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ENVIRONMENTAL IMPACT ASSESSMENT OF A SEMI-OPERATIONAL PERMETHRIN APPLICATION

by

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ABSTRACT

A semi-operational application of 17.5 g AI/ha Permethrin to a 640 ha forest block in northern Ontario demonstrated environmental effects similar to those documented from previous studies of the same application rate. Noticeable increases in the number of drifting organisms occurred in the treatment block and 2.1 km downstream over a 24 hour period immediately after the spray, followed by a slight reduction in bottom fauna at the downstream station. Yellow perch, *Perca flavescens* (Mitchill), exposed to the application in wire cages indicated no lethal effects and did not accumulate detectable amounts of the pesticide. Aboreal and flying invertebrates were affected to a moderate degree, demonstrating a 24 to 36 hour increase in knock-down. Ground dwelling invertebrates experienced a slight reduction in activity immediately following the application, but returned to normal within 14 days. No measurable effects were encountered in small mammal populations.

Permethrin residues in water persisted for less than 96 hours and attained peak concentrations of 147.0 µg/ℓ in ponds and 2.5 µg/ℓ in streams, but accumulations and persistance of pesticide in bottom sediment were negligible. Insecticide residues in foliage, soil, and litter were more stable and remained at detectable concentrations to the end of the 58-day sampling period.

RÉSUMÉ

Une application semi-opérationnelle de Permethrine à raison de 17,5 g MA/ha dans une forêt de 640 ha dans le nord de l'Ontario a produit sur l'environnement des effets similaires à ceux déjà relevés en expérimentant la même dose d'application. Des augmentations numériques remarquables quant à la migration des organismes se sont produites dans ce bloc de traitement et en aval sur une distance de 2,1 km dans les 24 heures consécutives au traitment, suivies d'une légère diminution de la basse faune dans la station en aval. Exposée au traitement dans des cages moustiquaires, la Perche jaune (*Perca flavescens* [Mitchill]) n'a accusé aucun effet mortal et n'a pas accumulé de quantités notables du pesticide. Les invertébrés volants et non boréaux étaient modérément affectés, en paraissant plus abattus durant 24 à 36 heures. Les invertébrés au sol ont accusé une légère réduction d'activité immédiatement après le traitement, mais on retrouvé leur état normal en 14 jours ou moins. On n'a observé aucun effet notable chez les populations de petits mammifères.

Des résidus de Permethrine ont persisté dans l'eau durant moins de 96 heures et ont atteint des concentrations maximales de 147,0 µg/ℓ dans les étangs et de 2,5 µg/ℓ dans les ruisseaux, mais les accumulations et la persistance du pesticide sur les fonds sédimenteux ont été negligeables. Par ailleurs ces mêmes concentrations dans le feuillage, le sol et la litière se sont avérées plus stables et sont demeurées décelables jusqu'à la fin de la période d'échantillonnage qui a duré 58 jours.

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INTRODUCTION

Experimental applications of the synthetic pyrethroid, Permethrin, at various dosage rates, have been implemented by the Forest Pest Management Institute to evaluate its suitability as a forest pest control product. Previous assessments have indicated that applications of 17.5 g AI/ha may be the maximum level acceptable for large scale operational use in important salmonid production areas because of disturbances to aquatic invertebrate populations caused by higher dosages. Double applications at this dosage have been shown to cause greater impact than single applications in that the second treatment further reduced populations to a point at which recovery of numbers was considerably slower than after the impact caused by a single application (Kingsbury and Kreutzweiser 1979, and in press). Since these experiments involved applications to small areas and short portions of streams, it was necessary to validate these findings by conducting an environmental impact study of Permethrin applied to an entire headwater stream watershed and surrounding forest block under simulated operational conditions.

Further to previous contract arrangements, Chipman Inc. was granted additional funding by the Department of Supply and Services through the unsolicited proposal program for research into the effects of a semi-operational application of 17.5 g AI/ha Permethrin. The assessment of environmental impact and fate of insecticide residues in terrestrial and aquatic ecosystems of a northern Ontario forest block was conducted by the Environmental Impact Section of the Forest Pest Management Institute in cooperation with Chipman Inc.

SITE DESCRIPTION

The semi-operational Permethrin application was conducted in the boreal forest region of northern Ontario, in an area adjacent to Highway 11, 61 km east of Longlac. The 640 ha treatment block consists mainly of mature black spruce, *Picea mariana* (Mill.), with occasional areas of balsam fir, *Abies balsamea* (L.) Mill., tamarak, *Larix laricina* (DuRoi) K. Koch, trembling aspen, *Populus tremuloides* Michx., and balsam poplar, *Populus balsamifera* h., and peripheral sections of speckled alder, *Alnus rugosa* Spreng., willow, *Salix* spp., white birch, *Betula papyrifera* Marsh., and choke cherry, *Prunus virginiana* L.

The headwater stream system within the treatment block is unnamed and was designated as Shaft Creek for the purposes of this study. The creek originates in the northcentral and north-eastern areas of the block and flows in a south-westerly direction to the confluence with Flynne Creek, approximately 2.5 km below the treatment area (Fig. 1). Two tributary stations (East Tributary and West Tributary), and a mainstream station (Upstream) were established for aquatic sampling in the treatment block. A second mainstream station was located 2.1 km below the southern boundary of the treatment block

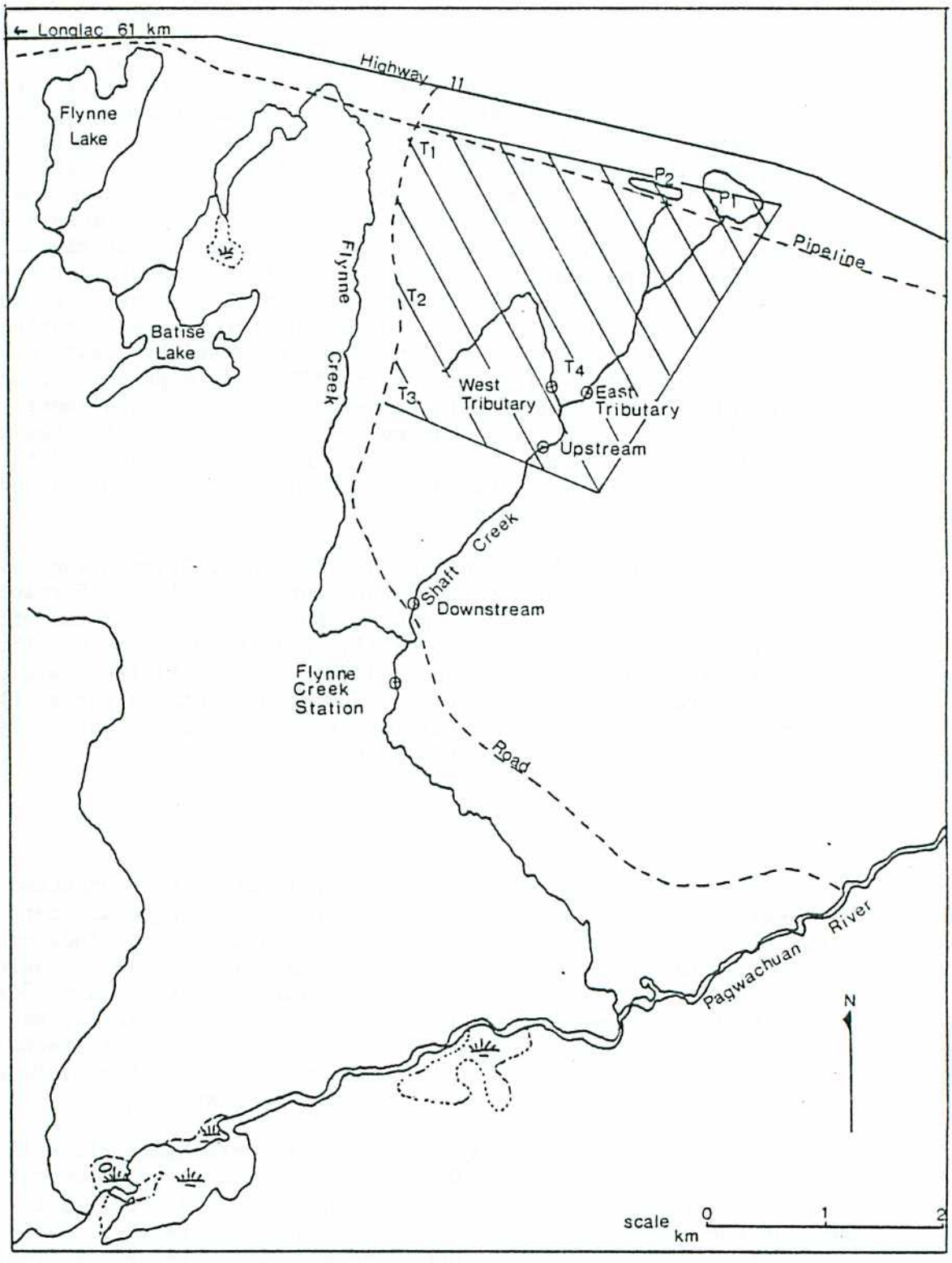

Figure 1
Permethrin treatment block
Longlac, Ontario
1979

and was designated as Downstream. Approximately 0.4 km below the confluence of Shaft Creek and Flynne Creek, a fifth stream station was established for water analysis only. Two ponds (P1 and P2) are located at the extreme headwaters of Shaft Creek, in a cleared section maintained for access to the trans-Canada gas pipeline (Fig. 2), and were used for certain aspects of biological and chemical sampling.

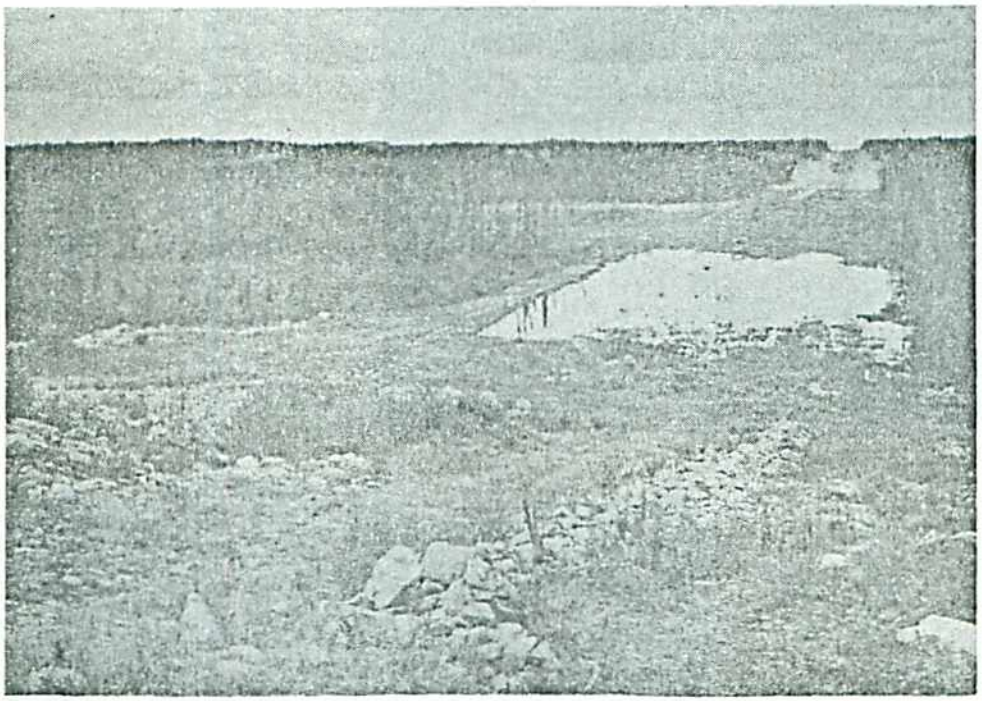

Figure 2. Headwater pond, P1, Longlac, Ontario

The Shaft Creek drainage system passes through black spruce lowland areas (Fig. 3) and is characterized by a slow velocity, silt, detritus, muck and clay bottom type, and a frequent interspersion of beaver ponds in the upper portions. The lower 800 m section (Fig. 4) changes considerably with increased velocity, rock, gravel, and sand bottom type, and an abundance of riffles. Table 1 outlines the physical and descriptive features of each sampling section.

Three terrestrial sampling areas (T1, T2, T3) established on the periphery of the treatment block (Fig. 1) were located in sections

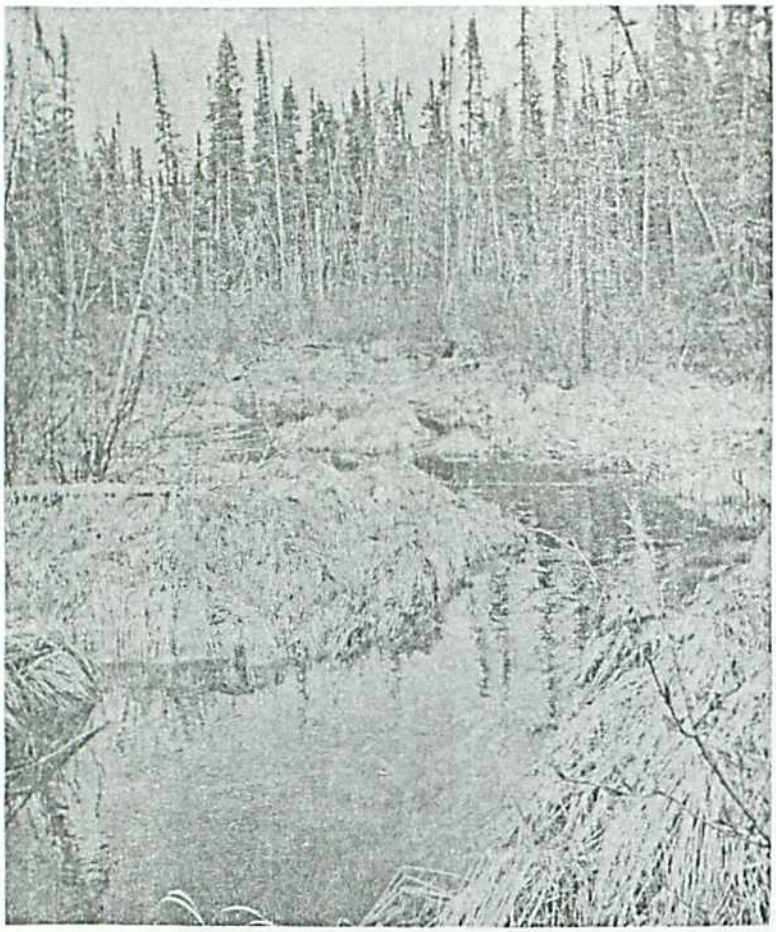

Figure 3. Upper section of Shaft Creek, Longlac, Ontario

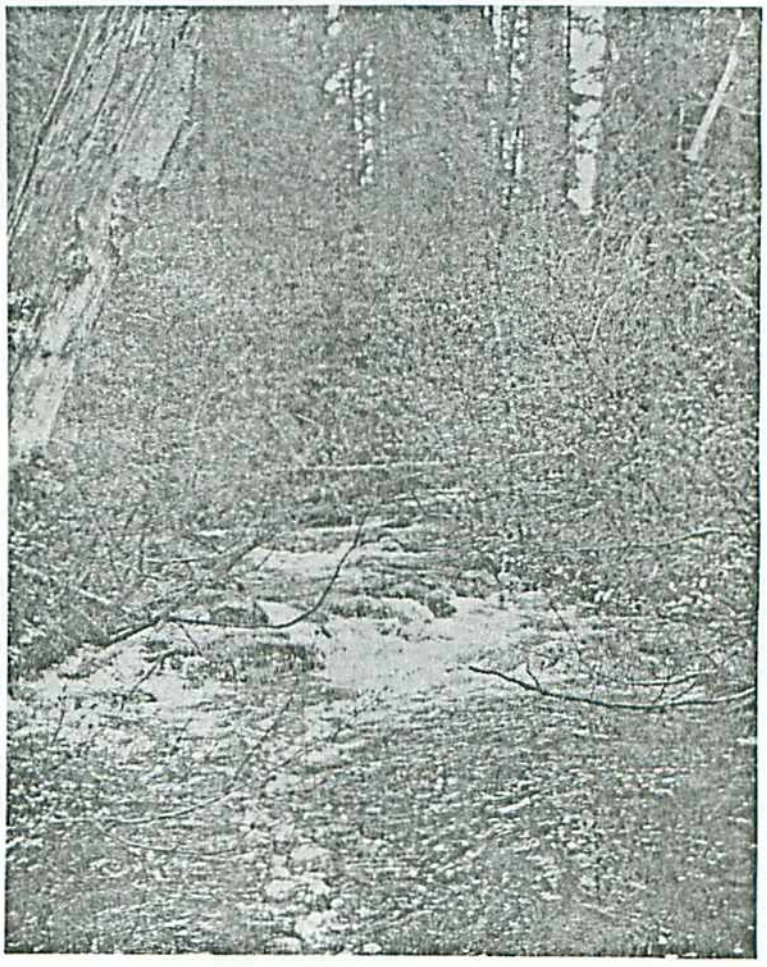

Figure 4. Lower section of Shaft Creek, Longlac, Ontario

Table 1
Site description for aquatic sampling stations
Longlac, Ontario
1979

Station	Approx. Width	Approx. Depth	Flow Description	Instream Cover	Shoreline Cover	Bottom Type
Control	1.5 m	10-30 cm	medium to fast current-frequent riffles	3%-fallen logs	10-20% canopy alder flanked by willow, spruce	sand, gravel, small rocks
Shaft Creek Downstream	2.0 m	15-50 cm	moderate to fast-frequent riffles	3%-boulders, fallen logs	20-50% canopy alder flanked by mature spruce	gravel, rocks, boulders
Upstream	3-6 m	50-150 cm	slow	5% fallen logs, undercut banks	0-5% canopy marsh grasses, alder tamarach	sand, muck, detritus
East tributary	2-3 m	50-100 cm	slow to moderate	none available	60-90% canopy, alder flanked by mature spruce	clay, muck, detritus
West tributary	1 m	50 cm	slow to moderate	1%-fallen logs	75-95% canopy alder, mature spruce	clay, muck, detritus
P1	50 m x 75 m	2 m	standing water-4 small outlet streams	-	grasses, poplar shrubs	muck, detritus
P2	5 m x 60 m	1 m	standing water 1 small outlet stream	-	grasses, cattails	muck, detritus

of forest consisting of a relatively dense composition of mixed hardwoods and coniferous trees. A fourth area (T4) was located near the centre of the block and is comprised almost entirely of mature black spruce.

The untreated control area was located approximately 12 km west of the treatment block and included a small stream flowing through a section of mixed forest consisting of white spruce, *P. glauca* (Moench) Voss, black spruce, poplar, white birch, willow, and alder.

METHODS

Insecticide Application and Deposit

Permethrin*, at a concentration of 17.5 g AI/ha, was applied to the treatment block from 0705 to 0900 hours on 24th of June, 1979. The insecticide was mixed with insecticide diluent 585** and automate "B" dye, and delivered at a rate of 1.46 ℓ/ha from a Pawnee D aircraft fitted with model AU 3000 Micronair atomizers.

Deposit was measured on double aluminum plates, one plate covered with a 100 cm^2 Kromekote paper card. The plates were placed at approximately 15 m intervals on 10 to 30 cm stakes in the pond, streams, along the banks, and in the terrestrial sampling areas. Following the application, the deposit samplers were transported to the laboratory for volumetric deposit analysis. The aluminum plates were washed with 5 ml of toluene and the amount of dye in the resulting solution was measured colourimetrically. Deposit on the Kromekote cards was determined using a spot-counting system (Hurtig et al. 1953).

Insecticide Residue Analysis

Pre and post-spray samples of water, sediment, fish, coniferous and deciduous foliage, soil, and forest litter were taken in the treatment and control areas to determine the levels and persistance of Permethrin residues. All solid samples were collected, sealed in plastic bags, and frozen until subsequent laboratory analysis was possible. Water samples were extracted in the field and later analyzed in the laboratory.

The pesticide residues were determined by the Technical Department of Chipman Inc. in Stoney Creek, Ontario. The methods used for

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*Permethrin 50% oil concentrate, 500 g AI/ℓ, Chipman Inc.

**Gulf stove oil supplied by Ashland Chemicals

determination of Permethrin residues were similar to those described by Kingsbury and Kreutzweiser (1979), although changes were made in the procedures for residue analysis of whole fish, and are described below.

A representative 25 g sample of whole fish was ground for 3 minutes in the presence of 150 ml 20/80, V/V, acetone/hexane, and 100 g of granular anhydrous sodium sulphate. The ground fish was transferred to a Buchner funnel and filtered through a No. 4 Whatman filter paper into an Erlenmeyer flask by suction. The filtered material was re-extracted a second time in the presence of 50 ml of extraction solvent and filtered as above. The blender container was rinsed twice with 50 ml acetone/hexane and the resulting solution drawn through the previously filtered material, this time to dryness. The extract was placed in a round bottomed flask and evaporated to dryness, then transferred quantitatively to a graduated centrifuge tube and made up to 10.0 ml with hexane, from which a 1.0 ml portion was taken and allowed to percolate into a florisil column at the rate of 1 ml/min. The column was washed with 30 ml of hexane and the eluate discarded. The eluate collected from a further washing with 100 ml of a 50% diethyl ether in hexane solution was reduced to 2.0 ml for analysis. A 7.5 µl aliquot of this elute was injected into a gas chromatograph and a measurement of the peak height at the retention time of Permethrin was recorded. Calculation of Permethrin residue levels were made using the following expressions:

$$\text{Residue } (\mu g/g) = \frac{PK(s) \times M(P) \times V(s)}{PK(p) \times I(s) \times M(s)}$$

where PK(s) = sample peak height in millimetres

PK(p) = reference standard peak height in millimetres

V(s) = solvent volume in sample solution in millimetres

M(p) = Permethrin weight injected in reference standard in micrograms

I(s) = sample solution injection volume in millimetres

M(s) = weight of crop equivalent in sample solution in grams

Water Quality and Stream Flow Analysis

Water quality parameters were measured in the streams and ponds at pre- and post-spray intervals using a Hach model AL-36B portable field test kit. Stream flow calculations were made using the following formula:

width (m) x average depth (m) x current velocity (m sec)
= m^3/sec stream flow

Measurements were taken with a metre stick and either a Teledyne Gurley No. 625 Pygmy Current Meter or a Teledyne Gurley No. 665 Direct Reading Current Metre.

Aquatic Biological Sampling

Drifting Organisms. Numbers of drifting invertebrates in the study streams were monitored with the use of drift nets before and after the spray application. The nets, measuring 0.47 x 0.32 m, were positioned in the streams to collect drifting organisms from a column of water for a predetermined length of time. The nets were placed such that a water column was sampled from the surface to the stream bottom where possible, and from the surface to the net bottom where water levels exceeded the height of the net opening. The current velocity and the depth of the water at the net opening were measured and recorded with each sample. The collected organisms were picked from the samples and preserved in 30% methanol to be counted and identified in the laboratory. The resulting numbers were then quantified and expressed as organisms per cubic metre of water using the following formula:

$$\frac{\text{number of organisms collected}}{\text{depth of water column sampled (m) x width of net opening (0.47 m) x current velocity (m/sec) x sample duration (sec)}}$$

Drift samples were taken twice daily, morning and evening, before and after the spray, and at more frequent intervals immediately following the treatment.

Benthic organisms. Because of the unsuitable bottom type, water depth, and stream flow at the tributary and Upstream stations, bottom fauna populations were measured quantitatively only at the Downstream and Control sites with the use of 0.093 m^2 Surber samplers (Surber 1936) and random rock collections. The Surber samples were picked immediately and preserved in 30% methanol and subsequently counted, identified and tabulated as mean number and standard deviation of four samples. Organisms collected from four randomly chosen rocks (approximately 15 cm in diameter) at the stations were used to supplement the bottom fauna population assessment. The invertebrates were picked and documented in the same way as described for Surber sampling.

