1980

FOREST INSECT AND DISEASE REPORT

Minnesota Department of
Natural Resources
Division of Forestry

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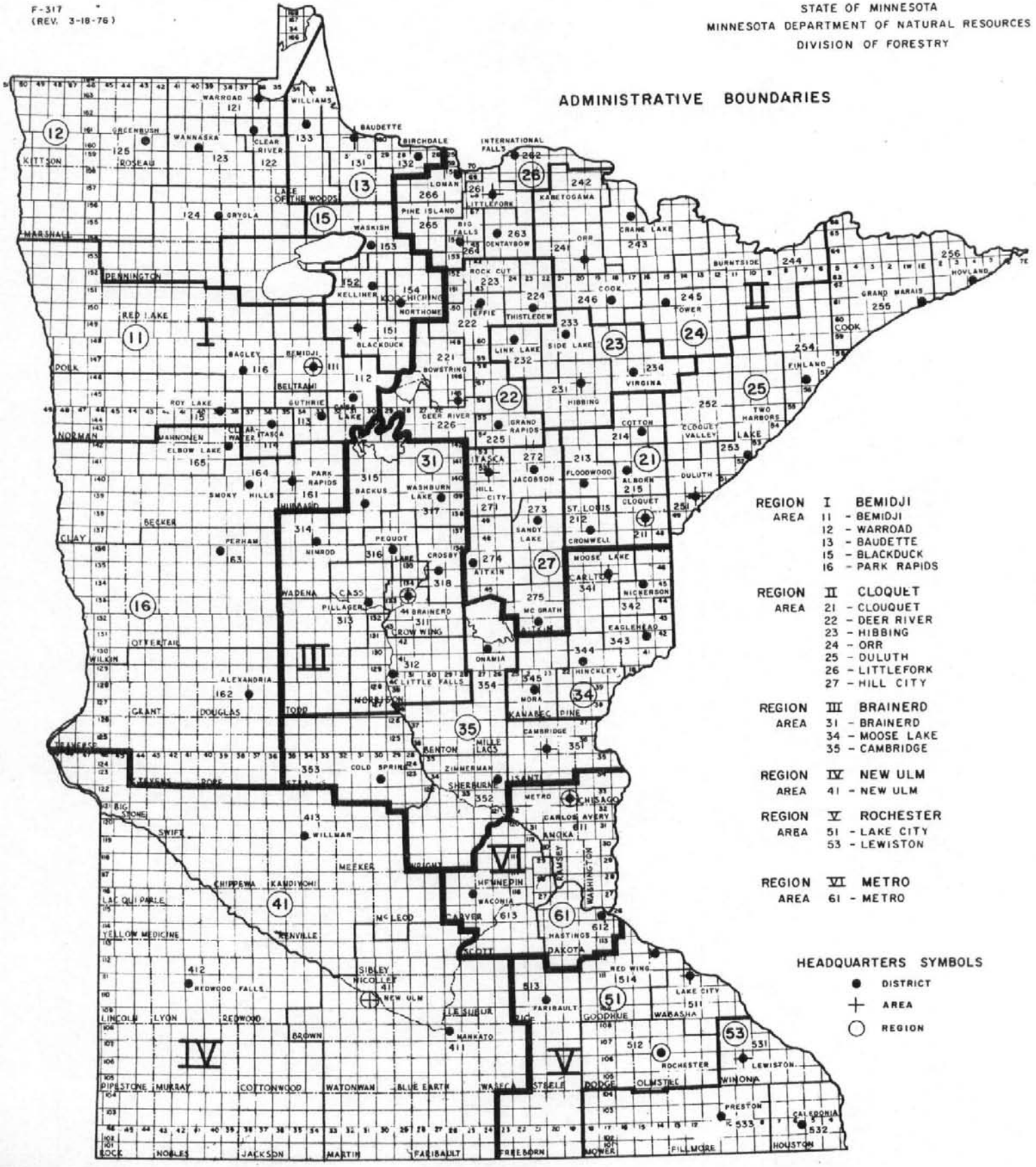
F-317
(REV. 3-18-76)

STATE OF MINNESOTA
MINNESOTA DEPARTMENT OF NATURAL RESOURCES
DIVISION OF FORESTRY

ADMINISTRATIVE BOUNDARIES



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 1.2 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 (see Figure 1). The insect and disease unit consists of a Forest Insect and Disease Supervisor, one Field Coordinator, four Regional Forest Insect and Disease Specialists and six seasonal Plant Health Specialists. The four Specialists and the six seasonal Plant Health Specialists have regional responsibilities.

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1980 FOREST INSECT AND DISEASE HIGHLIGHTS

The largest single activity conducted by the Forest Insect and Disease Unit during 1980 was the pine tussock moth spray project. The project covered an area of approximately 3,500 acres in Region III. It was successful in achieving foliar protection within the affected jack pine stands. A detailed report on this activity is included under the special projects section of this report.

A general reduction in the population levels of the jack pine budworm was expected in 1980. Concern over continued defoliation was eased as early larval surveys indicated a collapse of the budworm population. Only one area of budworm activity was detected in Region I.

The first verified report of the pinewood nematode in Minnesota occurred during 1980. The nematode was discovered in an abandoned Christmas tree plantation in Region III. Evidence of the nematode is expected to be found scattered throughout the state.

The forest tent caterpillar (FTC) populations are on the decline in Minnesota. However, outbreaks of the insect were discovered this year in scattered locations in Region IV on elm and basswood. Aspen stands in scattered areas within Region I failed to refoliate this year. This failure to refoliate was probably linked to the spring drought experienced in this area.

Insect and disease activity within Minnesota this year was affected and often enhanced by the drought conditions which were experienced. Region I was the most severely affected portion of the state. Moisture deficits were experienced across the state. The drought brought with it increased levels of bark beetle, birch decline, oak mortality and Saratoga spittlebug activity.

Aspen Defoliators

Forest Tent Caterpillar - *Malacosoma disstria* Hubner

The year 1980 saw the continuance of the present forest tent caterpillar outbreak which began in 1977. Approximately 4.7 million acres of aspen were moderately to heavily defoliated (see Map 1). There was some localized feeding on tamarack and white spruce where the aspen had been completely stripped. Egg masses in areas with repeated heavy defoliation from 1979 were noticeably smaller and less numerous than last year, indicating that overall populations may be declining. A pupal survey showed relatively high rates of disease and parasitism. Braconid wasps and disease were common and there were also large numbers of Sarcophagid flies present.

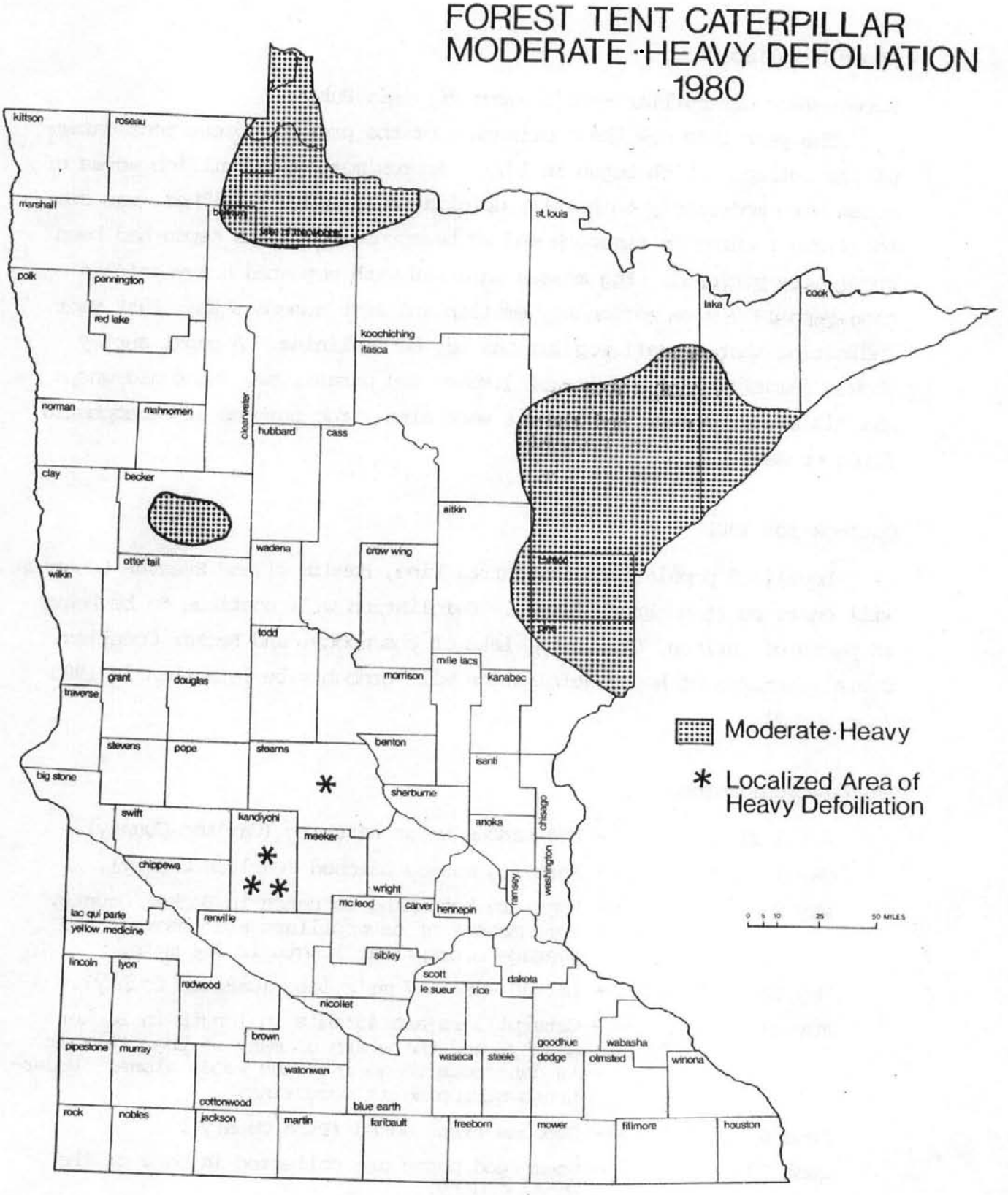
Outlook for 1981

Localized populations in central Pine, Kandihoyi and Stearns Counties will continue at outbreak levels. Defoliation will continue to be heavy in parts of Carlton, St. Louis, Lake of the Woods, and Becker Counties. Overall acreage of heavy defoliation will probably be less than in 1980 (see Map 2).

Phenological Notes

April 21	- Egg masses began hatching (Carlton County).
May 1	- Most egg masses hatched (Carlton County).
May 2	- Eggs are beginning to hatch in Becker County. Some masses of caterpillars are observed and average caterpillar length is 3-4 mm's.
May 12	- Larvae were 6-7 mm's long (Carlton County).
May 27	- Caterpillars are 45 mm's in length in Becker County, and there are so many of them that it is dangerous to go into the woods alone. Underbrush stripping is occurring.
June 6	- Cocoons first noted (Pine County).
June 23	- Unemerged pupae are collected in Lake of the Woods County.

Map 1


FOREST TENT CATERPILLAR
MODERATE-HEAVY DEFOLIATION
1980
kittson
roseau
marshall
pennington
red lake
polk
norman
mahnomen
clay
becker
wilkin
otter tail
clearwater
hubbard
cass
koochiching
itasca
st louis
lake
cook
aitkin
wadena
crow wing
todd
mille lacs
morrison
kanabec
grant
douglas
traverse
stevens
pope
stearns
benton
isanti
big stone
sherburne
swift
kandiyohi
meeker
anoka
chisago
chippewa
wright
washington
ramsey
lac qui parle
renville
mc leod
carver
hennepin
yellow medicine
sibley
lincoln
lyon
redwood
scott
dakota
le sueur
rice
nicollet
brown
goodhue
wabasha
pipestone
murray
waseca
steele
dodge
olmsted
winona
watonwan
cottonwood
blue earth
rock
nobles
jackson
martin
faribault
freeborn
mower
fillmore
houston
Moderate-Heavy
* Localized Area of Heavy Defoiliation
0 5 10 25 50 MILES

June 25 - Many larvae observed "sacked out" looped over twigs, apparently the result of disease (Carlton County).

July 6-8 - Major period of adult emergence in collections for pupal parasitism survey (St. Louis and Carlton Counties).

Other Aspen Defoliators

The aspen blotch miner *Lithocolletis tremuloidiella* Braun increased greatly in 1980. This insect mines out the leaf tissue between the upper and lower epidermal layers, creating large oval blotches in the leaves. Activity was heavy enough to cause aspen along highways to take on a yellowish-brown color by the beginning of August. This was noticeable in southern Beltrami, Itasca, northeastern Cass, Hubbard, Clearwater, Aitkin, Carlton, Lake, Koochiching, and St. Louis Counties.

Eastern tent caterpillar *Malacosoma americanum* (Fabricius) was a minor and local problem on plum, cherry, and juneberry in Carlton and southern St. Louis Counties. The populations were reduced from 1979. A local infestation first detected in 1979 causing light defoliation along Minnesota highway #26 (STR 23&26, 102-4) in Houston County, spread south to the Iowa border. Fifteen hundred acres of mixed hardwoods were involved.

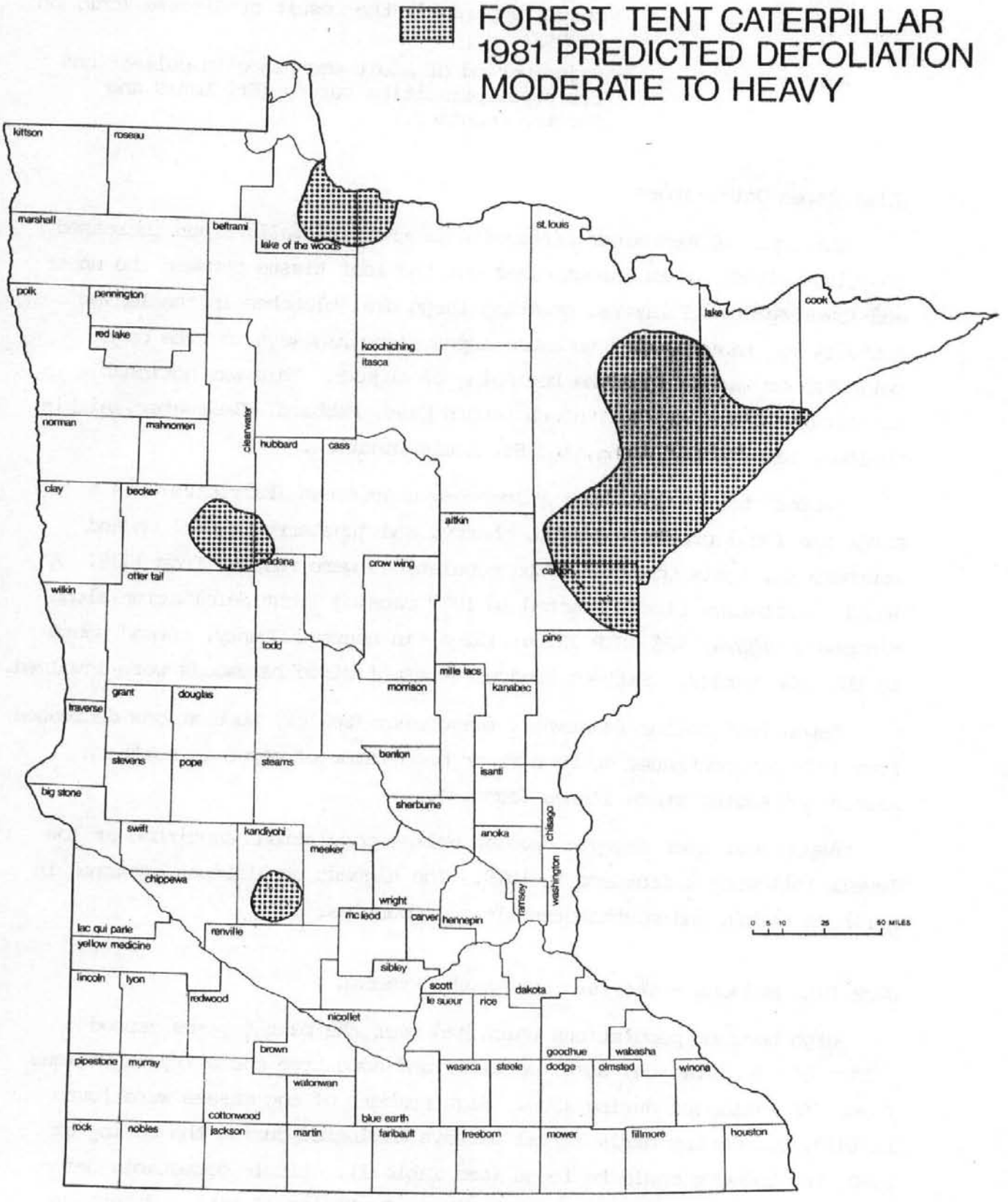
Aspen leaf roller *Anacampsis innocuella* (Zeller) populations decreased from 1979 but continued to be a minor defoliator of aspen in northern Aitkin and southeastern Itasca Counties.

