

Impact of Applications of the Nuclear
Polyhedrosis Virus of the Red-Headed
Pine Sawfly, *Neodiprion lecontei* (Fitch),
on Non-target Organisms in 1977

by

P. Kingsbury, B. McLeod and K. Mortensen
Forest Pest Management Institute
Sault Ste. Marie, Ontario

Report FPM-X-11

Canadian Forestry Service
Department of Fisheries and the Environment
December, 1978

Copies of this report may be obtained
from:

Director
Forest Pest Management Institute
Canadian Forestry Service
Department of Fisheries and the
Environment
Box 490, Sault Ste. Marie, Ontario
P6A 5M7

Abstract

Nuclear polyhedrosis virus (NPV) trials carried out in the Renfrew, Ontario area were monitored for possible adverse side-effects upon selected non-target organisms. An aerial application of 5.5 billion PIB/ha (emitted dosage rate) did not cause any adverse immediate or short-term impact upon bird populations or honeybee colonies located in the treated areas. Some decrease in chironomid and baetid mayfly larvae occurred in a treated stream immediately after the virus application but post spray sampling indicated these declines were related to the nature of the streams studied and not to the virus application.

Résumé

Des essais de virus de la polyédrose nucléaire (VPN), effectués à Renfrew, Ontario furent suivis minutieusement pour découvrir les effets secondaires possibles sur des organismes témoins choisis. Une application aérienne de 5.5 milliards PIB/ha (dose émise) n'a causé aucun impact adverse immédiat ou à court terme aux populations d'oiseaux ni aux essaims d'abeilles situés dans le secteur traité. Il se produisit une diminution des larves de chironomides et de baétides dans un ruisseau traité immédiatement après l'application du virus mais des échantillonnages effectués après l'arrosage démontrent que ces déclin étaient dus plutôt à la nature des ruisseaux étudiés qu'à l'application du virus.

Introduction

In 1977, further testing of the nuclear polyhedrosis virus (NPV) for the control of the red-headed pine sawfly, *Neodiprion lecontei* (Fitch), was carried out by the Forest Pest Management Institute. Two red pine plantations near Renfrew, Ontario, were sprayed from the air at an application rate of 5.5 billion PIB/ha emitted in an aqueous formulation at 9.4 l/ha (Kaupp, Cunningham and de Groot, 1978).

Laboratory tests have demonstrated the safety of this NPV to birds (Valli and Claxton, 1976) and mammals (Valli and Forsberg, 1978). The environmental impact section of FPMI conducted field studies on the effects of this NPV on aquatic and bird fauna and on colonies of honey bees, *Apis mellifera* L. (Italian strain), located within the blocks treated in 1977. This report describes the monitoring techniques and contains the summarized data.

Materials and Methods

The virus

The NPV used in the 1977 field trials was propagated in red-headed pine sawfly infesting a mature plantation of red pine on St. Joseph Island near Sault Ste. Marie, Ontario, in 1976. The plantation was sprayed with NPV when larvae were in the fourth instar. A mistblower was used and branches containing colonies of virus-infected larvae were snipped off and taken to the laboratory. Larvae were picked off, lyophilized and ground to a fine powder. The potency of the virus produced in 1976 was very high and the material contained 9.0 billion PIB/g (Kaupp et al., 1978).

The study area

Two plantations (designated plot no. 1 and plot no. 2) of red pine, *Pinus resinosa* Ait., 0.9 m to 3.4 m (mean 2.2 m) and 0.7 m to 1.8 m (mean 1.2 m) high respectively and with areas of 13.2 ha and 30.8 ha were located in Admonston Twp. near Renfrew, Ontario.

Plot no. 1 contained 1 bird census plot and a stream in which aquatic invertebrates were monitored. Plot no. 2 contained 2 bird plots and 3 colonies of honey bees.

Three honey bee colonies were located approximately 2 km south of plot 2. The control bird census plot was located in a red pine plantation of about 4 ha about 10 km from the treated plots, while the control stream was somewhat larger than the treated stream and located about 10 km from the treated blocks.

Treatments and formulations

Both plots were treated with the same dosage of virus, 5.5 billion PIB/ha at a rate of 9.4 l/ha. Just prior to the aerial spray, aqueous formulations were prepared by adding 250 ml/l molasses and 60 g/l

Sandoz Shade^{1/} sunlight protectorant to the correct volumes of water and concentrated virus suspension. Spraying commenced at 5:55 a.m. on the morning of 14 July on plot no. 1 and was completed on plot no. 2 at 7:10 a.m. (Kaupp, Cunningham and de Groot, 1978).

Birds

Forest songbird populations were assessed on treated and untreated plots employing methods similar to those described by Kendeigh (1944) and Buckner and Turnock (1965). Prespray censuses were conducted in the morning and evening of 13 July and prior to treatment on the morning of 14 July. Post spray censuses were conducted in the mornings of 15 to 19 July.

Bees

Six colonies of honeybees, *Apis mellifera* L., were moved from the headquarters apiary on the Central Forestry Experimental Station, Ottawa, to the spray area near Renfrew, Ontario, on 12 July. On 13 July, three colonies were located and the bees released in the approximate centre of plot no. 2, while 3 colonies were located approximately 2 km south of plot no. 2.

Each colony was monitored for hive weight, pollen collected, adult flight activity and adult mortality. The hive weights were taken by placing a scale under the back edge of the hive; pollen was collected

^{1/} Sandoz Inc., 480 Camino del Rio South, San Diego, Calif. 92108

from a standard Ontario Agriculture College (O.A.C.) designed pollen trap; adult flight activity was measured with a photo electric device that recorded activity at the entrance of the hive; dead bees were collected in a dead bee box attached to the front entrance of the hive. Monitoring was conducted daily for 6 days and measurements of cumulative totals were taken at weekly intervals for an additional three weeks. Samples of larvae and pollen were collected periodically from the treated hives to be assayed for the presence of viable virus. Results are not as yet available.

