THE IMPACT OF INSECTS AND DISEASES ON THE FORESTS OF ONTARIO

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ABSTRACT

Annual losses experienced by Ontario forests for the period 1977-1981 are presented for Ontario as a provincial summary, as regional reports for five of the administrative regions, and as a combined report for the three administrative regions in southern Ontario. An annual average loss of 46,766,000 m^3 gross total volume occurred in the five-year period. Most of this loss, i.e., 33,573,000 m^3, occurred as tree mortality, 9,062,000 m^3 was caused by wood decay, and the remaining 4,131,000 m^3 was lost growth. The data are presented by pest agent for the various host tree species. Wood decay, root rots, defoliation by spruce budworm, and Hypoxylon canker caused the greatest losses. Regions affected by the massive spruce budworm infestation experienced total losses that were about equivalent to forest growth for the period.

RÉSUMÉ

Les pertes annuelles causées par les insectes et les maladies dans les forêts de l'Ontario au cours de la période 1977 à 1981 sont présentées: un sommaire pour la province entière, des rapports régionaux pour cinq des régions administratives et un rapport commun pour trois régions administratives du sud de l'Ontario. Des pertes annuelles moyennes de 46,766,000 m^3 (volume total brut) ont été enregistrées au cours de la période. La majorité de ces pertes, soit 33,573,000 m^3, sont dues à la mortalité des arbres; un volume de 9,062,000 m^3 représente du bois de rebut atteint de pourriture; le reste des pertes, soit 4,131,000 m^3, constituent la croissance perdue. Les données sont présentées par ravageur pour les diverses espèces d'arbres hôtes. Les caries, les pourridiés, la défoliation par la tordeuse des bourgeons de l'épinette et le chancre Hypoxylonien ont causé les pertes les plus lourdes. Les régions frappées par une infestation massive de la tordeuse des bourgeons de l'épinette ont subi au total des pertes à peu près équivalentes au volume de la croissance forestière pour la période.

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TABLE OF CONTENTS

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TABLE OF CONTENTS (cont'd)

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TABLE OF CONTENTS (cont'd)

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TABLE OF CONTENTS (cont'd)

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TABLE OF CONTENTS (concl'd)

Cover photo: Extensive mortality in a spruce-fir stand caused by spruce budworm. Budworm caused an average loss of almost 12 million m^3 annually during the period of review, 1977-1981.

INTRODUCTION

Insects and diseases[1] cause considerable destruction of timber in our forests. The current spruce budworm infestation in eastern Canada is causing extensive mortality and loss of growth. Large areas with dead and dying fir and spruce testify to the magnitude of this drain on our wood supply. Losses caused by wood decay fungi are evident as rotten culls when forests are harvested.

In 1982, the Forest Insect and Disease Survey (FIDS) units of the Canadian Forestry Service (CFS) conducted a nationwide assessment of the impact of insects and diseases on the forest resources of Canada for the 5-year period 1977-1981. The results of this effort were summarized by Sterner and Davidson (1982) in the 1981 FIDS Annual Report. Canada experienced an annual average volume loss of 107 million m^3 to pests. Spruce budworm and wood decay were the most destructive pests, causing losses of 44 and 25 million m^3, respectively. The pest-caused depletion was equivalent to two-thirds of the volume of wood harvested in the same period, an indication that pests were destroying the forest at levels approaching the rate at which we utilize it. In a similar study (Anon. 1979), losses were estimated at 88 million m^3 for the year 1976.

Data for the 1977-1981 pest assessment exercise were compiled for Ontario Ministry of Natural Resources (OMNR) administrative regions. The regions constituted working areas of a convenient size in relation to the Ontario Forest Resource Inventory (OFRI), which was the source of the forest statistics used as a data base. Loss estimates are presented herein for the entire province, the Northwestern (NW), North Central (NC), Northern (N), Northeastern (NE) and Algonquin (AL) regions and the combined Central, Eastern, and Southwestern (C-E-SW) regions.

Before submission for the national compilation, the Ontario loss estimates were reviewed with OMNR personnel at a series of meetings that ultimately led to consideration by the Canada-Ontario Joint Forestry Research Committee (COJFRC) working group concerned with pest-caused depletions. Consideration by the working group led to the recommendation to publish these data as a means of determining the types of pest-loss data that are useful to forest managers. Plans are being formulated for estimating losses due to pests for the next 5-year period, 1982-1986. Improved inventory data and better estimators of such losses can be expected to provide a more comprehensive analysis. Readers interested in different or additional data on losses are urged to contact the author.

It is important to read the section entitled "Perspectives on Losses Due to Pests" before attempting to interpret the loss data contained herein. This reading is necessary if one is to gain an impression of the kinds of losses included in or omitted from the report. Also, some knowledge about the nature of certain losses is needed to interpret them with respect to other forest statistics. Some losses represent a depletion of inventoried volumes, whereas others are a projection of volumes that failed to accrue because of pest activity. Such volumes never appear in conventional inventories.

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[1] A glossary of scientific nomenclature is included in the **APPENDIX**. Consequently, this nomenclature has not been incorporated into the text.

Perspectives on Losses Due to Pests

The analysis and reporting of pest-caused losses are influenced by the expected uses of the data and often by personal attitudes about what constitutes damage. There are differences in the methods used to compile estimates, the kinds of pests included, and the forms of loss contained in reports. In this section an attempt is made to rationalize the approach taken throughout this report.

Whitney et al. (1983) discuss the type of disease impact data needed by foresters and the problems of gathering and interpreting these data. In many respects, the problems are the same as those listed by Brown (1940) in the first comprehensive report of forest insect damage in Canada. Forest statistics need to be interpreted as host content for pests, with loss estimators applied to this content on the basis of information available on the extent and intensity of pest activity. The expanse and diversity of the forest resource and pest activity within the forest almost preclude precise estimates of losses due to pests. This report is an attempt to estimate losses on the basis of current knowledge about the forest and the pests. Frequently, assumptions and predictions had to be made about items such as host tree content and volumes susceptible to pests.

Comparability of Reports on Losses

This report, like most others, features a total estimate of losses attributable to all insects and diseases. However, total loss estimates are rarely possible except for small areas or specific situations. The information necessary for estimating certain kinds of losses attributable to several important pests simply does not exist. Consequently, some description of the approach taken in this report is necessary.

Comparisons of pest reports need to be made with caution. For example, the data contained herein were submitted for inclusion in the nationwide pest assessment (Sterner and Davidson 1982) mentioned previously. That report noted a total annual disease-caused loss of 44,900,000 m^3 for Canada for the period 1977-1981. In the present report, a loss of 31,273,000 m^3 is reported for Ontario. Direct comparison of the two reports implies that the forests of Ontario are especially prone to disease-caused damage. However, losses of 11,853,000 m^3 caused by root rot in Ontario reported herein are not contained in the nationwide assessment by Sterner and Davidson (1982), as not all reporting units estimated root rot loss. This and other differences prevent presentation of this report as the Ontario portion of the nationwide situation.

Losses in Relation to Other Forest Statistics

The magnitude of the pest-caused losses reported herein is impressive (see Table 5). The 46,766,000 m^3 gross total volume of timber lost annually in Ontario is greater than half the current annual growth increment (CAI), and about the same as the annual rate of timber harvest for the period 1977-1981, if harvested volumes, which are usually reported in units of net merchantable volume, are adjusted to reflect gross total volumes. Also, the harvested timber had commercial value, but because some of the pest-caused loss occurred to species being utilized well below available supply, the economic impact of a considerable portion of the losses reported was slight. Similarly, losses occurred to a variety of tree species with a range in relative timber value and product potential. For example, a loss of 3,803,000 m^3 occurred for white birch but only about 80,000 m^3 were harvested; therefore, the value of the loss is low because the timber is not being utilized. No attempt was made to include an economic analysis. Since the data are expected to be interpreted by people with diverse backgrounds, timber drain caused by pests was considered a loss. Timber values and demand change. Poplar utilization, for example, almost doubled during the period 1977-1981.

Pest damage is treated in this report as loss, to keep loss statistics fairly basic. The loss can be depletion of timber that is present or is expected to appear on inventory, or it can be the type that probably would not affect inventory volumes. For example, root rots produce stand conditions that we accept as characteristic of the natural forest. The affected stands have less than optimal density, and the trees can have poor growth. Most losses caused by rots are never picked up by the inventory.

The concept of a pest-free ecosystem needs to be considered if we are to appreciate fully the magnitude of pest-caused losses. Such a forest would be vastly more productive than the natural system because of enhanced growth rates and better stocked stands. Also, stands would remain productive over a greater period of time as site conditions would become the only limiting factor. Stem decay, root rot, bark beetles, and other pests that gain prominence as stands mature would not exist.

The pest-free concept is idealistic, but it is a necessary starting point for pest appraisal. In reality, the analysis requires an interpretation of the pest-affected natural forest to get an impression of what could be present if pests were excluded. With this approach, the loss estimates contained in this report are conservative. Later discussion will show that certain kinds of loss, particularly forms of growth loss, could not be measured for many important pests, and therefore these were excluded.

For planning purposes and inventory adjustment, losses estimated herein should be interpreted in relation to inventory volumes and projection. All insect-caused mortality (12,482,000 m^3) and disease-caused cull (9,062,000 m^3) depleted inventoried volumes. These volumes were killed or became rotten. Most of the growth loss caused by insects and diseases (4,130,000 m^3) was a reduction in the volume of growth (CAI) predicted by the inventory. Most disease-caused mortality (21,091,000 m^3), however, was a volume loss that probably never appeared on inventory. Affected stands, when sampled, had a volume of dead timber that resulted from disease activity. Without question, this timber represents a volume loss, but the loss should not be applied as an inventory adjustment. Inventory methods for Ontario (Anon. 1978) record this mortality as reduced stocking; affected stands would have been better stocked if root rots had been absent. By contrast, most insect-caused mortality is of a catastrophic nature, affecting an inventoried volume that will be only partly salvaged or completely lost.

Pest-caused Losses Not Contained in the Data

Abiotic conditions, such as drought, unusually cold weather, windstorms and pollution, cause losses in the forest. In this report, direct losses caused by these conditions are ignored. However, these are often stress factors that contribute to pest activity, especially to the dieback and decline disease syndromes that affect many broadleaved species.

The total growth loss estimate of 4,130,000 m^3 should be doubled at least. Growth loss estimates for a number of important pests and for other kinds of loss were not included in this report. White pine weevil is an example of an important pest that causes distortion of pine stems and can render entire plantations valueless. Most of this additional growth loss is of a type that is not measured by inventory. Similarly, pests that affect immature trees and seedlings were not included in the analysis. Although the trees are small and have negligible volume, pests that affect them cause growth loss. For example, there would be many more white pines present in Ontario if white pine blister rust did not occur. Growth lost by small trees, regeneration failures, and reduced stocking caused by mortality are important forms of loss. Growth losses increase the time span required to reach harvestable size regardless of tree size when the reduced growth occurred. Also, mortality at an early age can cause reduced stocking throughout the life of a stand. Important pests that affect mainly immature trees are: Scleroderris canker, root weevils, damping off diseases, white pine blister rust, other stem rusts, and root rots. For these pests, damage appraisals normally include only the percentage of trees affected or killed. Information about the influence of stocking is also needed to estimate loss.

Growth loss experienced at any time has a long-term influence on future growth. Current growth loss will result in smaller trees. Future growth accrues on a smaller base. The lost growth simplistically results in an additional time requirement for reaching economic maturity. Mean annual increment over the life of the stand is reduced, and this type of loss applies to stands of all sizes.

Growth loss also occurs when trees die. New growing stock eventually achieves the growth rate of the previous trees, but considerable growth is lost in the interim. For some pests such as spruce budworm, this type of loss was estimated as a function of the growth expected in unaffected stands. Most disease-caused mortality resulted in reduced stocking, but the influence is difficult to quantify because growth rate under pest-free conditions is not known. During the period under consideration, an estimated 21,091,000 m^3 of timber were killed annually by diseases and this certainly caused gaps in the growing stock. However, growth loss data for diseases in this report include only loss experienced by trees that continue to live. The loss of 1,088,000 m^3 caused by root rots occurred to living trees with rotten root systems. In view of the magnitude of mortality caused by root rot and the area of stand openings represented by the mortality, growth loss could easily have been 2,000,000 m^3 higher. Similar losses seem appropriate for dieback diseases.

Growth is also lost when growing space is occupied by trees that have been rendered commercially valueless by pests. Growth occurs but is never utilized. Thus, wood decay fungi affect growth. Similarly, white pine weevil and other pests that distort trees to the point that they are no longer useful cause a loss. Data on the amount of space occupied by cull trees were not available. However, 1,000,000 ha seems a conservative estimate, and on the basis of the average mean annual increment for Ontario of 1.5 m^3 per ha (Bickerstaff et al. 1981), an additional pest loss of more than 1,500,000 m^3 could easily have been included in this report. The human tendency to bypass worthless material has, no doubt, contributed to this situation; however, pests are responsible for creating this worthless material.

Some pests of commercial-size trees are known to cause losses, but sufficient information to assess the magnitude of such losses was not available. Rather than assume a loss figure, I excluded these problems from the analysis. Root rot damage to broadleaved trees probably is a significant cause of loss. Root decay fungi often are associated with dieback and decline problems, and cull surveys show that these fungi are affecting many broadleaved tree species in Ontario. Some of the mortality reported for diebacks (see Table 5) was caused by root rots, but the total loss is not reflected in the data as the magnitude of this problem is unknown. Maple canker is an example of a problem for which the losses are known. Limited surveys indicate a loss of 48,000 m^3 in one district, but losses in some districts are negligible (Gross 1984). Hence, maple canker probably is a significant cause of loss but additional surveys are necessary to gauge the problem throughout the range of maple.

Factors That Could Have Inflated Loss Estimates

Throughout the analysis, an effort was made to exclude losses caused by other factors (including other pests) from impact estimates for a specific pest. However, loss data contained herein probably do include a volume that would have been lost regardless of pest influence. Sites free of a particular pest are often large distances from an infestation, and data to characterize the uninfested forest rarely exist. For example, plot data were available for estimating the percentage of dead spruce and fir in stands with various histories of spruce budworm activity. It was assumed that all of this mortality was caused by budworm defoliation; however, competition and other pests could have caused part of the loss. Ontario does not have a continuous forest inventory system in place; hence, normal mortality rates are not known. According to routine observations by FIDS staff, however, unaffected forests experienced minor mortality.

METHODS

Inventory

The forest statistics used as a data base for this exercise were taken mostly from the OFRI. Although that inventory was completed for only about 80% of the province, it was preferred to the previous inventory, *The Forest Resources of Ontario* (Dixon 1963), as it included more recent and comprehensive forest growth data. The data base actually used was a composite of both inventories, and it is referred to in this report as the Ontario Host Forest Inventory (OHFI). Usually data from the OFRI inventory were extrapolated to completion on the basis of averages for the appropriate items in completed portions. Some statistics for locations where much of the OFRI inventory was incomplete were taken directly from the Dixon (ibid.) report.

Regional sections of this report feature portions of the OHFI because the forest statistics contained in it, and used for estimating pest-caused losses, cannot be documented elsewhere.

The area considered currently exploitable for the OHFI (Fig. 1) includes some of the area considered potentially exploitable by Dixon (ibid.). OFRI inventory data were available for much of this area and timber is being harvested in some parts. Hence, the inclusion seemed logical.

The OHFI is compared to the Dixon (ibid.) inventory in Table 1. The total gross standing volume for all species determined for the OHFI is about 23% greater than the volume reported by Dixon. Most of the difference (81%) occurs for the volume of black spruce which is 839,334,000 m^3 higher for the OHFI. Black spruce occurs mostly in the NW, NC, and N regions where the OFRI was more than 75% complete. Therefore, the higher OHFI volume seemed justified. It is interesting that gross volume estimates for all boreal species are somewhat higher for the OHFI than for the Dixon inventory. CAI data are not in the Dixon inventory but annual allowable cut data are. The two parameters are somewhat comparable, and the two inventories show good agreement (Table 1).

Pest-caused growth losses were calculated to be proportional to current annual icrement (CAI). Bickerstaff et al. (1981) estimated a mean annual increment (MAI) for all of Ontario and all tree species of 85,186,000 m^3, and they provided estimates by forest region and forest section (Rowe 1972). CAI and MAI totals are similar for large forested tracts. If allowance is made for volume growth in portions of Ontario currently rated not exploitable (Fig. 1), then there is good agreement for the total CAI estimated for OHFI in comparison with the MAI estimate reported by Bickerstaff et al. (1981) and shown in Table 1.

Since the completion of this pest assessment, another inventory of Ontario forest resources became available as Canada's Forest Inventory 1981 (Bonnor 1982). This inventory features gross merchantable volume which, for Ontario, is based on a minimum inside-bark diameter of 10.2 cm. Data from that inventory are compared with data from the OHFI and from Dixon (1963) in Table 2. The volumes presented are in relative agreement if consideration is given to the difference between gross merchantable and gross total volume. Volumes in stumps, tree tops, and trees below merchantable size do not qualify as merchantable volume. With respect to inventory, considerable total volume is present in young stands that have little or no merchantable volume.

Gross total volume data were preferred because all stands are included, not only stands with trees of merchantable size. Although gross merchantable volume data are now available in the Canadian Forest Inventory (Bonnor 1982), data are presented for groups of species that often include both host and non-

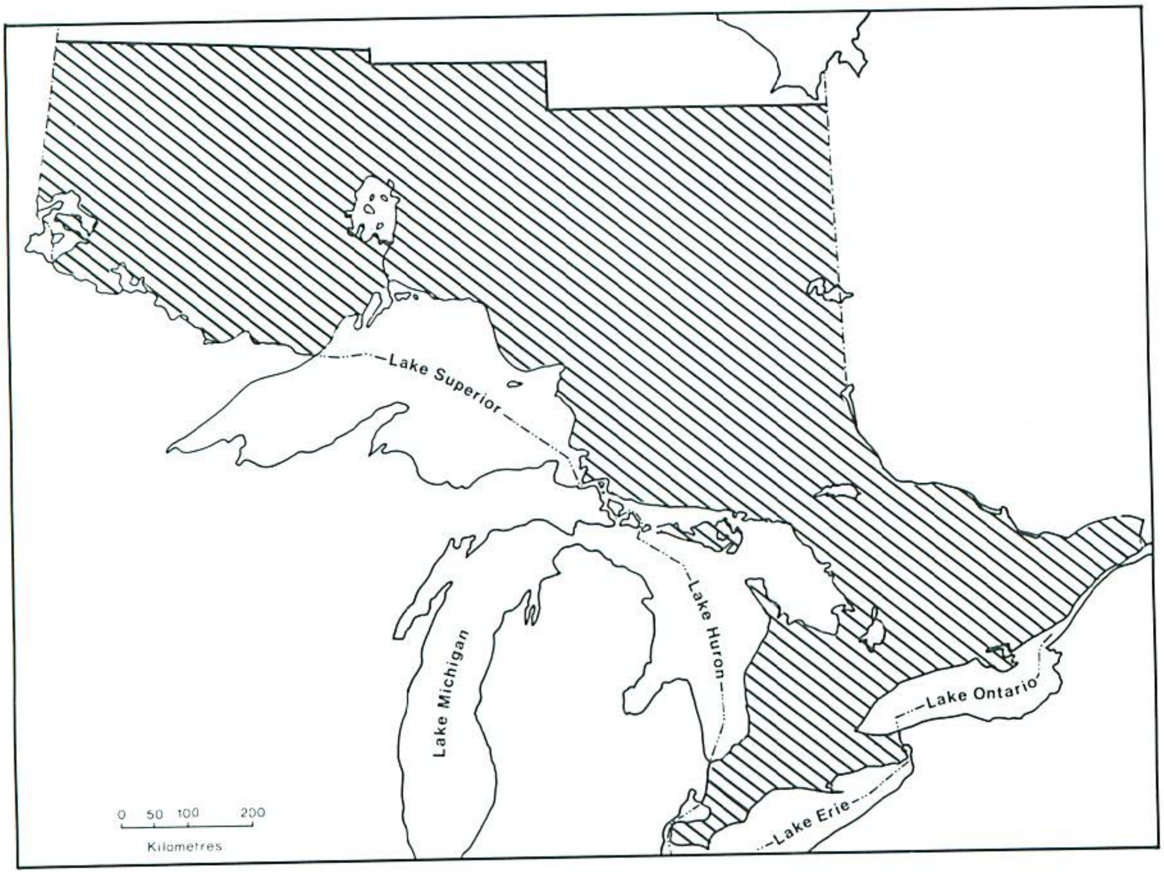


Figure 1. Area of Ontario currently containing exploitable forest.

host species in the same group. Hence, host merchantable volumes would be difficult to extract.

Productive forest: Productive forest, defined as the proportion of total land area producing commercial forest, was estimated for each region from land classification data in the Dixon (1963) report. There has been a considerable number of boundary changes since 1963, and estimates were based on the unweighted arithmetic average for all of the forest districts, as constituted in 1963, that were currently represented in a region. Estimates of productive forest area based on extrapolation of the OFRI were unrealistically high, probably because well forested areas were inventoried before areas of high agricultural use. Therefore, they were not used.

Total gross standing volume: Most volume estimates were based on the arithmetic average volume for the completed management units (MU) of the OFRI in each region. For the C-E-SW regions, volume estimates were those reported by Dixon (ibid.). In that instance, data for only a few MUs were available and average data from the OFRI generated unrealistic estimates.

Table 1. Forest statistics[a] for the Ontario host forest inventory (OHFI) used as a data base for estimating pest losses, and comparable data from the Dixon (1963) inventory.

