0	3	8	11	0	2/30	0
8-65-4W	5	3	1	9	0	7/30	0
15-64-1W	-	-	-	-	0	1/30	0
16-63-1E	2	1	37	40	0	0/30	0
KOOCHICHING COUNTY							
4-65-24	2	6	0	8	0	6/30	2
ITASCA COUNTY							
27-59-23	3	0	0	3	0	0/30	1
ROSEAU COUNTY							
32-160-37	14	8	3	25	M	20/30	2
34-161-37	4	10	10	24	M-H	14/30	2
LAKE OF THE WOODS COUNTY							
29-159-33	5	4	1	10	L	19/30	1

TABLE 2: 1986 JACK PINE BUDWORM PHEROMONE TRAPPING RESULTS (Continued)

Plot Location	Trap Catches 0.3	0.03	0.003	Total Catch	1986 Defol.	E. Larvae Survey	Eggmass Survey
Beltrami County							
15-147-34	1	0	1	2	L	16/30	1
34-146-32	1	0	0	1	H	-	2
26-146-35	0	0	0	0	L	18/30	2
HUBBARD COUNTY							
23-145-34	5	0	1	6	0	2/30	2
8-143-34	3	-	4	7	M	21/30	3
27-144-34	9	14	8	31	L	7/30	0
35-139-33	0	1	7	8	M-H	6/30	-
35-140-33	1	2	0	3	H	9/30	1
10-139-32	3	3	5	11	H	30/30	0
BECKER COUNTY							
15-139-36	2	4	0	6	H	9/30	3
27-141-36	1	1	0	2	L	2/30	1

DISCUSSION

There seems to be very little correlation between trap catches and current defoliation or life stage survey results. For example, for the spruce budworm, ranges and averages of trap catches compared to defoliation classes and life stage survey results are as follows:

TABLE 3: SBW TRAP CATCH SUMMARIES VS DEFOLIATION

Defoliation	Trap Catch Range	Difference	Average
0 - VL	619 - 1190	571	904
0	0 - 1953	1,953	658
L	241 - 3885	3,644	2,135
M	4 - 2401	2,397	987
M - H	451 - 2694	2,243	1,717
H	20 - 3243	3,223	1,967

TABLE 4: SBW EGG MASS SURVEY RESULTS VS TRAP CATCHES

Egg Masses	Trap Catch Range	Difference	Average
0	0 - 3,885	3,885	1,075
1 - 5	4 - 2,296	2,292	727
6 - 10	367 - 3,637	3,270	1,890
11 - 15	498 - 2,401	1,903	1,268
16 - 20	1322 - 2,538	1,216	1,930
20+	20 - 3,243	3,223	1,500

TABLE 5: SBW LARVAL SURVEY RESULTS VS TRAP CATCHES

Larvae	Trap Catch Range	Difference	Average
0	-	-	-
1 - 10	33 - 3,637	3,604	1,064
11 - 20	0 - 2,694	2,694	1,330
21 - 30	2,296	-	2,296
31 - 40	4 - 1,236	1,232	579
41 - 50	2637 - 3,243	606	2,940
51 - 60	20 - 1,322	1,302	528
61 - 70	367 - 1,961	1,594	1,000
71 - 80	-	-	-
81 - 90	777 - 1,059	282	918
91 - 100	-	-	-
100+	451	-	451

Correlations for the jack pine budworm trap catches were also nonexistent as summarized in Tables 6, 7, and 8.

TABLE 6: JPBW TRAP CATCH SUMMARIES VS DEFOLIATION

Defoliation	0.3 Range (AVG)	0.03 Range (AVG)	0.003 Range (AVG)	TOTAL Range (AVG)
0	0- 9 (2.8)	0-12 (2.2)	0-37 (3.5)	0-40 (8.5)
VL	4 (4.0)	3 (3.0)	16 (16.0)	23 (23.0)
L	0- 9 (3.8)	0-14 (3.3)	0- 8 (2.2)	0-31 (9.3)
M	3-14 (8.5)	8 (8.0)	3- 4 (3.5)	7-25 (16.0)
M-H	0- 4 (2.0)	1-10 (5.5)	7-10 (8.5)	8-24 (16.0)
H	1- 3 (1.8)	0- 4 (2.3)	0- 5 (1.3)	1-11 (5.3)

TABLE 7: JPBW EGG MASS SURVEY RESULTS VS TRAP CATCHES

Egg Masses	0.3 Range (AVG)	0.03 Range (AVG)	0.003 Range (AVG)	TOTAL Range (AVG)
0	0- 9 (3.2)	0-14 (2.8)	0-37 (5.1)	0-40 (11.2)
1	1- 5 (2.2)	0- 4 (1.3)	0- 1 (0.3)	2-10 (3.8)
2	0-14 (4.3)	0-10 (4.0)	0-10 (2.3)	0-25 (10.7)
3	2- 3 (2.5)	4 (4.0)	0- 4 (2.0)	6- 7 (6.5)

TABLE 8: JPBW EARLY LARVAL SURVEY RESULTS VS TRAP CATCHES

Larvae	0.3 Range (AVG)	0.03 Range (AVG)	0.003 Range (AVG)	TOTAL Range (AVG)
0	2- 4 (2.8)	0- 2 (0.8)	0-37 (9.3)	3-40 (12.8)
1-10	0- 9 (3.1)	0-12 (3.2)	0- 8 (2.3)	0-31 (3.6)
11-20	0-14 (4.1)	0-10 (3.6)	0-16 (4.4)	0-25 (12.1)
21-30	3- 3 (3.0)	3 (1.5)	4- 5 (4.5)	7-11 (9.0)

There was a wide variety of stages of infestations in Minnesota for both budworms in 1986. There were areas of heavy infestations causing greater than 50% defoliation and will probably cause tree mortality. In other spruce-balsam and jack pine areas, there were no budworms and no defoliation. The varied conditions should have provided a good test for the pheromones. From the trapping results, it appears that current year trap catches cannont be correlated with current year defoliation, egg mass counts or larval counts. Perhaps trap catches will have a better correlation with the following year defoliation or life stage survey results. At this point, however, it is obvious that more work will be needed to refine the chemistry and concentration of both budworm pheromones before a reliable budworm trapping system can be used operationally.

RED PINE STUNTING STUDIES

Jana Campbell and Mike Albers

University, DNR, and Federal insect and disease researchers have identified a stunting problem that occurs in conifer nurseries throughout the Lake States. Stunting and uneven height growth occurs in red pine, white pine, and white spruce. Stunting shows up in the 1-0 seedlings and becomes most evident when the trees are 2-0 and 3-0 (1). Researchers have looked at soils, nutrients levels, seed sources, cover crops, soil amendments, pesticide applications, and insects and diseases. No cause for the stunting problem has been found (1,2).

The impact of stunting on white spruce seedlings growing in Lake States nurseries has been documented (3). A 5-fold increase in the cull rate of white spruce seedlings occurred during 1981 at the Eveleth Nursery. Recently, Croghan (4) found that stunting did not adversely affect white spruce seedling growth after outplanting.

Whatever the cause or the impact in the nursery, no one is certain that stunting of red pine is detrimental to survival and growth once the stunted seedlings have been outplanted. A study was intitiated in 1982 to determine whether stunting has a significant impact on red pine plantation success. If stunting was found to reduce survival or height growth, then stunted seedlings could be culled at the nursery or in the field by planting crews. Since culling is costly, there is a need to know if the impact of stunting is severe enough to make culling worthwhile.

METHODS

Tall and stunted seedlings were planted side by side and their survival, and height growth were measured. Seedlings were established on typical Minnesota-DNR, Division of Forestry sites as part of larger red pine plantations. The shipping, handling, and planting were done by contracted laborers as part of the Division of Forestry's normal planting processes.

A total of 5 study plantings were established during the period of 1982-1984. Three-year old (3-0) red pine seedlings were shipped from General Andrews Nursery for spring planting. On each of the 5 sites, 100 tall and 100 stunted seedlings were randomly removed from shipping boxes and given to a contract planter who planted each of them next to a numbered wooden stake at an 8' by 8' spacing. Seedling selection was based on visual differences in tree heights. At the time of establishment, height measurements were taken for each seedling. Survival and height growth of each seedling were recorded one and two years after establishment on all sites. Survival and height growth data for seedlings were averaged, and the differences between tall and stunted seedling averages were tested for significance by using the F-test.

