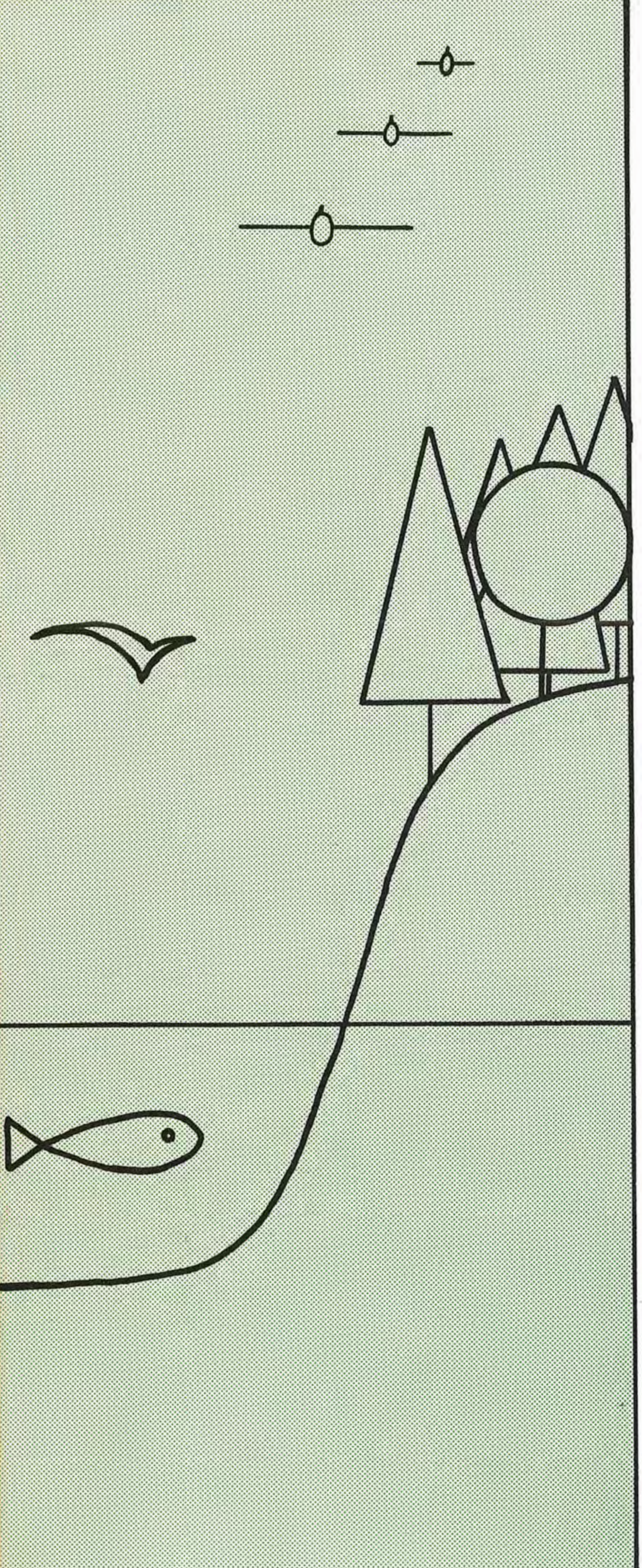

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1977 ENVIRONMENTAL SURVEILLANCE

OF INSECTICIDE SPRAY OPERATIONS IN NEW BRUNSWICK'S BUDWORM-INFESTED FORESTS

An interim report by the Committee for Environmental Monitoring of Forest Insect Control Operations - I.W. Varty Chairman

MARITIMES

ENVIRONMENTAL SURVEILLANCE OF INSECTICIDE SPRAY OPERATIONS IN NEW BRUNSWICK'S BUDWORM-INFESTED FORESTS, 1977

An interim report for 1977 by the Committee for Environmental Monitoring
Of Forest Insect Control Operations — I.W. Varty, Chairman

Maritimes Forest Research Centre

Fredericton, New Brunswick

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ABSTRACT

This multiple-author report describes ecological effects and insecticide persistence from an aerial spray program in New Brunswick, 1977, for 4,166,605 ac (1 686 201 ha) of budworm-infested fir-spruce forest.

The operational insecticides were formulations of fenitrothion, aminocarb and trichlorfon, while phosphamidon was used experimentally. The surveillance program incorporated 34 studies on songbirds, rodents, salmonids, stream organisms, pollinating insects, arboreal and ground predators, budworm parasitoids, and divers aspects of insecticide persistence in various tissues and habitats.

Most of the faunal studies were based on assessments of field population density. The insecticide regimes had little, if any, lethal effect on birds and fish. A mild increase in live and dead drift of stream benthos sometimes followed fenitrothion and trichlorfon usage, but not aminocarb usage. Methods of estimating wild bee populations in spray blocks were tested. Aminocarb treatment did not appear to be detrimental to wild bees or honey bees, but a long history of fenitrothion usage was reflected in lower abundance of some bumble bee species, and in lower pollination success. Wild bee abundance in blueberry fields appears to have fully recovered within 3 years of population reduction associated with fenitrothion drift from spray blocks. Parasitism in spruce budworm and the abundance of predators on firs do not appear to be much influenced by perennial fenitrothion usage. In contrast with fenitrothion, use of aminocarb produced heavy knockdown of spiders.

Residues of fenitrothion on fir foliage may persist for a year but do not constitute a chronic hazard to browsing deer. The discovery of trace quantities of fenitrothion in estuarine shellfish remote from spray blocks indicates rapid mobility of the insecticide over at least 30 km. New knowledge of the persistence and chemistry of fenitrothion in stream water was gained. Techniques for the preservation of aminocarb and fenitrothion in water samples were tested. Methods of measuring the distribution of insecticides in air and on foliage were investigated.

The impact of these insecticides in an ecological context is summarized and is considered tolerable in forest and stream ecosystems. Ten proposals for better surveillance and safer spraying were recommended.

FOREWORD

This report is aimed at a fairly broad readership; first, it offers advice on insecticide accountability and faunal responses, to the provincial and federal agencies that make decisions pertaining to forest protection and resource conservation; secondly, it provides some factual information on a controversial topic, for the benefit of the general public; thirdly, it gives notice of activity in scientific fields of interest to biologists and other professionals.

The various contributions were prepared in advance of full analysis of data collected in 1977 and are subject to the limitations of premature and summary reporting. Because full data are not reported, the reader cannot evaluate all the facts that led to the conclusions. However, most of the information will be published eventually in departmental reports and scientific journals. In the meantime, contributors to this composite report will be pleased to respond to individual requests for fuller detail.

The report is offered as an Information Report in the Canadian Forestry Service series only for library convenience and distribution facilities. Otherwise it is the composite product of several contributing agencies, viz. Fisheries and Environment Canada, Agriculture Canada, Department of Regional Economic Expansion, New Brunswick Departments of Natural Resources and of the Environment, Forest Protection Ltd, and the Universities of Moncton, Toronto, and New Brunswick.

I.W. Varty, Compiler.

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INTRODUCTION

(I.W. Varty, MFRC[1])

The main issues of the forest protection controversy in New Brunswick are:-

(1) is spraying effective in preventing damage to fir and spruce stands?
(2) is such protection necessary to the forest industry and the provincial economy?
(3) are broadcast chemicals a hazard to public health?
(4) do insecticides harm the fauna and interfere with productive processes in forest, stream, field, and elsewhere?

This report is concerned only with the fourth issue - aspects of the ecological integrity of the sprayed landscape as monitored in 1977. A similar report was issued for spray operations for 1976 (Varty 1976). The problem of ecological effects from forest spraying cannot be resolved, once and for all, by a single investigation. That solution requires annual increments of knowledge matching the changing circumstances of each year's spray operations. While some effects can be broadly anticipated on the basis of past experience, there are also elements of unpredictability because of variations in the system; —the weather in spring, the current populations of animal species, the changes in spray technology, and the shifting mosaic of budworm infestations and spray target blocks. The prediction of environmental hazards from fenitrothion spraying over forests has been reviewed recently by Symons (1977).

Environmental surveillance is conducted to verify and quantify expected ecological effects and to detect new ones, because pesticide ecology is notorious for its surprises. Such surveillance has two main components, monitoring and research. Monitoring, in the narrow sense, is the short-term measurement of the deposition and mobility of insecticide formulations, and of the faunal responses in behaviour and mortality. In its simplest expression, faunal monitoring is a comparison of species populations as sampled before and after spray operations. On the other hand, long-term monitoring is a research proposition over several years. Since it is impossible to study all animals in the forest, some species are selected for study as indicators of change over the years. Spray-induced mortality must be viewed in proper biological perspective, that is, as an additional component in animal population dynamics which frequently fluctuate widely in undisturbed nature.

Research applies also to techniques of monitoring, because survey efficiency is constrained by methodological problems. The challenge in New Brunswick is to maintain a descriptive surveillance over a province with 6 million hectares of forest land and a complex of intricate ecosystems. Yet, the overview must be conducted from a restricted budget commensurate with the low rating of resource risks. Long-term studies are not amenable to an extensive survey approach, and data-gathering methods are still evolving to get the best return from the research dollar. There is no expectation that monitoring will eventually settle into a comfortable routine, because spray techniques are continually under development, and natural responses in the forest are infinitely variable.

Environmental surveillance in New Brunswick is coordinated by the federal-provincial committee for Environmental Monitoring Of Forest Insect Control Operations. EMOFICO is a consortium of biologists, environmental specialists, and chemists from governmental, industrial and university institutions (Table 1), established in 1976. Historically, ever since the onset of spraying in New Brunswick in 1952, federal departments have taken responsibility for environmental surveillance. Currently, Fisheries and Environment Canada is shifting away from that responsibility for descriptive territorial survey in favour of a stronger long-term research approach. Meanwhile, the New Brunswick Department of Natural Resources is assuming more authority over ecological monitoring. Universities, particularly University of Moncton, are emerging as a source of expertise in insecticide chemistry and faunal effects. Regional monitoring and research capability have grown substantially in 1977, and the necessary close liaison between the sprayers and the monitors has been established.

