CONTROL OF RED-HEADED PINE SAWFLY WITH A BACULOVIRUS IN ONTARIO IN 1978 AND A SURVEY OF AREAS TREATED IN PREVIOUS YEARS

by

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ABSTRACT

An aerial spray trial was conducted with red-headed pine sawfly nuclear polyhedrosis virus near Sharbot Lake, Ontario in 1978. Two red pine, *Pinus resinosa* Ait., plantations with a total area of 26.1 ha, infested with red-headed pine sawflies, *Neodiprion lecontei* (Fitch), were sprayed with a dosage of 5 billion polyhedra/ha at a rate of 9.4 ℓ/ha in an aqueous formulation containing 135 ml/ℓ molasses and 32 g/ℓ Sandoz Shade® when larvae were predominantly in the second instar. Over 90% of the sawfly colonies were diseased or dead 16 days after the application and after 23 days no healthy colonies remained. Defoliation was lighter in the treated areas compared to untreated check plots.

When plantations near Renfrew and Richmond, Ontario, treated with nuclear polyhedrosis virus in 1977, were re-examined no sawfly colonies could be found. Also, no sawfly colonies were found in plantations near Lakefield, Ontario which were treated in 1976.

RESUME

En 1978, un essai d'épandage aérien du virus de la polyédrose nucléaire a été effectué près de Sharbot Lake, Ontario. Deux plantations de Pin rouge *Pinus resinosa* Ait., d'une aire totale de 26.1 ha infestées par le Diprion de Le Conte *Neodiprion lecontei* (Fitch), ont été arrosées d'une dose de 5 milliards à l'ha de polyèdres à raison de 9.4 ℓ/ha, en solution aqueuse contenant 135 ml/ℓ de mélasse et 32 g/ℓ de Sandoz Shade®, alors que les larves étaient en prédominance au second stade. Plus de 90% des colonies du Diprion étaient infectées ou mortes 16 jours après le traitement et, au bout de 23 jours, aucune colonie bien portante n'a été observée. La défoliation a été plus légère dans les aires traitées que dans les secteurs témoins non traités.

Lors du réexamen des plantations près de Renfrew et Richmond, Ontario, plantations déjà traitées avec le virus de la polyèdrose nucléaire en 1977, on n'a trouvé aucune colonie du Diprion. Il en fut ainsi dans des plantations près de Lakefield, Ontario traitées en 1976.

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INTRODUCTION

Aerial spray trials with a nuclear polyhedrosis virus to control red-headed pine sawfly, *Neodiprion lecontei* (Fitch), were conducted in 1976 and in 1977 (Kaupp and Cunningham, 1977; Kaupp, Cunningham and de Groot, 1978). Dosages ranging from 1.25 billion to 6.25 billion polyhedral inclusion bodies (PIB)/ha were tested. Applications were made mainly when larvae were in the second and third instars. Preliminary results from tests using an aerial spray simulator indicated that increased dosages are required to treat fourth instar larvae and that when fifth instar are treated many reach pupation. Also, if treatment is delayed beyond the third instar, severe defoliation results at a high population density (Hopewell and de Groot, unpublished).

Much of the data required for a petition for the registration of this virus under the Pest Control Products Act (Canada) has been gathered. Laboratory tests have shown the virus to be safe to mammals (Forsberg, Valli and Dwyer, 1978), to birds (Valli and Claxton, 1976), and to fish and an aquatic invertebrate, *Daphnia pulex* (Geraci and Hicks, 1979). Non-target organisms were monitored in the areas sprayed in 1977 and, following the application of nuclear polyhedrosis virus, there were no immediate undesirable effects on avian or aquatic fauna, or on colonies of honey bees, *Apis mellifera* L., located in the plots (Kingsbury, McLeod and Mortensen, 1978).

In this report details of a trial conducted in 1978 in Ontario are given. Insect mortality was closely monitored to confirm results obtained in 1977 with about the same dosage of virus; in 1977, 5.5 billion PIB/ha were applied and in 1978, 5.0 billion PIB/ha were applied. Plantations treated in 1976 and 1977 were re-examined to determine the durability of the virus treatment. In addition to the trials in Ontario, a total of 700 ha were treated in Quebec in 1978 in collaboraton with personnel of the Quebec Department of Lands and Forests. This operation will be reported elsewhere.