RESULTS

At establishment, the differences in height between the tall and the stunted seedlings were significant. See Table 1.

TABLE 1: PLANTATION ESTABLISHMENT

Site	Location	County	Year	Avg. Height (cm) Tall	Stunted
Bass Lake	16-56-26	Itasca	1983	15.8	10.5
Hill City	17-52-24	Aitkin	1983	10.8	7.4
Link Lake	33-60-24	Itasca	1983	14.2	6.7
Graves Lake	21-58-26	Itasca	1982	15.1	8.2
Cameron Lake	30-60-25	Itasca	1984	19.2	12.4
MEAN*				15.0a	9.0b

* Means followed by the same letter are not significantly different using the F-test (p=0.01).

Height growth averages after both the first and the second years were similar. In fact, the differences were 1 cm or less and were not significantly different. See Tables 2 and 3.

TABLE 2: AVERAGE HEIGHT GROWTH AND TOTAL SEEDLING HEIGHTS IN CENTIMETERS

Site	Height Growth After 1 Year		Height Growth After 2 Years		Total Height After 2 Years	
	Tall	Stunted	Tall	Stunted	Tall	Stunted
Bass Lake	4.0	3.5	4.7	6.4	24.5	20.4
Hill City	7.6	4.8	7.4	7.2	25.8	19.4
Link Lake	2.1	2.5	8.8	9.3	25.1	18.5
Graves Lake	6.9	4.0	25.5	20.6	47.5	32.8
Cameron Lake	2.0	3.8	6.3	4.2	27.5	20.4
MEAN	4.5a	3.7a	10.5b	9.5b	30.1c	22.3c

TABLE 3: AVERAGE SEEDLING SURVIVAL 1 AND 2 YEARS AFTER ESTABLISHMENT

Site	First Year Survival Percent		Second Year Survival Percent	
	Tall	Stunted	Tall	Stunted
Bass Lake	97	92	83	64
Hill City	96	85	71	52
Link Lake	56	29	48	23
Graves Lake	53	40	36	41
Cameron Lake	82	85	60	51
MEAN	77a	66a	59b	46c

Stunted seedlings grew faster than tall seedlings during the first and second year after establishment, and the differences between their respective growth rates were significant. See Table 4. Growth rate is the season's shoot growth divided by the total height at the onset of the growing season (4). Stunted seedlings start out shorter but are able to grow as fast or faster than tall seedlings.

TABLE 4: AVERAGE GROWTH RATES OF TALL AND STUNTED SEEDLINGS

	TALL	STUNTED
First Year		
Shoot growth during first year	4.5 cm	3.7 cm
Height at beginning of first year	15.0 cm	9.0 cm
GROWTH RATE	0.33a	0.43b
Second Year		
Shoot growth during second year	10.5 cm	9.5 cm
Height at beginning of second year	19.5	12.7 cm
GROWTH RATE	0.52c	0.80d

The survival of tall and stunted seedlings after 2 years was significantly different. Mortality to both tall and stunted seedlings occurred due to a variety of causes and was rather high overall in this study. However, it was assumed that mortality of stunted seedlings beyond the level that occurred to the tall seedlings was due to the effect of stunting. Stunting did have a measurable, negative impact on seedling survival at the end of two years.

DISCUSSION

Planting stunted seedlings would not be detrimental to plantation success as determined by height growth alone. However, when one considers survival, planting stunted trees could be detrimental to the success of a plantation since the survival of stunted seedlings after 2 years was 13% less than survival of the tall seedlings.

Whether or not stunting is detrimental to the success of a plantation depends on the total number of seedlings planted per acre and the percent of those seedlings that are stunted. For example, the percent of stunted seedlings being shipped from the General Andrews Nursery and planted in 1982 was 12% (Campbell, unpublished). If two plantations are established at 800 trees per acre and Plantation A has no stunted seedlings while Plantation B has 12% stunted seedlings, then Plantation A has only 13 more trees per acre surviving after two years. See Table 5. In this example there would be little adverse effect on the success of the plantation when including stunted seedlings. It probably would not be economically justified to cull the 12% stunted seedlings to increase plantation sucess by 13 trees per acre. On the otherhand, a large percentage of stunted seedlings planted in a plantation with a low number of trees per acre could cause plantation failure.

TABLE 5: COMPARISONS OF PLANTATION SUCCESS

	Plantation A 100% Tall Trees Per Acre	Plantation B 88% Tall/12% Stunted Trees Per Acre
At Establishment		
Tall	800	704
Stunted	0	96
Total	800	800
Mortality[1]		
Tall = 41%	-328	-289
Stunted = 54%	0	- 52
Number of Survivors		
Tall	472	415
Stunted	0	44
Total	472	459

[1]Mortality rates are based on the average rates observed in this study.

CONCLUSION

There was a discernable effect of stunting on survival rates of red pine seedlings in plantations in this study, but the effect was minimal when considering overall plantation success. We feel that it is not necessary to cull stunted seedlings as long as they remain a small proportion of the plantation's total composition.

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(2) Croghan, C.F., M. Palmer, and M. Wolosiewicz. 1987. Stunting of white spruce associated with ectomycorrhizal deficiency. Tree Planters Notes 38(1): 22-23.

(3) Croghan, C.F., and L. LaMadeleine. 1982. The impact of stunting of white spruce at Eveleth Nursery. USFS Forest Pest Mgt. Rpt. NE Area 82-7.

(4) Croghan, C.F. 1985. The effects of white spruce stunting on seedling growth. Tree Planters Notes 36(2): 10-12.

JACK PINE BUDWORM DEFOLIATION PREDICTION

Alan C. Jones

The Minnesota DNR relies on an early larval survey to help predict jack pine defoliation for the current year. The survey method consists of collecting 30 shoots from 5 trees and counting the number of shoots infested with budworm larvae. "When 20 or 30 shoots are infested the predicted larval populations will be 25 per 30 shoots" (1). Twenty or more shoots infested "is considered sufficient population to cause moderate to heavy defoliation when the larvae reach the late larval stage" (1,5).

This survey technique was developed by R.B. Stewart, formerly with the Wisconsin DNR, from his many years working with the jack pine budworm in northwestern Wisconsin. The U.S. Forest Service also endorses this survey (3). However, the Canadian Provinces and the state of Michigan generally do not conduct early larval surveys but rely on egg mass and overwintering L_2 larval surveys (4).

Because only Minnesota and Wisconsin are using this survey and it does require a sizeable investment in time and money to conduct the survey, a study was started in 1986 to try to determine how reliable is the early larval survey in predicting defoliation.

METHODS

The early larval survey was conducted in Region I in early June following the procedure outlined by Stewart (5). In early to mid-July through early August, defoliation was visually rated in the same "40" where the early larval survey had taken place. Defoliation rating was done without knowledge of the early larval count results, and the ratings were according to the following categories:

Rating	% current year needles chewed	Remarks
0-VL	0 - 9 %	Green/no defoliation detectable
L	10 - 20 %	Green/needle loss can be detected
M	21 - 50 %	Lt green to brown/needle loss obvious
H	50+ %	Bright red-brown/needle loss obvious

RESULTS

Eighty early larval survey areas were rated for infection and summarized in Table 1.