The aims of the EMOFICO committee in l977 were:

(1) to coordinate monitoring and research on environmental aspects of spruce budworm control operations;
(2) to identify environmental risks and benefits of the spray strategy;
(3) to assess the adequacy of knowledge, identify gaps, and recommend appropriate action;
(4) to advise spray agencies how to minimize

[1] For full titles of all abbreviations, see p. 24.

Table 1. 1977. Research and monitoring activities in New Brunswick

Responsibility	Funding agency[1]	Monitoring research agency	Leader	Study
Birds	DFE	CWS	P.A. Pearce	Songbird census in aminocarb regimes.
	FPL	U. Monc.	P. Germain	Songbird census in fenitrothion regimes.
	DFE	FPMI	B.B. McLeod	Songbird census in aminocarb and phosphamidon regimes.
	DFE	CWS	W.R. Whitman	Feasibility of study on black duck rearing success.
Fish	NBNR/DREE	MEL	G. Gillis	Comparison of fish productivity in control, aminocarb and fenitrothion regimes.
Aquatic fauna	NBNR/DREE	MEL	G. Gillis	Effects of aminocarb and fenitrothion on stream benthos.
	DFE	FMS	J.W. Saunders	Effects of trichlorfon on stream and lake invertebrates.
	DFE	FPMI	B.B. McLeod	Insecticide contamination of streams.
	DFE	EPS	L. Stuart	Long-term recuperation of stream invertebrates populations following spray.
Aquatic flora	DFE	MFRC	D.C. Eidt	Effects on fungal decomposition of leaves.
Terrestrial arthropods	DFE (MFRC)	U of T	R.C. Plowright	Bumble bees in aminocarb and fenitrothion regimes.
	DFE	FPMI	B.B. McLeod	Honey bees in aminocarb regime.
	DFE	MFRC	I.W. Varty	Solitary bees in aminocarb and fenitrothion regimes.
	FPL	UNB	E. Thorpe	Solitary bees in adulticide regimes.
	CDA/NBNR	CDA, Fredericton	G.W. Wood	Solitary bees and insecticide drift.
	DFE	MFRC	I.W. Varty	Predators and parasites in fir trees.
	DFE	MFRC	I.W. Varty	Litter-dwelling insects and sprays.
Insecticide residues and mobility	FPL	U Monc.	L. Lapierre	Fenitrothion in deer browse.
	DFE	EPS	L. Stuart	Insecticide residues in shellfish.
	FPL	U Monc.	V.N. Mallet	Fenitrothion residues in shellfish.
	FPL	U Monc.	B. Trottier	Biochemistry of fenitrothion in bird liver.
	FPL/NBH	U Monc.	B. Trottier	Biochemistry of fenitrothion in rat liver.
	DFE	IWD	J. Witteman	Insecticide persistence in aquatic habitats.
	DFE	CCIW	R.J. Maguire	Distribution and fate of fenitrothion in water.
	DFE	MFRC	D.C. Eidt	Mobility and penetration of fenitrothion and aminocarb in streams.
	DFE	MFRC	I.W. Varty	Insecticide deposition: assessment by tracer dyes.
	CDA	CDA, Fredericton	G.W. Wood	Insecticide drift.
Insecticide chemistry	FPL	U Monc.	V.N. Mallet	Insecticide preservation methods.
	DFE	IWD	G.L. Brun	Evaluation of XAD resins. Development of aminocarb analytical methods.
	FPL	U Monc.	M.C. Mehra	Interaction of insecticides and trace metals in water.
Regulation of operations	CDA	CDA, Sackville	A. LeLacheur	Purity of insecticide.
	DFE	EPS	L. Stuart	Spray mixture verification. Handling at air strips. Insecticide spills.
	NB Env	NB Env	B. Gamble	Insecticide spills.

[1] For full titles of all abbreviations, see p. 24.

environmental disturbance;

(5) to present to provincial and federal governments and the public an early report on the environmental consequences of spraying in 1977.

The cost of monitoring and research in New Brunswick in fiscal year 1977 was about $600,000. Two-thirds of the costs were borne by Fisheries and Environment Canada, nearly one-third by New Brunswick Natural Resources and Forest Protection Ltd., and small fractions by Agriculture Canada and the University of Moncton. The provincial effort was largely backed by the Department of Regional Economic Expansion through the Forestry Subagreement of the General Development Agreement.

THE INSECTICIDE REGIMES IN 1977

(E. G. Kettela, MFRC)

Some 1.6 million hectares of New Brunswick forest - about one-quarter of the province (Fig. I) - were sprayed in 1977 with formulated insecticide to minimize budworm-feeding damage to foliage. Most of the sprayed area (76%) received two treatments, while the rest received three treatments (16%) or one (8%). The operations were conducted mainly by FPL using Grumman TBM aircraft: a formation of three aircraft with full tanks can spray a 5000-ha block in 1 h. Other aircraft used were Thrush Commanders (0.1 million ha) operated by J.D. Irving Woodland Ltd., and helicopters (a few thousand hectares). All of the larvicide spraying was conducted between 22 May and 27 June, aiming at third- and fourth-instar budworm larvae, and timed to the phenological variation of development from warmer to colder zones in the province. Most spray sorties were conducted early in the morning (6-8 a.m.) or just before dusk (7–9 p.m.) to avoid air turbulence and minimize dissipation of the spray cloud drift above the trees.

An insecticide regime is the sequence of spray treatments applied at prescribed dosages by specific aircraft within one season. The 14 treatment regimes (Table 2) were designed for a variety of budworm densities and stand mortality hazards (Kettela 1977). The most widely-used insecticide was fenitrothion (Sumithion R) formulated in water with Arotex R solvent oil and Atlox R emulsifier. The next major insecticide was aminocarb (Matacil R) dissolved in No. 2 fuel oil. Third insecticide used was trichlorfon (Dylox R) dissolved in water. A very small quantity of phosphamidon (Dimecron R) dissolved in water was used for a spray experiment designed to kill moths.

All areas treated had a history of heavy defoliation for several years and a resident population of budworm sufficient to inflict severe damage and some tree mortality in 1977 (hazard rating - moderate to severe). The number of applications was varied according to the severity of the risk of damage to the mature crop. The single-spray regimes (fenitrothion) were effective in reducing budworm density, but did not generally give satisfactory damage control. Two applications of fenitrothion at 210 g/ha gave good foliage protection and moderate budworm kill (56%) over a very large area. Two applications of aminocarb at 70 g/ha gave outstanding reduction (95%) of larval abundance and preserved most of the foliage intact. However, two applications of trichlorfon were not very efficaceous in killing budworm (20%) and afforded only moderate foliage protection; application by helicopter was less effective than application by fixed-wing aircraft. The 3-treatment regime (fenitrothion at 210 g/ha preceding two sprays of aminocarb at 70 g/ha) was applied to forest blocks with the highest hazard rating (heavy previous defoliation and high current infestation); the results were excellent.

The spray operation as a whole was highly successful. Throughout most of the sprayed area trees grew well, regained vigor, and retained their foliage; the good results may be attributed, in part, to the cool wet weather in June which enhanced shoot growth while retarding budworm larval development. Nevertheless, only one-quarter of the province's forests were protected by chemicals. Elsewhere, the budworm infestation in untreated forest intensified in 1977. Thus, the Province of New Brunswick faces continuing infestation in 1978, with high hazard to tree growth and survival now distributed over Charlotte County, the Saint John River Valley, Westmorland County, and other areas left untreated in 1977. Districts with several years of protection, such as the Miramichi Valley, are now quite vigorous.

In addition, in early July some experimental blocks were sprayed with water-formulated phosphamidon at 70 g/ha dosage in three applications with 2-3 day intervals, to kill moths and suppress egg deposition. The largest block, more than 3000 ha, was near Heath Steele (Northumberland County) and much smaller blocks were located at Acadia Forest Research Station, (Sunbury County).

The efficacy of operational treatments was

Table 2. Area sprayed by insecticide carrier and dosage per acre and hectare 1977 New Brunswick

Insecticide	Insecticide a.i. oz/ac	Insecticide fl oz/ac	Carrier	Insecticide a.i. g/ha	Insecticide L/ha		Area Sprayed Acre	Area Sprayed Hectare
One Application	(Larvicidal)							
1. Fenitrothion	3	20	water	210	1.46		114,875	46 489
2. Fenitrothion	4	20	water	280	1.46		500,500	202 550
3. Fenitrothion	3	64	water	210	4.67		2,840	1 149
4. Trichlorfon	8	64	water	560	4.67		28,000	11 331
5. Trichlorfon	16	64	water	1120	4.67		9,140	3 699
Two Applications	(Larvicidal)							
6. Fenitrothion	3	20	water	210	1.46		1,643,250	665 016
Fenitrothion	3	20	water	210	1.46			
7. Fenitrothion	3	20	water	210	1.46		4,000	1 619
Aminocarb	1	20	oil	70	1.46			
8. Fenitrothion	3	20	water	210	1.46		95,500	38 648
Trichlorfon	8	20	water	560	1.46			
9. Trichlorfon	8	20	water	560	1.46		209,000	84 581
Trichlorfon	8	20	water	560	1.46			
10. Aminocarb	1	20	oil	70	1.46		888,500	359 571
Aminocarb	1	20	oil	70	1.46			
11. Aminocarb	¾	15	oil	51	1.09		98,500	39 862
Aminocarb	¾	15	oil	51	1.09			
Three Applications	(Larvicidal)							
12. Fenitrothion	3	20	water	210	1.40		306,000	123 836
Aminocarb	1	20	oil	70	1.40			
Aminocarb	1	20	oil	70	1.40			
						Total	3,900,105	1 578 351
Applied by J.D. Irving Woodlands for FPL								
Two Applications								
13. Fenitrothion	3	10	oil	210	0.73		258,500	104 613
Fenitrothion	3	10	oil	210	0.73			
						Grand Total	4,158,605	1 682 964
Three Applications	(Adulticidal)							
14. Phosphamidon	1	20	water	70	1.4		8,000	3 237
Phosphamidon	1	20	water	70	1.4			
Phosphamidon	1	20	water	70	1.4			

(Information supplied by FPL)

a.i. = active ingredient; oz/ac = ounces per acre; fl oz = fluid ounce;
g/ha = grams per hectare, L = litres of formulation.
Metric conversion 1 oz/ac = 70 g/ha; 1 fl oz/ac = .073 L/ha.

evaluated by the CFS with technical support by FPL. The survival of budworm pupae and the deposition of eggs were sampled from balsam fir and red spruce in province-wide grid of 1000 sampling plots. The cost of the survey was around $300,000, largely from Provincial funds.

