Environment Canada — Environnement Canada
Forestry Service — Service des Forêts

PEST REPORT

Pacific Forest Research Centre • 506 West Burnside Rd. • Victoria, B.C. • V8Z 1M5

STATUS OF

WESTERN SPRUCE BUDWORM

ON DOUGLAS-FIR IN BRITISH COLUMBIA

SEPTEMBER 1977

R. Shepherd, J. Harris, A. Van Sickle

L. Fiddick and L. McMullen

This report deals with the status of the budworm in British Columbia, and brings together information on defoliation patterns caused by the 1977 populations, egg mass density of the 1978 population together with defoliation estimates, damage studies of selected areas, historical tree ring analysis for previous outbreaks and implications of associated Douglas-fir beetle infestations. Although data on parasitism of the budworm, egg mass size, moth behavior, incidence of disease and the impact of defoliation upon bird populations were collected, they were not analysed in time for inclusion in this report. No attempt is made to equate current or predicted damage with economic or social effects.

SUMMARY

1. New areas of defoliation were greatest in Ashcroft, Bralorne, Nahatlatch and Skagit areas, while decreases in defoliated areas were most notable in Adams-Shuswap and Pemberton. The total result of these changes was an increase of 28% in defoliated area. When the Adams-Shuswap outbreak is excluded, defoliated area increased by 55% for the main Fraser-Lillooet outbreak.

2. Egg counts indicate continuing heavy defoliation in most areas in 1978, with the exception of Pemberton, Adams-Shuswap and Skagit.

3. Total present tree defoliation and projected defoliation of next year's flush appears worse in the areas of more recent infestation: Ashcroft, Fountain Valley, Clinton and Fraser River Valley.

4. Studies of the impact of the present outbreak upon trees included 15 cruise lines run in young stands under 100 years, mainly in the Fraser and associated valleys. No mortality was found on these cruise lines that could be attributed to budworm. Some mortality in a few scattered locations were observed from the air, but no specific survey data is available for these stands.

   In a more detailed study near Pemberton, the average length of top dieback in felled trees was 1.9 meters and was related to length of time and severity of defoliation. A failure to produce terminal growth because of bud destruction or inhibition probably results in greater losses; in one extreme example, estimates indicate an average of about 12 years' height growth could be lost in young vigorous stands before recovery is complete.

   Surveys of tree trunk distortions resulting from previous outbreaks within 1296 trees in the Anderson River Valley indicated 11% were affected. Diameter loss in 15 felled trees averaged 65% per year over the 11-year outbreak and recovery period of the last outbreak.

5. Ring analysis of trees defoliated in the current outbreak frequently indicate previous outbreaks in the 40s and 50s and occasionally earlier than that.

6. Douglas-fir beetle incidence is increasing within the outbreak area but does not appear closely related to budworm damage. A continuous watch is required of this situation.

DEFOLIATION PATTERNS

All stands in the infested area were surveyed from the air, using fixed wing aircraft; mapping of defoliation was based on color differences evident to the observer. Defoliation patterns were sketched on topographic maps at a scale of 2 miles to the inch.

The total area of budworm defoliation of Douglas-fir in the Fraser-Lillooet outbreak increased by over 50% in 1977 (Table I, Fig. 1). The outbreak spread into the Cariboo Forest District for the first time in 1977 and amounted to 2,400 hectares. There was a large reduction in area defoliated in the Adams-Shuswap region from 38,000 to 7,000 hectares (Fig. 2).

The heaviest defoliation occurred in the Carpenter Lake, Skagit, Nahatlatch, and Fraser Canyon areas. Budworm populations declined in the Lillooet River Valley west of Pemberton as well as in the Adams Lake and River and Shuswap Lake areas; defoliation was essentially light throughout these areas except for a few isolated moderate patches. Defoliation increased and extended along the Skagit, Nahatlatch and Yalakom rivers, and Carpenter Lake. New areas of defoliation occurred north of Spences Bridge along the Thompson River to Ashcroft and Cache Creek.

EGG MASS SURVEYS AND PREDICTION OF 1978 DEFOLIATION

Egg mass density was determined for 217 plots scattered through all types of stands over the area infested by budworm. Ten trees were sampled on 201 plots and 3 trees on 16 plots. Two branches 18 inches long were removed from the mid crown of each tree; the branch area was measured and the egg masses were counted under both natural and ultraviolet light. Different collection systems were used: pole pruners, line-gun, helicopter bucket, and helicopter hand collecting. The egg mass density per unit of branch area and the predicted defoliation for 1978 was determined for each plot and the average was calculated for each drainage division. Populations are extremely variable between stands and many plots have to be considered together to estimate future trends with any reliability.