TABLE 1: EARLY LARVAL COUNTS VS ACTUAL DEFOLIATION

No. Shoots Infested	No. Plots	DEFOLIATION 0-VL	Light	Moderate	Heavy
0	6	5	-	1	-
1	3	3	-	-	-
2	9	6	2	-	1
3	2	2	-	-	-
4	4	2	1	-	1
5	7	6	-	1	-
6	6	3	1	-	1
7	7	-	4	2	1
8	2	-	1	1	-
9	3	-	1	2	-
10	0	-	-	-	-
11	1	-	-	1	-
12	1	-	1	-	-
13	4	-	2	-	2
14	2	-	-	1	1
15	2	-	-	2	-
16	2	1	1	-	-
17	4	-	-	1	3
18	2	1	-	1	3
19	0	-	-	-	-
20	5	-	2	-	3
21	2	-	-	-	2
22	1	-	1	-	-
23	0	-	-	-	-
24	1	-	-	-	1
25	0	-	-	-	-
26	0	-	-	-	-
27	0	-	-	-	-
28	1	-	-	1	-
29	2	-	1	1	-
30	1	-	-	1	-

DISCUSSION

One year collection of data is not sufficient to compare early larval counts and actual defoliation with any certainty. If the 13 plots with 20 or more shoots infested are lumped together, 9 out of 13 plots or 69% have moderate to heavy defoliation. From this limited data, then, moderate to heavy defoliation can be predicted 70% of the time when there are 20 or greater shoots infested.

There does seem to be some patterns when numbers of infested shoots are lumped together:

TABLE 2: PREDICTED DEFOLIATION AND RELIABILITY FROM LARVAL COUNTS

No. Shoots Infested	No. Plots	Actual Defoliation (% of Plots) 0-VL	Light	Moderate	Heavy	Predicted Defol.	Reliability
0 - 6	37	73	14	5	8	0-VL	70%
7 - 13	18	0	50	33	17	VL-L	50%
14 - 19	12	17	8	42	33	L-M	50%
20 - 30	13	0	31	23	46	M-H	70%

It generally takes a greater population of insects to sustain the same level of damage as an outbreak "ages" from year to year. As the population ages, insect predators, parasites, and diseases build up and cause greater mortality. Habitat is also changed through needle loss and tree mortality. Food is more scarce and egg laying sites may be greatly reduced (2). Because of this, early larval counts used to predict defoliation will probably have to be related to the year or age of the infestation. In this current study, data was collected from both a young, building population as well as an older, declining population. This variation may be great enough that a reliability percentage in the range of 50-70% is as high as one can expect.

This study will be continued in 1987. An estimate of population age will be made at each plot location. The data will be analyzed separately and compared to 1986's data, and it will be combined with 1986's data and analyzed.

(1) Dixon, J.C. 1985. Jack pine budworm surveys. from Forest insect and disease survey methods notebook. U.S. For. Serv. S&PF, St. Paul,MN.

(2) Foltz, J.L. 1969. An analysis of population fluctuations of the jack-pine budworm, Choristoneura pinus, in Michigan, 1965-1968. PhD Dissertation, University of Michigan. 113p.

(3) Jackson, W. 1986. Personal communication. U.S.For.Serv. S&PF, St. Paul, MN.

(4) Munro, G. ed. 1986. Jack pine budworm information exchange. Proceedings. Winnipeg, Manitoba. 96p.

(5) Stewart, R.B. 1986. Surveys conducted in northwestern Wisconsin for the jack pine budworm, Choristoneura pinus (Freeman). in Proceedings: Jack pine budworm information exchange. G. Munro, ed. Winnipeg, Manitoba. p.10-11.

SURVEY RESULTS AND REGIONAL NOTES

-SPRUCE BUDWORM-

Region 2 Notes and Survey Results

Twenty-nine plots were monitored by District and Region personnel during the growing season. Many of the locations have been monitored for the past several years. On each plot life stage, population and impact data were taken (Table 1).

Defoliation of host trees on each plot was noted by visually estimating the precent of the current year's needles that were consumed.

Early larvae counts were made on each permanent plot during mid-June. By monitoring the early larvae, we can compare larval development and distribution to past years' and in older outbreak areas, predict defoliation for the same growing season. If there is one larvae per 10 buds for all the buds on a sample branch, the defoliation should be heavy in the stand that season.

Pheromone traps were set out starting in late June and retrieved starting in late July. Pheromone traps are baited with a synthetic sex-attactant. No correlations with other lifestage counts or impact have yet been established. It's hoped that trap catches can be used in the future to predict defoliation and monitor budworm populations in place of the time-consuming early larvae and eggmass counts.

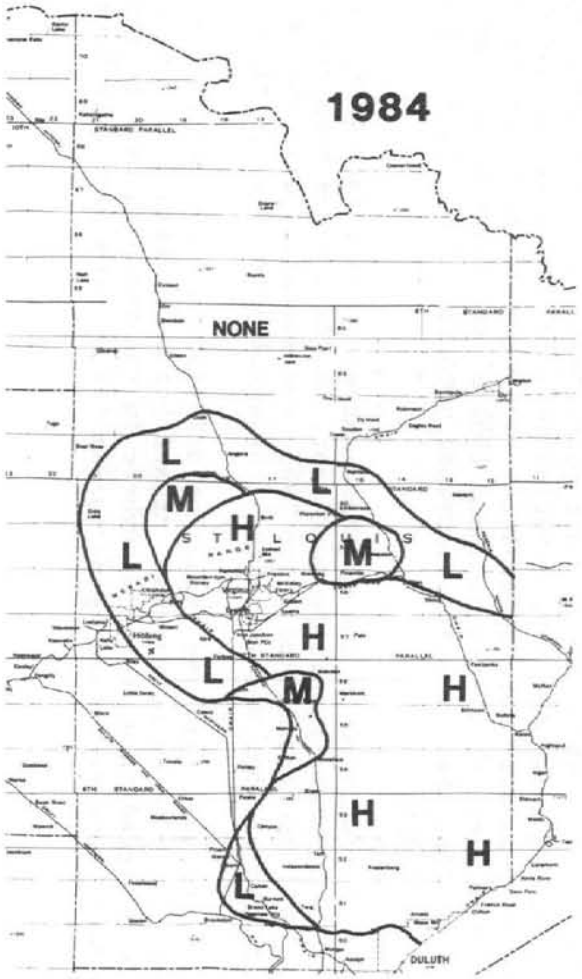
Eggmass counts were made in August in order to predict next year's defoliation in the same locations.