MATERIALS AND METHODS

The Virus

The nuclear polyhedrosis virus (NPV) of the red-headed pine sawfly was propagated in the field. Heavy populations of sawflies were selected and fourth instar larvae sprayed with NPV using a mist-blower. When sawfly colonies appeared diseased and moribund, the twigs they were colonising were clipped from the trees. These diseased larvae were picked off the foliage with fine forceps, frozen, lyophilized and ground to a fine powder in a Waring blender.

For the trials conducted in 1978, a mixture of material obtained from virus propagated in 1971, 1974 and 1976 was used. A total of 1,300 g of powdered, lyophilized, infected larvae was

suspended in 26 ℓ of water. When standardized, using a Petroff-Hausser bacteria counter, this suspension contained $3x10^8$ PIB/ml.

The Experimental Plots

The two treated plots and two check plots were located in Lanark County and Frontenac County near Sharbot Lake, Ontario. All four areas were planted in red pine, *Pinus resinosa* Ait. Descriptions of their size and location, tree age and height and average number of sawfly colonies per tree are given in Table 1. The location of the plots in relation to Sharbot Lake is shown in Figure 1. Both treated areas were irregularly shaped and are illustrated in Figure 2.

Spray Application and Larval Development

A virus dosage of 5×10^9 PIB/ha was applied to the two plantations at an application rate of 9.4 ℓ/ha. The formulation contained 25% v/v animal feed-grade molasses and 32 g/ℓ Sandoz Shade®. The Forest Pest Management Institute Cessna 185E fitted with 4 Micronair AU 3000 units was used for the application. Swath width was about 30 m and flying speed 176 km/hr.

Spraying commenced at 5:40 a.m. on July 8th on plot 1 and was completed at 6:05 a.m. The relative humidity was 80%, the temperature 21°C and the windspeed 5 to 8 km/hr. Larval development at the time of treatment was recorded as 20% in the first instar, 70% in the second and 10% in the third. After completing plot 1, the aircraft proceeded to plot 2, started spraying at 6:17 a.m. and finished at 6:41 a.m. Relative humidity was 92%, temperature rose from 20°C at the start to 24°C at the finish and windspeed ranged from periods of dead calm to gusts of 8 km/hr. Larval development on plot 2 was recorded as 5% in the first instar, 65% in the second, 25% in the third and 5% in the fourth.

Monitoring the Spray Deposit

The spray deposit was monitored on Kromekote® spray cards mounted on 100 x 150 mm aluminum backings. They were placed at 15 m intervals across each plot at what was intended to be at right angles to the flight lines. However, due to the irregular shape of the plantations and the presence of large deciduous trees on the perimeter of the plot, it was impossible to spray them in the usual manner and passes had to be made from several different angles. Spray droplet density/cm^2 and droplet sizes were determined from these cards.

Table 1. Location of treated and check plots, tree height and age and average number of red-headed pine sawfly colonies per tree.

Plot no.	Area (ha)	Location	Tree height (m) range and mean	Tree age (yr.)	Average no. sawfly colonies/ tree
1	12.55	Lot 21 Con. XI Dalhousie Twp. Lanark County	1.3 to 3.9 ($\bar{x}$ 2.5)	8	4.6
Check 1	0.8	Pt W½ Lot 31 Con. II Oso Twp. Frontenac County	0.7 to 1.9 ($\bar{x}$ 1.2)	5	2.0
2	13.55	Lot 2 Con. V-VII Oso Twp. Frontenac County	1.3 to 3.4 ($\bar{x}$ 2.1)	8	2.8
Check 2	1.8	Lot 2 Con. VII Oso Twp. Frontenac County	1.0 to 2.5 ($\bar{x}$ 1.6)	5	2.0

