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Aerial Spraying Operations Against Blackheaded Budworm On Vancouver Island - 1973

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J. R. Carrow, Editor

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ABSTRACT

In June 1973, an aerial spray project was conducted by the Council of Forest Industries of British Columbia and the Province of British Columbia to protect 29,000 acres of hemlock forest on northern Vancouver Island from additional defoliation by an outbreak of blackheaded budworm, *Acleris gloverana* (Wlshm.). Environment Canada provided entomological and technical advice and assessed the effectiveness of the operation, as well as its effects on non-target organisms. The formulation used was 2 oz fenitrothion in 20 oz water per acre applied twice at a four-day interval. Spraying resulted in 80% control of blackheaded budworm in young stands (up to 40 ft) and 46% control in older stands (over 100 ft). The foliage protection value of the spray was difficult to determine accurately because the larval population collapsed prior to heavy feeding; however, spraying resulted in a 14% improvement in the crown condition of young stands. The budworm population experienced a sudden collapse, due to natural causes, shortly after spraying and the evidence suggests that it was associated with 11 days of continuous rain and cool temperatures during early July. Spray assessment indicated a very low ground level deposit and spray drift onto the leave strips surrounding fish-bearing waters; trace amounts of spray were also detected up to six miles from the spray boundary.

Monitoring of the effects of the operation on non-target organisms revealed that populations of juvenile salmon, songbirds and small mammals suffered no immediate ill effects. However, there was considerable mortality of several families of aquatic and terrestrial insects.

Résumé

En juin 1973, le Council of Forest Industries of British Columbia, en collaboration avec la Province de Colombie-Britannique, procéda à des arrosages aériens pour protéger 29,000 acres de forêt de pruches, dans le nord de l'île de Vancouver, contre de nouvelles défoliations causées par *Acleris gloverana* (Wlshm.), une Tordeuse à tête noire. Environnement-Canada fut consulté quant à certains aspects entomologiques et techniques et ils évaluèrent l'efficacité des opérations et ses effets sur les organismes non visés. On utilisa la formule suivante: 2 oz de fénitrothion dans 20 oz d'eau par acre utilisées 2 fois en 4 jours. Cet arrosage fut efficace à 80% dans les jeunes peuplements (jusqu'à 40 pi) et à 46% dans les peuplements âgés dépassant 100 pi). La valeur de l'arrosage en ce qui concerne la protection du feuillage fut difficile à déterminer avec précision vu que les larves périrent partiellement avant qu'elles se nourrissent intensivement; cependant, il y eut une amélioration de 14% de la condition des couronnes dans les jeunes peuplements. La population des Tordeuses diminua subitement, pour cause naturelle, un peu après les arrosages et il semble s'avérer que ceci fut causé par 11 jours de pluies continuelles et par des températures fraîches au début de juillet. Très peu d'insecticide se déposa au sol et très peu se déposa sur les feuillus entourant les eaux poissonneuses; on trouva de faibles traces de l'insecticide jusqu'à 6 milles de limites de l'arrosage.

Quant aux autres organismes, les jeunes saumons, les oiseaux chanteurs et les petits mammifères, ne subirent pas de mauvais effets, du moins sur le coup. Cependant, des insectes terrestres et aquatiques appartenant à plusieurs familles furent tués en grand nombre.

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TABLE OF CONTENTS

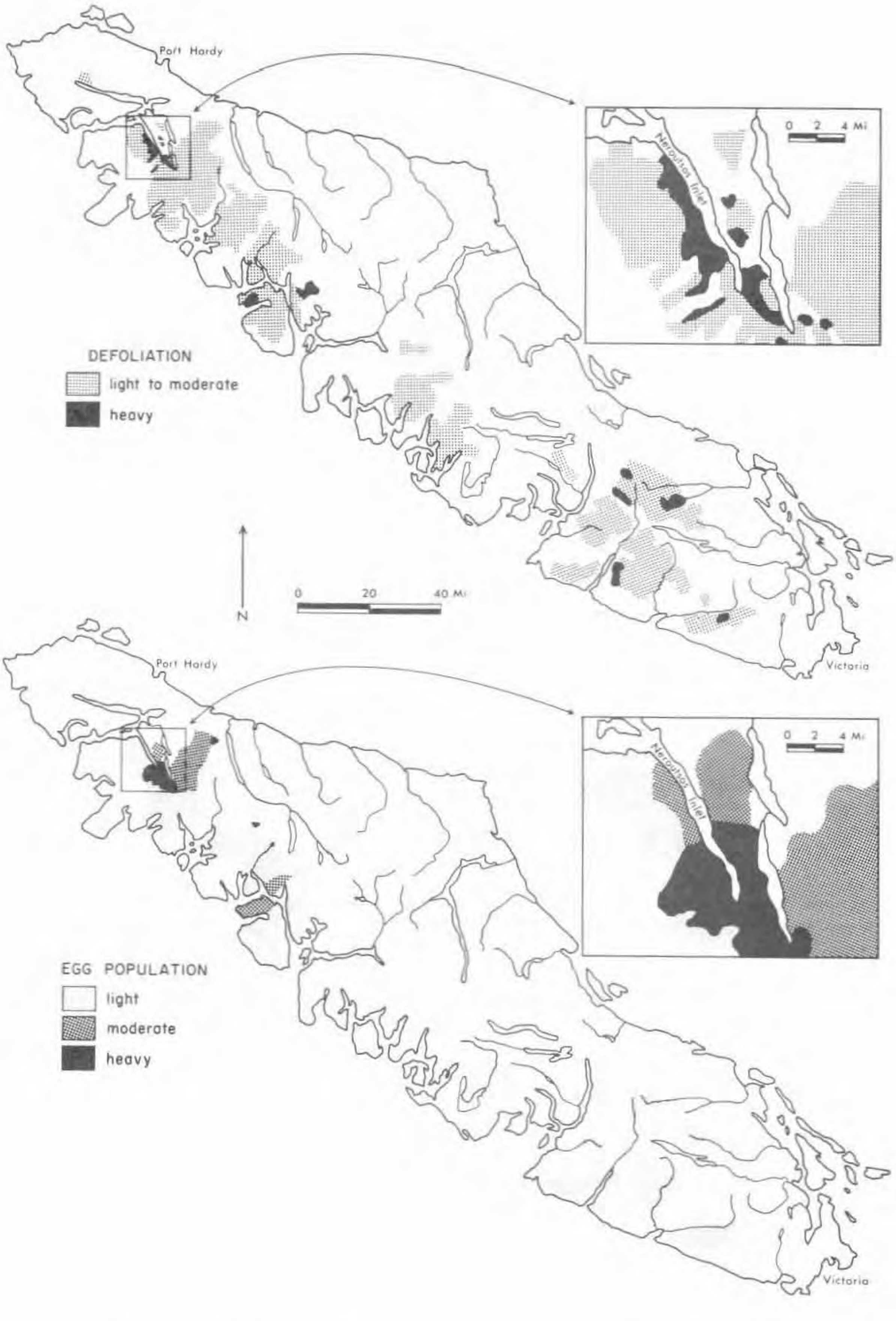

Figure 1. Status of blackheaded budworm outbreak on Vancouver Island - October 1972.

INTRODUCTION

J. R. Carrow

The control project against western blackheaded budworm, *Acleris gloverana* (Wlshm.), on Vancouver Island in 1973, was the first aerial spray operation against a forest pest in British Columbia since 1964. It was also the first operational test of fenitrothion in the province. The project was conducted by the Council of Forest Industries of British Columbia (COFI), which shared equally the cost of the operation ($39,345.78) with the Province of British Columbia.

The recent outbreak of blackheaded budworm started in 1966 when the Forest Insect and Disease Survey of the Canadian Forestry Service detected increases in the frequency of occurrence of larvae during routine sampling (Koot and Fiddick 1973). The outbreak developed first on southern Vancouver Island, peaking in 1970-71. On northern Vancouver Island, it started in 1969 and peaked in 1972, at which time defoliation of western hemlock and amabilis fir extended over 410,000 acres on Vancouver Island (Fig. 1). Aerial surveys in 1972 revealed that defoliation was particularly heavy on 17000 acres near Port Alice and moderate to heavy on about 17000 acres in the Benson Lake area, east of Port Alice. Egg sampling in the fall of 1972 showed that larval populations would remain high in 1973, with the risk of additional heavy feeding in the area. The stands most heavily defoliated were under management by Rayonier Canada (Tree Farm Licence 6) and MacMillan Bloedel Co. (TFL 39), who expressed concern that further defoliation would reduce annual increment and cause significant rootlet mortality and top-killing. In overmature timber, the possibility existed that additional defoliation would increase the mortality rate of trees over the next decade, since these trees have poor recuperative ability.

The two companies, in consultation with staff at the Pacific Forest Research Centre, delineated stands which, on the basis of 1972 damage and high fall egg counts, were considered to be high risk (Fig. 2). In TFL 39, these stands were generally overmature timber, most of which was inaccessible for immediate salvage; in TFL 6, they were composed of 20- to 50-year-old immature growing stock. A proposal was presented to the Pest Control Committee of the Council of Forest Industries to undertake a control project for protection of foliage in these high risk stands. Initially, Bacillus thuringiensis (B.t.) was proposed as the control agent, but inasmuch as B.t. had not been adequately tested against this pest, the CFS recommended that for an operational control project such as this, an agent of proven efficacy, viz. fenitrothion, should be used. Agreement was reached by member companies of the COFI and an application (see Appendix I) was submitted to the B.C. Interdepartmental Pesticide Committee and the Environmental Protection Service, Environment Canada. Although fenitrothion was not registered for use against this pest, approval to use the chemical in this operation was granted by the Control Products Section, Plant Products Division, Agriculture Canada. The proposal was accepted by the Interdepartmental Pesticide Committee and by EPS, subject to the following restrictions designed to minimize the risk of environmental damage (see Appendix II).

1. Fenitrothion was to be applied as two applications of 2 oz active ingredient (a.i.) per acre, with at least 5 days between applications. This plan included the option to stop the operation if unacceptable environmental effects were evident following the first application.

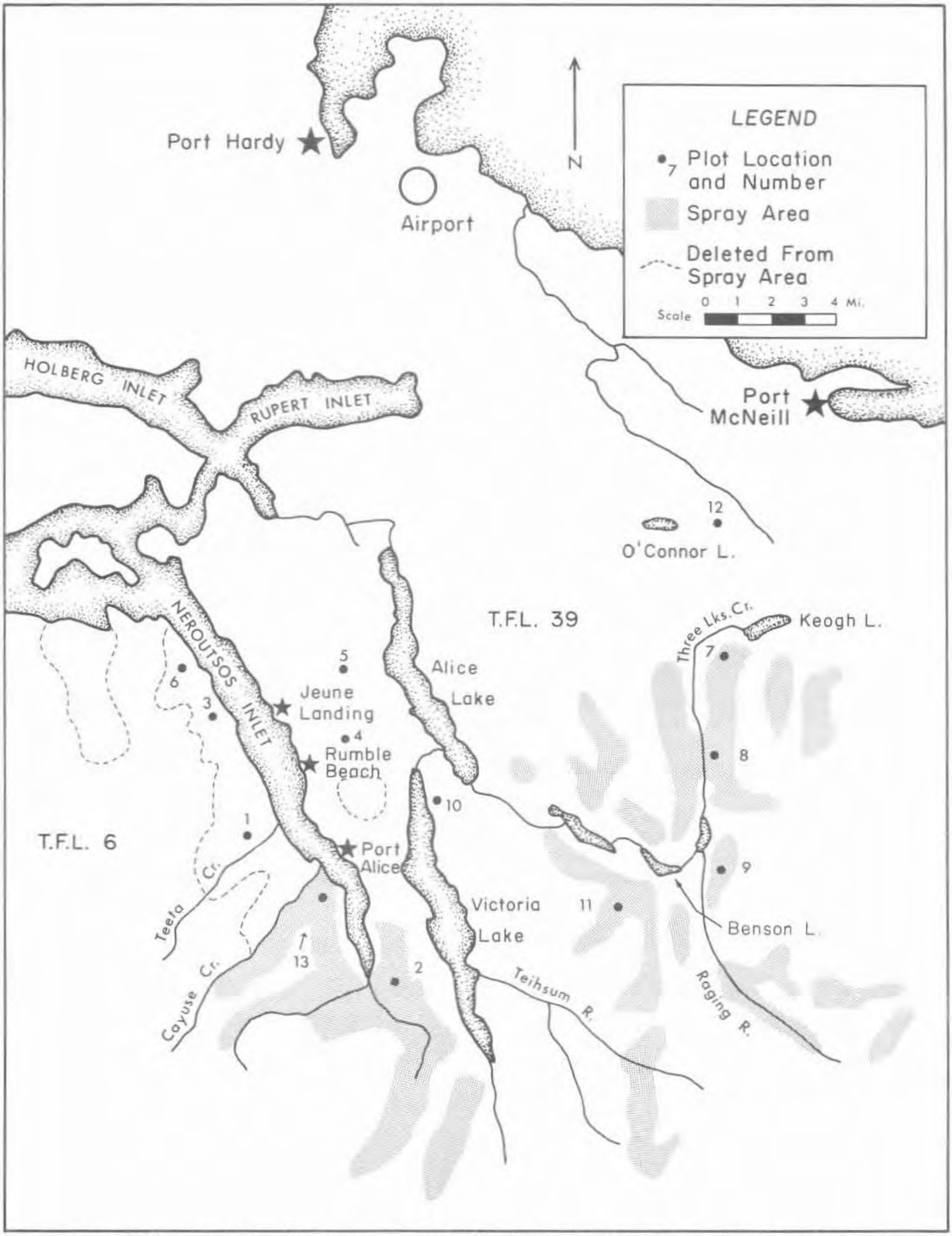

Figure 2. Blackheaded budworm spray operation: location of spray areas and study plots.

2. Buffer strips 600-ft wide were to be left unsprayed around the following bodies of water to prevent chemicals from reaching fish-frequented streams and inter-tidal zones in the spray area.

TFL 6 - Klootchlimmis Creek and estuary; Teeta Creek and estuary; Cayuse Creek and estuary; Cayeghle Creek and estuary; Colonial Creek; Utluh Creek (see Fig. 5)

TFL 39 - Lower Benson River; Upper Benson River; Malook Creek.

The same buffer strip was to be maintained along the marine foreshore of Neroutsos Inlet and precautions were to be taken to ensure that Three Lakes Creek and the Raging River (TFL 39) were not directly sprayed.

H. A. Richmond, COFI, acted as Project Manager and Environment Canada provided advice and services, as follows:

Environmental Management Service

Canadian Forestry Service

Pacific Forest Research Centre, Victoria

J.R. Carrow - entomological advice and assessment of effectiveness of operation

Chemical Control Research Institute, Ottawa

C.H. Buckner - assessment of effects on birds and small mammals

W. Haliburton and K.M.S. Sundaram - analysis of spray deposit

A.P. Randall - calibration of spray aircraft

Environmental Protection Service, Vancouver

M. Wan - assessment of effects on non-target arthropods

Fisheries and Marine Service, Vancouver

O.E. Langer and R. Taylor - assessment of effects on fish

The CFS also provided continuing advice on various operational aspects, e.g. spray formulation and safety procedures. Information on local weather patterns was provided by Atmospheric Environment Service at Port Hardy airport.