Aspen leaf tier *Enargia decolor* Walker populations continued at low levels following a decrease in 1979. The highest populations occurred in northern Aitkin and southeastern Itasca Counties.

Jack Pine Budworm - *Choristoneura pinus* Freeman

High budworm populations which had over the past 4 years caused noticeable defoliation, some top-kill, and some tree mortality in Regions I and III collapsed during 1980. High numbers of egg masses were found in 1979, but during early larval surveys conducted during the spring of 1980, few budworm could be found (see Table 1). Little detectable defoliation could be found in either Region. In Region II aerial detection did not detect any jack pine defoliation, but ground collections made in

Map 2


FOREST TENT CATERPILLAR
1981 PREDICTED DEFOLIATION
MODERATE TO HEAVY
kittson
roseau
marshall
beltrami
lake of the woods
st louis
polk
pennington
red lake
koochiching
itasca
lake
cook
norman
mahnomen
clearwater
hubbard
cass
clay
becker
aitkin
wadena
crow wing
carlton
otter tail
wilkin
pine
todd
mille lacs
morrison
kanabec
grant
douglas
traverse
benton
isanti
stevens
pope
stearns
big stone
sherburne
swift
kandiyohi
meeker
anoka
chisago
chippewa
wright
washington
ramsey
mc leod
carver
hennepin
lac qui parle
renville
yellow medicine
sibley
lincoln
lyon
scott
dakota
redwood
le sueur
rice
nicollet
brown
goodhue
wabasha
pipestone
murray
watonwan
waseca
steele
dodge
olmsted
winona
cottonwood
blue earth
rock
nobles
jackson
martin
faribault
freeborn
mower
fillmore
houston
0 5 10 25 50 MILES

southern Carlton County did find a low level population.

Budworm collapse may have been influenced by the following factors: widely fluctuating winter temperatures, a build-up of natural predators and parasites, reduced food supply on previously defoliated jack pine, reduced staminate flowering on the defoliated trees, and hot and dry conditions during the spring dispersal.

Egg mass surveys were conducted during August and September of 1980, and this survey reconfirmed the results of the early larval survey; the budworm population had collapsed (see Table 2).

Salvaging of previous budworm damaged jack pine continued in both Regions. In Region I approximately 100 acres of top-killed jack pine on state-owned lands in central Hubbard County were salvaged. On Potlatch-owned lands in Becker County, budworm-killed jack pine continued to be salvaged. Salvage also took place on private lands in central Hubbard County.

In Region III where jack pine losses were substantially higher than in Region I, a damage inventory and salvage program was instituted in Wadena County. Helicopter surveys identified and mapped 7,410 acres of budworm damaged jack pine on the basis of discoloration and needle loss. The damaged stands identified were then prioritized for salvage based on the amount of tree mortality in each stand. Most of the damaged stands were privately owned and amounted to 6,458 acres. DNR foresters assisted many of the owners of these damaged stands in salvaging those areas with the greatest damage. There were 952 acres of state-owned land identified during the helicopter survey, and these stands were ground checked in early August to determine which stands needed immediate salvaging.

During the ground check on state lands, timber cruise information was collected, along with additional information necessary to evaluate current damage and predict future losses. Additional information included identification of active bark beetle centers which will be rechecked during 1981 if these centers are not salvaged during the winter of 1980-81. Dead trees were sampled for red rot to determine merchantability. Increment cores from living trees were used to count the number of rings in the outer inch as an indicator of tree vigor. All this information will be analyzed

in conjunction with the known stand ages and stocking levels of heavily affected stands to determine if certain stand characteristics promote higher levels of budworm damage.

As a result of the special salvage cruise, 694 of the 952 acres of damaged jack pine were scheduled for immediate removal. Nineteen separate timber sales were offered at a Wadena County auction. To prevent additional timber degrade and bark beetle build-up, the sale length was limited to one year without any provisions for extensions. Of the 8,614 cords of jack pine pulp and bolts offered for sale at the auction, 7,737 cords were sold. The remaining volume was sold on an informal sale. Future removals as deemed necessary by stand conditions will be made through informal and fuelwood sales.

Outlook for 1981

Budworm populations should be at low levels throughout the major jack pine areas in Regions I, II, and III. No serious budworm caused defoliation should be evident during 1981.

Phenological Notes

May 15	- Staminate flowers are beginning to shed pollen in Roseau County. Early larval surveys were initiated.
May 22	- Second instar larvae found in a flower cluster in Hubbard County. Needles have not yet emerged out of their sheaths.
May 27	- Jack pine needles have elongated beyond their sheaths in Hubbard County.

TABLE 1

SUMMARY OF THE EARLY LARVAL SURVEY

Part A - Location of Plots with Budworm Larvae Present

County	Description	#Larvae/30 Shoots
Hubbard	16-140-32	3
	31-140-32	1
	13-139-33	1
	35-140-33	1
Becker	22-139-36	7
	14-139-36	2

Lake of the Woods	12-159-35	2
	13-159-34	1
Roseau	12-143-33	2
	34-161-37	1
	32-161-37	2
	25-161-37	1
Wadena	19-138-33	4
	19-138-33	2
	2-138-34	1
	25-138-34	2
Crow Wing	3-136-29	2

Part B - Number of Early Larval Sampling Plots Per County

County	Total Plots	No. Positive
Hubbard	25	4
Becker	3	2
Lake of the Woods	5	2
Roseau	16	4
Wadena	15	4
Cass	2	0
Crow Wing	1	1
TOTALS	67	17

TABLE 2

EGG MASS SURVEY SUMMARY

Part A - Locations of Plots with Egg Masses

County	Description	# of Egg Masses
Beltrami	17-147-34	1
	10-147-34	1
	29-148-35	1
Hubbard	35-145-34	2
	22-145-34	1
	2-143-35	1
	36-144-35	1
Wadena	36-137-34	1
Crow Wing	3-136-29	2

Part B - Number of Egg Mass Plots Per County

County	Total Plots	No. Positive
Beltrami	11	3
Hubbard	33	4
Becker	12	0

Roseau	6	0
Lake of the Woods	4	0
Wadena	8	1
Cass	3	0
Crow Wing	1	1
TOTALS	78	9

Spruce Budworm - *Choristoneura fumiferana* (Clemens)

In Region II, populations and the distribution of this pest increased over last year. Aerial and ground surveys indicated defoliation continued to expand westward into southwestern and west central St. Louis County. Populations were also found in the Cloquet and Cromwell Districts (Carlton County), but defoliation was not noticeable. An aerial survey, in cooperation with the U.S. Forest Service, was flown during the first week of July. All spruce-fir stands 12 acres and larger in size with noticeable defoliation were type mapped and rated for defoliation (see Map 3). The results of the survey were:

Light defoliation	- 36,270 acres
Moderate defoliation	- 46,832 acres
Heavy defoliation	- 19,972 acres
Total	103,074 acres

Direct control of spruce budworm was conducted on the white spruce seed orchard near Cotton (STR 20, 56-16) in St. Louis County. Nineteen acres were sprayed using Sevimol 4 (1 qt. in 100 gals. water). Sixty gallons of spray were applied on June 3, using a hydraulic sprayer mounted on a tractor. Although larval mortality was low, trees did not sustain heavy defoliation.

Outlook for 1981

Based upon the 1980 egg mass survey, indicated populations are expected to increase in southern St. Louis and Lake Counties. Budworm will also be more evident in Cook and Carlton Counties. The white spruce seed orchard near Cotton (St. Louis County) will have to be watched closely.

Map 3

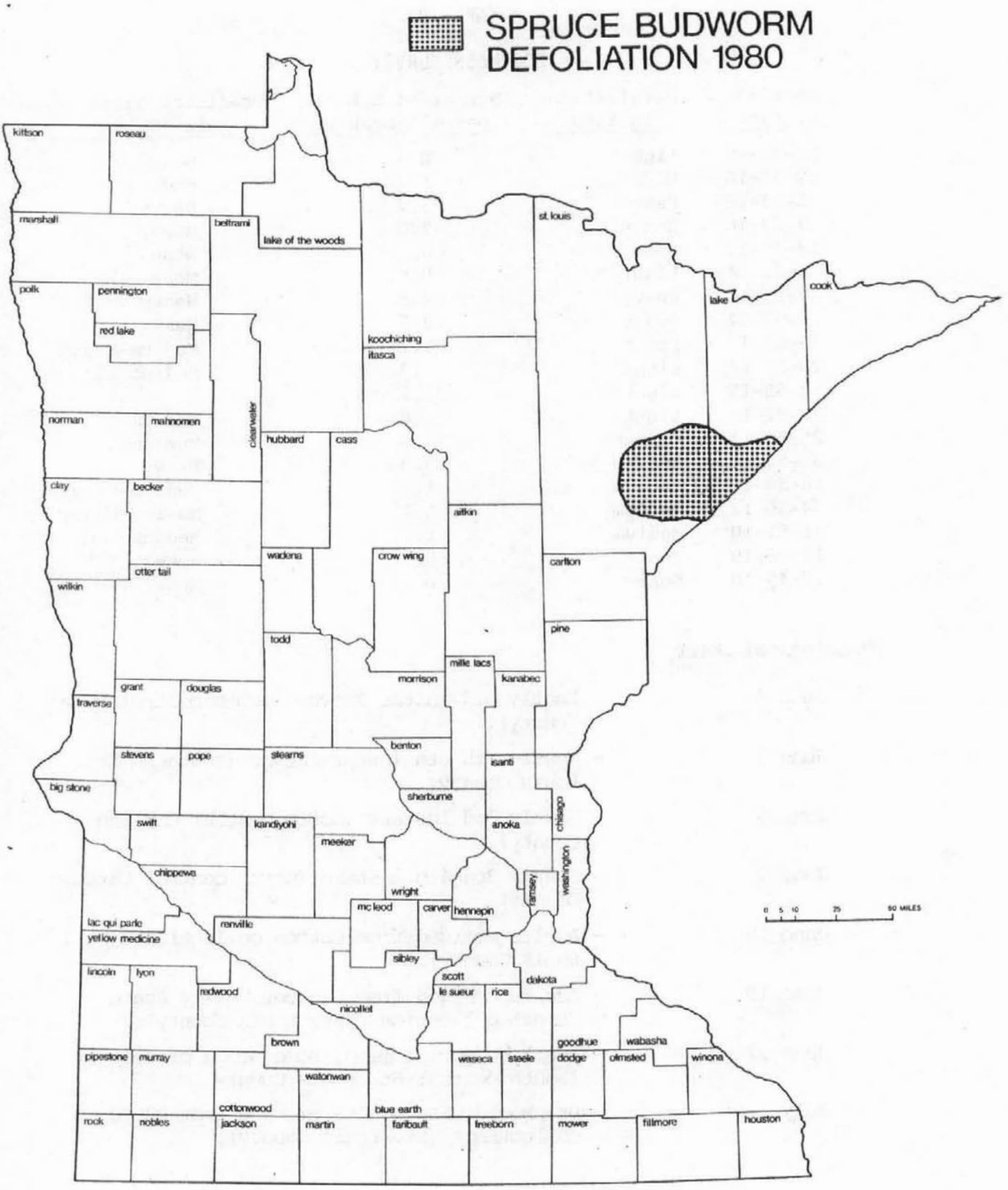

SPRUCE BUDWORM
DEFOLIATION 1980
kittson
roseau
marshall
beltrami
lake of the woods
st louis
lake
cook
polk
pennington
red lake
koochiching
itasca
norman
mahnomen
clearwater
hubbard
cass
clay
becker
aitkin
wadena
crow wing
carlton
otter tail
wilkin
pine
todd
mille lacs
morrison
kanabec
grant
douglas
traverse
benton
stevens
pope
stearns
isanti
big stone
sherburne
chisago
swift
kandiyohi
anoka
meeker
chippewa
wright
washington
ramsey
mc leod
carver
hennepin
lac qui parle
yellow medicine
renville
sibley
lincoln
lyon
scott
dakota
redwood
le sueur
rice
nicollet
goodhue
wabasha
brown
pipestone
murray
waseca
steele
dodge
olmsted
winona
watonwan
cottonwood
blue earth
rock
nobles
jackson
martin
faribault
freeborn
mower
fillmore
houston
0 5 10 25 50 MILES

TABLE 3

EGG MASS SURVEY

Location of Plot	Defoliation in 1980	Number of E.M.'s per 15" branch	Predicted Defoliation in 1981
12-51-18	Light	0	None
29-56-16	Moderate	1.2	Moderate
2-53-16	Heavy	3.7	Heavy
7-53-16	Heavy	2.0	Heavy
18-49-18	None	0	None
5-51-16	Light	0	None
27-53-14	Heavy	2.6	Heavy
3-53-14	Heavy	2.2	Heavy
15-55-13	Light	1.7	Medium-Heavy
23-55-14	Light	.7	Medium
2-55-15	Light	2.1	Heavy
32-57-13	Light	.8	Medium
25-56-17	Medium	.9	Medium
33-53-13	Medium	3.0	Heavy
18-54-12	Medium	1.7	Medium-Heavy
34-56-12	Medium	1.7	Medium-Heavy
31-55-10	Medium	1.2	Medium
14-49-19	None	0	None
7-49-18	None	0	None

Phenological Notes

June 3 - Mostly 3rd instar larvae (south central Lake County).

June 3 - Mostly 5th-6th instar larvae (southern St. Louis County).

June 5 - Mostly 3rd instars (north central Carlton County).

June 9 - Mostly 3rd-4th instars (north central Carlton County).

June 18 - Adults emerged from Cotton collections (St. Louis County).

June 19 - Adults emerged from Cloquet Valley State Forest collections (St. Louis County).

June 27 - Adult budworm common, some pupae present (south central St. Louis County).

July 1 - Brachonid wasp adults emerged from pupae in collections (St. Louis County).

Oak Defoliators

Two oak defoliators were reported in Region VI. Defoliation caused by the oak leaf skeletonizer *Bucculatrix ainsliella* Murt. was reported in late July on approximately 85 acres of northern pin oak *Quercus ellipsoidalis* on a river bluff above Marine on St. Croix (STR 1, 31-20) in Washington County. Solitary oak leaf miner *Lithocolletis hamadryadella* (Chambers) affected 100 bur oak trees in the Carlos Avery District (STR 8, 33-21) of Anoka County.

Hardwood defoliators such as the variable oak leaf caterpillar *Heterocampa manteao* (Doubleday), the *Anisota* and *Symmerista* spp. oak worms and the walkingstick *Diapheromera femorata* (Say) were at low levels during 1980 in Region III. Light defoliation by walkingsticks in mixed hardwoods was reported in Houston County (STR 26, 102-4) in Region V.

Outlook for 1981

Records indicate that the walkingstick infestation that occurs west of Gull Lake in the Pillager District of Cass County will cycle up in 1981.

Introduced Pine Sawfly *Diprion similis* (Hartig)

Low populations existed in most of the state. Twenty-seven plantations were surveyed in Region I. In three of these plantations, sawflies were found at very low levels, but no damage was apparent. In Region II, 3rd instar larvae were observed (Cloquet in Carlton County) on June 27, and 5th instar larvae were collected on July 15.

In Region III, populations were at low levels in the historic outbreak areas along the St. Croix River in Chisago County of the Cambridge District. Field checks around the village of Sunrise (STR 4, 35-20) and in the Grandy Pines area north of Cambridge (STR 33&34, 37-23 and STR 4, 36-23) indicated light defoliation. Populations appear to be building in these areas. Defoliation to yard and windbreak pines were reported by homeowners in Crow Wing County. Moderate to severe defoliation with some top-kill and tree mortality occurred in stands of mature white pine along the Mississippi River drainage in the Little Falls District of Morrison County. White pines in the Little Falls city park

(STR 18, 129-29) and Camp Ripley camping area (STR 9, 130-29) sustained moderate defoliation. Severe defoliation and crown thinning occurred in the Morrison County park (STR 14, 41-32). Twenty-four acres of the park were sprayed twice with Sevimol at 2 quarts formulation per acre. The first spray operation utilized ground equipment in conjunction with a fixed wing aerial application in late July. Ground equipment was used a second time in September. Larval mortality was high but noticeable defoliation continued until the second generation pupated with the onset of heavy rains and cool weather in early September.