Clay bricks were placed on the stream bottom at the tributary and Upstream stations to provide artificial substrate for colonizing invertebrates, and were collected at specific intervals before and after the application.

Caged invertebrates. Three groups of aquatic insects were exposed to the application in small submerged holding cages placed in the Upstream and Downstream stations

and Control. The cages consisted of 30 cm lengths of 10 cm diameter ABS tubing, screened at both ends, and fitted with a removable top section. Several small stones were laid in the tubes to provide substrate for the invertebrates. Caddisfly larvae (Trichoptera), dragonfly nymphs (Odonata: Anisoptera), and stonefly nymphs (Plecoptera) were counted and separated into several cages. The cages were placed in the streams in a position that allowed the water to flow through them, and were periodically checked for insect mortality after the Permethrin application.

Caged fish. Wire cages containing yellow perch, *Perca flavescens* (Mitchell) 10 to 15 cm in length, angled from a nearby lake were submerged at the Upstream, Downstream, P1, and Control stations prior to the Permethrin application and left for the duration of the post-spray sampling period. The cages were periodically checked for indications of fish mortality, and several specimens were collected from each location at specific post-spray intervals for laboratory analysis of pesticide accumulation.

Terrestrial Biological Sampling

Aboreal and flying invertebrates. Terrestrial insect knockdown over the treatment streams was measured quantitatively with the drift nets. Terrestrial organisms were separated from the drift samples, counted, identified, and recorded as number of organisms per $10m^2$ of surface water flowing through the net, calculated as follows:

$$\frac{\text{number of organisms}}{\text{width of net opening (0.47 m) x current velocity (m/sec)}}$$

x sample duration (sec) x 10

Plastic sampling buckets measuring 39 x 32 x 15 cm were used to collect and quantitatively assess the knockdown of non-target aboreal and flying invertebrates. In the three peripheral sampling areas of the treatment block (T1, T2, T3), the samples (5 at each location) were placed under coniferous or deciduous canopy foliage. The organisms were collected each evening prior to and following the Permethrin application, counted, identified and presented as the number of organisms per sampler, either of knockdown from coniferous foliage or of knockdown from deciduous foliage. A similar arrangement of collections and assessment was made in the control area.

A series of sampling buckets were also placed in a fourth area within the treatment block (T4). Fifteen samplers were set at 10 m intervals on a randomly selected compass transect located near the centre of the treated area. The invertebrates from these samplers were collected each evening before and after the spray, and were

counted, identified, and recorded as the number of organisms per sampler.

Ground dwelling invertebrates. The level of activity of ground dwelling invertebrates in the treatment and control areas was monitored prior to and at intervals following the Permethrin application with the use of pitfall traps. The traps consisted of plastic containers measuring 12 cm x 12 cm set in the forest litter such that the edges of the containers were flush with the surface of the litter. A small amount of a weak salt and detergent solution was added to the traps to act as a killing agent preventing escape of collected organisms. Ten traps were placed at approximately 7 m intervals on an arbitrarily chosen trap-line in each of three treated sample areas (T1, T2, T3), and control. The containers were emptied every evening of the sampling period, and the invertebrates were preserved in 30% methanol for subsequent counting and identification.

Although the samples contained significant numbers of foliage-inhabiting and flying invertebrates as well as ground dwelling organisms, only those included in the Araneida, Hymenoptera (Formicidae), Coleoptera, and Phalangida invertebrate groups were selected for this study. Previous investigations by Hydorn (1979), Varty (1977), and Buckner et al. (1974) have identified these particular taxa as potential indicators of ground dwelling invertebrate activity and pesticide effects.

Small mammals. Small mammal populations were sampled over a five day period in both the treated (T4) and control areas before and after the application. One hundred snapback kill traps were baited with a mixture of rolled oats and peanut butter, and set at approximately 5 m intervals in both areas, prior to the spray. A post-spray sample consisting of 300 traps in T4 and 200 traps in control was taken 36 to 40 days after the application. All animals were preserved in 10% formalin and returned to the laboratory for identification, aging, sexing, and determination of breeding condition.

RESULTS

Insecticide Deposit

The amount of insecticide deposited on or adjacent to the stream stations within the treatment block varied from a colourmetric analysis of 7.53 to 17.81% and a spot counting determination of 3.36 to 33.49% of deposition of the emitted spray. The percent spray deposited on the headwater ponds was calculated as high as 83.49%, while the terrestrial sampling areas received from 3.39 to 30.39%. The highest droplet densities and largest droplet sizes occurred in the relatively open areas of the ponds and Upstream station, and fewer

numbers and smaller sizes of droplets reached the samplers at the tributary stations. Complete deposit analysis results from the treatment area are listed on Table 2. No Permethrin deposits were found on sample cards placed in the control area.

Insecticide Residues

Insecticide residues in standing water peaked 1 to 6 hours after the application at levels of 147 and 121 µg/ℓ, and dissipated to non-detectable amounts after 6 to 24 hours. Measureable quantities of pesticide were found in the treated streams immediately after the spray and reached a level of 2.5 µg/ℓ at the Upstream station 1 hour post-spray. Other determinations of residues in the treated streams ranged from 0.05 to 0.89 µg/ℓ and persisted for a maximum of 96 hours. Permethrin residues appeared 2.1 km downstream from the treatment block at 6 hours postspray, reached a peak of 0.18 µg/ℓ at 12 hours and did not persist beyond 96 hours. Sampling at the Flynne Creek station located 2.9 km downstream from the treatment area and below the confluence with the treated stream, indicated only a trace (0.07 µg/ℓ) of pesticide 12 hours after the application. No detectable amounts of Permethrin were found in the control pond or stream throughout the sampling period (Table 3).

Accumulations of insecticide in pond sediment were minimal (0.005 to 0.008 µg/g) and persisted for less than 7 days. No Permethrin residues were found in stream sediments (Table 4). Yellow perch exposed to the application in wire cages set in ponds and streams did not accumulate detectable amounts of insecticide during the sampling period (Table 5).

Levels of Permethrin residues found in coniferous tree foliage ranged from 0.04 to 0.30 µg/g and persisted at a concentration of 0.05 µg/g to the end of the sampling period (57 days post-spray). Deciduous foliage also contained residue levels ranging from 0.02 to 0.78 µg/g and retained a concentration of 0.02 µg/g for at least 57 days (Table 6).

The amounts of pesticide accumulated in exposed soil in the treatment block were fairly consistent (0.04 to 0.07 µg/g) and although the residues disappeared in one sample area after 14 days, the level of Permethrin concentration remained stable in the other sample area to the end of the 58 day sampling period (Table 7).

Forest litter from within the treatment block contained 0.04 to 0.21 µg/g of Permethrin residue after the pesticide application, and remained at a relatively high level (0.07 µg/g) at least 58 days (Table 8).

Table 2
Deposit analysis of 17.5 g AI/ha Permethrin applied at an emission rate of 1.46 l/ha to treatment block
Longlac, Ontario
24 June 1979

		Colourimetric Analysis		Spot Counting Analysis		Mean Density $_2$ (Drops per cm^2)	Mean Droplet Diameter Deposited (μ)
		l/ha	% deposit	l/ha	% deposit		
Shaft Creek East Tributary							
	Instream	0.11	7.53	0.07	4.32	4.73	66.3
	Shoreline	0.12	8.22	0.08	5.20	4.21	69.1
West Tributary							
	Instream	0.12	8.22	0.05	3.36	4.07	63.2
	Shoreline	0.17	11.64	0.05	3.36	4.34	63.6
Upstream							
	Instream	0.16	10.96	0.49	33.49	19.34	80.4
	Shoreline	0.26	17.81	0.40	27.12	18.19	79.1
Downstream							
	Instream	0	0	0	0	-	-
	Shoreline	0	0	0	0	-	-
Headwater Pond	P1	0.75	51.37	1.20	82.26	68.02	82.7
	P2	1.00	68.49	1.22	83.49	59.58	79.0
Terrestrial Sampling Area	T1	0.44	30.14	0.44	30.39	15.96	84.3
	T2	0.20	13.70	0.12	8.13	5.55	80.3
	T3	0.20	13.70	0.05	3.39	1.02	80.3
	T4	0.30	20.55	0.19	13.14	8.37	72.7

Table 3
Permethrin residues* found in ponds and streams
Longlac, Ontario
12 June to 1 July 1979

Sample Period	Control Pond	P1	P2	Control Stream	Shaft Cr. East Trib.	Shaft Cr. West Trib.	Shaft Cr. Upstream	Shaft Cr. Downstream	Flynn Creek
Prespray		ND	ND	ND	ND	ND	ND	ND	-
1/2 hr postspray	-	-	-	-	0.13	0.41	0.06	ND	-
1 hr postspray	-	147.0	110.0	-	ND	0.10	2.50	ND	-
3 hr postspray	-	-	-	-	0.22	0.07	0.89	ND	ND
6 hr postspray	ND	ND	121.0	ND	0.11	0.06	ND	0.05	ND
12 hr postspray	-	ND	78.0	-	0.09	0.05	ND	0.18	0.07
24 hr postspray	**ND**	ND	0.20	ND	ND	0.06	ND	ND	ND
48 hr postspray	ND	ND	ND	ND	ND	ND	ND	ND	ND
96 hr postspray	ND	ND	ND	ND	ND	0.10	ND	0.05	ND
168 hr postspray	ND	ND	ND	ND	ND	ND	ND	ND	ND

*expressed as µg/l
Limit of detection = 0.05 µg/l
ND = No detectable quantity

Table 4
Permethrin residues* found in pond and stream sediment
Longlac, Ontario
11 June to 20 August 1979

Sample Period (Days)	Control Pond	P1	P2	Control Stream	Shaft Crk East Trib.	Shaft Crk Upstream	Shaft Crk Downstream
Prespray	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
1/4 postspray	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
1 postspray	-	N.D.	0.008	N.D.	N.D.	N.D.	N.D.
4 postspray	N.D.	0.005	0.007	-	N.D.	N.D.	N.D.
7 postspray	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
14 postspray	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
23 postspray	-	N.D.	N.D.	-	N.D.	N.D.	N.D.
36 postspray	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
58 postspray	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.

*expressed as µg/l
Limit of detection 0.004 µg/l
N.D. = No Detectable Quantity

Table 5
Permethrin residues* found in caged fish
Longlac, Ontario
11 June to 30 July 1979

Sample Period (Days)	Control Pond	P1	Control Stream	Shaft Crk Upstream	Shaft Crk Downstream
Prespray	N.D.	-	-	-	-
1 postspray	N.D.	-	N.D.	N.D.	N.D.
5 postspray	-	N.D.	-		-
7 postspray	-	-	-	N.D.	-
8 postspray	N.D.	N.D.	N.D.	N.D.	N.D.
14 postspray	N.D.	N.D.	N.D.	N.D.	N.D.
23 postspray	-	-	-	N.D.	-
36 postspray	-	-	N.D.	N.D.	-

*Expressed as µg/g
Limit of Detection 0.01 µg/g
N.D. = No Detectable Quantity

Table 6
Permethrin residues found in coniferous and deciduous foliage
Longlac, Ontario
11 June to 20 August 1979

Sample Period (Days)	Coniferous Control	Coniferous Treated	Deciduous Control	Decidous Treated
Prespray	N.D.	N.D.	N.D.	N.D.
1/4 postspray	N.D.	0.06	N.D.	0.18
1 postspray	N.D.	0.30	N.D.	*0.78
4 postspray	-	0.30	-	0.55
7 postspray	N.D.	0.30	N.D.	0.63
14 postspray	N.D.	0.23	N.D.	0.53
23 postspray	-	0.09	-	0.37
36 postspray	N.D.	0.04	N.D.	0.22
57 postspray	N.D.	0.05	N.D.	0.02

*Expressed as µg/g
Limit of Detection 0.01 µg/g
N.D. = No Detectable Quantity

Table 7
Permethrin residues found in soil
Longlac, Ontario
11 June to 20 August 1979

Sample Period (Days)	Control	T2	T3
Prespray	N.D	N.D.	N.D.
1/4 postspray	N.D.	0.05	0.04
1 postspray	N.D.	0.07	N.D.
4 postspray	-	0.06	0.04
7 postspray	N.D.	N.D.	N.D.
14 postspray	N.D.	0.04	0.07
23 postspray	-	N.D.	N.D.
36 postspray	N.D.	N.D.	N.D.
58 postspray	N.D.	0.05	N.D.

*Expressed as µg/g
Limit of Detection 0.004 µg/g
N.D. = No Detectable Quantity

Table 8
Permethrin residues found in forest litter
Longlac, Ontario
11 June to 20 August 1979

Sample Period (Days)	Control	T2	T3
Prespray	N.D	N.D.	N.D.
1/4 postspray	N.D.	0.05	0.11
1 postspray	N.D.	0.10	0.13
4 postspray	-	0.09	0.06
7 postspray	N.D.	0.19	0.21
14 postspray	N.D.	0.04	0.19
23 postspray	-	0.12	0.12
36 postspray	N.D.	0.15	0.04
58 postspray	N.D.	0.07	0.07

*Expressed as µg/g
Limit of Detection 0.004 µg/g
N.D. = No Detectable Quantity

Water Quality and Stream Flow Analysis

Water quality parameters measured in the streams and ponds are listed on Table 9. Levels of dissolved oxygen were generally found to be suitable for supporting aquatic fauna, although during periods of reduced water levels and increased temperatures, concentrations as low as 4.0 to 5.0 mg/ℓ were present at some sample stations. The pH values recorded ranged from 6.8 to 9.0 and reflected similarly high readings for total alkalinity and hardness (68.4 to 256.5 mg/ℓ $CaCO_3$).

Stream flow calculations were made only within an 8 day period of the application date, and were found to be relatively stable (Table 10). According to recorded field notes, the volume of discharge at each station began to decline noticeably approximately 10 days after the spray, and by the 23 day post-spray sampling date (17 July, 1979), had been reduced to an extent that the discharge was immeasurable. Thirty-six days after the application (30 July 1979), the streams had returned to near normal summer levels.

Aquatic Biological Sampling

Drifting organisms. Although no quantitative invertebrate sampling was carried out in the treatment ponds, observations of insect activity following the pesticide application were recorded. Numbers of distressed backswimmers (Hemiptera: Notonectidae), water boatmen (Hemiptera:Corixidae), and water striders (Hemiptera:Gerridae) appeared on the surface of the ponds shortly after the application. A 3 hour post-spray visual check showed several predacious diving beetles (Coleoptera:Dytiscidae) distressed on the pond surfaces. Twenty-four hours after the spray, a number of adult dragonflies (Odonata:Anisoptera) were found lying on the surface of the ponds.

All three stream stations within the treatment block demonstrated an increase in drifting organisms ranging from 2.3 to 13.7 times greater than the pre-spray average, immediately following the application (Fig. 5). The number of drifting organisms had returned to pre-spray levels within 6 hours.

West Tributary showed the greatest increase in drift of the three treated stations, with a 1 hour post-spray peak 13.7 times higher than the pre-spray average. The greatest proportion of the increased drift (28.2-79.9%) was comprised of stonefly (Plecoptera) nymphs, which had been completely absent from the drift prior to the Permethrin application. Caddisfly larvae (Trichoptera), predacious diving beetle larvae and riffle beetle adults (Coleoptera:Elmidae) also demonstrated noticeable, though less dramatic, increases in drift. A complete compilation of the drift sampling results from West Tributary is included in Appendix Table A-1.

Table 9
Summary of water quality parameters
Longlac, Ontario
20 June to 20 August 1979

Sample Station	Date '79	Temp °C	O_2 mg/l	pH	mg/l $CaCO_3$	Hardness mg/l $CaCO_3$
Control	20 June	10.0	10.0	8.5	153.9	171.0
	2 July	11.5	8.0	8.2	188.1	188.1
	7 July	13.0	9.0	9.0	222.3	205.2
	17 July	9.0	9.0	8.5	256.5	256.5
	30 July	13.0	8.0	8.0	-	205.2
	20 Aug.	12.0	9.0	8.9	205.2	222.3
Shaft Creek East Tributary	14 June	12.0	10.0	8.2	119.7	119.7
	2 July	13.5	9.0	8.2	153.9	153.9
	17 July	13.0	4.0	8.0	171.0	188.1
	30 July	14.0	8.0	8.0	-	153.9
West Tributary	14 June	8.5	9.0	8.0	102.6	102.6
	2 July	9.0	9.0	8.0	119.7	136.8
	17 July	8.0	7.0	8.5	153.9	158.9
	30 July	12.0	7.0	7.7	-	171.0
Upstream	14 June	11.0	10.0	8.5	102.6	119.7
	2 July	13.0	9.0	8.2	136.8	136.8
	17 July	14.0	6.0	8.0	153.9	171.0
	30 July	14.0	8.0	7.7	-	153.9
Downstream	20 June	-	9.0	8.5	136.8	171.0
	2 July	12.5	10.0	9.0	153.9	171.0
	7 July	13.0	10.0	9.0	171.0	153.0
	17 July	13.0	8.0	9.0	222.3	205.2
	30 July	14.5	9.0	8.3	-	153.9
	20 Aug.	15.0	10.0	8.7	119.7	136.8
P1	14 June	9.0	7.0	7.7	85.5	68.4
	2 July	19.0	8.0	7.7	119.7	119.7
	30 July	20.0	6.0	7.2	-	136.8
P2	14 June	14.0	6.0	7.5	102.6	119.7
	2 July	23.0	6.0	7.8	136.8	153.9
	30 July	18.0	5.0	6.8	-	153.9

Table 10
Summary of stream flow calculations
Longlac, Ontario
20 June to 28 June 1979

Sample Station	Date (1979)	Volume of discharge (m^3/sec.)
Control	20 June	0.03
	24 June	0.04
	28 June	0.04
Shaft Creek East Tributary	20 June	-
	24 June	0.04
	28 June	0.04
West Tributary	20 June	0.03
	24 June	0.02
	28 June	0.02
Upstream	20 June	0.07
	24 June	0.05
	28 June	0.08
Downstream	20 June	0.13
	24 June	0.12
	28 June	0.14

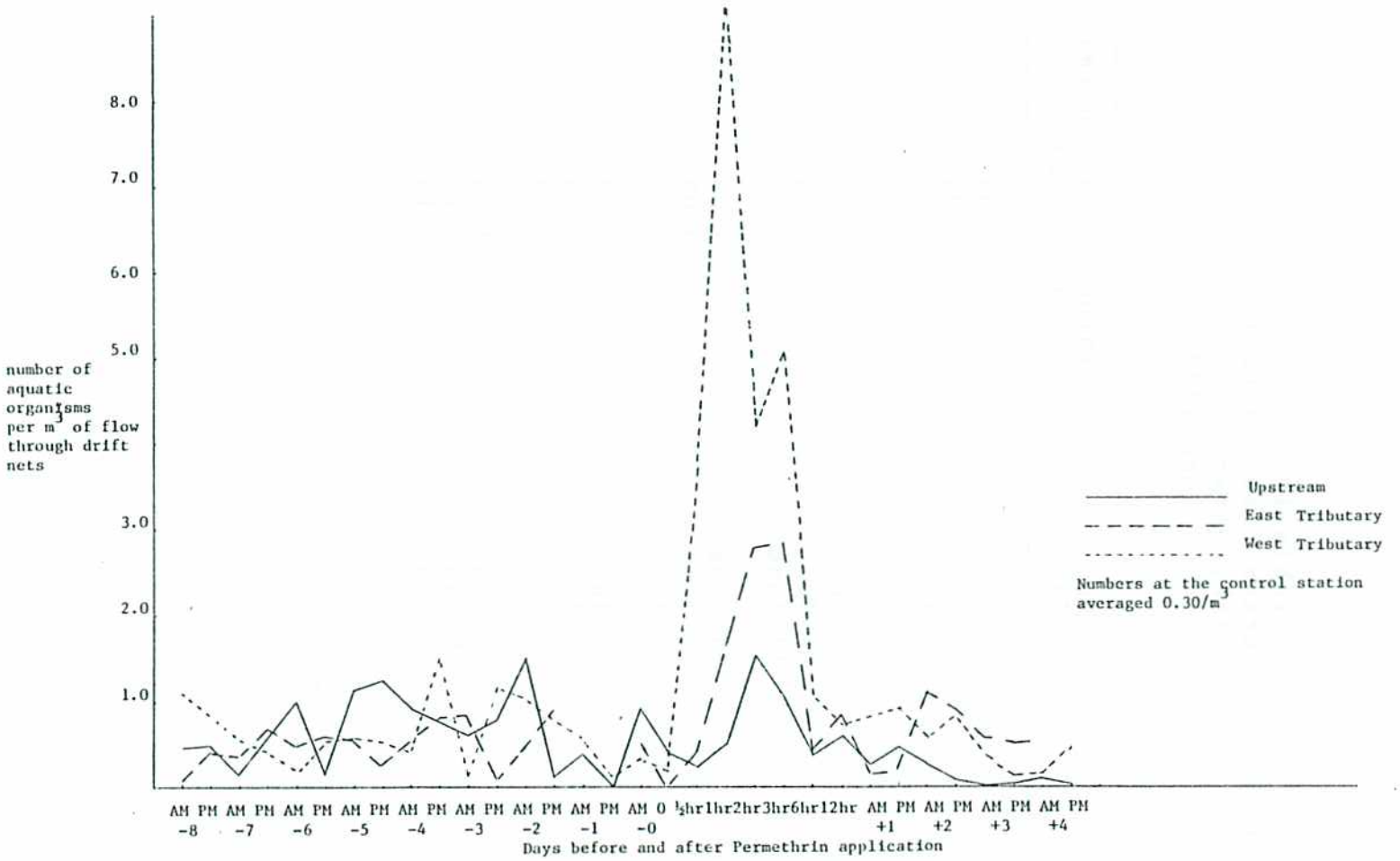

Figure 5. Aquatic organisms caught in drift nets set in Shaft Creek, Longlac, Ontario, 16 June to 28 June 1979

The number of drifting organisms in East Tributary also increased immediately after the pesticide application, but to a lesser extent. The 3 hour post-spray peak attained a level 5.5 times higher than the pre-spray average. Mayfly nymphs (Ephemeroptera:Heptageniidae and Baetidae) were not present in the drift prior to the application but appeared 1/2 to 6 hours after the spray and comprised 25.0 to 87.2% of the total number of drifting organisms. Chironomid larvae (Diptera:Chironomidae), also increased from a pre-spray average of $0.04/m^3$ to a 3 hour post-spray peak of $1.40/m^3$. Appendix Table A-2 outlines the drift sampling results in detail.

The number of drifting organisms at the Upstream stations increased only slightly after the Permethrin application with a post-spray peak reaching 2.3 times higher than the average pre-spray level. Although the total number of organisms did not change substantially, a noticeable increase was evident among several invertebrate groups including water boatmen, water striders, ripple bugs (Hemiptera: Velliidae), and riffle beetles. More detailed results from drift sampling at the Upstream station are summarized in Appendix Table A-3.

Twelve hours after the Permethrin application the number of drifting organisms at Downstream station reached a level 110.3 times higher than the pre-spray average (Fig. 6). The peak in drifting invertebrates was comprised almost entirely of Baetid mayfly nymphs (Ephemeroptera:Baetidae), which increased from a pre-spray average of 0.005 to $82.72/m^3$, and stonefly nymphs, which increased from 0.003 to $77.28/m^3$. Virtually all the mayfly and stonefly nymphs found in the drift were in first or early instar stages of development. A return to normal drift levels was documented 24 hours after the application (Appendix Table A-4).

The number of organisms drifting at the control station remained relatively stable throughout the duration of the sampling period, with numbers ranging from 0.0 to 1.57 organisms/m^3 (Appendix Table A-5).