There are two figures given in Table II which summarizes the data collected. The first, average percentage of defoliation Sept. '77, gives an estimate of the condition of the total tree crown at the present time. The second is a prediction of the percentage of plots which are expected to exhibit heavy defoliation of next year's new flush. Together they give some idea of the expected condition of the tree after another year of feeding if

Table I - Thousands of Hectares (Acres) Defoliated by Budworm

	Fraser-Lillooet Outbreak			Adams-Shuswap Outbreak	Total
	Vancouver District	Kamloops District	Total		
1976	71(176)	83(206)	154(382)	38(93)	192(475)
1977	90(223)	149*(362)	239(585)	7(18)	246(603)
% change	+27	+80	+55	-82	+28

* Includes 2,400 hectares in Cariboo District

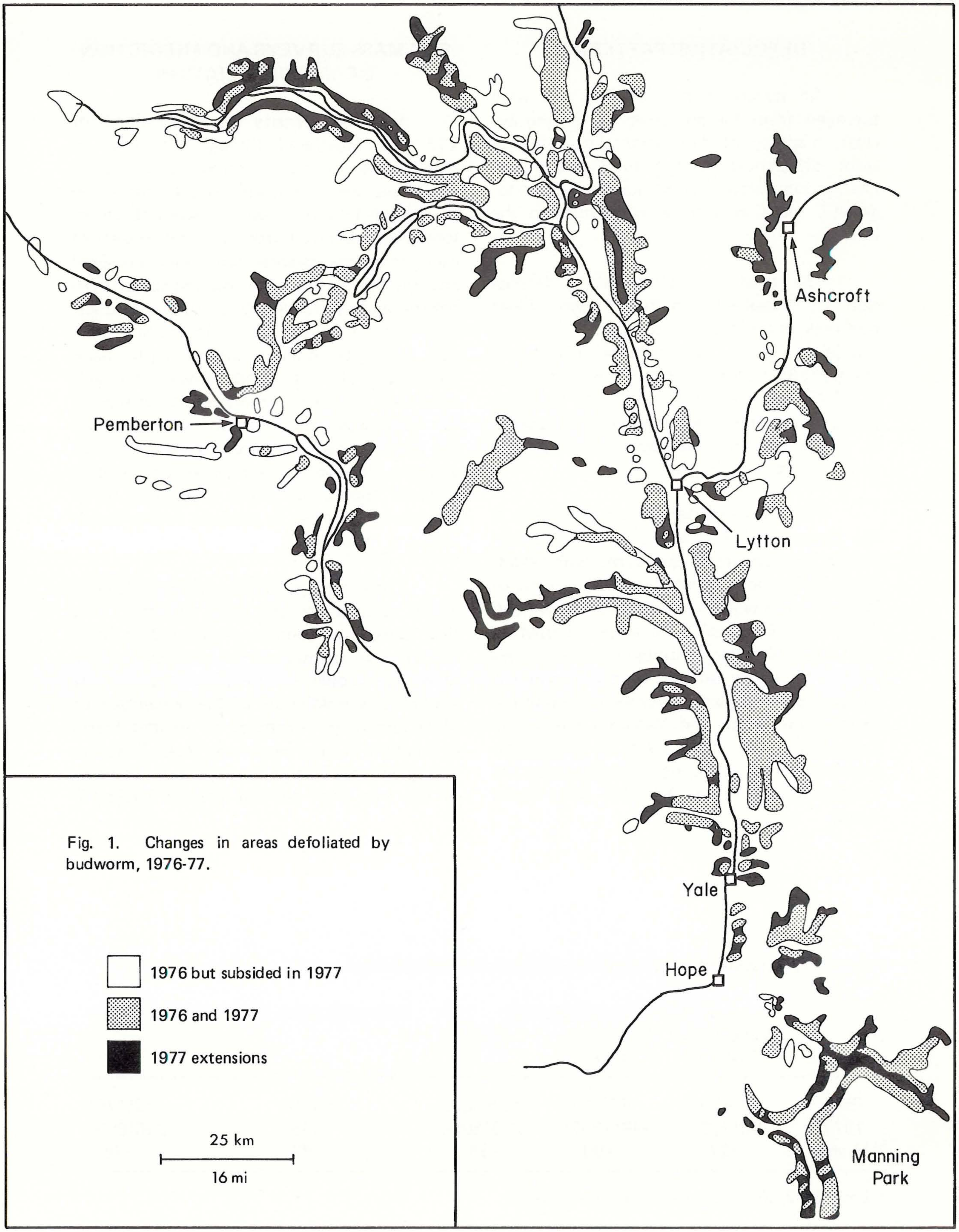

Fig. 1. Changes in areas defoliated by budworm, 1976-77.

