

CONDITION OF BALSAM FIR ON CAPE BRETON ISLAND FOLLOWING
FOUR YEARS OF UNCONTROLLED SPRUCE BUDWORM INFESTATION

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ABSTRACT

Twenty-three sample plots were established in Cape Breton Island, Nova Scotia in 1976 to monitor the effect of defoliation on mortality of balsam fir during the current budworm outbreak. Sixteen plots were located in the Highlands (south of the National Park) and seven in the Lowlands.

Results show that about 16% of the balsam fir in the Highlands is dead. An additional 10% can be expected to die in 1978 and over 50% is heavily defoliated.

Damage to Lowland fir is about half as severe as in the Highlands. Using Nova Scotian inventory data, over 1 million cords of balsam fir can be presumed dead on the Island (south of the National Park) and a minimum of 400,000 cords can be expected to die in 1978, if the budworm outbreak persists.

RESUME

Vingt-trois placettes d'échantillonnage ont été établies au Cape-Breton (N.-E.) en 1976 afin de déterminer l'effet des défoliations sur le taux de mortalité du sapin baumier durant la présente infestation de la tordeuse. Seize des placettes ont été établies des les Hautes Terres (au sud du Parc National) et sept dans les Basses Terres.

Les résultats de cette étude indiquent que 16% du sapin baumier des Hautes Terres est mort. On s'attend de plus qu'un autre 10% périra en 1978. Plus de 50% du sapin à été soumis à de sévères défoliations.

Les dégâts des Basses Terres sont à peu près la moitié de ceux observés dans les Hautes Terres. En se basant sur l'inventaire de la Nouvelle-Ecosse, on peut supposer qu'un million de cordes de sapin baumier sont morts et que probablement au moins un autre 400,000 cordes périront en 1978, si les pullulations de la tordeuse persistent.

INTRODUCTION

Cape Breton Island is experiencing a severe budworm outbreak which began in 1974 and is continuing unabated. By 1976, virtually all the fir (and spruce) on Cape Breton Island had been attacked. Current defoliation was severe and back feeding on older foliage had occurred on 400,000 acres (162,000 ha) of the Highlands. The budworm normally feeds on current foliage but at high population levels depletion of current foliage forces the insect to backfeed. Repeated loss of current foliage over four years may kill the tree, but death occurs much sooner when reserves of older needles are depleted. By 1977, backfeeding was occurring throughout the Island.

In 1976, a study was begun by the Forest Insect and Disease Survey of the Maritimes Forest Research Centre to measure budworm damage to balsam fir on the Island. This paper reports the results of the study to September 1977.

METHODS

Twenty-three permanent sample plots were established in 1975 (Fig. 1), 16 in the Highlands and 7 in the Lowlands. Plot locations had been established earlier for budworm egg sampling studies. They were near the roadside for ease of sampling and were well separated to obtain maximum coverage of the area.

For the damage appraisal study, each plot consisted of three prism point stations. In 1977, some of the plots were extended to five

prism points in areas where more detailed studies of budworm behavior and damage are now underway. Stations were located at 2, 4, 6, and when there were five stations, 8 and 10 chains from the roadside. Where necessary, points were offset at right angles so that they would remain in the same stand type. Basal area, dbh, percent defoliation; percentage dead or bare tops, and the number of dead balsam fir and other tree species were measured and estimated by forest technicians with long experience in this type of work. Plots were measured in October 1976 and September 1977. Four of the plots were cut in 1977 before the September survey.

Balsam fir (and spruce) were classified as follows:

- 1) Healthy and no defoliation
- 2) Healthy with only current defoliation
- 3) Less than 50% complete defoliation - no top kill
- 4) Less than 50% complete defoliation - with top kill
- 5) 50 to 90% complete defoliation - no top kill
- 6) 50 to 90% complete defoliation - with top kill
- 7) More than 90% complete defoliation - no top kill
- 8) More than 90% complete defoliation - with top kill
- 9) Dead - 1 year or less (cambium dead and beetle emergence holes, 1-2 mm, usually present)
- 10) Dead - 2 years or more (bark loose and emergence holes, 3-5 mm, usually present, nearly all needles missing, fungus fruit bodies may be present).

