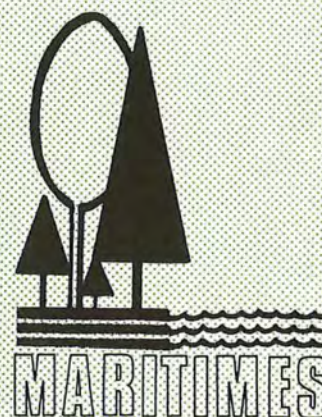


# **CONDITION OF THE FIR-SPRUCE FORESTS ON CAPE BRETON ISLAND FIVE YEARS AFTER THE ONSET OF THE CURRENT SPRUCE BUDWORM OUTBREAK**

by

**L. P. Magasi**





## **MARITIMES FOREST RESEARCH CENTRE**

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## ABSTRACT

One hundred and six sample plots were established in Cape Breton Island, Nova Scotia to determine the condition of fir-spruce stands as a result of the current spruce budworm (Choristoneura fumiferana (Clem.)) outbreak. Twenty of the plots had been established in 1976 to monitor the changes in conditions.

Results show that almost one-third (31.7%) of the balsam fir trees are dead on the Central Highlands and another 11.0% are expected to die within a year. On the Lowlands, mortality is about one-half that on the Highlands.

Fir-spruce stands on Cape Breton Island contain about 2.8 million cords\* of dead wood and another 700 000 cords will be dead within a year.

\*All data on inventory based on Nova Scotia Lands and Forests Inventory 1970.

## RESUME

Cent six placettes d'échantillonnage ont été établies au Cap-Breton (N.-E.) afin de déterminer l'état des peuplements mélangés d'épinette et sapin suite aux ravages de la Tordeuse des bourgeons de l'épinette (Choristoneura fumiferana (Clem.)). Vingt de ces placettes avaient été établies en 1976 afin de signaler tout changement d'état.

Les résultats révèlent que près d'un tiers (31.7%) du sapin baumier dans les Hautes Terres centrales est mort et qu'un autre 11.0% mourra très probablement d'ici un an. La mortalité dans les Basses Terres est à peu près la moitié de celles observée dans les Hautes Terres.

Les peuplements mélangés d'épinette et sapin au Cap-Breton représentent environ 2.8 million de cordes\* de bois mort et 700,000 de cordes qui vraisemblablement périront d'ici un an.

\*Toutes les données d'Inventaire sont basées sur l'Inventaire du ministère des Terres et Forêts de la N.-E.

## INTRODUCTION

A severe spruce budworm (Choristoneura fumiferana (Clem.)) outbreak began on Cape Breton Island, Nova Scotia in 1974. By 1976, virtually all the balsam fir (Abies balsamea (L.) Mill.) and spruce (Picea spp.), had been attacked. Defoliation of new growth was severe and backfeeding on older foliage had occurred for several consecutive years on about 162 000 ha (400,000 acres) of the Central Highlands. Backfeeding occurs when very high populations of spruce budworm larvae that normally feed on current foliage are forced to feed on older needles to avoid starvation. Four consecutive years of severe loss of current foliage may kill trees but death occurs faster when the old needles are also depleted. By 1977, backfeeding was occurring throughout Cape Breton Island. In 1978, in spite of lower larval populations in parts of the Island, the situation for survival of the spruce forest remained critical.

In 1976, a study was begun by the Forest Insect and Disease Survey of the Maritime Forest Research Centre to measure spruce budworm damage to balsam fir on Cape Breton Island. Results to September 1977 were reported by Sterner et al. (1977). The study was continued in 1978. More plots were assessed to give greater statistical reliability and to include the fir-spruce forest. This paper reports the results to September 1978 and compares them to those reported in 1977.

## METHODS

The methods used were basically those described by Sterner et al. (1977).