EFFECTS ON FOREST BIRDS

(J. Baird, NBNR; P. Germain, U Monc; B.B. McLeod, FPMI; and P.A. Pearce, CWS)

Introduction

Birds are the most visible group of forest animals and are enjoyed by a broad segment of the public for their song, beauty, or attributes as game. Since adverse effects of some insecticide regimes on songbirds have been observed in the past, it is important to assess the relationship between forest spray operations and the status of bird populations in order to minimize such hazards in future. Moreover, birds are a vital component of forest ecosystems; during some portion of their life cycle, most species of birds act as predators on insects, and are at times critically important in stabilizing populations of potential pests. No tactic which might produce large-scale mortality of forest birds is ecologically acceptable. Based on previous experience (Pearce and Peakall 1977), there was no reason to expect major adverse effects on birds from the chemicals and dosages employed in operational spraying in 1977. However, surveys were aimed at documenting bird responses to the major fenitrothion (210 g/ha, twice) and aminocarb (70 g/ha, twice) operational treatments, and the phosphamidon experiment (70 g/ha, three times).

Songbird numbers or population indices are determined through direct observation and the recording of singing activities. Censuses may be conducted along road transects and results stated in terms of identified birds per kilometer. Counts may also be taken on plots in selected forest stands, thereby establishing territorial boundaries for individual male birds; it is possible to estimate densities or birds per hectare employing this technique.

As these measurements of bird numbers rely largely on bird song heard day after day in the same place, a significant decrease in song is likely to relate to toxic effects on the birds. If the song of an individual has been recorded at a given location for several days prior to spraying and not on the days after, the bird may be dead or too sick to advertise its territory. North-bound migration in May and the local mobility of non-breeding or subdominant males present within populations of resident songbirds pose problems in interpretation of the data recorded.

The task of monitoring populations of forest songbirds is complex and requires special skills. Establishing a cause - effect link between recorded counts and the spray is extremely difficult because of the host of factors that influence bird numbers. The principal objective of our efforts was to detect any gross changes for which the most reasonable explanation is insecticide toxicity.

Agencies and Monitoring Programs in 1977

The monitoring agencies were CWS, FPMI, and U. Monc. Their surveys were structured to provide geographical coverage and an assessment of various spray regimes (Fig. 1). However, it should be recognized that the combined effort monitored less than 0.02% of the total sprayed area.

The CWS monitored bird populations in Restigouche County within an area receiving two applications of aminocarb at 70 g/ha. Its team conducted a census on alternate days along eight 5-km transects in treated blocks and daily on the 5-km transect in an untreated check area.

Twenty-two 5-ha plots were monitored by FPMI personnel. Plots were located in operational spray blocks receiving 2 applications of aminocarb at 70 g/ha (Restigouche County), within experimental blocks sprayed with phosphamidon in 3 applications of 70 g/ha (Northumberland County), and phosphamidon in 2 applications of 70 g/ha + a moth-irritant chemical (Sunbury County), and in accompanying untreated control areas.

Monitoring was conducted by the University of Moncton in areas receiving 2 applications of fenitrothion at 210 g/ha and in control areas. A total of 24 plots, each 5 ha, was monitored for 6 weeks in locations near Edmundston, Fredericton, Doaktown, and Moncton.

Results

Aminocarb No major impact was attributable to the operational spraying of aminocarb, in two independent surveys incorporating some 30 spp. of songbirds The data do not reveal any immediate mortality or influence on song frequency among sparrows, warblers, kinglets, and others. Searches failed to find any dead or sick birds. Approximately 100 nests were located and no rearing failures could be linked to spraying.

Fenitrothion The University of Moncton team[2] detected no apparent effect on populations of 13 species of the most common forest-dwelling warbler species, (e.g. bay-breasted, ovenbird, blackburnian, and Tennessee warblers). Territory occupation by ruby-crowned kinglets decreased about 40% in treated plots, but it is not possible to draw firm conclusions because the sampling intensity was too light.

Phosphamidon The census of bird song revealed no alteration of frequency except for a brief reduction in activity by white-throated sparrows. Plot searches did not reveal any dead or sick birds after experimental treatment in July. Two broods of nestlings (magnolia warbler, Swainson's thrush) were kept under observation, but appeared unaffected by the aerial sprays.

In summary, the surveys revealed no influence on songbird survival in the sampled areas of operational and experimental spray treatments in 1977. There remains still some doubt as to the influence of fenitrothion on kinglets, probably the most vulnerable bird species.

Effect of aminocarb on small mammals

(B.B. McLeod, FPMI)

The overwhelming toxicological evidence is that conventional forest spray dosages of aminocarb, as intercepted by contact, ingestion, and inhalation, are essentially harmless to mammals.

Small mammals (the red-backed vole, woodland jumping mouse, the masked shrew, and the deer mouse) are the most convenient animals for field check of adverse effects. The hypothesis is that if age-class structure and fertility can be shown to be normal 2-3 months after spray, then the spray had no effect on the seasonal reproductive success. The techniques are to snap-trap animals to determine the distribution of age classes, and to dissect adult females for pregnancy or for counts of placental scars as a measure of within-season reproduction of a litter.

In 1977, in northern New Brunswick, 76 small mammals were trapped in a spray block and 39 in a similar but untreated forest stand (Fig. I). In the treated block, 75% of the trapped animals were "young of the year" and 42% of adult females were in breeding condition. In the control block, 33% were young of the year and 61% of adult females were in breeding condition. These results are disparate and difficult to interpret, but certainly the high proportion of young in the treated plot does not suggest that aminocarb had reduced the reproductive success of small mammals.

This information, although useful experience in the further application of the technique, indicates the inadequacy of available sampling methodology for monitoring small mammals. Much larger replicated samples are needed to eliminate local variation in population structure unrelated to the test parameter.

EFFECTS ON FISH AND OTHER AQUATIC ORGANISMS

Introduction (I.W. Varty MFRC)

Lakes and streams in and adjacent to spray blocks are apt to be contaminated by insecticides through surface deposition, drainage flow, and drift of poisoned insects. Usually, the contamination of water is extremely dilute and brief, such that there is little or no measurable toxicity to sports fish such as trout or salmon. However, a large fraction of the freshwater fauna consists of immature aquatic insects, together with some mites, worms, crustaceans, and molluscs. These macroinvertebrates are sensitive to contamination of water by insecticides in the parts-per-billion range, such that portions of species populations may be killed or induced to undertake live drift. Drifting and resident invertebrates are the main food source for sports fish. The hypothesis thus emerges that insecticide intervention may dislocate the normal availability of preferred fish foods and thus cause a long-term reduction of fish-growth rates or population strength.

Most of the monitoring hitherto has been focussed on efforts to quantify the amount of kill of stream insects in relation to the emitted dosage introduced into the spray block around the stream. More recently, attempts have been made to relate dead and live benthic drift to the measured quantity of insecticides in a stream over a few hours or days. Other work is aimed at determining the survival of insects sequestered in the gravel substrate, and at measuring the rate of recuperation of populations

[2] Unpublished report: Germain P. 1978. Songbird census in fenitrothion regime and 1977 forest spray program in New Brunswick. Submitted under contract to Forest Protection Ltd.