Benthic organisms. The composition of stream bed at the three treatment stations was such that bottom fauna assessment by Surber sampling and rock collection was not possible. Bricks placed in the streams as artificial substrate produced variable results and because of low numbers of organisms colonizing the bricks, did not provide sufficient data to determine a level of impact. The results from brick sampling are listed in Appendix Tables A-6, A-7, and A-8.

Surber and rock samples were taken periodically at the Downstream station and control to monitor bottom fauna populations. Although total numbers were relatively few, Surber sampling at the Downstream station indicated a reduction in bottom dwelling organisms

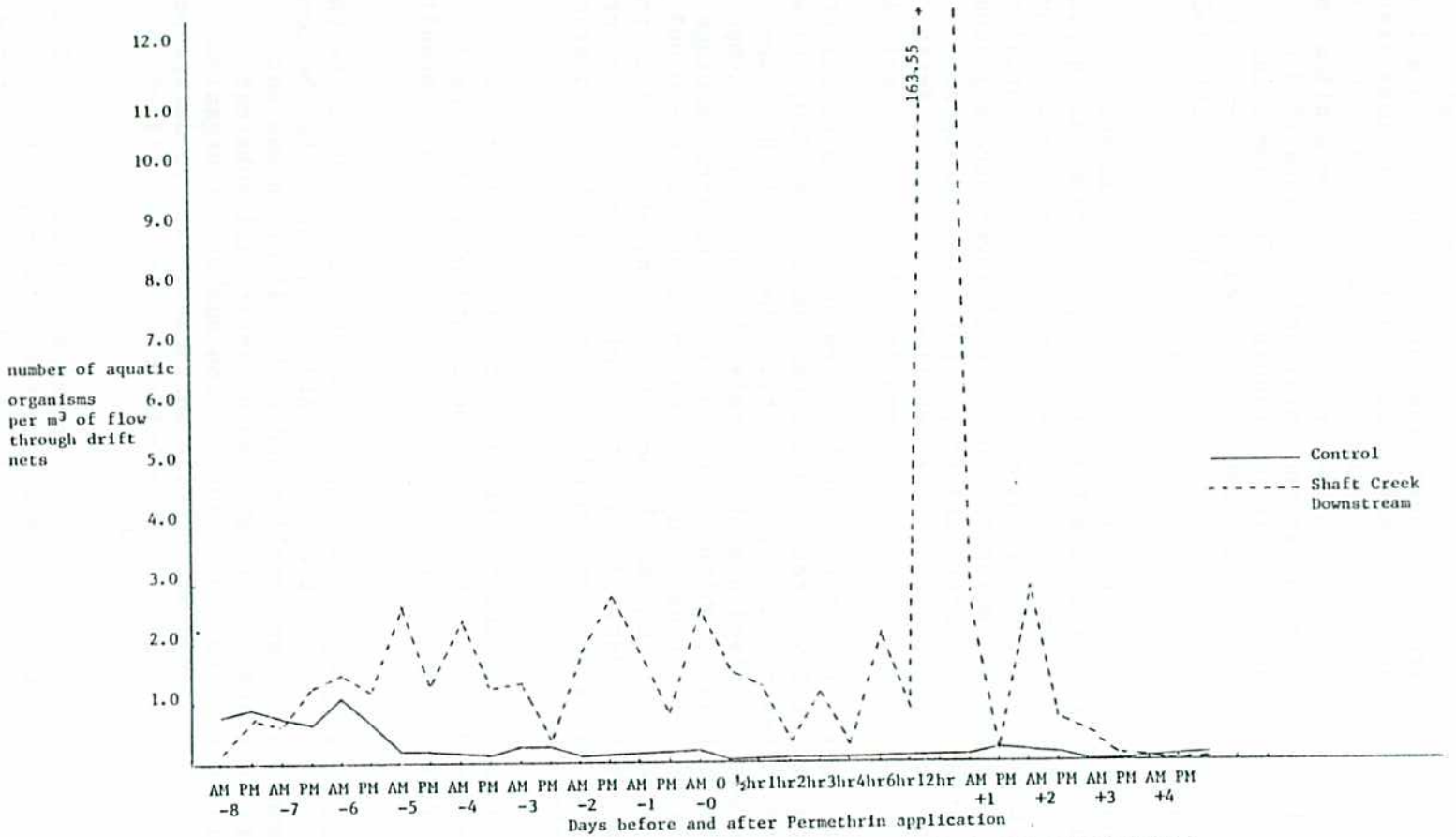

Figure 6. Aquatic organisms caught in drift nets set in Shaft Creek Downstream and untreated control station Longlac, Ontario, 16 June to 28 June 1979

following the Permethrin application (Fig. 7). Bottom fauna populations remained low for at least 13 days, with a return to or above pre-spray levels after 23 days. Chironomid larvae were reduced to the greatest extent from a pre-spray average of 3.26 to a 13 day post-spray average of $0.26/0.093m^2$. Populations at the control stream remained relatively stable throughout most of the sampling period with a definite trend of increasing numbers beginning approximately 10 days after the pesticide application to the treatment block.

A second noticeable reduction in bottom fauna at the Downstream station was evident from Surber sampling 33 days after the spray. This reduction, however, reflected a similar decrease in bottom dwelling organisms in the control stream. Complete Surber sampling results are listed in Appendix Tables A-9 and A-10.

Results obtained from rock sampling at the Downstream station also indicated a noticeable but less dramatic decrease in botton fauna (Fig. 8). A general trend of decline began 3 days after the application and continued for 23 days despite a sharp increase in the number of organisms at the control station beginning 8 days after the pesticide application to the treatment block. A reduction in bottom fauna similar to the decline indicated by Surber sampling 33 days after the spray, was also evident from rock sampling in the Downstream and control stations.

Although total numbers obtained from rock sampling results indicated a gradual decline, specific numbers showed a sharp reduction in the number of Chironomid larva colonizing the rocks. From a prespray average of 61.8 organisms per four rocks, Chironomids were reduced to a 23 day post-spray average of 11.1 per four rocks. Conversely, the number of blackfly larvae colonizing the rocks increased sharply after the pesticide application. Appendix Tables A-11 and A-12 outline rock sampling results in detail.

Caged invertebrates. Caddisfly larvae, stonefly nymphs, and dragonfly nymphs placed in cages at the Upstream and Downstream stations were unaffected by the Permethrin application. No mortalities occurred for at least 4 days after the spray. A loss of certain organisms at the Downstream station 8 days after the spray reflected similar mortalities at the control station (Table 11).

Caged fish. Extensive electro-shocking and trap setting prior to the spray produced no evidence of native fish populations in the study streams. Several specimens of what were apparently sticklebacks, Gasterosteidae, were observed in the treatment streams on two occasions following the application but were not in adequate numbers for sampling. Yellow perch exposed to the application in wire cages at the Upstream and Downstream stations indicated no lethal effects.

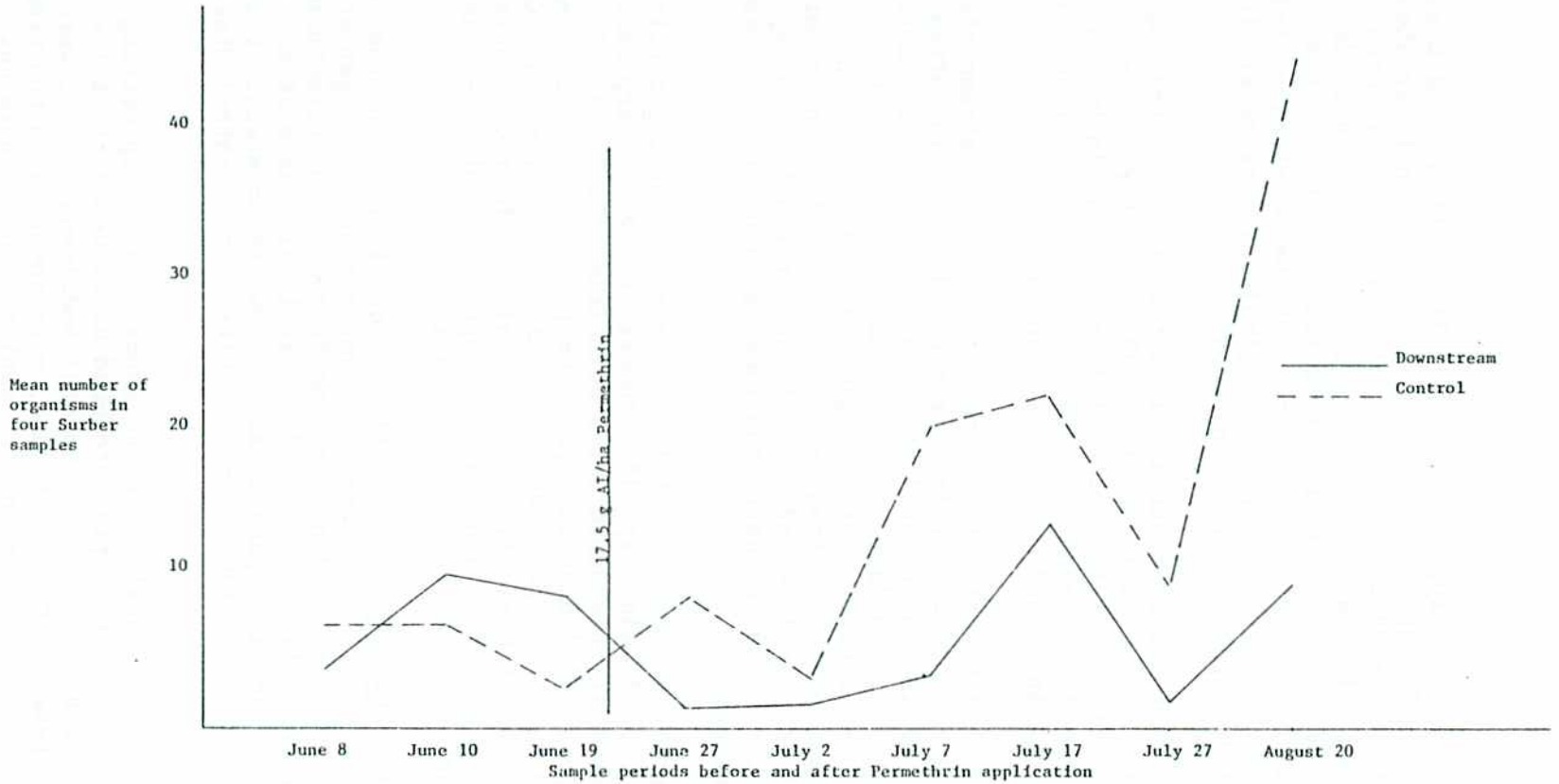

Figure 7 Aquatic invertebrates collected in Surber samples from Shaft Creek Downstream and Control stations, Longlac, Ontario, 8 June to 20 August 1979

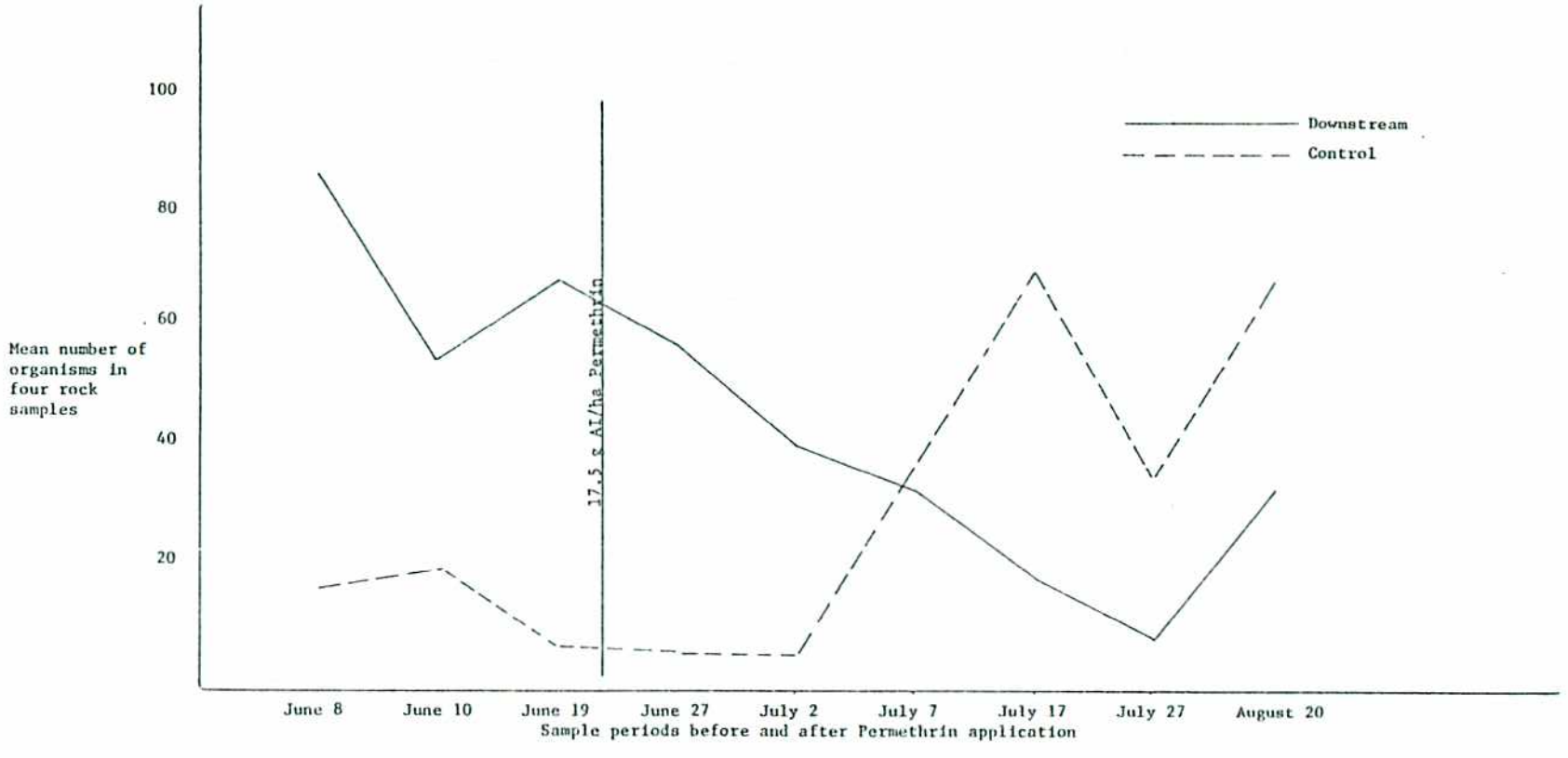

Figure 8: Aquatic invertebrates collected from rocks taken from Shaft Creek Downstream and Control stations, Longlac, Ontario, 8 June to 20 August 1979

Table 11
Results from cage invertebrates
exposed to Permethrin* application
Longlac, Ontario
1979

	Prespray	4 Day Post-spray	8 Day Post-spray
Shaft Creek Upstream			
Caddisfly larvae	22	-	22
Dragonfly nymphs	1	-	0
Stonefly nymphs	4	-	4
Shaft Creek Downstream			
Caddisfly larvae	13	13	4
Dragonfly nymphs	7	7	5
Stonefly nymphs	8	8	6
Control			
Caddisfly larvae	15	-	10
Dragonfly nymphs	4	-	2
Stonefly nymphs	6	-	2

*17.5 g AI/ha Permethrin applied on 24 June 1979

"-" indicates results not recorded

Terrestiral Biological Sampling

Aboreal and flying invertebrates. The Permethrin application to the treatment block resulted in only moderate increases of terrestrial invertebrates floating on the stream surfaces (Appendix Tables A-13, A-14, and A-15). The number of drifting terrestrial organisms did not alter significantly at West Tributary, but did substantially increase at East Tributary and Upstream (Fig. 9). The increases consisted mainly of dipterans and springtails (Collembola) at both stations, as well as fewer but noticeable numbers of adult stoneflies, treehoppers (Homoptera), and spiders (Araneida) at West Tributary, persisting in some instances up to 56 hours (Fig. 10).

Terrestrial invertebrate drift at the Downstream station varied in magnitude both before and after the Permethrin application (Fig. 11). However, noticeable increases in the number of drifting adult dipterans occurred 6 hours after the spray, and in the number of thrips (Thysanoptera) 12 hours after the application. Total drift numbers had returned to minimal pre-spray levels within 36 hours. Appendix Tables A-16 and A-17 specifically outline terrestrial organisms caught in drift nets set in Shaft Creek Downstream and Control.

An increase in terrestrial invertebrate knockdown occurred to some extent in all treated sample areas immediately following the pesticide application, and persisted for less than 36 hours (Fig. 12 and 13). In the 3 selected treatment areas (T1, T2, T3), knockdown from deciduous foliage tended to contain comparable numbers but greater diversification of invertebrates than that from coniferous foliage. This coincided with the pattern of knockdown composition found in the Control plots. The sample transect in T4 area received an invertebrate knockdown similar in content but smaller in magnitude than the other 3 treated plots.

Although the knockdown composition varied to some degree within the sample areas, the most commonly occurring organisms included adult dipterans, hemipterans, and tree hoppers. Peak increases in knockdown exceeded prespray averages by 2.81 to 6.38 times from deciduous foliage, 5.38 to 11.49 times from coniferous foliage, and 5.54 times from the forest canopy on the sample transect. Complete terrestrial knockdown results are listed in Appendix Tables A-18 to A-26.

Ground dwelling invertebrates. Pitfall trapping in T1, T2, T3 and Control plots produced a great number and diversity of ground and foliage dwelling invertebrates as well as flying insects (Appendix Tables A-27 to A-30).

Sampling results from ground dwelling invertebrates selected for this study are presented in Tables 12 and 13. Spiders comprised

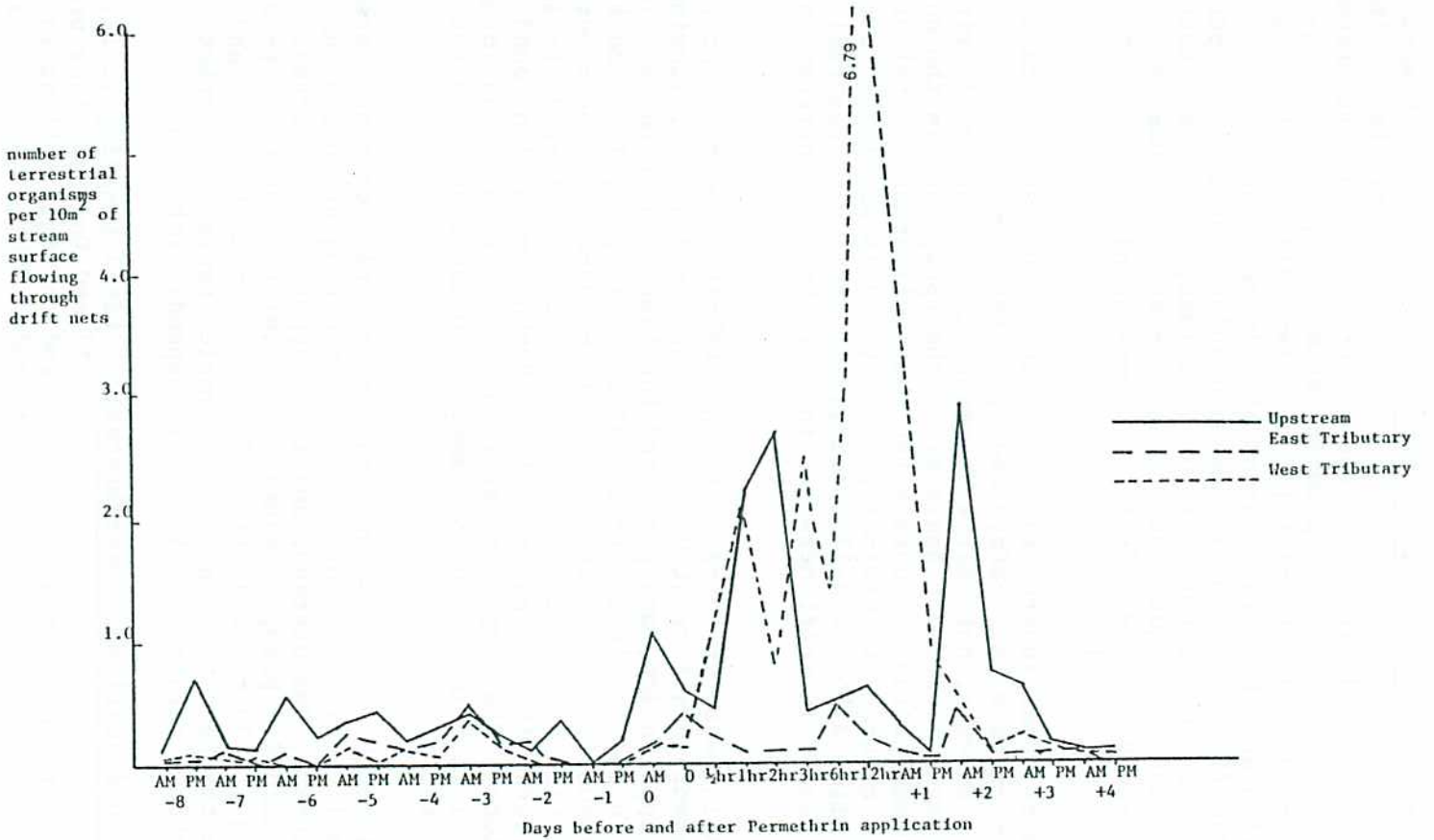

Figure 9. Terrestrial organisms caught in drift nets set in Shaft Creek, Longlac, Ontario, 16 June to 28 June 1979

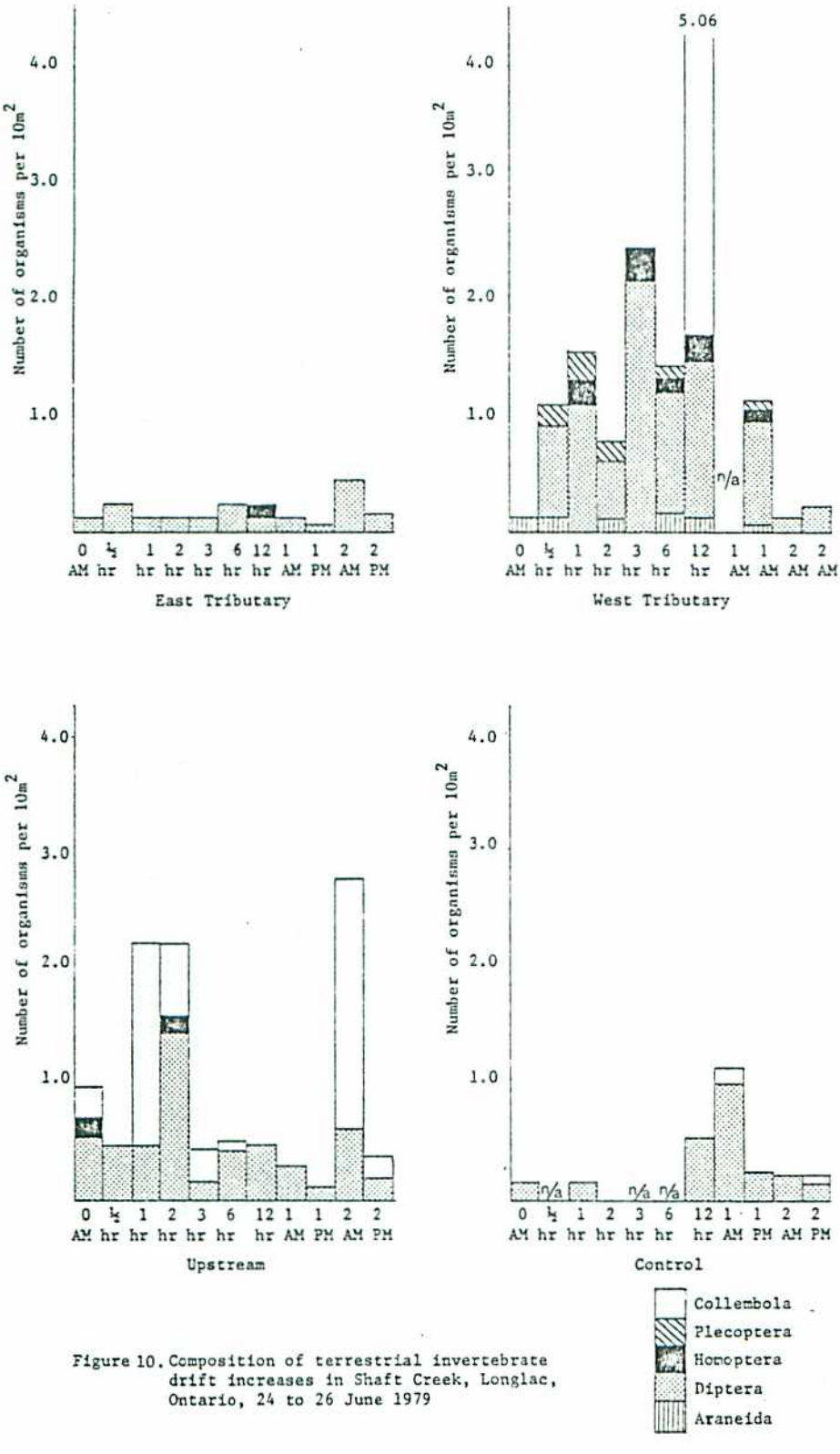

Figure 10. Composition of terrestrial invertebrate drift increases in Shaft Creek, Longlac, Ontario, 24 to 26 June 1979