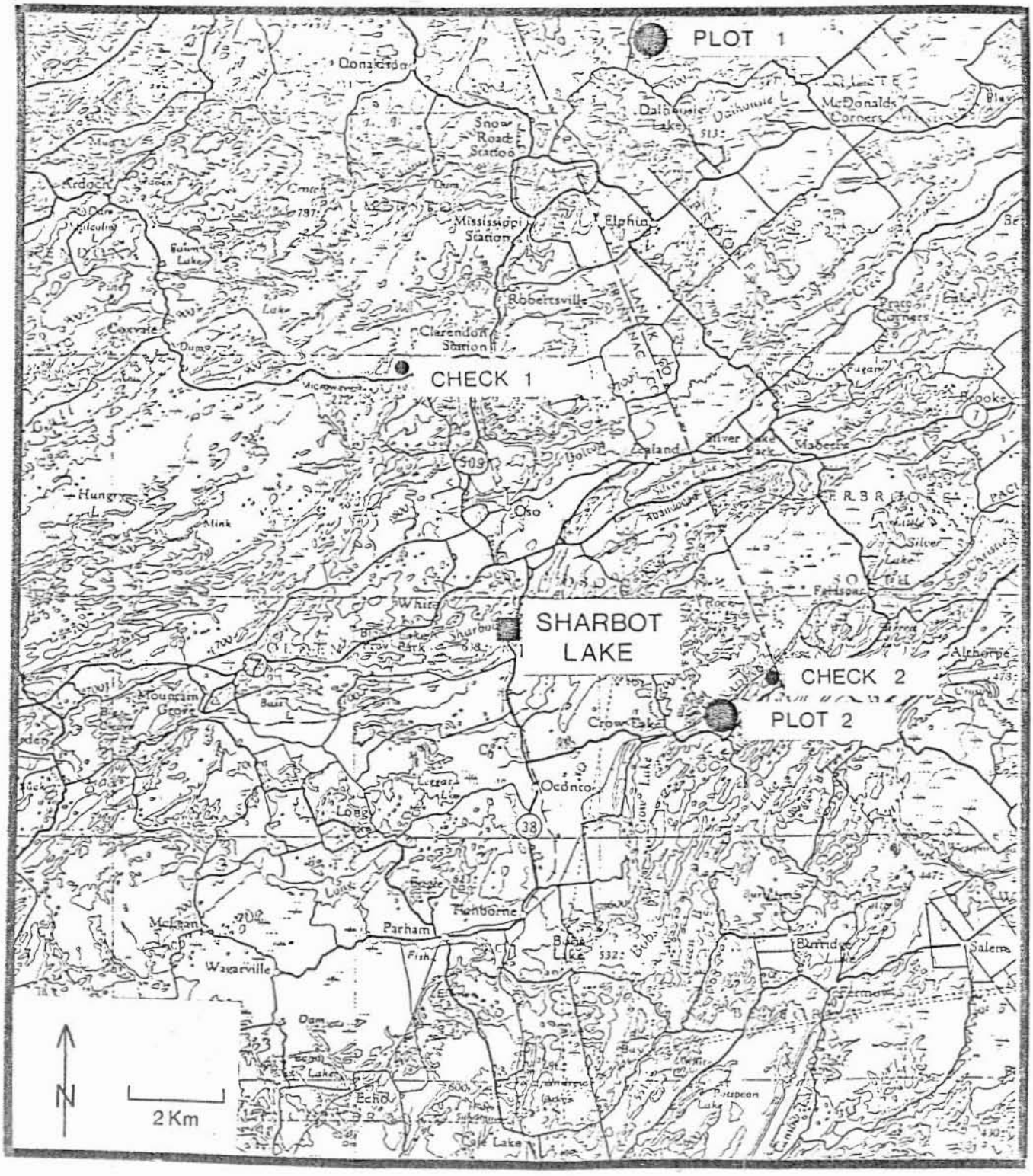

Fig. 1. The location of plots treated with nuclear polyhedrosis virus and check plots in relation to Sharbot Lake, Ontario.

