



Insect- and disease-caused losses of wood volume in forests of the Maritime Provinces, 1982-1987

B.A. Pendrel
Maritimes Region • Information Report M-X-180E



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Cover photo: Dead and dying white spruce (*Picea glauca* (Moench) Voss) caused by spruce beetle (*Dendroctonus rufipennis* (Kby.)) attack, near Truro, Nova Scotia. **Photo credit:** L.J. Coady.

**INSECT- AND DISEASE-CAUSED LOSSES OF WOOD VOLUME IN FORESTS OF
THE MARITIME PROVINCES, 1982-1987**

By

B.A. Pendrel

Information Report M-X-180E

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ABSTRACT

Annual losses of wood volume caused by insects and diseases are presented for the Maritime provinces for the period 1982 to 1987. An average annual loss of 8.9 million m³ was estimated, of which 87% was caused by insects and 13% was caused by disease. Mortality accounted for about 8% of the remainder. Estimates are presented by province and by insect or disease. The pest causing the greatest loss was the spruce budworm. Estimates were not made for many pests due to their relatively low impact or lack of information on which to base a calculation. A variety of techniques were used, and the shortcomings of some of these are recognized.

RÉSUMÉ

Les pertes annuelles de volume de bois causées par les insectes et les maladies sont présentées pour la région des Maritimes de 1982 à 1987. On a évalué à 8,9 millions m³ les pertes moyennes annuelles et 87 % d'entre elles sont imputables aux insectes et 13 %, aux maladies. Toute autre perte était due à la mortalité. Les chiffres sont donnés par province et par insecte ou maladie. La tordeuse des bourgeons de l'épinette a entraîné les plus fortes pertes. Aucun chiffre n'est fourni à l'égard de certains insectes et maladies, en raison du manque de données pour effectuer des calculs ou des faibles dommages qu'ils causent. Une grande gamme de techniques ont été utilisées et les lacunes de certaines d'entre elles sont expliquées.

TABLE OF CONTENTS

	Page
INTRODUCTION	7
TECHNIQUES FOR ESTIMATING PEST LOSSES	7
SUMMARY OF LOSSES	8
LOSSES BY PEST	11
Spruce budworm	11
Forest tent caterpillar	11
Eastern larch beetle	11
Spruce beetle	12
Hypoxylon canker	12
White pine blister rust	12
Stem and root decays	12
OTHER PESTS	13
ACKNOWLEDGEMENTS	13
REFERENCES	14

INTRODUCTION

Forest resources are depleted annually by a variety of causes, such as fire, harvesting, and conversion to non-forest uses. Among the more significant depletions are those caused by insect and disease pests.

The term "depletion" includes not only mortality caused by pest outbreaks or chronic conditions, but also losses of volume due to unrealized growth. For example, an insect outbreak that does not kill trees but results in reduced wood accumulation over several years is considered to have caused a real and quantifiable loss to the productivity of the forest. Losses are expressed as volume of wood removed from the inventory of merchantable trees (or, in the case of growth losses, potential inventory) in cubic meters.

Aggregated loss estimates for forest pests underestimate actual losses, given the many lesser pests for which losses are not calculated and a weak understanding of relationships between many pest conditions and the damage that they cause. Gross (1985) provided an informative discussion of the interpretation, calculation, and precision of pest loss estimates. The reader should keep in mind that this report only represents those losses that we undertook to estimate, rather than the total of what may be occurring.

Reported are estimates of pest-caused losses that occurred from 1982 to 1987, a period designated by the Forest Insect and Disease Survey (FIDS) for the assembly of depletion information from across Canada. Losses from the previous reporting period, 1977-1981, were presented in Sterner and Davidson (1982). Losses are reported here, initially as an aggregate for all pests, then the major pests are reviewed and other losses are discussed. Estimates are presented in some cases without comprehensive knowledge of their accuracy. They are based on a variety of plot samples, aerial and ground surveys, and inventory estimates conducted with varying and sometimes unknown levels of precision. Critical use of these estimates may demand a review of the methods used.