Permanent Plots

The 20 permanent sampling plots established in the fall of 1976 at budworm egg sampling stations were near roadsides for ease of sampling. Fifteen of the plots were located on the Central Highlands and five on the Lowlands. For the damage assessment study, each plot consisted of three prism point stations. All trees on the three stations were numbered before the 1977 assessment. Although in 1977 some of the plots were extended to five prism points, only the three original points were assessed in 1978 for comparison with temporary plots. Prism points were located at 2, 4, and 6 chains from the roadside. Where necessary, points were offset at right angles to the original direction of travel to keep them within the same stand type. Basal area, dbh, and condition of the trees were measured and estimated by the same forest technicians who had done the previous surveys.

The classification system used in 1978 was that agreed on by both the Forest Insect and Disease Survey and the Forest Inventory Section of the Nova Scotia Department of Lands and Forests. It included the requirements of both groups and made their surveys comparable.

Coniferous trees were classified as follows:

1. Healthy and no defoliation.
2. Healthy and only current defoliation.

3. More than current but less than 25% total defoliation.
4. 26-50% total defoliation - no bare tops.
5. 26-50% total defoliation - with bare tops.
6. 50-75% total defoliation - no bare tops.
7. 50-75% total defoliation - with bare tops.
8. 75-90% total defoliation - no bare tops.
9. 75-90% total defoliation - with bare tops.
10. More than 90% total defoliation - no bare tops.
11. More than 90% total defoliation - with bare tops.
12. Dead - 1 year or less (cambium dead; beetle emergence holes, 1-2 mm, usually present).
13. Dead - 2 years or more (bark loose, and emergence holes, 3-5 mm, usually present; nearly all needles missing, fungus fruiting bodies may be present).
14. Dead - 1-2 years (first classified dead, on permanent plots only, in 1977).

Defoliation and the presence of bare tops were evaluated by using binoculars.

The most significant change from the 1977 methods was implemented in assessing the "top kill" classification. It was difficult to determine whether the bare top of a standing tree was actually dead, and although trees could be reliably classified as "with bare top", the "dead top" (see 1977 classification) grouping was uncertain. To obtain a "dead top factor", 292 trees were examined at three locations on the ground

to determine the bare top - dead top ratio. Of the 292 trees examined, 59 trees had bare tops 0.6 m or more, and 31 had dead tops 0.6 m or more, capable of providing entry of decay fungi into the lower portion of the stem. In 1978, bare tops were recorded during field work and the 0.456 dead/bare top ratio was used to calculate the dead top percentages.

The cambium was checked near breast height with an increment hammer or knife before trees were classed 10, 11, 12, or 14.

#### Temporary Plots

Analysis of the 1977 results (Appendix 2 of Sterner et al. 1977) showed that for a statistically valid survey on Cape Breton Island 30 plots on the Central Highlands and 74 on the Lowlands should be assessed.\* For this reason but also to obtain wider coverage, temporary plots were assessed.

On the Lowlands, forest inventory permanent plots of the Nova Scotia Department of Lands and Forests were selected whenever possible, the center of the first prism point coinciding with the center of the permanent plot. For the analysis of the results, the 76 Lowland plots assessed were stratified by elevation, separating those below 150 m elevation from those above this level.

On the Central Highlands, the 15 temporary plots were located for even coverage. Points were randomly selected in the laboratory and field crews assessed the nearest balsam fir stand regardless of tree conditions.

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\*Courtesy Forest Management Institute, Canadian Forestry Service.