Aquatics

A small stream approximately 1 m in width flowing through plot no. 1 and a larger control stream approximately 4 m in width and located about 10 km east of the spray area were monitored by benthos sampling 1 day before the spray, 4 days after and then weekly an additional three times. Four 0.093 m² (foot square) Surber samples (Surber, 1936) were taken on each sampling occasion and preserved in their entirety in the field with formaldehyde. Benthic organisms were later separated from the substrate with the aid of a "bubbler" (Kingsbury and Beveridge, 1977) and identified to order or family using the classification of Usinger (1974).

Results

Birds

The total number of birds recorded daily during pre and post spray censuses is shown in Fig. 1. The bird families showing the greatest post treatment increase on the treated plots are the trochilidae, picidae, tyrannidae, turdidae and fringillidae. Overall numbers on the untreated control plot declined slightly. The complete census records for the 4 bird plots are presented in Tables 1 - 6.

Territorial mapping was carried out for birds thought to be in breeding territories on the plots. No loss of territories were found among song sparrows, *Melospiza melodia* (Wilson), (Fig. 2) or other resident birds, with the exception of a single territory of the common yellowthroat, *Geothlypis trichas* (Linnaeus), which appeared to have become vacant on plot no. 2 (Fig. 3). The loss of a single territory could be due to a predator or natural cessation of breeding activity and cannot be attributed to the NPV treatment in the absence of any other signs of impact on the avifauna.

Many fledglings were observed on the treated plots and appeared to be unaffected by the spray. The young birds observed included: common flicker, *Colaptes auratus* (Linnaeus), eastern kingbird, *Tyrannus tyrannus* (Linnaeus), northern oriole, *Icterus galbula* (Linnaeus), rose-breasted grosbeak, *Pheucticus ludovicianus* (Linnaeus) and song sparrow.

Field observations throughout the census period and at weekly intervals during the aquatic sampling did not indicate any detrimental effects on the bird communities.

Honey bees

Ample native plants were in bloom on the plots at the time bee colonies were located and it is likely that the bees confined their foraging to the immediate area for at least several days after being released (Karmo, 1972). Table 7 summarizes the data collected. The total numbers of dead bees collected per day was very low and almost the same for both groups. The hive weights were also very similar with a slightly better gain being made on the treated plots. Adult flight activity also showed little significant difference between treated and untreated colonies. As the weather was hot with frequent thunderstorms, the two very high counts, (one on each of the treated and untreated groups) could have resulted from clustering at the entrance of the hives. The amount of pollen collected, while not differing significantly between groups was greater for the untreated group, hinting at the possibility of a repellent action of the spray, due perhaps to the presence of molasses in the formulation. However, since the amounts remained lower even three weeks after spraying, it is more probable that the difference is due to the pollen supplies on hand between the groups, rather than the spray application.

Observations on swarming, queen supercedure, honey production and disease resistance were continued at the headquarters apiary and at the time of wintering there were no significant differences between the two groups of colonies.

Aquatics

The data from the benthos study are shown in Tables 8 and 9. Generally, the data from the treated stream showed less variance than the untreated stream. There was an initial decrease after the virus application,

especially in the chironomid larvae and baetid mayfly nymphs. However, in both cases, the data from the control stream showed such a large standard deviation that a dependable comparison could not be made. The samples taken on 2 August were low for both streams but the totals rose on 8 August. There were no consistent indications that the NPV treatment adversely affected aquatic invertebrates. The variations in populations found within and between samples can be directly attributed to the nature of the streams studied.

Conclusions

From the data collected and the field observations, it would appear that there were no immediate undesirable effects due to the NPV spray application on the avian or aquatic fauna nor on colonies of honeybees. The absence of one bird territory is a common occurrence in nature. The honey bees suffered no discernable losses, although further studies would be necessary to determine if there had been any rejection of contaminated pollen by the bees. There were some anomalies in the control stream which made the aquatic study less deterministic than ideal, but except for unexplained decreases in chironomid and mayfly counts the benthic fauna was clearly unaffected.

Acknowledgements

The authors wish to acknowledge the assistance of Dr. J.C. Cunningham, W.J. Kaupp and P. de Groot of the Forest Pest Management Institute who conducted the virus spray trial and to D. Thompson, R. Lancaster and C. Metcalf who collected the field data on environmental impact.

References

- Buckner, C.H. and W.J. Turnock. 1965. Avian predation on the larch sawfly, *Pristiphora erichsonnii* HTG. (Hymenoptera: Tenthredinidae). Ecology 46: 223 - 236.
- Karmo, E.A. 1972. Nova Scotia Depart. of Agriculture and Marketing, Horticulture and Biology Service, Apiculture No. 109.
- Kaup, W.J., J.C. Cunningham and P. de Groot. 1977. Aerial application of baculovirus on red-headed pine sawfly, *Neodiprion lecontei* (Fitch), Forest Pest Management Institute, Report FPM-X-1.
- Kendeigh, S.C. 1944. Measurement of bird populations. Ecol. Monog. 14: 67 - 106.
- Kingsbury, P.D. and J.W. Beveridge. 1977. A simple bubbler for sorting bottom fauna samples by elutriation. Can. Ent. 109: 1265 - 1268.
- Surber, E.W. 1936. Rainbow trout and bottom fauna production in one mile of stream. Trans. Amer. Fish. Soc. 66: 193 - 202.
- Usinger, R.L. (ed). 1974. Aquatic insects of California with keys to North American genera and California species. Univ. of California Press, Berkley, 1974.
- Valli, V.E.O. and M.J. Claston. 1976. Avian toxicity test of the nuclear polyhedrosis virus of the red-headed pine sawfly, *Neodiprion lecontei*. Report prepared under DSS contract no. OSS5-0194. 237 pp.
- Valli, V.E.O., C.M. Forsberg and P. Dwyer. 1978. Mammalian pathogenicity of the nuclear polyhedrosis virus of the red-headed pine sawfly, *Neodiprion lecontei*. Report prepared under DSS contract No. OSU76-00226. 524 pp.