No attempt was made to determine to what extent the depletion estimates were mitigated by normal harvesting operations or directed salvage programs.

TECHNIQUES FOR ESTIMATING PEST LOSSES

The inventory base on which all estimates were made was the gross merchantable timber volume in the 1986 Canada Forest Resource Data System (CFRDS) (Gray and Niemann, 1989). Accordingly, the loss estimates reflect the accuracy of those data.

Spruce budworm losses were estimated by extrapolating the relationships between the area of moderate to severe defoliation and mortality and growth loss, used in the previous depletion estimation exercise of 1977-1981 (Sterner and Davidson, 1982). Methods for the production of these estimates have not been published, although a description is available in file reports (Power and Taylor, 1985, unpublished). For mortality, the cumulative area of infestation, average volume of host species and percent mortality found on a variety of FIDS study plots were used. For growth loss, the periodic growth rate and growth reduction caused by defoliation from some of the same plot sources were used. Data were compiled at the level of the resource region (New Brunswick), the forest subdivision (Nova Scotia), and the county (Prince Edward Island).

In New Brunswick, regression lines were calculated for defoliation versus mortality for balsam fir (*Abies balsamea* (L.) Mill.) and the spruces (*Picea* spp.) ($r^2 = 0.58$ and $r^2 = 0.50$, respectively), and these were used to determine mortality in each of the following 6 years. The drawback to this method was the assumption that the relationship had not changed in the last decade. This approach does yield estimates comparable with previous estimates, although the methodology is oversimplified. Techniques are being developed (Power and D'Eon, 1991) which should revolutionize these calculations in the future.

In Nova Scotia, simple "defoliated area" to "mortality loss" ratios were determined, as there was insufficient range in the data to develop regression lines. To calculate growth loss, the same ratio between mortality and growth loss as was applied in New Brunswick was used. Calculation of a new ratio, using the same techniques as for New Brunswick, would have resulted in an extreme under-estimate, given the catastrophic budworm mortality reported for Nova Scotia in the 1977-1981 period (Magasi, 1987; MacLean and Ostaff, 1989). On Cape Breton Island, specifically, vast areas were destroyed, resulting in high mortality figures relative to the growth loss. The Nova Scotia

Table 1 Average annual losses of hardwood and softwood in the three Maritime provinces (million m³), 1982-1987

	Softwood	Hardwood	Total
New Brunswick	6.228	0.519	6.747
Nova Scotia	1.717	0.171	1.888
Prince Edward Island	0.265	0.039	0.304
Total	8.210	0.729	8.939

method was applied to Prince Edward Island as well.

Calculations of aspen growth loss caused by forest tent caterpillar were based on a geographic information system (GIS) which overlaid annual defoliation estimates to yield defoliation histories for geographic areas. These were in turn overlaid with the CFRDS inventory at the various resolutions available for each province, ranging in average size from about 42 km² for some New Brunswick cells to about 2,216 km² for some Nova Scotia cells (Gray and Niemann, 1989). The mean annual incremental growth for Maritime aspen of 3.8% (McDonald, NBDNRE, pers. comm.) was then applied to estimate affected volume. The final loss calculation was the summed products of the potential volumetric growth of the affected inventory multiplied by a growth loss factor assigned for each defoliation history. The factors were averaged values from a review of a number of published studies from across Canada. These techniques, developed by FIDS at the Petawawa National Forest Institute of Forestry Canada (Power and D'Eon, 1991), will eventually be applied to other forest pests for depletion analysis.

Losses caused by spruce beetle and eastern larch beetle were calculated by applying loss factors estimated from a variety of FIDS sample plots and surveys, to the CFRDS inventories of white spruce and eastern larch, at the provincial level. Red spruce mortality was insignificant relative to white spruce and so was excluded. Hypoxylon canker and white pine blister rust losses were calculated similarly, except that factors from the previous depletion period were used.

