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ASSESSMENT OF EARLY MULTIPLE APPLICATIONS OF PESTICIDES ON HIGH POPULATIONS OF SPRUCE BUDWORM LARVAE, CHORISTONEURA FUMIFERANA (CLEM.) QUEBEC, 1977

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ABSTRACT

A large-scale operational field trial utilizing three applications of chemical insecticides and covering 120,960 hectares (298,900 acres) was conducted in 1977 to prevent severe defoliation of balsam fir (*Abies balsamea* [L.] Mill.), red spruce (*Picea rubens* Sarg.) and black spruce (*Picea mariana* [Mill.]) in the Gaspé region of Québec. Egg mass surveys in 1976 indicated unprecedented levels (2800+ egg masses/10 sq. meters of foliage), thus posing the problem of forest resources protection under abnormal conditions of pest populations. Two treatments of oil-formulated fenitrothion were applied at 0.28 kg AI/ha (4 oz AI/ac) to reduce second- and early third-instar stages of the spruce budworm. A third application of oil-formulated aminocarb was applied at 0.07 kg AI/ha (1 oz AI/ac) when the larval population had reached 25% fourth instar. All formulations were applied at 0.84 ℓ/ha (11.52 fluid oz (U.S.)/ac) using Douglas DC-6B spray aircraft, incremental application technology and inertial guidance swath navigation.

Results of the cumulative effects of two early treatments of fenitrothion spray against the second- and early third-instar budworm larvae indicated an average larval population reduction of 70% in *Abies balsamea* and 84% in *Picea mariana* and *Picea rubens*. Assessment of the third aminocarb spray, applied when 25% of the remaining budworm population had reached the fourth instar stage of development, indicated an average population reduction of 32-33% on balsam fir and 0% on spruce host trees, with an average total population reduction of less than 10%.

Assessment of dosage/population reduction data on an individual tree basis within spray volume deposit categories indicated that spray coverage (drops/cm^2) was far more important than volume deposits (ℓ/ha) in reducing larval population of budworm within the tree canopy.

The most consistent feature of uni-directional spray drift from multiple spray applications was the underdosing of the downwind side of the sample trees with resultant low larval reduction and subsequent high defoliation.

Data on the effects of extremely light deposits of multiple fenitrothion sprays indicated that sublethal doses of small aerosol droplets appeared to exert a knockdown or irritant effect on the second- and early third-instar larvae. The overall effect appeared as a reduction in larval population numbers within the tree crown.

Average current defoliation within the sprayed area was 50% as compared to 100% in the non-spray check area. Defoliation on individual trees varied from 0% to 100% with the highest degree of defoliation occurring on trees located on south-facing slopes, i.e. downwind side of sample trees.

RÉSUMÉ

En 1977, en Gaspésie, 120,960 ha (298,900 acres) ont reçu trois applications expérimentales d'insecticides afin d'éviter la défoliation du sapin baumier (*Abies balsamea* [L.] Mill.), de l'épinette rouge (*Picea rubens* Sarg.) et de l'épinette noire (*Picea mariana* [Mill.]). L'année précédente, les masses d'oeufs avaient atteint un chiffre sans précédent (plus de 2800 sur 10 m^2 de feuillage), ce qui laissait entrevoir des difficultés de protéger la forêt contre des infestations anormales. Deux préparations huileuses de fénitrothion ont été appliquées à raison de 0,28 kg IA/ha (4 onces IA/acre) contre les larves du deuxième stade et du début du troisième stade de la tordeuse des bourgeons de l'épinette. Une troisième préparation huileuse d'aminocarbe a été appliquée à la dose de 0,07 kg IA/ha (1 once IA/acre) lorsque le quart des larves était au quatrième stade. Toutes les préparations ont été appliquées à raison de 0,84 ℓ/ha (11,52 onces liquides U.S./acre) au moyen de Douglas DC-6B, par les techniques d'application de doses croissantes et de navigation par inertie.

Les effets cumulatifs des deux premiers traitements ont été une réduction moyenne de 70 % de la population larvaire sur *A. balsamea* et de 84 % sur *P. mariana* et *P. rubens*. L'aminocarbe a globalement réduit les populations résiduelles de moins de 10 % (de 32 à 33 % sur *Abies* et de 0 % sur les *Picea*).

D'après le rapport dose/taux de réduction des populations, par arbre et par intervalle de volume d'épandage, le nombre de gouttes au centimètre carré est un facteur beaucoup plus important de réduction des populations du couvert forestier que le volume (litres) par hectare.

La dérive unidirectionnelle du nuage pulvérisé en applications multiples a eu comme caractéristique la plus constante d'exposer le côté sous le vent des arbres à une dose moindre, ce qui s'est traduit par une faible réduction des populations larvaires et par conséquent une forte défoliation.

Les données sur les effets de dépots extrêment faibles de pulvérisations multiples de fénitrothion montrent que les doses sublétales des gouttelettes d'aérosol ont semblé exercer un effet de choc ou une irritation chez les larves du deuxième et des débuts du troisième stade. L'effet global a semblé être une réduction des populations dans les cimes.

La défoliation moyenne dans la zone traitée était de 50 %, comparativement à 100 % dans la zone témoin. Dans les arbres pris individuellement, elle variait entre 0 % et 100 %, étant maximale dans les arbres des versants faisant face au sud, c.-à-d. sous le vent d'autres arbres.

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INTRODUCTION

The history of spruce budworm, *Choristoneura fumiferana* (Clem.), outbreaks in eastern Canada has shown that severe infestations of this species over large areas of spruce and fir forest, if unchecked, eventually lead to the destruction of a major portion of that resource (Swaine 1924, Morris 1963, Prebble 1975). In the fall of 1976, egg mass counts taken from the Gaspé Region of Quebec indicated that unprecedented population levels of budworm larvae would be present the following spring to attack a forest that had survived two years of severe defoliation (Desaulniers 1977).

In view of the severity of the expected infestation (2800+ egg masses/10 m^2 of foliage) the Protection Service of the Department of Lands and Forests, Quebec, (Direction de la Conservation, Service d'Entomologie et de Pathologie) requested the Forest Pest Management Institute, Sault Ste. Marie, Ontario to assist in the selection of a suitable insecticide spray regime for the protection of high value stands in the Gaspé.

The severity of the budworm infestation indicated that extensive bud and hence foliage damage would occur before phenological conditions (i.e. flaring of the new shoot growth) were ideal for normal spray application against the fourth-, fifth- and early sixth-instar larvae. It was therefore recommended that maximum effort be made to prevent the establishment of second- and early third-instar larvae on developing current year's foliage. Studies undertaken during the late 1960's and early 1970's indicated that fenitrothion and aminocarb were highly effective against the second and early third instars of the budworm (Randall 1970). Furthermore, multiple applications at reduced dosages were more effective than single heavy dosages (Randall 1971, 1976).

A working committee composed of members from Quebec Dept. Lands and Forests, Environment Canada and Agriculture Canada suggested that a multiple-spray regime for spruce budworm control in the Gaspé region would require dosage rates above the levels currently registered for forest use (i.e. maximum seasonal application of 0.42 kg AI/ha fenitrothion [6.0 oz AI/acre] and/or 0.106 kg AI/ha aminocarb [1.5 oz AI/acre]). A final recommendation of <u>two</u> early successive applications of 0.28 kg of fenitrothion/ha (4 oz AI/ac) at a five-day interval (i.e. to strike the emerging second- and early third-instar larvae), to be followed by a third spray of aminocarb 0.088 kg AI/ha (1.25 oz AI/acre) applied when the larval population had reached 25% fourth instar was approved by a working group of the Federal Interdepartmental Committee on Pesticides under procedures set out in Trade Memorandum T-104, established under the Pest Control Products Act.

By agreement, the use of the above dosages was predicated on a system of complete monitoring studies to be carried out within the spray area. On the basis of the above recommendations, an area of 120,960 hectares (298,900 acres), designated as Block 305, was selected as the trial site. Spraying was to be carried out over rivers, lakes, streams and forest to provide research data on the environmental impact of early multiple sprays of high levels of fenitrothion on early-instar larvae of the spruce budworm and non-target organisms within the forest ecosystem (Kingsbury 1978).

This report is an in-depth study of the deposit and efficacy data collected in 1977-78, a preliminary analysis of which appeared in FPMI Information Report FPM-X-5 (Randall et al. 1977).

MATERIALS AND METHODS

Experimental Site and Block Design

An irregular area of 120,960 hectares (298,900 acres) in the interior of the Eastern Gaspé Region (where egg mass counts in excess of 2800 egg masses/10 m^2 of foliage were recorded) was selected as the experimental/operational area and designated as Block 305 (Fig. 1). The terrain within the block varied from rolling table lands in the central and southern areas to the extremely rough terrain of the Chic-Choc mountain range in the northwest corner of the block. The forest within this area was predominantly a young black spruce (*Picea mariana* [Mill.])/balsam fir (*Abies balsamea* [L.] Mill.) complex with 90-100% defoliation of the new growth. Within this complex, red spruce (*Picea rubens* Sarg.) hybrids were interspersed amongst the black spruce and balsam fir, particularly on hill-top sites.

Review of meteorological data within the Gaspé land mass indicated that morning and evening winds occurred predominantly from the northern or southern quadrants. Programmed flight lanes for the Douglas DC-6B spray aircraft were, therefore, established in an east/west direction to utilize the expected crosswind components for spray droplet dispersal. The most desirable biological transect lines for spray deposit retrieval and biological sampling were initially planned to follow a north/south road system to provide a transect of deposit recovery data at right angles to the proposed swath lanes across the block. This, however, was impossible, due to the abundance of snow on the north/south road system. Thus, the less desirable east/west interconnecting road from highway 299 to 198 via Murdochville in the northern third of the spray block was selected as the sampling line. The sampling line was divided into 13 zones or areas to provide sampling sites for the selection of sample trees and spray deposit recovery stations. These zones were designated alphabetically from east to west (Fig. 1) to provide a variety of swath-lane transects of spray deposits for dosage/efficacy studies on the early-instar stages of the spruce budworm.

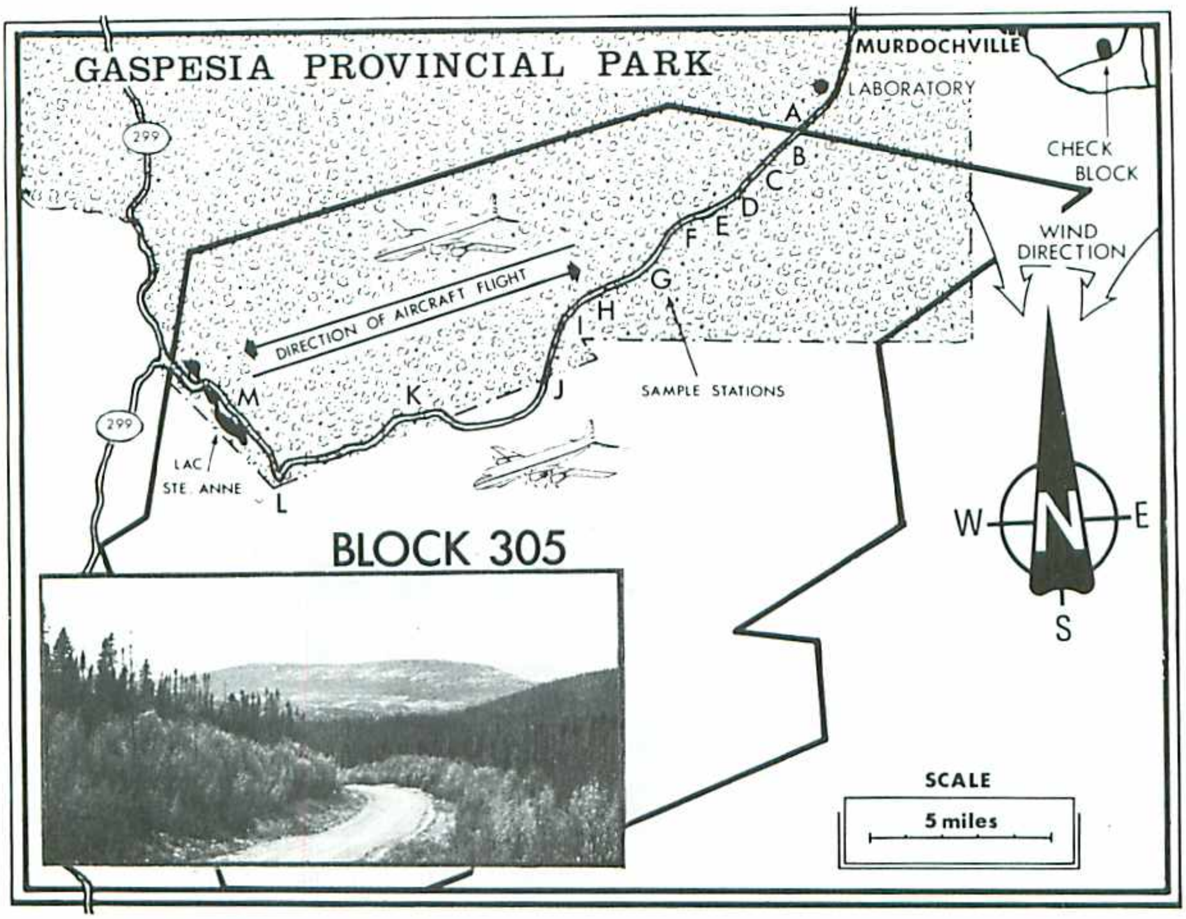

FIG. 1 Map of operational experimental area (Block 305) showing aircraft flight lanes, terrain characteristics (Chic Chock mountain range in western section), and tree sampling stations across the block.

Aircraft and Spray Equipment

Douglas DC-6B spray aircraft equipped with the Litton LTN-51 inertial guidance system, full-wing-span booms and open-orifice nozzles mounted above the wings (Fig. 2) were used throughout the program (Randall 1975). The spray system was updated to include a computerized flow unit to regulate the flow-rate of spray formulation through the nozzles according to air speed. This, theoretically, should provide a constant emission volume of pesticide/acre by increasing the flow rate with increasing air speed and decreasing the flow rate at lower air speeds. The effect of this modification on droplet spectrum characteristics, however, was unknown, since there was insufficient time to undertake low- and high-speed calibration trials before the commencement of the spray operation.

Each aircraft carried a total of 12,113.0 liters (3200 gal U.S.) of spray formulation per sortie. Rate of flow was calibrated at 476.95 ℓ/minute (126 gal [U.S.]/minute) at 200 knots airspeed using 110 open Spraying Systems nozzles (3/16-inch orifice) set at a contact angle

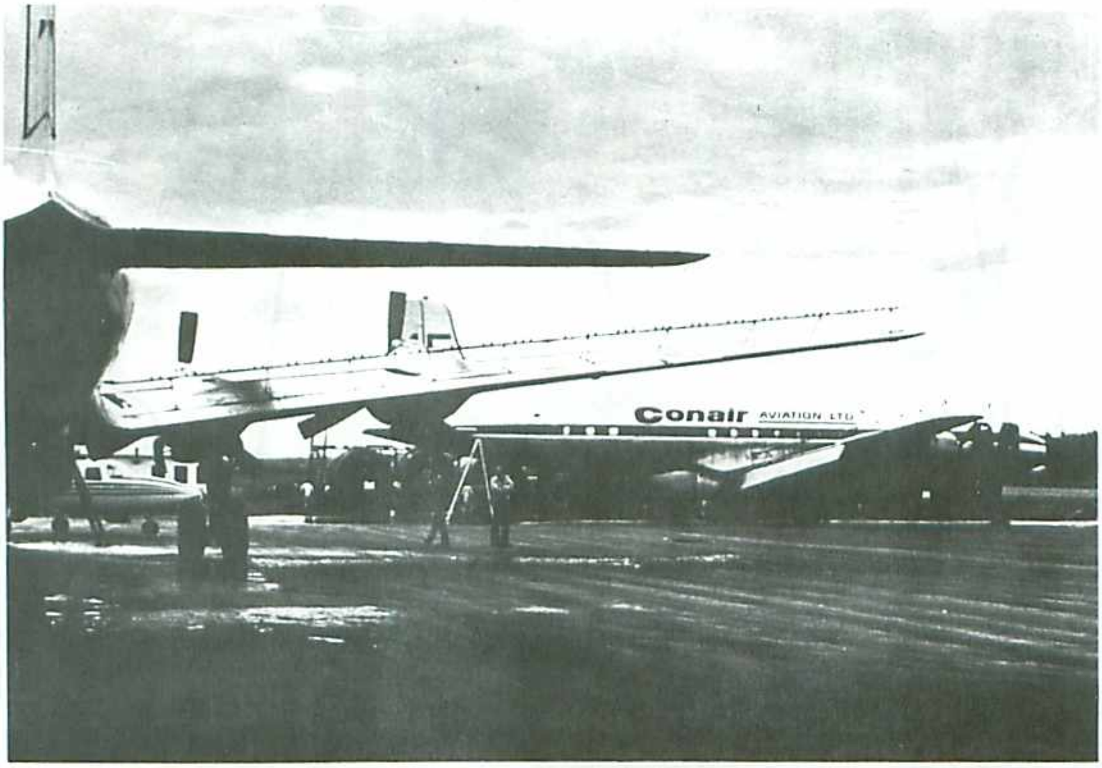

FIG. 2 Douglas DC-6B spray aircraft equipped with full-span, above-the-wing booms and open nozzle system.

of 7° to the airflow across the nozzle opening. Swath lane intervals of 914 meters (3000 ft) were used throughout the block with spray emission height established by line-of-sight clearance of hill tops at a minimum altitude of 30 m (100 feet). Spray emission height, therefore, could vary from 30 m to 350 m (100 to 1200 feet) above the forest canopy according to terrain characteristics (Fig. 3) in order to maintain a constant air speed for the production of a uniform spray droplet spectrum throughout the spray area.

Spray Formulation

Spray formulations and the physical characteristics of each are presented in Table 1.

All formulations were applied at a spray emission rate of 0.842 ℓ/ha (11.52 fluid U.S. oz/acre).

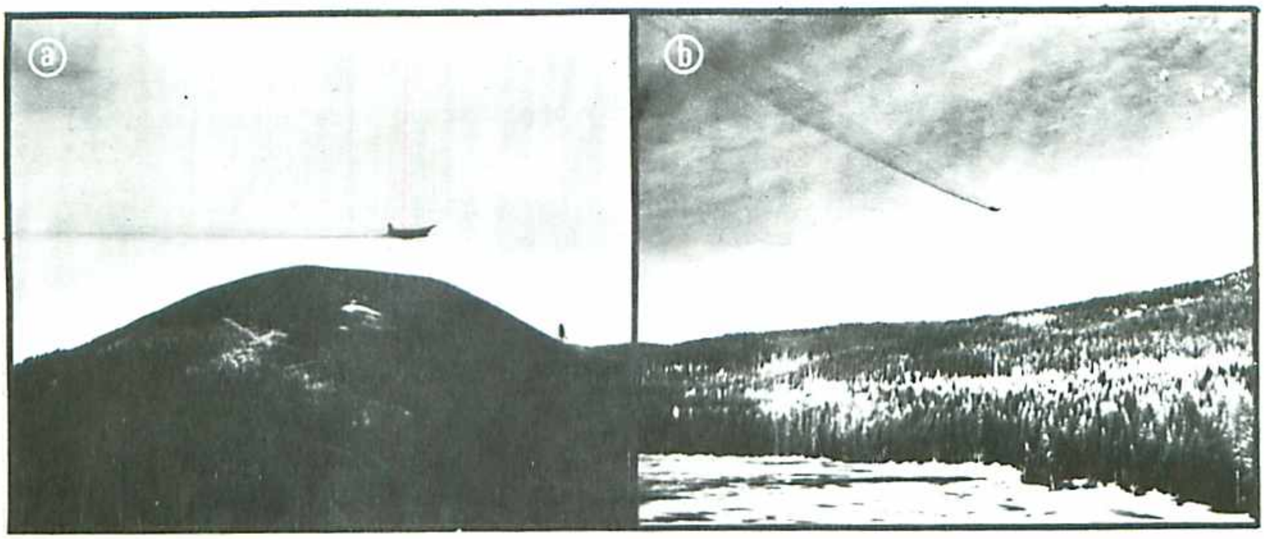

FIG. 3 Spray emission height relative to terrain characteristics (a) above hilltops, (b) above valley floor (note forest conditions 20/5/77).

Table 1
Physical and chemical composition of the fenitrothion and aminocarb formulations

Spray Application	Formulation Composition %		Density (g/ml) 25°C	Viscosity* 25°C
1st and 2nd applications	Fenitrothion	26.27	1.323	32.8
	Arotex 3470	30.93	0.926	1.9
	No. 2 Fuel Oil	13.40	0.848	2.7
	No. 4 Fuel Oil	29.40	0.926	33.0
(May 20/77) (May 29/77)	Total	100.00	1.021	7.8
3rd application (June 16/77)	Aminocarb** (Matacil®)	49.60	0.933	82.0
	No. 2 Fuel Oil	26.20	0.848	2.7
	No. 4 Fuel Oil	24.20	0.926	33.0
	Total	100.0	0.902	14.5

*Saybolt using Ostwald Fensky viscosimeters.
**Aminocarb concentrate solution formulated with nonylphenol solvent, thus accounting for the relatively high viscosity reading.

Spray Meteorology

Meteorological limits for spray application were established as follows:

(a) Wind- speed: ground 0 to 9 km/hr (0-6 mph)
aloft 1.6 to 20 km/hr (1 to 12 mph) with minimal turbulence
- direction: within 45° of crosswind to flight lanes

(b) Temperature: preferably constant with minimal rate of change, (below 0°C acceptable)

(c) Spray emission height: pilot responsible for safe flight path with minimal clearance above hill tops at 30 m (100 feet)

(d) Humidity: not critical when using oil formulations, no spraying when foliage wet.

Selection of spray limits, within the established meteorological parameters, was undertaken by the Aerial Service Team (Quebec Department of Transport), Conair Aviation, and the Quebec Department of Lands and Forests to ensure acceptable spray deposition and use of available spraying weather.

Spray Regime and Timing of Applications

Due to the severity of the infestation and the high probability of extensive bud damage, the committee recommended that maximum efforts be made to prevent a high proportion of larvae from becoming established in the developing buds. The proposed recommendations, therefore, suggested two early treatments each of 0.28 kg AI/ha fenitrothion (4 oz AI/acre) in an oil-based formulation to be applied as follows:

1. The first application at 20% emergence of the second-instar larvae;

2. The second application to occur 5 days later, weather permitting.

A third application of 0.08 kg AI/ha aminocarb (1.25 oz/acre) was recommended to be applied when 25% of the budworm population had reached the fourth-instar stage of development. This was eventually reduced to 0.07 kg AI/ha (1.00 oz AI/acre).

Furthermore, it was recommended that budworm populations be carefully monitored for evidence of acceptable control in the second-instar stage, such that subsequent aminocarb treatment could be reduced or deleted from the program.

Monitoring and Assessment of Spray Deposits

Samples of the deposited sprays were taken at fixed locations across the spray block to ensure reliability of deposit data for the determination of cumulative volume and drop/cm^2 counts. A sampling station consisted of a fixed 30 cm metal stake in the ground with attached metal platform for holding the sampling unit. Each station was located in close proximity to a sample tree and consisted of an open area 6 meters or greater in diameter to allow unobstructed fall of spray droplets onto the sampling units (Fig. 4).

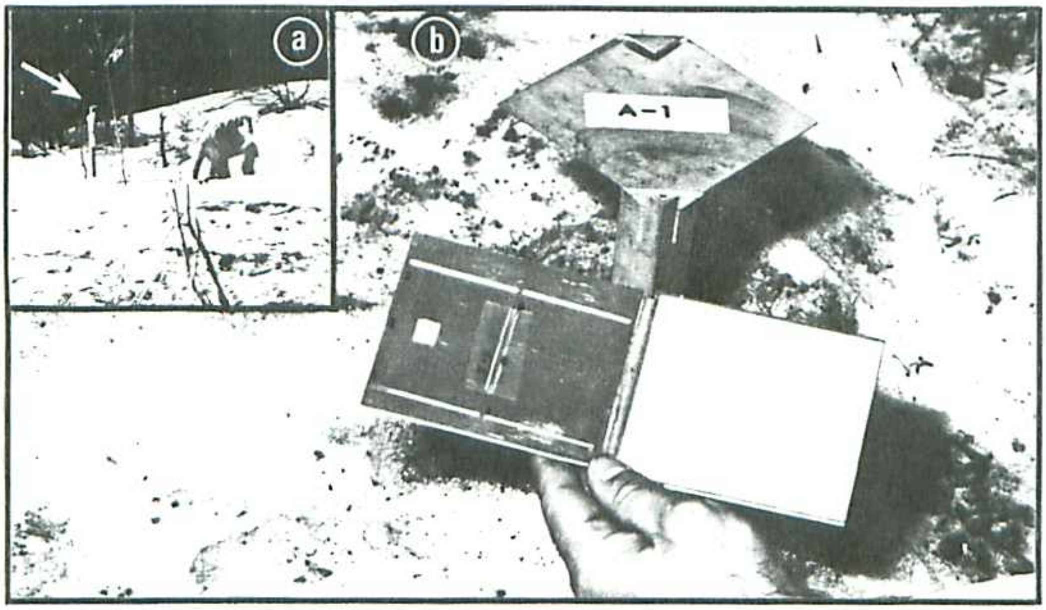

FIG. 4 (a) Typical sampling station for spray deposit retrieval (20/5/77) and (b) close-up of horizontal platform and sample unit.

The sampling unit (Randall 1980) consisted of a 100-cm^2 (4" x 4") Kromekote card and two 50 x 75-mm hinged glass slides. These were fastened to two 10.5 x 10.5 cm x 0.83-mm (22 gauge AMS) aluminum plate, hinged together to form a sampling unit that could be opened and closed like a book. These units were clipped on to the metal platforms in the open book configuration. After spray deposition, both the glass slides and the unit were closed to form a compact 100-cm^2 unit for the protection and storage of spray deposit data.

The glass slides were subjected to colorimetric assessment of the dye fraction of No. 4 fuel oil against a standard of the insecticide formulation to provide volume deposits in terms of ℓ/ha (oz/ac).

Physical assessment of the spray deposit on the Kromekote cards included the determination of drop stain sizes, drop numbers per unit area (cm^2), spread factor of drop sizes on Kromekote cards and the calculation of volume deposits in ℓ/ha (oz/acre). In addition, droplet spectrum characteristics for the whole spray for each application, and at individual sampling stations, were determined to assist in dosage-mortality effects of drop size and drop number on larval reduction.

The spray deposit stains on the Kromekote cards were counted and sized using a N.C.R. microcard reader calibrated to provide a 26X screen image resolution of 1 sq. cm of the Kromekote card surface. A calibrated graticule containing a series of stain image sizes was developed for classification and grouping of the various spray deposit images for each microcard reader. A minimum of 200 stains or 5 square centimeters of card area were counted to obtain a representative population of drop sizes. All stain diameters over 500 microns were sized and counted on the basis of a 100-cm^2 card surface area to provide a realistic volume deposit measurement. Volume deposits (ℓ/ha) and area coverage (drops/ cm^2) were determined from these data.

Monitoring and Assessment of Budworm Populations

Since the major emphasis of the spray program was directed to the protection of the new bud growth, (i.e. the interception and destruction of the second- and early third-instar larvae) an accurate and reliable system of determining pre- and post-spray larval populations on each tree was of prime importance. The standard apical 45-cm (18-inch) branch tip, while acceptable for the determination of population levels of fourth, fifth and sixth instars (Balch 1952, Hurtig et al. 1953 part 6 and 7, Fettes 1950) would not provide a realistic population index of emerging second instars, since the over-wintering larvae can be found on all segments of the branches and tree trunk (Miller 1958). Subsequent studies by Miller, using whole branch samples, indicated that 35% of the hibernating population occurred within the peripheral area, with 65% of the emerging population recovered from the remainder of the branch (Morris 1963).