Tree species	Volume of primary growing stock[b] (m^3)	Gross total volume (OHFI) (m^3)	Allowable cut[c] (m^3)	Current annual increment (OHFI) (m^3)
Red pine	31,756,000	26,400,000	484,000	231,000
Jack pine	569,864,000	693,299,000	12,169,000	11,457,000
White pine	110,343,000	104,770,000	1,302,000	1,262,000
Black spruce	1,253,459,000	2,092,793,000	16,234,000	22,019,000
White spruce	223,675,000	137,461,000	3,331,000	1,362,000
Balsam fir	266,871,000	323,952,000	4,506,000	5,600,000
Cedar	85,492,000	78,326,000	808,000	513,000
Larch	5,742,000	16,835,000	94,000	109,000
Hemlock	39,916,000	50,230,000	295,000	429,000
Other conifers	68,000	176,000	22,000	1,000
Conifer total	2,587,186,000	3,524,242,000	39,245,000	42,983,000
Poplar	795,223,000	927,535,000	23,856,000	21,833,000
White birch	459,167,000	491,142,000	8,361,000	4,836,000
Yellow birch	118,532,000	40,990,000	1,426,000	695,000
Hard maple	181,415,000	200,034,000	2,078,000	3,040,000
Red maple	24,518,000	31,921,000	808,000	555,000
Ash	17,550,000	14,207,000	238,000	118,000
Red oak	13,276,000	15,474,000	194,000	330,000
White oak	1,592,000	1,613,000	19,000	2,000
Elm	30,302,000	28,180,000	489,000	107,000
Basswood	10,817,000	9,008,000	268,000	54,000
Beech	17,833,000	15,182,000	178,000	318,000
Cherry	2,507,000	2,034,000	34,000	46,000
Other hardwoods	6,962,000	5,102,000	147,000	27,000
Hardwood total	1,679,694,000	1,782,422,000	38,096,000	31,961,000
Total, all species	4,266,880,000	5,306,664,000	77,341,000	74,944,000

[a]Data are expressed as gross total volume
[b]Dixon 1963, Table 5
[c]Dixon 1963, Table 6

Note:

Total administrative land area	96,818,000 ha
Current exploitable land area	55,976,000 ha
Productive forest area	43,606,000 ha

Table 2. Comparative inventory data for Ontario.

	Gross total volume (m^3)		Gross merchantable volume (m^3)
Tree species	The forest resources of Ontario (Dixon 1963)	Ontario host forest inventory (OHFI)	Canada's forest inventory 1981 (Bonnor 1982)
Pine	711,963,000	824,469,000	552,942,000
Spruce	1,477,134,000	2,230,254,000	1,292,347,000
Fir	266,871,000	323,952,000	157,323,000
Hemlock	39,916,000	50,230,000	11,547,000
Cedar	85,492,000	78,326,000	48,609,000
Other conifers	5,810,000	17,011,000	11,947,000
Conifer total	2,587,186,000	3,524,242,000	2,074,715,000
Aspen-poplar	795,223,000	927,535,000	609,265,000
Birch	577,699,000	532,132,000	337,313,000
Maple	205,933,000	231,955,000	138,801,000
Other hardwoods	100,839,000	90,800,000	37,503,000
Hardwood total	1,679,694,000	1,782,422,000	1,122,882,000
All species	4,266,880,000	5,306,664,000	3,197,598,000

Current annual increment: CAI estimates were the unweighted arithmetic average of CAI data for completed portions of MUs in the OFRI in each region. CAI for a particular species was the average for the appropriate working group (WG), and this CAI estimate was used for that species as it existed in all other WGs. For example, CAI for black spruce was the average for the spruce WG and this average was applied to black spruce growth in all WGs.

Pest Loss Estimates

Estimates were prepared for each pest in each OMNR administrative region as follows. First, OHFI data by WG were investigated to determine the proportion of the productive forest area that contained host stands. Host content within these stands was proportional to the host species content in a WG, on the basis of total gross standing volumes in a WG. Growth loss was estimated as a proportion of the CAI lost for host species in the host stands. Usually, mortality was rated as the percentage of gross standing volume that died.

The methodology used for estimating the loss caused by each pest is somewhat repetitive and a complete listing of methods would require considerable space. Methods are outlined for the spruce budworm as a model of the general approach used for other pests for which only summary descriptions are included.

Spruce budworm growth loss: Budworm defoliation histories, which stratified the total land area over which moderate-to-severe defoliation had occurred by the number of consecutive years of defoliation that took place, were prepared for each region. Growth loss caused by budworm was a function of: 1) the proportion of the total land area that was productive forest; 2) the proportion of the productive forest that contained host stands; 3) the proportion of the total volume in the host stands that was balsam fir, black spruce, or white spruce; 4) CAI for the appropriate host species; and 5) the appropriate reduction in the CAI based on the number of years of consecutive defoliation (see Table 3).

The host stand area that sustained impact from spruce budworm defoliation was estimated from OHFI data according to the following rationale. Some stands containing spruce and fir are not very susceptible to budworm attack, e.g., stands in which the density of host trees is low, pure stands of black spruce, and stands in which black spruce was associated mostly with jack pine or other nonhost species. The percentage of host stand content varied by WG. For the spruce WG, host stand area (Y_1) was based on the proportion of the gross total volume that was balsam fir (X_1), white spruce (X_2), and black spruce associated with balsam fir (X_3, estimated as the proportion of volume that was black spruce, multiplied by X_1) and the area of productive forest in the WG (Z_1):

$$Y_1 = (X_1 + X_2 + X_3) \times Z_1$$

X_3 seemed to provide the best estimate of the amount of black spruce likely to be affected by budworm. Black spruce growing in pure stands and in association with certain species such as jack pine does not experience much defoliation. This method weighs black spruce content in host stands on the basis of the amount expected to be associated with balsam fir.

All stands in the balsam fir WG were considered host stands. Stands in the jack pine WG were not included. Stands not in the spruce, jack pine, or balsam fir WGs were included as host stand areas (Y_2) if the WG contained more than 10% content of the host species balsam fir (X_1), white spruce (X_2), and black spruce associated with balsam fir (X_3). Then the estimate of host stand area was based on the area of productive forest in the WG (Z_1), the proportion of gross total volume that was composed of host species ($X_1 + X_2 + X_3$), and the assumption that half of the host volume was probably too diffuse to be attractive to budworm:

$$Y_2 = 0.5 \times (X_1 + X_2 + X_3) \times Z_1$$

Host species content in the host stands affected (as estimated above) was proportional to the host species volume in the respective WGs and the total volume of the WG. As was the case in calculations of host stand area, black spruce content in the spruce WG was proportional to the content of balsam fir in the group. Hence, for black spruce, both the area of host stands affected and host content in those stands were functions of the portion that was associated with balsam fir.

The impact of spruce budworm on growth loss was interpreted from data reported by Kulman (1971). Regression models were fitted to those data and the percentage growth reduction by number of years defoliated at the moderate-to-severe level of damage was determined for balsam fir, white spruce, and black spruce. The growth rate reductions are shown in Table 3.

Table 3. Growth rate reductions associated with spruce budworm defoliation.

Years of moderate-to-severe defoliation	Reduction in growth rate (%)	
	Black spruce or white spruce	Balsam fir
1	22	00
2	31	18
3	40	35
4	50	57
5	60	81
6	70	91
7	78	100

Spruce budworm mortality: Mortality caused by spruce budworm was based on data reported by Howse et al. (1980). The data show the percentage of standing volume that was dead in successive years following the detection of mortality in affected stands. The model was used to estimate balsam fir mortality (Table 4). For black spruce and white spruce, plot data were interpreted as the percentage of spruce dead in relation to the percentage of balsam fir dead on a plot. This transformation permitted linear regression analysis on the assumption that the shape of spruce mortality models was the same as that of the balsam fir model. Both black spruce and white spruce mortality had good correlation with balsam fir mortality ($r \geqslant .625$); the respective mortality rates are shown in Table 4.

Estimates of losses due to mortality were based on the total gross standing volume of the host species that was considered susceptible to budworm and on the proportion of land area mapped as experiencing mortality in proportion to total land area. Mapped land areas were stratified by the number of years that areas had experienced mortality, and appropriate mortality factors (Table 4) were applied. The volume of host species that was considered susceptible was determined as follows: All of the jack pine WG was considered non-host. For all other WGs, volumes of host species susceptible to budworm

Table 4. Percentage of volume loss based on the number of years that mortality caused by spruce budworm was present in a stand.

No. of years' mortality	Balsam fir	White spruce	Black spruce
1	5.0	0	0
2	20.0	0	0
3	35.7	8.1	4.8
4	52.5	15.5	9.7
5	75.0	26.6	16.2
6	82.5	30.2	18.3
7	90.0	33.9	20.5
8	95.0	36.4	22.2
9	97.0	37.3	22.5

included all of the white spruce and balsam fir and a volume of black spruce proportional to the content of balsam fir in the spruce WG as determined for growth loss calculations.

Forest tent caterpillar: Host stand was determined differently for the NW, NC and NO regions and the NE, AL, and C-E-SW regions. For the former group, all stands in the poplar and white birch WGs were considered host stands. Any other WG that had more than 10% poplar and white birch was considered to have a host stand area susceptible to defoliation that was proportional to half the content of poplar and white birch in the WG on the basis of gross standing volumes. For the NE, AL, and C-E-SW regions, all hardwood WGs were considered host stands and the conifer WGs were excluded. Host species content in a WG was the gross standing volume of poplar, white birch, yellow birch, sugar maple, ash, red oak, white oak, elm, basswood, beech, and black cherry, summed and divided by the total gross standing volume of the WG. Growth rate reductions were based on data from Rose (1958) and on plot data for sugar maple (Gross, unpublished data). Reductions were 0.75 for poplar, 0.43 for hard maple, and 0.40 for all other species. Rate reductions were applied to poplar and sugar maple whenever moderate-to-severe defoliation was present, and to other species after two consecutive years of moderate-to-severe defoliation.

Mortality loss data were accumulated by special surveys of areas experiencing mortality.

Other Insect Defoliators

In most instances the total land area affected was recorded by aerial sketch mapping procedures similar to methods used for spruce budworm and forest tent caterpillar defoliation. Then the affected host stand area was based on the logical WG content. For a few pests, defoliated stands were delineated and considered to be totally host type.

Root Rot

Damage to spruce and balsam fir caused by root rot was described for northwestern Ontario by Whitney (1976). He also had unpublished data that were useful for estimating root rot damage for other parts of Ontario. However, most of the stands sampled in his studies were not randomly selected. Many were on upland sites where he noted that the amount of root rot is significantly higher than on lowland sites. On the basis of consultation with Whitney, and of additional unpublished data, the damage levels detected in northwestern Ontario were adjusted to reflect average stand conditions for each region. Damage levels were reduced to 30% for the NW and NC regions, 21% for the N region, and 24% for all other regions. This adjustment was intended to make the data representative of the general level of root rot in all spruce or fir stands by compensating for a larger percentage of stands that are on lowland sites and for other stands with little or no root rot.

Levels of mortality caused by root rots of spruce and fir were derived from Table 1 in Whitney (1976). The percentage of trees that were dead was assumed to have accrued over a 10-year period. For growth loss of black spruce, white spruce and balsam fir, the weighted average diameter loss reported by Whitney (ibid.) was considered to represent 22, 10, and 9% volume loss, and the percentage of host trees that had root rot was 60, 65, and 79%, respectively.

Wood Decay

Loss caused by wood decay was estimated as the proportion of CAI that was defective on the basis of the average amount of defect for all age classes reported for each species by Morawski et al. (1958) or Basham and Morawski (1964). Thus, annual losses were proportional to annual growth.

Hypoxylon Canker

Mortality of aspen caused by Hypoxylon canker was based on an average of 2% of trees with cankers and a mortality rate for cankered trees of 33%. Two surveys conducted in the N and NC regions indicated that about 2% of the trembling aspen had stem cankers. Survey data also indicated that recently dead cankered trees were about as prevalent as live cankered trees. Anderson and Martin (1981) found that aspen die within 6 years of the time cankers are initially detected on the stem below the live crown. Their data indicated that the average period of survival after trees became cankered was 3 years. Growth and cull losses were excluded as unimportant because most cankered trees die rapidly and most of the loss occurs as mortality. We are currently investigating the kind and amount of cull loss that occurs when cankers are found in the live crown. Trees affected in this way often survive, but suffer stem deterioration.

Sweetfern Blister Rust Canker

Estimates of growth loss and cull necessitated by this disease of jack pine were based on Gross et al. (1978). The percentage of pines with cankers was based on a 1976 FIDS survey indicating that 6.5% of the jack pine are cankered within the range of the sweetfern alternate host. This area was essentially in the N, NE, and AL regions. Losses were estimated only for the N and NE regions. Jack pine CAI for the AL region was only 14,000 m^3 and rust-caused losses were negligible.

Diebacks

With the exception of white birch dieback, losses from mortality were based on surveys or plot data. For white birch dieback, the gross standing volume in a region was multiplied by the percentage volume that was mature, as reported by Dixon (1963), and an assumed mortality rate of 2%.

PEST-CAUSED LOSSES IN ONTARIO

Introduction

Pest-caused losses in Ontario (Fig. 2, Table 5) averaged 46,766,000 m^3 gross total volume annually over the period 1977-1981. About one-third of the loss was caused by insects and the remainder by diseases. Defoliation by spruce budworm, causing an annual average loss of 13,252,000 m^3, was the most important problem. Loss caused by wood decay was estimated at 9,045,000 m^3 and root rots were responsible for mortality and growth loss of 11,853,000 m^3 annually. Other pests caused the remaining loss (12,616,000 m^3). As discussed in the section on perspectives, several forms of loss were not included in the analysis, and a conservataive estimate of the total loss caused by pests is in excess of 50,000,000 m^3.

Ontario is largely a forested province, and for the currently exploitable portion (Fig. 1), about 80% is productive forest (Table 1). Three major forest regions (Rowe 1972) are represented: Boreal (62%), Great Lakes-St. Lawrence (35%), and Deciduous (3%). Data for the OHFI are summarized by tree species in Table 1. A net volume of about 17,000,000 m^3 of timber is harvested annually, but the allowable annual cut is more than double the volume harvested. It is difficult to compare net volumes harvested with pest losses reported as gross total volumes. However, one can assume that the ratio of gross total volume to net merchantable volume is about 2:1. At this ratio, pest losses occurred at 1.5 times the harvest rate. Poplar, white birch, and balsam fir are being utilized well below the potential for these species. The magnitude of losses caused by pests among these species is at least partially due to low utilization and a resultant large volume of overmature timber. Forest stands cannot last forever, and as they age, susceptibility to pests increases. In a sense, pests are utilizing this leftover part of the forest. Low utilization reduces the importance of losses among these hosts; however, pest-caused loss and defect are major reasons for the unpopularity of poplar, white birch, and fir.

Table 5. Average annual pest-caused losses in Ontario forests[a].

Pest	Tree species	Growth (m³)	Cull	Mortality (m³)	Total (m³)
Spruce budworm	black spruce	281,000		1,188,000	1,469,000
	white spruce	151,000		1,539,000	1,690,000
	balsam fir	1,027,000		9,066,000	10,093,000
		1,459,000		11,793,000	13,252,000
Forest tent caterpillar	poplar	933,000			933,000
	white birch	59,000			59,000
	sugar maple	341,000		653,000	994,000
	other	15,000			15,000
		1,348,000		653,000	2,001,000
Aspen complex	poplar	155,000			155,000
White birch complex	white birch	42,000			42,000
Oak complex	red oak	6,000		36,000	43,000
Total, insects		3,010,000		12,482,000	15,493,000
Root rot	conifers	1,088,000		10,765,000	11,853,000
Wood decay	conifers		2,788,000		2,788,000
	hardwoods		6,257,000		6,257,000
			9,045,000		9,045,000
Hypoxylon canker	poplar			6,184,000	6,184,000
Sweetfern rust	jack pine	32,000	17,000		49,000
Diebacks	sugar maple			377,000	377,000
	white birch			3,702,000	3,702,000
	red oak			63,000	63,000
				4,142,000	4,142,000
Total, diseases		1,120,000	9,062,000	21,091,000	31,273,000
Total, all pests		4,130,000	9,062,000	33,573,000	46,766,000

[a]Data are expressed as gross total volume.

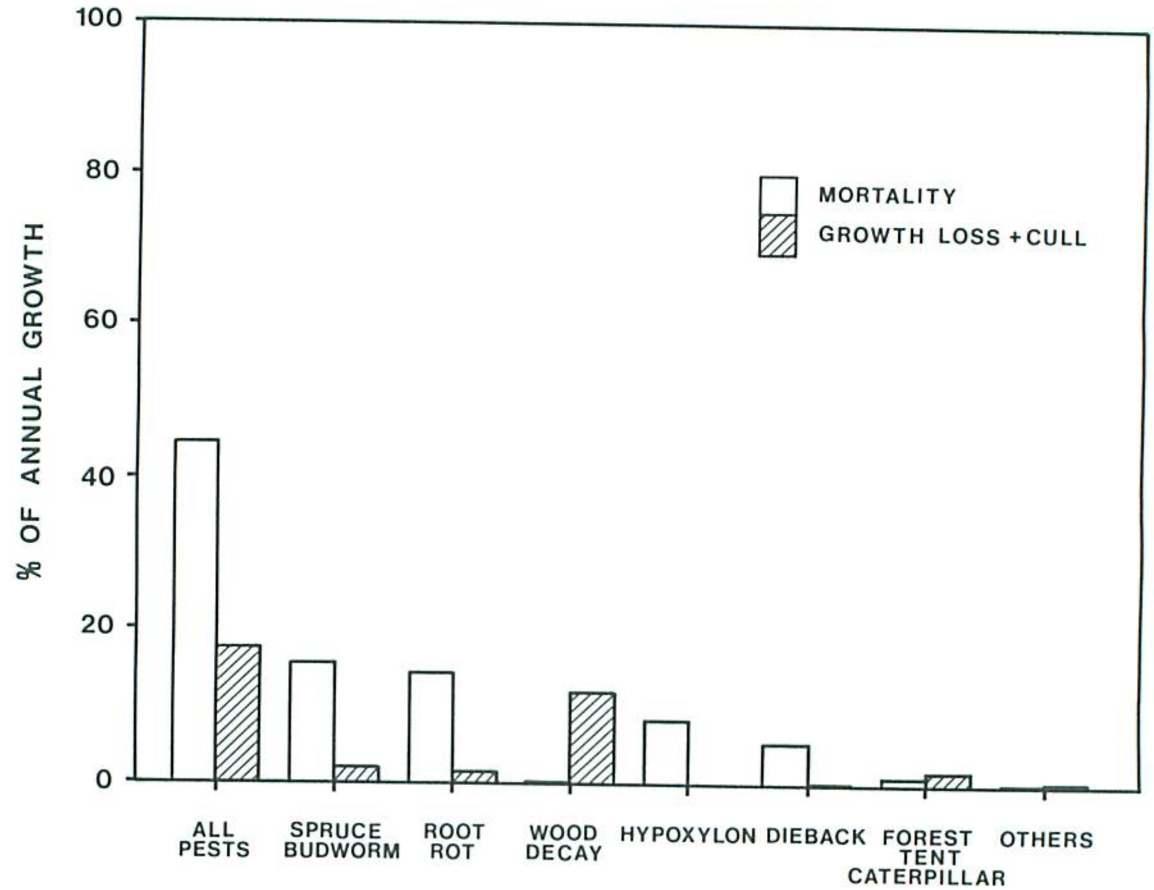


Figure 2. Pest-caused timber losses in Ontario totalled 46,766,000 m^3 annually (equivalent to 62% of the growth (CAI) during the period 1977-1981).

Spruce Budworm

The current spruce budworm infestation started in 1967. The infestation seemed to reach a peak in 1980 when moderate-to-severe defoliation was present on a total area of just under 18.9 million ha (Table 6). Another 1.6 million ha suffered negligible defoliation, but previous defoliation had devastated the balsam fir. Hence, the total area of infestation was 20.5 million ha or about a third of the currently exploitable area of the province. By the end of 1981, Ontario forests had experienced a cumulative volume loss of 74,000,000 m^3, of which 64,000,000 m^3 occurred as mortality and 10,000,000 m^3 as lost growth (Fig. 3). Average annual growth loss for the period 1977-1981 was 1,459,000 m^3, and mortality averaged 11,793,000 m^3 (Table 5). Total loss for the 5-year period was 66,246,000 m^3. About 75% of this loss occurred to balsam fir. The remainder was about equally split between white spruce and black spruce. Summary data by host species are given in Tables 5 and 7.

Table 6. Areas affected by spruce budworm in Ontario, 1977-1981.

Year	Area mapped as defoliated (ha)	Area mapped as having mortality (ha)	Total area[a] infested (ha)	Host stands affected (ha)
1977	14,088,000	5,484,000	14,990,000	1,885,000
1978	15,156,000	6,090,000	16,467,000	2,073,000
1979	18,429,000	7,515,000	19,279,000	2,384,000
1980	18,850,000	8,356,000	20,491,000	2,540,000
1981	18,271,000	11,210,000	20,265,000	2,577,000

[a]Most of the area mapped as having mortality was contained in the area mapped as defoliated; however, stands in some areas were devastated to the extent that very little current defoliation was present, as most host trees were dead.

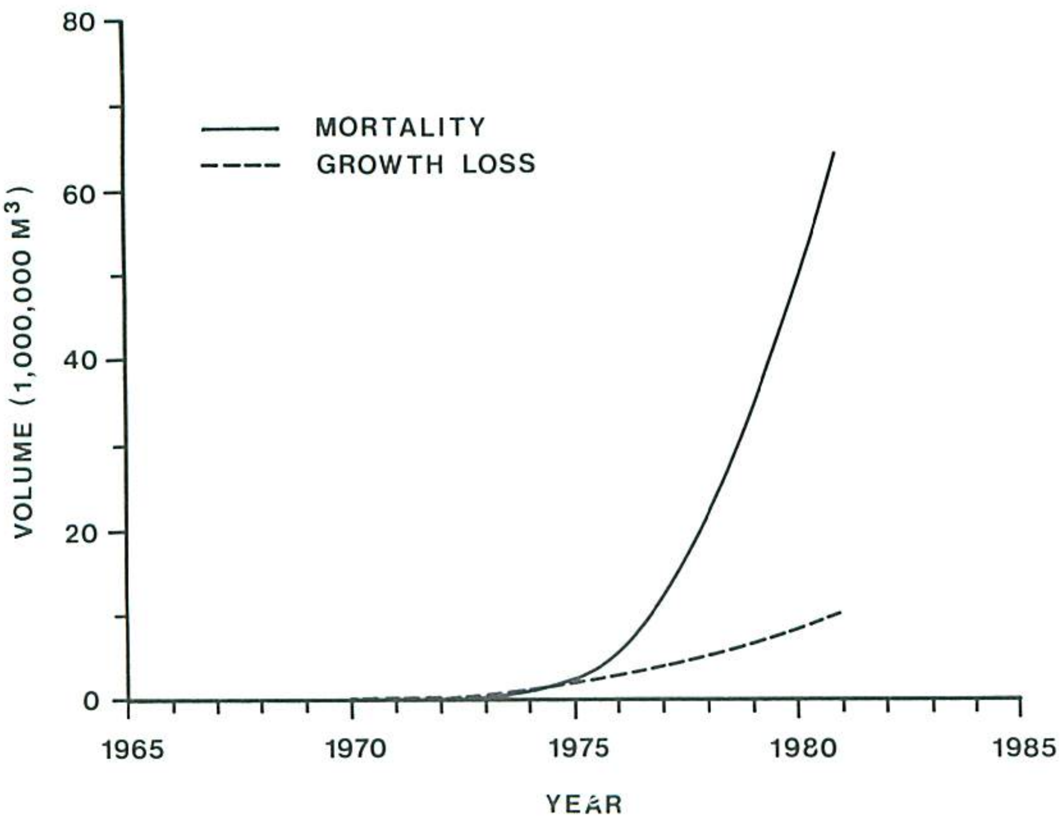


Figure 3. Cumulative volume of mortality and growth loss caused by the current spruce budworm infestation. By the end of 1981, total losses were more than 74,000,000 m^3.