Defoliation and presence of dead and bare tops were evaluated through use of binoculars. In classifying defoliation, the absence of

1975, 1976, and 1977 terminal growth was considered. Tops were considered dead only if the distal 2 ft (60 cm) or more of the stem had no red or green foliage and no evidence of current growth or bud production. This meant that the tops had been dead for at least one year. Examination of tops in a current cutting verified this method. The length of the bare top was the estimated length of stem and associated branches that had more than 90% of their foliage missing and was assessed on trees in the first prism point of each plot. The cambium was checked near breast height with an increment hammer or knife before placing trees in classes 7, 8, or 9. All trees were numbered in 1977, but in 1976 only the trees on the first prism point were numbered. For this reason some discrepancies occurred in records of trees 1 year dead and those 2 years dead.

Conditions of Balsam Fir

Trees that were dead 1 year or less in October 1976 and September 1977 were assumed to have been killed by the budworm. Trees dead more than 2 years are assumed to have died from other causes since their numbers approximate the figure given for trees dead in unaffected stands in the Nova Scotia Forest Inventory 1971 and 1972.

Volume calculations are based on tables in Nova Scotia Forest Inventory, Cape Breton Island Subdivision, 1970, and numbers of stems per acre was calculated using basal area values from Forestry Factors for Eastern Canada, CFS Publication Number 1287, 1970. Defoliation histories were extracted from Forest Insect and Disease Survey files at the Maritimes Forest Research Centre.

RESULTS

Condition of Trees on the Highlands

By September 1977, over 13% of the trees on the plots had been killed by the budworm, i.e. died during 1976 or 1977 (Table 1). Five percent of this mortality occurred during the winter 1976-1977 and 2% occurred during the summer of 1976. The average size of dead trees was 18 cm (7 in) dbh. The surviving trees are generally in poor condition. In October 1976, 10% of the trees were more than 90% defoliated and it was mostly these trees that died during 1976. By September 1977, an additional 10% were more than 90% defoliated. Of the remaining trees, 72% (53% of the total) have lost more than half of their needles. Dead and bare tops are prevalent. Top kill occurred only on trees over 50% defoliated and by far the largest proportion of dead tops occurred on trees 90-100% defoliated.

Condition of Trees on the Lowlands

The mortality rate in the Lowlands appears to be half that of the Highlands with 6.5% of the trees having been killed by the budworm since 1975 (Table 2). The trees are in slightly better condition than in the Highlands with about half of the surviving trees having lost more than half of their needles. Bare and dead tops are appearing.

Loss of Merchantable Volume on the Highlands

The volume of dead trees per plot averaged 3.6 cords per acre, over three quarters of which had been killed by the budworm (Table 2).

Based on the Nova Scotia forest inventory for the Highlands south of the National Park, the total dead wood is almost 600,000 cords (Table 2). An additional 400,000 cords of over 90% defoliated balsam fir can be expected to die in 1978, and 2 million cords of growing stock can be expected to have substantially reduced increments.

Loss of Merchantable Volume on the Lowlands

The volume of dead trees on the Lowland plots averaged 1.5 cords per acre of which 60% was killed by the budworm. The amount of wood presumed dead on the Lowlands could amount to 500,000 cords. In addition, possibly 4 million cords will have reduced increments.

Accuracy of the Study

Sampling data are shown in Appendices 1-4. Individual point sampling results were too variable to permit analyses of individual plots, so data were pooled in two groups, the Highland plots and the Lowland plots. In the Highlands, estimates of total dead trees and those 50-90% defoliated have standard errors that are within 10% of the mean, and are statistically acceptable. Estimates of trees dead 1 year, and living trees more than 90% defoliated are reasonably accurate. The number of plots in the Lowlands is too low to obtain a statistically acceptable degree of accuracy. Estimates of trees 50-90% defoliated are reasonably accurate, but generally results indicate trends only. Calculations involving the forests inventory do not take into account the statistical error in inventory measurements.

SUMMARY

Based on sample plot results, about 16% of the balsam fir on the Cape Breton Highlands (south of the National Park) is dead. An additional 10% can be expected to die in 1978 and over 50% is heavily defoliated.