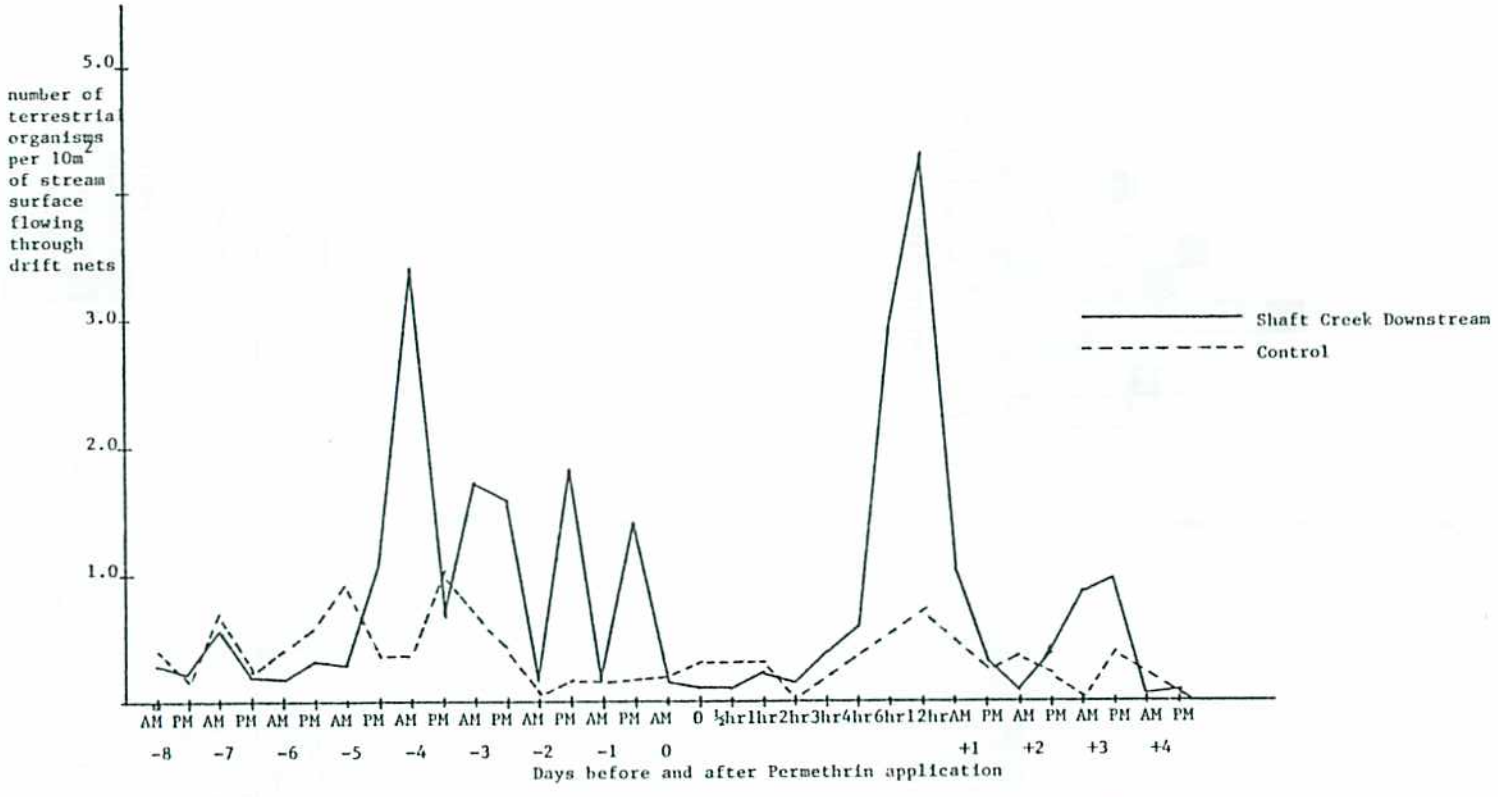

Figure 11. Terrestrial organisms caught in drift nets set in Shaft Creek Downstream and Control, Longlac, Ontario, 16 June to 28 June 1979

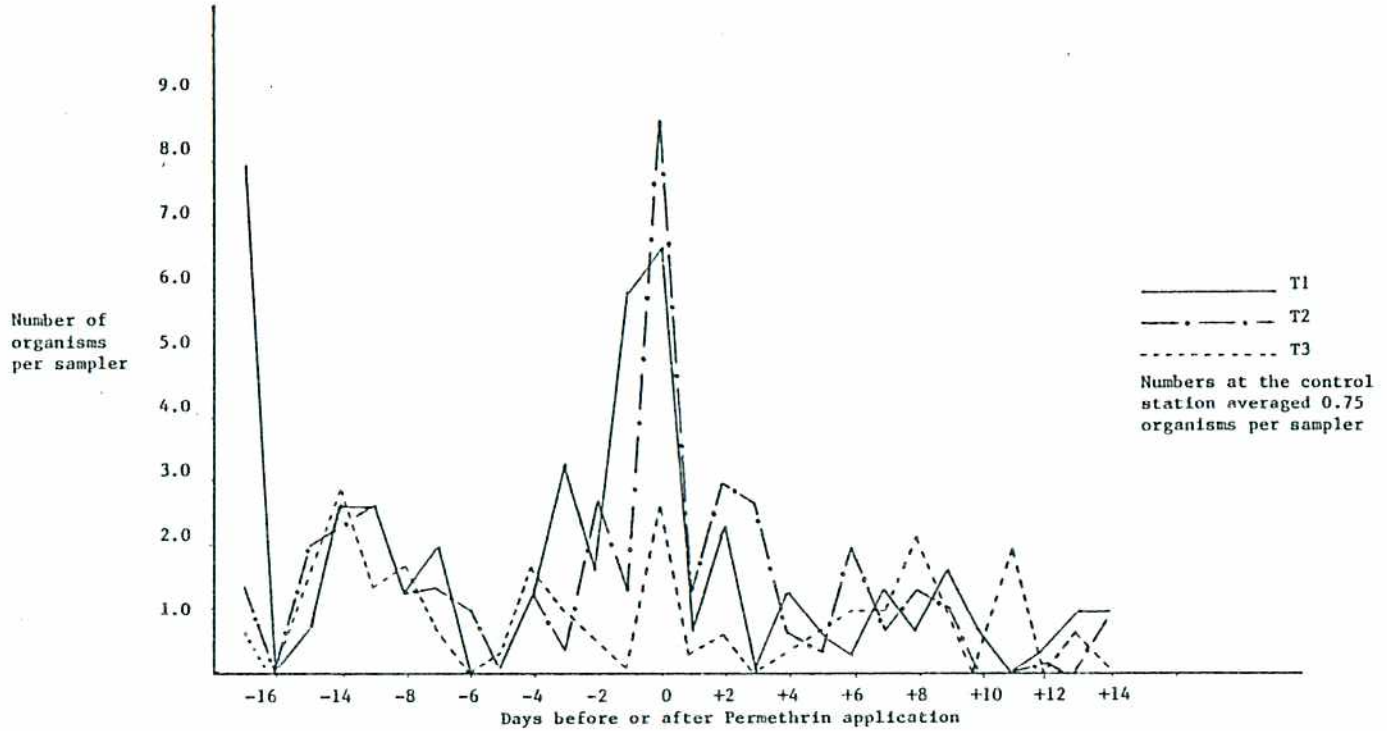

Figure 12. Terrestrial invertebrate knockdown from deciduous foliage in treatment block, Longlac, Ontario
7 June to 8 July 1979

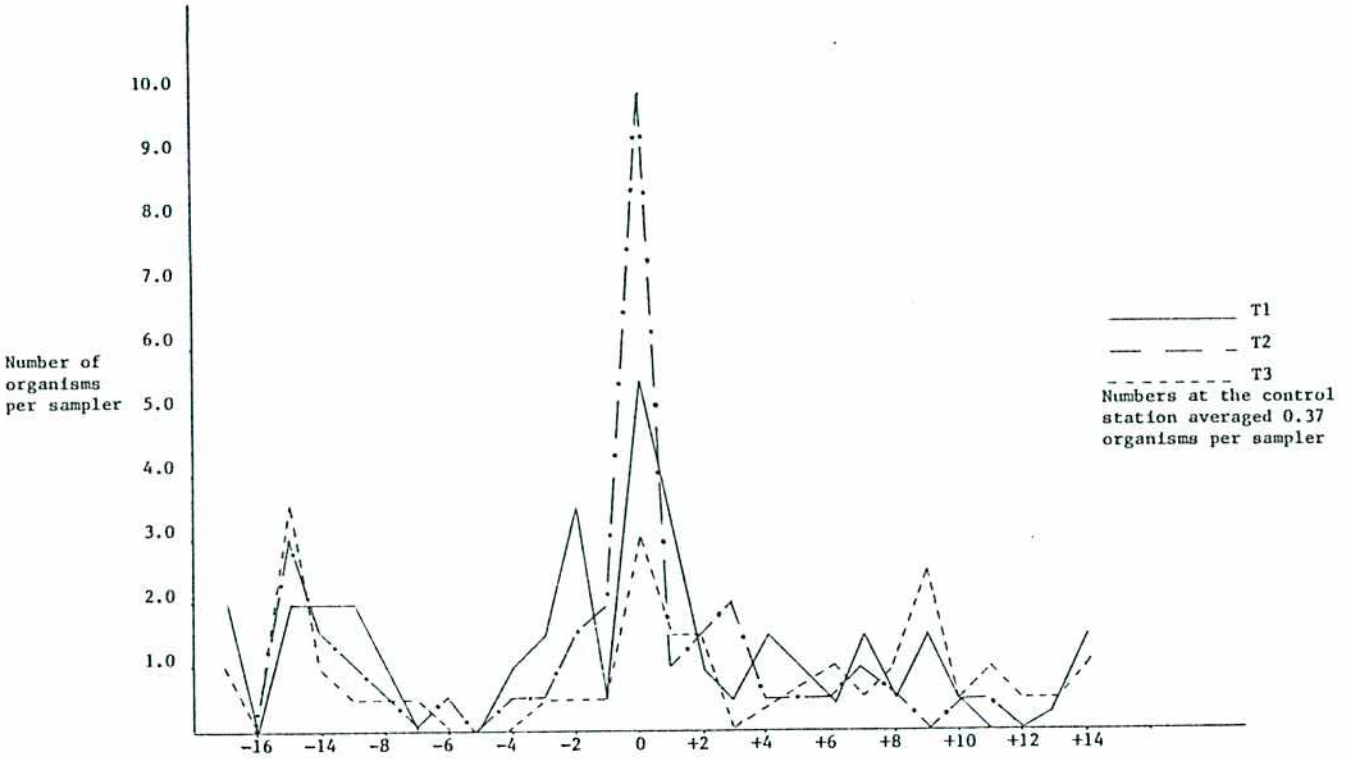

Figure 13. Terrestrial invertebrate knockdown from coniferous foliage in treatment block, Longlac, Ontario 7 June to 8 July 1979

Table 12

Selected terrestrial organisms caught in pitfall traps set in treatment* and control areas, Longlac, Ontario
7 June to 30 July 1979

Date		June 7	8	9	10	June 20	21	22	23	24	25	26	27	28	July 5	6	7	8	July 26	27	28	29	30
T1																							
Phalangida		0	0	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	1	1	1	4	1
Araneida		93	94	47	27	58	14	14	68	38	21	32	37	50	14	33	41	38	187	96	257	59	56
Coleoptera	Carabidae	1	2	8	1	2	0	1	2	3	0	0	1	2	0	0	0	0	3	1	1	4	0
	Staphylinidae	0	1	2	1	2	0	1	0	0	0	1	1	0	0	2	0	0	0	0	0	16	0
	Elateridae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Other	2	3	3	4	2	3	2	0	3	1	4	4	1	0	6	5	1	4	2	5	1	0
Hymenoptera	Formicidae	94	37	34	9	26	1	4	4	18	9	4	10	15	13	22	21	21	53	32	33	36	23
T2																							
Phalangida		1	0	0	1	1	0	0	1	0	0	0	0	0	1	0	0	1	7	1	12	4	4
Araneida		28	80	23	7	0	19	3	32	12	13	13	22	30	18	15	12	33	14	50	0	23	0
Coleoptera	Carabidae	0	1	4	3	4	3	0	0	2	1	3	1	1	0	0	0	2	0	0	3	3	2
	Staphylinidae	1	3	0	0	0	0	0	1	3	1	0	0	0	0	5	0	1	0	1	1	5	0
	Elateridae	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Other	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1	2	0	0	0
Hymenoptera	Formicidae	19	22	13	2	11	8	2	2	8	11	4	3	10	17	7	7	15	10	18	18	9	17
T3																							
Phalangida		0	1	2	1	7	3	1	2	2	2	0	2	1	0	0	0	2	6	4	14	1	2
Araneida		44	36	46	15	43	12	2	12	32	14	21	23	22	21	16	16	17	35	162	205	88	13
Coleoptera	Carabidae	6	2	7	1	6	2	0	1	7	1	1	4	2	4	1	0	2	2	2	1	1	0
	Staphylinidae	1	3	3	0	3	0	0	1	4	2	3	0	0	1	2	1	2	2	3	8	21	4
	Elateridae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
	Other	0	1	1	1	2	2	0	0	2	1	0	4	2	0	0	1	1	0	0	0	1	0
Hymenoptera	Formicidae	55	33	12	3	10	5	1	5	14	7	4	6	6	12	21	20	18	14	6	8	35	14
Control																							
Phalangida		1	0	0	0	0	3	0	1	0	1	0	0	1	2	1	2	6	8	2	3	0	3
Araneida		27	63	64	11	58	27	2	35	59	46	34	87	49	37	30	36	35	22	84	31	47	14
Coleoptera	Caribidae	7	10	3	5	3	4	2	3	1	1	5	4	0	1	0	0	0	0	0	4	3	4
	Staphylinidae	2	8	9	0	5	2	0	3	7	3	5	4	2	1	1	3	2	2	2	2	6	9
	Elateridae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0
	Other	0	6	3	3	2	1	1	0	1	1	0	3	0	2	1	3	3	1	1	2	4	1
Hymenoptera	Formicidae	2	19	11	4	42	22	0	1	7	9	13	17	13	4	12	13	17	5	1	14	49	44

* treated with 17.5 g AI/ha Permethrin, 0705 to 0900 hrs on 24 June 1979

Table 13

Summary of pitfall trapping results for selected organisms caught in treatment* and control areas, Longlac, Ontario
7 June to 30 July 1979

Days before or after Permethrin application		-14 to -11			-4 to -1			+1 to +4			+11 to +14			+32 to +36		
		TOTAL	MEAN	S.D.**	TOTAL	MEAN	S.D.	TOTAL	MEAN	S.D.	TOTAL	MEAN	S.D.	TOTAL	MEAN	S.D.
T1																
Phalangida		0	-	-	3	0.75	0.50	0	-	-	0	-	-	8	1.60	1.34
Araneida		261	65.25	33.63	154	38.50	28.58	140	35.00	12.03	126	31.50	12.12	655	131.00	88.10
Coleoptera	Carabidae	12	3.00	3.37	5	1.25	9.57	3	0.75	0.96	0	-	-	9	1.80	1.64
	Staphylinidae	4	1.00	0.82	3	0.75	0.96	2	0.50	0.58	2	0.50	1.00	16	3.20	7.16
	Elateridae	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-
	Other	12	3.00	0.82	7	1.75	1.26	10	2.50	1.73	12	3.00	2.94	12	2.40	2.07
Hymenoptera	Formicidae	174	43.50	35.93	35	8.75	11.59	38	9.50	4.51	77	19.25	4.19	177	35.40	10.97
T2																
Phalangida		2	0.50	0.58	2	0.50	0.58	0	-	-	2	0.50	0.58	28	5.60	4.16
Araneida		138	34.50	31.63	54	13.50	14.89	78	19.50	8.19	78	19.50	9.33	87	17.40	20.68
Coleoptera	Carabidae	8	2.00	1.83	7	1.75	2.06	6	1.50	1.00	2	0.50	1.00	8	1.60	1.52
	Staphylinidae	4	1.00	1.41	1	0.25	0.50	1	0.25	0.50	6	1.50	2.38	7	1.40	2.07
	Elateridae	0	-	-	1	0.25	0.50	0	-	-	0	-	-	0	-	-
	Other	1	0.25	0.50	0	-	-	2	0.50	0.58	0	-	-	3	0.75	0.96
Hymenoptera	Formicidae	56	14.00	8.83	23	5.75	4.50	28	7.00	4.08	46	11.50	5.26	72	14.40	4.51
T3																
Phalangida		4	1.00	0.82	13	3.25	2.63	5	1.25	0.96	2	0.50	1.00	27	5.40	5.18
Araneida		141	35.25	14.17	69	17.25	17.80	80	20.00	4.08	70	17.50	2.38	503	100.60	81.86
Coleoptera	Carabidae	16	4.00	2.94	9	2.25	2.63	8	2.00	1.41	7	1.75	1.71	6	1.20	0.84
	Staphylinidae	7	1.75	1.50	4	1.00	1.41	5	1.25	1.50	6	1.50	0.58	38	7.60	7.83
	Elateridae	0	-	-	0	-	-	0	-	-	0	-	-	1	0.20	0.45
	Other	3	0.75	0.50	4	1.00	1.15	7	1.75	1.71	2	0.50	0.58	1	0.20	0.45
Hymenoptera	Formicidae	103	25.75	23.20	21	5.25	3.69	23	5.75	1.26	71	17.75	4.03	77	15.40	11.52
Control																
Phalangida		1	0.25	0.50	4	1.00	1.41	2	0.50	0.58	11	2.75	2.22	16	3.20	2.95
Araneida		165	41.25	26.51	122	30.50	23.10	216	54.00	22.93	138	34.50	3.11	198	39.60	27.68
Coleoptera	Carabidae	25	6.25	2.99	12	3.00	0.82	10	2.50	2.38	1	0.25	0.50	11	2.20	2.05
	Staphylinidae	19	4.75	4.43	10	2.50	2.08	14	3.50	1.29	7	1.75	0.96	21	4.20	3.19
	Elateridae	0	-	-	0	-	-	0	-	-	1	0.25	0.50	1	0.20	0.45
	Other	12	3.00	2.45	4	1.00	0.82	4	1.00	1.41	9	2.25	0.96	9	1.80	1.30
Hymenoptera	Formicidae	36	9.00	7.70	65	16.25	19.94	52	13.00	3.27	46	11.50	5.45	113	22.60	22.39

* treated with 17.5 g AI/ha Permethrin, 0705 to 0900 hrs on 24 June 1979

** S.D. - Standard Deviation

the major portion of the selected organisms, followed by ants (Hymenoptera:Formicidae), beetles and harvestmen (Phalangida). Prior to the Permethrin application, trends in the total number of these organisms collected in the treatment and control blocks paralleled each other closely, with a substantial drop in numbers evident 2 days before the spray. During the sampling period 1 to 4 days after the application, numbers in the treated areas declined or remained relatively low while those in the control block increased significantly (Fig. 14, 15 and 16). Eleven to fourteen days following the application, the numbers in T1, T2, and T3 areas reflected similar patterns found in the control area and by 32 days post spray, had paralleled or in two instances had greatly exceeded the number of organisms collected from the control plot.

Small mammals. Very low small mammal populations were encountered throughout the sampling period in both the treatment and control areas. Single adult males of the masked shrew, *Sorex cinereus* Ken, and meadow jumping mouse, *Zapus hudsonius* Zimmerman, an adult female masked shrew in breeding condition, and a juvenile red-backed mole, *Clethrionomys gapperi* Vigors, were the only animals trapped during the pre-spray trap period on the treatment plot. No specimens were trapped during the five day pre-spray trapping period on the control plot (Table 14).

A moderate increase in trap success occurred during the post-spray trap period when a total of 18 small mammals were trapped on the treatment plot and 24 in the control area. A substantial portion of the sample trapped on the treated plot was recorded as young of the year (50 percent on the treated plot, 13 percent on the untreated), and all adult female animals from both areas were in breeding condition.

DISCUSSION AND CONCLUSIONS

Insecticide Deposit

The calculated volumes of the pesticide formulation deposited in the treatment area are comparable to measurements obtained from operational aerial forest pesticide applications. The amount of emitted spray formulation deposited on the sample units placed at ground level generally reflects the extent of the overhead forest canopy. The greatest droplet density and largest droplet sizes occurred at the unobstructed headwater ponds while the tributary stream stations, with a 60-95% canopy cover, received fewer numbers and smaller droplet sizes.