Table 1. Condition of balsam fir on permanent plots on Cape Breton Island, examined in Oct. 1976, Sept. 1977 and Sept. 1978

Tree Condition	% stems, 10 cm and over dbh					
	Highlands			Lowlands		
	1976	1977	1978	1976	1977	1978
<u>Dead</u>						
1 year or less	1.8	11.5	10.0	1.2	5.3	3.4
1 year to 2 years	-	-	14.7	-	-	7.4
2 years or more	4.5	4.9	7.0	4.3	3.5	3.7
Total	6.3	16.4	31.7	5.5	8.8	14.5
<u>Defoliated</u>						
Current foliage only	0	0	0	2.7	0	0
less than 50%	27.2	20.7	14.4	83.6	40.9	44.9
50 - 90%	55.4	53.0	43.1	3.9	49.7	40.1
more than 90%	11.1	9.9	10.8	4.3	0.6	0.5

## RESULTS

### Condition of Balsam Fir on Permanent Plots

Nearly one-third (31.7%) of the balsam fir trees on the Central Highland plots were dead by the fall of 1978 (Table 1). Even if all of the 4.5% trees classified in 1976 as "dead for more than 2 years" died from other causes, over 27% of tree mortality is attributable to the spruce budworm. The pattern of recent mortality equalling the percentage of the "more than 90% total defoliation" of the previous year was once again borne out. Based on this, at least another 11.0% of the balsam fir can be expected to die on these plots during the next year, and by the fall of 1979 mortality will reach 43%. The figure will be higher if trees which have lost or did not develop their current

foliage for several consecutive years are not able to sustain themselves on their aging old-foliage.

Mortality on the Lowland plots is about half of that of the Central Highlands (14.5%); 10.2% having been killed by the spruce budworm since the start of the outbreak. Mortality occurred in trees with 50-90% total defoliation and more than half of those that died did so during the winter of 1977/78. About one-third (34.8%) of the trees on the Lowland plots improved in appearance between June and September 1978. This explains the 4.0% increase in the less than 50% defoliated group but it is too soon to speculate on the possible fate of these trees. Only 12.0% of the Central Highland trees showed such improvement.

The same mortality pattern with somewhat lower percentages is evident on a volume basis (Table 2) but apparently the "improvement" in levels of defoliation shown for the Lowland plots in Table 1 occurs only in smaller trees.

#### Condition of Balsam Fir on Cape Breton Island

Based on assessment on 30 plots (Table 3) on the Central Highlands, balsam fir conditions are comparable to results obtained on the permanent plots.

Over one-quarter of the volume is standing dead timber (25.4%), another 10% can be expected to die by the fall of 1979, and only one-tenth (10.3%) of the volume is represented in trees with less than 50% defoliation (Table 3).

On 60 plots at elevations less than 150 m (500 feet) balsam fir is in better condition than that on the higher elevations especially in terms of less than 50% total defoliation, probably because of the shorter duration of the budworm outbreak on the lower elevation plots.

"Lowland" locations at elevations higher than 150 m (16 plots) occupy an intermediate position in terms of dead and dying balsam fir volume. The remaining trees, however, are comparable to those on the Central Highlands, and 65.8% are void of more than 50% of their foliage. The highest number of trees with dead tops, indicating the possibility of decayed heartwood, was found on these plots (11.4%).

Table 2. Condition of balsam fir on permanent plots on Cape Breton Island, examined in Oct. 1976, Sept. 1977 and Sept. 1978

Tree Condition	% Merchantable Volume					
	Highlands			Lowlands		
	1976	1977	1978	1976	1977	1978
<u>Dead</u>						
1 year or less	1.7	10.1	9.7	0.5	4.4	1.7
1 year to 2 years	-	-	8.9	-	-	3.8
2 years or more	4.3	4.8	5.5	3.6	3.6	3.9
Total	6.0	14.9	24.1	4.1	8.0	9.4
<u>Defoliated</u>						
Current foliage only	0	0	0	3.9	0	0
less than 50%	27.2	18.0	12.8	86.5	44.2	34.1
50 - 90%	56.8	56.0	52.4	2.7	47.5	54.7
more than 90%	10.0	10.0	10.7	2.8	0.3	1.8



Table 3. Condition of balsam fir stands in three ecological areas in Cape Breton Island in September 1978