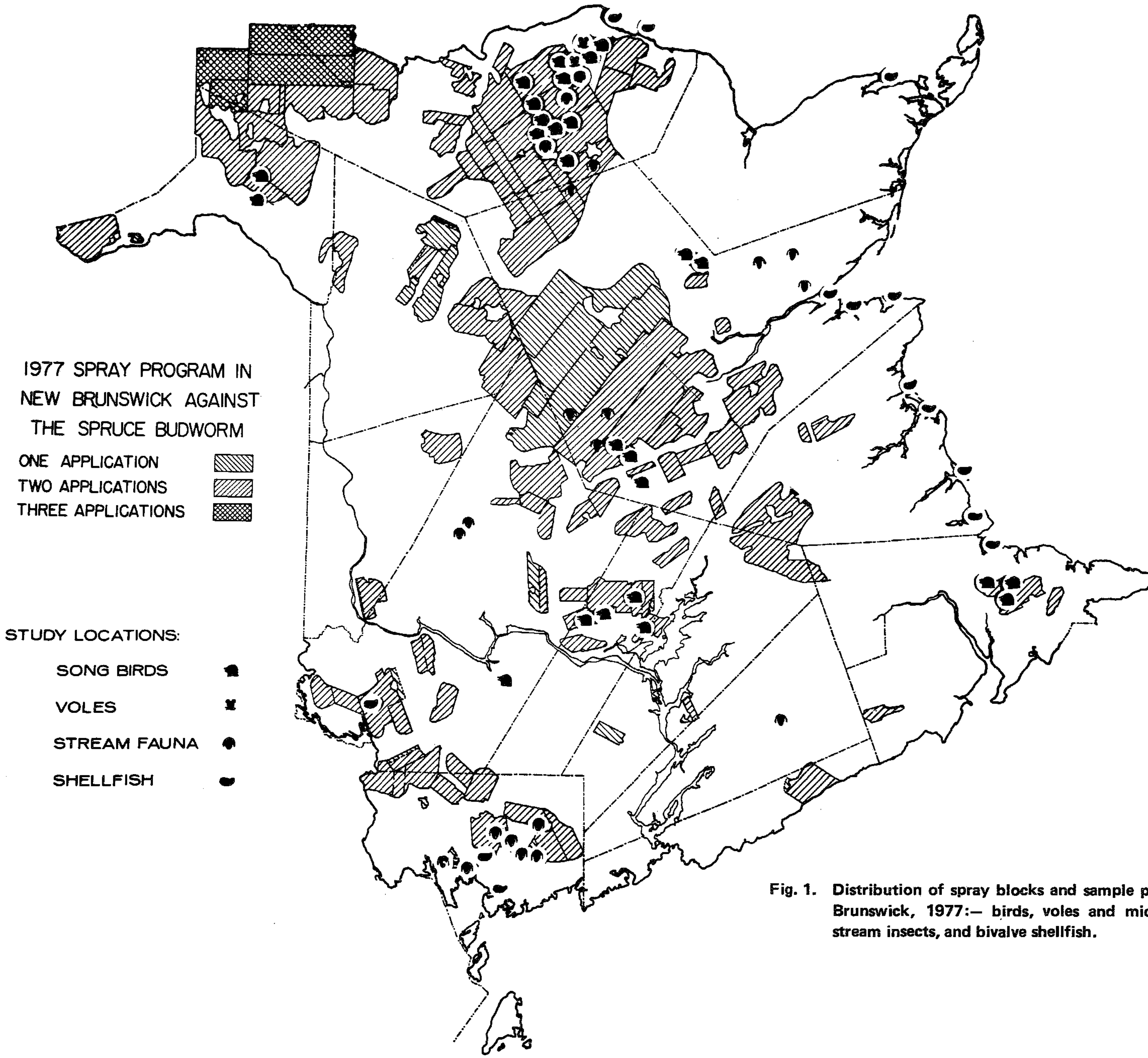

Fig. 1. Distribution of spray blocks and sample plots in New Brunswick, 1977:— birds, voles and mice, fish and stream insects, and bivalve shellfish.

after spraying. Monitoring of effects on stream fauna is technically difficult and expensive, so that comprehensive surveys across the province have been impractical.

In spite of the accumulated experience in aquatic biology, the gaps in our knowledge of how to monitor the sports-fishing resource remain large. In particular, brook trout production appears to be low in New Brunswick compared with earlier times, but populations are stressed by many factors such as overfishing, mining and agricultural practices, and siltation from forest practices. Thus, it is difficult to assess the independent influence of forest sprays.

Monitoring and research on spray effects on aquatic fauna were done in various parts of the province (Fig. I) by six agencies:- MEL Fredericton, MFRC Fredericton, FMS St. Andrews, FPMI Sault Ste. Marie, EPS Halifax, and CWS Sackville.

Fish-Growth Rates (G. Gillis, MEL)

This study on fish productivity was designed to compare fish-growth rates in three different but comparable test areas in northern and central New Brunswick: treatment with fenitrothion (210 g/ha twice), treatment with aminocarb (70 g/ha twice), and not treated. The fenitrothion-treatment area (Priceville) has a long history of perennial treatment for experimental and operational purposes (8 years since 1969). The other two areas have histories of sporadic treatment by insecticides, none of them being fenitrothion. Ten streams in each treatment area were electrofished three times in 1977 (July, August, September). All fish were identified, weighed, measured, and released, giving data on a total of 12, 000 fish. A few fish were dissected to determine seasonal diets.

Fenitrothion at 1 to 27 ppb was measured in the designated streams soon after spraying, with a few erratic peaks up to 15 ppb on non-spray days. In the area treated with aminocarb, no insecticide was detected, but it is not known whether this result was due to lack of deposit or to insensitivity of analytical methods available.

The area treated with fenitrothion had consistently higher numbers of salmon per 100 m^2 of stream, but the density of trout was similar in all three areas. However, within any one area there was strong variation in fish abundance, suggesting a wide range in habitats within a single drainage system. As expected, stream sections with plentiful salmon parr had few trout, and vice versa.

The tentative conclusion is that the long history of fenitrothion does not appear to have resulted in depletion of populations or biomass of salmon parr and trout, compared with the aminocarb and control areas. Similarly, there was no suggestion that aminocarb treatment had affected the pattern of seasonal abundance of fish. The results[3] give a firm baseline for future studies of growth and production of trout and juvenile salmon.

Benthic Drift (G. Gillis, MEL)

Benthic drift response to insecticides was studied in the same streams used for fish growth studies. Drift collectors and benthic colonization pots were installed for studies of invertebrate kill and population change, respectively. Drift was collected in the two days following sprays and sorted to separate living and dead animals. Most of the drift is composed of immature forms of species of mayflies, caddisflies, stoneflies, chironomid flies, and beetles. Fenitrothion contamination of stream water apparently caused an increase in dead drift, but peak concentrations of insecticide independent of duration did not correlate well with counts of organisms. Mayflies and stoneflies were the most sensitive insect orders, and comprised 90% of the dead drift after treatment, compared with 28% before. The resident benthos were less strongly affected. The combined effect on both drift and benthos suggests a light depletion of the invertebrate populations, but the density stabilized within one month to be comparable with the untreated control, despite the perennial history of fenitrothion usage.

No increase in the proportion of dead macroinvertebrates in drift and benthos was observed in streams in the aminocarb area.

Penetration of fenitrothion and aminocarb into stream gravel, and effects on benthic insects (D.C. Eidt, MFRC)

It can be reasonably hypothesized that insecticides in streams offer a diminishing hazard to benthic invertebrates with depth in the stream bed. To test the hypothesis, two field experiments were

[3] Unpublished report: Anon (Montreal Engineering Ltd.) 1978. Assessment of the effects of the 1977 New Brunswick spruce budworm control program on fish food organisms and fish growth. Submitted under contract to NBNR and DREE.

designed whereby insecticides (fenitrothion, aminocarb) were dripped slowly into streams to give concentrations approximating the heaviest contaminations likely through aerial spraying. The experiments were conducted in early June in tributaries of the upper Nashwaak River.

In the fenitrothion experiments, the calculated concentration was 50 ppb for 2.5 h, but water samples indicated about 20 ppb for 4 h. The insecticide slowly permeated interstitial water in the gravel crevices and persisted there longer than in the main body of stream flow. Caged stonefly larvae (*Leuctra*) placed on the stream bed or embedded in the gravel were not affected. However, a brief small kill and drift of benthic insects mainly (*Nemoura*) stoneflies and (*Baetis*) mayflies occurred.

Because this concentration showed no effect on the caged stoneflies, the experiment was redesigned, with a calculated concentration of 69 ppb fenitrothion for 2.5 h, and was conducted two weeks later. This time the caged insects were clearly affected, with most toxicity being evident on the insects caged on the stream bottom and closest to the insecticide injection site, while the least toxicity was in deep gravel and further downstream.

New information on insecticide concentration and duration of exposure from the experiment, together with past experience, suggest ways to relate rapid change in field concentration to biological effects. The method will be developed.

The aminocarb experiments were conducted in mid-June and early July. In the early experiment, an aminocarb emulsion was dripped into the stream to give a calculated concentration of 2.2 ppb for 1.5 h. This was a reasonable experimental rate since peak concentrations in an operational spray program would be in the vicinity of 5 ppb. Neither caged insects nor benthic drift were disturbed by the treatment. The later experiment (6 July) was designed to test much heavier contamination. The stream was subjected to two successive treatments (4.7 ppb for 1.5 h, discontinued 1.5 h, then 13.7 ppb for one h), but even these dosages produced no effect on caged insects or benthic drift. The experiment confirms the general experience that aminocarb at conventional dosages is safe in fast-water streams.

Effect of aminocarb in ponds (W.R. Whitman, CWS)

A preliminary study was undertaken to determine the desirability of testing the hypothesis that aminocarb contamination of ponds might affect the spring abundance of macroinvertebrates, and therefore the food supply and welfare of nestling waterfowl such as black duck. Pond water was sampled for three days after the operational spray and showed concentrations from trace to 8 ppb. Aquatic insects were sampled by activity traps and sweep nets. Preliminary analysis shows no major reduction in invertebrates or probability that further work is urgent. While the hypothesis is not supported, replication of the study is necessary to validate the conclusion.

Insecticide contamination of streams (B.B. McLeod, FPMI)

Aquatic insect abundance was estimated by Surber sampling and densities were compared in sprayed and untreated streams. There was an indication of slight decrease in heptageniid mayflies and chironomid larvae in the aminocarb-treated stream (70 g/ha, twice) in northern New Brunswick but the abundant elmid beetle larvae appeared to be unaffected. In a stream exposed to phosphamidon (moth suppression trials) emitted at 70 g/ha (twice with a 4-day interval), no effects on aquatic invertebrates were detected (Acadia Forest Research Station).