Table 7. Volume of growth loss and mortality[a] resulting from defoliation caused by spruce budworm in Ontario, 1977-1981.

Year	Tree species	Growth loss (m^3)	Mortality (m^3)
1977	balsam fir	713,000	5,298,000
	white spruce	114,000	457,000
	black spruce	204,000	358,000
		1,031,000	6,113,000
1978	balsam fir	829,000	7,835,000
	white spruce	125,000	1,147,000
	black spruce	235,000	871,000
		1,189,000	9,853,000
1979	balsam fir	989,000	9,034,000
	white spruce	149,000	1,819,000
	black spruce	280,000	1,318,000
		1,418,000	12,171,000
1980	balsam fir	1,204,000	10,908,000
	white spruce	175,000	2,020,000
	black spruce	320,000	1,613,000
		1,699,000	14,541,000
1981	balsam fir	1,398,000	12,254,000
	white spruce	195,000	2,242,000
	black spruce	364,000	1,778,000
		1,957,000	16,274,000
Total: 1977-1981	balsam fir	5,133,000	45,329,000
	white spruce	758,000	7,685,000
	black spruce	1,403,000	5,938,000
		7,294,000	58,952,000

[a] Data are expressed as gross total volume.

Annual spruce budworm reports were published by FIDS for Ontario (Howse and Harnden, 1978, 1979, 1980; Howse et al. 1981; Meating et al. 1982). These provide infestation histories and other interesting information. The infestation seemed to start and expand in three general areas that are featured in these FIDS reports as the southern, northeastern, and northwestern infestations. In the present report, data are presented by OMNR administrative regions; however, the regional data do approximate the data for the three infestations. The southern infestation corresponds to budworm activity mostly in the AL and C-E-SW regions, with a small amount of infestation in the NE Region. The northeastern infestation occurred mainly in the NO and NE regions, with minor extensions into the NC and AL regions. The northwestern infestation occurred in the NW and NC regions.

Forest Tent Caterpillar

Two large forest tent caterpillar infestations were present in 1977. One infestation affected a total area of about 8 million ha in the NW Region and another infestation covered about 6 million ha in the NO, NE, AL and C-E-SW regions. In 1978, the northwestern infestation nearly doubled in size and extended into about 0.2 million ha in the NC Region, but the infestation in northeastern and southern Ontario began to collapse, and only 2.2 million ha were mapped as moderately to severely defoliated. In 1979, both infestations were virtually gone. Then, in 1980, several new infestations started in the N Region.

About 78% of the 6,742,000 m^3 growth loss occurred in 1977 and 1978 (Table 8). In part of the AL and C-E-SW regions, many of the sugar maple stands had suffered three or more years of severe defoliation by the end of the 1977 season, and mortality of maple trees had started. By midseason in 1978, maple mortality was widespread in the Owen Sound, Bracebridge, and Parry Sound districts of the AL and C-E-SW regions. About 3,265,000 m^3 of valuable sugar maple timber was dead. Maples began recovering after the infestation collapsed, and since then, mortality has been negligible. Logging operations salvaged some of the dead trees, but more than half of the mortality was an outright loss.

Aspen Defoliator Complex

In addition to forest tent caterpillar, a variety of other defoliating insects caused growth loss of aspen totalling 775,000 m^3 for the period 1977-1981. Aspen leafroller was the principal insect causing this damage. In comparison with the forest tent caterpillar, this insect was relatively unimportant as a pest of aspen in this period.

White Birch Defoliator Complex

White birch was also defoliated by a variety of insects in addition to forest tent caterpillar. These caused a total growth loss of 210,000 m^3 in the period 1977-1981. Birch skeletonizer and spearmarked black moths were the most prominent of the insects reported.

Table 8. Volume of growth loss and mortality[a] resulting from defoliation caused by forest tent caterpillar in Ontario, 1977-1981.

Year	Tree species	Mortality loss (m^3)	Growth loss (m^3)
1977	poplar		1,893,000
	white birch		135,000
	sugar maple	2,700,000	458,000
	yellow birch		23,000
	other hardwoods		49,000
		2,700,000	2,558,000
1978	poplar		2,241,000
	white birch		118,000
	sugar maple	567,000	316,000
	yellow birch		1,000
	other hardwoods		2,000
		567,000	2,678,000
1979	poplar		428,000
	white birch		34,000
	sugar maple		311,000
	yellow birch		T[b]
	other hardwoods		T
			773,000
1980	poplar		80,000
	white birch		7,000
	sugar maple		312,000
	yellow birch		T
	other hardwoods		T
			399,000
1981	poplar		22,000
	white birch		2,000
	sugar maple		310,000
	yellow birch		T
	other hardwoods		T
			334,000
Total: 1977-1981	poplar		4,664,000
	white birch		296,000
	sugar maple		1,707,000
	yellow birch		24,000
	other hardwoods		51,000
		3,267,000	6,742,000

[a] Data are expressed as gross total volume
[b] T = Trace (less than 500 m^3)

Oak Defoliator Complex

Defoliating insects, mostly the oak leaf shredder, caused growth loss of red oaks totalling about 35,000 m^3 over the period 1977-1981. Mortality seemed to be more intense in stands with histories of defoliation. Hence, 180,000 m^3 of the mortality associated with oak dieback was considered to be caused by insect defoliation.

Wood Decay

Cull volume loss caused by wood decay was 45,225,000 m^3 for the entire period 1977-1981. Average annual loss data by species are listed in Table 9. As a group, hardwoods were far more defective than conifers and had 19.6% cull in comparison with 6.5% cull for conifers. Cedar, hemlock, and balsam fir were the most defective conifers. Tolerant hardwood species were the most defective hardwoods.

Root Rot

Conifer mortality totalling 53,825,000 m^3 and growth loss totalling 5,440,000 m^3 were caused by root rots in the period 1977-1981. Losses to broadleaved species were not estimated. Average annual data by species are listed in Table 9.

Hypoxylon Canker

Hypoxylon canker of aspen caused losses resulting from mortality that totalled 30,920,000 m^3 for the period 1977-1981. Most of this damage seemed to occur in stands over 30 years of age.

Sweetfern Blister Rust Canker

Sweetfern blister rust canker caused a total growth loss of 160,000 m^3 and 85,000 m^3 of mortality in the period 1977-1981. The disease is probably more important as a killer of young pines.

Diebacks

Diebacks of broadleaved species caused a total loss of 20,710,000 m^3 as a result of mortality in the period 1977-1981. Most of this mortality (89%) affected white birch, which is not a commercially valuable species. However, the remainder of the loss was in valuable red oak and sugar maple. Also, diebacks probably cause growth loss, as is evidenced by the dieback and growth loss associated with defoliation by forest tent caterpillar in the AL and C-E-SW regions. Growth loss caused by diebacks that were not associated with defoliation was not estimated in this analysis. In addition, 3,267,000 m^3 of the mortality caused by forest tent caterpillar occurred as maple decline and 180,000

Table 9. Average annual timber volume losses[a] caused by wood decay and root rot diseases in Ontario, 1977-1981.

Tree species	Wood decay (m^3)	Root rot: Mortality (m^3)	Root rot: Growth loss (m^3)
Red pine	2,000	37,000	T[b]
Jack pine	1,076,000	693,000	23,000
White pine	213,000	231,000	4,000
Black spruce	571,000	8,121,000	826,000
White spruce	58,000	309,000	20,000
Balsam fir	594,000	1,374,000	215,000
Cedar	180,000		
Larch	5,000		
Hemlock	86,000		
Other conifers	3,000		
Conifer total	2,788,000	10,765,000	1,088,000
Poplar	4,305,000		
White birch	290,000		
Yellow birch	286,000		
Sugar maple	919,000		
Red maple	202,000		
Ash	32,000		
Red oak	66,000		
Elm	21,000		
Basswood	13,000		
Beech	111,000		
Cherry	4,000		
Other hardwoods	8,000		
Hardwood total	6,257,000		
Total, all species	9,045,000	10,765,000	1,088,000

[a] Data are expressed as gross total volume.

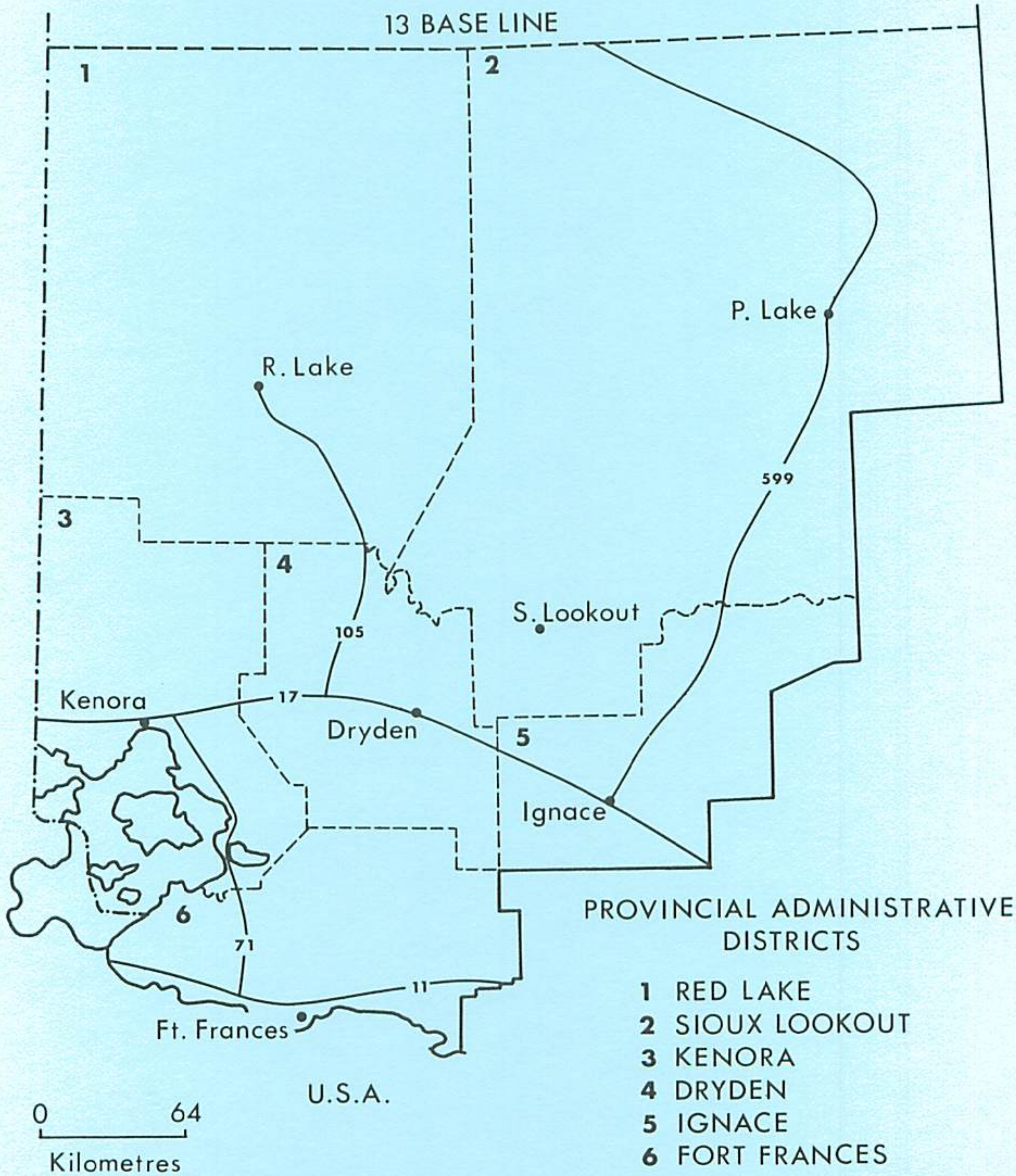
[b] T = trace (less than 500 m^3)

m^3 of red oak mortality caused by oak defoliators occurred as oak dieback. These losses are listed as caused by insects.

Summary

Pest-caused losses in Ontario forests were high during the period 1977-1981. The N, NE and AL regions experienced losses that were roughly equivalent to the forest growth (CAI) for this period. These losses were attributable mostly to the massive spruce budworm infestation that affected large parts of these regions. Other regions experienced losses that were equivalent to about half of the CAI. Forest tent caterpillar, wood decay, root rot, and Hypoxylon canker were the other principal pests. The average annual loss of almost 47 million m^3 of timber was impressive and represents a significant drain on the timber resource of the province.

Northwestern Region



PROVINCIAL ADMINISTRATIVE DISTRICTS

1 RED LAKE
2 SIOUX LOOKOUT
3 KENORA
4 DRYDEN
5 IGNACE
6 FORT FRANCES

PEST-CAUSED LOSSES IN THE NORTHWESTERN REGION

Introduction

Pest-caused losses in the NW Region averaged about 6,762,000 m^3 gross total volume annually in the period 1977-1981 (Table 10, Fig. 4). This was equivalent to 35% of the growth (CAI) and about the same as the amount of timber harvested annually in that period. The major pests (Table 10) were forest tent caterpillar, root rot, wood decay and Hypoxylon canker. Efforts to control spruce budworm in the late 1960s and early 1970s had been largely successful, and the infestation was just beginning to expand at the end of the period 1977-1981.

Forest Resources

The NW Region is mostly forested. About half of the total area of 22,466,000 ha is currently exploitable. The area administered extends far into the north. The exploitable forest is considered to extend up to about 52° 30' north latitude (Fig. 1). Dixon (1963) indicated that considerable area north of this latitude contains potentially exploitable forest, but the current inventory and harvesting operations do not yet extend farther north.

The southern part of the Region is in the Quetico Section of the Great Lakes-St. Lawrence forest region and the remainder is in the Boreal forest region (Rowe 1972). Forests of the Quetico Section are somewhat boreal in character. The poplar and balsam fir stands of the NW Region are highly productive, averaging about 3 and 2.5 m^3/ha annual growth (CAI), respectively. Growth for jack pine stands was rated at 1.5 m^3 and for spruce and white birch stands at just over 1 m^3/ha. About 90% of the OFRI was complete. Data for the OHFI are summarized by tree species in Table 11.

Spruce Budworm

There was some defoliation by spruce budworm throughout the period 1977-1981 (Table 12). The total area affected in 1977 was 147,000 ha. This increased to 256,000 ha in 1978 and the infestation remained at about 256,000-350,000 ha through 1981. Budworm-caused mortality was first noted in 1977 and by 1981 the area of mapped mortality was 88,000 ha, which included about 9,000 ha of host stands. A total of 39,000 m^3 of mortality occurred in the period 1977-1981 (Table 12), and in 1981 the percentage of host species dead in these stands was 14% for balsam fir, 3% for white spruce, and 2% for black spruce. Growth loss for the period was estimated at 31,000 m^3, of which 60% was balsam fir. The cumulative loss from the start of the infestation through 1981 was 43,000 m^3 of growth loss and 39,000 m^3 of mortality.

Table 10. Average annual pest-caused losses[a] in the NW Region, 1977-1981.

Pest	Tree species	Growth loss (m^3)	Cull (m^3)	Mortality (m^3)	Total (m^3)
Spruce budworm	black spruce	2,000		1,000	3,000
	white spruce	T[b]		T	T
	balsam fir	4,000		7,000	11,000
		6,000		8,000	14,000
Forest tent caterpillar	poplar	562,000			562,000
	white birch	21,000			21,000
		583,000			583,000
Aspen complex	poplar	12,000			12,000
White birch complex	white birch	T			T
Total, insects		601,000		8,000	609,000
Root rot	conifers	352,000		2,553,000	2,905,000
Wood decay	conifers		786,000		786,000
	hardwoods		992,000		992,000
			1,778,000		1,778,000
Hypoxylon canker	poplar			1,046,000	1,046,000
Diebacks	white birch			424,000	424,000
Total, diseases		352,000	1,778,000	4,023,000	6,153,000
Total, all pests		953,000	1,778,000	4,031,000	6,762,000

[a] Data are expressed as gross total volume.
[b] T = trace (less than 500 m^3)

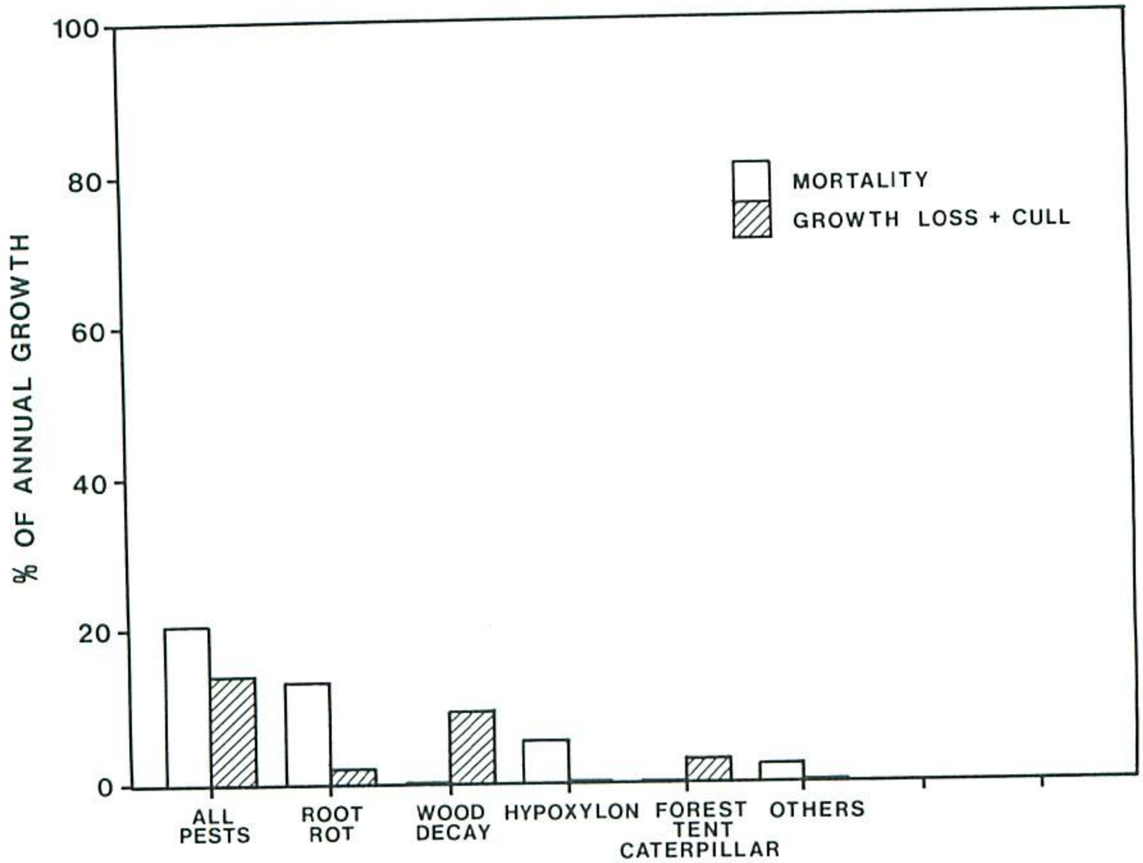


Figure 4. Pest-caused timber losses in the NW Region totalled 6,762,000 m^3 annually (equivalent to 35% of the growth (CAI) during the period 1977-1981).

Forest Tent Caterpillar

Extensive areas of forest were defoliated by the forest tent caterpillar (Fig. 5) in 1977, 1978, and 1979 (Table 13). The population started to collapse in 1979 and no significant defoliation occurred thereafter. Most of the 2,917,000 m^3 of growth loss caused by defoliation occurred in 1978 (Table 13), when almost all of the area in the NW Region considered exploitable had some defoliation. The actual area affected in 1978 extended well north of the exploitable area and the total area of mapped defoliation was 14,500,000 ha. Aspen accounted for 96% of the growth loss.

Aspen Defoliator Complex

Aspen was defoliated by the aspen leafroller in 1977 and 1978. The area affected by aspen leafroller was just south and west of that defoliated by forest tent caterpillar. The total area affected by leafrollers was 130,000 ha in 1977 and 360,000 ha in 1978. About 11% of this area was considered host type. Growth loss was estimated at 16,000 m^3 in 1977 and 43,000 m^3 in 1978.

Table 11. Forest statistics[a] for the NW Region.

Tree species	Gross total volume (m³)	Gross total volume (%)	Current annual increment (m³)	Current annual increment (%)
Red pine	1,868,000	T[b]	26,000	T
Jack pine	253,330,000	25	5,348,000	28
White pine	3,496,000	T	56,000	T
Black spruce	470,659,000	47	7,523,000	39
White spruce	12,119,000	1	194,000	1
Balsam fir	32,481,000	3	643,000	3
Cedar	5,133,000	1	5,000	T
Larch	1,304,000	T	1,000	T
Hemlock	7,000	T	T	T
Other conifers	33,000	T	T	T
Conifer total	780,430,000	79	13,796,000	71
Poplar	156,893,000	16	4,658,000	24
White birch	55,779,000	5	933,000	5
Red maple	49,000	T	1,000	T
Ash	838,000	T	16,000	T
Other hardwoods	T	T	T	T
Hardwood total	213,559,000	21	5,608,000	29
Total, all species	993,989,000	100	19,404,000	100

[a] Data are expressed as gross total volume.
[b] T = trace (less than 500 m^3)

Note:		
	Total administrative land area in region	22,466,000 ha
	Current exploitable forest area in region	15,525,000 ha
	Productive forest area	10,854,000 ha

Table 12. Volume of growth loss and mortality[a] resulting from defoliation caused by spruce budworm in the NW Region, 1977-1981.