Tree condition	% Merchantable Volume		
	Central Highlands	Lowlands	
		more than 150 m elevation	less than 150 m elevation
<u>Dead</u>			
1 (2) year or less	17.0	8.7	6.3
2 years or more	8.4	7.9	4.9
Total	25.4	16.6	11.2
<u>Defoliated</u>			
Current foliage only	0	0	0.4
Less than 50%	10.3	13.5	42.0
50-90%	54.3	65.8	44.1
More than 90%	10.0	4.1	2.3
Dead tops % of trees	10.5	11.4	6.6

Condition of Fir-Spruce Stands on Cape Breton Island

Balsam fir is the main species in most stands on the Central Highlands. On the Lowlands, however, spruce constitutes the major portion of volume in many mainly coniferous stands. The death of the few balsam fir trees in mixed stands gave 100% mortality figures for a few plots. For fear of misrepresenting the true situation and because the forest manager's concern is for the stand rather than for a single species, an analysis based on the total fir-spruce volume on each plot was also carried out.

Total mortality on the Central Highlands (Table 4) was 24.6%, only slightly lower than the 25.4% for balsam fir alone, because these stands are predominately balsam fir.

Combined fir-spruce mortality on the Lowlands at elevations less than 150 m was actually higher (11.9%) than for balsam fir alone (10.9%). This was because these stands were also infested by the spruce bark beetle, which was a major cause of spruce mortality. In Cape Breton County, where most of the bark beetle damage was found, fir-spruce mortality was

Table 4. Condition of fir-spruce stands in three ecological areas in Cape Breton Island in September 1978

Tree condition	% Merchantable Volume		
	Central Highlands	Lowlands	
		More than 150 m elevation	Less than 150 m elevation
<u>Dead</u>			
1 (2) year or less	16.2	7.2	6.4
2 years or more	8.4	6.9	5.5
Total	24.6	14.1	11.9
<u>Defoliated</u>			
Current foliage only	0	2.9	1.9
Less than 50%	12.3	24.1	59.2
50-90%	53.5	55.7	25.5
More than 90%	9.6	3.2	1.5
Dead tops % of trees	10.0	9.0	3.6

more than double that of balsam fir alone.