Effects of insecticide contamination on stream litter decomposition processes (D.C. Eidt, MFRC)

Decomposition of organic detritus in streams is one vital process that has been overlooked in impact studies on insecticidal practices. In 1977, a laboratory experiment was performed by J.H. Meating to test the hypothesis that fenitrothion and/or aminocarb might interfere with fungal decomposition of broadleaved tree litter in field conditions. Tanks were set up with agitated stream water and with placid swamp water to simulate environmental conditions for the breakdown of alder and birch leaves. Three concentrations each of fenitrothion and aminocarb were tested, and measurements were kept of the change in ash-free weight of the leaf tissue and the fungal density in that tissue. The results were:

1. There was no effect of fenitrothion on growth of six species of fungi on birch leaves incubated in stream or swamp water up to 3 months. Rates of 15, 150, and 1500 ppb of fenitrothion were tested.
2. There was significantly better growth of fungi on alder leaves in the controls than in the three treatments in stream waters. There

was no difference between control and treated swamp waters. The concentrations of fenitrothion were the same as for birch.

3. There was less growth of fungi with increasing concentration of aminocarb using birch leaves in both stream water and swamp water. Similar inhibition was observed for alder leaves in stream water but not in swamp water. Rates were 0.9, 9, and 90 ppb.

4. It is important to note that no tested concentration of aminocarb or fenitrothion entirely prevented germination of fungus spores and subsequent growth.

Effects of trichlorfon in stream and lake habitats (J.W. Saunders, FMS)

Toxicological tests have shown that salmon mortality from conventional spraying of trichlorfon is extremely unlikely (Kingsbury 1975). Further, the residual toxicity of trichlorfon is very low so chronic poisoning at low levels can be discounted.

Studies in southern New Brunswick in 1976 (pers. comm. Dr. P.E.K. Symons FMS), showed that caged caddisflies could suffer high mortality rate when the peak concentration of trichlorfon in water was 170 ppb. It was concluded that aerial application at 560 g/ha over forest land has the potential for perturbation of the aquatic insect community.

Thus, in 1977, study sites were established at six spray blocks in Charlotte County (Fig. 1), where treatments were to be either 2 applications of 560 g/ha or 1 application of 1120 g/ha. The sampling methods for invertebrate fauna included drift netting, artificial substrates, Surber samplers, tallies from stones, plankton tows, and the use of caged test caddisflies and crayfish.

Some of the work was frustrated by high water levels due to heavy rain in June, and results of much of the field work have not yet been analyzed. Chemical analyses of water showed peak concentrations of trichlorfon lower than 10 ppb in most streams, but one site (Lake Stream) had an exceptionally high peak at 58 ppb.

The drift pattern in June was strongly affected by the frequent spates due to rainfall, such that it is difficult to identify the possible contribution of insecticides. There was some evidence that high concentrations of trichlorfon were hazardous to ***Picnopsyche*** and ***Limnephilus*** caddisfly larvae. At Lake Stream, all caged caddisflies died, but in four other streams where the concentrations did not exceed 5 ppb, no caged caddisflies died. The observations fit the finding by Symons that caddisflies emerge from their cases and some die when peak concentrations exceed 50 ppb. The preliminary conclusion from this limited sampling is that little damage occurred in stream ecosystems exposed to aerial spraying of trichlorfon at conventional dosages, but further observations are needed to check this generalization.

Recuperation of aquatic insect populations after cessation of spray (L. Stuart, EPS)

Cove Stream near Sussex (Fig. 1) has a history of fenitrothion spraying in 1970, 1971, 1972, and 1973. A long-term study of the abundance of stream insects was begun in 1971, and censuses have been conducted annually to 1977. The abundance of stream insects was reduced in 1972 and 1973. After spraying ceased, the insect population increased and has remained relatively constant since 1975. A complete interpretation of the data is in preparation.

POLLINATORS

Effect on pollinators in and adjacent to spray blocks (G.W. Wood, CDA)

The importance of pollinating insects in the production of farm crop plants is well documented and is a major consideration in the development of pest control strategies in agriculture. In such crops as blueberries and apples, reduced pollination from any cause affects the livelihood of many growers in New Brunswick, and farmers have a legitimate reason for being sensitive to the use of broad spectrum insecticides in woodlands adjacent to their fruit growing operations. Earlier monitoring showed sharply-reduced populations of native bees in some commercial blueberry fields located near forests sprayed with fenitrothion. Forest Protection Ltd. now refrains from spraying in a 2- to 4-mile zone adjacent to such fields, to lower the risk of exposure of bees to direct spraying or insecticidal drift, and has replaced fenitrothion with the less toxic insecticide trichlorfon (Dylox R).

Insect pollinators are also essential for normal seed-set and fruit-set of various trees and plants in the forest, thus promoting production of food for many species of fruit-seed and seed-eating birds and small mammals. The most important pollinators in both woodland and farmland are bumble bees and solitary bees, but on some farms, honey bees are a useful supplement to crop pollination. While new information shows significant reductions in bumble bee populations in forests sprayed with fenitrothion, there is, so far, no evidence of mortality of forest-dwelling solitary bees. Each year new or modified insecticide regimes are liable to be introduced into budworm spray operations so pollinator abundance will require continued monitoring, together with research into the long-term status of pollination success in forest systems.

The immediate technical problems are wild-bee-census methodology and the measurement of spray drift. The ecological problem is to determine whether seed and fruit production in the forest are depressed by repeated spray applications over years.

Effects of aminocarb on honey bees (B. B. McLeod, FPMI)

Colonies of honey bees are useful indicators of the impact of insecticides on pollinators. Known populations can be placed in target forests, and bee mortality and pollen collecting activity can be accurately measured by trained technicians.

Colonies of honey bees were established in an aminocarb block (70 g/ha twice) in northern New Brunswick (Fig. 2) in early June 1977. Cool wet weather caused bees to forage near the hives. The first aminocarb treatment (June 14) caused very light mortality to foraging bees ($< .1\%$ of colony), and the volume of pollen brought to the hive was reduced by one-third for about two days. Activity appeared to be normal thereafter, and examination of the hives showed that queens, drones, nurse bees, and brood were not affected. The second application (June 19) had no effect on the colonies.

This confirms earlier experience by FPMI that conventional dosages of aminocarb are unlikely to damage honey bee colony strength or productivity.

Bees and blueberries (G.W. Wood, CDA)

The 1977 forest spray program had no measurable effect on the commercial blueberry crop in New Brunswick. A census of native bee activity in blueberry fields (Fig. 2) was supported by a contract with FPL. The aim of the census was to determine the abundance of pollinators and to document the rate of recuperation of bee populations in plots with known spray histories and crop yields.

Native bee activity continued to improve in central Charlotte County where blueberry fields were exposed to fenitrothion drift in 1973-4, and fruit-set and yields of blueberry have reached satisfactory levels. Full recovery of the native bee population was also indicated in one field in Kings County which had been exposed to fenitrothion drift in 1975.

Fenitrothion spray blocks were remote from blueberry fields in 1977. Only one field was within five miles of such a spray block, and a local census indicated above-average wild bee density.

Further indication of the toxicity of fenitrothion drift was obtained from a new blueberry field in Kent County. That field, completely surrounded by fir-spruce forest, was embedded in a spray block in 1976. In that year, insecticide deposit assessments suggested that the field received heavy drift or was inadvertently sprayed directly. The native bee census in 1977 showed exceptionally low density, presumable in consequence of treatment in 1976.

The toxicity of conventional dosages of trichlorfon to wild bees in forests has never been investigated in New Brunswick. However, trichlorfon is known to be relatively innocuous to honey bees, and the insecticide is prescribed by Canada Agriculture for use by blueberry growers with defoliator problems.

Solitary bees (E. Thorpe, UNB, and I. W. Varty, MFRC)

Solitary bees of many kinds (andrenid, halictid, leafcutter, cuckoo, yellowfaced, and carpenter bees) represent about 90% of all wild bees in forest, bog, and other wilderness habitats in New Brunswick. These obscure and little-known pollinators are largely responsible for the fruit-set of such common wild plants as blueberries, raspberries, and strawberries, and for seed-set in various broadleaved trees, shrubs, and herbs. The integrity of floral composition in a forest is thus dependent upon normal densities of species populations of solitary bees.

Monitoring of bee species diversity and density was conducted in 1977 to establish baseline census data and to compare the complexes in a perennial fenitrothion regime, in an aminocarb regime, a phosphamidon (adulticide) regime, and in a never-treated check area (Fig. 2). The census also was a test of the adequacy of Malaise trapping as a sampling procedure.

