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Forest Pest Management Institute (Ottawa)
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LIST OF F.P.M.I. (OTTAWA) REPORTS PREPARED

FOR THE CANADIAN FOREST PEST CONTROL FORUM

DECEMBER 6-7, 1977

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Forest Pest Management Institute (Ottawa)
Canadian Forestry Service
Environment Canada
Ottawa, Ontario

December, 1977

A SUMMARY OF THE 1977 FOREST PEST MANAGEMENT INSTITUTE (OTTAWA) FIELD AND LABORATORY STUDIES

by

P. Chandra Nigam

Prepared for the Canadian Forest Pest Control

Forum December 6 & 7, 1977

A SUMMARY OF THE 1977 F.P.M.I. (OTTAWA) FIELD AND LABORATORY STUDIES

by

P. Chandra Nigam

A semi-operational experimental control study against spruce budworm larvae was carried out by spraying 2 applications of fenitrothion at 280 g AI/ha against second instars followed by a single application of aminocarb at 70 g AI/ha against fourth instar with a DC-6 aircraft in the Gaspé region of Quebec. Population reduction ranging from 60 to 90% and defoliation of 40 to 46% was observed in treated blocks. Eighty to ninety-eight percent defoliation was found in the untreated block. No adverse effect on bird activity or fish was found although aquatic insect fauna was slightly affected.

Field trials with permethrin and chlorpyrifos-methyl were also carried out in Gaspe region using a Cessna 185, calibrated to deliver 0.5 US gal/acre (*ca* 4.7 ℓ/ha), against fourth instar budworm larvae. Permethrin was superior to chlorpyrifos-methyl. Triple application of permethrin (3 x 18 g AI/ha) gave 92% population reduction and 25% defoliation as compared to 81% population reduction and 31% defoliation in the triple application of chlorpyrifos-methyl (3 x 52 g AI/ha). Average defoliation in check plot was 80%. Permethrin at 70 g AI/ha caused very significant mortality of aquatic invertebrates, but fish were not affected. In 1976, when permethrin was applied at 140 g AI/ha, it reduced invertebrate populations considerably and in 1977 recovery was not to the pre-spray level. The composition of invertebrate species and population levels were altered. No environmental impact studies have been carried out with chlorpyrifos-methyl to-date. It is suggested that multiple applications of permethrin at 18 g AI/ha should be considered for semi-operational evaluation in 1978.

Aerial applications of *Bacillus thuringiensis* plus acephate against the third and fourth instar larvae of spruce budworm were very effective and it is suggested that two applications, each of 10 BIU of Thuricide® + 28 g AI acephate per hectare, should be tried on 5 - 10 thousand hectares at the peak of third and fourth instar larvae in 1978.

An aerial spraying system for forest insect pest control by helicopter was developed, incorporating Beecomist® spray head and a Hughes Model 500 helicopter. It is hoped the system can be certified by 1979.

Studies on the drift of insecticide were carried out using a Dursban formulation in a Leco cold fogger mounted on a truck. The drift cloud was visible at the 265 and 500 m sample stations and ground deposits were observed up to 150 m downwind on Kromekote cards.

Environmental impact studies were carried out in the Maritimes, Quebec, Newfoundland and Ontario. Fenitrothion, aminocarb and virus at various dosages had no noticeable effect on bird or small mammal populations. Phosphamidon applied at 0.140, 0.420 and 1.121 kg AI/ha as a special study to determine sensitivity of the census technique, bird behaviour, etc., caused bird mortaltiy and a shift in bird territories. However, bird populations appeared to have recovered two weeks after the final application. There was no adverse effect of these heavy dosages of phosphamidon on stream ecosystems.

Laboratory toxicity studies against various species of insects showed that permethrin was most effective against adults of white pine weevil and spruce budworm. NRDC-161 was very effective against fifth instar spruce budworm larvae. The encapsulation of fenitrothion had increased the residual toxicity against spruce budworm larvae. Residues of fenitrothion were more toxic against the second instar larvae as compared to those of phosphamidon and aminocarb.

Analytical methods for determination of trichlorphon residues were developed. Aminocarb was found to dissipate to undetectible levels in foliage and soil after 47 and 27 days from initial deposit of 10 and 2 ppm in foliage and soil respectively. Studies on the translocation of C^{14} fenitrothion in fir, spruce, and jack pine revealed that some translocation through xylem occurred in fir but little or none in the other species.

Abstracts of each study are as follows:

Study No. CC-1-001

Operational Monitoring of the Efficacy of Multiple Application of Pesticides on Extremely High Populations of Spruce Budworm Larvae (*Choristoneura fumiferana* (Clem)).
A. P. Randall.

In 1977 semi-operational application of fenitrothion twice at 280 g AI/ha against second instar and 70 g AI/ha of aminocarb against fourth instar in 0.84 ℓ/ha oil formulation was made over block 305 (120,960 hectares) in the Gaspé region, Quebec, using a DC-6 aircraft.

The two applications of fenitrothion were effective and reduced the population by 60-70% on fir and by 80-91% on spruce. The third application, using aminocarb, was not effective due to poor timing and deposit. Defoliation within the spray block was 46% in fir and 40% in spruce as compared to 98% and 82% in the check block, respectively. Increase in dosage and spray coverage appears to be important for overall efficacy of the treatment. It appears that similar results could be achieved with a more efficiently applied lower dose of fenitrothion (210 g AI/ha or so twice).

Study No. CC-1-025 — Pesticide Efficacy Research: Spruce Budworm.
R. F. DeBoo

Efficacy of permethrin and chlorpyrifos-methyl by aerial application against spruce budworm larvae were investigated. Permethrin was applied at the rate of 18 g AI/ha as a single, double and triple applications at an interval of 2-5 days; single applications at 35 and 70 g AI/ha were also evaluated. Chlorpyrifos-methyl was applied at 52 and 140 g AI/ha as single sprays and three applications at an interval of 2-5 days of 52 g AI/ha. Each application of permethrin and chlorpyrifos-methyl treatments were compared with a standard treatment of fenitrothion at 252 g AI/ha emitted as a single application.

The experiment was carried out in the Gaspé region, north of the Chic-Choc Mountains and near Ste. Anne des Monts, Quebec. The treatments were randomly assigned to 22 stands of 50-120 acres. The defoliation was severe to moderate for the first time in 1976. The Institute's Cessna 185, fitted with four Micronair® AU 3000 atomizers and calibrated to 0.5 US gal/acre (*ca* 4.7 ℓ/ha) was used.

The spray was applied during the peak of the fourth-instar larvae period during early morning and evening periods. The average number of larvae per 45 cm branch tip varied from 32-60 before treatment. Single application of permethrin at 18 g AI/ha and chlorpyrifos-methyl at 140 g AI/ha appear to be equivalent to an application of fenitrothion at 252 g

AI/ha, especially in terms of foliage protection (*ca* 15% improvement over untreated trees) and did not provide satisfactory levels of population reduction and foliage protection. Triple application of both insecticides were superior to single applications and permethrin was superior to chlorpyrifos-methyl. The double application of permethrin was also effective. Permethrin triple application gave 92% population reduction and 25% defoliation and the triple application of chlorpyrifos-methyl gave 81% population reduction and 31% defoliation. An average of 80% defoliation occurred in untreated check blocks.

It is suggested that multiple applications of permethrin at 18 g AI/ha, (two or more depending upon population densities) should be considered for semi-operational trial during 1978. If aircraft costs are high, a single application of 70 g AI/ha may be equally effective, but may cause disruption in aquatic insect fauna. Chlopyrifos-methyl should be tested at 280-420 g AI/ha for single dose during 1978 and 70-140 g AI/ha for multiple application as it has not provided satisfactory control at tested dosages to date.

Study No. CC-1-015

Aerial Field Trials of Two New Formulations of *Bacillus thuringiensis* against the Spruce Budworm.
O. N. Morris and J.A. Armstrong.

In 1977, plots of 20-hectares each were aerially sprayed with Thuricide® 16B and Dipel® 36B in combination with Orthene® (acephate), carboxymethyl cellulose (Dipel only) and sunlight screens at Mattawa, Ontario. The plots were sprayed twice with a total of 20 BIU Bt + 56 g A.I. acephate/ha and acephate alone at 56 g AI/ha. There were two untreated check plots. The population of spruce budworm varied before treatment from 7 to 28 larvae per 45 cm branch. A good deposit was obtained with Bt formulations but poor deposit was achieved with acephate.

Thuricide + acephate, Dipel + acephate, acephate alone and check plots had population reductions of 94.6, 94.3, 88.6 and 74.5%, respectively and defoliation was 21-37% in Bt + acephate plots, 55-61% in acephate and 55-74.6% in check plots.

It is suggested that two applications of 10 BIU of Thuricide + 28 g acephate/ha should be tested semi-operationally on 5-10 thousand hectares at the peak of L_3 and L_4 in 1978.

Study CC-1-012

Development of a Helicopter-specific Aerial Spray System.
J. C. Edwards.

Complete aerial spraying system for forest spraying by helicopter was developed incorporating two Beecomist Model 350 spray heads attached to each boom. Two custom-built booms were mounted, one on each side of air frame. They can be rotated and locked in various positions from 45° forward to full aft.

Hughes Model 500 helicopter was used and contracted from Viking Helicopters (selection criteria - rotor blade characteristics appear to be better as compared to two-blade helicopters, better speed for ferrying and unique availability of accessory drive guide). Calibration was done in October, 1977 using 4.7 ℓ/ha with a swath width of 30 m using water and fuel oil formulations. Helicopter speed was 48, 72, and 96 km/h. Beecomist plastic sleeves of 40 micron porosity were used for both formulations and 80-100 micron porosity metal sleeves were also used for the oil formulation.

Spray height was 25 feet above canopy.

The preliminary results were encouraging. The effective swath width appeared three times greater and deposits were excellent. Deposit analysis and data compilation are underway. Further modifications are planned to make the whole system lighter and more rugged; and it is hoped that the system can be certified by 1979.

Study No. CC-1-011

Studies on the drift of a pesticide cloud through open forest.
J. A. Armstrong*.

The study was carried out in a valley located near Burney about 200 km north of Sacramento, California. The forest was predominantly Ponderosa pine of 4-25 m height and 15-50 cm d.b.h. With wind prevailing from north to northwest in this area there was about 1 km of forest downwind, followed by an open valley of about 5 km.

A Dursban formulation (360 g AI/ℓ) was released from the ground using a Leco cold fogger at the rate of 127.4 g AI/min. The fogger was mounted on a truck moving at a speed of 8 km/h. The drift was evaluated through the forest and out into the open valley, under measured meteorological conditions. Nine different sampling devices were used to measure various characteristics of drift. The cloud was visible up to 500 m sample stations. A visual observation of kromekote cards showed ground deposits up to 150 m. The other chemical and physical characteristics are under analysis.

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* At present on a one year work transfer at the Department of Agricultural Engineering, University of California, Davis, California, U.S.A.

Study No. CC-3-014

Summary Report on Studies of the Impact of Insecticides on Forest Ecosystems.
C. H. Buckner, B. B. McLeod and P.D. Kingsbury.

(A) Environmental Monitoring of Control Operations:

(i) Maritimes:

Aminocarb - At the emitted dosage rate of 0.070 kg A.I./ha applied twice there was no apparent effect on the bird or small mammal populations. Foraging honey bee colonies suffered light mortality in first application. The second application had no adverse effect. Mayfly and blackfly larvae were slightly reduced, but beetle larval populations were not affected.

(ii) Quebec:

No hazard to populations of breeding birds or small mammals after various applications of insecticides were observed.

(B) Environmental Monitoring of Experimental Trials

(i) Newfoundland:

(a) Aminocarb - Three applications each of 0.070 kg A.I./ha and two applications each of 0.087 kg A.I./ha, had no effect on bird populations.

(b) Fenitrothion + Aminocarb - Two applications of fenitrothion each of 0.210 kg A.I./ha, followed by one application of aminocarb at 0.070 kg A.I./ha did not result in bird mortality, but reductions in activity after the second application of fenitrothion and decline in warbler activity after the aminocarb treatment occurred. Activity returned to pre-spray level after the third day.

(c) Acephate + Bt - At the rate of 0.560 kg AI/ha had no adverse effect on bird populations or their breeding activity.

(ii) New Brunswick:

(a) Phosphamidon - Three applications each of 0.070 kg AI/ha for spruce budworm adults control did not affect song bird populations.

(b) Phosphamidon + pyrethrum - Two applications of phosphamidon each of 0.070 kg AI/ha + pyrethrum against the spruce budworm adults, had no adverse effect on bird and aquatic fauna.

(iii) Quebec:

(a) Fenitrothion + Aminocarb - Two applications of fenitrothion each of 0.280 kg AI/ha caused no bird mortality; an observed sharp decline in activity was ascribed to severe weather conditions.

(b) Phosphamidon - Three consecutive applications of 0.140, 0.420 and 1.121 kg AI/ha were applied at an interval to the test area to determine census technique sensitivity, bird behaviour, sub-lethal effects and mortality assessment. The first application (0.140 kg AI/ha) had no effect on bird populations, after the second application (0.420 kg AI/ha) some mortality was observed. The final application caused a significant reduction in bird activity, shift in bird territories and an increase in mortality. Inspite of considerable mortality, populations appeared to be recovering two weeks after final application. Two streams were monitored, and showed no adverse effect of insecticides.

(iv) Ontario:

Virus - NP Virus (5.5 x 10^9 PIB/ha) applied against *N. lecontei* showed no adverse effect on birds, aquatic insects or honeybees.

(v) British Columbia:

Spray program was cancelled. Bird populations were monitored to determine the bird species complex as related to stand form and budworm infestation.

A strong negative correlation was found between defoliation, resulting from the western spruce budworm and bird density and species diversity. A positive correlation was found with eastern spruce budworm density and abundance of late nesting bird species e.g., evening grosbeak and pine siskin.

Study No. CC-3-027

Summary Report on Studies of Pesticide in Aquatic Ecosystems.
P. D. Kingsbury.

Fenitrothion, aminocarb and permethrin were studied in various aquatic systems in the Gaspé region in 1977, and a follow-up study of a permethrin treatment of 0.140 kg AI/ha in 1976 was carried out.

Lac Ste-Anne was experimentally treated with two applications of 0.280 kg AI/ha of fenitrothion followed by one application of 0.070 kg AI/ha aminocarb. No dramatic adverse effect was found on zooplankton, benthos or fish population, significant impact was noticed on shallow dwelling caddisfly and mayfly nymphs. Fish samples for fenitrothion analysis have not yet been analyzed.

Effects of fenitrothion in trout streams varied from nil to large increases in drift of blackfly larvae and lesser impact on stonefly, mayfly nymphs and midge larvae. Aminocarb application caused slight increase in drift of larvae of blackfly, mayfly, midge and stonefly in some streams. None of the applications caused substantial decrease in bottom fauna. Brook trout diets did not change significantly. Fish were collected to study fenitrothion accumulation and persistence, data is being analyzed.

Permethrin at 0.070 kg AI/ha caused massive increase in drift of aquatic invertebrates. Aquatic insect populations were eliminated. Re-population of midge larvae was evident in late summer and fall, but other groups did not show recovery. Trout were forced to feed on terrestrial insects and were able to find reasonable quantities of food. Further study is recommended to document the recovery of aquatic insects and to quantify the effects on fish growth.

Recovery of lake ecosystem from impact of 1976 permethrin (at 0.140 kg AI/ha) application: In 1976, Zooplankton and benthic populations were heavily reduced. In 1977, species composition of the Zooplankton community remained altered, and cladoceran numbers had resurged and exceeded pre-spray populations. Midge larvae, dragonfly and damselfly nymphs had recovered substantially by the spring of 1977. Burrowing mayfly nymphs were completely absent from bottom samples. Oligochaetes and molluscs increased in numbers as compared to pre-treatment. Fish samples were collected for diet composition and growth study, but these have not yet been analyzed.

Study No. CC-2-006

Summary of Laboratory Evaluation of Insecticides Against Various Species of Forest Insect Pests During 1977.
P.C. Nigam.