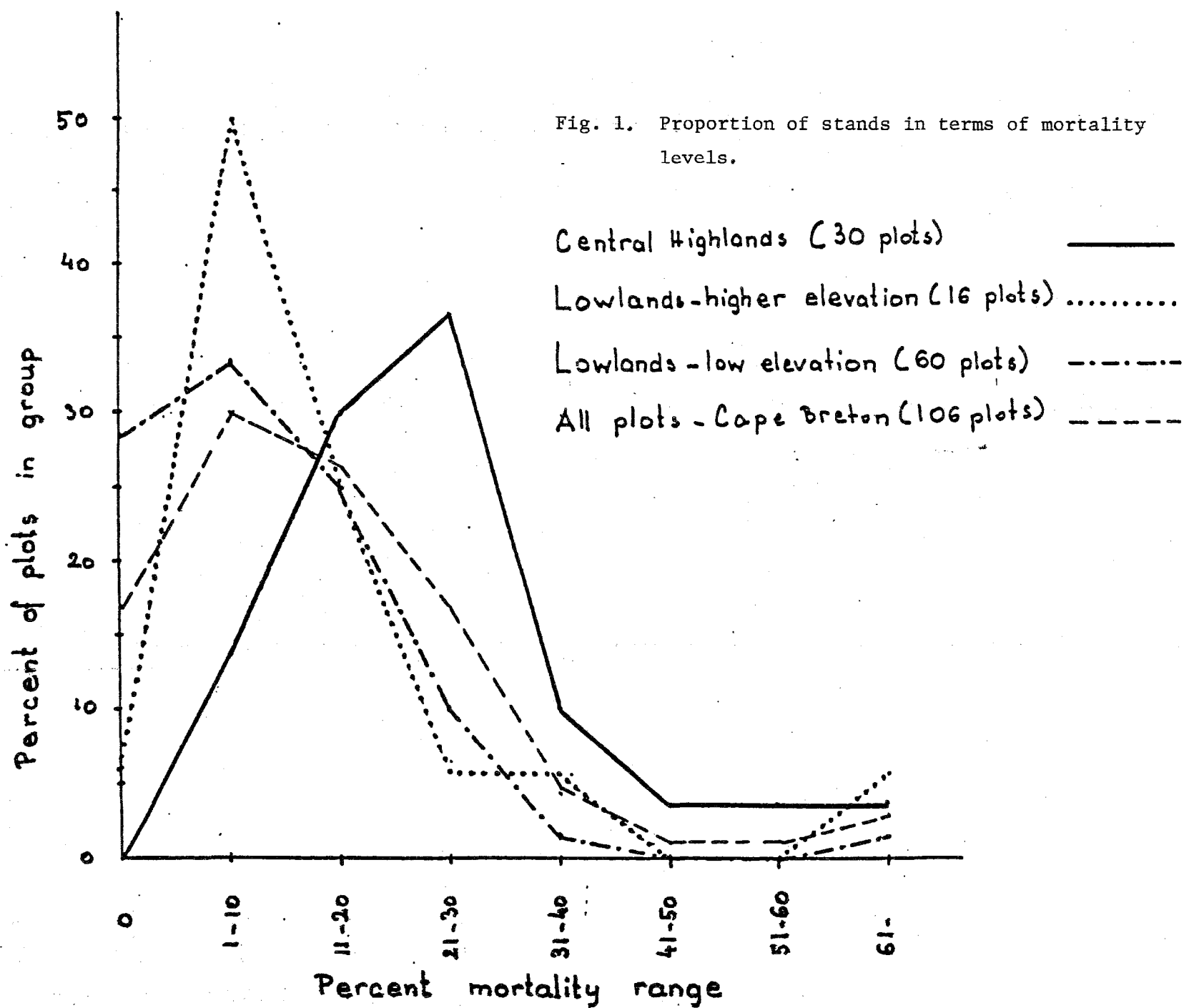
A much higher proportion of the stands on the Central Highlands fell into higher mortality range groups than either of the other two "ecological" areas (Fig. 1).

Figure 2 indicates the approximate locations of the assessment plots, Appendices I-IV give the mortality figures and the percentage of fir-spruce volume expected to die within a year, for each plot.

#### Loss of Merchantable Volume in Fir-Spruce Stands

Of the about 2.8 million cords of dead spruce and fir the loss of almost 1.6 million cords is recent mortality and so can be attributed to the spruce budworm. Another almost 700 000 cords are expected to die by the fall of 1979. The greatest volumes of dead wood are in Victoria and Inverness counties (which include the Central Highlands). These counties have been subjected to budworm attack longer than the Lowland counties, Cape Breton and Richmond (Table 5).

Accuracy of the Study  
See Appendix V.



