INSECTICIDE IMPACT AND RESIDUE STUDIES ON NORTHERN VANCOUVER ISLAND - 1973

by

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SUMMARY

These monitoring studies indicate that the fenitrothion treatment had no effect on the small songbird, small mammal, forest slug or aquatic fauna complexes in the areas studied. DDT residues within the 1957 spray area were found to have dropped to background levels in soil, mouse brains, forest slugs and fish. Examination of past salmon run estimates showed that the impact of the 1957 DDT treatment on salmon populations wasn't noticeable in terms of the number of adult salmon from this year class returning to spawn in later years.

RÉSUMÉ

Ces études révèlent que le traitement au fénitrothion n'a eu aucune répercussion sur les complexes de petits oiseaux chanteurs et mammifères, de limaces des forêts et de la faune aquatique dans la région étudiée. Dans la région qui a fait l'objet d'un arrosage de DDT en 1957, les taux de résidus de ce produit dans le sol, dans le cerveau des souris et chez les limaces et les poissons sont revenus à leur niveau initial. Une étude des estimations des montaisons de saumon pour les années précédentes révèle que le traitement au DDT de 1957, n'a pas eu de répercussions notables sur les populations de saumons du point de vue du nombre de sujets adultes de la classe de cette année qui sont revenus frayer les années suivantes.

INTRODUCTION

The forests of the coast and outlying islands of British Columbia have periodically become infested with outbreaks of black-headed budworm, *Acleris gloverana* (Wlshm.). Chemical control measures to protect the infested forests were first conducted on Northern Vancouver Island in 1957 (British Columbia Loggers Association, 1957), using the chlorinated hydrocarbon insecticide DDT. This insecticide had been shown by spray trials conducted in 1956 to provide excellent control of black-headed budworm larva at an application rate of 1 lb. of DDT per gallon of spray solution per acre (Brown et al, 1958).

The operational program conducted in 1957 was organized by the Pest Control Committee of the B.C. Loggers Association. The federal Department of Fisheries and the B.C. Fish and Game Commission were invited to participate in the planning of the treatment operation in order to suggest procedures to avoid damage to fish populations within the treatment area. Consultation with these fisheries bodies led to numerous modifications in the operational procedure used including the elimination of the use of streams as spray plot boundaries, the establishment of untreated zones one swath wide alongside major streams, the shutting off of spray when crossing streams, reduction of the dosage of DDT applied to lower value timber areas and removal of some areas near streams from the area treated (Crouter & Vernon, 1959). Fisheries observers in an observation aircraft reported that these precautionary measures were adhered to as closely as possible by the pilots of the spray planes. Despite these precautions, Crouter and Vernon (1959) reported extensive damage to fish and bottom fauna populations in several streams within the treatment area. They expressed particular

concern over the apparently complete mortality among Coho salmon fry in the Keough River, a major Coho salmon producing river-system. Coho salmon have a predominantly three-year life cycle and they felt that their population might not be restored for many cycles with the low populations being reflected in poor salmon catches every third year.

In 1973 an infestation of black-headed budworm had again reached high hazard proportions in the same area of Northern Vancouver Island treated with DDT in 1957. The Pest Control Committee of the B.C. Loggers Association carried out a chemical control program using the organophosphate insecticide fenitrothion applied in two successive applications of two ounces per acre three days apart. Fenitrothion has been used extensively at this application rate in New Brunswick and has been shown to have no effects upon caged or native fish populations and no significant effects upon aquatic insect populations (MacDonald and Penney, 1969; Penney, 1970). Fenitrothion has also been shown to have no detectable effects on forest songbird and mammal populations at operational application rates (Buckner et al 1973).

The Environmental Impact Section of the Chemical Control Research Institute monitored the effects of the 1973 operational Fenitrothion treatment on several components of the forest ecosystem. Bird populations on treatment and control plots were monitored throughout the treatment period and small mammal and aquatic fauna populations on the treatment and control plots were compared about six weeks after treatment. At the same time, samples were collected for DDT residue analysis and fish and bottom fauna populations in the Keough River were assessed to determine any environmental damage still evident from the 1957 operational DDT treatment.

METHODS

Breeding bird and small mammal population census plots were set out on budworm monitoring plots established in treatment areas by R. Carrow of the Pacific Forest Research Centre. Treatment plot 7 was established in an immature stand (approximately 30 ft high): treatment plots 8 and 9 were established in mature timber (150 ft). One control plot (plot 12) was located in an immature stand and the other control (plot 12A) was established in a mature stand.