Forty-two insecticides were tested against spruce budworm, white pine weevil, jack pine and larch sawflies. In contact toxicity studies permethrin (NRDC-143) was most effective against adults of white pine weevil and spruce budworm. NRDC 161 was most effective against fifth instar spruce budworm larvae. In residual toxicity, fenitrothion was better than phosphamidon and aminocarb against the second instar larvae of spruce budworm. Residues of S 5602 TG were most effective against fifth instar larvae of spruce budworm. The encapsulation of fenitrothion increased its residual toxicity against fifth instar larvae of spruce budworm. The residues of permethrin were more effective than any other insecticide tested against adult spruce budworm.

Study No. CC-3-018

Studies on the Distribution, Persistence and Fate of Pesticides in Forest Environments.
K. M. S. Sundaram.

Analytical methods for trichlorphon were developed. Water, soil and foliage samples were collected after field application of trichlorphon, and are being analysed for its residue. Preliminary evaluation showed that trichlorphon is labile and dissipates rapidly. The aminocarb residue in spruce foliage and forest soil were studied at intervals up to 69 days after simulated aerial spray of 3.4 ℓ/ha containing 57 g AI. Initial concentrations of *ca* 10 ppm of aminocarb in foliage and 7 ppm in soil and half-lives of *ca* 7 and 2 days, respectively and had dropped to trace or non-detectable levels within 47 and 27 days.

Studies with C^{14} labelled acephate, phosphamidon, and aminocarb were carried out on spruce trees. They were found to translocate via xylem stream and exhibited low systemic properties.

Study No. CC-3-013 & CC-3-023 Tree Physiology and Biochemistry.
R. Prasad.

Fungitoxic action of various compounds against *Ceratocystis ulmi* and *Verticillium albo-atrum* was studied. Hymexazol and Thiophanate-methyl were most effective. Translocation of C^{14} fenitrothion in balsam fir, spruce and jack pine was studied. Xylem transport of fenitrothion appears to be greater in balsam fir than spruce and no systemic activity was found in jack pine.

Operational Monitoring of the Efficacy of Multiple Application of Pesticides on Extremely High Populations of Spruce Budworm Larvae (_Choristoneura fumiferana_ Clem.)

by

A. P. Randall

Report to the Canadian Forest Pest Control Forum December 6 & 7, 1977

(Study Ref. No. CC-1-001)

Forest Pest Management Institute
Canadian Forestry Service
Environment Canada
Sault Ste. Marie, Ontario.

Operational Monitoring of the Efficacy of Multiple Application of Pesticides on Extremely High Populations of Spruce Budworm Larvae (*Choristoneura fumiferana* Clem.)

by

A. P. Randall

A large-scale semi-operational spray trial utilizing multi-engine aircraft and incremental application technology was conducted for the sixth consecutive year in Quebec to develop improved control strategies for the reduction of extremely high populations of 2nd and 4rd instar spruce budworm larvae. The objectives of the 1977 program were: (1) to monitor and report the efficacy of heavy dosages of two applications of 4 ounce of active fenitrothion pesticide (formulated in oil with 4 oz w/v of active ingredient in 11.52 oz) upon second and third instar larvae; (2) the efficacy of a single dosage of aminocarb (Matacil) (1.25 ounces active ingredient in 11.52 ounces of oil formulation) upon the 4th instar larvae; (3) the effectiveness of three early spray applications upon the host trees (balsam fir and eastern spruce) in terms of foliage protection and; (4) the effectiveness of timing of spray applications upon the larval populations and host trees.

An experimental/operational area of 120,960 hectares (298,900 acres) (designated as Block 305) was established in a high density spruce budworm infestation area (2800+ egg masses/10 m^2). Pesticide treatment for the area was established by the CCRI Recommendation Committee as follows: two applications of 0.84 l/ha*(11.52 oz/ac US) of oil formulated fenitrothion containing 0.28 kg/ha (4 oz w/v/ac) active ingredient against the 2nd instar larvae and one application of 0.84 l/ha of oil formulated aminocarb (Matacil) containing 0.088 kg/ha (1.25 oz/ac active ingredient). Timing of spray applications was recommended for the first fenitrothion spray to occur when 20% emergence of the second instar larvae had occurred, to be followed five days later by the second application of fenitrothion. The single late application of aminocarb was to be scheduled against the 4th instar larvae when 25% emergence had occurred.

Acceptance of these higher dosage rates of chemicals on the forest environment were predicated on the condition of total monitoring of all aspects of target and non-target organisms. This resumé is a preliminary report on the results of limited field monitoring of three applications of oil formulated insecticides on the early instar stages of the spruce budworm larvae and its host trees at dosages higher than those currently approved for forest insect control.

* 1 ha = 2.471054 acres

Methodology

Application

The application and timing of spray applications were carried out by the Quebec Department of Lands and Forests to conform with the recommendations set for the experimental/operational program. All aspects and conditions of operational spraying were carried out as specified, with the exception of the 2nd application which was delayed 4 days by weather to conform to requests by the Wildlife Monitoring Team for a morning spray application. Maximum effectiveness of incremental application of the sprays were ensured by utilizing four DC-6 aircraft per sortie with two sorties per aircraft to complete the spray over the block during the designated morning of operation.

Chemical and Biological Monitoring

A total of 60 sample trees (29 fir, 31 spruce) were selected along an east-west highway in the northern third of the block to represent the biological sampling stations within the semi-operational spray block. Two branch samples of 96 cm length were selected at each sampling schedule to provide pre- and post-spray population densities of budworm larvae. A check area of 20 trees was selected approximately 15 miles east of the block to provide biological data on natural larval mortality for the area. At each biological station, an open area of approximately 10 meters square was selected or cleared to provide ground sampling stations for drop deposit analysis in terms of drop numbers per square centimeters and volume (ounces/acre and litres/hectare) deposits. All biological data was subjected to correction for natural mortality using Abbotts formulae. (% population reduction = $\frac{\text{Expected Pop. - observed}}{\text{expected}}$ x 100)

Results

Spray Deposit Assessment

Deposit assessment of the three applications of the oil formulated pesticides indicated a very irratic deposit that was quite unlike deposit data collected in Quebec following the perfection of the Litton navigation system and incremental application technology. The results plotted in terms of drops/cm^2 and volume deposits (oz/ac) are presented in Figures 1, 2 and 3 for the 1st fenitrothion spray, the second fenitrothion spray, and the cumulative deposit for the two fenitrothion sprays respectively. The droplet deposit pattern for the 3rd application (aminocarb) is presented in Fig. 4.

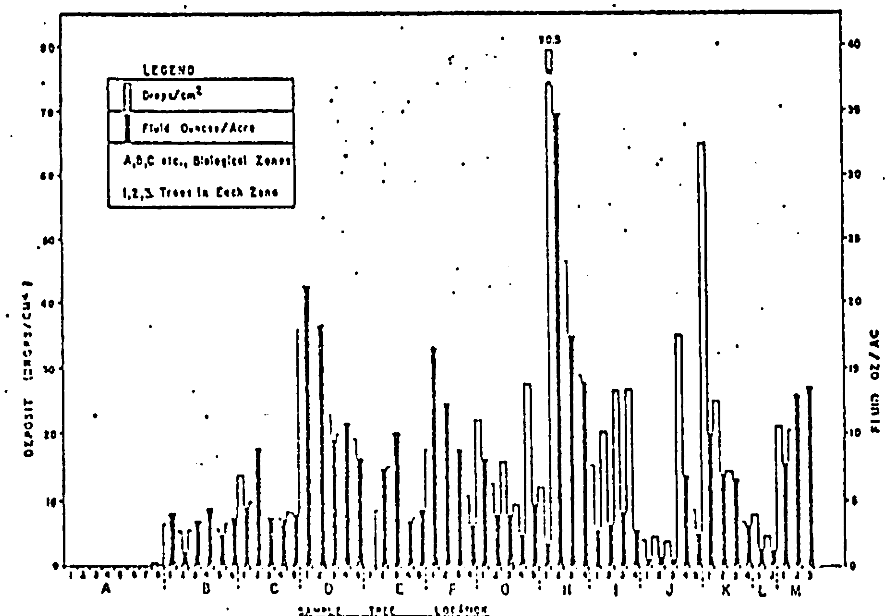

FIG. 1 COLLECTED DEPOSIT - FIRST APPLICATION -

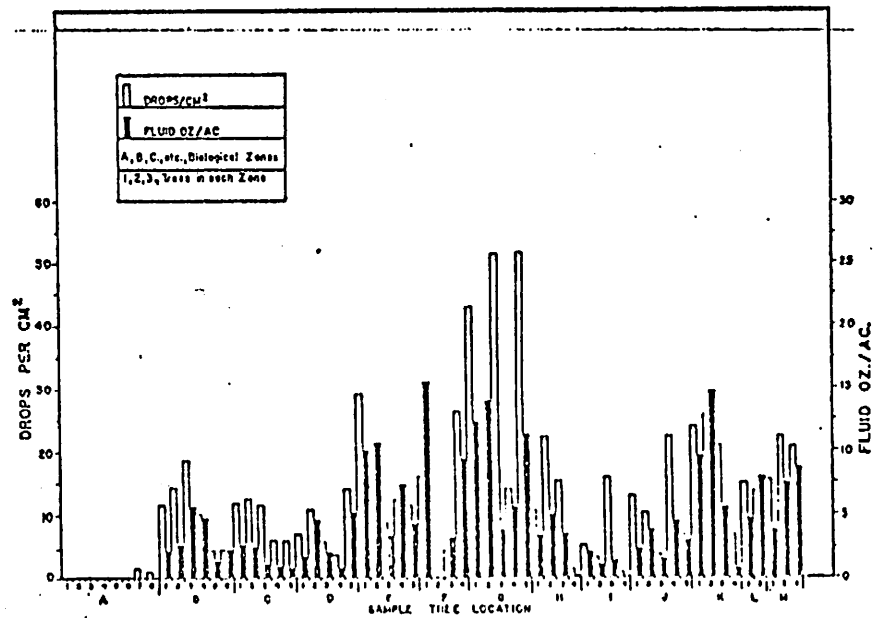

FIG- 2 COLLECTED DEPOSIT - 2nd APPLICATION

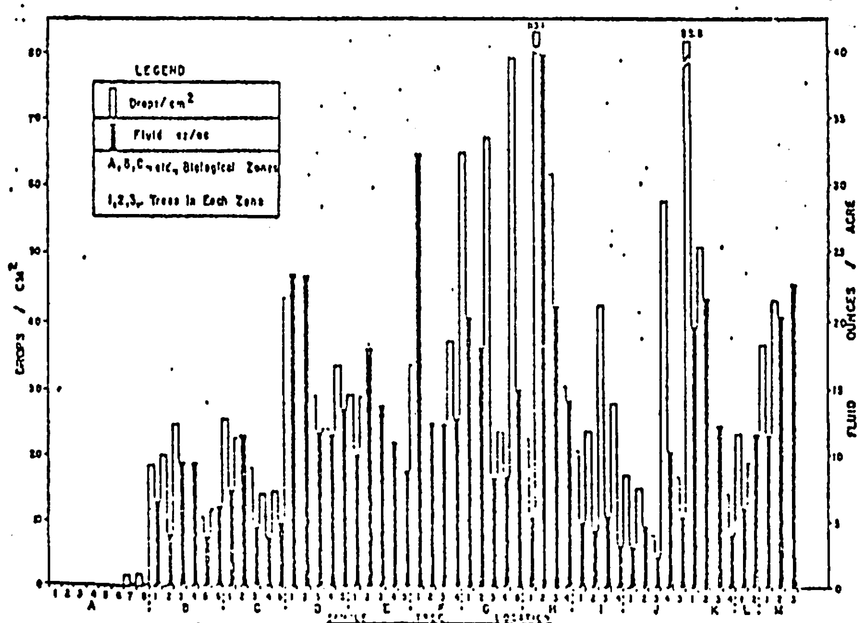

FIG. 3 COLLECTED DEPOSIT - TOTAL 1st & 2nd APPLICATIONS

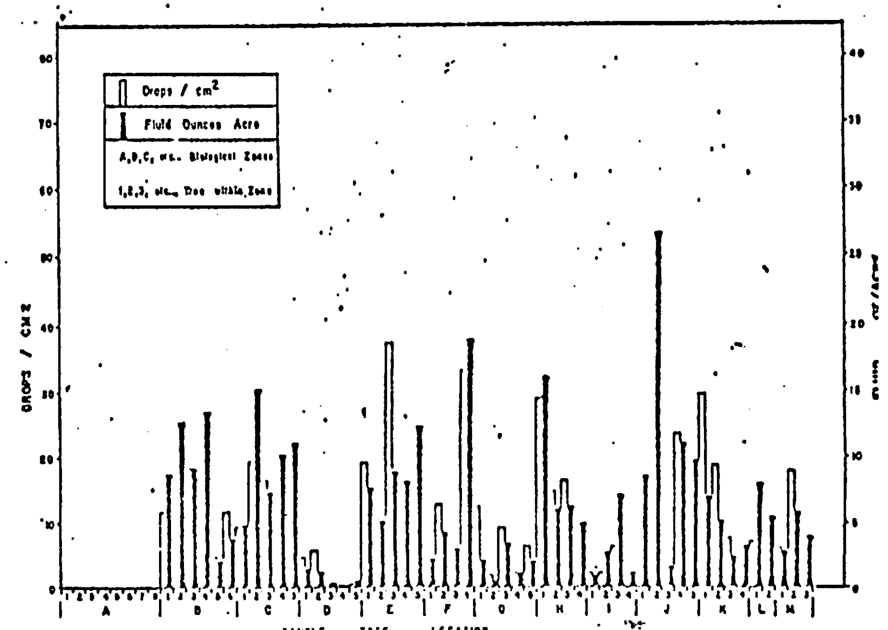

FIG. 4 COLLECTED DEPOSIT — THIRD APPLICATION — MATACIL

An analysis of the droplet spectrum characteristics of each spray in terms of maximum drop size; mass median diameter and number median diameter are presented in Fig. 5 and 6. The pertinent data representing each of the three sprays are condensed in the following table along with the expected drop deposit characteristics of previous sprays (calibration and field data, Quebec 1972 to 1976).

FIG. 5. DROP SPECTRUM CHARACTERISTICS OF FENITROTHION SPRAYS

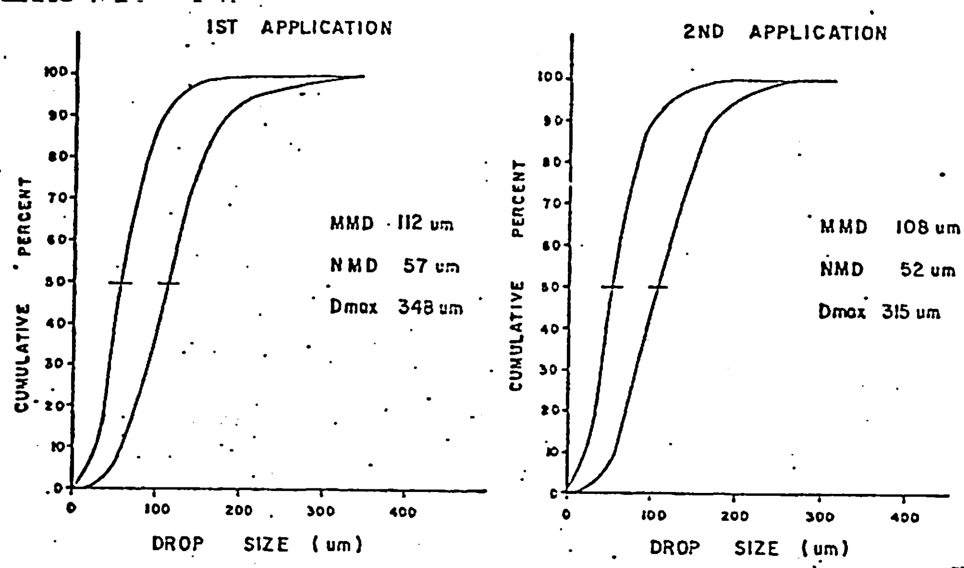

FIG. 6. DROP SPECTRUM CHARACTERISTICS OF MATACIL SPRAY (1.25 oz in 11.52 oz/ac)

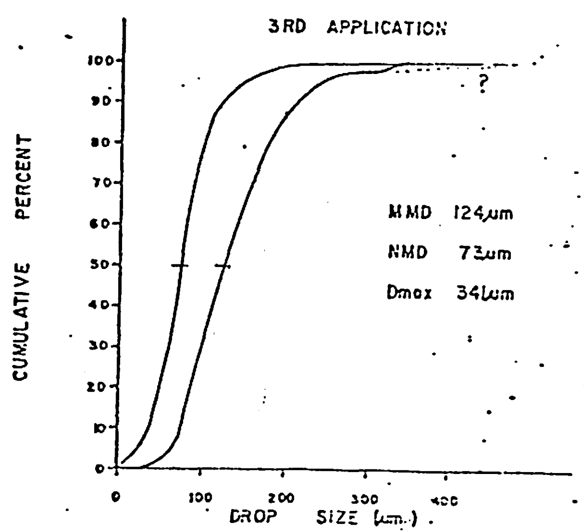

Table I

Droplet Characteristic of 1977 Spray Deposits

	Fenitrothion Formulation		Aminocarb formulation	
	1st spray	2nd spray	3rd spray	Expected (1972-1976)
Dmax	348 μ	315 μ	341+μ	200-250 μ
MMD	112 μ	108 μ	124 μ	70-90 μ
NMD	57 μ	52 μ	73 μ	40-60 μ

The above results would appear to indicate a reversal of the trend towards the use of a fine spray to achieve spray coverage rather than volume deposits and would, therefore, represent a regression of application technology to that of the coarse sprays of the 1950's.