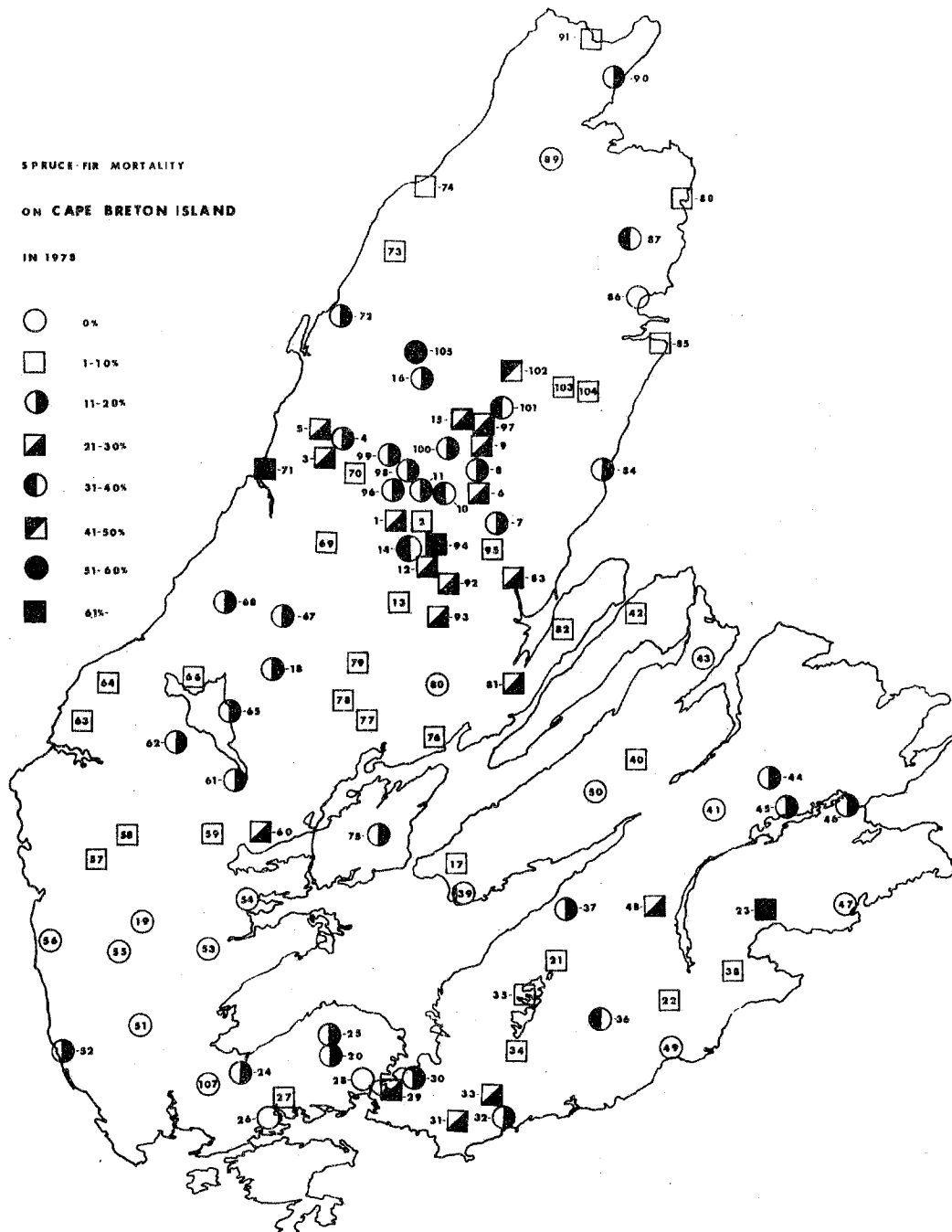


Fig. 2 Map of Cape Breton showing location of plots.



Table 5. Gross merchantable fir-spruce volume losses in the four counties of Cape Breton Island in 1978<sup>1</sup>

Condition	Inverness Co.		Victoria Co.		Richmond Co.		Cape Breton Co.		Cape Breton Is.
	%	Cords <sup>2</sup>	%	Cords	%	Cords	%	Cords	Cords
Dead - 1 yr or less	7.6	460 000	12.9	687 000	9.2	173 000	9.8	332 000	1 652 000
Dead - 2 yrs or more	<u>7.2</u>	<u>436 000</u>	<u>7.0</u>	<u>373 000</u>	<u>6.1</u>	<u>115 000</u>	<u>6.0</u>	<u>203 000</u>	<u>1 127 000</u>
Total	14.8	896 000	19.9	1 060 000	15.3	288 000	15.8	535 000	2 799 000
Dying (90% + defoliated)	4.9	297 000	7.4	394 000	0.2	4 000	0	0	695 000

<sup>1</sup>Based on total gross merchantable volume minus that in parks and military reserves of spruce and fir. Nova Scotia Forest Inventory, Cape Breton Subdivision, 1970. The heavy harvesting in some parts of the island, especially on the Central Highlands ~~was~~ not taken into consideration during the calculations.