Year	Total area affected (ha)	Host stands defoliated (ha)	Tree species	Growth loss (m^3)	Mortality (m^3)
1977	147,000	13,000	balsam fir	1,000	T[b]
			white spruce	T	0
			black spruce	1,000	0
				2,000	0
1978	256,000	22,000	balsam fir	2,000	1,000
			white spruce	T	0
			black spruce	1,000	0
				3,000	1,000
1979	300,000	26,000	balsam fir	3,000	5,000
			white spruce	1,000	T
			black spruce	2,000	T
				6,000	5,000
1980	265,000	23,000	balsam fir	5,000	8,000
			white spruce	1,000	1,000
			black spruce	2,000	1,000
				8,000	10,000
1981	265,000	23,000	balsam fir	8,000	19,000
			white spruce	1,000	1,000
			black spruce	3,000	3,000
				12,000	23,000
Volume lost, 1977-1981:			balsam fir	19,000	33,000
			white spruce	3,000	2,000
			black spruce	9,000	4,000
				31,000	39,000

[a] Data are expressed as gross total volume.
[b] T = trace (less than 500 m^3)

Table 13. Volume of growth loss[a] resulting from defoliation caused by forest tent caterpillar in the NW Region, 1977-1981.

Year	Total area affected (ha)	Host stands defoliated (ha)	Tree species	Growth loss (m^3)
1977	5,957,000	579,000	poplar	833,000
			white birch	25,000
				858,000
1978	12,009,000	1,168,000	poplar	1,680,000
			white birch	60,000
				1,740,000
1979	2,120,000	206,000	poplar	297,000
			white birch	22,000
				319,000
Volume lost, 1977-1981			poplar	2,810,000
			white birch	107,000
				2,917,000

[a] Data are expressed as gross total volume.

Figure 5. Defoliation damage caused by the forest tent caterpillar

Root Rot

Root rots (Fig. 6) caused an estimated 1,760,000 m^3 growth loss and 12,765,000 m^3 mortality over the 5-year period. Eighty-one percent of this loss was in black spruce, which is by far the most important species in the Region as far as standing volume and timber value are concerned. For black spruce, losses due to root rot were equivalent to 32% of the growth (CAI). Average annual losses for conifer species are shown in Table 14.

Root rots likely had a considerable impact on broadleaved species, as cull studies (Basham and Morawski 1964) and other surveys indicate that root-rotting organisms are common in the butt and roots of most species. For example, a survey of young aspen stands in 1977 (Gross and Basham 1981) indicated that about 50% of the immature aspen had stain or rot defect in the roots.

Losses due to root rot among conifer species can be expected to be lower in the future. Root rot damage increased with stand age among spruce and balsam fir (Whitney 1976). Stands managed on the basis of appropriate rotation ages can be expected to experience fewer losses from root rot than the overmature stands now present in many areas.

Figure 6. Damage caused by root rot in a spruce-fir stand (photograph courtesy of R.D. Whitney).

Table 14. Average annual timber volume[a] losses caused by wood decay and root rot diseases in the NW Region, 1977-1981.

Tree species	Wood decay (m^3)	Root rot: Mortality (m^3)	Root rot: Growth loss (m^3)
Red pine	T[b]	2,000	T
Jack pine	503,000	253,000	11,000
White pine	9,000	3,000	1,000
Black spruce	195,000	2,063,000	308,000
White spruce	7,000	17,000	3,000
Balsam fir	69,000	195,000	29,000
Cedar	2,000		
Other conifers	1,000		
Conifer total	786,000	2 533,000	352,000
Poplar	931,000		
White birch	56,000		
Ash	4,000		
Other hardwoods	1,000		
Hardwood total	992,000		
Total, all species	1,778,000	2,533,000	352,000

[a] Data are expressed as gross total volume.
[b] T = trace (less than 500 m^3)

Wood Decay

Total volume loss (cull) caused by wood decay fungi for the period 1977-1981 was 8,890,000 m^3. The majority of this was in poplar (52%), with jack pine (28%) and black spruce (11%) accounting for most of the remainder. Average annual losses by tree species are shown in Table 14. Timber utilization is expected to eliminate the highly defective overmature stands, and thus reduce decay losses.

Hypoxylon Canker

Hypoxylon canker caused losses of 5,230,000 m^3 as a result of mortality in aspen during the period 1977-1981. Average annual loss was equivalent to 22% of the aspen growth (CAI).

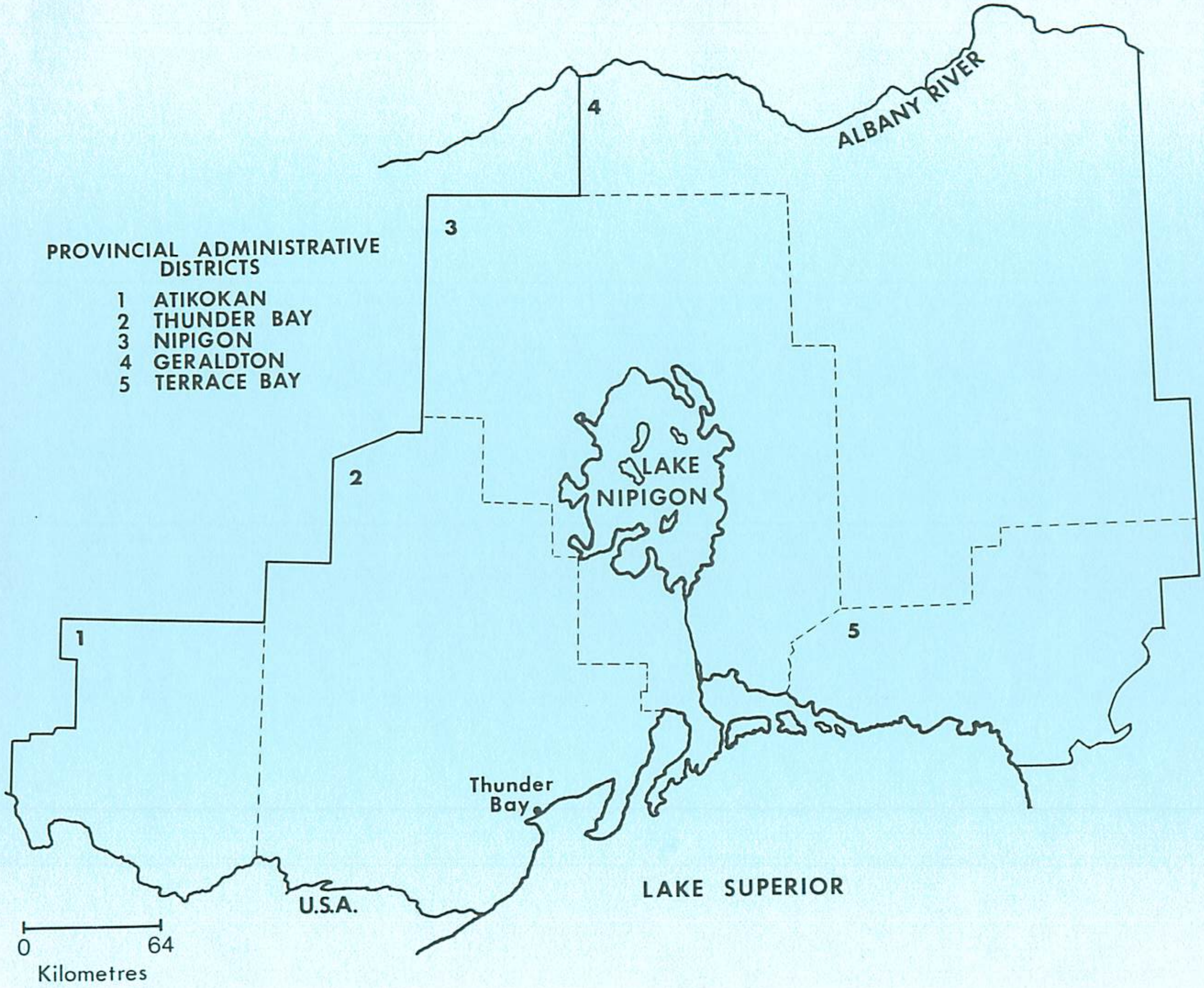
Diebacks

Dieback of white birch caused 2,120,000 m^3 mortality. The actual pest or pests associated with this problem can vary, and climatic and site factors seem to be implicated as well as pests. Drought seems to have been a major contributing factor to the white birch mortality that occurred in the NW Region in this 5-year period.

Summary

The NW Region experienced pest-caused losses of about 7,000,000 m^3 over the period 1977-1981. Poplar and black spruce were the species most affected. Poplar lost the equivalent of about 60% of its growth to Hypoxylon canker, wood decay and insect defoliators. Black spruce lost the equivalent of 34% of its growth, mostly to root rot. Granted, much of the loss was among poplar and white birch, which are not highly valued species. However, the utilization of poplar is increasing rapidly and even the white birch resource could be a valuable asset in the future.

North Central Region



PEST-CAUSED LOSSES IN THE NORTH CENTRAL REGION

Introduction

Pest-caused losses in the NC Region averaged 8,609,000 m^3 annually in the period 1977-1981 (Table 15, Fig. 7). This was equivalent to 41% of the growth (CAI), and about 75% of the timber harvested annually in that period. The major pests were wood decay, root rot, Hypoxylon canker and birch dieback. Insect activity was low. Spruce budworm infestations encroached on the Region from both east and west; however, the total area influenced increased to only 393,000 ha by the end of the period. The extensive forest tent caterpillar infestation in the NW Region moved into only a small part of the NC region in 1977 and 1978.

Figure 7. Pest-caused timber losses in the NC Region totalled 8,609,000 m^3 annually (equivalent to 41% of growth (CAI) during the period 1977-1981).

Table 15. Average annual pest-caused losses[a] in the NC Region, 1977-1981.

Pest	Tree species	Growth loss (m^3)	Cull (m^3)	Mortality (m^3)	Total (m^3)
Spruce budworm	black spruce	2,000			2,000
	white spruce	1,000			1,000
	balsam fir	5,000			5,000
		8,000			8,000
Forest tent caterpillar	poplar	29,000			29,000
	white birch	1,000			1,000
		30,000			30,000
Aspen complex	poplar	5,000			5,000
White birch complex	white birch	1,000			1,000
Total, insects		44,000			44,000
Root rot	conifers	402,000		3,289,000	3,691,000
Wood decay	conifers		757,000		757,000
	hardwoods		1,482,000		1,482,000
			2,239,000		2,239,000
Hypoxylon canker	poplar			1,603,000	1,603,000
Diebacks	white birch			1,032,000	1,032,000
Total, diseases		402,000	2,239,000	5,924,000	8,565,000
Total, all pests		446,000	2,239,000	5,924,000	8,609,000

[a] Data are expressed as gross total volume.

Forest Resources

The NC Region is mostly a forested area. About three-quarters of the total area is currently exploitable, but the area administered extends far to the north. The exploitable forest is considered to extend up to about 52° 30' north latitude (Fig. 1), which includes most of the area rated potentially exploitable by Dixon (1963). The Region is mostly in the Boreal forest region, although the southwestern part of the Thunder Bay District is in the Great Lakes-St. Lawrence region (Rowe 1972). The forests are mostly boreal in character, with extensive stands of black spruce, jack pine, poplar, and white birch. The poplar stands are the most productive and grow at 3.5 m^3 per ha annually. Jack pine, balsam fir, and spruce stands are moderately productive, at just over 2 m^3/ha for pine and fir and about 1.5 m^3/ha for spruce. About 70% of the current OFRI was complete. Data for the OHFI are summarized by tree species in Table 16.

Table 16. Forest statistics[a] for the NC Region.

Tree species	Gross total volume		Current annual increment	
	(m^3)	(%)	(m^3)	(%)
Red pine	159,000	T[b]	2,000	T
Jack pine	203,081,000	15	3,633,000	17
White pine	1,550,000	1	11,000	T
Black spruce	661,016,000	48	7,732,000	36
White spruce	24,009,000	2	281,000	1
Balsam fir	87,445,000	6	1,588,000	7
Cedar	12,939,000	1	90,000	T
Larch	2,903,000	T	20,000	T
Hemlock	7,000	T	T	T
Other conifers	9,000	T	T	1
Conifer total	993,118,000	73	13,357,000	62
Poplar	240,417,000	17	7,071,000	33
Red maple	49,000	T	1,000	T
Other hardwoods				T
White birch	135,841,000	10	1,127,000	5
Ash	52,000	T	1,000	T
Hardwood total	376,359,000	27	8,200,000	38
Total, all species	1,369,477,000	100	21,557,000	100

a Data are expressed as gross total volume.
b T = trace (less than 500 m^3)

Note: Total administrative land area in region 19,080,000 ha
Current exploitable forest area in region 15,133,000 ha
Productive forest area 11,558,000 ha

Spruce Budworm

There was some defoliation by spruce budworm throughout the period 1977-1981. The Region was adjacent to the massive infestation in northeastern Ontario and there were small pockets of defoliation in the western part of the Region. The total area affected by defoliation expanded from 65,000 ha in 1977 to 393,000 ha in 1981. The intensification of budworm defoliation over the 5-year period is shown in Table 17. Mortality was not detected until 1982. Growth loss totalling 41,000 m^3 occurred during the period 1977-1981 and about 60% of this loss was in balsam fir.

Forest Tent Caterpillar

The massive forest tent caterpillar infestation in the NW Region extended into the Atikokan District in 1977 and increased in size to about 188,000 ha in 1978. Also, an isolated infestation in the Thunder Bay District increased in size to about 70,000 ha that year. Other small scattered infestations present in the Nipigon District in 1977 were gone in 1978. The remaining infestations collapsed in 1980, and no significant defoliation occurred in 1981 (Table 18). For the 5-year period the total growth loss was 149,000 m^3, 96% of which was in poplar.

Aspen Defoliator Complex

The aspen leafroller also defoliated aspen in 1977 and 1978. Total area influenced and host stand area defoliated were 119,000 ha and 15,000 ha, respectively, in 1977, and 15,000 ha and 700 ha in 1978. Total growth loss was 23,000 m^3, 94% of which occurred in 1977.

White Birch Defoliator Complex

The birch skeletonizer defoliated birch on a total area of about 300,000 ha that had a host stand area of about 26,000 ha in 1981. Growth loss was 5,500 m^3 that year.

Root Rot

Root rots caused 2,010,000 m^3 of growth loss and 16,445,000 m^3 of mortality during the period 1977-1981. Ninety percent of this loss was in black spruce, which is by far the most important species in the Region in terms of standing volume and timber value. For black spruce, losses due to root rot were equivalent to 42% of the growth (CAI). The average annual losses for conifer species are shown in Table 19.

Much of the research that provided data for estimating the effect of root rot on spruce and fir (Whitney 1976) was done in this Region. The data show distinct increases in losses caused by root rots as stands increase in

Table 17. Volume of growth loss[a] resulting from defoliation caused by spruce budworm in the NC Region, 1977-1981.

Year	Total area affected (ha)	Host stands defoliated (ha)	Tree species	Growth loss (m^3)
1977	65,000	8,000	balsam fir	1,000
			white spruce	T[b]
			black spruce	1,000
				2,000
1978	87,000	11,000	balsam fir	1,000
			white spruce	T
			black spruce	1,000
				2,000
1979	188,000	24,000	balsam fir	3,000
			white spruce	1,000
			black spruce	2,000
				6,000
1980	459,000	59,000	balsam fir	6,000
			white spruce	2,000
			black spruce	4,000
				12,000
1981	393,000	50,000	balsam fir	12,000
			white spruce	2,000
			black spruce	5,000
				19,000
	Volume lost, 1977-1981:		balsam fir	23,000
			white spruce	5,000
			black spruce	13,000
				41,000

[a] Data are expressed as gross total volume.
[b] T = trace (less than 500 m^3)

Table 18. Volume of growth loss[a] resulting from defoliation caused by forest tent caterpillar in the NC Region, 1977-1981.

Year	Total area affected (ha)	Host stands defoliated (ha)	Tree species	Growth loss (m^3)
1977	3,000	1,000	poplar	1,000
			white birch	T[b]
				1,000
1978	240,000	33,000	poplar	62,000
			white birch	T
				62,000
1979	259,000	36,000	poplar	66,000
			white birch	5,000
				71,000
1980	54,000	7,000	poplar	14,000
			white birch	1,000
				15,000
Volume lost, 1977-1981:			poplar	143,000
			white birch	6,000
				149,000

[a] Data are expressed as gross total volume.
[b] T = trace (less than 500 m^3)

age. Consequently, losses in the future will be reduced as overmature stands are replaced by managed stands on shorter rotations.

Root rots likely had considerable impact on broadleaved species. Cull studies (Basham and Morawski 1964) and other surveys indicate that root rotting organisms are common in the butt and roots of most species. For example, a survey of young aspen in 1977 (Gross and Basham 1981) indicated that about 66% of the immature aspen in this Region had rot or stain defect in the roots.

Wood Decay

Volume loss (cull) caused by wood decay fungi for the period 1977-1981 was 11,195,000 m^3. Most of this was in poplar (63%), with jack pine (15%), black spruce (9%), and balsam fir (8%) accounting for most of the remainder. Average annual losses by tree species are shown in Table 19. Timber utilization

Table 19. Average annual timber volume[a] losses caused by wood decay and root rot diseases in the NC Region, 1977-1981.

Tree species	Wood decay (m^3)	Root rot: Mortality (m^3)	Root rot: Growth loss (m^3)
Jack pine	341,000	203,000	7,000
White pine	2,000	2,000	T[b]
Black spruce	201,000	2,975,000	318,000
White spruce	10,000	58,000	5,000
Balsam fir	170,000	52,000	71,000
Cedar	32,000		
Larch	1,000		
Other conifers	T		
Conifer total	757,000	3,290,000	401,000
Poplar	1,414,000		
White birch	68,000		
Other hardwoods	1,000		
Hardwood total	1,483,000		
Total, all species	2,240,000	3,290,000	401,000

[a] Data are expressed as gross total volume
[b] T = trace (less than 500 m^3)

is expected to reduce losses due to decay as the highly defective overmature stands are harvested.

Hypoxylon Canker

Hypoxylon canker of aspen caused 8,015,000 m^3 of mortality in the period 1977-1981. Average annual loss was equivalent to about 25% of the growth (CAI). A recent survey indicates that the percentage of trees affected by the canker is about 2%.

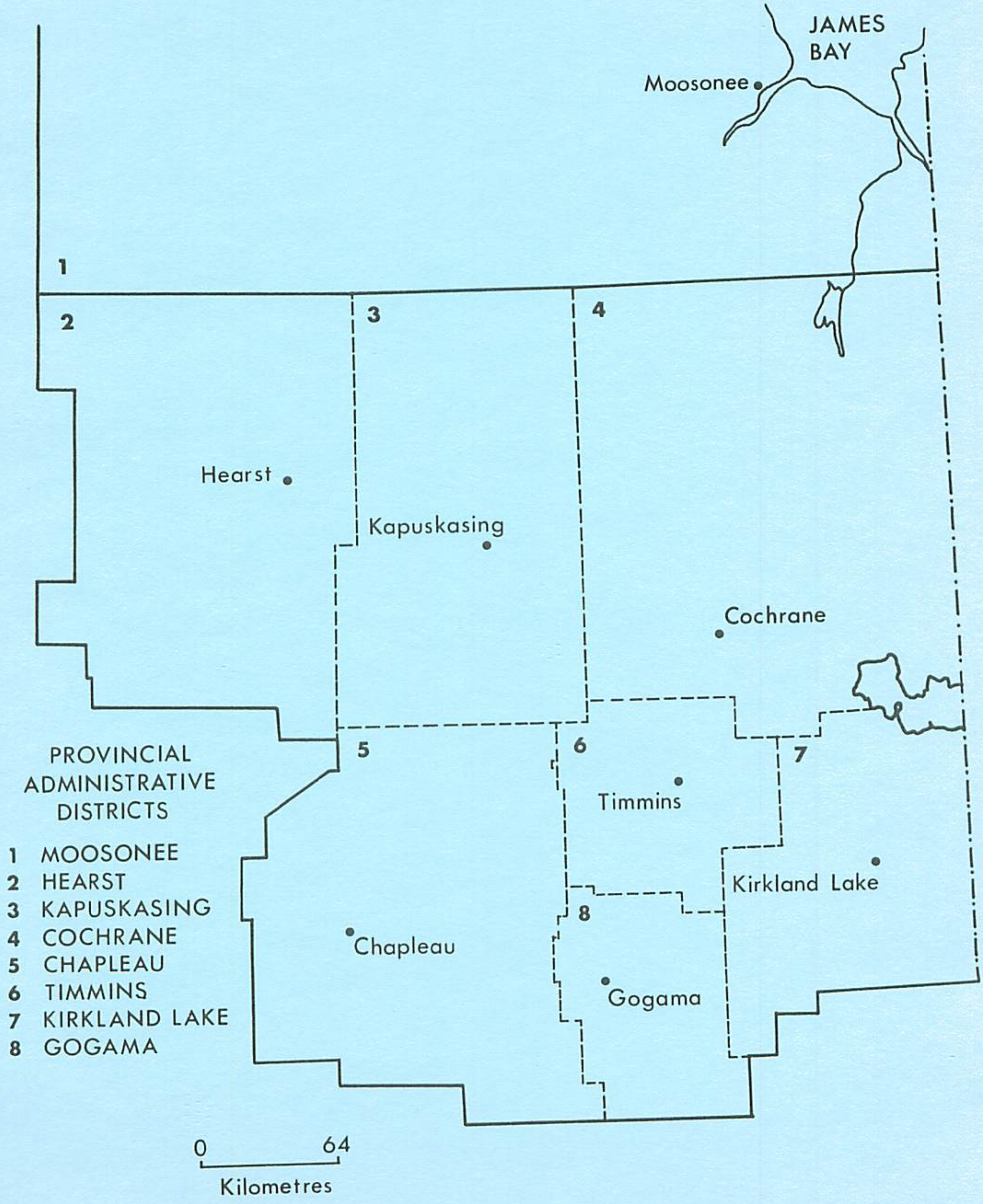
Diebacks

Dieback of white birch accounted for 5,160,000 m^3 of mortality loss during the period 1977-1981. The actual pest or pests associated with this problem can vary, and climatic and site factors seem to be implicated as well as pests.

Summary

In the NC Region, pests accounted for a volume loss equivalent to 41% of the growth for the period 1977-1981. Aspen and black spruce were the species most affected, each losing a volume equivalent to about half the growth (CAI). Aspen utilization is increasing in the Region, and even the impact of white birch dieback could be important in the future.

Northern Region



PEST-CAUSED LOSSES IN THE NORTHERN REGION

Introduction

Pest-caused losses in the N Region averaged 16,072,000 m^3 annually in the period 1977-1981 (Table 20, Fig. 8). This figure was 8% higher than the growth (CAI) figure for the Region and about twice the amount of timber harvested. Defoliation by spruce budworm, the most serious pest problem, accounted for about 45% of total loss. Other important pests were root rot, wood decay, and Hypoxylon canker. All pest-caused losses are summarized in Table 20.