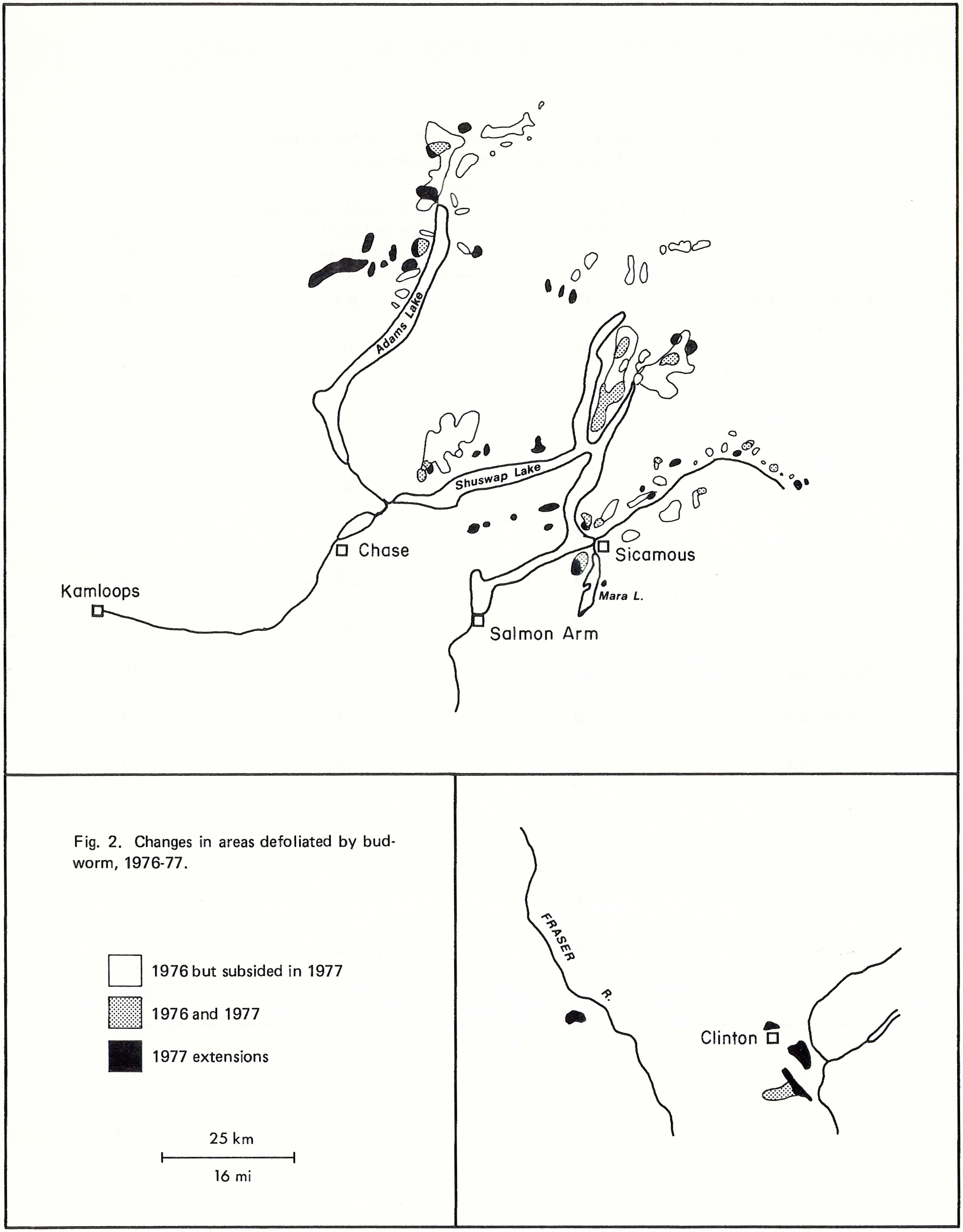

Fig. 2. Changes in areas defoliated by budworm, 1976-77.

Table II. Present total defoliation and predicted defoliation of 1978 flush by drainage divisions.