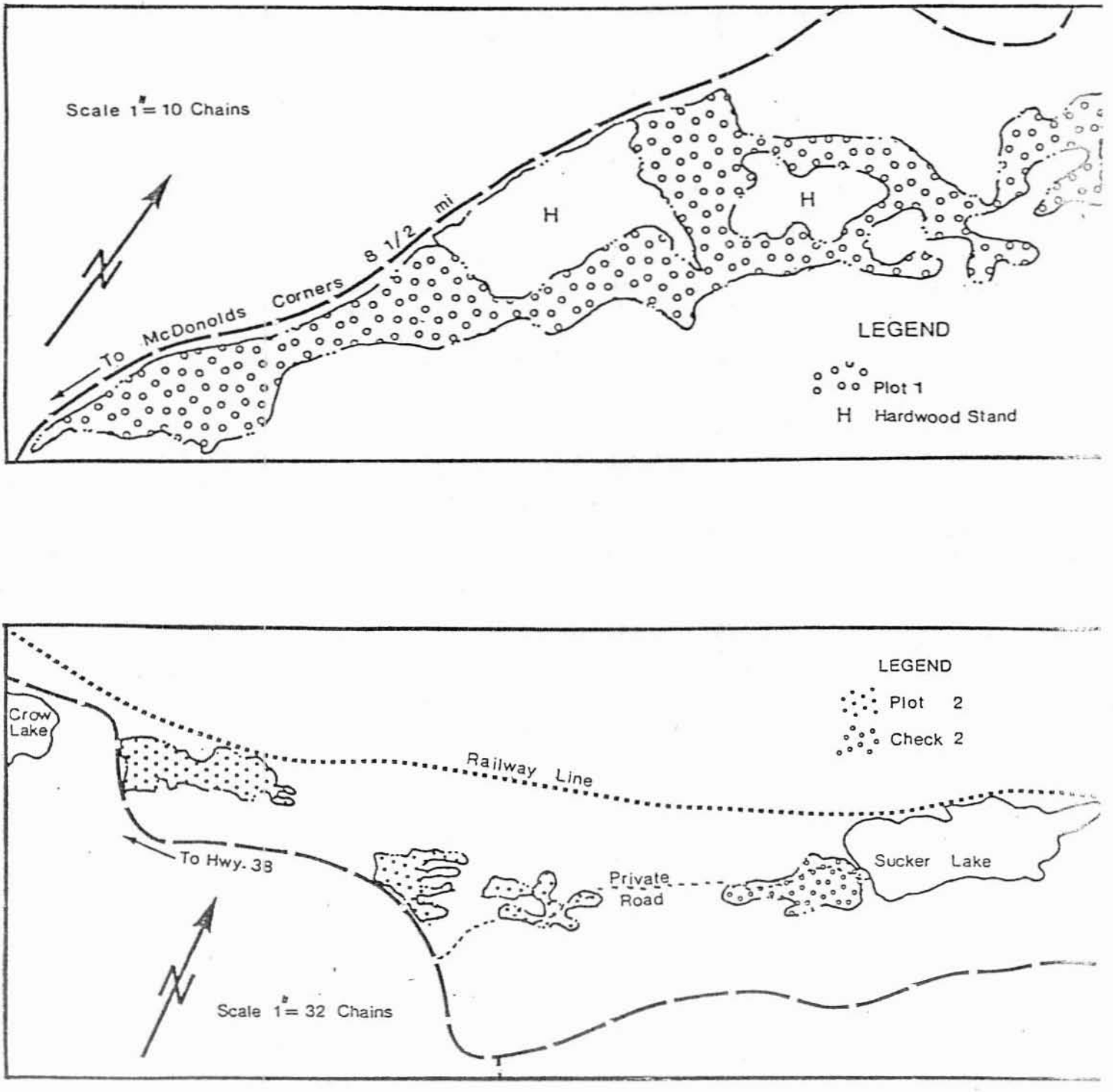

Fig. 2. The configuration of the two red-pine plantations treated with nuclear polyhedrosis virus in 1978.

Meteorological Observations

Temperature and rainfall were recorded in plot 1 using a thermograph and standard rain gauge.

Assessment of Efficacy

One hundred trees were selected and tagged in each treated plot with no regard to the sawfly population. In plot 1, there were 5 lines of 20 trees and in plot 2, 4 lines of 25 trees at approximately right angles to the flight lines. In the two check plots, 50 trees were selected and tagged in each. Before the spray application the number of sawfly colonies per tree was recorded in the treated and check plots. Counts of healthy and infected colonies were then made 5, 9, 10, 11, 12, 15, 16, 18 and 23 days post-spray on the treated plots. In the check plots, observations were made on the same days except for days 10, 12 and 16 which were omitted.