Depletion estimates for decays were based on Pearce and Hoyt (1969), which contains the most comprehensive information on decay and cull available for a variety of Maritimes species. They made measurements of loss to the standing inventory for more than 770 one-tenth acre sample plots

across New Brunswick. Loss factors calculated from the above paper were applied to the current CFRDS inventories at the provincial level. An alternative method proposed by Gross (1985) applied loss factors to an estimate of the net annual growth, which in turn was estimated from the inventory. The method presented here treats decay as a mortality loss while the Gross method treats decay as a loss of potential growth. A separate calculation was also possible for immature versus mature trees which yielded surprisingly similar loss factors, contrary to observations by other investigators. By taking into account the average age of trees of each species in Pearce and Hoyt (1969) annual loss factors were obtained. For softwoods other than spruce and fir, and for hardwoods, estimates were based on the relationships among species groups that were used in the previous Maritime depletion study.

SUMMARY OF LOSSES

The total amount of wood lost to insects and diseases in the Maritime provinces from 1982 to 1987 is estimated to be at least 53.6 million m³ (8.9 million m³ annually), equivalent to about 14.8 million cords (2.5 million cords annually).

The volume loss reported here from all pests in the Maritimes is almost 100 times the loss from fire and equal to about 70% of the average volume harvested (Figure 1).

Average annual losses by province were: 6.7 million m³ for New Brunswick, 1.9 million m³ for Nova Scotia, and 0.3 million m³ for Prince Edward Island (Table 1). Losses identified for softwoods greatly exceeded losses for hardwoods.

Insects were responsible for average annual losses of 7.7 million m³ while diseases accounted for 1.2 million m³. The spruce budworm alone caused 80% of all estimated losses in the Maritimes region. Average annual insect-caused losses by province were: 5.882 million m³ for New