<sup>2</sup>Calculated on basis of 80 GMV cu.ft./cord.

## SUMMARY

Over 25% of balsam fir is dead on the Central Highlands of Cape Breton Island in Nova Scotia, another 10% is dying and over 50% is heavily defoliated. Damage to balsam fir on the Lowlands at less than 150 m elevation is about one-half as much as on the Highlands and fir at elevations higher than 150m is in an intermediate position.

Mortality in fir-spruce stands is comparable to that of balsam fir, except in low lying areas (especially in Cape Breton County) where spruce bark beetle attack also caused tree mortality.

There is about 2.8 million cords of dead fir-spruce wood on Cape Breton Island, 1.6 million cords having been killed by the spruce budworm. Another 700 000 cords of wood are expected to die in 1979.

## ACKNOWLEDGMENTS

The author wishes to thank all members of the Forest Insect and Disease Survey who contributed to the planning, execution or reporting of the work, particularly Mr. W.R. Newell. Dr. R.A. Fisher is also thanked for doing the computer analysis.

## REFERENCE

- Sterner, T.E., D.G. Embree, G.D. van Raalte, 1977. Condition of balsam fir on Cape Breton Island following four years of uncontrolled spruce budworm infestation. Marit. For. Res. Cent., Fredericton, N.B. Info. Rep. M-X-80. 16 pp.

11  
APPENDIX I

Condition of fir-spruce stands in Cape Breton Island in terms of mortality and almost complete (+90%) total defoliation).

INVERNESS COUNTY

Plot No.	Recent (1 (2) yr or less) % of total fir - spruce volume	Old (2 yrs or more)	+90% total defoliation	Avg. total mortality
<u>Central Highlands</u>				
3	20.3	4.4	7.3	
4	5.7	11.4	3.1	
5	14.7	7.5	10.1	
16	17.7	0	9.9	
96	8.4	4.2	13.6	
98	11.1	2.9	0	
99	9.7	3.2	7.3	
105	0	57.2	12.6	
Average	10.9	11.4	7.9	22.3
<u>Lowlands (more than 150 m elevation)</u>				
61	7.7	5.6	0	
62	5.8	6.1	2.9	
64	4.1	1.2	2.9	
60	12.9	10.4	7.3	
71	52.5	47.5	0	
74	5.1	0	10.2	
73	2.4	4.1	5.4	
18	6.4	6.5	2.2	
19	0	0	4.8	
57	3.5	3.2	0	
69	5.5	0	1.6	
63*	7.4	0	1.9	
Average	9.4	7.0	3.3	16.5
<u>Lowlands (less than 150 m elevation)</u>				
54	0	0	0	
53	0	0	0	
51	0	0	0	
52	11.4	0	2.6	
58	5.1	0	7.4	
65	8.0	12.1	0	
66	0	1.7	0	
68	8.5	3.2	9.1	
67	12.9	0	0	
70	4.4	1.9	16.6	
72	8.6	4.5	0	
56	0	0	0	
59	1.7	0	0	
55	0	0	0	6.0
	4.3	1.7	2.6	

\* At least part of spruce mortality due to spruce bark beetle.

12  
APPENDIX II

Condition of fir-spruce stands in Cape Breton Island in terms of mortality and almost complete (+90%) total defoliation.