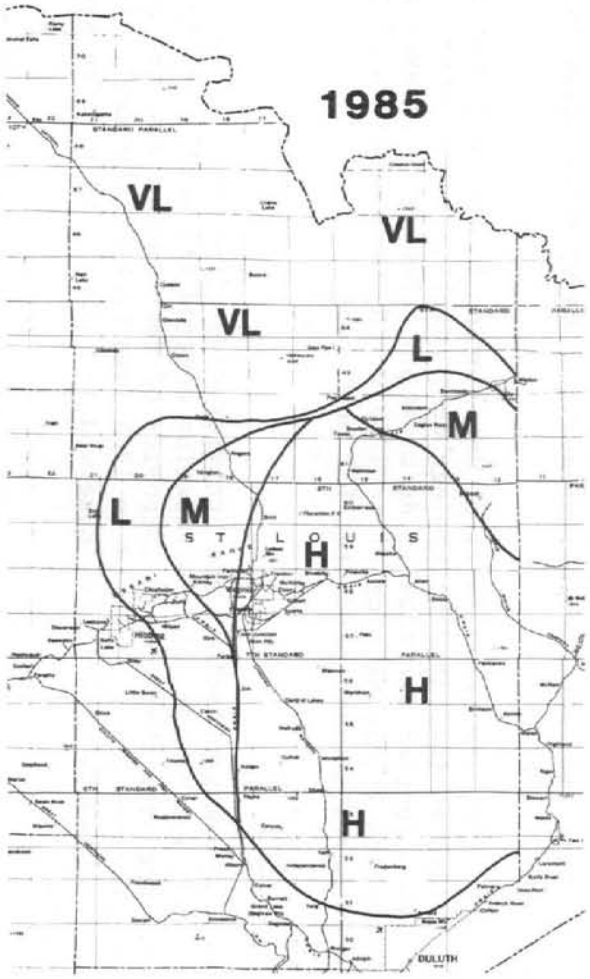
St. Louis County

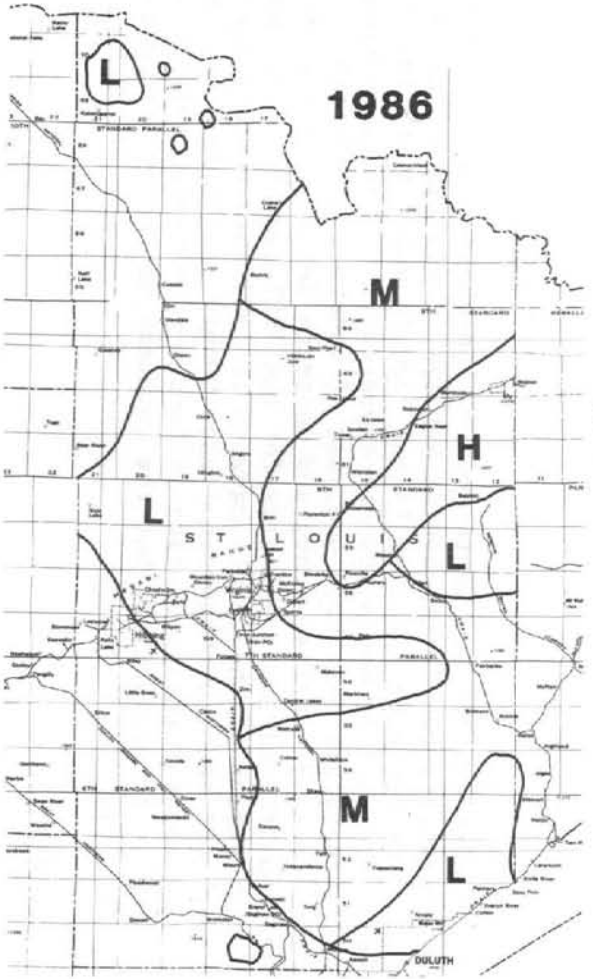
1986 was the first year in the past five years that the outbreak area in St. Louis County experienced less than heavy defoliation (see St. Louis County map). Activity decreased in Hibbing, Cotton, and Cloquet Valley Districts. For example, in the Cotton District, defoliation severity decreased from heavy to moderate and light, and there was an 80% decrease in the number of egg masses found when compared to the 1985 egg mass survey results. No changes in early larval populations were observed, but the feeding habit changed. Instead of feeding in the upper crowns, budworm fed in the lower crowns which allowed the tree tops to remain green. This may be a trend, as decreased activity and impact were observed in a few scattered locations within this area in 1985. If the trend continues, this area might expect decreased defoliation in 1987, but the area will continue to experience top kill and tree mortality for the next few years due to the effects of the previous years' defoliations.

Budworm activity increased slightly in Side Lake District including a small portion of Itasca County.

Spruce Budworm in St. Louis County







In northeastern St. Louis County, the whole range of defoliation levels was detected during aerial surveys. Defoliation jumped from barely detectable to moderate in one year in most of the infested areas. Neither top kill or mortality are expected in the newer outbreak areas because there has only been one year of moderate defoliation. Based on egg mass survey results, heavy and moderate defoliation are predicted throughout the new outbreak area for the 1987 season. There may be some westward spread of the spruce budworm in 1987 into the Orr District west of Buyck and into northeastern Itasca County from Side Lake. Based on egg mass counts, the population in Voyageurs National Park should cause low levels of defoliation, but the outbreak may cover more area in the Park in 1987.

Lake County

Budworm defoliation occurred over the entire county in 1986. In the areas labeled "very light" (VL) in 1985, budworm activity intensified and caused light, moderate or heavy defoliation in 1986 (see Lake County map).

In 1987, the heavy level of defoliation in the northwest will be maintained as indicated by the egg mass counts. The southwest corner may see a further decrease in defoliation intensity. Elsewhere, 1987's defoliation should be similar to 1986's. No new locations of budworm caused mortality are predicted for next year.

Cook County

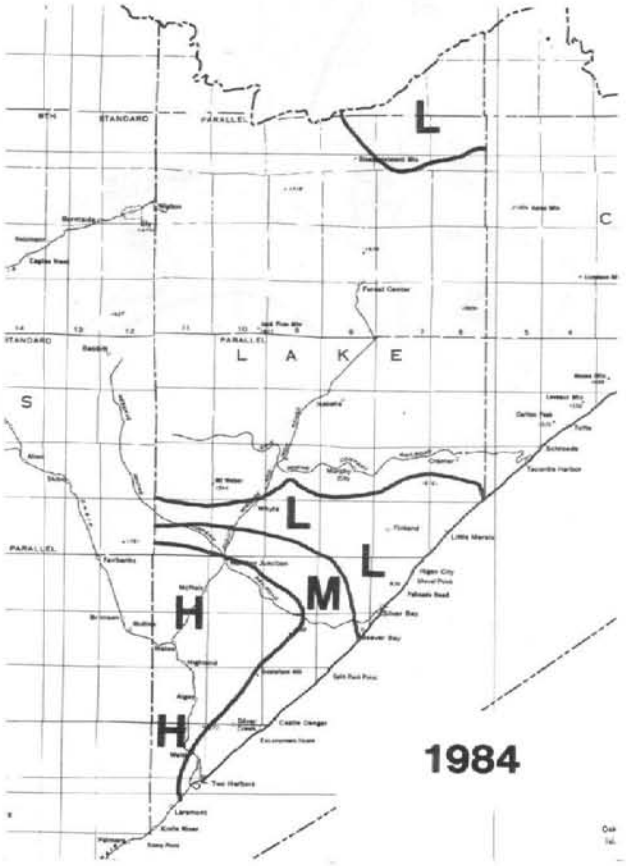
Budworm populations and activity were first detected in Cook County in 1983, and by 1985 the infestation covered the entire county. In 1986, the distribution and intensity of defoliation was very similar to the situation which occurred in 1984 (see Cook County map). In 1985, the same levels of activity observed in either 1984 or 1986 were not detected.

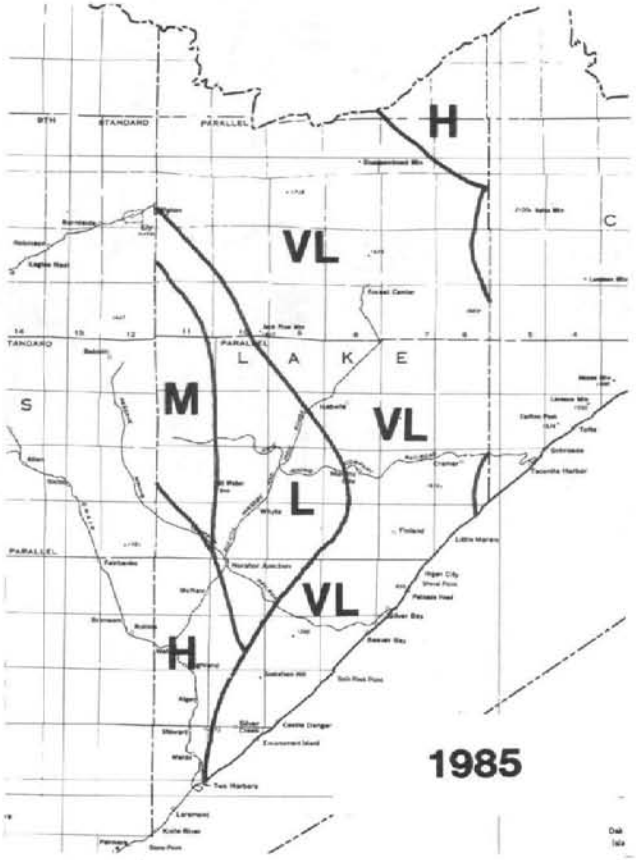
The area by Loon Lake on the Gunflint Trail has had four years of defoliation, and defoliation was heavy during the last three years. Balsam fir in this area are not quite dead. The areas near Loon Lake access and Iron Lake have experienced a 30% top kill and mortality rate. In 1986, budworm were intensively feeding on white spruce in these areas. Where they have consumed 100% of the current year needles on balsam fir, they have also consumed upto 80% of the current year needles on white spruce.