A comparison of spray deposit pattern using 11.52 oz/ac emission volumes across a six mile transect of an experimental block in 1976 is presented in Fig. 7. The incremental nature of cumulative spray deposition from eleven spray swaths illustrates the expected spray coverage under ideal spraying conditions over rough hilly terrain as found in the LaMacaza area of Quebec. This type of terrain is not unlike that found in the central part of Block 305. Meteorological conditions during the first spray application in 1977 were ideal, i.e. cool with winds aloft at 1-2 mph, thus one would expect to find a relatively uniform deposit pattern within the experimental/operational spray block of 298,900 acres. The anomolies in drop numbers/cm^2 and volume deposits found in all three spray deposits strongly suggests problem areas in spray formulation, nozzle orientation, flow rate, spray pressure, and possibly swath alignment.

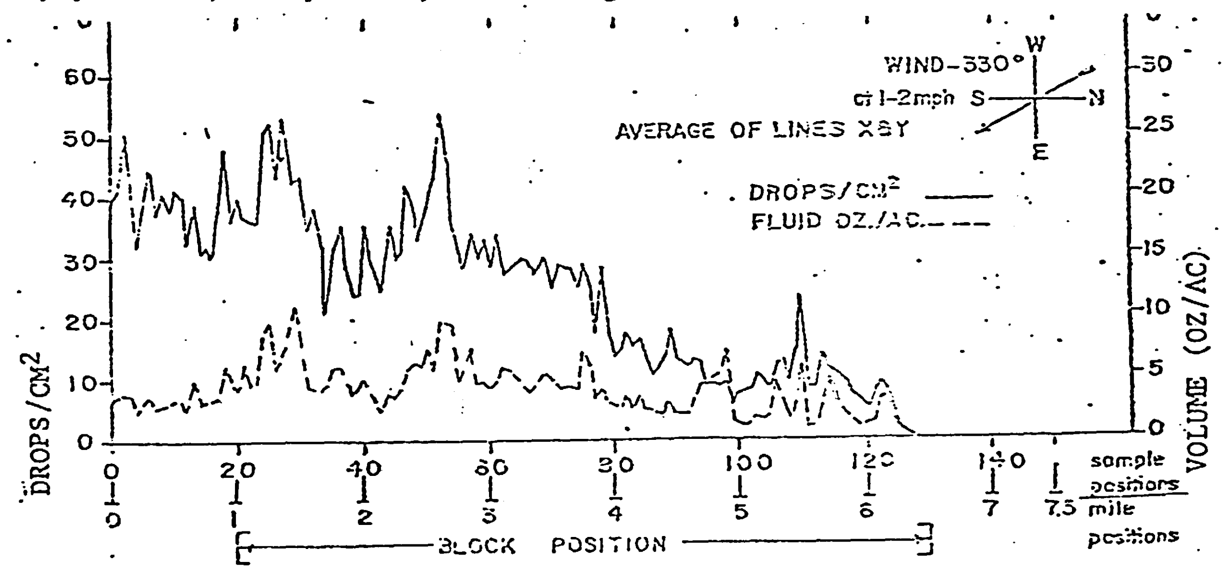

Fig. 7. Incremental spray deposition (1976).

Biological Assessment

Preliminary assessment of the biological data from the non-spray check area using emergence cage counts of 2nd instar larvae from 96 cm branch lengths indicated an average population density of 240 larvae/branch for balsam fir trees, and 265 larvae/branch for spruce. Natural decline of the early larval populations on both host trees are shown in Fig. 8 along with the daily emergence pattern for 2nd instar larvae collected under cool indoor conditions using a special designed emergence box for 2nd instar larval retrieval. The emergence data, however, does not totally reflect the true field pattern of larval emergence in the forest, it does, however, provide an Index of approximate emergence for a set of temperature/time parameters comparable to early field conditions.

Efficacy of two applications of fenitrothion sprays

Pre-spray population densities of 2nd instar larvae from the experimental Block 305 indicated an average count of 400 larvae/96 cm branch for balsam fir and 337 larvae/branch for spruce. Expected population reduction of 2nd and subsequent budworm larvae along with the actual population reduction due to each application of pesticide is graphically presented in Fig. 9. The pertinent data on the effectiveness of early application of fenitrothion sprays is presented in tabular form in Table II.

Table II

Population reduction of 2nd instar larvae following two applications of fenitrothion (4 oz. ai/11.52 fluid oz./ac.)

Host Tree	Population Density 2nd Instar	Post Spray			% Population Reduction from Expected		
	Pre-Spray	1st (48 hr.)	2nd (48 hr.)	3rd 6 days	1st Post	2nd Post	3rd Post
Fir	400	130.9	56	70.6	56	77	58
Spruce	337	132.8	21	43	57	91	80
Check	248.9	204.8	156.5	128.9	0	0	0

The above data reflects the effectiveness of early applications of fenitrothion sprays against 2nd and 3rd instar stages of the spruce budworm even under high larval densities/branch. These findings

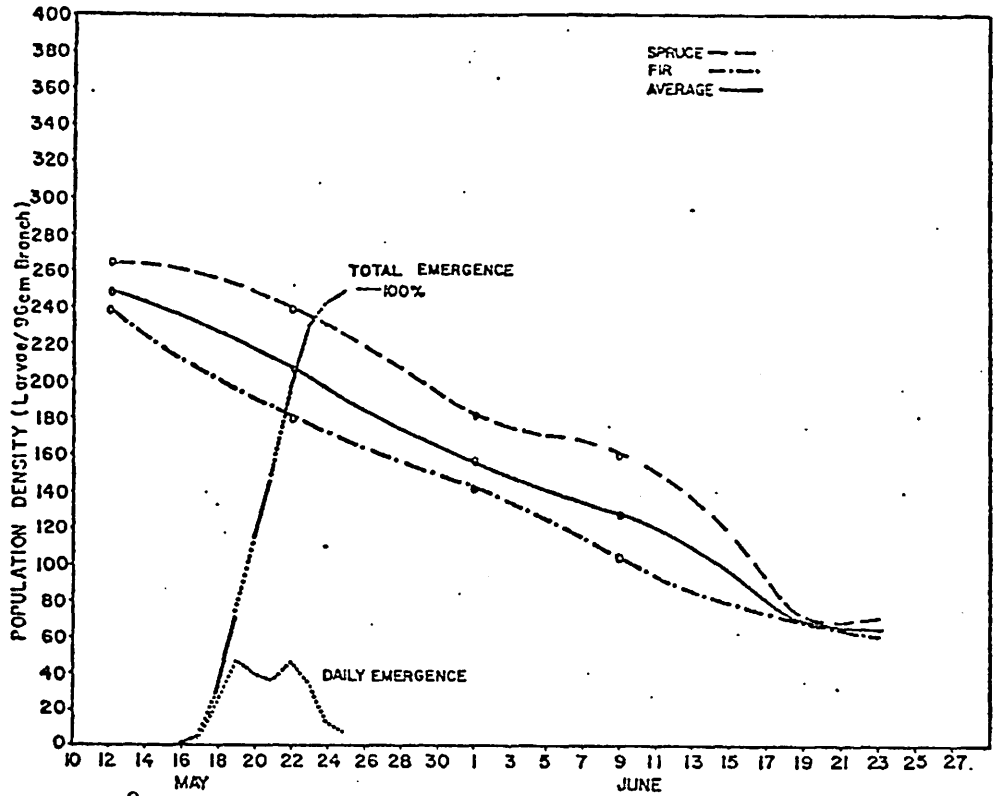

FIG.- 8 NATURAL LARVAL POPULATION DECLINE IN CHECK BLOCK (SPRUCE, FIR AND AVERAGE)

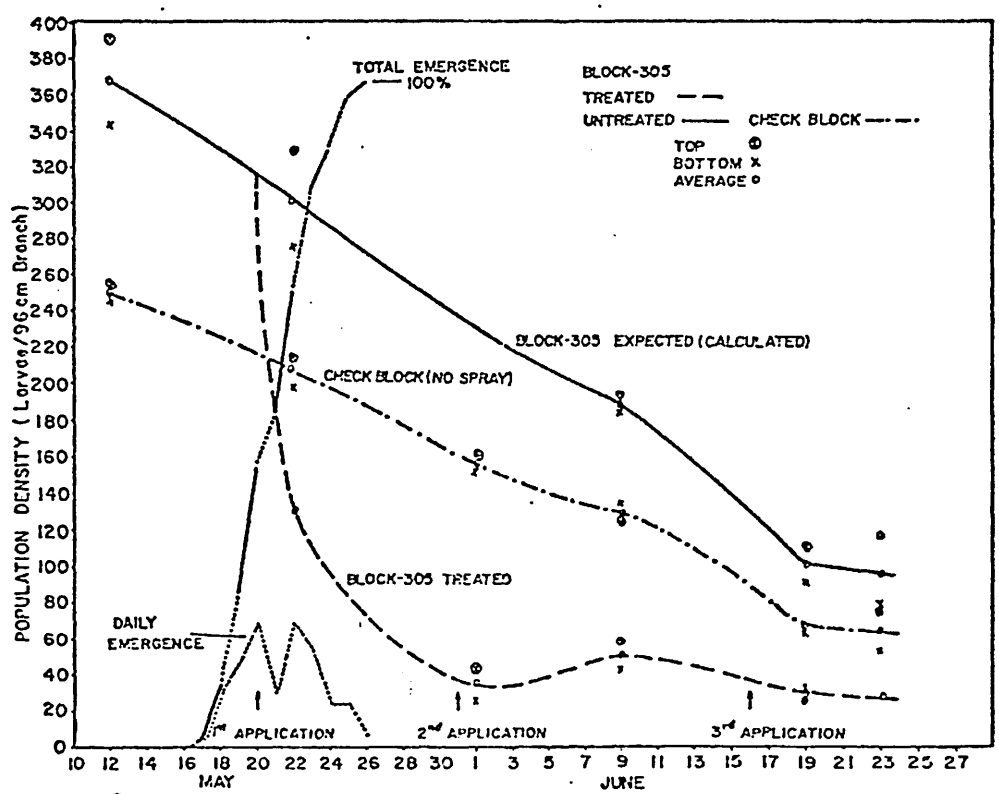

FIG. 9 NATURAL AND EXPECTED LARVAL POPULATION DECLINE IN CHECK AND SPRAY BLOCK-305 (SPRUCE AND FIR)

are in agreement with earlier experimental data by (Hurtig et al 1953) and (Randall, 1970) whereby the strategy of early application for the suppression of 2nd and 3rd instar larvae may be considered as a viable pest management tool. This strategy was further strengthened in 1976 using multi-engine aircraft technology and incremental application techniques whereby minimal quantities of fenitrothion (1 oz. active/11.52 oz./ac.) provided a significant 2nd instar larval reduction even under light population densities as illustrated in Fig. 10 (Randall and Desaulniers 1976). The similarity of the population reduction curves (1976 and 1977) (after correction for natural mortality) are quite striking and suggest that the early mobile phase of the spruce budworm larvae are readily susceptible to pesticide pressures.

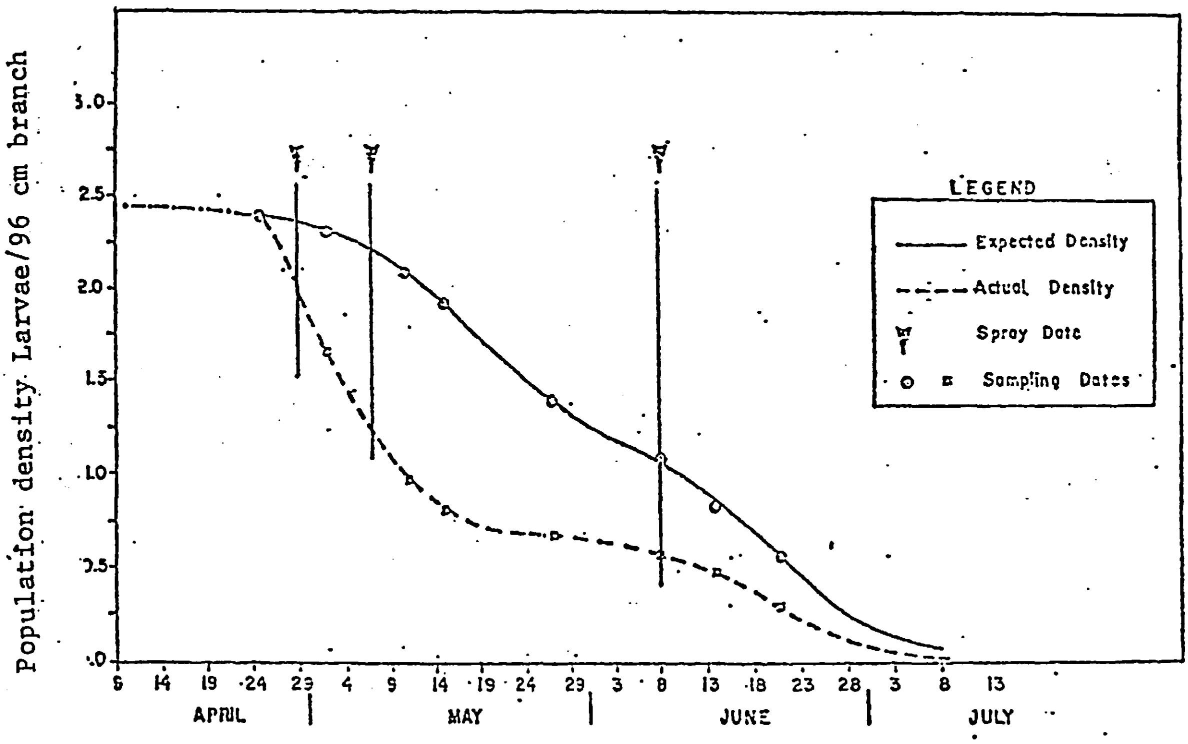

Fig. 10. EXPECTED SBW POPULATION. DENSITY VS TREATED
(1 oz. fenitrothion in 11.52 fluid oz./ac. spray application)

The extreme variability of spray deposits obtained across the experimental/operational Block 305 is unlike the previous deposit data recorded in Quebec using multi-engine aircraft. A visual analysis of the deposit data (Figs. 1, 2, 3 and 4) indicate regions ranging from areas of overdosing to areas of insufficient deposition of sprays. An examination of the effectiveness of the higher fenitrothion dosage on the basis of volume deposit (fluid oz./ac.) and 2nd instar larval mortality is presented in Table III.

Table III

Dosage Volume Deposit and Percentage Larval Reduction Following the 1st and 2nd Application of Fenitrothion (4 oz. ai in 11.52 oz./ac.)