Publicity and Public Opposition

In view of the environmentally sensitive nature of the project, the matter of publicity was considered carefully by COFI. News releases noted the possibility of a control program as early as October 1972, and the provincial government formally announced the project in the news media on April 30, 1973, in order to gauge public opinion. During May, H.A. Richmond met with various groups on the northern Island to explain the operation. However, no public meetings were held and some residents of the Port Alice area interpreted this as an attempt to conceal the program from the public. In addition, the doctor in Rumble Beach became convinced that the program constituted a public health hazard, in that local weather conditions might result in drift of the spray from the west side of Neroutsos Inlet onto Rumble Beach and expose the population to fenitrothion for an extended time period. The doctor presented an ultimatum to the provincial Minister of Health: if the spraying proceeded as planned the local hospital would be evacuated and parents advised to remove their children from the area during the operation. The media became involved, misinformation prevailed, and many of the residents became very apprehensive of the operation (see Appendix III). Consequently, the Minister suspended the project until a modified plan was drafted in which parts of the spray area closest to Rumble Beach were deleted (Fig. 2). This resulted in a total spray area of 28,800 acres.

2. SPRAY OPERATIONS

H. A. Richmond and J. R. Carrow

2.1 Spray Application

The base of operation for the project was Port Hardy airport, 20-25 miles from the spray area. All mixing was done at the air base with portable equipment supplied by the contractor. The emulsifiable concentrate (insecticide + emulsifier + solvent) was formulated the day before intended application. The concentrate was pumped into the aircraft simultaneously with water and final mixing was achieved within the aircraft during flight. Technical details of the operation are provided in Table 1.

Table 1. Blackheaded Budworm Spray Project on Vancouver Island: Technical Data.

Area Treated: 28,800 acres (TFL 6 - 11,200 acres; TFL 39 - 17,600 acres)

Total Cost: $39,345.78 ($1.37/acre)

Emulsifiable Concentrate: Sumithion (97% fenitrothion).... 76.5% by volume
Atlox[1] (emulsifier)............. 11.9%
Arotex[2] (solvent)................ 11.6%

Application: 2 oz active ingredient fenitrothion in 20 oz water carrier per acre. Application repeated after 4-5 days.

Aircraft: Guidance - Cessna Skymaster
Spraying - Grumman Avenger (TBM)[3]
capacity - 500 gal (Imperial)
swath width - 880 ft
area covered/load - ca. 4,000 acres
boom time - 17 min

Contractor: Conair Aviation Ltd., Abbotsford, B.C.

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1 Atlox 3409, Atlas Chemical, Brantford, Ontario
2 Arotex 3470, Texaco Canada Ltd.
3 Calibration of the TBM was done by A.P. Randall, Ottawa. Further details on calibration are provided in Appendix IV.

Sumithion was applied twice at a rate of 2 oz a.i. per acre (emitted), with 4 to 5 days between applications[4]; thus, the total application was 4 oz a.i. per acre. The spraying schedule was as follows:

June 22 - TFL 6, first application

June 25-26 - TFL 39, first application

June 26 - TFL 6, second application

June 29-30 - TFL 39, second application

Company foresters (D. Beaumont, MacMillan-Bloedel; D. McLeod, Rayonier) acted as observers in the guidance aircraft for spraying conducted on their respective licences.

2.2 Safety and Security Arrangements

Arrangements were made to ensure that treatment for organophosphate poisoning was available at the Campbell River hospital, if required. The antidote, atropine, was also kept on hand at the operations base. Arrangements for emergency rescue were made with Vancouver Island Helicopters, Port Hardy. Soda ash, caustic soda and detergent were available at the air base for detoxification of equipment, cleanup of the tarmac at the airport following completion of the project and for use in case of an accidental spill.

Because of opposition to the project by some elements and to avoid problems with a curious public, a security service was employed to provide continuous surveillance at the air base for the duration of the program. Fortunately no accidents or security problems arose during the project.

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4 Due to uncertain weather conditions and the absence of any adverse effect following the first application, EPS approved shortening the interval to 4 days.

All materials associated with the project (chemicals, empty drums, etc.) were stored at the B.C. Forest Service warehouse in Port Hardy and removed only as required. The responsibility for disposal of empty drums was assumed by MacMillan Bloedel, who crushed and buried them on July 4 in road fill located in TFL 39. Due to deletion of part of the spray area, six full drums of Sumithion remained at the end of the operation and these were donated to the Chemical Control Research Institute, Ottawa.

2.3 Spray Coverage and Drift

Spray coverage and deposit were assessed, using glass slides and Kromekote cards located in 12 of the 13 study plots situated throughout the area (see Fig. 2). In each plot, spray card stations were located along a line perpendicular to the anticipated flight path. In plots 2,7,8 and 13, 15 stations were established at 75-foot intervals and in plots 1,3,4,5,9,10,11 and 12, four stations were located at 200-ft intervals. Where morning spraying was planned, cards and slides were placed out the previous evening. For evening spraying, they were placed out in late afternoon. Cards and slides were retrieved as soon as possible after spraying, usually within 2 hours. They were forwarded to CCRI for analysis immediately following the operation.

Examination of Kromekote cards was made difficult because only the first two loads of spray contained Rhodamine-B dye. Nevertheless, the cards indicated that distribution was non-uniform and deposit levels were far from adequate (Table 2).

Table 2. Analysis of Spray Deposit in Unsprayed Plots and Plots Sprayed with Fenitrothion

Plot	Treatment	Kromekote Cards	Glass Slides (oz fenitrothion/acre)
1	unsprayed	NVD	ND
2	sprayed	+	0.0027
3	unsprayed	NVD	T
4	unsprayed	NVD	ND
5	unsprayed	trace	ND
7	sprayed	+	T
8	sprayed	+	0.0008
9	sprayed	+	0.0005
10	unsprayed	trace	T
11	sprayed	NVD	ND
12	unsprayed	NVD	T
13	sprayed	-	0.0006

Analysis by W. Haliburton and K.M.S. Sundaram, CCRI, Ottawa
NVD = no visible deposit; ND = none detected; T = <0.0002 oz/acre

These findings were confirmed by analysis of deposits eluted from the glass slides. Of the 6 plots within the spray zone, only one (plot 11) apparently received no spray at ground level. In the other 5 plots, deposits were extremely low; the highest concentration was less than 1% of the emitted volume. Three of the 7 check plots (unsprayed) received traces of spray (<0.0002 oz/acre).

Due to public concern about the possibility of spray drift onto the community of Rumble Beach, an effort was made to monitor fenitrothion deposit on hemlock foliage. Ten sampling stations, located throughout the town site, were used to collect foliage before and after spraying. At each station, a hemlock twig was taken from the lower crown of a tree, and the 10 twigs were placed in a sealer jar with 200 ml pesticide-grade methanol. The lid was lined with aluminum foil. Samples were taken prior to spraying (June 21) and at 2-day intervals after spraying. Immediately following the operation, they were sent to CCRI, Ottawa for analysis. Two days after the first application, a deposit of 0.01 ppm fenitrothion was detected (Table 3). This level decreased until the second application, whereupon the deposit level rose to 0.02 ppm. Four days after the second application, the level had decreased to 0.01 ppm.

Table 3. Analysis of fenitrothion on hemlock foliage collected from Rumble Beach before and after spraying.

Foliage Collection Date[a]	Fresh Wt of Foliage (g)	Fenitrothion[b] (ppm)
June 21	62.9	none detected
24	88.9	0.01
26	117.0	<0.01
28	85.0	0.02
30	56.3	0.01

Analysis by K.M.S. Sundaram, CCRI, Ottawa
a. Spray dates were June 22 and June 26
b. ppm of fresh weight of foliage

3. BIOLOGICAL ASSESSMENT

3.1 Target Organisms - J. R. Carrow

Assessment of budworm development, mortality and defoliation was conducted primarily in study plots established in April 1973 (Fig. 2). Each plot (4.8 acres) consisted of two lines of trees 300 ft apart, oriented perpendicular to the anticipated flight path of the aircraft. On each line, 8 trees were selected at ca. 100 ft intervals and permanently marked; thus, each plot consisted of 16 trees. The trees chosen were dominant-codominant; those which had been heavily defoliated during 1972 were avoided. Characteristics of the plots are provided in Table 4.

In April, plots 1 to 12 were established, with 4 unsprayed check plots and 8 plots within the spray zone. Modification of the plan in May resulted in deletion of the spray area containing plots 1,3 and 6. These plots were subsequently maintained as checks and one additional plot (# 13) was established within the spray zone.

Table 4. Characteristics of Plots Used to Assess Blackheaded Budworm Development and Control and Foliage Protection.

Plot	Age of Stand (years)	Elevation (feet)	Aspect
1	44	500	E
2	30	1000	W
3	43	300	E
4	18	2000	W
5	17	1300	E
6	50	500	E
7	20	700	N
8	mature	1000	W
9	mature	800	W
10	mature	500	W
11	mature	1500	E
12	20	1000	N
13	44	200	NE

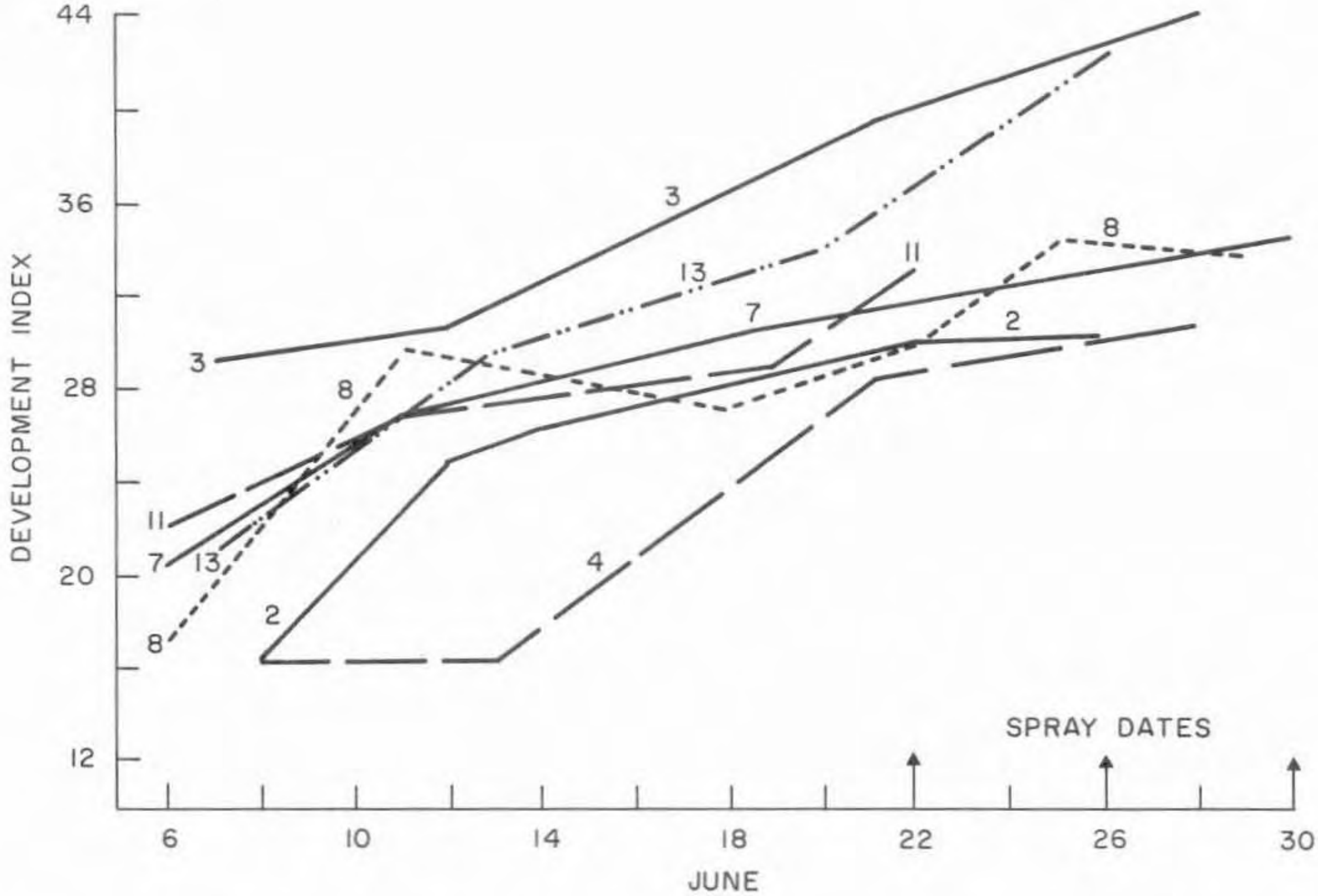

Figure 3. Development of blackheaded budworm larvae on study plots in Port Alice region (numbers indicate plot number). See text for explanation of Development Index.

3.1.1 Blackheaded Budworm Development. Egg hatch and larval development were monitored at plots 2,3,4,7,8,11 and 13. Hatch was first detected on June 4 on the west shore of Neroutsos Inlet (plot 3), although it appeared to have started about June 1. In the Benson Lake Valley, hatch started on June 5 at lower elevations (plots 7, 8 and 11) but at higher elevations hatch was delayed; larvae did not appear at the Empire Mine site (ca. 2500 ft) near Benson Lake until about June 22.

Following hatch, populations of about 100 larvae were collected periodically from each of the above plots. Larvae were classified as to instar by comparing head capsule width with standards established by Brown and Silver (1957). The percentage of the population in each instar was calculated and development was expressed as a Development Index (DI)[5] used by Lejeune et al. (1957) in a previous spray project.

In lower elevation mature-immature stands (below 1500 ft), larval development throughout the area was similar until about June 12, as shown by DI trends in plots 3,7,8,11 and 13 (Fig. 3). Thereafter development in the Neroutsos Inlet area was somewhat faster than in the Benson Lake valley (Fig. 4), which is known locally to be relatively cool. In plots 3 and 13 on the west side of Neroutsos Inlet, where hatch first occurred, larval development remained ahead of all other areas. Elevation had a considerable effect on development. Figure 3 illustrates that during mid-June, development at 1000 ft (plot 2) was well ahead of that at 2000 ft (plot 4).