Location	Avg percent defoliation Sept. '77	% of plots predicted to be heavily defoliated of new flush	No. of plots
Fountain Valley	49	83	6
Lytton	38	75	16
Ashcroft	30	89	9
Nahatlatch	23	80	10
Clinton	13	80	5
Anderson	38	43	28
Merritt	29	54	13
Bralorne	23	50	14
Boston Bar	22	55	44
Coquihalla	19	67	9
Birkenhead	21	25	8
Skagit	22	19	26
Pemberton	17	20	15
Adams-Shuswap	6	0	12
Princeton	0	0	2
			217

no control action is taken. In interpreting this information, it should be remembered that defoliation is heaviest in the upper crown, i.e. 50% total defoliation means most of the foliage in the upper half of the tree is gone. The same information is located on a map (Fig. 3) to show the interrelationships between areas.

In the years prior to 1976, average egg mass density ranged from 95 to 175 per 100 sq ft foliage in our long-term plots, resulting in heavy defoliation in most infested areas. In autumn 1976, unusually high average egg mass numbers were recorded (505) but the defoliation in 1977 appeared no more severe. In autumn 1977, the number of average egg masses were within the usual range previously experienced (134) and defoliation is again expected to be heavy in most areas sampled.

Low to medium populations are generally expected in the Adams-Shuswap, Pemberton and Skagit-Silverhope areas (Fig. 3). An outbreak was reported in the Adams-Shuswap area only once before and it lasted for a very short time. This area is apparently on the fringe of suitable budworm habitat and outbreaks are probably not sustained for extended periods. This is the second decline in the Lillooet River Valley. In 1974-75, the outbreak appeared to have dropped but, in 1976, it increased back to severe defoliation; in 1977, defoliation and egg counts were again less. The private area sprayed in 1975 near the Hope slide still has lower egg counts than the surrounding areas, three generations later. It appears that moth dispersal into this area has been light. The Skagit-Silverhope area has a wide range of egg densities and some stands can be expected to be severely defoliated even though the average counts for the drainage are low.

There are a few points of high egg density along the eastern edge of the outbreak between Nicola and Princeton, indicating that the outbreak may be spreading in that direction and that defoliation can be expected in some new areas in 1978. Highest populations appear to be in the north Fraser River area from Ashcroft, through the Fountain Valley and Clinton south as far as the Nahatlatch and Anderson River valleys.

A granulosis virus was found infecting about 30% of the larva in a small isolated patch of defoliation near Revelstoke and a few larvae were found infected with a nuclear polyhedral virus near Mission Mt. A special survey for microsporidia indicated a relatively healthy population throughout most of the area with a low incidence of disease.

DAMAGE APPRAISAL SURVEYS

The Canadian Forestry Service undertook 20 cruises in 1976 and 17 in 1977, along with fellings and critical analyses of individual trees in both years, to better define the nature of the impact upon the forest. Six of the 17 lines in 1977 were run twice, before and after feeding. The objective of this work was to determine how repeated defoliation affects the trees and to devise the best way of measuring that impact. The cruises were run in areas of repeated heavy defoliation and were not designed to be representative samples of all infested stands. Rather, the results should be interpreted as what is happening in the more severely defoliated young stands. In addition, it should be realized that data collection and analysis is currently underway and that the final impact cannot be assessed until after the outbreak disappears and the trees have recovered their normal growth rates.

Cruises consisted of 10 to 22 prism points established at 80-metre intervals along random lines through the forest. Lines run in 1977 were concentrated in the Anderson River, Fraser Canyon, Manning Park, Nahatlatch Lake and Fountain Valleys. Stands selected were 20 to 100 years old because growth loss, die-back and deformity were expected to be more important in this