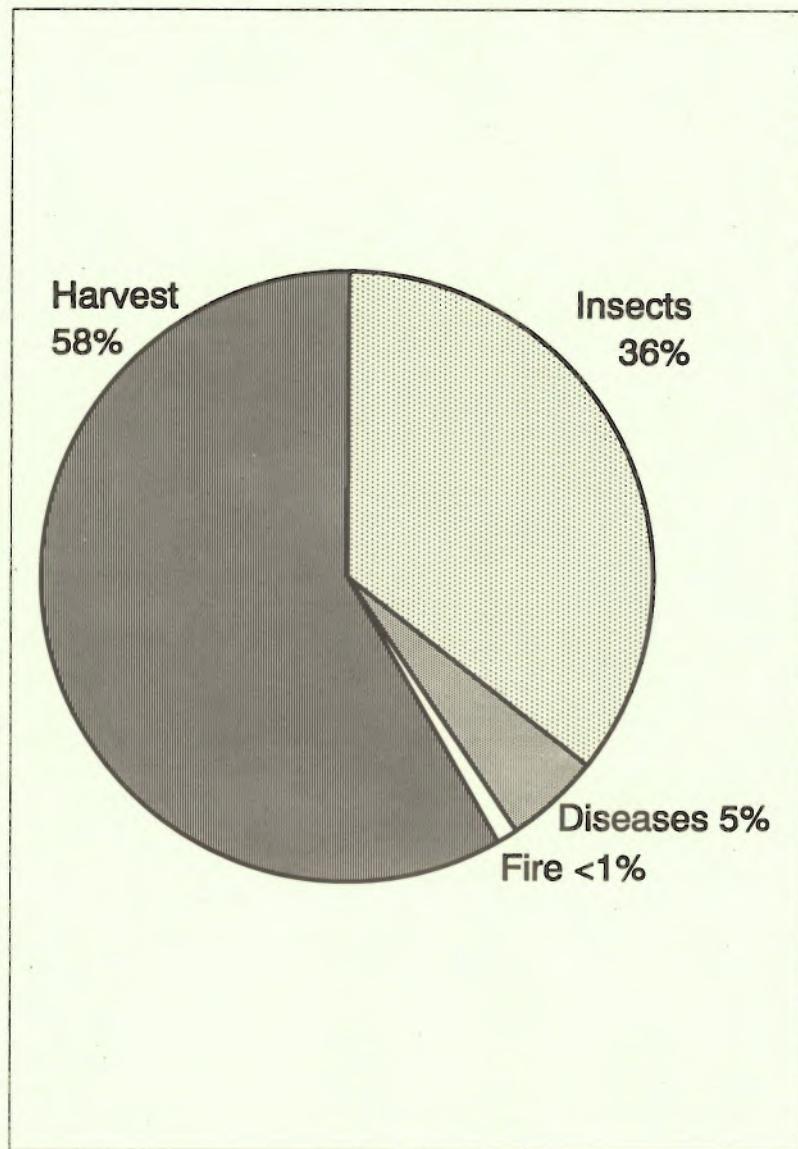


Figure 1. Comparative average annual depletion due to insects, diseases, fire and harvesting in the three Maritime provinces, 1982 - 1987.
Data for non-pest losses from Timber Management Branch, New Brunswick Department of Natural Resources and Energy, and the Nova Scotia Department of Natural Resources, Annual Reports.

Table 2 Areas of moderate and severe defoliation by spruce budworm in the three Maritime provinces from 1982 to 1987 ('000 ha) (Magasi, 1988)

	New Brunswick	Nova Scotia	Prince Edward Island
1982	1202	175	13
1983	2028	294	22
1984	730	59	15
1985	1070	319	54
1986	927	289	65
1987	430	0	0

Table 3 Annual losses of wood volume due to mortality and unrealized growth caused by the spruce budworm in each of the Maritime provinces, 1982-1987 (million m³)

Province/ Year	Mortality		Growth Loss	
	Balsam fir	Spruces*	Balsam fir	Spruces*
New Brunswick				
1982	3.800	2.000	0.456	0.216
1983	4.590	2.550	0.770	0.385
1984	2.805	1.540	0.277	0.137
1985	3.248	1.804	0.406	0.203
1986	3.158	1.693	0.352	0.170
1987	2.413	1.307	0.163	0.079
Total	20.014	10.894	2.424	1.190
Average	3.336	1.816	0.404	0.198
Nova Scotia				
1982	0.751	0.114	0.091	0.075
1983	1.261	0.191	0.153	0.018
1984	1.315	0.205	0.159	0.019
1985	1.369	0.208	0.166	0.019
1986	1.240	0.188	0.150	0.018
1987	0.000	0.000	0.000	0.000
Total	5.936	0.906	0.719	0.149
Average	0.989	0.151	0.120	0.025
Prince Edward Island				
1982	0.030	0.040	0.004	0.004
1983	0.060	0.079	0.007	0.007
1984	0.030	0.040	0.004	0.004
1985	0.120	0.160	0.015	0.015
1986	0.120	0.160	0.015	0.015
1987	0.000	0.000	0.000	0.000
Total	0.360	0.479	0.045	0.045
Average	0.060	0.080	0.008	0.008

* Includes white, red, and black spruce.

Table 4 Areas of moderate to severe defoliation by forest tent caterpillar in the three Maritime provinces from 1982 to 1987 ('000 ha) (Magasi, 1987)

	New Brunswick	Nova Scotia	Prince Edward Island
1982	1389	5	19
1983	1119	35	67
1984	94	46	37
1985	0	0	0
1986	0	0	0
1987	0	0	0

Brunswick, 1.610 million m³ for Nova Scotia, and 0.271 million m³ for Prince Edward Island; and disease-caused losses were 0.864 million m³ for New Brunswick, 0.278 million m³ for Nova Scotia, and 0.033 million m³ for Prince Edward Island.

