

DOUGLAS FIR TUSSOCK MOTH

OPERATIONAL PROJECT

HEDLEY - 1981

by

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Forest Service Internal Report PM-K-1

November 1981

NOT FOR PUBLICATION

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DOUGLAS FIR TUSSOCK MOTH OPERATIONAL PROJECT

HEDLEY, 1981

1. INTRODUCTION:

The Douglas-fir Tussock Moth (DFTM), Orgyia pseudotsugata (McDunnough) occurs periodically (every eight to ten years) in outbreak numbers in the interior of British Columbia (Figure 1) and in the western states of the U. S. A. The reasons for this cyclic pattern are not clear but are probably climate related (Graham, 1975). Tussock Moth larvae feed on the foliage of several tree species which include Douglas-fir (Pseudotsuga menziesii (Mirb) Franco), grand fir (Abies grandis (Dougl.) Lindl.) and white fir (Abies concolor (Gord. and Gland.) Lindl.). The host species of major importance in British Columbia is Douglas-fir because of its hectarage as a cover type, wood quality and large volumes. Larval populations are often extremely high and are capable of defoliating and killing trees in one or two seasons. Damaging infestations have occurred mainly in the Kamloops Forest Region, in British Columbia, in dry belt Douglas-fir stands that contain a mixed component of Ponderosa Pine and Douglas Fir on bench lands adjacent to the Thompson River, Similkameen River and the Okanagan Lake Valley. During outbreaks of the Douglas-fir Tussock Moth stands of host trees suffer varying degrees of defoliation. Sometimes damage is very light and hardly visible; at other times trees can be completely stripped of their needles. The amount of tree mortality, top-kill growth reduction and foliage recovery at the end of an outbreak is directly related to the degree of defoliation (Wickman, 1978). Larvae start feeding shortly after bud break in late spring and continue feeding until shoot elongation and needle development are completed in late July or early August. Young larvae (first and second instars) feed on the underside of new needles, turning the needles a reddish-brown. Older larvae (third to fifth instars) eat new and older needles from the tip down. Defoliation progresses inward and downward on the tree crown.

Tussock moth populations usually last from two to four years in an area before there is a natural collapse of the population. Natural control agents of the population include parasites, predators, pathogens and starvation. Viruses, notably nuclear polyhedrosis virus (NPV), are

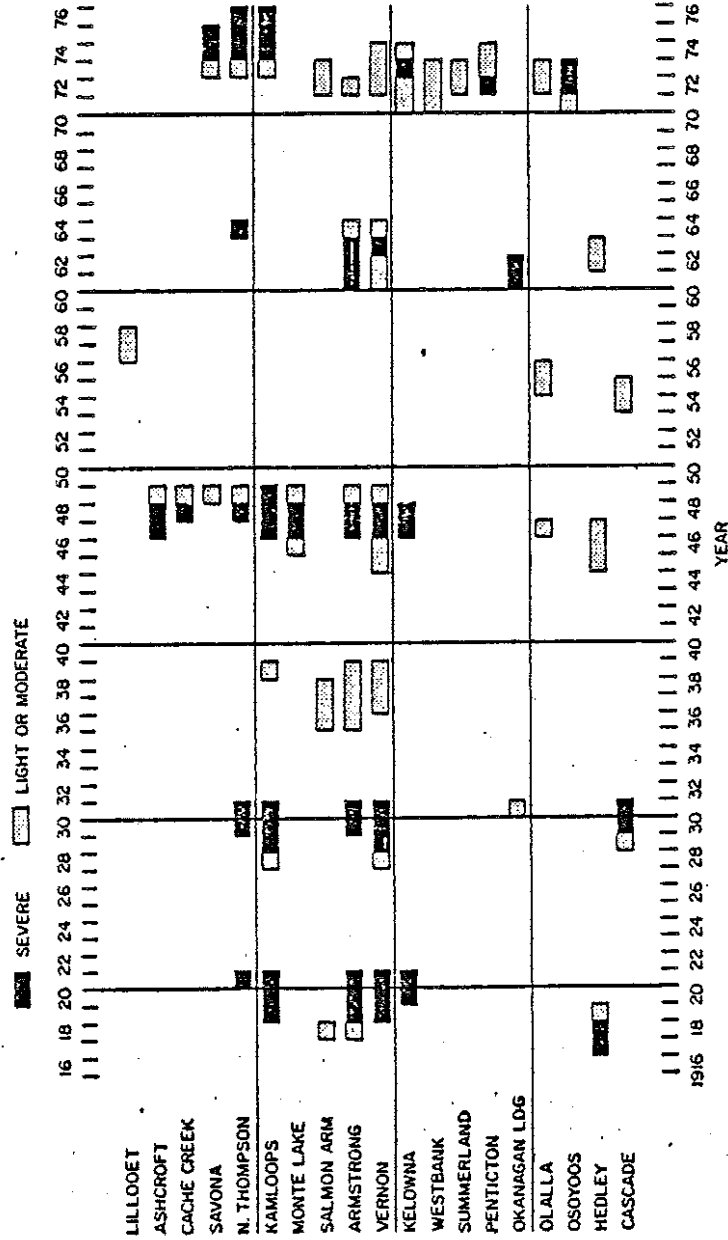


FIGURE ONE: Douglas-fir Tussock Moth outbreak periods from 1916 to 1976 by geographical locations in British Columbia.

generally regarded as the most important of the factors in DFTM population decline. Under natural conditions the amount of NPV built up within the population which would be sufficient to cause the population collapse usually only occurs after 2 to 3 years of defoliation. During this period tree growth loss, topkill, dieback and some tree mortality has already occurred.

In previous aerial application projects NPV has caused an epizootic (viral epidemic within the population) however, the infested area has still suffered considerable damage. The main objective, in the 1981 Hedley DFTM population, was to initiate an epizootic at an early stage of larval development and phase of outbreak, to reduce tree damage. A comparison was made between ground and aerial application of the NPV. Specific objectives of this study were to determine:

- (1) The spread of NPV from small localized ground applications.
- (2) The effect of the initial population density of DFTM larvae on viral epizootic.
- (3) The dynamics of NPV movement within a forest.

2. ORGANIZATION

Several small spots of Douglas-Fir Tussock Moth population buildup were detected in the Hedley-Keremeos area of the Similkameen Valley in south-central British Columbia in 1980. An egg mass density survey, conducted in the fall of 1980 by representatives of the Canadian Forestry Service (C.F.S.) and the British Columbia Ministry of Forests (B.C.M.F.) suggested that low to severe defoliation could be expected within the area in 1981. A DFTM Project advisory committee was established to review the situation. Agencies represented on the committee were as follows: British Columbia Ministry of Forests, B. C. Ministry of Environment; B. C. Ministry of Health; a representative from the general public; the Faculty of Forestry, U.B.C. A public information program was initiated for the proposed control project. Owners of private lots within the designated study plots were mailed covering letters describing the proposed program, a pest leaflet and fact sheets on the DFTM, and the Nuclear Polyhedrosis Virus (NPV)

(Appendix A). Response letters requesting permission to spray private property with NPV were sent to all landowners. All responses to the project were positive. The public was informed of the proposed research project through press releases, in the local newspapers. A special Information Day was held in Hedley April 17th, 1981 with displays, photographs, live larvae, and a team of experts to answer questions; only a few people visited the information centre. An operational crew of 12 individuals and a project co-ordinator was formed by the B.C.M.F. to carry out all data collection and monitoring aspects of the project.

3. OPERATIONAL ASPECTS

The NPV trial project was a joint operation between the British Columbia Ministry of Forests (BCMF) and the Canadian Forestry Service (CFS). The program was conducted in the Hedley-Keremeos area of the Similkameen Valley in south-central British Columbia. Plot selection was based on egg mass density surveys of the area in 1980 and accessibility to infested stands. Ten plots were selected for the study. (Fig. 2). Two plots were selected for ground treatment with one control plot; four plots were selected for aerial treatment with three control plots. The ground treated plots were of moderate and high DFTM densities while the control had a high DFTM density. One of the aerial treated plots had a high population, two had moderate and one had a low population. There was a control plot for each of these population levels of the aerial treated plots. The size of the aerial sprayed plots varied from 0.37 hectares to 9.03 hectares (Table 1). The total aeriaily sprayed areas was 19.9 hectares. One plot (plot 5 check) was relocated when the landowner voiced concern over using his area for this project. All sample trees, were selected on the basis of being 7-15 meters in height and in open or semi-open areas. This insured that each sample tree would be exposed to NPV spray in the ground and aerial application plots. Each tree had sufficient foliage to withstand a weekly two branch sampling scheme of the midcrown.

3.1 GROUND APPLICATION

A modified orchard type hydraulic sprayer was mounted on a pickup

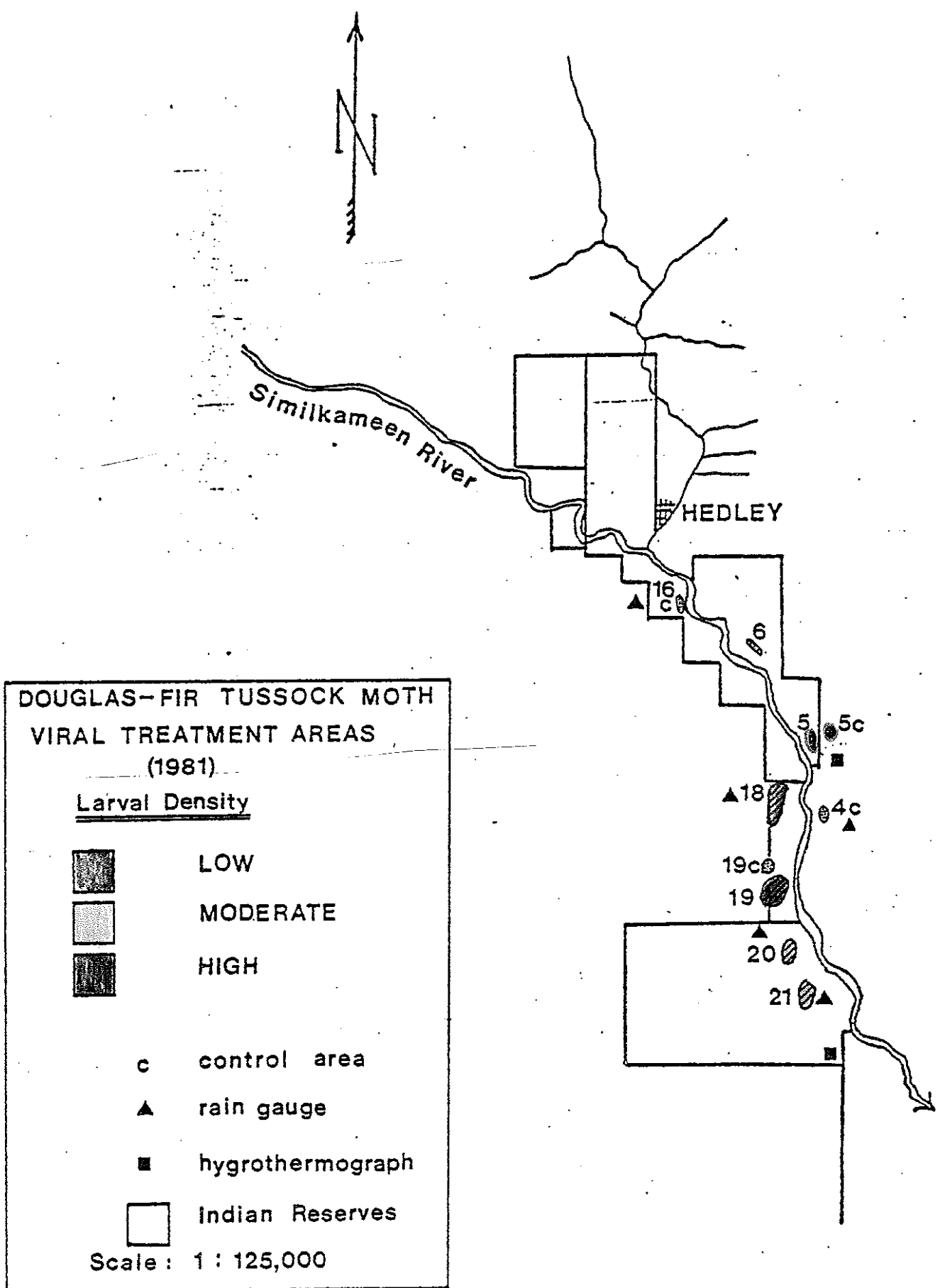


FIGURE 2: STUDY AREA

TABLE ONE: PLOT AREAS IN HECTARES

Plot Number	Pre-spray larval density	NPV Ground Application	Ground Control (ha)	NPV Aerial Application (ha)	Aerial Control
5	High	15 trees sprayed			
6	Moderate	13 trees sprayed			
5c	High		1.4		
18	Low			2.26	
19	High			9.03	
20	Moderate			8.24	
21	Moderate			0.37	
4	Moderate				3.38
16	Low				2.19
19c	High				5.0

TOTAL HECTARAGE AERIAL APPLICATION = 19.90

truck for the ground application of NPV. The sprayer consisted of a 50 gallon fiberglass mixing tank with mechanical agitator and a spray system gun, (jet number 2A with a nozzle type AYHSS60). A 'PM technola pump' drove the system. The spray gun was attached to a 45 meter hose and the nozzle of the gun was adjustable to spray vertically up to 11 meters. The spray mixture consisted of 25% molasses formulation containing 55 cc sticker and 5 billion (5×10^9) NPV polyhedra per 100 litres.