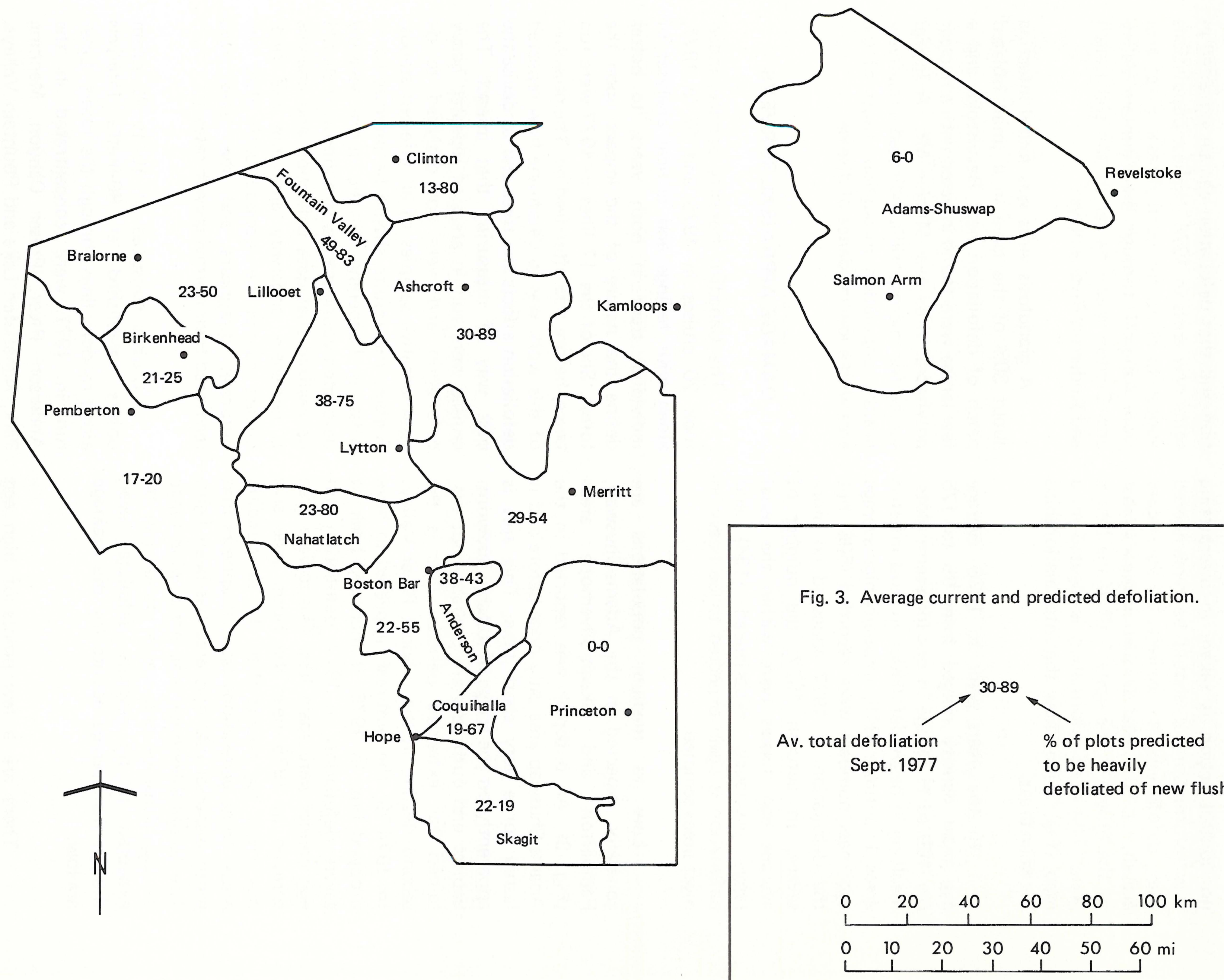

Fig. 3. Average current and predicted defoliation.

age class. Mature and old growth are already growing slowly so reduced increment should not be a problem, and if top-killing or forking does result, it will be largely restricted to the non-merchantable portion of the tree.

MORTALITY

In 1976, Douglas-fir mortality from budworm averaged less than 1% in 16 of 20 stands but reached 22 in part of the stand at Rutherford Creek and 4 to 6% in three other stands. Additional stands exhibiting mortality were observed in 1977, but no specific cruise data is available for these areas.

In the younger stands, cruised in 1977 for the first time, no recent mortality attributable to budworm was found.

LOSS OF HEIGHT GROWTH

Height growth is affected in three ways: die-back resulting in loss of growth from previous years, prevention of height growth through terminal bud feeding or inhibition, and a deformation of the main stem resulting in non-commercial future growth.

At Railroad Creek, near Pemberton, 31 living trees were felled, but the length of the top-kill was surprisingly short, considering the severity of attack in 1970-74, inclusive. Trees in defoliation classes 0-50%, 51-70% and 71-90% had dead tops averaging 0.2, 1.1 and 1.9 m, respectively. Similarly, only 3 of 10 trees cut in 1977 in the Anderson River had top-kill which ranged from 0.1 to 0.6 m in length. Estimating die-back of standing trees is difficult until recovery is complete. Tree tops will often produce foliage after being completely stripped for a year or more.

Combined with loss in diameter increment, failure to produce any height growth (terminal internodes) during an outbreak is probably the most serious impact from budworm infestations. Tops from more than 40 trees cut at Railroad Creek await analysis, but observations indicate that in severely defoliated trees no top growth occurred from 1970-1976; about 3 whorls existing before the outbreak have died, and 1 or 2 more years will probably be required for recovery of normal height growth. In total, about 12 potential internodes will have been lost, and with each about 0.5 m long, this represents a loss in tree height of about 6 m. Similar observations in the Anderson area indicate many trees failed to produce a terminal internode from 1975-1977, inclusive, and at least the 1974 internode has died.