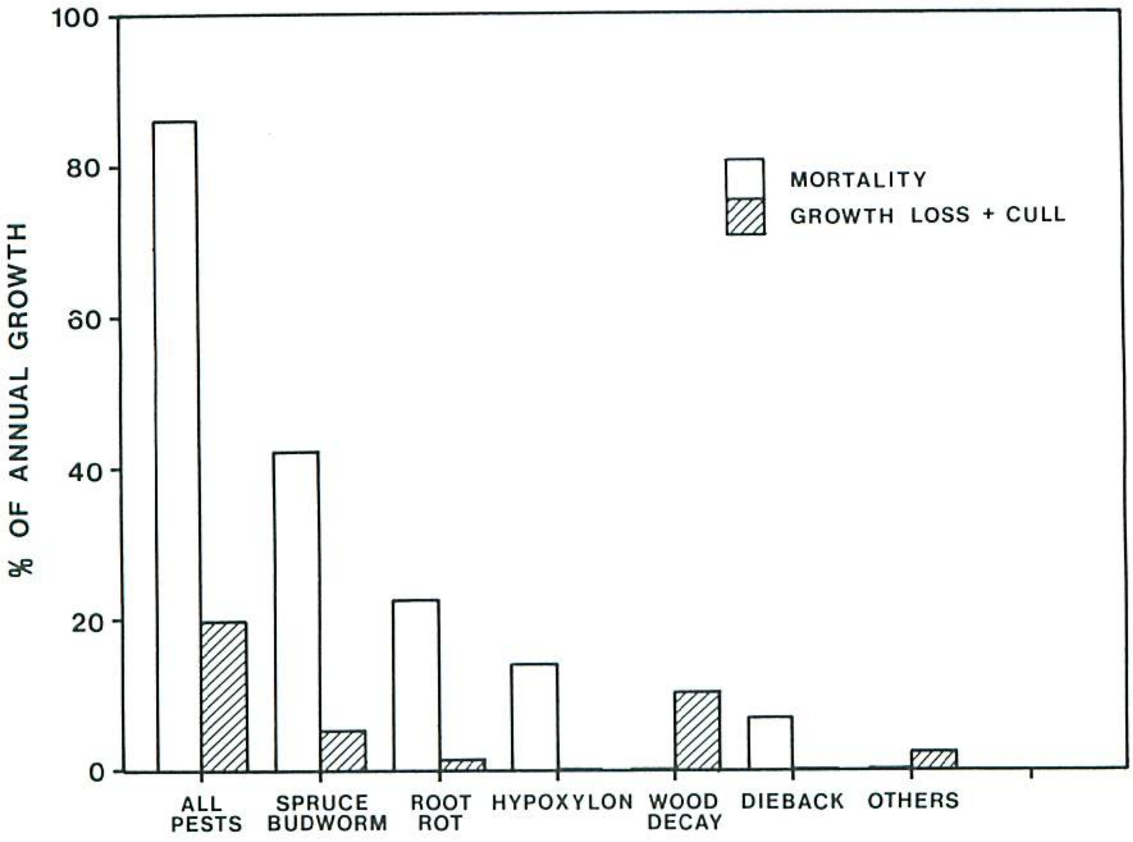


Figure 8. Pest-caused timber losses in the Northern Region totalled 16,072,000 m^3 annually (equivalent to 108% of the growth (CAI) during the period 1977-1981).

Table 20. Average annual pest-caused losses[a] in the N Region, 1977-1981.

Pest	Tree species	Growth loss (m^3)	Cull (m^3)	Mortality (m^3)	Total (m^3)
Spruce budworm	black spruce	172,000		883,000	1,055,000
	white spruce	76,000		694,000	770,000
	balsam fir	568,000		4,823,000	5,391,000
		816,000		6,400,000	7,216,000
Forest tent caterpillar	poplar	191,000			191,000
	white birch	19,000			19,000
		210,000			210,000
Aspen leafroller	poplar	132,000			132,000
White birch complex	white birch	19,000			19,000
Total, insects		1,177,000		6,400,000	7,577,000
Root rot	conifers hardwoods	216,000		3,434,000	3,650,000
Wood decay	conifers		500,000		500,000
	hardwoods		1,091,000		1,091,000
			1,591,000		1,591,000
Hypoxylon canker	poplar			2,150,000	2,150,000
Sweetfern rust	jack pine	17,000	9,000		26,000
Diebacks	sugar maple			2,000	2,000
	white birch			1,076,000	1,076,000
				1,078,000	1,078,000
Total, diseases		233,000	1,600,000	6,662,000	8,495,000
Total, all pests		1,410,000	1,600,000	13,062,000	16,072,000

[a] Data are expressed as gross total volume.
[b] T = trace (less than 500 m^3)

Forest Resources

The N Region is mostly a forested area. About one-third of the total administrative area has currently exploitable forest, but the area administered extends far to the north. The exploitable forest extends to about 51° north latitude (Fig. 1), and includes about one-third of the area considered potentially exploitable by Dixon (1963). All of this exploitable area is in the Boreal forest region (Rowe 1972), and extensive stands of spruce, spruce-fir, jack pine, and poplars are present. Poplar and balsam fir stands are the most productive, with growth (CAI) for these WGs rated at 2.8 and 2.5 m^3/ha annually. Jack pine, spruce, and white birch stands are moderately productive at 1.6, 1.2, and 1.3 m^3/ha CAI. About 67% of the OFRI is complete for the area considered exploitable. The OHFI is summarized by species in Table 21.

Spruce Budworm

An extensive spruce budworm (Fig. 9) infestation in 1977 affected a total area of 9,005,000 ha that contained about 1,184,000 ha of susceptible host type. Budworm-caused mortality (see cover photo) was evident in about 25% of this area, and for stands experiencing mortality, the percentage of volume dead were as follows: balsam fir 21%, white spruce 3%, and black spruce 2%. By 1981, a total area of 10,450,000 ha containing 1,374,000 ha of host stands was affected and 60% of this area was experiencing mortality. The percentage of volume dead increased to 41% for balsam fir, 13% for white spruce, and 8% for black spruce. Virtually all (93%) of the commercially valuable host forest of the Region was affected by spruce budworm.

Figure 9. Defoliation by spruce budworm caused an average annual loss of more than 7,000,000 m^3 in the N Region in the period 1977-1981.

Table 21. Forest statistics[a] for the N Region.

Tree species	Gross total volume (m^3)	Gross total volume (%)	Current annual increment (m^3)	Current annual increment (%)
Red pine	342,000	T[b]	1,000	T
Jack pine	151,792,000	9	1,312,000	9
White pine	5,230,000	T	23,000	T
Black spruce	862,937,000	51	5,626,000	37
White spruce	49,572,000	3	323,000	2
Balsam fir	113,502,000	7	1,487,000	10
Cedar	13,291,000	1	151,000	1
Larch	9,556,000	1	71,000	T
Hemlock	8,000	T	T	T
Other conifers	9,000	T	T	T
Conifer total	1,206,239,000	72	8,994,000	59
Poplar	322,495,000	19	5,070,000	33
White birch	141,527,000	8	1,034,000	7
Yellow birch	589,000	T	8,000	T
Hard maple	1,147,000	T	10,000	T
Red mpale	932,000	T	19,000	T
Ash	52,000	T	1,000	T
Red oak	T	T		
White oak				
Elm	T	T	T	T
Basswood				
Beech				
Cherry	T		T	T
Other hardwoods	T	1	T	1
Hardwood total	466,742,000	28	6,142,000	41
Total, all species	1,672,981,000	100	15,136,000	100

[a] Data are expressed as gross total volume.
[b] T = trace (less than 500 m^3)

Note: Total administrative land area in region 34,549,000 ha
Current exploitable forest area in region 11,182,000 ha
Productive forest area 9,483,000 ha

Losses caused by the spruce budworm for the period 1977-1981 were just over 36,000,000 m^3, of which 4,080,000 m^3 was growth loss and 31,958,000 m^3 was mortality (Table 22). By the end of 1981 the cumulative loss due to defoliation amounted to 34,530,000 m^3 of mortality and 5,263,000 m^3 of growth loss (Fig. 10). While 75% of this damage occurred to balsam fir, white spruce and black spruce also sustained considerable losses (Table 22). The volume and growth data for balsam fir in Table 21 are really an indication of what would be present if budworm had not existed. For balsam fir, about two-thirds of the growth did not occur and about one-third of the standing volume died.

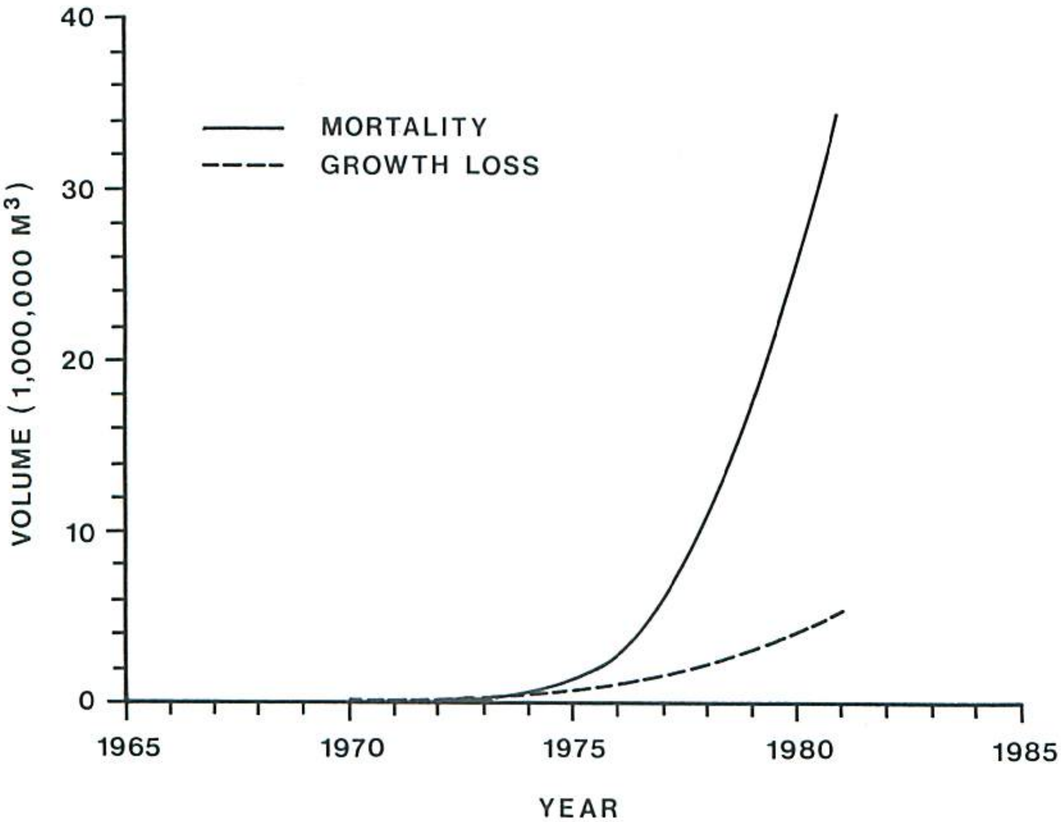


Figure 10. Cumulative growth loss and mortality caused by the current spruce budworm infestation in the N Region of Ontario. By the end of 1981, the total volume lost was 39,793,000 m^3.

Forest Tent Caterpillar

There was a large forest tent caterpillar infestation in the Region in 1977. Favorable weather conditions resulted in the expansion of the infestation in 1977 to 1,979,000 ha, containing 292,000 ha of host stands (Table 23). The infestation remained fairly static in 1978, declined appreciably to about 226,000 ha in 1979, and completely collapsed in 1980. The small infestation that started in the southwestern part of the Cochrane District in 1979 expanded and affected a total area of about 93,000 ha in 1980 and 1981.

Table 22. Volume of growth loss and mortality[a] resulting from defoliation caused by spruce budworm in the N Region, 1977-1981.

Year	Total area affected (ha)	Host stands defoliated (ha)	Tree species	Growth loss (m^3)	Mortality (m^3)
1977	9,005,000	1,184,000	balsam fir	348,000	2,536,000
			white spruce	55,000	178,000
			black spruce	142,000	232,000
				545,000	2,946,000
1978	9,797,000	1,289,000	balsam fir	456,000	3,804,000
			white spruce	65,000	471,000
			black spruce	169,000	616,000
				690,000	4,891,000
1979	10,690,000	1,406,000	balsam fir	574,000	4,755,000
			white spruce	77,000	748,000
			black spruce	201,000	929,000
				852,000	6,432,000
1980	10,228,000	1,345,000	balsam fir	678,000	6,086,000
			white spruce	84,000	942,000
			black spruce	220,000	1,220,000
				982,000	8,248,000
1981	10,450,000	1,374,000	balsam fir	785,000	6,911,000
			white spruce	96,000	1,136,000
			black spruce	251,000	1,394,000
				1,132,000	9,441,000
Volume lost, 1977-1981:			balsam fir	2,841,000	24,092,000
			white spruce	377,000	3,475,000
			black spruce	983,000	4,391,000
				4,201,000	31,958,000

[a] Data are expressed as gross total volume.

Total growth losses for the 5-year period were 1,076,000 m^3 (Table 23), 91% of which were sustained by aspen and the remainder by white birch.

Aspen Leafroller

There was a large infestation of aspen leafroller in 1977 just south of the forest tent caterpillar infestation previously described. A total area of 3,334,000 ha containing 550,000 ha of host stands was defoliated in 1977. The area infested was greatly reduced in 1978, and there was no significant defoliation after 1979. Total growth loss was estimated at 647,000 m^3, and 95% of this loss occurred in 1977.

White Birch Defoliator Complex

White birch was affected by several other defoliating insects including the birch skeletonizer, birch leafminer, fruittree leafroller, and spearmarked black moth, in addition to the forest tent caterpillar. These other defoliators caused a total growth loss of 93,000 m^3 for the period 1977-1981.

There was birch leafminer damage each year throughout the period. The scattered nature and varying levels of defoliation recorded made impact assessment difficult. Growth loss was estimated to be about 10,000 m^3 for the 5-year period.

Fruit tree leafroller caused significant defoliation in a total area of 750,000 ha in 1977, and there were low levels of defoliation in 1978 and 1979. Growth loss in 1977 was estimated at 15,000 m^3.

Defoliation by birch skeletonizer and spearmarked black moth affected 2,804,000 ha and 456,000 ha, respectively, in 1981, and caused growth losses of 59,000 m^3 and 9,000 m^3, respectively.

Root Rot

Root rots caused an estimated 1,080,000 m^3 of growth loss and 17,170,000 m^3 of mortality over the 5-year period (Table 24). In other northern regions, most of the damage occurred to black spruce, which is the most important species in terms of standing volume and timber value. For black spruce, losses due to root rot were equivalent to 51% of the current annual volume increment. Average annual losses for conifer species are shown in Table 24.

Root rots probably had considerable impact on broadleaved species as cull studies and other surveys indicate that root rotting organisms are common in the butt and roots of most hardwood species. For example, a survey of young aspen stands in 1977 (Gross and Basham 1981) indicated that about 45% of the root systems had stain or decay defect.

Table 23. Volume of growth loss[a] resulting from defoliation caused by forest tent caterpillar in the N Region, 1977-1981.

Year	Total area affected (ha)	Host stands defoliated (ha)	Tree species	Growth loss (m^3)
1977	1,979,000	292,000	poplar	460,000
			white birch	47,000
				507,000
1978	1,743,000	257,000	poplar	406,000
			white birch	42,000
				448,000
1979	226,000	33,000	poplar	53,000
			white birch	5,000
				58,000
1980	150,000	22,000	poplar	35,000
			white birch	4,000
				39,000
1981	93,000	14,000	poplar	22,000
			white birch	2,000
				24,000
Volume lost, 1977-1981:			poplar	976,000
			white birch	100,000
				1,076,000

[a] Data are expressed as gross total volume.

The root rot losses for conifer species can be expected to be lower in the future. As the overmature stands are harvested, younger stands managed by appropriate rotation ages can be expected to suffer fewer losses from root rot.

Table 24. Average annual timber volume[a] losses caused by wood decay and root rot diseases in the N Region, 1977-1981.

Tree species	Wood decay (m^3)	Root rot: Mortality (m^3)	Root rot: Growth loss (m^3)
Jack pine	123,000	152,000	3,000
White pine	4,000	5,000	T
Black spruce	146,000	2,718,000	162,000
White spruce	12,000	82,000	4,000
Balsam fir	159,000	477,000	47,000
Cedar	53,000		
Larch	3,000		
Other conifers	T[b]		
Conifer total	500,000	3,434,000	216,000
Poplar	1,014,000		
White birch	62,000		
Yellow birch	4,000		
Sugar maple	3,000		
Red maple	7,000		
Other hardwoods	1,000		
Hardwood total	1,091,000		
Total, all species	1,591,000	3,434,000	216,000

[a] Data are expressed as gross total volume.
[b] T = trace (less than 500 m^3).

Wood Decay

Volume loss (cull) caused by wood decay fungi for the period 1977-1981 was 7,955,000 m^3. Most of this loss was in poplar (64%), with jack pine (8%), balsam fir (10%), and black spruce (9%) accounting for most of the remainder. Average annual losses due to decay are shown by species in Table 24. As for losses due to root rot, timber utilization is expected to eliminate the highly defective overmature stands, and thus reduce losses due to wood decay as well.

Hypoxylon Canker

Hypoxylon canker of aspen caused 10,750,000 m^3 of mortality during the period 1977-1981. The average annual loss was equivalent to 41% of the current annual volume increment. The 2% of trees cankered seems low, but in a recent survey in the Kirkland Lake District, that level of cankering was detected.

Sweetfern Blister Rust Canker

Sweetfern blister rust canker caused 8,000 m^3 of growth loss and 45,000 m^3 of cull defect over the 5-year period. This disease is probably more important as a killer of young trees, but it is difficult to appraise such damage, and pest problems of precommercial-size trees have been left out of this analysis.

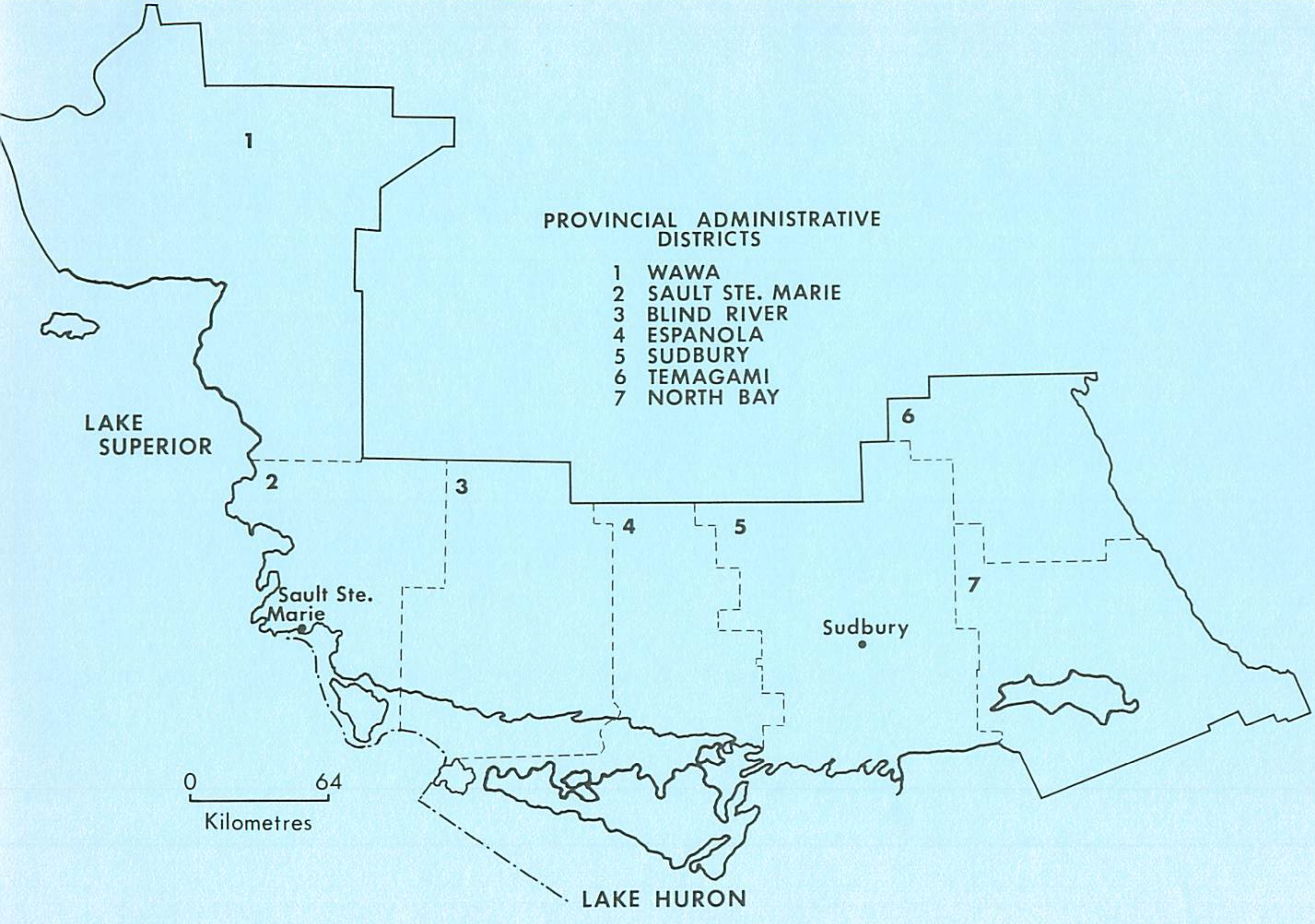
Diebacks

Mortality was rated for maple dieback and birch dieback. Mortality for the 5-year period accounted for 10,000 m^3 of sugar maple and 1,078,000 m^3 of birch. Maple dieback similar to that present throughout the range of maple was detected, but sugar maple is not prevalent in the Region. Dieback of white birch was part of a general birch decline. The actual pests involved in these problems vary, and climatic and site factors seem to be implicated as well as pests.

Summary

The N Region experienced pest-caused losses of about 16,000,000 m^3 during the period 1977-1981. Balsam fir was depleted at a rate of 4,391,000 m^3 annually, which is three times the expected annual growth. Black spruce and poplar were depleted at 80% and 69% of the annual growth rate, respectively, and as stated initially, total depletion by pests was greater than the current annual increment expected for the Region. The total loss of 80,330,000 m^3 for the 5-year period was approximately 5% of the gross standing volume (Table 21). Naturally, the inclusion of species that are being utilized well below their potential such as white birch, aspen, and balsam fir makes this loss less significant. However, as current and projected utilization of aspen indicates, preferences and trends change. Hence, all of this impact could be important in the near future.