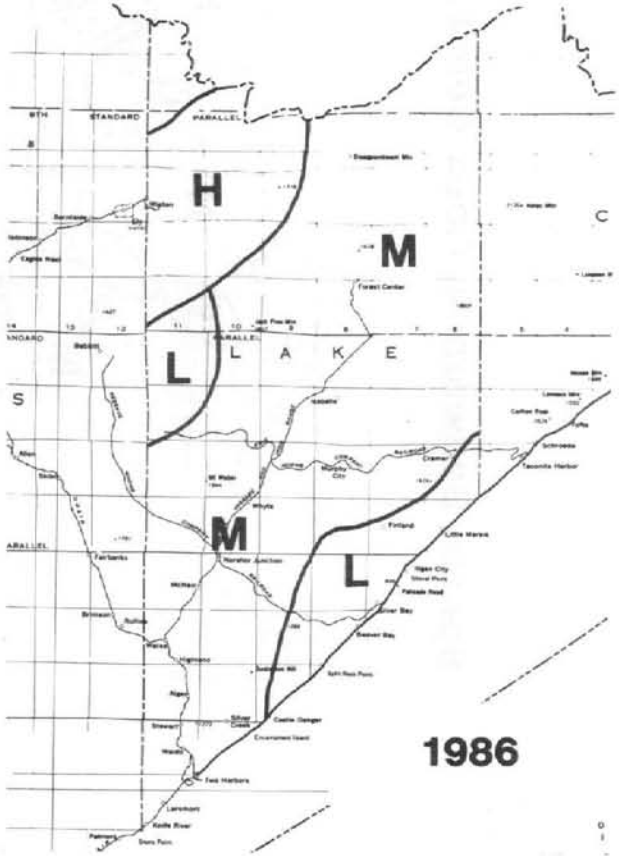
As predicted by the egg mass surveys, heavy defoliation is expected in the northern townships next year. Mortality has been observed near Sea Gull and Loon Lakes since 1985, and mortality will continue to increase as long as heavy levels of defoliation are sustained.

The intensity and impact of defoliation decreases as the trail descends into Grand Marais. At and below Lullabye Creek, no top kill was observed this year. Elsewhere in the southern part of the county, budworm have been feeding on balsam fir for the past 2 to 3 years, and

Spruce Budworm in Lake County

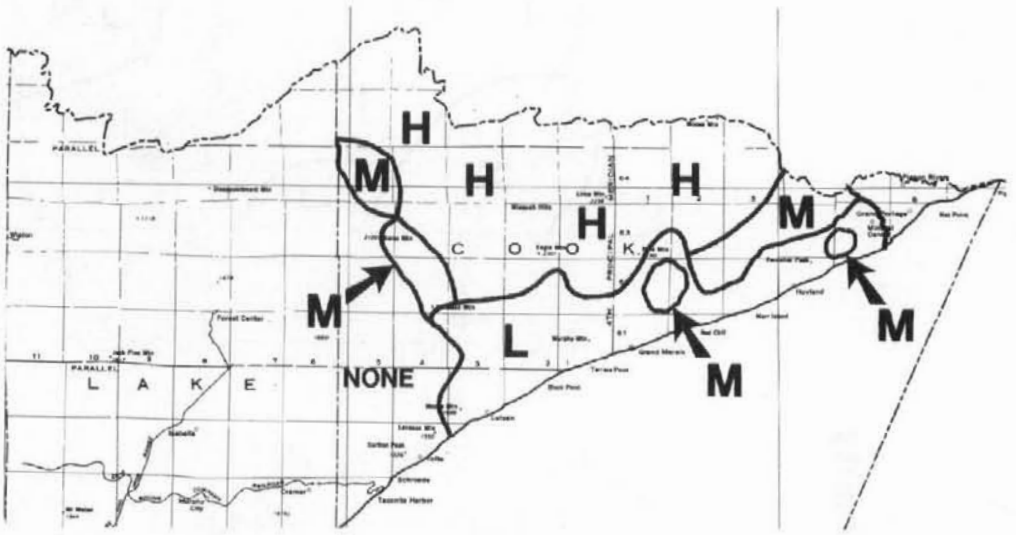






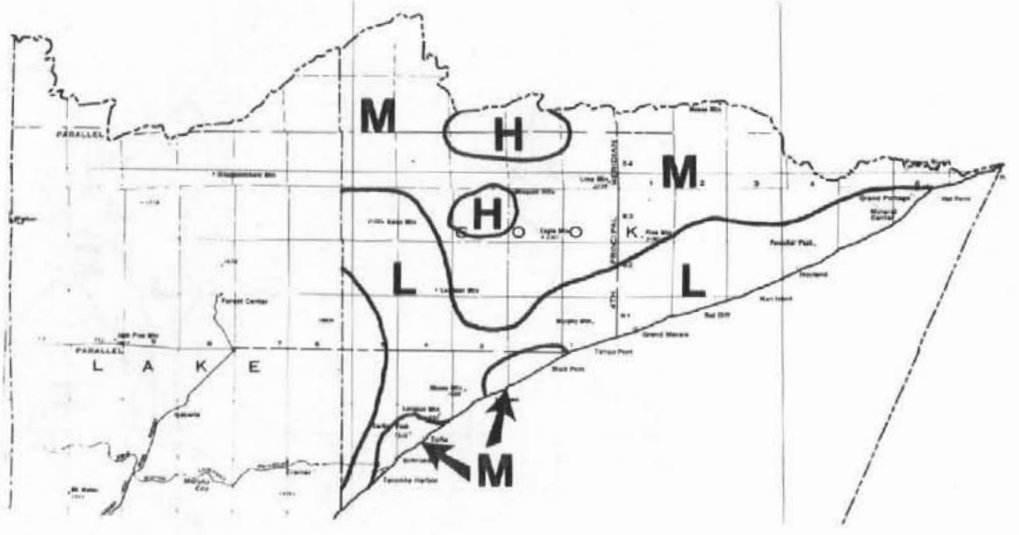
Spruce Budworm in Cook County

1984



1985

1986



they have begun feeding on white spruce in 1986. Egg mass counts have increased and indicate a likelihood of heavy defoliation in 1987. This increase also may indicate a spread of heavy defoliation to the southwestern townships.

Feeding intensity has remained moderate to heavy along the Arrowhead Trail in the Hovland District. This intesnity level should remain the same in 1987.

Carlton County

Very light budworm populations have been detected from the ground for the past few years in the Fond du Lac State Forest. Defoliation is not visible from the air. A few early larvae and moths were collected near Lost and Miller Lakes in 1986. No changes in severity or extent of the infestation are predicted for 1987.

Phenological notes

May 30	Mostly 3rd, some 4th instars at Cotton seed orchard.
June 3	Mostly 3rd instars: Cloquet Dist.
4	Phenology: Mertensia, apple and wild sarsasparilla in bloom; crabapple bloom ending: Lake Co.
9	Mostly 4th instar: Orr District
9	Phenology: rose and iris in bloom: Orr Dist.
10	Predominantly 4th and 5th instars; finding a few pupae: Kabetogama Dist.
11	Predominantly 4th instars: Finland Dist.
11	Phenology: yellow trout lilies, bluebells, Queen Anne's lace blooming: Finland Dist.
12	50% pupated, Hwy 53 & 49: St. Louis Co.
12	3rd, 4th & 5th instars, mostly 4th: Bally Cr., Cook Co.
18	20% pupated: Esquagama L, Virginia Dist.
19-24	Moths emerged in collections from southern St. Louis Co.
27	Pupae collected: Cook Co.
29	64% emergence of pupae observed: Britt, Virginia Dist.
July 1	First moth emerged in collections from Cook Co.
2	Balsam fir taking on reddened appearance
14	A few moths still active: Kabetogama Dist.