A forty-acre private stand (STR 10, 42-32) in Morrison County sustained severe defoliation for the third consecutive year. Mortality approached 60 percent in the center of the stand and longhorn beetle galleries were common in the dead trees. Needles were sparse to nonexistent on the remaining trees. Salvage cuts by the owner could not utilize all the dead material. Chemical control was deemed too expensive. Sawfly pupae were abundant on the ground and understory vegetation. Many were parasitized (at 50 percent). Unless the combination of biological and environmental factors severely reduces emergence in the spring of 1981, the weakened trees will not survive additional defoliation or beetle attack.

An aerial survey was conducted on October 21 to photograph the white pine type along the Mississippi drainage from Brainerd to Little Falls. These photographs will be used to pinpoint areas for ground checks in June of 1981 to determine population levels, infestation spread, and the need for comprehensive control.

Outlook for 1981

This sawfly will continue to exist in low numbers in parts of Regions I and II. In Region III, the potential exists for top-kill and tree decline in the Little Falls District of Morrison County. Increased defoliation is expected in white pine stands throughout Region III.

Bark Beetles - Ips & *Dendroctonus* spp.

The dry spring and improper removal of cut products contributed to two bark beetle outbreaks in Region II. In the Hibbing District (STR 16, 55-21) in St. Louis County and (STR 24, 55-22) in Carlton County, red pine plantations were thinned and pruned during the fall and winter of 1979. The slash was left in piles. Pockets of beetle killed trees were observed in the plantations in July. All infested trees were removed and trap trees were cut and left to attract emerging beetles. The trap trees were removed and burned after two weeks. Additional trap trees were then placed in the stand and removed two weeks later. Sanitation, the use of trap trees and the summer rains, prevented additional tree mortality. In the Hill City District of Aitkin County, cut and piled jack pine was left on the landing through the summer. Bark beetles built up in the cut products and killed 12 to 15 year old jack and red pine within 100 feet of the landings.

In the Itasca District of Region I, (STR 19, 144-37) in Clearwater County, trees in a timber stand of red pine had been killed by bark beetles in 1979. The pocket had been salvaged and the slash piled for burning. However, the dangerous spring fire season of 1980 would not allow burning. On June 13, the slash piles were found to contain high populations of first generation beetles. The piles were burned immediately and no activity was detected during the remainder of the year in the residual stand.

In Region III, harvest wounding and improper slash removal during the spring drought resulted in bark beetle build-up in a small private plantation in the Cambridge District (STR 3, 26-23) in Isanti County. Outbreaks were related to fire damage in Villard Township of Todd County in the Pillager District (T133N-R33W) and in Shell River (T138N-R34W) and Huntersville (T138N-R33W) Townships of Wadena County in the Nimrod District. Beetle activity was also high throughout the unsalvaged budworm-killed jack pine in the Nimrod Distirct. Salvage operations are underway in both areas.

Bark beetle activity became much more obvious in August in both Regions I and III. Numerous bark beetle epicenters could be detected

In the jack pine types, particularly in central Hubbard and Wadena Counties where the budworm had most recently been active. Single trees and groups of trees attacked earlier in the summer showed up as fading in color from yellow to red.

Dendroctonus simplex Le Conte

Two areas of tamarack in Maplewood State Park of Ottertail County were killed by the eastern larch beetle. Bark beetles had been active for more than one year. When the trees were inspected in late summer, no foliage was present and the bark was beginning to fall off some trees.

The beetle was common in tamarack stands in the Brainerd Area. The infested stands were 5 to 20 acres in size and bordered by marshes or slow moving water. Fluctuating water tables, spring drought and pockets of blow down had contributed to population build-ups around the perimeter of stands or in pockets. Sanitation and salvage cuts were marked in infected stands in the Brainerd (STR 36, 44-31) and Pequot Districts (STR 32, 135-27) of Crow Wing County to remove dead trees and potential brood material. The sale proposals were based on a local demand for poles and firewood.

Heavy beetle-induced mortality was reported in two stands in the Pillager District in Todd County. Ten acres (STR 9, 128-34) had sustained beetle activity for three years. The trees were approximately 45 years old and ranged in size from 4 to 10 inches in diameter. All diameter classes were attacked and mortality was approaching 90 percent. No cuts were implemented due to poor markets. The second infestation occurred in a high quality stand (SI 60) of 26 acres (STR 23, 132-32). Several harvest methods were attempted to regenerate the stand and control the beetles. In February 1980, fifteen acres were clear-cut and the brush crushed. Ten uninfested acres were not cut and one acre was thinned, leaving seed trees. Regeneration was adequate in both cuts, but the seed tree area suffered 80 percent beetle-induced mortality and the edges of the ten-acre untreated areas were also infested. Active brood trees were still present in the fall.

Outlook for 1981

Beetle activity will continue in stressed, improperly thinned, and wind and fire damaged stands.

Saratoga Spittlebug - *Aphrophora saratogensis* (Fitch)

In Regions I, II, and III, very little current year damage from the saratoga spittlebug was found. However, in all three Regions, damage sustained in 1979 and prior years was apparent and fairly common. Spittlebug populations were high, particularly in 1979, and heavy feeding occurred on both red and jack pines. The heavily injured branches desiccated and turned brown during the winter, and were noticed during the spring and summer of 1980. In plantations with flagged trees, green branches showed evidences of feeding scars. Population collapse may have resulted from a high mortality to the nymphs during the hot, dry spring of 1980.

Pockets of stunted, deformed, flagged, and dead trees were found in plantations throughout all three Regions. In Region I on state and county lands, there were three major locations which experienced heavy damage, as follows:

County	Description (STR)	Acres Showing Some Degree of Damage
Beltrami	19, 152-30	28 acres
Beltrami	9&16, 147-34	50+ acres
Mahnomen	35, 146-39 and 1,2&12, 145-39	200-300 acres

In Region II, the more heavily damaged plantations were as follows:

County	Description (STR)	Areas of Heavy Damage
St. Louis	9&10, 60-21	10 acres
St. Louis	12, 59-21	5 acres
Itasca	13, 60-24	1 acre
Aitkin	1&2, 52-24	4 acres
Aitkin	22, 52-24	½ acre
Aitkin	3, 51-27	4 acres

In Region III, ground checks were made in the Menahga Demonstration Woodlot (STR 19, 138-34), and in a plantation on the Huntersville State Forest (STR 10, 138-34), where branch mortality and stem deformation were widespread. A 5-acre Christmas tree plantation in the Washburn Lake District (STR 19, 139-26) showed scattered flagging on sheared trees around frost pockets.

In addition to state and county plantations, Bureau of Indian Affairs and USFS plantations were also damaged.

A scar count survey is being conducted during the winter of 1980-81. This survey is limited to red and jack pine plantations 5 to 15 years old. Plantations with a ground cover of sweet fern, willows, or raspberries are checked first, since these species serve as the alternate host for the spittlebug. During this survey, a ten-centimeter section of the two-year old branch wood is inspected. On this section, the bark is removed to reveal any brown flecks on the surface of the wood indicating past feeding wounds. These brown flecks are counted, and an idea of past populations is gained. Plantations with signs of past high populations will be monitored closely during the spring of 1981.

Pine Spittlebug - *Aphrophora parrallela* (Say)

In Regions I and II, this pest of jack pine was much reduced in comparison to previous years' populations. In Region III, this pest was detected at low levels on jack pine in the Moose Lake District, Pine County, and in a Scots pine Christmas tree plantation in the Zimmerman District, Sherburne County.

In Region I, nymphal surveys were conducted during the jack pine budworm early larval survey. The percentage of branches with nymphs on each sample plot ranged between 0 and 40 percent. The number of plots and the percentage of plots on which nymphs were found are summarized as follows:

County	Number of Plots	% Positive
Becker	8	62.5%
Hubbard	24	33.0%
Lake of the Woods	5	0%
Roseau	16	0%

The highest nymphal count was made in Hubbard County (STR 13, 139-33). During general plantation surveys some spittlebug nymphs were found, but spittle masses were generally difficult to find in the plantations.

Outlook for 1981

Unknown.

Larch Sawfly - *Pristiphora erichsonii* (Hartig)

Populations were low generally, but reported to be increasing in some areas.

There was localized defoliation in the Virginia and Cotton Districts in St. Louis County, and in the McGrath District in Aitkin County. Populations were building in the Nickerson and Eaglehead Districts in Pine County, and in the Backus and Pequot Lakes Districts of Cass County, with isolated areas showing light to moderate defoliation.

Outlook for 1981

Expanded surveys will be conducted in July of 1981.

Yellowheaded Spruce Sawfly - *Pikonema alaskensis* (Rohwer)

In Region I, sawfly activity was much reduced over 1979 levels in white spruce plantations. In Regions II, III, and VI, sawfly populations were at high levels again in some white spruce, especially small, open-grown, ornamental, and roadside plantings.

Discussions were held with the Minnesota Department of Transportation forester regarding the problem on roadside spruce plantings throughout the state. Control suggestions included the planting of alternate species, mixed plantings with faster growing shrubs to provide shading, and direct control in high value plantings with progressive damage.

The 5-acre white spruce seed tree orchard west of General Andrews State Nursery (STR 16, 45-21) in Pine County, was sprayed with malathion because of high sawfly populations. This site will need to be inspected in 1981.

Sawflies were active in an 85-acre white spruce plantation (STR 16, 139-27) in the Washburn Lake District in Cass County. Open-grown spruce exhibited heavy defoliation and reduced growth. Spruce partially shaded or overtopped by aspen exhibited light or no defoliation and adequate terminal growth (12"+). Release projects on this site will be delayed another three to four years until the trees reach 12+ feet.

Plantations should be checked early in June so control operations can be planned. Spraying should be done when the majority of the larvae are in the third instar, mid to late June, depending on the weather.

Gypsy Moth *Lymantria dispar* (Linnaeus)

Gypsy moth pheromone traps were placed in the following state parks and state forest campgrounds by DNR personnel. No moths were trapped.

State Parks

Banning	Moose Lake	John A. Latsch
Lindbergh	Itasca	Savanna Portage
Interstate	Beaver Creek Valley	Frontenac
Lake Maria	Bearhead Lake	Whitewater
Wild River	Forestville	Carley
Crow Wing	William O'Brien	Helmer Myre
Father Hennepin	Jay Cook	Nerstrand Woods
Mille Lacs Kathio	O.L. Kipp	Flandrau
St. Croix	Gooseberry Falls	Camden

State Forest Campgrounds

Little Birch Lake	Sand Dunes
Gafvert	Willow River

Other Areas

Hoo Doo Point	Carlos Avery Wildlife
Municipal Campground, Tower	Management Area

Twenty-six male moths were collected in pheronome traps placed by the State Department of Agriculture in the six county metropolitan areas of Region VI. Four moths were caught in a trap in Phalen Park in St. Paul, and three in a trap in Minnetonka.

Outlook for 1981

The potential for population establishment exists. Ground checks of defoliation reports and intensified pheronome trapping will be used to detect developing outbreaks.

Walnut Tip Moth - *Acrobasis* spp.

An early spring survey detected an *Acrobasis* spp. tip moth endemic to planted black walnut on state land throughout the southeast. A low incidence infestation was being monitored until a late spring frost on

May 7, 1980, resulted in a significant terminal shoot loss throughout the area and caused a masking of the evidence of tip moth injury.

One state land planting in Winona County (STR 2, 108-9) sustained no frost injury but lost 35 percent of the new terminal shoots by June 1, due to the tip moth.

Walnut Caterpillar - *Datana integerrima* (G.&R.)

Moderate to heavy defoliation of mature walnut scattered throughout the southeast area was detected in two locations, Olmsted County (STR 35, 107-15) and Winona County (STR 24, 107-10).

DISEASES

Dwarf Mistletoe of Black Spruce - *Arceuthobium pusillum* Peck

The major problem of black spruce is dwarf mistletoe. Currently, the chief method of controlling this disease is the use of a 5-foot cutting rule on all black spruce timber sales. This rule calls for the killing during the harvest of all live black spruce stems 5 feet and taller.

Two areas in Region II were identified in which timber sales had taken place before the 5-foot cutting rule was initiated. In these two areas, special efforts were made to reclaim the old sale areas by treating the remaining infected black spruce. These areas are as follows:

1. Rockcut District: A 90-acre timber sale had been sold by auction, and many infected trees were left after the harvest. A state-owned skidder and a private contractor's dozer were used to knock down the standing trees and to construct a fire break around the site. This operation occurred during March of 1980. The site will be burned and then aerially seeded to black spruce.
2. Big Falls District: A 150-acre auction sale which was finished in the spring of 1980, left many infected black spruce standing. About 25 additional acres were cut 10 to 20 years ago, and there is so much mistletoe infected black spruce on this site that a merchantable stand will not be produced. For the winter of 1981, the entire 175 acres will be sheared with a K/G blade.

In order to evaluate the effectiveness of the 5-foot cutting rule, a study was initiated in 1977 and has continued each year since then. The study consists of establishing permanent plots in mistletoe-infected pockets before harvesting takes place. Data are collected to determine the amount of mistletoe infection and the number of live black spruce stems on the site before and after the harvest.

In 1980, five plots in both Region I and II were reread after being harvested. A summary of the data collected is as follows:

Descrip.	Tree Size	(Before Cutting) Inf.	Non-Inf.	Ave. Ht.	(After Cutting) Inf.	Non-Inf.	Ave. Ht.
6-159-28	Merchantable	0	0	--	0	0	--
	Less than 5' tall	14	20	3.35'	1	20	2.69'
	More than 5' tall	--	--	--	2	5	7.21'
1-152-27	Merchantable	3	0	--	0	0	--
	Less than 5' tall	2	65	2.69'	1	93	2.51'
	More than 5' tall	--	--	--	1	3	6.00'
5-153-25	Merchantable	0	0	--	0	0	--
	Less than 5' tall	0	35	2.47'	0	80	1.93'
	More than 5' tall	0	0	--	0	2	5.50'
5-153-25	Merchantable	0	1	8.50'	0	0	--
	Less than 5' tall	6	52	3.41'	1	107	2.49'
	More than 5' tall	0	0	--	0	3	6.50'
3-70-23	Merchantable	0	3	6.50'	0	0	--
	Less than 5' tall	1	16	2.79'	0	2	4.00'
	More than 5' tall	0	0	--	0	0	--

In addition to these plots that were reread in 1980, four new plots were established. Since 1977 there have been 12 plots established but have never been reread due to non-cutting, deep snow, or poor access. There are also five plots that were established and reread prior to 1980. In total, 25 plots have been established since the study began in 1977.

It is still too early to draw any conclusions. It does seem, however, from the limited data collected that infected trees are being left after the harvest is completed. The question remains whether or not these small, infected trees in the two to three-foot height class will live long enough to reinfect the future stand. To help to answer this question, the remaining infected trees on the plots will be tagged and periodically rechecked to monitor their survival and to monitor infections in the new stand.

Diplodia Tip Blight - *Diplodia pinea* (Desm.) Kickx

In Region I, 27 red pine plantations were inspected in a survey for insect and disease damage. Diplodia was found infecting trees in 43 percent of the plantations. Infection levels were low with only two to ten percent of the trees infected, with damage confined to less

than ten percent of the branch tips.

In Region II, several areas were found where heavy Diplodia infections in 1978 and 1979 continued to stunt, deform and kill trees in 1980. One of the heaviest infected areas was in STR 2&3, 60-23, Itasca County, were approximately 60 acres of red pine plantations were affected. Trees infected were from 4 to 15 feet in height. Ten acres of a 60-acre red pine plantation in STR 9&10, 60-21, Itasca County, planted in 1972 also suffered heavy damage from Diplodia. Approximately 50 percent of the trees on this ten acres were infected. The major infection appeared to have occurred in 1978. No overstory pines occur on this site but it was surrounded by more mature jack pine stands.

Outlook for 1981

Diplodia outbreaks have been related to stress situations. The fungus is a weak pathogen and generally does not kill trees unless they are under stress. A continuation of dry weather through spring and summer could result in increased top-kill and tree mortality similar to 1976 and 1977.