During the cruises of 195 prism plots, including 1296 Douglas-fir trees bole distortions caused by up to three previous infestations were evident on 11% of the trees, but ranged from none in three stands to a maximum of 35% in the East Anderson. In the infestation of the 1950's, which accounted for 75% of the evident distortions, 79% were major forks, 17% were obvious crooks with or without an evident dead spike top, and 4% were bark creases, samples of which, when split, revealed an overgrown spike top. The type of tree recovery, however, was not always related to the severity (length or diameter) of dead top. In some cases, forking resulted from a dead top as small as 1.5 cm, while other larger tops had been successfully overgrown, leaving little more than a slight crook or crease. Predicting the type of tree form recovery and thus the final impact from the present infestation is, therefore, difficult.

REDUCTION OF DIAMETER GROWTH

The effect of defoliation may extend well beyond the last year of feeding so analysis of the current outbreak is not yet possible. Instead, attention has been directed to the effects of previous infestations, particularly the one reported in the Anderson River area from 1953-1958, inclusive. Fifteen Douglas-fir, averaging 74 years at stump, were felled and 10 disks were taken inter-

Year and probable age of infestation		% loss
1953-55	1-3	No distinguishable change in increment
1956	4	50%
57	5	70
58	6	73
59	(Population collapsed, first year of recovery)	83 Av. = 65%
60	2 of recovery	78
61	3 of recovery	72
62	4 of recovery	55
63	5 of recovery	38

nodally at regular intervals along the bole of each tree. Half of the trees exhibited major deformations and half minor external signs of die-back. An average annual diameter loss, during the infestation, of 65% over an 11-year period is indicated, assuming that potential growth during the period was equal to the average of pre- and post-infestation increments (Fig. 4). On an 80-year rotation basis, this one infestation represented an 8% loss in diameter (Fig. 5).

On a yearly basis, the loss, as a percentage of potential, is shown above.

The combined effect of lost height and diameter on volume varies with time to rotation and has not been calculated.

EVIDENCE OF PREVIOUS INFESTATIONS

Reduced diameter increment is evidence of past defoliator outbreaks. The duration and timing of these may not exactly match periods of observed defoliation because of the lag between cause and effect, length of recovery and, in some cases, very limited observations. Also, some apparent differences with other existing records may occur because the location of specific stands was not precisely described. The periods of increment reduction are listed in Table III.

DOUGLAS-FIR BEETLE IN DEFOLIATED STANDS

Douglas-fir beetle was found in some budworm-defoliated stands in 1976 (Railroad Creek, Rutherford Creek, Snass Creek), but was generally absent in most stands. Brood productivity was low, indicating that budworm-defoliated trees were not as ideal for beetle buildup, as is the case with trees defoliated by Douglas-fir tussock moth. Preliminary results of plot cruises in 1977 again showed little evidence of an association between budworm defoliation and the beetle, but a few new areas of beetle damage were found (Tables IV and V).

The general low frequency of Douglas-fir beetle in the budworm defoliation, together with the evidence of low brood productivity, suggests that factors other than budworm defoliation may be responsible for the presence of the beetle in those areas where it is occurring. Nevertheless, further information from plot cruises and brood studies this fall will be obtained in an effort to clarify the situation, and the beetle should continue to be regarded as a potential hazard to defoliated stands.