Additional, significant insect losses were caused by the spruce beetle and the larch beetle. The major disease losses were a consequence of decay (various species) and hypoxylon canker of aspen. The 1982-1987 period was characterized by a lessening in intensity of many insect and disease conditions; few new ones appeared.

LOSSES BY PEST

Spruce budworm

A widespread spruce budworm (*Choristoneura fumiferana* (Clem.)) outbreak continued in New Brunswick during 1982-1987 (Table 2), reaching 2.028 million ha of moderate and severe defoliation in 1983 and declining to 0.430 million ha by 1987 (Magasi, 1988). Considerable tree mortality caused by the spruce budworm already existed by 1982 (Clowater and Andrews, 1981) and many trees were in such a weakened state that little additional defoliation was required for more mortality to occur. In Nova Scotia, a reduction in defoliated area occurred from that found during the 8 years prior to 1982, until by 1987 no significant amounts were detected. Mortality occurred, however, as a result of previous defoliation. On Prince Edward Island, defoliation was less than the preceding 6 years, so that by 1987, no significant amounts were encountered.

Losses: the average annual volume of conifers lost to the spruce budworm from 1982 to 1987 was 5.754 million m³ in New Brunswick, 1.285 million m³ in Nova Scotia and 0.154 million m³ in Prince Edward Island. Of these estimates (Table 3),

about 10% was growth loss and 90% was mortality. Average annual losses estimated for the 5-year period preceding 1982 were lower in New Brunswick at 4.62 million m³ but twice the amount for Nova Scotia at 3.15 million m³. Damage estimates had not been made previously for Prince Edward Island.

Forest Tent Caterpillar

The year 1982 coincided with the most intense and widespread defoliation by forest tent caterpillar (*Malacosoma disstria* Hbn.) in the Maritimes in recent years, but by 1987 this infestation had declined to a few patches of variable intensity defoliation (Table 4). Most of the depletion was growth loss, since mortality was uncommon and usually only occurred in immature aspen stands where trees were under additional stress, apparently caused by overstocking. Growth losses were considerable, given the large areas and high volume of aspen affected.

Losses: The average annual volume of aspen lost to the forest tent caterpillar from 1982 to 1987 was 49,200 m³ in New Brunswick, 27,000 m³ in Nova Scotia, and 19,000 m³ on Prince Edward Island. These amounts represent 10%, 3%, and 5%, respectively, of the potential aspen growth that could have occurred in each jurisdiction if the forest tent caterpillar had not been present. No significant losses due to the forest tent caterpillar had been reported during the 1977-1981 period.

Eastern Larch Beetle

Larch beetle (*Dendroctonus simplex* Lec.) infestations, which were first noticed in 1976, declined from about 1984 (Magasi, 1988). In Nova Scotia and Prince Edward Island, where outbreaks began 2-3 years before those in New Brunswick, many old-dead trees began to fall to the forest floor, where they were no longer counted during damage surveys. After 1982, additional stands

Table 5 Average annual losses of wood volume due to root and stem decays from 1982 to 1987 (m^3)

	Tree species/Species groups			
	Balsam fir	Spruces	Other Softwoods	Hardwoods
New Brunswick	179,800	87,200	55,400	225,800
Nova Scotia	65,000	44,400	16,100	101,300
Prince Edward Island	7,200	5,000	1,200	10,800

became infested but the intensity of infestation lessened, so that the incidence of infested stands alone does not accurately reflect the degree of impact.

Losses: The average annual volume of larch lost was 65,000 m^3 in New Brunswick, 81,000 m^3 in Nova Scotia, and 18,000 m^3 on Prince Edward Island. These results are close to the 70,000 m^3 reported for New Brunswick in the 1977-1981 period, but are significantly less than the 200,000 m^3 previously reported for Nova Scotia (Sterner and Davidson, 1982). No previous estimate was published for Prince Edward Island, however, the current loss is estimated to be about 50% of the 1977-1981 values.