Shoestring Root Rot - *Armellariella mellea* (Vahl. ex Fr.) Karst

This root rot was primarily observed on oak trees in Regions I, III and IV, and has been identified as one of the factors responsible for red oak dieback. The dry conditions experienced during 1980 led to an increase in the numbers of red oaks dying and the incidence of shoestring root rot.

During a red pine plantation survey conducted in Region I, shoestring root rot was observed occurring in 14.3 percent of the 21 plantations surveyed. Infection rate in these plantations ranged between one and seven percent. The average ages of these plantations ranged between five and ten years.

These observations were made in pine plantations established on former jack pine sites. The mortality rate in these plantations would be expected to be lower than in similar pine plantations

established on former hardwood sites. Since the more dense hardwood stumps take longer to break down than the jack pine stumps, *A. mellea* can survive longer on former hardwood sites. This longer survival period exposes the pine to infections for a longer period of time, thereby potentially increasing the mortality rate. This potential problem should be recognized when establishing conifers on hardwood sites.

Outlook for 1981

This disease should be more evident in 1981 because of the dry conditions putting stress on both the red oaks and the pine.

Scleroderris Canker and Dieback - *Gremmeniella abietina* (Gremmen)

The North American strain of Scleroderris canker was not found in any new locations in 1980. However, it remains active in the dozen or so plantations in which it has been found. Most of these plantations occur along the north shore.

The European strain of Scleroderris canker has not been found west of New York.

Outlook for 1981

The North American strain will continue to be a minor problem in Minnesota. No accurate prediction of the spread of the European strain of Scleroderris out of northeastern United States and southeastern Canada can be made.

Red Pine Shoot Blight - *Sirococcus strobilinus* Preuss

In Region III, *Sirococcus strobilinus* caused the death of new shoots and buds of red pine seedlings in a plantation within the Eaglehead District of Pine County (STR 26, 42-17). The damage occurred in circular patterns beneath infected residual red pines (70+ years) left on small hills within and on the edge of the plantation.

In Region II (STR 2&3, 60-23) in Link Lake District, Itasca County, *Sirococcus* was found to be stunting, deforming and killing

red pine. Most of the infection occurred in the past several years, affecting a total of 20 acres. Thirty-five to forty percent of the trees were heavily damaged. Some tree mortality has occurred, especially among the smaller trees four to ten feet tall, directly beneath overstory red pine trees. Very little infection occurred in 1980.

The problem in both Regions is that the red pine were regenerated under infected overstory red pine. The microclimate beneath the overstory red pines favors *Sirococcus*. Also the understory trees are subjected to large numbers of fungal spores from the infected trees over them. Removal of the overstory trees at this time may reduce future damage in these stands.

Outlook for 1981

Red pine shoot blight will continue to be a problem where red pine are regenerated on sites with standing infected overstory red pine whenever environmental conditions are favorable for the disease.

Pine Wilt Disease - *Bursapheleneus lignicolus* Mamiya and Kiyohora

The pine wilt disease caused by this nematode has been confirmed as present in Minnesota by USFS personnel. The confirmed sample was taken from an abandoned Austrian and Scots pine Christmas tree plantation in Sherburne County (STR 5, 34-26). The nematode has now been isolated from 17 species of pine and eastern larch. It is now believed to have been present in this country for at least 50 years or possibly to be a native species.

Outlook for 1981

Since this disease has now been confirmed in Minnesota, and has been shown to have effective carriers, the long-horned beetles, it will probably continue to develop as a problem primarily on introduced pines and ornamentals.

Oak Mortality

In Region I, the two-lined chestnut borer *Agrilus bilineatus* (Weber) caused extensive mortality to red oaks in Maplewood State Park

in Ottertail County. The timber demonstration area in the park was heavily infested and the resultant mortality caused the area to be removed from demonstration status.

In Region II, the beetle caused red oak mortality near the town of McGregor in Aitkin County. Several trees had died the year before and were cut up for firewood and piled under the other oaks in the yard. This maintained a high population of the borer in the yard and enabled it to kill additional trees.

Oak mortality continues to be widespread in both Region III (Central) and Region VI (Metro). The majority of calls in the Central Region were drought or construction damage related with subsequent invasion by two-lined chestnut borer and armillaria root rot *Armillariella mellea* Karst. The primary mortality agents in Region VI were oak wilt, *Ceratocystis fagacearum* Hunt, and construction damage. In the Carlos Avery Wildlife Management Area, existing oak wilt pockets are being removed through clear-cuts. Treatments of hazard trees with frilling and silvicides will begin in 1981.

An oak wilt field day was held in conjunction with the University and Agriculture Extension Service (Anoka County) on July 19 at the Bunker Hills Activities Center, east of Anoka in Anoka County. A slide presentation and field trip for homeowners were conducted to compare oak wilt development with construction damage, armillaria and insect attack. Control demonstrations included the use of the vibratory plow and mechanical frilling with silvicide application.

In Region V, the incidence of oak wilt disease was down from 1979, with only a few active pockets reported in Houston (STR 2, 101-4) and Wabasha (STR 7, 110-10) Counties. Other field examinations of oak mortality indicated pockets of scattered dead trees, the result of past drought with evidence of armillaria root rot, and two-lined chestnut borer in Fillmore (STR 30, 104-11) and Winona (STR 2, 107-10) Counties.

Outlook for 1981

Oak decline and mortality will continue in Minnesota in off-site and drought stressed stands.

Aspen Bronzing

Aspen bronzing was first noted in Minnesota during 1980. It was observed occurring on both bigtooth aspen and trembling aspen, although it was more common on bigtooth aspen. The numbers of trees affected at each location ranged from one to about 20. No mortality was observed.

There are five locations identified as aspen bronzing. They are as follows:

1. SE NE, Section 35; and NW NW, Section 36 of T. 147 N, R. 33 W, Beltrami County.
2. SE SE, Section 19 of T. 147 N, R. 32 W, Beltrami County.
3. NE NE, Section 4, of T. 142 N, R. 34 W; and the SE SE, Section 33 of T. 143 N, R. 34 W, Hubbard County.
4. SE SE, Section 29 of T. 144 N, R. 33 W, Hubbard County.
5. Section 6 of T. 142 N, R. 36 W, along Highway 113, Becker County.

Symptoms observed include the following:

1. Leaf color change: The leaves turned a purple or bronze color at first; then, a brown or reddish-brown color became evident. Color change was observed in August.
2. Petioles: The petioles remained green as the leaves turn color. Green petioles were still observed up to leaf fall.
3. Position of color change: On bigtooth aspen, the color change was found on the older leaves of individual branches, and color change seemed to start in the lower portions of the crown. On trembling aspen, color change was more evenly distributed throughout the crown.
4. Cambium: The cambium was green on all the branches exhibiting color change.
5. Age of trees: All ages of trees were affected.

Outlook for 1981

Additional areas of aspen bronzing will likely be found in 1981. It is unknown at this time how important this new disease will be.

Fusarium Canker of Black Walnut

For the second year, two species of *Fusarium* spp. fungi have been isolated from perennial cankers on plantation black walnut found in Fillmore County. Isolations were made at the University of Wisconsin. Field examinations have so far detected cankered trees in Goodhue, Wabasha, Winona, and Fillmore Counties. Two plantings, one each in Goodhue (STR 13, 112-15) and Fillmore (STR 14, 103-9) Counties, contain a high percentage of cankered trees greater than 50 percent. Most cankers range in age from two to five or six years old. Most of the infection sites appear to be either lateral pruning scars or dead branch stubs.

The growth of these cankers has been highly variable from one year to the next. Most of the current visible injury occurred three years ago. For the last two years only minor growth of cankers has occurred, if at all. Many of these trees are now beginning to callus over these cankers. Permanent plots have been established to follow the future development of these trees.

The life cycle of these fungi and the conditions favoring infection remain unknown. This fusarium canker has been reported in the states of North Carolina, Indiana, Tennessee, Missouri, Iowa, and Minnesota. As a general guideline, walnut should not be laterally or correctively pruned after the first week of April or before the first of November.

Instances of mortality caused by this canker disease have not been detected. However, value losses due to internal decay can be expected on individual trees that recover and become merchantable.

Walnut Dieback

Newly detected this year was a minor dieback disease found on black walnut in two locations in Region V. In a natural pole-size stand in Houston County (STR 8, 102-6) the disease was detected on a two-acre tract. In a ten-year-old six-acre state planting in Fillmore County (STR 14, 103-9), ten to fifteen trees have been infected over the past two years.

Samples cultured at the University of Wisconsin yielded *Phyllosticta* sp., *Xanthomonas* sp. from new shoots, and *Phomopsis* sp. from small cankers on the one-year-old wood. Similar findings have been made in Iowa and Wisconsin.

Walnut Anthracnose - *Gnomonia leptostyla*

Detected at minor levels throughout the southeast. Caused moderate defoliation by August 1 in one state planting in Goodhue County (STR 13, 112-14).

Frost Injury to Black Walnut

On the morning of May 7, 1980, a reradiation frost occurred throughout the southeast. The forestry station at Lewiston reported a temperature of 27 degrees F.

Surveys made that day and the following week detected frost injury on planted black walnut in all southeast counties. The only plantings escaping injury were those at higher elevations.

Late spring surveys yielded a 38 percent loss of new terminal shoots in one planting in Goodhue County (STR 13, 112-14) and a 42 percent loss of new shoots on a planting in Winona County (STR 27, 105-9).

Birch Decline

The decline of paper birch continued in Minnesota in 1980. Many factors alone and in combination including drought, poor site conditions, insect defoliation, and the bronze birch borer *Agrilus anxius* Gory accounted for much of the mortality.

In Region II, new areas of dieback were reported in Aitkin County with the bronze birch borer being detected. In Region III, early leaf drop caused by the feeding of the skeletonizer, *Bucculatrix canadensisella* Chambers, was observed in the Brainerd and Pequot Lakes Districts and around the Badoura State Forest Nursery. Throughout the Regions, scattered pockets of decline were reported.

Maple Decline

The decline of hard maple in urban areas of Region V continued in 1980. Trees in various stages of decline in 1979 continued to weaken in 1980.

The city of Rochester reported a similar number of hard maple removed in 1980 as were taken down in 1979. Leaf scorch on declining hard maple was common in July, the result of dry soil conditions early in the growing season.

Dutch Elm Disease - *Ceratocystis ulmi* (Buism)

Dutch Elm Disease continues to kill trees in both urban and forested locations throughout Minnesota. In 1980, the incidence of the disease increased throughout the state, apparently due to the mild winter and successful overwintering of the adult beetles.

In Region I the incidence of the disease extended into the northern part of the Region.

In Region III removal projects were severely limited due to time delays and loss of some removal funds. Hot shot crews removed dead elms and hazard hardwoods in Interstate, Lake Maria and Father Hennepin State Parks. The Department of Transportation conducted elm marking and removal projects along the Mille Lacs Lake right-of-way in the Garrison Area.

In the Metro Region, due to the reduced funding, the amount of elms cut in 1980 was not as high as other years. The majority of elms have been removed from the state parks, trails, waysides and public accesses. With the extensive cutting of past years, the trees are now in the more inaccessible locations.

In 1980 a commercial chipper was contracted at a public access. The sale of the chips helped defray the cost of the chipper. Merchantable logs in the 504 trees cut in 1980 were sawed for in-house use. Most of the remaining debris was used for fuelwood sales.

The total cost for 1980 was $19,618 with an average cost of $38.92 per tree. This increase over last year's figure of $20.58 per tree

reflects labor expenditures for spring tree hauling, fire suppression and oak wilt control in William O'Brien State Park and the Carlos Avery Wildlife Management Area.

In Regions IV and V, removal projects reduced significantly due to a cutback in funds and to the decreased number of elm remaining on state land in these areas.

Removal projects were conducted in the following state parks:

State Park	No. Trees Removed	Cost
Beaver Creek Valley	10	$ 390
Camden	12	$ 494
Flandrau	40+6 felled only	$1,475
O.L. Kipp	25 felled only	$ 235
Rice Lake	14	$ 239
Sakatah Lake	22+6 felled only	$ 474
Whitewater	40	$ 824
Total	175	$4,131

Average Cost of Tree = $23.60

Pine Needle Rust - *Coleosporium asterum* (Diet.) Syd.

Red pine needle rust was common throughout central and southeastern Minnesota in the spring of 1980. Inspections made in Region III in Mora (STR 21, 40-24), Nickerson (STR 16, 45-17) and Eaglehead (STR 26, 42-17) Districts indicated up to 80 percent of the red pine seedlings were infected where the alternate hosts, aster and goldenrod were abundant.

In Region V, field surveys made in Olmsted and Houston Counties detected similar infection rates on young red pine.

Little injury occurs as a result of pine needle rust infection. Reinspections made in Mora and Nickerson plantations in late October indicated no mortality and adequate growth of previously infected seedlings.

MISCELLANEOUS PROBLEMS

Nursery Problems

The major effort in pest control in the nurseries in 1980 centered on pine tussock moth chemical control in the wind rows and surrounding pine stands of the General Andrews State Forest. Additional insect and disease identifications and control information request received from the General Andrews (STR 26, 45-20) and Badoura (STR 16, 139-32) State Forest Nurseries were as follows:

General Andrews Nursery

Host	Time and Location	Symptoms	Agent	Control Action
Black Walnut	Spring Storage	White flocculence on roots	Storage molds *Tricoderma spp.* *Penicillium spp.*	None
Black Walnut	Spring Storage	Cankered & soft tap & feeder roots	*Phytophthora spp.* Root rot	Captan Dip
Black Walnut	Summer Beds	Yellowing foliage	Unknown	Increased bed drainage
Jack Pine	Summer Beds	Round/stem galls	Oak Gall Rust *Cronartium quercuum* (Berk.) Miy. ex Shirai	Oak Control in windows
Balsam Fir White Spruce	Summer Beds	Foliage burn	Dessication & heat scorch	Increased irrigation
Grafted spruce stock	Summer Beds	Needle drop & shoot mortality	Chemical burn	Soil drench with water & plant food
White pine	Spring Beds	Stem swelling & discoloration	Unknown	None
Shippable conifers	Winter Beds	Lack of snow cover, needle browning, bud dessication	Winter burn	Artificial snow cover

Badoura Nursery

Host	Time and Location	Symptoms	Agent	Control Action
Red Pine transplants	Spring beds	Root loss & flagging, seedling mortality	White Grubs *Phyllophaga* spp.	None-past hazard
Soft Maple	Spring Beds	Defoliation	White Grubs Adult *Phyllophaga* spp.	Foliar Spray
1-0 Conifers	Summer Beds	Seedlings smothered with particulate matter	Irrigation splash	None
Cedar Wind rows	Fall	Foliage browning & leaf drop	Leaf Miner *Argyresthia* spp.	None

Outlook for 1981

Activities in both nurseries in 1981 will center on implementation of standardized bed surveys, coordination of federal and university research efforts, and pest identification training sessions for nursery personnel.

Non-Insect and Disease Problems

Iron chlorosis of hardwood and conifer species was common throughout southeast Minnesota. In the hardwoods, the red and white oaks and aspen were most affected.

In the Brainerd Region, herbicide damage to pines was evident along the railroad right-of-way adjacent to highway 371 in the Pequot Lakes and Backus Districts. A jack pine plantation in the Backus District (STR 18, 140-31) was sprayed for release and suffered 60 percent plus mortality. Rolling terrain, the presence of power lines, and an uneven overstory of large trees contributed to uneven spray distribution.

A 40-acre red pine plantation in STR 16, 149-25 in northwestern Itasca County suffered heavy damage from herbicide in the aerial release spraying done in 1979. Approximately 50 to 60 percent of the trees in the plantation had dead needles, buds and branches. Five to ten percent

of the trees were killed as a result of the herbicide. The most severe damage appeared to occur in bands through the affected area as though overlap occurred during application.

Numerous reports were received about jack pine on which the outer bark had been removed by woodpeckers *Picoides* spp. The newer bark was left intact which gave stems a coppery color. Woodpeckers remove dead outer bark to feed on insects found under the bark scales. This activity did not harm the trees since only the dead outer bark was removed.

Red squirrels, too, caused flagging of larger branches when cones were torn off the branches.

Christmas Trees

In Region III numerous requests from Christmas tree growers were processed in 1980. A red pine grower in the Nimrod District (STR 10, 134-33) in Wadena County sustained needle damage from a pine midge, *Contarinia* spp. and from *Lophodermium pinastri* (Schrad. ex Hook) Chev.