Control plot 12 was located in a very dense stand of hemlock about 30 ft high with a few scattered alder and cedar regenerating 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 is very similar except for a slightly higher percentage of alder. Plots 12A, 8 and 9 were located in mature stands of a very similar nature, mainly hemlock with scattered fir, cedar and spruce. Understory was sparse and there was very little cover between the very high canopy and the forest floor. The forest floor was damp and received very little sunlight. A deep moss layer covered the ground and scattered blowdowns were found throughout the plots.

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 two weeks before the first application and running through to about six days after the second spray.

Small mammals were trapped on all plots approximately six 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 or 150 trap nights per plot. Three consecutive nights were trapped and all animals were examined for species, sex, age and parasites and then dissected to determine general health and breeding conditions. The brain of each specimen was carefully removed and individually preserved in residue-free methanol to be taken to the laboratory for DDT residue analysis.

A soil sample was collected from each plot for DDT residue analysis by mixing together soil collected at 10 yard intervals along the mammal trap-line. Once thoroughly mixed a quart sealer was filled with a portion of the composite sample and taken back to the laboratory for analysis. Large forest slugs were also collected from some of the plots to be analysed for DDT content. Observations were made on the relative abundance of these slugs before and after fenitrothion treatment.

Aquatic studies were conducted at two sampling locations on the Keough River watershed and in a small pond on treatment plot 7. A small unnamed creek, called Keough Lake Creek in this report, was sampled at the point where it flows past treatment plot 7 before flowing into Keough Lake. This stream wasn't sprayed during the treatment operation but may have been contaminated by drift of the spray products or by insecticide washed down the steep slopes of the valley by the heavy rains which are common in this area. The stream was very shallow, slow flowing and silty when it was sampled (August 19-21) but had been faster flowing and somewhat deeper when the adjacent forest was treated with fenitrothion (July 26-29). The area from which bottom samples were

collected was a very shallow (1 to 2 inches) moderately flowing riffle area with a bottom consisting primarily of gravel and coarse sand.

Fish and bottom fauna populations from Keough Lake Creek were compared with populations present at a station in the Keough River adjacent to the control plots (plot 12 and 12A). The area sampled was the same as one of the stations (station III) established on the Keough River by Crouter & Vernon (1959) when they studied the effects of the 1957 operational DDT treatment. The river is very clear and fast flowing but when sampled (August 19-21) the water level was very low and much of the river bed was dry in the riffle areas. Bottom samples were taken from a typical fast-flowing, shallow (3 to 6 inches) riffle area with a bottom of fairly large (3 inch diameter) well rounded stones and gravel. Pools below riffle areas were up to three feet deep and had coarse sand, rubble, or bedrock bottoms.

Basic water chemistry parameters of the areas sampled were determined in the field using a Hach kit. Bottom fauna samples were collected with a foot-square Surber sampler (Surber, 1936) and all organisms were picked from the sample while still alive and preserved in methanol. Later they were identified to Class or Order and counted and in some cases measured. Fish and water striders were collected with a dip net. Observations on the abundance of juvenile salmonoids were made from the shore and on one occasion by snorkeling in a pool at the Keough River station. The use of snorkeling equipment facilitated the collection of salmon, trout, sculpins and caddisfly larvae for DDT residue analysis. This material was preserved in residue-free methanol and brought back to the laboratory.

Observations were made throughout the treatment period on salamander eggs and larvae exposed to Fenitrothion in a small silt-bottomed pond located in a clearing on treatment plot 7. On August 21 this pond was sampled with a dip net and organisms found in it were preserved and later identified to family. At the time it was sampled much of the pond had dried up and its area and volume were greatly reduced from the levels present during treatment.

RESULTS

Fenitrothion Treatment

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 only located in stands of mature timber while winter wrens and several species of thrushes were found only in the lower crown of forest floor areas in all stand types. Golden-crowned 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 also remained unaffected.

Comparison of populations of birds on the control plots (Tables I and II) and the treatment plots (Tables III, IV and V) indicates that the treatment had no significant impact upon the resident bird populations.

Small Mammals.- Only one species of small animal, the deer mouse, *Peromyscus maniculatus* (Wagner) was taken during the three day trap period (August 19-21). Populations were fairly even in both mature and immature stands. No juvenile animals were taken and only four (two males and two females) sub-adult animals were trapped. Only one female was pregnant but several others contained placental scars. None of the male mice were in breeding condition. These data (Table VI) indicate 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 were apparently in good health. No adverse affect upon this species of small mammal could be determined.