Pre-selected treatment trees, 7-15 meters in height, were sprayed on two sides. A total of 4.5 litres of spray mix was applied to each tree. Treatment time was 1.5 minutes per tree. The actual NPV dosage was 2.4×10^{10} poly inclusion bodies per tree. The spray stream was adjusted during the spraying from a stream spray, used to reach the upper crown of the trees, to a wide mist spray towards the lower crown. Fifteen trees were treated in one plot and 13 trees in another plot in this manner. Spraying was carried out on May 28th, 1981 in the early morning when wind was minimal and on a day when rain was not expected for at least 24 hours thereafter.

The only problem associated with the NPV ground application was a pin-hole leak which developed in the pressurized system during spray application. Teflon sealing tape or electricians tape should be part of any emergency repair kit.

3.2 AERIAL APPLICATION

Spray mixing and aircraft loading took place at the Princeton airport. Refueling took place on site, next to the treatment areas. The aerial treatment was applied by a Bell 206-B helicopter equipped with a Sorenson fixed boom spray kit, using a flat fan spray system nozzle (nozzle size Tee jet 8010). This nozzle produced a wide droplet spectrum and reduced any nozzle clogging which might occur from the NPV mixture. The helicopter tank capacity was 100 imperial gallons (454.49 litres). Calibration of the helicopter spray system was carried out by measuring droplet distribution and spray swath widths at set heights and flying speeds. The helicopter flew approximately 20 meters above the tree tops at 120 KMH

75 mph). Spray swath width was 12m (40 ft.) All treatments were applied at wind speeds of less than 10 KMH (6 mph). The virus formulation was an aqueous mixture of 25% molasses and 192×10^{11} polyhedra + 55 cc of sticker and 2% of 25% solution water soluble Rhodamine B. This mixture was applied at 11.3 litres per hectare. The actual NPV dosage was 2.2×10^{11} poly inclusion bodies per hectare.

Spray plots were marked on aerial photographs (natural scale 1:20,000) ~~for use by the pilot and ground personnel.~~ Plot corner markers of three orange plastic sheets (3' x 3') were placed on lines between tree tops by shooting a monofilament line over a tree with a line gun. These markers were pulled into position 24 hours prior to spray time. Placing the markers on a line between the tops of two trees rather than a single marker on the top of one tree increased the pilots visibility of the corners from the helicopter. The helicopter pilot was in radio communication with ground personnel within the treatment areas at all times. Personnel at every spray plot placed Kromekote spray deposit cards on the ground and monitored spray cloud behaviour and wind conditions. Whenever spray drift was observed the operation was stopped until wind conditions became stable. NPV application had to be repeated on the corner of one plot (plot 20) after a check of the spray cards showed no deposit on these cards. The aerial spraying took place on May 27th, 1981 at dawn when the prevailing winds of the area were minimal. Egg hatch and larval development were monitored during the prespray period on preselected trees in each of the treatment and control plots. Spraying, both ground and aerial application, was done shortly after 90.8% of the larvae had hatched and moved from the egg masses under observation, to adjacent foliage.

4. ASSESSMENT METHODS

Various procedures and data collection sheets were used during the pre-spray and post-spray periods to assess and record larval density, mortality, and development, defoliation and incidence of virus, in both the treated and non-treated plots. Table two summarizes these procedures and when they were used in the project. A detailed outline of all procedures is found in Appendix B. Appendix C has examples of all data collection sheets.

PROCEDURE	PRE-SPRAY	POST-SPRAY EVERY WEEK	FIRST SIGN EPIZOOTIC	75% PUPATION
Egg Hatch	■			
Larval density Branch samples	■	■		■
Larval mortality Larvae in diet cups	■	■		■
Larval Development Pickled larvae	■	■		■
Virus Incidence Larvae in diet cups	■	■		■
Cunningham's larvae (NPV in live larvae)		■	■	■
Sand traps	■	■*		■*
Soil samples	■			■*
Kaupp's foliage (Bioassay of NPV on on Foliage)	■	■	■	■
Atmospheric Conditions Hygrothermographs	■	■	■	■
Rain gauges	■	■		■
Defoliation Estimates	■	■		■
Egg Mass Detection Survey				○

* Selected Plots

○ 16 weeks after NPV application

TABLE TWO PROCEDURAL OUTLINE FOR THE DFTM HEDLEY PROJECT

All equipment used in the control plots were cleaned with a bleach solution to reduce any cross-contamination from treated plots. In nine of the plots all samples were collected from 15 pre-selected coded trees. In the remaining plot, (a ground spray plot), only 13 trees were pre-selected and coded as sample trees. Coding consisted of stapling an aluminum tag (10 cm x 15 cm) to the trunk of each tree. An identification number was then inscribed on each tag. In addition each tree was tagged with orange flagging for identification in the field. Maps were made of the location of the sample trees in each plot.

DFTM larval density was monitored weekly by clipping two 45 cm branch tips, using a basket equipped pole pruner, from the mid-crown section of each of the pre-selected sample trees in each plot. The foliated surface areas was measured and the number of larvae, and new shoots were counted and recorded for each branch. Larval development was also monitored weekly by collecting and perserving 50 to 100 larvae in 70% ethanol from each plot during the pre-spray week and each of the 10 post spray weeks. This allowed larval instar identification to be made at a later date. Larval mortality attributed to virus was determined in two ways. In the first method smears were made from 100 live larvae placed on separate microscope slides, at each collection date and examined under oil immersion microscopic (400X) for the presence of NPV particles. In the second method 100 larvae from each plot were collected each week and reared individually in small cream cups with an artifical diet for 4 weeks. Diet cups were checked once or twice a week and smears were made of dead insects to determine the presence or absence of NPV particles. Those larvae which did not die were reared to emergence to determine the adult DFTM sex ratio of the survivors in each sample. Larvae were placed on new diet when the old diet appeared dry and discolored (brown).

The spread of the introduced virus from ground treated trees was followed by measuring the incidence of virus in larval samples collected from untreated (interval) trees (n=13) left intermingled between the treated ones, and from untreated trees selected in three dispersal lines running parallel to the line of treated trees. These three lines were 44m below

(n=10) 50 m above (n=12) and 90 m above (n=15) from the lines of the treated trees. The average distance of the check trees in this plot (n=15) was 210 m from the treated trees. (Fig. 3).

To assess the effect of initial population density of DFTM larvae on viral epizootic, aerial NPV application was made on sample plots which were pre-determined to have high, moderate or low larvae densities prior to NPV application. The dynamics of NPV movement within a forest was assessed in two ways:

- (1) Soil samples were taken during the pre-spray period from five pre-selected trees, in each plot, both the treated controls. At each of the trees the samples were taken in the cardinal directions directly under the perimeter of the lower crown. A second set of soil samples was taken 10 weeks after aerial application of NPV, on the same sample 5 trees per plot, to make a comparative analysis of NPV in the soil from pre-spray to last post-spray week.
- (2) Four sand traps placed in the cardinal directions, under 5 pre-selected trees in each of a low, moderate and high larval density aerial spray plot and 3 check plots of low, moderate and high density. These sand traps were left in the field for the duration of the project. In addition four sand traps were placed under 5 trees in a high larval density aerial spray plot. These traps were brought in and replaced at weekly intervals. The former assessed the overall change in virus accumulating on the Forest floor over a ten week period while the latter assessed the accumulation of virus on the Forest floor for each week.

Egg mass distribution was examined on eight trees in each of the low, moderate and high larval density plots to develop a low density level egg mass sampling system. Four branches were cut in each of the cardinal directions from the upper, middle and lower crown levels as well as the four lowest branches of each tree. Each branch was cut into two sections, the outer 45 cm and the rest of the branch. The length of each section and the average width of the foliated portion was measured and recorded. Counts were made of the number of egg masses and cocoons on each section. All egg masses were collected and reared for parasitism.

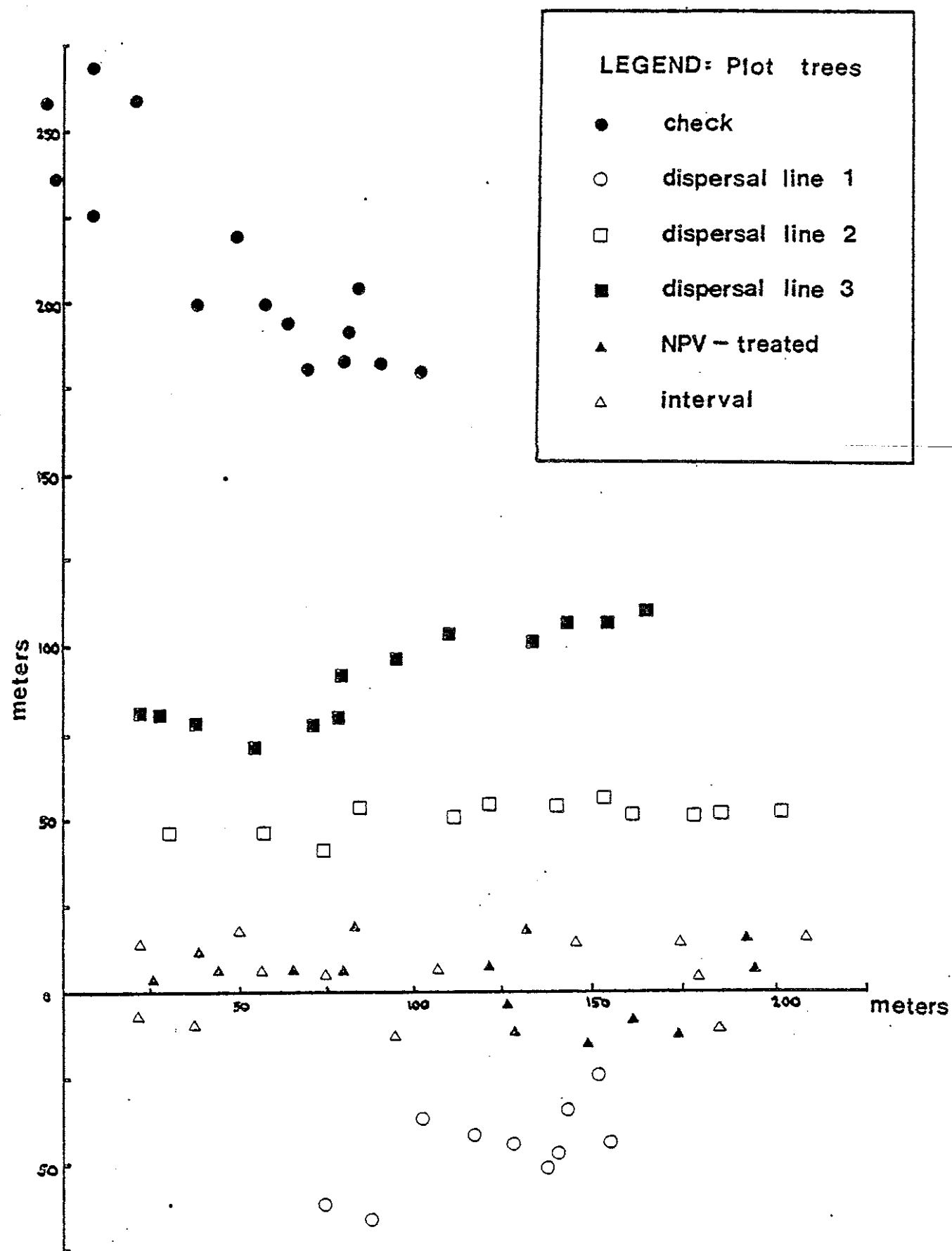


FIGURE 3: Location of sample trees (plots 5 & 5 check)

To monitor the efficiency of the NPV introduction by ground and aerial application, extensive pheromone trapping and egg mass surveys were initiated after larvae pupation. Pheromone traps were placed out at 26 pre-selected sites, including the NPV treated and non-treated plots (Fig. 4) from Keremeos to Princeton. In all plots where larval density measurements were made (ie. 10 plots) a three concentration system (ie. 0.1%, 0.01% and 0.001%) was used. Fifteen traps, (5 per concentration) were placed in a random mix pattern, approximately 30 meters apart at a height of 6 feet, on the host trees. These traps were set out in either 2 or 3 lines. In the remaining 16 plots, 5 traps with a 0.1% pheromone concentration were set out in a line or loop.