The Zimmerman District (Sherburne County) contains numerous individually owned and larger company Christmas tree plantations. Inspection of three operations (STR 20, 35-29, STR 15, 34-25, STR 32, 35-28) indicated several common problems. Blue spruce stock was commonly degraded by Rhizosphaera needlecast *R. kalkhoffii* (Bud.). White spruce was damaged by the yellowheaded spruce sawfly *Pikonema alaskensis* (Rohwer) and spruce spider mites *Oligonychus ununguis* (Jacobi). The most common pine problems were the stump weevil complex *Hylobius* spp., Lophodermium needlecast, pine tortoise scale *Toumeyella parvicornis* (Cockerell) and the associated sooty mold, the Zimmerman pine moth *Dioryctria zimmermani* (Grote) and winter burn in the shorter needled Scots varieties. Chemical control of the weevils has been attempted, using Dursban 2E in the spring with varying results.

Several new problems were also encountered. The pine wood nematode *Bursaphelenchus lignicolus* Mamiya was verified from an abandoned Christmas tree plantation of Austrian and Scots pine in STR 5, 34-26.

Survey in 1981 will determine the extent of damage in managed stands. False loopers, *Syngrapha* spp. caused light defoliation to blue spruce in one plantation. Another needlecast, *Naemacyclus* sp. is common on Scots pine in Isanti County. Growers are interested in developing a survey procedure in 1981 to determine the extent of damage and timing for control. Growers currently control *L. pinastri* by applying fungicidal sprays from July to October. Spray programs to control *Naemacyclus* should be extended until late November. The recommended fungicide is Dithane M-45.

Minor and Incidental Problems

Pest	Hosts	Location	Comments
Pine Pitch Midge *Cecidomyia* spp. and Pitch Nodule Maker *Petrova* spp.	Jack pine	On host throughout state	Branch die-back, highly visible & causing public concern
June Beetles *Phyllophaga* spp.	Red pine and white spruce plantation	Near Park Rapids	Private planting with adult feeding
Balsam Fir Sawfly *Neodiprion abietis* (Hams)	Balsam fir	Central St. Louis, N. Aitkin, SE Itasca, & Lake Counties	Evident branch firing
Elm Leaf Miner *Fenusa almi* sundervall	Slippery elm	Aitkin, Fillmore, Olmsted, Winona, & Wabasha Counties	Low levels
Spruce spider mite *Oligonychus ununguis* (Jacobi)	Black Hills spruce, white cedar	Steele and Carlton Counties	
Elm Lace bugs *Corythuea ulmi* O & D	Slippery elm	Aitkin County	Causing chlorosis and light browning
Pine tortoise scale *Toueyella numismatica* (P & McD.)	Jack pine	Carlton, N. Pine, & Aitkin Counties	
White pine weevil *Pissodes strobi* (Peck)	Jack pine	NE Itasca, Aitkin, St. Louis & Carlton Counties	Adults emerged August 3 from Carlton County collections

Pest	Hosts	Location	Comments
White spotted sawyer *Monochamus scutellatus* (Say)		Various	Homeowner calls
Northern pine weevil *Pissodes approximatus* Hopk.	Red pine	Aitkin & South St. Louis Counties	
Poplar borer *Saperda calcarata* Say	Aspen	Aitkin & South St. Louis Counties	Common
Striped ambrosia beetle *Trypodendron betula* Swaine and Bronze birch borer *Agrilus anxius* Gory	Birch	Aitkin County	
Jack pine sawfly *Neodiprion pratti banksianae* swaine	Jack pine	N. Pine, St. Louis, & Lake Counties	Low populations
Neodiprion maurus Rohwer	Jack pine	Aitkin & Pine Counties	Low populations
Neodiprion virginianus	Jack pine	St. Louis County	Local heavy defoliation
Red-headed pine sawfly *Neodiprion lecontei* (Fitch)	Jack pine	North Pine County	Local heavy defoliation
Mountain ash sawfly *Pristiphora geniculata* Hartig	Mountain Ash	Carlton & St. Louis Counties	Populations generally low
Spring cankerworm *Paleacrita vernata* (Peck)	Siberia elm & mixed hardwoods	Kandihoyi, Renville, Redwood & Brown Counties	Shelterbelts & small stands heavily defoliated
Walkingstick *Diapheromera femorata* (Say)	Mixed hardwoods	Houston County	Minor defoliation

Pine Tussock Moth Control Project

Introduction

In Region III a low population of pine tussock moth, *Dasychira pinicola* (Dyar), existed in a historic problem area in Mission Township (136-27) of Crow Wing County. Outbreak levels continued for the third year in the jack pine stands surrounding the General Andrews State Forest Nursery in Sturgeon Lake (45-20), Windemere (45-19), Kettle River (44-20), and Norman (44-19) townships of Pine County (see map). Egg mass surveys conducted in the fall of 1979 indicated the outbreak area had expanded from the 350 acres sprayed in July of 1979 (see Minnesota Forest Insect and Disease Annual Report 1979). Larval surveys conducted in June of 1980 (Table 5) indicated approximately 3,500 acres supported populations high enough to cause extensive defoliation and top-kill with a potential for heavy tree mortality if left unchecked. Outbreak levels recorded in 1960, 61 and 62 caused heavy defoliation and resulted in the salvage of approximately 1,000 acres of top-killed pine. Present allowable cut levels in the Moose Lake Area could not absorb a potential salvage operation of this size or the resulting time lag in softwood production. Control attempts using directed harvests would not eliminate high population centers in young plantations and noncommercial stands. The decision to utilize direct control in 1980 to reduce pine tussock moth populations and provide foliar protection was based on the need to protect the local red pine seed orchard, the pine windbreaks and pine seedlings in the General Andrews Nursery, and an estimated $400,000 worth of pine timber and plantations in the threatened area.

Methods and Materials

Larval Surveys

An early larval survey (Table 4) was conducted to determine if the early instars could be found using a system similar to the Jack Pine Budworm Survey. A standard branch length (24") was examined to record the number of larvae and number of staminate flowers.

A larval survey conducted in June recorded the number of larvae on an arm length branch. Five branches, one each from knee, waist, chest, mid crown and upper crown levels were sampled from 12 trees on 47 plots in and around the outbreak area. This simple system was carried out by two local laborers not previously trained in pest surveys. Plots with counts of 50 or more larvae were found to be sustaining heavy defoliation. Spray blocks were established using: (1) these counts and existing defoliation, (2) stand boundaries as determined from aerial photos, and (3) distinct breaks in the pine type produced by lakes, roads, fields or swamps.

Public Information

Public interaction was handled on several levels: (1) Two news releases were provided to the local paper prior to the operation. (2) An informational packet was developed and provided for homeowners that were not contacted directly. The packet was also made available through the Moose Lake Area office and General Andrews Nursery headquarters. (3) A public meeting was held on Thursday, June 12 at 8:00 p.m. at the nursery. During the meeting the spray project was outlined, questions from attendees were solicited and answered, and additional informational packets distributed as requested. (4) Warning signs (forest insecticide spray) were posted on all roads in and around the spray blocks. (5) In order to address a specific non-target action of the chemical, a list of local beekeepers was compiled using State Department of Agriculture records and local knowledge. They were then contacted by phone or in person, advised of the spray project and provided information on removing or protecting their hives. Attempts were made to contact all beekeepers the day before spraying was conducted in their area. No bee mortality claims resulting from the spray were filed.

With increased public concern over pesticide use in our forests, all spray projects are coming under closer review. This is particularly true in the General Andrews State Forest area where recreational use (canoeing, camping, fishing, blueberry picking) is high. Small private beekeeping is expanding in the area and environmental awareness is increasing. The public must and will be made aware of the purposes, benefits, and hazards of chemical control in multiple use forest management.

Spray Project

Sevin 4 oil was selected for use on 3,300 acres based on its suitability for aerial applications, toxicity, limited persistence and low aquatic residue. Sevin XLR, a new water formulation, was tested on 20 acres as an alternative to the oil formulation. Orthene was tested at two rates: one pound/acre on 13 acres and one-half pound/acre on 11 acres, to determine if the chemical would produce higher mortality counts over a longer period of time in order to justify the greater cost. Thuricide HPC was tested on 20 acres of the Interstate 35 median strip and rest area to determine if this environmentally safe formulation would provide effective control of pine tussock moth.

The actual spray operation began on June 19, 1980 when the majority of larvae were in the 3rd and 4th instar. Spray blocks were drawn on aerial photographs and supplied to the contract operator. Operation headquarters and the helicopter spray pad, equipped with water, were established in the General Andrews State Nursery. The operational log is as follows:

Aerial Spraying Operations - Pine Tussock Moth Control Project-
General Andrews State Forest June 19-20, 1981

Test Sprays

Sevin XLR (Carbaryl) - Began spraying at 8:50 a.m. June 19, 1980, weather calm and sunny. Previous night very humid. Mixed five gallons XLR in 15 gallons water giving one quart actual insecticide per acre. Used ten #8003 flat fan nozzles at 50 psi, sprayed north block (20 acres) in Highway 35 median near Sturgeon Lake, completed 9:00 a.m., Mike Atkinson of Union Carbide assisting.

Orthene FS (Acephate) - Mixed 12 gallons water with 24 cans Orthene plus six ounces plyac sticker. Sprayed two blocks on north end of nursery as planned, began 9:18 a.m. Completed 9:29 a.m. Sprayed 13 acres east-west block twice, one pound AI per acre and 11 acres north-south block once, giving one-half pound per acre. Mike Danley of Chevron provided technical assistance.

Thuricide (high potency concentrate) - Mixed ten gallons Thuricide 16B in 20 gallons water plus six ounces Plyac sticker to give one-half gallon actual per acre. Sprayed middle and south Highway 35 median strips plus Sturgeon Lake rest area (20 acres). Began spraying 9:40 a.m. Chemical supplied by the Sandoz Company. For test sprays weather was calm and sunny throughout (almost no motion of higher tree tops). System was flushed with five gallons water after each test spray.

Operational Spraying with Sevin 4 Oil (One pound active ingredient per acre) - The area of operational spraying had been broken up into 22 blocks based on boundaries easily distinguished from the helicopter. Acreage ranged from a low of 24 to a high of 380 gross acres. A few of the blocks were not completely sprayed. They included cut-over areas not noted during the acreage counts and swampy off type areas:

Block A - 24 acres
Block B - 90 acres
Block C - 105 acres
Block D - 105 acres
Block E - 225 acres
Block F - 150 acres
Block G - 70 acres
Block H - 62 acres
Block I - 162 acres (very broken up jack pine type)
Block J - 260 acres (very broken up jack pine type)
Block K - 145 acres
Block L - 115 acres
Block M - 70 acres
Block N - 90 acres
Block O - 260 acres
Block P - 380 acres
Block Q - 340 acres
Block R - 310 acres
Block S - 220 acres
Block T - 260 acres
Block U - 60 acres
Block V - 175 acres

The boom was mounted with nozzles angled 45 degrees down and forward to facilitate particulate break-up. Spraying was carried out using ten #8003 flat-fan nozzles without screens. Each load comprised 63 gallons Sevin 4 oil mixed with seven gallons deodorized kerosene as carrier. Mixture was agitated periodically in pre-mix

tank to maintain the chemical in suspension. Operating pressure was 50-55 psi. The system was calibrated to deliver 40 ounces of mixture per acre. A full load covered approximately 224 acres. When possible, spraying was done perpendicular to wind direction. Spraying was stopped when wind speed recorded at the pad exceeded six MPH.

Spraying Operations

Date	Spray Block	Time Out	Return	Remarks
6/19	Q	10:42 a.m.	11:08 a.m.	Calm and sunny
6/19	Q & S	11:16 a.m.	11:36 a.m.	Broken hose repaired
6/19	S		12:06 p.m.	Clogged nozzles cleaned
6/19	S	12:10 p.m.	12:39 p.m.	
6/19	R	12:44 p.m.		
6/19	R	1:06 p.m.	1:25 p.m.	Winds 5 MPH, sunny
6/19	R	1:30 p.m.	1:58 p.m.	Spraying all state land
	Went to lunch			
6/19	P	2:28 p.m.	3:00 p.m.	Light wind gusts noted
6/19	O & N	3:06 p.m.	3:37 p.m.	Pilot said same
6/19	V & E	4:02 p.m.	4:30 p.m.	
6/19	V, M & nursery windbreaks		5:30 p.m.	Quit as pilot tired

6:19 p.m. - Total of 2,185 (gross) acres sprayed, mostly state land, weather at 5:30 p.m. still calm and sunny. Checked ten supposedly empty drums and drained a total of 55 gallons Sevin 4 oil from them.

6/20	K & B	7:07 a.m.	7:35 a.m.	No clogging
6/20	F & U	7:45 a.m.	8:16 a.m.	
6/20	U & T	8:19 a.m.	8:55 a.m.	
6/20	I & J	8:59 a.m.	9:31 a.m.	No wind yet
6/20	G & H	9:41 a.m.	10:12 a.m.	Finished, started to cloud up (high clouds) 1,260 (gross) acres sprayed

Weather Records

Date	Rainfall	Maximum Temp.	Minimum Temp.
6/18	.4"	58 degrees F.	37 degrees F.
6/19	0	74 degrees	40 degrees
6/22	.2"	88 degrees	46 degrees
6/23	0	89 degrees	60 degrees
6/25	0	94 degrees	59 degrees
6/27	.6"	not taken	not taken
6/30	.1"	not taken	not taken

Total Cost

The total cost of spraying was approximately $24,000. The contract bid on 3,500 acres helicopter (Hiller 12E) spray came in at $3.69 per acre from Judd Enterprises in Rice, Minnesota, to a total of $12,915. Cost of the chemical (880 gallons) was $9,910 plus 220 gallons deodorized kerosene at $370. Test chemicals were supplied by the manufacturers. Boundary markers, warning signs, sampling equipment and other support materials cost $805. Man hours, lodging and meals for the survey and operational crews are not included.

Spray Monitoring and Evaluation

Spray areas were monitored with standardized test plots that included 12 marked trees for larval counts, one Kromecote card to record spray dispersal, and four drop tarps to monitor mortality. Two plots were established in each of the test plots: XLR, Orthene 1, Orthene ½, and Thuricide. Eight plots were placed in the Sevin 4 oil area. Foliage samples were also collected on three of these plots to verify white Sevin droplets in the tree crowns. Six water sampling points were chosen. Four one-quart samples were taken in the Willow River drainage: one in the flowage above the spray area, one in the flowage in the Sevin 4 area, one in a reservoir in the Sevin 4 area and one below the spray area. Two samples were also taken from lakes within the Sevin 4 area.

Post Spray Collections

Collections included drop tarp mortality counts (Table 7), branch sampling of the designated sample trees (Table 8), tree fellings and residual insect counts (Table 9), pheromone trapping of adult male moths (Tables 10 and 11) and egg mass surveys inside and outside of the spray area (Table 12).

Results and Discussion

Phenological Notes

May 7	- 2nd instar larvae becoming active but hard to find. One-third instar collected.
June 9	- Uneven larval development. Most larvae in 3rd instar. Fourth instar and new 5th instars also present in small numbers.
July 2	- First pupa observed.
July 18	- First adult collected.

Phenological Notes

August 1	- Major flight period over.
August 4	- First instars emerging from egg clusters.
August 12	- Seventy percent of surveyed egg masses hatched. No caterpillars or unemerged pupae observed.

General Observations

Several historical observations of past pine tussock moth outbreaks held true. Larval counts were higher in stands with an abundance of open-grown staminate flower producing trees. Populations apparently build on edge trees or in understocked stands. When adjacent, dense, stagnated jack pine stands are attacked, defoliation is more visible and mortality is high. Red pine is not a preferred host but is defoliated when growing adjacent to,or in a mixture with jack pine.

Larval Surveys

These surveys were conducted to verify indications from a 1979 egg mass survey that an expanded area of jack pine would sustain heavy defoliation and top-kill in 1980. Branch sampling procedures are being developed to replace the old system of shaking small open-grown trees for drop tarp counts. The system of permanent plots and larval surveys established in and around the General Andrews State Forest in 1980 will be continued annually to record counts for future comparison. The surveys will be modified with experience and within the dictates of available manpower and funding.

The limited early larval survey conducted in 1980 (Table 4) was time consuming and few larvae were detected. The small second and third instar larvae are firmly attached and often hidden at the base of male cones or groups of needles on exposed branches. Water floatation was attempted, but it proved unsuccessful in dislodging all the larvae on a given branch. Branch sampling from the upper crown of edge and open-grown trees will again be conducted in 1981.