Aquatic fauna.- Large numbers of hatching salamander eggs were present throughout the treatment period in the silty bottomed pond located in an open area on treatment plot 7. Close observations revealed no mortality up to a week after the second spray. The pond was examined again approximately two months after treatment and still contained many larval salamanders and the aquatic invertebrate listed in Table VII.

Table I

Bird Population Census on Control Plot No. 12 (Immature Forest)
North Vancouver Island, British Columbia
June 13 to July 6

Avian Populations		Pre-Spray								Post Spray # 1					Post Spray # 2						
		Day							Ave. No. of Birds Per Day	Day				Ave. No. of Birds Per Day	Day						Ave. No. of Birds Per Day
Family	Species	-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
Sittidae	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 II
Bird Population Census on Control Plot 12A (Mature Stand)
North Vancouver Island, British Columbia
June 13 to July 6, 1973

Avian Species		Pre-Spray								Post Spray # 1					Post Spray # 2						
Family	Species	Day							Ave. No. of Birds Per Day	Day				Ave. No. of Birds Per Day	Day						Ave. 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
Sittidae	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 III

Bird Population Census on Treatment Plot 7 (Immature Forest)
North Vancouver Island, British Columbia
June 22 to July 6

Family	Species	Pre-Spray Census Day					Ave. No. of Birds Per Day	Post Spray # 1 Day			Ave. No. of Birds Per Day	SPRZ Post Spray # 2 Day						Ave. No. of Birds Per Day
		-5	-4	-3	-2	0		+1	+2	+3		+1	+2	+3	+4	+5	+7	
Tetranonidae	Rufted 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	Steller'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 IV

Bird Population Census on Treatment Plot 8 (Mature Forest)
North Vancouver Island, British Columbia
June 22 to July 6

Avian Populations		Pre-Spray Census							Post Spray # 1			Post Spray # 2						
Family	Species	Day						Ave. No. of Birds Per Day	Day		Ave. No. of Birds Per Day	Day						Ave. No. of Birds Per Day
		-8	-7	-4	-2	-1	0		+1	+2		+1	+3	+4	+5	+6	+7	
Corvidae	Gray Jay	0	0	0	0	0	0	0.0	0	30	15.0	0	30	0	0	0	0	5.0
	Steller'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 Spp.		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 V

Bird Population Census on Treatment Plot 9 (Mature Forest)
North Vancouver Island, British Columbia
June 10 to July 6, 1973

Avian Fauna		Pre-Spray Census								1st Spray Census			2nd Spray Census						
Family	Species	Day.							Average No. of Birds Per Day	Day		Average No. of Birds Per Day	Day						Average 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
	Stellar'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	30	13.5	10	60	35.0	30	50	10	0	20	30	23.3
Sittidae	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
	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 VI

Small Mammal Populations on Treatment and Control Plots
North Vancouver Island, British Columbia
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 treatment	0	1	5	6	0	0	0	0	1	1	2	8
8 mature stand treatment	0	1	7	8	0	2	0	0	4	0	4	12
9 mature stand treatment	0	0	8	8	0	0	0	0	1	0	1	9
12 immature stand control	0	0	3	3	0	0	0	1	2	0	4	7
12A mature stand control	0	0	8	8	0	0	0	0	0	9	9	17
Totals	0	2	31	33	0	2	0	1	8	10	20	53

Table VII

Aquatic Invertebrates Collected Live from the Salamander Pond, Treatment Plot 7, Aug 21, 1973

Oligochaeta		fresh water bristleworm
Ephemeroptera	Fam. Baetidae	mayfly nymph
Hemiptera	Fam. Gerridae	water strider
	Fam. Corixidae	water boatman
Coleoptera	Fam. Dytiscidae	diving beetle and its larva (water tiger)
Diptera	Fam. Tipulidae	cranefly larva
	Fam. Chironomidae	midge larva
	Fam. Heleidae	biting midge larva
Pelecypoda	Fam. Sphaeriidae	fingernail clam
Gastropoda	Fam. Planorbidae	snail

The variety and abundance of aquatic invertebrates found in this pond two months after fenitrothion spraying indicates that the insecticide had no effect on the aquatic fauna of this system. Similar results have been obtained from forest ponds in experimental fenitrothion spray plots in Larose Forest. Ontario (Kingsbury, unpublished data).