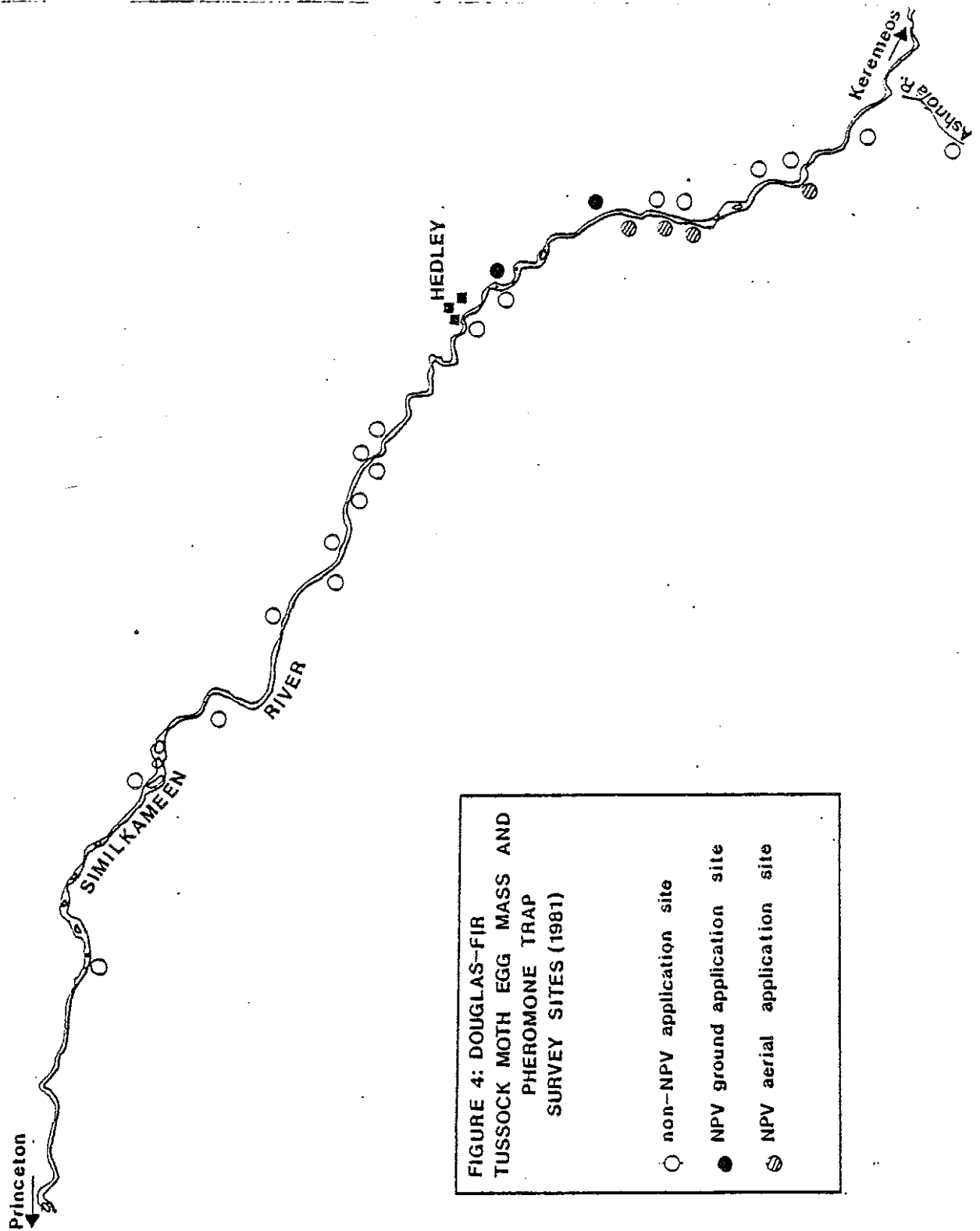
After DFTM mating had occurred and the females had laid their eggs a sequential egg mass detection survey (Appendix B) was made at each of the pheromone trap sites. Fifty trees were examined at each site. The number of egg masses on three lower branches were recorded and the number of egg masses per tree was calculated. Each pre-selected site was rated high, moderate or low with respect to probable defoliation expected in each area in 1982.

5. EFFECTIVENESS OF THE MICROBIAL INSECTICIDE

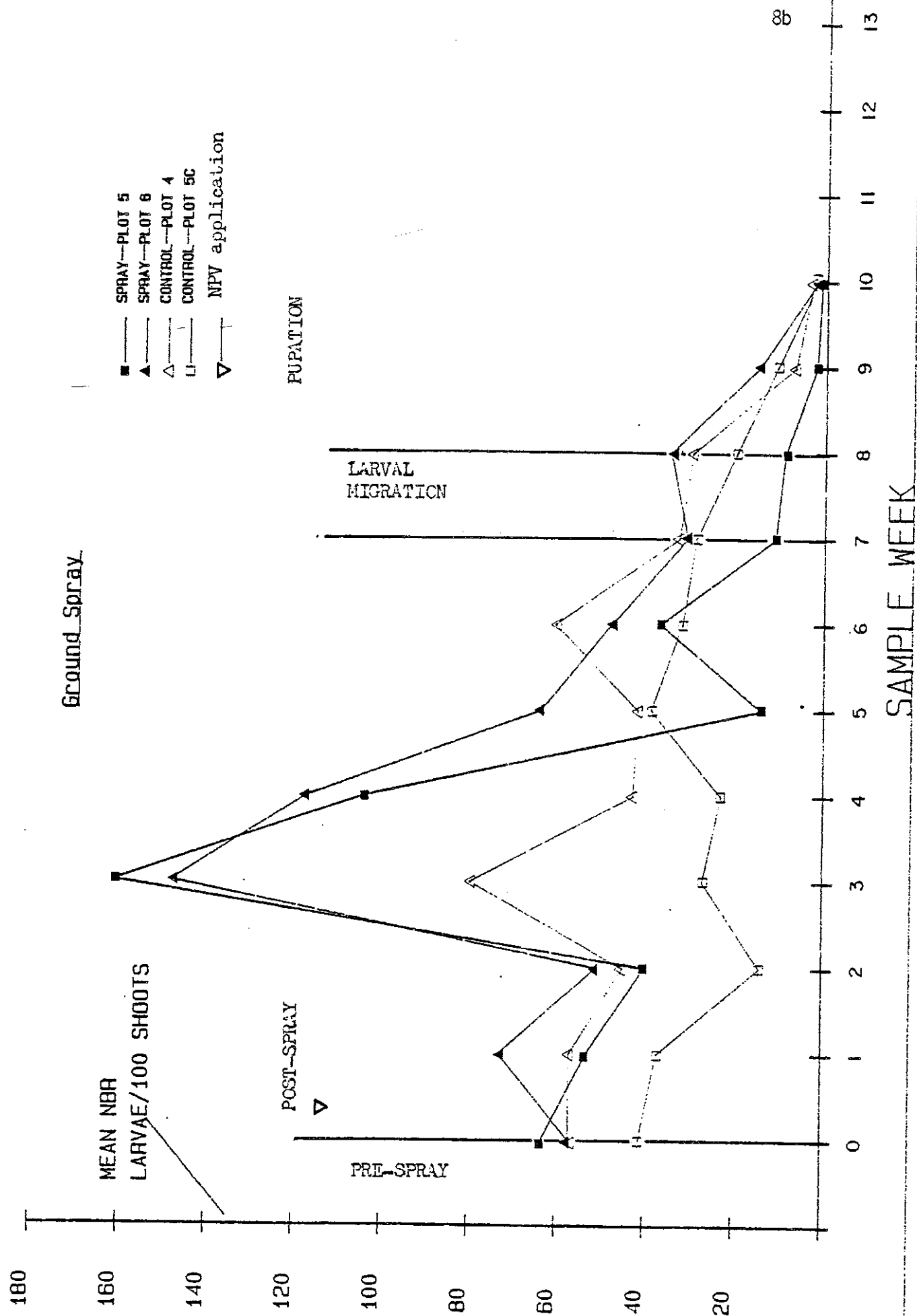
This section presents only partial and preliminary results because data analysis have not been completed. A bioassay is as yet to be made of the NPV in the sand traps and soil samples, and the data collected on branch foliation. Larval development from pre-spray to last post-spray will also be examined along with the results from the pheromone trap studies.

5.1 EFFECTIVENESS OF THE NPV

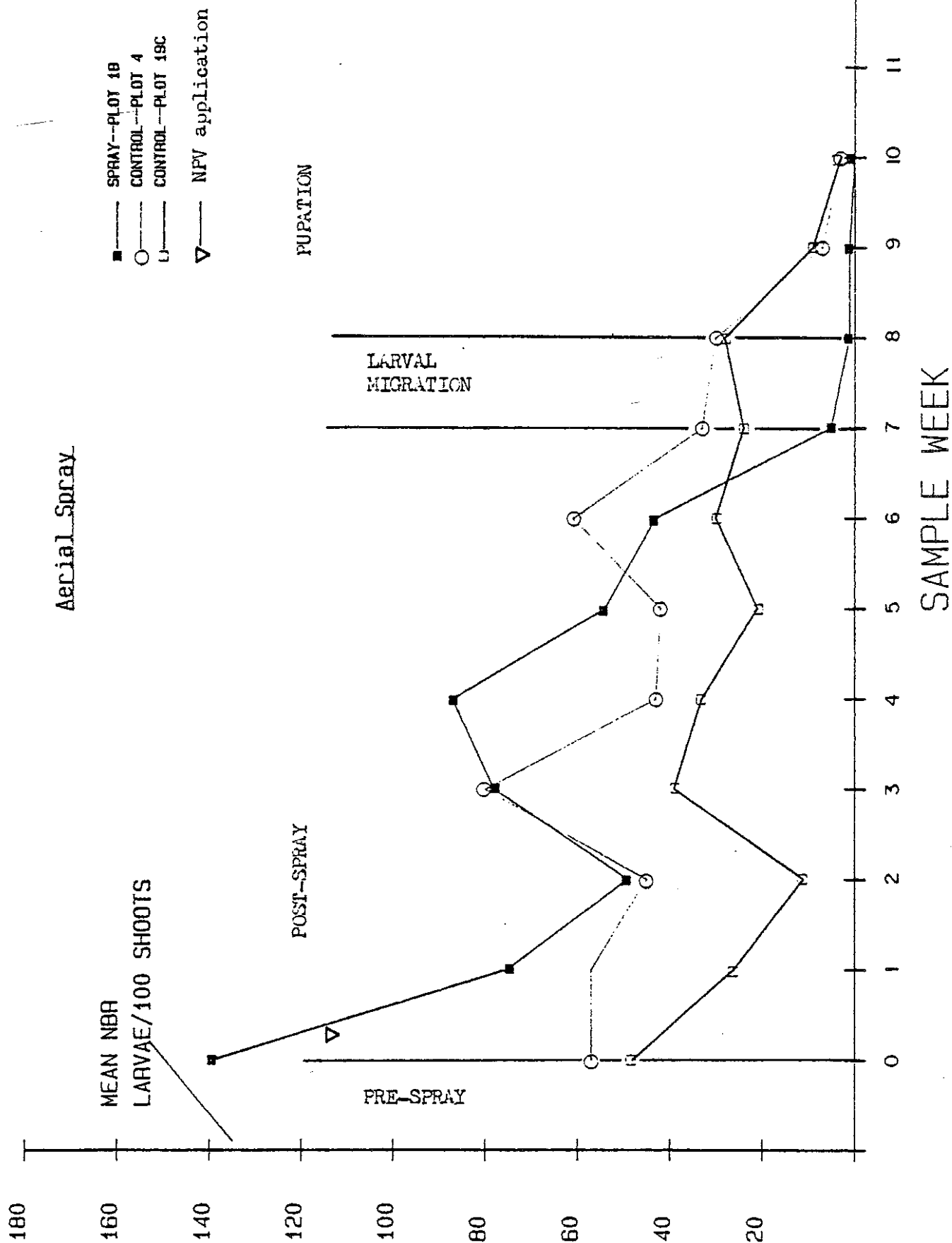
Larval density was monitored weekly in all plots. (Fig. 5). Initially, the NPV had no real effect and the number of larvae per 100 buds reached a maximum three weeks after spray application in the ground treated plots. This was likely due to the record cooler than normal temperatures experienced during this time period. Larval development was also 2-3 weeks behind that of normal years. The delay in larval development and virus