Dosage Category		No. of samples	% Population Reduction	Deposit Data		Population Reduction 1st + 2nd Application*	
Fluid oz./ac.	Active ingredient oz./ac.		1st Application (48 hr.)	2nd Application (Fluid oz./ac.)	Cumulative* Deposit (Fluid oz./ac.)	(48 hrs.)	6 Days
34.8 - 11.52	12-4	9	71.4	5.8	23.7	96.0	86.2
11.51- 5.76	4-2	13	63.4	6.1	12.5	89.8	82.5
5.75- 2.7	2-1	19	63.8	4.0	7.7	90.6	76.5
2.69- 1.40	1-0.5	6	59.8	6.4	8.4	89.6	73.5
1.39- 0.0	0.5 - 0	12	29.9	5.0	5.6	88.6	68.1

*Cumulative effect of 1st & 2nd spray using the same biological tree samples for each dosage category established after the first spray.

An assessment of the deposit data (fluid oz./ac.) in terms of insect reduction does not follow the expected trend of increased mortality with increase in dosage whether a single application or multiple application of fenitrothion is applied. It is also interesting to note that dosage deposits between 1 oz. to 12 oz. active/acre provide 48 hour population reduction ranging from 60% to 71.4% for a single application of fenitrothion. The addition of a second application of fenitrothion over the biological samples increased the percentage of larval reduction uniformally for all dosage deposits by 20 to 30% thus, suggesting that factors other than volume deposits are responsible for larval mortality.

A reappraisal of the above data in terms of spray coverage are presented in Table IV where in spray coverage in terms of drops/cm^2 are classified into two categories, i.e. below 20 drops/cm^2 and above 20 drops/cm^2.

Table IV

Dosage coverage ($drops/cm^2$) and percentage larval reduction following the 1st and 2nd application of fenitrothion (4 oz. ai in 11.52 oz./ac.)

Dosage Category Fluid oz./Acre		Deposit Data: Drops cm^2	Deposit Data: Fluid oz. Acre	Deposit Data: No. of Samples	Per Cent Population Reduction 1st Application (48 hrs.)	Cumulative Deposit Data 1st & 2nd Application: Drops cm^2	Cumulative Deposit Data 1st & 2nd Application: Fluid oz. Acre	Cumulative Deposit Data 1st & 2nd Application: No. of Samples	Per Cent Population Reduction (Cumulative 1st & 2nd Application): (48 hrs.)	Per Cent Population Reduction (Cumulative 1st & 2nd Application): (6 days)
34.8-11.52	High	40.7	18.7	6	76.5	36.4	24.2	9	96.0	86.2
	Low	17.3	16.1	3	56.6	-	-	-	-	-
11.52-5.76	High	30.2	8.5	7	59.8	39.7	14.5	13	91.6	85.7
	Low	13.9	8.3	6	67.0		-	-	-	-
5.76-2.7	High	25.3	3.8	4	69.4	37.3	8.9	10	95.6	76.6
	Low	9.1	3.7	15	61.7	15.6	6.5	9	82.5	76.5
2.7-1.41	High	-	-	-	-	23.1	6.5	3	86.9	84.9
	Low	8.3	2.1	6	59.8	15.2	6.3	3	93.0	59.8

An examination of the per cent mortality figures within and between each dosage category shows that a stronger relationship exists between spray coverage in terms of drops/cm^2 and insect mortality than between volume and mortality. This is particularly noticeable between the first three categories where larval mortalities of 96.0, 91.6 and 95.6% are recorded for dosage volumes of 24.2, 14.5 and 8.9 fluid oz./ac. where as spray coverage for the three categories are 36.4, 39.7, and 37.3 drops/cm^2.

Population reduction of 2nd instar larvae following the first application of fenitrothion were recorded 48 hours after spray emission. The mortality values of 60 to 70% which appear to be low, do not reflect the total effectiveness of the first spray. The mortality figures are based on total expected population levels and not on the actual numbers of emerged larvae present on the foliage at the time of spray application as shown in Fig. 9 by the daily and total 2nd instar emergence graphs. Furthermore, biological data collected from trees that had received a high spray deposit (over 20 drops/cm^2) coverage during the 1st spray application and a subsequent low spray deposit coverage on the second application recorded a relatively high larval mortality, thus indicating a post 48 hour effectiveness for the first fenitrothion spray.

It was unfortunate that limitations of funds and resources prevented the collection of a second post spray sample prior to the application of the second fenitrothion spray, otherwise a positive set of data could well have established the time effectiveness and degree of each fenitrothion spray against the early larval instars.

Efficacy of a single late application of Aminocarb (Matacil)

Pre-spray residual population densities of 3rd and 4th instar larvae within the experimental Block 305 indicated average counts of 69.8 larvae/96 cm branch for balsam fir and 42.5 larvae/96 cm branch for spruce. Recommended spray application was schedule and carried out when 25% emergence of 4th instar occurred in the block. Expected population reduction and actual population reduction following application of the aminocarb pesticide is presented as grouped data (fir & spruce) in Fig. 9. Assessment of the biological data 48 hours and six days after treatment are presented in Table V.

Table V

Relation Between Dosage Coverage (drops cm^2) and Larval Mortality Following a Single Application of Matacil (1.25 ai. oz./ac.) at 25% 4th Instar Emergence

Host Tree	Drop Category drops/cm^2	No. of Samples	Deposit Data		Population Reduction		Per Cent Defoliation*
			Fluid oz./ac.	Active oz./ac.	48 hr.	6 days	
Fir	0-1	7	0.08	0.01	27	27	N/A
	1-10	12	3.28	0.0354	30	2	
	10-20	7	7.00	0.76	28	22	
	20-30	1	11.04	1.19	69	0	
	30-40	1	19.11	2.06	79	55	
	40-50	-					
Average							
Spruce	0-1	4	0.11	0.01	2	0	N/A
	1-10	14	4.06	0.44	31	0	
	10-20	11	9.83	1.06	16	0	
	20-30	2	11.49	1.24	11	0	
	30-40	-					
Average							

*Effect of Matacil upon surviving larval population and subsequent impact on defoliation are difficult to assess at this time.

The mortality data unfortunately are in complete disagreement with past experimental and operational findings for this insecticide and strongly suggest a loss of efficacy that could be attributed to factors such as (a) the production of an extremely coarse spray (D_{max} 341 + μ, MMD 124μ and NMD 73μ) that would seriously reduce the drop count/cm^2 throughout the target area; and (b) improper timing of the 3rd spray with reference to the bud habitat of the 4th instar larvae. Phenological development of the host trees within the spray block were predominately in the swollen bud stage with some evidence of flared buds in the north western end of the block. The overall effectiveness of the third aminocarb spray, therefore, could be considered as negligible both in terms of larval mortality and foliage protection.

Host Tree Defoliation

Defoliation data from the non-spray check block indicated a natural current foliage loss of 98% on balsam fir and 82% on spruce trees. By comparison average post spray estimates of defoliation within the spray block were 46% on fir and 40% on host trees in spite of the erratic deposit within the block and total lack of effectiveness of the 3rd spray.

An analysis of the effectiveness of the first and second fenitrothion sprays on 2nd and 3rd instar larval populations are presented in Tables III whereas the impact of early larval control express in terms of spray coverage and foliage protection is shown in Table VI. It is evident from the data that a very strong correlation exists between early insect mortality, degree of spray coverage and degree of foliage protection.

These results are in strong agreement with the earlier research finding of (Hurtig et al 1953_2) and (Randall 1970).

Conclusions

1. Early application of multiple sprays of fenitrothion at the pre needle- and pre-bud mining stage of development will provide a high degree of larval control and foliage protection even under conditions of extremely high population densities.

2. An analysis of the biological data in terms of spray deposit and insect mortality would indicate that spray coverage rather than increased dosage of chemical accounted for most of the larval mortality. It would appear that the recommended dosage rate of 4 oz. of active ingredient per acre per treatment was in excess of that required to provide adequate control and loss of foliage.

3. Analysis of the spray droplet spectrum of all three spray applications indicated problem areas in spray formulation, nozzle adjustment, uniformity of spray deposition and swath interval.

Table VI

Relation between dosage coverage (drops/cm^2), larval mortality and host tree defoliation following two applications of fenitrothion sprays

Treatment (4 oz ai in 11.52 oz/ac)	Drop category drops/cm^2	Balsam Fir: No. of Samples	Balsam Fir: Deposit Data: Fluid oz/ac	Balsam Fir: Deposit Data: Active oz/ac	Balsam Fir: Population Reduction %: 48 hr.	Balsam Fir: Population Reduction %: 6 days	Balsam Fir: Percent Defoliation (Final Count)	Spruce: No. of Samples	Spruce: Deposit Data: Fluid oz/ac.	Spruce: Deposit Data: Active oz/ac	Spruce: Population Reduction %: 48 hrs.	Spruce: Population Reduction %: 6 days	Spruce: Percent Defoliation (Final Count)
First application	0-1	6	0.00	0.00	31	-	-	2	0.05	0.02	26	-	-
	1-10	5	3.56	1.24	56	-	-	15	2.69	0.93	45	-	-
	10-20	11	6.77	2.35	72	-	-	3	12.22	4.24	60	-	-
20/5/77	20-30	4	6.80	2.36	61	-	-	5	8.71	3.02	76	-	-
	30-40	1	6.75	2.34	52	-	-	1	21.28	7.39	84	-	-
	40-50	0	-	-	-	-	-	1	17.45	6.06	88	-	-
	50+	1	34.74	12.06	52	-	-	1	9.94	3.45	36	-	-
Cumulative	0-1	5	0.00	0.00	26	0	99	1	0.00	0.00	74	40	99
	1-10	2	1.14	0.40	65	55	81	1	0.19	0.07	66	76	97
1st + 2nd	10-20	3	6.43	2.23	78	74	32	12	5.48	1.90	90	75	59
(20/5/77)	20-30	10	11.05	3.81	90	68	57	8	9.91	3.44	91	82	29
+	30-40	4	15.03	5.22	95	83	55	3	19.18	6.66	94	78	26
(29/5/77)	40-50	1	5.03	1.75	99	81	39	2	21.67	7.52	99	88	11
	50+	4	19.84	6.89	93	95	6	4	19.52	6.78	99	98	19

4. The 3rd spray of 1.25 oz. of aminocarb/acre, contributed very little in terms of insect mortality or foliage protection to the overall project. This could be attributed to improper timing of application in terms of % emergence of the 4th instar larvae rather than consideration of the host phenology, whereby late spray application be applied at the fully flared needle stage of new bud growth.

5. The critera of using % emergence of 2nd instar larvae as an index for the timing of early spray application is subject to error since it is extremely difficult to obtain a total emergence population prior to the date the spray should be applied. A far better criteria would be the use of insect activity and needle mining activity. This data should be coupled with meteorological data favorable to further 2nd instar emergence. It is because of the uncertainty of the total emergence period in days that multiple application (2 or 3X sprays) are recommended.

6. Although 11.52 fluid oz./acre appear to be adequate for spruce budworm control under conditions of gently rolling forest terrain (where spray emission height may vary from 300-500 feet above the forest canopy), it would appear that under conditions of rugged hilly terrain emission volumes could be increased to 16 or even 20 oz./ac. to maintain a high drop deposit coverage.

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PESTICIDE EFFICACY RESEARCH: SPRUCE BUDWORM

(Study Ref. No. CC-1-025)

Report to the Canadian Forest Pest Control Forum

by

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Ottawa, Ontario

December, 1977

PESTICIDE EFFICACY RESEARCH: SPRUCE BUDWORM

by

R. F. DeBoo

Two insecticides, permethrin (NRDC-143, Ambush[R]) and chlorpyrifos-methyl (Dowco 214, Reldan[R]) were selected for field evaluation of efficacy by aerial application against larvae of the spruce budworm (*Choristoneura fumiferana*). Preliminary studies of permethrin, a synthetic pyrethroid, during 1975 and 1976 indicated that the effective dosage to minimize defoliation could be less than 1 oz. AI/acre (70 g AI/ha). Chlorpyrifos-methyl was evaluated for the first time during 1976 as a simulated aerial spray and found to be at least as effective as fenitrothion for control of spruce budworm. Objectives of the studies for 1977, were:

(1) to determine the efficacy of permethrin applied at 0.25 oz. AI/ac (18 g AI/ha), 0.50 oz. AI/ac (35 g AI/ha), and 1.0 oz. AI/ac (70 g AI/ha);

(2) to determine the relative efficacy of the lowest dosage of permethrin (0.25 oz. AI/ac) applied as a single, double and triple spray treatment;

(3) to determine the efficacy of chlorpyrifos-methyl applied at 0.75 oz. AI/ac (52 g AI/ha) and 2.0 oz. AI/ac (140 g AI/ha);

(4) to determine the relative efficacy of the lower dosage of chlorpyrifos-methyl (0.75 oz. AI/ac) applied as a single, double and triple spray treatment.

(5) to compare each of the permethrin and chlorpyrifos-methyl treatments with a standard treatment of fenitrothion at 3.6 oz. AI/ac (252 g AI/ha) emitted as a single application.

Mixed balsam fir (*Abies balsamea*)-white spruce (*Picea glauca*) stands located north of the Chic - Choc Mountains and scattered from St. Jean de Cherbourg to Cap Chat in the Gaspé region of Quebec were selected as spray treatment blocks and untreated check areas. Treatments were assigned randomly to 22 representative stands (50-120 ac. rectangular blocks) which had suffered moderate to severe defoliation for the first time in 1976. Predictions indicated similar attack by the budworm for 1977.

All treatments were applied by the Institute's Cessna 185 fitted with four Micronair[R] AU3000 spray atomizers and calibrated to emit 0.5 U.S. gal./ac. (*ca.* 4.7 ℓ/ha). The carrier for all spray mixtures was No. 2 fuel oil. Sprays were applied primarily during the peak of the fourth larval instar (L_4) during early morning and evening periods of good weather (Table I).

Table I

Larval development and weather conditions during spray applications

Treatment*	Date (June)	Larval Development (%) L_3	L_4	L_5	Weather Conditions (Range) Temp (°C)	RH (%)	Wind (km/hr)
Permethrin							
1	14, 15, 16	15	75	5	8-12	50-93	0-8
2	17	12	70	15	9-11	52-73	2-6
3	22	4	48	28	12	86	0-3
Chlorpyrfos-methyl							
1	16, 17	12	70	15	9-11	50-54	0-6
2	19	8	58	19	11	85	4-7
3	22	4	48	28	12	74	0-3
Fenitrothion 1	17	12	70	15	10	52	2-4

* treatments followed by 1 indicates either single or first of multiple applications; 2 indicates second application; 3 indicates third application. Interval between sprays at same location 2-5 days.

Spruce budworm population densities were estimated once prior to treatment and at least twice after treatment in each of the replicates (e.g. treatment blocks receiving two or three applications were sampled 2-5 days after each spray; untreated check blocks were sampled 11 times during the period June 2 - July 21). Numerical estimates taken just prior to spray treatment and from 5-12 days following application were used to determine population reduction due to treatment. Foliage protection was determined for each block from representative branch samples at time of pupation using the method developed by Fettes.

Results (Table II) indicated that aerial applications of either permethrin or chlorpyrifos-methyl can effectively reduce population densities of spruce budworm larvae and intesity of defoliation. Single applications of permethrin at 18 g AI/ha (0.25 oz. AI/ac) and chlorpyrifos-methyl at 140 g AI/ha (2.0 oz. AI/ac) appear to be equivalent to an application of fenitrothion at 252 g AI/ha (3.6 oz. AI/ac), especially in terms of foliage protection afforded (*ca.* 15% improvement over untreated trees). However, all of the single applications of these dosages did not provide satisfactory levels of either population reduction or foliage protection.

Permethrin was most effective when applied at 70 g AI/ha (1.0 oz. AI/ac) as a single spray or when applied two or three times at 0.25 oz. AI/ac (i.e. cumulative emitted total of 0.50 or 0.75 oz. AI/ac.). Likewise, the lower dosage of chlorpyrifos-methyl (0.75 oz. AI/ac) was effective only as a triple application. Superiority of these sprays was clearly related to increased dosages and coverage.