Northeastern Region



PEST-CAUSED LOSSES IN THE NORTHEASTERN REGION

Introduction

Pest-caused losses in the NE Region averaged 8,188,000 m^3 annually over the period 1977-1981. This loss was equivalent to 83% of the annual growth (CAI) for the Region (Table 25, Fig. 11) and represents about twice the amount of timber harvested annually in that period. Defoliation by spruce budworm had the greatest impact and accounted for about 47% of the total loss (Fig. 12). Other important pests were forest tent caterpillar, diebacks, root rot, wood decay and Hypoxylon canker (Table 25).

Forest Resources

The NE Region is largely a forested area, 89% of it productive. The Region is mostly in the Great Lakes-St. Lawrence forest region, with some of the northern portion in the Boreal forest region (Rowe 1972). Tolerant hardwood forests and oak forests prevail east of Lake Superior and in the southern part of the Region. Growth (CAI) in these forests is about 1 m^3/ha/year. To the

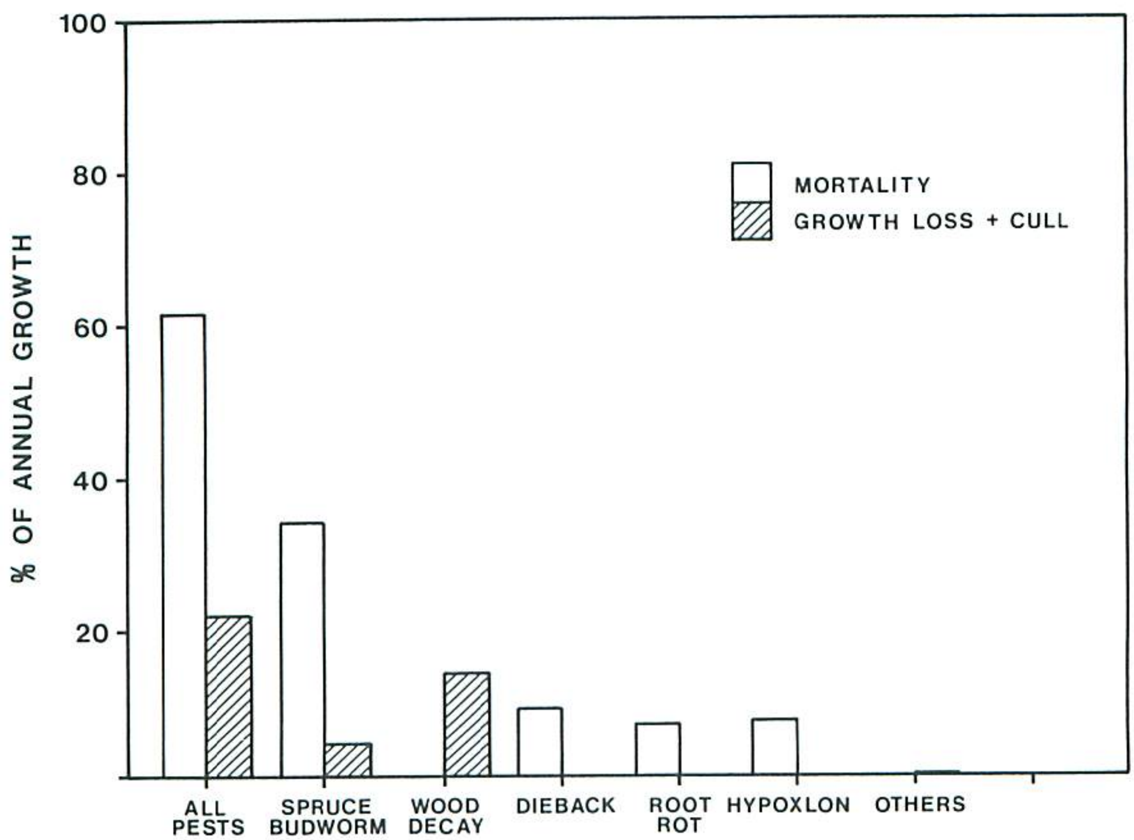


Figure 11. Pest-caused timber losses in the NE Region totalled 8,188,000 m^3 annually (equivalent to 83% of growth (CAI) for the period 1977-1981).

Table 25. Average annual pest-caused losses[a] in the NE Region, 1977-1981.

Pest	Tree species	Growth loss (m^3)	Cull (m^3)	Mortality (m^3)	Total (m^3)
Spruce budworm	black spruce	74,000		260,000	334,000
	white spruce	65,000		547,000	612,000
	balsam fir	400,000		2,610,000	3,010,000
		539,000		3,417,000	3,956,000
Forest tent caterpillar	poplar	66,000			66,000
	white birch	10,000			10,000
	sugar maple	5,000			5,000
	other	1,000			1,000
		82,000			82,000
Aspen complex	poplar	2,000			2,000
White birch complex	white birch	22,000			22,000
Oak complex	red oak	T[b]			T
Total, insects		645,000		3,417,000	4,062,000
Root rot	conifers	86,000		783,000	869,000
Wood decay	conifers		415,000		415,000
	hardwoods		1,012,000		1,012,000
			1,427,000		1,427,000
Hypoxylon canker	poplar			821,000	821,000
Sweetfern rust	jack pine	15,000	8,000		23,000
Diebacks	sugar maple			65,000	65,000
	white birch			914,000	914,000
	red oak			7,000	7,000
				986,000	986,000
Total, diseases		101,000	1,435,000	2,590,000	4,126,000
Total, all pests		746,000	1,435,000	6,007,000	8,188,000

[a] Data are expressed as gross total volume.
[b] T = trace (less than 500 m^3).

north, forests containing black spruce, jack pine, poplar, white birch, and balsam fir cover most of the land. The poplar and balsam fir stands are highly productive, averaging about 3 and 2.5 m^3/ha growth (CAI) annually, respectively. Average annual growth (CAI) in spruce stands and jack pine stands is about 1.5 m^3 per ha; however, well stocked stands of these species grow at several times the average rate. The current OFRI is about 70% completed. The data for the OHFI are summarized by tree species in Table 26.

Spruce Budworm

There was a massive spruce budworm infestation throughout the period 1977-1981. In 1977, spruce budworm affected a total land area of 4,443,000 ha and a host stand area of 592,000 ha. Mortality occurred in about 44% of this area, and for host stands experiencing mortality, the percentage of volume dead for balsam fir, white spruce, and black spruce was 25%, 5%, and 3% respectively. By 1981, virtually the entire Region, 7,200,000 ha of the total land area, and 1,001,000 ha of the host stand area, had been attacked by budworm. The size of the area experiencing mortality increased to 3,321,000 ha of the total land area, and mortality increased to 60% for balsam fir, 20% for white spruce and 12% for black spruce. Budworm-caused damage is summarized by year in Table 27. Losses for the 5-year period were estimated at 2,693,000 m^3 of growth loss and 17,086,000 m^3 of mortality. By the end of 1981, the cumulative result of the defoliation was 19,292,000 m^3 of mortality and 3,974,000 m^3 of growth loss (Fig. 12). While 75% of this loss was in balsam fir, white spruce and black spruce also suffered considerable damage (Table 27). The balsam fir content of the forest changed dramatically, and by 1981 many of the stands had very little balsam fir remaining.

Forest Tent Caterpillar

In 1977, a large forest tent caterpillar infestation affected a total area of 783,000 ha and defoliated trees in 125,000 ha of host stands. Most of the defoliation was in the southern parts of the Sudbury, North Bay, and Espanola districts. Parts of the Sault Ste. Marie and Temagami districts were also affected. In 1978, the area defoliated was about half this size, and by 1979, total area affected was only 45,000 ha. A few areas of defoliation persisted through 1980, and a few scattered new locations suffered defoliation that year. Growth loss for the 5-year period was 409,000 m^3 (Table 28). Some mortality of sugar maple in the Sault Ste. Marie District seemed to be at least partially the result of defoliation by the forest tent caterpillar. However, the association of mortality with defoliation in this Region was not as obvious as it was in the Algonquin and Southwestern regions. Hence, all maple mortality was reported as caused by maple dieback.

Aspen Defoliator Complex

In addition to forest tent caterpillar, a variety of other defoliating insects affected aspen during the period 1977-1981. Most of the damage occurred in 1978 and 1979, and was caused by the aspen leafroller. Only 8,000 ha of host stands were defoliated, and growth loss totalled 10,000 m^3 for the 5-year period.

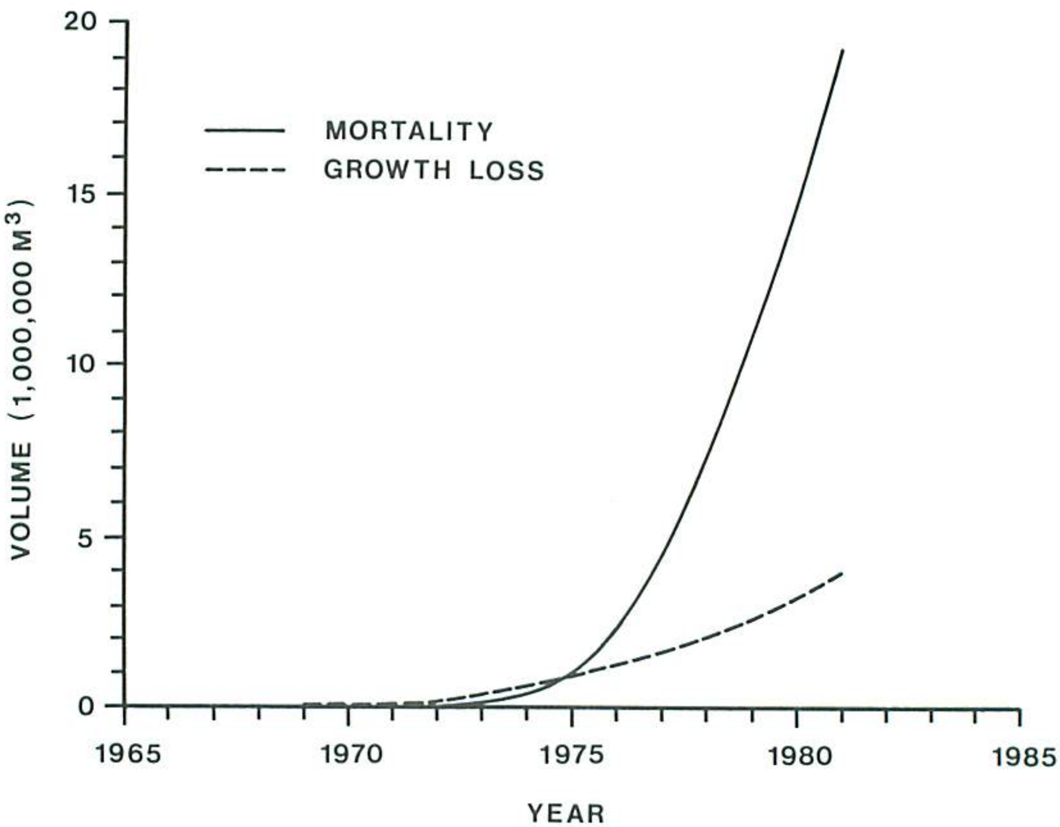


Figure 12. Cumulative growth loss and mortality resulting from the current spruce budworm infestation in the NE Region of Ontario. By the end of 1981, the total volume lost was 23,266,000 m^3.

White Birch Defoliator Complex

White birch suffered extensive defoliation by the birch skeletonizer and the spearmarked black moth in 1981. The total area affected by these two insects was 2,480,000 ha and 316,000 ha, respectively. Host stand area defoliated totalled 532,000 ha, and growth loss was 113,000 m^3, of which 90% was attributed to birch skeletonizer defoliation.

Swaine Jack Pine Sawfly

This sawfly defoliated several hundred hectares of jack pine in 1980 and spread to an additional 4,663 ha in 1981. Some growth reduction was evident. The rate of reduction is being studied, and a conservative estimate of growth loss is about 2,000 m^3. However, this volume loss is not included in the data presented in Table 25, as impact studies are not complete.

Table 26. Forest statistics[a] for the NE Region.

Tree species	Gross total volume (m^3)	Gross total volume (%)	Current annual increment (m^3)	Current annual increment (%)
Red pine	13,656,000	2	70,000	1
Jack pine	83,451,000	13	1,150,000	12
White pine	41,521,000	7	356,000	4
Black spruce	88,590,000	14	1,000,000	10
White spruce	32,980,000	5	372,000	4
Balsam fir	54,723,000	8	1,223,000	12
Cedar	22,766,000	4	129,000	1
Larch	1,403,000	T[b]	8,000	T
Hemlock	5,747,000	1	140,000	1
Other conifers	15,000	T	T	T
Conifer total	344,852,000	54	4,448,000	45
Poplar	123,178,000	19	3,488,000	35
White birch	120,236,000	19	1,255,000	13
Yellow birch	5,667,000	1	77,000	1
Sugar maple	32,430,000	5	380,000	4
Red maple	6,331,000	1	129,000	1
Ash	1,519,000	T	29,000	T
Red oak	1,190,000	T	28,000	T
Elm	210,000	T	6,000	T
Basswood	309,000	T	7,000	T
Beech	440,000	T	13,000	T
Cherry	123,000	T	4,000	T
Other hardwoods	321,000	1	7,000	1
Hardwood total	291,954,000	46	5,423,000	55
Total, all species	636,806,000	100	9,871,000	100

[a] Data are expressed as gross total volume.
[b] T = trace (less than 500 m^3)

Note: Total administrative land area in region 7,974,000 ha
Current exploitable forest area in region 7,272,000 ha
Productive forest area 6,499,000 ha

Table 27. Volume of growth loss and mortality resulting from defoliation caused by spruce budworm in the NE Region, 1977-1981.

Year	Total area affected (ha)	Host stands defoliated (ha)	Tree species	Growth loss (m^3)	Mortality (m^3)
1977	4,443,000	592,000	balsam fir	286,000	1,757,000
			white spruce	46,000	241,000
			black spruce	52,000	120,000
				384,000	2,118,000
1978	4,973,000	662,000	balsam fir	332,000	2,404,000
			white spruce	53,000	482,000
			black spruce	60,000	224,000
				445,000	3,110,000
1979	5,868,000	781,000	balsam fir	371,000	2,524,000
			white spruce	61,000	662,000
			black spruce	69,000	318,000
				501,000	3,504,000
1980	7,200,000	959,000	balsam fir	467,000	2,926,000
			white spruce	78,000	648,000
			black spruce	88,000	318,000
				633,000	3,892,000
1981	7,200,000	1,001,000	balsam fir	544,000	3,437,000
			white spruce	87,000	708,000
			black spruce	99,000	317,000
				730,000	4,462,000
Volume lost, 1977-1981:			balsam fir	2,000,000	13,048,000
			white spruce	325,000	2,741,000
			black spruce	368,000	1,297,000
				2,693,000	17,086,000

[a] Data are expressed as gross total volume.

Ta e 28. Volume of growth loss[a] resulting from defoliation caused by the forest tent caterpillar in the NE Region, 1977-1981.

Ye	Total area affected (ha)	Host stands defoliated (ha)	Tree species	Growth loss (m^3)
19	783,000	125,000	poplar	203,000
			white birch	31,000
			sugar maple	15,000
			yellow birch	1,000
			other hardwoods	3,000
				253,000
1 8	325,000	52,000	poplar	84,000
			white birch	15,000
			sugar maple	6,000
			yellow birch	T[b]
			other hardwoods	1,000
				106,000
1 79	45,000	6,000	poplar	12,000
			white birch	2,000
			sugar maple	1,000
			yellow birch	T
			other hardwoods	T
				15,000
30	122,000	19,000	poplar	31,000
			white birch	2,000
			sugar maple	2,000
			yellow birch	T
			other hardwoods	T
				35,000
Volume lost, 1977-1981:			poplar	330,000
			white birch	50,000
			sugar maple	24,000
			yellow birch	1,000
			other hardwoods	4,000
				409,000

[a] Data are expressed as gross total volume.
T = trace (less than 500 m^3)

Root Rot

Root rot caused an estimated 430,000 m^3 of growth loss and 3,915,000 m^3 of mortality in the period 1977-1981. Average annual losses for conifer species are shown in Table 29. Most of the root rot was in balsam fir and black spruce, which accounted for 35% and 41% of the estimated total loss, respectively. Losses can be expected to be lower in the future as the highly defective stands are harvested.

Table 29. Average annual timber volume[a] losses caused by wood decay and root rot diseases in the NE Region, 1977-1981.

Tree species	Wood decay	Root rot	
		Mortality	Growth loss
Red pine	1,000	14,000	
Jack pine	108,000	83,000	2,000
White pine	60,000	41,000	1,000
Black spruce	26,000	319,000	33,000
White spruce	19,000	63,000	5,000
Balsam fir	127,000	263,000	45,000
Cedar	45,000		
Hemlock	28,000		
Other conifer	1,000		
Conifer total	415,000	783,000	86,000
Poplar	698,000		
White birch	75,000		
Yellow birch	40,000		
Sugar maple	126,000		
Red maple	51,000		
Ash	8,000		
Red oak	6,000		
Elm	1,000		
Basswood	2,000		
Beech	4,000		
Other hardwoods	1,000		
Hardwood total	1,012,000		
Total, all species	1,427,000	783,000	86,000

[a] Data are expressed as gross total volume.

Root rots probably have a considerable impact on broadleaved species. Cull studies and other surveys indicate that root-rotting organisms are common in the butt and roots of most species, and Armillaria root rot is frequently present on trees affected by dieback problems.

Wood Decay

Volume losses (cull) caused by wood decay fungi (Fig. 13) were 7,135,000 m^3 for the 5-year period, and average annual losses are shown in Table 29. Most of this decay was in poplar (49%), jack pine (8%), balsam fir (9%), and sugar maple (9%). Utilization of the highly defective overmature stands can be expected to reduce losses to wood decay in jack pine and spruce. Defect data were available only for stands that had not been cut previously, and the defect for second-growth stands could be somewhat higher, especially when stands are not clear cut at the final harvest.

Figure 13. Cull necessitated by wood decay results in losses of about 1.5 million m^3 annually in the NE Region. (photo courtesy of R.D. Whitney).

Hypoxylon Canker

It was estimated that Hypoxylon canker caused a total of 4,105,000 m^3 of aspen mortality over the 5-year period. Hence, this one disease is killing a volume equivalent to 23% of the current annual increment of aspen.

Diebacks

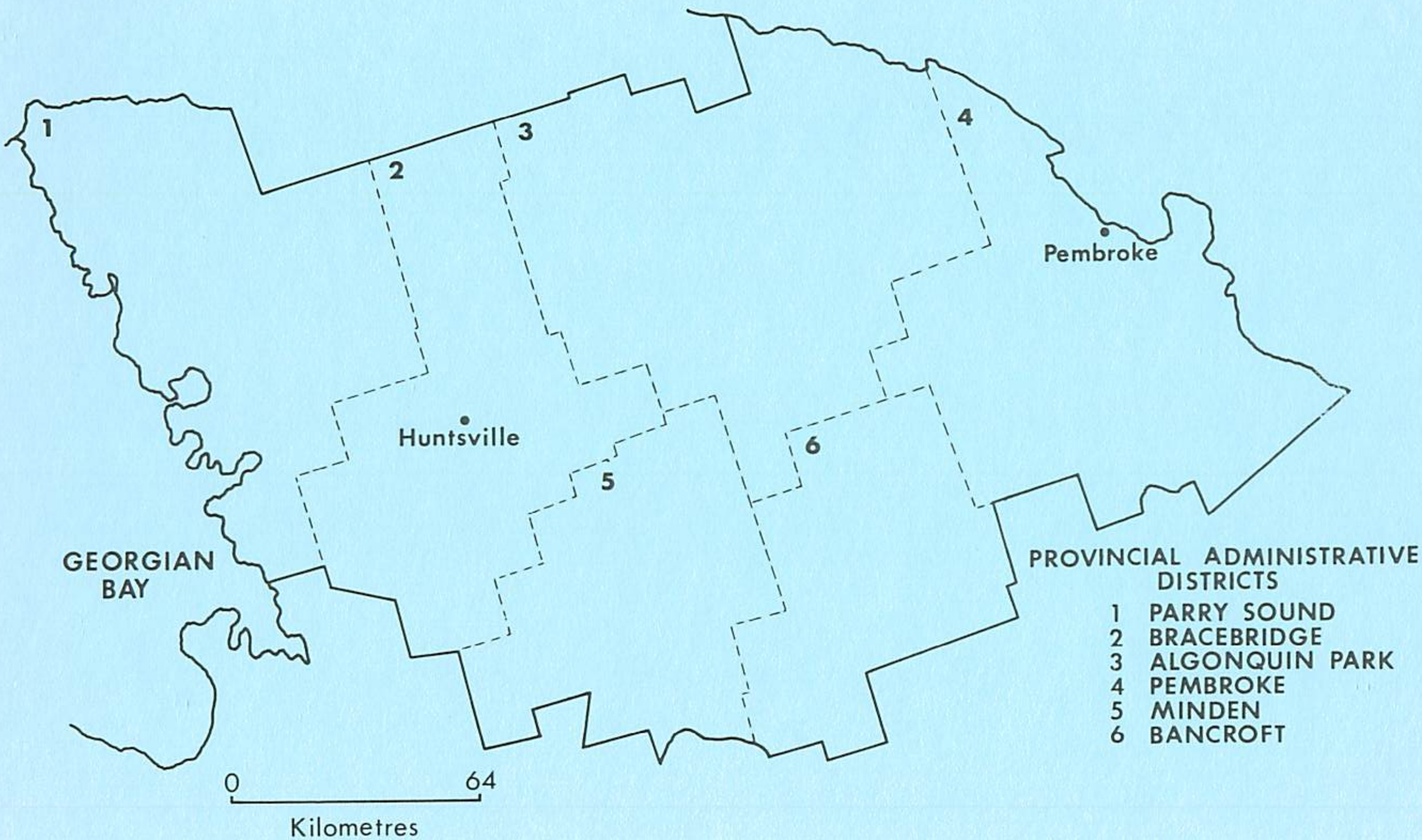
It was estimated that maple dieback caused 325,000 m^3 of sugar maple mortality during the 5-year period. Most of this mortality seemed to be part of a general maple decline that has been evident throughout the range of hard maple in recent years. As noted previously, defoliation by the forest tent caterpillar seemed to aggravate this mortality, particularly in the Sault Ste. Marie District.

Mortality was also calculated for birch dieback and oak dieback. Losses for the 5-year period were 4,570,000 m^3 for white birch and 35,000 m^3 for red oak. The actual causes of diebacks vary, and climatic and site factors seem to be implicated, as well as insect and disease pests. Plots monitoring the progress of oak dieback do show more mortality where insect infestations were previously present.