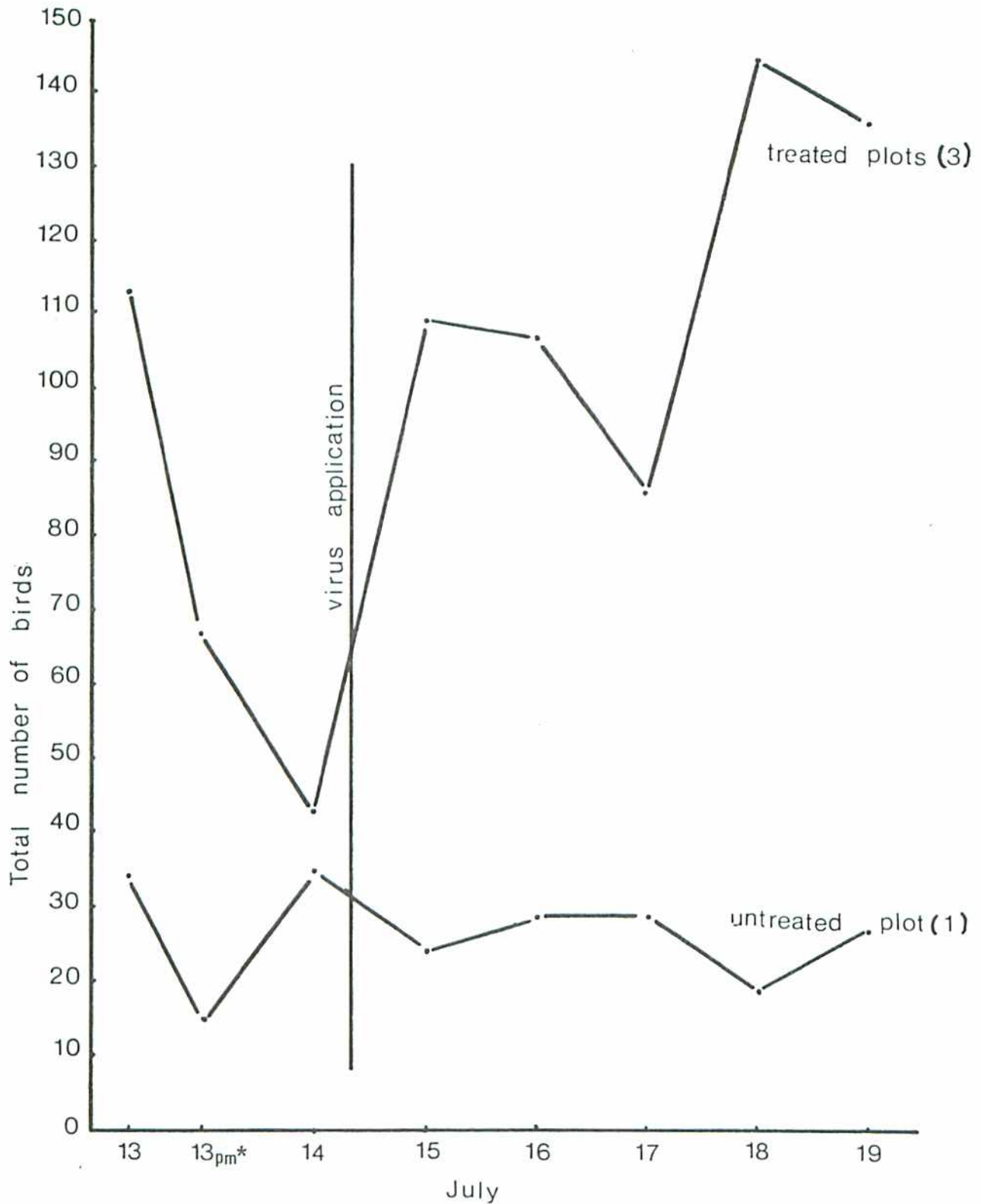


Fig. 1. Forest bird activity on 3 NPV treated and 1 untreated plot, Renfrew experimental area, Ontario.

July, 1977

* Evening census, all others are morning censuses.

Table 1

Forest Bird Population Census
Family totals for the three plots treated with the nuclear polyhedral virus
Renfrew, Ontario, July, 1977

Family	Pre-spray treatment				Post-spray treatment					
	July 13 -1	July 13* -1	July 14 -0	Daily Avg.	July 15 +1	July 16 +2	July 17 +3	July 18 +4	July 19 +5	Daily Avg.
Charadriidae	1	0	0	0.3	1	0	0	0	0	0.2
Apodidae	0	0	0	0.0	0	0	0	0	1	0.2
Picidae	0	4	0	1.3	9	1	3	12	8	6.6
Tyrannidae	1	3	1	1.7	7	8	7	4	5	6.2
Hirundinidae	4	0	4	2.7	5	4	2	6	11	5.6
Corvidae	1	1	0	0.7	2	2	2	4	0	2.0
Paridae	1	0	3	1.3	2	0	1	3	1	1.4
Sittidae	0	0	0	0.0	4	4	2	2	2	2.8
Mimidae	0	2	2	1.3	1	0	0	0	0	0.2
Turdidae	1	2	2	1.7	3	6	0	8	8	5.0
Sturnidae	20	0	0	6.7	0	3	0	0	0	0.6
Vireonidae	0	2	0	0.7	0	2	0	0	2	0.8
Parulidae	10	6	2	6.0	4	8	6	17	12	9.4
Icteridae	24	10	5	13.0	17	14	17	27	17	18.4
Fringillidae	50	37	24	37.0	54	55	46	61	69	57.0
Total	113	67	43	74.3	109	107	86	144	136	116.4

* evening census

Table 2

Forest Bird Population Census
Family totals for the untreated plot
Renfrew, Ontario, July 1977.