Water chemistry data and bottom fauna populations in the Keough River and Keough Lake Creek are presented in Tables VIII and IX. The differences between the bottom faunas in these two streams appear to be attributable to differences in their physical and chemical characteristics. Organisms typical of slower flowing water (oligochaetes, leeches, water mites, zooplankton) were found in Keough Lake Creek

whereas organisms better suited for faster flowing waters (mayfly nymphs, caddisfly larvae) were abundant in the Keough River. There were also distinct differences in the size distribution of mayfly and stonefly nymphs in the two streams due to development differences related to altitude. The effect of altitude on insect development in this area has also been commented on with respect to the target organism, blackheaded budworm (Carrow 1974). The presence of large numbers of very small (2 mm in length) mayfly nymphs in the Keough River shows that oviposition and hatching of the eggs had already occurred. The mayfly nymphs present in Keough Lake Creek were mostly relatively large indicating that they belonged to an older generation which hadn't yet emerged and oviposited. The reverse situation was found for stonefly nymphs with the Keough Lake Creek population being composed primarily of very small individuals (2 mm in length) and the Keough River population of larger individuals. This can be interpreted as earlier hatching and faster growth of stonefly nymphs in the Keough River because of its lower altitude and subsequently warmer climate.

Table VIII

Water Chemistry Parameters of the Keough River
and Keough Lake Creek
Aug 18 and 20, 1973

	Keough River	Keough Lake Creek
Date sampled	Aug 18	Aug 20
Temp	10°C	10.5°C
02 (mg/l)	10	8
pH	7.0	6.5
Acidity (gpgCaCO3)		
Free	0	0
Total	0	0.7
Alkalinity (gpgCaCO3)		
Phenolphthalein	0	0
Total	2.3	2
Hardness (gpgCaCO3)	2.3	3

Table IX

Bottom Fauna Population in the Keough River and Keough Lake Creek
as Numbers and Standard Deviations of Organisms/sq ft
Vancouver Island, B.C., Aug 19 to 21, 1973

	Keough River	Keough Lake Creek
Number of samples	5	5
Water Temperature	9.5°C	10°C
Ephemeroptera	100.6 ± 32.1	12.6 ± 8.2
Plecoptera	50.2 ± 18.6	41.2 ± 19.8
Trichoptera	23.8 ± 10.9	0.6 ± 0.8
Coleoptera	20.6 ± 13.2	0.4 ± 0.5
Diptera	62.2 ± 23.9	57.8 ± 27.2
Turbellaria	0.4 ± 0.7	———
Oligochaeta	5.4 ± 2.8	75.6 ± 33.1
Hirudinea	———	0.4 ± 0.5
Hydracarina	4.2 ± 3.1	7.0 ± 6.3
Amphipod	0.2 ± 0.4	———
Mollusca	———	———
Total	267.6 ± 77.5	195.8 ± 55.4

Rainbow trout (*Salmo gairdneri* Richardson) and coho salmon (*Oncorhynchus Kisatch* Walbaum) fingerlings and paar were very abundant at both the stations where bottom samples were taken. Small (4 to 5 cm) trout and salmon were collected from riffle areas in the Keough River and larger trout (up to 20 cm) were observed and collected from pools. Stomach content analysis showed that all the fish at this station were feeding primarily on mayfly nymphs and midge larvae with caddisfly larvae, stonefly nymphs, adult insects, cranefly larvae, beetles and water mites making up the rest of their diet. There was a higher proportion of salmon to trout present in Keough Lake Creek than in the Keough River. The salmon and trout from this stream were quite uniform in size (4 to 6 cm), with the absence of larger trout being due to the lack of suitable deep pools along the section of stream sampled. These fish were feeding primarily on midge larvae and zooplankton with mayfly nymphs, adult insects, stonefly nymphs, water mites and isopods occasionally present in the stomach contents. Some of the coho paar had hundreds of cladocerans in their stomachs whereas the rainbow trout paar stomachs which had zooplankton in them contained primarily ostracods.

Other fish observed or captured at the Keough River station were freshwater sculpins (*Cottus* sp) and the threespine stickleback, *Gasterosteus aculeatus* Linnaeus. Water striders were very abundant at both the Keough River and Keough Lake Creek stations.