The following conclusions and recommendations are drawn from the results of the field studies this year:

(1) Permethrin is a very effective insecticide for the control of spruce budworm larvae. Multiple applications (2 or more depending upon severity of attack) each at the rate of 0.25 oz. AI/ac should be considered for semi-operational evaluation during 1978. Alternatively, when aircraft costs are high, a single application at 1.0 oz. AI/ac may be equally as effective. Companion studies of toxicity to aquatic fauna should be continued also (see Kingsbury report).

(2) The applications of chlorpyrifos-methyl at the dosages selected provided only preliminary information on the efficacy of this insecticide. It was apparant that the highest dosage evaluated (2.0 oz. AI/ac) was too low to obtain a reliable index of performance. Dosages of 4 to 6 oz. AI/ac should be evaluated during 1978 for single application and from 1-2 oz. AI/ac for multiple application.

Table II

Results of aerial applications of permethrin, chlorpyrifos-methyl and fenitrothion near Ste. Anne des Monts, Quebec, 1977

Treatment*	No. Replicates	Avg. No. Larvae/45-cm Branch Tip Prespray	Avg. No. Larvae/45-cm Branch Tip Postspray	Corr. % Pop. Reduction**	% Defoliation
I. PERMETHRIN					
1. 0.25 oz. AI/ac. (1 application)	3	36	14	37	62
2. 0.25 oz. AI/ac. (2 applications)	2	29	7	61	19
3. 0.25 oz. AI/ac. (3 applications)	1	60	3	92	25
4. 0.50 oz. AI/ac. (1 application)	2	38	13	45	43
5. 1.00 oz. AI/ac. (1 application)	2	32	5	71	24
II. CHLORPYRIFOS-METHYL					
6. 0.75 oz. AI/ac. (1 application)	2	54	25	26	78
7. 0.75 oz. AI/ac. (2 applications)	1	52	10	31	69
8. 0.75 oz. AI/ac. (3 applications)	1	40	5	81	31
9. 2.00 oz. AI/ac. (1 application)	2	35	15	31	64
III. FENITROTHION					
10. 3.60 oz. AI/ac. (1 application)	2	40	21	16	65
IV. UNTREATED CHECK					
11. Untreated Check	4	39	24	-	80

* - 0.25 oz. AI/ac. = 18 g AI/hectare
0.75 oz. AI/ac. = 52 g AI/hectare
2.00 oz. AI/ac. = 140 g AI/hectare
3.60 oz. AI/ac. = 252 g AI/hectare

** - corrected by Abbott's formula.

Aerial Field Trials of Two New Formulations of *Bacillus thuringiensis* against the Spruce Budworm

(Study Ref. No. CC-1-015)

Report to the Annual Forest Pest Control Forum

by

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Aerial Field Trials of Two New Formulations of

of Bacillus thuringiensis against

the Spruce Budworm

by

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Prepared for the Pest Control Forum Meeting, 1977

During the past 5 years, research at the Forest Pest Management Institute, Ottawa, has concentrated on methods of improving the efficacy of commercial formulations of Bacillus thuringiensis aerially applied against the spruce budworm. Laboratory and small scale field results indicated that the addition of carboxymethyl cellulose or Kelzan, two carbohydrate materials used in the food industry, considerably improved suspensibility of the active ingredients of B. thuringiensis and that Kelzan increased flowability of the microbial suspensions. It was also found that two commercially available chemical sunlight screens, viz. Uvitex ERN-P and Uvinul DS 49, were effective sunlight screens for B.t. Addition of these ultraviolet screens effectively prolonged the viability of B.t. under natural conditions.

In 1977, 20 hectare plots were aerially sprayed with Thuricide 16B and Dipel 36B commercial formulations of B.t. with the carbohydrate (Dipel only) and sunlight screens added. Plots were sprayed at the rate of 10 B.I.U. of B.t. plus 28 gm acephate/ha on May 26 and May 30 for a total of 20 B.I.U. + 56 gm acephate/ha. An acephate alone plot was sprayed at 56 gm/ha and two untreated check plots were included in the test. Twenty-five white spruce and 25 balsam fir trees were sampled at day 2 and days 12, 18 and 25 for biological efficacy. Larval development was 76 - 79% L_{3-4}.

The main results summarized in Table 1 show that:

1. Pre-spray larval population densities were moderately high on all plots. The densities in terms of larvae/45 cm branch tip were 19/15, 23/13, 28/15 and 17/7, for Thuricide, Dipel, acephate and untreated check, respectively.
2. Ground level deposits of active ingredient were far higher than usual. The highest prior deposit rate of aerially applied B.t. was 8.1 B.I.U./ha of Thuricide applied at 10 B.I.U./ha in 1972. The present deposit rate about doubled that. The highest deposit rate previously achieved with Dipel was 6.9 B.I.U./ha in 1976 applied at 20 B.I.U./ha, again about one-half the present deposit rate.
3. For some unknown reason, very little of the acephate alone treatment reached ground surface. However, the spray cloud was observed to reach the tree canopy shortly after spray application.
4. Drop density in the Thuricide plot was twice the highest density previously achieved with Thuricide applied at 10 B.I.U./ha. Drop density in the Dipel plot was comparable with that achieved in 1976 ($88/cm^2$) when carboxymethyl-cellulose was used in the formulation.
5. Deposit of viable spores in the Thuricide plot was about the same as the highest previously achieved with Thuricide (i.e. 9.1×10^9/ha in 1972). Viable spore deposit rate of Dipel was triple that of the 1976 test even though the B.I.U. emitted in the present test was only two-thirds that of the 1976 B.t. dosage.

6. Droplet size in both plots was mainly in the desirable 70 - 210 μm diameter range.

7. Residual budworm density per 100 buds in the untreated check plots was 3.4 compared with an average of 0.3 in the B.t.-treated plots and 0.7 in the acephate-treated plot.

8. Development rate of budworm was greatly reduced in the B.t-acephate plots compared with the acephate alone and check plots.

9. The B.t-acephate treatments were highly effective in terms of foliage protection (21% - 37% defoliation in B.t.-treated compared with 55% - 75% defoliation in acephate alone and untreated check.

10. Pupal and egg parasitism rates were not affected by any of the treatments.

11. Viable egg mass densities at the end of the season were not substantially different between the test plots. This was expected since the test plots were small and were simple patches in a large budworm-infested stand.

Conclusions and Recommendations

Both Thuricide and Dipel in combination with acephate and sunlight protectants are effective alternatives to chemical insecticides alone. The present Thuricide commercial formulation appears to be more desirable than the present Dipel formulation. It is strongly recommended that the combinations now be tried on larger plots of 5 - 10 thousand hectares. Two applications of 10 B.I.U. + 28 gm acephate/ha each should be applied when larvae are at peak L_3 and peak L_4, respectively.

Table 1

Summary of Results of Aerial Applications of Thuricide 16B and Dipel 36B against the Spruce Budworm at Matawa, Ontario, 1977

Assessment Criteria	Treatments			Check
	Thuricide	Dipel	Orthene alone	
Pre-spray larval density per 100 buds, wS/bF	24/20	25/17	30/16	18/11
B.I.U. of B.t. deposited at ground level/ha	15.9	11.4	–	–
Gm acephate deposited/ha	45.1	32.4	6.2	–
Droplet density (drops/cm^2)	198	71	?	–
Viable spores deposited/ha	7.4×10^9	25.3×10^9	–	–
% of droplets in 70 – 110 (μ) range	56	76	?	–
" " " " 111 – 210 " "	41	22	?	–
Residual budworm density/100 buds wS/bF	0.4/0.1	0.5/0.3	0.6/0.7	3.3/3.5
Corrected % population reduction (plot)	94.6	94.3	88.6	74.5
% Pupal development on final day of population assessment	33	44	68	70
% Defoliation				
wS	22	37	55	55
bF	21	33	61	74.6
% Pupal parasitism	10.5	3.4	14.5	8.0
% Egg-mass parasitism	51	34	21	27
Emerged egg mass density/9.3 m^2 of foliage	74.2	85.4	138.5	90.8

A HELICOPTER-SPECIFIC AERIAL SPRAY SYSTEM FOR FORESTRY APPLICATIONS: PRELIMINARY DESIGN, DEVELOPMENT AND FIELD CALIBRATION

(Study Ref. No. CC-1-012)

Report to the Canadian Forest Pest Control Forum

December 6-7, 1977

by

J. C. Edwards

Forest Pest Management Institute
Canadian Forestry Service
Environment Canada
Ottawa, Ontario

November, 1977

A HELICOPTER-SPECIFIC, AERIAL SPRAY SYSTEM FOR FORESTRY APPLICATIONS: PRELIMINARY DESIGN, DEVELOPMENT AND FIELD CALIBRATION

by

J. C. Edwards

During the past decade, government agencies and private industry alike, from coast to coast in Canada, have displayed an increasing, serious interest in the use of helicopters to aerially apply chemicals for forest pest management.[1]

A report[2] currently on file enlarges on this subject, defines the reasons for the helicopter's high potential in this role and for its often limited success to date. Chief among the latter is the present absence either of an aerial spray system specifically engineered for forest spraying by helicopter or of established airspeed, altitude and meteorological parameters which optimize spray efficacy and deposit[1]. Equipment designed for agricultural spraying by fixed-wing aircraft has proven inadequate.

Accordingly, in 1977, the Chemical Control Research Institute initiated a program to design and develop to an operational level a helicopter-specific aerial spray system for forest pesticide application, and to establish operational guidelines for maximization of treatment efficacy through use of the helicopter rotor wake.

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1 See appended minutes of meeting of the Spray Technology Committee, Eastern Spruce Budworm Council, Ottawa, Ontario, September 14, 1977.

2 See Edwards, J.C. 1976. The use and potential of helicopters in forest pest management. Report prepared under contract for the Chemical Control Research Institute, 334 pp.

In designing the spray system, a number of basic criteria were adhered to. The helicopter's wide airspeed capability range demanded an atomization device whose operation is completely independent of airspeed. For spray economy and efficacy compatible with helicopter payloads, this device must produce superior droplet spectra to those obtainable with standard hydraulic nozzles. In addition, the system must be light-weight, simple, reliable, easily-maintained and economical. For ease of installation and removal it should consist of three modules: two booms complete, and a palletized tank/pump module for cabin installation, all with standard anchor points and quick-disconnect attachments to the ship electrical and hydraulic systems.

For various reasons[2], the Hughes Model 500 helicopter was selected as the test aircraft, and one was contracted from Viking Helicopters Ltd. of Ottawa. The Hughes 500 is equipped with a four-bladed, 26.33-feet diameter main rotor (see Figure 1a) and a Detroit Deisel Allison 250-C18 gas turbine engine developing 317 shaft horsepower at sea level. The prototype spray system included off-the-shelf items representing the better features of existing systems plus components specific to the programs.

The palletized, internal, cabin module (see Figure 1b and c) consists of a 200-liter, fiberglass tank with loading strainer and jet agitator, tank shut-off valve with pressure by-pass to the tank, and pressure guage. Flow to the booms is controlled by electric solenoid valves wired to the cargo-hook release switch on the pilot's cyclic stick.

Two Beecomist Model 350 spray heads were installed on each boom (see Figure 1a), sufficiently inboard to minimize rotor tip vortex effect, each using a diaphragm check valve and Micronair Variable Restrictor Unit to facilitate calibration, and a mounting bracket which permits turning the complete unit for proper, longitudinal alignment. The Beecomist porous sleeves are rotated by an integral, one-quarter horsepower electric motor.

The booms, constructed by Viking engineers, were 10 feet in length and can be rotated and locked in various positions from 45° forward to full aft. This feature permits the experimental location of the Beecomists in various positions relative to the rotor wake and the centre-line of the aircraft, as well as a "trail" position (see Figure 1a, position 4) of the booms for ferry purposes.

Preliminary calibration was carried out near Ottawa in a plantation area during September 29 through October 6, 1977 and was based on an application rate of 64 ounces per acre over a swath width of 100 feet. Two formulations were used: water with 20 percent ethylene glycol and Rhodamine B dye, and #2 fuel oil with 20 percent Arotex and Automate B dye. Emission altitude was 45 feet above ground and 25 feet above canopy. Each formulation was sprayed at 30, 45 and 60 miles per hour indicated airspeed, and each trial was replicated.

Beecomist plastic sleeves of 40-micron porosity were employed with both formulations, and 80-100-micron perforated metal sleeves were also used for the oil application.

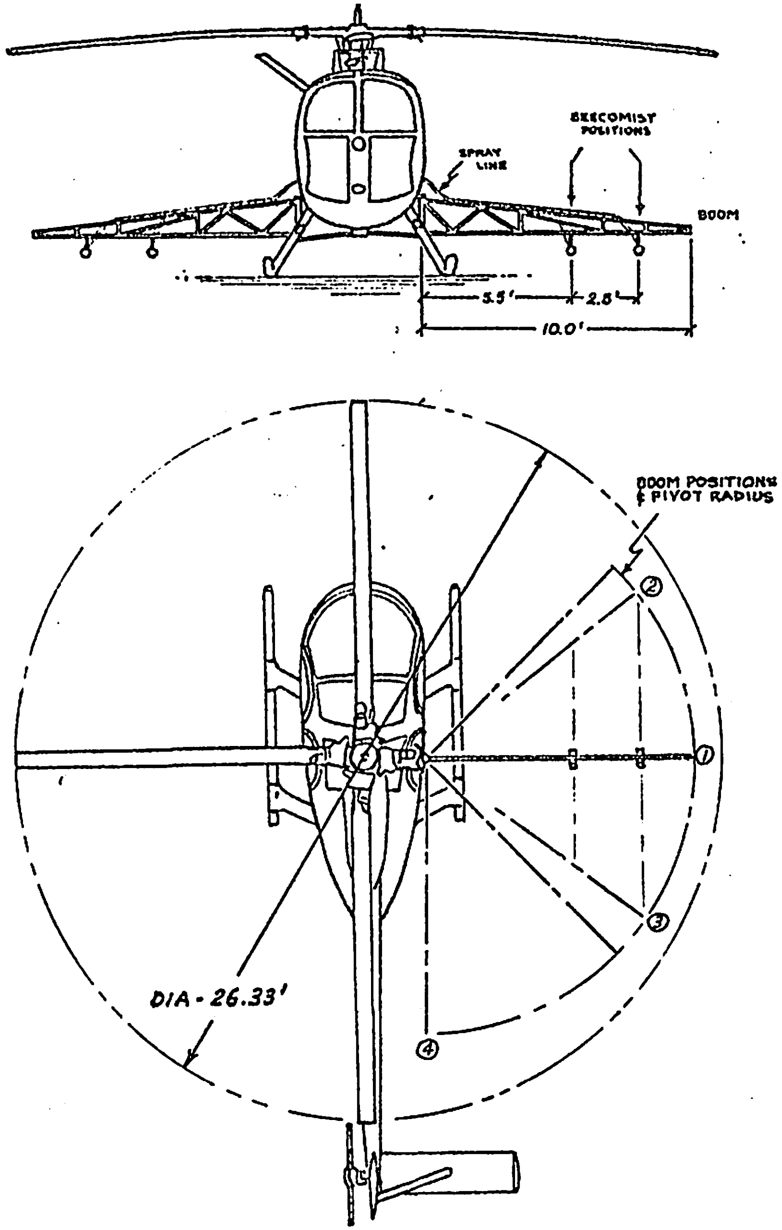
Deposit cards and glass slides were suspended in the canopy and were located on the ground, both in the open and under the canopy, for each trial.

Calibration work was hampered initially by mechanical problems with the Micronair VRU's, and throughout by very inclement weather. Consequently, not all the planned work could be completed. Nevertheless, preliminary results are extremely encouraging. On completion of ground run and shakedown, the system functioned perfectly. The observed interaction of the spray cloud and rotor wake from the Hughes 500 was as expected, with excellent deposit and an apparent, effective swath width of up to three times that anticipated and used as the basis for calibration. Deposit analysis and data compilation are underway and a full report is in preparation.