Family	Pre-spray treatment				Post-spray treatment					
	July 13 -1	July 13* -1	July 14 -0	Daily Avg.	July 15 +1	July 16 +2	July 17 +3	July 18 +4	July 19 +5	Daily Avg.
Trochilidae	0	1	0	0.3	2	3	3	1	1	2.0
Picidae	4	0	1	1.7	1	0	0	0	0	0.2
Tyrannidae	5	0	0	1.7	1	0	2	5	4	2.4
Hirundinidae	2	0	0	0.7	1	0	4	0	1	1.2
Corvidae	0	0	2	0.7	0	0	0	0	1	0.2
Paridae	0	0	0	0.0	0	2	0	0	0	0.4
Sittidae	1	0	0	0.3	0	1	1	0	0	0.4
Mimidae	2	1	4	2.3	1	2	1	1	1	1.2
Turdidae	0	0	3	1.0	0	1	0	0	0	0.2
Sylviidae	0	0	0	0.0	0	0	0	1	3	0.8
Vireonidae	0	0	0	0.0	0	2	0	0	2	0.8
Parulidae	0	2	2	1.3	1	4	4	0	5	2.8
Icteridae	3	3	8	4.7	4	0	1	0	0	1.0
Fringillidae	17	8	15	13.3	13	13	12	11	9	11.6
Total	34	15	35	28.0	24	28	28	19	27	25.2

* evening census

Table 3

Forest Bird Population Census
 Untreated bird plot 1
 Control for Nuclear Polyhedral Virus treatment blocks
 Renfrew, Ontario, July, 1977

Family	Species	Pre-spray treatment			Daily avg.	Post-spray treatment					Daily avg.
		July 13	July 13 *	July 14		July 15	July 16	July 17	July 18	July 19	
		-1	-1	-0		+1	+2	+3	+4	+5	
Trochilidae	Ruby-throated Hummingbird	0	1	0	0.3	2	3	3	1	1	2.0
Picidae	Common Flicker	4	0	1	1.7	1	0	0	0	0	0.2
Tyrannidae	Eastern Kingbird	4	0	0	1.3	0	0	1	3	0	0.8
	Great Crested Flycatcher	0	0	0	0.0	0	0	0	0	4	0.8
	Alder Flycatcher	1	0	0	0.3	1	0	1	2	0	0.8
Hirundinidae	Barn Swallow	2	0	0	0.7	1	0	4	0	1	1.2
Corvidae	Blue Jay	0	0	1	0.3	0	0	0	0	1	0.2
	Common Crow	0	0	1	0.3	0	0	0	0	0	0.0
Paridae	Black-capped Chickadee	0	0	0	0.0	0	2	0	0	0	0.4
Sittidae	Red-breasted Nuthatch	1	0	0	0.3	0	1	1	0	0	0.4
Mimidae	Catbird	2	1	4	2.3	1	2	1	1	1	1.2
Turdidae	American Robin	0	0	3	1.0	0	1	0	0	0	0.2
Sylviidae	Ruby-crowned Kinglet	0	0	0	0.0	0	0	0	1	3	0.8
Vireonidae	Red-eyed Vireo	0	0	0	0.0	0	2	0	0	2	0.8
Parulidae	Yellow-rumped Warbler	0	0	0	0.0	0	0	0	0	1	0.2
	Common Yellow throat	0	2	2	1.3	1	4	4	0	4	2.6

* evening census

Table 3 cont'd.

Family	Species	Pre-spray treatment			Daily avg.	Post-spray treatment					Daily avg.
		July 13	July 13*	July 14		July 15	July 16	July 17	July 18	July 19	
		-1	-1	-0		+1	+2	+3	+4	+5	
Icteridae	Redwinged Blackbird	1	1	0	0.7	0	0	1	0	0	0.2
	Baltimore Oriole	2	2	0	1.3	4	0	0	0	0	0.8
	Common Grackle	0	0	8	2.7	0	0	0	0	0	0.0
Fringillidae	Rose-breasted Grosbeak	3	0	0	1.0	0	1	2	1	3	1.4
	Indigo Bunting	0	0	0	0.0	3	3	0	0	2	1.6
	Purple Finch	0	0	0	0.0	0	0	0	1	0	0.2
	American Goldfinch	5	0	3	2.7	3	4	4	5	0	3.2
	Vesper Sparrow	0	2	2	1.3	0	0	2	0	0	0.4
	Chipping Sparrow	2	2	4	2.7	2	2	2	2	3	2.2
	Song Sparrow	7	4	6	5.7	5	3	2	2	1	2.6
Unidentified Birds		0	0	0	0.0	0	0	1	0	0	0.2
Total Birds		34	15	35	27.9	24	28	29	19	27	25.6

16

* evening census

Table 4

Forest Bird Population Census
 Bird plot 2, Treatment block
 Nuclear Polyhedral Virus Application
 Renfrew, Ontario, July, 1977

Family	Species	Pre-spray treatment			Daily avg.	Post-spray treatment					Daily avg.
		July 13	July 13 *	July 14		July 15	July 16	July 17	July 18	July 19	
		-1	-1	-0		+1	+2	+3	+4	+5	
Picidae	Common Flicker	0	1	0	0.3	4	1	0	4	5	2.8
	Downy Woodpecker	0	0	0	0.0	0	0	0	0	1	0.2
Tyrannidae	Eastern Kingbird	0	0	0	0.0	4	4	5	0	0	2.6
	Eastern Wood Pewee	0	2	0	0.7	2	3	2	1	2	2.0
Hirundinidae	Barn Swallow	2	0	0	0.7	3	1	1	1	8	2.8
Corvidae	Blue Jay	1	0	0	0.3	0	1	1	1	0	0.6
Paridae	Black-capped Chickadee	0	0	0	0.0	0	0	1	3	0	0.8
Sittidae	Red-breasted Nuthatch	0	0	0	0.0	2	2	2	2	2	2.0
Mimidae	Catbird	0	2	2	1.3	1	0	0	0	0	0.2
Turdidae	American Robin	0	2	2	1.3	0	1	0	1	1	0.6
	Hermit Thrush	0	0	0	0.0	0	2	0	2	0	0.8
	Eastern Bluebird	0	0	0	0.0	0	0	0	0	1	0.2
Vireonidae	Solitary Vireo	0	0	0	0.0	0	2	0	0	0	0.4
	Red-eyed Vireo	0	0	0	0.0	0	0	0	0	2	0.4
Parulidae	Black-and-white Warbler	0	0	0	0.0	0	2	0	2	0	0.8
	Yellow-rumped Warbler	0	0	0	0.0	2	0	0	2	0	0.8
	Chestnut-sided Warbler	0	0	0	0.0	0	0	0	2	2	0.8
	Ovenbird	0	2	0	0.7	0	0	0	2	0	0.4
	Common Yellow- throat	6	4	2	4.0	0	2	2	2	2	1.6

* evening census

Table 4 cont'd.