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5. Development Index (DI) = $\frac{\text{SUM (\% of population in each stage x stage value)}}{100}$

stage values: egg = 16; first instar = 28; second instar = 40; third instar = 52; fourth instar = 64; fifth instar = 76

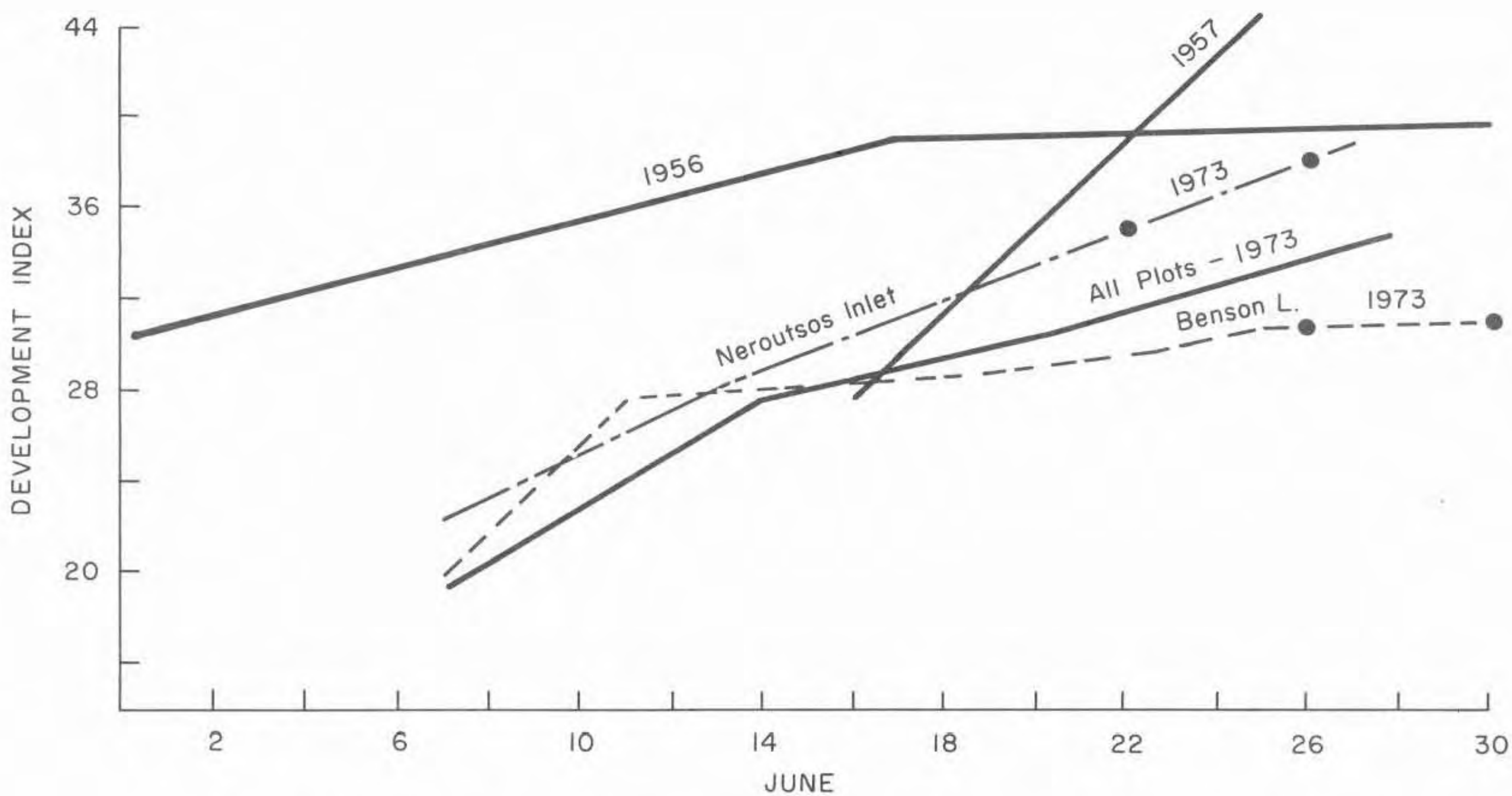

Figure 4. Development of blackheaded budworm on northern Vancouver Island during 1956, 1957 and 1973. Dates of spraying during 1973 relative to development are indicated by circles. See text for explanation of Development Index.

Compared to the last outbreak in this region, development during the second half of June was much slower in 1973 than in 1957 (Fig. 4) (Lejeune et al. 1957). Egg hatch and development during 1956 was also several weeks ahead of 1973 (Fig. 4); in 1956, egg hatch at 1500-ft elevation was complete by June 2 (Brown and Silver 1957).

The DI was used as a guide to the timing of applications. In the Neroutsos Inlet area, the first application was made when the mean DI for the area was 35; at this point, the population was about 50% first instar, 42% second instar, and 8% third instar. The second application took place when the DI was 38. In the Benson Lake area, the DI was about 31 when both applications were made. This timing of application was earlier than in the previous control operation in 1957, in which a DI of 40 was used as the threshold for application. Several factors contributed to the decision to spray at an earlier point in larval development this year: well-advanced 1973 bud flush; the desire to protect trees from bud damage and defoliation (see Silver and Lejeune 1956, p.7); highly unstable weather and potential difficulties in completing two applications of spray, and the fact that egg hatch was complete.

3.1.2 Blackheaded Budworm Mortality. The efficacy of the spray project was evaluated by examination of population mortality, defoliation and bud development. Egg counts made in April 1973 indicated that the potential for heavy defoliation was present, the mean population being 21 eggs per sample[6] (Table 5). Larval populations in the plots, 1 to 3 days prior to the first spraying, averaged 7 per branch, although larger populations (25-30/branch) were found outside the plots in overmature hemlock at

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6. The standard sample unit throughout the study was one 18-inch branch per tree taken from the mid-third of the crown. Larger trees were sampled, using a line gun and cutter described by Collis and Harris (1973). Eggs were extracted from foliage, using hot water (Gray et al. 1973).

Table 5. Survival and Control of Blackheaded Budworm Following Fenitrothion Application

Age of Stand	Treatment	Plot	No. Insects/Branch		% Survival	% Control[a]
			eggs	pupae		
Regeneration	Unsprayed (check)	4	16	0	0	-
		5	21	0.44	2.10	-
		12	21	0.06	0.29	-
		$\overline{X}$			0.80	
	Sprayed	2	39	0.06	0.15	81
		7	33	0.06	0.18	78
		$\overline{X}$			0.17	80
Immature -Mature	Unsprayed (check)	1	20	0.38	1.90	-
		3	16	0.19	1.19	-
		6	8	0.31	3.88	-
		10	25	0.44	1.76	-
		$\overline{X}$			2.18	
	Sprayed	8	23	0.19	0.83	62
		9	18	0.31	1.72	21
		11	22	0	0	100
		13	10	0.38	3.80	0
		$\overline{X}$			1.59	46

a. Calculation for % control based on survival from egg to pupa (see text for calculation).

the Empire Mine site. Pupal counts made in August showed that the larval population had experienced high natural mortality some time after spraying; survival of larvae to the pupal stage in unsprayed plots averaged only 3.9%. Reasons for this collapse will be discussed later. A summary of population levels and survival in unsprayed plots is given in Appendix V.

Since study trees in the mature and immature stands ranged from 150 to 250 ft in height, it was impossible to sample larvae without losing them in the process; furthermore, the first- and second-instar larvae feed within the expanding buds and are difficult to find. Because of this potential for error, no attempt was made to assess control using larval counts; instead, control was calculated using populations of eggs and pupae, both of which can be sampled more reliably than larvae, especially in larger trees. Using Abbott's formula[7], control in regeneration stands, i.e. mortality from the egg to pupa due to insecticide alone, ranged from 78 to 81% (mean 80%)(Table 5). In immature and mature stands, control was highly variable, ranging from no control in plot 13 to 100% control in plot 11, with an average of 46%.

3.1.3. <u>Foliage Protection</u>. The crown condition of each study tree was examined in April and in August to determine the effects of 1973 feeding in sprayed and unsprayed areas. Defoliation was assessed from the ground by one observer, who visually estimated the percent defoliation in each quarter of the crown. Defoliation of the top two quarters and bottom two quarters was then averaged to provide estimates of upper crown and lower crown condition. During the summer of 1973, very little feeding

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7. $\% \text{ control} = \frac{X - Y}{X} \times 100$, where X = % survival in unsprayed plots and Y = % survival in sprayed plots

occurred in any of the study plots, resulting in a general improvement in crown condition, i.e. a reduction in percent defoliation. This made it difficult to detect whether the spray provided much foliage protection. However, it appears that regeneration stands benefitted from the spray; in sprayed plots, upper crown defoliation decreased an average of 14% from April to August, whereas on unsprayed trees, there was no reduction in defoliation (Table 6). The lower crown stratum in regeneration stands also benefitted from the spray, but to a lesser extent. In immature and mature stands, spraying provided no foliage protection value.

In addition to the consumption of needles by older larvae, unopened buds may be damaged in early summer by the feeding and mining activity of young larvae. Thus, trees were sampled in August to assess bud and shoot development during 1973. Using one branch sample from each tree, four branchlets were selected for examination. On each branchlet, 3 inches of twig representing growth prior to 1973 was isolated and the fate of buds present at the time of bud break in 1973 was classified, as follows:

normal - normal flush and development in 1973

incomplete - flushed but little or no elongation of new growth during 1973

none - no flushing during 1973

The frequency of normal bud development was unaffected by spraying; in regeneration stands, about 80% of the buds flushed normally, whereas in immature-mature stands, normal bud development was 54% (Table 7). This examination also indicated that the number of new buds formed during 1973 may have been considerably decreased by larval feeding.

Tables 6. Changes in Upper and Lower Crown Defoliation of Western Hemlock Following Fenitrothion Application

			Defoliation (%)						Change in % Defoliation	
			April			August				
Age of Stand	Treatment	Plot	upper crown	lower crown	average	upper crown	lower crown	average	upper crown	lower crown
Regeneration	Unsprayed	4	7	2	5	9	7	8	+2[a]	+5
		5	9	5	7	6	6	6	-3[b]	+1
		12	4	3	4	5	3	4	+1	0
		$\overline{X}$	7	3	5	7	5	6	0	+2
	Sprayed	2	62	16	39	36	14	26	-26	-2
		7	6	4	5	5	3	4	- 1	-1
		$\overline{X}$	34	10	22	20	9	15	-14	-1
Immature -Mature	Unsprayed	1	42	20	31	35	21	29	-7	+1
		3	52	28	40	39	21	31	-13	-7
		6	68	37	53	50	24	36	-18	-13
		10	14	6	10	6	4	5	-8	-2
		$\overline{X}$	44	23	34	33	18	25	-11	-5
	Sprayed	8	40	21	31	24	11	18	-16	-10
		9	25	18	22	12	8	10	-13	-10
		11	34	9	22	8	3	6	-26	-6
		13	23	4	14	34	16	25	+11	+12
		$\overline{X}$	31	13	22	20	10	15	-11	-3

a - 2% more defoliation in August than in April
b - 3% less defoliation in August than in April

Table 7. Hemlock Bud Development in 1973 in Relation to Fenitrothion Application

Age	Treatment	Plot	Bud Development (% of total buds examined)		
			normal	incomplete	none
Regeneration	Unsprayed	4	93	4	3
		5	69	12	19
		12	70	12	18
		$\overline{X}$	78	9	13
	Sprayed	2	88	7	5
		7	74	9	17
		$\overline{X}$	81	8	11
Immature -Mature	Unsprayed	1	40	22	38
		3	67	6	27
		6	58	15	27
		10	46	11	43
		$\overline{X}$	53	13	34
	Sprayed	8	48	18	34
		9	50	25	25
		11	60	9	31
		13	60	12	28
		$\overline{X}$	55	16	29

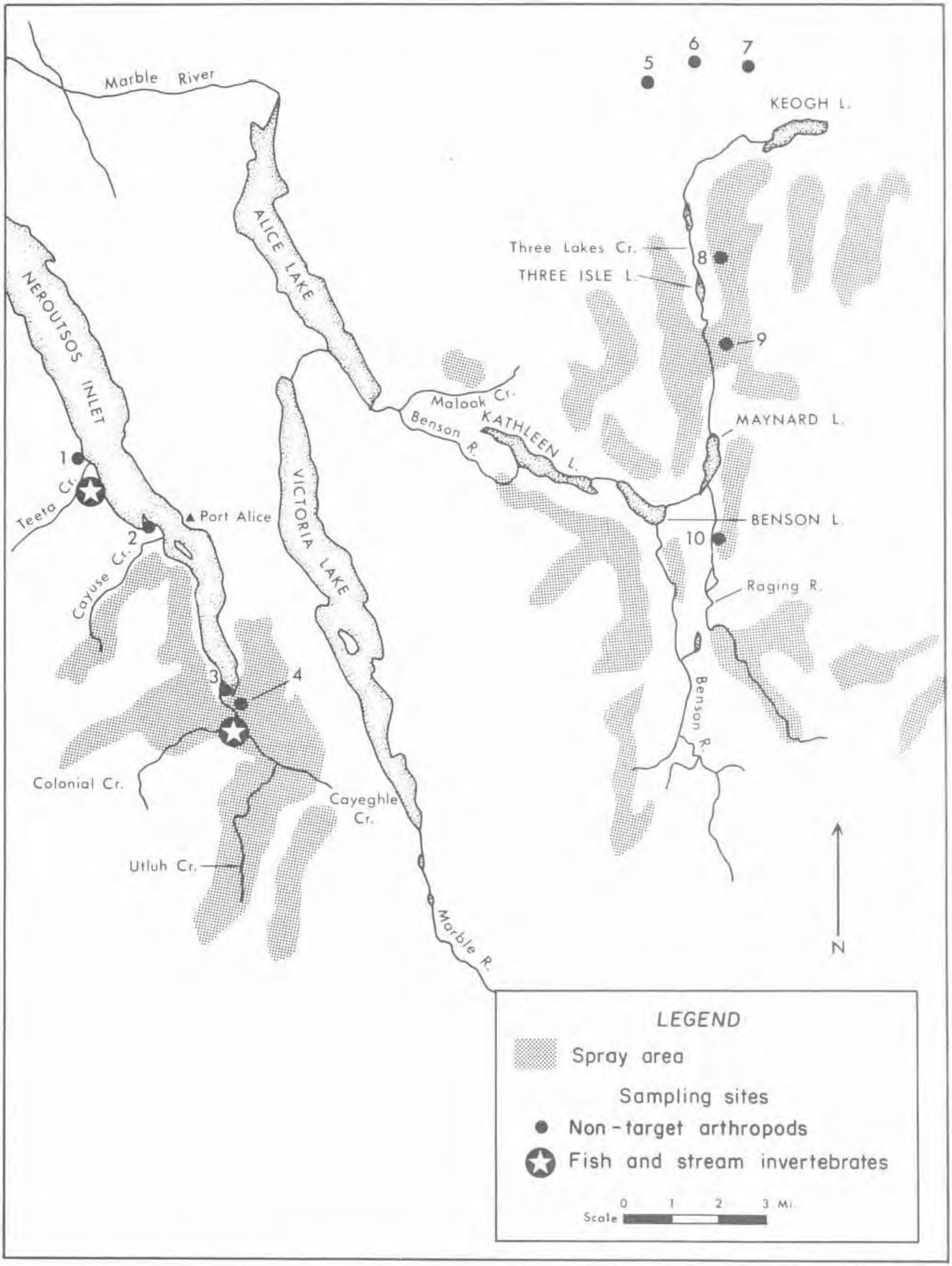

Figure 5. Sampling sites for studies on populations of fish, stream invertebrates and non-target arthropods.

3.2 Non-target Organisms

3.2.1 Effects on the Aquatic Ecosystem - O.E. Langer and R. Taylor

The blackheaded budworm spray project conducted by the Council of Forest Industries in 1973 contained significant salmon spawning and rearing streams, i.e. Cayuse, Colonial, Cayeghle and Utluh Creeks in T.F.L. 6, and the Benson River and Malook Creek in T.F.L. 39. Accordingly, the Fisheries Operations conducted a pre-spray assessment of the aquatic environment in the treatment area and monitored the spray program to evaluate the effectiveness of a 600-ft stream side untreated strip designed to prevent spray from entering the water. In addition, an attempt was made to document possible deleterious effects of the spray program on rearing salmonid populations.

METHODS

Stream Description. Two main streams were selected to assess the impact of the spray program on aquatic life. The Teeta Creek watershed, located across Neroutsos Inlet from Rumble Beach (Fig. 5), was not sprayed and served as a check stream. A large portion of Cayeghle Creek watershed, at the head of Neroutsos Inlet, was sprayed and was selected as the experimental stream.