Damage to Lowlands fir is about half as severe as in the Highlands. Using the Nova Scotia inventory data, over 1 million cords of balsam fir can be presumed dead on the Island (south of the National Park) and a minimum of 400,000 cords can be expected to die in 1978 if the budworm outbreak persists.

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Table 1. Condition of balsam fir examined on Cape Breton Island,
Oct. 1976 and Sept. 1977

Tree Condition	% stems, 10 cm and over dbh			
	Highlands		Lowlands	
	1976	1977	1976	1977
<u>Dead</u>				
1 year or less	1.8	11.5	1.2	5.3
2 years or more	4.5	4.9	4.3	3.5
<u>Total</u>	<u>6.3</u>	<u>16.4</u>	<u>5.5</u>	<u>8.8</u>
<u>Defoliated</u>				
Current foliage only	0	0	2.7	0
< 50%	27.2	20.7	83.6	40.9
50-90%	55.4	53.0	3.9	49.7
> 90%	11.1	9.9	4.3	0.6
<u>Bare Tops</u>				
< 12.7 cm (5 in) long	23.8	18.4	13.4	8.3
12.7-25.4 cm (5-10 in) long	9.4	13.7	0	1.8
> 25.4 cm (10 in) long	1.7	1.6	0	0
<u>Total</u>	<u>34.9</u>	<u>33.7</u>	<u>13.4</u>	<u>10.1</u>
<u>Dead Tops</u>	1.0	8.3	0.4	2.4
<u>Broken Tops</u>	7.8	8.1	0.8	1.2

Table 2. Condition of balsam fir examined on Cape Breton Island
Oct. 1976 and Sept. 1977

Tree Condition	% Merchantable Volume			
	Highlands		Lowlands	
	1976	1977	1976	1977
<u>Dead</u>				
1 year or less	1.7	10.1	0.5	4.4
2 years or more	4.3	4.8	3.6	3.6
<u>Total</u>	6.0	14.9	4.1	8.0
<u>Defoliated</u>				
Current foliage only	0	0	3.9	0
< 50%	27.2	18.0	86.5	44.2
50-90%	56.8	56.0	2.7	47.5
> 90%	10.0	10.0	2.8	0.3

Table 3. Gross merchantable volume and 95% confidence limits of balsam fir affected by budworm defoliation on Cape Breton 1974-1977

Tree Condition	Highlands ¹	Lowlands ²
<u>Dead</u>		
1 year or less	400,460 ± 126,885	281,680 ± 276,680
2 years or more	190,320 ± 7,546	211,260 ± 211,260
<u>Total</u>	<u>594,750 ± 130,845</u>	<u>492,940 ± 316,890</u>
<u>Defoliated</u>		
Current foliage only	713,700 ± 555,100	2,820,000 ± 1,334,780
< 50%	2,220,000 ± 833,050	3,732,000 ± 1,338,240
> 90%	396,500 ± 142,740	42,252

¹Percentage of balsam fir affected x Nova Scotia Forest Inventory record. Based on GMV of 3,965,000 cd (in stand of more than +7 cd/acre on Crown Land).

²Percentage of balsam fir affected x Nova Scotia Forest Inventory record. Based on GMV of 7,042,000 cd (in stands of more than +7 cd/acre on Crown Land).