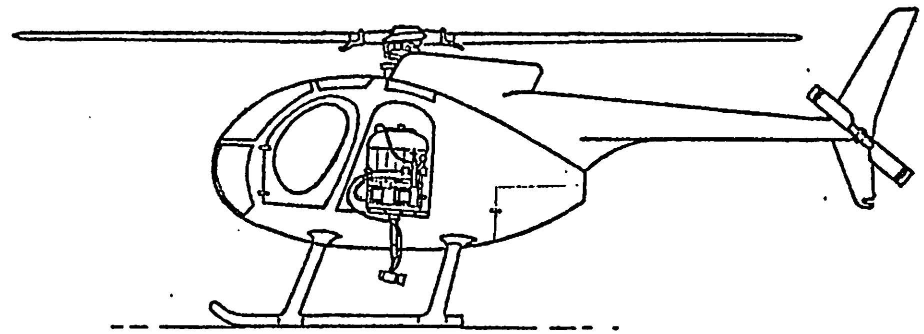
Further field work is planned for 1978 and, prior to the spring, modifications to the pump and boom are planned. In addition, all electric motors in the system will be replaced by light-weight hydraulic motors, making the total system lighter, simpler and more rugged, and greatly increasing both its versatility and available horsepower. It is hoped that a system will be ready for certification by 1979, although further bioassay work and deposit analysis may still remain at that time.

Great interest is being displayed in this program, both domestically and internationally and, with adequate funding and support, it is strongly anticipated that its systems-development phase will proceed to completion on schedule.

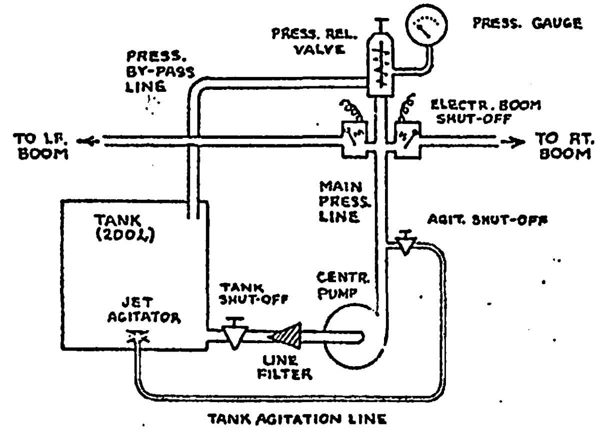
Figure 1. Prototype FPMI Helicopter Experimental Spray System on Hughes Model 500 Helicopter



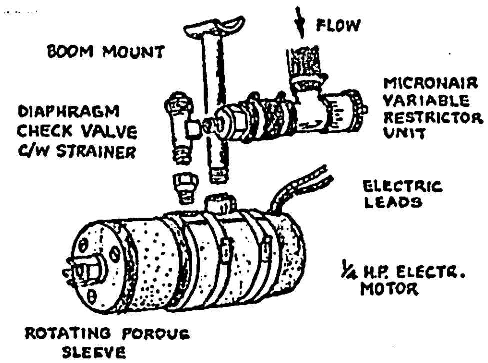
a) Front and plan views of spray boom installation and configuration.



b) Side view showing internal system installation.



c) Schematic diagram of spray delivery system.



d) Detail of Beecomist boom installation.

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FREDERICTON, N.B.
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September 16, 1977

TO MEMBERS OF THE SPRAY TECHNOLOGY COMMITTEE:

Copies to: B. Campbell
B. A. McDougall
A. Thurston

Gentlemen:

Enclosed is a copy of the minutes of the informal meeting of the Spray Technology Committee held in Ottawa on September 14th as interpreted from the notes I made. If there are errors and omissions I will have to take the responsibility.

Yours truly,

H. J. IRVING,
Chairman.

HJI:mg

Enc. 1

Eastern Spruce Budworm Council

Informal Meeting of the Spray Technology Committee

Held on September 14 at 25 Pickering Place, Ottawa

This informal meeting was held specifically to discuss the use of helicopters for forest insect spraying. Present were:

Forest Pest Management Institute:	Robert F. DeBoo Craig Edwards P. C. Nigam
Forest Protection Limited:	H. J. Irving B. A. McDougall
Maine Forest Service	Ancyl Thurston
Newfoundland Dept. of Forestry & Agriculture:	J. A. Doyle
Ontario Dept. of Natural Resources:	Bob Campbell
Quebec Dept. of Lands & Forests:	Michel Pelletier

It was generally agreed:

1. That helicopters should not be used simply to replace fixed-wing aircraft for normal forest spraying, but for specialized uses:

    a. For high value areas where better protection is required through uniform impingement of droplets on all parts of the tree and on all parts of the foliage which can only be accomplished by helicopters flying at low enough air speeds and altitudes to permit the rotor wake to accomplish acceptable canopy penetration. Helicopters spraying at normal cruise speed and at normal fixed-wing spray height perform as fixed-wing aircraft as far as canopy penetration is concerned.

    b. In sensitive areas where control of drift is a critical factor, in which case the air speeds and spray height mentioned in (a) must be respected to avoid drift control problems similar to those associated with fixed-wing aircraft.

    c. Where work site is beyond economic range from useable airstrips.

    d. Where, because of terrain conditions, the use of fixed-wing aircraft is hazardous or impractical.

e. Improper use of helicopters; i.e., with inadequate equipment, technology or spray techniques, for purely political or cosmetic reasons, can seriously harm the development and acceptance of this high potential but poorly understood spray aircraft.

2. Aerial spraying systems for use by helicopters in treatment of forested areas for insect control should adhere to the following criteria:

   a. An atomization device capable of producing the required droplet spectra independent of airspeed.

   b. The entire spray system should be so designed as to meet the requirements inherent in the use of helicopters for forest spraying of insecticides.

   c. In general equipment must be simple, light weight, dependable and readily available.

3. In view of the speed and spray height limitations mentioned in (1) seat of the pants and/or presently used navigational systems are inadequate and helicopter specific systems need to be researched.

4. The interest in using helicopters for forest insect control is demonstrated by recent use; for example:

Quebec	1976	17,000 acres
Maine	1977	60,000 acres
Newfoundland	1977	4,000 acres
New Brunswick	1977	12,000 acres

5. All agencies recognized that improved dispersal and navigational systems are required.

6. It is recommended that research and development on helicopter spraying carried out by agencies represented on the Eastern Spruce Budworm Council be co-ordinated through the Spray Technology Committee and it is hoped that this will avoid duplication of effort and accelerate solutions of the problems involved.

7. Research and development currently in progress includes:

   a. <u>Forest Pest Management Institute:</u>

      Development of a helicopter specific aerial spraying system involving atomization devices which are independent of air speed.

   b. <u>University of New Brunswick, Chemical Engineering Department:</u>

      An evaluation of droplet spectra from Beecomist atomizers.

   c. <u>Forest Protection Limited:</u>

      A review of navigational systems currently available.

September 15, 1977

H. J. Irving,
Chairman.

Studies on the drift of a pesticide cloud through open forest

(Study Ref. No. CC-1-011)

Report to the Canadian Forest Pest Control Forum

by

J. A. Armstrong*

Forest Pest Management Institute
Forestry Directorate
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Sault Ste Marie, Ontario

*At present on a one year work transfer at Dept. of Agricultural Engineering, University of California, Davis, California. U.S.A.

Studies on the drift of a pesticide cloud through open forest

The drift of a cloud of pesticide particles through open forest was studied as part of an ongoing program to gain information on the downwind dispersal of pesticides. The study is under the direction of Professor N.B. Akesson, Department of Agricultural Engineering, University of California, Davis. The author, at present on a work transfer to UCD joined in the project as a member of the study team. The author's role in the project was to be responsible for a study on pesticide deposits on tree foliage at distances downwind from the line of emission. This necessitated tagging of suitable sample trees, determining the position of these trees relative to other sample systems used, collection of pre- and post-spray branch samples, storage of these samples prior to deposit analysis, and interpretation of the results.

The drift studies were carried out in a partially forested valley located near Burney about 200 km north of Sacramento. The valley, approximately oval in shape is about 4.5 km wide by 6 km from the head of the valley to the mouth. The valley floor is flat with the surrounding hills rising to 100-200 m above the floor. In the northwest portion of the valley is a forested area, basically an extension of the forest on the slopes in that portion of the valley. This forested area extends out onto the valley floor for about 2 km with a width of about 2.5 km. The predominant trees are Ponderosa pine from 4 to 25 m tall and 15 to 50 cm in diameter. Also present were a few Douglas Fir, these were not used in the study. The area had been logged and was open with many clearings and trails. The forested area was cut by a road running roughly southwest to northeast along the northwestern portion. The road was relatively straight, about 2 km long and there was about 1 km of of forest south of the road. With the prevailing winds in the valley from the north to northwest this gave about 1 km of forested area downwind of the road followed by about 5 km of open valley.

The aim of the study was release a cloud of insecticide from a ground emission system under measured meteorological conditions and to measure the extent of its drift through the forest and out onto the open valley floor.

The experimental layout was as follows: at about the midpoint of the road a line was surveyed running at right-angles to the road and extending through the forested area. Starting at 7 m from the road sample stations were tagged; the stations extended out to 5 km from the road. At each sample station sets of sample units and insecticide collecting devices were positioned; trees from which branch samples would be taken were also identified. A meteorological tower and radio command post were stationed on the open valley floor about half way down the sample line. The following sample systems were used:

Magnesium oxide plates (MgO) on rotorod base: for drop-size characterisation of the spray cloud.

Mylar sheets: for chemical analysis of deposit.

Kromekote cards (mounted flat): for drop-size characterisation of the deposit.

Staplex and Unico air samplers: to measure concentration of insecticide in the air mass according to drop-size categories.

Andersen air samples: six of these were mounted at intervals on a 30 m tower to measure pesticide concentrations at different heights.

Kromekote cards wrapped on 8 cm diam. forms: this technique for droplet assessment was being studied by the U.S. Forest Service group in Davis.

Pipe cleaners: mounted vertically in banks of 12 for a chemical assessment of collection efficiency (U.S. Forest Service study).

Branch samples: 25 cm long branch tips were collected for chemical analysis of deposit at 2 m and 4 m above ground level.

In table 1 are shown the number and position of the various sampling systems used.

The insecticide used was Dursban (6 lb/US gal) diluted 1:1 with Super 94 oil to give a 3 lb/gal mix. This was applied using a truck mounted Leco cold fogger at the rate of 354 ml/min to give an emission of 127.4 gm AI/min. Allowing for a 1.6 km downwind drift of the cloud a single pass gave an estimated deposit of 0.017 kg/ha. Vehicle speed was 8 km/hr during all application runs. Preliminary calibration of the Leco cold fogger applying this mixture indicated a spray cloud with the majority of the droplets in the 10-30 μm class.

With the low emission rate of active ingredient and the possibility of the deposit being so low as to be unmeasurable it was decided to do two separate single passes and then one multiple (5 emission runs) pass. The MgO slides, Mylar sheets, Kromekote cards (flat) and the Staplex, Unico and Andersen samplers were changed after each pass. The Kromekote (round) and pipe cleaners were changed after the first application pass to give an assessment of the first pass and of the second pass plus the multiple run series. A pre-spray set of branch tips were taken and a set of 8 replicates was taken after the first single application pass. A second series of 4

Table 1

Position of sample units for pesticide drift study

Distance from emission line (m)	Sampling Technique with number of replicates								
	MgO slide	Mylar	Kromekote (flat)	Staplex	Unico	Andersen	Kromekote (round)	Pipe cleaner	Branch tips
7	2	-	-	-	-	-	-	-	8(4)[(1)]
15	-	4	1	-	-	-	-	-	-
37	2	4	1	-	-	-	-	-	-
70	2	4	1	1	1	6[(2)]	3	12	8(4)
150	2	4	1	2	1	-	-	-	8(4)
265	-	4	1	2	1	-	3	12	8(4)
500	-	4	1	2	1	-	3	12	8(4)
900	-	4	1	-	-	-	-	-	-
1800	-	4	1	2	1	-	-	-	-
2820	-	4	1	-	-	-	-	-	-
5280	-	4	1	2	1	-	-	-	-

(1) 8 replicates 1st trial, 4 replicates 2nd

(2) set on a vertical tower to 30 m height

replicates was taken on completion of the applications which would give an indication of the total amount of material collected on the branch tips after the total of seven applications.

Pesticide applications were made under inversion conditions and wind speeds of about 3 km/hr. The first application was made 27 July between 0600 and 0630 hours; branch samples were collected starting at 0955 hours. The second single application was made 27 July from 2115 to 2145 hours and the final, multiple run application was made 28 July between 0520 and 0645 hours. The last set of branch samples were collected starting at 0800 hours. Individual branch tips were placed in marked brown paper bags, sealed and transferred to a cold box at about 1°C. These were returned to the laboratory and held in a cold room, again at 1°C at which time they were taken to a chemical laboratory for analysis using GLC techniques.

During the course of the last application series the insecticide cloud was visible between the 265 and 500 m sample stations. A visual examination of the kromekote cards showed deposits down to 150 m. No deposits were seen on the rolled kromekote cards. Droplets were collected on all MgO slides. The flat kromekote cards were analysed by a Quantimet; the mylar sheets by chemical analysis after washing and the air samples by a chemical analysis of total deposit.

At the time of writing of this report the chemists analysis was not complete; on receipt of this information a full report will be prepared.

SUMMARY REPORT ON STUDIES OF THE IMPACT OF INSECTICIDES ON FOREST ECOSYSTEMS

(Study Ref. No. CC-3-014)

Report to the Canadian Forest Pest Control Forum

by

C. H. Buckner

B. B. McLeod

P. D. Kingsbury

Forest Pest Management Institute

Canadian Forestry Service

Environment Canada

November 1977

Summary Report on Studies of the Impact of Insecticides on Forest Ecosystems

by

C. H. Buckner, B. B. McLeod and P. D. Kingsbury

The Ecological Effects team of the Forest Pest Management Institute carried out surveillance monitoring of spruce budworm control operations in New Brunswick and Quebec in 1977. The extent of the operation is presented in Table I.

Table I

Surveillance Monitoring of Operational Spruce Budworm Control Programmes in New Brunswick and Quebec in 1977

Area	Insecticide Treatment	Ecological component monitored: birds	aquatics	mammals	bees
New Brunswick	aminocarb	x	x	x	x
Quebec	phosphamidon + fenitrothion + aminocarb	x		x	
	phosphamidon + aminocarb	x			

In addition to the budworm control operations, numerous studies were carried out to provide data and information on specific trials and formulations in 1977 (Table II).

Table II

Area	Experimental Trials	Dosage Rate	Ecological Component Monitored
Newfoundland	aminocarb	0.070 x 3	birds
	aminocarb	0.087 x 2	"
	fenitrothion + aminocarb	0.210 x 2 + 0.070	"
	acephate + Bt	0.560 + 8 BIU	"
New Brunswick	phosphamidon	0.070 x 3	"
	phosphamidon + irritant	0.070 x 2	birds, aquatics
Quebec	fenitrothion + fenitrothion + aminocarb	0.280 + 0.280 + 0.070	birds, aquatics, mammals
	phosphamidon	0.140 + 0.420 + 1.121	birds, mammals, aquatics
Ontario	N.P. virus	5.5×10^9 PIB/ha	birds, bees, aquatics
British Columbia	spray programme cancelled		birds (baseline data collected for bird species - budworm infestation relationship.

RESULTS

Surveillance Monitoring of Control Operations: In New Brunswick, operational treatments of aminocarb at the emitted dosage rate of 0.070 kg AI/ha applied twice did not affect the bird or small mammal populations. The foraging component of honey bee colonies suffered very light mortality resulting from the initial application. Observations indicate that the second treatment missed the foraging area and no mortality resulted. Queens, nurse bees and brood were not affected.

Mayfly and blackfly larval populations were slightly reduced in treated streams, but high populations of beetle larvae were not affected, indicating a minimal impact upon aquatic insect fauna.

In Quebec, the operations involving the use of several insecticides at various stages of budworm development (Table I) did not present a hazard to populations of breeding birds or the complex of small mammals.

Ecological Monitoring of Experimental Trials: In Newfoundland, three applications of aminocarb at the emitted dosage rate of 0.070 kg AI/ha and two applications at 0.087 kg AI/ha did not affect breeding bird populations. Plot searches following each application failed to recover any mortality and no birds exhibiting typical symptoms of pesticide stress were observed. The experiment involving two applications of fenitrothion at 0.210 kg AI/ha followed by an application of aminocarb at 0.070 kg AI/ha did not result in bird mortality, but reductions in activity followed the 2nd treatment of fenitrothion and activity of the warbler group (family Parulidae) declined following the aminocarb treatment. No mortality was recorded and activity returned to pre-spray levels by the 3rd day. The double application of acephate and Bt did not affect bird populations or disrupt breeding activity.