Family	Species	Pre-spray treatment			Daily avg.	Post-spray treatment					Daily avg.
		July 13	July 13*	July 14		July 15	July 16	July 17	July 18	July 19	
		-1	-1	-0		+1	+2	+3	+4	+5	
Icteridae	Redwinged Blackbird	0	0	0	0.0	0	0	0	1	2	0.6
	Baltimore Oriole	0	0	0	0.0	2	0	1	2	0	1.0
	Common Grackle	0	2	0	0.7	4	0	0	0	1	1.0
Fringillidae	Rose-Breasted Grosbeak	0	0	0	0.0	2	0	0	0	0	0.4
	Evening Grosbeak	0	0	0	0.0	0	0	0	0	5	1.0
	American Goldfinch	3	0	3	2.0	4	2	1	2	2	2.2
	Vesper Sparrow	4	4	2	3.3	0	4	6	4	6	4.0
	Chipping Sparrow	6	6	0	4.0	1	4	2	4	4	3.0
	White-throated Sparrow	2	2	0	1.3	0	2	2	0	2	1.2
	Song Sparrow	7	5	6	6.0	8	8	8	10	9	8.6
Total Birds		31	33	17	27.0	39	41	34	47	57	43.6

* evening census

Table 5

Forest Bird Population Census
 Bird plot 3, Treatment block
 Nuclear Polyhedral Virus Application
 Renfrew, Ontario, July, 1977

Family	Species	Pre-spray treatment			Daily avg.	Post-spray treatment					Daily avg.
		July 13	July 13*	July 14		July 15	July 16	July 17	July 18	July 19	
		-1	-1	-0		+1	+2	+3	+4	+5	
Charadriidae	Killdeer	0	0	0	0.0	1	0	0	0	0	0.2
Apodidae	Chimney Swift	0	0	0	0.0	0	0	0	0	1	0.2
Picidae	Common Flicker	0	3	0	0.3	5	0	1	1	2	1.8
Tyrannidae	Eastern Kingbird	1	1	1	1.0	1	1	0	3	3	1.6
Hirundinidae	Barn Swallow	2	0	4	2.0	2	3	1	3	3	2.4
Corvidae	Common Crow	0	0	0	0.0	0	0	0	3	0	0.6
Paridae	Black-capped Chickadee	1	0	3	1.3	1	0	0	0	1	0.4
Turdidae	American Robin	0	0	0	0.0	3	1	0	1	5	2.0
Sturnidae	Starling	20	0	0	6.7	0	3	0	0	0	0.6
Parulidae	Common Yellow- throat	0	0	0	0.0	0	0	0	3	2	1.0
Icteridae	Eastern Meadowlark	2	1	0	1.0	1	0	0	2	1	0.8
	Redwinged Blackbird	18	2	5	8.3	2	2	13	4	3	4.8
	Baltimore Oriole	0	0	0	0.0	1	0	0	1	5	1.4
	Common Grackle	1	5	0	2.0	0	0	0	0	2	0.4
Fringillidae	Rose-breasted Grosbeak	2	0	0	0.7	2	0	0	3	1	1.2
	Purple Finch	0	0	0	0.0	1	0	0	0	0	0.2

* evening census

Table 5 cont'd.

Family	Species	Pre-spray treatment			Daily avg.	Post-spray treatment					Daily avg.
		July 13	July 13 *	July 14		July 15	July 16	July 17	July 18	July 19	
		-1	-1	-0		+1	+2	+3	+4	+5	
Fringillid (cont'd)	American Gold- fish	6	2	0	2.7	2	5	2	2	5	3.2
	Vesper Sparrow	0	0	0	0.0	0	0	0	2	4	1.2
	Chipping Sparrow	0	0	2	0.7	0	3	2	0	0	1.0
	White-throated Sparrow	0	0	0	0.0	0	0	0	0	2	0.4
	Song Sparrow	10	12	7	9.7	16	15	10	16	14	14.2
Unidentified birds		0	0	0	0.0	0	0	0	0	2	0.4
Total Birds		63	26	22	36.4	38	33	29	44	56	40.0

* evening census

Table 6

Forest Bird Population Census
 Bird plot 4, Treatment block
 Nuclear Polyhedral Virus Application
 Renfrew, Ontario, July, 1977

Family	Species	Pre-spray treatment			Daily avg.	Post-spray treatment					Daily avg.
		July 13	July 13*	July 14		July 15	July 16	July 17	July 18	July 19	
		-1	-1	-0		+1	+2	+3	+4	+5	
Charadriidae	Killdeer	1	0	0	0.3	0	0	0	0	0	0.0
Picidae	Common Flicker	0	0	0	0.0	0	0	2	6	0	1.6
	Hairy Woodpecker	0	0	0	0.0	0	0	0	1	0	0.2
Hirundinidae	Barn Swallow	0	0	0	0.0	0	0	0	2	0	0.4
Corvidae	Blue Jay	0	1	0	0.3	2	1	1	0	0	0.8
Paridae	Black-Capped Chickadee	0	0	0	0.0	1	0	0	0	0	0.2
Sittidae	Red-breasted Nuthatch	0	0	0	0.0	2	2	0	0	0	0.8
Turdidae	American Robin	1	0	0	0.3	0	2	0	2	1	1.0
	Hermit Thrush	0	0	0	0.0	0	0	0	2	0	0.4
Vireonidae	Solitary Vireo	0	2	0	0.7	0	0	0	0	0	0.0
Parulidae	Chestnut-sided Warbler	2	0	0	0.7	0	2	2	0	2	1.2
	Common Yellow- throat	2	0	0	0.7	2	2	2	4	4	2.8
Icteridae	Eastern Meadowlark	2	0	0	0.7	6	8	3	10	3	6.0
	Redwinged Blackbird	1	0	0	0.3	0	1	0	0	0	0.2
	Baltimore Oriole	0	0	0	0.0	0	0	0	7	0	1.4
	Common Grackle	0	0	0	0.0	1	3	0	0	0	0.8
Fringillidae	Rose-breasted Grosbeak	0	0	0	0.0	4	0	3	3	0	2.0
	American Goldfinch	1	0	0	0.3	1	1	1	2	0	1.0

* evening census

Table 6 cont'd.