TABLE 1: SPRUCE BUDWORM SURVEY RESULTS

Plot Location	1985 Defoliation	1986 Early Larvae	1986 Defoliation	1986 Trap Catches	1986 Eggmass	1987 Predictions
Kabetogama						
36-69-19	VL	3,1,3	0-VL	259	1,0,1	VL
St. Louis		0,3,2		360	0,0,0	
		0,0,1		-	0,0,0	
1-68-20	VL	0,1,1	0-VL	655	0,0,0	VL
St. Louis		0,1,0		133	0,0,0	
		2,3,1		402	0,0,0	

Plot Location	1985 Defoliation	1986 Early Larvae	1986 Defoliation	1986 Trap Catches	1986 Eggmass	1987 Predictions
Kabetogema						
8-68-20	VL	0,0,1	O	193	0,0,0	VL
St. Louis		2,2,1		119	0,0,0	
		0,0,1		85	0,0,0	
Orr						
14-65-14	VL	0,1,1	M-H	552	1,1,2	M
St. Louis		0,2,2		660	1,3,0	
		2,2,1		825	0,0,0	
7-65-15	L	2,1,5	M	145	0,0,0	M
St. Louis		8,4,2		198	5,2,0	
		6,4,8		155	2,1,2	
16-65-17	VL	4,2,1	M	325	1,0,0	H
St. Louis		5,3,9		490	2,9,3	
		2,2,6		421	2,0,4	
Tower						
24-64-13	O	-	M	580	0,0,1	M
St. Louis				626	2,1,1	
				1195	2,1,4	
8-60-14	H	-	H	522	1,0,0	M
St. Louis				819	1,3,1	
				369	3,2,1	
7-63-9	H	-	H	999	3,2,1	H
Lake				729	0,0,1	
				810	3,3,6	
Virginia						
32-60-17	VL	-	M	186	0	L
St. Louis				307	1	
				206	0	
Side Lake						
1-59-22	L	0,4,0	O	-	0,0,0	O
Itasca		0,1,2			0,0,0	
		3,1,1			0,0,0	
4-59-21	M	1,2,1	M-H	1174	2,1,0	M
St. Louis		0,0,5		525	0,0,2	
		3,3,1		995	1,0,0	
Side Lake						
13-59-20	L	3,9,4	M	606	0,0,0	L
St. Louis		7,8,8		919	0,0,0	
		14,3,9		436	0,0,0	

Plot Location	1985 Defoliation	1986 Early Larvae	1986 Defoliation	1986 Trap Catches	1986 Eggmass	1987 Predictions
Hovland						
22-63-3E	VL	2,6,0	M	1	0,2,0	L
Cook		0,5,7		3	1,2,0	
		3,8,8		0	0,0,0	
11-63-4E	H	4,5,4	L	0	0,0,1	L
Cook		5,10,5		7	0,0,0	
		12,7,6		234	0,0,0	
32-64-3E	M-H	8,6,2	H	2	3,2,4	H
Cook		3,10,3		4	2,4,2	
		4,3,12		14	2,3,4	
2-63-4E	-	-	L	1343	0,0,0	L
Cook				29	0,0,0	
				2513	0,0,0	
Grand Marais						
32-65-3W	L-M	2,4,3	H	464	1,0,0	M
Cook		1,1,9		891	0,2,1	
		1,0,1		941	0,1,0	
1-61-1W	L-M	6,4,4	H	685	6,8,1	H
Cook		5,3,3		1199	3,1,6	
		6,9,5		1359	2,1,3	
25-61-4W	L	7,9,11	H	665	9,3,1	H
Cook		8,3,3		278	1,1,0	
		5,7,7		379	1,1,2	
Finland						
9-58-6	VL	15,10,17	L	209	0.2,0	L
Lake		8,5,9		312	0,0,1	
		8,5,5		256	1,0,0	
Two Harbors						
36-52-12	M	0,0,1	L	1792	0,0,0	M
St. Louis		1,0,2		829	4,0,1	
		1,2,1		1016	1,0,0	
19-55-10	H	14,4,6	M	357	3,1,2	M
Lake		11,17,9		345	3,2,1	
		10,7,8		357	0,1,0	
36-59-11	VL	2,2,7	H	600	0,0,1	M
Lake		2,8,10		997	0,0,0	
		2,2,10		1040	2,2,2	

Plot Location	1985 Defoliatio	1986 Early Larvae	1986 Defoliation	1986 Trap Catches	1986 Eggmass	1987 Predictions
Cloquet						
12-49-19	0	0,0,1	VL	20	0,0,0	0
Carlton		1,0,1		21	0,0,0	
		0,1,0		21	0,0,0	
14-49-19	0	1,0,0	VL	5	0,0,0	0
Carlton		0,0,0		3	0,0,0	
		0,0,0		25	0,0,0	
Cotton						
18-53-17	H	2,8,15	M	189	0,1,0	M
St. Louis		9,3,5		145	0,1,0	
		5,13,9		33	3,0,1	
14-52-16	H	52,26,18	M-H	230	0,2,0	L
St. Louis		12,18,20		8	0,0,0	
		2,9,9		213	0,1,0	
3-53-16	H	11,6,12	M	236	4,0,1	M
St. Louis		3,6,13		193	1,0,2	
		2,6,9		244	1,1,3	

-JACK PINE BUDWORM-

Region I Survey Results

TABLE 2: REGION 1 JACK PINE BUDWORM SURVEY RESULTS

Plot Location County	Description	1986 Defoliation	No. Shoots W/Larvae	No. of Egg Masses	1987 Defoliation
Becker	2-139-36	H	14	-	-
	4-139-36	L	1	2	M
	14-139-36	H	17	-	-
	14-139-36	H	13	3	H
	15-139-36	H	8	2	M
	22-139-36	H	6	-	-
	22-139-36	H	14	-	-
	23-139-36	H	21	-	-
	24-139-36	H	13	-	-
	26-138-36	L	1	-	-
	26-139-36	L	3	-	-
	4-140-36	0	2	-	-
	28-140-36	0	0	0	0
	33-140-36	M	5	-	-
	34-140-36	-	9	3	H
	21-141-36	L	4	-	0
	27-141-36	L	2	1	L
	33-141-36	0	2	0	0
	25-142-36	M	6	1	L
	27-142-36	0	0	0	0
Beltrami	34-146-32	H	-	4	H
	16-146-35	L	12	-	-
	21-146-35	L	7	-	-
	22-146-35	L	5	-	-
	25-146-35	L	21	-	-
	26-146-35	L	16	2	M
	26-146-35	L	18	-	-
	34-146-35	L	2	1	L
	31-147-33	L	-	2	M
	31-147-33	L	-	1	L
	4-147-34	M	20	3	H
	6-147-34	M	-	4	H
	8-147-34	L	3	0	0
	10-147-34	M	15	2	M
	12-147-34	L	-	1	L
	13-147-34	L	5	-	-
	14-147-24	M	-	0	0
	22-147-34	0	-	0	0
	23-147-34	M	16	1	L
	26-147-34	L	20	-	-
	26-147-34	M	6	-	-
	1-147-35	0	4	0	0
	2-147-35	0	6	-	-
	4-147-35	0	2	-	-

Plot Location County	Description	1986 Defoliation	No. Shoots W/Larvae	No. of Egg Masses	1987 Defoliation
Beltrami	4-147-35	0	0	-	-
	11-147-35	0	1	-	-
	13-147-35	0	3	-	-
	19-148-35	0	0	-	-
	19-148-35	0	1	-	-
	20-148-35	0	1	-	-
	28-148-35	0	2	-	-
	28-148-35	0	2	-	-
	30-148-35	0	1	-	-
	31-148-35	0	1	-	-
Cass	7-139-31	0	15	-	-
	18-140-31	0	13	-	-
	19-140-31	0	13	-	-
Clearwater	17-145-38	0	0	-	-
	19-145-38	0	0	-	-
	20-145-38	0	0	-	-
	30-145-38	0	0	-	-
Hubbard	1-139-32	L	20	-	-
	6-139-32	L	13	-	-
	9-139-32	L	7	-	-
	10-139-32	L	28	0	0
	10-139-32	L	30	-	-
	13-139-32	0	22	-	-
	30-139-32	L	24	-	-
	5-139-33	H	14	-	-
	5-139-33	M	12	-	-
	13-139-33	L	26	-	-
	20-139-33	L	17	-	-
	35-139-33	L	6	-	-
	30-139-34	L	5	-	-
	30-139-34	M	6	-	-
	30-139-34	M	8	-	-
	34-139-35	0	0	-	-
	34-139-35	M	8	-	-
	35-139-35	H	19	-	-
	36-139-35	M	8	-	-
	13-140-32	0	13	-	-
	14-140-32	0	24	-	-
	17-140-32	H	20	-	-
	18-140-32	M	14	-	-
	21-140-32	0	30	-	-
	23-140-32	0	23	-	-
	25-140-32	0	29	0	0
	30-140-32	H	13	-	-
	33-140-32	0	24	-	-
	34-140-32	-	17	-	-
	35-140-32	-	-	0	0
	13-140-33	H	15	-	-
	24-140-33	H	17	-	-
	24-140-33	H	11	-	-