Several hundred solitary bees were collected

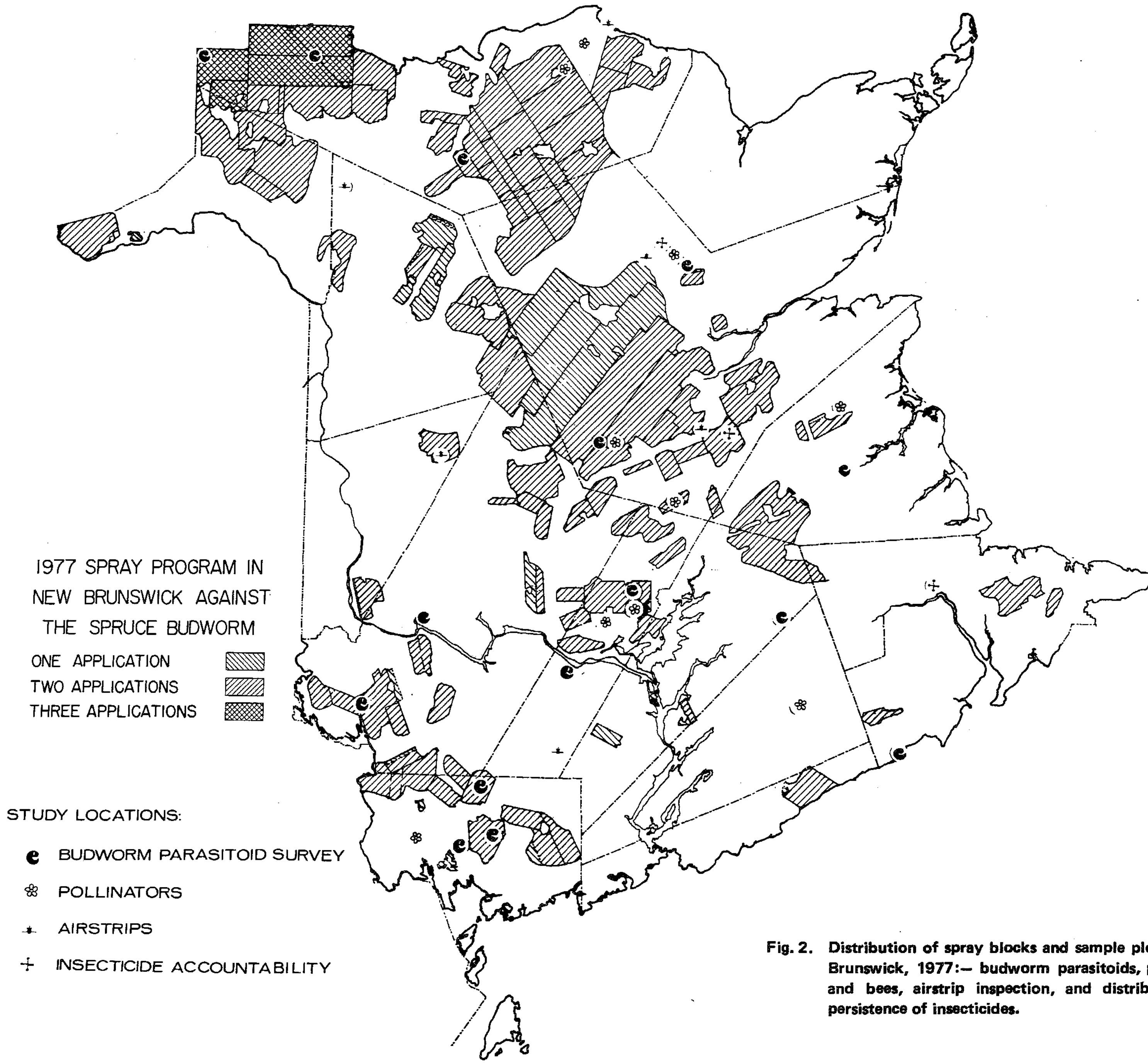

Fig. 2. Distribution of spray blocks and sample plots in New Brunswick, 1977:— budworm parasitoids, pollination and bees, airstrip inspection, and distribution and persistence of insecticides.

in fir-spruce woodland and have been classified to species. The complex includes at least 30 species, and the seasonal occurrence of foraging adults has been documented. Thus, we now know what species are vulnerable at any given spray date.

The phosphamidon spray (70 g/ha three times in mid-July), designed to kill budworm moths, caused no perceptible change in solitary flight bee activity; however, the Malaise-trapping method, at least at its present development, is not a very sensitive means of checking changes in density due to insecticide knockdown. Foraging by these small bees is inhibited by weather conditions such as rain, low temperature, and high winds. More knowledge is needed on the biology of the more common species, nesting patterns, diurnal flight times, brood rearing success, and flower associations, to assess the magnitude of the pollinator problem.

The Malaise-trap was tested in different topographical settings, and it is tentatively concluded that the best trap site is across a forest track to intercept the flight lanes. In August, the most productive trapping hours were 13:00 - 17:00 hours. The timing of foraging activity in spring may be critical to the vulnerability of solitary bees; most sprays are applied in the morning or evening, so species which forage mainly on warm afternoons might escape toxic exposure to the drifting spray cloud.

In future work, a variety of sampling techniques should be tested, such as nest-stick trapping, sweeping, and tallies along transects. Pollen analysis can be used to determine the flower constancy of indicator species of bees. Pollination and seed-set studies should be conducted to measure the consequences of change of bee densities. Emphasis should be placed on assessment of hazard to bee abundance posed by aminocarb regimes.

Bumble bee survival in fenitrothion and aminocarb regimes (R.C. Plowright, U of T)

The study[4] was a major effort in 1976-7 to determine the seasonal effects of aminocarb and fenitrothion usage in spring on the abundance and ecology of the complex of bumble bee species dwelling in forests, and to assess effects of reduced bee densities on pollination of indicator plants. It was conducted in various regions of the province.

June 1977 proved to be unusually wet, cool, and dull, apparently causing low establishment of bumble bee queens in both sprayed and untreated areas in the early season.

Exposure-cage experiments indicated that contact with fenitrothion deposits from aerial operations could be lethal to foraging queen bumble bees of early-emerging species, but that aminocarb at conventional dosages is not hazardous. Experimental colonies of one species were placed in fenitrothion-treated, aminocarb-treated, and control areas soon after spraying. Worker longevity, caste production, and the reproductive success of established queens were not influenced by insecticide residues in the habitat. One disappointment was that it was not possible to test the hypothesis that insecticide-caused reduction of the queen population density leads to relaxation of competition stress in survivors. The hypothesis proposes that surviving queens will have above-average reproductive success because of lower competition for pollen and nectar. However, the wet June appeared to cause a general reduction of queen establishment in all areas, so the "planted" colonies were effectively in a low-competition situation regardless of treatment.

The role of pollinating insects in fruit and seed production was tested by pollinator-exclusion experiments, and it was demonstrated that the selected four common shrubs and one perennial herb were highly dependent upon insects for fruit- and seed-set. In general, about twice as much fruit and seed per flower were produced in the control and aminocarb-treated areas than in the fenitrothion-treated area. These results were consistent with the heavy depletion of bumble bee queen abundance in the fenitrothion area compared with the relatively good survival in aminocarb-treated and control areas.

A post-spray survey of bumble bee abundance in areas with greater or lesser perennial exposure to fenitrothion treatments was conducted in 20 sampling sites. Two common early-emerging species were found in significantly lower abundance in sites with a history of recent consecutive treatments.

It was demonstrated that fenitrothion spraying was associated with a shift in species composition of the bumble bee complex; late-emerging species (emerging after spray dates) became more abundant while early-emerging species (vulnerable to spray) become less dominant in the complex.

The study has produced a reasonable assu-

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[4] Unpublished report: Plowright, R.C., Pendrel, B.A., and G.R. Thaler 1978. The impact of spruce budworm control operations on forest pollination in New Brunswick during 1977. Submitted under contract to Canadian Forestry Service.

rance that conventional treatments with aminocarb pose no hazard to bumble bees and probably not to solitary bees. It is possible that aminocarb toxicity to spiders, some of which are predators on bees, may be responsible for the unexpectedly good survival and performance of bumble bees in aminocarb-treated areas. On the other hand, pollination of dependent plants exposed to perennial application of fenitrothion may be substantially depressed.

HAZARD TO NON-TARGET INSECTS

(I. W. Varty, MFRC)

Surveillance in 1977 was conducted in fir-spruce stands with special attention to the parasitoid insects which prey on spruce budworm. More restricted studies were made of the predatory arthropods and minor pests in fir crowns and of the soil fauna under those crowns. The principal problems were to determine whether or not;

(1) parasitism is diminished by insecticide usage;
(2) predation of pests in fir crowns is abnormally low in perennially treated areas,
(3) the soil faunal community is destabilized by insecticidal interference.

The answers lie beyond our survey capacity, but the expectation was that limited sampling would indicate whether gross adverse change is a likely prospect requiring more intensive study.

Parasitism

There are tens of thousands of different insect host-parasitoid relationships in forest ecosystems but it is feasible only to examine the few that are relatively easy to sample, such as spruce budworm parasitoids. Sampling in 1976 across the Maritime Provinces had shown that parasitism of budworm hosts was higher in sprayed stands than in untreated stands.

In 1977, a survey of budworm parasitoids was conducted by the Forest Insect and Disease Survey of MFRC in 21 permanent plots scattered over the three Maritime Provinces, and covering the four main larvicidal treatment regimes as well as untreated stands (Fig. 2). The results again indicate that the conventional insecticidal strategy is compatible with maintenance of normal rates of parasitism in budworm populations. Data from the two years compare favourably and indicate little difference among treatments or regions.

	% (larval & pupal)parasitism	
	1976	1977
Sprayed (N.B.)	13.9	16.1
Not treated (N.B.)	12.1	10.1
Not treated (N.S. & P.E.I.)	10.3	12.6

The evidence supports the hypothesis that larvicidal treatments discriminate in favour of higher percent parasitism in residual budworm populations.

However, it is worth noting that pupal parasitism (that small fraction of total parasitism where the host stage is the budworm pupa) was substantially smaller in sprayed plots than in untreated plots. Parasitism of spruce budworm eggs - an important factor in pest population control - was almost identical in sprayed plots (23% parasitism of egg masses) and in untreated plots (24%). From 1973 onward, a steadily rising trend in egg parasitism has been apparent regardless of insecticidal treatment or no treatment (data per E.G. Kettela).

The adulticidal treatments are more worrisome because of greater insect activity during the summer. The phosphamidon sprays to kill moths in the Heath Steele experimental area were applied in mid-July, which is the time of peak flight of the two important wasp species which attack budworm larvae. Drop-tray studies showed that the three successive sprays killed 80-90% of these minute wasps (mainly ***Glypta*** and ***Apanteles*** spp.), before most of them could reproduce. However, that mortality apparently had little effect on rates of parasitism in the new generation of budworm. Mean parasitism of overwintering larvae (April 1978) in the treated block was 22%, compared with 26 and 30% in two adjacent untreated areas.

Predation

Measurement of the incidence of predation - as a factor of biological control of minor and major pests - is extremely difficult. About 100 species of predaceous insects, mites, and spiders live on fir and spruce trees, but there is no practical survey technique to measure density and population trends of that complex or of indicator species across the province.