The larger, active later instars are more readily detected with branch sampling (Table 5). The five level branch sampling procedure will be changed to disregard lower branches that are not exposed to sunlight. The 1980 tally sheets indicated over 85 percent of the larvae

were collected from the upper crown foliage. In 1981, two branches from exposed areas of the mid-crown and three from the upper crown will be taken from 12 sample trees per plot. Larger pole pruners will be needed. Larvae counts will be correlated to defoliation to establish new thresholds.

Spray Monitoring and Evaluation

Post Spray Collections

Collections were solely qualitative to verify spray dispersal (Kromecote cards and foliage samples), target affect (Table 7), and relative mortality (Tables 8 and 9). In only one area, Plot 20, did the Kromecote cards indicate poor spray coverage. Low mortality counts on this plot reflect this problem. This evaluation is based on a general standard of acceptable spray coverage when six or more oil-diluted spray droplets per square centimeter are recorded on ground level spray cards. Eight to ten droplets per square inch on the cards was considered acceptable with the water carried test chemicals. Droplets were not measured, but visual checks were made to assess size distribution and pinpoint potential clogging problems.

The 1980 pine tussock moth control project using Sevin 4 oil achieved its primary goal of foliage protection to limit top-kill and stand degradation in this prime softwood and nursery production area. The population, however, has not been eliminated.

Water samples were processed by the Ecological Services Section of the DNR Division of Fish and Wildlife (see Table 6). The level of Sevin residues in the samples ranged from .02 to .004 ppm and indicated no pesticide build-up.

If Sevin 4 oil is withdrawn from the market or its use in aerial spraying is severely restricted, chemical costs will at least double.

No quantitative comparison of the test chemicals can be made. All were targeted to stands with high larvae counts. The stands differed in composition, age, basal area and the amount of edge. Results indicate good foliage protection and larval mortality with Sevin XLR (see Tables 7, 8 and 9).

Orthene produced high mortality counts (Table 7) and good foliage protection at both rates. Egg mass counts (Table 12) indicate poor overall population reduction. This may be due to the extremely high number of larvae in these test blocks and the dense nature of these stands. Exposed larvae were killed, but post spray counts were high (Tables 8 and 9).

Our analysis did not confirm or disprove the reported "local systemic" effect. Foaming and odor problems were encountered during the 1979 control spray using Orthene. No problems occurred during the 1980 test spray. This chemical was twice the price of Sevin 4 oil.

Thuricide HPC did kill tussock moth larvae. Its action, however, was too slow to provide foliage protection and too limited in total kill to reduce population levels. The use of this chemical (possible in one of its newer formulations) in a two spray operation, once in late May or early June and again in mid-June, might provide adequate control. The presence of Bt on the foliage during the dispersal and initial feeding of smaller instars might reach a greater number of larvae, over a longer period of time, during a stage when they are more susceptible. Kill could occur early enough to provide foliage protection. Limited environmental and non-target impact would occur.

Any chemical control of pine tussock moth is difficult. Uneven larval development occurs during the single annual generation. The spray operation should be timed early enough to avoid fourth instar and larger larvae. They are harder to kill and the fifth and sixth instar larvae drop from the exposed portions of the crown at the slightest disturbance. The spray operation should be late enough, however, so that the second and third instar larvae are fully dispersed and more readily contacted by chemical in the outer crown foliage. During the 1980 spray project, third, fourth and fifth instar larvae were present during the spray operation.

The multistoried jack pine stands in the General Andrews State Forest reduce the effective penetration of any spray system. Better spray coverage might be achieved by adding one pint of carrier to one quart of Sevin 4 oil, rather than .5 pint. This delivery of 48 ounces per acre might provide better break-up and coverage with less clogging.

Project Needs

A prolonged fire season in the spring of 1980 delayed extensive early larvae surveys and condensed the time period available for planning and public information dispersal. It is essential to get an early indication of larvae activity and numbers to plan control. A filed survey is needed to determine when second instar larvae are dispersed, active and feeding. An adequate and stable source of contingency control funds under the direction of the Forest Insect and Disease Unit should exist to support the total scope of spray planning, public interaction and control operations. The 1980 control project was hindered in planning, implementation and cost analysis due to centralized, unquantified accounts, and contract delays.

A portable weather station should be purchased to monitor humidity, temperature and wind conditions at the spray pad and then in targeted areas as they are sprayed. Deposit cards and foliar samples should be examined on site and within one hour to redirect control sprays to poorly covered sites.

Special Projects

A cooperative project with the Minnesota Department of Transportation was conducted in the winter of 1980-81 to mark and remove bark beetle infested or susceptible trees, suppressed trees and heavily defoliated jack pine in the rest stop and median areas of Interstate 35. These areas had been treated with Thuricide (poor control) and Sevin XLR (good control). It is hoped that this reduction of the susceptible jack pine component in these stands will reduce the need for future chemical control in these visible, high use areas.

Pheromone trials during the 1980 season indicated that both the Canadian and Douglas fir tussock moth compounds can be used to monitor the pine tussock moth flight periods (see Tables 10 and 11). A variety of different trap types were used. The Douglas fir pheromone reportedly only attracts male moths flying within one meter of the trap. This range needs to be tested for pine tussock moth. The heavy catches in the Excello traps indicate a potential for concentrated grid, mass trapping. Repeated annual tests are needed to refine the use of these survey tools in determining dispersal periods and distances, and obtain some indicator of population levels. This information would provide a useful "early warning" system.

Outlook for 1981

The 1980 egg mass survey indicated the potential for heavy defoliation in scattered pockets in and around the General Andrews State Forest. Larval surveys will be used to monitor winter mortality and pinpoint individual stands that need treatment or salvage.

Timber stand improvement cuts based on tussock moth damage and subsequent bark beetle build-up, similar to that conducted on Department of Transportation land, will be scheduled for targeted state stands. Analysis of attacked stands will continue to try and quantify hazard in relation to basic inventory data (age, basal area, species composition), growth rates and soil fertility.

Pheromone trapping will continue in cooperation with the Canadians and Douglas fir project to develop a diagnostic survey tool.

A survey of the larvae and pupal parasites of pine tussock moth in the General Andrews area will be conducted.

PINE TUSSOCK MOTH SPRAY PROJECT

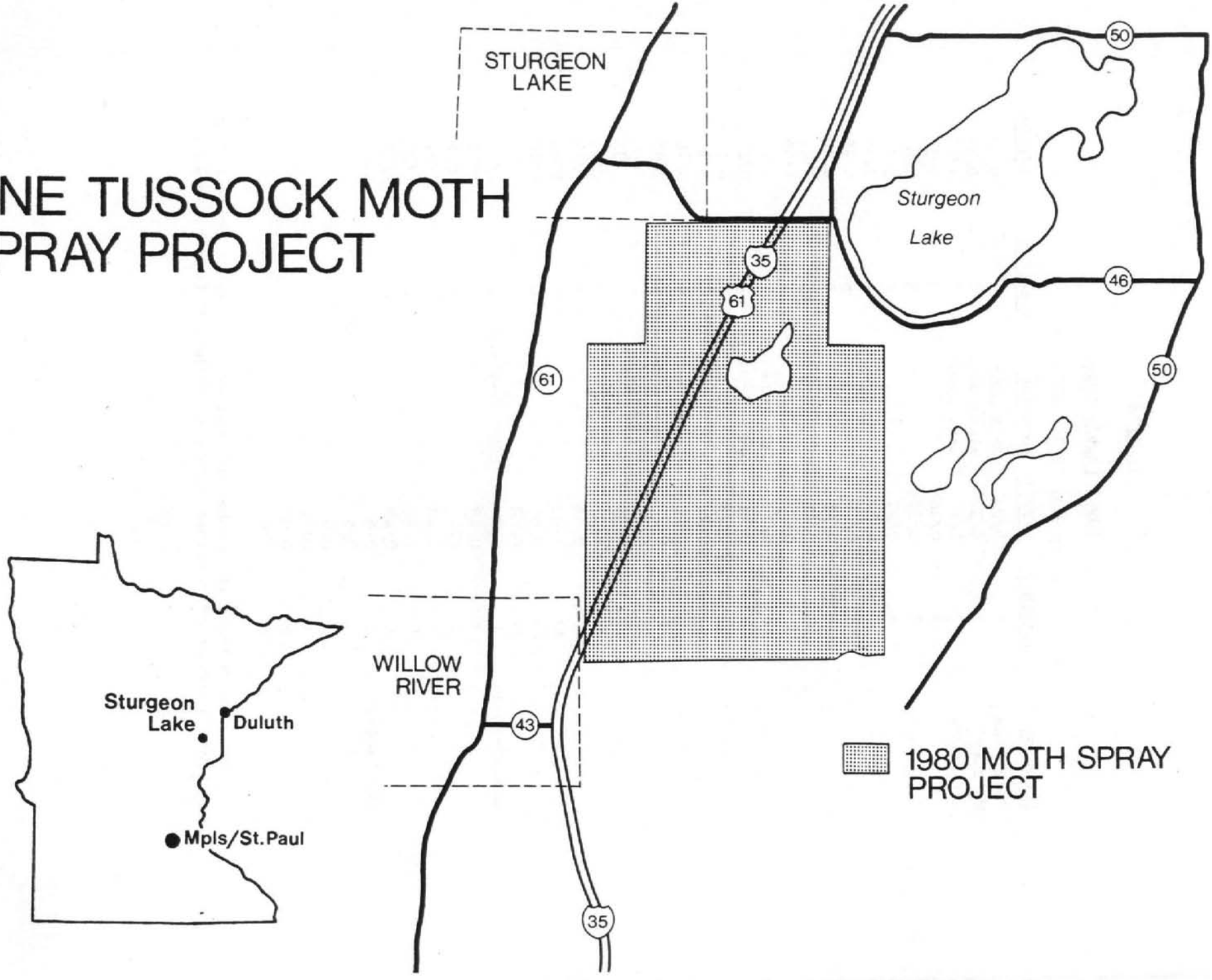


TABLE 4

EARLY LARVAE SURVEY

May 15-16, 1980

Location	Branch #	L/F/B*	Location	Branch #	L/F/B*
Jack Pine	1	0/24	Jack pine	1	0/83
Nursery	2	0/27	along Dago	2	0/81
Wind rows	3	1/12	Lake Road	3	1/78
	4	0/36		4	2/16
	5	0/35		5	0/6
	6	0/27		6	1/40
	7	0/52		7	3/75
	8	0/39		8	0/40
	9	0/46		9	0/40
	10	0/45		10	1/42
	11	0/32		11	1/90
	12	0/18	Jack pine	1	0/6
	13	0/11	NWNW 36-45-20	2	0/1
	14	0/32		3	0/1
	15	0/7		4	0/1
	16	0/59		5	0/70
	17	0/20		6	0/42
	18	0/86	NWNW 36-45-20	1	7/2
	19	0/36		2	2/32
	20	0/31		3	0/4
	21	0/45		4	1/15
	22	1/32		5	1/9
	23	0/66		6	0/16
	24	0/64			
SESW 36-45-20	1	0/7	SENE 36-45-20	1	2/19
	2	0/19		2	1/37
	3	0/1		3	10/27
	4	1/28		4	2/27
	5	2/40		5	1/29
	6	0/45		6	2/22
NENE 1-44-20	1	0/9			
	2	0/0			
	3	0/0			
	4	0/77			
	5	0/0			
	6	0/0			

*Counts indicate the number of tussock moth larvae collected in relation to number of staminate flowers on the 24" branch samples.

TABLE 5

LARVAL SURVEY*

Plot #	Location	Collection Date	# Larvae/5 branches from each tree												Total
			1	2	3	4	5	6	7	8	9	10	11	12	
1	Center NE¼ 25-45-20	6-2-80	5	0	13	9	-	1	20	6	0	1	15	0	70
2	SWSE 25-45-20	6-2-80	6	5	2	0	15	5	7	2	4	4	2	3	55
3	SENE 36-45-20	6-2-80	18	3	5	6	23	7	4	10	7	11	12	12	118
4	NWNE 31-45-19	6-2-80	2	4	9	1	0	0	6	4	8	3	9	2	48
5	NWNE 26-45-20	6-3-80	1	0	0	0	0	0	0	0	0	0	0	1	02
6	SWNW 6-44-19	6-3-80	15	19	13	11	18	27	7	7	15	8	4	26	170
7	SENE 7-44-19	6-3-80	0	2	1	4	0	1	0	0	0	0	2	0	10
8	NENE 12-44-20	6-3-80	2	0	0	0	0	1	1	0	1	0	0	0	05
9	SESE 13-45-20	6-3-80	13	26	42	26	4	3	7	21	5	5	4	8	164
10	NWNE 24-45-20	6-4-80	7	14	12	11	36	11	23	10	8	8	6	8	154
11	NESW 24-45-20	6-4-80	17	4	6	6	26	10	6	8	15	6	5	12	121
12	NWSW 19-45-19	6-4-80	2	1	5	5	0	9	2	3	3	0	9	1	40
13	SESW 19-45-19	6-4-80	0	0	2	3	1	3	0	0	3	4	6	17	39
14	Center NE 29-45-19	6-4-80	0	0	0	0	0	0	0	0	0	0	0	0	0
15	NESE 29-45-20	6-4-80	0	0	0	0	0	0	0	0	0	0	0	0	0
16	SWNE 32-45-19	6-4-80	0	0	0	0	0	0	0	0	0	0	0	0	0
17	NENE 26-45-20	6-5-80	1	1	3	0	3	5	1	0	1	3	6	9	33
18	NENE 35-45-20	6-5-80	0	0	0	0	0	0	0	0	0	0	0	0	0
19	NENW 35-45-20	6-5-80	24	2	26	9	4	6	12	5	1	6	7	2	104
20	NESW 36-45-20	6-5-80	0	1	1	4	2	11	5	5	6	3	9	3	53

Plot #	Location	Collection Date	# Larvae/5 branches from each tree												Total
			1	2	3	4	5	6	7	8	9	10	11	12	
21	SWNW 36-45-20	6-5-80	1	0	0	3	1	1	0	0	1	0	1	0	08
22	Middle SW 36 & SE 35-45-20	6-5-80	0	1	0	0	0	0	0	0	0	0	0	1	02
23	SWSE 35-45-26	6-5-80	0	0	0	0	0	1	0	1	0	0	0	0	02
24	NWSW 35-45-20	6-6-80	0	0	0	0	0	0	0	0	0	0	0	0	0
25	SENW 35-45-26	6-6-80	0	0	0	1	0	0	0	0	0	0	1	0	02
26	Between SW & SE 36-45-20	6-6-80	1	6	2	12	2	4	7	6	3	4	3	4	54
27	SWSW 31-45-20	6-6-80	3	3	2	3	3	8	12	2	2	6	2	11	57
28	NWSE 31-45-19	6-6-80	1	3	0	1	2	1	0	4	1	0	1	1	15
29	NENE 31-45-29	6-6-80	2	2	1	2	1	3	1	1	0	4	1	2	20
30	SESW 30-45-19	6-6-80	0	6	4	3	0	3	4	13	4	3	0	1	41
31	SESE 30-45-19	6-9-80	0	1	2	10	1	3	6	2	4	2	3	2	36
32	SWNE 6-44-19	6-9-80	3	2	8	3	5	11	20	4	4	5	12	7	84
33	NWNE 5-44-19	6-9-80	0	0	0	0	0	1	0	0	0	0	0	0	01
34	NWSW 5-44-19	6-9-80	0	0	0	0	0	0	0	0	0	0	0	0	0
35	SWNW 4-44-19	6-9-80	0	0	0	0	0	0	0	0	0	0	0	0	0
36	NESE 19-45-19	6-9-80	0	0	0	0	0	0	0	0	0	0	0	0	0
37	NESW 12-45-20	6-10-80	0	0	0	0	1	0	0	1	1	0	0	1	04
38	NESW 17-45-19	6-10-80	1	0	0	0	0	0	0	0	0	0	0	0	01
39	NWNW 5-44-19	6-10-80	0	0	0	0	0	0	0	0	0	0	0	0	0
40	SESE 11-44-20	6-10-80	0	0	0	0	0	0	0	0	0	0	0	0	0

Plot #	Chemical	Location	# Larvae/5 branches from each tree												Total
			1	2	3	4	5	6	7	8	9	10	11	12	
41	Orthene ½#	Andrews Nursery	49	3	12	3	0	3	21	4	11	24	3	19	152
42	Orthene ½#	Badoura Nursery	10	9	10	3	16	10	9	8	16	21	8	7	127
43		Nursery Wind row	15	6	3	12	10	16	12	10	13	5	3	4	109
44	Orthene 1#	Andrews Nursery	14	6	6	10	9	3	9	1	2	14	18	7	99
45	Thuricide	A. median I-35	4	5	5	4	6	1	15	16	5	8	4	7	80
46	Sevin XLR	A. median I-35	12	30	6	8	5	51	26	2	23	12	25	18	218
48	Sevin XLR	B. median I-35	12	5	6	16	5	10	2	1	3	12	3	5	80

*Five arm length branches (20") were taken from 12 randomly selected trees on a plot. Branches were to be selected from knee, waist and chest high level where present, and from the mid and upper crown.