Studies by the authors in the fall of 1976 (to determine suitable branch length for establishing a reliable index of pre-emergent populations of second-instar larvae) indicated that the majority of upper crown branch lengths ranged from 75 to 114 cm (30-45 inches). Mid-crown branches of similar lengths contained over 90% of the needle foliage (6-7 years growth), thus conforming to the whole branch concept suggested by Morris (1955). NaOH extraction of 46-cm (18-inch) branch tips and 96-cm (36-inch) whole branches has indicated that approximately 2/3 of the hibernating second-instar population occurs beyond the 46-cm terminals, thus confirming the use of a whole branch or at least the foliated portion of the branch as the sampling universe for studies of emerging budworm populations (Randall unpublished data). These larvae, after feeding on the needles, flowering buds, and small adventitious buds, eventually move to the larger terminal buds where the greatest defoliation damage occurs.

In the spring of 1977, a wax-impregnated corrugated cardboard box, 100 cm x 50 cm x 8 cm, with a wooden divider and replaceable top and bottom caps, was developed as the basic rearing unit for determining the emergence of early instar stages of the spruce budworm. The top caps were designed to accommodate two tubular (60-cm x 1.5 cm-diam.) clear plastic light probes with 6.5-cm diam. plastic dixie cups and lids as the collecting site for the emerging larvae (Fig. 5). The design and development of the emergence units were based on the early findings of Wellington (1948) that all stages of the spruce budworm larvae are

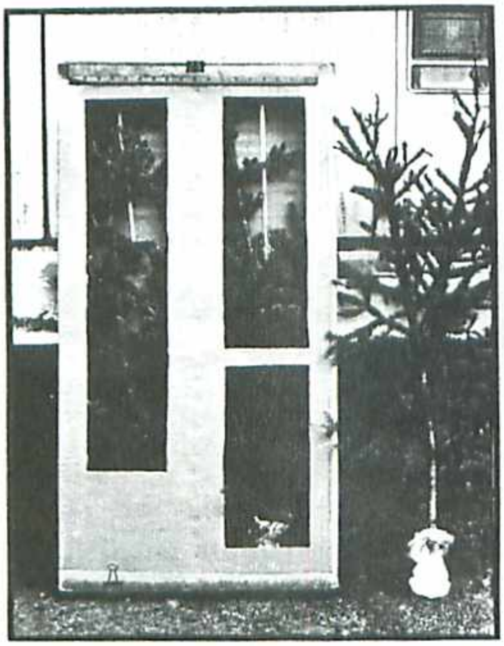

FIG. 5

Insect emergence unit for field collection of second-and early third-instar larvae from host tree foliage (outer cardboard sections of unit removed to show correct positioning of light probe (left) relative to branch sample).

phototropic to a discrete source of light. The emerging larvae are positively phototropic and thus move towards the light probe and upwards into the plastic dixie cups where they are collected.

Each box served as an emergence unit for a single tree sample, i.e. an upper and a mid-crown 96-cm branch sample. The cut end of each branch sample was covered with wetted cotton (100 cc) and enclosed in a small plastic bag prior to placement within the boxes. Completed boxes were then placed on the rearing racks with the proximinal ends of the plastic light probes and covering dixie cups in close proximity to a fluorescent light tube. The latter were integral parts of the rearing racks. Each rack contained 58 emergence boxes, the equivalent of one sampling schedule of the block.

Daily emergence counts were taken over a period of 15 days. The containers were then opened and the foliage and container checked for remaining larvae. Assessment of the larger fourth and fifth instar larvae on the 96-cm branch samples following the third spray application were made using the beating drum technique (Deboo et al 1973), Fig. 6.

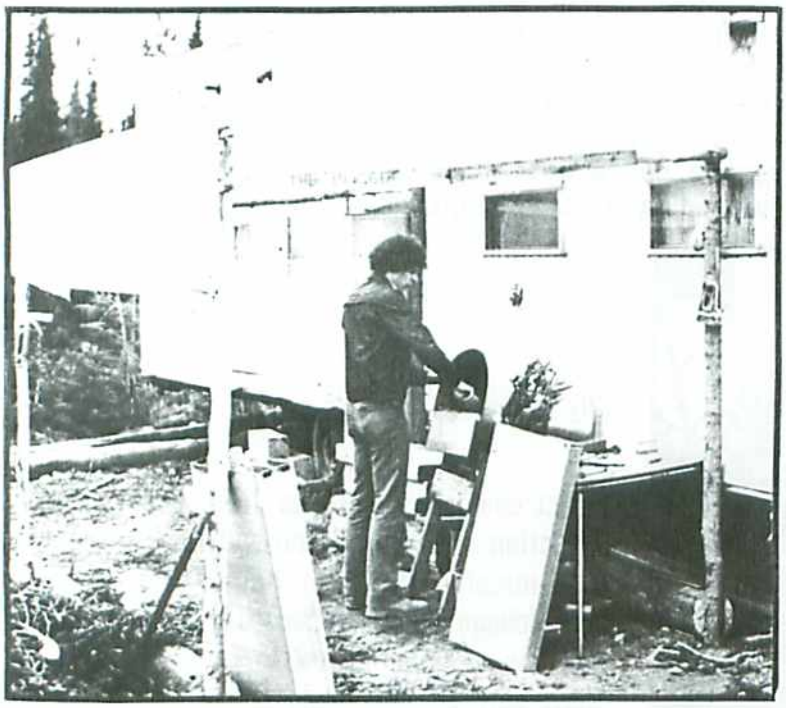

FIG. 6

Use of beating drum (DeBoo et al 1973) for determination of late fourth, fifth and sixth instar larval populations.

All biological data was subjected to correction for natural mortality using Abbott's formula:

$$(\%\ \text{population reduction} = \frac{\text{expected - observed}}{\text{expected}} \times 100).$$

RESULTS

Meteorological and Phenological Observations during the Spray Regimes.

Meteorological observations using ground meteorological equipment, Pibal weather balloons, records of host tree phenology and larval development taken within the spray block during the period of each spray application are summarized in Table II.

Table II

Observed meteorological conditions, larval instars and host tree phenology at time of spray application.

Meteorological Conditions		1st Application Fenitrothion (20/5/77 AM)	2nd Application Fenitrothion (29/5/77 PM)	3rd Application Aminocarb (16/6/77 PM)
Wind direction (Mag)		045°	310°	350°
Wind speed (k/hr)	aloft	1.6 - 4.8	6.4 - 8.0	9.6 - 12.8
	ground	0.0 - 3.2	0.0 - 3.2	4.8 - 9.6
Cloud Cover		4/10	10/10	1/10
Temperature	wet	2°C (35°F)	3°C (37°F)	8°C (47°F)
	dry	3°C (37°F)	8°C (47°F)	13°C (55°F)
	RH	86%	37%	56%
Ground Cover		Snow in woods with open water on frozen lakes	Snow in woods with patches of bare ground	Vegetative ground cover
Larval Instar (approx.)		2nd (100%)	2nd (70%) 3rd (30%)	3rd (75%) 4th (25%)
Host Tree Phenology		Buds on balsam fir and spruce species dormant, deciduous trees showing signs of spring growth.	Buds on balsam fir and red spruce tacky and swollen, deciduous hardwoods in early flowering stage of development.	Buds on balsam fir and red spruce showing needle growth but not flared, deciduous hard-woods in early leaf develop-ment.

During the early spray periods (May 20-29/77), the following observations were noted: abundant snow coverage within the forest, open patches of water on ice-covered lakes and depressions, streams and river tributaries active with above-normal water levels.

By contrast, during the aminocarb spray (June 17/77), a marked change in phenological development was observed between the western valley bottoms of the spray block and the higher elevations of the northeast corner. In the western lake region, some signs of shoot flaring were observed on balsam fir trees, particularly on southern exposures. By contrast, the following phenological conditions were recorded in the northeast area of the block: areas of cooler conditions with patches of snow evident in the woods, pin cherry (*Prunus pensylvanica* L.F.) in full blossom, leaves 3-5 cm long, yellow birch (*Betula alleghaniensis* Britton) with leaves 5-7 cm long and trembling aspen (*Populus tremuloides*) with leaves 1-2 cm in size were well past the flowering stage. Plants such as dandelions (*Tarasacum* sp.) and coltsfoot (*Tussilago farfara*) were in full bloom. Balsam fir and red spruce buds were swollen, with signs of needle growth protruding at the tips.

Spray Application and Timing

Special care was taken to adhere to the committee recommendations on spray timing for both the early fenitrothion and late aminocarb sprays. With the exception of the second fenitrothion spray, which occurred four days later than anticipated, the program plans were completed on schedule as outlined in the recommendations. The single departure from the original plan was carried out to accommodate a request by the Environmental Impact Team of FPMI and the Quebec Dept. of Wildlife for an early morning spray in preference to an evening application. Meteorological conditions, however, remained unfavorable for morning application; thus, the second fenitrothion spray occurred on the evening of May 29/77, four days later than planned. Larval activity was at the early bud-mining stage.

Spray Deposit Analysis

The results of spray deposit analysis of the Kromekote cards and colorimetric analysis of volume deposits on the glass slides for each spray application are presented in Appendix A, Table I. The deposit data in terms of drops/cm^2 and volume ℓ/ha (oz/ac) from each spray application are illustrated in Fig. 7 (A), (B), (C) and (D), for the first early fenitrothion spray, second early fenitrothion spray, cumulative fenitrothion deposit, and the third late aminocarb spray respectively. Volumetric measurements are shown as ℓ/ha and oz/ac for easy comparison purposes with past ultra low volume deposit measurements. For conversion purposes 1 fluid oz (US)/ac ≃ 0.0731 ℓ/ha.

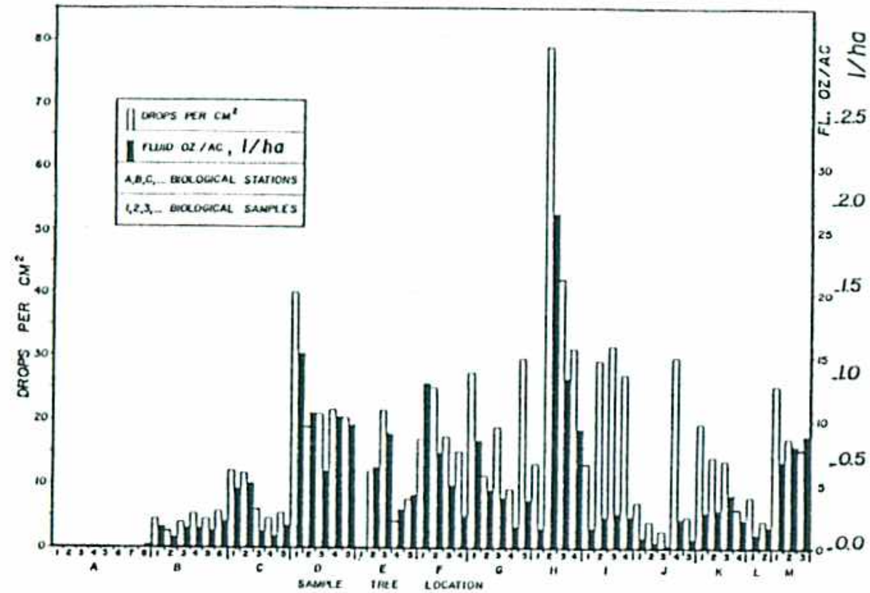

FIG. 7A COLLECTED DEPOSIT - 1st APPLICATION 20/5/77

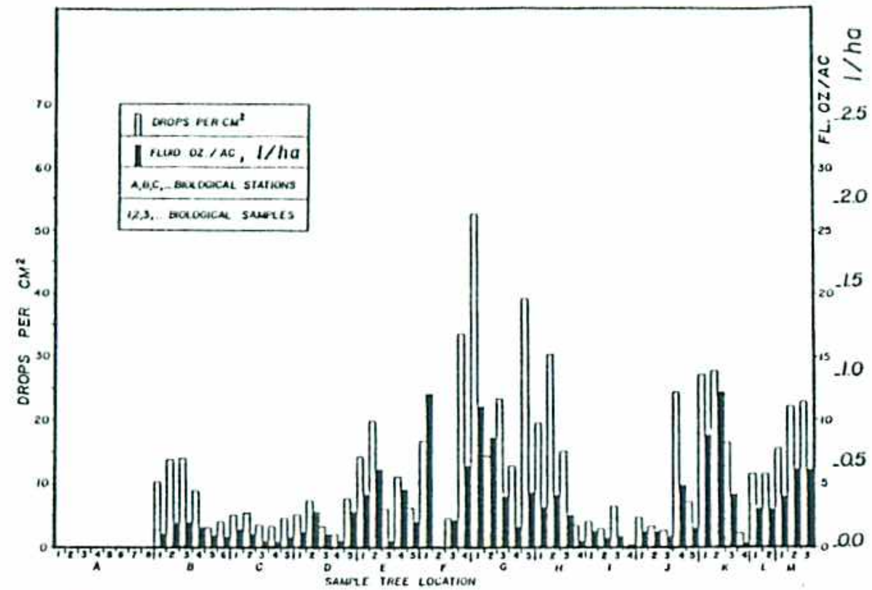

FIG. 7B COLLECTED DEPOSIT - 2nd APPLICATION 29/5/77

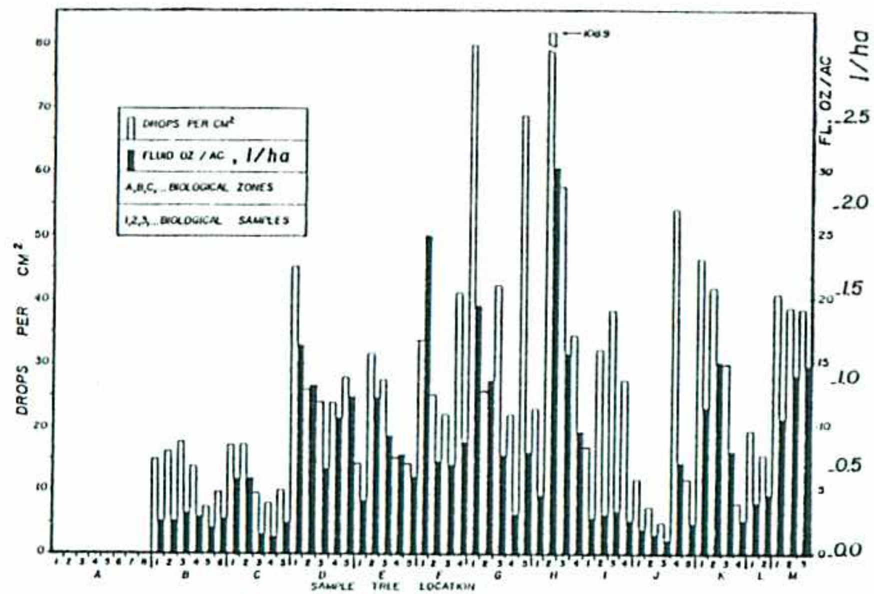

FIG. 7C CUMULATIVE DEPOSIT - 1st & 2nd APPLICATIONS

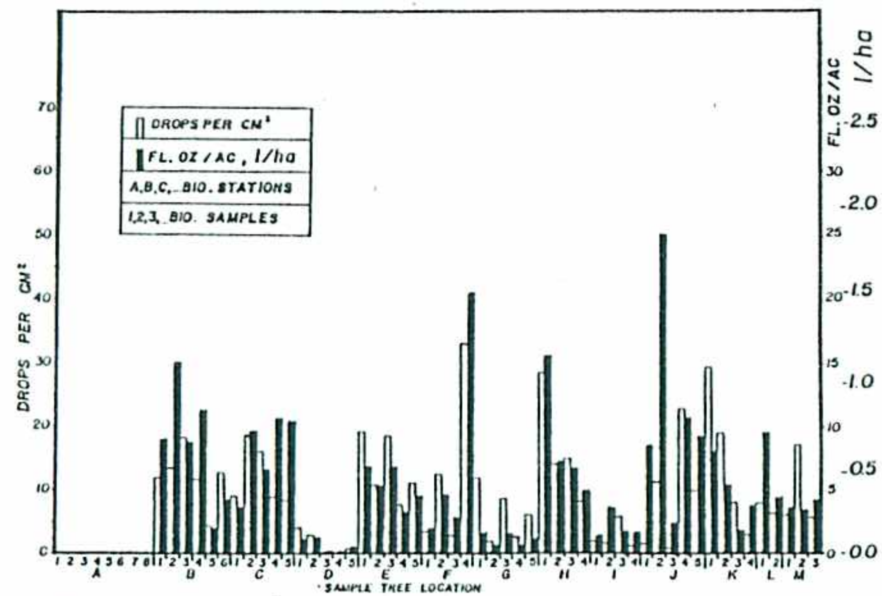

FIG. 7D COLLECTED DEPOSIT - 3rd APPLICATION 16/6/77

A visual assessment of the droplet densities (drops/cm^2) and volume deposits (ℓ/ha), from each of the three sprays (Fig. 7) shows an extremely wide inter-zone as well as inter-tree sample variation of deposits across the spray block. The low deposits recorded in Zone A are typical of boundary deposits on the upwind side of the spray block that are subject to spray line cut-off effects. Unusually high deposits (above nominal emission dosages of 11.52 oz/ac) such as H-2 (Fig. 7 A) and J-2 (Fig. 7 D) indicate either multiple swath effects, low emission swath height (Randall 1975) or ground turbulence (Armstrong 1977). The overall erratic deposit values recorded throughout the area represent departures from the usual uniformity of ULV spray deposits as recorded on calibration trials and operational spray programs utilizing multi-engine aircraft and incremental application technology (Randall and Zylstra 1972, Randall 1975, Randall 1977).

The preponderance of high volume deposits with low drop counts/cm^2 is not typical of a ULV spray droplet deposit pattern and therefore suggests a relatively coarse droplet spectrum. This is particularly evident of the aminocarb deposits Fig. 7(D) where volume deposits are greater than drop densities using a graphic scale wherein 40 drops/cm^2 is representative of the emission volume, i.e. 0.84 ℓ/ha (11.52 oz/ac). The advantage of multiple-spray application to circumvent this problem is partially illustrated in Fig. 7(C).

Droplet Spectrum Characteristics of Spray Deposits

Analysis of the drop stain sizes of the spray deposit from each application, and conversion of stain diameters into appropriate drop diameter classes using calibrated drop size/stain diameter conversion factors, provided the basic data for the determination of maximum drop size (D max), volume median diameter (VMD), and number median diameter (NMD) of the droplet spectrum characteristics of each spray cloud at point of impaction. These data are presented in Table III and graphically illustrated in Fig. 8(a), (b) and (c) for the first, second and third spray applications respectively.

A visual assessment of the droplet spectrum characteristics of the fenitrothion spray deposits (Fig. 8a and b) indicated a relatively medium-fine type of spray (NMD and VMD lines close together) that does not appear to agree with the pattern deposits as shown in Figs. 7A and 7B. The latter two figures show a preponderance of volume deposits over coverage deposits (drops/cm^2) which is characteristic of a coarse droplet spray (NMD and VMD lines far apart). This is partially evident in the aminocarb droplet spectrum graph (Fig. 8C) and shows up again in Fig. 7D as a loss of spray coverage in terms of drops/cm^2. This loss can be attributed to the extremely high viscosity of the nonyl phenol co-solvent in the aminocarb formulation that affected the production of a fine spray droplet spectrum at the air/liquid interface of the spray nozzle orifice.

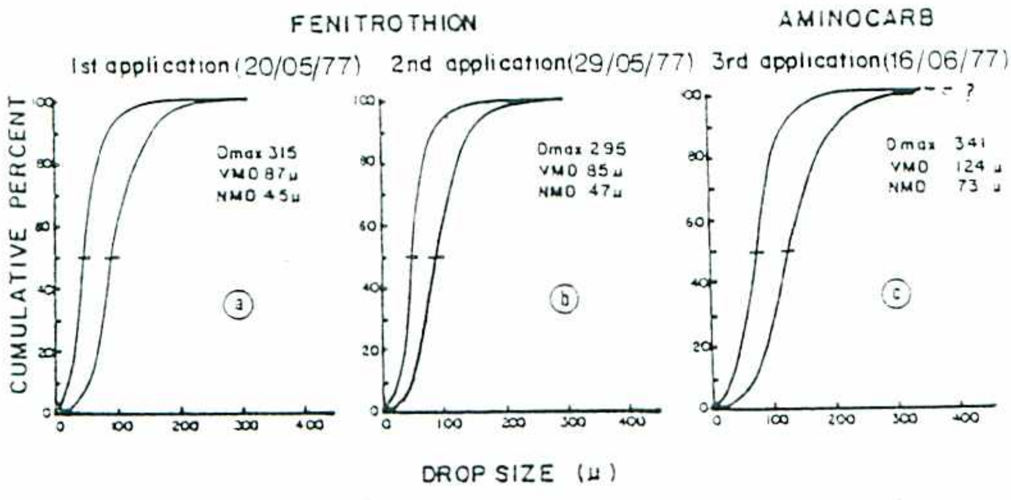

FIG. 8 Volume median and number median diameters of the fenitrothion (a & b) and aminocarb (c) sprays.

Table III

Droplet spectrum characteristics of sprays

Deposit Classification	Insecticide Formulation Fenitrothion 1st Spray	2nd Spray	Aminocarb 3rd Spray	Calibration Data (1972)
Dmax	315 µ	295 µ	341+µ	200 - 250 µ
VMD	87 µ	85 µ	124 µ	70 - 90 µ
NMD	45 µ	47 µ	73 µ	40 - 60 µ

Dmax = maximum drop size of spray

VMD = Volume median diameter. The droplet diameter at which half the volume is made up of droplets larger than the stated diameter.

NMD = Number median diameter = Frequency Median Diameter (FMD). The droplet diameter at which half the detectable number of droplets are smaller than the stated diameter.

Drop spread factors:

fenitrothion formulation: $\chi = 0.532y^{0.891} + 12$
(Sumithion®)

aminocarb formulation: $\chi = 0.643y^{0.83} + 10$
(Matacil®)

The anomalies in the fenitrothion spray deposit patterns must be attributed to factors other than formulation and equipment characteristics (since the formulation, spray aircraft and boom-and-open-nozzle system have provided excellent spray coverage on calibration and operational spray programs prior to 1977) or the use of the computerized flow unit.

BIOLOGICAL ASSESSMENT OF BUDWORM POPULATIONS

Untreated Check Population of Spruce Budworm

The biological data collected from the unsprayed check area throughout the monitoring program are presented in Appendix A, Tables II (a), (b) and (c). The data are summarized in Table IV and graphically illustrated in Fig. 9 to show average larval emergence and population decline in balsam fir and spruce host trees.

Emergence of second-instar larvae occurred over a period of approximately 10 days. During this period (May 16-26) the larvae were found wandering over the foliage, and/or mining needles. Evidence of bud mining and the appearance of third-instar larvae occurred in the latter half of this period. Natural population decline of budworm larvae on balsam fir and spruce host trees followed somewhat different patterns within the check area. This is particularly evident in the population stability of second-instar larvae on spruce early in May, followed by a dramatic decline in larval numbers in the second week of June. By contrast, a consistent gradual decline in larval numbers occurred on balsam fir during the same time interval (Fig. 9 and Table IV).

Assessment of emergence data indicated average host populations of 237 second-instar larvae/96-cm branch on balsam fir and 262 second-instar larvae/branch on spruce. These values represent the average counts taken from upper and midcrown branch samples as summarized in Table IV. It is interesting to note that larval population densities on both balsam fir and spruce host trees were higher on the top branch samples throughout the sampling period than on the midcrown positions. This difference in population numbers could well account for the severe defoliation of terminal shoots on both spruce and balsam fir trees, particularly under conditions of high population densities where the ratio of larvae to buds becomes exceedingly large.

The above biological data served as the base line for the establishment of the expected population density trends for larval populations within the experimental spray block. Prespray larval densities from Block 305 were used as the base line for calculations of expected densities throughout the program using the % larval survival values on balsam fir and spruce host trees from the non-spray check area (Table IV).

Table IV

Average population survival density of spruce budworm larvae / 96-cm branch sample from the Untreated Check Plot

Host Tree	Branch Position	No. of Branch Samples	Sampling Schedule 12/5/77	21/5/77	1/6/77	9/6/77	19/6/77	23/6/77
Fir	Top	11	247.3	186.3	145.4	98.5	72.4	72.2
	Midcrown	11	228.0	168.8	141.0	99.7	65.6	49.2
Average		22	237.6	177.5	143.2	99.1	69.0	60.7
% Survival			100	74.7	60.3	41.7	29.0	25.3
Spruce	Top	9	260.1	246.8	176.6	156.6	71.3	81.0
	Midcrown	9	265.4	229.8	169.2	174.1	60.1	57.6
Average		18	262.7	238.3	172.9	165.3	65.7	69.3
% Survival			100	90.7	65.8	63.0	25.0	26.5
Plot Average		40	248.9	204.8	156.5	128.9	67.6	64.1
% Survival			100	82.3	62.9	51.8	27.2	25.7

Biological monitoring of pesticide efficacy on Block 305 as a whole

Pre- and post-spray biological data collected from Block 305 throughout the spray program are presented in Appendix A, Tables IV and V. The data are graphically illustrated in Figs. 10, 11 and 12 consecutively to show the impact of insecticide treatment on larvae from the block as a whole, and the effects of treatments on larvae developing on balsam fir and spruce host trees respectively. The pertinent data are summarized in Table V to show the cumulative effect of two early applications of fenitrothion on larval populations within the forest canopy.

Larval populations within the spray block were considerably higher on balsam fir (400 larvae/96 cm branch) than on spruce host trees (337 larvae/96 cm branch) as compared to population figures within the unsprayed check area which recorded higher initial larval populations on spruce host trees. This anomaly may be due to minimal sample numbers, tree vigor or site location of the control trees.