Plot Location					
County	Description	1986 Defoliation	No. Shoots W/Larvae	No. of Egg Masses	1987 Defoliation
Hubbard	26-140-33	H	18	-	0
	27-140-33	H	15	-	-
	33-140-33	H	9	-	-
	35-140-33	H	9	1	L
	35-140-33	-	-	1	L
	7-143-32	0	6	1	L
	9-143-33	0	5	-	-
	11-143-33	0	4	-	-
	12-143-33	-	-	0	0
	13-143-33	0	5	0	0
	5-143-34	0	7	-	-
	8-143-34	0	21	3	H
	9-143-34	0	8	3	H
	10-143-34	0	5	2	M
	16-143-34	0	4	-	-
	16-143-34	0	1	-	-
	16-143-34	0	0	-	-
	2-143-35	0	26	7	H
	14-143-35	0	7	1	L
	9-144-32	0	0	-	-
	16-144-32	0	0	-	-
	4-144-34	L	3	-	-
	10-144-34	0	0	0	0
	15-144-34	0	0	-	-
	22-144-34	0	7	1	L
	27-144-34	0	7	-	-
	28-144-34	0	11	-	-
	32-144-34	0	5	0	0
	9-145-32	0	17	-	-
	3-145-32	-	-	5	H
	2-145-34	L	14	0	L
	4-145-34	-	-	3	H
	11-145-34	L	2	-	-
	23-145-34	L	2	2	M
	24-145-34	L	7	-	-
	27-145-34	L	2	-	-
	27-145-34	L	4	1	L
	33-145-34	0	2	0	0
	4-145-35	-	-	2	M
Lake of the Woods	17-158-32	0	5	-	-
	18-158-32	-	7	-	-
	28-158-33	0	2	-	-
	7-158-34	0	7	-	-
	10-158-34	-	-	1	L
	18-159-33	0	11	-	-
	19-159-33	0	7	-	-
	29-159-33	0	19	2	M
	29-159-33	-	-	0	0
	30-159-33	0	9	-	-
	34-159-33	0	9	-	-

Plot Location County	Description	1986 Defoliation	No. Shoots W/Larvae	No. of Egg Masses	1987 Defoliation
Lake of the Woods	35-159-33	-	-	0	0
	36-159-33	0	2	-	-
	2-159-34	0	7	-	-
	8-159-34	-	-	0	0
	10-159-34	0	3	-	-
	11-159-34	0	7	-	-
	13-159-34	0	13	0	0
	15-159-34	-	-	0	0
	25-159-34	0	8	-	-
	36-159-34	0	10	-	-
	2-159-35	0	1	0	0
	2-159-35	0	0	-	-
	3-159-35	0	0	0	0
	5-159-35	0	0	-	-
	7-159-35	0	8	-	-
	8-159-35	-	-	0	0
	16-159-35	0	0	-	-
	19-195-35	0	4	-	-
	24-159-35	0	1	-	-
	13-159-36	0	5	-	-
	13-159-36	0	7	1	L
	14-159-36	0	7	-	-
	15-159-36	-	-	0	0
	20-159-36	0	0	-	-
	22-159-36	0	2	-	0
	33-160-34	0	3	-	-
	34-160-34	0	2	-	-
	6-161-34	0	1	-	-
	9-161-34	0	5	-	-
	9-161-34	0	2	-	-
	18-161-34	0	7	-	-
	29-161-34	0	6	-	-
	29-161-34	0	5	-	-
Mahnomen	2-145-39	0	0	-	-
	35-146-39	0	0	-	-
	6-159-37	0	19	-	-
Roseau	8-159-37	-	-	0	0
	10-159-37	-	-	0	0
	11-159-37	0	1	-	-
	16-159-37	0	13	-	-
	4-160-37	L	26	4	H
	6-160-37	L	23	-	-
	6-160-37	L	17	1	L
	8-160-37	-	-	1	L
	14-160-37	-	-	0	0
	18-160-37	L	17	1	L
	20-160-37	-	-	1	L
	30-160-37	L	20	-	-
	32-160-37	-	-	2	M
	22-160-38	L	16	1	L

Plot Location					
County	Description	1986 Defoliation	No. Shoots W/Larvae	No. of Egg Masses	1987 Defoliation
Roseau	26-160-38	L	28	-	-
	27-160-38	L	10	-	-
	28-160-38	L	24	-	-
	35-160-38	L	22	-	-
	36-160-38	L	7	-	-
	3-161-35	0	0	-	-
	10-161-35	0	0	-	-
	15-161-35	0	0	-	-
	27-161-35	0	0	-	-
	29-161-35	0	0	-	-
	30-161-35	0	1	-	-
	34-161-35	0	0	-	-
	22-161-36	0	0	-	-
	27-161-36	0	0	-	-
	28-161-36	0	0	-	-
	29-161-36	0	1	-	-
	30-161-36	L	23	-	-
	19-161-37	-	-	1	L
	24-161-37	-	-	1	L
	25-161-37	L	17	-	-
	26-161-37	L	20	-	-
	26-161-37	L	28	-	-
	30-161-37	-	-	1	L
	32-161-37	-	-	2	M
	33-161-37	L	25	-	-
	34-161-37	L	14	3	H

Region 2 Survey Results

May 28 Phenology: dandelions fulffy, marsh marigold full bloom, Kalmia & lab tea in bloom
29 Larvae feeding in staminate cones: Fernberg
June 9 Mostly 3rd & 4th instars: Moose R., Orr Dist.
9 Phenology: Queen Anne's lace blooming: Orr Dist.
18 5th instar predominant: Esquagama L., Virginia Dist.
18 Phenology: harbells & Hieracum in bloom
29 Late instars and pupae present: Britt, Virginia Dist.

Surveys

Nineteen plots were monitored by District and Region personnel during the growing season. On each plot, life stage, population and impact data were taken.

TABLE 3: REGION 2 JACK PINE BUDWORM SURVEY RESULTS

Plot Location	1985 Defoliation	1986 Early Larvae Survey	1986 Defoliation Observed	1986 Trap Catches Pheromone Concen. .3	.03	.003	1986 Eggmass Survey	1987 Predicted Defoliation
Orr								
14-65-14 St. Louis	L-M	7/30	Light	9	12	5	0,0 0,0 0,0	None
7-65-15 St. Louis	VL	13/30	0	1	0	0	0,0 0,0 0,0	"
30-67-17 St. Louis	0	1/30	0	2	0	2	0,0 0,0 0,0	"
Tower								
25-61-13 St. Louis	0-VL	7/30	0	1	2	2	0,0 0,0 0,0	"
24-64-13 St. Louis	M	7/30	0	4	4	2	0,0 0,0 0,0	None
9-63-9 Lake	H	14/30	0-VL	4	3	16	0,0 0,0 0,0	"
Virginia								
35-58-15 St. Louis	L	1/30	0	2	1	0	1,0 0,0 0,0	Light
9-57-16 St. Louis	L	3/30	0	0	0	0	0,0 0,0 0,0	None
4-57-16 St. Louis	L	2/30	0	3	0	0	0,0 0,0 0,0	"
26-60-18 St. Louis	L-M	6/30	Light	7	1	3	0,0 0,0 0,0	"
Side Lake								
27-59-23 Itasca	0	0/30	0	3	0	0	0,0 1,0 0,0	"
23-60-21 St. Louis	0	0/30	0	4	0	0	0,0 0,0 0,0	Light

Plot Location	1985 Defoliation	1986 Early Larvae Survey	1986 Defoliation Observed	1986 Trap Catches Pheromone Concen. .3	.03	.003	1986 Eggmass Survey	1987 Predicted Defoliation
Grand Marais								
28-62-4W Cook	VL	0/30	0	2	2	0	0,0 0,0 0,0	None
16-65-4W Cook	VL	2/30	0	0	3	8	0,0 0,0 0,0	"
8-65-4W Cook	L	7/30	0	5	3	1	0,0 0,0 0,0	"
15-64-1W Cook	0	1/30	0		--		0,0 0,0 0,0	None
16-63-1E Cook	0	0/30	0	2	1	37	0,0 0,0 0,0	"
Two Harbors								
34-56-12 Lake	0	2/30	0	2	3	2	0,0 0,0 0,0	"
Littlefork								
4-65-24 Koochiching	0-VL	6/30	0	2	6	0	0,0 1,0 0,1	Light

Region 3 Survey Results

A July 3 collection of jack pine budworm pupae from Crow Wing and Wadena counties was placed in see-thru plastic containers to study parasitism and disease. By July 9, several moths and a few Hymenopteran parasites had emerged. Fifty-six percent of the pupae were killed by insect parasites and disease organisms. Ichneumons or Chalcid insect parasites accounted for 40% of the pupae kill, and disease accounted for 16% of the kill.