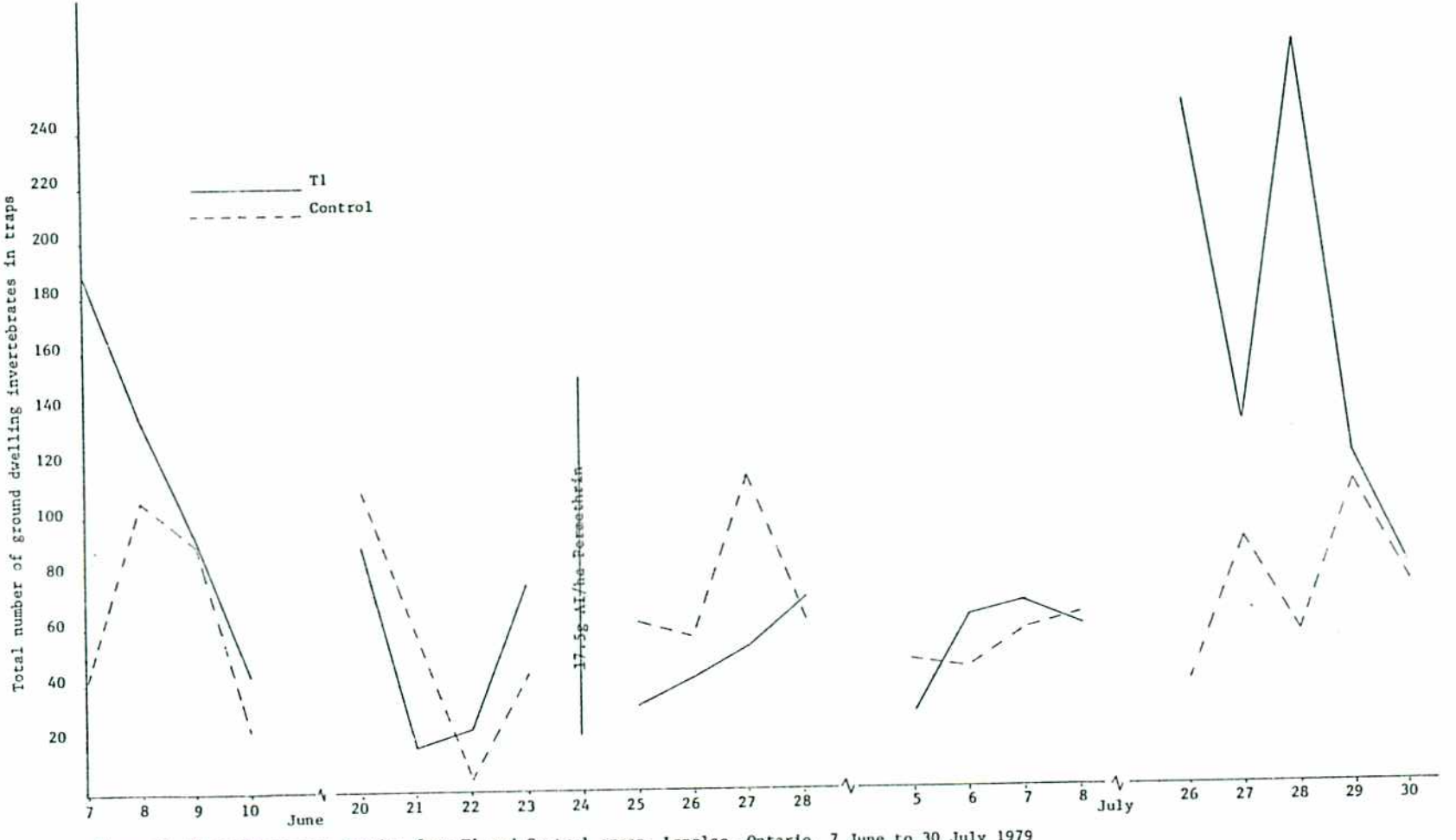

Figure 14. Pitfall trapping results from T1 and Control areas, Longlac, Ontario, 7 June to 30 July 1979

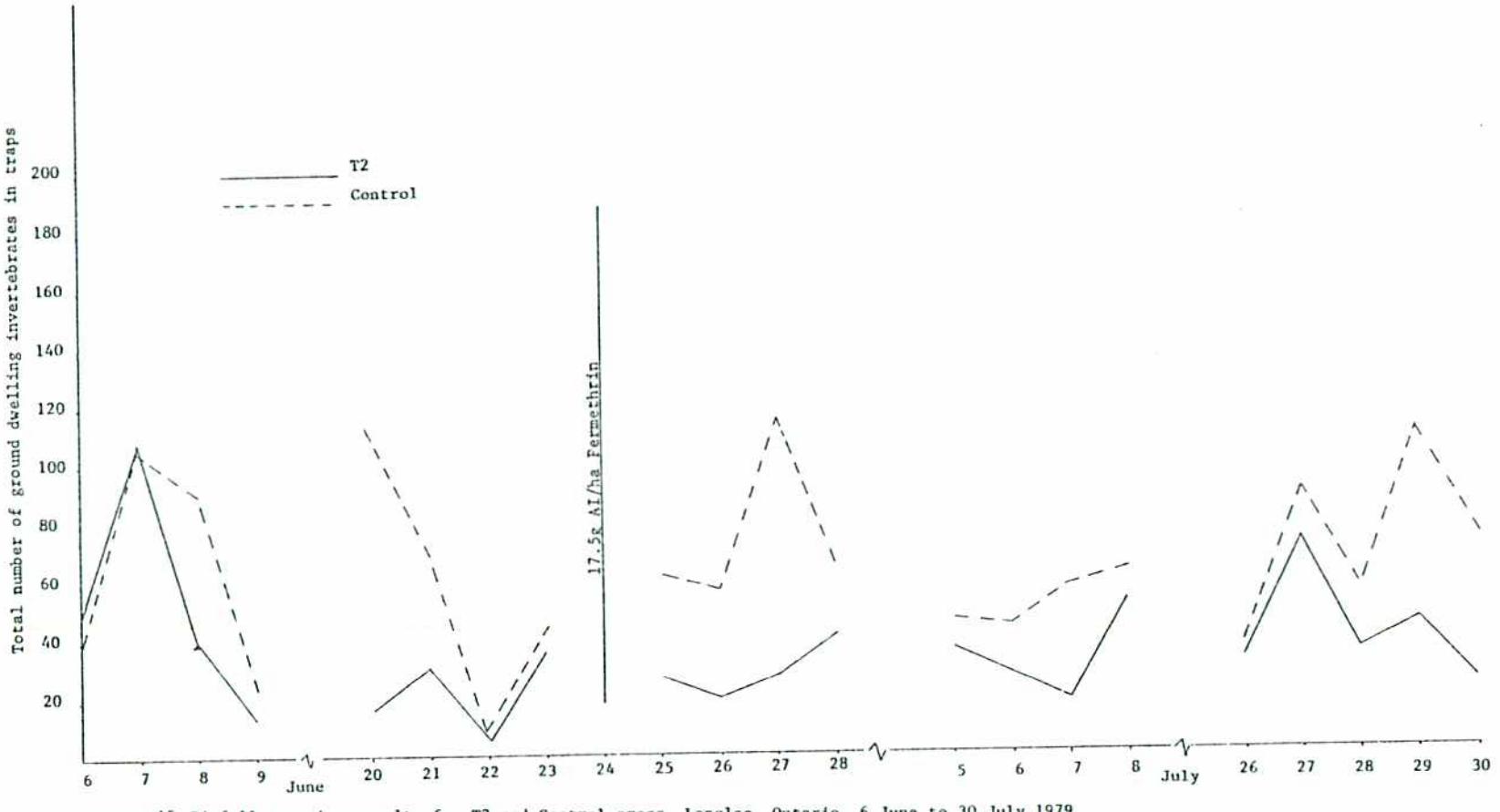

Figure 15. Pitfall trapping results for T2 and Control areas, Longlac, Ontario, 6 June to 30 July 1979

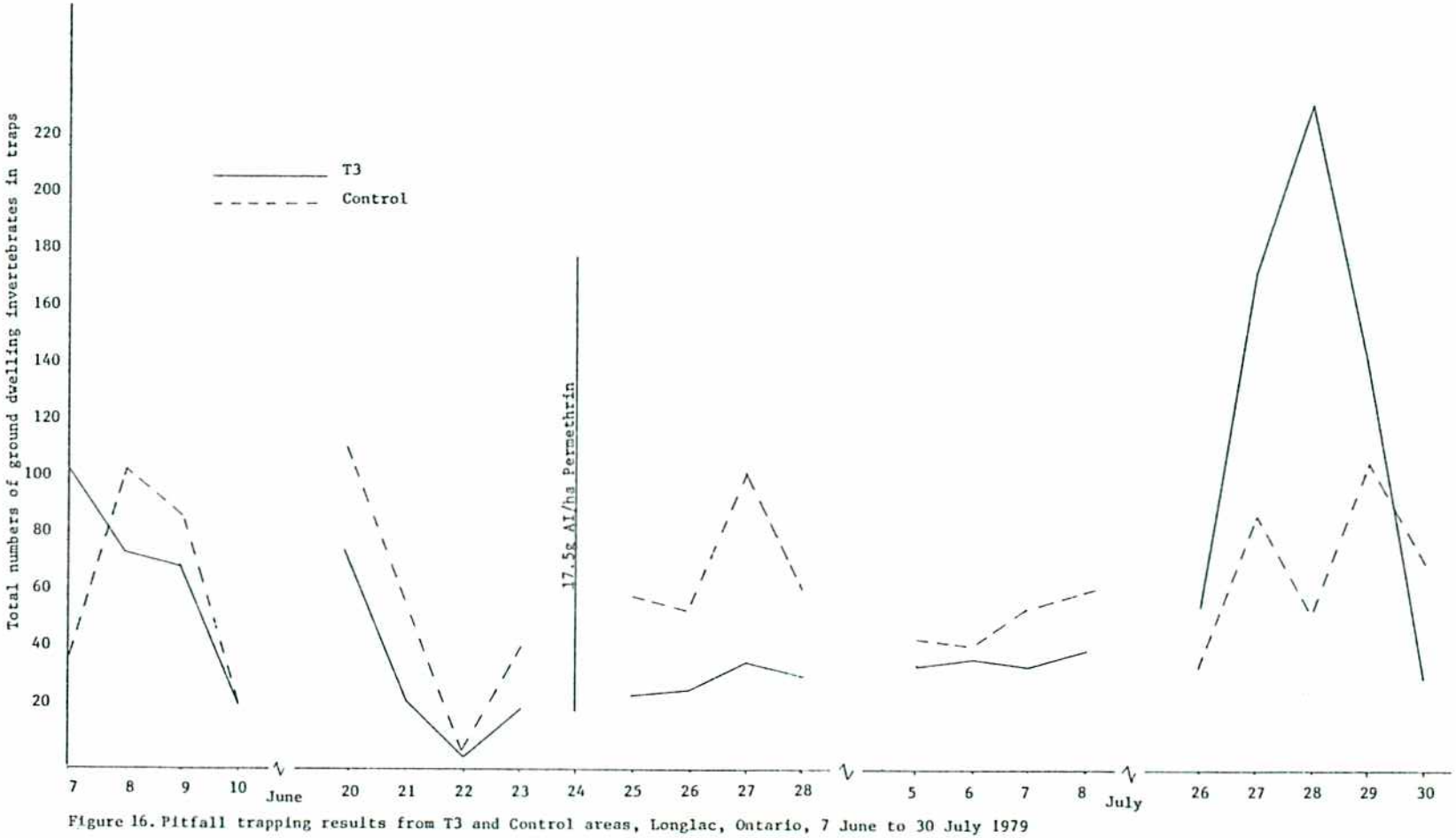

Figure 16. Pitfall trapping results from T3 and Control areas, Longlac, Ontario, 7 June to 30 July 1979

Table 14
Small mammal population census
in treatment* and control areas
Longlac, Ontario
1979

	Treatment						Control					
	males		females				Males		females			
Pre-spray	sub-adult	adult	sub-adult	adults breeding	adults not breeding	totals	sub-adult	adult	sub-adult	adults breeding	adults not breeding	totals
Sorex cinereus	0	1	0	1	0	2	0	0	0	0	0	0
Clethrionomys gapperi	0	0	1	0	0	1	0	0	0	0	0	0
Zapus hudsonius	0	1	0	0	0	1	0	0	0	0	0	0
totals	0	2	1	1	0	4	0	0	0	0	0	0
Post-spray												
Sorex cinereus	7	2	0	1	0	10	0	0	0	1	0	1
Clethrionomys gapperi	0	1	1	2	0	4	0	4	0	1	0	5
Zapus hudsonius	0	1	0	1	0	2	0	0	0	0	0	0
Synaptomys cooperi	0	1	1	0	0	2	0	0	0	0	0	0
Tamias striatus	0	0	0	0	0	0	1	0	1	0	0	2
Peromyscus maniculatus	0	0	0	0	0	0	0	8	0	4	0	12
Napeozapus insignis	0	0	0	0	0	0	1	2	0	1	0	4
totals	7	5	2	4	0	18	2	14	1	7	0	24

*Treated with 17.5 g AI/ha Permethrin from 0795 to 0900 hrs on 24 June 1979

Insecticide Residues

Accumulations of pesticide in water reached significantly high levels (147 µg/ℓ in ponds and 2.5 µg/ℓ in streams) but were relatively unstable and had been greatly reduced by 6 to 24 hours after the application and had completely disappeared within 96 hours. In every instance, the concentration of residual insecticide found in the treated water correlated to the calculated volume of deposit at that station.

Despite relatively high amounts of pesticide in the treated water, adsorption and accumulation of Permethrin was minimal in pond sediments and absent in stream sediments and fish. The physical properties of the spray formulation substantiate this indication that dispersion of the insecticide below the surface of the water is limited, unless induced by mechanical means. The formulation has a density of 0.88 g/ml (lighter than water) and is basically non water soluble, and therefore, will form a surface film when brought in contact with still or slowly moving water. This significantly reduces the likelihood of the pesticide being exposed to bottom sediment and fish in the treated ponds and streams. In the lower portions of Shaft Creek, where dispersion of the formulation throughout the water was possible by imbuing action of riffles and fast water, residual Permethrin concentrations had been reduced to an extent that accumulations of detectable residues were not probable.

Kingsbury and Kreutzweiser (1979) reported substantial accumulations of Permethrin found in fish caught in Quebec streams treated with 17.5 g AI/ha dosages in 1978. As a result of further development of procedures for measuring Permethrin residues in fish tissue, prior to and during the 1979 program, the analytical chemists involved have suggested that these previous values are unreliable because of such factors as inconsistent and incomplete labelling, contamination from handling and poor transporting facilities. As well, the method of laboratory analysis, only then being developed, contained several extra steps that may have contributed to the possibility of contamination through increased handling of the samples. Before any residue sampling or analysis was initiated in the 1979 program, these problems were identified and eliminated.

Insecticide residue found in the terrestrial sampling areas appeared to be much more stable than those in the aquatic systems. Sampling of deciduous and coniferous foliage indicated a slightly greater accumulation of pesticide by deciduous species, but concentrations were noticeably reduced in both types by the end of the 57 day post-spray sampling period. Permethrin residues in soil and forest litter were not excessive but remained fairly consistent for at least 58 days.

Effects of Insecticide on Aquatic Invertebrates

Recorded observations of the headwater ponds indicated that the Permethrin application resulted in noticeable levels of distress and mortality to surface and littoral invertebrates, and produced effects similar to the impact on lentic organisms documented from previous studies (Kingsbury and Kreutzweiser, 1979).

The three stream stations within the treatment block demonstrated appreciable increases in the number of drifting aquatic organisms following the application. However, despite insecticide residues in the water reaching levels as high as 2.5 µg/ℓ, the extent of the increases did not approach the order of magnitude of drift increases documented from studies of the same application rate to coldwater streams in Quebec. Kingsbury and Kreutzweiser (1979) reported total aquatic invertebrate drift increases of from 130 to 1900 times higher than the pre-spray level after an application of 17.5 g AI/ha Permethrin to streams in Temiscouata Country, Quebec, while drift increases in Shaft Creek at the treated stations did not exceed a level 14 times greater than the pre-spray average. The comparatively lesser impact to the treated Shaft Creek stations reflects the extremely low levels of pre-spray drift and, the apparent unsuitability of the stream type for supporting large populations of aquatic insects.

The increased number of drifting organisms in the treatment block is significant, however, in that certain organisms (Ephemeroptera: Heptageniidae and Baetidae, Plecoptera nymphs) were not represented in the pre-spray drift samples, but comprised the major portion of the immediate post-spray drift increases. This indicates that although the populations of these aquatic insects were relatively low, the impact of the Permethrin application was such that most or possibly all of the organisms in the groups may have been adversely affected.

A major increase in the number of drifting baited mayfly and stonefly nymphs was documented at the Downstream station, 2.1 km below the treatment block, 12 hours after the application. This increase correlates to the peak insecticide residue level of 0.18 µg/ℓ found in the water at this station in the 12 hour post-spray sample period. Because of the low numbers of drifting invertebrates in the treatment block, and the poor quality of stream type above the Downstream sampling area, it is apparent that the drifting organisms collected at the station had originated from the lower portions of the creek. This demonstrates that residual insecticide from the upstream treated sections had retained concentrations toxic to certain aquatic invertebrates for at least 2 km downstream. The increased drift was comprised almost entirely of first- or early-instar baetid mayfly and stonefly nymphs, while much larger caged stoneflys, caddisflys, and dragonfly nymphs were unaffected. The apparent differences in sensitivity to that specific level of pesticide concentration may be due to taxonomical differences or variations in stages of development.

A noticeable reduction in the bottom fauna populations at the Downstream station substantiates the probability of residual pesticide retaining toxic though greatly reduced, concentrations to that point. Recovery was relatively quick, with a return to or above pre-spray levels within 23 days after the application. A second reduction in bottom fauna populations was evident 33 days post-spray, but reflected a similar decrease in bottom dwelling organisms in the control stream and was apparently the result of drastically reduced water levels.

Effects of Insecticide on Terrestrial Invertebrates

The increase in knockdown of aboreal and flying invertebrates was similar in composition and duration to the terrestrial inverebrate knockdown recorded from previous studies (Kingsbury and McLeod 1979; Kingsbury and Kreutzweiser 1979). The magnitude of the knockdown was comparatively low, and may have resulted from the weather conditions at the time of the spray. Air temperatures during the period of application reached a low of -2°C, limiting the degree of insect activity and thus reducing the probability of contact with the pesticide. The extent of invertebrate knockdown generally correlated to the volume of insecticide deposited, with areas receiving the highest deposit values demonstrating the greatest invertebrate knockdown.

The activity of ground dwelling invertebrates varied considerably throughout the sampling period and appeared to be most affected by prevailing weather conditions and natural reproductive cycles. A significant reduction in activity in both treatment and control areas two or three days before the application corresponded to the persistently wet weather occurring at that time. A second low level of activity in both areas was recorded 11 to 14 days after the spray and may have been the result of unusually hot and dry conditions over 10 consecutive presample days. The large increases in the numbers of ground dwelling invertebrates found during the 32 to 36 day post-spray sampling were comprised primarily of recently hatched spiders.

Numbers in the treatment block declined appreciably immediately following the application while those in the control area showed trends of increase, but despite relatively stable Permethrin residues in the forest litter, invertebrate activity had regained a level comparable to the control area within 14 days after the spray.

Effects of Insecticide on Fish

Virtually no native fish populations existed in the treatment block streams and therefore an assessment of impact of the pesticide on indigenous fish species was not possible. Yellow perch exposed to the application in wire cages did not demonstrate any adverse or sub-lethal effects, and did not accumulate detectable amounts of Permethrin.

Effects of Insecticide on Small Mammals

Because of the low number of small mammals encountered during the pre- and post-spray sampling periods, the possible effects of Permethrin on the mammals were not clearly defined. However, results from the limited sample showed a high degree of animal fecundity, indicating that while populations were naturally low the small mammal complex was healthy and unaffected by the experimental treatment of Permethrin. These results coincide with those of a more extensive study previously reported (Kingsbury and McLeod 1979).

GENERAL CONCLUSIONS

Residue analysis results substantiate indications from the 1978 study that residual Permethrin exhibits a rapid rate of disappearance in standing and flowing water. Peak accumulations of pesticide in Shaft Creek exceeded those of previous applications by 51.2 times in ponds and 1.4 times in streams. Despite higher initial concentrations of Permethrin in the water, adsorption of the pesticide to bottom sediment was minimal and attained a level 5.0 times lower than the peak accumulation in pond sediment resulting from the 1978 applications. No detectable amounts of insecticide were found in pond sediment from Larose Forest resampled 455 days after the double application in 1978.

Yellow perch exposed to the application in the streams and ponds did not accumulate detectable amounts of Permethrin. Because of alterations made in sampling and analysing procedures, it is felt that these results provide a more reliable indication of the actual pesticide accumulation in fish than those previously reported (Kingsbury and Kreutzweiser 1979).

The persistence of Permethrin residues in foliage, soil, and litter was considerably more stable than in aquatic substrate. Concentrations of the insecticide reached levels similar to those found in the 1978 studies, and remained at measurable quantities to the end of the 58 day sampling period. Fifteen month post-spray samples of coniferous foliage and soil collected from the double application area of 1978 contained no detectable amounts of Permethrin.

The effects of the Permethrin application on aquatic organisms were similar to those resulting from previous applications of the same dosage (Kingsbury and Kreutzweiser 1979). Although the pattern of biological effects reflected those of previous studies, the magnitude of impact was greatly decreased because of the poor quality of stream habitat. Heavily silted and muck bottom types, minimal stream flow, a frequent interspersion of beaver dams, and the absence of riffles produced conditions less than ideal for sustaining viable populations of fish and invertebrates.

The Permethrin application resulted in a noticeable increase in the number of drifting organisms in the treatment block and 2.1 km downstream over a 24 hour period, followed by a slight reduction in bottom fauna at the Downstream station. Because of the nature of the stream, it was evident that the increase in drifting organisms at the Downstream station was due to toxic levels of residual Permethrin adversely affecting the invertebrates at that point rather than affected organisms drifting down from the treatment area.

Aboreal, flying, and ground dwelling invertebrates demonstrated an immediate but brief impact following the pesticide application. No measurable effects were encountered in small mammal populations.

Despite the short-comings of this study because of the poor quality of stream system, it is apparent that the single application of 17.5 g AI/ha Permethrin to an entire watershed on a semi-operational basis did not introduce or compound hazards to aquatic fauna or persistence of the pesticide further to those documented from small-scale experimental applications of the same dosage rate.

LITERATURE CITED

Buckner, C.H., P.D. Kingsbury, B.B. McLeod, K.L. Mortensen, and D.G.H. Ray. 1974. Impact of aerial treatment on non-target organisms, Algonquin Park, Ontario and Spruce Woods, Manitoba; in Evaluation of commercial preparations of *Bacillus thuringiensis* with and without Chitinase against spruce budworm. Chemical Control Research Institute, Canadian Forestry Service, Ottawa, Ontario. Information Report CC-X-59. p. F1-F72.

Hurtig, H., J.J. Fettes, A.P. Randall, and W.W. Hopewell. 1953. A field investigation of the relation between the amount of D.D.T. spray deposited, the physical properties of the spray, and its toxicity to larvae of the spruce budworm. Can. Dept. Nat. Defence, Defence Res. Bd., Suffield Exp. Sta. Rep. No. 176. 41 p.

Hydorn, S.B. 1979. The influence of pesticide sprayed for spruce budworm control on certain non-target terrestrial invertebrates in the forest; in Environmental monitoring of cooperative spruce budworm control projects, Maine 1978. Main Department of Conservation, Bureau of Forestry, Augusta, Maine, p. 23-52.

Kingsbury, P.D. and D.P. Kreutzweiser. 1979. Impact of double applications of Permethrin on forest streams and ponds. Information Report FPM-X-27, Forest Pest Management Institute, Sault Ste. Marie, Ontario.

Kingsbury, P.D., and D.P. Kreutzweiser. In press. Dosage-effect studies on the impact of Permethrin on trout streams. Forest Pest Management Report in press.

Kingsbury, P.D., and B.B. McLeod. 1979. Terrestrial impact studies in forest ecosystems treated with double applications of Permethrin. Information report FPM-X-28, Forest Pest Management Institute, Sault Ste. Marie, Ontario.

Surber, E.W. 1936. Rainbow trout and bottom fauna production in one mile of stream. Trans. Amer. Fish. Soc. 66:193-202.

Varty, I.W. 1977. Long-term effects of fenitrothion spray programs on non-target terrestrial arthropods: in Proceedings of a symposium on Fenitrothion: the long term effects of its use in forest ecosystems. National Research Council, Ottawa, Ontario. NRCC/CNRC No. 16073. p. 343-375.