DFTM LARVAL DENSITY



DFTM LARVAL DENSITY



DFM LARVAL DENSITY

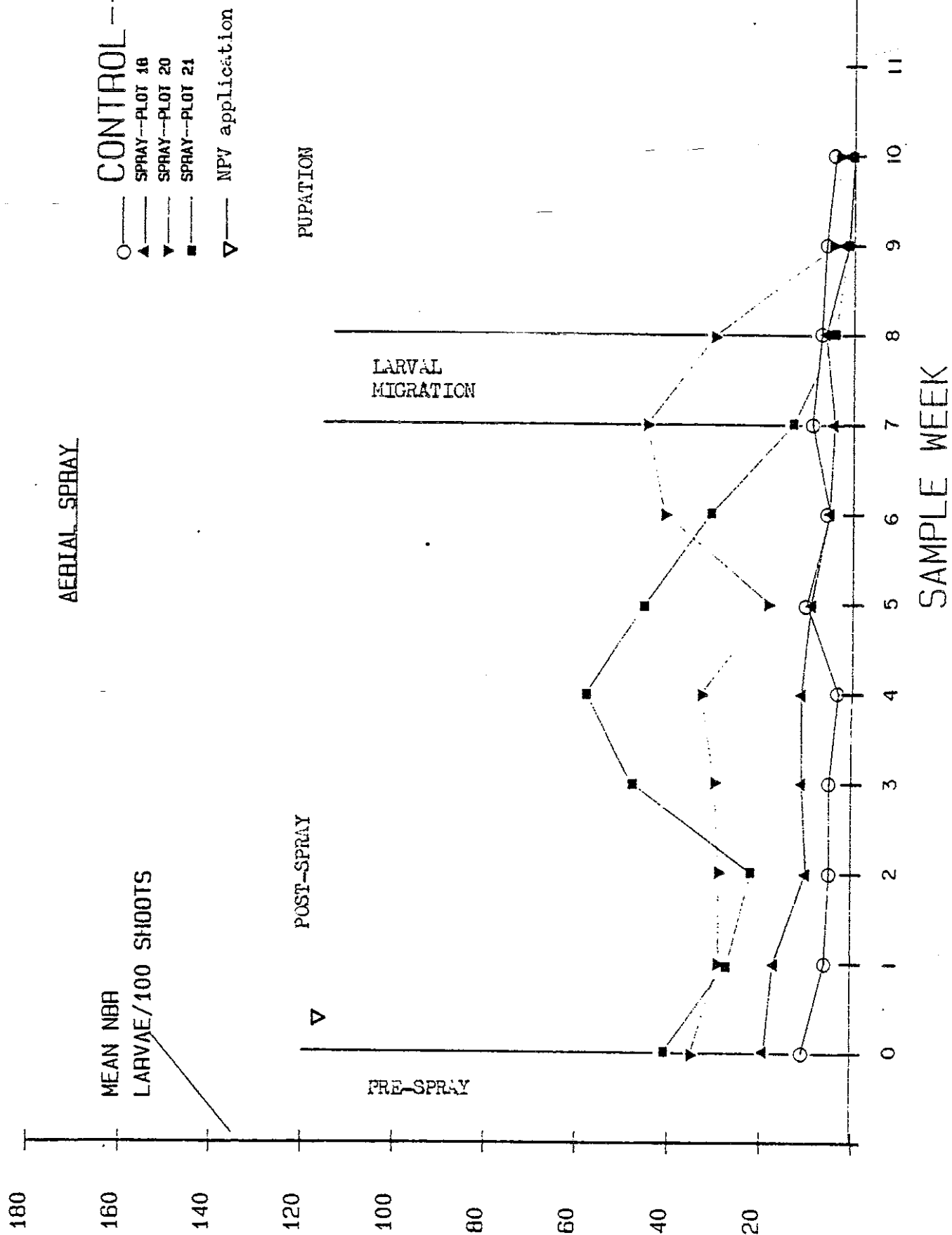


FIGURE FIVE CONTINUED

epizootic can probably be attributed to these cooler temperatures. The rapid decrease in larval populations which subsequently occurred in the treated plots is due to the virus epizootic, stimulated by the onset of warmer weather than occurred at that time.

A natural epizootic did occur in the check plots with high (Plot 5 check) and moderate (Plot 4) pre-spray larval densities, NPV infection was of a greater magnitude in the treated areas indicating the beneficial effect of the NPV spray. At low population densities treatment effects were excellent and a natural epizootic in the low check plot (Plot 16) did not occur.

The occurrence of an epizootic was further substantiated through the microscopic diagnosis (ie. smears) of live larvae collected from all plots, each week (Fig. 6 Table three). By post-spray week eight NPV percent infection of larvae had reached a maximum of 97.2% in a low density (Plot 18), 100% and 77.2% in moderate density (Plots 20 and 21, respectively) and 96.9% in the high density aerial sprayed plots. By comparison, the high density aerial spray check (Plot 19 check) reached 47.4% NPV infection by post week eight. The infection here may be due to the close proximity of this check plot to an aerial spray or as natural epizootic which developed in this area.

The high (Plot 5) and moderate (Plot 6) ground spray plots reached over 80% NPV infection by post spray week eight.

An egg mass survey was made 16 weeks after NPV application. Three lower branches on 50 trees, in each plot, were examined for the presence of egg masses. Those plots where NPV infection occurred either naturally or artificially had an egg mass rating of zero egg masses per tree. The 1982 defoliation due to DFTM, in these areas, is expected to be minimal. The proportion of egg masses per tree in check plot 16, previously of low DFTM density, was 0.92 indicating there will be a greater than 20% defoliation (noticeable defoliation) of this area in 1982.

FIGURE 6

AT 2,4,6,8 WEEKS AFTER APPLICATION
FOR EACH STUDY PLOT

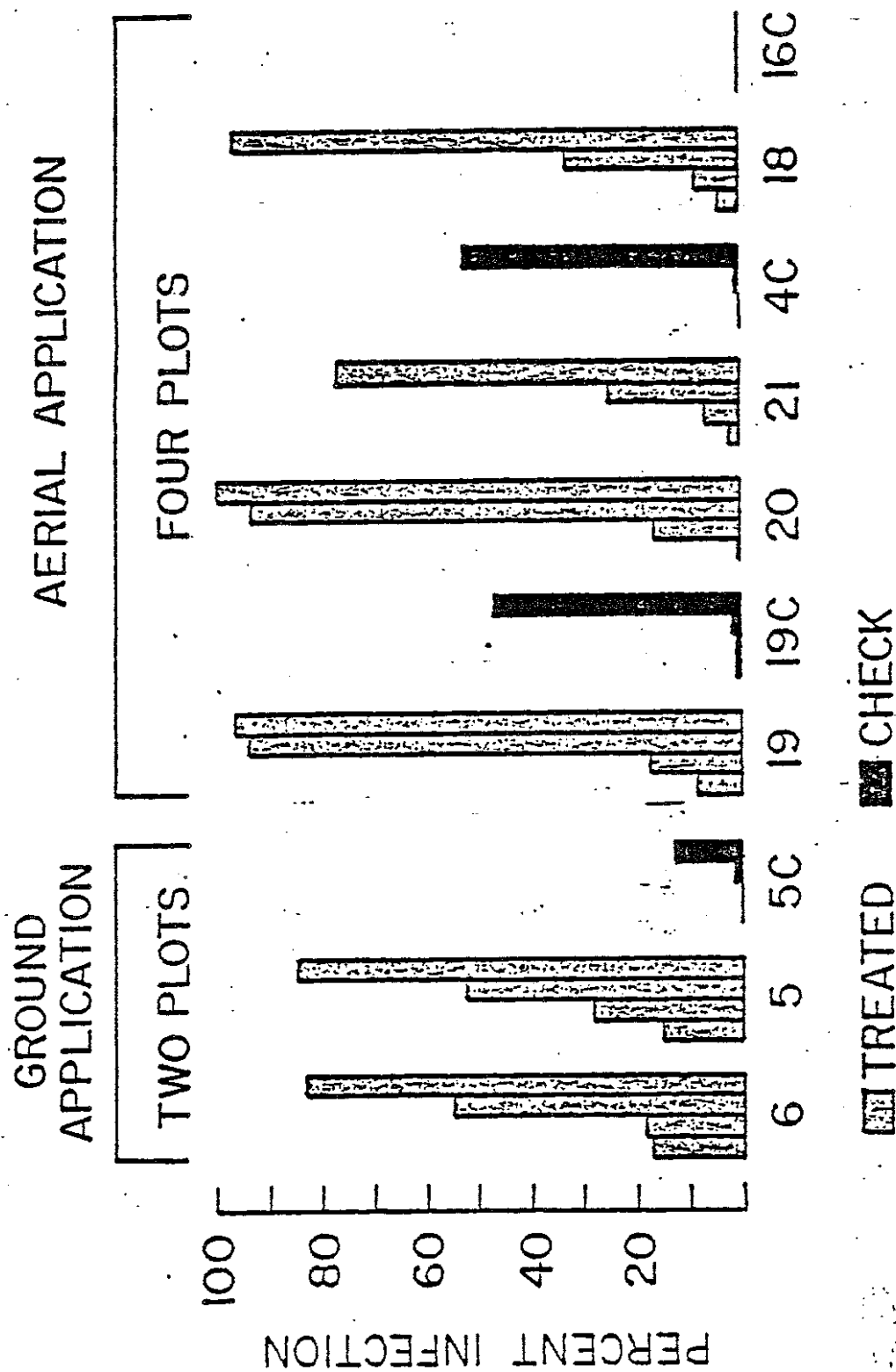


TABLE III : PERCENT INFECTION OF DFTM LARVAE BY NPV
(based on smear analysis)

Plots	X NPV Infection Per Week Post Spray							
	1	2	3	4	5	6	7	8
Aerial Spray								
18 (n=13) *	11.2	3.4	30.9	8.3	55.6	32.7	63.0	97.2
19 (n=111)	13.1	8.4	27.5	17.6	98.7	94.2	96.9	ND
20 (n=118)	4.0	0.0	0.6	16.2	72.0	93.2	95.2	100
21 (n=151)	3.2	2.5	4.1	6.6	23.4	25.0	55.6	77.2
Aerial Check								
16 (n=108)	0.0	ND	0.0	0.0	2.4	0.0	0.0	ND
19 (n=161)	0.0	ND	1.5	0.5	2.2	1.7	13.8	47.4
Ground Spray								
5 (n=140)	1.5	14.9	23.3	29.1	62.5	52.4	58.8	84.9
6 (n=148)	1.4	17.6	20.5	18.3	24.4	54.8	83.5	83.1
Ground Check								
4 (n=180)	0.0	ND	0.0	0.0	0.0	0.6	10.2	53.6
5 (n=175)	0.0	ND	0.0	0.0	1.8	1.3	5.5	12.9
Dispersal Lines								
Plot 5								
Incidence								
(n=148)	ND	ND	ND	ND	ND	23.8	79.1	63.3
Line 1								
(n=162)	ND	ND	ND	ND	ND	10.0	40.7	41.4
Line 2								
(n=159)	ND	ND	ND	ND	ND	8.3	37.2	28.5
Line 3								
(n=177)	ND	ND	ND	ND	ND	10.7	28.7	26.0

* n = the average sample size per week

ND = NO DATA COLLECTED

5.2 SPREAD OF NPV

The spread of virus from ground treated trees (n=15) was followed by measuring the incidence of virus in larval smear samples collected from untreated trees (n=13) which were intermingled between the treated trees, and from untreated trees selected in three dispersal lines running parallel to the line of treated trees. These three lines were 44 meters below (n=13 trees), 50 meters above (n=12 trees), and 90 meters above (n=13 trees) the line of the NPV ground treated trees. The average distance from the check trees was 210 meters from the treated trees. (Fig. 7). The data depicted in this figure indicates that ground treatment of individual trees may be sufficient to start an epizootic up to 100 m (line 3) on either side of the treated trees.