An aerial survey of browned jack pine, and an egg mass survey of the budworm, was completed in late July.

TABLE 4: REGION 3 JACK PINE BUDWORM LARVAL SURVEY SUMMARY

COUNTY	DESCRIPTION	SHOOTS INFESTED	DATE	REMARKS
CASS	NWSE 17-134-30	20	6-11	Budworms counted on shoots of understory white pine. Jack pines were 40+ feet tall and about 20% of these jack pine were dead.
	SESE 3-136-29	12	6-11	Less than 10% of the jack pines had produced staminate cone clusters this spring.
	SESE 16-136-29	10	6-11	
	SESW 17-138-29	7	6-11	
CROW WING	NWNW 15-44-31	18	6-24	90+% shoots webbed and somewhat browned. Six pupae, two prepupae, and four dead budworms (one hollowed out).
	SWSW 9-136-27	16	6-24	Three pupae. 40% of jack pines had webbing on 80% of shoots, but only about 30% of webbed shoots had budworms.
	SENE 23-136-27	17	6-24	Nine pupae and one dead budworm. Most budworm 22mm and black. New shoots show little browning and their chewed needle bases green and growing.
PINE	NESW 16-40 (St. Croix State Park)	7	6-26	Five pupae. Less budworm than in 1985. Little damage to new shoots.

COUNTY	DESCRIPTION	SHOOTS INFESTED	DATE	REMARKS
PINE Con't.	SWNW 16-44-19	1	6-26	One pupae.
	SWSE 25-45-20	No Count	6-26	70% of jack pine with 90% browned and webbed shoots, but almost no feeding on old needles. 60% of budworms pupated.
	13-45-20	14	6-26	Three pupae and two dead budworms. 90% of shoots webbed but with some green needles (entire or chewed basal sections).
	North side of General Andrews Nursery	12	6-26	Six pupae, most 24mm. A few jack pine had 70% slightly browned shoots, but with many green needles in shoots.
WADENA	4-135-32	12	6-16	
	NE 28-136-32	14	6-16	
	15-136-33	4	6-16	
	NENE 30-136-33	13	6-19	
	3-137-32	9	6-16	
	SWSW 36-137-34	8	6-19	One pupae.
	SWNE 26-138-32	28	6-16	90% of vegetative shoots webbed.
	SESE 3-138-33	1	5-28	
	NENE 3-138-33	13	6-19	Many webbed vegetative shoots with no budworm. Several stunted and sick budworms.
	SWSE 4-138-33	0	5-28	
	NWNW 8-138-33	0	5-28	
	NESW 8-138-33	2	5-28	
	NESE 9-138-33	1	5-28	
	NESE 10-138-33	6	5-28	

COUNTY	DESCRIPTION	SHOOTS INFESTED	DATE	REMARKS
WADENA	SENE 10-138-33	9	6-19	Many webbed vegetative shoots with no budworm. Several stunted and sick budworms.
	NENE 16-138-33	15	6-17	
	NWNW 27-138-33	19	6-17	No defoliation in 1985.
	SW 13-138-34	13	6-17	

-PINE TUSSOCK MOTH-

In 1986, only one caterpillar was observed in all Region 3 checkpoints. No egg masses were found. Defoliation by this insect, at a low population level, may be masked by defoliation from the jack pine budworm.

The trap data, the caterpillar observed, and lack of observed egg masses allow the following conclusions:

1. The insect is at minor levels in Region 3.
2. The insect is at lower levels than in 1985 (trap data for 1985 not included in this report).
3. Moth emergence extends over one month, probably beginning in late June and ending in late August or mid-September.

TABLE 5: 1986 PINE TUSSOCK MOTH PHEROMONE TRAPPING IN REGION 3

Trap Location (placed 6/30)	Date	Pine Tussock Moth Caterpillars Trapped
CROW WING COUNTY		
NWSW 9-136-27	7-10	14
	7-18	5
	7-28	7
	8-11	1
NWSW 9-136-27	7-10	8
	7-18	1
	7-28	6
	8-11	Missing Trap
NWSW 9-136-27	7-10	4
	7-18	6
	7-28	12
	8-11	2

Trap Location (placed 6/30)	Date	Pine Tussock Moth Caterpillars Trapped
NESW 10-136-27	7-10	7
	7-18	3
	7-28	11
	8-11	16
SENE 10-136-27	7-10	13
	7-18	5
	7-28	7
	8-11	13
SWSW 11-136-27	7-10	7
	7-18	4
	7-28	11
	8-11	14
SWNE 23-136-27	7-10	9
	7-18	6
	7-28	9
	8-11	4 (bird in trap)
CASS COUNTY		
SESW 25-138-32	7-10	20
	7-18	3
	7-28	11
	8-11	4
SWSW 35-137-32	7-10	11
	7-18	7
	7-28	17
	8-11	5
WADENA COUNTY		
SWNW 15-138-33	7-10	17
	7-18	13
	7-28	11
	8-11	2
SENW 10-138-33	7-10	22
	7-18	17
	7-28	20
	8-11	14
SESE 3-138-33	7-10	23
	7-18	21
	7-28	11
	8-11	20

Trap Location (placed 6/30)	Date	Pine Tussock Moth Caterpillars Trapped
NENE 3-138-33	7-10	27
	7-18	20
	7-28	12
	8-11	20

Trap Location (placed 6/26)	Date	Pine Tussock Moth Caterpillars Trapped
PINE COUNTY		
NESE 13-45-20	7-7	1
	7-15	1
	7-29	0
	8-7	7
SESE 18-45-19	7-7	1
	7-15	0
	7-29	5
	8-7	2
SWNW 6-44-19	7-7	3
	7-15	3
	7-29	3
	8-7	14
SENE 6-44-19	7-7	5
	7-15	0
	7-29	5
	8-7	15
SWSE 25-45-20	7-7	6
	7-15	5
	7-29	3
	8-7	11
NWSE 30-45-19	7-7	5
	7-15	1
	7-29	1
	8-7	23
SESW 29-45-19	7-7	4
	7-15	3
	7-29	0
	8-7	8

Trap Location (placed 6/26)	Date	Pine Tussock Moth Caterpillars Trapped
West side of General Andrews Nursery Beds	7-7	0
	7-15	2
	7-29	7
	8-7	5
NW side of General Andrews Nursery Beds	7-7	2
	7-15	3
	7-29	6
	8-7	13
NE side of General Andrews Nursery Beds	7-7	3
	7-15	4
	7-29	0
	8-7	6

-LARGE ASPEN TORTRIX-

REGION 2 OBSERVATIONS

Phenological Notes

June 11 Pupae collected at Finland, Lake County
June 19 Moths emerging from pupae in collection from Lake County

-FOREST TENT CATERPILLAR-

REGION 2 OBSERVATIONS

Phenological Notes

June 3 Larvae 1 to 1¼ inches long: SW St. Louis County
12 6th instar larvae present: Cook County
17 5% of larvae starting to web leaves together for pupation: SW St. Louis County

July 8 Moths emerging from cocoons in collections from SW St. Louis County
13 Tail end of major moth flight: SW St. Louis County