Both streams are in mountainous, heavily vegetated terrain subject to heavy rainfall. The lower sections of these streams, where monitoring procedures were carried out, have shallow gradients and low water velocities (estimated 1 to 2 ft per second). The lower portions of both streams were tidally influenced. At the time of observation, flows of 20 to 30 ft^3 per second and 75 to 100 ft^3 per second were estimated for Teeta Creek and Cayeghle Creek, respectively. Stream bottoms in both cases consisted of a gravel substrate suitable for salmon spawning.

Both streams support moderate runs of coho and chum salmon, in addition to steelhead trout and other native species. Healthy populations of rearing coho fry were observed in both streams.

Population Sampling.

a) Invertebrate drift. Daily macro invertebrate drift was measured in Cayeghle and Teeta creeks for 4 days before and 4 days after the first spray application. Drift from each stream was collected with two fyke nets staked to the streambed. The sampling area of each net was a vertical slot 1-ft deep by 0.1-ft wide (0.1 ft^2 cross section). The trapped contents of each net were removed each day and preserved in 10% formalin solution for later qualitative and quantitative invertebrate identification.

Three Lakes Creek was selected to obtain a sample of downed non-aquatic (i.e. aerial and terrestrial) insects that occurred as drift on the stream surface. A 50-ft marquisette seine was set across the stream for 24 hr following the first spray application. A sample of this collection was preserved in formalin and forwarded to the Chemical Control Research Institute in Ottawa for quantitative analysis of fenitrothion.

b) Benthic invertebrates. A surber sampler was used to sample benthic invertebrate populations in Cayeghle and Teeta creeks twice before and twice after the first spray application. On each occasion four samples were obtained from each stream. Samples were preserved in a 10% formalin solution for later qualitative and quantitative invertebrate identification. Care was taken to avoid resampling identical areas of the stream bed.

c) Fish and invertebrates. Coho salmon fry were seined from Teeta Creek for *in situ* bioassays. Two cages of 10 animals each were placed in both Cayeghle and Teeta creeks. The fish were held in the stream from 24 hr prior to spraying until 96 hr after the first spray. The fry were checked daily for survival.

In addition, a sample of Sumithion mixed with Arotex and Atlox, in the same proportions as used in the spray program, was tested with coho fry for threshold toxicity and median lethal tolerance toxicity (TLM_{96})[8]. Static bioassays were conducted at the Fisheries Operations laboratory at the Pacific Environmental Institute.

In situ viability observations were made for two groups of 10 randomly selected caddis fly larvae in Cayeghle Creek before and after spray application. The larvae were semi-isolated in a backwater of the stream.

Pesticide drift detection. Approximately 24 hr before the first spray at Cayeghle Creek, 15 one-foot-square glass plates and 10 glossy spray indicating cards were placed along the stream margin of lower Cayeghle Creek. The plates and cards were no further than 25 yards from the stream margin. As a check, 6 glass plates and 4 spray cards were placed along the perimeter of lower Teeta Creek. The spray cards stain when in contact with spray droplets and are used as a visual indication of spray deposit. Glass plates were rinsed with pestiquality benzene for the collection of fenitrothion residue. Field rinsing as well as laboratory rinsing was tried. It was hoped that laboratory rinsing would lead to more simplified field techniques. Glass plates for laboratory rinsing (4 at Cayeghle Creek; 2 at Teeta Creek) were collected the evening of the first spray, after spray termination.

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8. TLM_{96} Pollutant concentration at which half of test animals die in 96 hr.

Field rinsing of the remaining plates (6 at Cayeghle Creek; 2 at Teeta Creek) was done the following morning when better light conditions prevailed. All samples (i.e. unrinsed glass plates as well as benzene rinseates) were frozen for transport to the British Columbia Department of Agriculture Pesticide Laboratory in Vancouver. Gas chromatography was used for residue analysis, with a sample of Sumithion brand fenitrothion obtained from the spray project used as the standard.

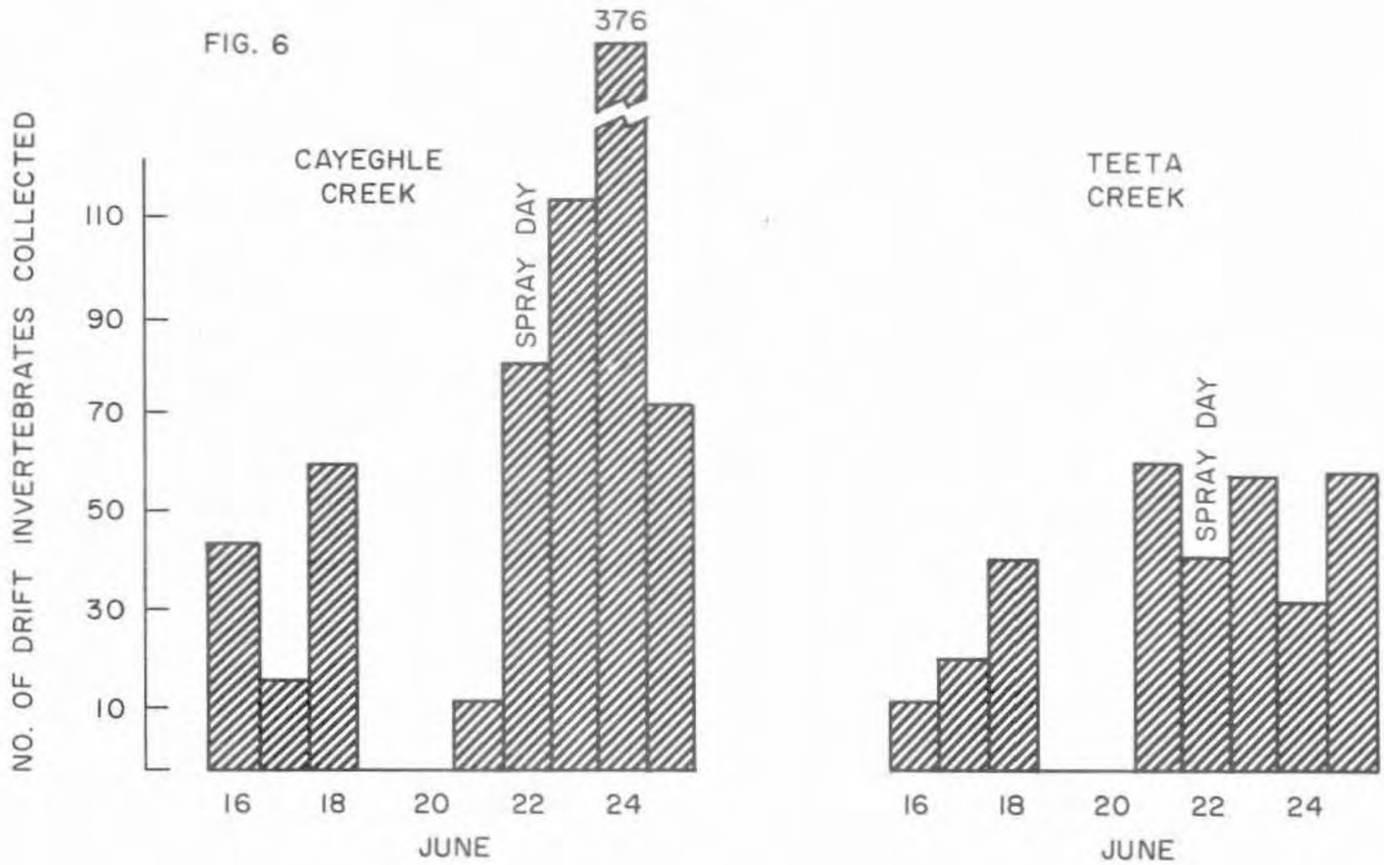
RESULTS AND DISCUSSION

Effects on Populations

a) Invertebrate drift. Approximately 5 hr after the first spray in the Cayeghle watershed, large numbers of non-aquatic dipteran adults were observed as surface drift in lower Cayeghle Creek. It was estimated that 40% of these insects were dead and the other 60% distressed. Coho fry were observed feeding on these downed insects.

Figure 6 represents the total numbers of drift organisms collected daily from Cayeghle and Teeta creeks. Plecoptera, Ephemeroptera and Hemiptera accounted for approximately 80% of organisms collected; Diptera, Trichoptera, Arachnida, Coleoptera and Hymenoptera made up the rest. The majority of specimens collected were in the nymph or larva stages.

The rise in numbers of aquatic drift organisms in Cayeghle Creek on June 23 correlates with the spraying of that watershed the previous day. Although large numbers of non-aquatic dipterans were observed as surface drift after the first spray, these insects were not included in the fyke net collections. Tidal influence at the sample site caused immersion of the apparatus at high tide and the surface fraction of drift was missed. The increased number of aquatic drift invertebrates could be



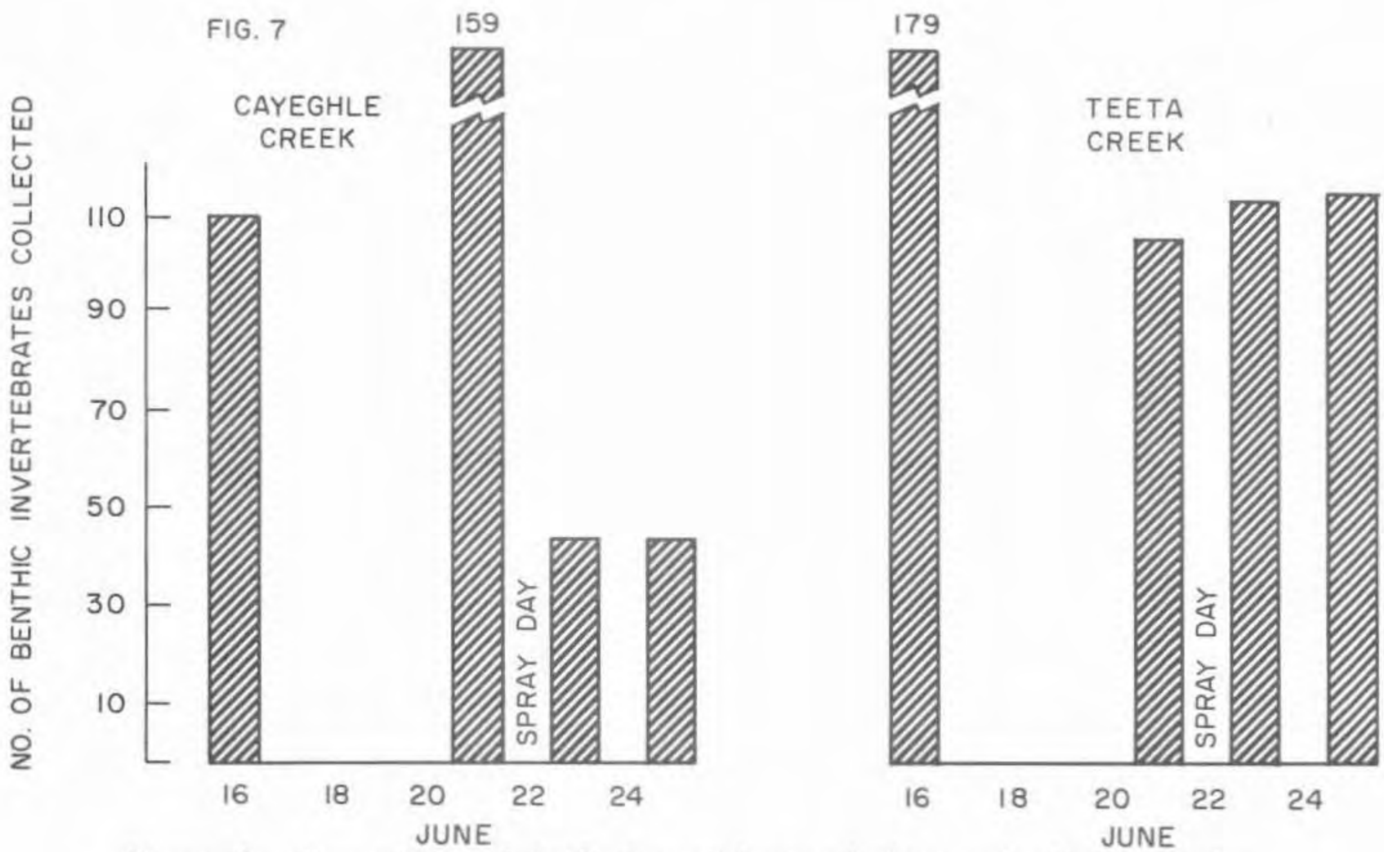


Figure 6. Comparison of drift invertebrates before and after spraying.

Figure 7. Comparison of benthic invertebrates before and after spraying.

related to a spray induced disruption of aquatic insect populations.

Downed non-aquatic insects sampled from the surface drift of Three Lakes Creek had a fenitrothion residue of 0.20 ppm. Coho fry were observed feeding on these contaminated drift organisms. The consumption of one gram of these organisms by a fry would account for an oral ingestion of 0.2 micrograms of fenitrothion. The effects of such pesticide intake are not known.

b) Benthic invertebrates. Fewer benthic insects were collected after spraying than before spraying at the Cayeghle Creek station (Fig. 7). The numbers of benthic insects collected at the Teeta Creek check station remained relatively constant. Fenitrothion could have been responsible for the observed decline in numbers of benthic invertebrates. The decreased benthic invertebrate population would help explain the increased aquatic drift (Fig. 6).

Unfortunately, a sample of benthic invertebrates was not analysed for fenitrothion residue. Due to the small number of samples collected, a proper statistical comparison of invertebrate collections obtained before and after spraying could not be made.

c) Fish and invertebrates. There was 100% survival in all *in situ* experimental and check animals after 96 hr. There was no apparent loss of vigor in either group of animals. The laboratory bioassays indicated that the spray formulation used in the spray program had a threshold of toxicity of 1.0 ppm and TLM_{96} of 2.4 ppm.

The two applications of 2 oz fenitrothion per acre were recommended because, even with complete spray overlap (i.e. 4 oz per acre), no acute fish toxicity would be expected. Four ounces of fenitrothion per acre applied over a 6-inch depth of water, with complete mixing, would produce a concentration of approximately 0.2 ppm fenitrothion in the water column. This is below the threshold of toxicity to coho fry. The highest concentration of fenitrothion plus its breakdown product (fenitrooxon) detected along the stream was 0.0108 oz/acre (Table 8). When applied to a water depth of 6 inches, this dosage produces no known acute toxicity problems to fish populations.

After the spray program, no mortality was noted in the group of caddis fly larvae observed in a backwater of Cayeghel Creek.

Pesticide drift. There was no visible spray deposit on either the glass plates or the spray cards. Therefore, the paper spray cards were of no use in determining if spray deposition had occurred. Table 8 indicates the levels of fenitrothion and its major breakdown product detected on the foot square glass plates at Cayeghle and Teeta creeks. It is noted that fenitrothion residues were observed at the check stream. The higher fenitrothion residues found on field-rinsed plates are probably because these plates were exposed much longer (12 hr) than lab-rinsed plates. The ratio of breakdown product to fenitrothion is higher at the control stream than at the experimental stream. These observations suggest that the spray remained airborne for a considerable time, undergoing degradation prior to deposition on the glass plates. From ground and aerial observations, it was apparent that there were breeches of the 600-ft stream protection zones. Considering the mountainous terrain and the aircraft height, drift was inevitable.