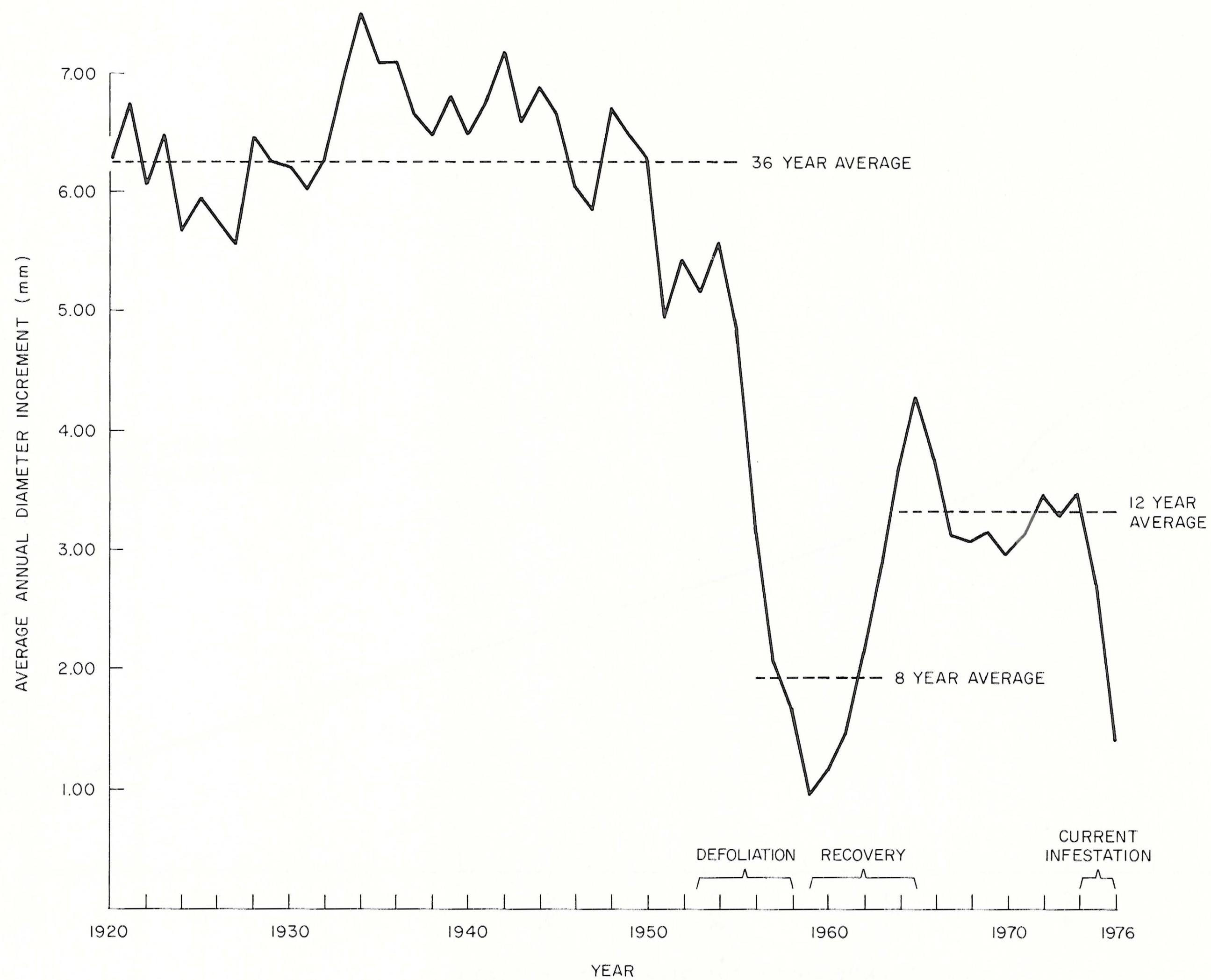

Fig. 4. Average annual diameter increment for 15 Douglas-fir affected by spruce budworm along the East Anderson River.