Family	Species	Pre-spray treatment			Post-spray treatment						Daily avg.
		July 13	July 13*	July 14	Daily avg.	July 15	July 16	July 17	July 18	July 19	
		-1	-1	-0		+1	+2	+3	+4	+5	
Fringillidae (cont'd)	Vesper Sparrow	2	2	0	1.3	4	4	2	3	4	3.4
	Chipping Sparrow	0	0	0	0.0	0	0	0	0	2	0.4
	White-throated Sparrow	2	0	0	0.7	2	0	0	2	2	1.2
	Song Sparrow	5	4	4	4.3	7	7	7	8	7	7.2
	Total Birds	20	10	4	11.3	33	33	24	53	25	33.6

* evening census

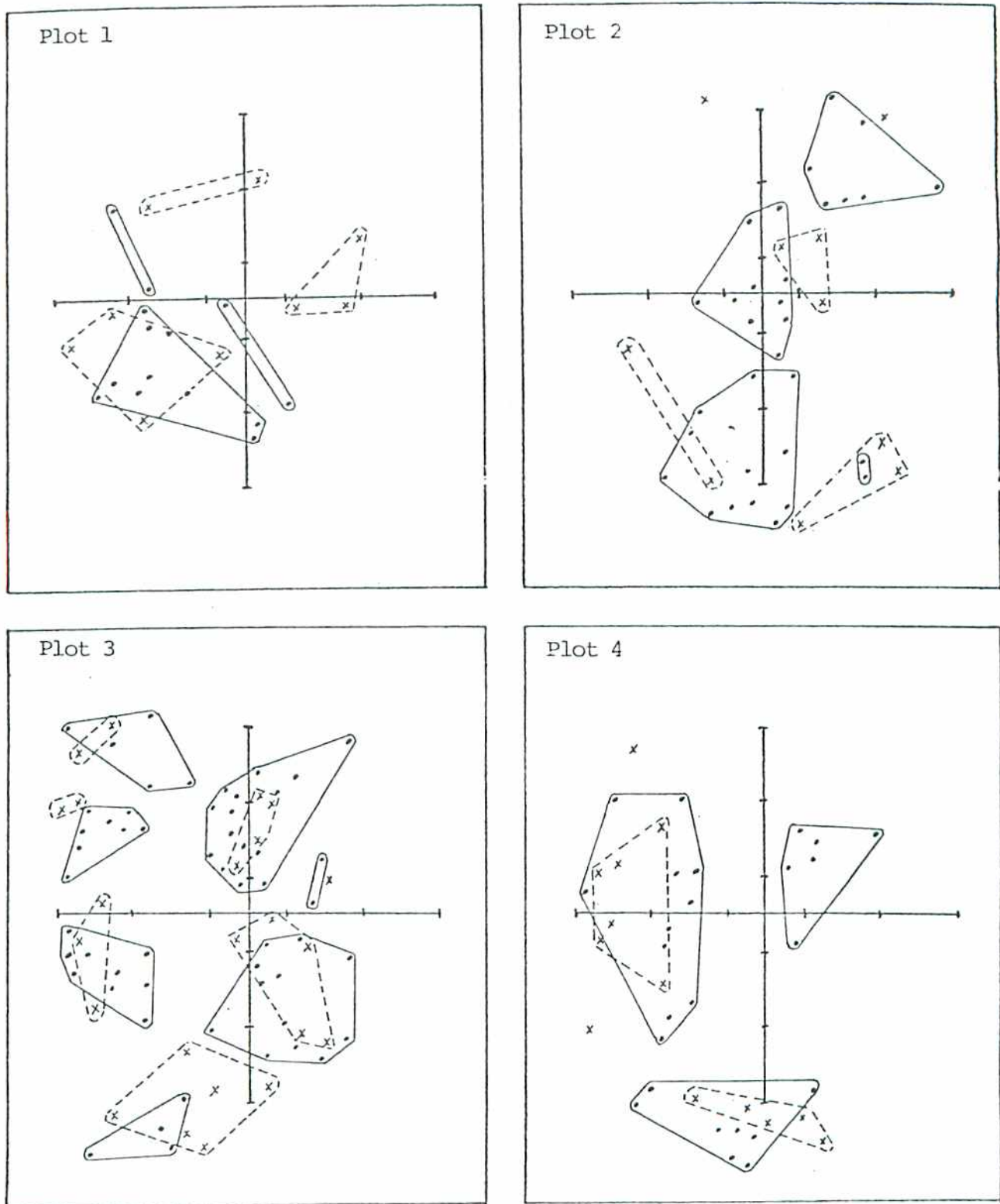


Fig. 2. Pre-treatment ('x''s and dotted lines) and post-treatment (dots and solid lines) territories of the song sparrow on an untreated control plot (1) and three NPV treated plots (2,3,4). Renfrew, Ontario. 1977.