In previous years, random collections of larvae were made following spray applications and their guts examined microscopically in the laboratory (Kaupp and Cunningham, 1977; Kaupp, Cunningham and de Groot, 1978). Microscopic examination of guts from larvae displaying a wilted appearance or from larvae which were hanging by their prolegs from the foliage showed that all such larvae were heavily infected with NPV. Hence, this year no microscopic diagnosis was undertaken and colonies containing larvae showing these symptoms were rated as being diseased and certain to die.

At the termination of the experiment on July 31, a defoliation survey was made of the tagged trees in the treated and check plots. Five defoliation categories were selected and percent defoliation was rated as follows:

Rating	Percent defoliation
1	0 - 10
2	11 - 25
3	26 - 50
4	51 - 75
5	76+

Follow-up Studies on 1976 and 1977 Trials

Three plots treated with NPV and 2 check plots used in 1977 (Kaupp, Cunningham and de Groot, 1978) were re-examined. On July 12, plot 1, plot 2, and an area designated "A" to which virus spread in the year of application were inspected. One hundred tagged trees in plot 1 and 150 tagged trees in plot 2 were examined and random checks

were also made throughout the area. On July 15, check plot 1, check plot 2 and treated plot 3 were examined the same way.

In 1977, a re-examination was made of the 3 treated plots and one check area used in the 1976 operation (Kaupp and Cunningham, 1977). As there was still a heavy population in the check plot, it was treated with NPV using a mistblower. All 4 plots were examined again in 1978 by Mr. H. Weir of Great Lakes Forest Research Centre.

RESULTS

Meteorological Observations

Records were maintained from July 8 to July 31. In this period 4.6 cm of rain fell, the mean minimum temperature was 12.2°C and the mean maximum temperature 29.6°C. The highest and lowest temperatures were 32.7°C and 4.4°C. The summer of 1978 was one of the dryest summers on record for this region with many areas suffering severe drought conditions.

Deposit Assessment

On Kromekote® cards the mean numbers of droplets/cm^2 and standard deviations were 62 $\pm$ 29 and 103 $\pm$ 48 on plots 1 and 2, respectively. The range of sizes of the droplets is shown in Figure 3. It can be seen that they were small with 84.0% less than 150 µ on plot 1 and 84.7% less than 150 µ on plot 2.

Population Reduction Due to Treatment

The number of healthy red-headed pine sawfly colonies per 100 tagged trees in the treated plots and number of colonies per 50 trees in the check plots are given in Table 2 for the 9 observations made on the treated plots and the 6 observations on the check plots. There are slight anomalies in such observations due to colonies splitting-up and others uniting when there is more than one colony per tree.

The decline in healthy colonies is shown in Figure 4. Significant mortality from virus was noted 10 days post-spray with 42.7% and 47.1% of the colonies with larvae killed by virus in plots 1 and 2, respectively. Between days 10 and 12 post-spray, there was a hiatus in virus mortality, but by day 15 there was a drastic decline in the number of healthy colonies. The reason for this hiatus is unknown, but could be due to spread of virus and secondary infection throughout the plantation.