Summary

The NE Region experienced pest-caused losses of about 8 million m^3 annually during the period 1977-1981. Balsam fir was depleted at a rate of 3,361,000 m^3 annually, which is almost three times the current annual increment for that species, and most of this loss (87%) was attributed to budworm. Other species suffering extensive damage were black spruce, poplar, white birch and hard maple. As stated initially, pest-caused depletion was almost as great as the current annual increment. Viewed as a loss in gross standing volume, loss for the period 1977-1981 totalled 40,945,000 m^3, which is over 6% of the gross standing volume and about four times the volume harvested in this period. The inclusion of species such as poplar, white birch and balsam fir, that were being utilized well below their potential, somewhat reduces the importance of these losses. However, our inability to assess known pest problems such as root rot of broadleaved species and pest problems of precommercial-size trees makes the overall estimate conservative. Also, utilization trends change, and the future importance of pest-caused losses in aspen, and possibly white birch and balsam fir, may be greater than is currently apparent. Viewed in another way, pest-caused defect of aspen is one of the major deterrents to increased utilization of aspen.

Algonquin Region



PEST-CAUSED LOSSES IN THE ALGONQUIN REGION

Introduction

Pest-caused losses in the AL Region averaged 5,124,000 m^3 annually during the period 1977-1981 (Table 30, Fig. 14). This was roughly equivalent to the annual growth (CAI), and about twice the volume of timber harvested. Defoliation by spruce budworm was the most serious problem, and was equivalent to about three times the expected growth for the host species, spruce and balsam fir. Other important pests were forest tent caterpillar, diebacks, wood decay, root rot and Hypoxylon canker.

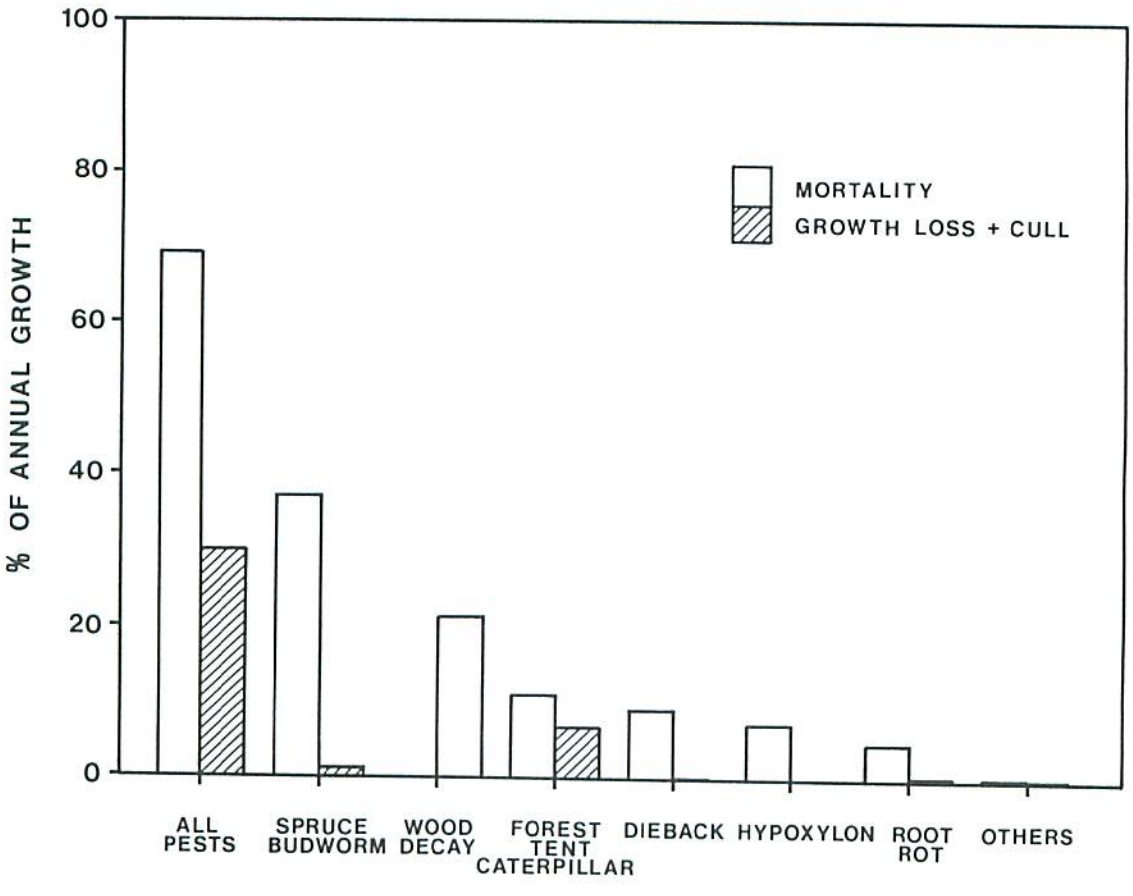


Figure 14. Pest-caused timber loss in the AL Region totalled 5,124,000 m^3 annually (equivalent to annual growth (CAI) during the period 1977-1981).

Table 30. Average annual pest-caused losses[a] in the AL Region, 1977-1981.

Pest	Tree species	Growth loss (m^3)	Cull (m^3)	Mortality (m^3)	Total (m^3)
Spruce budworm	black spruce	6,000		49,000	55,000
	white spruce	10,000		285,000	295,000
	balsam fir	49,000		1,580,000	1,629,000
		65,000		1,914,000	1,979,000
Forest tent caterpillar	poplar	66,000		0	66,000
	white birch	5,000		0	5,000
	sugar maple	269,000		571,000	840,000
	other	10,000		0	10,000
		350,000		571,000	921,000
Aspen complex	poplar	4,000			4,000
White birch complex	white birch	T[b]			T
Oak complex	red oak	2,000		16,000	18,000
Total, insects		421,000		2,501,000	2,922,000
Root rot	conifers	20,000		243,000	263,000
Wood decay	conifers		189,000		189,000
	hardwoods		908,000		908,000
			1,097,000		1 097,000
Hypoxylon canker	poplar			373,000	373,000
Diebacks	sugar maple			239,000	239,000
	white birch			210,000	210,000
	red oak			20,000	20,000
				469,000	469,000
Total, diseases		20,000	1,097,000	1,085,000	2,202,000
Total, all pests		441,000	1,097,000	3,586,000	5,124,000

[a] Data are expressed as gross total volume.
[b] T = trace (less than 500 m^3)

Forest Resources

The AL Region is mostly forested land. Only about one-third of the current OFRI is complete. The entire Region is in the Great Lakes-St. Lawrence forest region (Rowe 1972). In the northern part of the Region, forests contain considerable spruce, balsam fir, aspen and white birch. Farther south, tolerant hardwood forests prevail. About 84% of the area is productive forest, and much of the remainder is agricultural. OHFI data by species are presented in Table 31.

Spruce Budworm

The budworm infestation in 1977 and 1978 was greatly reduced from that of 1975. In 1979 and 1980, the infestation increased to just over 2 million ha, which was about the size of the area affected before 1977. In 1981 the infestation was reduced again to approximately the same size as the 1977 and 1978 infestations. The area defoliated is not apparent in Table 32 because areas experiencing mortality but no current defoliation are included as affected area. For example, the total area affected in 1977 was 1,250,000 ha, which was actually the area reported as showing mortality. About 400,000 ha suffered defoliation in 1977.

In 1977, the 1,250,000-ha area experiencing tree mortality contained host stands of 83,000 ha in which 14% of balsam fir and 1% of white spruce had been killed. The area with mortality increased to 1,402,000 ha by 1981, at which time mortality was 75% for balsam fir, 25% for white spruce, and 16% for black spruce. Total loss for the 5-year period was approximately 10 million m^3 (Table 32, Fig. 15). Most of this loss (82%) was in balsam fir, but white spruce was also severely affected.

Forest Tent Caterpillar

An extensive forest tent caterpillar infestation in 1977 affected a total area of 1,846,000 ha and trees in 743,000 ha of host stands were defoliated. The infestation collapsed in 1978 and only 46,000 ha were defoliated that year. Growth loss for the period 1977-1981 was 1,750,000 m^3 and mortality amounted to 2,857,000 m^3 (Table 33). Most of these losses (90%) were confined to sugar maple, which was more extensively damaged than other host tree species.

Sugar maple suffered extensive mortality in 1977 and 1978 (Fig. 16). While other species may have experienced some mortality, the losses were equivalent to those in nondefoliated areas. The problem was called maple dieback; however, the association of mortality with defoliation by forest tent caterpillar was distinct. Hence, 2,857,000 m^3 of the mortality caused by maple dieback in the Region was considered to be caused by forest tent caterpillar defoliation. Growth studies of sugar maple defoliated for several years by forest tent caterpillar showed that it did not recover normal growth until 1981. Therefore, for a host stand area of 500,000 ha, sugar maple was considered to suffer a growth loss of 249,000 m^3 annually for 1977 through 1981.

Table 31. Forest statistics[a] for the AL Region.

Tree species	Gross total volume (m³)	Gross total volume (%)	Current annual increment (m³)	Current annual increment (%)
Red pine	9,144,000	2	98,000	2
Jack pine	1,615,000	T[b]	14,000	T
White pine	38,918,000	10	485,000	9
Black spruce	9,034,000	2	85,000	2
White spruce	13,944,000	4	131,000	3
Balsam fir	27,885,000	7	395,000	8
Cedar	6,836,000	2	60,000	1
Larch	952,000	T	8,000	T
Hemlock	36,981,000	9	167,000	3
Other conifers	42,000	T	T	T
Conifer total	145,351,000	36	1,443,000	28
Poplar	55,886,000	14	973,000	19
White birch	27,643,000	7	299,000	6
Yellow birch	26,862,000	7	365,000	7
Hard maple	121,468,000	30	1,485,000	29
Red maple	9,816,000	3	200,000	4
Ash	1,467,000	T	28,000	1
Red oak	5,810,000	1	112,000	2
White oak	20,000	T	1,000	T
Elm	1,048,000	T	30,000	1
Basswood	442,000	T	10,000	T
Beech	5,421,000	1	160,000	3
Cherry	584,000	T	19,000	T
Other hardwoods	413,000	1	9,000	T
Hardwood total	256,880,000	64	3,691,000	72
Total, all species	402,231,000	100	5,134,000	100

[a] Data are expressed as gross total volume.
[b] T = trace (less than 500 m^3)

Note:		
	Total administrative land area in region	3,931,000 ha
	Current exploitable forest area in region	3,553,000 ha
	Productive forest area	2,972,000 ha

Table 32. Volume of growth loss and mortality[a] resulting from defoliation caused by spruce budworm in the AL Region, 1977-1981.

Year	Total area affected (ha)	Host stands affected (ha)	Tree species	Growth loss (m^3)	Mortality (m^3)
1977	1,250,000	83,000	balsam fir	76,000	968,000
			white spruce	13,000	37,000
			black spruce	8,000	6,000
				97,000	1,011,000
1978	1,304,000	86,000	balsam fir	37,000	1,584,000
			white spruce	7,000	182,000
			black spruce	4,000	31,000
				48,000	1,797,000
1979	2,182,000	144,000	balsam fir	37,000	1,705,000
			white spruce	9,000	397,000
			black spruce	6,000	71,000
				52,000	2,173,000
1980	2,231,000	147,000	balsam fir	47,000	1,815,000
			white spruce	10,000	424,000
			black spruce	6,000	74,000
				63,000	2,313,000
1981	1,898,000	125,000	balsam fir	48,000	1,826,000
			white spruce	9,000	385,000
			black spruce	6,000	64,000
				63,000	2,275,000
Volume lost, 1977-1981:			balsam fir	245,000	7,898,000
			white spruce	48,000	1,425,000
			black spruce	30,000	246,000
				323,000	9,569,000

[a] Data are expressed as gross total volume.

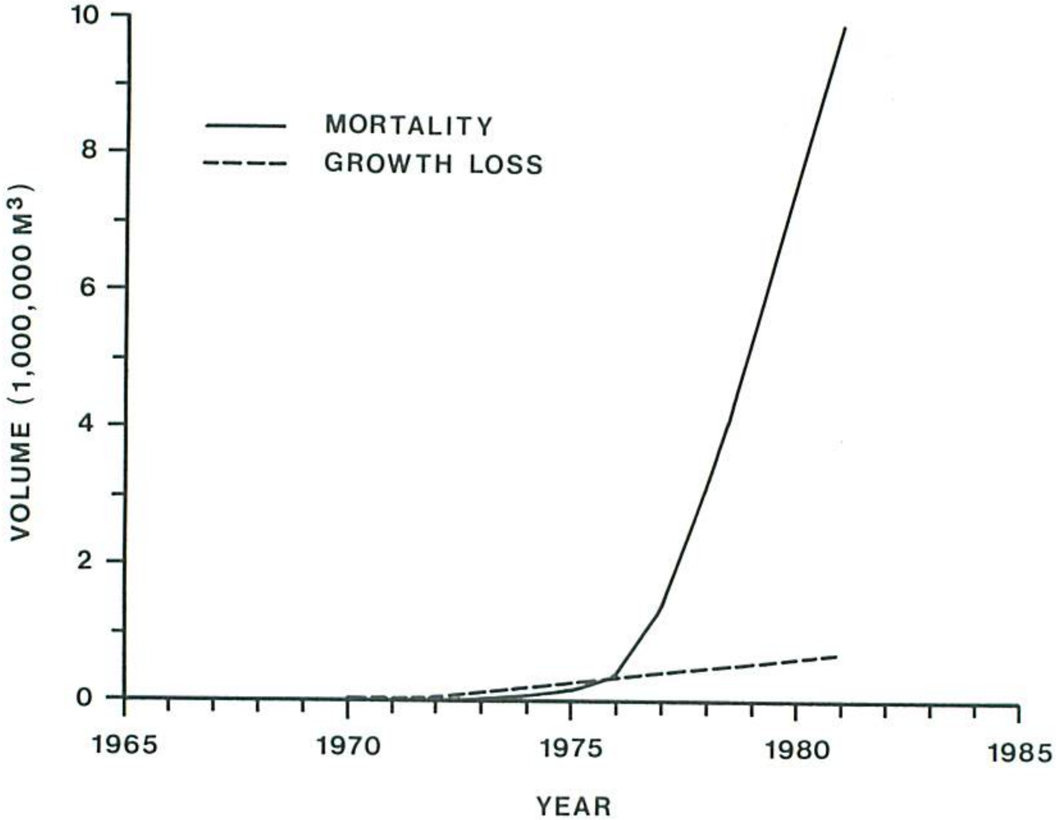


Figure 15. The cumulative growth loss and mortality caused by spruce budworm defoliation in the Algonquin Region of Ontario. By the end of 1981, the total volume lost was 10,616,000 m^3.

Aspen Defoliator Complex

In addition to forest tent caterpillar, a variety of other defoliating insects affected aspen in the period 1977-1981. Significant defoliation by the aspen leafroller and leaftier affected a host stand area of 15,000 ha in 1979 and 1,000 ha in 1980. The defoliation caused a growth loss of about 20,000 m^3.

Oak Defoliator Complex

Red oak was defoliated by a variety of insects throughout the period 1977-1981. Oak leaf shredder was responsible for most of the defoliation, and most of the damage (90%) occurred in 1979 when a host stand area of about 25,000 ha showed defoliation. Total growth loss for the 5-year period was 10,000 m^3. Some mortality was probably caused by this defoliation because plots established to study oak dieback showed that mortality was greater in stands that had already been defoliated. Also, control of the oak leaf shredder in one sampled stand resulted in lower mortality than in an adjacent defoliated stand. The association of oak decline with defoliation was not as distinct as that of maple decline. However, some influence was apparent, and for the period 1977-1981 a total volume of 80,000 m^3 of oak mortality associated with the decline was assigned to defoliators.

Table 33. Volume of growth loss and mortality[a] resulting from defoliation caused by forest tent caterpillar in the AL Region, 1977-1981.

Year	Total area affected (ha)	Host stands defoliated (ha)	Tree species	Growth loss (m^3)	Mortality (m^3)
1977	1,846,000	743,000	poplar	322,000	
			white birch	25,000	
			sugar maple	349,000	557,000
			yellow birch	17,000	
			other hardwoods	30,000	
				743,000	557,000
1978	1,333,000	46,000	poplar	8,000	
			white birch	1,000	
			sugar maple	249,000	2,300,000
			yellow birch	1,000	
			other hardwoods	1,000	
				260,000	2,300,000
1979	1,333,000	0	sugar maple	249,000	
1980	1,333,000	0	sugar maple	249,000	
1981	1,333,000	0	sugar maple	249,000	
Volume lost, 1977-1981:			poplar	330,000	
			white birch	26,000	
			sugar maple	1,345,000	2,857,000
			yellow birch	18,000	
			other hardwoods	31,000	
				1,750,000	2,857,000

[a] Data are expressed as gross total volume.

Root Rot

Root rots caused an estimated 100,000 m^3 of growth loss and 1,215,000 m^3 of mortality during the period 1977-1981. Fifty-six percent of this loss was in balsam fir. White pine, black spruce, and white spruce suffered most of the remainder of the damage (Table 34). Red pine probably would have experienced considerable damage if control of Annosus root rot had not been practised following thinnings and harvest cuts.

Root rots likely have considerable impact on broadleaved tree species, as cull studies (Basham and Morawski 1964) and other surveys show that root-rotting organisms are common in the butt and roots of trees of most species. Also, the almost constant association of Armillaria root rot with dieback problems indicates that this root rot is at least partly responsible for the mortality reported to be caused by dieback disease.

Figure 16. Maple mortality associated with defoliation by forest tent caterpillar was prevalent in the Parry Sound and Bracebridge districts of the AL Region in 1978.

Wood Decay

Volume loss (cull) caused by wood decay during the period 1977-1981 was 5,490,000 m^3 (Table 34). Sugar maple was by far the most valuable species in the Region in terms of standing volume and timber value, and 40% of the cull was sugar maple. Other broadleaved species that were fairly defective were yellow birch, red maple, basswood, and beech. Average annual decay losses by tree species are presented in Table 34.

Table 34. Average annual timber volume[a] losses caused by wood decay and root rot diseases in the AL Region, 1977-1981.

Tree species	Wood decay (m^3)	Root rot: Mortality (m^3)	Root rot: Growth loss (m^3)
Red pine	1,000	9,000	T[b]
Jack pine	1,000	2,000	T
White pine	82,000	39,000	1,000
Black spruce	2,000	33,000	3,000
White spruce	7,000	26,000	2,000
Balsam fir	41,000	134,000	14,000
Cedar	21,000		
Hemlock	33,000		
Other conifers	1,000		
Conifer total	189,000	243,000	20,000
Poplar	133,000		
White birch	18,000		
Yellow birch	145,000		
Sugar maple	443,000		
Red maple	71,000		
Ash	8,000		
Red oak	22,000		
Elm	6,000		
Basswood	2,000		
Beech	56,000		
Cherry	2,000		
Other hardwoods	2,000		
Hardwood total	908,000		
Total, all species	1,097,000	243,000	20,000

[a] Data are expressed as gross total volume.
[b] T = trace (less than 500 m^3)

The reduction in loss expected when overmature stands are harvested may not occur in the tolerant hardwood stands. Cutting practices frequently left defective trees, and as a result, second-growth stands often have a high number of defective trees. Stand improvement practices that remove defective trees can greatly reduce future losses to wood decay.

Hypoxylon Canker

Hypoxylon canker of aspen caused 1,865,000 m^3 of mortality in the period 1977-1981. Average annual loss was equivalent to 38% of the growth increment (CAI) for aspen. The percentage of trees cankered was estimated at 2% on the basis of surveys in northern Ontario. The quality of aspen seems to improve in the northern latitudes, so this impact estimate may be conservative.

Diebacks

In addition to the maple dieback associated with defoliation by forest tent caterpillar noted previously (Fig. 16), sugar maple was affected by a general dieback throughout its range in Ontario. About 5% of the maples in woodland situations had more than 20% of the branches dead (Howse et al. 1977), and there was mortality associated with dieback. About 1,195,000 m^3 of mortality of sugar maple, in addition to that caused by the forest tent caterpillar, occurred in the period 1977-1981.

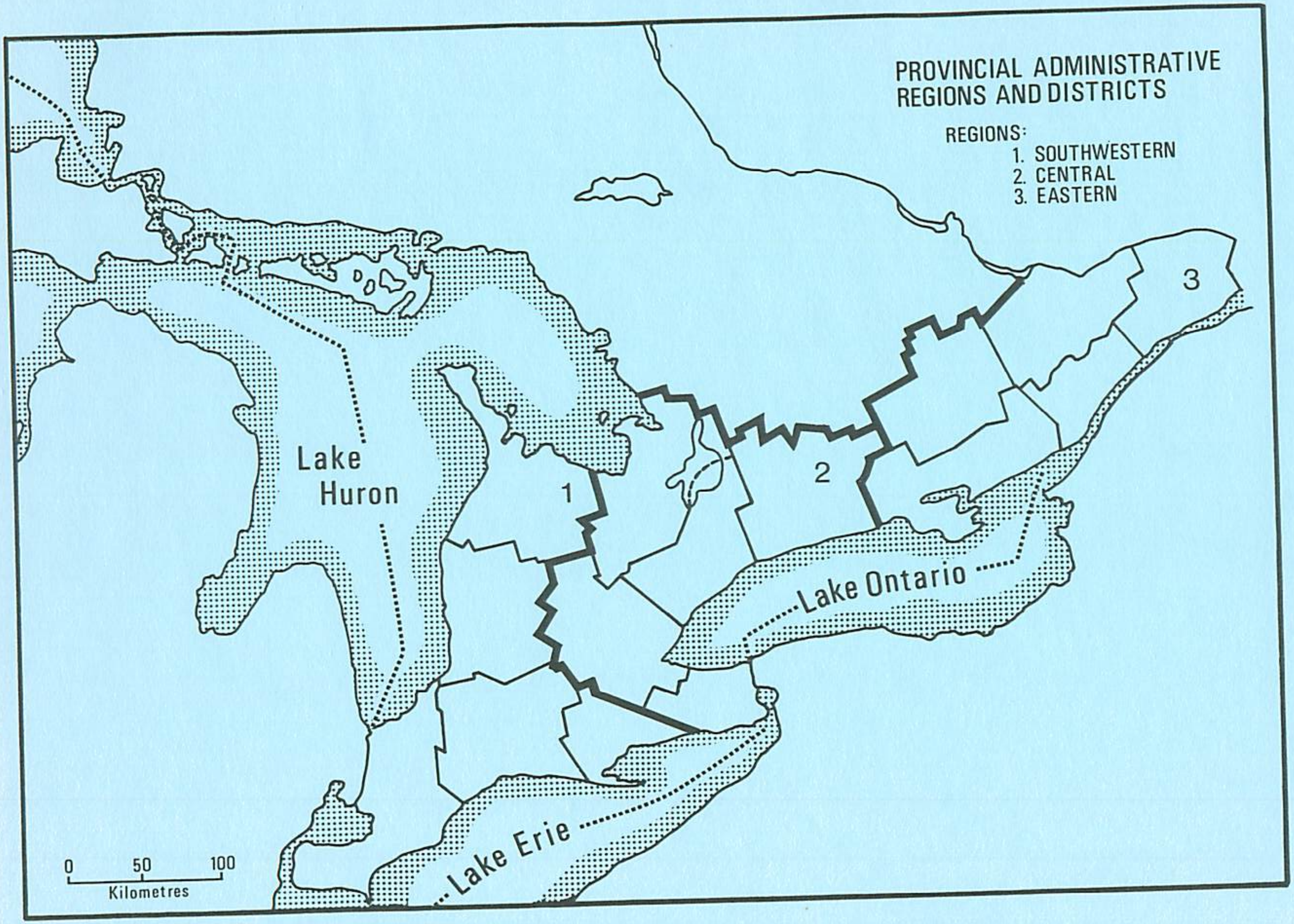
Oak dieback caused 180,000 m^3 of mortality during this period. Studies on plots established to follow the progress of the dieback indicate that about 6% of the trees died in the 5-year period. Stands that experienced defoliation by oak leaf shredder seem to have more oak dieback. Hence, 80,000 m^3 of this mortality was reported as caused by insects and the remaining 100,000 m^3 was caused by disease.