VICTORIA COUNTY

Plot No.	Recent (1 (2 yr) or less) % of total fir - spruce volum	Old (2 yrs or more)	+90% total defoliation	Avg. total mortality
<u>Central Highlands</u>				
1	17.5	4.1	5.6	
2	18.7	2.6	8.4	
6	25.4	8.0	6.4	
7	4.0	10.7	1.1	
8	10.7	9.0	9.4	
9	25.8	1.0	14.3	
10	20.2	11.4	10.2	
11	14.6	2.3	15.2	
12	21.2	3.3	7.9	
13	0	1.3	2.5	
14	38.1	0	4.6	
15	8.3	14.1	30.5	
92	20.6	2.1	5.9	
93	22.2	6.2	0	
94	48.7	13.8	29.2	
95	2.5	0	1.3	
97	29.3	0	7.5	
100	8.6	5.5	4.8	
101	20.8	13.5	8.6	
102	27.1	16.8	24.1	
103	1.7	5.8	7.3	
104	0	2.1	0	
Average	16.7	6.1	9.4	22.8
<u>Lowlands (more than 150 m elevation)</u>				
82	0	4.0	0	
85	0	1.9	1.6	
87	0	34.4	0	
90	6.9	11.9	3.6	
Average	1.7	13.0	1.3	14.8
<u>Lowlands (less than 150 m elevation)</u>				
75	10.8	0	0	
76	0	5.6	0	
77	2.7	4.7	7.9	
81*	3.3	26.2	0	
83	3.3	24.3	1.1	
84	0	20.1	0	
86	0	0	1.2	
88	2.6	3.6	0	
89	0	0	0	
91	0	10.2	23.4	
80	0	0	2.8	
78	2.1	2.1	0	
79	4.0	0	0	
Average	2.2	7.4	2.8	9.7

\* At least part of spruce mortality due to spruce bark beetle.



## APPENDIX III

Condition of fir-spruce stands in Cape Breton Island in terms of mortality and almost complete (+90%) total defoliation.

## RICHMOND COUNTY

Plot No.	Recent	Old	+90% total	Avg. total mortality
	(1 (2) yr or less) % of total fir - spruce volume	(2 yrs or more)	defoliation	
<u>Lowlands (less than 150 m elevation</u>				
29*	6.4	20.2	0	
31	6.1	24.0	0	
32	12.7	0	0	
33	19.6	5.8	0	
34	6.2	2.8	0	
35	0	4.6	0	
36*	26.2	8.9	0	
49	0	0	0	
107	0	0	0	
20	9.4	3.4	0	
24	10.2	5.3	3.2	
25	10.3	3.0	0	
26	0	0	0	
27	9.9	0	0	
28	0	0	0	
30	8.3	0	0	
Average	<u>7.8</u>	<u>4.9</u>	<u>0.2</u>	12.7

\*At least part of spruce mortality due to spruce bark beetle.

## APPENDIX IV

Condition of fir-spruce stands in Cape Breton Island in terms of mortality and almost complete (+90%) total defoliation.

## CAPE BRETON COUNTY

Plot No.,	Recent (1 (2) yr or less) % of total fir - spruce volume	Old (2 yrs or more)	+90% total defoliation	Avg. total mortality
<u>Lowlands (less than 150 m elevation)</u>				
22*	5.5	1.9	0	
23*	54.2	9.2	0	
50	0	0	0	
48*	23.3	2.9	0	
47	0	0	0	
46	6.9	9.5	0	
45	0	17.5	0	
44	9.2	3.1	0	
43	0	0	0	
42	0	9.7	0	
17	5.2	2.7	0	
21	7.6	0	0	
39	0	0	0	
37	0	20.2	0	
38	4.8	2.7	0	
40	0	9.4	0	
41	0	0	0	
Average	6.9	5.2	0	12.1

\* At least part of spruce mortality due to spruce bark beetle.

## APPENDIX V

Means percent total mortality of fir-spruce stands, and 95% confidence limits for the different ecological areas.

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Central Highlands	$23.3 \pm 5.3$	$n = 30$
Lowlands		
- more than 150 m	$16.1 \pm 12.7$	$n = 16$
- less than 150 m	$10.3 \pm 3.0$	$n = 60$
- all plots	$11.5 \pm 3.4$	$n = 76$

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