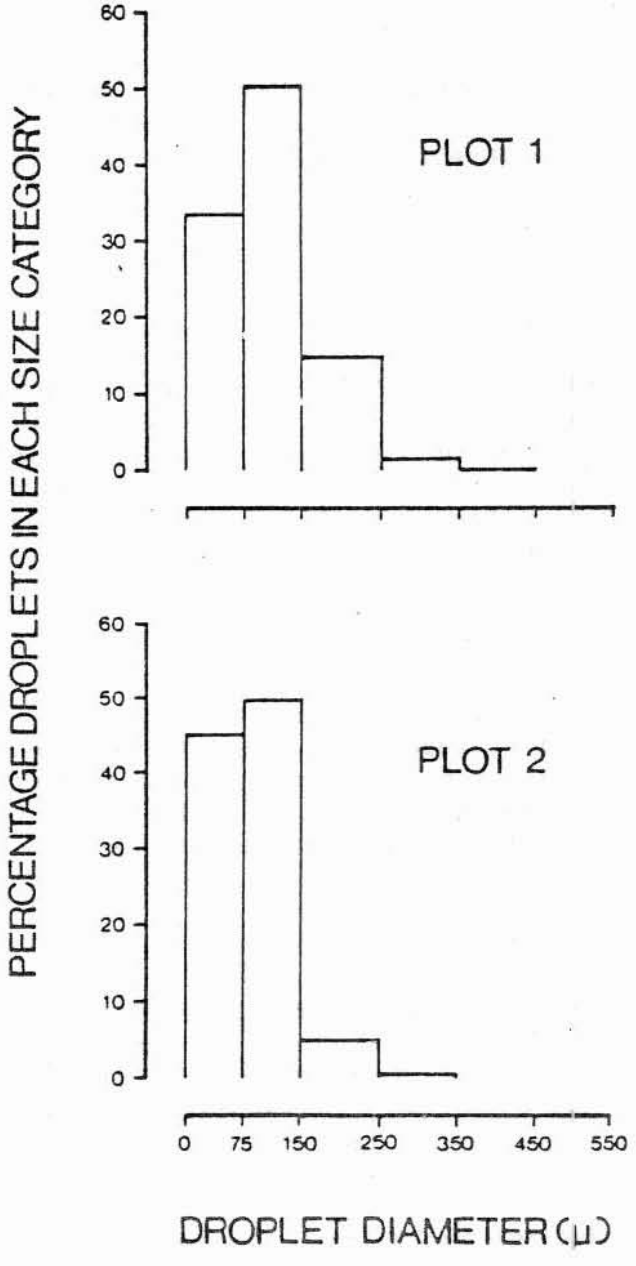

Fig. 3. Analysis of spray droplets on Kromekote® cards following aerial application of nuclear polyhedrosis virus.