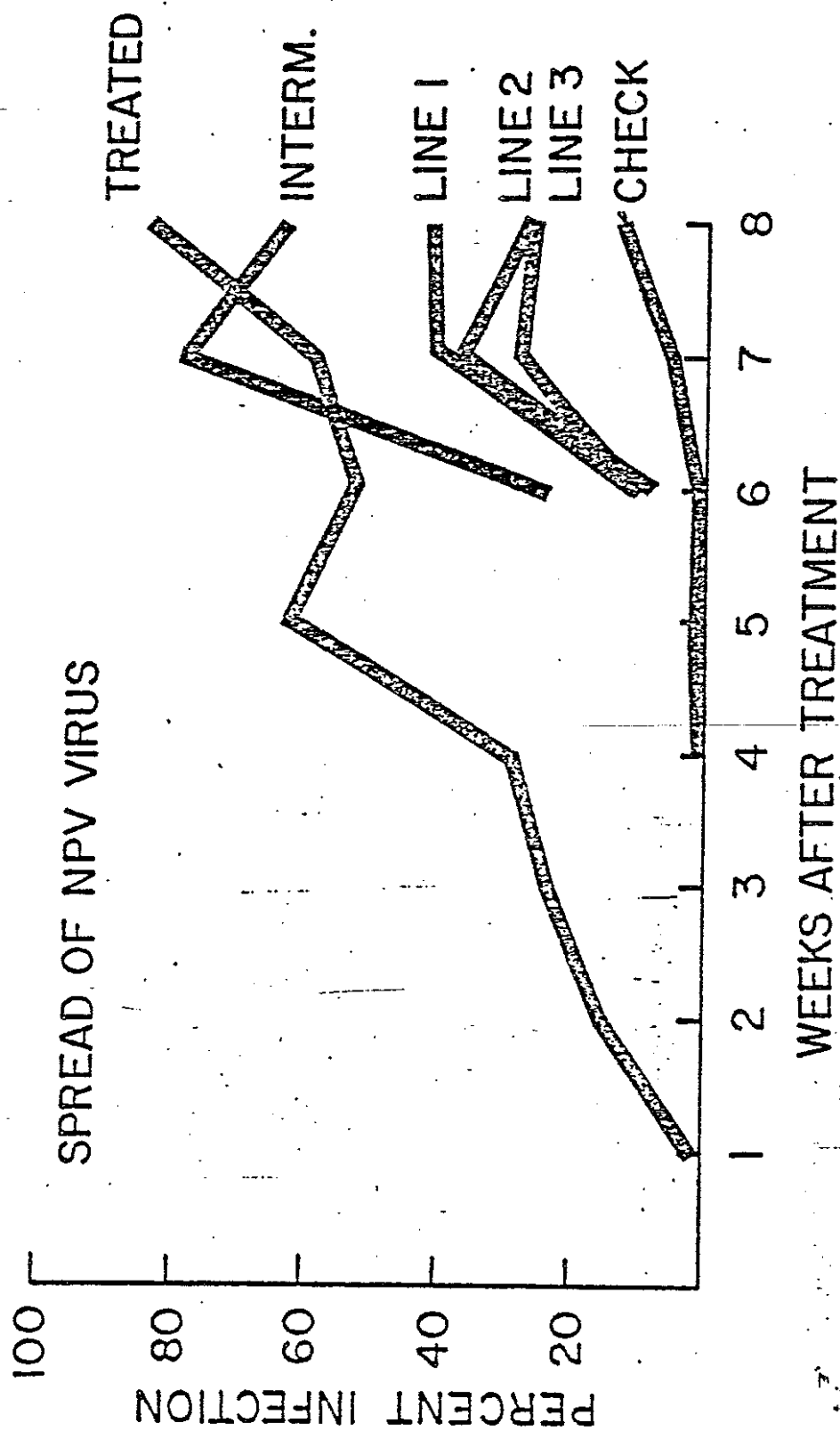
EGG MASS DISTRIBUTION

Egg mass distribution was based on a unit of nondefoliated branch area so a comparative analysis could be made of different size branches. The 45 cm tip always had a lower number of egg masses than the rest of the branch within each crown level. There was a uniform decrease in the number of egg masses from the upper to the lower crown of each sample tree. The upper, middle and lower crowns had a greater number of egg masses than the lowest branch level. The greatest number of egg masses and cocoons was found in the upper crown of each sample tree as compared to the lower crown and bottom whorl level. Future egg mass surveys may have to utilize a "distribution factor" in order to obtain a better indication of egg masses in an area.

5. SUMMARY

All virus treatments (ground or aerial) provided control of the tussock moth. The population reductions were associated with high levels of NPV infection induced by the spray applications. Foliage protection was less than expected. The adverse cool

FIGURE 7



weather and consequent slower virus development may have been the determining factor. The egg mass detection survey conducted in the Fall indicated no egg masses in the aerial and ground treated areas. Indications are that the spread of NPV in an area can be accomplished through the ground spraying of a line of trees. NPV appears capable of spreading 100 meters in either direction of inoculation line. Subsequent monitoring of the treated areas is needed for three years to determine the effect of NPV treatment on this developing outbreak. This project provided information necessary for the registration of NPV in Canada.

6. RECOMMENDATIONS

- (1) Agreement should be secured with the private land owners where plot sites (both NPV-treated and non-treated) to allow further monitoring of these areas. This would allow assessment of the long term effects of NPV artificial application DFTM populations.

Monitoring would consist of:

- (1) an egg mass detection survey in late April-early May to confirm the presence of egg masses in the treated and non-treated areas.
- (2) to collect and examine egg masses to determine over winter egg mortality.
- (3) DFTM population estimates by the mid-crown branch sample method. Samples from the 1981 sample trees should be taken:
 (1) ten days after egg hatch
 (2) mid summer (late June)
 and (3) late summer (early August)
to ascertain larval density and defoliation throughout the infestation, at each plot location.
- (4) an egg mass detection and pheromone trap survey in the fall (late September-early October) to determine initial DFTM population densities for the following year.

- (5) Trees which are severely defoliated (weakened) by Douglas-fir Tussock Moth larvae may be secondarily attacked by the Douglas Fir Beetle (Dendroctonus pseudotsuga Hopk.) Detection and monitoring of the Douglas Fir Beetle should be included in further monitoring of the Douglas Fir Tussock Moth in the Hedley area.

This monitoring scheme should be conducted over a three year period to collect valuable information on how NPV application affects the duration of a DFTM infestation.

Such a monitoring scheme may not be possible due to the present concern of Landowners in the Hedley area about any further defoliation of their fir trees. These landowners may choose to use a chemical spray to control defoliation by the DFTM. This would eliminate any monitoring of the effect of NPV on DFTM population in NPV treated areas. In addition the 1981 autumn egg mass detection survey has located additional areas in the Princeton-Keremeos region of the Similkameen Valley of high egg mass density. Noticeable defoliation will result in these presently non-defoliated areas in 1982. A large scale program may be deemed necessary for future control of DFTM in the area.

- (2) Whenever possible Crown Land should be used for an ongoing project such as described herein. This would allow for a long term monitoring scheme to be put into effect without apprehension or concern by private landowners.

- (3) Radios should be standard equipment for all crews during a monitoring season. Information with respect to personal accidents, truck breakdowns, or late field work could be communicated to the field office or other crew members in the field.

- (4) Snake bite kits should be issued to every crew member when working in known rattle snake regions.

APPENDIX A
PUBLIC INFORMATION SHEETS

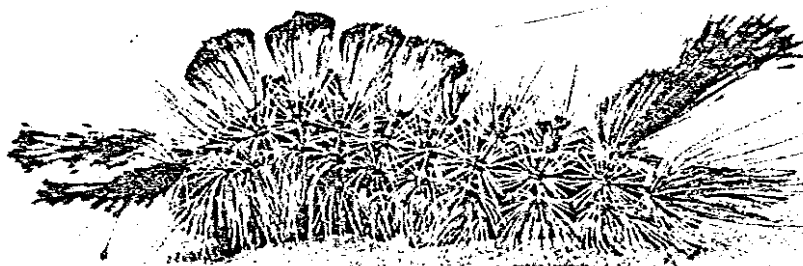
Pest Leaflet

CANADIAN
FORESTRY
SERVICE
FPL 9

Pacific Forest Research Centre

506 West Burnside Road

Victoria, B.C.



Douglas-fir tussock moth larva

The Douglas-fir Tussock Moth

R.D. Erickson

The Douglas-fir tussock moth, *Orgyia pseudotsugata* (McDunnough) (Lepidoptera: Lymantriidae), is a destructive defoliator of Douglas-fir, *Pseudotsuga menziesii* (Mirb.) Franco, in the semi-arid portions of southern British Columbia. Severe infestations occurred in 1916-21, 1928-31, 1945-49, 1961-1964, and 1970-1976, resulting in top-killing or complete tree mortality.

HOSTS

The major host is Douglas-fir, although in the United States the tussock moth may also attack true firs, *Abies* spp. In British Columbia ponderosa pine and western larch adjacent to infested Douglas-fir trees have occasionally been severely defoliated during epidemics. Ornamental spruce have also been damaged.



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DISTRIBUTION

Infestations in British Columbia have occurred from Cache Creek along the Thompson Valley to Shuswap Lake, up the North Thompson to Barriere, from Salmon Arm south through Okanagan Valley, up the Similkameen Valley to Princeton, and in the Kettle River Valley from Rock Creek to Cascade. Larvae infested a few trees near Victoria in 1967-72 and in Clearbrook in the Lower Fraser Valley in 1969-72.

DESCRIPTION

Egg: the eggs are laid on the empty female cocoon in a mass of about 200 embedded in a frothy cement covered with hairs from the female's body. Eggs are white and spherical.

Larva: up to 30 mm (1¼ inches) long; head glossy black; body hairy, grey and black with small red tubercles, and with a broken orange-yellow stripe on each side. On the fore-part of the body are two prominent black lateral pencil-tufts; on the posterior is one black dorsal pencil-tuft preceded by a shorter recurved rust-coloured tuft. Dense rust-tipped tooth-brush-like tufts occur on the back of the mid-body.

Pupa: the larva spins a 20-25 mm (¾ - 1 inch) long grey-brown spindle-shaped cocoon of silk and larval hairs in which it changes into a brown pupa. Tussock moth cocoons are found usually on the foliage or twigs.

Adult: the grey to dark brown female moth is stout, wingless, 16 mm (5/8 inch) long. The male has a slender body; wing-spread, 32 mm (1¼ inches); wings, brown with a small white spot in the posterior angle of the fore-wing.

LIFE HISTORY

The tussock moth overwinters in the egg stage; hatching occurs late in May or early in June. Dispersal most frequently occurs in the first larval stage when larvae are light and hairy and may be borne great distances on air currents. The larvae feed voraciously on the foliage until pupation at the end of June or mid-July. The pupal stage lasts about 10-14 days. The adults emerge, mate and the females deposit eggs (many times on their own cocoons) shortly afterwards.

DAMAGE

The larvae eat new and old foliage. Open-grown trees, frequently those about farm buildings, are particularly subject to attack. The upper third of the crown is defoliated first (see figure). Trees may die after one or two years of severe defoliation; top-killing is common in shade trees or stands of Douglas-fir that have already been moderately to severely defoliated. Hairs from the body of the caterpillars may cause a mild to severe rash of the skin and eyes of some people. In 1976 Douglas-fir beetle, Dendroctonus pseudotsugata attacked some trees defoliated by tussock moth in the Vancouver and Kamloops Forest districts.