*Knee and waist level live branches were rarely encountered. Survey realistically represents three branch counts.

*Plot number 47 was not sampled.

TABLE 6

WATER SAMPLES TAKEN

June 20, 1980

Water Sample Location		Levels of Sevin (ppm)
Willow River, middle drainage	-In spray area	0.020
Willow River, dam	-Below spray area	0.004
Willow River, I-35 bridge	-In spray area	0.004
Willow River, east drainage	-Above spray area	0.005
Willow River Reservoir	-Below Spray area	0.004
Dago Lake	-In spray area	0.005

TABLE 7

MORTALITY COUNTS*

Number of Larvae on Tarps

Chemical	Plot	6-20	6-23	6-26	7-8	Totals
Orthene 1#	A	75	194	53	44	366
	B	65	94	40	44	243
Orthene ½#	A	82	61	42	50	235
	B	118	58	33	tarp gone	209+
Thuricide	A	26	26	30	27	109
	B	11	34	45	86	176
Sevin XLR	A	75	179	182	245	681
	B	67	84	85	149	385
Sevin 4 Oil	1	42	156	43	16	257
	2	9	33	42	3	87
	9	162	523	79	30	794
	11	no count	186	27	49	262+
	13	38	42	31	17	128
	20	0	19	5	8	32
	32	79	136	39	7	261

*Number of dead larvae/4 drop tarps (2 each under the 2 trees selected for felling). Tarp size (6' 10" x 4' 9") = approximately 3 square yards. Total collection area = approximately 12 square yards.

TABLE 8

POST SPRAY LARVAE COUNTS

Plot #	Chemical	Collection Date	# Larvae/5 branches from each tree												Total
			1	2	3	4	5	6	7	8	9	10	11	12	
1	Sevin 4 (S)	7-15-80	0												0
2	(S)	7-15-80	0												0
3	(S)	7-17-80	0												0
4	(S)	7-17-80	0												0
6	(S)	7-14-80	0												0
9	(S)	7-16-80	0												0
10	(S)	7-16-80	4	0											4
11	(S)	7-16-80	0	0	0	0	1	0	0	2	0	1	0	0	4
12	(S)	7-16-80	0	1	1	0	1	3	0	0	2	3	0	0	11
13	(S)	7-15-80	0												0
14	not sprayed (NS)	7-17-80	0												0

Plot #	Chemical	Collection Date	# Larvae/5 branches from each tree 1	2	3	4	5	6	7	8	9	10	11	12	Total
15	(NS)	7-17-80	0												0
17	(S)	7-17-80	0												0
18	(S)	7-15-80	0												0
19	(S)	7-15-80	0												0
20	(S)	7-14-80	0	0	0	1	2	2	1	3	0	1	2	1	13
21	(S)	7-14-80	0												0
22	(S)	7-14-80	0												0
23	(NS)	7-17-80	0												0
26	(S)	7-17-80	0	1	0										1
27	(S)	7-17-80	0												0
28	(S)	7-17-80	0												0
29	(S)	7-17-80	0												0
30	(S)	7-15-80	0	0	0	0	0	0	0	0	1	0	0	0	1
31	(S)	7-17-80	0												0
32	(S)	7-14-80	0	0	0	2	0	0	0	2	2	2	0	1	9
33	(NS)	7-17-80	0												0
34	(NS)	7-17-80	0												0
35	(NS)	7-17-80	0												0
39	(S)	7-17-80	0												0
41	Orthene ½B	7-17-80	2	1	3	0	1	1	1	2	2	3	0	2	18
45	Thuricide B	7-14-80	0	1	0	2	1	0	1	1	2	3	1	1	13

TABLE 9

TREE FELLING COUNTS*

July 22-23, 1980

Plot #	Pupal/larval Counts Tree 1	Tree 2
1[1]	0/0	0/0
2[1]	4/2	0/0
9[1]	0/0	0/0
11[1]	2/2	13/3
20[1]	40/0	12/2
30[1]	2/1	0/1
31[1]	0/0	0/0
Orthene ½# A[2]	59/5	22/11
Orthene ½# B[2]	17/1	28/3
Orthene 1 A[2]	12/5	3/0
Orthene 1 B[3]	5/2	3/0
Thuricide A[2]	58/38	22/20
Thuricide B[3]	4/1	1/1
Sevin XLR A[2]	5/3	10/5
Sevin XLR B[2]	8/1	14/1

*Counts reflect the remaining pupae and larvae found on two of the sample trees in each plot designated for tarp mortality counts and felling.

1-Trees were sampled in the pre and post spray branch survey.
2-Trees did not receive the post spray branch sampling.
3-Trees did not receive the pre-spray branch sampling.

TABLE 10

CANADIAN PHEROMONE TEST*

July 18 - August 1, 1980

Plot		A Septum Trial Pheromone	(Moths per) (Trap)	B Septum Control
41	-Orthene ¼#	39		0
42	-Orthene ½#	41		0
44A	-Orthene 1#	28		0
44B	-Orthene 1#	33		0
45	-Thuricide A	19		0

*Pherocon Zoecon 1 C traps and test septums were provided by G.G. Grant, Forest Pest Management Institute, Sault Ste. Marie, Ontario, Canada.

TABLE 11

DOUGLAS FIR TUSSOCK MOTH PHEROMONE TEST*

July 19 - August 10, 1980

Spray Block	Plot	Trap	Trap Type	# Male Moths
Sevin 4 Oil	2	A	Gypsy Moth	18
		B	Gypsy Moth	20
		C	Gypsy Moth	27
		D	Gypsy Moth	7
		E	Gypsy Moth	19
Sevin 4 Oil	3	A	Gypsy Moth	20
		B	Gypsy Moth	10
		C	Gypsy Moth	28
		D	Gypsy Moth	10
		E	Gypsy Moth	12
Sevin 4 Oil	6	A	Gypsy Moth	4
		B	Gypsy Moth	20
		C	Gypsy Moth	7
		D	Gypsy Moth	12
		E	Gypsy Moth	6
	9	A	Excello	21
		B	Excello	32
		C	Excello	33
		D	Excello	29
		E	Excello	35
	11	A	Excello	31
		B	Excello	52
		C	Excello	48
		D	Excello	31
		E	Excello	37

Spray Block	Plot	Trap	Trap Type	# Male Moths
	13	A	Excello	36
		B	Excello	40
		C	Excello	24
		D	Excello	28
		E	Excello	37
Sevin 4 Oil	20	A	Gypsy Moth	16
		B	Gypsy Moth	4
		C	Gypsy Moth	6
		D	Gypsy Moth	7
Thuricide	45	A	Gypsy Moth	5
		B	Gypsy Moth	13
		C	Gypsy Moth	8
		D	Gypsy Moth	13

*Pheromone (0.1% Z-6-Heneicosen-11-one) for all traps provided by Gary Daterman, USDA, Forest Science Lab, 3200 Jefferson Way, Corvallis, Oregon. Traps (White-Excello-Weyerhauser-½ gallons) provided by USDA, Methods Applications Group, Davis, California.

TABLE 12

1980 EGG MASS SURVEY

Plot or Location	Spray Block	Collection Date	Egg Masses/Tree (# of trees below) 1	2	3	4	5	Avg/ Plot*	Visible* Defoliation in August
6	Sevin 4	8-4-80	5	9	7	5	-	6.5	L-M
19	Sevin 4	8-4-80	0	1	3	0	-	1	-
9	Sevin 4	8-4-80	0	1	3	4	-	2	M
SWNW 19-45-19	Sevin 4	8-4-80	1	1	1	0	-	.8	-
SWNW 19-45-19	Sevin 4	8-4-80	2	0	0	-	-	.7	-
NESE 1-44-20	not sprayed	8-4-80	6	13	6	9	32	13.2	S
SWSW 19-45-19	Thuricide	8-4-80	0	3	2	4	-	2.3	S
SWSW 19-45-19	Thuricide	8-4-80	3	7	5	-	-	5	M-S
NWSW 25-45-20	Thuricide	8-4-80	0	0	7	2	1	2	M-S
NWNW 30-45-19	Thuricide	8-4-80	14	15	23	-	-	17.3	S
10	Sevin 4	8-6-80	10	6	0	5	2	4.6	L-M

Plot or Location	Spray Block	Collection Date	Egg Masses/Tree (# of trees below) 1	2	3	4	5	Avg/ Plot*	Visible* Defoliation in August
NWNE									
23-45-20	Sevin 4	8-6-80	0	0	0	1	-	.3	-
5	not sprayed	8-6-80	0	3	4	2	-	2.3	L
44A	Orthene 1#	8-6-80	10	2	5	10	-	6.8	L-M
44B	Orthene 1#	8-6-80	12	17	22	-	-	17	M
41	Orthene ½#	8-6-80	7	9	10	9	0	7	M
42	Orthene ½#	8-6-80	15	4	5	6	-	7.5	L-M
6	Sevin 4	8-8-80	11	5	8	-	-	8	M
17	Sevin 4	8-8-80	2	8	6	3	-	4.8	L
18	Sevin 4	8-8-80	1	0	0	0	-	.3	L
19	Sevin 4	8-8-80	5	1	1	-	-	2.3	L
20	Sevin 4	8-8-80	0	0	7	2	1	2	M-S
48	Sevin XLR	8-8-80	0	0	0	-	-	0	M
SWNW 30-45-19	not sprayed	8-8-80	25	12	22	-	-	19.7	S
99-SWSE									
26-45-20	Sevin 4	8-8-80	0	0	0	1	-	.3	L-M
2	Sevin 4	8-11-80	0	0	0	-	-	0	L
30	Sevin 4	8-11-80	3	2	2	-	-	2.3	-
31	Sevin 4	8-11-80	2	1	1	-	-	1.3	-
1	Sevin 4	8-12-80	0	2	2	-	-	1.3	L-M
3	Sevin 4	8-12-80	3	0	1	-	-	1.3	-
4	Sevin 4	8-12-80	3	3	2	-	-	2.7	-
6	Sevin 4	8-12-80	5	4	3	-	-	3.7	-
11	Sevin 4	8-12-80	6	4	3	-	-	4.3	M
12	Sevin 4	8-12-80	1	4	4	0	-	3	-
13	Sevin 4	8-12-80	3	0	0	-	-	1	L-M
21	Sevin 4	8-12-80	0	0	0	-	-	0	-
22	Sevin 4	8-12-80	0	0	2	-	-	.7	-
23	Sevin 4	8-12-80	1	1	0	-	-	.7	-
26	Sevin 4	8-12-80	0	1	2	-	-	1	-
27	Sevin 4	8-12-80	6	0	1	-	-	2.3	-
28	Sevin 4	8-12-80	0	0	3	-	-	1	-
29	S/NS Line	8-12-80	6	2	1	1	-	3.3	L
32	Sevin 4	8-12-80	4	5	2	-	-	3.7	L
39	Sevin 4	8-12-80	1	1	0	-	-	.7	-

*H = Heavy (top-kill and brown crowns), M = Moderate (thin crowns, no browning), L = Light (no noticeable needle loss).

*Historically a seven egg mass per plot average indicates the potential for heavy defoliation the next year.

White Pine Blister Rust Study

An ongoing investigation into the possibilities of re-establishing white pine as an important timber producing tree in Minnesota continued during 1980. At the heart of this investigation is a white pine site evaluation and a continuation of a pruning study started in the early 1970's.

Two areas have been included in the pruning study. One area is located in the Paul Bunyan State Forest in southern Hubbard County, and the other area is in the Pillsbury State Forest in southern Cass County. The Paul Bunyan stand is a natural understory stand of white pine under aspen and oak, and blister rust infection is very low. The Pillsbury site is an open-grown plantation with a high blister rust infection rate. Efforts during 1980 were concentrated on the Pillsbury site where additional pruning took place and the trees were more permanently marked.

Eight white pine sites were evaluated during 1980. At this time, not enough information has been collected to accurately identify sites where white pine can be satisfactorily grown. A summary of the information collected on the eight sites is found in Table 13.

TABLE 13

WHITE PINE BLISTER RUST SITE EVALUATION SUMMARY

County	STR Description	Hazard Zone	Overstory	Topography	Blister Rust
Clearwater	36-143-38	3	Hardwoods >50% cover	Top of Slope, westerly, aspect	20% infection 10% fatal cankers 6% mortality
Hubbard	26-145-32	4	None	Level	34% infection 18% fatal cankers 2% mortality*
Lake-of the-Woods	19-159-33	3	None	Level	57% infection 38% fatal cankers 12% mortality*

County	STR Description	Hazard Zone	Overstory	Topography	Blister Rust
Lake-of the-Woods	10-159-34	3	Red & Jack Pine <50% cover	Level	22% infection 14% fatal cankers 36% mortality
Lake-of the-Woods	4-160-34	3	None	Level	24% infection 20% fatal cankers 22% mortality
St. Louis	13-53-13	4	Hardwoods >50% cover	Level	34% infection 20% fatal cankers 2% mortality
St. Louis	19-55-24	4	Hardwoods >50% cover	Level	24% infection 14% fatal cankers 10% mortality 6% non BR mor.
Aitkin	12-52-25	4	Hardwoods >50% cover	Level	42% infection 5% fatal cankers 2% mortality 18% non BR mor.

*These are plantations in which some of the dead trees had obviously been removed. Blister rust caused mortality is probably somewhat higher.

This survey is based on 50 trees; and levels of infection, fatal cankers and mortality are percentages of the 50-tree sample. Fatal cankers are defined as those cankers on the main bole of the tree or within four inches of the main bole. These trees would be expected to die sometime in the future from these fatal cankers.

Outlook for 1981

Both the Paul Bunyan and Pillsbury pruning studies will be reread in 1981. Additional pruning will also take place on the Pillsbury site. An additional 80 white pine sites will be evaluated statewide. In Regions I, II, and III approximately 25,000 white pine seedlings will be out-planted in the spring of 1981. In future years these plantings will be monitored for the blister rust disease.

Shelterbelt Insect and Disease

Introduction

The shelterbelt program in southern Minnesota is a large one in which approximately 1.2 million trees and shrub species are planted each year. Statewide there are approximately 2.5 million trees and shrubs planted in shelterbelts each year.

In 1980, the DNR Region IV and V Soil and Water Conservation Districts were notified of the availability of specialists to examine any important insect and disease problems. The Counties visited were: Brown, Cottonwood, Freeborn, Jackson, Kandihoyi, Lac Qui Parle, Le Sueur, Lincoln, Lyon, Martin, Meeker, Olmsted, Pipestone, Redwood, Steele, Swift, Waseca, and Watonwan.

Technical assistance was accomplished through personal contact with technicians and private landowners. The objective was to provide up-to-date recommendations on pest management, diagnosis, controls and cultural practices such as species selection. Field data was collected on the occurrence of specific pest problems and management information. Field visits involved pest identification and discussions with technicians and landowners covering pest management problems.