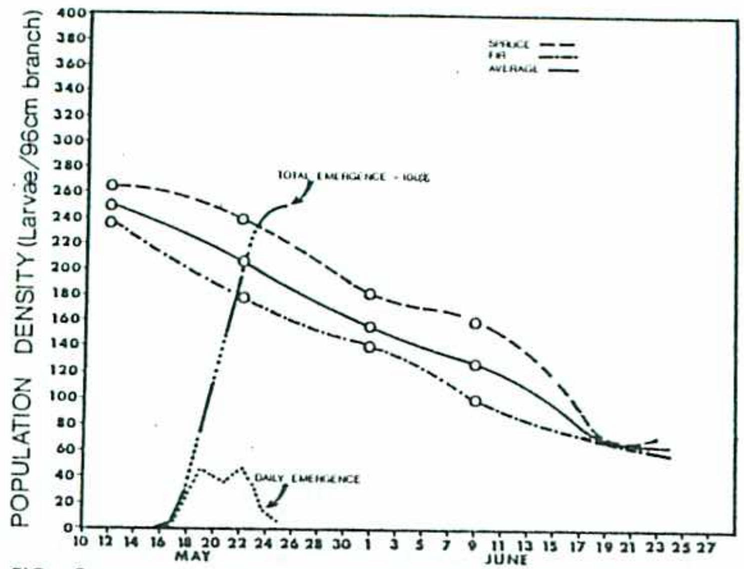

FIG. 9 NATURAL LARVAL POPULATION DECLINE IN CHECK BLOCK (SPRUCE, FIR AND AVERAGE)

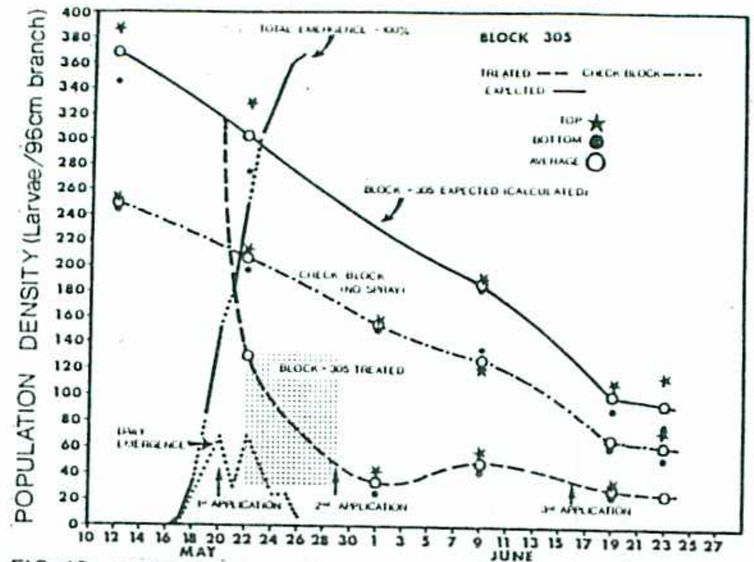

FIG. 10 NATURAL AND EXPECTED LARVAL POPULATION DECLINE IN CHECK AND SPRAY BLOCK 305 (SPRUCE AND FIR)

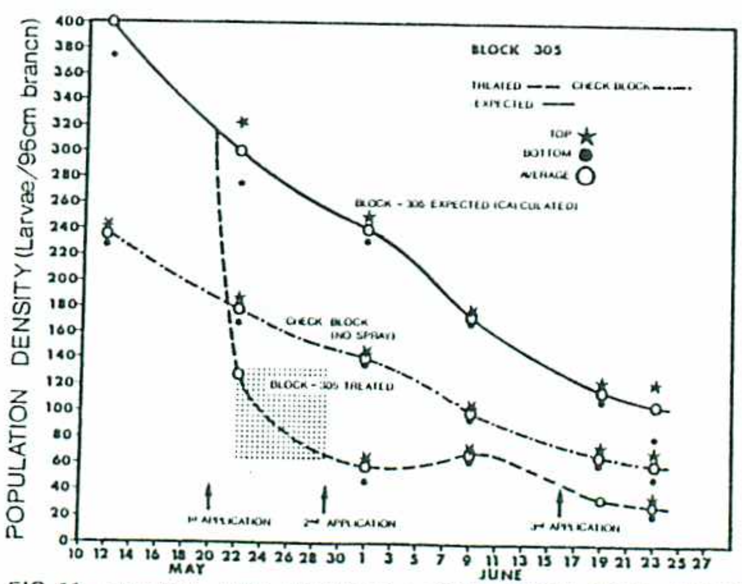

FIG. 11 NATURAL AND EXPECTED LARVAL POPULATION DECLINE IN CHECK AND SPRAY BLOCK 305 (FIR TREES ONLY)

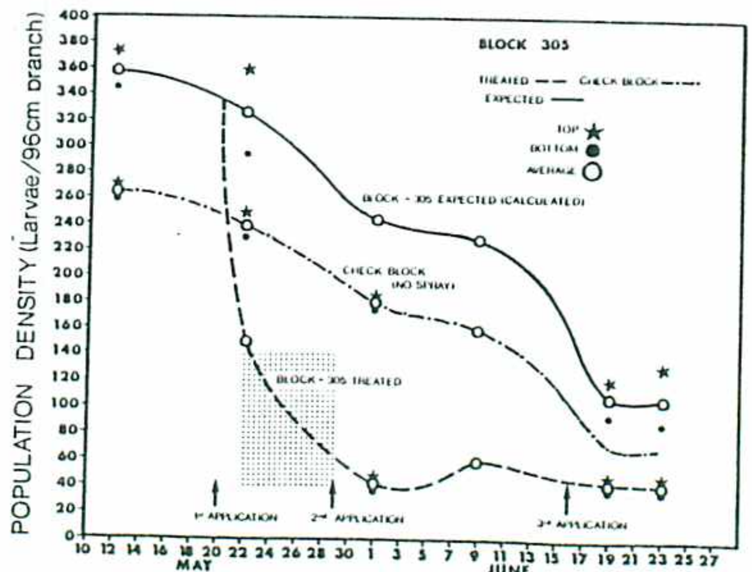

FIG. 12 NATURAL AND EXPECTED LARVAL POPULATION DECLINE IN CHECK AND SPRAY BLOCK 305 (SPRUCE TREES ONLY)

Table V

Second- and early third-instar population reduction on upper & midcrown branch samples following two applications of oil formulated fenitrothion sprays at 0.28 Kg AI in 0.84 ℓ/ha (4 oz AI in 11.52 fluid oz/ac)

Tree Host	No. of Samples*	Pre-Spray	Average population density/96 cm branch: 1st Post Spray 48 hours, Expected	1st Post Spray 48 hours, Actual	2nd Post Spray 48 hours, Expected	2nd Post Spray 48 hours, Actual	3rd Post Spray 6 days, Expected	3rd Post Spray 6 days, Actual	Percent Population Reduction: 1st Post	2nd Post	3rd Post
Fir											
Top	29	427.7	320.8	128.5	250.2	50.4	170.1	66.1	59.9	79.9	61.1
Botom	29	372.7	275.8	129.9	231.7	61.7	164.5	73.5	52.9	73.4	55.3
TOTAL	58	400.2	298.3	129.7	240.9	56.0	167.8	69.8	56.4	76.6	58.2
Spruce											
Top	31	357.3	339.4	136.1	244.4	18.1	217.5	43.0	59.9	92.6	80.2
Bottom	31	316.7	275.5	129.0	203.9	24.5	210.0	42.0	53.2	88.0	80.0
TOTAL	62	337.0	307.4	132.6	224.1	21.3	213.7	42.5	56.5	90/3	80.1
Fir & Spruce											
Top	60	391.2	328.6	132.6	246.5	33.7	192.2	54.2	59.6	86.3	71.8
Bottom	60	343.7	275.0	129.8	214.5	42.5	186.6	57.5	52.8	80.2	69.2
TOTAL	120	367.2	301.8	131.2	230.5	38.1	189.4	55.8	56.5	83.5	70.5
Check (Un-treated	20	249.0		204.8		156.5		128.9	0.0	0.0	0.0

First spray application (20/5/77)

Second spray application (29/5/77)

*All biological samples included irrespective of spray deposits.

A visual analysis of the data presented in Figs. 10, 11 and 12 shows the initial impact of the first early fenitrothion spray on second- and early third-instar larvae during the early wandering and needle-mining stages of activity. The addition of a second fenitrothion spray, 9 days later, resulted in a further substantial reduction in larval numbers. The degree and extent of this reduction, however, cannot be accurately evaluated since a pre-spray population fix was not established prior to the second application of fenitrothion. The results, therefore, are graphically shown as a rectangular 'twilight zone' of unknown larval numbers within which the population decline curve is extrapolated to meet the 48-hr first post-spray larval count following the second application of fenitrothion.

Daily emergence data of second-instar larvae (Fig. 9) shows that approximately 50% of the total expected larval population were on the foliage at the time of the first spray application. Total emergence of the second-instar population occurred prior to the second fenitrothion spray. Larval activity of the second- and early third-instars was not sampled within the spray block during the time interval between the 48-hr post-spray period following the first fenitrothion spray and the second spray application. Thus, a definite dosage/population reduction value cannot be assigned to each of the fenitrothion sprays due to possible larval recovery and/or larval migration into the spray area. The overall cumulative action of both fenitrothion sprays, however, resulted in a marked decline in larval numbers within the tree canopy.

Efficacy of a Single Late Application of Aminocarb (Matacil®)

Pre-spray residual population densities of third- and fourth-instar larvae within Block 305 indicated average counts of 69.8 larvae/96-cm branch samples on balsam fir and 42.5 larvae/96-cm branch samples on spruce. Recommended timing for spray application was scheduled and carried out when 25% of the early field population of budworm had reached the fourth-instar stage of development within the spray block. Phenological development of the host trees within the block was predominantly in the swollen-bud stage, with some evidence of flared buds on balsam fir in the northwestern regions of the spray area. Expected population reduction and actual population reduction are presented in Appendix A, Table V. Summarized assessment of the biological data for balsam fir and black/red spruce are presented in Table VI.

Results indicated an overall larval population reduction within the spray block of 4 to 7% with an average effectiveness of 32-33% population reduction on balsam fir trees and 0% reduction on spruce tree species. Anomalies, however, can be found on individual tree data (Appendix A, Table V) wherein a measure of effectiveness both on spruce and fir host trees occurs at both high and low volume dosages, as well as zero control at exceptionally high dosages such as found on tree numbers H-1 (16.1 oz/ac) and J-2 (23.4 oz/ac). The latter two examples would indicate a lack of contact between the insecticide and the larvae within the bud complex. The third spray recommendation was based on the percentage of fourth-instar larvae within the budworm population without

Table VI

Population reductions following a single late* application of aminocarb (70.4 gm/ha)

Host Tree	Number of Tree Samples	Average Population Density/96 cm Branch: Pre-spray Larval Population	4th Post Spray Sample (19/6/77): Expected	4th Post Spray Sample (19/6/77): Actual	5th Post Spray Sample (23/6/77): Expected	5th Post Spray Sample (23/6/77): Actual	Percent Population Reduction from Expected: 4th Post (48 hr)	Percent Population Reduction from Expected: 5th Post (5 days)
Fir	29	69.3	48.9	33.3	43.2	29.0	31.9	32.9
Spruce	31	42.5	17.3	29.0	18.4	28.6	0	0
Both	60	55.8	32.6	31.3	30.3	28.6	4.0	7.5
Checks	20	158.1	67.4	67.4	64.1	64.1	0	0

*Applied at 25% emergence of fourth-instar larvae.

due consideration of the phenology of the target site, i.e. the contact surface area of the needle growth. The relatively poor results with the aminocarb spray, therefore, can be directly attributed to faulty recommendations for the timing of the third spray application which should have occurred at a much later date, i.e. the time period when the new needle growth was sufficiently flared to intercept and collect falling spray droplets. This period coincides with the late fourth and early fifth instar and not the late third - and early fourth-instar stage of larval development.

Spray Coverage versus Larval Population Reduction

The goal of an operational spray program is to reduce budworm larval populations such that adequate foliage protection is achieved. A review of the deposit data (Figs. 7 A, B, C, and D) shows deposits ranging from extreme overdosing (greater than emission volumes) to areas of insufficient deposits both in terms of volume deposits and spray coverage. Since the criterion for optimum effectiveness of insecticide activity is spray coverage (drops/cm^2) rather than dosage volume (ml/ha) (Hurtig et al, 1953) the data from the two fenitrothion sprays were examined on the basis of spray coverage and larval reduction for a single and cumulative (48-hour and 10-day) post spray effectiveness. The data are presented in Tables VII(a) and VII(b) for balsam fir and black/red spruce host trees respectively and graphically illustrated in Fig. 13.

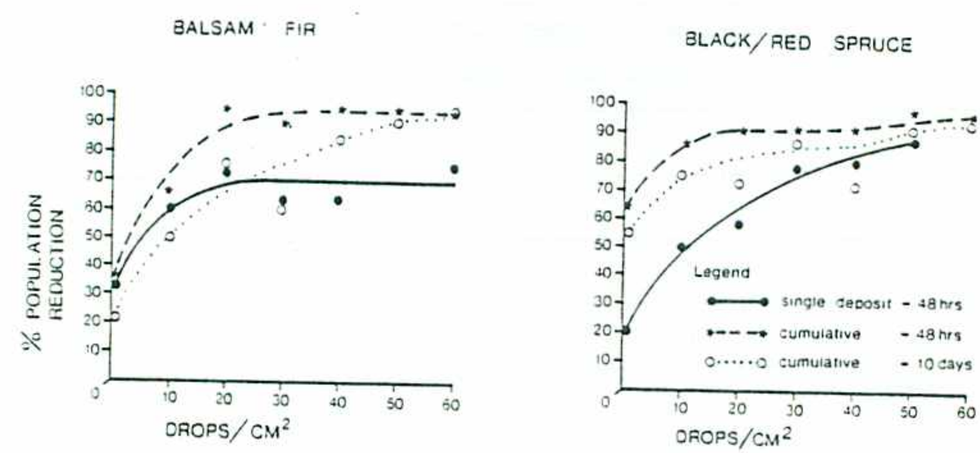

Fig. 13 Relation between spray coverage (drops/cm^2) and population reduction of second and early third instar spruce budworm larvae on balsam fir and spruce host trees

Table VII(a)

Spray coverage (drops/cm²), larval reduction and host tree defoliation following two applications of fenitrothion sprays.

Balsam Fir

Treatment	Spray Coverage Category (Drops/cm²)	Number of Samples	Dosage Deposit Data* Formulation (ml/ha)	Formulation (oz/ac)	Active Ingredient (gm/ha)	Active Ingredient (oz/ac)	% Population Reduction (48 hrs)	% Population Reduction (10 days)	Percent Defoliation
1st fenitrothion Spray (20/5/77)	0-1	6	9.5	0.13	3.3	0.05	31.7	-	-
	1-10	5	117	1.6	40.7	0.56	62.2	-	-
	10-20	9	350	4.8	121.6	1.67	71.0	-	-
	20-30	6	475	6.5	165.1	2.26	63.7	-	-
	30-40	1	190	2.6	65.3	0.90	62.9	-	-
	40-50	-	-	-	-	-	-	-	-
	50⁺	1	1915	26.2	665.6	9.1	76.9	-	-
Cumulative fenitrothion Sprays (20/5/77) + (29/5/77)	0-1	5		Trace		-	36.2	20.4	99
	1-10	4	95	1.3	33.0	0.5	67.3	50.6	60
	10-20	4	482	6.6	167.5	2.3	95.9	76.2	55
	20-30	7	650	8.9	225.9	3.1	89.5	58.7	78
	30-40	3	738	10.1	256.6	3.5	96.0	34.4	35
	40-50	2	607	8.3	210.9	2.9	96.5	91.0	8
	50⁺	3	1381	18.9	480.0	6.6	92.2	95.7	7

* 11.52 oz (US)/ac = 842 ml/ha (V/V)
4.0 oz AI/ac = 281.7 gm/ha (W/W)

Table VII(b)

Spray coverage (drops/cm²), larval reduction and host tree defoliation following two applications of fenitrothion sprays.

Black/Red Spruce

Treatment	Spray Coverage Category (Drops/cm²)	Number of Samples	Dosage Deposit Data* Formulation (ml/ha)	Formulation (oz/ac)	Active Ingredient (gm/ha)	Active Ingredient (oz/ac)	% Population Reduction (48 hrs)	% Population Reduction (10 days)	Percent Defoliation
1st fenitrothion Spray (20/5/77)	0-1	3	29.2	0.4	10.1	0.1	20.5	-	-
	1-10	14	116.7	1.6	40.6	0.6	50.1	-	-
	10-20	6	459.4	6.3	159.7	2.2	59.2	-	-
	20-30	5	423.9	5.8	147.3	2.0	79.1	-	-
	30-40	2	891.7	12.2	309.9	4.2	80.6	-	-
	40-50	1	964.8	13.2	335.3	4.6	88.3	-	-
	50⁺	-		-				-	-
Cumulative fenitrothion Sprays 1st and 2nd (20/5/77) + (29/5/77)	0-1	2	1.2	0.03	0.4	0.01	64.7	55.8	100
	1-10	5	167.7	2.3	58.3	0.8	37.5	75.1	52
	10-20	9	247.9	3.4	86.2	1.2	90.1	72.1	51
	20-30	5	561.5	7.7	195.1	2.7	90.9	37.5	26
	30-40	4	940.6	12.9	326.9	4.5	91.9	73.1	44
	40-50	-	969.8	13.3	337.1	4.6	98.9	92.7	20
	50⁺	2	862.5	11.8	299.8	4.1	97.5	96.7	5

* 11.52 oz (US)/ac = 842 ml/ha (V/V)
4.0 oz AI/ac = 281.7 gm/ha (W/W)

Analysis of larval reduction in terms of spray coverage shows that a plateau of maximum effectiveness occurs within spray coverage limits of 10 to 50 drops/cm^2 on both balsam fir and spruce host trees (Table VII). This is particularly evident on balsam fir (Table VIIa) where very little increase in second-instar population reduction occurs with increased spray coverage, 48 hours after the first fenitrothion spray. This "plateau of effectiveness" (i.e. 62.2, 71.0, 63.7 and 62.9%) represents the percent reduction of the total expected second-instar larval population of which approximately 70 percent had emerged by May 22 (Fig. 9). The addition of a second fenitrothion spray nine days later raised the level of maximum 48-hr effectiveness to a mean of 96% for the same range of drop deposit categories. At that point in time, the remaining segment of the emerged larval population was exposed to the cumulative action of the fenitrothion sprays. Anomalies, however, occur within the volume deposit categories that require further clarification.

By contrast, the effectiveness of the first fenitrothion spray on larvae inhabiting spruce host trees (Table VIIb), indicates a progression of larval reductions between the spray deposit categories of 10 to 50 drops/cm^2 (i.e. 50.1, 59.2, 79.1, 80.6 and 88.8%). The addition of the second fenitrothion spray, however, produced a plateau of effectiveness (i.e. 87.5, 90.1, 91.9 and 98.9%) within the same drop deposit categories of 10 to 50 drops/cm^2. Anomalies are evident between the volume deposit categories and larval reduction. This is particularly evident in the 10-30 and 30-50 drop/cm^2 categories (Table VIIb).

Ten-day post-spray population counts of budworm larvae on both balsam fir and spruce host trees indicated a resurgence in larval numbers within the tree canopy. This is particularly evident on balsam fir (Fig. 13). Resurgence in larval population numbers may possibly be attributed to recovery of a portion of the larval population that spun out of the tree canopy and/or to air-borne invasion of second-instar larvae from surrounding non-sprayed areas north of Block 305.

The overall impact of the aminocarb spray on the surviving larval population within the spray block was negligible and, therefore, not subjected to further analysis. The results, however, indicate the importance of proper timing of spray applications in order to obtain maximum benefits from proven pesticides.

Host Tree Defoliation

The impact of the early fenitrothion and late aminocarb sprays on host tree foliage protection was determined from individual branch samples collected in August/77 using the method of Fettes (1950). Upper and mid-crown samples were averaged to provide a mean defoliation value.

Data from the non-sprayed check area indicated an average defoliation value of 98% on balsam fir and 82% on spruce host trees. Within these values, 80% of the balsam fir trees were 100% defoliated as compared to 40% of the spruce trees.

Preliminary data based on 60 sample trees from the spray block indicated an average defoliation of 46% on balsam fir and 40% on spruce host trees (Randall et al. 1977). The addition of defoliation data taken in March 20-26/78 from adjacent tree samples on alternate host tree species indicated that the average defoliation figures (based on 97 sample trees) within the spray block were 54% on balsam fir and 46% on spruce host trees. These values, however, while more realistic than the preliminary findings, do not provide an absolute index of defoliation for each of the host tree species since equal representation of each tree species was not taken at each sampling station under comparable dosage deposit levels. The data represent 97 out of a total of 120 sample trees, i.e., 49 B. fir and 48 spruce trees at random locations within the 60 sample tree positions.

A breakdown of the defoliation data into 20% arithmetic categories of defoliation damage according to host tree species (Table VIII) shows that 28% of the trees received less than 20% defoliation, 29% of the trees received 20 to 80% defoliation and the remaining 43% were severely defoliated. The latter category, however, included sixteen trees from boundary zone A that received trace deposits of spray droplets. The data also indicated that the host tree species, i.e., balsam fir and black/red spruce, appear to be well represented within each of the various defoliation categories.

Table VIII

Defoliation damage of Balsam fir and Spruce host trees within Block 305

Defoliation Category	Total No. of Samples	Balsam Fir No. of Trees	Balsam Fir %	B/R Spruce No. of Trees	B/R Spruce %	Percent of Trees within each Category
0-20	27	13	13.4	14	14.4	27.8
20-40	8	3	3.1	5	5.2	8.3
40-60	8	5	5.2	3	3.1	8.3
60-80	12	3	3.1	9	9.2	12.3
80-100*	42	25	25.8	17	17.5	43.3
Total	97	49	50.5	48	49.5	100.0

*Sixteen trees from boundary zone A (trace quantities of spray) were 100% defoliated.

Biological Monitoring of Individual Trees, Concept, Methodology of Assessment and Results

The irregularity of the spray deposits in terms of drops/cm^2 and dosage volumes ℓ/ha (oz/ac) collected at each biological sampling station across the experimental block raised many questions regarding the efficacy of each spray application against the early-instar stages of the spruce budworm. The use of averages to express mortality values for each spray application, or the cumulative effect of all sprays, would tend to mask the true efficacy value of each insecticide treatment in terms of dosage/coverage/effectiveness, application timing, larval density and subsequent host tree defoliation.

In order to understand the impact of early application technology on the mobile second- and early third-instar budworm larvae, it is necessary to conduct a complete analysis of the dosage mortality effects as they occurred at each biological sampling station. Studies by Morris (1955) indicated that inter-branch variation is of less concern than inter-tree variation when attempting to define mean density of larvae for a particular habitat. The decision to use individual tree samples as the basic unit for dosage/mortality studies, therefore, was based on these early findings of Morris (1955) and expanded to encompass the extreme inter-tree variation of dosage deposits encountered throughout the sampling area of Block 305. The use of individual tree data for dosage/mortality studies of similar spray deposits was particularly suitable for the study of second- and third-instar larvae in the field, since the whole tree represents the sampling universe for the wanderings of these early larvae, and the 96-cm branch sample is a good representation of the major portion of the foliage/larval habitat that intercepts the falling spray droplets. The destruction of a forest is the result of individual tree mortality which in turn is a function of excessive larval numbers and total defoliation of productive buds and needles.

To delineate the dosage/mortality effects of each spray application on the second- and early third-instar larval populations and subsequent host tree damage, the prespray, second-instar larval density at each biological tree station became the base line for the individual calculation of expected population levels for each particular tree, and for subsequent postspray sampling dates. These latter values were based on the average percentage population decline of budworm larvae on each host tree species as found in the unsprayed check area (Table IV).

The use of a single figure to express the dosage/mortality results of an aerial spray against a particular insect stage may be statistically acceptable, but it does not represent the multi-factorial ramifications of dosage/mortality effects within the spray area. A visual analysis of the spray deposit patterns of the fenitrothion sprays across the experimental Block 305 shows the presence of three distinct spray deposit parameters. These can be separated on the basis of volume deposits in ℓ/ha (oz/ac) using the emission volume of the first spray application of fenitrothion as the base line for ½-volume categories as follows:

1) excessive volume deposits, emission deposits of over 0.842 ℓ/ha (11.52 oz/ac),

2) high volume deposits of 0.841 → 0.421 ℓ/ha (11.52 → 5.76 oz/ac), and

3) low volume deposits under 0.421 ℓ/ha (5.76 oz/ac to trace).

To encompass the above parameters, the biological data was arranged in descending order of spray deposit volumes and subdivided into six categories of ½ volume deposits based on the original emission dosage of 11.52 oz/ac as follows:

1) series A over 0.842 ℓ/ha (over 11.52 oz/ac)

2) series B 0.842 → 0.421 ℓ/ha (11.52 - 5.76 oz/ac)

3)
- series C 0.42 → 0.21 ℓ/ha (5.75 - 2.88 oz/ac)
- series D 0.21 → 0.10 ℓ/ha (2.87 - 1.44 oz/ac)
- series E 0.10 → 0.05 ℓ/ha (1.43 - 0.72 oz/ac)
- series F 0.05 → Trace (0.71 - Trace).

This would provide equivalent active ingredient categories of 0.292+kg/ha, 0.29-0.146 kg/ha, 0.14-0.073 kg/ha, 0.07-0.036 kg/ha etc., (4+ oz/ac, 4-2 oz/ac, 2-1 oz/ac, 1-0.5 oz/ac, etc.). The pertinent biological and chemical data for each series is presented in Appendix B, Table I. Data analysis in terms of population reduction and host tree defoliation for each series is presented in Appendix B, Table II. Each series is grouped together (i.e. Series A, Tables I and II, etc.) for ease of data retention and comparison. The level of larval reduction within and between each dosage category should, theoretically, act as an indicator of the efficacy of each deposit class of the fenitrothion sprays in terms of a single or cumulative application. Changes in larval populations between each dosage series, therefore, would provide data for determining the degree of efficacy of early applications of fenitrothion sprays against high population levels of second- and early third-instar larvae.

The summarized data for each series are presented below in Tables IX(a) and IX(b), to show the relationship between dosage deposit and larval survival between each category. The data are graphically illustrated in

Table IX(a)

Relationship between dosage deposit categories of fenitrothion sprays and second- and early third-instar population survival/96 cm branch samples

(Condensed from Table 1 Appendix B)

Volume Deposit Category* (ℓ/ha)	Number of tree Samples	Pre-Spray Larval Density/ 96 cm Branch	1st Application (20/5/77) Average Deposit		1st Post Spray Larval Density/ 96 cm Branch (48 hrs)	2nd Application (29/5/77) Average Deposit		Post Spray Larval density/ 96 cm Branch	
			(ℓ/ha)	(Drops/cm^2)		(ℓ/ha)	(Drops/cm^2)	2nd Post (30/5/77)	3rd Post (9/6/77)
A (over 0.842)	4	309.3	1.226	44.4	80.7	0.358	16.7	11.7	20.2
B (0.84 - 0.42)	12	262.1	0.606	21.3	61.9	0.270	14.7	17.6	29.2
C (0.42 - 0.21)	11	418.6	0.292	14.5	110.3	0.343	16.3	5.0	27.2
D (0.21 - 0.10)	15	413	0.139	12.6	142.3	0.153	9.9	28.2	50.5
E (0.10 - 0.05)	7	347	0.073	5.3	128.7	0.095	7.2	69.7	68.6
F_1 (0.05 - trace)	8	450	Trace	0.8	228	Trace	0.7	92	102
F_2 (No spray)	2	305	0.000	0.0	301	0.000	0.0	281	283
Check "C"	20	253	-	-	213.5	-	-	159.4	124.6

*Based on deposits from first fenitrothion spray

Table IX(b)

Dosage/population reduction of second- and early third-instar spruce budworm larvae following two early applications of fenitrothion sprays (Condensed from Table II Appendix B)

Volume Deposit Category* (ℓ/ha)	Number of Tree Samples	1st Spray Application (20/5/77)			2nd Spray Application (29/5/77)			
		Spray Deposit		Population Reduction	Cumulative Deposit		% Population Reduction 1st and 2nd Application	
		Fluid ℓ/ha	Active kg/ha	% (48 hrs)	Fluid ℓ/ha	Active kg/ha	2nd Post (48 hrs)	3rd (10 days)
A (over 0.842	4	1.226	0.41	73.4	1.584	0.53	94.2	87.3
B (0.84 - 0.42)	12	0.606	0.20	66.0	0.854	0.28	89.5	70.5
C (0.42 - 0.21)	11	0.292	0.09	68.2	0.635	0.21	98.0	84.7
D (0.21 - 0.10)	15	0.139	0.05	58.5	0.241	0.08	88.7	75.7
E (0.10 - 0.05)	7	0.073	0.01	58.3	0.168	0.01	84.8	53.2
F_1 (0.05 - Trace)	8	0.058	Trace	29.7	Trace	Trace	68.9	51.1
F_2 (No spray)	2	0.000	0.00	0	0	0	0	0
Check "C"	20	-	-	0	-	-	0	0

*Based on deposits from first fenitrothion spray.