In New Brunswick, spruce budworm moth suppression trials were monitored. Three applications of phosphamidon at the emitted dosage rate of 0.070 kg AI/ha did not affect song bird populations. Nestling and fledgling birds were observed unharmed throughout the experimental period. Phosphamidon, coupled with a pyrethrin irritant, also did not damage the bird component. A small portion of a stream was also treated with the combination of phosphamidon and irritant. Surber and drift samples indicate that the aquatic and benthos fauna were unharmed.

In Quebec, two applications of fenitrothion at the emitted dosage rate of 0.280 kg AI/ha followed by aminocarb at 0.070 kg AI/ha did not cause any bird mortality; however, periods of severe weather conditions caused sharp declines in activity. Three applications of phosphamidon at 0.140, 0.420 and 1.121 kg AI/ha were applied to an experimental area to determine census technique sensitivity, bird behaviour, sub-lethal effects and mortality assessment. The initial application (0.140 kg AI/ha) did not affect bird populations, but some mortality occurred following the 0.420 kg AI/ha treatment. The final application of 1.121 kg AI/ha caused a very noticeable reduction in activity, accompanied by the shifting of some bird territories and an increase in mortality. Although mortality was considerable, a population survey two weeks following the final application show a very good recovery of bird populations in the treated area. Two treated streams were monitored and although benthic population levels were low, there was no evidence suggestive of any insecticide caused disturbance.

In Ontario, an application of virus for control of *Neodiprion lecontei* (Fitch) did not affect bird populations, aquatic insects or colonies of domestic honeybees. No mortality of foragers took place and the queens, nurse bees and brood in the hives were unharmed.

In British Columbia, where the experimental spray programme was cancelled, a study was carried out to determine the bird species complex as related to stand form and budworm infestation. A strong negative correlation was found between defoliation, resulting from Western Spruce Budworm and both bird species richness and bird density. A strong positive correlation was also found between spruce budworm density and the abundance of certain late-nesting bird species such as evening grosbeak and pine siskin.

SUMMARY REPORT ON STUDIES OF PESTICIDES IN AQUATIC ECOSYSTEMS

(Study Ref. No. CC-3-027)

Report to the Canadian Forest Pest Control Forum

by

P. D. Kingsbury

Forest Pest Management Institute

Canadian Forestry Service

Environment Canada

November 1977

Summary Report on Studies of Pesticides

in Aquatic Ecosystems

by

P. D. Kingsbury

Studies were carried out in 1977 on the ecological implications of the introduction of the insecticides fenitrothion, aminocarb and permethrin into various aquatic systems in the Gaspé region of Quebec. Follow-up studies were also made to document recovery of aquatic invertebrate populations and investigate effects on fish growth, related to a heavy impact on aquatic invertebrates in a lake experimentally treated with 0.140 kg AI/ha permethrin in 1976.

RESULTS

Fenitrothion and aminocarb in Lac Ste-Anne: Zooplankton, benthic invertebrate and native fish populations were studied in Lac Ste-Anne, experimentally treated with two 0.280 kg AI/ha fenitrothion applications followed by an application of 0.070 kg AI/ha aminocarb. This was part of a co-operative study on this lake involving a number of federal and provincial agencies. No dramatic adverse effects on overall zooplankton, benthos or fish populations were found, but a significant impact on shallow dwelling baetid mayfly nymphs was evident as were indications of opportunistic feeding by resident fish on affected mayfly nymphs and caddisfly larvae. Fish populations were sampled to study fenitrothion residue accumulation and persistence, but results from this program are not yet available.

Fenitrothion and aminocarb in trout streams: Invertebrate drift, bottom fauna populations and brook trout, *Salvelinus fontinalis* Mitchell, feeding habits were studied in a number of Gaspesien streams exposed to insecticide applications, similar to those applied to Lac Ste-Anne. Effects of fenitrothion treatments measured by sampling invertebrate drift, ranged from nil to large increases in the drift of blackfly larvae (Diptera:Simuliidae) and lesser impacts on stonefly nymphs (Plecoptera), mayfly nymphs (Ephemeroptera) and midge larvae (Diptera:Chironomidae). Aminocarb caused small increases in the drift of blackfly larvae, mayfly nymphs, midge larvae and stonefly nymphs in some treated streams. None of the applications caused substantial decreases in bottom fauna populations. Brook trout diets did not change significantly following insecticide applications. Fish were again collected to study fenitrothion accumulation and persistence in their tissues.

Permethrin in trout streams: Permethrin applied to small trout streams at 0.070 kg AI/ha caused massive increases in the drift of aquatic invertebrates. The higher dosage virtually eliminated populations of most groups of aquatic insects. Re-population by midge larvae was evident in late summer and fall, but other groups of aquatic insects did not show substantial recovery in the year of treatment. Trout in the stream were forced to feed almost exclusively on terrestrial organisms entering the stream, but appeared to find reasonable quantities of food. Severe lasting effects of the lower dosage of permethrin were limited to mayfly nymphs and significant recovery of this group was apparent by the fall.

Further studies in these experimental streams will attempt to document the rate of recovery of aquatic insect populations and quantify effects on fish growth.

Recovery of a lake ecosystem from an insecticide impact: A small forest lake in Quebec was treated experimentally with 0.140 kg AI/ha permethrin in 1976, and a heavy impact occurred on zooplankton and benthic invertebrate populations. Follow-up sampling in 1977 showed that cladoceran numbers had resurged and exceeded pre-spray populations, but the species composition of the zooplankton community had been substantially altered. Midge larvae and dragonfly and damselfly nymph (Odonata) populations showed substantial recovery in the spring of 1977, but burrowing mayfly nymphs (Ephemeroptera:Ephemeridae) were still completely absent from bottom samples and oligochaetes and molluscs were of greater importance to total numbers of aquatic invertebrates than prior to treatment. Fish were collected to study diet and growth, but these samples have not yet been analyzed.

SUMMARY OF LABORATORY EVALUATION OF INSECTICIDES AGAINST VARIOUS SPECIES OF FOREST INSECT PESTS DURING 1977

(Study Ref. No. CC-2-006)

A REPORT TO THE ANNUAL FOREST PEST CONTROL FORUM

by

P. C. NIGAM

Forest Pest Management Institute
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Environment Canada
Ottawa, Ontario

November, 1977

SUMMARY OF LABORATORY EVALUATION OF INSECTICIDES AGAINST VARIOUS SPECIES OF FOREST INSECT PESTS DURING 1977

by

P. C. NIGAM

Fourty-two insecticides, and their formulations, were tested for contact, stomach, stomach-contact and residual toxicity using modified Potter towers. Nine of these were new insecticides and formulations. The results are summarized under contact, stomach, stomach-contact and residual toxicity studies. Unless otherwise specified, mortality data is given for 72 hours after treatment.

CONTACT TOXICITY

Thirty-eight insecticides were tested for contact toxicity against insects from Ontario and Quebec. The results are summarized by the area of origin and by species, Insect collections were provided by personnel of the toxicology section, Chemical Control Research Institute and the laboratory culture from the Insect Pathology Research Institute, S.S. Marie. Insecticides are arranged in descending order of toxicity, on the basis of 100% mortality.

ONTARIO

White Pine Weevil - *Pissodes strobi* (Peck)

Seven insecticides were tested against the adults of the white pine weevil. The corrected percentage mortality ranged from 17% to 95%.

NRDC 143 > S 5602 > Guthion > San 155 > San 197 > Bay 9306 > methoxychlor

Spruce Budworm - *Choristoneura fumiferana* (Clemens) - Laboratory Reared Larvae

Matacil technical was tested against second instar larvae. The average of these experiments was 0.27 $\mu g/cm^2$ for 100% mortality.

Three insecticides were tested against the third instar larvae of the spruce budworm. The corrected percentage mortality ranged from 82 to 97%.

Fenitrothion = phosphamidon = Matacil

Thirty-four insecticides were tested against the fifth instar of the spruce budworm. The corrected percentage mortality ranged from 49% to 98.5%.

FMC 45498 = NRDC 161 = NRDC 168 S > FMC 45497 > WL 43467 >
FMC 30980 > PP 383 > FMC 45812 > S 3206 > CGA 18809 >
FMC 33297 > S 5602 > WL 43775 > NRDC 143 > WL 41706 >
FMC 40963 > Matacil > CGA 15324 > SBP 1382 > fenitrothion >
Bay 9306 = CGA 19795 > Dimecron > A 41286 > A 5675A = malathion >
phosphamidon > ABG 6070 > Orthene > DDT > A 47170 > A 47171

Two insecticides were tested against the sixth instar of the spruce budworm. The corrected percentage mortality ranged from 65% to 97%.

Fenitrothion > A 41286

Six insecticides were tested against the spruce budworm adults. The corrected percentage mortality ranged from 28% to 97%.

Female: NRDC 143 > fenitrothion > Bay 9306 > Matacil > phosphamidon > DDT

Male: NRDC 143 > fenitrothion > Matacil > phosphamidon > Bay 9306 > DDT

Male & Female: NRDC 143 > fenitrothion > Bay 9306 > phosphamidon > Matacil > DDT

Six insecticides were tested against the sixth instar of the spruce budworm larvae. The corrected percentage mortality ranged from 60% to 97%.

PP 383 > FMC 30980 = NRDC 143 > phosphamidon > fenitrothion > Orthene

Larch Sawfly - *Pristiphora erichsonii* (Hartig)

Four insecticides were tested against the fifth instar larvae of the larch sawfly. The corrected percentage mortality ranged from 47% to 89%.

WL 43775 > fenitrothion > S 5602 > Bay 9306

ABG 6070 was tested against the fourth instar larvae. For 100% mortality, 0.0448 $\mu g/cm^2$ was required.

Jack Pine Sawfly - *Neodiprion pratti banksiannae* Rohwer

Nine insecticides were tested against the fourth instar larvae of the jack pine sawfly. The corrected percentage mortality ranged from 43% to 97%.

FMC 45498 > WL 43467 > FMC 30980 > PP 383 > fenitrothion > WL 43775 > SBP 1382 > WL 41706 > A 47170

Two insecticides were tested against the fifth instar larvae of the jack pine sawfly. The corrected percentage mortality ranged from 14% to 83%.

FMC 33297 > A 47171

QUEBEC

Spruce budworm - *Choristoneura fumiferana* (Clemens) - Field collected

Three insecticides were tested against fifth instar larvae of the spruce budworm. The corrected percentage mortality ranged from 86% to 97%.

S 5602 > phosphamidon > fenitrothion

Three insecticides were tested against the adults of field collected pupae and late instar larvae. The corrected percentage mortality ranged from 64.5% to 93.0%.

Male: WL 43467 > fenitrothion > phosphamidon

Female: WL 43467 > fenitrothion

STOMACH TOXICITY

Seven insecticides were tested against fifth instar larvae of laboratory reared spruce budworm. The toxicity of the treatments were evaluated after 72 hours. The corrected percentage mortality ranged from 73% to 96.5%.

Orthene > fenitrothion > phosphamidon > WL 43467 > Matacil >
Bay 9306 > S 5602

STOMACH-CONTACT TOXICITY

Three insecticides were tested against the fifth instar larvae of the spruce budworm. The toxicity of the treatments were evaluated after 72 hours. The corrected percentage mortality ranged from 89.5% to 96.5%.

Phosphamidon > fenitrothion > Matacil

RESIDUAL TOXICITY

The insecticides were tested for residual toxicity by spraying potted jack pine, balsam fir, white spruce, and European larch trees in the spraying chamber. The sprayed host plants were then exposed to weathering conditions for up to ten days. The insects used for bioassay of residues were either reared in the laboratory or collected in the field and maintained in the laboratory until their release on the insecticide treated foliage. A change in technique for bioassay of insecticide residues was introduced last year for all white spruce and jack pine trees, and extended this year to include balsam fir trees. Only the larch trees in the larch sawfly series were used according to the old technique i.e. insects confined to branches by means of nylon mesh sleeves. With the new technique, the insects were released on clipped foliage that was obtained after a particular period of weathering of the treated trees.

The clipped foliage was placed, together with the insects, inside a clear plastic dish equipped with a perforated plastic lid. The dishes were kept in an environmental chamber that was maintained at 24°C and 70% R. H. with a 16 hour photoperiod. The insecticides are arranged in descending order of residual toxicity at 0 and 10 days of residual life. The corrected percentage mortality, 72 hours after release of insects is given in brackets.

Spruce budworm - *Choristoneura fumiferana* (Clemens)

Residual toxicity of thirteen insecticides was tested against the spruce budworm. Of these, three were tested against second instar, eight against the fifth instar, and eight against the spruce budworm adult.

Treatments of Second Instar

This is the second year that an attempt to study the residual toxicity against the second instar spruce budworm was made. Treated white spruce was in the development stage where approximately half of the new buds were about to shed their protective bud caps and the other half of the new buds were open. Phosphamidon and fenitrothion, each at 48, 24, 12, and 6% active ingredient were applied at the rate of 0.14 and 0.28 kg of active ingredient in 0.585, 1.169 and 2.338 ℓ per hectare. Matacil at 18, 9, 4.5, and 2.25% active ingredient was applied at the rate of 0.053 and 0.105 kg of active ingredient in 0.585, 1.169 and 2.338 ℓ per hectare. The insecticides are arranged in descending order of residual toxicity, giving the kg of active ingredient in the total volume per hectare. The corrected percentage mortality is given in brackets and it is the one observed 72 hours after insect addition.

Treatments of Fifth Instar

The residual toxicity tests against the fifth instar spruce budworm were carried out on white spruce (Series I) and balsam fir (Series II). Bay NTN 9306, DOWCO 214, NRDC 143, S 5602, fenitrothion, encapsulated Sumithion, SBP 1382, and encapsulated resmethrin, were all applied as a 2% active ingredient solution. The rate of application was as follows:

Series I-A on white spruce against field collected larvae,
first four insecticide = 11.233 ℓ/ha

Series I-B on white spruce against lab. reared larvae,
last four insecticides = 20.22 ℓ/ha

Series II on balsam fir against field collected larvae,
all eight insecticides at = 11.233 ℓ/ha.

The encapsulated Sumithion and resmethrin were new formulations whereas the rest were repeated from previous years.

Treatments of Adults

This is the third season that a study of residual toxicity against the spruce budworm adult was carried out. In the adult Series I, phosphamidon, NRDC 143, DDT, and fenitrothion were applied to white spruce at the rate of 0.14 kg active ingredient in 1.462 ℓ per hectare. In the spruce budworm adult Series II, Matacil, Guthion, Bay NTN 9306, and Orthene were applied to white spruce at the rate of 0.14 kg active ingredient in 1.462 ℓ per hectare. All eight insecticides represent a repeat from previous year where high mortality of adults occurred in the controls.

Second Instar Spruce Budworm on White Spruce

0 day - Fenitrothion 0.28 kg a.i. in 1.169 ℓ/ha (75) > Fenitrothion 0.28 kg a.i. in 0.585 ℓ/ha (73) > Phosphamidon 0.28 kg a.i. in 0.585 ℓ/ha (71) > Fenitrothion 0.14 kg a.i. in 0.585 ℓ/ha (67) > Phosphamidon 0.14 kg a.i. in 1.169 ℓ/ha (64) > Fenitrothion 0.14 kg a.i. in 1.169 ℓ/ha (63) > Fenitrothion 0.28 kg a.i. in 2.338 ℓ/ha (56) > Phosphamidon 0.28 kg a.i. in 1.169 ℓ/ha (55) > Fenitrothion 0.14 kg a.i. in 2.338 ℓ/ha (50) > Phosphamidon 0.14 kg a.i. in 2.338 ℓ/ha (46) > Phosphamidon 0.14 kg a.i. in 0.585 ℓ/ha = Phosphamidon 0.28 kg a.i. in 2.338 ℓ/ha (44) > Matacil 0.105 kg a.i. in 2.338 ℓ/ha (43) > Matacil 0.105 kg a.i. in 1.169 ℓ/ha (35) > Matacil 0.105 kg a.i. in 0.585 ℓ/ha (32) > Matacil 0.053 kg a.i. in 1.169 ℓ/ha (28) > Matacil 0.053 kg a.i. in 0.585 ℓ/ha = Matacil 0.053 kg a.i. in 2.338 ℓ/ha (24).