Low level spills of chemicals were observed during the aircraft loading procedure. The equipment on hand required a coupling to be broken each time a batch was loaded. These chemical spills could threaten local

TABLE 8. Fenitrothion residues detected on glass plates following spraying (values in oz/acre)

	Plate	Field Rinse		Lab Rinse	
		Fenitrothion	Breakdown Product[a]	Fenitrothion	Breakdown Product[a]
Teeta Creek	1	T[b]	0.0010	Not Detected	Not Detected
	2	T	T	T	T
(Unsprayed)	3	T	0.0017		
	4	T	0.0007		
		$\bar{X}$=T	$\bar{X}$=0.0009	$\bar{X}$=T	$\bar{X}$=T
Cayeghle	5	0.0040	0.0018	0.0007	T
Creek	6	0.0039	0.0023	0.0009	T
(Sprayed)	7	0.0052	0.0056	0.0005	Not Detected
	8	0.0023	0.0030		
	9	0.0009	0.0036		
		$\bar{X}$=0.0032	$\bar{X}$=0.0032	$\bar{X}$=0.0007	$\bar{X}$=T

a) fenitrooxon

b) T < 0.0002 oz/acre

fish populations if flushed into nearby drainage channels.

Field communications were at best sketchy. The decision to commence spraying was often not known until the spray aircraft passed overhead. Efficient communications between operational and experimental facets of the program are necessary to allow timely placement of experimental equipment. Great dissimilarities in the weather (e.g. fog in Port Hardy and bright sun in the Port Alice region) caused delays in the spray schedule, resulting in confusion and wasted effort in field monitoring.

3.2.2 Effects on Small Birds and Mammals - C.H. Buckner and B.B. McLeod

The effects of fenitrothion spraying on non-target vertebrates have been studied extensively in connection with spruce budworm spraying in eastern Canada. However, the impact of this chemical on vertebrates in the B.C. forest ecosystem was unknown; consequently, the Chemical Control Research Institute established a study to monitor the effects of the black-headed budworm spray project on small birds and mammals.

Breeding bird and small mammal population census plots were established at several of the plots used for study of budworm populations (Fig. 2). Treatment plot 7 was in a young stand (ca. 30-ft high) and treatment plots 8 and 9 were in mature timber (>150 ft). One check plot (No. 12) was located in a young stand; the other (plot 12A) in a mature stand. Plot 12 was in a very dense stand of hemlock, about 30-ft high, with a few scattered alder and cedar along an old logging road running through the plot. Ground cover was very dense, with numerous blowdowns scattered throughout the area. The immature stand where plot 7 was located was similar, except for a slightly higher percentage of alder. Plots 12A, 8 and 9 were located in mature stands of a similar nature, mainly hemlock with scattered spruce, cedar and balsam. Understory was sparse and there was very little cover between the high canopy and the forest floor. The damp forest floor received little sunlight and a deep moss layer covered the ground. Scattered blowdowns were found throughout the plots

METHODS

Breeding bird populations were monitored on 20-acre plots, using techniques similar to those described by Buckner and Turnock (1965). Rotating daily population censuses were conducted (either early morning or evening), starting about 2 weeks before the first application and running through to about 6 days after the second spray.

Small mammals were trapped on all plots approximately 6 weeks after the last spray, using standard snap-back traps set at 10-yard intervals along a 90-yard line. Five traps at one-yard intervals across the center line provided a total of 50 traps per plot. Traps were set three consecutive nights resulting in 150 trap nights per plot. All animals were examined for species, sex, age and parasites and then dissected to determine general health and breeding conditions.

Observations were also made on the abundance of large forest slugs inhabiting all plots, as well as larval salamanders inhabiting a small pond in plot 7.

RESULTS

Birds.-The small song bird complex was well established in breeding and foraging territories prior to the first fenitrothion treatment. Some bird species prefer a particular habitat and are seldom found outside it. For example, brown creepers were located only in stands of mature timber, while winter wrens and several species of thrushes were found only in the lower crown or forest floor areas in all stand types. Golden-crown kinglets and several warbler species foraged in the upper crowns. The upper crown foraging species were the most likely to make direct contact with the aerially applied insecticide and were watched very carefully for any signs of impact. The ground or lower crown foraging species were the least likely group to be in direct contact with the spray, but could have shown signs of poisoning through eating contaminated food. Populations of the varied thrush, Swainson's thrush, American robin and winter wren which inhabit the lower crown and forest floor area remained fairly constant throughout the census period. Populations of upper crown foraging species, such as the golden-crowned kinglet, orange-crowned warbler, Wilson's warbler and Hutton's vireo, were also fairly constant. Fox sparrows, which frequent openings or fringe areas, were also unaffected.

Comparison of populations of birds on the check plots (Tables 9 and 10) and the sprayed plots (Tables 11,12 and 13) indicates that spraying had no impact on the resident bird populations.

Small Mammals.-Only one species of small mammal, the deer mouse, *Peromyscus maniculatus* (Wagner), was taken during the 3-day trap period (Aug 19-21). Population numbers were similar in mature and immature stands. No juvenile animals were taken and only four (2 males and 2 females) sub-adult animals were trapped. Only one female was pregnant, but several others contained placental scars. None of the male mice was in breeding condition. These data (Table 14) indicated a recent decline of the breeding cycle as was expected at that time of year. All animals were covered with a dense coat and dissections revealed good fat deposits and apparently good health. No adverse affect upon this species of small mammal could be determined.

Other Animals.-A small pond located in an open area on treatment plot 7 contained large numbers of hatching salamander eggs during both

TABLE 9

BIRD POPULATION CENSUS ON CHECK PLOT # 12 (IMMATURE FOREST)

JUNE 13 TO JULY 6

AVIAN POPULATIONS		Pre-Spray								Post Spray # 1					Post Spray # 2						
FAMILY	SPECIES	DAY							Avg No. of Birds Per Day	DAY				Avg No. of Birds Per Day	DAY						Avg No. of Birds Per Day
		-13	-12	-11	-10	-7	-4	-1		+0	+1	+2	+3		+1	+2	+3	+4	+5	+6	
Tetraonidae	Ruffed Grouse	0	0	0	0	0	0	5	0.5	0	0	0	0	0.0	15	0	10	0	5	0	5.0
Trochilidae	Rufous Hummingbird	0	0	0	5	0	0	5	1.4	0	0	10	0	2.5	10	0	0	0	10	0	3.3
Tyrannidae	Western Flycatcher	0	0	0	0	0	0	0	0.0	0	0	0	0	0.0	0	5	0	0	0	0	0.8
Corvidae	Stellars Jay	0	0	0	40	10	0	5	7.8	0	0	15	5	5.0	0	0	5	0	0	0	0.8
Paridae	Chestnut-backed Chickadee	0	0	0	0	30	10	10	7.1	0	0	0	0	0.0	0	60	0	0	40	20	20.0
Stittidae	Red-breasted Nuthatch	0	0	0	0	10	0	0	1.4	0	0	0	0	0.0	0	0	0	0	0	0	0.0
Troglodytidae	Winter Wren	*90	*45	10	65*	40	40	30	45.7	10	0	35	10	13.7	0	40	20	0	20	20	16.6
Turdidae	American Robin	0	0	10	0	0	10	0	2.8	5	0	0	0	1.2	5	0	0	0	0	0	0.8
	Hermit Thrush	0	20	0	10	0	10	10	7.1	0	0	0	0	0.0	0	0	0	0	0	0	0.0
	Varied Thrush	0	0	0	0	0	25	10	5.0	0	0	0	10	2.5	0	10	0	20	0	0	5.0
	Swainson's Thrush	55	20	30	5	45	60	60	39.2	30	20	30	30	27.5	40	20	10	5	40	35	24.1
Sylviidae	Golden-crowned Kinglet	0	0	0	0	0	10	10	2.8	0	0	0	0	0.0	0	0	20	0	20	0	6.6
Vireonidae	Hutton's Vireo	0	0	0	20	0	10	30	8.5	0	0	20	0	5.0	0	5	10	10	0	5	5.0
Parvlidae	Orange-crowned Warbler	50	20	10	30	50	20	30	30.0	20	0	20	0	10.0	0	20	0	0	10	20	8.3
	Wilson's Warbler	20	10	0	40	10	10	20	15.7	0	10	10	10	7.5	0	20	10	10	10	30	13.3
Fringillidae	Oregon Junco	*45	*40	10	10	0	65*	0	24.2	0	0	15	0	3.7	10	0	0	0	0	0	1.6
	Fox Sparrow	0	10	0	10	10	10	10	7.1	0	0	0	0	0.0	0	10	0	0	0	10	3.3
	American Goldfinch	0	10	0	0	0	10	20	5.7	0	0	0	0	0.0	0	0	0	0	0	0	0.0
	TOTALS	260	175	70	235	205	290	255	212.8	65	30	155	65	78.7	80	190	85	45	155	140	115.8
	* Fledglings Observed																				

TABLE 10

BIRD POPULATION CENSUS ON CHECK PLOT 12A (MATURE STAND)

JUNE 13 TO JULY 6 1973

AVIAN SPECIES		Pre-Spray								Post Spray # 1					Post Spray # 2						
FAMILY	SPECIES	DAY							Avg No. of Birds Per Day	DAY				Avg No. of Birds Per Day	DAY						Avg No. of Birds Per Day
		-13	-12	-11	-10	-7	-4	-1		0	+1	+2	+3		0	+1	+2	+3	+4	+5	
Trochilidae	Rufous Hummingbird	0	0	0	0	0	10	10	2.8	0	5	15	20	10.0	0	10	10	0	15	0	5.8
Picidae	Hairy Woodpecker	0	0	0	0	5	0	0	0.7	0	0	0	0	0.0	0	0	0	0	0	0	0.0
Corvidae	Stellar's Jay	0	0	0	0	15	10	20	6.4	5	10	15	0	7.5	0	0	20	10	5	10	7.5
Paridae	Chestnut-backed Chickadee	80	15	0	0	70	30	60	36.4	10	0	55	65	32.5	0	90	20	20	15	10	25.8
Stitidae	Red-breasted Nuthatch	20	0	0	0	0	0	5	3.5	0	0	0	20	5.0	10	0	0	0	0	10	3.3
Certhiidae	Brown Creeper	0	0	0	0	0	0	0	0.0	0	0	0	10	2.5	0	0	0	0	0	0	0.0
Troglodytidae	Winter Wren	40	50	30	30	50	40	35	39.2	0	10	35	40	21.2	20	75	25	40	40	35	39.1
Turdidae	American Robin	0	0	0	0	10	45	0	7.8	5	0	0	0	1.2	0	0	0	0	0	0	0.0
	Varied Thrush	0	10	0	0	10	20	10	7.1	0	15	10	0	6.2	25	20	0	0	10	0	9.1
	Swainson's Thrush	10	10	10	0	10	5	15	8.5	20	0	15	10	11.2	10	20	10	10	10	10	11.6
Sylviidae	Golden-crowned Kinglet	70	20	0	0	0	0	0	12.8	0	0	0	0	0.0	30	0	50	0	10	5	15.8
Vireonidae	Hutton's Vireo	60	15	0	50	30	20	30	29.2	0	0	20	0	5.0	5	50	0	10	20	30	19.1
Parulidae	MacGillivray's Warbler	0	10	0	0	0	0	0	1.4	0	0	0	0	0.0	10	0	0	0	0	0	1.6
	Orange-crowned Warbler	20	30	0	10	20	40	20	20.0	0	0	20	10	7.5	15	0	0	0	0	0	2.5
	Wilson's Warbler	0	0	0	0	0	0	10	1.4	0	0	0	0	0.0	0	0	0	0	0	0	0.0
Fringillidae	Fox Sparrow	0	10	0	0	0	0	0	1.4	0	0	0	0	0.0	0	0	0	0	0	0	0.0
	Oregon Junco	35	135	0	35	0	15	0	31.4	10	0	15	5	7.5	10	10	20	0	5	135	30.0
	American Goldfinch	75	0	0	0	0	0	0	10.7	0	0	0	0	0.0	0	0	25	0	0	0	4.1
	TOTALS	510	305	40	125	220	235	215	235.7	55	40	200	180	118.7	135	175	180	90	130	245	159.1

TABLE 11

BIRD POPULATION CENSUS ON TREATMENT PLOT 7 (IMMATURE FOREST)

JUNE 22 - JULY 6

FAMILY	SPECIES	Pre-Spray Census						Post Spray # 1				SPRZ Post Spray #2						
		DAY					Avg No. of Birds	DAY			Avg No. of Birds	DAY						Avg No. of Birds
		-5	-4	-3	-2	0	Per Day	+1	+2	+3	Per Day	+1	+2	+3	+4	+5	+7	Per Day
Tetranonidae	Ruffed Grouse	0	0	0	0	5	0.8	0	0	0	0.0	5	0	0	0	0	0	0.8
Trochilidae	Rufous Hummingbird	0	5	20	5	30	10.0	25	5	25	18.3	15	20	15	0	5	0	9.1
Tyrannidae	Olive-sided Flycatcher	0	0	13	10	40	10.5	20	10	0	10.0	20	20	0	0	0	10	8.3
	Western Flycatcher	0	0	0	0	0	0.0	0	0	10	3.3	0	0	0	0	0	0	0.0
Corvidae	Stellar's Jay	5	15	5	10	40	12.5	25	5	10	13.3	10	20	5	15	10	0	10.0
Paridae	Chestnut-backed Chickadee	0	5	23	10	5	7.1	30	15	25	23.3	55	40	0	60		20*	29.1
Troglodytidae	Winter Wren	10	15	35	25	70	25.8	40	30	25	31.6	30	95	0	40	50	40	42.5
Turdidae	American Robin	5	0	3	0	0	1.3	5	0	0	1.6	0	0	0	0	10	0	1.6
	Hermit Thrush	10	15	10	5	0	6.6	10	10	0	6.6	0	0	0	0	10	5	2.5
	Varied Thrush	10	5	10	5	20	8.3	0	20	5	8.5	25*	15	15*	20	10	5	15.0
	Swainson's Thrush	100	73	47	45	85	58.6	50	75	55	60.0	85	45	40	45	80	25	53.3
Vireonidae	Hutton's Vireo	10	10	20	13	25	13.0	20	30	40	30.0	20	20	0	15	20	10	14.1
Parulidae	Orange-crowned warbler	0	20	63	50	45	28.8	20	0	10	10.0	40	75	10	20	30	30	34.1
	MacGillivray's Warbler	20	10	17	5	45	16.1	40	20	60	40.0	10	20	10	20	20	10	15.0
	Wilson's Warbler	10	10	23	10	10	10.5	30	0	0	10.0	0	20	10	0	10	10	8.3
Fringillidae	Fox Sparrow	0	0	3	0	10	2.1	15	0	0	5.0	0	0	0	40	15	0	9.1
	Song Sparrow	0	10	0	10	10	5.0	35*	20	0	18.3	10	20	10	10	0	10	10.1
	Oregon Junco	30	5	7	0	15*	9.5	20	25	15	20.0	0	30	20	5	0	20*	12.5
Unknown Species		0	25	3	0	10	6.3	0	0	0	0.0	0	0	0	0	0	0	0.0
	TOTALS	210	223	302	203	465	280.6	385	265	280	310.0	325	440	135	290	270	195	275.8
	*Fledglings Observed																	

TABLE 12

BIRD POPULATION CENSUS ON TREATMENT PLOT 8 (MATURE FOREST)