Other Observations. - Two species of large forest slugs, *Arion ater* and *Limax maximus* were observed inhabitating the forest floor on all plots. Observations indicate that populations were not affected by the applications of fenitrothion and that both species were observed to be quite numerous on all plots two months after the second spray.

DDT Residues

Mammals. - DDT residues found in the brains of deer mice are presented in Table X. The specimens from plots 12 and 12A, the only plots within the 1957 DDT spray area, don't contain residues greater than the mice collected from the other plots. The exception to this is a single mouse brain from plot 12A with a total DDT residue of 0.487 ppm, almost four times higher than the total DDT residue found in any other specimen analysed (0.123 ppm from plot 8). With the exception of this individual, the range of residues found in mice from plots outside of the 1957 DDT spray area was similar to that found for mice from plots 12 and 12A.

Soil. - DDT residues found in soil samples collected from the same areas where mice were trapped are presented in Table XI. Total DDT in the soil of plots 12 and 12A lie within the range of values for soil from the plots outside of the 1957 DDT spray area. The ratios of residues in soil to residues in mice brains from the various plots range from 1:08 for plot 8 to 1:25.8 for plot 7A. Plots 12 and 12A have ratios intermediate in this range (1:3.6 and 1:4.4 respectively).

Forest Slugs. - DDT residues in forest slugs were similar to the levels found in soil (Table XII). The ratio of total DDT in soil

Table X

Averages and Ranges of DDT Residues (ppm) Found in Deer Mouse, Peromyscus maniculatus, Wagner, Brains from Plots on Northern Vancouver Island, Aug 19 to 21 1973

Plot	Number of Brains	DDE Ave	DDE Range	o,p-DDT Ave	o,p-DDT Range	p,p'-DDT Ave	p,p'-DDT Range	Total DDT Ave	Total DDT Range
12	8	0.002	T-O.012	0.003	N.D.-0.020	0.015	T-0.060	0.020	T-0.060
12A	15	0.003	T-0.017	T	T	0.042	N.D.-0.470	0.044	T-0.487
7	14	0.0004	T-0.005	0.002	N.D.-0.015	0.022	N.D.-0.105	0.024	T-0.105
7A	6	0.002	T-0.014	T	T	0.016	N.D.-0.074	0.018	T-0.088
7B	8	T	T	T	N.D.-T	0.014	T-0.048	0.014	T-0.048
8	14	0.004	T-0.016	0,002	N.D.-0.032	0.021	T-0.108	0.027	T-0.123
9	9	0.0004	T-0.004	0.001	T-0.006	0.013	T-0.045	0.015	T-0.055

DDE 2,2-Bis(p-chlorophenyl)1,1-dichloroethylene

o,p-DDT 2,2-Bis (o,p-chlorphenyl)1,1,1-trichloroethane

p,p'-DDT 2,2-Bis (p-chlorophenyl) 1,1,1-trichloroethane

T = Trace (< 0.002 ppm)

N.D. = Not detected

Table XI

DDT Residues (ppb) Found in Soil from Plots on Northern Vancouver Island, Aug 21, 1973

Plot	DDE	o,p-DDT	p,p'-DDT	Total DDT
12	T	T	5.5	5.5
12A	2.9	2.3	4.8	10.0
7	1.4	0.6	5.4	7.4
7A	0.4	T	0.3	0.7
7B	T	T	1.0	1.0
8	4.7	1.2	28.8	34.7
9	3.2	0.8	12.6	16.6

T = Trace (< 0.3 ppb)

Table XII

Averages and Ranges of DDT Residues (ppb) Found in Forest Slugs, *Arion ater* and *Limax maximus*, from two Plots on Northern Vancouver Island, Aug 20, 1973

Plot	Number of Animals	DDE		o,p-DDT		p,p'-DDT		Total DDT	
		Ave	Range	Ave	Range	Ave	Range	Ave	Range
12	2	0.4	0.3-0.6	0.6	0.6-0.7	0.6	T-1.2	1.7	1.0-2.4
7B	3	0.2	T-0.3	0.5	T-1.0	0.3	T-0.9	1.0	T-2.3

T = Trace (< 0.2 ppb)

Table XIII

DDT Residues (ppm) Found in Pooled Fish and Caddisfly Larvae
Samples from the Keough River, Northern Vancouver Island
August 21, 1973

Species	Average Length	DDE	o,p-DDT	DDD	p,p'-DDT	Total DDT
Coho salmon paar	8.5	0.002	0.001	0.001	0.002	0.006
Rainbow trout paar	8.8	0.002	0.002	0.003	0.007	0.015
Rainbow trout	16.5	0.002	0.001	0.001	0.003	0.007
Freshwater sculpins	5.9	0.001	0.001	0.001	0.001	0.004
Caddisfly larvae*	2.1	0.007	0.011	0.010	0.024	0.052

* Results uncertain due to small size of sample.

to total DDT in slugs was 1:0.3 for plot 12 and 1:1 for plot 7B.