APPENDICES

Table A-1
Aquatic organisms* caught in drift nets set in
Shaft Creek West Tributary**,
Longlac, Ontario
16 June to 28 June 1979

Days before or after Permethrin application			-8 am	-8 pm	-7 am	-7 pm	-6 am	-6 pm	-5 am	-5 pm	-4 am	-4 pm	-3 am	-3 pm	-2 am	-2 pm	-1 am	-1 pm
Volume of drift column (m^3)			23.10	29.70	23.84	33.08	15.99	19.04	20.98	22.05	13.03	10.15	10.72	9.90	7.99	27.54	13.96	20.43
Current velocity (m/sec)			0.21	0.27	0.23	0.34	0.27	0.27	0.31	0.34	0.21	0.15	0.19	0.13	0.09	0.31	0.15	0.21
Ephemeroptera	Baetidae		0.04															
Plecoptera																		
Hemiptera	Gerridae								0.05									
Trichoptera		larvae			0.04				0.11						0.13			
Coleoptera	Amphizoidae	adult																
	Dytiscidae	larvae																
	Noteridae	adult						0.05						0.10				
	Elmidae	adult																0.05
Diptera	Culicidae	larvae					0.06											
	Simuliidae	larvae				0.06		0.11	0.05		0.08	0.20				0.40	0.14	
	Chironomidae	larvae pupae	0.95	0.74	0.46	0.27	0.19	0.21	0.11	0.45	0.38	0.89	0.19	0.91	0.75	0.40	0.36	0.05
	Heleidae	larvae		0.03						0.04								
	Tabanidae	larvae			0.04	0.03												
Nematomorpha			0.09		0.13	0.06		0.05	0.29	0.09		0.30		0.10	0.13	0.04	0.07	
Oligochaeta																		
Gastropoda												0.09		0.13				
Arachnida	Hydracarina		0.04	0.03														
Total			1.12	0.80	0.67	0.42	0.25	0.52	0.61	0.58	0.46	1.48	0.19	1.24	1.01	0.84	0.57	0.10

* expressed as organisms/m^3 of flow through drift net

** treated with 17.5 g AI/ha Permethrin at 0840 hrs on 24 June 1979

Table A-1 (cont'd)

Days before or after Permethrin application			-0 am	+0 hr	+½ hr	+1 hr	+2 hr	+3 hr	+6 hr	+12 hr	+1 am	+1 pm	+2 am	+2 pm	+3 am	+3 pm	+4 am	+4 pm
Volume of drift column (m^3)			8.88	8.88	8.88	4.44	8.88	8.88	12.79	14.47		17.32	24.87	23.60	23.98	17.13	15.23	7.99
Current velocity (m/sec)			0.15	0.15	0.15	0.15	0.15	0.15	0.27	0.27		0.21	0.21	0.31	0.21	0.15	0.15	0.09
Ephemeroptera	Baetidae																	
Plecoptera					2.48	7.21	2.82	3.49	0.31	0.48		0.35	0.48	0.34	0.21	0.06		0.13
Hemiptera	Gerridae																	
Trichoptera		larvae						0.45	0.16			0.06			0.04			
Coleoptera	Amphizoidae	adult					0.11											
	Dytiscidae	larvae			0.23		0.56	0.11										
	Noteridae	adult																
	Elmidae	adult			0.68	0.90		0.23						0.04				
Diptera	Culicidae	larvae					0.11											
	Simuliidae	larvae					0.11			0.07			0.12				0.13	
	Chironomidae	larvae	0.23	0.23	0.11	0.45	0.56	0.79	0.63	0.21		0.46		0.42	0.08		0.07	0.25
		pupae										0.06	0.04	0.04				
	Heleidae	larvae																0.13
	Tabanidae	larvae																
Nematomorpha			0.11			0.23										0.06		
Oligochaeta						0.23												
Gastropoda																		
Arachnida	Hydracarina											0.05			0.04			
Total			0.34	0.23	3.50	9.02	4.27	5.07	1.10	0.76	--	0.98	0.64	0.84	0.37	0.12	0.20	0.51

Table A-2
Aquatic organisms* caught in drift nets set in
Shaft Creek East Tributary station**,
Longlac, Ontario
16 June to 28 June 1979

Days before or after Permethrin application		-8 am	-8 pm	-7 am	-7 pm	-6 am	-6 pm	-5 am	-5 pm	-4 am	-4 pm	-3 am	-3 pm	-2 am	-2 pm	-1 am	-1 pm
Volume of drift column (m^3)		44.58	27.54	22.84	21.32	19.04	22.08	22.84	17.77	16.29	17.77	10.66	10.66	6.60	17.26	--	--
Current velocity (m/sec)		0.34	0.21	0.18	0.18	0.15	0.18	0.18	0.15	0.14	0.15	0.09	0.09	0.06	0.24	--	--
Ephemeroptera																	
Heptageniidae	nymph																
Baetidae	nymph																
Odonata																	
Libellulidae	nymph																
Coleoptera																	
Haliplidae	adults																
Dytiscidae	larvae										0.06						
Elmidae	adults																
Diptera																	
Culicidae	larvae		0.04														
Chaoboridae	larvae																
Simulidae	larvae	0.02	0.04	0.22	0.28	0.37	0.27	0.48	0.17	0.37	0.56	0.47	0.09	0.45	0.87		
	pupae																
Chironomidae	larvae	0.02		0.04		0.05	0.05			0.06	0.06	0.09	0.09	0.15	0.06		
	pupae									0.06							
Tabanidae	larvae																
Nematomorpha			0.11	0.13	0.05			0.04			0.06	0.28					
Gastropoda																	
Arachnida																	
Hydracarina			0.22		0.23	0.05	0.23	0.04	0.06								
Total		0.04	0.41	0.39	0.56	0.47	0.55	0.56	0.23	0.49	0.74	0.84	0.18	0.06	0.93	--	--

* expressed as organisms/m^3 of flow through drift net

** treated with 17.5 g AI/ha Permethrin at 0840 hrs on 24 June 1979

Table A-2 (cont'd)
Aquatic organisms* caught in drift nets set in
Shaft Creek East Tributary station**,
Longlac, Ontario
16 June to 28 June 1979

Days before or after Permethrin application		-0 am	+0 hr	+½ hr	+1 hr	+2 hr	+3 hr	+6 hr	+12 hr	+1 am	+1 pm	+2 am	+2 pm	+3 am	+3 pm	+4 am	+4 pm
Volume of drift column (m^3)		9.31	9.31	9.31	9.31	9.31	9.31	9.31	9.73	19.99	19.54	14.28	17.77	18.40	18.40	17.77	13.20
Current velocity (m/sec)		0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.21	0.21	0.15	0.15	0.15	0.15	0.15	0.12
Ephemeroptera																	
Heptageniidae	nymph			0.22		0.11											
Baetidae	nymph			0.11	1.50	1.61	0.75	0.11									
Odonata																	
Libellulidae	nymph	0.11															
Coleoptera																	
Haliplidae	adults						0.22						0.06				
Dytiscidae	larvae														0.05		
Elmidae	adults										0.05						
Diptera																	
Culicidae	larvae												0.11				
Chaoboridae	larvae													0.05			
Simuliidae	larvae	0.54		0.11	0.11	0.11			0.41	0.20	0.21	1.05	0.51	0.49	0.43	0.56	0.08
	pupae					0.11	0.22		0.10	0.05							
Chironomidae	larvae				0.11	0.75	1.40	0.22	0.10				0.06	0.05			
	pupae					0.11	0.22	0.11	0.10			0.07		0.05	0.05	0.06	
Tabanidae	larvae													0.05			
Nematomorpha																	
Gastropoda															0.05		
Arachnida																	
Hydracarina												0.07	0.17				
Total		0.65	0.00	0.44	1.72	2.80	2.81	0.44	0.71	0.25	0.26	1.19	0.91	0.69	0.58	0.62	0.08

* expressed as organisms/m^3 of flow through drift net

** treated with 17.5 g AI/ha Permethrin at 0840 hrs on 24 June 1979

Table A-3
Aquatic organisms* caught in drift nets set in
Shaft Creek Upstream Station**,
Longlac, Ontario
16 June to 28 June 1979

Days before or after Permethrin application			-8 am	-8 pm	-7 am	-7 pm	-6 am	-6 pm	-5 am	-5 pm	-4 am	-4 pm	-3 am	-3 pm	-2 am	-2 pm	-1 am	-1 pm
Volume of drift column (m^3)			23.98	23.10	26.40	19.80	15.86	29.69	25.38	28.55	29.69	30.84	31.98	28.93	15.40	28.43	25.32	27.92
Current velocity (m/sec)			0.21	0.21	0.24	0.18	0.15	0.27	0.24	0.27	0.27	0.27	0.27	0.24	0.21	0.24	0.21	0.24
Ephemeroptera	Baetidae															0.04	0.04	
Plecoptera																		
Hemiptera	Corixidae																	
	Cerridae																	
	Vellidae																	
Coleoptera	Haliplidae																	
	Dytiscidae																	
	Gyrinidae																	
	Elmidae	larvae																
		adult						0.03		0.04							0.04		
	Dryopidae																	
Diptera	Culicidae																	
	Simulidae	larvae	0.08	0.13	0.08		0.50	0.07	0.79	0.14	0.44	0.03	0.38	0.03	0.65	0.04	0.36	
	Chironomidae	larvae	0.21							0.08	0.03		0.03		0.39			
		pupae							0.04		0.03							
Nematoda										0.04								
Nematomorpha			0.13	0.04		0.10	0.06	0.03			0.03	0.03	0.06	0.03			0.04	
Oligochaeta										0.04								
Gastropoda							0.19	0.03	0.12	0.14	0.07	0.16	0.06	0.07				0.04
Pelecypoda				0.30		0.15	0.06	0.07	0.04	0.04			0.06	0.07	0.06	0.11		
Arachnida	Hydracarina		0.04		0.04	0.40	0.19	0.03	0.16	0.70	0.34	0.55	0.09	0.62	0.39			
Total			0.46	0.47	0.12	0.65	1.00	0.26	1.15	1.22	0.94	0.77	0.68	0.82	1.49	0.23	0.44	0.04

* expressed as organisms/m^3 of flow through drift net

** treated with 17.5 g AI/ha Permethrin at 0850 hrs on 24 June 1979

Table A-3 (cont'd)

Days before or after Permethrin application			-0 am	+0 hr	+½ hr	+1 hr	+2 hr	+3 hr	+6 hr	+12 hr	+1 am	+1 pm	+2 am	+2 pm	+3 am	+3 pm	+4 am	+4 pm
Volume of drift column (m^3)			23.10	15.40	7.70	7.70	7.70	9.30	26.40	17.26	25.38	26.40	48.52	35.41	44.58	40.65	40.65	30.29
Current velocity (m/sec)			0.21	0.21	0.21	0.21	0.21	0.24	0.24	0.24	0.24	0.24	0.37	0.27	0.34	0.31	0.31	0.27
Ephemeroptera	Baetidae																	
Plecoptera									0.04									
Hemiptera	Corixidae		0.17			0.23	0.39	0.11	0.04				0.02					0.03
	Gerridae						0.13											
	Vellidae		0.04				0.13											
Coleoptera	Haliplidae		0.04								0.08	0.04						
	Dytiscidae		0.39		0.13		0.13		0.04		0.04							
	Gyrinidae										0.04							
	Elmidae	larvae			0.13								0.04					
		adult					0.23	0.22		0.16								
	Dryopidae																0.02	
Diptera	Culicidae																	
	Simuliidae	larvae		0.26		0.23	0.23	0.43				0.04	0.02					
	Chironomidae	larvae	0.22				0.23	0.11	0.11	0.16			0.04					
		pupae							0.04		0.04				0.04	0.02		0.03
Nematoda																		
Nematomorpha				0.06		0.13			0.04	0.12			0.02					
Oligochaeta																		
Gastropoda			0.04	0.06			0.13	0.22	0.04	0.12						0.07	0.02	0.03
Pelecypoda														0.14				
Arachnida	Hydracarina		0.04						0.04		0.08	0.38	0.16				0.10	
Total			0.94	0.38	0.26	0.59	1.60	1.09	0.39	0.56	0.28	0.46	0.30	0.14	0.04	0.09	0.14	0.09

Table A-4
Aquatic organisms* caught in drift nets set in
Shaft Creek Downstream station**,
Longlac, Ontario
16 June to 28 June 1979

Days before and after Permethrin application		-8 am	-8 pm	-7 am	-7 pm	-6 am	-6 pm	-5 am	-5 pm	-4 am	-4 pm	-3 am	-3 pm	-2 am	-2 pm	-1 am	-1 pm	-0 am
Volume of drift column (m^3)		65.57	43.71	61.34	59.22	29.33	28.76	24.00	21.86	22.96	19.67	20.14	21.09	20.13	19.23	24.00	24.52	19.23
Current velocity (m/sec)		0.50	0.50	0.50	0.50	0.40	0.40	0.37	0.31	0.37	0.31	0.34	0.34	0.34	0.31	0.37	0.37	0.31
Ephemeroptera																		
Heptageniidae																		
Baetidae								0.04										0.05
Plecoptera																		0.05
Trichoptera	larvae							0.04				0.05					0.04	
Coleoptera																		
Haliplidae	adults		0.05				0.03	0.04										
Dytiscidae	larvae			0.02														
	adults																	
Noteridae	adults																	
Elmidae	adults																	
Dryopidae	adults																	
Diptera																		
Tipulidae	larvae																	
Culicidae	larvae																	
Simuliidae	larvae	0.02		0.03	0.34	0.51	0.35	1.38	0.55	1.52	0.25	0.94	0.19	1.49	1.77	1.63	0.41	2.24
	pupae																	0.10
Chironomidae	larvae	0.11	0.50	0.36	0.61	0.89	0.49	0.75	0.60	0.39	0.25	0.15	0.14	0.35	0.68	0.13	0.16	0.10
	pupae	0.02		0.15	0.14		0.07	0.29	0.14	0.39	0.20	0.20	0.05	0.10	0.21	0.08	0.16	
Heleidae	pupae																	
Nematoda						0.03				0.09	0.10							
Nematomorpha		0.02	0.09	0.03	0.05		0.14	0.04	0.05	0.04	0.20		0.05	0.05	0.10	0.08	0.04	
Oligochaeta								0.04										
Arachnida																		
Hydracarina		0.03	0.05		0.19	0.07	0.21	0.04	0.09	0.04	0.25	0.05		0.05				
Total		0.20	0.69	0.59	1.33	1.50	1.29	2.66	1.43	2.47	1.25	1.39	0.43	1.94	2.76	1.92	0.81	2.54

* expressed as organisms/m^3 of flow through net

** 2.1 km downstream from treatment area (treated with 17.5 g AI/ha Permethrin at 0705 to 0900 hrs on 24 June 1979)

Table A-4 (cont'd)
Aquatic organisms* caught in drift nets set in
Shaft Creek Downstream station**,
Longlac, Ontario
16 June to 28 June 1979

Days before and after Permethrin application		+0 hr	+½ hr	+1 hr	+2 hr	+3 hr	+4 hr	+6 hr	+12 hr	+1 am	+1 pm	+2 am	+2 pm	+3 am	+3 pm	+4 am	+4 pm
Volume of drift column (m^3)		19.23	19.23	19.23	19.23	19.23	19.23	19.23	22.05	21.09	16.00	47.38	30.78	24.75	32.13	36.00	32.78
Current velocity (m/sec)		0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.34	0.34	0.27	0.40	0.37	0.39	0.43	0.37	0.31
Ephemeroptera																	
Heptageniidae									0.05								
Baetidae									82.72	0.19		0.06	0.03	0.08	0.03		
Plecoptera			0.10				0.05		77.28	0.62							
Trichoptera	larvae								1.00	0.14							
Coleoptera																	
Halipiidae	adults						0.36					0.02					
Dytiscidae	larvae								0.68	0.05		0.02	0.03				
	adults											0.02					
Noteridae	adults																
Dryopidae	adults										0.06						
Other													0.03				
Diptera																	
Tipulidae	larvae										0.06	0.02					
Culicidae	larvae																
Simulidae	larvae	1.20	1.04	0.10	0.83	0.16	1.46	0.57		0.81		1.81	0.32	0.24	0.09		
	pupae			0.05													
Chironomidae	larvae	0.26	0.26	0.21	0.26	0.05	0.26	0.26	0.81	0.66		0.42	0.06	0.08			
	pupae	0.05			0.10			0.10	0.86	0.33	0.06	0.32	0.06	0.08	0.06		
Heleidae	pupae																
Nematoda									0.05								
Nematomorpha				0.05	0.05	0.05			0.05				0.03			0.03	
Oligochaeta																	
Arachnida																	
Hydracarina									0.05		0.06	0.21	0.13	0.04		0.03	
Total		1.51	1.40	0.41	1.24	0.26	2.13	0.93	163.55	2.80	0.24	2.90	0.69	0.52	0.18	0.06	0.00

* expressed as organisms/m^3 of flow through net

** 2.1 km downstream from treatment area (treated with 17.5 g AI/ha Permethrin at 0705 to 0900 hrs on 24 June 1979)

Table A-5
Aquatic organisms* caught in drift nets set in
Untreated Control Station
Longlac, Ontario
16 June to 16 July 1979

Days before or after Permethrin application		-8 am	-8 pm	-7 am	-7 pm	-6 am	-6 pm	-5 am	-5 pm	-4 am	-4 pm	-3 am	-3 pm	-2 am	-2 pm	-1 am	-1 pm
Volume of drift column (m^3)		30.16	16.75	22.84	26.65	16.07	13.54	15.23	16.24	15.74	13.77	15.23	12.18	18.27	25.17	--	--
Current velocity (m/sec)		0.31	0.27	0.30	0.30	0.20	0.20	0.24	0.24	0.24	0.21	0.24	0.24	0.27	0.34		
Ephemeroptera																	
Baetidae																	
Plecoptera		0.03		0.04													
Hemiptera																	
Corixidae				0.04													
Gerridae			0.06		0.07		0.07					0.13					
Trichoptera	larvae	0.03	0.06		0.04												
Coleoptera																	
Haliplidae	adults																
Dytiscidae	larvae			0.04									0.08		0.04		
Noteridae	adults																
Diptera																	
Tipulidae	larvae																
Chaoboridae	larvae																
Culicidae	larvae																
Simuliidae	larvae		0.06		0.04	0.06			0.12			0.07		0.05	0.08		
	pupae																
Chironomidae	larvae	0.27	0.54	0.48	0.41	0.75	0.44	0.26	0.12	0.13	0.07	0.13	0.08	0.05	0.04		
	pupae					0.06											
Heleidae	larvae																
	pupae																
Empididae	larvae																
Muscoidae	larvae																
Nematoda			0.06														
Nematomorpha		0.43	0.06		0.07	0.12	0.15				0.07		0.08				
Oligochaeta																	
Pelecypoda				0.04						0.06							
Arachnida																	
Hydracarina			0.12	0.13		0.06							0.08				
Total		0.76	0.96	0.77	0.63	1.05	0.66	0.26	0.24	0.19	0.14	0.33	0.32	0.10	0.16	--	--

* expressed as organisms/m^3 of flow through drift net

Table A-5 (cont'd)
Aquatic organisms* caught in drift nets set in
Untreated Control Station
Longlac, Ontario
16 June to 16 July 1979

Days before or after Permethrin application		-0 am	0700 hrs.	0800 hrs.	0900 hrs.	1900 hrs.	+1 am	+1 pm	+2 am	+2 pm	+3 am	+3 pm	+4 am	+4 pm	+22 pm	+23 am
Volume of drift column (m^3)		12.56	12.56	12.18	12.18	12.18	12.18	12.18	24.45	13.32	13.32	13.32	15.23	12.43	12.18	2.54
Current velocity (m/sec)		0.27	0.27	0.27	0.27	0.27	0.27	0.27	0.34	0.21	0.21	0.21	0.24	0.24	0.18	0.12
Ephemeroptera																
Baetidae									0.04							
Plecoptera								0.08								
Hemiptera																
Corixidae																
Gerridae														0.08		
Trichoptera	larvae							0.08								
Coleoptera																
Haliplidae	adults															
Dytiscidae	larvae	0.08						0.08								
Noteridae	adults															
Diptera																
Tipulidae	larvae			0.08												
Chaoboridae	larvae															
Culicidae	larvae															
Simuliidae	larvae						0.08		0.08	0.08				0.08		
	pupae															
Chironomidae	larvae								0.08	0.08			0.06		0.08	1.57
	pupae	0.08					0.08	0.08	0.04							
Heleidae	larvae															
	pupae															
Empididae	larvae															
Muscoidae	larvae															
Nematoda																
Nematomorpha		0.08			0.08											
Oligochaeta																
Pelecypoda																
Arachnida																
Hydracarina									0.04							
Total		0.24	0.00	0.08	0.08	0.00	0.16	0.32	0.28	0.16	0.00	0.00	0.06	0.16	0.08	1.57

* expressed as organisms/m^3 of flow through drift net

Table A-6
Aquatic organisms collected from bricks placed in
Shaft Creek East Tributary*
Longlac, Ontario
17 June to 29 June 1979

Brick number		1 & 2	3 & 4	5 & 6	1 & 2	3 & 4	5 & 6	1 & 2			3 & 4	5 & 6	1 & 2	
Date		17 June	18 June	19 June	20 June	21 June	22 June	23 June	24 June	25 June	26 June	27 June	28 June	29 June
Ephemeroptera														
Heptageniidae								1						
Odonata														
Anisoptera		1												
Trichoptera	larvae		1			2								
Diptera														
Simuliidae	larvae			3	8	10	28	2			3	4	6	
Chironomidae	larvae	1		3	3	1	1	1						
Unidentified	larvae						1	1						
	pupae							1						
Total		2	1	6	11	13	30	5	-	-	3	4	6	-

* treated with 17.5 g AI/ha Permethrin
at 0840 hrs on 24 June 1979

Table A-7
Aquatic organisms collected from bricks placed in
Shaft Creek West Tributary*
Longlac, Ontario
17 June to 29 June 1979

Brick number		1 & 2	3 & 4	5 & 6	1 & 2	3 & 4	5 & 6	1 & 2		1 & 2	3 & 4	5 & 6	1 & 2	3 & 4
Date		17 June	18 June	19 June	20 June	21 June	22 June	23 June	24 June	25 June	26 June	27 June	28 June	29 June
Oligochaeta				1										
Plecoptera												1	1	1
Trichoptera	larvae	1	1			2					1			
Diptera														
Simulidae	larvae					1					1	1		
Chironomidae	larvae			1	1	1	2						1	
Heleidae	larvae						1							
Unidentified	larvae			1										
Total		1	1	3	1	4	3	0	-	0	2	2	2	1

* treated with 17.5 g AI/ha Permethrin
at 0840 hrs on 24 June 1979

Table A-8

Aquatic organisms collected from bricks placed in
untreated control stream
Longlac, Ontario
10 June to 29 June 1979

Brick number		1 & 2	1 & 2			1 & 2	3 & 4	5 & 6			1 & 2	3 & 4	5 & 6	1 & 2	3 & 4
Date		10 June	17 June	18 June	19 June	20 June	21 June	22 June	23 June	24 June	25 June	26 June	27 June	28 June	29 June
Ephemeroptera															
Heptageniidae												1			
Baetidae			3												
Plecoptera		1	3			4	6	1			1				1
Trichoptera	larvae		1												
Coleoptera															
Elmidae	adults												1		
Diptera															
Simuliidae	larvae						45					3		5	5
Chironomidae	larvae		3			1	4	1				1		2	1
	pupae					1									
Total		1	10	-	-	6	54	2	-	-	1	5	1	7	7

Table A-9
Bottom fauna populations*,
Shaft Creek downstream station**
Longlac, Ontario
8 June to 20 August 1979

Date			8 June	10 June	19 June	27 June	2 July	7 July	17 July	27 July	20 August
Days before or after Permethrin application			-16	-14	-5	+3	+8	+13	+23	+33	+57
Ephemeroptera	Heptageniidae										0.3 ± 0.5
	Baetidae						0.3 ± 0.5		8.5 ± 7.0		0.3 ± 0.5
Odonata	Anisoptera			0.3 ± 0.5					0.3 ± 0.5	0.3 ± 0.5	
Plecoptera				1.0 ± 2.0			0.3 ± 0.5	0.5 ± 1.0	0.3 ± 0.5		1.0 ± 1.4
Trichoptera		larvae		0.5 ± 0.6			0.3 ± 0.5	0.3 ± 0.5	0.5 ± 1.0	0.5 ± 0.6	2.0 ± 2.4
		pupae		2.5 ± 3.3	0.3 ± 0.5						0.5 ± 0.6
Coleoptera	Dytiscidae	adult							0.3 ± 0.5		
	Elmidae	larvae									0.5 ± 1.0
	Curculionidae	adult	0.3 ± 0.5								
Diptera	Tipulidae	larvae									1.0 ± 1.4
	Simuliidae	larvae	0.3 ± 0.5		1.0 ± 1.4	0.8 ± 1.5	0.3 ± 0.5	0.3 ± 0.5	0.3 ± 0.5	0.5 ± 1.0	
		pupae						0.3 ± 0.5	0.3 ± 0.5		
	Chironomidae	larvae	2.0 ± 4.0	3.5 ± 4.1	4.3 ± 2.6	0.3 ± 0.5		0.5 ± 1.0	3.5 ± 3.1	0.5 ± 0.6	2.8 ± 2.1
		pupae		0.5 ± 1.0	1.5 ± 1.9	0.3 ± 0.5	0.3 ± 0.5				0.3 ± 0.5
	Heleidae	larvae		0.8 ± 1.5							0.3 ± 0.5
	Tabanidae	larvae	0.8 ± 1.0		1.3 ± 2.5		0.3 ± 0.5	1.3 ± 1.9			
Nematoda					0.5 ± 1.0			0.3 ± 0.5			
Oligochaeta				0.8 ± 1.5				0.5 ± 1.0			
Gastropoda			0.3 ± 0.5	0.3 ± 0.5							0.8 ± 1.0
Arachnida	Hydracarina		0.5 ± 0.6				0.3 ± 0.5				
Total			4.0 ± 5.4	10.3 ± 13.7	8.8 ± 3.9	1.3 ± 1.9	1.8 ± 0.5	3.8 ± 1.9	13.8 ± 6.1	1.8 ± 0.5	9.5 ± 4.1

* Mean numbers and standard deviations of organisms collected in four 0.093 m^2 Surber samples.