In 1977, the effect of aminocarb treatments (70 g/ha) was measured by; (a) the drop-tray technique - counting insect cadavers under sprayed stands, and (b) the beating technique - counting densities of living insects on a given branch surface area, before and after spraying.

The results showed that aminocarb was highly effective against spruce budworm larvae without discriminating heavily against most other members of the arthropod community on firs. However, heavy mortality (60-70%) was inflicted on populations of spiders and adult chalcid wasps, and moderate mortality (40-50%) occurred in beetles and ichneumonoid wasps. The dynamics of these sensitive groups should be monitored if aminocarb is to be applied perennially in operations.

Ladybeetles on fir and spruce continued to be scarce in permanent sample plots in both perennially-sprayed and rarely-treated areas in New Brunswick. It is speculated that this apparent scarcity (compared with records from the 1950's and 1960's) may be due to hypersensitivity to organophosphate insecticides, or may be a function of normal predator-prey relationships, dependent upon the abundance of aphids feeding on conifers.

The moth suppression experiment (phosphamidon in three applications) produced heavy kills of bugs, beetles, lacewings, and predatory mites, but not of spiders. Again it is too early to assess the importance of such mortality to the integrity of the fir ecosystem.

In all these measurements of predator densities, it is apparent that no authorized spray regime has produced drastic change in the predation process as a whole. As long as present spray practices persist (frequency, area, dosage), it is likely that the recuperative capacity of predatory arthropods will be sufficient to absorb the insecticidal stress without long-term damage to the functioning of ecosystems. Certainly, if the criterion of damage to biological control is the irruption of minor defoliator pests, then we have no evidence of system stress. During the 1970's, there have been no minor pest resurgences that could be linked with the pattern or timing of spray treatments. A special survey of birch sawflies in 1977 - relative to their hypothetical high susceptibility to insecticides - was inconclusive; that is, the data did not reveal either a positive or a negative effect on sawfly abundance.

Soil fauna

The soil in forested stands is not a major site for deposition of insecticide aerosol droplets; nevertheless, contamination of the soil may subsequently follow from rainwash and the fall of contaminated insects and foliage. The soil is also the site of foliage decomposition by macroinvertebrates so the integrity of the fauna is important, perhaps crucial, to adequate nutrient turnover.

An adequate survey of soil faunal responses would require the full-time attention of a scientist. Since that was not possible, some experience was gained by employing a pitfall sampling technique to determine the seasonal abundance of the main species foraging across the litter surface. Pitfall traps collect a great variety of insects, spiders, mites, harvestmen, and millipedes, - even frogs, toads, mice and shrews which stumble into the collecting cone.

The main effort in 1977 was to compare pitfall catches in three areas with different treatment histories: (l) fenitrothion in 1977, and for the previous eight consecutive years; (2) aminocarb in 1977, and fenitrothion sporadically in earlier years; and (3) never treated. In these three areas, the numbers of organisms trapped were, respectively, 3522, 5682, and 7044 over a 10-wk period from May to July. The most noticeable feature of the data is the low number of springtails in the long-term fenitrothion area. There is also a lower apparent abundance of millipedes, spiders, and beetles, especially the important predatory carabid beetles in the areas with insecticide history. These differences among faunal abundances in the three plots do not in themselves indicate insecticide stress. The differences could be due to natural variation in habitat, despite the choice of similar plots on the basis of stand structure and tree dominants. However, the pitfall data are prima facie evidence warranting concern over the long-term impact of insecticides on the soil fauna. In comparison with similar pitfall-sampling in 1972 in the same plot with the long-term fenitrothion history, the 1977 data show catches of about one-third of the number of the carabid beetles and one-half, the spiders. Such declines, while not drastic in arthropod population dynamics, bear watching in the insecticide context.

The year's work on terrestrial forest insects represents a substantial increase in our knowledge of the effects of aminocarb and a confirmation of the effects of fenitrothion, but our knowledge of the ecological effects of trichlorfon remains weak.

INSECTICIDE DISTRIBUTION, PERSISTENCE, AND CHEMISTRY

The National Research Council's review of fenitrothion (1977) details the wide internationally-researched knowledge of insecticide deposition patterns, persistence, and breakdown of the active ingredients, and the chemistry and toxicology of degradation products. In Canada, research on such basic qualities of insecticides is primarily a national responsibility; in New Brunswick a substantial contribution, funded both federally and provincially, was in progress in 1977. At the operational level, the sampling of formulations and inspection of air strips and other sites of potentially heavy contamination have provided assurance that the spraying is conducted in a professionally responsible manner.

Deposition pattern (I.W. Varty, MFRC)

A major technical problem in forest spraying is to lay down evenly-spaced swaths i.e. a uniformly distributed spray cloud. Three factors are involved: correct navigation to assure parallel runs at even spacing; correct aircraft height and speed so that horizontal drift is uniform; stable meteorological conditions so that each swath settles at the same rate. Failure to achieve uniform deposition may be a major reason for the survival of 10-40% of target budworm populations. Similarly, local high concentrations of spray cloud drift and droplet deposition due to double swathing might account for sporadic mortality of songbirds.

The ecologist has no cheap and accurate way of checking the deposition of insecticide in any macrohabitat. Colorimetric and fluorescent dyes have previously been used experimentally, but spray operators object to the formulation of stain dyes which might discolor cottages or cars. A cheap colorless fluorescent dye - detectable only with a fluorometer - offers possibility of tracing insecticide distribution without environmental harm or public antagonism. Knowledge of insecticide deposit is needed to relate cause and effect in ecological events.

The colorless water-soluble dye Pontamine, which can be detected fluorometrically at extreme dilution, shows promise as an insecticide tracer. It was incorporated (4% by volume) in the phosphamidon formulation used in the moth suppression trial at Heath Steele in July 1977. The results of the experiment showed that:

(1) Pontamine can be measured in a wide range of deposits on foliage.
(2) The phosphamidon spray was deposited fairly evenly over a large number of sample plots.
(3) Within a fir stand, some trees were more prone to spray interception than others.
(4) Within the average tree, the lower crown received a much lighter dye deposit than the upper and mid crown areas, but there is a wide variability in deposition pattern (by a factor of 10) among branches in the same crown zone. Surprisingly, in these measurements there was no difference between leeward and windward sides of a tree, indicating good penetration of partly defoliated fir crowns.
(5) There was a problem of background fluorescence due to natural material. Aphid-infested shoots had three times the fluorescence found on non-infested shoots; thus, there was some confusion between readings from lightly-sprayed shoots and heavily-infested shoots.

Unfortunately, this water-soluble dye is unsuitable for oil-formulated insecticides.

Measurement of the airborne spray cloud (G.W. Wood, CDA)

An air-sampling technique was used to measure the concentration of airborne fenitrothion near blueberry areas in central New Brunswick in 1977. The insecticide aerosol was removed from the air by a chemical filter, then quantitatively analyzed by gas-liquid chromatography (GLC). Although sampling was carried out in periods of minimal air turbulence, there was a large variability between different samples and collection heights above ground. Generally, more insecticide was collected at the 10-m level than at 5-m or 1-m, but patterns were not consistent either in elevation or in time. For example, at one site the concentration of aerosol in air tripled in the fourth hour after spraying, compared with the first hour. Changes in weather conditions can affect the concentration and drift of insecticide, and thus influence the hazard to flying insects such as bees.

Distribution and persistence of insecticides in aquatic habitats (J. Witteman, IWD, and R.J. Maguire, CCIW)

A new method of collecting samples for surface deposit of insecticides was tried in 1977. Receptor dishes of XAD-2 resin, which is a granular chemical with high affinity for fenitrothion, were placed at intercepts on a 500-m grid and retrieved 2 h after spray for GLC analysis. The data showed sevenfold range in local deposit values at ground level across a flat open terrain.

The main thrust of research in 1977 was to find the sites and persistence of fenitrothion and aminocarb in stream and pond waters (Fig. 2). Samples of various water compartments are being analyzed, but results have not yet been compiled. These compartments are sediments, suspended solids, water column, surface water, and air.

These experiments are the first stages of a new and thorough kinetic analysis of the rates and routes of fenitrothion degradation and disappearance under environmental conditions. There is special interest in the products of hydrolysis, photolysis, and reduction of fenitrothion. A significant feature of the work is the investigation of the surface "skin" of water where quantities of the spray formulation may lodge for some time before it is volatilized, photolyzed, or incorporated into the underlying waters. Early observations have shown that the peak insecticide concentration of the surface water just after spray may diminish by a factor of 70 in 10 h. Thus surface-dwelling animals may face special insecticide hazard.

Fenitrothion residues in deer browse (L. Lapierre, U Monc.)

Ruminants such as white-tailed deer possess an intestinal flora and fauna essential to their physiological well-being. The hypothesis is that insecticide contaminants on deer browse might change the population norms of those microorganisms and thus cause physiological stress in the deer. Most of the research[5] in 1977 was devoted to sampling deer browse throughout the year and to determining the levels of fenitrothion residues. Samples of balsam fir collected at 2-week intervals for one year showed residues of fenitrothion that never exceeded 0.51 ppm, but some residues were always present; only traces of fenitrooxon were detected. These concentrations are far below those that might have a toxic effect, and indeed in-vitro tests of rumen microbial digestion indicated that even a 5-ppm concentration was ineffective.

Fenitrothion residues in shellfish (V.N. Mallet, U Monc, L. Stuart, EPS)

Two independent studies of insecticide residues in shellfish were conducted in 1977 (Fig. 1), to check an EPS report in 1976 that traces of fenitrothion had been detected in mussels and oysters at Buctouche.

Professor Mallet's analyses[6] of traces of fenitrothion in Shediac oysters and Eel River mussels and clams appear to validate the credibility of the 1976 report. Similar confirmation is found in data produced by L. Stuart, EPS Halifax[7]. Pooling the data, these reports show that residues of fenitrothion (16-200 ppb) were detected in 7 of 28 samples in littoral shellfish in the Bay of Chaleur, Miramichi Estuary, and Northumberland Strait collected in June, during and shortly after the spray season, even as far as 30 km from the nearest spray block.