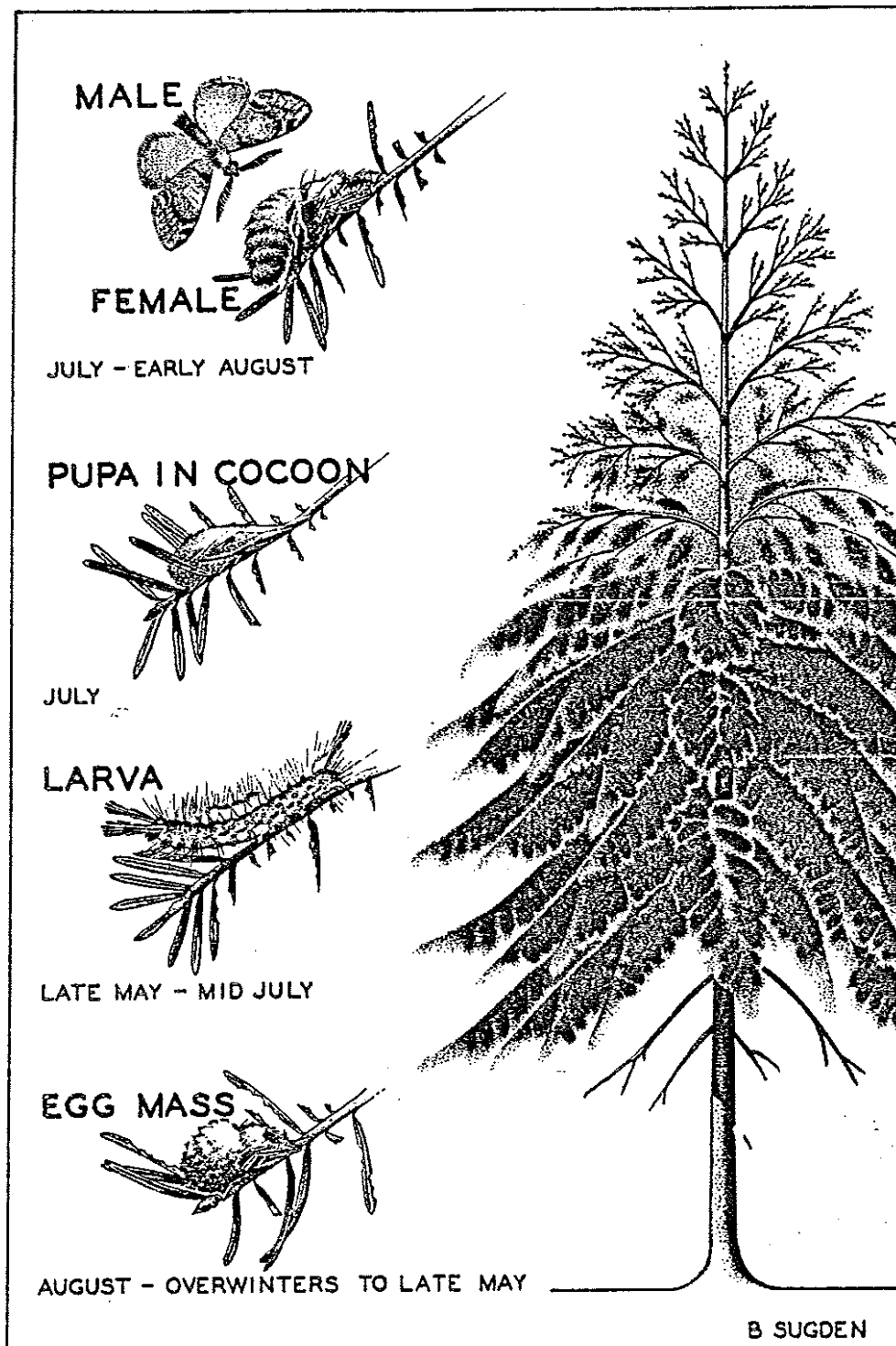
CONTROL

Natural Control Factors

Numerous parasites attack the eggs, larvae and pupae. More important is a polyhedral virus that frequently causes a sudden collapse of epidemics.



Douglas-fir trees defoliated by Douglas-fir tussock moth



Life cycle of Douglas-fir tussock moth



Ministry of Forests,
Kamloops Forest Region
515 Columbia Street
Kamloops, B.C.
V2C 2T7

Honourable T.M. Waterland, Minister

FOR RELEASE: February 27th, 1981

CONTACT: Ron Edward, Regional Pest Control Coordinator Phone: 374-7741
J.D. (Jack) Feka, Regional Information Officer 374-7741

TUSSOCK MOTH ATTACK PLANNED

An attack on the Douglas Fir Tussock Moth outbreak in the Hedley area is being planned for this spring by the Ministry of Forests.

"We've decided to launch an operational trial to determine the most efficient manner of applying control measures which we know are safe and effective", explained Ron Edward, Pest Management Coordinator for the Kamloops Forest Region. "As one of our initial steps we've begun contacting all land owners in the area who would be affected, to request their permission to apply our program on their property."

"We'll be using a biological control which is similar to one advocated by many organic gardeners in insect control...we make a solution of ground-up Tussock Moths, water and molasses, and spray this on infested trees using either helicopters or ground spray-applicators", continued Edward.

The moths used to prepare the solution are ones which have been killed by a virus which naturally occurs in the forest and attacks this insect but has no effect on other insects, fish, birds, humans or other mammals.

"While we already know that this virus will eventually attack and destroy the Tussock Moth population, what we wish to learn is if our exposing the insect to this virus at an early stage in its life cycle will result in the insect dying before it has a chance to cause any serious damage to the forests," Edward said.

Meetings have already been held with the Ministry of Health, Ministry of the Environment -- which includes the Fish and Wildlife, Water Management and Waste Management Branches -- and the Federal Department of Fisheries. These agencies have all approved the method proposed.

The project is being carried out in close co-operation with the Canadian Forestry Service who will be providing technical guidance and who will carefully document the progress of the program for future reference.

Edward concluded, "Before we proceed with any actual applications we plan to hold an open-house to permit the residents in Hedley and surrounding areas an opportunity to look over our plans and to have any questions answered that may occur. We'll be making a public announcement of this once we've settled on a date and location, however, if anyone has an urgent concern that cannot wait until then, I'd be pleased to have them contact me at my Kamloops office."

Editor's Note: Attached are two fact sheets regarding the Douglas Fir Tussock Moth and Nucleopolyhedrosis Virus.

VIRUS FACT SHEET

- Full Name: Nucleopolyhedrosis Virus.
- Virus is specific to the two Tussock Moths found in B. C., the Douglas Fir Tussock Moth and Rusty Tussock Moth.
- Virus has no harmful effects on other insects, birds, humans or other mammals.
- This virus is the major natural agent that contributes to the collapse of Tussock Moth epidemics.
- Virus is spread most widely at the larval (caterpillar) stage.
- Virus has been successfully used in the U.S.A. and in Kamloops in 1975-76.
- Virus was first identified in 1947.
- The virus to be used is obtained from dead infected Tussock Moths, freeze dried and kept in cold storage. When used, it is mixed with water and molasses, which acts as an ultra violet filter to protect the virus, and sprayed on infected trees.
- Virus is usually present in forest soils and may remain viable for 10 or more years.
- The size of the area to be treated with virus will be approximately 50 hectares.

DOUGLAS FIR TUSSOCK MOTH - FACT SHEET

- Primary host is the Douglas Fir
- The damage is caused by the larval or caterpillar stage which feeds on the needles of Douglas Fir trees. First on the new growth then onto the older needles.
- Often kills the upper third of the tree or kills the entire tree if defoliation is severe for one or two years.
- Trees weakened by partial defoliation are often successfully attacked and killed by the Douglas Fir Bark Beetle.
- The range of this pest in B.C. is from Cache Creek along the Thompson Valley to Shuswap Lake, up the North Thompson to Barriere, South from Salmon Arm through the Okanagan Valley, up the Similkameen Valley to Princeton and in the Kettle Valley from Rock Creek to Cascade.
- Hairs from the body of this caterpillar may cause a mild to severe rash of the skin and eyes of some people. This reaction is known as Tursokosic. It affects about one person in 5.
- Homeowners may protect yard trees by the use of common pesticides.
- Life cycle - The eggs hatch in the spring and the larvae commence feeding on the new foliage. It is during these 5 or 6 growing stages of the larvae that the damage is done, first on the new growth then the older needles. The larvae then spin cocoons, grey-brown in color, and enter a pupal stage which lasts 10-14 days. The adult emerge, mate, the female deposits eggs, usually 150-200 and dies shortly thereafter.

APPENDIX B

DETAILED DATA COLLECTION INSTRUCTIONS

- B.1. Branch Sampling For DFTM Population Density
- B.2. Larval Collections
- B.3. Foliage Samples
- B.4. Defoliation Estimation
- B.5. Egg Mass Distribution
- B.6. Egg Parasites
- B.7. Sequential Egg Mass Detection Survey
- B.8. Soil Sampling
- B.9. Sand Traps
- B.10. Pheromone Trapping

B.1. BRANCH SAMPLING FOR DFTM POPULATION DENSITIES

Two 45 cm branch tips are cut from the midcrown of 15 sample trees with the use of telescoping orchard pruning pole modified with a nylon cloth basket attachment at the cutting end. Each branch is cut and treated separately in the following manner.

The branch tip beaten above a canvas tarp to dislodge all larvae. The total number of larvae is recorded and 100 small larvae are placed individually into separate small cream cups which contain artificial diet. Larvae collected in this manner will be reared for subsequent NPV incidence studies.

Each branch is carefully scrutinized and information is recorded as to the length and average width of the foliated branch, the number of 1981 breaking buds or shoots of each branch and the number of egg masses found on each branch. All data is recorded on the Population Density Form (Appendix C).

DFTM population density will be monitored weekly in each plot until 75 percent pupation is reached. Insect density (the number of larvae per 100 shoots) is calculated a program (Appendix D) developed for a Hewett Packard 55 calculator.

To monitor DFTM population densities at different crown tree levels five additional trees will be sampled in a high density aerial spray plot. Two 45 cm branch tip will be cut from the upper, middle and lower crown of each tree. Each branch will be processed in the same manner as already described above.

B.2. LARVAL COLLECTIONS

Types of larval collections.

- (1) from branch samples for rearing.
- (2) for determination of larval development.
- (3) for incidence of NPV in live larvae samples (Dr. Cunningham's Larvae).
- (4) from beating samples.

(1) Larvae from branch samples for rearing

This involves both pre-spray and post-spray branch samples from all plots. A total of 100 larvae, collected from the 15 sample trees in each plot are placed, individually, in separate

small diet cups which contain artificial diet. Post-spray samples are collected once a week until larvae start forming cocoons on the sample trees. Each sample collected each week should be color coded (ie. pre-spray (blue), post-spray week one (red), post-spray week two (orange), etc.) for easier identification of the various samples.

Post-spray larval samples from the control plots should kept with the pre-spray larval samples. These samples must be reared in a different room or hut from the weekly samples collected from the ground and aerial spray plots to avoid contamination. All diet cups should be checked twice a week, up to four weeks after the collection date. On each check day the number of dead larvae per sample is recorded in the following manner:

Collection date	: Check date	: Plot number	: Tree number	: number of dead larvae
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A 3 x 5 inch file card for each tree in each plot is a good means of recording this type of data.

Smears are made of each dead insect by placing the insect on a microscope slide and pulling its body apart, using two toothpicks. The fluid (hemolymph) coming out of the body is then spread thinnly on one half of the slide. Care should be taken not to leave any of the hairs of the larva in the smear. A new wet of toothpicks should be used to smear each insect. Two smears can be made on one slide. Care should be taken not to allow the smears to touch one another. Use a grease pencil or diamond tip pen to identify each smear on the slide. For example if the third larva from tree 5 from plot 20 (treated) died and that smear was made on June 4th, 1981 write on the slide: T20-5-3/81-6-4. A color coded dot or color initial code, donating the sample week the larva was collected, should also be placed next to the smear identification information. The completed smear slides should be stored in slide boxes for examination later.

Live larvae from the pre-spray samples are to be discarded after four weeks of rearing. The fact that these larvae remained alive up to the discard date should be recorded on the data cards. Larvae from each of the post-spray sample weeks which remain alive after four weeks. Should continued to be reared and checked once weekly up to pupation and adult moth or parasite emergence. The dates of pupation, adult emergence, sex of adult and parasite emergence should also be recorded on the data card. Live larvae should be placed on new artificial diet every second week or whenever the diet appears dry and discolored (Brown).

(2) Larval development

At the time of the weekly branch sampling, after 100 larvae have been placed into individual diet cups for rearing, collect up to 10 larvae from each of 10 trees (100 larvae total) and preserve them in vials containing 70% ethanol. Label each vial as to plot number and collection date. These preserved larvae will be examined at a later date to determine the age (instar) composition of DFTM at the various sample collection dates.

(3) Incidence of NPV in live larvae samples (Cunningham's larvae)

The following number of larvae are to be collected on each post-spray sample date:

- (1) 200 live larvae from non-sample trees in each of the aerial spray plots and their respective check plots.
- (2) 100 live larvae from treated trees in the ground spray plots and their control plot.

Collect 100 larvae from the interval sample trees and each of the dispersal line (three lines) sample trees only on sample collection days after the epizootic starts.

Each sample should be processed as follows:

Place larvae in double paper bags which contain foliage (mainly new growth). Seal the top of the bag with masking

tape or staples. Identify the bag with respect to Plot number, Plot type (aerial ground or control plot) date of collection, and sample week number. These bags will be air freighted to Dr. Cunningham at the Forest Pest Management Institute, Saulte Ste. Marie, Ontario for live larvae smear analysis for the presence of NPV virus.