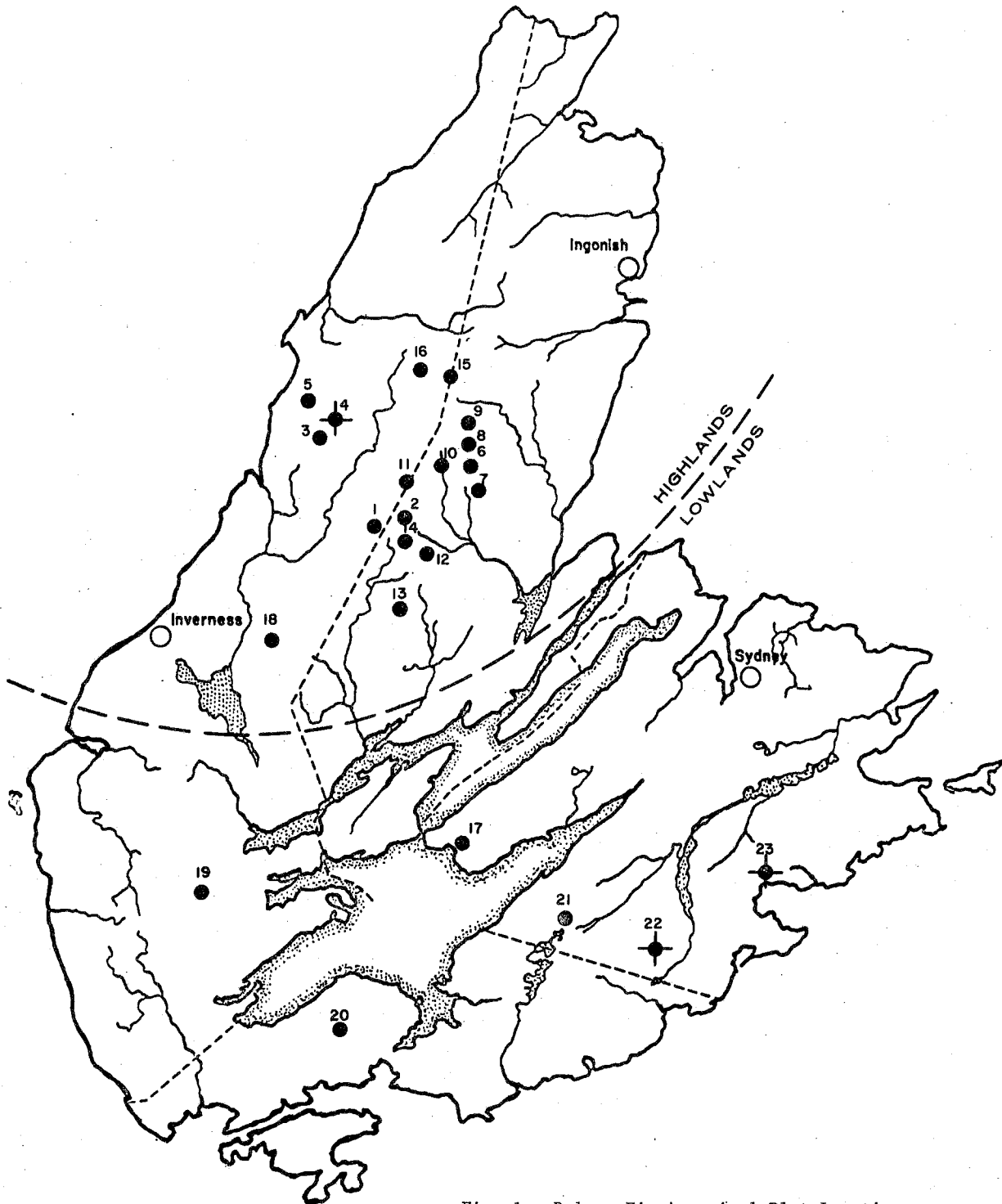


Fig. 1. Balsam Fir Appraisal Plot Locations
October 1976 and September 1977.

✦ cut before examination in 1977

Appendix 1. Results of analyses plot data, Sept. 1977.

Tree Condition	% volume affected and 95% confidence limits	
	Highlands	Lowlands
<u>Dead</u>		
1 year or less	10.1 ± 3.2 (15) ¹	4 ± 4.0 (50)
2 years or more	4.8 ± 2.8 (25)	3 ± 3.0 (50)
<u>Total</u>	15 ± 3.3 (10)	7 ± 4.5 (32)
<u>Defoliated</u>		
Current foliage only	0	
< 50%	18 ± 14 (38)	40 ± 19 (24)
50-90%	56 ± 11 (9)	53 ± 19 (18)
> 90%	10 ± 3.6 (15)	< 1

¹Standard error as % of mean.