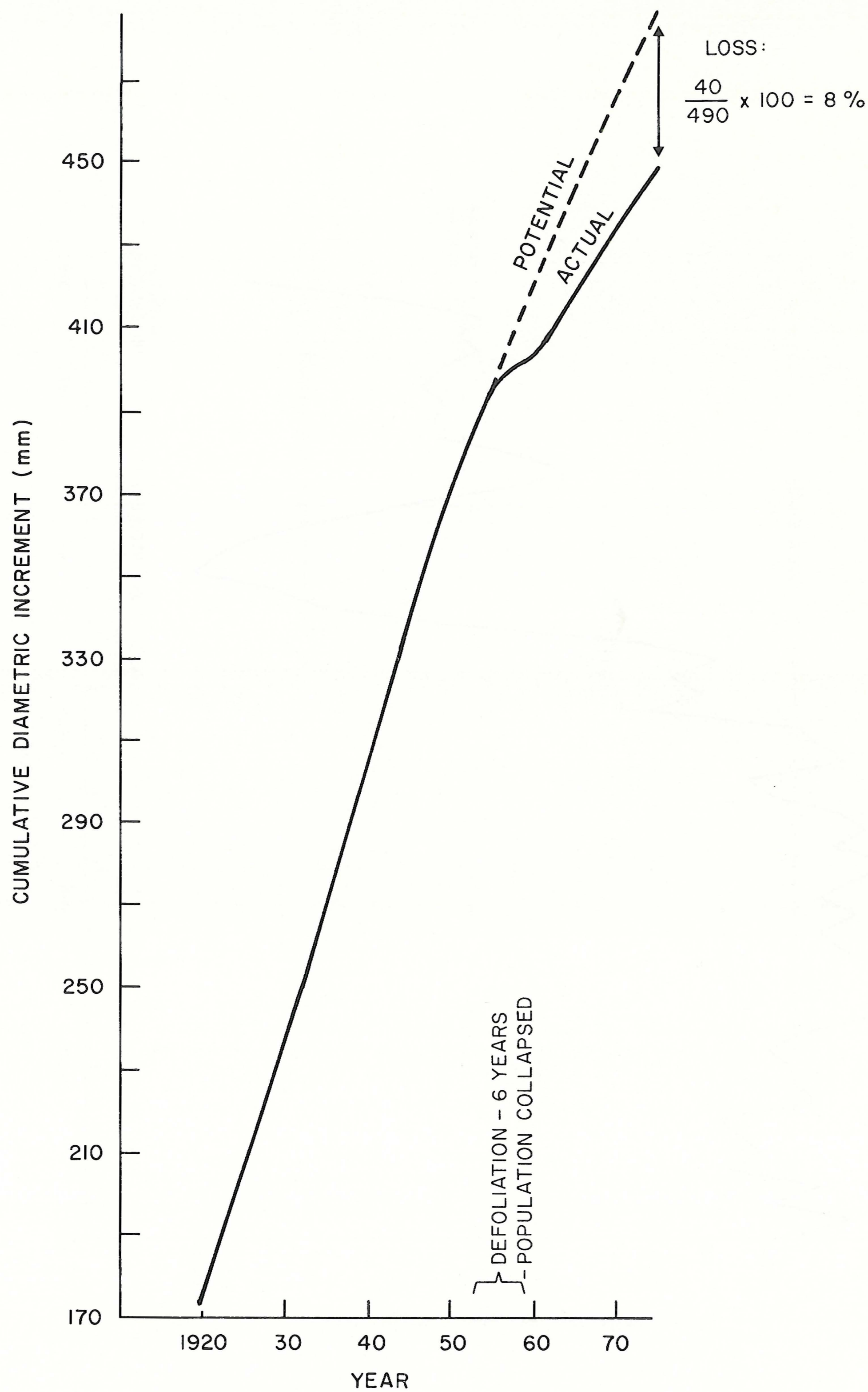

Fig. 5. Actual and potential diameter growth for average of 15 Douglas-fir, 74 years old at stump.

Table III. History of budworm outbreaks as detected by tree ring analysis

Location	Periods of increment reduction				
Railroad Creek		1931-35,	1945-48,	1956-60,	1971-76
Birkenhead River			43-46	57-62	
Lillooet Trail (Mt. Currie)			42-46	55-60	
Lillooet River, south of lake			42-46	55-61	
Rutherford Creek			35-47		71-76
Haylmore Creek (5 miles, by road)	1916-18	27-33	43-48	56-60	70-75
East Anderson				56-63	75-77
Sumallo River			43-47	50 ?	73-76
Nahatlatch River			42-47	52-59	

Table IV. Incidence of attack by Douglas-fir beetle in budworm defoliated stands, Pemberton District, July 1977.

Location	No. of plots	No. of trees	% trees attacked 1977	% trees attacked before 1977
North Cr (mile 2.0)	13	47	0.0	0.0
North Cr (mile 3.2)	6	43	9.3	9.3
McKenzie Basin	5	44	13.6	0.0
Rutherford Cr (mile 5.8)	12	98	1.0	2.0
Lizzie Cr	13	62	0.0	0.0
Birkenhead L Rd (N) (mile 3.6)	4	42	16.7	9.5
Birkenhead L Rd (N) (mile 2.8)	4	27	11.1	22.2
Birkenhead L Rd (S)	13	84	0.0	0.0
Railroad Cr	—	331	0.0	10.0
Total	70	778	4.7	3.6

Table V. Percentage of trees unattacked and attacked by Douglas-fir beetle in defoliation (1976) and diameter classes, Pemberton, July 1977[1/]

Diam (cm)	Unattacked				Attacked in 1977				Attacked prior to 1977	No. of trees
	Defoliation			Total	Defoliation			Total		
	0-40	41-70	71-100		0-40	41-70	71-100			
0-22.5	20	30	50	100	0	0	0	0	0	30
22.5-42.5	41	20	30	91	0	0	5	5	4	138
42.5-62.5	60	19	8	87	1	1	5	7	6	146
62.5+	75	14	3	92	0	1	4	5	3	71
All diameters	52	19	18	90	1	1	4	6	4	385

1/ Not including Lizzie Cr.

Canadian Forestry Service
Pacific Forest Research Centre
506 West Burnside Road
Victoria, B.C.   V8Z 1M5

October, 1977