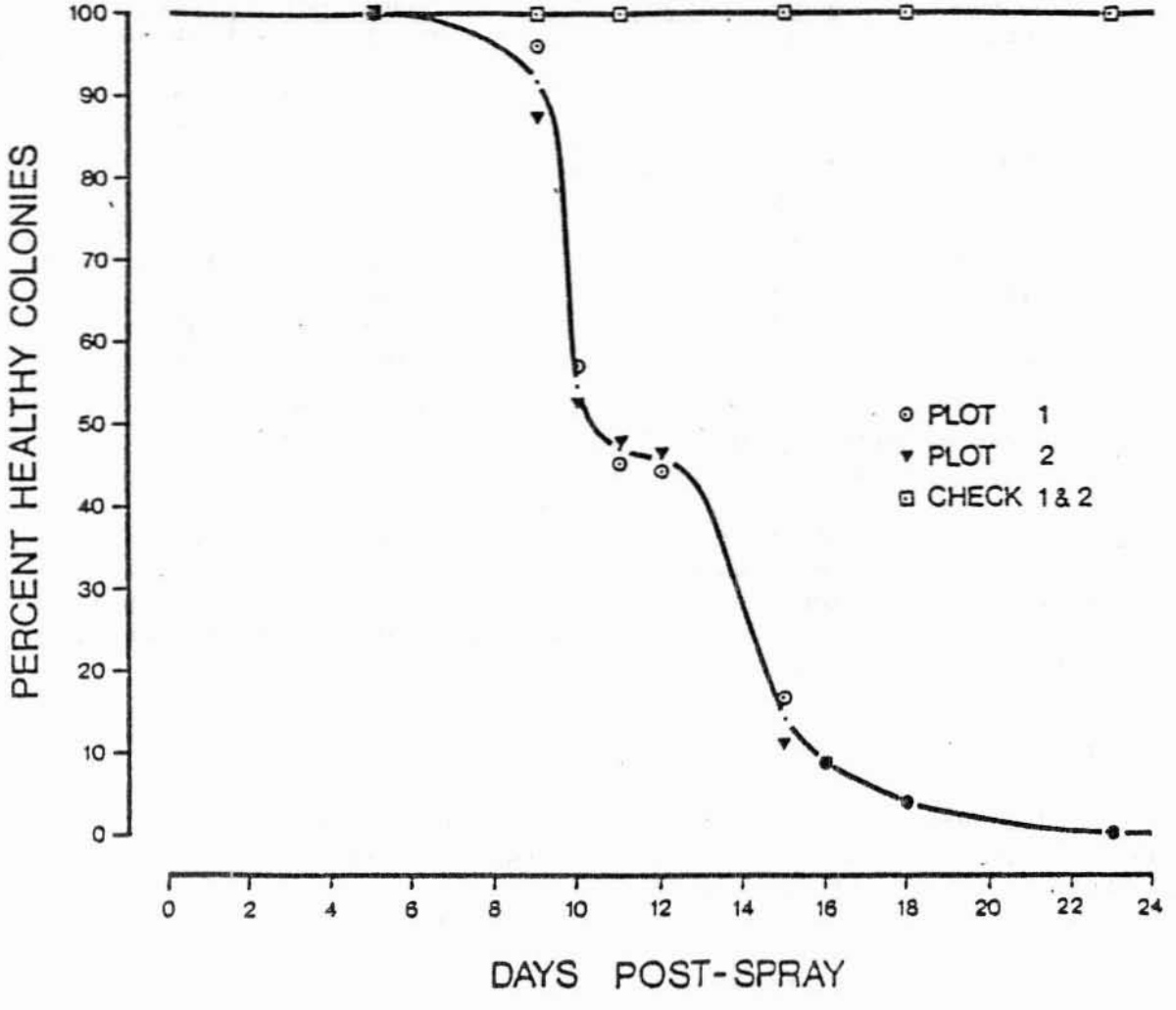

Fig. 4. Decline in the number of healthy red-headed pine sawfly colonies on plots 1 and 2 following application of nuclear polyhedrosis virus at 5.0 billion PIB/ha compared to two untreated check plots.

Table 2. Number of healthy sawfly colonies on tagged trees in nuclear polyhedrosis virus treated plots and check plots in 1978.

Days post-spray	Number per 100 trees		Number per 50 trees	
	Plot 1	Plot 2	Check 1	Check 2
5	459	285	101	102
9	441	250	107	102
10	263	151	---	---
11	207	137	97	99
12	204	135	---	---
15	76	32	98	103
16	39	24	---	---
18	18	11	103	92*
23	0	0	105	84

* Onset of pupation in Check 2.

By 18 days post-spray, there were few healthy colonies left and by day 23 none could be found on the tagged trees in plots 1 and 2. In contrast, the populations held steady in both check plots. A drop in the number of colonies at day 18 in check plot 2 was due to the onset of pupation.

Defoliation Survey

The percentage of trees in each defoliation category is given in Table 3. It can be seen that there was less defoliation in the treated plantations than in the untreated checks.

Table 3. Defoliation survey made after insect pupation in plantations treated with nuclear polyhedrosis virus to control red-headed pine sawfly compared to untreated check plots.

Rating category	Percent of trees in each rating category			
	Plot 1	Check 1	Plot 2	Check 2
1	56	30	76	56
2	24	22	14	32
3	18	26	8	8
4	2	8	1	4
5	0	14	1	0

Follow-up Studies on 1976 and 1977 Trials

Plots near Lakefield, Ontario, treated with red-headed pine sawfly NPV in 1976 (Kaupp and Cunningham, 1977), were re-examined in 1977 and 1978. The numbers of colonies per 50 trees pre-spray and post-spray in 1976 are shown in Table 4 along with counts on an untreated check plot. When examined in 1977, no colonies were found in the treated areas but 51 colonies per 50 trees were counted in the check area. This check area was treated with NPV using a mistblower in 1977. In 1978, the three treated plots and the area which was originally the check were all found to be free from sawfly colonies.

Table 4. Numbers of red-headed pine sawfly colonies in 1976, 1977 and 1978 following application of nuclear polyhedrosis virus in 1976 on plots located near Lakefield, Ontario.

Time of count	Numbers of colonies per 50 trees			
	Plot 1	Plot 2	Plot 3	Untreated check
Pre-spray 1976	59	138	173	119
Post-spray 1976 (22 days)	7	46	1	115
1977	0	0	0	51*
1978	0	0	0	0

* Treated with nuclear polyhedrosis virus disseminated from a mistblower in 1977.

Plots near Renfrew and Richmond, Ontario treated with NPV in 1977 were also re-examined in 1978. The numbers of sawfly colonies per 100 trees on plots 1 and 3 and per 150 trees on plot 2 are shown in Table 5. No sawfly colonies could be found in these 3 treated plots or in an area, designated "A", adjoining plot 1, to which the virus spread in the year of application (Kaupp, Cunningham and de Groot, 1978). The sawfly population had declined drastically in Check 1 from 248 colonies per 100 trees in 1977 to 32 colonies in 1978. This is not surprising as many of the tagged trees had died. Only a slight population decline was observed in Check 2, with a count of 217 colonies per 100 trees in 1977 falling to 156 colonies per 100 trees in 1978.