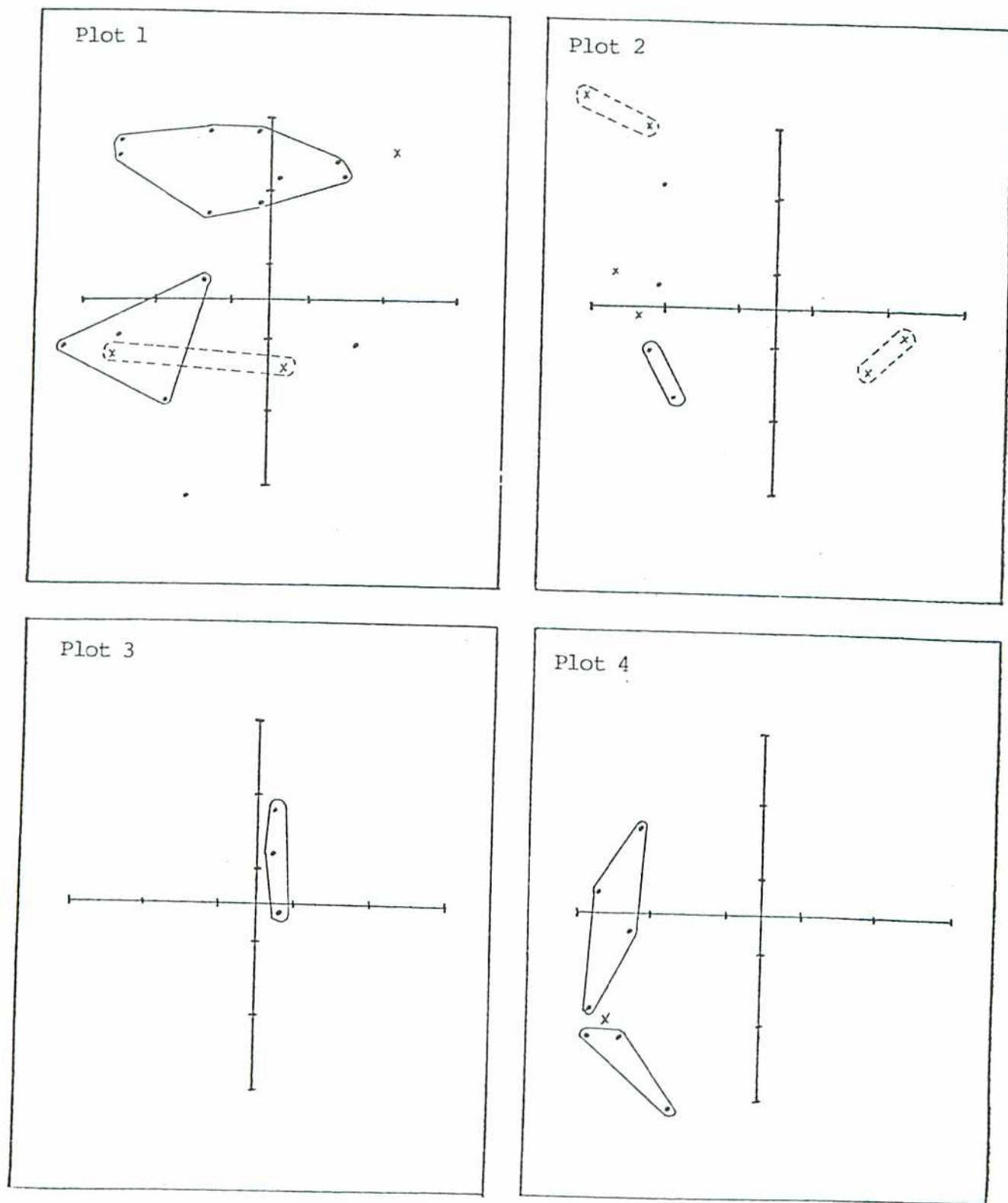


Fig. 3. Pre-treatment ('x's and dotted lines) and post-treatment (dots and solid lines) shows territories of the common yellowthroat on an untreated control plot (1) and three NPV treated plots (2,3,4). Renfrew, Ontario. 1977.

Table 7

Measurements from honey bee colonies on
NPV treated and untreated areas.
Renfrew, Ontario. July - August, 1977

Average of 3 colonies - Treated area*					Average of 3 colonies - Untreated area				
Date	adult bee mortality	pollen collected (gms)	activity count	hive wt. (kilograms)	Date	adult bee mortality	pollen collected (gms)	activity count	hive wt. (kilograms)
July 13	3.3	2.0	127,402	19.5	July 13	0.6	3.3	132,416	23.2
14	1.3	1.3	136,320		14	0.0	7.6	154,560	
15	0.0	4.6	226,688		15	0.3	18.6	216,640	
16	0.0	1.0	69,120		16	0.3	10.6	122,432	
17	2.0	4.3	1,077,760		17	2.6	9.6	275,840	
18	2.0	5.0	193,365		18	2.0	10.6	232,000	
23	0.6	43.3	859,904	19.8	23	0.3	89.6	338,240	23.6
Aug. 2	4.0	157.6	572,074	19.8	Aug. 2	1.6	265.6	1,093,376	23.8
8	0.3	190.3	585.856	20.9	8	0.3	243.6	452,032	23.8

* Treated early in the morning of 14 July before measurements for that day were taken.

Table 8

Stream benthos populations* from a stream treated with a
nuclear polyhedral virus at 5.5×10^9 PIB per hectare
Renfrew, Ontario. July - August, 1977