JUNE 19 - JULY 6 1973

AVIAN POPULATIONS		Pre-Spray Census							Post Spray # 1			Post Spray # 2						
FAMILY	SPECIES	DAY						Avg No. of Birds	DAY		Avg No. of Birds	DAY						Avg No. of Birds
		-8	-7	-4	-2	-1	0	Per Day	+1	+2	Per Day	+1	+3	+4	+5	+6	+7	Per Day
Corvidae	Gray Jay	0	0	0	0	0	0	0.0	0	30	15.0	0	30*	0	0	0	0	5.0
	Stellar's Jay	10	0	0	10	0	40	10.0	0	0	0.0	25	15	10	0	35	5	15.0
Paridae	Chestnut-backed Chickadee	25	0	0	0	20	30	12.5	0	0	0.0	15	40	0	0	105	5	27.5
Certhiidae	Brown Creeper	20	0	0	0	0	0	3.3	5	30	17.5	0	10	0	0	10	0	3.3
Troglodytidae	Winter Wren	70	90	60	50	0	50	36.6	60	40	50.0	40	50	75	30	60	30	47.5
Turdidae	American Robin	10	0	0	0	0	10	3.3	0	0	0.0	0	0	0	0	0	0	0.0
	Swainson's Thrush	10	30	25	20	30	40	25.8	45	40	42.5	20	50	50	40	55	40	42.5
	Varied Thrush	10	5	15	10	10	25*	12.5	0	10	5.0	10	20	0	0	10	10	8.3
Sylviidae	Golden-crown Kinglet	10	30	20	70	10	0	23.3	0	20	10.0	10	20	20	10	30	0	15.0
Vireonidae	Hutton's Vireo	40	40	20	40	20	20	30.0	25	20	22.5	30	40	30	20	45	25	31.6
Parulidae	MacGillivray's Warbler	0	0	0	0	30	30	10.0	10	0	5.0	0	10	10	0	20	10	8.3
	Wilson's Warbler	30	30	10	10	25	30	22.5	30	30	30.0	40	30	20	0	20	20	21.6
Fringillidae	Fox Sparrow	0	0	0	0	0	0	0.0	0	0	0.0	0	20	0	0	5	0	4.1
Unknown Species		0	0	0	0	0	0	0.0	0	0	0.0	10	0	0	0	0	0	1.6
	TOTALS	235	225	150	220	145	275	208.3	175	220	197.5	200	345	215	100	395	145	233.3
	*Fledglings Observed																	

TABLE 13

BIRD POPULATION CENSUS ON TREATMENT PLOT 9 (MATURE FOREST)

JUNE 10 - JULY 6 1973

AVIAN FAUNA		Pre-Spray Census								Post Spray # 1			Post Spray # 2						
FAMILY	SPECIES	DAY							Avg No. of Birds Per Day	DAY		Avg No. of Birds Per Day	DAY						Avg No. of Birds Per Day
		-10	-8	-7	-4	-2	-1	0		+1	+2		+1	+3	+4	+5	+6	+7	
Tetronidae	Ruffed Grouse	0	0	10	0	0	0	0	1.4	5	5	5.0	*15	0	0	0	0	0	2.5
Trochilidae	Rufous Hummingbird	5	5	0	0	0	0	0	1.4	0	0	0.0	0	0	0	0	0	0	0.0
Picidae	Hairy Woodpecker	0	0	10	0	5	0	0	2.1	0	0	0.0	0	0	10	0	10	0	3.3
Corvidae	Gray Jay	0	0	0	0	15	0	0	2.1	0	0	0.0	0	0	0	0	0	0	0.0
	Steller's Jay	0	0	0	0	0	5	0	0.7	0	0	0.0	0	5	0	0	0	0	0.8
Paridae	Chestnut-backed Chickadee	0	0	40	15	10	0	0	13.5	10	60	35.0	30	50	10	0	20	30	23.3
Stittidae	Red-breasted Nuthatch	0	0	0	0	0	0	0	0.0	0	0	0.0	10	10	0	0	0	5	4.1
Certhiidae	Brown Creeper	0	0	10	0	0	0	0	1.4	0	5	2.5	5	0	0	0	20	0	4.1
Troglodytidae	Winter Wren	30	40	30	30	40	40	50	37.1	60	60	60.0	55	40	30	0	40	25	31.6
Turdidae	Varied Thrush	0	20	0	10	20	10	10	10.0	0	0	0.0	30	30	0	5	10	25	12.5
	Hermit Thrush	0	0	10	0	0	0	10	2.8	20	10	15.0	10	0	0	0	0	0	1.6
	Swainson's Thrush	15	0	0	0	10	20	0	6.4	15	10	12.5	5	0	0	10	0	5	3.3
Sylviidae	Golden-crowned Kinglet	10	10	40	20	30	30	20	22.8	45	0	22.5	0	0	0	0	0	10	1.6
Vireonidae	Hutton's Vireo	10	50	60	70	60	35	50	47.8	35	25	30.0	25	20	40	10	30	30	25.8
Parulidae	Wilson's Warbler	5	10	0	0	0	10	0	3.5	10	5	7.5	10	0	0	0	0	0	1.6
	Orange-crowned warbler	0	0	0	0	0	0	0	0.0	10	5	7.5	0	0	0	0	0	10	1.6
	MacGillivray's warbler	0	0	0	0	0	0	0	0.0	0	0	0.0	0	0	0	10	0	0	1.6
Fringillidae	Fox Sparrow	0	0	0	0	0	0	0	0.0	10	10	10.0	0	0	0	0	0	0	0.0
	TOTAL BIRDS	75	135	210	145	190	150	170	153.5	220	195	205.7	240	155	90	35	130	115	127.5
	*Fledglings Observed																		

TABLE 14

Deer mouse populations on sprayed and unsprayed plots

August 1973

Plot Number and Description	Males				Females							Total Animals
							Adults					
	Juv	Sub Adults	Adults	Total	Juv	Sub Adults	Pregnant	Pregnant With Scars	Placental Scars Only	Not Pregnant	Total	
7 immature stand sprayed	0	1	5	6	0	0	0	0	1	1	2	8
8 mature stand sprayed	0	1	7	8	0	2	0	0	4	0	4	12
9 mature stand sprayed	0	0	8	8	0	0	0	0	1	0	1	9
12 immature stand unsprayed	0	0	3	3	0	0	0	1	2	0	3	6
12A mature stand unsprayed	0	0	8	8	0	0	0	0	0	9	9	17
TOTALS	0	2	31	33	0	2	0	1	8	10	19	52

applications of insecticide. No mortality was found up to a week after the second spray. This same pond was examined again approximately 2 months after spraying and it still contained large numbers of hatching salamanders (probably different species), indicating that no adverse effects had been suffered by this group of amphibia.

Two species of large forest slugs, Arion ater and Limax maximus, were observed inhabiting the forest floor on all plots. Observations indicated that populations were not affected by applications of fenitrothion and that both species were numerous on all plots 2 months after the second spray.

3.2.3 Effects on Non-target Arthropods - M.T.K. Wan

During the 1973 blackheaded budworm spraying operation, a monitoring program was conducted by the Environmental Protection Service to investigate the impact of fenitrothion on non-target arthropods.

METHODS

Sampling Locations

Specimens were collected from 10 locations (Fig. 5). A short description of each site follows:

(a) Neroutsos Inlet; coastal saline estuary, edge of spruce and hemlock forest, grasses, etc., along stream banks:

Site No. 1 -- Teeta Creek Inlet (Check).

Site No. 2 -- Shoreline of Neroutsos Inlet, ½ mile north of Cayuse Creek Inlet (Check).

Sites No. 3 and 4 -- Confluence of Colonial and Cayeghle creeks (Sprayed).

(b) Keogh Lake area; elevation 500 - 1000 ft, consisting of juvenile alder, ferns, grasses, salmonberry, edges of spruce and hemlock forest, etc., along creeks.

Sites No. 5, 6 and 7 -- Second growth north of Keogh Lake (Check)

Site No. 8 -- Mature forest, north of Three Isle Lake (Sprayed).

Site No. 9 -- Mature forest, north of Maynard Lake (Sprayed).

Site No. 10 -- Mature forest, south of Maynard Lake (Sprayed).

Sampling Methods

Two methods of sampling were employed: net-sweeping and light trapping. Net-sweeping was carried out in grass and brush where walking was feasible. The sweep net consisted of a muslin bag with circular opening 14 inches in diameter. Sampling was conducted between 1000 and 1500 hr. Two hundred sweeps per sample were made along a distance of approximately 100 yards. One complete set of samples was taken on June 19-20, prior to treatment. Post-spray samples were collected 5 - 12 hr after treatment on June 22, 1973. Ten samples were taken from the unsprayed and 10 from the sprayed areas. All material collected was preserved in formalin and retained for identification and counts in the laboratory.

Two Rothamsted light traps were used to sample flying insects in one check plot (no. 1) and one treated plot (no. 4). They were modified for operation with two HD-4D 12V Marine batteries; two units of 12V sealed beam (Volkswagen) were used as the light emitting source. To protect the traps from rain, wind and large animals, they were placed in wooden shelters. The traps were operated from 2200 to 0800 hr for 5 nights -- 3 nights before (June 16, 17, 18) and 2 following the day of spraying (June 23, 24).

RESULTS AND DISCUSSION

Tables 15 and 16 present the composition of arthropods obtained by net-sweeping and light trapping from check and treated plots. Three classes of arthropods were found in the sweep-net samples: Arachnida (spiders, ticks and mites), Diplopoda (millipedes) and Insecta (insects). Some Mollusca (slugs and snails) were also collected. Only the Insecta were caught in the light traps. The majority of the arthropods collected belonged to 10 insect Orders.

The total number collected in the check plots (1, 2, 5, 6, 7) after spraying was twice that collected before spraying. This was due to large increases in numbers of the Arachnida and Diptera, even though populations of Hemiptera, Hymenoptera and Lepidoptera decreased (Table 15).

TABLE 15. Changes in Net-sweep Arthropod Populations in Unsprayed Plots and in Plots Sprayed with Fenitrothion.

ARTHROPODS[a]	CHECK PLOTS			SPRAYED PLOTS		
	Number Collected		Change[b]	Number Collected		Change[b]
	Pre-spray (June 19)	Post-spray (June 26)		Pre-spray (June 20)	Post-spray (June 26)	
Arachnida	19	329	17.32	85	216	2.54
Coleoptera	41	46	1.12	23	27	1.17
Diplopoda	4	1	-	1	0	-
Diptera	145	453	3.12	701	221	0.31
Ephemeroptera	3	1	-	2	1	-
Hemiptera	140	63	0.45	7975	2413	0.30
Hymenoptera	95	59	0.63	43	33	0.76
Lepidoptera	13	3	0.23	79	21	0.26
Neuroptera	1	0	-	1	1	-
Mollusca	3	2	-	1	2	-
Plecoptera	0	1	-	1	0	-
Thysanoptera	4	7	1.75	2	5	2.50
Trichoptera	5	2	0.40	3	1	-
Total Numbers[c]	473	967	2.04	8917	2941	0.33

a Immature and Adult stages.

b Change = $\frac{\text{post-spray number}}{\text{pre-spray number}}$; >1 = increase, <1 = decrease; change involving populations less than 5 considered insignificant.

c Ten plots per sampling date.

TABLE 16. Changes in Light Trap Arthropod Populations in Unsprayed Plot and in Plot Sprayed with Fenitrothion.

ARTHROPODS[a]	CHECK PLOT			SPRAYED PLOT		
	Number Collected		Change[b]	Number Collected		Change[b]
	Pre-spray	Post-spray		Pre-spray	Post-spray	
Coleoptera	1	1	-	0	0	-
Diptera	175	158	0.90	8	9	1.02
Hymenoptera	1	1	-	2	3	-
Trichoptera	3	3	-	1	1	-
Total Numbers[c]	180	163	0.91	11	13	1.18

a Adults only.

b Change = $\frac{\text{post-spray number}}{\text{pre-spray number}}$; >1 = increase, <1 = decrease; change involving populations less than 5 considered insignificant.

c Average number per night.

In the treated plots (3, 4, 8, 9, 10), the post-spray population was approximately one third the pre-spray estimation. This resulted from notable decreases in the number of Diptera, Hemiptera and Lepidoptera, even though the number of Arachnida increased (Table 15).

Light trap catches of arthropods obtained after treatment were similar to those caught before treatment for both the check and sprayed plots (Table 16).

The most significant change, post spraying, was in populations of Arachnida and Diptera. There was a 17- and 3-fold increase in Arachnida and Diptera, respectively, in check plots. However, in sprayed plots, Arachnida increased by a factor of only 2.5, while Diptera decreased 69%. The apparent population explosion in the check plot could be ascribed to egg hatching in Arachnida and to adult emergence from pupae in Diptera. The significantly smaller population increase in Arachnida and reduction in Diptera in the sprayed plots could be attributed to the effects of fenitrothion, since this chemical is considered to be a selective acaricide and contact insecticide (Spencer 1968; Martin 1972; Krehm 1973).

At Cayeghle Creek (with a large part of its watershed within the spray plots), some moribund adult dipteran and hymenopteran insects were observed drifting downstream approximately 5 hr after spray application. Analyses carried out on samples of these insects by the Chemical Control Research Institute, Ottawa, yielded a residue of 0.20 ppm fenitrothion in the insect tissues. Therefore, it may be assumed that the mortality of insects collected from the stream was related to the spray. Aquatic organisms, particularly juvenile salmonid fishes, were observed feeding on these insects.

The reduction in numbers and mortality of some Orders of non-target insects in treated plots, following spray application, could be taken as an indication that fenitrothion had immediate short-term effects on some groups of non-target arthropods. However, it is difficult at present to determine the extent of impact attributed to the insecticide. Weather changes, habitat variation, sampling techniques, natural mortality, emergence and migration of arthropods could also cause fluctuation in numbers. The possibility of long-term effects of the chemical was not investigated.

4. DISCUSSION

J. R. Carrow

4.1 The Spray Project

The primary purpose of this project was to protect trees in certain designated stands from further defoliation in 1973. The general collapse of the budworm population during the summer made assessment of the efficacy of the program difficult, but it appears that the spray provided good budworm control in young hemlock stands. Had the population collapsed after feeding, instead of before, the foliage protection value in young stands would logically have been much more evident, particularly in view of the high larval mortality. However, in stands consisting of trees over 100 ft, spraying apparently provided poor population control and foliage protection. Four modifications in the operational plan may have produced better results in the taller stands.

1. A slower aircraft should have been used. The very rough terrain and steep slopes made it virtually impossible for an Avenger, with a flying speed of ca. 150 mph, to be flown close to the canopy, for reasons of safety. During much of the spraying, the aircraft operated 300 to 1200 ft above the canopy, with the result that considerable drifting occurred. This is substantiated by the detection of fenitrothion in plot 3, 6 miles from the spray area, in Rumble Beach about 3 miles away, and in the 600-ft leave strips around water bodies. Fenitrothion deposit within the spray area was also very low. In the 1957 control operation in this area, Lejeune et al. (1957) noted that the height of the aircraft (also an Avenger) above the forest resulted in excessive drift outside the spray area.

2. On-site monitoring of changes in air temperature would have

ensured that spray was applied during inversion conditions, thus improving the deposit of spray and reducing drift. With low volume spraying, it is essential to maximize the descent of spray onto the canopy.