Fig. 14(a) and (b) using individual tree data from balsam fir and spruce host species.

The 48-hr postspray data (Table IXa) and results (Table IXb) following the first application of fenitrothion indicate that the early second-instar larvae are very sensitive to fenitrothion sprays even at deposits as low as 0.057 ℓ/ha (0.7 fluid oz/ac). The similarity of population reduction values between the first three spray deposit categories, i.e. A: 73.4%, B: 66.0%, and C: 68.2%, and the subsequent two lower categories, D: 58.5%, and E: 58.3% (Table IXb), are indicative of the effective knockdown properties of fenitrothion sprays on the emerged population of second-instar larvae within the tree canopy. The addition of a second fenitrothion spray 7 days later increased the percentage order of larval reduction for all deposit categories except in F_2 (a non-detectable spray deposit area of tree samples). The data suggest that high dosages of fenitrothion are not necessary to disrupt second- and early third-instar larval activities within the forest canopy. The resurgence of larval populations in the upper branches of the trees after the second application of fenitrothion (Fig. 14a) is evident in all spray deposit categories (3rd post-spray) and would suggest that a third spray application during the early larval activity period might have been very beneficial. Studies by Randall (1970) indicated that the optimum periods for spray application would coincide with periods of (a) initial second-instar appearance and wanderings, (b) needle-mining and (c) initial bud-mining activity. It would appear that if a third spray were to be considered, the 5-day interval between sprays (weather permitting) would cover the emergence parameters for second- and early third-instar activities prior to total bud mining.

Spray Coverage and Reduction of 2nd and 3rd Instar Larvae

A reappraisal of the above data in terms of spray coverage (drops/cm^2) within each dosage category is presented in Table X wherein spray coverage is classified into two main categories, i.e. above 20 drops/cm^2 and below 20 drops/cm^2, for the first spray application and into the expected higher category of ±35 drops/cm^2 for the cumulative deposit for the two spray applications.

Examination of the percent population reduction figures within and between each dosage category shows that a stronger relationship exists between spray coverage in terms of drops/cm^2 and second-instar larval reduction than between volume deposit and larval reduction. This is particularly noticeable in the second and third post-spray population reduction values between the spray deposit categories A, B, C and D, wherein a very high order of larval reduction (74 to 94%) occurred in each of the above categories where spray coverage exceeded 35 drops/cm^2. The relationship also appears to hold true for spray coverage and foliage protection. The results are in close agreement with the earlier experimental findings of Hurtig et al. (1953), where results showed that

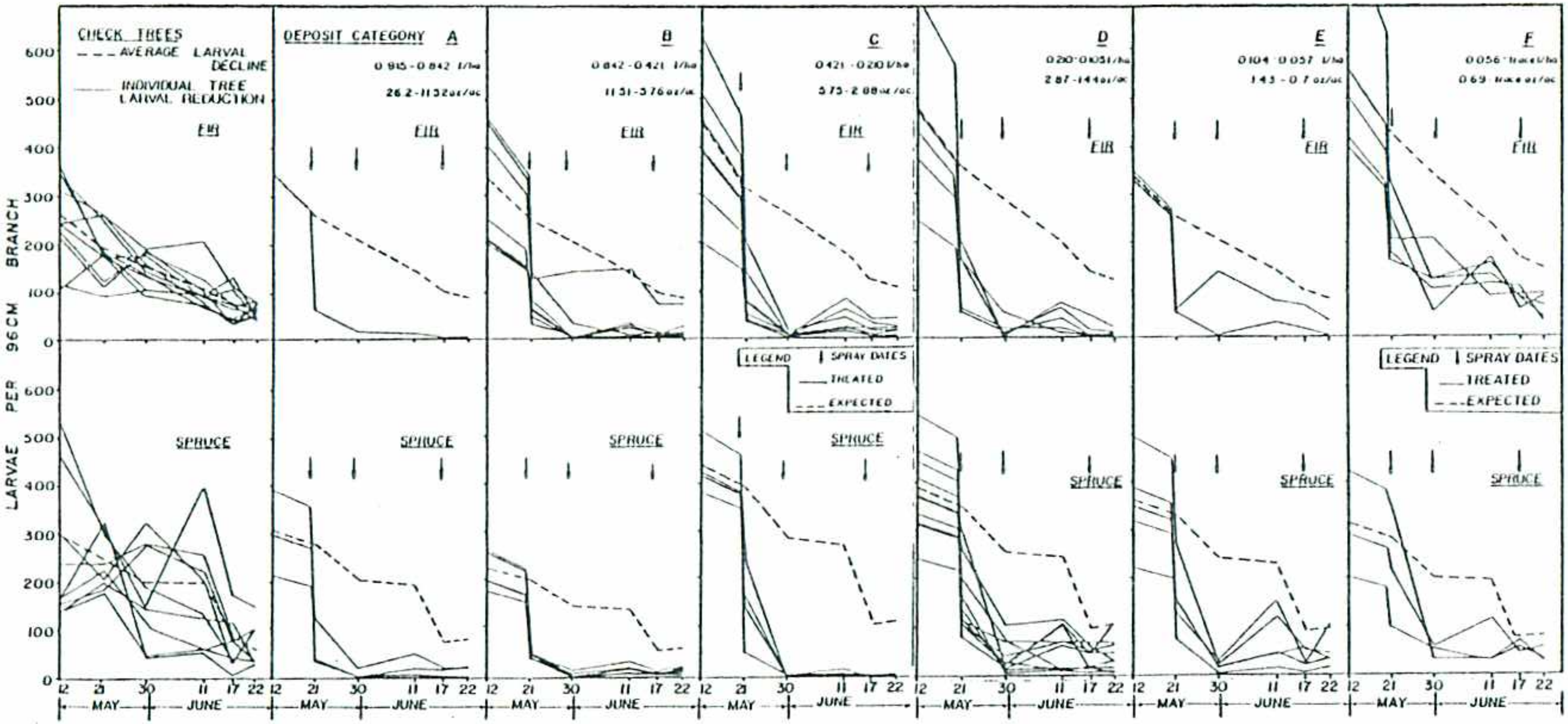

FIG. 14a Larval population (second-& early third-instars) reduction by dosage deposit categories of fenitrothion sprays (based on 1st application deposits).

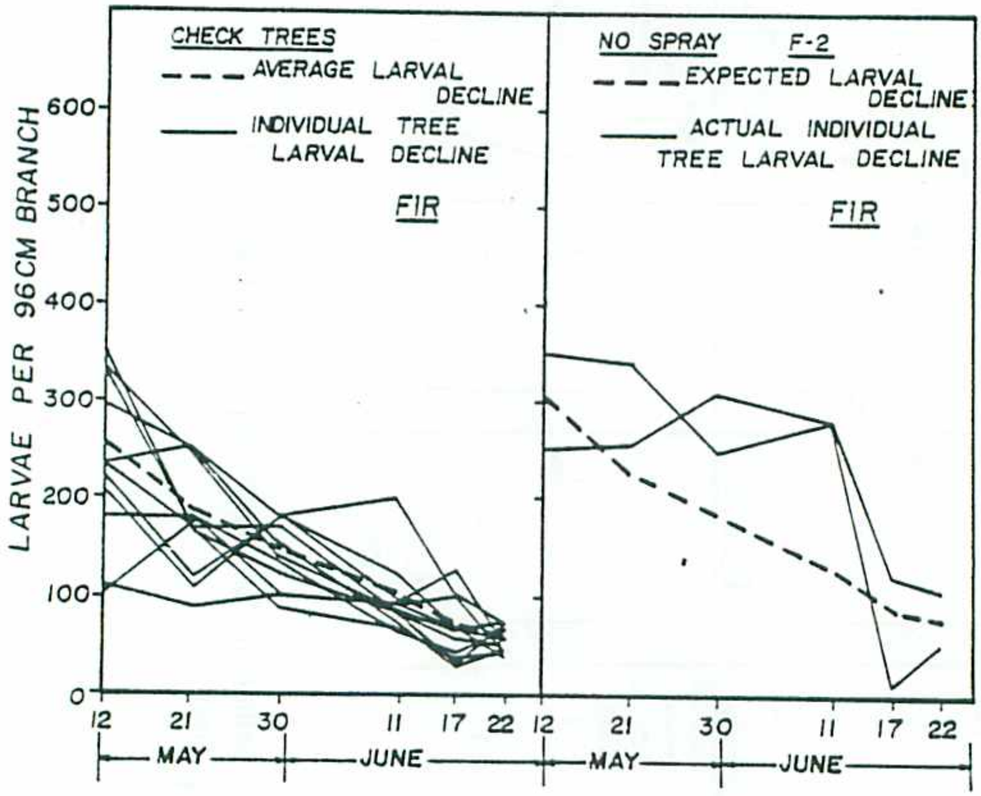

FIG. 14b Larval population decline in non spray area and two tree samples in Block 305 (A-1, A-3) which were located on the upwind side of spray block.

high volume deposit with low drop counts (coarse sprays) produced low population reduction values whereas low volume deposit with high drop counts/cm^2 (fine sprays) produced high population reduction values. These findings apparently hold true for ULV sprays as shown in Table X.

Of greater research interest, however, are the striking results obtained from extremely low deposits of fenitrothion against the second and early third instar larvae as represented by the spray categories E and F, (Fig. 14 a), Table IX and X. By contrast, the check Block C and two sample trees (A-1 and A-3) on the upwind side of Block 305 show a consistent high larval population count throughout the biological sampling program (Fig. 14 b). The data strongly suggest that the early

Table X

Spray coverage (Drops/cm^2) and percentage larval reduction* following the first and second application of fenitrothion sprays
(Condensed from Appendix B Tables I and 2)

Spray Coverage** within Volume Deposit Categories (ℓ/ha) (High vs Low)**	1st Spray (20/5/77) Drops/cm^2	(ℓ/ha)	No. of Samples	Percent Population Reduction* 1st Spray (48 hrs)	Cumulative Deposit 1st + 2nd Spray Drops/cm^2	(ℓ/ha)	No. of Samples	% Population Reduction (1st & 2nd Application) 2nd Post (48 hrs)	3rd Post (10 days)	Percent Defoliation
A (over 0.84) High	54	1.33	3	86.3	70	1.53	3	96.5	94.2	10
A (over 0.84) Low	<20	0.93	1	35.4	<35	1.83	1	83.8	64.3	70
B (0.84 - 0.421) High	24	0.61	8	73.6	37	0.99	4	98.5	83.9	10
B (0.84 - 0.421) Low	<20	0.61	4	67.7	<35	0.79	8	86.6	76.9	39
C (0.42 - 0.210) High	30	0.27	1	87.8	50	0.77	4	99.1	96.8	21
C (0.42 - 0.210) Low	<20	0.29	10	62.9	<35	0.58	7	97.3	78.5	57
D (0.21 - 0.105) High	29	0.17	4	61.1	46	0.38	2	92.7	73.4	40
D (0.21 - 0.105) Low	<20	0.12	11	55.8	<35	0.28	13	87.4	75.6	53
E (0.104 - 0.057) High	-	-	-	-	0	-	-	-	-	-
E (0.104 - 0.057) Low	<10	0.07	7	57	<20	0.18	7	85.6	68.5	57
F_1 (0.056 - Trace) High	-	-	-	-	-	-	-			-
F_1 (0.056 - Trace) Low	<1	0.06	8	35.8	<2	Trace	2	67	51	96
F_2 (No spray)	0	0	2	0	0	0	2	0	0	100

*All calculation based on $\frac{\text{Expected-Actual}}{\text{Expected}}$ X 100 = % Population Reduction (Appendix B, Tables I & II)

**Spray Coverage (drops/cm^2) High = above 20 drops/cm^2 after first spray and above 35 drops/cm^2 cumulative deposit
Low = less than 20 drops/cm^2 after first spray and less than 35 drops/cm^2 cumulative deposit

stages of the spruce budworm larvae are readily dislodged from the tree canopy by small quantities of fenitrothion sprays. The data further confirms the 1976 experimental findings wherein two applications of 0.07 kg AI/ha (1 oz AI/ac) of fenitrothion accounted for the greater part of the second- and early third-instar mortality figures. By contrast, 0.07 kg AI/ha applied at the early fourth instar stage was virtually ineffective (Randall and Desaulniers, unpublished data 1976).

The importance of closely-spaced spray applications appears to be crucial in preventing knocked-down larvae from returning to the upper crown branches. Evidence of the need for sustained chemical stress sprays is shown in Fig. 14(a) on balsam fir trees in deposit categories B and E in which a resurgence of larval numbers occurs on the host trees E-3 (N) and C-4 (Appendix B) because of insufficient spray coverage. In C-4, an increase in larval number, from 48 to 139, was recorded 48 hours after the second fenitrothion spray. The importance of the second fenitrothion spray is illustrated in the spray deposit categories E and F (Fig. 14a) where light deposits of fenitrothion sprays occurred during the first spray application, with correspondingly small decreases in larval reduction. The addition of the second fenitrothion spray resulted in a marked decrease in larval population numbers, especially in category F (spruce). The lack of sufficient spray coverage during the first and second fenitrothion sprays, however, resulted in the establishment of sufficient larvae within the new buds to cause severe defoliation of buds, needles and shoots.

Sample Position Effect, Larval Reduction and Host Tree Defoliation

The presence of numerous dosage/mortality anomalies within the biological data suggests factors other than deposit volumes or coverage that may influence the mortality or population reduction of second-instar larvae and subsequent defoliation of individual host trees. Experimental data have shown that the upwind side of balsam fir and spruce trees consistently received a higher spray deposit than the downwind side of the trees, with significant effects on the resulting mortality of fifth- and sixth-instar spruce budworm larvae (Hurtig et al. 1953). Variation in mean mortality as high as 6% was recorded in favour of the upwind side of sample trees.

To investigate sample position effects, the sample trees were selected on the north and south sides of the east/west Murdochville Road in the event that wind directions during spray application were consistently from either northern or southern quadrants.

Meteorological data (Table II) during both of the early fenitrothion sprays show that prevailing winds were from the northern quadrants (NE and NW) thus suggesting that maximum spray deposition should occur on the northern face of the trees. Maximum spray deposition, therefore, should have occurred on trees selected on the southern side of the road as depicted in Fig. 15.

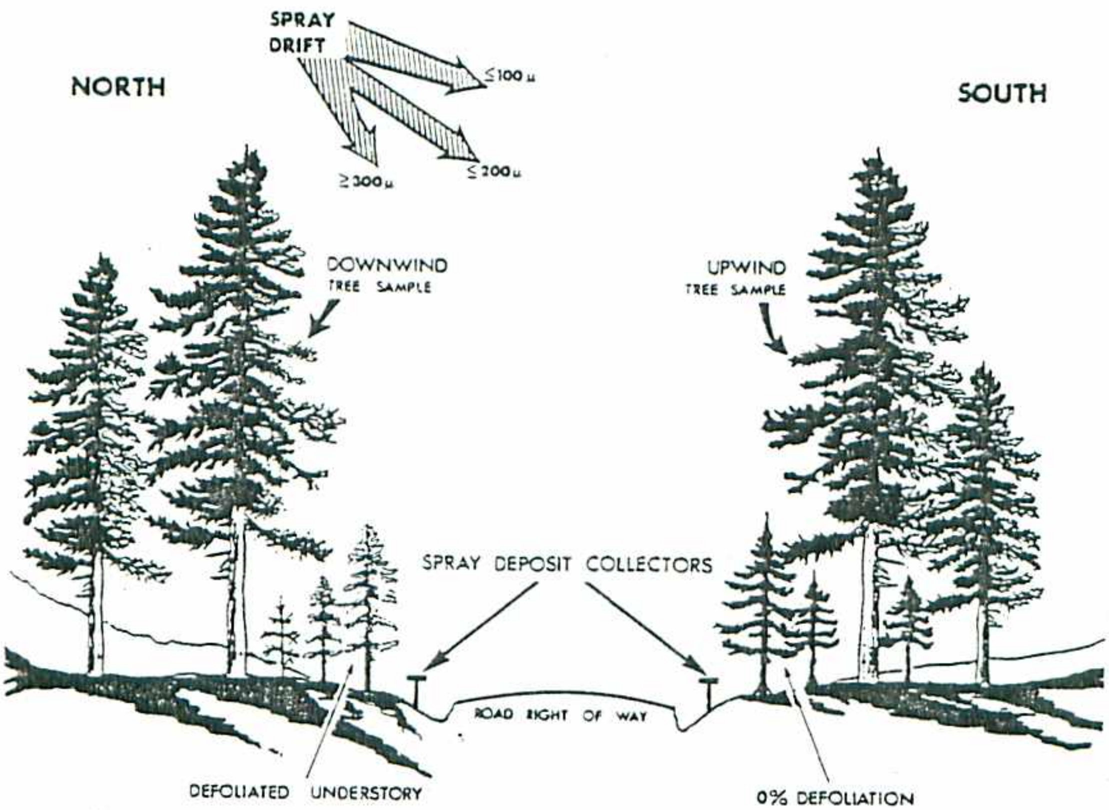

FIG. 15 Position effect of biological tree samples in relation to spray trajectory.

The biological data, therefore, were separated into two main groups, i.e. north sample trees and south sample trees. The data were further divided into volume deposit categories to show variation in larval reduction for each class of spray deposits. The basic data are presented in Appendix B, Tables I and II and summarized by volume deposit categories below in Tables XI and XII for larval survival and percent larval reduction following two applications of fenitrothion sprays.

The data confirm the early experimental findings of Hurtig et al. (1953), and show that, under conditions of high second- and early third-instar larval populations, variations in larval reductions as high as 30% (Tables XI and XII) may occur between upwind and downwind branch samples with resultant defoliation effects as great as 80 to 90% as

Table XI

Position Effect of Branch Samples and Second-Instar
Larval Population Survival (Condensed from Appendix B Table I)

Volume Deposit Category ℓ/ha (oz/ac)	North Side of Road (downwind samples): No. of Tree Samples	North: Pre-spray Larval Counts/ Branch	North: Larval Counts/Branch 1st Spray (48 hrs)	North: Larval Counts/Branch 2nd Spray (48 hrs)	North: Larval Counts/Branch 2nd Spray (10 days)	North: Percent Defoliation	South Side of Road (upwind sample): No. of Tree Samples	South: Pre-spray Larval Counts/ Branch	South: Larval Counts/Branch 1st Spray (48 hrs)	South: Larval Counts/Branch 2nd Spray (48 hrs)	South: Larval Counts/Branch 2nd Spray (10 days)	South: Percent Defoliation
A 0.915-0.842	2 Sp.	252.7	82.5	12.0	33.0	40	1 Sp.	389.0	39.5	5.0	5.0	0-5
(26.2-11.52)	1 B. fir	341.5	59.0	16.5	10.0	5	-	-	-	-	-	-
B 0.84-0.421	2 Sp.	258.3	45.8	13.0	26.5	21	3 Sp.	194.6	45.6	2.3	17.0	5-15
(11.51-5.76)	2 B. fir	297.5	74.0	70.3	81.5	90	5 B. fir	218.4	73.9	6.9	27.0	5-20
C 0.42-0.210	-	-	-	-	-	-	4 Sp.	535.1	150.1	2.8	6.8	30
(5.75-2.70)	2 B. fir	388.8	77.5	5.5	71	70	5 B. fir	432.5	92.8	7.9	25.4	45
D 0.21-0.105	5 Sp.	413.2	197.1	60.3	73.4	78.2	5 Sp.	346.6	109.6	13.5	39.3	26
(2.69-1.44)	2 B. fir	333.0	106.8	6.5	54	100	3 B. fir	508.8	142.7	23.5	28.3	24
E 0.104-0.057	4 Sp.	363.1	158.6	16.5	81.5	73	1 Sp.	318.0	160.5	15.0	47.0	54
(1.43-0.70)	-	-	-	-	-	-	2 B. fir	335.3	54.3	71.8	112.8	78
F_1 0.056-Trace	3 SP.	301.2	239.5	46.5	58.8	85	-	-	-	-	-	-
(0.69-Trace)	1 B. fir	411.5	253.0	52	167.5	75	4 B. fir	574.5	214.5	136.3	120.1	99
F_2 No spray	-	-	-	-	-	-	0					
	2 B. fir	305.0	301.0	281.0	283.0	100	-	-	-	-	-	-

Table XII

Sample Tree Position Effect and Second-Instar
Larval Population Reduction
(Condensed from Appendix B, Table II)

Volume Deposit Category ℓ/ha (oz/ac)	Sample tree position relative to spray drift							
	North side of road (Downwind)				South side of road (Upwind)			
		% Population Reduction				% Population Reduction		
	No. of Samples	1st Spray (48 hrs)	2nd Spray (48 hrs)	2nd Spray (10 days)	No. of Samples	1st Spray (48 hrs)	2nd Spray (48 hrs)	2nd Spray (10 days)
A 0.915-0.842	2 Sp	64.0	93.3	79.2	1 Sp	88.8	98.0	97.9
(26.2-11.52)	1 Fir	76.9	92.0	93.0	–	–	–	–
B 0.84-0.421	2 Sp	80.5	92.0	83.7	3 Sp	73.8	98.2	86.1
(11.51-5.76)	2 Fir	66.7	60.8	34.3	5 B. fir	55.3	94.7	70.4
C 0.42-0.210	–				4 Sp	61.9	99.0	97.5
(5.75-2.70)	2 B. fir	73.3	97.6	56.2	5 B. fir	71.3	96.9	85.9
D 0.21-0.105	5 Sp	47.4	77.8	71.8	5 Sp	65.1	94.1	82.0
(2.69-1.44)	2 B. fir	62.6	96.8	61.1	3 B. fir	62.4	92.3	81.4
E 0.104-0.057	4 Sp	51.8	93.1	64.4	1 Sp	44.3	92.8	76.5
(1.43-0.70)	–	–	–	–	2 B. fir	78.3	64.3	19.3
F_1 0.056-Trace	3 Sp	33.7	76.5	69.0	–	–	–	–
(0.69-Trace)	1 B. fir	17.7	79.0	2.4	4 B. fir	50.0	60.7	49.8
F_2 No spray	–	–	–	–	0	–	–	–
	2 B. fir	0	0	0	0	–	–	–

shown in Fig. 16. These data, however, should be reconfirmed experimentally on individual trees where both sides of the tree surface are used for sampling larval populations and foliage loss. It is quite

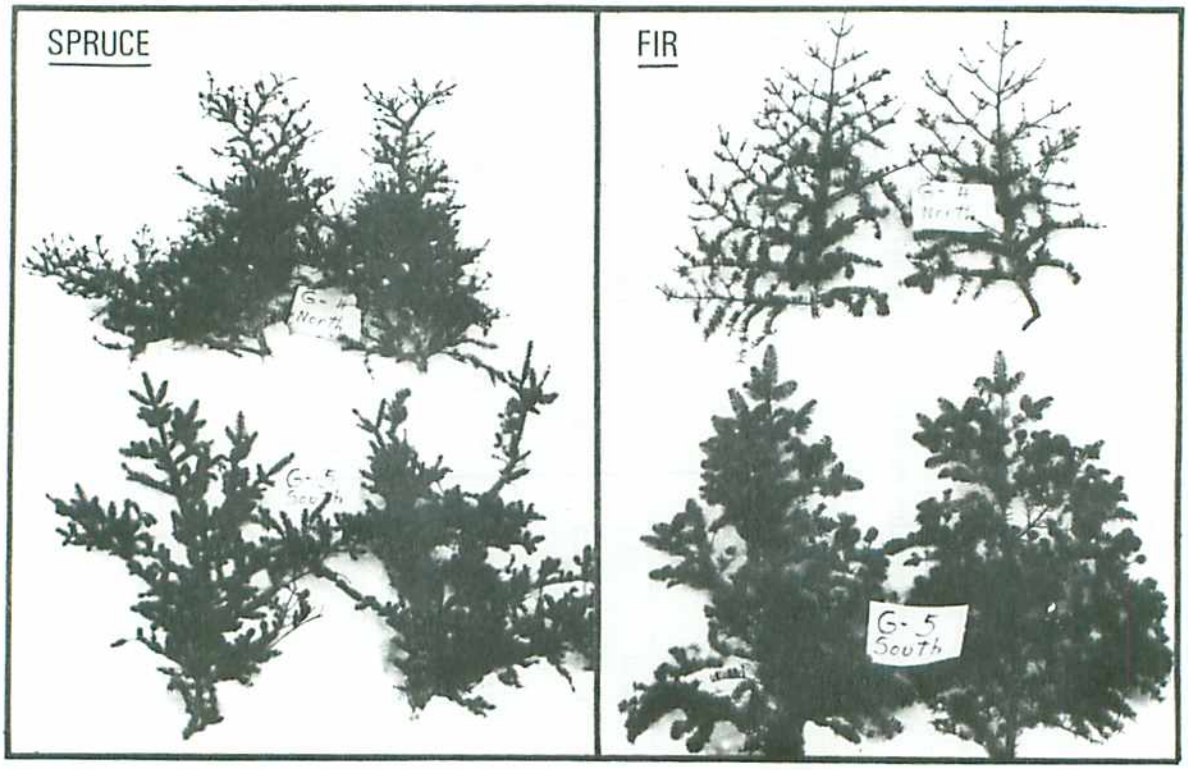

FIG. 16 Variation in extent of defoliation damage on red spruce and balsam fir branch samples taken from the north and south side of a road right-of-way.

conceivable that dosage/mortality results within north and south tree positions may be influenced by meteorological conditions created by the road right of way. This break in the forest canopy may have a significant effect on spray droplet impaction and, hence, larval reduction on trees adjacent to road rights-of-way. This point may be illustrated by the significant defoliation results recorded in Fig. 16 showing branch samples from a north spruce sample G-4* and a south spruce tree sample G-5* as well as adjacent fir trees. The spray deposit and biological data from both tree locations are presented in Table XIII.

Table XIII

Comparative data from biological tree sample positions G-4* North and G-5* South

Sampling Date	G-4*North Larval Counts	Spray Deposits* Drops/cm^2	Fluid oz/ac	G-5*South Larval Counts	Spray Deposit Drops/cm^2	Fluid oz/ac
13/5/77	541			512		
20/5/77	1st spray	9.2	1.6	1st spray	29.5	3.7
21/5/77	117			56.5		
29/5/77	2nd spray	12.7	1.5	2nd spray	39.0	2.4
1/6/77	68			2.5		
9/6/77	69			15.0		
15/6/77	3rd spray	2.3	0.8	3rd spray	6.4	2.0
19/6/77	49			3.0		
23/6/77	62			1.0		
20/3/78	Defoliation - Spruce 60%				Spruce 6%	
	Adjacent B. fir 100				B. fir 5%	

*One fluid oz/ac = 0.073 ℓ/ha

Both tree samples had extremely high populations of budworm larvae prior to spray application. Sample trees were in relatively close proximity (50 m) to each other and thus subject to a similar cloud pattern of spray droplets.

Details of larval counts, spray deposition and host tree defoliation are presented in Table XIII. Evidence of similar examples are presented in Appendix B.