White birch was also affected by a dieback. Overmaturity seemed to be a factor here; however, juvenile and mature stands often suffer dieback as a result of other factors such as drought and defoliation. An estimated 1,050,000 m^3 of mortality of white birch occurred in the period 1977-1981.

Summary

Pest-caused losses of 5,124,000 m^3 occurred annually in the AL Region in the period 1977-1981. Defoliation by spruce budworm caused about 40% of this loss, and much of the balsam fir in the Region died. The forest tent caterpillar infestation collapsed in 1978, but up to four successive years of defoliation had a devastating effect on the sugar maple in some stands. Probably the most affected area was along the Moon River in Parry Sound District, where about 1,200,000 m^3 of sugar maple were killed. The defoliation, coupled with a general dieback of sugar maple throughout its range, caused extensive mortality and also resulted in considerable growth loss. Other important pests were wood decay, root rot, and Hypoxylon canker.

Central - Eastern - Southwestern Regions



PEST-CAUSED LOSSES IN THE CENTRAL, EASTERN AND SOUTHWESTERN REGIONS

Introduction

Pest-caused losses in the C-E-SW regions totalled 1,959,000 m^3 annually (Table 35, Fig. 17) during the period 1977-1981. This was equivalent to about half of the annual growth (CAI). Forest tent caterpillar, spruce budworm, wood decay, root rot and dieback problems were the important pests.

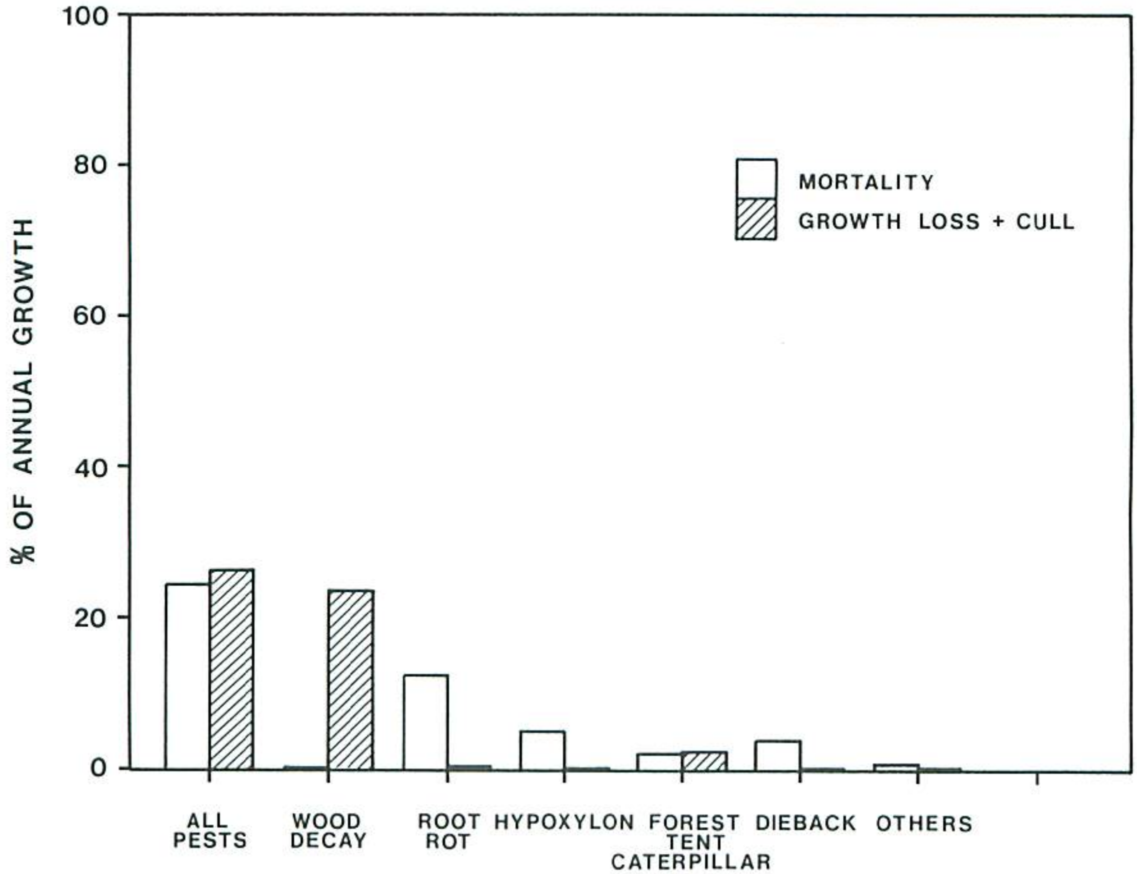


Figure 17. Pest-caused timber loss for the C-E-SW regions totalled 1,959,000 m^3 annually (equivalent to half the annual growth during the period 1977-1981).

Forest Resources

Southern Ontario is predominantly agricultural and urban land. About 27% of the C-E-SW regions is forested and about 75% of the forested land is privately owned land. A large portion of the forest is in small woodlots. Current OFRI data were available for only a few management units. Dixon's (1963) is the latest complete inventory for southern Ontario and gross standing volumes used for this analysis are from Table 12 of that report. A total of 231,180,000 m^3 gross standing volume was present in the area. Growth increment (CAI) based on

Table 35. Average annual pest-caused losses[a] in the C-E-SW regions, 1977-1981.

Pest	Tree species	Growth loss (m^3)	Cull (m^3)	Mortality (m^3)	Total (m^3)
Spruce budworm	black spruce	T[b]		T	T
	white spruce	T		12,000	12,000
	balsam fir	1,000			1,000
		1,000		12,000	13,000
Forest tent caterpillar	poplar	15,000			15,000
	white birch	1,000			1,000
	sugar maple	68,000		82,000	150,000
	other	4,000			4,000
		88,000		82,000	170,000
Aspen complex	poplar	T			T
Oak complex	red oak	5,000		20,000	25,000
Total, insects		94,000		114,000	208,000
Root rot	conifers	13,000		482,000	495,000
Wood decay	conifers		141,000		141,000
	hardwoods		771,000		771,000
			912,000		912,000
Hypoxylon canker	poplar			191,000	191,000
Diebacks	sugar maple			71,000	71,000
	white birch			46,000	46,000
	red oak			36,000	36,000
				153,000	153,000
Total, diseases		13,000	912,000	826,000	1,751,000
Total, all pests		107,000	912,000	940,000	1,959,000

[a] Data are expressed as gross total volume.
[b] T = trace (less than 500 m^3)

the completed portions of the current OFRI was 3,841,000 m^3 annually. Data by species for standing volume and growth are shown in Table 36.

Most of the C-E-SW regions are in the Great Lakes-St. Lawrence forest region, and about 25% of the area in the southern part is in the Deciduous forest region (Rowe 1972). Tolerant hardwood forests prevail, with sugar maple the predominant species and oak the secondary species. Conifers comprise about one-quarter of the standing volume. Although only 27% of the area is occupied by forests, these woodlands are a very important resource as the timber species are mostly valuable hardwoods. Also, other forest values such as esthetics, recreation, and wildlife habitat are more significant in these woodlands than in other regions that have an abundance of forest land.

Spruce Budworm

Some defoliation caused by budworm persisted through the entire period 1977-1981. The total area affected was 80,000 ha in 1977, and increased to about 150,000 ha by 1981. Most of the area affected was part of a large infestation that extended well into the adjacent AL Region. Scattered pockets of defoliation occurred elsewhere. Host stands accounted for about one-eighth of the total land area that was mapped as defoliated. The assumption of this estimate was that host stands were more concentrated in the mapped area and that the percentage that was productive forest land was greater within this area than in the remainder of southern Ontario.

Mortality was present throughout most of the area affected during the 5-year period. A total of 310,000 m^3 of host timber died. Data by host species are shown in Table 37. In 1977, mortality in the stands affected was 9% for balsam fir, and negligible for black spruce and white spruce. By 1981, mortality increased to 49% for balsam fir, 9% for black spruce, and 15% for white spruce. Growth loss for the 5-year period was 4,300 m^3, with about 75% of this occurring in balsam fir (Table 37). The cumulative loss caused by budworm over the entire infestation up to 1981 was 15,000 m^3 of growth and 326,000 m^3 of mortality.

Forest Tent Caterpillar

There was a large forest tent caterpillar infestation in 1977, mostly in the SW Region (Table 38). The total area affected was 1,534,000 ha in 1977; in 1978 the infestation collapsed and only about 20,000 ha were mapped as defoliated. Sugar maple was severely affected by the defoliation, and extensive mortality occurred in 1977 and 1978 from maple dieback. In this instance, defoliation was considered a key factor in the dieback problem; hence, the mortality associated with the defoliation is reported as caused by the forest tent caterpillar. There was a total of 410,000 m^3 of sugar maple mortality in 1977 and 1978. Subsequently, most maples experiencing dieback showed good crown recovery. However, growth studies of defoliated trees showed that defoliation caused a 40% reduction in growth and that this growth reduction persisted through

Table 36. Forest statistics[a] for the C-E-SW regions.

Tree species	Gross total volume (m³)	Gross total volume (%)	Current annual increment (m³)	Current annual increment (%)
Red pine	1,231,000	1	34,000	1
Jack pine	30,000	T[b]	T	T
White pine	14,055,000	6	331,000	9
Black spruce	557,000	T	53,000	1
White spruce	4,837,000	2	61,000	2
Balsam fir	7,916,000	3	264,000	7
Cedar	17,361,000	8	78,000	2
Larch	717,000	T	1,000	T
Hemlock	7,480,000	3	122,000	3
Other conifers	68,000	T	T	T
Conifer total	54,252,000	23	944,000	25
Poplar	28,666,000	12	573,000	15
White birch	10,116,000	4	188,000	5
Yellow birch	7,872,000	3	245,000	6
Hard maple	44,989,000	20	1 165,000	30
Red maple	14,744,000	6	205,000	5
Ash	10,279,000	4	43,000	1
Red oak	8,474,000	4	190,000	5
White oak	1,593,000	1	1,000	T
Elm	26,922,000	12	71,000	2
Basswood	8,257,000	4	37,000	1
Beech	9,321,000	4	145,000	4
Cherry	1,327,000	1	23,000	1
Other hardwoods	4,368,000	2	11,000	T
Hardwood total	176,928,000	77	2 897,000	75
Total, all species	231,180,000	100	3 841,000	100

[a] Data are expressed as gross total volume.
[b] T = trace (less than 500 m^3)

Note: Total administrative land area in region 8,818,000 ha
Current exploitable forest area in region 8,421,000 ha
Productive forest area 2,240,000 ha

Table 37. Volume of growth loss and mortality[a] resulting from defoliation caused by spruce budworm in the C-E-SW Regions, 1977-1981.

Year	Total area affected (ha)	Host stands defoliated (ha)	Tree species	Growth loss (m^3)	Mortality (m^3)
1977	80,000	5,000	balsam fir	900	37,000
			white spruce	100	1,000
			black spruce	100	0
				1,100	38,000
1978	50,000	3,000	balsam fir	600	42,000
			white spruce	100	12,000
			black spruce	100	0
				800	54,000
1979	51,000	3,000	balsam fir	600	45,000
			white spruce	100	12,000
			black spruce	100	0
				800	57,000
1980	108,000	7,000	balsam fir	600	73,000
			white spruce	100	15,000
			black spruce	100	0
				800	88,000
1981	59,000	4,000	balsam fir	600	61,000
			white spruce	100	12,000
			black spruce	100	0
				800	73,000
Volume lost, 1977-1981:			balsam fir	3,300	258,000
			white spruce	500	52,000
			black spruce	500	0
				4,300	310,000

[a] Data are expressed as gross total volume.

Table 38. Volume of growth loss and mortality[a] resulting from defoliation caused by forest tent caterpillar in the C-E-SW regions, 1977-1981.

Year	Total area affected (ha)	Host stands defoliated (ha)	Tree species	Growth loss (m^3)	Mortality (m^3)
1977	1,534,000	194,000	poplar	74,000	
			white birch	7,000	
			sugar maple	94,000	10,000
			yellow birch	5,000	
			other hardwoods	16,000	
				196,000	10,000
1978	1,000,000	3,000	poplar	1,000	
			white birch	T[b]	
			sugar maple	61,000	400,000
			yellow birch	T	
			other hardwoods		
				62,000	400,000
1979	1,000,000	3,000	sugar maple	61,000	
1980	1,000,000	3,000	sugar maple	61,000	
1981	1,000,000	3,000	sugar maple	61,000	
Volume lost, 1977-1981:			poplar	75,000	
			white birch	7,000	
			sugar maple	338,000	410,000
			yellow birch	5,000	
			other hardwoods	16,000	
				441,000	410,000

[a] Data are espressed as gross total volume.
[b] T = trace (less than 500 m^3)

1981. Hence, impact on hard maple is reported for the entire period (Table 38). Total growth loss for all species for the period was 441,000 m^3. Most of this loss was in maple because of the continued growth reduction and the relatively large volume of sugar maple affected in comparison with other species.

Oak Defoliator Complex

Some defoliation by oak leaf shredder (Fig. 18) occurred throughout the period 1977-1981, but most of the activity took place in 1977 and 1978 (Table 39). A total growth loss of 24,000 m^3 occurred in red oak. Annual data are summarized in Table 39. The defoliation seemed to aggravate the oak dieback problem. Hence, about 100,000 m^3 of mortality in the 5-year period, or 36% of the total amount of mortality ascribed to oak dieback (Table 35), was considered to be caused by oak leaf shredder defoliation.

Figure 18. Defoliation by oak leaf shredder causes significant growth loss and seems to be a major factor in the dieback and mortality of oaks.

Aspen Defoliator Complex

Aspen leafroller defoliation affected a total land area of 80,000 ha in 1979 and 10,000 ha in 1980, causing a total growth loss of about 2,000 m^3.

Root Rot

Root rot caused an estimated 13,000 m^3 of growth loss and 482,000 m^3 of mortality during the period 1977-1981 (Table 40). Efforts to control Annosus root rot have been largely successful; otherwise, losses in red pine would have been more severe. Balsam fir and white pine were the species most affected.

Table 39. Volume of growth loss and mortality[a] resulting from defoliation by oak leaf shredder in the C-E-SW regions, 1977-1981.

Year	Total area affected (ha)	Host stands defoliated (ha)	Growth loss (m^3)	Mortality loss (m^3)
1977	100,000	20,000	8,000	30,000
1978	170,000	34,000	12,000	50,000
1979	25,000	5,000	2,000	8,000
1980	34,000	7,000	2,000	8,000
			T[b]	4,000
			24,000	100,000

[a] Data are expressed as gross total volume.
[b] T = trace (less than 500 m^3)

The total loss data (Table 40) do not represent a complete estimate of loss, as information on the impact of root rots on broadleaved species was not available. Much of the 153,000 m^3 of mortality listed as caused by diebacks was probably associated with root rot infection, and some growth loss in broadleaved species was likely caused by root rots.

Wood Decay

Volume loss (cull) for the period 1977-1981 was 4,560,000 m^3 (Table 40). Sugar maple was affected at a cull rate of 30%. Sugar maple is probably the most important tree species in southern Ontario in terms of standing volume and timber value, and this species accounted for 38% of the total loss due to decay in all species. Other valuable broadleaved species such as yellow birch, red maple, red oak, and beech also had relatively high cull losses (see Table 40).

The trend to reduced cull losses with increased utilization noted for boreal species in the northern regions probably has not occurred for the second growth broadleaved species in southern Ontario. Cutting practices have frequently left many low-value cull trees. Timber stand improvement work, such as girdling undesirable trees, should be encouraged and intensified.

Hypoxylon Canker

Hypoxylon canker of aspen caused 955,000 m^3 of mortality during the period 1977-1981. This figure was based on the estimated 2% incidence of canker

Table 40. Average annual timber volume[a] losses caused by wood decay and root rot diseases in the C-E-SW regions, 1977-1981.

Tree species	Wood decay (m^3)	Root rot: Mortality (m^3)	Root rot: Growth loss (m^3)
Red pine	T[b]	12,000	T
White pine	56,000	141,000	1,000
Black spruce	1,000	13,000	2,000
White spruce	3,000	63,000	1,000
Balsam fir	28,000	253,000	9,000
Cedar	27,000		
Hemlock	25,000		
Other conifers	1,000		
Conifer total	141,000	482,000	13,000
Poplar	115,000		
White birch	11,000		
Yellow birch	97,000		
Sugar maple	347,000		
Red maple	73,000		
Ash	12,000		
Red oak	38,000		
Elm	14,000		
Basswood	9,000		
Beech	51,000		
Cherry	2,000		
Other hardwoods	2,000		
Hardwood total	771,000		
Total, all species	912,000	482,000	13,000

[a] Data are expressed as gross total volume.
[b] T = trace (less than 500 m^3)

determined by surveys in northern Ontario. The actual amount of cankering in southern Ontario may be somewhat higher as aspen quality seems to improve in the more northern latitudes. Hence, this mortality estimate is probably conservative.

Diebacks

Dieback problems affect numerous broadleaved species. Maple dieback and oak dieback are aggravated by insect defoliation and there are some data for quantifying losses attributable to these agents. Other species are known to be suffering dieback, but reliable estimators were not available to rate the impact of problems such as ash dieback and beech dieback. Hence, there is considerable mortality of broadleaved tree species that does not appear in this analysis.

Maple dieback was estimated to cause a total of 855,000 m^3 of mortality in sugar maple, of which 410,000 m^3 (Table 38) was associated with forest tent caterpillar defoliation, as noted previously. Surveys indicate that about 25% of the sugar maples in southern Ontario show evidence of dieback, and the remaining 445,000 m^3 of mortality were associated with the general decline of sugar maple throughout its range in Ontario.

Red oaks are also affected by a dieback problem that is often intensified by insect-caused defoliation. The oak defoliator complex was considered to have caused 100,000 m^3 of mortality loss. An additional 180,000 m^3 of loss occurred as part of general oak decline in the C-E-SW regions.

White birch dieback accounted for 230,000 m^3 of mortality loss in the 5-year period.

Summary

The impact of pests in the C-E-SW regions was equivalent to about half the growth (CAI) for the period 1977-1981. About half of this loss was attributed to wood decay. Diebacks and mortality associated with insect defoliation caused about 20% of the loss, and mortality caused by root rots accounted for about 25% of the loss.

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APPENDIX

DISEASES

Common Name	Scientific Name
Annosus root rot	*Heterobasidium annosum* (Fr.) Bres.
Armillaria root rot	*Armillaria mellea* (Vahl ex Fr.) Kummer
Hypoxylon canker	*Hypoxylon mammatum* (Wahlenb.) J. Miller
Maple canker	*Eutypella parasitica* Davidson & Lorenz
Scleroderris canker	*Gremmeniella abietina* (Largerb.) Morelet
Sweetfern blister rust canker	*Cronartium comptoniae* Arth.
White pine blister rust	*Cronartium ribicola* J.C. Fischer ex. Rabh.

INSECTS

Common Name	Scientific Name
Aspen leafroller	*Pseudexentera oregonana* Wlshm.
Aspen twinleaf tier	*Enargia decolor* (Wlk.)
Bark beetle	*Scolytidae*
Birch leafminer	*Fenusa pusilla* (Lep.)
Birch skeletonizer	*Bucculatrix canadensisella* Cham.
Forest tent caterpillar	*Malacosoma disstria* Hbn.
Fruittree leafroller	*Archips argyrospilus* (Wlk.)
Oak leaf shredder	*Croesia semipurpurana* (Kft.)
Spearmarked black moth	*Rheumaptera hastata* L.
Spruce budworm	*Choristoneura fumiferana* (Clem.)
Swaine jack pine sawfly	*Neodiprion swainei* Midd.
White pine weevil	*Pissodes strobi* (Peck)

TREES AND HERBACEOUS PLANTS

Common Name	Scientific Name
Ash	*Fraxinus* sp.
Aspen, trembling	*Populus tremuloides* Michx.
Basswood	*Tilia americana* L.
Beech	*Fagus* sp.
Birch, white	*Betula papyrifera* Marsh.
yellow	*Betula alleghaniensis* Britt.
Cedar	*Thuja* sp.
Cherry, black	*Prunus serotina* Ehrh.
Elm	*Ulmus* sp.
Fir, balsam	*Abies balsamea* (L.) Mill.
Hemlock	*Tsuga* sp.
Larch	*Larix* sp.
Maple, red	*Acer rubra* L.
sugar	*Acer saccharum* Marsh.

(cont'd)

TREES AND HERBACEOUS PLANTS (concl.)

Common Name	Scientific Name
Oak, red	*Quercus rubra* L.
white	*Quercus alba* L.
Pine, jack	*Pinus banksiana* Lamb.
red	*Pinus resinosa* Ait.
white	*Pinus strobus* L.
Poplar	*Populus* sp.
Spruce, black	*Picea mariana* (Mill.) B.S.P.
white	*Picea glauca* (Moench) Voss
Sweetfern	*Comptonia peregrina* L.