3. Although it was considered impractical, better results would likely have been achieved had spraying of the older stands been delayed 1 to 2 weeks. First- and second-instar budworm larvae normally feed within the expanding buds and consume only small amounts; thus, they are not likely to be exposed to the spray, either by contact or by ingestion. Since fenitrothion is a short residual chemical with a half-life of 4-5 days (Krehm 1973), the spray should be applied when larvae have abandoned the buds and are feeding openly on the new foliage. In retrospect, however, rainfall in early July would likely have made it impossible to spray effectively during that period.

4. A higher application rate might have given better results. Twenty ounces of formulation per acre gave good foliage coverage and results in young stands, but possibly this volume was insufficient to adequately cover the deep canopy which is characteristic of mature coastal forests. The fact that foliage protection was best in the upper crown of regeneration stands (Table 6) lends support to this suggestion. In the 1957 operation, about six times as much volume was applied (128 oz/acre) and ground level deposits and population control were generally more satisfactory than in 1973.

Ground-level assessment of spray deposit was of little value in explaining between-plot differences in population control and foliage protection. In plot 13, with a deposit of 0.0006 oz/acre, population control was nil and defoliation increased 11% (Table 17); in contrast, in plot 11, which had no ground deposit, control was 100% and defoliation was reduced 26%. Undoubtedly the low ground deposit was primarily a product of spray drift and low volume application; but, in addition, the deep canopy in mature and immature stands probably intercepted almost all the spray. Even though spray cards and glass slides were placed in openings in the stands, the openings may not have been large enough relative to the canopy depth to permit descent of the spray to the ground. Clearly, the deposit and the per cent control were much higher in regeneration (plot 2) than in older stands. The low deposit in plot 7 was probably related to the fact that it was located just inside the spray boundary.

Table 17. Summary of population control and foliage protection related to ground level deposits of fenitrothion in plots within the spray area.

Age	Plot	Deposit (oz fenitrothion per acre)	% Control	Change in % Defoliation (upper crown)
Regeneration	2	0.0027	81	-26
	7	T	78	- 1
Mature-Immature	8	0.0008	62	-16
	9	0.0005	21	-13
	11	ND	100	-26
	13	0.0006	0	+11

T = <0.0002 oz/acre ND = none detected

History indicates that control of defoliator epidemics in B.C. is generally undertaken one year too late, often during the year of population collapse (Anon. 1960). This operation was no exception, and it is evident that in order to derive the greatest benefit in terms of foliage preservation, spraying should be conducted in the second year of the outbreak, in this case, 1972. However, widespread heavy defoliation did not occur until 1972, and it is usually difficult to convince managers of the necessity for control action until <u>after</u> extensive damage is evident. In order to spray in the second year of the outbreak, and provide maximum foliage protection, high risk stands must be identified before they are defoliated. At present, fall egg sampling can provide a reasonably good prediction of regional population levels and defoliation in the next year, but delineation of high risk stands is very difficult. Improvement in techniques for detecting low level populations, e.g. pheromones, could facilitate the identification of these stands during the early stages of future outbreaks.

The environmental impact of this spray project appears to have been very low. Monitoring of juvenile salmon, songbirds and small mammals revealed no mortality, though all groups of animals were exposed to fenitrothion in their habitats. Immediate effects were confined to non-target invertebrates, with considerable mortality of certain aquatic and terrestrial insects and spiders, i.e. Plecoptera, Ephemeroptera, Hemiptera (Fig. 6), Diptera and Arachnida (Table 15). Although salmon were not obviously affected, the possibility exists that fish may be adversely affected by sub-lethal doses of fenitrothion contained in the dead invertebrates which form a major part of the fish diet.

4.2 Natural Control of the Blackheaded Budworm Population

As is frequently the case with defoliator outbreaks on the west coast, the budworm population experienced a sudden collapse during the summer of 1973. Since larvae appeared normal up to the time of spraying, a collapse was not anticipated and no studies were established to identify causal factors. The evidence indicates that the larval population declined sharply soon after spraying, before any significant feeding activity. One can deduce that this occurred in the first 2 weeks of July when larvae were still predominantly second and third instar.

Several processes are thought to contribute to such a decline.

Although *parasitism* of eggs, larvae and pupae is common, mortality is heaviest in older larvae (third to fifth instar) and pupae (Silver and Lejeune 1956; Brown and Silver 1957). Throughout development sampling of eggs and young larvae, a small amount of egg parasitism (blackened eggs) was observed but no larval parasitism was evident. A small number of second- and third-instar larvae (40) were examined for Ascogaster, the most common larval parasite, but none was found.

A *virus* disease has been associated with collapsing larval populations in the past (Prebble and Graham 1945). No external symptoms of disease were evident in the young larvae during development examination. Larvae were also collected at seven sites from Port Renfrew north to Ououkinsh Inlet (ca. 15 miles south of Port Alice) and examined at the Insect Pathology Research Institute. No disease was found, except for some Isaria sp. fungus in a few larvae from the Zeballos area.

In areas of heavy defoliation, *starvation* has been suggested as a factor in population collapse (Prebble and Graham 1945), but there has been little experimentation to substantiate this. Certainly severe defoliation did not appear to be widespread enough in 1973 to account for the general collapse of the larval population in the Port Alice region.

The one remaining factor - *weather*- was mentioned by both Prebble and Graham (1945) and Silver and Lejeune (1956) in connection with two previous outbreaks. They suggested that prevalence of cold wet weather in this region during June inhibits feeding and development of the larvae and contributes to larval mortality by drowning and dropping off the tree. The weather conditions in 1973 were considerably cooler and wetter than in 1972, when populations thrived and defoliation was extensive. During the period June 1 to June 20, temperatures at Jeune Landing were much warmer in 1972 than in 1973 (Fig. 8); also, rainfall was 1.70 inches in 1972 and 3.14 inches in 1973. This would likely retard development and increase the mortality of young larvae in 1973 relative to 1972. From July 1 to July 11, there was rainfall every day in 1973 (total 1.89 inches), whereas in 1972, it rained on only 4 days (total 1.28 inches). Since the continuous rain and cool temperatures occurred during early July, when larvae are beginning to feed openly on the new foliage, these conditions may have inhibited feeding on the new foliage. Third- to fifth-instar budworm larvae are very sensitive to physical disturbance and respond by dropping immediately from the tree on a thread. Thus the disturbance of 11 days of continuous rain may have caused large numbers of larvae to drop from the trees. The combination of inhibited feeding and larval dropping could logically lead to starvation of the population. In the absence of direct experimental evidence, the continuous cool wet weather during early July appears to be the most plausible explanation for the rapid decline of the larval population during 1973. The one observation that would discount <u>any</u> hypothesis for the general collapse of the larval population in the region was that moderate to heavy feeding did occur during 1973 in a few distinct areas in the region; viz. Mahatta River, Jeune Landing and the northeast end of Neroutsos Inlet.

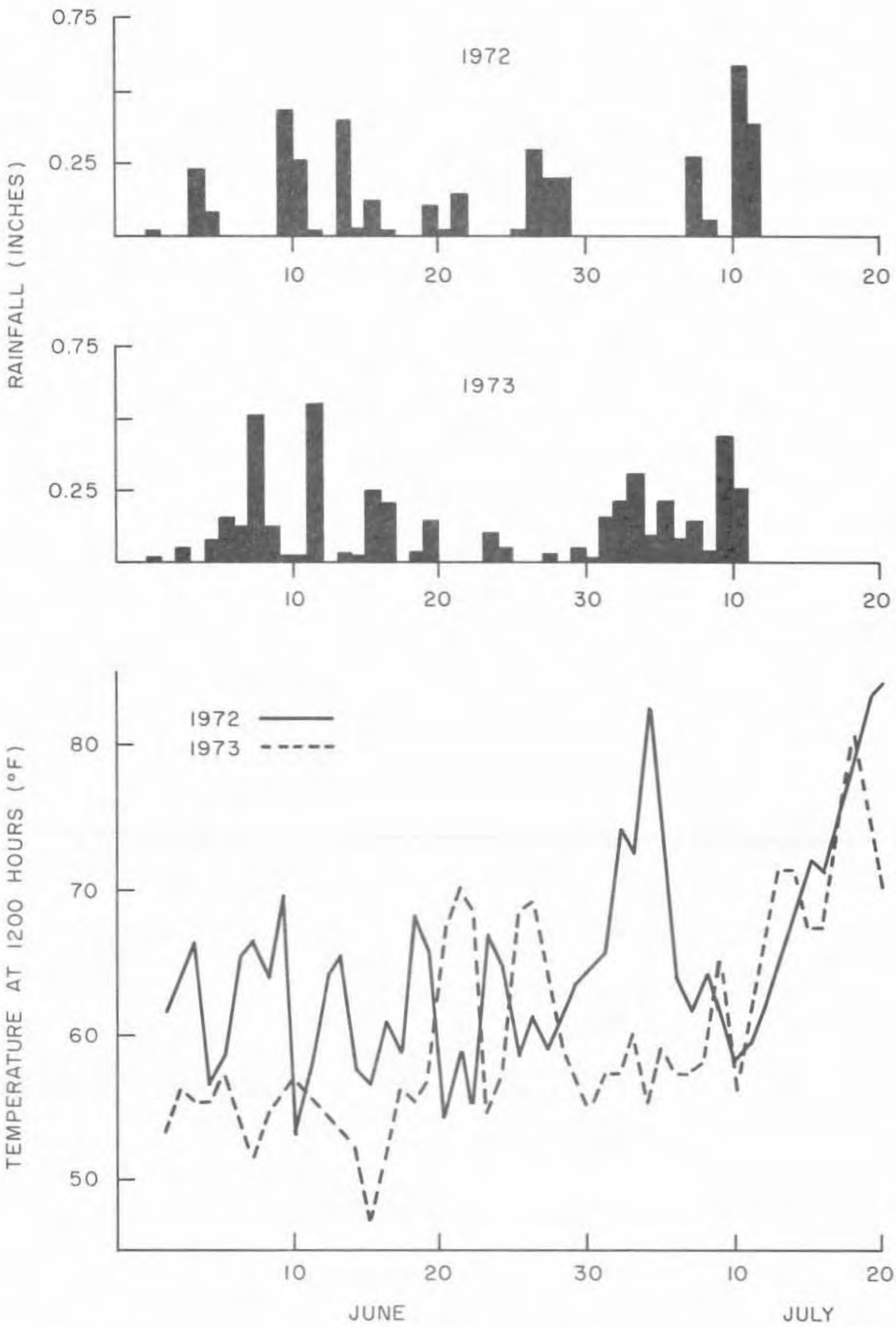


Figure 8. Temperature and rainfall at Jeune Landing during June and July, 1972 and 1973.

5. CONCLUSIONS

1. Aerial application of fenitrothion resulted in 80% control of blackheaded budworm populations in young stands and 46% control in mature stands.

2. Assessment of the foliage protection value of the spray was complicated by the natural collapse of the larval population prior to heavy feeding. In young stands, spraying resulted in a 14% improvement in crown condition, but in older stands there was little benefit.

3. The budworm population collapsed suddenly prior to heavy feeding activity. The available evidence suggests that the collapse was associated with 11 days of continuous rainfall and cool temperatures during early July.

4. No fish mortality, in either the in situ bioassays or wild stream populations, was observed.

5. The spray program apparently caused considerable mortality of stream invertebrates, particularly the Plecoptera, Ephemeroptera and Hemiptera. A decrease in benthic invertebrate populations also followed spraying.

6. Large numbers of terrestrial invertebrates, particularly the Arachnida and Diptera, were killed by spraying. Many of these became part of the surface stream drift and were available as fish food.

7. The data obtained from breeding bird population census and the dissection of small mammal specimens, coupled with direct observations, indicate that spraying caused no damage to the small songbird or small mammal complex. They also suggest there was no impact on the populations of hatching salamanders or forest slugs observed in the treatment areas.

8. The 600-ft streamside untreated zone specified by Fisheries was not effective in preventing spray drift from reaching fish-bearing waters.

6. RECOMMENDATIONS

1. In future outbreaks of blackheaded budworm in coastal British Columbia, control action will likely be considered for the purpose of preserving foliage and reducing the risk of tree mortality. If foliage protection is the primary objective, every attempt should be made to conduct spray operations in the second year of the outbreak, prior to heavy defoliation. In coastal B.C., it seems evident that the benefits derived from spraying in the third year of an outbreak will be much less than if spraying were conducted one year earlier.

2. Where spray operations are planned in coastal forests, several modifications in the operational plan would improve the deposit of spray and reduce drift. These should include: a) use of a slower fixed wing aircraft, e.g. Agwagon, or helicopter which can operate closer to the canopy, and b) monitoring of local weather conditions so that spraying can be conducted under inversion conditions.

3. Studies are needed to establish what volume of spray is required to provide adequate coverage in the various age classes of stands. In the meantime, however, it would seem advisable to use a higher volume of spray formulation, e.g. 64-128 oz/acre, in situations involving tall stands (over 100 ft) such as those in coastal British Columbia.

4. Monitoring of forest insect spray programs should emphasize the investigation of possible sublethal effects on fish populations through the study of the effects of:

   a. pesticide applications on aquatic and non-aquatic invertebrate populations which serve as fish food;

   b. the ingestion of contaminated invertebrate food organisms on rearing fish, and

   c. sub-lethal levels of pesticide on fry growth and behavior.

5. In reviewing proposals for major insect control programs, a detailed description of spray equipment and chemical formulation (e.g. aircraft type, flying speed, spray swath width, droplet size, chemical additives) should be provided.

6. An efficient communication setup is necessary when operational and experimental elements must be coordinated in one program. Radio equipment providing communication between project supervisor, spray or 'bird dog' aircraft and all monitoring staff is necessary.

7. To prevent pesticide spills, more efficient mixing equipment and loading than that used during this operation is necessary.

7. ACKNOWLEDGMENTS

Many people in government and industry contributed willingly to this project, but the authors wish to express their appreciation particularly to Messrs. D.G. Collis, D.R. Macdonald, R. Lidstone and N. Ward (Canadian Forestry Service), D. McLeod (Rayonier Co.) and D. Beaumont (MacMillan Bloedel Co.) for their advice and assistance in the completion of the program. Special thanks are due Messrs. P. Schreiber and M. Watkinson (Rayonier Co.) for the hospitality provided to the field crew at Jeune Landing.

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APPENDIX I

APPLICATION TO APPLY PESTICIDES

Proposed Treatment: Insecticide

Name of Applicant: Council of Forest Industries of B.C.

Address: 1500/1055 West Hastings Street, Vancouver 1, B.C.

Name of Applicator Contractor: Con Air and/or TransWest.

Address: Con Air
Abbotsford Airport, B.C.

TransWest Helicopters Ltd.
2792 Norland
Burnaby, B.C.

Project Location: a) General-- Port Alice vicinity, Vancouver Island

b) Specific-- West side Neroutsos Inlet and area east of Alice and Kathleen Lakes

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Purpose of Project: Control of black headed budworm *(Acleris variana)* on hemlock.

Total Acreage of Project;

MacMillan Bloedel -- 12,650 acres

Rayonier (Canada) Ltd. -- 19,000 acres

Estimated Acreage Actually Receiving Treatment: Same as above

Name of Pesticide: Fenitrothion (Sumithion) and/or "Dipel" *(Bacillus thuringiensis)*

Fenitrothion, if used, would be probably Sumithion 100 EC or Sumithion Technical from the Sumitomo Co., Japan.

Bacillus thuringiensis, if used, would be probably "Dipel", produced by Abbott Laboratories, California.