A further observation of the effects of uni-directional spray drift on a forest complex indicated that the phenomenon was not only evident on an individual tree basis, but also in relation to topographic features such as upwind and downwind slopes as shown in Fig. 17. In this particular case the northern slopes would receive maximum spray impaction from both fenitrothion sprays with a resultant protection of a larger

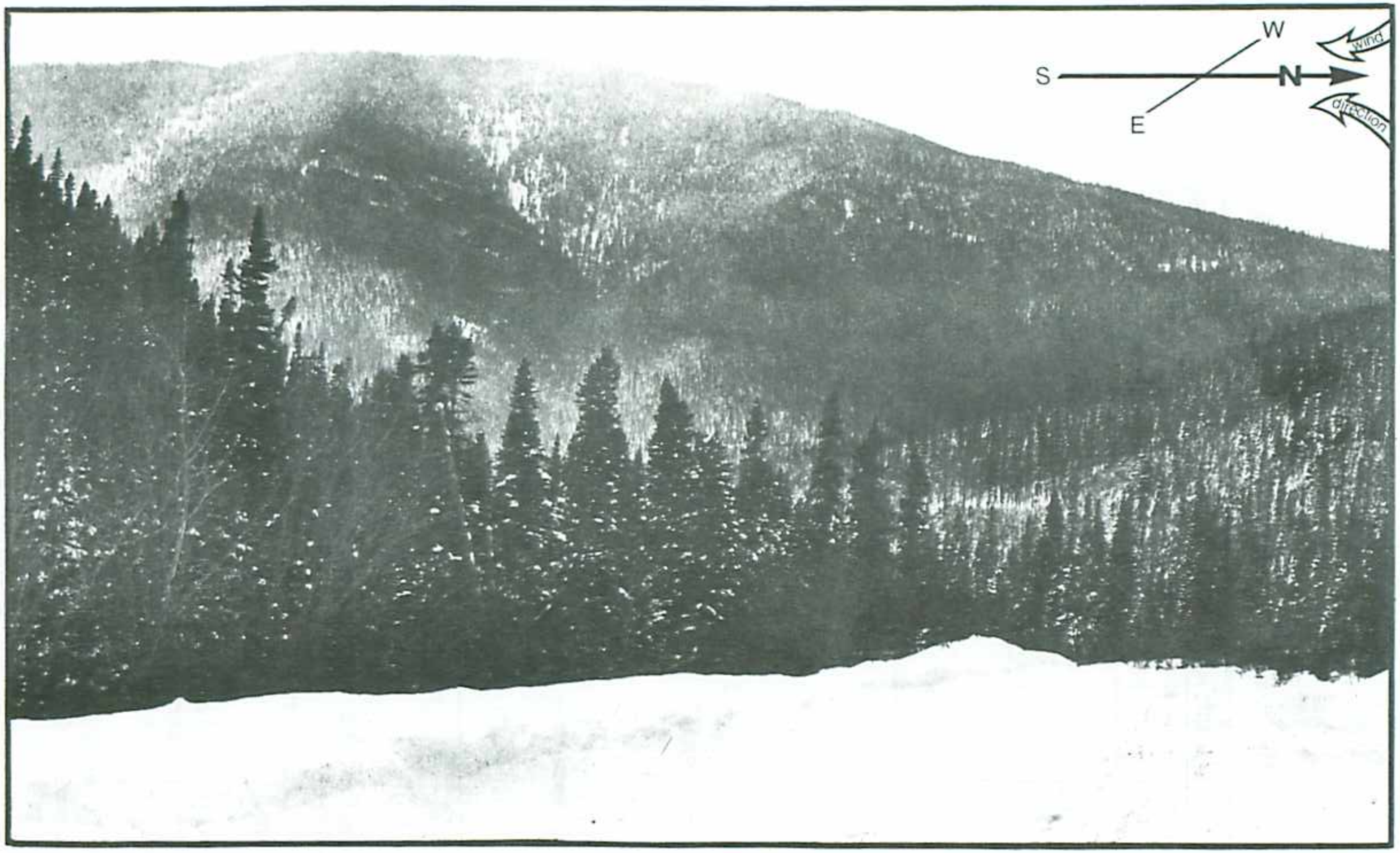

FIG. 17 Effect of topographic features on spray impaction and tree defoliation. [Photo taken from east to west towards sample trees L-1 & L-2 at valley bottom beyond bend in road. Note difference in foliage density on south slopes (downwind) versus that of the north slopes (upwind areas of spray impaction).]

quantity of foliage biomass. The southern slopes, on the other hand, because of the negative slope angle to spray drift, would receive substantially less spray volume and coverage per unit surface area of forest. The resultant effect would be a greater loss of foliage biomass which would be evident, under winter conditions, as light areas on the photograph.

Dosage Deposit Categories vs. Individual Tree Defoliation

The concept of individual tree studies with reference to dosage deposit categories and larval population reduction was extended to include the effect of the latter on host tree defoliation. Sample and adjacent sample trees within each spray deposit category were classified into arithmetic classes of defoliation damage to determine whether foliage protection was a function of spray volume deposits.

The summarized data are presented in Table XIV for balsam fir and spruce trees.

Table XIV

Host Tree Defoliation Damage Within Dosage Volume Deposit Categories (Individual Tree Data)*

Spray Deposit Category (ℓ/ha)	Total Number of Tree Sample	Host Tree Defoliation Category (%)											
		0-19		20-39		40-59		60-79		80-99		100	
		BF	Sp	BF	Sp	BF	Sp	BF	Sp	BF	Sp	BF	Sp
A(over 0.842)	5	1	2	0	0	0	0	0	1	1	0	0	0
B(0.842→0.421)	19	2	6	3	2	1	2	0	0	1	0	1	1
C(0.42→0.21)	16	3	3	1	1	1	2	1	0	2	1	1	0
D(0.21→0.10)	24	3	3	0	1	0	1	1	6	2	2	5	0
E(0.10→0.05)	12	2	1	0	1	1	0	0	1	1	2	2	1
F(0.05→Trace)	21	0	0	0	0	0	0	1	1	3	0	13	3
Sub Total	97	11	15	4	5	3	5	3	9	10	5	22	5
Percent of Total	100	26.8		10.3		8.3		12.4		15.4		27.8	
Non-spray Check Area	20	0	0	0	0	0	0	0	3	4	6	7	0

Surprisingly, many of the trees with very little defoliation damage occurred within the first five spray deposit categories, i.e. A, B, C, D and E. Both species of host trees were represented within these categories thus indicating that foliage protection may not be species-dependent nor dependent on high volume deposits of pesticide formulations. The data, however, suggest that tree sample position effect, i.e. north vs. south side of road (Table XI), may account for the diverse defoliation results.

As expected, spray deposit category F recorded the greater number and degree of foliage loss, thus indicating limitations in the deposit parameters for effective foliage protection. Results within this deposit category are in close agreement with those found in the non-spray check area.

Carryover effects of spray programs on next years' hazard assessments of budworm populations and, hence, tree damage are often very difficult to evaluate unless there are parallel data collected from identical sample trees using identical assessment methods. The collection of a second set of 96-cm branch samples in March 1978 (for confirmation of 1977 defoliation results) provided the opportunity to evaluate the potential second-instar budworm population levels present on the same trees in 1978.

The summarized larval emergence data from the 1978 branch samples, and pre- and post-spray 1977 larval counts from the same sample trees, are presented in Table XV. The data are arranged categorically within spray deposit series A, B, C, etc., to provide a range of post-spray (1977) residual larval populations and, hence, defoliation damage levels within the block.

From the limited data available, it would appear that a very low level of overwintering, vigorous, budworm larvae were present on trees that were severely infested in the spring of 1977. Furthermore, an examination of potential new buds on the 1978 branch samples indicated a substantial gain in buds/branch over that of the preceeding year, thus providing a very low ratio of larvae/bud for the 1978 season. The data further suggests that future tree protection does not occur in category "F" (trace spray deposits) where a loss of new bud development occurred in 1978, with an increase in the ratio of larvae to buds.

Unfortunately, the above data lacks the 1978 information from the check area, but does indicate a potential methodology for the assessment of a hazard index prior to spray application.

Table XV
Comparison of pre-spray 1977 and early spring 1978 average second-instar larval and host tree bud counts (Block 305)

	1977 Volume Deposit Category ℓ/ha (oz/ac)	No. of Tree Samples	1977 Pre-Spray Larval Counts/ 96 cm Branch (12/5/77)	1977 Residual Post-spray Larval Population (23/6/77)	1978 Emergence data (96 cm branch) Ave. Larval Emergence/ 96 cm Branch (April/78)	1978 Emergence data (96 cm branch) Average NaOH Larval Count/br.	Average Buds/ 96 cm Branch 1977 (Pre-spray)	Average Buds/ 96 cm Branch 1978 (March)	1978 Larval Density Larvae/Buds
A	0.84+ (11.52+)	4	309	13	no comparative data		-	-	-
B	0.84-0.42 (11.51-5.76)	9	288	20	27	3.6	58	195	0.138
C	0.42-0.21 (5.75-2.70)	4	368	25	12	4.0	87	127	0.094
D	0.21-0.11 (2.69-1.44)	6	455	31	19	3.8	85	128	0.148
E	0.10-0.05 (1.43-0.70)	3	335	48	14	2.4	51	100	0.140
F	0.05-Trace (0.69-Trace)	3	422	58	26	5.0	83	62	0.419
Check Area		20	249	62	no comparative data		71	-	-

DISCUSSION

Block vs. Individual Tree Analysis

<u>Block Analysis</u>: The original purpose of the spray program was the protection of a valuable forest resource under extreme conditions of biological stress, i.e. unprecedented levels of overwintering second-instar spruce budworm larvae. Assessment of results, therefore, was planned on a global or operational basis to determine the overall effectiveness of three spray treatments under the operational conditions of the program. Success or failure of the operation was judged on the degree of foliage protection and on the extent and numbers of residual population of budworm larvae remaining on the trees.

From an operational point of view, the spray program was a success in spite of the fact that the third spray application of 0.7 kg/ha of aminocarb formulation contributed very little to the control program. Approximately 50% of the current year's foliage was saved with no evidence of tree mortality, as compared to 100% defoliation of new growth on non-sprayed check trees. Larval population counts within the sprayed block were reduced from an average of 367 larvae/96-cm branch to a post-spray level of 56 larvae/96-cm branch (Table V), with a total population reduction of 70.5%. Since normal attrition of budworm larvae during the remainder of the larval period is in the order of 75% (Table IV), the final field population would be reduced through predation, disease, etc., to a level of 13 larvae/96-cm branch, which would be the equivalent of 4 larvae/45-cm branch (foliage area basis).

Analysis of spray deposit data indicated a total deposit of 0.92 ℓ/ha comprised of 0.30, 0.22 and 0.40 ℓ/ha for the first, second and third spray applications respectively. Total volume emitted over the spray block was 2.52 ℓ/ha (34.56 fluid oz U.S./ac) of which 36.5% reached the target area. Since the third spray did not contribute proportionally to the program, the overall cost/benefit of the spraying operation were increased due to the failure of the third application to significantly reduce residual larval population levels.

<u>Individual Tree Analysis</u>: A reassessment of the block data, in terms of spray impact of three separate aerial sprays on individual trees having different topographic locations, defoliation stresses, host tree levels of budworm larvae and subsequent levels of spray deposit densities (volume and coverage), provides a multi-factorial analysis of efficacy levels within the forest canopy, from which research feedback can be obtained to improve future operational spray programs.

A qualitative analysis of the impact of two early applications of fenitrothion sprays against the second and early third instar stages of the spruce budworm larvae reveals that the block average of 50% foliage protection reflects units of total protection (27%), partial protection (45%) and zero protection (28%). It also reveals that the above units are the result of uni-directional sprays and the technique of sampling budworm populations on upwind and downwind portions of the host trees. In numerous cases total protection (less than 10% defoliation) was obtained on trees where larval numbers in excess of 500 larvae/96-cm branch length occurred and where deposit coverage exceeded 40 drops/cm^2. Volume deposits were of less importance than drop coverage/cm^2 in reducing population levels of larvae from the tree canopy and, therefore, represent an undesirable form of pesticide waste and/or pollution.

Dosage/mortality or dosage/efficacy of two applications of fenitrothion sprays, in terms of controlling population numbers of second- and early third-instar larvae within the forest canopy, indicated that extremely small quantities of fenitrothion sprays were effective in dislodging large numbers of these larvae from the host trees. The sequence of dosage efficacy is well illustrated in Fig. 14(a) and supports the concept of minimal quantities of chemicals using multiple applications of low concentrate formulations to disrupt the second-early third-instar larvae from the tree canopy. One may speculate that the results were partially due to knockdown effects by "stressful" concentrations of spray droplets smaller than 30 μ and below the visual identification threshold on the Kromekote cards. Measurements of ground deposits of chemicals, observations of insect mortality in non-target areas and subjective reports of carrier oil odour many miles away from spray operations have indicated that significant quantities of toxic chemicals are translocated by atmospheric transport during large-scale aerial spraying of forests for insect pest control (Yule and Cole 1969). Miller (1958) has indicated that, under certain meteorological conditions of stress, a very high loss of second-instar larvae can occur, thus reducing subsequent foliage destruction. Himel and Moore (1967), and Himel (1969) have reported that the optimum drop size for impingement on budworm larvae is in the order of less than 30 μ and thus below the visual threshold of drop stain sizes on Kromekote cards. The concept of Biological Optimum Droplet Size Ranges (BODS) has been reported by Joyce (1975) on studies against *Heliothis armigera* wherein spray droplets below 50 μ are transmitted from aircraft to the target site (cotton plant terminals) by turbulent diffusion, using wide swath lanes and incremental application technology. This concept is not unlike that employed in the Province of Quebec using DC-6B spray aircraft and incremental spray drift where the VMD and NMD of the spray cloud is in the order of 70 and 40 μ respecitvely.

The importance of the screening effect of coniferous foliage on airborne spray droplets was recorded by Hurtig et al (1953) where 50-60% of the deposited spray volume and, hence, spray droplets falling on the tree silhouette, were screened out by the tree foliage. Furthermore, the screening effect of the foliage appeared to be selective where a preponderance of droplet size classes below 100 μ were recorded on both the upwind and downwind sides of the sample tree as compared to the open ground sample position.

The use of low-concentrate stress sprays applied during the natural dispersal phase of the emerged budworm larvae may provide an environmentally acceptable strategy for budworm control. Confirmation of these findings through additional research and experimentation may well provide a new and bold approach to operational insect control programs since the non-target species of beneficial insects, birds and aquatic fauna appear much later in the spring and thus would not be affected by these early sprays.

SUMMARY

1. Early multiple spray treatment of spruce budworm populations immediately following the first signs of emergence of the second-instar larvae and early third-instar larvae resulted in a high degree of larval reduction and subsequent foliage protection of the host trees (balsam fir, red spruce and black spruce) in spite of the severity of the budworm infestation. Pre-spray larval populations as high as 500+ larvae/96 cm branch length were successfully reduced by two early applications of fenitrothion sprays (30-40 drops/cm^2) to below five larvae/branch with a resultant foliage protection index in the order of 90-95% (Table XIII).

2. An assessment of spray deposition within spray Block 305 indicated that the most consistent feature of unidirectional spray application, with reference to wind direction and hence spray drift, was the under-dosing of the downwind side of the sample trees. This difference had a significant effect on post-spray larval reduction and subsequent defoliation of the host trees.

3. Analysis of the spray droplet spectrum and deposit data obtained from all three sprays indicated problem areas in spray formulation, nozzle adjustment and, possibly, swath tracking which resulted in the extreme variability of spray deposits across the experimental block.

4. An analysis of the biological data in terms of spray deposit coverage (volume deposits and drops/cm^2) and reduction of second- and early third-instar larvae indicates that spray coverage, rather than increased dosage of chemical, accounted for most of the larval reduction and foliage protection. It would appear that the

recommended higher dosage rate of 0.280 kg/ha (4 oz. A.I./acre) per treatment was in excess of that required to provide adequate control of the spruce budworm.

5. The third spray of 0.07 kg/ha (1 oz. A.I./acre) of aminocarb (Matacil®), contributed very little in terms of larval reduction or foliage protection of the host trees. This could be attributed to improper timing recommendations for spray application in terms of the fourth-instar larvae present on the trees, and the lack of consideration of host tree phenology. A late spray should have been applied at the fully flared needle stage of new shoot growth for maximum interception of falling spray droplets at the target site.

6. A study of the effects of extremely light deposits of fenitrothion sprays on second- and early third-instar larval populations strongly indicates that sublethal doses of aerosol-size droplets appear to exert a knockdown or irritant action on the larvae causing them to spin out of the forest canopy. This effect has been observed in the field with late fourth-, fifth- and sixth-instar larvae during the early DDT/oil sprays in New Brunswick. The significance of the removal of the second- and early third-instar larvae from the forest canopy cannot be over-stressed, since the protection of the meristematic tissue within each bud is a prerequisite for the prevention of shoot and foliage damage.

RECOMMENDATIONS

1. Aerial spray equipment and spray formulations that have been modified prior to use on spray programs should be recalibrated to meet the standard specifications for droplet spectrum characteristics and deposit coverage on the type of aircraft scheduled for use on the particular program at the recommended dosage emission rates.

2. Although 0.84 ℓ/ha (11.52 fluid oz/ac) of spray formulation appears to be adequate for controlling the spruce budworm under conditions of gently rolling forest terrain, using multiple sprays and ULV incremental application technology, these volumes are insufficient over rugged terrain where spray emission height and forest canopy surface area are greatly increased. Emission volumes of 1.17 or 1.46 ℓ/ha (16 or 20 oz/ac) per treatment should be considered in order to maintain an adequate deposit (20-40 drops/cm^2) on the target site in accordance with actual topographic surface area.

3. When more than one spray application is recommended, it would be advisable to use wind directions that are 180°, ± 45°, from that which occurred during the first spray application. This would reduce the effect of uni-directional deposits on the same surface of the host tree and thus allow upwind spray impaction on both sides of the host tree for maximum uniformity of deposit on the target site.

4. The concept of using percent emergence of second-instar larvae as an index for the timing of early spray applications is subject to questioning, since it is extremely difficult to determine a total emergence population prior to the date the spray should be applied. A far better criterion would be the use of insect activity such as larval wandering, needle mining and bud mining. These data should be correlated with meteorological data favorable to second-instar activity. It is because of the uncertainty factor of the total emergence period in days that multiple applications using two or three sprays are recommended.

5. The influence of topography, and wind direction relative to topography, requires further investigation in relation to spray deposition and subsequent dosage/mortality results in budworm larvae. Observations suggest that spray deposition follows a pattern of buildup on the windward and on the crowns of ridges or hills with areas of low deposits on leeward slopes and valley bottoms.

6. The experimental data indicate that future field investigations should include research on the contribution of multiple applications of low concentrate ULV sprays of fenitrothion as a lethal-irritant spray against second- and early third-instar larvae of the spruce budworm. The objective of the multiple-spray program is to force the second-instar larvae to disperse from the forest canopy and to prevent their subsequent return to their prime food source. This was the original concept of the 1977 program (Randall and Desaulniers, unpublished).

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REFERENCES

ABBOTT, W.S. 1925. A method for computing the effectiveness of an insecticide. Jour. Econ. Ent. 18:265-267.

ARMSTRONG, J.A. 1977. Relationship between the rates of pesticide application and the quantity deposited on the forest. NRCC/CNRC No. 16073. National Research Council, Ottawa, Canada.

BALCH, R.E. 1952. The spruce budworm and aerial forest spraying. Can. Geographical Jour. Vol. XLV, No. 5:201-209.

DEBOO, R.F., L.M. CAMPBELL, and A.G. COPEMAN. 1973. A sampling technique for estimating numerical trends in larval populations of insect defoliators on conifers. Part I. Phyto-protection 54:9-22.

DESAULNIERS, R. 1977. Programme de Pulverisation Aerienne Contre la Tordeuse en 1977. Information Report. Ministere Des Terres Et Forets. Quebec, Canada.

FETTES, J.J. 1950. Investigations of sampling techniques for population studies of the spruce budworm on balsam fir in Ontario. Forest Insect Lab., Sault Ste. Marie, Ont., Ann. Tech. Rept. (14).

FETTES, J.J. 1960. Control of the spruce budworm by aircraft spraying and the hazard to aquatic fauna. Can. Dept. Agr., Forest Biol. Div., Bi-monthly Prog. Rept. 16(1):1-2. (39).

HIMEL, C.M., and A.D. MOORE. 1967. Spruce budworm mortality as a function of aerial spray droplet size. Science 156:1250-1251.

HIMEL, C.M. 1969. New concepts in insecticides for silviculture and old concepts revisited. Proc. 4th Int. Agric. Aviat. Congr. (Kingston, 1969).

HIMEL, C.M. and U. SOLANG. 1975. The biological optimum spray droplet size. Proc. 5th Int. Agric. Aviat. Congress (Warwickshire, England 1975).

HURTIG, H., J.J. FETTES, A.P. RANDALL, and W.W. HOPEWELL. 1953. A field investigation of the relation between the amount of DDT deposited, the physical properties of the spray and its toxicity to larvae of the spruce budworm (*Choristoneura fumiferana* Clem.). Can. Defense Res. Bd., Suffield Expt. Sta. Tech. Paper No. 176. Part 6.

HURTIG, H., J.J. FETTES, A.P. RANDALL, and W.W. HOPEWELL. 1953. The effect of an early season airplane spray on spruce budworm larvae and tree defoliation. Can. Defense Bd., Suffield Expt. Sta., Tech. Paper No. 31. Part 7.

JOYCE, R.J.V., L.C. MARMOL, and J. LUCKEN. 1969. Swath distribution and aircraft guidance. Proc. 4th Int. Agric. Aviat. Congress (Kingston, Ont., Can. 1969).

JOYCE, R.J.V. 1975. Sequential aerial spraying of cotton at ULV rates in the Sudan Gezira as a contribution to synchrozied chemical application over the area occupied by the pest population. Proc. 5th Int. Agric. Aviat. Congress (Warwickshire, England 1975).

KINGSBURY, P.D. 1978. Aquatic impact studies by FPMI in Quebec Spruce Budworm Spray Block 305, 1977 For. Pest Management Inst., Environ. Can., For. Serv., Rept. FPM-X-12.

MARTINEAU, R., and P. BENOIT. 1973. A sampling technique for estimating numerical trends in larval populations of insect defoliators. Part II. Phytoprotection, 54:23-31.

MILLER, C.A. 1958. The measurement of spruce budworm populations and mortality during the first and second larval instars. Can. J. Zool. 36:409-422.

MILLER, C.A., E.G. KETTELA and G.A. McDOUGAL. 1971. A sampling technique for overwintering spruce budworm and its applicability to population surveys. For. Res. Lab., Fredericton, N.B., Can. For. Serv. Info. Rept. M-X-25.

MORRIS, R.F. 1955. The development of sampling techniques for forest insect defoliators with particular reference to the spruce budworm. Can. J. Zoo. 33:225-294.

MORRIS, R.F. 1960. Sampling insect populations. Ann. Rev. Entomol. 5:243-264.

MORRIS, R.F. 1963. The Dyanmics of Epidemic Spruce Budworm Populations. Memoirs of the Ent. Soc. of Can. No. 31.

PREBBLE, M.L. 1975. Aerial Control of Forest Insects in Canada. Can. For. Serv., Environ., Canada.

RANDALL, A.P. 1969. Some aspects of aerial spray experimentation for forest insect control. Proc. 4th Int. Agric. Invest. Congr. (Kingston, Ont., Can. 1969).

RANDALL, A.P. 1970. Some recent aspects of forest insect control. Sixth Northeast Aerial Applicators Conference, Cornell University, Ithaca, N.Y., U.S.A.

RANDALL, A.P. 1971. Effect of early spring application of ULV aerial sprays of Matacil®, Sumithion® and Zectran® on pre-emergent populations of spruce budworm larvae. Report to Interdepartmental Committee on Forest Spraying Operations. Can. For. Serv. Environ. Can., Ottawa.

RANDALL, A.P. and B. ZYLSTRA. 1972. Evaluation of a modified Douglas DC-7B aircraft and spray system for forest insect control. Chem. Contr. Res. Inst. Can. For. Serv., Info. Rept. CC-X-23.

RANDALL, A.P. 1975. Field evaluation of the Litton LTN-51 inertial guidance system, multi-engine spray aircraft and incremental spraying for the dispersal of liquid insecticides for the control of the spruce budworm *Choristoneura fumiferana* (Clem.) Proc. 5th Int. Agric. Aviat. Congr. Warwickshire, England 1975).

RANDALL, A.P. 1976. "Application technology" in Aerial Control of Forest Insects in Canada, Prebble, M.L. 1976., Can. For. Serv. Environ., Canada.

RANDALL, A.P. and R. DESAULNIERS. (1976 unpublished data). An assessment of the efficacy of early applications of fenitrothion for control of the second instar larvae of the spruce budworm. Report of Annual Forest Pest Control Forum. Can. For. Serv. Environ. Can. pp 106-115.

RANDALL, A.P. 1977. Research developments in aerial application techniques for spruce budworm control in the Province of Quebec (with reference to fenitrothion) NRCC/CNRC No. 16073. National Research Council, Ottawa, Canada.

RANDALL, A.P. 1980. A simple device for collecting aerial-spray deposits from calibration trials and spray operations. Bi-mon. Res. Notes Vol. 36, No. 5, pp 23.

SWAINE, J.M., and F.C. CRAIGHEAD. 1924. Studies on the Spruce budworm. Can. Dept. Agr. Tech. Bull. 37.

WELLINGTON, W.G. 1948. The light reactions of the spruce budworm, *Choristoneura fumiferana* Clemens (Lepidoptera: Tortricidae) Can. Ent. 80:56-82.

YULE, W.N. and A.F.W. COLE. 1969. Measurement of Insecticide drift in forestry operations. Proc. 4th Int. Agric. Congr.

Appendix A

BLOCK 305 1977

Block Analysis

Table I. Spray deposit data Block 305]977

Table II. Biological data collected from non-spray check area "C".

(a) Daily emergence of 2nd instar larvae from 96 cm branch samples (1st count, 12/5/77 Check Block C).

(b) Biological data collected from untreated check plot C to show natural larval population decline with reference to Block 305 spray program.

(c) Spruce budworm larval emergence data (Control Block C) Host tree: Balsam Fir.

(d) 2nd Instar emergence data (Control Block C) Host trees: Black and Red Spruce.

Table III. Biological data collected from Spray Block 305.

(a) Pre-spray daily emergence data of second instar larvae from 96 cm branch sample (1st count).

(b) Total spruce budworm larval data collected from 96 cm branch samples (balsam fir and spruce host trees) during the course of studies on Block 305.

Table IV. Aerial spray deposits of aminocarb formulation (1 oz/ai in 11.52 fluid oz/ac) and summarized biological data at corresponding field sampling positions.