Table 5. Numbers of red-headed pine sawfly colonies in 1977 and 1978 following application of nuclear polyhedrosis virus on plots near Renfrew and Richmond, Ontario.

Time of count	Number of colonies per 100 trees				
	Plot 1 (Renfrew)	Plot 2* (Renfrew)	Plot 3 (Richmond)	Untreated Check 1 (Richmond)	Untreated Check 2 (Renfrew)
Pre-spray 1977	163	81	132	248	217
Post-spray 1977 (26 days)	7	0	2	114	200
1978	0	0	0	32	156

* Number of colonies per 150 trees.

DISCUSSION

This is the third year of aerial spray trials with NPV on red-headed pine sawfly. As in previous years, the results were considered highly successful. Excellent results were also obtained on the 700 ha of infested red pine plantations treated in Quebec. It is now considered that there is adequate experimentation to prove that this nuclear polyhedrosis virus is highly efficaceous for management of this pest.

The deposit was considered to be very good this year. However, little difference in the length of time from spray application until first mortality and till total mortality was noted when compared to results obtained in 1976 and 1977 when fewer droplets/cm^2 were deposited. In 1976, on three plots, 33, 48 and 27 droplets/cm^2 were obtained with boom and nozzle equipment. First mortality was observed about 12 days post-spray and heavy mortality 18 days post-spray. In 1977, a very poor deposit was obtained on two plots using boom and nozzle equipment, with 10/cm^2 on one plot and 11 on the other. A third plot sprayed with Micronair equipment in 1977 had a deposit of 60 droplets/cm^2. Again, first mortality occurred in about 11 days and heavy mortality in 20 days. This year, 62 droplets/cm^2 were obtained on one plot and 103/cm^2 on the other. The mortality pattern was identical on both plots as shown in Figure 4 and similar to the mortality pattern obtained in 1976 and 1977.

These results lead one to conclude that complete coverage is not necessary to obtain a high level of control. A colony of sawfly larvae represents a large target area. Using European pine sawfly, *Neodiprion sertifer*, and its NPV, it has been shown that one infected larva placed in a colony will infect the other insects in that colony in 4 days (Kaupp, pers. comm.). This spread of virus infection within a colony

is almost certainly obtained with red-headed pine sawfly. Hence, the use of virus is preferable to chemical insecticides where much greater coverage is required to give control.

It was particularly gratifying to find no sawfly colonies in areas treated in 1976 and 1977 or even in an area to which the virus spread following application on an adjoining plantation in 1977. The durability of a control agent is of paramount importance and it is hoped that one application of this virus will protect a plantation for several years against attack by red-headed pine sawfly. A plantation near Sault Ste. Marie treated with NPV in 1968 is still free from this pest (unpublished data). Of course, this is one isolated instance and considerably more monitoring of treated areas should be done before a categorical statement is made regarding durability of the treatment.

This year, a less detailed method was used to estimate defoliation compared to that used in trials conducted in 1976 and 1977. Accurate defoliation estimates of plots treated with population regulating agents as compared to untreated checks are difficult to obtain in red pine plantations because both areas should have trees of the same height and age, similar red-headed pine sawfly population densities and the same amount of defoliation due to sawfly feeding in previous years. A further problem is added when assessing virus trials; due to the spread of the virus in the year of application, it is necessary to select check plots a reasonable distance from treated areas. Hence, it is virtually impossible to find truly comparable treated and check plots.

At a time when non-chemical methods of pest management are being sought, it is most desirable to promote the use of this highly efficaceous and inexpensive virus (cost is estimated at about $2.50/ha for the virus material). However, the same problem exists with this agent as with many other promising bio-control agents; the market is too small to interest commercial companies in production and marketing. Therefore, the production and standardisation of red-headed pine sawfly NPV will probably remain a project of the Forest Pest Management Institute even when its development is past the experimental stage and when it is an operational, registered, pest control agent.

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