4. Beating samples

Larvae may have to be collected from "beating samples" in order to obtain the required number of larvae for each sample. The small beating tray is placed under the tip (45 cm) of each of three lower branches of each sample tree. The foliage is then beaten with a stick or ones hand. Knocking larvae onto the tray. Larvae for diet cup rearing should be coded as a beating sample and numbered consecutively for each plot collection.

B.3. FOLIAGE SAMPLES

To determine the distribution of virus on foliage, over time, two branch samples (45 cm tips) will be collected from each of the upper, middle and lower crown levels of five sample trees in the High DFTM density aerial spray plot. Samples will be collected weekly until 75 percent pupation is found in the plots. Place each branch in a separate small plastic bag. Each bag should be identified with respect to Plot number, tree number, crown level, branch number, collection date and post-spray week number. All branches will be shipped each week to the Forest Pest Management Institute, Saulte Ste. Marie, Ontario for a bioassay analysis of NPV on foliage at different crown levels.

At the first sign of an epizootic in the plots and at 75 percent pupation all plots will be sampled as described above.

To determine the distribution of virus on foliage before and after a DFTM generation foliage samples will be collected from

each of the four aerial spray plots during the pre-spray, last larval sample, as well as at the first sign of epizootic (ie. 3 times). Two branches (45 cm tips) are to be cut from the upper, middle and lower crown level of each of 5 trees from each plot. Place each branch in a separate plastic bag and tag the branch with the following information: Plot number, branch number (1 or 2), crown section, collection date and sample week number. All branches will be shipped to Saulte Ste. Marie, Ontario for bioassay.

To determine the carry over of virus on foliage in the Kamloops area, five trees will be sampled in each of four plots. Two midcrown, 45 cm tip branches will be cut from each tree. The samples will be taken only once, before NPV application in the Hedley area.

B.4. DEFOLIATION ESTIMATION

The same two 45 cm tip branches cut from the midcrown of each sample tree in each plot, for population estimates should be bagged, tagged and scaled. All bagged branches from one plot should be placed in a larger plastic bag. This larger bag should be tagged indicating, plot number, collection date and sample week. Foliage should be collected on a weekly basis, brought into the field lab and stored in a cool place (ie. refrigerator truck) until careful analysis can be done.

Each branch is analysed as described below with all data being recorded on data form 4 or 5 (Appendix B). From each branch the terminal plus 4 lateral (every 2nd. shoot down the "bushiest" side of the branch) shoots, are selected and cut off. Each shoot should include the 1979, 1980 and 1981 growth in the pre-spray sample. Post spray samples should include 1980 and 1981 growth only.

When determining the % of needles remaining, damaged needles will be treated as completely lost. The percent needles remaining on an internode will be estimated to the nearest 20%

by using the following:

0, 1-19, 20-39, 40-59, 60-79, 80-99, 100 will be expressed as 1, 10, 30, 50, 70, 90 and 100% respectively.

B.5. EGG MASS DISTRIBUTION

The purpose of this study is to determine the egg mass distribution over the tree as a requisite to the development of a low density level egg-sampling system.

Pick fully branched climable trees in plots where larval density measurements are being taken but do not use sample trees. Use 3 plots: high, medium and low, eight trees per plot.

Cut four branches from the upper, middle, and lower-crown levels as well the four lowest branches. Branches are selected from each cardinal direction. Cut each branch in two: outer 45 cm and the rest. Measure length and average width of foliated portion and number of egg masses and number of cocoons for each branch section. This can be done at any time when slack time is available.

B.6. EGG PARASITISM

The purpose of this study is to determine the species of parasites, the amount of egg parasitism and the distribution of egg parasitism over the tree. The egg masses and cocoons used in this study will be obtained during the egg mass distribution work (section B.5) Cocoons and egg masses from each branch will be handled in the following manner:

Place cocoons from 45 cm tip, egg masses from 45 cm tip, cocoons from rest of branch, egg masses from rest of branch, into separate large petri dishes. Seal the edge of each dish with masking tape to prevent escape of the emerging parasites. Label each dish with the branch section (45 cm tip or rest), the crown level, Plot number, tree number and date of collection.

Keep these dishes on rearing shelves. Check the dishes at two-

to-three day intervals and remove emerged parasites using fine forceps, a wetted camels hair brush or toothpick. To slow down the parasites movement the petri dish can be placed on a frozen 'liquid-ice' pack. Place parasites collected from each petri dish in a separate vial containing 70 percent ethanol. Code the vial to correspond to the petri dish. Check egg masses and cocoons, removing parasites and recording their emergence, for 60 days. When emergence becomes sporadic, check only once a week. Record emergence on Data Form One (see Appendix C).

B.7. DOUGLAS FIR TUSSOCK MOTH EGG MASSES

This scheme was modified in that "Stop" totals were ignored. Fifty trees were examined regardless of the total number of egg masses observed after 10 tree intervals.

B.8. SOIL SAMPLING

Collect soil or samples from underneath the crown of 5 sample trees in each of a high, moderate and low density DFTM, NPV aerial treated plot and in a control plot of moderate DFTM density.

(1) Amount of NPV in soil before NPV treatments and after a generation of DFTM has developed in an aerial sprayed area.

Pre-spray sample:

Four soil core samples will be taken per tree, one per cardinal direction, 50 cm from the crown edge, under 5 sample trees in each of the plots. Each soil sample should be wrapped in tin foil. All samples should be coded with respect to that number, tree number, sample direction, sample distance (if needed) and collection date.

Post-spray (at 75% pupation)

Four samples will be taken, in each cardinal direction at the following distances from the trunks of 5 sample trees:

- (1) at the trunk of the tree
- (2) at 50% of the crown radius
- (3) at 50 cm inside the crown edge
- (4) at 130 cm from the crown radius

(2) Changes over time in the incidence and concentration of NPV in the soil in a high density Tussock Moth area which has been aerally treated.

- The pre-spray and post-spray samples taken in the plot with a high DFTM population described above will be used here.

(3) Incidence of virus in soil from 2 areas treated with virus in 1975 (near Kamloops).

- One sample, 50 cm within the crown edge will be taken in the four cardinal directions under each of 5 sample trees in the four plots.

B.9. SAND TRAPS

Plastic containers, approximately 10 cm in diameter are filled with washed sand to a depth of approximately 4 cm. These traps are to be placed 50 cm within the Crown edge of 5 pre-selected trees in each of 4 aerial spray plots (1 high, 1 moderate, 1 low, and a check with a moderate DFTM population density).

To determine the amount of virus falling onto the ground before and after the NPV treatment, in each of the four plots, the following sample scheme will be used.

Pre-spray: 1 trap x 1 direction x 5 trees x 4 plots = 20 traps.

Post-spray: 1 trap x 4 directions x 5 trees x 4 plots = 80 traps (after 75% pupation).

To determine the change in virus over time in a high density DFTM aerally sprayed plot samples will be taken on a weekly basis. Traps are placed 50 cm within the crown edge.

Pre-spray: use the same trap as in the 'before and after' NPV treatment scheme.

Post-spray: 1 trap x 4 directions x 5 trees x 1 plot = 20 traps

per week until 75% pupation is reached in the field.

B.10. EXTENSIVE PHEROMONE TRAPPING

Use pheromone traps with three concentration system (5 traps/conc.) in all plots with larval density measurements. Use high concentration pheromone traps in surrounding non-treated stands to monitor low population levels to see if they also collapse after virus introduction. Probably all suitable stands between Princeton and Keremeos will be sampled.

Traps should be placed on the lower branches of host trees at about eye level, traps should be at least 30 m apart. Where three concentrations are used the traps are randomly mixed in a 3 x 5 pattern. Where one concentration is used they can be set out in a line or loop.

Pheromone - trap seeding of Virus

Test 1. Visitation rate of males.

In an area of abundant DFTM males, preferably with larval population measurements, set out a 10 x 5 grid with points at least 30 M apart. Use two types of traps: "marking" and "catching". These are placed out alternately. Marker traps have a fluorescent dye powder and a freeze-dried DFTM female plus .01% lure. Catching traps are changed daily and marker traps are also changed daily with a different color dye used each of four nights. After four nights, the catching traps are replaced DFTM cocoons plus a lure. The cocoons are left out for 5 nights and then collected. Catching traps and cocoons are checked with an ultraviolet light for presence of dye.

Test 2. Sample native population of egg masses to determine incidence of virus. "Marker" traps are set up with dye and virus and "catching" traps are replaced with female cocoons. After ten days cocoons are checked for presence of female and dye. At the end of the moth flight season 1/2 of the egg masses

are recovered, overwintered in lab and bioassayed for incidence of virus. The following spring the other half of the egg masses are recovered and incidence of virus determined. If an isolated virus-free population is found, this study could be undertaken there using native females.

PRELIMINARY SEQUENTIAL SURVEY SYSTEM FOR

D. FIR TUSSOCK MOTH EGG MASSES

R.F. Shepherd, I.S. Otvos and R. Chorney

Introduction

The proposed system based on 1981 data, of only 14 plots, is designed to determine for each plot the mean number of egg masses on the lower three branches per tree (within 33% of the true mean).

Methods

Select non-defoliated stands. Walk 100 metres into the stand from the stand periphery; follow the lower contour across the stand and return along a line approximately 100 m parallel. Continue in this manner until the stand has been covered or until the infestation has been delineated.

Mark the point where the highest density of egg masses has been observed, then locate and mark the centre of the infestation.

Select ten sample trees with three "average size branches" near to ground level to observe and record the number of egg masses per branch (i.e. for each branch individually). Select sample trees near the centre of the infestation, working progressively outward from that point.

Total the number of egg masses for the ten sample trees, and if the sample total:

- a) exceeds the "Stop" total on the form, terminate the sampling,
- b) is less than or equal to "Stop" total, sample an additional ten trees,
- c) continue sampling until a "Stop" total is exceeded, or
- d) a total of 50 trees are sampled.

Calculate the average egg mass density for each plot by dividing the total number of egg masses found by the total number of trees sampled, as outlined on the form.

If more than one infestation centre is found determine the egg mass density independently for each centre.

Record the location and sketch the stand on the reverse side of the form. Record the centre and extents of the infestation.

Preliminary Sequential Survey System for
D. Fir Tussock Moth Egg Masses
R.F. Shepherd, I.S. Otvos and R. Chorney

Conclusion

The main purpose of the system is to detect pre-outbreak populations and the sampling system is no longer valid in defoliated stands. The system is designed to determine the number of egg masses at the point of highest density, not the average density in the infested stand. There is currently insufficient data to establish a good relationship between the egg mass density and expected defoliation, however, the following guidelines are presented which should be used with caution.

1. Below (less than) 0.10 average egg mass density per tree per plot, the population is considered endemic.
2. Between 0.10 and 0.75 average egg mass density per tree per plot indicates a pre-outbreak condition (status), i.e. the population density in at least one year away from outbreak levels, and no noticeable defoliation will result from those egg masses.
3. At 0.75 average egg mass density per tree, per plot 20% defoliation would be expected, i.e. most of the current growth in the upper crown would be lost and complete stripping of the old foliage would begin. Beyond 20% defoliation significant effects on growth would be expected to occur.