10 day - Fenitrothion 0.28 kg a.i. in 0.585 ℓ/ha (30) > Fenitrothion 0.14 kg a.i. in 0.585 ℓ/ha = Fenitrothion 0.28 kg a.i. in 2.338 ℓ/ha (22) > Fenitrothion 0.28 kg a.i. in 1.169 ℓ/ha (21) > Matacil 0.105 kg a.i. in 1.169 ℓ/ha (20) > Matacil 0.105 kg a.i. in 0.585 ℓ/ha = Matacil 0.105 kg a.i. in 2.338 ℓ/ha (18) > Fenitrothion 0.14 kg a.i. in 2.338 ℓ/ha = Matacil 0.053 kg a.i. in 1.169 ℓ/ha (15) > Phosphamidon 0.14 kg a.i. in 1.169

ℓ/ha (12) > Matacil 0.053 kg a.i. in 2.338 ℓ/ha (11) > Fenitrothion 0.14 kg a.i. in 1.169 ℓ/ha = Phosphamidon 0.28 kg a.i. in 2.338 ℓ/ha (10) > Phosphamidon 0.14 kg a.i. in 0.585 ℓ/ha = Phosphamidon 0.14 kg a.i. in 2.338 ℓ/ha (9) > Phosphamidon 0.28 kg a.i. in 1.169 ℓ/ha (6) > Phosphamidon 0.28 kg a.i. in 0.585 ℓ/ha > (5) > Matacil 0.053 kg a.i. in 0.585 ℓ/ha (0).

Fifth Instar Spruce Budworm on White Spruce

Series I-A Field collected larvae

0 day - S 5602TG = NRDC 143 (100) > Bay NTN 9306 = DOWCO 214 (96)

10 day - S 5602TG (61) > Bay NTN 9306 (44) > DOWCO 214 (26) > NRDC 143 (12)

Series I-B Laboratory reared larvae

0 day - Fenitrothion = Encapsulated Sumithion = Encapsulated Resmethrin = SBP 1382 (all 100%)

10 day - Encapsulated Sumithion (97) > Fenitrothion (10) > Encapsulated Resmethrin = SBP 1382 (0)

Fifth Instar Spruce Budworm on Balsam Fir

Series II Field collected larvae

0 day - S 5602TG = NRDC 143 = Encapsulated Sumithion = Bay NTN 9306 (100) > Encapsulated Resmethrin = DOWCO 214 (96) > SBP 1382 (78) > Fenitrothion (72)

10 day - SBP 1382 (86) > DOWCO 214 (81) > S 5602TG (54) > Bay NTN 9306 (46) > Fenitrothion (42) > NRDC 143 (15)

Spruce Budworm Adult, Series I on White Spruce

0 day - Fenitrothion = Phosphamidon (100) > NRDC 143 (97) > DDT (25)

10 day - NRDC 143 (31) > Fenitrothion (4) > Phosphamidon = DDT (0)

Spruce Budworm Adult, Series II on White Spruce

0 day - Matacil (100) > Orthene (97) > Guthion (96) > Bay NTN 9306 (93)

10 day - Matacil (13) > Orthene (10) > Guthion = Bay NTN 9306 (3)

Jack Pine Sawfly - *Neodiprion pratti banksiannae* Rohwer

One percent concentrations of four insecticides: FMC 33297, NRDC 143, DOWCO 214, and WL 43467, applied to jack pine at rate of 11.233 ℓ/ha, were tested for residual toxicity against fourth instar jack pine sawfly. The first three insecticides represent a repeat from the previous year whereas WL 43467 is new material tested for the first time against the jack pine sawfly.

0 day - WL 43467 = NRDC 143 = DOWCO 214 (100) > FMC 33297 (93)

10 day - WL 43467 (100) > FMC 33297 (56) > NRDC 143 (34) > DOWCO 214 (2)

Larch Sawfly - *Pristiphora erichsonii* (Hartig)

Four insecticides, Matacil, fenitrothion, Imidan, and WL 43467 were tested against fourth instar larch sawfly using European larch as host trees. Fenitrothion and Imidan were applied as a 1.0% active ingredient solution, Matacil as a 0.5% a.i. solution, and WL 43467 as a 0.25% a.i. solution. The rate of application was 11.233 ℓ/ha for all four insecticides. WL 43467 represents a new material tested for the first time against the larch sawfly. Fenitrothion, Matacil, and Imidan are repeats from two previous runs (1970 or 1971, and 1975).

0 day - Matacil = Imidan = Fenitrothion = WL 43467 (all 100%)

10 day - Matacil = Imidan (100) > WL 43467 (94) > Fenitrothion (93)

INSECT USED IN 1977

CONTACT TOXICITY

INSECT	AREA OF ORIGIN	INSTAR	NO. USED
Spruce budworm	lab. reared, S.S. Marie Ont.	II	1,260
" "	" "	III	1,260
" "	" "	V	30,030
" "	" "	VI	630
" "	" "	adult	6,000
" "	field, Mattawa, Ont.	V	1,260
" "	field, Trois Pistoles, Que.	V	630
" "	" " " "	adult	1,365
White pine weevil	northern Ont.	adult	3,990
Jack pine sawfly	Lanark, Ont.	IV	3,360
" " "	" "	V	420
Larch sawfly	Alfred, Ont.	IV	210
" "	" "	V	840

STOMACH TOXICITY

INSECT	AREA OF ORIGIN	INSTAR	NO. USED
Spruce budworm	lab. reared, S.S. Marie, Ont.	V	8,400

STOMACH-CONTACT TOXICITY

INSECT	AREA OF ORIGIN	INSTAR	NO. USED
Spruce budworm	lab. reared, S.S. Marie, Ont.	V	4,620

INSECT USED IN 1977

RESIDUAL TOXICITY

INSECT	AREA OF ORIGIN	INSTAR	NO. USED
Spruce budworm	lab. reared, S.S.Marie, Ont.	II	6,600
" "	" "	V	900
" "	Mattawa, Ont.	V	3,360
" "	Trois Pistoles, Quebec	V	1,080
" "	lab. reared, S.S. Marie, Ont.	adult	1,800
Jack pine sawfly	Lanark, Ont.	IV	1,500
Larch sawfly	Alfred, Ont.	IV	3,540

INSECTICIDES TESTED IN 1977

INSECTICIDE	FORMULATION % A.I.	TYPE	SOURCE
A 5675A	30	organophosphate	Ciba-Geigy
A 41286	40	"	Abbott
A 47170	93	chlorinated hydro-carbon	Abbott
A 47171	24	"	Abbott
ABG 6070	40	pyrethroid	Abbott
Bay 9306	72	organophosphate	Chemagro
CGA 15324	50		Ciba-Geigy
CGA 18809	99.8	organophosphate	Ciba-Geigy
CGA 19795	40 EC		Ciba-Geigy
DDT	100	chlorinated hydrocarbon	Math. Col. & Bell
Dimecron®	100	organophosphate	Ciba-Geigy
DOWCO® 214	95.6	"	DOW chemical
Dylox® ULV (THFA)	40.5	"	Chemagro
Dylox® 3.4 (DM)	34	"	Chemagro
Fenitrothion	98.7	organophosphate	Sumitomo
FMC 30980	30	pyrethroid	FMC Corp.
FMC 33297	40	"	"
FMC 40963	5 EC	"	"
FMC 45497	10	"	"
FMC 45498	2.6	"	"
FMC 45812	20	"	"
Guthion®	22	organophosphate	Chemagro
Imidan	12.5	"	Stauffer
Malathion	50 EC	"	Chevron
Matacil® tech.	99	carbamate	Chemagro
Methoxychlor	88	chlorinated hydrocarbon	Dupont
NRDC 143	25 EC	pyrethroid	Chipman
NRDC 161	2.5	"	Procida
NRDC 168S	2.5	"	Procida
Orthene®	94	organophosphate	Chevron

INSECTICIDES TESTED IN 1977

INSECTICIDE	FORMULATION % A.I.	TYPE	SOURCE
Phosphamidon	93.9	organophosphate	Ciba-Geigy
PP 383	93		Chipman
Resmethrin (encapsulated)	3	pyrethroid	Pennwalt Corp.
S 3206	20 EC	pyrethroid	Sumitomo
S 5602	20 EC	"	Sumitomo
SAN 155	90		Sandoz-Wander
SAN 197	93		Sandoz-Wander
SBP 1382	90	pyrethroid	S.B. Penick
Sumithion (encapsulated)	20	organophosphate	Pennwalt Corp.
WL 41706	30	pyrethroid	Shell
WL 43467	40	"	Shell
WL 43775	30	"	Shell

STUDIES ON THE

DISTRIBUTION, PERSISTENCE AND FATE OF

PESTICIDES IN FOREST ENVIRONMENTS

(Study Ref. No. CC-3-018)

Report to the Canadian Forest Pest Control Forum

by

K.M.S. Sundaram

Forest Pest Management Institute

Canadian Forestry Service

Environment Canada

November, 1977

REPORT BY THE PESTICIDE CHEMISTRY SECTION
OF F.P.M.I. TO THE ANNUAL FOREST
PEST CONTROL FORUM

by

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Insecticides are the most powerful tool currently available in forest pest management programs in Canada. They are highly effective, rapid in curative action, adaptable to most situations, flexible in meeting changing ecological conditions and very economical. Consequently, the demand for contemporary insecticides which are readily degradable and less hazardous to the environment is increasing. In recent years various organophosphorus and carbamate insecticides have been applied to the forest environment over very great acreages and in staggering quantities. Their environmental effects especially their distribution, persistence, cycling and ultimate fate in different components of the forest environment are not yet fully explored. The pesticide chemistry section at FPMI takes a lead role in this program.

During the year 1977, the section has been relocated from Ottawa to Sault Ste. Marie resulting in staff transfer, staff depletion and equipment misplacement, affecting considerably the overall performance and productivity of the section. Due to these interruptions, methodology research, environmental monitoring, advisory and service aspects of the section proceeded at a diminshed level. The achievements attained during the year 1977 are summarized below:

1. During the year 1977, the pesticide chemistry section has developed sensitive and reliable analytical methods and sampling techniques for trichlorphon insecticide used operationally at present in New Brunswick and Quebec for budworm control. Residue levels of the material in spray formulations, water, soil and coniferous and deciduous foliage samples from the spray area were collected and measured and the data are being analyzed currently to study the distribution, persistence and fate of the chemical in the forest environment. Preliminary evaluation of the residue data show that the compound is labile and dissipated rapidly from the forest components.
2. The rate of disappearance of aminocarb residues in spruce foliage and forest soil were studied under natural meteorological conditions over a 69-day period following treatment. The aminocarb formulation was applied as a simulated aerial spray at a rate of 3.4 l/ha containing 57 g AI. Initial concentrations of ca 10 ppm aminocarb in foliage and 7 ppm in soil had half-lives of ca 7 and 2 days respectively, and had dropped to trace or non-detectable levels within 47 and 27 days. Aminocarb was found to

be environmentally and ecologically safe due to its lability and ready dissipation under normal weathering conditions.

3. The uptake, translocation, metabolism and systemic properties of C-14 labeled acephate, phosphamidon and aminocarb were investigated in spruce trees under normal weathering conditions of a forest environment. The insecticides were administered by trunk implantation (TI), basal bark painting (BBP) and foliar painting (FP) techniques. The foliar residues were determined by gas chromatography, liquid scintillation and autoradiographic techniques. The insecticides penetrated the treated region and translocated apoplastically via xylem vessels (transpiration stream) in different tree parts depending upon the mode of application. Uptake and foliar accumulation through xylem transport were high in TIT, considerably less in BBP and least in FP. Autoradiographic studies confirmed the aeropetal translocation of the radiolabels via the transpiration stream into the young and growing spruce foliage which decreased eventually through metabolic and chemical processes. The insecticides present on the foliage in FP was rapidly lost due to various physical processes. The low systemic properties observed in some insecticides were evaluated for budworm control.

In addition to these in-house research programs, the section has collaborated actively in various mission-oriented, problem-solving research projects carried out at the Institute and other government establishments such as MFRC, PFRC, LFRC, NRC, CDA (FICP) H and W and USDA.

TREE PHYSIOLOGY AND PATHOLOGY

(Study Ref. No. CC-3-013 & CC-3-023)

Report to the Canadian Forest Pest Control Forum

by

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Forest Pest Management Institute

Canadian Forestry Service

Environment Canada

November, 1977

ANNUAL REPORT TO PESTICIDE FORUM

(TREE PHYSIOLOGY AND BIOCHEMISTRY)

CANADIAN FORESTRY SERVICE - 1977

A. Studies of Systemic Pesticides for Control of Forest Pests

Systemic pesticides, when applied carefully, cause minimal contamination to forest environments and are, thus, thought to be one of the safest methods of combatting forest pests. Unfortunately research in this area is scanty and the purpose of this study is to develop or modify materials and methods for increasing the systemicity and efficacy of pesticides. Initially much of the effort was concentrated on a study of systemic fungicides (benomyl and Lignasan - BLP) associated with the control of vascular diseases of urban and amenity trees. Dutch elm disease caused by Ceratocystis ulmi in elm trees, maple wilt caused by Verticillium albo-atrum and leafspot of poplar incited by Cercospora populae, were studied.

Normally a series of 20-40 chemical compounds exhibiting fungitoxic properties were screened under laboratory conditions against these pathogens and the resultant half a dozen promising compounds were then subjected to systemicity tests using greenhouse and field trees. In the laboratory screening trials, the following compounds were found fungitoxic against the pathogens tested: -

C. ulmi : Hymexazol > EL-222 E.C. > Terraclor W.P. > Rovral LFA 2043 > Nystatin > PP 588

V. albo-atrum: Thiophanate methyl > Demosan > Terraclor > EL-228 > Isobac-20 >

Hymexazol > Ertral LFA 2043 > Bay Meb

6447 > PP 388 > Busan-72 > Lignasan BLP

B. Environmental Impact of Pesticides

To control the outbreaks of spruce budworm (C. fumiferana), the insecticide, fenitrothion, is extensively used as foliar sprays in Canadian forests. Because about 30% residues persist on conifer foliage two weeks after spray applications, studies were initiated to determine the fate of fenitrothion in the forest ecosystem.

(a) Fate, Persistence and Translocation of C^{14} - Fenitrothion in Conifers.

An investigation was carried out to determine the fate and persistence of C^{14} - labelled fenitrothion in four year old seedlings of balsam fir (Abies balsamea) and white spruce (Picea glauca) in the greenhouse. The insecticide disappeared rapidly from the surface of conifer tissue while the absorbed residues were more persistent. An in vitro study carried out on glass surfaces demonstrated that rapid disappearance of the pesticide was probably due to volatilization. TLC analysis of the conifer extracts was consistent with this dissipation mechanism since C^{14} - ring metabolites were present for the most part only in trace amounts.

Autoradiographic tracing studies demonstrated the ability of C^{14} - fenitrothion to be translocated acropetally into the young foliage of fir and to a lesser extent in spruce. That this took place via the xylem vessels (apoplastically) was confirmed by histoautoradiography.

These results were taken as evidence for the systemic potential of fenitrothion for spruce budworm control.

(b) Fate, Persistence and Translocation of C^{14} - Fenitrothion in Jack Pine (*Pinus banksiana*)

The collaborative research study with Laurentian Forest Research Centre (Dr. McLeod) was completed. No evidence of presence of toxic substances of fenitrothion which were lethal to sawfly larvae (*Neodiprion swainei*) was found on treated jack pine foliage.

Employing modern analytical techniques - autoradiography, liquid scintillation spectrometry, gas liquid and thin-layer chromatography - detailed examination of Fenitrothion C^{14} treated tissue showed no direct evidence of systemic action except that radioactivity (silvergranules) were present in the hypodermis and xylem regions. It seemed that the cause of the sawfly mortality was related to extreme sensitivity of the parasite to minute quantities of residues of fenitrothion deposited after extensive spray operations.