Appendix A

Table 1

Spray Deposit Data Blk. 305 1977

Tree Sample Position	Fenitrothion Formulation (4 oz (ai) in 11.52 oz/ac)						Aminocarb Formulation (1 oz (ai) in 11.52 oz/ac)		
	1st Application (20/5/77)			2nd Application (29/5/77)			3rd Application (16/6/77)		
	Drops /cm²	Fluid oz/ac	Liters/ Hectare	Drops /cm²	Fluid oz/ac	Liters/ Hectare	Drops /cm²	Fluid oz/ac	Liters/ Hectare
A-1 (N)	0.07	trace		0.00	0.00		0.00	0.00	0.00
A-2	0.15	trace		0.00	0.00		0.00	0.00	0.00
A-3 (N)	0.07	trace		0.00	0.00		0.00	0.00	0.00
A-4	0.02	trace		0.00	0.00		0.00	0.00	0.00
A-5 (N*)	0.03	trace		0.00	0.00		0.00	0.00	0.00
A-6	0.01	trace		0.00	0.00		0.00	0.00	0.00
A-7	0.06	trace		1.00	0.10		0.00	0.00	0.00
A-8 (N*)	0.08	trace		0.51	0.06		0.00	0.00	0.00
B-1 (N*)	4.6	1.6	0.12	10.2	1.1	0.08	11.8	9.6	0.70
B-2 (*)	2.5	0.8	0.06	13.7	1.9	0.14	13.7	15.2	1.11
B-3 (*)	3.7	1.4	0.10	14.0	1.9	0.14	18.4	8.4	0.61
B-4 (N*)	5.1	1.4	0.10	3.8	1.6	0.12	12.5	11.3	0.86
B-5 (N*)	4.4	1.3	0.09	3.0	0.8	0.06	4.9	2.1	0.15
B-6 (*)	5.6	2.0	0.15	4.1	0.8	0.06	11.8	4.7	0.34
C-1 (N*)	12.0	4.6	0.34	5.1	1.4	0.10	9.5	4.0	0.29
C-2	11.8	5.0	0.36	5.4	1.0	0.06	19.3	10.0	0.73
C-3	6.0	1.2	0.09	3.6	0.4	0.03	16.4	6.0	0.50
C-4	4.6	0.9	0.06	3.3	0.4	0.03	9.4	11.4	0.83
C-5 (*)	5.4	1.7	0.12	4.6	0.8	0.06	8.9	11.1	0.81
D-1 (N*)	40.0	15.1	1.10	5.0	1.2	0.09	4.5	1.6	0.12
D-2 (N*)	18.3	10.5	0.77	7.3	2.8	0.20	3.3	1.7	0.12
D-3 (N*)	20.8	5.9	0.43	3.3	0.9	0.06	0.1	0.1	0.01
D-4 (N*)	21.6	10.2	0.74	2.1	0.5	0.04	0.1	0.3	0.02
D-5 (N)	20.2	9.5	0.70	7.6	2.8	0.20	0.4	0.4	0.03
E-1	Closed sample			14.3	4.2	0.31	19.2	7.3	0.53
E-2	11.8	6.2	0.45	19.8	6.1	0.44	10.7	5.7	0.42
E-3 (N)	21.4	8.8	0.64	6.0	0.5	0.04	18.8	7.1	0.52
E-4	4.1	3.1	0.23	11.0	4.5	0.33	8.1	3.7	0.27
E-5 (N*)	7.8	4.2	0.31	6.3	1.9	0.14	10.8	4.9	0.36
F-1 (N*)	16.8	12.8	0.93	16.6	12.0	0.88	3.4	2.4	0.17
F-2	25.0	7.3	0.53	Closed sample		—	12.9	5.0	0.36
F-3 (N)	17.3	4.9	0.36	4.6	2.0	0.15	2.7	3.3	0.24
F-4	7.5	2.5	0.18	33.5	6.3	0.46	33.5	20.9	1.53
G-1	27.2	8.4	0.61	52.5	11.0	0.80	12.4	2.1	0.15
G-2 (N)	11.3	4.5	0.33	14.3	8.6	0.63	2.1	0.9	0.06
G-3	18.8	3.9	0.28	23.2	3.9	0.28	9.4	2.1	0.15
G-4 (N*)	9.2	1.6	0.12	12.6	1.5	1.10	2.3	0.8	0.06
G-5 (*)	29.5	3.7	0.27	39.0	4.2	0.31	6.4	2.0	0.15
H-1 (*)	13.1	1.5	0.11	9.7	3.1	0.23	29.0	16.2	1.18
H-2 (N)	78.7	26.2	1.91	30.2	4.1	0.30	14.7	7.5	0.55
H-3 (*)	42.2	13.2	0.96	15.1	2.4	0.17	16.2	7.7	0.56
H-4 (*)	31.0	9.2	0.67	3.2	0.4	0.03	8.2	5.3	0.39
I-1 (N)	13.0	1.6	0.12	3.8	5.2	0.38	2.1	1.8	0.13
I-2 (N*)	29.2	2.4	0.17	2.8	0.7	0.05	2.2	4.0	0.29
I-3	31.5	2.6	0.19	6.5	0.8	0.06	6.3	2.3	0.17
I-4 (N)	27.0	2.4	0.17	0.3	0.2	0.01	1.7	2.2	0.16
J-1 (N*)	7.1	0.7	0.05	1.9	4.6	0.34	2.2	8.6	0.63
J-2 (N*)	4.1	0.4	0.03	3.1	1.2	0.09	11.9	25.4	1.86
J-3 (N)	2.3	0.2	0.01	2.5	0.8	0.06	1.6	2.7	0.20
J-4	29.5	2.3	0.17	24.2	4.8	0.35	23.5	11.0	0.80
J-5 (N*)	4.6	0.7	0.05	6.9	1.6	0.12	10.3	9.4	0.69
K-1 (*)	19.2	2.8	0.20	27.0	8.7	0.63	29.5	7.9	0.58
K-2 (*)	14.1	2.9	0.21	27.5	12.0	0.88	18.7	5.6	0.41
K-3	13.5	4.1	0.30	16.3	3.9	0.28	7.5	2.1	0.15
K-4 (N*)	5.7	2.2	0.16	2.1	0.3	0.02	2.5	3.9	0.28
L-1 (N*)	7.9	1.1	0.08	11.5	2.9	0.21	7.2	9.8	0.72
L-2 (*)	4.1	1.6	0.12	11.2	2.9	0.21	6.3	4.8	0.35
M-1 (*)	25.2	6.7	0.49	15.3	3.9	0.28	6.1	3.8	0.28
M-2 (*)	16.3	7.9	0.58	21.8	6.0	0.44	17.3	3.6	0.26
M-3	15.6	8.7	0.63	22.6	6.0	0.44	5.3	4.5	0.33

NB = 1 oz (US)/ac = 0.0730757 l/ha

N* = balsam fir tree
* = spruce tree
N = north side of road hence downwind sample tree
Unmarked = south side of road hence upwind balsam fir sample tree

Appendix A

Table II(a)

Daily Emergence of 2nd Instar Larvae from 96 cm
Branch Samples (1st Count, 12/5/77 Check Block C)

Tree Sample Number	Branch Position	Larval Counts (Days after Collection) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Larvae remaining in Emergence Boxes after 15 days	Total Larval Counts/Branch
CA-1 *	Top				1	2	36	52	44	26	70	23	10	10	0	–	50	324
	Bottom					4	17	35	46	21	31	62	0	8	0		52	265
CA-2	Top					0	3	4	11	4	6	12	5	7	0		4	56
	Bottom					1	13	24	31	10	42	24	4	6	0		9	164
CA-3 *	Top					0	3	1	6	2	6	15	4	4	8		46	95
	Bottom				3	0	5	23	6	20	38	37	12	3	0		34	181
CA-4	Top					0	26	55	25	37	29	15	14	8	0		20	229
	Bottom					1	25	33	31	34	10	3	6	17	0		19	179
CA-5	Top				1	1	10	28	18	22	10	19	5	0	0		8	122
	Bottom					2	34	57	40	63	7	18	4	0	0		15	240
CA-6	Top					2	20	25	26	19	57	31	11	0	0		14	205
	Bottom					0	15	42	18	32	37	46	17	0	0		26	233
CA-7 *	Top					6	6	9	7	30	27	25	7	4	0		17	138
	Bottom					3	9	10	4	27	12	46	7	3	0		46	167
CA-8 *	Top					4	10	20	15	23	42	34	11	14	0		84	257
	Bottom					1	9	24	15	15	49	31	10	13	0		44	211
CA-9 *	Top					0	3	20	27	27	37	2	10	31	0		72	229
	Bottom					1	5	29	46	39	47	10	12	6	0		47	242
CA-10	Top				1	4	22	18	11	12	16	13	6	3	0		10	116
	Bottom				2	1	14	16	7	3	7	13	10	4	0		15	92
CA-11	Top				1	2	18	66	48	30	46	29	1	1	0		8	250
	Bottom					2	27	29	46	19	46	32	4	5	0		8	218
CA-12 *	Top					1	5	6	27	17	19	21	11	9	0		20	126
	Bottom					0	6	13	42	28	39	36	7	6	0		17	194
CA-13 *	Top					0	13	22	25	19	13	12	4	4	0		11	123
	Bottom				2	2	19	31	34	27	22	13	9	4	0		44	207
CA-14	Top					6	41	70	27	36	50	63	15	0	0		69	377
	Bottom				2	–	38	55	37	57	4	27	17	0	0		20	257
CA-15 *	Top					2	12	65	84	47	81	67	24	8	0		75	465
	Bottom				3	2	35	113	81	63	163	60	13	7	0		44	584
CA-16	Top				1	5	47	94	110	69	56	17	23	0	0		23	445
	Bottom					4	33	40	48	35	23	57	5	0	0		8	253
CA-17	Top				1	12	22	124	34	46	32	36	33	0	0		20	360
	Bottom				2	12	40	57	48	28	36	39	10	0	0		40	312
CA-18 *	Top				1	1	20	57	69	62	139	52	26	20	0		123	570
	Bottom				4	5	17	22	58	34	38	32	7	15	0		122	354
CA-19	Top					4	17	42	15	12	27	34	26	0	0		58	235
	Bottom					3	18	48	28	37	21	39	20	0	0		29	243
CA-20	Top				2	1	37	78	44	79	56	26	3	10	0		14	350
	Bottom					3	26	60	48	59	59	30	10	4	0		8	317
Totals					27	100	776	1627	1387	1270	1550	1201	442	234	8		1373	9995

* = spruce host trees

Table 11(b)

Biological data collected from the untreated check Plot C to show natural larval population decline with reference to Block 305 spray program.

Tree Sample	Spruce Budworm Emergence Populations (2nd, 3rd and 4th instars) 1st Pre Spray 12/5/77	1st Post Spray 21/5/77	2nd Post Spray 30/5/77	3rd Post Spray 11/6/77	4th Post Spray 17/6/77	5th Post Spray 22/6/77	Pre Spray Buds/Branch	Percent Defoliation
CA-1*	294	202	319	199	27	98	151	96
CA-2	110	89	101	94	33	72	118	100
CA-3*	138	173	46	57	27	6	30	61
CA-4	205	109	188	99	74	39	29	100
CA-5	181	181	134	65	44	66	35	100
CA-6	219	118	181	124	70	85	78	100
CA-7*	152	182	272	220	72	99	84	99
CA-8*	236	236	275	254	91	-	104	71
CA-9*	235	194	140	121	113	36	72	85
CA-10	104	174	89	68	38	44	82	99
CA-11	234	170	129	91	69	77	44	100
CA-12*	165	325	39	50	5	22	15	100
CA-13*	165	222	105	59	39	33	46	81
CA-14	304	259	185	202	111	73	58	100
CA-15*	525	298	186	128	40	-	29	99
CA-16	349	170	170	86	61	56	45	100
CA-17	336	246	140	89	103	56	139	99
CA-18*	454	312	173	399	168	149	154	44
CA-19	239	254	157	77	31	50	67	82
CA-20	334	182	102	94	129	50	51	-
Total	499	407	3131	2575	1345	1111	1431	
Avg.	248.9	204.8	156.5	128.7	67.2	61.7	71	90
% Population Decline	0	18	37	48	73	75	-	-
% Population Survival	100	82	63	52	27	25	-	-

* = spruce host trees

Appendix A

Table II(c)

Spruce Budworm Larval Emergence Data (Control Block C)

Host Tree: Balsam Fir

Tree Sample	*	Sampling Schedule (12/5/77)	(21/5/77)	(1/6/77)	(9/6/77)	(19/6/77)	(23/6/77)	Buds /Br.	Percent Defoliation
CA-2	T	56	74	54	99	18	100	146	100
	B	164	104	148	89	48	44	90	100
CA-4	T	229	124	267	65	69	47	29	100
	B	179	95	109	134	79	32	28	100
CA-5	T	122	135	166	76	60	51	47	100
	B	240	227	101	54	28	81	24	100
CA-6	T	205	130	157	97	66	119	109	100
	B	233	105	204	151	75	50	47	100
CA-10	T	116	200	85	38	50	59	83	99
	B	92	148	92	98	27	29	81	99
CA-11	T	250	138	103	55	90	129	63	100
	B	218	202	155	127	38	25	21	100
CA-14	T	352	218	144	268	101	86	102	100
	B	257	301	225	137	121	60	15	100
CA-16	T	445	238	202	82	51	66	68	100
	B	253	103	139	91	70	48	22	100
CA-17	T	360	228	118	71	102	38	172	98
	B	312	264	162	106	104	73	106	100
CA-19	B	243	167	158	35	20	37	86	73
CA-20	T	250	222	147	113	147	37	62	92
	B	317	141	56	75	112	62	40	-
Total	T	2720	2049	1600	1084	796	794	930	
	B	2508	1857	1551	1097	722	541	560	
Ave.	T	247.3	186.3	145.4	98.5	724	72.2	84	98.9
	B	228.0	168.8	141.0	99.7	65.6	49.2	51	97.2
Ave/Br		237.6	177.6	143.2	99.1	69.0	60.7	68	98%
Percent Survival		100	74.7	60.3	41.7	29.0	25.5		

*T = Top 96 cm branch sample
B = Mid-crown 96 cm branch sample

Appendix A

Table II(d)

2nd Instar Emergence Data (Control Block C)

Host Trees: Black & Red Spruce

Tree Sample	*	Sampling Schedule (12/5/77)	(21/5/77)	(1/6/77)	(9/6/77)	(19/6/77)	(23/6/77)	Buds /Br.	Percent Defoliation
CA-1	T	324	214	327	210	27	142	204	100
	B	265	190	311	189	26	55	99	93
CA-3	T	95	166	51	80	27	8	34	65
	B	181	181	41	35	26	4	25	57
CA-7	T	138	216	305	256	99	122	67	100
	B	167	146	240	184	45	77	101	98
CA-8	T	261	228	391	220	126	-	162	48
	B	211	245	160	288	57	140	46	94
CA-9	T	229	231	127	110	125	45	98	76
	B	242	156	152	133	101	27	46	93
CA-12	T	136	393	28	60	8	30	14	99
	B	194	257	50	40	2	13	15	100
CA-13	T	123	175	95	72	39	53	36	72
	B	207	270	115	44	-	13	55	91
CA-15	T	465	370	180	116	33	-	45	99
	B	584	226	193	91	47	48	13	99
CA-18	T	570	228	85	285	158	167	161	31
	B	338	297	261	513	177	132	147	57
Total	T	2341	2221	1589	1409	642	567	821	
	B	2389	2068	1523	1567	481	461	547	
Ave.	T	260.1	246.8	176.6	156.6	71.3	81.0	91	76.7
	B	265.4	229.8	169.2	174.1	60.1	57.6	61	86.9
Ave/Br		262.7	238.3	172.9	165.4	65.7	69.3	76	81.7%
Percent Survival		100	90.7	65.8	63.0	25.0	26.5		

*T = Top 96 cm branch sample
B = Mid-crown 96 cm branch sample

Appendix A

Table III(a)

Pre-spray daily emergence data of second-instar larvae from 96 cm branch sample (1st count)

Free Sample Number	Branch Position	Spruce budworm larval counts (Days After Collection) 1	2	3	4	5*	6*	7*	8	9	10	11	12	13	14	15	Larvae Remaining in Emergence Boxes After 15 Days	Total (Larvae/Branch) Balsam fir	Spruce sp.
A-1 (N)	T						5	9	36	19	17	46	61	13	13	10	7	257	
	B						5	29	29	20	15	16	22	12	14	11	81	245	
A-2	T					4	15	60	47	31	33	87	79	16	7	4	42	426	
	B						11	66	44	15	19	15	19	18	24	19	31	36	
A-3 (N)	T						4	70	79	125	5	29	18	3	22	6	55	443	
	B						3	32	21	108	5	27	5	3	21	3	12	255	
A-4	T						15	78	62	59	64	53	46	27	21	11	24	460	
	B					2	7	109	73	64	67	93	32	23	10	12	29	333	
A-5 (N*)	T					1	6	30	47	33	32	63	90	9	13	5	9		340
	B					1	6	21	26	11	23	39	57	11	24	12	4		235
A-6	T					21	40	107	95	112	49	66	87	78	37	30	25	707	
	B					2	18	101	41	36	37	33	61	19	29	30	17	424	
A-7	T					22	32	190	27	61	28	134	75	68	12	4	51	706	
	B					27	49	277	30	131	34	147	113	32	20	21	48	979	
A-8 (N*)	T					5	9	31	34	46	8	34	23	20	13	5	13		141
	B						2	32	20	35	3	18	9	3	17	7	2		153
B-1 (N*)	T					3	9	28	65	50	45	33	31	11	13	12	54		354
	B					2	1	19	33	18	34	33	52	13	4	5	8		274
B-2 (*)	T					2	5	11	35	19	25	123	64	15	14	9	3		322
	B						4	40	63	35	47	20	80	13	3	5	2		314
B-3 (*)	T					3	10	25	41	74	5	42	15	18	17	5	31		291
	B					2	8	49	59	152	8	23	20	5	21	7	21		375
B-4 (N*)	T						5	9	31	23	47	28	46	23	10	3	19		251
	B					2	4	30	60	48	36	119	119	19	7	3	43		492
B-5 (N*)	T					1	1	32	31	85	24	11	9	7	12	4	5		213
	B					4	10	64	74	127	54	54	36	25	20	15	23		466
B-6 (*)	T						4	68	190	153	45	55	35	32	24	7	17		530
	B						5	46	50	73	5	17	19	19	3	5	3		254
C-1	T							14	26	14	10	24	38	10	4	3	2	145	
	B						1	20	16	30	25	57	21	4	12	11	1	251	
C-2	T						5	41	62	95	20	16	52	64	15	15	43	149	
	B						2	27	36	65	7	78	13	18	24	8	29	320	
C-3	T						5	56	67	28	48	75	38	7	2	5	10	341	
	B						3	51	55	23	42	30	41	6	8	12	20	311	
C-4	T						5	31	59	90	24	38	15	21	14	2	62	361	
	B						1	25	79	80	12	46	17	10	14	9	23	328	
C-5 (*)	T						3	46	52	104	31	25	21	13	18	6	12		331
	B					1	1	29	34	47	36	38	18	22	18	5	24		293
D-1 (N*)	T					2	2	13	44	40	4	27	38	13	9	3	13		238
	B						7	25.	80	72	17	44	16	24	29	5			351
D-2 (N*)	T					2	0	24	53	55	24	27	20	19	15	6	0		246
	B						1	24	27	34	12	26	7	12	6	3	5		157
D-3 (N*)	T							1	12	34	12	17	15	17	16	15	82		221
	B							17	22	44	21	47	33	13	31	12	54		304
D-4 (N*)	T							13	10	23	4	34	21	20	9	7	61		231
	B						3	11	18	42	13	65	43	39	17	11	42		306
D-5 (N)	T					1	15	17	16	19	7	25	14	9	15	1	10	152	
	B						4	22	37	24	10	53	33	6	17	8	25	250	
E-1	T							25	73	75	22	49	50	25	44	10	12	296	
	B							9	36	41	3	52	25	21	17	3	10	222	
E-2	T						3	13	33	111	7	146	17	18	18	5	12	285	
	B						1	8	50	93	42	26	80	87	14	9	50	315	
E-3 (N)	T							25	52	85	45	46	91	58	22	3	50	447	
	B							14	32	51	14	106	52	25	20	7	20	341	
E-4	T							14	41	93	24	127	120	59	45	14	56	613	
	B							12	53	25	9	36	33	32	19	3	60	292	
E-5 (N*)	T							5	20	55	27	119	83	56	24	6	20		418
	B							10	26	60	22	91	66	39	8	3	25		350
F-1 (N*)	T							5	12	29	13	29	29	26	10	4	20		178
	B							25	28	31	10	39	36	28	12	4	3		244
F-2	T						1	34	90	108	19	105	44	32	31	12	20	316	
	B							15	33	66	11	91	34	30	23	4	37	364	
F-3 (N)	T					1	0	8	20	27	13	120	32	14	14	5	30	257	
	B						1	4	14	42	19	138	25	11	11	4	24	303	
F-4	T							10	37	36	15	138	45	17	22	7	19	347	
	B							2	24	44	27	105	99	22	9	12	38	297	
G-1	T							2	20	98	13	17	21	12	5	2	24	165	
	B							3	48	117	11	23	7	4	3	2	7	229	
G-2 (N)	T					1	0	10	42	29	16	123	107	18	10	21	23	410	
	B					1	3	7	46	63	19	99	69	20	10	3	14	366	
G-3	T						1	12	48	24	49	43	56	33	21	10	19	146	
	B						6	33	178	84	103	69	25	22	27	4	25	568	

Appendix A

Table III(a) continued

Pre-spray daily emergence data of second-instar larvae from 96 cm branch sample (1st count)

Tree Sample Number	Branch Position	Spruce budworm larval counts (Days After Collection) 1	2	3	4	5*	6*	7*	8	9	10	11	12	13	14	15	Larvae Remaining in Emergence Boxes After 15 Days	Total (Larvae/Branch) Balsam fir	Spruce sp.
G-4 (N*)	T					1	3	7	34	63	17	67	71	105	78	15	34		395
	B						6	29	110	92	24	65	81	39	88	10	44		588
G-5 (*)	T						1	52	94	109	23	48	35	10	35	19	32		368
	B					1	3	41	47	78	15	40	77	80	50	4	21		436
H-1 (*)	T						2	10	37	64	20	34	67	25	32	14	37		393
	B					1	2	28	36	54	28	60	41	70	47	5	49		421
H-2 (N)	T						3	22	47	42	25	37	36	20	54	1	44	341	
	B					4	7	24	35	40	14	26	30	28	48	4	52	342	
H-3 (*)	T						4	28	65	71	26	37	61	23	42	7	35		471
	B					1	2	26	41	72	14	54	26	26	4	5	16		307
H-4 (*)	T					2	1	5	33	74	15	40	24	6	33	4	18		255
	B						2	5	13	29	11	14	11	15	13	3	32		148
I-1 (N)	T						3	13	37	55	26	41	24	11	36	4	38	290	
	B						1	5	14	30	12	42	28	10	22	3	22	189	
I-2 (N*)	T					5	7	16	66	101	56	88	91	18	44	14	67		373
	B							8	47	58	36	72	34	28	44	2	32		361
I-3	T					1	12	69	128	193	96	167	77	32	75	12	50	722	
							8	45	65	170	37	83	45	23	49	11	7	534	
I-4 (N)	T					4	0	62	64	92	24	109	68	9	39	5	75	331	
	B					2	18	26	78	27	39	39	36	22	25	6	23	302	
J-1 (N*)	T					3	4	22	29	89	23	45	51	23	28	5	12		334
	B					2	10	42	69	126	45	137	66	32	68	7	52		556
J-2 (N*)	T					3	5	29	43	79	28	34	81	22	40	17	101		352
	B							14	4	58	18	34	46	27	18	4	59		266
J-3 (N)	T					1	2	19	20	61	16	61	49	36	48	2	66	381	
	B					1	4	19	18	32	27	77	69	37	25	4	109	442	
J-4	T						2	23	46	93	24	106	66	29	33	8	133	573	
	B							7	20	53	15	30	62	28	39	5	111	370	
J-5 (N*)	T						1	9	19	73	45	96	69	20	37	11	55		435
	B						4	15	30	92	22	45	47	28	10	5	45		343
K-1 (*)	T						2	13	1	92	52	107	81	36	28	10	67		489
	B					2	1	8	1	66	28	68	86	23	22	3	56		364
K-2 (*)	T						2	21	86	122	43	94	73	9	21	1	19		491
	B						2	6	46	56	68	39	46	14	19	7	22		345
K-3	T						3	45	55	104	53	206	88	37	39	11	91	734	
	B						2	34	40	91	44	106	67	37	21	3	62	507	
K-4 (N*)	T					1	3	25	54	38	32	116	64	13	30	5	54		436
							4	12	34	55	21	33	59	4	21	8	37		308
L-1 (N*)	T							19	53	36	24	49	36	9	19	2	20		257
	B						2	2	27	24	27	21	25	5	10	3	25		171
L-2 (*)	T						8	10	42	64	28	44	56	12	9	5	50		329
	B						2	7	9	39	12	19	23	3	9	3	24		150
M-1 (*)	T					1	2	21	40	24	9	45	44	16	10	3	19		233
	B					3	1	4	11	7	4	5	4	3	13	8	58		123
M-2 (*)	T						1	8	25	42	7	46	37	5	12	1	12		194
	B					1	3	14	31	35	30	38	17	7	11	8	18		222
M-3	T					2	3	24	31	75	25	43	43	8	10	6	30	300	
	B					1	1	14	28	35	16	24	20	1	4	4	39	187	
Totals						153		3543		7580		7520		2731		900	4172	13298	20820
							513		5361		3145		5707		2793				
Bottom Totals		20665				Average	344.4											Total Spruce and Fir	
Top Totals		23453				Average	390.9											44118	

BF = balsam fir tree
* = spruce tree
N = north side of road hence downwind sample tree
Unmarked = south side of road hence upwind balsam fir sample tree

Table III(b)

Appendix A

Total spruce budworm larval data collected from 96 cm branch samples (balsam fir and spruce host trees) during the course of studies on Block 305.

SAMPLING SCHEDULE

Tree Sample	Branch Position	Pre-Spray (12/5/77)	1st Post (21/5/77)	2nd Post (1/6/77)	3rd Post (9/6/77)	4th Post (13/6/77)	5th Post (22/5/77)	Defoliation (%) Sample Tree	Adj. Tree
A-1 (M)	T	267	229	195	231	119	53	100	100 (Spruce)
	B	253	289	427	236	128	172		
A-2	T	426	188	103	175	76	48	100	100 (Spruce)
	B	361	136	150	95	37	41		
A-3 (M)	T	443	409	136	175	16	59	95	100 (Spruce)
	B	265	220	148	227	14	53		
A-4	T	463	214	148	98	149	50	100	100 (Spruce)
	B	513	125	48	127	57	13		
A-5 (M*)	T	340	99	51	139	39	10	100	100 (B. fir)
	B	235	233	43	49	52	103		
A-6	T	707	219	110	169	96	61	100	100 (Spruce)
	B	426	421	125	126	67	26		
A-7	T	706	161	291	66	129	117	100	100 (Spruce)
	B	979	264	122	106	42	62		
A-8 (M*)	T	241	96	17	43	67	27	100	100 (B. fir)
	B	153	102	38	20	50	43		
Average	T	448.7	202	133.3	143.2	86.1	53.1		
	B	399.4	242.3	170.5	155.3	54.6	49.0		
B-1 (M*)	T	354	263	62	115	54	33	70	60 (B. fir)
	B	274	255	144	-	58	26		
B-2 (*)	T	322	174	15	29	17	44	50	85 (B. fir)
	B	216	157	15	55	19	22		
B-3 (*)	T	191	69	20	93	31	25	10	- (B. fir)
	B	275	137	14	111	6	25		
B-4 (M*)	T	251	306	26	124	65	55	95	100 (B. fir)
	B	472	276	3	98	16	21		
B-5 (M*)	T	213	104	27	129	22	92	100	100 (B. fir)
	B	485	154	26	171	22	121		
B-6 (*)	T	630	155	4	10	14	18	70	100 (B. fir)
	B	254	119	12	23	15	12		
Average	T	343.5	178.5	27.2	83.3	30.5	44.7		
	B	363.8	183.5	37.0	91.5	26.0	39.3		
C-1	T	145	38	4	27	19	37	10	10 (Spruce)
	B	241	43	5	25	19	14		
C-2	T	449	38	3	21	12	21	15	20 (Spruce)
	B	330	41	19	19	7	7		
C-3	T	341	45	8	31	16	2	10	20 (spruce)
	B	111	55	1	31	13	4		
C-4	T	361	50	172	82	68	58	55	-
	B	325	57	108	49	66	17		
C-5 (*)	T	331	30	17	83	41	136	30?	-
	B	293	68	9	28	46	33		
Average	T	325.4	38.2	40.3	48.8	31.2	54.8		
	B	300.6	52.8	28.6	26.4	31.2	19.8		
D-1 (M*)	T	238	51	2	23	16	29	10	-
	B	253	32	1	13	11	19		
D-2 (M*)	T	246	41	1	7	3	15	5	-
	B	157	61	4	10	7	5		
D-3 (M*)	T	221	37	8	42	39	32	20	(B. fir)
	B	204	66	21	21	-	13		
D-4 (M*)	T	202	26	13	13	10	23	20	25 (B. fir)
	B	204	54	7	11	5	26		
D-5 (M)	T	152	17	2	18	5	16	95	-
	B	220	40	3	23	3	24		
Average	T	211.8	34.4	5.2	21.3	14.6	23		
	B	223.8	50.4	9.0	19.2	5.5	19.2		
E-1	T	396	124	3	22	4	13	5	5 (Spruce)
	B	222	127	7	35	1	7		
E-2	T	395	132	21	4	-	3	15	50 (Spruce)
	B	515	138	22	4	-	15		
E-3 (M)	T	467	87	57	149	53	88	100	100 (Spruce)
	B	241	152	223	217	83	48		
E-4	T	513	166	0	17	4	11	75	-
	B	292	110	1	12	9	47		
E-5 (*)	T	418	175	0	5	6	14	50	-
	B	350	149	2	6	4	3		
Average	T	451.8	138.8	42.2	43.2	16.3	25.8		
	B	344.0	123.2	51.0	59.6	24.0	24.2		
F-1 (M*)	T	178	115	3	31	12	10	70	90 (B. fir)
	B	244	122	42	44	30	31		
F-2	T	316	77	5	22	10	9	20	-
	B	264	76	2	18	12	2		
F-3 (M)	T	287	96	11	76	15	52	90	90 (Spruce)
	B	303	77	3	38	73	37		
F-4	T	347	65	24	20	1	7	5	-
	B	297	58	12	7	1	2		
Average	T	332.0	85.8	10.8	39.8	9.8	19.5		
	B	277.0	85.8	15.7	49.3	29.5	18.0		

Appendix A

Table III(b)—continued

Total spruce budworm larval data collected from 96 cm branch samples (balsam fir and spruce host trees) during the course of studies on Block 305.