Aquatic Fauna.- The DDT residues found in aquatic fauna from the Keough River are presented in Table XIII. The results represent the residues present in a pooled sample of several individuals homogenized together. The total DDT residues are relatively low and not greatly different for fish of different trophic levels or size. Caddisfly larvae appear to have accumulated significantly higher DDT residues than fish, but the small size of the sample collected (0.5 grams) may have affected the analytical results.

Discussion

Fenitrothion Treatment.- There is no evidence from the monitoring of birds, small mammal, fish and aquatic fauna populations that any of these groups suffered adverse effects in the fenitrothion treatment areas monitored. Aquatic monitoring conducted by the Environmental Quality Unit of the Fisheries and Marine Service suggest that fenitrothion treatment did adversely affect bottom fauna populations in the Cayeghle Creek watershed but there was no effect on caged coho salmon fry or caddisfly larvae held in this stream (Carrow, 1974).

DDT Residues.- Relatively few studies have been made on the duration of DDT residue persistence in populations of small mammals from treated areas. Dimond and Sherburne (1969) reported whole body residues in small mammals from plots in Maine with various treatment histories. Deer mice and voles had very similar residue levels which decreased from an average of 1.06 ppm (range of 0.43 to 2.69 ppm) in the year of treatment to 0.04 ppm (range of 0.03 to 0.06 ppm) in animals from plots treated eight or nine years previously. Animals from untreated areas contained average residues of 0.03 ppm which ranged from 0.005 to 0.07 ppm in individual

specimens.

Residues of organochlorine pesticides in brains of mammals seem to provide the best diagnostic criteria of toxic effects (Stickel, L.F. 1973). The average residues found in the brains of deer mice from plots on Northern Vancouver Island are of about the same level as found in whole bodies of deer mice from untreated forest areas in Maine.

With one exception, mice from plots within the 1957 DDT spray area contained residues of the same mignitude as mice from untreated areas, indicating that DDT residues had dropped to background levels. The 0.487 ppm residue found in a single mouse from within the 1957 spray area remains an enigma. The DDT residues found in soil on the mice plots are also very low and represent background levels of contamination. The low residue levels found in forest slugs indicates that they don't concentrate DDT residues to any extent.

Many surveys have been made of organochlorine pesticide residues in fish. Almost all species of fish from all across Canada have been shown to carry total DDT residues of 0.02 ppm or greater (Reinke et al 1972). The levels of DDT found in fish from the Keough River all fall below this level and can be considered as background levels. The higher (0.052 ppm) level found in caddisfly larvae may be due to analytical error as noted. It could also result from their feeding on particulate matter filtered from the current. DDT is known to become concentrated on suspended particulate matter in streams to levels many times higher than found in the water itself (Yule and Tomlin, 1971).

Crouter and Vernon (1959) reported severe mortality of coho salmon in the Keough River during the 1957 DDT spraying. Coho salmon

in this river have a predominant 3-year life cycle and the spawining runs consist almost exclusively of fish of the same age class. Concern was therefore expressed by fisheries officers that the number of adult salmon of the affected year-class returning to spawn would be insufficient to restore coho populations in this river for many cycles. Similar concern was expressed over the salmon populations in other rivers and streams within the 1957 spray area.

Examination of estimates of the number of adult Coho salmon returning to spawn in these streams in succeeding years fails to reveal such an effect. The numbers of individuals present as fry in 1957 and returning to spawn in the fall of 1959, fall within the range of estimates of spawning runs during the 6 years preceding DDT spraying and are not noticeably lower than the numbers of adults unaffected by spraying and returning to spawn in 1958 and 1960. However, commercial fishing in 1959 was curtailed owing to a strike of fishermen, and runs into the spawning streams may have been proportinately greater than usual on that account. Examination of similar data on spawning runs of pink, chum, spring and sockeye salmon in streams within the treated areas reveals no effects of DDT spraying.

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