To supplement existing data and strengthen the statistical base copies of completed field data, forms are to be returned to:

Canadian Forestry Service,
Pacific Forest Research Centre,
506 West Burnside Road,
Victoria, B.C. V8Z 1M5

Attention: Drs. R.F. Shepherd and I. Otvos

D-FIR Tussock Mtn Sequ. TAL Egg Mass Sample

Plot location

Observer

1

[illegible]

Total Number Egg Masses

Total Number Eggs	M
Total	- Trees

_____ Average number egg masses per tree

2011-12-11

APPENDIX C
DFTM DATA COLLECTION FORMS

<u>Form</u>	<u>Description</u>
1	Egg Mass Rearing
2	Egg Mass Distribution
3	Larval Population Estimates
4	Defoliation Estimates (Pre-Spray)
5	Defoliation Estimates (Post-Spray)

Egg Mass Rearing

[illegible]

DEFOLIATION ESTIMATES, MID CROWN

Crew Names _____ Date of Sample _____

APPENDIX D

INSECT DENSITY PROGRAM

For HP-55 Handcalculator

HP-55 Program Form

Title Determine number of lanes, run time, mean and standard deviation Page 1 of 1
 Press **EST** in RUN mode, switch to PRGM mode. Then key in the program. number of lanes per 100 blocks

DISPLAY		KEY ENTRY	X	Y	Z	T	COMMENTS	REGISTERS
LINE	CODE							
00.								R0 <u>V</u>
01.	<u>Δ1</u>	<u>ENTER</u>						
02.	<u>24</u>	<u>R/S</u>						R1 <u>24</u>
03.	<u>1</u>	<u>+</u>						
04.	<u>01</u>	<u>1</u>						
05.	<u>00</u>	<u>0</u>						R2 <u>57²</u>
06.	<u>00</u>	<u>0</u>						
07.	<u>71</u>	<u>X</u>						R3 <u>7</u>
08.	<u>11</u>	<u>5+</u>						
09.								
10.								R4
11.								
12.								
13.								R5
14.								
15.								R6
16.								
17.								R7
18.								
19.	<u>Switched back to run mode Push EST</u>							R8
20.	<u>Run ahead overleaf, go to line 35</u>							
21.								R9
22.	<u>Push in # lanes of branch #1, Push R/S</u>							
23.	<u>Push in # lanes of branch #1, Push R/S</u>							
24.	<u>Push in # lanes of branch #2, Push R/S</u>							R0
25.	<u>Push in # lanes of branch #2, Push R/S</u>							
26.								
27.								R1
28.	<u>Push in # lanes of branch 30, Push R/S</u>							
29.	<u>Push in # lanes of branch 30, Push R/S</u>							
30.	<u>Read display: record N</u>							R2
31.	<u>Push R/L: 1 record 24</u>							
32.	<u>Push R/L: 2 record 24²</u>							R3
33.	<u>Push R/L: 3 record 36</u>							
34.	<u>Push 0 S record 8</u>							R4
35.	<u>Push 1</u>							
36.	<u>CLX</u>							R5
37.	<u>0</u>							
38.	<u>CLX</u>							R6
39.	<u>EST</u>							
40.	<u>Start new slot (line 22)</u>							R7
41.	<u>Note: If calculator is turned off, program</u>							
42.	<u>must be re-entered (line 01)</u>							R8
43.								
44.								
45.								R9
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48.								
49.								

HP-55 User Instructions

Title _____ Page _____ of _____

Programmer _____

[illegible]

APPENDIX E
COST ANALYSIS OF DFTM HEDLEY PROJECT

Costs:BRITISH COLUMBIA MINISTRY OF FORESTS

Wages (13 individuals)	\$ 83,245.54
Travel Expenses	2,671.93
Postal and Courier Services	241.41
Advertising, Public Relations	103.92
Hall Rental - Information Day	25.00
Operating and Maintenance	
Materials - General Supplies	536.75
 Motor Vehicles - Rental	
4 units (average cost \$1259.28 (month)	7,261.44
Motive fuels, Lubricants	3,462.00
Repair and Maintenance Parts and Supplies	
- Operative Equipment	65.87
Scientific - engineering Supplies and Expendable Equipment	125.22
Tools and minor expendable equipment	136.37
Films and Processing	63.81
Helicopter Rental	
NPV application - B and W Agricultural Services (Bell 206B) 16.6 hr. hel. time)	
Aerial photography - Okanagan (Bell 206B) 2.6 hr. hel. time)	11,938.40

TOTAL EXPENDITURE BCMF

109,977.66-

Costs: CANADIAN FORESTRY SERVICE

Forest Pest Management Institute
Sault Ste.-Marie, Ontario

John Cunningham
and John MacPhee

Travel expenses (return trip) 2,805.33 *

Viral Production (estimated)
(based on U.S. dollars in 1980)

\$19.00 (CND)/acre
(\$7.68 (CND)/hectare) x 19.9 hectares 152.83

Pacific Forest Research Centre
Victoria, B. C.

Supplies, artificial diet,
travelling expenses, petri dishes,
microscope slides, etc.

8,860.00 *

TOTAL EXPENDITURE TODATE 11,818.16

* These figures exclude salaries

APPENDIX F

- F. 1. Application for Research permit.
- F. 2. Application for Pesticide use Permit.
- F. 3. Conditions for Pesticide Use.



Agriculture
Canada

Pesticides Section
Plant Products and
Quarantine Division

Section des pesticides
Division des produits végétaux
et de la quarantaine des plantes

APPLICATION FOR RESEARCH
PERMIT

Under the Pest Control Products Act

DEMANDE DE PERMIS DE
RECHERCHE

Aux termes de la loi sur les produits antiparasitaires

Research Permit No. - Permis de recherche N°.

Date Received
Date de réception

Submission No.
N° de la demande

1. Brand name or experimental No. - Marque de commerce ou N° d'essai du produit N/A		2. Formulation type - Nature du produit INSECTICIDE		Registration No. - N° d'enregistrement N/A	
3. CSA common name, Chemical name and percent for each active ingredient - Nom usuel (ACNOR), formule chimique et pourcentage de chaque ingrédient actif. NUCLEOPOLYHEDROSIS VIRUS. A naturally occurring virus obtained from Tussock Moth cadavers.					
4. Name of applicant - Nom de demandeur MINISTRY OF FORESTS			5. Name of research coordinator - Nom du co-ordonnateur de la recherche R. D. EDWARD		
Address - Adresse 515 Columbia Street, Kamloops, B. C. V2C 2T7			Address - Adresse 515 Columbia Street, Kamloops, B. C. V2C 2T7		
Tel. No. - N° de tél. 374-7741			Tel. No. - N° de tél. 374-7741		
6. Signature of applicant - Signature du demandeur <i>R. D. Edward</i>				7. Date of application - Date de la demande Jan 26/81	
8(a). Host, Crop or site of application - Hôte, récolte ou région de l'application Douglas Fir Trees Pseudotsuga Menziesii			8(d). Timing and number of repeat applications - Intervalle et nombre d'applications One application in late May - early June by aerial and ground spray.		
8(b). Pest - Agent nuisible Douglas Fir Tussock Moth Orgyia Pseudotsugata					
8(c). Rate - Taux 250 billion viral inclusion bodies per ha.			8(e). Additional directions - Directives supplémentaires Aerial application by helicopter. Ground application by individual tree appli- cation.		
9. Preharvest interval - Intervalle de sécurité N/A			10. Purpose - But Residue ☐ Efficacy ☒ Environment ☐ Résidu Efficacité Écologie		
11. Location and area of test plots - Région et emboisement des parcelles d'essai HEDLEY, B. C. Total 45 ha in 8 separate stands. Test plot location: All plots are located more than 100 metres from water source. Trial control of the Douglas Fir Tussock Moth infestation in the insipient stage with a biological agent.					
12. Comments (Reserved for use by Federal Government Officials) - Commentaires (Réservé à l'usage des Agents du gouvernement)					

Pursuant to the application and attachments and subject to amendments (if any) made therein, authorization is granted to proceed with research involving the specified pest control product.

Sur la foi des renseignements contenus dans la formule et les documents en annexe et sous réserve, (s'il y a lieu) des modifications qui leur sont apportées, le demandeur est autorisé à entreprendre la recherche sur le produit antiparasitaire susmentionné.

THIS AUTHORIZATION OF RESEARCH
IS FOR THE YEAR ENDING:
LA PRÉSENTE AUTORISATION
PREND FIN LE:

31 DEC. 19

Reviewing Officer - Agent de révision

Date



Province of
British Columbia

Ministry of
the Environment

Pesticide Control Branch
Box 1172 Station 'A'
Surrey
British Columbia
V3S 4P9
Telephone: 575-2911

APPLICATION FOR A PESTICIDE USE PERMIT

Seven copies of proposed project (including seven maps showing treatment areas) are required. Seven copies of the proposal must be provided to the Pesticide Control Branch, British Columbia Ministry of the Environment, Box 1172, Station A, Surrey, B.C. V3S 4P9, at least six weeks prior to treatment date. We will forward one copy to Environment Canada for their review.

Proposed treatment: Herbicide ☐ Insecticide ☒

Other pesticide (specify) _____

Name of applicant Ministry of Forests

Address 515 Columbia Street, Kamloops, B. C. V2C 2T7

Name of contractor (if applicable) N/A

Address _____

Project location: (a) general (i.e., nearest town) Hedley, B. C.

(b) specific As per attached map

Purpose of project Operational trial to control the Douglas Fir Tussock Moth -

Orgyia Pseudotsugata

Total area of project _____ Estimated area actually receiving treatment 41.3 ha

Trade name of pesticide N/A

Pest Control Products Act
registration No. N/A

Active ingredient Nucleopolyhedrosis Virus. A naturally occurring virus obtained from
Tussock Moth cadavers.

Rate of application (express in pounds of active ingredient per acre or hectare or rate of active ingredient:
diluent for spot treatments) 250 Billion viral inclusion bodies per ha.

Total chemical used on project (express in pounds of active ingredient) _____

Carrier or diluent Water Method of application Aerial and ground.

Approximate dates of application (state as close as possible expected time of application) _____

Late May - Early June.

Target species (briefly list target species and stage of development) Douglas Fir Tussock Moth,

Orgyia Pseudotsugata. Early larval stage.

Are lakes, rivers, streams, or other waterbodies involved? Yes ☐ No ☒

All treated plots will be more than 100 metres from any water bodies.

If "yes," are they used for municipal _____ or other domestic water supply _____?

Maps attached? Yes ☒ No ☐

The above project will be conducted under the supervision of (name and title) _____

Whose telephone number is _____ Pesticide Applicator Certificate

(number and category) _____

Date _____ Signed (name) _____

Title _____

(See reverse for "Basic Requirements of B.C. Government Ministries to Satisfy Statutes and
Safe Use of Pesticides")



Province of
British Columbia

Ministry of
Environment

Pesticide Control Branch
310 Blanshard Street
Victoria
British Columbia
V8W 3E1
Phone: 387-1181

April 30, 1981

Permit No. 104-183*RES-81

Your File: 890-6-3

The Minister of Forests,
515 Columbia Street,
Kamloops, British Columbia
V2C 2T7

Attention: Mr. P. Hall, Forest Entomologist

Dear Sir:

Pesticide Control Act Forestry Research
Pesticide Use Permit for Trial Use of
Nuclear Polyhedrosis Virus for Control
of Douglas Fir Tussock Moth, Hedley
area, (41.3 hectares)

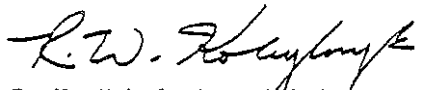
The Pesticide Control Branch, in consultation with the British Columbia Pesticide Control Committee, has completed its review of the above trial as detailed in your application received on February 9, 1981, and authorization is hereby provided for the trial to be carried out subject to the following conditions:

1. That all insecticide use be carried out by or under the direct supervision of an individual with a valid British Columbia pesticide applicator certificate in the forestry category.
2. That the contracting firm hired to conduct the project possess a current British Columbia Pest Control Service Licence, and that this office be notified in writing of the name and licence number of the contractor prior to any pesticide application.
3. That the helicopter pilot responsible for the application of the pesticide possess valid British Columbia pesticide applicator certification in the forestry category, and that this office be notified in writing of the name and certificate number of the pilot prior to any pesticide application.
4. That appropriate authorization for insecticide use be obtained from private landholders involved.
5. That the insecticide be applied by both ground based and aerial methods.

6. That a 10 metre pesticide-free zone be maintained along all waterbodies and wetland areas, and that the pilot be instructed to maintain whatever size buffer zone topography and climatic conditions necessitate to ensure this 10 metre pesticide-free zone is achieved. A minimum buffer zone of 100 metres is suggested.
7. That the pilot conduct a thorough pre-treatment aerial inspection of the treatment site in the company of a Ministry of Forests employee to ensure the pilot's familiarity with the target area.
8. That the effective date of this permit is May 13, 1981, and that the pesticide use be carried out between May 28, 1981, and June 30, 1981.
9. That the public be advised of the purpose and scope of the trial and of the issuance of this experimental permit by means of a notice published in one or more newspapers with circulation at Hedley by May 13, 1981.
10. That a copy of this permit and maps of the treatment areas be posted continuously in a public access area of the Ministry of Forest's District office between May 13, 1981, and June 30, 1981.
11. That the Pesticide Control Branch in Kelowna (860-7393) be given at least five (5) days advance notification prior to the commencement of the project, to arrange on-site inspections.
12. That the preceding conditions be communicated to all personnel involved in the project.
13. That this office be provided with a copy of the trial report.

Any person wishing to appeal the issuance of this permit, or any conditions contained herein, must provide this office with written notice of appeal by May 28, 1981.

Yours truly,


R. W. Kobylnyk, Administrator
Pesticide Control Act

DEC/lc

cc: BCPOC
S. M. Craig

References

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