SAMPLING SCHEDULE

Tree Sample	Branch Position	Pre-Spray (12/5/77)	1st Post (21/5/77)	2nd Post (1/6/77)	3rd Post (9/6/77)	4th Post (19/6/77)	5th Post (23/6/77)	Defoliation (%) Sample Tree	Defoliation (%) Adj. Tree
G-1	T	165	47	1	1	1	0	5	0 (Spruce)
	B	229	51	0	2	1	0		
G-2 (N)	T	410	36	1	48	16	13	80	50 (Spruce)
	B	266	53	4	73	42	16		
G-3	T	346	26	0	16	4	0	10	-
	B	448	41	1	10	1	0		
G-4 (N*)	T	495	141	43	36	27	52	70	100 (B. fir)
	B	188	94	71	102	59	72		
G-5 (*)	T	568	69	1	12	5	0	5	5 (B. fir)
	B	436	44	4	18	1	2		
Average	T	396.8	75.8	13.6	22.6	13.0	13.0		
	B	461.4	38.6	16.0	41.0	10.8	22.0		
H-1 (*)	T	393	73	12	6	2	5	15	-
	B	421	159	37	9	4	8		
H-2 (N)	T	341	55	5	9	1	3	5	-
	B	242	63	27	11	2	1		
H-3 (*)	T	471	37	7	7	4	3	5	-
	B	307	42	3	3	0	1		
H-4 (*)	T	255	45	0	15	1	14	5	-
	B	148	40	3	23	2	8		
Average	T	365.0	52.5	6.3	9.3	2.0	6.5		
	B	304.5	75.9	21.3	11.5	2.0	4.5		
I-1 (N)	T	290	72	10	43	6	4	100	75 (Spruce)
	B	189	27	11	32	1	5		
I-2 (N*)	T	573	104	44	36	64	74	85	-
	B	341	109	32	99	73	58		
I-3	T	922	186	4	70	17	5	90	70 (Spruce)
	B	334	217	3	48	16	16		
I-4 (N)	T	551	193	3	72	8	22	100	75 (Spruce)
	B	302	135	2	69	29	20		
Average	T	584.0	139.5	15.3	55.3	24.0	26.3		
	B	346.5	122.0	12.0	62.0	43.3	24.8		
J-1 (N*)	T	334	258	9	163	44	45	85	100 (B. fir)
	B	654	277	26	75	37	18		
J-2 (N*)	T	552	472	38	39	51	20	60	90 (B. fir)
	B	256	335	22	23	92	26		
J-3 (N)	T	381	198	41	102	58	33	75	30 (B. fir)
	B	442	308	63	232	44	136		
J-4	T	573	188	62	8	3	6	10	-
	B	270	142	26	7	0	4		
J-5 (N*)	T	435	144	14	39	65	38	75	-
	B	343	179	13	47	48	26		
Average	T	455.0	254.0	32.8	70.2	46.2	28.4		
	B	419.4	248.2	34.0	76.8	48.2	50.0		
K-1 (*)	T	489	234	2	3	4	18	10	-
	B	264	191	1	7	4	1		
K-2 (*)	T	491	160	4	2	2	0	55	-
	B	345	129	2	1	1	1		
K-3	T	734	210	19	38	19	7	100	-
	B	507	195	15	49	14	24		
K-4 (N*)	T	434	303	81	10	7	22	50	80 (Spruce)
	B	308	39	49	3	21	4		
Average	T	537.5	239.3	26.5	13.3	10.0	11.8		
	B	381.0	153.5	21.3	15.5	10.5	9.0		
L-1 (N*)	T	267	97	2	20	5	12	10	20 (B. fir)
	B	171	46	3	8	5	18		
L-2 (*)	T	328	139	1	7	15	3	5	5 (B. fir)
	B	150	48	0	13	7	1		
Average	T	297.5	118.0	1.5	13.5	10.0	7.5		
	B	160.5	47.0	1.5	10.5	6.0	9.5		
M-1 (*)	T	233	53	3	23	10	10	5	-
	B	123	37	1	18	7	2		
M-2 (*)	T	196	35	3	24	12	19	15	10 (B. fir)
	B	213	47	2	20	21	5		
M-3	T	300	69	3	29	3	7	20	40 (Spruce)
	B	187	49	0	20	1	4		
Average	T	243.0	52.3	3	25.3	10.0	12.0		
	B	174.3	44.3	1.0	19.3	9.7	4.0		
Total Counts	T	22453	7950	2024	3252	1689	1725		
	B	20665	7789	2552	3394	1696	1712		
Ave./Branch	T	390.9	132.5	33.7	54.2	28.0	28.7		
	B	344.4	129.8	42.5	56.5	28.2	28.5		
Spruce (total)	T	10992	4225	561	1334	766	920		
	B	9828	4021	761	1218	776	929		
Average/Branch	T	354.6	136.2	18.0	43.0	24.0	29.6		
	B	317.0	129.7	24.5	39.2	25.0	26.7		
Ave./Branch/Tree		335.8	133.0	21.2	41.1	24.5	28.2		
Balsam fir Totals	T	12461	3725	1463	1918	941	805		
	B	10837	3768	1790	2176	920	783		
Average/Branch	T	429.6	128.4	50.4	66.1	32.5	27.7		
	B	373.5	129.9	61.7	75.0	31.7	27.4		
Ave/Branch/Tree		401.6	124.8	56.3	70.5	32.1	29.1		

N = north side of road hence downwind sample tree
* = spruce tree
Unmarked = south side of road hence upwind balsam fir sample tree

Appendix A

Table IV

Aerial Spray Deposits of Aminocarb Formulation (1 oz/ai in 11.52 fluid oz/ac)
and Summarized Biological Data at Corresponding
Field Sample Positions

Tree Sample Number	3rd Application (16/6/77) Fluid oz/ac	Drops /cm²	Larval Population (4th) 3rd Post Actual (9/6/77)	4th Post Expected (20/6/77)	20/6/77) Actual (20/6/77)	Population Reduction %	Larval Population 5th Post Expected	(23/6/77) Actual	Residual Pop. Reduction due to 3rd Spray (%)	Pop. Reduction due to 1st - 2nd & 3rd Spray %	Final Tree Defoliation % Sample Tree	Adjacent Host Tree
A-1 (N)	0.00	0.00	283	197.0	123	37.6	173.2	112	35.3	0	100	100 BF
A-2	0.00	0.00	129	89.8	81	9.8	78.9	64	18.9	0	98	100 BF
A-3 (N)	0.00	0.00	283	191.0	15	92.3	173.2	56	67.7	36.1	95	100 BF
A-4	0.00	0.00	112	77.9	103	0	68.5	31	54.7	30.2	100	100 BF
A-5 (N*)	0.00	0.00	114	45.6	45	1.3	47.2	56	0	25.2	99	100 BF
A-6	0.00	0.00	152	105.8	80	24.4	93.0	42	54.3	48.5	100	100 S
A-7	0.00	0.00	86	59.8	90	0	52.6	90	0	0	100	100 S
A-8 (N*)	0.00	0.00	31	12.4	58	0	12.8	35	0	31.9	97	100 BF
B-1 (N*)	9.6	11.8	115	46.0	56	0	47.6	29	39.1	64.4	70	60 BF
B-2 (*)	15.2	13.7	47	18.8	18	4.2	19.4	33	0	60.2	50	85 BF
B-3 (*)	8.4	18.4	102	40.8	18	55.9	42.2	25	40.7	70.6	10	—
B-4 (N*)	11.8	12.6	106	42.4	40	5.7	43.9	43	2.0	55.6	85	100 BF
B-5 (N*)	2.1	4.9	150	60.0	22	63.3	62.1	106	0	0	100	100 BF
B-6 (*)	4.7	11.8	16	6.4	14	0	6.6	15	0	87.0	70	100 BF
C-1	4.0	9.5	26	18.1	19	0	15.9	25	0	49.2	10	10 S
C-2	10.0	19.3	20	13.9	9	35.2	12.2	14	0	85.9	35	20 S
C-3	6.9	16.4	31	21.6	17	21.3	19.0	5	73.7	94.0	10	20 S
C-4	11.4	9.4	75	52.2	67	0	45.9	37	19.4	56.4	55	—
C-5 (*)	11.1	8.9	60	24.0	43	0	24.8	104	0	0	30?	—
D-1 (N*)	1.6	4.3	18	7.2	15	0	7.4	23	0	70.0	9	—
D-2 (N*)	1.7	3.3	8	3.2	5	0	3.3	10	0	80.9	6	—
D-3 (N*)	0.1	0.1	33	13.2	28	0	13.7	25	0	63.4	21	40 BF
D-4 (N*)	0.3	0.1	20	8.0	8	0	8.3	23	0	65.4	21	20 BF
D-5 (N)	0.4	0.4	20	8.0	7	12.5	8.3	21	0	32.2	95	—
E-1	7.3	19.2	28	19.5	2	89.7	17.1	10	41.5	87.3	90	—
E-2	5.7	10.7	6	4.2	-	-	3.7	9	0	92.1	16	50 BF
E-3 (N)	7.1	18.3	142	98.8	68	31.2	86.9	68	21.7	32.3	100	100 S
E-4	3.7	8.1	24	16.7	6	64.1	14.7	29	0	74.3	75	—
E-5 (N*)	4.9	10.8	5	2.0	5	0	2.1	8	0	92.0	50	—
F-1 (N*)	2.4	3.4	47	18.8	21	0	19.4	20	0	63.8	70	90 BF
F-2	5.0	12.9	30	20.9	11	47.4	18.4	5	72.8	95.5	21	—
F-3 (N)	3.3	2.7	82	57.1	44	22.9	50.2	44	12.3	41.5	79	90 BF
F-4	20.9	33.5	18	12.5	2	84.0	11.0	4	63.6	95.8	5	—
G-1	2.1	12.4	1	0.7	1	0	0.6	0	100	100.0	5	0.5
G-2 (N)	0.9	2.1	60	41.8	29	30.6	36.7	24	34.6	75.7	30	50 S
G-3	2.1	9.4	13	9.0	2	77.8	7.9	0	100	100.0	10	— .
G-4 (N*)	0.8	2.3	69	27.6	49	0	28.6	62	0	56.1	70	100 BF
G-5 (*)	2.0	6.4	15	6.0	3	50.0	6.2	1	83.9	99.2	5	5 BF
H-1 (*)	16.2	29.0	7	2.8	3	0	2.9	7	0	93.7	15	—
H-2 (N)	7.5	14.7	10	7.0	1	85.7	6.1	2	67.2	97.7	1	—
H-3 (*)	7.7	15.2	5	2.0	2	0	2.1	2	4.3	98.3	3	—
H-4 (*)	5.3	8.2	19	7.6	1	86.8	7.9	11	0	79.0	5	—
I-1 (N)	1.8	2.1	37	25.7	5	80.5	22.6	4	82.3	93.4	100	75 S
I-2 (N*)	4.0	2.2	67	26.8	68	0	27.7	66	0	45.8	85	—
I-3	2.3	6.3	59	41.1	16	61.1	36.1	10	72.3	94.3	90	70 S
I-4 (N)	2.2	1.7	70	48.7	44	9.6	42.8	21	50.9	80.7	100	75 S
J-1 (N*)	8.7	2.2	119	47.6	50	0	49.3	46	6.7	64.3	85	100 BF
J-2 (N*)	25.4	11.9	31	12.4	71	0	12.8	28	0	74.4	55	90 BF
J-3 (N)	2.7	1.6	167	116.2	56	51.8	102.2	83	18.8	0	75?	80 BF
J-4	11.0	23.5	7	4.9	1	79.6	4.3	5	0	95.8	10	—
J-5 (N*)	9.4	10.3	43	29.9	56	0	26.3	32	0	68.5	75	—
K-1 (*)	7.9	29.5	5	2.0	5	0	2.1	10	0	91.3	10	—
K-2 (*)	5.6	18.7	1	0.4	1	0	0.4	1	0	99.1	55?	—
K-3	2.1	7.5	43	29.9	16	46.5	26.3	15	43.0	90.5	100	—
K-4 (N*)	3.9	2.5	9	3.6	14	0	3.1	13	0	89.5	50	80 BF
L-1 (N*)	9.8	7.2	14	5.6	5	10.7	5.8	15	0	73.7	10	20 BF
L-2 (*)	4.8	6.3	10	4.0	11	0	4.1	2	51.2	96.8	5	5 BF
M-1 (*)	3.8	6.1	20	8.0	8	0	8.3	6	27.7	87.1	4	—
M-2 (*)	3.6	17.8	22	8.8	16	0	9.1	12	0	77.4	13	10 S
M-3	4.5	5.7	24	16.7	4	76.0	14.7	5	66.0	92.3	20	40 BF

BF = balsam fir tree
*/S = spruce tree
N = north side of road hence downwind sample tree
Unmarked = south side of road hence upwind balsam fir sample tree

Appendix B

Appendix B BLOCK 305 1977

Individual Tree Analysis

Table I. Biological data* arranged in descending order within volume deposit categories of fenitrothion sprays. (Based on emission volume of first application)

A - over 0.842 ℓ/ha (over 11.52 fluid oz/ac)
B - 0.84 - 0.42 ℓ/ha (11.51 - 5.76 fluid oz/ac)
C - 0.42 - 0.21 ℓ/ha (5.75 - 2.88 fluid oz/ac)
D - 0.21 - 0.10 ℓ/ha (2.87 - 1.44 fluid oz/ac)
E - 0.10 - 0.05 ℓ/ha (1.43 - 0.70 fluid oz/ac)
F - 0.05 - trace (0.69 - trace fluid oz/ac)

*Exception of E-1 sample tree from this data due to closed deposit sampling unit.

Table II. Percent larval reduction within each volume deposit category following two applications of fenitrothion sprays (Based on emission volume of first application)

NB - For ease of data retention and comparison the data from Table I and Table II are grouped according to deposit categories, i.e., Series A Table I and II, etc.

Fig. 1. Examples of defoliation damage on black/red spruce and balsam fir host trees taken from different locations and spray deposit categories to illustrate variations in foliage protection as a result of sample position effect and spray coverage of two fenitrothion sprays.

Appendix B

Table 1-A

Biological data arranged in descending order within dosage/ deposit category (26.2 →11.52 oz/ac) of fenitrothion deposits

Tree Sample	1st Application (20/5/77)		Emergence Pop. 2nd/3rd instars		2nd Application (29/5/77)		Cumulative Deposit (1+2)		Residual Population		Pre-Spray Buds/18" Branch	Ratio of Insects/ Buds		Percent Defoliation	
	Fluid oz/ac (U.S.)	Drops /cm²	1st Pre- (12/5/77)	1st Post (48 hrs) (21/5/77)	Fluid oz/ac (U.S.)	Drops /cm²	Fluid oz/ac (U.S.)	Drops /cm²	2nd Post (48 hrs) (30/5/77)	3rd Post (10 days) (9/6/77)		After 3rd Post Count	After Matacil Spray	Sample Tree	Adjacent Tree
H-2(N)	26.2	78.7	341.5	59	4.1	30.2	30.3	108.9	16.5	10.0	74	0.14	0.03	5	-
D-1(N*)	15.1	40.0	294.5	41.5	1.2	5.0	16.3	45.0	1.5	18.0	98	0.18	0.23	10	-
H-3(*)	13.2	42.2	389.0	39.5	2.4	15.1	15.6	57.3	5.0	5.0	52	0.10	0.04	5	-
F-1(N*)	12.8	16.8	211.0	123.5	12.0	16.6	24.8	33.4	22.5	47.5	26	1.85	0.77	70	90 B. fir
Total	67.3	177.7	1236	263.5	19.7	66.9	87.0	244.6	45.5	80.5	250	-	-		
Ave.	16.8	44.4	309.0	65.8	4.9	16.7	21.7	61.1	11.3	20.1	62	0.19	0.33	22	N/A

N - north side of road hence downwind sample tree
* - spruce tree
Unmarked - south side of road hence upwind balsam fir sample tree

Table II-A

Dosage volume deposit category (26.2-11.52 oz/ac) and percentage larval reduction following the 1st and 2nd application fenitrothion formulation (4 oz AI/11.52 fluid oz/ac/treatment)

Tree Sample Number	1st Application (20/5/77)		Emergence Pop. 1st Post spray (48 hrs)		Percent Population Reduction	Cumulative Deposit (1+2)		Emergence Pop. 2nd Post Spray (48 hrs)		Percent Population Reduction	Emergence Pop. 3rd Post Spray (10 days)		Percent Population Reduction	Percent Defoliation	
	Fluid oz/ac (U.S)	Drops /cm²	Expected	Actual		Fluid oz/ac (U.S.)	Drops /cm²	Expected	Actual		Expected	Actual		Sample Tree	Adjacent Tree
H-2(N)	26.2	78.7	255.1	59.0	76.9	30.3	108.9	205.9	16.5	94.4	142.4	10.0	93.0	5	-
D-1(N*)	15.1	40.0	267.1	41.5	84.5	16.3	45.0	193.7	1.5	99.2	185.5	18.0	90.3	10	-
H-3(*)	13.2	42.2	352.8	39.5	88.8	15.6	57.3	255.9	5.0	97.6	245.0	5.0	98.0	5	-
F-1(N*)	12.8	16.8	191.3	123.5	35.4	24.8	33.4	138.8	22.5	83.8	132.9	47.5	64.3	70	90 B. fir
Total	67.3	177.8	1066.3	263.5		87.0	244.6	794.3	45.5		705.8	80.5	327.0		
Ave.	16.8	44.4	266.5	65.8	75.3	21.7	61.1	198.5	11.3	93.1	176.4	20.1	88.6	22	N/A

N - north side of road hence downwind sample tree
* - spruce
Unmarked - south side of road hence upwind balsam fir sample tree

Appendix B

Table 1-B

Biological data arranged in descending order within dosage deposit category (11.52-5.76 oz/ac) of fenitrothion deposits

Tree Sample	1st Application (20/5/77) Fluid oz/ac (U.S.)	1st Application (20/5/77) Drops/cm²	Emergence Pop. 2nd/3rd instars) 1st Pre- (12/5/77)	Emergence Pop. 2nd/3rd instars) 1st Post (48 hrs) (21/5/77)	2nd Application (29/5/77) Fluid oz/ac (U.S.)	2nd Application (29/5/77) Drops/cm²	Cumulative Deposit (1+2) Fluid oz/ac (U.S.)	Cumulative Deposit (1+2) Drops/cm²	Residual Population 2nd Post (48 hrs) (30/5/77)	Residual Population 3rd Post (10 days) (9/6/77)	Pre-Spray Buds/18" Branch	Ratio of Insects/Buds After 3rd Post Count	Ratio of Insects/Buds After Matacil Spray	Percent Defoliation Sample Tree	Percent Defoliation Adjacent Tree
D-2 (N*)	10.5	18.8	201.5	51.0	2.8	7.3	13.4	26.1	2.5	8.5	60	0.15	0.17	5	-
D-4 (N*)	10.2	21.6	254.0	40.0	0.5	2.1	10.7	23.7	10.0	20.0	122	0.16	0.19	20	20 B. fir
D-5 (N)	9.6	20.2	201.0	28.5	2.8	7.6	12.4	27.8	5.5	20.5	52	0.40	0.40	95	-
H-4 (*)	9.2	31.0	201.5	42.5	0.4	3.2	9.6	34.2	1.5	19.0	79	0.24	0.14	5	-
E-3 (N)	8.8	21.4	394.0	119.5	0.5	6.0	9.3	27.4	135.0	142.5	14	10.21	4.86	100	100 Spruce
H-3	8.7	15.6	243.5	59.0	6.0	22.6	14.7	38.2	1.5	24.5	29	0.86	0.17	20	40 B. fir
G-1	8.4	27.2	197.0	54.0	11.0	52.5	19.4	79.7	0.5	1.5	55	0.04	0.00	5	0 Spruce
H-2 (*)	7.9	16.8	204.5	41.0	6.0	21.8	13.9	38.6	2.5	22.0	178	0.12	0.07	15	10 Spruce
F-2	7.3	25.0	440.0	76.5	Closed sample unit		(7.3)†	(25.0)†	3.5	30.0	34	0.88	0.15	20	-
H-1 (*)	6.7	25.2	178.0	45.0	3.9	15.3	10.6	40.5	2.0	20.5	35	0.86	0.18	5	-
E-2	6.2	11.8	450.0	135.0	6.1	19.8	12.3	31.6	27.5	6.0	61	0.10	0.15	15	50 B. fir
D-3 (N*)	5.9	20.8	262.5	51.5	0.9	3.3	6.8	24.1	16.0	33.0	219	0.15	0.11	20	40 B. fir
Total	99.4	255.4	3227.5	743.5	40.9	161.5	140.4†	416.9†	208.0	348.0	938	-	-		
Ave.	8.3	21.3	268.9	61.9	3.7	14.7	11.7†	34.7†	17.3	29.0	78	0.23	0.37	27	37

N - north side of road hence downwind sample tree
* - spruce tree
Unmarked - south side of road hence upwind balsam fir sample tree

Appendix B

Table II-B

Dosage volume deposit category (11.52-5.76 oz/ac) and percent larval reduction following the 1st and 2nd application of fenitrothion formulation (4 oz AI/11.52 fluid oz/ac/treatment)

Tree Sample Number	1st Application (20/5/77) Fluid oz/ac (U.S.)	1st Application (20/5/77) Drops/cm²	Emergence Pop. 1st Post spray (48 hrs) Expected	Emergence Pop. 1st Post spray (48 hrs) Actual	Percent Population Reduction	Cumulative Deposit (1+2) Fluid oz/ac (U.S.)	Cumulative Deposit (1+2) Drops/cm²	Emergence Pop. 2nd Post Spray (48 hrs) Expected	Emergence Pop. 2nd Post Spray (48 hrs) Actual	Percent Population Reduction	Emergence Pop. 3rd Post Spray (10 days) Expected	Emergence Pop. 3rd Post Spray (10 days) Actual	Percent Population Reduction	Percent Defoliation Sample Tree	Percent Defoliation Adjacent Tree
D-2 (N*)	10.5	18.8	182.7	51.0	72.0	13.4	26.1	132.5	2.5	98.1	126.9	8.5	93.3	5	-
D-4 (N*)	10.2	21.6	230.3	40.0	82.6	10.7	23.7	167.1	10.0	94.0	160.0	20.0	87.5	20	20 B. fir
D-5 (N)	9.6	20.2	150.1	28.5	81.0	12.4	27.8	121.2	5.5	95.4	83.8	20.5	75.5	95	-
H-4	9.2	31.0	182.7	42.5	76.7	9.6	34.2	132.2	1.5	98.8	126.9	19.0	85.0	5	-
E-3 (N)	8.8	21.4	294.3	119.5	59.4	9.3	27.4	237.5	135.0	43.2	164.2	142.5	13.2	100	100 Spruce
H-3 *	8.7	15.6	181.8	59.0	67.5	14.7	38.2	146.8	1.5	98.9	101.5	24.5	75.8	20	40 B. fir
G-1	8.4	27.2	147.1	54.0	63.2	19.4	79.7	118.7	0.5	99.5	82.1	1.5	98.1	5	0 Spruce
H-2 (*)	7.9	16.8	185.4	41.0	77.9	13.9	38.6	134.5	2.5	97.4	128.8	22.0	82.9	15	10 Spruce
F-2	7.3	25.0	328.6	76.5	76.7	(7.3)+	(25.0)+	265.3	3.5	98.7	183.4	30.0	83.1	20	-
H-1 (*)	6.7	25.2	161.4	45.0	72.1	10.6	40.5	117.1	2.0	98.3	112.1	20.5	81.7	5	-
E-2	6.2	11.8	336.1	135.0	59.8	12.3	31.6	271.3	27.5	89.9	187.6	6.0	96.8	15	50 B. fir
D-3 (N*)	5.9	20.8	238.0	51.5	78.3	6.8	24.1	172.7	16.0	90.7	165.3	33.0	80.0	20	40 B. fir
Total	99.4	255.4	2618.5	743.5	-	140.4	416.9	2016.9	208.0		1622.6	348.0			
Ave.	8.3	21.3	218.2	61.9	71.6	11.7	34.7	168.0	17.3	89.7	135.2	29.0	78.5	27	37

N - north side of road hence downwind sample tree
* - spruce tree
Unmarked - south side of road hence upwind balsam fir sample tree

Appendix B

Table I-C

Biological data arranged in descending order within dosage deposit category (5.76-2.88 oz/ac) of fenitrothion deposits