** Located 2.1 km downstream from treatment area (treated with 17.5 g AI/ha Permethrin from 0705 to 0900 hrs on 24 June 1979).

Table A-10
Bottom fauna populations*,
untreated control stream
Longlac, Ontario
8 June to 20 August 1979

Date			8 June	10 June	19 June	27 June	2 July	7 July	16 July	27 July	20 August
Days before or after Permethrin application			-16	-14	-5	+3	+8	+13	+22	+33	+57
Ephemeroptera	Baetidae		1.3 ± 1.3	4.5 ± 4.5	0.8 ± 1.5	2.5 ± 2.6	1.0 ± 0.8	2.0 ± 2.7	2.8 ± 3.1	2.0 ± 2.4	8.8 ± 6.4
Plecoptera			1.0 ± 2.0	0.5 ± 0.6		1.0 ± 0.8		1.0 ± 1.2	4.3 ± 2.5		1.3 ± 2.5
Trichoptera		larvae	0.3 ± 0.5	0.8 ± 1.0		0.3 ± 0.5	0.3 ± 0.5	1.3 ± 1.5	1.0 ± 0.8	1.0 ± 1.2	12.0 ± 5.9
		pupae	2.5 ± 5.0	0.3 ± 0.5	0.8 ± 1.0	0.3 ± 0.5	0.5 ± 1.0	2.5 ± 2.5	5.3 ± 9.8		0.5 ± 1.0
Coleoptera	Dytiscidae	larvae							0.3 ± 0.5		
	Elmidae	larvae									0.3 ± 0.5
Diptera	Tipulidae	larvae				0.3 ± 0.5				1.0 ± 2.0	2.8 ± 2.4
	Culicidae	larvae	0.3 ± 0.5								
	Simuliidae	larvae			0.5 ± 1.0			0.8 ± 1.5			0.5 ± 0.6
		pupae									0.3 ± 0.5
	Chironomidae	larvae	0.5 ± 1.0	0.8 ± 1.5	0.5 ± 1.0	3.5 ± 1.3	1.0 ± 2.0	8.0 ± 6.8	6.5 ± 4.8	4.8 ± 4.1	17.0 ± 14.5
		pupae				0.5 ± 0.6	0.3 ± 0.5	1.0 ± 1.4	1.0 ± 1.4	0.3 ± 0.5	0.3 ± 0.5
	Heleidae	larvae							0.5 ± 1.0		
	Tabanidae	larvae	0.3 ± 0.5	0.3 ± 0.5			0.3 ± 0.5	0.8 ± 1.5	0.3 ± 0.5		0.5 ± 0.6
	Empididae	larvae								0.5 ± 0.6	
	Muscidae	larvae									0.3 ± 0.5
Nematoda					0.3 ± 0.5						
Oligochaeta			0.5 ± 0.6				0.3 ± 0.5	2.3 ± 2.1	0.8 ± 0.5	0.3 ± 0.5	0.5 ± 0.6
Gastropoda									0.3 ± 0.5		
Arachnida	Hydracarina		0.5 ± 1.0		0.3 ± 0.5	0.3 ± 0.5		0.5 ± 0.6			
Totals			7.0 ± 5.3	7.0 ± 6.7	3.0 ± 3.2	8.5 ± 3.9	3.5 ± 4.0	20.0 ± 12.3	22.8 ± 12.7	9.8 ± 8.7	44.8 ± 28.8

* Mean numbers and standard deviations of organisms collected in four 0.093 m^2 Surber samples.

Table A-11
Aquatic invertebrates* collected from rocks
taken from Shaft Creek Downstream Station**
Longlac, Ontario
8 June to 20 August 1979

Date			8 June	10 June	19 June	27 June	2 July	7 July	17 July	27 July	20 August
Days before or after Permethrin application			-16	-14	-5	+3	+8	+13	+23	+33	+57
Ephemeroptera	Heptageniidae		--	--	--	--	--	--	--	--	1.0 ± 1.4
	Baetidae		--	--	--	--	--	0.5 ± 0.6	0.5 ± 1.0	0.8 ± 1.0	--
Plecoptera			--	--	--	--	--	0.3 ± 0.5	--	--	--
Trichoptera		larvae	0.3 ± 0.5	--	--	--	0.3 ± 0.5	0.8 ± 1.0	3.5 ± 2.6	1.0 ± 1.4	7.0 ± 4.2
		pupae	0.3 ± 0.5	0.5 ± 0.6	1.8 ± 2.9	0.5 ± 1.0	--	--	1.5 ± 1.3	0.3 ± 0.5	1.8 ± 1.5
Coleoptera	Elmidae	larvae	0.3 ± 0.5	--	--	--	--	--	0.3 ± 0.5	--	--
Diptera	Simuliidae	larvae	2.0 ± 3.4	0.3 ± 0.5	6.5 ± 11.7	55.3 ± 81.5	24.5 ± 43.8	13.8 ± 26.2	4.3 ± 4.0	2.0 ± 4.0	--
		pupae	--	--	--	0.3 ± 0.5	--	--	0.3 ± 0.5	--	--
	Chironomidae	larvae	84.0 ± 20.8	53.5 ± 72.5	47.8 ± 20.5	2.3 ± 1.7	16.0 ± 7.5	18.5 ± 12.9	7.8 ± 10.6	5.5 ± 5.6	24.0 ± 19.2
		pupae	--	1.3 ± 1.0	13.0 ± 3.7	0.3 ± 0.5	0.5 ± 0.6	0.3 ± 0.5	--	--	0.5 ± 0.6
	Heleidae	larvae	--	--	--	--	--	--	0.3 ± 0.5	--	--
Oligochaeta			--	--	--	--	--	--	0.3 ± 0.5	--	--
Gastropoda			--	--	--	--	--	--	0.3 ± 0.5	--	--
Arachnida	Hydracarina		--	--	0.3 ± 0.5	--	--	0.3 ± 0.5	--	0.3 ± 0.5	0.5 ± 1.0
Total			86.8 ± 20.5	55.5 ± 73.3	69.3 ± 27.7	58.5 ± 81.5	41.3 ± 46.4	34.3 ± 26.4	18.8 ± 14.2	9.8 ± 8.9	34.8 ± 17.1

* Mean numbers and standard deviations of organisms collected from four rocks approximately 15 cm in diameter.

** Located 2.1 km downstream from treatment area (treated with 17.5 g AI/ha Permethrin from 0705 to 0900 hrs on 24 June 1979).

Table A-12
Aquatic invertebrates* collected from rocks
taken from the untreated control station
Longlac, Ontario
8 June to 20 August 1979

Date			8 June	10 June	19 June	27 June	2 July	7 July	16 July	27 July	20 August
Days before of after Permethrin application			-16	-14	-5	+3	+8	+13	+22	+33	+57
Ephemeroptera	Heptageniidae										0.3 ± 0.5
	Baetidae		0.3 ± 0.5	4.3 ± 5.2	0.5 ± 1.0	0.3 ± 0.5	0.3 ± 0.5	1.3 ± 1.3		1.3 ± 1.5	1.3 ± 1.9
Plecoptera						0.3 ± 0.5		2.0 ± 2.2	0.3 ± 0.5	0.3 ± 0.5	0.5 ± 0.6
Hemiptera		nymph						0.3 ± 0.5			
Trichoptera		larvae		0.5 ± 0.6	0.3 ± 0.5	0.3 ± 0.5	0.5 ± 1.0	0.3 ± 0.5	1.0 ± 1.4	7.8 ± 8.1	35.3 ± 11.1
		pupae	14.0 ± 16.6	14.8 ± 24.4	5.0 ± 10.0	3.5 ± 7.0	0.5 ± 0.6	2.3 ± 4.5		1.8 ± 2.9	18.3 ± 23.4
Diptera	Simuliidae	larvae	1.3 ± 1.5		1.0 ± 1.4	0.3 ± 0.5		1.8 ± 2.2	0.3 ± 0.5	0.3 ± 0.5	
	Chironomidae	larvae	1.0 ± 1.4	0.8 ± 0.5	1.3 ± 1.0	2.3 ± 1.5	5.8 ± 6.9	28.8 ± 22.4	67.8 ± 42.7	24.3 ± 19.0	13.5 ± 11.0
		pupae				0.5 ± 0.6		0.5 ± 0.6	0.5 ± 1.0	0.5 ± 1.0	
	Heleidae	larvae					0.3 ± 0.5	1.3 ± 2.5			
	Empididae	larvae						0.3 ± 0.5		0.3 ± 0.5	
		pupae								0.3 ± 0.5	
Nematoda					0.3 ± 0.5						
Oligochaeta						0.3 ± 0.5			0.3 ± 0.5		
Arachnida	Hydracarina		1.0 ± 1.2			0.3 ± 0.5				0.3 ± 0.5	
Total			17.5 ± 16.7	20.3 ± 23.7	8.3 ± 9.7	7.8 ± 8.9	7.3 ± 7.5	38.5 ± 23.8	70.0 ± 43.2	36.8 ± 12.7	69.0 ± 24.7

* Mean numbers and standard deviations of organisms collected from four rocks approximately 15 cm in diameter.

Table A-13
Terrestrial organisms* caught in drift nets set in
Shaft Creek East Tributary Station**
Longlac, Ontario
16 June to 28 June 1979

Days before or after Permethrin application	-8 am	-8 pm	-7 am	-7 pm	-6 am	-6 pm	-5 am	-5 pm	-4 am	-4 pm	-3 am	-3 pm	-2 am	-2 pm	-1 am	-1 pm
Surface area of drift column (m^2)	306	189	162	162	135	162	162	135	126	135	81	81	54	216	--	--
Orthoptera																
Plecoptera																
Homoptera																
Diptera	0.03	0.05	0.06		0.07		0.25	0.15	0.08	0.15	0.49	0.12	0.19			
Total	0.03	0.05	0.06	0.00	0.07	0.00	0.25	0.15	0.08	0.15	0.49	0.12	0.19	0.00	--	--

* expressed as organisms/$10m^2$ of stream surface flowing through drift net

** treated with 17.5 g AI/ha Permethrin at 0840 hrs on 24 June 1979

Table A-13 (cont'd)
Terrestrial organisms* caught in drift nets set in
Shaft Creek East Tributary Station**
Longlac, Ontario
16 June to 28 June 1979

Days before or after Permethrin Application	-0 am	+0 hr	+½ hr	+1 hr	+2 hr	+3 hr	+6 hr	+12 hr	+1 am	+1 pm	+2 am	+2 pm	+3 am	+3 pm	+4 am	+4 pm
Surface area of drift column (m^2)	90	90	90	90	90	90	90	90	189	189	135	135	135	135	135	108
Orthoptera							0.11									
Plecoptera		0.11														
Homoptera								0.11								
Diptera	0.11	0.22	0.22	0.11	0.11	0.11	0.22	0.11	0.11	0.05	0.44	0.15	0.07	0.07	0.07	
Total	0.11	0.33	0.22	0.11	0.11	0.11	0.33	0.22	0.11	0.05	0.44	0.15	0.07	0.07	0.07	0.00

* expressed as organisms/$10m^2$ of stream surface flowing through drift net

** treated with 17.5 g AI/ha Permethrin at 0840 hrs on 24 June 1979

Table A-14
Terrestrial organisms* caught in drift nets set in
Shaft Creek West Tributary Station**
Longlac, Ontario
16 June to 28 June 1979

Days before or after Permethrin application	-8 am	-8 pm	-7 am	-7 pm	-6 am	-6 pm	-5 am	-5 pm	-4 am	-4 pm	-3 am	-3 pm	-2 am	-2 pm	-1 am	-1 pm
Surface area of drift column (m^2)	189	243	207	306	162	162	186	204	126	90	114	117	81	279	135	189
Collembola																
Plecoptera																
Homoptera				0.03												
Hymenoptera		0.04								0.11						
Coleoptera																
Staphylinidae																
Other																
Diptera		0.04	0.05	0.03			0.05		0.16		0.35	0.17				
Arachnida																
Araneida	0.05						0.11									
Total	0.05	0.08	0.05	0.06	0.00	0.00	0.16	0.00	0.16	0.11	0.35	0.17	0.00	0.00	0.00	0.00

* expressed as organisms/$10m^2$ of stream surface flowing through drift net

** treated with 17.5 g AI/ha Permethrin at 0840 hrs on 24 June 1979

Table A-14 (cont'd)
Terrestrial organisms* caught in drift nets set in
Shaft Creek West Tributary Station**
Longlac, Ontario
16 June to 28 June 1979

Days before or after Permethrin application	-0 am	+0 hr	+½ hr	+1 hr	+2 hr	+3 hr	+6 hr	+12 hr	+1 am	+1 pm	+2 am	+2 pm	+3 am	+3 pm	+4 am	+4 pm
Surface area of drift column (m^2)	90	90	90	45	90	90	130	162	--	189	189	186	189	135	135	81
Collembola								5.06								
Plecoptera			0.22	0.22	0.11		0.08			0.05						
Homoptera				0.22		0.22	0.08	0.19		0.11						
Hymenoptera											0.05					
Coleoptera																
Staphylinidae				0.66												
Other								0.06								
Diptera		0.11	0.77	1.11	0.55	2.22	1.08	1.36		0.85	0.42	0.16	0.21	0.15	0.07	
Arachnida																
Araneida	0.11		0.11		0.11		0.15	0.12		0.05						
Total	0.11	0.11	1.10	2.11	0.77	2.44	1.39	6.79	--	1.06	0.47	0.16	0.21	0.15	0.07	0.00

* expressed as organisms/$10m^2$ of stream surface flowing through drift net

** treated with 17.5 g AI/ha Permethrin at 0840 hrs on 24 June 1979

Table A-15
Terrestrial organisms* caught in drift nets set in
Shaft Creek Upstream Station**
Longlac, Ontario
16 June to 28 June 1979

Days before or after Permethrin application	-8 am	-8 pm	-7 am	-7 pm	-6 am	-6 pm	-5 am	-5 pm	-4 am	-4 pm	-3 am	-3 pm	-2 am	-2 pm	-1 am	-1 pm
Surface area of drift column (m^2)	189	189	216	162	135	243	216	243	243	243	243	216	126	216	189	216
Collembola					0.07	0.08	0.14	0.21		0.12	0.08					
Plecoptera																
Thysanoptera																
Hemiptera																
Homoptera							0.05									
Lepidoptera larvae								0.04								
Hymenoptera								0.04								
Coleoptera																
Staphylinidae						0.04		0.04								
Other	0.05		0.05													
Diptera	0.11	0.16	0.14	0.06	0.52	0.08	0.14	0.12	0.21	0.16	0.25	0.19	0.08	0.14		0.19
Arachnida																
Araneida		0.58				0.04								0.19		
Total	0.16	0.74	0.19	0.06	0.59	0.24	0.33	0.45	0.21	0.28	0.33	0.19	0.08	0.33	0.00	0.19

* expressed as organisms/$10m^2$ of stream surface flowing through drift net

** treated with 17.5 g AI/ha Permethrin at 0850 hrs on 24 June 1979

Table A-15 (cont'd)
Terrestrial organisms* caught in drift nets set in
Shaft Creek Upstream Station**
Longlac, Ontario
16 June to 28 June 1979

Days before or after Permethrin application	-0 am	+0 hr	+½ hr	+1 hr	+2 hr	+3 hr	+6 hr	+12 hr	+1 am	+1 pm	+2 am	+2 pm	+3 am	+3 pm	+4 am	+4 pm
Surface area of drift column (m^2)	189	126	63	63	63	72	216	144	216	216	333	243	306	279	279	243
Collembola	0.21	0.16		1.75	0.63	0.28	0.09				2.10	0.16	0.03			
Plecoptera								0.07								
Thysanoptera									0.05							
Hemiptera								0.07								
Homoptera	0.16				0.16						0.09		0.03			
Lepidoptera larvae																
Hymenoptera											0.03			0.04		
Coleoptera																
Staphylinidae	0.05															
Other	0.05															
Diptera	0.58	0.48	0.48	0.48	1.43	0.14	0.42	0.49	0.28	0.09	0.66	0.21	0.59	0.26	0.11	0.12
Arachnida																
Araneida					0.48						0.03	0.37			0.04	
Total	1.05	0.64	0.48	2.23	2.70	0.42	0.51	0.63	0.33	0.09	2.91	0.74	0.65	0.30	0.15	0.12

* expressed as organisms/$10m^2$ of stream surface flowing through drift net

** treated with 17.5 g AI/ha Permethrin at 0850 hrs on 24 June 1979

Table A-16
Terrestrial organisms* caught in drift nets set in
Shaft Creek Downstream Station**
Longlac, Ontario
16 June to 28 June 1979

Days before or after Permethrin application	-8 am	-8 pm	-7 am	-7 pm	-6 am	-6 pm	-5 am	-5 pm	-4 am	-4 pm	-3 am	-3 pm	-2 am	-2 pm	-1 am	-1 pm	-0 am
Surface area of drift column (m^2)	450	300	450	450	240	240	222	186	222	186	204	204	204	186	222	222	186
Collembola											0.05					0.23	
Ephemeroptera											0.05						
Plecoptera											0.05						
Thysanoptera																	
Hemiptera									0.05								
Homoptera			0.02								0.05					0.09	
Trichoptera											0.05						
Lepidoptera larvae																	
Hymenoptera												0.05					
Coleoptera																	
Staphylinidae																	
Other																	
Diptera	0.27	0.23	0.51	0.22	0.21	0.29	0.27	1.08	3.24	0.70	1.42	1.52	0.10	1.77	0.09	0.95	0.16
Siphonoptera																0.05	
Arachnida																	
Araneida								0.05			0.05				0.05		
Total	0.27	0.23	0.53	0.22	0.21	0.29	0.27	1.13	3.29	0.70	1.72	1.57	0.10	1.77	0.14	1.32	0.16

* expressed as organisms/$10m^2$ of stream surface flowing through drift net

** 2.1 km downstream from treatment area (treated with 17.5 g AI/ha Permethrin at 0705 to 0900 hrs on 24 June 1979)

Table A-16 (cont'd)
Terrestrial organisms* caught in drift nets set in
Shaft Creek Downstream Station**
Longlac, Ontario
16 June to 28 June 1979

Days before or after Permethrin application	+0 hr	+½ hr	+1 hr	+2 hr	+3 hr	+4 hr	+6 hr	+12 hr	+1 am	+1 pm	+2 am	+2 pm	+3 am	+3 pm	+4 am	+4 pm
Surface area of drift column (m^2)	186	186	186	186	186	186	186	204	204	162	360	222	234	258	333	279
Collembola			0.05				0.27	0.05						0.12		
Ephemeroptera													0.47			
Thysanoptera								3.53				0.05				
Hemiptera							0.05									
Homoptera				0.05				0.05		0.06						
Trichoptera																
Lepidoptera larvae							0.05									
Hymenoptera						0.16		0.05						0.04		
Coleoptera																
Staphylinidae																0.04
Other																
Diptera	0.05	0.11	0.16	0.11	0.38	0.38	2.42	0.59	1.08	0.25	0.11	0.27	0.38	0.78	0.01	0.07
Siphonoptera																
Arachnida																
Araneida	0.05															
Total	0.10	0.11	0.21	0.16	0.38	0.54	2.79	4.27	1.08	0.31	0.11	0.32	0.85	0.94	0.01	0.11

* expressed as organisms/10m^2 of stream surface flowing through drift net

** 2.1 km downstream from treatment area (treated with 17.5 g AI/ha Permethrin at 0705 to 0900 hrs on 24 June 1979)

Table A-17
Terrestrial organisms* caught in drift nets set in
Untreated Control Station
Longlac, Ontario
16 June to 28 June 1979

Days before or after Permethrin application		-8 am	-8 pm	-7 am	-7 pm	-6 am	-6 pm	-5 am	-5 pm	-4 am	-4 pm	-3 am	-3 pm	-2 am	-2 pm
Surface area of drift column (m^2)		279	162	270	270	180	180	216	216	216	189	144	216	243	306
Collembola															
Plecoptera													0.05		
Thysanoptera							0.06								
Hemiptera		0.04													
Homoptera		0.04									0.05				
Trichoptera							0.06								
Lepidoptera	larvae														
Hymenoptera				0.07	0.07		0.06		0.14					0.04	0.03
Coleoptera															
Staphylinidae															
Other	larvae														
	adults		0.06		0.07			0.05							
Diptera		0.36	0.12	0.63	0.11	0.39	0.44	0.83	0.18	0.32	0.85	0.69	0.37	0.04	0.10
Arachnida															
Pseudoscorpionida															
Araneida				0.04											
Total		0.44	0.18	0.74	0.25	0.39	0.62	0.88	0.32	0.32	0.90	0.69	0.42	0.08	0.13

* expressed as organisms/$10m^2$ of stream surface flowing through drift net

Table A-17 (cont'd)
Terrestrial organisms* caught in drift nets set in
Untreated Control Station
Longlac, Ontario
16 June to 28 June 1979

Days before or after Permethrin application		-1 am	-1 pm	-0 am	+0 hr	+1 hr	+2 hr	+12 hr	+1 am	+1 pm	+2 am	+2 pm	+3 am	+3 pm	+4 am	+4 pm
Surface area of drift column (m^2)		--	--	162	162	162	162	162	162	162	306	189	189	189	216	216
Collembola					0.06				0.12			0.05				
Plecoptera																
Thysanoptera											0.03					
Hemiptera																
Homoptera									0.06							
Trichoptera																
Lepidoptera	larvae							0.06						0.05		
Hymenoptera				0.06		0.06		0.12	0.12							
Coleoptera																
Staphylinidae																
Other	larvae										0.03					
	adults					0.06										
Diptera				0.12	0.25	0.12		0.56	1.00	0.25	0.23	0.16		0.26	0.19	
Arachnida																
Pseudoscorpionida																
Araneida						0.06					0.03			0.05		
Total		--	--	0.18	0.31	0.30	0.00	0.74	1.30	0.25	0.32	0.21	0.00	0.36	0.19	0.00