Pest Control Products Act No.

(a) Fenitrothion products registered under PCP Act as follows:

Cyanamid 10525 Accothion 8 EC
Chemagro 10776 Folithion Liquid Concentrate
Sumitomo 1138 Sumithion 100 EC
Sumitomo 11137 Sumithion Technical
Green Cross 10983 Fenitrothion Technical

Pest Control Products Act No. (cont.)

Fenitrothion products are registered for use against spruce budworm, hemlock looper and sawfly larvae but not yet registered against black headed budworm. If used, a provisional registratio for one year can be obtained through the Federal Plant Products Division.

(b) "Dipel" *(Bacillus thuringiensis)*
P.C.P. Act No. 11, 252
Dipel registered against loopers on broccoli, cabba cauliflower, lettuce etc. but not for use against budworm. Provisional registration can be obtained.

Active Ingredient: Fenitrothion

"Dipel": 16,000 International Units of potency per mg. (equivalent of 7.26 billion International Units of potency per pound of this product.)

Concentration to be Used:

Fenitrothion: 4 oz. active in 8 oz. water per acre.

"Dipel": 16 oz. active in one gal. water per acre.

Total Chemical Used on Project:

Fenitrothion: 7,900 lbs.
"Dipel": 32,000 lbs.
(depending on which material is used)

Carrier or Diluent: Water

Application Method: Aircraft. Probably by fixed-wing (TBM) although some may be applied by helicopter.

Approximate Dates of Application: June 15 to July 10 depending on seasonal development.

Target Species: Black headed budworm

Are lakes, rivers, streams or other water bodies involved? Yes

Are they used for municipal or other domestic water supply? No

Maps Attached? Yes

The above treatments will be conducted under supervision of H.A. Richmond, R.P.F., Entomologist, Council of Forest Industries of B.C. whose telephone number is (Vancouver) 684-0211; (Nanaimo) 754-9945 and whose Pesticide Application Certificate is No. 720 (Forestry).

This project will be conducted by the Council of Forest Industries of B.C. for the companies involved (MacMillan Bloedel Ltd. and Rayonier Canada Ltd.)

Final decision to spray will be with held to the latest possible date on the chance that natural control might make such applied treatment unnecessary.

DATE: February 15, 1973   SIGNED: ______________________

H.A. Richmond, R.P.F.
Entomologist
Council of Forest Industries
of B.C.

APPENDIX II

Environment Canada Environnement Canada

Environmental Protection Protection de l'Environnement
1090 West Pender Street,
Vancouver 1, B.C.

April 6, 1973

Your file Votre référence

Our file Notre référence 4463-548

Mr. H.A. Richmond, R.P.F.,
Entomologist,
Council of Forest Industries of B.C.,
1055 W. Hastings Street,
Vancouver 1, B.C.

Dear Mr. Richmond:

I am writing regarding your submission dated February 15, 1973, which outlined a pesticide treatment program for the control of black headed budworm in the Port Alice region of Vancouver Island.

The Department of the Environment has reviewed the submission and wishes to make the following comments:

1) The program is regarded to be a reasonable approach to forest management accepting that the winter survival of the black headed budworm is sufficiently severe to indicate the likelyhood of future tree mortalities in the areas in which the treatment is proposed and provided that undesireable environmental side effects are not a consequence.

2) In assessing the potential for undesireable side effects, the following should be considered:

   i) most available data regarding the effects of fenitrithion treatments originate in Eastern Canada and the species of fish upon which Fisheries assessments have been made are the Atlantic Salmon and trout. The Pacific Salmon will not necessarily be similarily affected.

   ii) in Eastern Canada, small numbers of Atlantic Salmon mortalities attributable to spray operations have been noted at spray concentrations of 2 x 2 oz/acre.

...2

iii) alterations to the food chain of resident fish populations might occur as a result of losses of aerial insects and an increased drift of aquatic insects should the spray material enter streams at concentrations equivalent to that anticipated from applications of 2 oz/acre or greater.

iv) coho and trout streams will be at near carrying capacity in June and July. Any reduction of their food supply (aquatic invertebrates and terrestrial drift) may reduce stream carrying capacity.

v) the potential for bird mortalities at the spray levels proposed has not been assessed in the forests of Western Canada.

Should it be decided to proceed with the proposed program, this Department would first request your assurance that the following recommendations will be adopted:

1) The proposed program should be altered to incorporate two applications of fenitrithion at 2 oz/acre rather than a single application of 4 oz/acre. These applications should take place at least five days apart. This will minimize any possible adverse side effects and will permit a quick assessment of the first application prior to commencement of the second. Should any adverse environmental effects be noted after the first application, the program will be terminated or altered to the satisfaction of this Department.

2) Leave strips shall be maintained around water bodies sufficient to prevent chemicals from reaching fish-frequented streams and inter-tidal zones in the spray areas. The size of leave strip necessary to achieve this objective is difficult to determine because of variables such as weather conditions, rough terrain, type of aircraft and spray droplet size. A minimum of 600 feet should be considered around intertidal zones, the following streams, and their associated estuaries:

...3

Klootchlimmis Creek and estuary	Rayonier Spray Area
Teeta Creek and estuary	" " "
Cayuse Creek and estuary	" " "
Cayeghle Creek and estuary	" " "
Colonial Creek	" " "
Utluh Creek	" " "
Lower Benson River	MacMillan Bloedel Area
Upper Benson River	" " "
Malook Creek	" " "

The Rayonier spray area covers about 12 miles of marine foreshore. A leave strip must be maintained to prevent any chemical from reaching the intertidal zone.

The MacMillan Bloedel spray area also includes Three Lakes Creek and the Raging River. These streams do not contain salmon but precautions must also be taken to prevent direct application over them.

The logistics and operational procedures implemented to achieve these aims should be discussed with this Department prior to commencement of the program.

3) Pre and post assessment of the effects of this program upon species of birds and the fisheries resource in these areas will be undertaken. A close liaison and co-operation between the agency contracted to do the spraying and the agencies conducting such assessments will be essential.

   Although the use of Bacillus thuringiensis is generally considered to be acceptable with respect to its effects on fisheries and wildlife non-target organisms, this material is not registered for use in controlling black headed budworm. A major program is proposed in Eastern Canada for this year to assess various formulations of Bacillus thuringiensis for spruce budworm control, both with respect to its effectiveness and its environmental acceptability.

...4

Until the results of this program have been reviewed, this Department does not consider the use of Bacillus thuringenlensis a desireable alternative to your proposed use of fentrithion.

Yours truly,

R. E. McLaren

Robert E. McLaren,
Regional Director, Pacific Region.

c.c. Mr. Dave Beamont,
MacMillan Bloedel Limited,
55 Cooper Street,
Nanaimo, B.C.

Mr. Doug McLeod,
Supervisor of Forestry,
Rayonier Canada (B.C.) Limited,
1111 West Georgia Street,
Vancouver 5, B.C.

APPENDIX III

NEWS REPORTS ON BLACKHEADED BUDWORM SPRAY PROJECT

Island's Forests Threatened

Budworm Epidemic

Infestations of a destructive forest insect, the black-headed budworm have reached epidemic proportions on northern Vancouver Island, threatening to destroy extensive stands of timber, the B.C. Forest Service reported Tuesday.

About 40,000 acres of forest may have to be sprayed with a solution of insecticide to give the trees a chance to survive, the forest service said.

It explained that the budworm has been active on the island for several years, gradually spreading from south to north and becoming more destructive as it moves further north.

Normally infestations subside before they have an opportunity to kill any trees except the weakest ones. But now stands of fast-growing healthy young trees are being attacked.

The forest service is particularly concerned about infestations in the Port Alice-Neroutsos Inlet area where there is a particularly high egg count.

Unless some natural predator or weather phenomenon destroys most of the eggs before they hatch about the end of May, the spraying will have to take place, the forest service said.

Otherwise the budworm larvae will kill the trees by eating the needles, particularly those of balsam and hemlock trees. The spraying will kill enough of the worm larvae that "the trees have a reasonable chance of survival," said the forest service.

The insecticide to be used is a weak solution of fenitrothion which has been found to have no bad effects on fish or wildlife when used properly, the service said.

Colonist May 3/73.

'Nerve-Gas Type'

MAY 25/73 Vic. Col.

Spruce Forests Spray Barred

VANCOUVER (CP) — Health Minister Dennis Cocke said Thursday he is ordering Rayonier Canada Ltd. to halt plans to spray spruce forests on upper Vancouver Island following a complaint from a Port Alice doctor.

Dr. D. G. Morris, said his research indicated that the proposed spraying program would use enough of the chemical fenithrothion to kill up to 240,000 persons when inhaled.

Cocke called it a "very toxic, nerve-gas type of spray.

Dr. Hector Richmond, director of the project planned by the Council of British Columbia Forest Industries, said the chemical kills insects by attacking the nervous system.

He said there is no record of injury to humans in widespread use of it over several years in New Brunswick.

The spray was to have been used to control spruce budworm.

Dr. Richmond said a final decision to proceed with spraying would not have been made until it was established whether there was a large winter survival of the budworm.

Target date would have been about June 11, he aid.

Dr Richmond said spraying had been approved by the provincial inter-departmental pest control committee and by federal officials concerned with environmental problems.

He said the industry is concerned, however, and will co-operate with Dr. Morris in ensuring there is no danger to humans.

Dr. Morris said he learned "they were going to spray 88,000 ounces, which is sufficient when inhaled to kill 240,000 human beings according to the lethal dose given in international reference books.

He said the same amount could kill 60,000 persons by skin contact alone.

Dr. Morris said droplets of the spray would be blown directly over Port Alice and that "in a five mile an hour wind, 50 per cent of the spray would hit the town."

APPENDIX III

VANCOUVER SUN - 29 MAY

Doctor OKs new spray plan

Port Alice physician Dr. D. G. Morris said Monday night he has approved the modified forest s p r a y i n g program planned for Northern Vancouver Island next month.

Dr. Morris said he was approving modifications outlined earlier Monday by provincial health department officials that will see none of the controversial aerial spraying of 30,000 acres of forest being carried out anywhere near Port Alice.

Health M i n i s t e r Dennis Cocke last week imposed a ban on the spraying after Dr. Morris protested the dangers involved in the use of a nerve-gas type of pesticide known as fenitrothion.

Dr. Morris, whose original protest against the spraying program was praised by Cocke, had warned the government and forestry firms their first plans had failed to take into consideration the near-constant wind conditions in Port Alice.

Cocke announced the lifting of the ban Monday. Discussions on the modified spraying program were held between Dr. Morris and deputy health minister Dr. G. R. Elliot.

Dr Elliot told The Sun the discussions had resulted in mapping out a definite area to which the anti-insect spraying must be confined — timber lands of Rayonier-Canada and MacMillan Bloedel.

Dr. Elliot said the forest companies have been told they must not spray anywhere on the west side of Neroutsos Inlet, north of a guideline running in a southwesterly direction from Port Alice to Cayuse Creek.

"This should ensure there will be no fallout of the spray on the Port Alice and Rumble Beach areas," Dr. Elliot said.

Rumble Beach is the residential section of Port Alice.

Dr. Elliot said that in addition to laying out the spray area boundary lines, Cocke has made clear he wants a handful of people living in the Victoria Lake area, near Port Alice, w a r n e d about the spraying "and moved out, if possible."

Elliot said the modified spraying project will reduce the Rayonier section to be covered from 30,000 to 15,000 acres. He said the modification will not affect the spraying of 12,600 acres of MacMillan Bloedel timber.

He said the program now approved means that all the spraying will be done south of the Port Alice area.

JUN. 22 1973
VANCOUVER SUN

Budworm spray program gets forest service okay

3/2

Special to The Sun

PORT ALICE — Federal biologists have given the go-ahead to the B.C. Council of Forest Industries to start budworm spraying here today.

Approval came from research scientist Rod Carrow of the Canadian Forest Service after the number of eggs hatched Thursday afternoon reached the appointed level.

Pat Hrushowy, a Council of Forest Industries spokesman, said earlier preparations to start spraying at 4 a.m. today were cancelled because of fog, followed by cloudy conditions.

If wind conditions are favorable and clouds lift, the program will start, Hrushowy said.

The original spraying plan was abandoned last month after health authorities said it w o u l d endanger populated areas.

Modified plans were later approved by the provincial health department calling for the spraying to be confined to a limited area and taking wind conditions into account.

The council is spraying 24,600 acres near Port Alice with Fenitrothion to kill b l a c k-headed budworm infestation.

The budworm eats the needles of the evergreens.

Timber being sprayed is in a weakened condition from a 1972 swarming of the parasites.

Spraying was scheduled to start earlier this month but cool weather had prevented the eggs from hatching.

Hrushowy said the first section to be sprayed is 12,000 acres of Rayonier timber on the east end of Neroutsos Inlet, with 12,600 acres of MacMillan Bloedel land to follow.

He said the MacMillan Bloedel land is at a higher altitude and the difference in temperature would delay the budworms' hatching in that area.

A Second World War vintage Avenger, guided by a Cessna 337, is being used for the spraying program.

APPENDIX IV

TBM Calibration - New Boom & Open Nozzle System

A.P. Randall[a]

A C.C.R.I. proposal to update the TBM for aerial application of pesticides for the blackheaded budworm project was accepted by Conair Ltd., Abbotsford, B.C. on a cooperative basis to improve the existing boom and nozzle arrangement. Conair would provide the aircraft, equipment and engineering and C.C.R.I. the expertise. At the suggestion of C.C.R.I., a new boom for mounting above the wing and open nozzle system was designed and built by Conair using the technical knowledge gained from the DC-7B project in eastern Canada.

Calibration trials were undertaken during the early part of April 1973, at Abbotsford, using two spray simulants, one comprised of fuel oil and Arotex 3470 and ethylene glycol/H_2O mixtures. A total of 9 calibration trials were completed of which 2 were carried out using the old trailing edge mounted boom and nozzle system using Spraying Systems flat fan 8010 nozzles.

Results of the trials, i.e. subsequent analyses of the deposit data, indicated that a finer droplet spectrum and increased droplet numbers were obtained using the open nozzle atomizers and above the wing mounting of the boom than with the standard trailing edge configuration. A total of 34 nozzles were used,operated at fluid pressures of 13 to 18 p.s.i. The spray droplets delivered by this system had a mass median diameter (MMD) of 101 to 129 microns. On the basis of the trials, it was recommended that the TBM could be used at swath intervals of 1000 ft provided the spray application techniques utilizing the Porton Method of incremental spraying was adopted.

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[a]Chemical Control Research Institute, Ottawa.

APPENDIX V

Survival of Blackheaded Budworm Populations in Unsprayed Plots During 1973

Age of stand	Plot	No. Insects/Branch				% Survival	
		eggs (April)	larvae	pupae	eggs (Oct.)	egg to pupa	larva to pupa
Regeneration	4	16	8.3	0	1.4	0	0
	5	21	7.2	0.44	0.9	2.10	6.11
	12	21	12.8	0.06	1.4	0.29	0.47
	$\overline{X}$	19.3	9.4	0.17	1.2	0.80	2.19
Immature -Mature	1	20	-	0.38	1.4	1.90	-
	3	16	5.4	0.19	1.0	1.19	3.52
	6	8	-	0.31	0.1	3.88	-
	10	25	5.8	0.44	1.9	1.76	7.59
	$\overline{X}$	17.3	5.6	0.33	1.1	2.18	5.56