Spruce Beetle

Spruce beetle (*Dendroctonus rufipennis* (Kby.)) damage occurred primarily in Nova Scotia and on Prince Edward Island, where damage intensities peaked by about 1980-81, so that by 1984 little new mortality was occurring. Primarily white spruce and, to a lesser extent, red spruce were attacked by these beetles.

Losses: In Nova Scotia, average annual losses of white spruce were estimated at 217,000 m^3 , while Prince Edward Island lost 79,000 m^3 . No significant amounts were lost in New Brunswick. These losses are less than half of the 500,000 m^3 reported in Nova Scotia and the 150,000 m^3 reported on Prince Edward Island for the 1977-1981 period.

Hypoxylon Canker

Hypoxylon canker (*Hypoxylon mammatum* (Wahl.) Mill.) is a chronic disease which was estimated to affect 16% of all trembling aspen in the Maritimes (Magasi 1988), killing 0.6% per year. Growth loss and mortality both occur, however, insufficient information is available for a growth loss calculation.

Losses: Average annual mortality losses were estimated at 240,000 m^3 for New Brunswick, 43,000 m^3 for Nova Scotia, and 9,000 m^3 for Prince Edward Island. These calculations are approximately double the annual losses estimated during the 1977-1981 reporting period. Some of these losses would have occurred where the forest tent caterpillar was active, however, these would be insufficient to affect any calculations of growth losses caused by the tent caterpillar.

White Pine Blister Rust

White pine blister rust (*Cronartium ribicola* J.C. Fisch.) is a chronic condition, presumed to have about the same impact on trees from year to year. Depletion calculations reflect changes in inventory and improved loss rate estimates. Volume is also lost due to top kill, but no attempt was made to calculate this.

Losses: Average annual mortality was estimated at 75,000 m^3 for New Brunswick and 9,000 m^3 for Nova Scotia, based on the loss rates found in 1977-1981.

Stem and Root Decays

Major losses occur from largely unseen decays within the tree. Outright mortality is not always the problem and growth loss estimates are difficult to make as the inside of a stem slowly deteriorates or as the roots lose their vigor. Cull is that portion of the tree containing both sound and decayed wood that cannot be used because of the presence of the decay. It was not calculated. Various tree species are host to different decay fungi and so loss calculations must be host species specific in many cases.

Losses: Average annual losses due to decays were 548,000 m^3 for New Brunswick, 227,000 m^3 for Nova Scotia, and 24,000 m^3 for Prince Edward Island (Table 5). Cull would account for an additional loss of usable product of about 12%.

OTHER PESTS

Forests are under a constant assault by many insects and diseases whose impacts go relatively unnoticed or which have virtually no ill effect upon the tree. A great many pests have a modest effect or impact restricted to a relatively small area such that a separate calculation of loss is not feasible. While collectively the effects of these can be considerable, they are often viewed as a natural and expected part of the forest ecosystem.

Losses that are small on a regional scale, however, may be catastrophic on a local scale. Forest tent caterpillar on sugar maple, orangehumped mapleworm on sugar maple, spruce budmoths on white spruce plantations, Dutch elm disease on white elm, and European pine shootmoth on red pine plantations are some examples. Similarly, losses in plantations would be small compared to regional estimates for more widespread forest pests, but their long-term impacts may be significant.

A few pests that have significant impact are even more difficult to deal with. Beech bark disease, while allowing trees to grow, reduces growth and causes mortality, but in the slow fashion of a chronic condition (the initial invasion of the disease, long since past in most of the Maritimes, can cause considerable mortality). The ultimate effect of this disease in Maritime forests is the relegation of beech to a new status quo, from which further

depletions by other factors can then be considered.

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