TABLE 14

MAJOR PEST PROBLEMS OF SHELTERBELT SPECIES

Diseases	Host Species	Region/Counties
Cytospora canker *Cytospora kunzei* (Sacc.)	Colorado Blue Spruce Norway Spruce	South-central Region Dodge County
Dothistroma needle cast *Dothistroma pini* (Hulbary)	Austrian Pine Ponderosa Pine	Redwood County Lac Qui Parle, Waseca, Redwood Counties
Canker Diseases of Hybrid Poplars	Souixland and Robusta Poplar	Southern Region
Rhizosphaera needle cast *Rhizosphaera kalkhoffi* (Bud.)	Colorado Blue Spruce	Meeker, Waseca, Brown and Watonwan Counties

Insects	Host Species	Region/Counties
Cankerworm *Paleacrita* spp.	Several Species	South-central Region
Eastern Tent Caterpillar *Malacosoma americanum* (Fabricius)	*Prunus* sp.	Southern Region
Spruce spider mite *Oligonychus ununguis* (Jacobi)	Black Hills and Colorado Blue Spruce	South-central Region Steele County

TABLE 15

MINOR PEST PROBLEMS OF SHELTERBELT SPECIES

Diseases	Host Species	Region/Counties
Anthracnose *Gloeosporium* spp.	Ash	Brown & Redwood Counties
Gnomonia spp.	Oak	Steele County
Verticillium Wilt *Verticillium albo-strum* (Reinke and Berth)	Russian Olive	Olmsted County
Fire Blight *Erwinia amylovora* (Burr.)	Apple	Watonwan County

Insects	Host Species	Region/Counties
Fall Webworm *Hyphantria cunea* (Drury)	Deciduous trees	South-central Region Brown County
Ash Flower Gall Mite *Eriophyes fraxinflora* (Felt)	Ash	Waseca, Lincoln, & Martin Counties
Ash Plant Bug *Tropidosteples amoenus* (Reuter)	Ash	Southern Region
Ash Borer *Podesia syringae fraxini* (Lugger)	Ash	Lincoln County

Other	Host Species	Region/Counties
Herbicide Injury	Spruce & Ash Ash Caragana	Freeborn County Lyon County Kandihoyi County
Animal Injury (Rabbits)	Hackberry	Southern Region

Weed Control

Weed competition was the major limiting factor in the establishment and growth of shelterbelt plantings in Minnesota. However, species selection, pruning, and spacing must also be considered.

Species Selection

Comments will be directed to major species used in Minnesota as follows:

A. Deciduous Trees

Green ash is probably the best suited tree available at this time without major pest problems. Hackberry is becoming more frequently used and is apparently as well suited as green ash for shelterbelt use. It is also relatively free of pest problems. Silver maple is well suited and has no major problems associated with it; however, eventually the tree may require more room in the grove than it has been allowed at current spacings. If a hybrid poplar is needed for fast, short term wind protection, then Norway would be the best choice. Butternut should not be used as it is highly susceptible to a canker disease.

B. Conifers

Ponderosa pine is planted widely in the southwest and does well once established. It is susceptible to Dothistroma needle cast. Austrian pine is highly susceptible to Dothistroma needle cast and should not be used unless a resistant seed source can be obtained.

White pine grows well in southern Minnesota and in this Region is less susceptible to white pine blister rust. Care should be taken to locate white pine on the leeward side of the grove as it is susceptible to winter injury. Other conifers should be considered over Scots pine since this species is susceptible to Brownspot needle blight and Lophodermium needle cast, both of which would require chemical sprays to control once they become established.

Black Hills, white, and Norway spruce have good growth rates and few major problems associated with them. Norway is

susceptible to Cytospora canker disease but to a lesser extent than Colorado blue spruce. Colorado blue spruce should not be used unless a resistant seed source can be obtained.

Pruning

Pruning can be utilized to eliminate multiple stems (when this characteristic is undesirable), correcting for poor branching, removal of damaged branches, and control of insect and disease problems.

Spacing

An estimate of the final spacing to achieve for trees would be a minimum of 18 to 20 feet or more, depending on the species. Species planted on eight, nine, and ten-foot spacings and held over time will eventually begin to compete for available soil moisture. Tree vigor and growth will be reduced, making them more susceptible to insects and diseases. Thinnings should be planned for at these close spacings.

The spacing of small trees and shrubs will have less impact on the grove in the long run, but presents some important problems in the short run. One problem affecting the growth and development of small trees is the location and density of the outside single or double row of honeysuckle or any other shrub planted as a snow catch. Russian olive, when planted short distances away from a single or double row of honeysuckle, will likely suffer breakage three or four years after establishment, due to the heavy accumulation of snow adjacent to the now dense snow catch.

Ways to avoid this problem include: locating the snow catch 50 feet away from the grove and utilize the space in between as crop land; maintain a less dense snow catch adjacent to the grove by thinning and allowing the snow cover to be distributed more uniformly and at a gradually decreasing depth across the grove; plant the Russian olive one year ahead of the honeysuckle allowing it to stay above the snow pack.

Effectiveness of Sodium Trichloroaceticacid (Sodium TCA) in Controlling Dwarf Mistletoe of Black Spruce

This study began in July of 1979 and was described in the 1979 Forest Insect and Disease Report of the Minnesota DNR Division of Forestry. The report included a description of the areas treated, reasons for the study, method, rate and cost of herbicide application, and the results of the water monitoring. The final data were collected from the sites in 1980 and a summary of the results are presented below. The study was divided into two parts: (1) effects of Sodium TCA on residual black spruce on the harvested areas of the sites, and (2) effects of Sodium TCA on black spruce on unproductive areas bordering the harvested areas.

A detailed report on part one titled, "Control of Dwarf Mistletoe on Black Spruce with the Herbicide Sodium TCA", was written by F.A. Baker and D.W. French of the University of Minnesota. Data used below, but not the recommendations, were taken from their paper. A detailed report on part two titled, "Effectiveness of Sodium TCA in Protecting Black Spruce Sites from Invasion by Dwarf Mistletoe from Unproductive Edges", was written by M.A. Albers, Minnesota DNR. Data used in this paper were taken from the report.

Part One - Effects of Sodium TCA on Residual Black Spruce on the Harvested Areas of the Sites

University personnel established plots and collected data on the harvested areas of the sites before spraying. Data were collected on these plots eleven months after spraying to determine the effectiveness of the spraying. Data were also collected on the number of brush and hardwood stems. Presence and abundance of Labrador tea *(Ledum groenlandicum)*, leatherleaf *(Chamaedaphne calyculta)*, and bog laurel, percent grass coverage and percent moss coverage were also reported.

Populus tremuloides was completely eliminated by Sodium TCA. *Betula pumila* was injured by the herbicide, but survived. Sphagnum mosses were apparently not adversely affected. Grass coverage and abundance of Labrador tea and leatherleaf were greatly reduced by the herbicide.

The sites in this study averaged 400 mistletoe-infected stems per

acre before spraying. Of these, 219 stems per acre were greater than five feet in height. The stems taller than five feet in height were on acres sold and/or harvested before the Division began to include a provision in timber sales to require operators to kill all trees larger than five feet in height. This was during 1976.

Eleven months after spraying, all black spruce were dead on the plots established on the International Falls site. However, only 50 percent of the spruce were killed on the Big Falls site and 75 percent were killed on the Pine Island Site. Percentage kill on the sample plots varied from 24 to 100. An average of 133 infected trees per acre survived on these three sites 11 months after spraying.

Clumping of trees, where one tree shielded another from the herbicide spray, was believed to have been partially responsible for so many trees surviving. Skips in spray coverage probably also played a role.

Part Two - Effects of Sodium TCA on Black Spruce on Unproductive Areas Bordering the Harvested Areas

To avoid placement of sample plots in spray coverage skip areas, plots were established on the unproductive areas, bordering the harvested areas of the three sites. Two months after Sodium TCA was applied, vegetation showed symptoms of herbicide damage but the black spruce had not yet died. Plots were then established and data collected so that unsprayed skip areas were avoided. Plots were revisited one year after establishment and data were collected to determine the effectiveness of spraying.

At the time of initial plot establishment, the three sites had an average of 736 black spruce stems per acre. An average of 134 stems per acre were infected with dwarf mistletoe. Tree size varied from seedlings to trees eight inches in diameter. Basal area on the plots varied from ten to 100 square feet, averaging 30 square feet.

Fourteen months after spraying, 65 percent of the black spruce on the plots on the Big Falls site were dead. On the Pine Island site, 84 percent of the black spruce were killed, and on the International Falls site 44 percent of the spruce were killed. Percentage kill on the sample plots varied from 0 to 100. An average of 52 mistletoe

infected black spruce stems per acre survived on these three sites 14 months after spraying. The herbicide killed a greater proportion of the smaller trees than large trees. Eighty-eight percent of the trees less than six feet in height were killed while 57 percent of the trees greater than or equal to six feet in height were killed.

Conclusions and Recommendations

When a black spruce stand infected with dwarf mistletoe is harvested, it is important to kill as many of the infected trees on the harvested area and within a one to two chain area surrounding the harvested area as possible. If many infected stems are left alive, the harvest at the end of the next rotation will be greatly reduced, and in fact, a merchantable stand may never develop.

Research at the University of Minnesota has shown that a dwarf mistletoe pocket in a black spruce stand expands at an average rate of 4.8 feet in diameter per year.[1] Research has also indicated that most black spruce will die within 16 years of infection.[2] Once dwarf mistletoe becomes established in an area, it will continue to be a problem unless some action is taken to eradicate it. Where dwarf mistletoe has existed in an infection pocket for more than 15 or 20 years, merchantable volume in the pocket is likely to be very low at best.

Treatment with Sodium TCA left an average of 133 infected trees per acre on the harvested areas of the sites and an average of 52 infected trees per acre in the two chain wide strip of unmerchantable spruce bordering the cut-over areas. The data on the rate of spread of mistletoe and on the mortality of infected trees indicates that leaving this many infected seedlings per acre would likely prevent a merchantable stand from developing.

It appears that Sodium TCA would only be an effective control on sites where there was no clumping of trees, no overstory trees or brush and only if spray coverage was complete. Any recommendations to use Sodium TCA would have to include very specific guidelines dealing with all factors which cause variable results in control.

The Minnesota DNR does not recommend the use of Sodium TCA for control of dwarf mistletoe on cut-over areas or in unmerchantable spruce

bordering cut-over areas on a routine basis.

(1) Hudler, G.W. 1973. Seed dispersal and spread of the eastern dwarf mistletoe *Arceuthobium pusillium* Peck. M.S. thesis, University of Minnesota, St. Paul 49 pp.

(2) Baker, F.A. and French, D.W. 1980. Spread of *Arceuthobium pusillium*, and rates of infection and mortality in dwarf mistletoe infected black spruce stands. In press.

Spruce Budworm

(A) Estimation of Timber Mortality Caused by the Spruce Budworm in Minnesota

The Minnesota DNR in cooperation with the USFS-State and Private Forestry, conducted a survey in an effort to determine an economical and accurate method to assess losses of commercial timber due to spruce budworm defoliation in 1979-80.

In the aerial survey flown in July, all stands 12 acres and larger in size with noticeable defoliation were type-mapped and rated for defoliation. A total of 19,972 acres were rated as heavily defoliated.

Based on probability proportional to size (Lund, 1978) 16 of the heavily defoliated stands on state, county and private lands were selected for loss assessment. The plots were located in southeastern St. Louis and southwestern Lake Counties. Because only stands 12 acres and larger in size were included in the calculations, the volume loss and stumpage loss have been underestimated. Data were collected on merchantable balsam fir and white spruce. To be classified merchantable, a tree had to be more than five inches DBH and contain at least one 8-foot stick. Balsam fir was considered merchantable to a four-inch top and white spruce to a three-inch top. A ten BAF prism or angle gauge was used to determine spruce and fir strees counted as live, dead or risk. A tree was recorded as risk if it was likely to die within one or two years. A tree was recorded as dead if it had brown cambium on at least two faces, most of the bark was intact, and the fine twigs still remained in the crown.

It was difficult to accurately estimate the length of time a tree had been dead. Therefore, the volume and stumpage loss figures are

presented as the best estimate available for a one-year period but may include timber dead for slightly more than one year. The results of this survey are tabulated below.

Mean Volume	Cds/Ac Fir	Spruce	Spruce & Fir
Dead	1.8	0.1	1.9
Risk	4.0	0.1	4.1
Live	5.8	3.9	9.7
Totals	11.6	4.1	15.7

Total estimated merchantable volume loss of spruce and fir was equal to 37,947 cords (1.9 cds/ac dead x 19,972 acres rated as heavily defoliated).

Total dollar loss:*

Spruce	27,961.00
Fir	142,001.00
	169,962.00

*Based on Minnesota DNR stumpage rates of $14.00 per cord (spruce) and $3.95 per cord fir pulpwood.

(B) Field Test of the Synthetic Spruce Budworm Pheromone, Fulure, for Detecting Low Level Populations

The Minnesota DNR cooperated on a Canada/United States Spruce Budworms Project (CANUSA) to test fulure, the synthetic sex lure (pheromone) of the spruce budworm female. The objectives of the field test were to determine the degree of correlation of the following factors: (1) low-level late larval spruce budworm populations, (2) defoliation levels of spruce and fir, and (3) numbers of male moths caught in the pheromone traps.

Two spruce-fir stands in the Fond Du Lac State Forest were selected for this test because of their low budworm populations. Stand one was in STR 11&14, 49-19, and stand two was in STR 7, 49-18 of Carlton County.

Larval populations were determined during the second week of June by taking one 18-inch branch sample from the middle one-third of each tree crown. Enough trees were sampled in each stand to provide an estimate of larval populations with a standard error within 20 percent of

the mean (120 trees in stand one, and 26 trees in stand two were sampled). Stand one averaged 0.30 larvae per branch sample and stand two averaged 0.31.

Pheromone traps (Pherocon ICP) were used in this test. Each trap was baited with the lure, fulure, which was incorporated into PVC cylindrical pellets measuring 4mm x 10mm. In each stand, two groups of five traps were deployed, one group baited with 0.03 percent and the other baited with 0.0003 percent synthetic lure by weight. Traps were placed in the stands on June 20 and collected August 4.

Numbers of Budworm Moths Caught in the Traps

Stand 1	0.03%	lure average = 52 moths per trap
	0.0003%	lure average = 49 moths per trap
Stand 2	0.03%	lure average = 51 moths per trap
	0.0003$	lure average = 54 moths per trap

This trapping study did not produce the expected results. A trap is considered filled up with moths if 50 to 70 moths are caught. The traps in both stands and at both concentrations of the lure were essentially filled up with moths. Because of this, no correlation could be drawn between trap catches, defoliation and larval populations. Other agencies cooperating on this project had similar results. CANUSA does not plan to do additional field trials at this time because of the poor results.

Diplodia Tip Blight Studies

(A) A Study to Develop Chemical Control for Diplodia Tip Blight in the Nurseries

Diplodia continues to be a problem in scattered nurseries in the Lake States. In 1979, the North Central Forest Experiment Station (NCFES) began a study in General Andrews State Nursery at Willow River, Minnesota, and in several Wisconsin nurseries to determine the effectiveness of several chemicals in preventing infection of nursery stock by *Diplodia pinea*. Due to a lack of Diplodia infection in General Andrews State Nursery, the study was discontinued in Minnesota. The study has been continued in Wisconsin where it continues to be a problem in scattered nurseries.

North Central Forest Experiment Station reports that Benomyl has given good control and was the most effective chemical tested. Testing of Benomyl and additional chemicals will continue in Wisconsin in 1981 to gether enough data to obtain registration of a chemical for control of Diplodia in nurseries. NCFES will issure a progress report on this work in the spring of 1981 for anyone wishing more information.

(B) Study on the Growth and Survival of *Diplodia pinea* Infected Red Pine seedlings after Outplanting

In 1979, Diplodia-infected and healthy 3-0 red pine seedlings from General Andrews State Nursery were planted on two sites (STR 11, 49-19 and STR 16, 49-19) in the Fond Du Lac State Forest in Carlton County. Seventy infected and 70 healthy seedlings were planted on each site. The average height of the healthy seedlings at the time of planting was 8.7 inches, while the infected seedlings averaged 7.7 inches. The location of the Diplodia infection, terminal leader or side branch, was also recorded at the time of planting. Height growth and survival of healthy and infected seedlings were to be compared after one and two years to determine if Diplodia infection caused significant damage to seedlings after outplanting.

Rabbit damage and planting failure were very high in both plantings. In Section 11, rabbits damaged 73 seedlings, usually by cutting the tops off. Ninety-one seedlings died in this planting. In Section 16, rabbits damaged 67 seedlings and 81 seedlings died.

In Sections 11, 70 percent of the trees infected with Diplodia died, while 62 percent of the non-infected trees died. In Section 16, 70 percent of the infected trees died, while only 41 percent of the non-infected trees died.

Because of the heavy rabbit damage and planting failure, no conclusions can be drawn. Only 22 of the live seedlings on both sites suffered no rabbit damage and this is not a large enough population to work with; therefore, this study will not be continued.

Yellow-headed Spruce Sawfly Project

The objective of this project was to determine the relationship

between release of white spruce and the rate of defoliation by the yellow-headed spruce sawfly.

The yellow-headed spruce sawfly is a major pest of white spruce plantations. More damage has been observed in open-grown situations than when there has been an over-topping canopy. Because of this, there has been some question as to releasing these trees before they reach a height of ten to 12 feet.

To study the effects of release, two plantations were selected in the Jacobson District (Aitkin County). Part of each plantation was released from competing aspen and the rest left. Growth and amount of defoliation will be compared between the released and un-released portions.