* expressed as organisms/$10m^2$ of stream surface flowing through drift net

Table A-18
Terrestrial invertebrate knockdown*
from coniferous foliage in T1 area**,
Longlac, Ontario
7 June to 8 July 1979

Days before or after Permethrin application	-17	-16	-15	-14	-13	-8	-7	-6	-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14
Arachnida																												
Acari					1.0																							
Araneida	0.5		1.0		0.5	0.5				0.5	0.5	0.5			0.5							0.5	0.5					
Collembola	0.5																											
Hemiptera			0.5																0.5									
Coleoptera																												
Elateridae																0.5												
Other																					0.5		0.5					0.5
Diptera																												
Chironomidae			0.5	0.5							0.5			0.5														
Simuliidae											0.5			1.0														
Sciaridae				0.5								1.5			1.0		0.5		0.5		0.5							0.5
Phoridae	0.5											0.5						0.5			0.5							
Muscoidae													0.5			0.5												
Other					0.5							1.0		3.5	2.0			1.0		0.5				0.5			0.5	0.5
Hymenoptera																												
Other	0.5			1.0		0.5				0.5				0.5									0.5					
Total	2.0	0.0	2.0	2.0	2.0	1.0	0.0	0.0	0.0	1.0	1.5	3.5	0.5	5.5	3.5	1.0	0.5	1.5	1.0	0.5	1.5	0.5	1.5	0.5	0.0	0.0	0.5	1.5

* expressed as organisms per sampler

** treated with 17.5 g AI/ha Permethrin
at 0710 hrs on 24 June 1979

Table A-19
Terrestrial invertebrate knockdown*
from deciduous foliage in T1 area**,
Longlac, Ontario
7 June to 8 July 1979

Days before or after Permethrin application	-17	-16	-15	-14	-13	-8	-7	-6	-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14
Arachnida																												
Acari														0.67														
Araneida			0.33		0.33	0.33	0.33			1.33	0.67		0.33	0.33	0.33			0.67				0.33	0.67					
Collembola	0.33											0.67																
Hemiptera																							0.33					
Homoptera																												
Cercopidae													0.67	0.33														
Cicadellidae													0.33	0.67													0.33	
Coleoptera																												
Carabidae	0.67		0.33																									
Staphylinidae													0.33	0.33														
Elateridae	0.33													0.33														
Other							0.33						0.67	0.33	0.33					0.33								
Trichoptera	0.33																											
Diptera																												
Chironomidae	1.00																											
Simuliidae							0.33						0.67	0.67														
Sciaridae														1.33				0.33	0.33		0.67							0.33
Phoridae					0.33									0.33													0.33	
Muscoidae				0.33																								
Other	3.30			1.33	1.00	1.00	0.33			2.33	1.00	3.00	1.00		1.33			0.33				0.67	0.67					0.33
Hymenoptera																												
Formicidae				0.33			0.33							0.33		0.33					0.67	0.33					0.33	0.33	
Other	2.00			0.67	1.00		0.33				0.33					0.67		0.33										0.33
Total	8.00	0.00	0.67	2.67	2.67	1.33	2.00	0.00	0.00	1.33	3.30	1.67	6.00	6.67	0.67	2.33	0.00	1.33	0.67	0.33	1.33	0.67	1.67	0.67	0.00	0.33	1.00	1.00

* expressed as organisms per sampler

** treated with 17.5 g AI/ha Permethrin
at 0710 hrs on 24 June 1979

Table A-20
Terrestrial invertebrate knockdown*
from coniferous foliage in T2 area**,
Longlac, Ontario
7 June to 8 July 1979

Days before or after Permethrin application	-17	-16	-15	-14	-13	-8	-7	-6	-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14
Arachnida																												
Araneida			2.0								0.5		0.5	1.0														
Chilopoda																					0.5							
Collembola					0.5																							
Hemiptera													1.0			0.5	0.5			0.5								
Homoptera																												
Cicadellidae														1.0														
Other																									0.5			
Coleoptera																												
Carabidae															0.5													
Other														0.5														
Lepidoptera larvae														0.5														
Diptera																												
Tipulidae														0.5														
Chironomidae														1.5														
Sciaridae																					0.5			0.5				
Other			0.5	1.0				0.5		0.5		1.5	0.5	4.5	0.5	1.0	1.5	0.5				0.5						
Hymenoptera																												
Formicidae					0.5																							
Other			0.5	0.5										0.5														
Total	0.0	0.0	3.0	1.5	1.0	-	0.0	0.5	0.0	0.5	0.5	1.5	2.0	10.0	1.0	1.5	2.0	0.5	-	0.5	1.0	0.5	0.0	0.5	0.5	0.0	0.0	0.0

* expressed as organisms per sampler

** treated with 17.5 g AI/ha Permethrin
at 0835 hrs on 24 June 1979

Table A-21
Terrestrial invertebrate knockdown* from deciduous foliage in T2 area**, Longlac, Ontario
7 June to 8 July 1979

Days before or after Permethrin application		-17	-16	-15	-14	-13	-8	-7	-6	-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14
Arachnida																													
Phalangida									0.67			0.33	0.33																
Araneida				0.33	0.33	0.33					0.67		0.67	0.33	1.00		0.33				0.33						0.33		0.33
Collembola						0.33																							
Hemiptera															1.00		0.33												
Homoptera																													
Cercopidae															0.67														
Cicadellidae				0.33		0.33							0.33											0.33					
Coleoptera																													
Carabidae							0.33	0.33	0.33																				
Elateridae								0.33																					
Unidentified	adults	0.33													0.33														
	larvae																						0.33						
Lepidoptera	larvae				0.33											0.33													0.33
Diptera																													
Chironomidae													0.33		0.67														
Simulidae		0.67																											
Sciaridae																				0.33	1.00		0.67						0.33
Phoridae															0.33														
Muscoidae																						0.33							
Other				1.00	1.33	1.33	0.33				0.33		0.67	0.67	3.67	1.00	0.33	2.67	0.67		0.67	0.33		0.33					
Hymenoptera																													
Formicidae		0.33				0.33	0.67	0.67									0.67												
Other				0.33	0.33						0.33		0.33	0.33	1.00		1.33						0.33	0.33					
Total		1.33	0.00	2.00	2.33	2.67	1.33	1.33	1.00	0.00	1.33	0.33	2.67	1.33	8.67	1.33	3.00	2.67	0.67	0.33	2.00	0.67	1.33	1.00	0.00	0.00	0.33	0.00	1.00

* expressed as organisms per sampler

** treated with 17.5 g AI/ha Permethrin at 0835 hrs on 24 June 1979

Table A-22
Terrestrial invertebrate knockdown*
from coniferous foliage in T3 area**,
Longlac, Ontario
7 June to 8 July 1979

Days before or after Permethrin application	-17	-16	-15	-14	-13	-8	-7	-6	-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14
Arachnida																												
Araneida	0.5		1.5	0.5												0.5							1.0				0.5	
Chilopoda																					0.5							
Collembola												0.5		0.5									0.5					
Hemiptera														0.5									0.5					
Coleoptera																												
Carabidae							0.5																					
Staphylinidae			0.5								0.5				0.5													
Elateridae			0.5																									
Unidentified pupae																				0.5								
Lepidoptera adults	0.5																											
Lepidoptera larvae														0.5														
Diptera																												
Tipulidae																						0.5						
Chironomidae																									0.5			
Simuliidae			1.0	0.5		0.5								1.5						0.5								
Sciaridae																							0.5	0.5		0.5		
Muscoidae																0.5												
Other					0.5								0.5	0.5	1.0	0.5						0.5			0.5			
Hymenoptera																												
Formicidae																												0.5
Other																												0.5
Total	1.0	0.0	3.5	1.0	0.5	0.5	0.5	0.0	0.0	0.0	0.5	0.5	0.5	3.5	1.5	1.5	0.0	-	-	1.0	0.5	1.0	2.5	0.5	1.0	0.5	0.5	1.0

* expressed as organisms per sampler

** treated with 17.5 g AI/ha Permethrin
at 0900 hrs on 24 June 1979

Table A-23
Terrestrial invertebrate knockdown*
from deciduous foliage in T3 area**,
Longlac, Ontario
7 June to 8 July 1979

Days before or after Permethrin application	-17	-16	-15	-14	-13	-8	-7	-6	-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14
Gastropoda			0.33			0.33					0.33										0.33							
Arachnida																												
Phalangida																											0.33	
Acari																						0.33						
Araneida	0.33		0.67	0.67						0.33		0.33								0.33		0.33			1.00			0.33
Diplopoda					0.33																							
Collembola				0.67																								
Homoptera																												
Unidentified															0.33													
Coleoptera																												
Carabidae			0.33			0.33			0.33		0.67									0.33	0.33	0.67	0.67					
Staphylinidae										0.33																		
Elateridae																					0.33	0.67						
Other										0.33																		
Lepidoptera larvae										0.33										0.33								
Diptera																												
Tipulidae														0.33														
Chironomidae																											0.33	
Simulidae					0.67		0.33			0.33		0.33		1.67														
Other				1.67	0.33	0.33	0.33							0.67		0.33		0.33				0.33			0.33			
Hymenoptera																												
Formicidae	0.33					0.33																			0.67			
Other						0.33										0.33							0.33					
Total	0.67	0.00	1.33	3.00	1.33	1.67	0.67	0.00	0.33	1.67	1.00	0.67	0.00	2.67	0.33	0.67	0.00	0.33	--	1.00	1.00	2.33	1.00	0.00	2.00	0.00	0.67	0.33

* expressed as organisms per sampler

** treated with 17.5 g AI/ha Permethrin
at 0900 hrs on 24 June 1979

Table A-24
Terrestrial invertebrate knockdown*
from forest canopy in T4 area**,
Longlac, Ontario
7 June to 8 July 1979

Days before or after Permethrin application	-17	-16	-15	-14	-13	-8	-7	-6	-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14
Arachnida																												
Phalangida																0.07												
Acari			0.07							0.07								0.07					0.07	0.07	0.07		0.13	
Araneida	0.07	0.33	0.07	0.13		0.27		0.07		0.27	0.07			0.27					0.07	0.07			0.20	0.07		0.07	0.07	
Chilopoda																						0.07						
Collembola										0.13								0.07										
Hemiptera				0.07		0.13			0.07		0.07			0.20			0.07											
Homoptera																												
Other						0.07		0.07						0.27			0.07	0.07			0.07	0.07	0.20			0.07		
Coleoptera																												
Carabidae		0.07																										
Staphylinidae														0.07														
Elateridae																	0.07				0.07						0.07	
Other														0.07														
Lepidoptera																												
Microlepidoptera																0.07									0.07			
Unidentified larvae		0.07																										
Diptera																												
Tipulidae																								0.07				
Culicidae								0.07																				
Chironomidae	0.07	0.07		0.07							0.07		0.13							0.07		0.07			0.13		0.07	
Simulidae	0.13	0.20		0.07										0.07											0.07			
Muscoidae												0.13		0.13						0.07		0.13			0.13		0.07	
Sciaridae						0.07			0.07		0.13	0.13	0.20	0.13		0.13	0.07			0.07			0.07	0.07	0.20			0.07
Phoridae												0.07		0.07								0.07	0.07					
Other		0.07		0.07		0.07			0.07			0.13		0.80			0.07			0.07		0.13	0.07	0.13			0.07	
Hymenoptera																												
Formicidae		0.07						0.13																				0.07
Other	0.20					0.13					0.07	0.07		0.20							0.07			0.07				
Gastropoda	0.07																											
Total	0.53	0.87	0.13	0.40	0.00	0.73	--	0.33	0.20	0.47	0.40	0.53	0.33	2.27	0.00	0.27	0.33	0.20	0.07	0.33	0.20	0.53	1.67	1.17	1.67	0.13	1.17	0.13

* expressed as organisms per sampler

** treated with 17.5 g AI/ha Permethrin
at 0840 hrs on 24 June 1979

Table A-25
Terrestrial invertebrate knockdown*
from coniferous foliage in untreated control area,
Longlac, Ontario
7 June to 8 July 1979

Days before or after Permethrin application	-17	-16	-15	-14	-13	-8	-7	-6	-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14
Gastropoda								0.50													0.25							
Arachnida																												
Acari																				0.25								
Araneida			0.25					0.25					0.25	0.25									0.25			0.25		0.25
Collembola													0.25								0.25							
Homoptera																												
Aphididae																									0.25			
Coleoptera																												
Staphylinidae													0.25	0.25														
Cicindelidae																0.25												
Lepidoptera larvae																		0.25										
Diptera																												
Psychodidae			0.25																									
Culicidae				0.25																								
Simuliidae																		0.25										
Sciaridae																				0.50	0.50							
Phoridae			0.25																									
Other				0.25					0.25		0.25	0.25					0.25			0.25							0.25	
Hymenoptera																												
Formicidae																				0.25						0.25		
Unidentified adults												0.50								0.25								0.25
larvae															0.25													0.25
Total	0.00	0.00	0.75	0.50	0.00	0.00	0.00	0.75	0.25	0.00	0.25	0.75	0.75	0.50	0.25	0.25	0.25	0.50	--	1.50	1.00	0.00	0.25	0.00	0.25	0.50	0.25	0.75

* expressed as organisms per sampler

Table A-26
Terrestrial invertebrate knockdown*
from deciduous foliage in untreated control area,
Longlac, Ontario
7 June to 8 July 1979

Days before or after Permethrin application	-17	-16	-15	-14	-13	-7	-6	-5	-4	-3	-2	-1	0	+1	+2	+3	+4	+5	+6	+7	+8	+9	+10	+11	+12	+13	+14
Arachnida																											
Acari																						0.67					
Araneida	0.17		0.50		0.17	0.17			0.17					0.33								0.17	0.17			0.17	0.17
Diplopoda					0.17																						
Odonata												0.17															
Hemiptera																				0.17							
Homoptera																											
Cicadellidae																	0.17		0.17					0.17	0.17		0.50
Other													0.17														
Coleoptera																											
Carabidae	0.17			0.17	0.17		0.17						0.17				0.17				0.17	0.33		0.17			
Staphylinidae			0.33																								
Other																					0.33				0.17	0.17	0.17
Lepidoptera																											
Unidentified larvae											0.33	0.17	0.17	0.83	1.00	0.17	0.17										
Diptera																											
Tipulidae					0.17																	0.17					
Culicidae		0.17	0.17																								
Simuliidae		0.33	0.17																								
Sciaridae				0.50	0.50	0.17													0.17	0.50	0.17						0.17
Phoridae											0.33																
Muscoidae																						0.17					
Other											0.17	0.17			0.33					0.17	0.17						0.17
Hymenoptera																											
Formicidae	0.33								0.17				0.17											0.17			0.17
Other			0.33	0.17															0.50	0.33							
Total	0.67	0.50	1.50	0.83	1.17	0.33	0.17	0.00	0.33	0.00	0.83	0.50	0.67	1.17	1.33	0.17	0.50	--	0.83	1.17	0.83	1.50	0.17	0.50	0.33	0.33	1.33

* expressed as organisms per sampler

Table A-27
Terrestrial organisms caught in pitfall traps set in T1 area*, Longlac, Ontario
7 June to 30 July 1979

Date		June 7	8	9	10	20	21	22	23	24	25	26	27	28	July 5	6	7	8	26	27	28	29	30
Nematoda																						1	
Oligochaeta		1			1																		
Gastropoda		3	2	1	1								1				1					1	
Arachnida																							
Phalangida						1		1	1										1	1	1	4	1
Acari		1	9	2		6		3	12	17	32	9	23	38	9	32	36	115	103	68	106	7	91
Araneida		93	94	47	27	58	14	14	68	38	21	32	37	50	14	33	41	38	187	96	257	59	56
Collembola		2	1	2	4			21	434	54	2	2	8	322				4	1		1		3
Odonata									2														
Orthoptera																							
Acrididae		4	1	2		2	3			1	4			3	2	2	2	2	10	9	16	7	11
Other						1																	
Hemiptera							2			1	1								4		3		
Homoptera																							
Cicadellidae			3	1	1	7	4	2	1	2	1	2	4	1	2	8	5	19	7	10	4	7	13
Other		1	3	1	7	1	2	1	1			8	1	1			2	2	4	1	2		5
Coleoptera																							
Carabidae		1	2	8	1	2		1	2	3			1	2					3	1	1	4	
Staphylinidae			1	2	1	2		1				1	1			2						16	
Unidentified	larvae				1			2						1			1		4	3	2		
Unidentified	adults	2	3	3	4	2	3	2		3	1	4	4	1		6	5	1	4	2	5	1	
Lepidoptera	larvae			1	1	1				1	1	3		1			1				1		
Diptera	adults	14	31	27	31	21	20	10	1	5	1	13	21	12	12	10	13	46	28	9	19	86	27
	larvae				1																		
Siphonaptera		2						1	1														
Hymenoptera																							
Formicidae		94	37	34	9	26	1	4	4	18	9	4	10	15	13	22	21	21	53	32	33	36	23
Other			1		1	3	3	2		1	2	3		1	1	4	2	3	4	7	7	9	
Total		218	188	131	91	133	52	65	527	144	75	81	111	448	53	119	130	251	413	239	458	238	230

* treated with 17.5 g AI/ha Permethrin at 0710 hrs on 24 June 1979

Table A-28
Terrestrial organisms caught in pitfall traps set in T2 area*, Longlac, Ontario
7 June to 30 July 1979

Date		June 7	8	9	10	20	21	22	23	24	25	26	27	28	5	6	7	8	July 26	27	28	29	30
Gastropoda		1			1	1													1				
Arachnida																							
Phalangida		1			1	1			1						1			1	7	1	12	4	4
Acari			5	1		40	1		6	5	5	2	4	6	5	5	9	4	2	8	18	8	14
Araneida		28	80	23	7		19	3	32	12	13	13	22	30	18	15	12	33	14	50		23	
Chilopoda																					1		
Collembola		5		1		1	5			2			1					1		2	4	1	
Orthoptera																							
Acrididae								1														1	
Other																			2				1
Thysanoptera						1																	
Hemiptera										4	1					1		1		1	1		
Homoptera																							
Cercopidae				1			1							1									
Cicadellidae		3	12				2	1	2		2	3	2	1	2	1	1	6	1	4	3	4	2
Other							1				1	2					1				1		
Coleoptera																							
Carabidae			1	4	3	4	3			2	1	3	1	1				2			3	3	2
Staphylinidae		1	3						1	3	1					5		1		1	1	5	
Elateridae							1																
Unidentified	larvae				1																		
Other	adults		1								1		1						1	2			
Mecoptera																				1			
Trichoptera																					2		1
Lepidoptera	adults																	2				2	
	larvae	1	1			1	1		1			4	1		1								
Diptera	adults	11	27	28	2	27	20	2	11	9	21	23	8	15	16	14	34	27	23	64	50	43	9
	larvae																1						
Hymenoptera																							
Formicidae		19	22	13	2	11	8	2	2	8	11	4	3	10	17	7	7	15	10	18	18	9	17
Other			1	3		3	4			3	4	1	2			2	4	3	3	4	4	2	
Total		70	153	74	17	90	155	9	56	48	61	55	45	64	60	50	69	96	64	156	118	105	50

* treated with 17.5 g AI/ha Permethrin at 0835 hrs on 24 June 1979

Table A-29
Terrestrial organisms caught in pitfall traps set in T3 area*, Longlac, Ontario
7 June to 30 July 1979

Date		June 7	8	9	10	20	21	22	23	24	25	26	27	28	5	6	7	July 8	26	27	28	29	30
Gastropoda		1	1				1					1							3			1	
Arachnida																							
Phalangida			1	2	1	7	3	1	2	2	2		2	1				2	6	4	14	1	2
Acari					4	5			6	16	7	6	22	20	12	15	17	42	3	8	28	15	14
Araneida		44	36	46	15	43	12	2	12	32	14	21	23	22	21	16	16	17	35	162	205	88	13
Collembola		3	2		6	1	3		1	3		1	3					1	3	4	1	4	3
Orthoptera																							
Acrididae		2		1			2										1		2			1	
Hemiptera							2			1		2						2	3		3	3	4
Homoptera																							
Cercopidae			1	1						1		1						5				1	
Cicadellidae			6							1									4	2	1	1	
Other		1											1			1				1			
Coleoptera																							
Carabidae		6	2	7	1	6	2		1	7	1	1	4	2	4	1		2	2	2	1	1	
Staphylinidae		1	3	3		3			1	4	2	3			1	2	1	2	2	3	8	21	4
Elateridae																				1			
Unidentified	adults		1	1	1	2	2			2	1		4	2			1	1				1	
Unidentified	larvae		1							1	1	1	1										1
Trichoptera											1				1								3
Lepidoptera	adults																1		1				
	larvae			1		2	1		1			1											
Diptera		12	45	25	58	12	32	5	6	13	13	30	32	16	20	18	23	107	44	102	186	53	82
Hymenoptera																							
Formicidae		55	33	12	3	10	5	1	5	14	7	4	6	6	12	21	20	18	14	6	8	35	14
Other			3		2	1	7	3		2		4	1	4	4		3	7	7	5	6	10	4
Diplura																			2				
Total		125	135	99	91	92	72	12	35	99	49	76	99	73	75	74	83	206	131	300	461	236	144

* treated with 17.5 g AI/ha Permethrin at 0900 hrs on 24 June 1979

Table A-30
Terrestrial organisms caught in
pitfall traps set in the untreated control area,
Longlac, Ontario
7 June to 30 July 1979

Date		June																July				
		7	8	9	10	20	21	22	23	24	25	26	27	28	5	6	7	8	26	27	28	29	30
Nematoda			1								1						1						
Oligochaeta		2		2	1			2			1	1			1				1		1		
Gastropoda				2					1				1	1					1				
Arachnida																							
Phalangida		1					3		1		1			1	2	1	2	6	8	2	3		3
Acari		2	6	2	3				1	4		1		3	9	1	1	5	2	10	10	93	4
Araneida		27	63	64	11	58	27	2	35	59	46	34	87	49	37	30	36	35	22	84	31	47	14
Diplopoda												1											
Collembola			2	2	5	2					2	1			2		1		1			1	2
Orthoptera																							
Acrididae				1		1		1	1	1	2			1	1	6	10	4	1	10	15	17	20
Hemiptera				1		1				1		2	1			1		1				6	1
Homoptera																							
Cercopidae													1	1					1			1	2
Cicadellidae				2	1								2		1	3	2	3	1	5	11	6	10
Other			1										1	2	2		1	1					
Coleoptera																							
Carabidae		7	10	3	5	3	4	2	3	1	1	5	4		1						4	3	4
Staphylinidae		2	8	9		5	2		3	7	3	5	4	2	1	1	3	2	2	2	2	6	9
Elateridae																	1					1	
Other			6	3	3	2	1	1		1	1		3		2	1	3	3	1	1	2	4	1
Lepidoptera	adults			1												2		2				1	
	larvae	1				1					1	1					1			2			
Diptera	adults	6	45	99	21	8	10	9	2	21	32	22	17	19	21	17	14	41	18	10	20	13	58
Hymenoptera																							
Formicidae		2	19	11	4	47	22		1	7	9	13	17	13	4	12	12	17	5	1	14	49	44
Unidentified	adults	1		7	1		2		3	2	4				3			1			6	4	9
Unidentified	larvae				2															1	1	1	1
Total		51	161	209	57	128	71	17	51	104	104	86	138	92	89	75	88	121	64	128	120	253	182