Date	July 13	July 18	July 25	Aug. 2	Aug. 8
Number of days before or after treatment	-1	+4	+11	+19	+25
Water temperature	21°C	21°C	19°C	17°C	25°C
No. of samples	4	4	4	4	4
Ephemeroptera:Heptogeniidae	0.0	0.0	0.0	0.3 ± 0.5	0.5 ± 0.6
:Baetidae	14.5 ± 14.3	1.8 ± 1.7	4.5 ± 3.3	1.0 ± 1.2	7.5 ± 9.3
Odonata:Gomphidae	0.3 ± 0.5	0.0	2.0 ± 4.0	0.0	0.5 ± 0.6
:Aeshnidae	0.0	0.5 ± 1.0	1.0 ± 2.0	0.0	0.0
:Cordulegastridae	1.5 ± 2.4	1.8 ± 1.3	3.0 ± 3.6	6.5 ± 4.8	7.8 ± 6.9
:Libellulidae	0.0	1.8 ± 2.1	0.0	0.0	0.3 ± 0.5
Plecoptera	0.5 ± 1.0	0.0	0.0	0.0	0.3 ± 0.5
Hemiptera:Notonectidae	0.0	0.5 ± 1.0	0.0	0.0	0.0
:Gerridae	0.0	0.3 ± 0.5	0.3 ± 0.5	0.0	0.0
Megaloptera:Sialidae	3.8 ± 3.3	1.5 ± 2.4	0.0	1.0 ± 0.8	0.0
:Corydalidae	0.0	0.3 ± 0.5	0.3 ± 0.5	0.0	0.0
Trichoptera	0.0	3.0 ± 3.5	1.3 ± 1.0	3.8 ± 3.3	4.5 ± 1.9
Coleoptera:Dytiscidae	0.3 ± 0.5	0.0	0.0	0.0	0.0
:Gyrinidae	0.0	0.5 ± 0.6	0.0	0.0	0.0
:Elmidae	2.0 ± 1.4	1.3 ± 1.5	0.3 ± 0.5	0.5 ± 0.6	2.5 ± 3.1
Diptera:Tipulidae	0.5 ± 0.6	22.8 ± 41.6	54.5 ± 54.9	0.5 ± 0.6	8.5 ± 15.1
:Simuliidae	0.0	0.0	0.5 ± 1.0	0.0	0.8 ± 1.5
:Chironomidae	110.8 ± 23.2	32.3 ± 26.2	23.5 ± 23.0	24.0 ± 20.5	110.3 ± 115.1
:Heleldidae	2.8 ± 1.3	0.3 ± 0.5	0.8 ± 1.5	0.8 ± 0.5	6.5 ± 7.5
:Tabanidae	6.8 ± 7.0	4.3 ± 6.0	3.0 ± 2.9	10.0 ± 10.6	7.3 ± 6.1
TOTAL INSECTS	143.5 ± 21.6	71.0 ± 37.7	94.3 ± 70.6	48.3 ± 29.9	161.3 ± 139.7
Nematoda	0.0	0.8 ± 1.5	1.8 ± 1.3	0.0 ±	0.3 ± .5
Oligochaeta	0.5 ± 1.0	3.3 ± 2.2	2.0 ± 3.4	1.0 ± 2.0	0.5 ± .6
Gastropoda	0.8 ± 1.0	2.3 ± 1.5	0.3 ± 0.5	1.0 ± 1.4	2.8 ± 1.7
Pelecypoda:Sphaeridae	3.8 ± 1.5	36.0 ± 36.7	23.8 ± 32.1	3.3 ± 3.4	45.0 ± 44.9
Arachnida:Acari	0.3 ± 0.5	0.3 ± 0.5	0.0	0.0	0.0
Crustacea:Amphipoda	0.5 ± 0.6	0.0	0.3 ± 0.5	0.0	0.3 ± 0.5
TOTAL BENTHOS	149.3 ± 23.8	113.5 ± 34.2	132.0 ± 99.1	53.5 ± 33.8	210.0 ± 185.8

* Mean numbers and standard deviations per 0.093 m².

Table 9

Stream benthos populations* from an untreated stream.
Renfrew, Ontario. July - August, 1977

Date	July 13		July 18		July 25		Aug. 2		Aug. 8	
Number of days before or after treatment	-1		+4		+11		+19		+25	
Water temperature	N.D.		26°C		22°C		22°C		25°C	
Number of samples	4		4		4		4		4	
Ephemeroptera:Heptageniidae	33.0 ±	57.4	152.0 ±	186.5	46.3 ±	19.5	17.0 ±	10.2	119.5 ±	86.6
:Baetidae	12.5 ±	8.2	29.8 ±	30.9	10.5 ±	4.4	3.3 ±	3.4	8.0 ±	6.7
Odonata:Libellulidae	0.0		0.0		0.3 ±	0.5	0.0		0.0	
:Agrionidae	0.0		0.0		0.0		0.3 ±	0.5	0.0	
Plecoptera	0.3 ±	0.5	0.0		0.0		0.0		0.0	
Hemiptera:Veliidae	0.0		0.0		0.0		0.0		0.5 ±	0.6
Megaloptera:Sialidae	0.0		0.3 ±	0.5	1.0 ±	1.2	0.5 ±	0.6	0.3 ±	0.5
:Corydalidae	0.0		0.0		0.0		0.0		1.0 ±	1.2
Neuroptera:Sisyridae	0.0		0.0		0.0		0.0		0.3 ±	0.5
Trichoptera	13.5 ±	25.0	232.3 ±	278.3	19.3 ±	31.6	0.8 ±	1.0	37.8 ±	26.2
Coleoptera:Elmidae	10.8 ±	10.8	115.0 ±	160.8	12.6 ±	10.7	3.5 ±	2.4	60.6 ±	68.4
Diptera:Tipulidae	0.5 ±	0.6	19.5 ±	27.8	1.0 ±	1.4	0.3 ±	0.5	3.0 ±	4.1
:Chironomidae	30.8 ±	7.5	266.3 ±	290.3	28.8 ±	21.9	10.8 ±	4.9	28.5 ±	20.1
:Heleidae	0.8 ±	0.5	3.3 ±	2.8	0.5 ±	0.0	0.0		0.0	
:Tabanidae	0.0		0.0		0.0		0.0		0.3 ±	0.5
TOTAL INSECTS	102.0 ±	115.4	818.5 ±	918.9	120.3 ±	52.3	36.3 ±	12.3	246.3 ±	174.9
Tubellaria	0.3 ±	0.5	5.3 ±	6.1	0.0		0.3 ±	0.5	0.5 ±	0.6
Oligochaeta	1.5 ±	1.3	3.3 ±	3.6	0.0		0.0		0.0	
Hirudinea	0.0		0.0		0.3 ±	0.5	0.0		0.0	
Gastropoda	0.0		0.8 ±	1.0	0.0		0.0		0.3 ±	0.5
Pelecypoda:Sphaeriidae	0.0		4.0 ±	6.7	0.0		0.3 ±	0.5	0.8 ±	1.5
Arachnida:Acari	0.0		0.5 ±	0.6	0.0		0.0		0.0	
Crustaceae:Amphipoda	0.0		0.3 ±	0.5	0.0		0.0		0.8 ±	1.5
:Decapoda	0.5 ±	0.6	0.3 ±	0.5	0.0		0.0		1.5 ±	1.7
TOTAL BENTHOS	104.3 ±	113.5	832.5 ±	924.4	120.5 ±	52.5	36.8 ±	12.7	249.5 ±	177.7

* Mean numbers and standard deviations per 0.093 m².