Tree Sample	1st Application (20/5/77) Fluid oz/ac (U.S.)	1st Application (20/5/77) Drops /cm²	Emergence Pop. 2nd/3rd Instars 1st Pre- (12/5/77)	Emergence Pop. 2nd/3rd Instars 1st Post (48 hrs) (21/5/77)	2nd Application (29/5/77) Fluid oz/ac (U.S.)	2nd Application (29/5/77) Drops /cm²	Cumulative Deposit (1+2) Fluid oz/ac (U.S.)	Cumulative Deposit (1+2) Drops /cm²	Residual Population 2nd Post (48 hrs) (30/5/77)	Residual Population 3rd Post (10 days (9/6/77)	Pre-Spray Buds/18" Branch	Ratio of Insects/Buds After 3rd Post Count	Ratio of Insects/Buds After Matacil Spray	Percent Defoliation Sample Tree	Percent Defoliation Adjacent Tree
C-2	5.0	11.8	389.5	49.5	1.0	5.4	6.0	17.2	11.0	20.0	11	0.55	0.27	35	20 Spruce
F-3(N)	4.9	17.3	295.0	81.5	2.0	4.6	9.5	21.9	8.0	82.0	57	1.44	0.44	80	90 B. fir
C-1	4.6	12.0	193.0	40.5	1.4	5.1	6.0	17.1	5.0	26.0	102	0.25	0.25	10	10 Spruce
C-2(N)	4.5	11.3	388.0	74.5	8.6	14.3	13.1	25.6	2.5	60.5	79	0.77	0.30	80	50 Spruce
E-5(N*)	4.2	7.8	384.0	162.0	1.9	6.3	6.1	14.1	1.0	5.5	66	0.09	0.13	50	-
K-3	4.1	13.5	620.5	202.5	3.9	16.3	8.0	29.8	17.0	43.5	57	0.94	0.34	100	-
G-3	3.9	18.8	507.0	33.5	3.9	23.2	7.8	42.0	0.5	13.0	108	0.12	0.00	10	-
G-5(*)	3.7	29.5	512.0	56.5	4.2	39.0	7.9	68.5	5.5	15.0	81	0.19	0.01	10	10
E-4	3.1	4.1	452.5	138.0	4.5	11.0	7.6	15.1	0.5	24.5	13	1.92	2.23	75	-
K-2(*)	2.9	14.1	418.0	144.5	12.0	27.5	14.9	41.6	3.0	1.5	70	0.03	0.01	55	
K-1(*)	2.8	19.2	426.5	237.5	8.7	27.0	11.5	46.2	1.5	5.0	128	0.04	0.08	10	-
Total	43.7	159.4	4586.0	1220.5	52.2	179.7	98.4	339.1	55.5	296.5	782	-	-		
Ave.	4.0	14.5	416.9	110.9	4.7	16.3	8.9	30.8	5.0	26.9	71	0.07	0.38	47	36

N - north side of road hence downwind sample tree
* - spruce tree
Unmarked - south side of road hence upwind balsam fir sample tree

N.B. - Reason for high defoliation on E-4 was because of low bud counts

Appendix B

Table II-C

Dosage volume deposit category (5.75-2.88 oz/ac) and percent larval reduction following the 1st and 2nd application of fenitrothion formulation (4 oz AI/11.52 fluid oz/ac/treatment)

Tree Sample Number	1st Application (20/5/77) Fluid oz/ac (U.S.)	1st Application (20/5/77) Drops/cm^2	Emergence Pop. 1st Post spray (48 hrs) Expected	Emergence Pop. 1st Post spray (48 hrs) Actual	Percent Population Reduction	Cumulative Deposit (1+2) Fluid oz/ac (U.S.)	Cumulative Deposit (1+2) Drops/cm^2	Emergence Pop. 2nd Post Spray (48 hrs) Expected	Emergence Pop. 2nd Post Spray (48 hrs) Actual	Percent Population Reduction	Emergence Pop. 3rd Post Spray (10 days) Expected	Emergence Pop. 3rd Post Spray (10 days) Actual	Percent Population Reduction	Percent Defoliation Sample Tree	Percent Defoliation Adjacent Tree
C-2	5.0	11.8	290.9	49.5	82.9	6.0	17.2	234.8	11.0	95.3	162.4	20.0	87.7	35	20
F-3 (N)	4.9	17.3	220.3	81.5	63.0	9.5	21.9	177.8	8.0	95.5	123.0	82.0	33.3	80	90
C-1	4.6	12.0	144.1	40.5	71.9	6.0	17.1	116.3	5.0	95.7	80.4	26.0	67.7	10	10
G-2 (N)	4.5	11.3	289.8	74.5	74.3	13.1	25.6	233.9	2.5	98.9	161.7	60.5	62.5	80	50
E-5 (N*)	4.2	7.8	348.2	162.0	53.4	6.1	14.1	252.6	1.0	99.6	241.9	5.5	97.7	50	-
K-3	4.1	13.5	463.5	202.5	56.3	8.0	29.8	374.1	17.0	95.5	258.7	43.5	83.1	100	-
G-3	3.9	18.8	378.7	33.5	91.1	7.8	42.0	305.7	0.5	99.8	211.4	13.0	93.9	10	-
G-5 (*)	3.7	29.5	464.3	56.5	87.8	7.9	68.5	336.8	5.5	97.4	322.5	15.0	95.3	10	10
E-4	3.1	4.1	338.6	138.0	59.2	7.6	15.1	272.8	0.5	99.8	188.6	24.5	87.0	75	-
K-2 (*)	2.9	14.1	379.1	144.5	61.8	14.9	41.6	275.0	3.0	98.9	263.3	1.5	99.4	55	-
K-1 (*)	2.8	19.2	386.8	237.5	38.5	11.5	46.2	280.6	1.5	99.4	268.6	5.0	98.1	10	-
Total	43.7	159.4	3604.3	1220.5		98.4	339.1	2860.4	55.5		2120.1	296.5			
Ave.	4.0	14.5	327.6	110.9	66.1	8.9	30.8	260.0	5.0	98.0	192.7	26.9	86.0	47	36

N - north side of road hence downwind sample tree

* - spruce tree

Unmarked - south side of road hence upwind balsam fir sample tree

Table 1-D

Biological data arranged in descending order within dosage deposits category (2.87→1.44 oz/ac) of fenitrothion deposits

Tree Sample	1st Application (20/5/77) Fluid oz/ac (U.S.)	1st Application (20/5/77) Drops/cm^2	Emergence Pop. 2nd/3rd instars) 1st Pre- (12/5/77)	Emergence Pop. 2nd/3rd instars) 1st Post (48 hrs) (21/5/77)	2nd Application (29/5/77) Fluid oz/ac (U.S.)	2nd Application (29/5/77) Drops/cm^2	Cumulative Deposit (1+2) Fluid oz/ac (U.S.)	Cumulative Deposit (1+2) Drops/cm^2	Residual Population 2nd Post (48 hrs) (30/5/77)	Residual Population 3rd Post (10 days) (9/6/77)	Pre-Spray Buds/18" Branch	Ratio of Insects/Buds After 3rd Post Count	Ratio of Insects/Buds After Matacil Spray	Percent Defoliation Sample Tree	Percent Defoliation Adjacent Tree
1-3	2.6	31.5	728.0	201.5	0.8	6.5	3.4	38.0	3.5	59.0	159	0.37	0.06	90	70 Spruce
F-4	2.5	7.5	372.0	61.5	6.3	33.5	8.8	41.0	18.0	18.5	178	0.11	0.02	5	-
1-2 (N*)	2.4	29.2	467.0	106.5	0.7	2.8	3.1	32.0	38.0	67.5	80	0.84	0.83	85	-
1-4 (N)	2.4	27.0	426.5	164.0	0.2	0.3	2.6	27.3	2.5	70.5	94	0.76	0.22	100	75 Spruce
J-4	2.3	29.5	471.5	165.0	4.8	24.2	7.1	53.7	49.0	7.5	48	0.17	0.10	10	-
K-4 (N*)	2.2	5.7	372.0	201.0	0.3	2.1	2.5	7.8	75.0	9.5	126	0.06	0.10	50	80 B. fir
B-6 (*)	2.0	5.6	442.0	137	0.8	4.1	2.8	9.7	8.0	16.5	40	0.40	0.38	70	100 B. fir
C-5 (*)	1.7	5.4	312.0	79.0	0.8	4.6	2.5	10.0	13.0	60.5	132	0.46	0.78	30	-
I-1 (N)	1.6	13.0	239.5	49.5	5.2	3.8	6.8	16.8	10.5	37.5	19	2.00	0.21	100	75 Spruce
L-2 (*)	1.6	4.1	239.0	113.5	2.9	11.2	4.5	15.3	0.5	10.0	194	0.05	0.01	5	5 B. fir
B-1 (N*)	1.6	4.6	314.0	259.5	1.1	10.2	2.7	14.8	103.0	115.0	126	0.91	0.23	70	60 B. fir
G-4 (N*)	1.6	9.2	541.5	117.5	1.5	12.6	3.1	21.8	68.0	69.0	110	0.63	0.56	70	100 B. fir
H-1 (*)	1.5	13.1	407.0	115.5	3.1	9.7	4.6	22.8	24.5	7.5	98	0.08	0.07	15	-
B-3 (*)	1.4	3.7	333.0	103.0	1.9	14.0	3.3	17.7	21.5	102.0	55	1.85	0.45	10	-
B-4 (N*)	1.4	5.1	371.5	301.0	1.6	8.8	3.0	13.9	17.5	106.0	124	2.31	0.35	85	100 B. fir
Total	28.8	188.1	6036.5	2175.0	32.0	148.4	60.8	342.6	452.5	756.5	1583	-	-		
Ave.	1.9	12.6	402.4	145.0	2.1	9.9	4.05	22.8	30.1	50.4	105.5	0.28	0.48	53	74

N - north side of road hence downwind sample tree
* - spruce trees
Unmarked - south side of road hence upwind balsam fir sample tree

N.B. - Reason for high defoliation on 1-1 was because of low bud counts.

Appendix B

Table IID

Dosage volume deposit category (2.87-1.44 oz/ac) and percent larval reduction following the 1st and 2nd application of fenitrothion formulation (4 oz AI/11.52 fluid oz/ac/treatment)

Tree Sample Number	1st Application (20/5/77) Fluid oz/ac (U.S.)	1st Application (20/5/77) Drops/cm²	Emergence Pop. 1st Post spray (48 hrs) Expected	Emergence Pop. 1st Post spray (48 hrs) Actual	Percent Population Reduction	Cumulative Deposit (1+2) Fluid oz/ac (U.S.)	Cumulative Deposit (1+2) Drops/cm²	Emergence Pop. 2nd Post Spray (48 hrs) Expected	Emergence Pop. 2nd Post Spray (48 hrs) Actual	Percent Population Reduction	Emergence Pop. 3rd Post Spray (10 days) Expected	Emergence Pop. 3rd Post Spray (10 days) Actual	Percent Population Reduction	Percent Defoliation Sample Tree	Percent Defoliation Adjacent Tree
I-3	2.6	31.5	543.8	201.5	62.9	3.4	38.0	438.9	3.5	99.2	303.5	59.0	80.5	90	70 Spruce
F-4	2.5	7.5	277.9	61.5	77.8	8.8	41.0	265.3	18.0	93.2	155.1	18.5	88.0	5	-
I-2 (N*)	2.4	29.2	423.5	106.5	74.8	3.1	32.0	307.2	38.0	87.6	294.2	67.5	77.0	85	-
I-4 (N)	2.4	27.0	318.5	164.0	48.5	2.6	27.3	257.1	2.5	99.0	177.8	70.5	60.3	100	75 Spruce
J-4	2.3	29.5	352.2	165.0	53.2	7.1	53.7	284.3	49.0	82.8	196.6	7.5	96.1	10	-
K-4 (N*)	2.2	5.7	337.4	201.0	40.4	2.5	7.8	244.7	75.0	69.3	234.3	9.5	95.9	50	80 B. fir
B-6 (*)	2.0	5.6	400.8	137.0	65.8	2.8	9.7	290.8	8.0	97.2	278.4	16.5	94.0	70	100 B. fir
C-5 (*)	1.7	5.4	282.9	79.0	72.1	2.5	10.0	205.2	13.0	93.7	196.5	60.5	69.2	30	-
I-1 (N)	1.6	13.0	178.9	49.5	72.3	6.8	16.8	144.4	10.5	92.7	99.8	37.5	62.4	100	75 Spruce
L-2 (*)	1.6	4.1	216.7	113.5	47.6	4.5	15.3	157.2	0.5	99.6	150.5	10.0	93.3	5	5 B. fir
B-1 (N*)	1.6	4.6	284.7	259.5	8.8	2.7	14.8	206.6	103.0	50.1	197.8	115.0	41.8	70	60 B. fir
G-4 (N*)	1.6	9.2	491.1	117.5	76.0	3.1	21.8	356.3	68.0	80.9	341.1	69.0	79.8	70	100 B. fir
H-1 (*)	1.5	13.1	379.1	115.5	69.5	4.6	22.8	267.8	24.5	90.8	256.4	7.5	97.1	15	-
B-3 (*)	1.4	3.7	302.0	103.0	65.9	3.3	17.7	219.1	21.5	90.1	209.7	102.0	51.3	10	-
B-4 (N*)	1.4	5.1	336.9	301.0	10.6	3.0	13.9	244.4	17.5	92.8	234.0	106.0	54.7	85	100 B. fir
Total	28.8	188.1	5126.3	2175.0	-	60.8	342.6	3889.3	432.5	-	3325.7	756.5	-		
Ave.	1.92	12.6	341.7	145.0	57.5	4.1	22.8	259.2	30.1	88.3	221.7	50.4	77.3	53	74

N - north side of road hence downwind sample tree

* - spruce tree

Unmarked - south side of road hence upwind balsam fir sample tree

Appendix B

Table 1-E

Biological data arranged in descending order within dosage deposit category (1.43-0.7 oz/ac) of fenitrothion deposits

	1st Application (20/5/77)		Emergence Pop. 2nd/3rd instars)		2nd Application (29/5/77)		Cumulative Deposit (1+2)		Residual Population			Ratio of Insects/Buds		Percent Defoliation	
Tree Sample	Fluid oz/ac (U.S.)	Drops/ cm^2	1st Pre- (12/5/77)	1st Post (48 hrs) (21/5/77)	Fluid oz/ac (U.S.)	Drops/ cm^2	Fluid oz/ac (U.S.)	Drops/ cm^2	2nd Post (48 hrs) (30/5/77)	3rd Post (10 days) (9/6/77)	Pre-Spray Buds/18" Branch	After 3rd Post Count	After Matacil Spray	Sample Tree	Adjacent Tree
B-5(N*)	1.3	4.4	349.5	129.0	0.8	6.5	2.1	7.4	27.5	150.0	65	2.31	1.63	100	100 B. fir
C-3	1.2	6.0	326.0	50.0	0.4	3.6	1.6	9.6	4.5	31.0	44	0.70	0.11	10	20 Spruce
L-1(N*)	1.1	7.9	219.0	71.5	2.9	11.5	4.0	19.4	2.5	14.0	144	0.10	0.10	10	20 B. fir
C-4	0.9	4.6	344.5	58.5	0.4	3.3	1.3	7.9	139.0	75.5	83	0.92	0.45	55	-
B-2(*)	0.8	2.5	318.0	160.5	1.9	13.7	2.7	16.2	15.0	47.0	33	1.42	1.00	60	85 B. fir
J-5(N*)	0.7	4.6	389.0	161.5	1.6	6.9	2.3	11.5	13.5	43.0	120	0.36	0.27	80	-
J-1(N*)	0.7	7.1	495.0	272.5	4.0	1.9	5.3	10.0	22.5	119.0	51	2.33	0.90	85	100 B. fir
Total	6.7	37.1	2441.0	903.5	12.6	47.4	19.3	82.0	224.5	479.5	540	-	-		
Ave.	1.0	5.3	348.7	129.0	1.8	6.9	2.7	11.7	32.1	68.5	77.1	0.90	0.89	57	65

N - north side of road hence downwind sample tree
* - spruce tree
Unmarked - south side of road hence upwind balsam fir sample tree

Appendix B

Table II-E

Dosage volume deposit category (1.43-0.7) and percent larval reduction following the 1st and 2nd application of fenitrothion formulation (4 oz AI/11.53 fluid oz/ac/treatment)

Tree Sample Number	1st Application (20/5/77) Fluid oz/ac (U.S.)	1st Application (20/5/77) Drops/cm²	Emergence Pop. 1st Post spray (48 hrs) Expected	Emergence Pop. 1st Post spray (48 hrs) Actual	Percent Population Reduction	Cumulative Deposit (1+2) Fluid oz/ac (U.S.)	Cumulative Deposit (1+2) Drops/cm²	Emergence Pop. 2nd Post Spray (48 hrs) Expected	Emergence Pop. 2nd Post Spray (48 hrs) Actual	Percent Population Reduction	Emergence Pop. 3rd Post Spray (10 days) Expected	Emergence Pop. 3rd Post Spray (10 days) Actual	Percent Population Reduction	Percent Defoliation Sample Tree	Percent Defoliation Adjacent Tree
B-5(N*)	1.3	4.4	316.9	129.0	59.3	2.1	7.4	229.9	27.5	88.0	220.1	150.0	31.8	100	100 B.fir
C-3	1.2	6.0	243.5	50.0	79.4	1.6	9.6	196.5	4.5	97.7	135.9	31.0	77.2	10	20 Spruce
L-1(N*)	1.1	7.9	198.6	71.5	63.7	4.0	19.4	144.1	2.5	98.3	137.9	14.0	89.8	10	20 B.fir
C-4	0.9	4.6	257.3	58.5	77.2	1.3	7.9	207.7	139.0	33.0	143.6	75.5	47.4	55	-
B-2(*)	0.8	2.5	288.4	160.5	44.3	2.7	16.2	209.2	15.0	92.8	200.3	47.0	76.5	60	85 B.fir
J-5(N*)	0.7	4.6	352.8	161.5	54.2	2.3	11.5	255.9	13.5	94.7	245.0	43.0	82.4	80	-
J-1(N*)	0.7	7.1	448.9	272.5	39.3	5.3	10.0	325.7	22.5	93.1	311.8	119.0	61.8	85	100 B.fir
Total	6.7	37.1	2106.4	903.5	-	19.3	82.0	1569.0	224.5	-	1394.6	479.5			
Ave.	1.0	5.3	300.9	129.0	57.1	2.7	11.7	224.1	32.1	85.6	199.2	68.5	65.6	57	65

N - north side of road hence downwind sample tree
* - spruce tree
Unmarked - south side of road hence upwind balsam fir sample tree

Appendix B

Table 1-F

Biological data arranged in descending order within dosage deposit category (0.69-0.00 oz/ac) of fenitrothion deposits

Tree Sample	1st Application (20/5/77) Fluid oz/ac (U.S.)	1st Application (20/5/77) Drops/ cm^2	Emergence Pop. 2nd/3rd instars) 1st Pre- (12/5/77)	Emergence Pop. 2nd/3rd instars) 1st Post (48 hrs) (21/5/77)	2nd Application (29/5/77) Fluid oz/ac (U.S.)	2nd Application (29/5/77) Drops/ cm^2	Cumulative Deposit (1+2) Fluid oz/ac (U.S.)	Cumulative Deposit (1+2) Drops/ cm^2	Residual Population 2nd Post (48 hrs) (30/5/77)	Residual Population 3rd Post (10 days) (9/6/77)	Pre-Spray Buds/18" Branch	Ratio of Insects/ Buds After 3rd Post Count	Ratio of Insects/ Buds After Matacil Spray	Percent Defoliation Sample Tree	Percent Defoliation Adjacent Tree
J-2(N*)	0.4	4.1	419.0	403.5	1.2	3.1	1.6	7.2	30.0	31.0	184	0.07	0.15	60	90 B. fir
J-3(N)	0.2	2.3	411.5	253.0	0.8	2.5	1.0	4.8	52.0	167.5	89	1.30	0.93	75	80 B. fir
A-8(N*)	Trace	0.08	197.0	99.0	0.06	0.5	0.06	0.58	52.5	31.5	53	0.98	0.58	100	100 B. fir
A-7	"	0.06	842.5	202.5	0.10	1.0	0.10	1.06	206.5	86.0	26	7.92	3.30	100	100 Spruce
A-6	"	0.01	565.5	320.0	0.00	0.0	Trace	0.01	119.0	152.5	17	7.00	8.94	100	100 Spruce
A-5(N*)	"	0.03	287.5	216.0	0.00	0.0	"	0.03	57.0	114.0	52	1.09	2.19	100	100 B. fir
A-4	"	0.02	496.5	174.5	0.00	0.0	"	0.02	98.0	112.5	55	1.78	2.03	100	100 B. fir
A-2	"	0.15	393.5	161.0	0.00	0.0	"	0.15	121.5	129.5	26	4.65	4.96	100	100 B. fir
Total	"	6.75	3613.0	1829.5	Trace	7.1	-	13.85	736.5	824.5	502	-	-		
Ave.	"	0.83	451.6	228.6	"	0.76	Trace	1.73	92.1	103.0	63	1.46	1.90	92	96

Table 1-F2

A-3(N)	No spray		354.0	344.5	0.00	0.0	0.00	0.00	252.0	283.5	77	3.27	3.68	95	100 B. fir
A-1(N)	" "		256.0	259.0	0.00	0.0	0.00	0.00	311.0	283.5	111	2.80	2.55	100	100 B. fir
Total			610	603.5	0.00	0.0	0.00	0.00	563.0	567.0	188				
Ave.			305	301.7	0.00	0.0	0.00	0.00	281.5	283.5	94	2.99	3.01	97.5	100

N - north side of road hence downwind sample tree
* - spruce tree
Unmarked - south side of road hence upwind balsam fir sample tree

Appendix B

Table II-F_1

Dosage volume deposit category (0.69 → Trace) and percent larval reduction following the 1st and 2nd application of fenitrothion formulation (4 oz. AI/ 11.52 fluid oz/treatment)

Tree Sample Number	1st Application (20/5/77) Fluid oz/ac (U.S.)	Drops/cm^2	Emergence Pop. 1st Post spray (48 hrs) Expected	Actual	Percent Population Reduction	Cumulative Deposit (1+2) Fluid oz/ac (U.S.)	Drops/cm^2	Emergence Pop. 2nd Post Spray (48 hrs) Expected	Actual	Percent Population Reduction	Emergence Pop. 3rd Post Spray (10 days) Expected	Actual	Percent Population Reduction	Percent Defoliation Sample Tree	Adjacent Tree
J-2(N*)	0.4	4.1	380.0	403.5	0	1.6	7.2	275.7	30.0	89.1	263.9	31.0	88.2	60	90 B. fir
J-3(N)	0.2	2.3	307.3	253.0	17.6	1.0	4.8	248.1	52.0	79.0	171.5	167.5	2.3	75	80 B. fir
A-8(N*)	Trace	0.08	178.6	99.0	44.5	0.06	0.58	129.6	52.5	59.5	124.1	31.5	74.6	100	100 B. fir
A-7	"	0.'06	629.3	202.5	67.8	0.10	1.06	508.0	206.5	59.3	351.3	86.5	75.3	100	100 Spruce
A-6	"	0.01	422.4	320.0	24.2	Trace	0.01	340.9	119.0	65.1	235.8	152.5	35.3	100	100 Spruce
A-5(N*)	"	0.03	260.7	216.0	17.1	"	0.03	189.1	57.0	69.8	181.1	114.0	37.0	100	100 B. fir
A-4	"	0.02	370.8	174.5	52.9	"	0.02	299.3	98.0	67.2	207.0	112.5	45.6	100	100 B. fir
A-2	"	0.15	293.9	161.0	45.2	"	0.15	237.2	121.5	48.8	164.0	129.5	21.0	100	100 B. fir
Total	"	6.75	2843.0	1829.5		–	13.85	2227.9	736.5	–	1699.6	824.5	–		
Ave.	"	0.83	355.3	228.6	35.8	Trace	1.73	278.4	92.1	67.0	212.4	103.0	51.5	92	96

Table II-F2

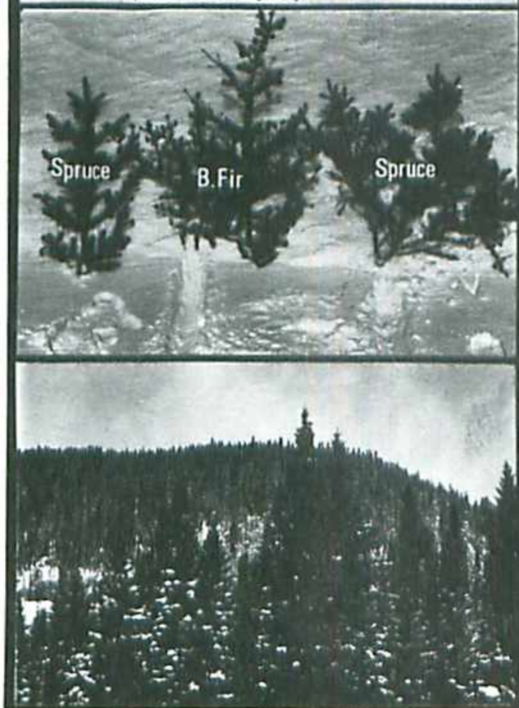
A-3(N)	No spray		264.4	344.5	0.0	0.00	0.00	213.4	252.0	0	147.6	283.5	0	95	100
A-1(N)	"	"	191.2	259.0	0.0	0.00	0.00	154.3	311.0	0	106.7	283.5	0	100	100
Total	–	–	455.6	603.5	0.0		0.00	367.7	563.0	0.00	254.3	567.0		97.5	100
Ave.	–	–	227.8	301.7	0.0		0.00	183.9	281.5	0.00	127.1	283.5	0.00		

N – north side of road hence downwind sample tree
* – spruce tree
Unmarked – south side of road hence upwind balsam fir sample tree

Appendix B

FIG. 1

Spray Deposit Category "E"
(1.43 – 0.7 oz/ac)



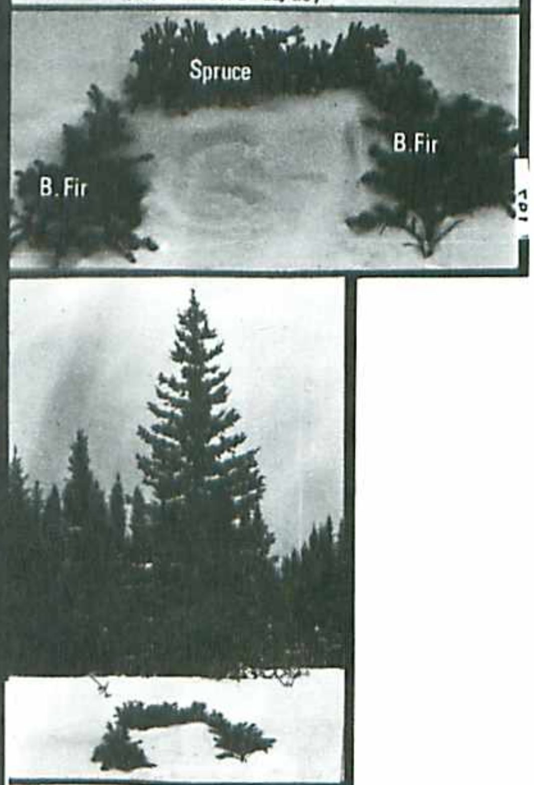
Sample Tree L-1* North (Open)

Sampling Date	Larval Count	Spray Deposit Drops $/cm^2$	Spray Deposit Fluid oz/ac
13/5/77	219.0		
20/5/77	-	7.9	1.1
21/5/77	71.5		
29/5/77	-	11.5	2.9
1/6/77	2.5		
9/6/77	14.0		
16/6/77	-	7.2	9.8
19/6/77	5.0		
23/6/77	15.0		

Defoliation Spruce 10%
Adj. Balsam Fir 40%

N.B. Sample Tree L-1 is situated well within the spray block on a north facing slope thus exposed to drift from numerous spray swaths.

Spray Deposit Category "B"
(11.52 – 5.76 oz/ac)



Sample Tree G-1 South

Sampling Date	Larval Count	Spray Deposit Drops $/cm^2$	Spray Deposit Fluid oz/ac
12/5/77	197.0		
20/5/77	-	27.2	8.4
21/5/77	54.0		
29/5/77	-	52.5	11.0
1/6/77	0.5		
9/6/77	1.5		
16/6/77	-	12.4	2.1
19/6/77	1.0		
23/6/77	0.0		

Defoliation Balsam Fir 5%
Spruce 0%