Appendix 2. Plot Statistics - Volume/Acre (GMV cd/acre)
(Revised)

Plot No.	Stand Description	Total ¹ Volume (cd)	Dead Volume	
			%	cd
(Highlands)				
1	Mature	36.0	16.6	6.0
2	"	17.3	12.7	2.2
3	Overmature	17.1	14.6	2.5
4	"	-	-	
5	Semimature	11.6	17.8	2.1
6	Mature	31.9	20.3	6.5
7	Semimature	23.3	14.2	3.3
8	Mature	24.2	15.6	3.8
9	Semimature	28.2	15.6	4.4
10	Mature	20.7	22.6	4.7
11	"	30.5	3.9	1.2
12	Semimature	24.3	24.8	6.0
13	"	28.9	3.2	0.9
14	Mature	34.2	20.0	6.8
15	"	40.4	17.6	7.1
16	"	28.5	5.3	1.5
Ave.		26.5 + 4.6		
(Lowlands)				
17	Semimature	9.5	5.4	0.5
18	Mature	34.3	9.0	3.1
19	Semimature	14.8	0	0
20	"	18.9	13.4	2.5
21	"	18.1	8.4	1.5
Ave.		19.1 + 0.8		

¹Calculated on basis of 80 CMV cu ft/cd.

Appendix 3. Gross merchantable volume in cu ft/acre per individual prism points* in the Highlands
(Revised)

Class	Plot																			
	1	2	3	5	6	7	8	9	10	11	12	13	14	15	16					
Current	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Defoliation only	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<50%	0	57	67	190	0	504	395	281	0	0	98	0	98	1113	670	0	0	60	0	0
Defoliation	0	54	0	103	0	521	190	98	0	0	60	0	57	931	282	54	0	0	0	0
No top kill	0	51	0	0	0	226	188		311	0	0		60	584		57		123	0	
50-90%	594	184	294	139	495	281	90	315	463	507	639	734	419	0	0	565	301	776	611	448
Defoliation	872	118	547	286	249	46	131	441	579	0	487	450	271	0	104	787	510	849	813	269
No top kill	638	474	116	0	638	0	237		218	453	662		447	0		476		746	758	
50-90%	66	23	0	0	111	0	0	0	0	0	57	60	0	0	0	0	0	0	0	0
Defoliation	0	102	0	0	0	0	0	0	0	0	0	180	0	0	0	0	0	0	0	128
Top kill	0	0	0	45	0	0	57		0	0	0		0	0		0		0	0	
90-100%	61	51	0	0	85	23	0	0	68	205	54	54	45	0	0	0	51	54	23	91
Defoliation	116	0	0	0	224	0	0	140	240	51	0	0	0	0	0	86	161	0	51	54
No top kill	0	0	0	0	45	0	34		0	23	0		0	0		41		57	98	
90-100%	0	94	63	0	143	0	0	0	23	0	54	0	0	0	0	123	90	0	98	98
Defoliation	54	0	45	0	0	0	0	91	0	45	125	92	34	0	54	142	158	0	0	0
Top kill	0	0	34	0	45	0	34		0	0	101		34	0		45		0	61	
Dead, 1 yr	130	23	61	68	149	57	45	23	241	0	0	51	68	0	34	0	257	0	115	0
	253	0	0	46	181	0	124	57	111	91	0	45	201	0	54	86	278	0	34	0
	41	108	139	0	0	0	45		0	0	0		139	0		290		129	54	
Dead, +2 yr	0	45	0	0	143	0	91	118	0	239	0	0	41	0	0	0	0	108	0	0
	54	0	0	0	45	0	0	0	0	45	0	0	0	34	0	0	0	126	0	0
	0	0	0	51	0	209	0		0	0	61		34	0		0		206	0	

* All readings are 1/3 of actual values.

Appendix 4. Gross merchantable volume in cu ft/acre per individual prism points* in the Lowlands

(Revised)

Class	Plot				
	17	18	19	20	21
<50%	196	527	118	79	0
Defoliation	126	708	276	303	98
No Top Kill	0	631	172	91	57
50-90%	335	377	238	315	412
Defoliation	60	230	130	262	457
No Top Kill	0	0	248	259	201
50-90%	0	0	0	0	102
Defoliation	0	0	0	0	0
Top Kill	0	0	0	0	0
90-100%	0	0	0	0	0
Defoliation	0	0	0	0	0
No Top Kill	0	0	0	0	0
90-100%	0	0	0	0	0
Defoliation	0	23	0	0	0
Top Kill	0	0	0	0	0
Dead, 1 yr	0	0	0	104	23
	0	68	0	0	98
	0	0	0	45	0
Dead, +2 yr	0	51	0	54	0
	0	34	0	0	0
	41	94	0	0	0

*All readings are 1/3 of actual values.