No fenitrothion residues were present in 3 samples collected in May, or in 14 samples collected in July-August. No degradation products from fenitrothion were detected in any samples taken at any time. Fenitrothion was not detected in 5 samples of freshwater clams and sponges collected in June-July.

No residues of aminocarb (30 samples of shellfish), trichlorfon (9 samples) or phosphamidon (8 samples) were detected in shellfish from lakes and estuarine waters draining from spray blocks treated with those insecticides. However, in any surveys in 1978, analyses for both fenitrothion and aminocarb in both fresh and saltwater sites should be conducted.

In view of the safety limit for fenitrothion in meat for human consumption suggested by FAO/WHO[8] there is a case for concern over a possible health hazard. Surveys should be undertaken to determine the extent, duration, and severity of contamination.

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[5] Unpublished report. Lapierre L. (1978). The persistence of fenitrothion insecticide on balsam fir (***Abies balsamea***) deer browse. Submitted under contract to Forest Protection Ltd.

[6] Unpublished report. Mallet, V.N. 1977. Analytical results for fenitrothion in shellfish. Submitted under contract to Forest Protection Ltd.

[7] Stuart, L. 1977. A summary report on EPS monitoring of the 1977 spruce budworm spray program in New Brunswick. Submitted to Forest Pest Control Forum, Ottawa.

[8] The FAO/WHO Joint Meetings on Pesticide Residues (1978) established an acceptable daily intake (for life) from food, 0.005 mg fenitrothion per kg of body weight, and set the maximum residue limit in meat at 0.05 mg/kg.

Fenitrothion in livers of vertebrates (B. Trottier, U. Monc.)

Exploratory research on the binding of fenitrothion to the liver membranes in rats and chickens is under way at the University of Moncton. This work, which has medical rather than ecological implications, is aimed at testing physiological stress on liver, which is a site of insecticide breakdown by enzymes. Work, so far, has been concerned with development of the radio-isotype methodology.

Interaction of fenitrothion and trace metals in streamwater (M.C. Mehra ***et al.***, U Monc.)[9]

The starting hypothesis was that free ions of trace metals in fresh water might bond with fenitrothion molecules or cause a catalytic acceleration of normal hydrolysis of fenitrothion residues. Laboratory studies on the aqueous reactions of ions of zinc, magnesium, copper, cadmium, iron, and lead with fenitrothion solutions showed little complexation tendency. However, there were some initial indications that catalysis by trace metals is a probable mechanism for the rapid breakdown of fenitrothion in fresh water. This research may help to elucidate the unexplained rapid rate of loss of parent fenitrothion in bodies of water exposed to spray deposition.

Extraction of insecticide from samples of contaminated water (V.N. Mallet, U Monc.)

A major problem with insecticide contamination of water is the measurement of residues before they break down to materials which cannot be measured by standard chromatographic procedures. Water samples held for only a few hours or days may rapidly lose their residues of the parent insecticide unless some analytical, extraction, or stabilization procedure is used. One method developed at the University of Moncton is to pass the water sample through a column of XAD resins, whereby the insecticides are absorbed and stabilized for months. The method was first developed for fenitrothion (Berkane ***et al.***, 1977) and research on its applicability to the extraction of aminocarb was conducted in 1977. XAD resins 2 and 4 can be used for recovering aminocarb from water and the insecticide is then stable for some weeks. An ***in-situ*** fluorometric method has been developed that will detect aminocarb down to 10 ppb. However, still greater senstivity is required since under operational conditions the contamination of water by aminocarb sprays will often be less than 10 ppb.

Aminocarb analysis (G.L. Brun, IWD)

In spite of its efficacy as a budworm larvicide and relatively light environmental impact, aminocarb has the major disadvantage that methods of chemical analysis are insensitive, costly, and sometimes erratic, while relatively little is known about its pathways of breakdown and about its degradation products. In 1977, chemists at EPS-Halifax and Quebec, CCIW-Burlington, FPMI-Sault Ste Marie, and at Moncton have gained considerable experience in the analysis methodology for the parent compound. Suitable methods include high pressure liquid chromatography (UV detection), GLC (Hall nitrogen detector), and extraction by XAD columns together with fluorometry on thin layer chromatography. The established methods, using compounds derived from aminocarb, are tedious and costly. The several chemists have now organized a committee to compare and if possible to standardize methods. Sensitivity in water to less than 1 ppb seems attainable and costs can be lowered.

The factor in residue methodology which makes complete analysis very difficult is the lack of knowledge of degradation products and synthetic procedures. In various samples, unknown components containing acidic and neutral nitrogen could not be identified for lack of analytical standards. These materials, if they are byproducts of aminocarb breakdown, could be important toxicologically because some decomposition products might be more potent than the parent compound itself.

Inspection of operations (L. Stuart, EPS)

EPS personnel conducted surveillance of insecticide handling procedures at airstrips (Fig. 2) throughout the spray period. The mixing and loading procedures were unchanged but were more carefully conducted and more closely supervised in 1977 than in 1976. Nevertheless, some spillage in the loading pit did occur as a result of leaking nozzles and hoses and the cleaning of filters. Efforts were made to minimize spillage and clean up accidental contamination. Air-

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[9] Unpublished report. Guay, M., Mehra, M.C., and V.N. Mallet, 1978. Preliminary report on a study of the interaction of some metal ions with fenitrothion in an aqueous medium. Submitted under contract with Forest Protection Ltd.

port security and safety measures were strengthened to avoid accidents and risk to worker's health.

Formulations being delivered to aircraft were sampled regularly to verify the uniformity of mixtures and authorized concentrations of insecticides. The 51 samples of fenitrothion and three samples of trichlorfon showed reasonable uniformity. However, a single spot sampling of aminocarb showed median concentrations 50% in excess of the authorized concentration. Note however, that 15 analyses conducted independently by Agriculture Canada on three occasions showed excellent agreement with the approved formulation.

Local contamination of soil in mixing and handling areas was measured by chemical analysis. High values of residues were recorded from mixing sites used in 1977, and from those used in 1976.

Analysis of technical and formulated insecticides
(A. G. LeLacheur, CDA)

The Plant Products Division of Agriculture Canada is responsible for enforcement of the Pest Control Products Act. In 1977, as in previous years, inspectors sampled insecticides from the barrel for purity. The analyses showed the products to be in compliance with the Act. There was no unacceptable isomerization of the stored insecticides.

Insecticide spills resulting from aircraft accidents
(L.Stuart) EPS, and R.W. Gamble, NB Env)

Separate inspections of insecticide spills resulting from jettisoned loads and aircraft crashes were conducted by the provincial Department of the Environment and by EPS. It is the policy of NB Env to investigate all chemical spills, while EPS has a mandate to investigate environmental emergencies, including spot contamination.

There were ten incidents of insecticide loss, four due to crashes and six due to load jettison when flight emergencies arose. The average amount of insecticide formulation lost was 1444 L (380 U.S. gals) per incident, but almost all the incidents occurred on forest land where no significant environmental hazard ensued. Incidents occurred at Blissville, Rollingdam, Upper Blackville, Ludlow, Nepisiguit River, Upsalquitch Lake, and St. Jacques; the insecticides were fenitrothion, aminocarb and trichlorfon.

One incident posed a potential hazard. A TBM crash into the Miramichi River released some fenitrothion into the water; it produced locally high concentrations of 0.34 and 0.50 ppm, when the aircraft was being retrieved. These values are much higher than the expected peaks from normal spray deposition, and approach toxic concentrations for fish, but no fish kill was observed.

THE ECOLOGICAL PERSPECTIVE

(I.W. Varty, MFRC)

Some definitions

People have become uneasy about the known and unknown effects of chemical spraying upon the vertebrate and invertebrate animals living in forest and aquatic habitats. These fears are sometimes well-defined, but more often stem from news accounts of exceptional pesticide disasters far removed in place and time, or reflect the normal suspicion of toxic chemicals spread thinly over the landscape. Recollection of H-bomb dusts, DDT residues, lead and mercury pollutants, and so on, make public caution very understandable and legitimate.

Nevertheless, there is a need for forest protection decisions to be made with relevance to the actual situation in New Brunswick - that is, pertinent to the accumulated experience with organophosphate and carbamate insecticides as used in the 1970's. At stake is the conservation of mature forests for future pulp demand.

Canadian ecologists already know a great deal about insecticide effects on wildlife and insects in forests. The temporal sequence of effects can be defined as follows:

Immediate effects are the mortality and sublethal responses of animals during the period of persistence of insecticide residues in biologically effective concentrations; this period is usually one to several days in a given habitat. Toxicity to animals is governed by two factors: ***susceptibility***, the inherent reaction of a species at a specified growth stage to insecticide poisons in a range of concentrations; and ***vulnerability***, the risk of exposure to those residues, occasioned by the animal's diurnal and seasonal patterns of behaviour.

Short-term effects, for convenience, can be defined as the population responses and community interactions in a given habitat from spray day until the onset of winter.

Long-term effects are the influence of immediate and short-term effects on population trends over a period of years, particularly when spraying is a perennial exercise in a given habitat. If annually repeated, short-term effects could establish new norms of species abundance and community function, and create a new ecological balance.

It is useful to consider non-target animals under three functional classes relative to human need. Some animals are ***resource animals*** (sports fish, game, pelt animals, songbirds), in that we value their flesh or some other material or aesthetic benefit. Other species are ***process animals*** (shrews, wild bees, centipedes, mites) which are important in the web of biological activities related to energy transfer, soil nutrient turnover, defoliator control, and plant reproduction. We may never see some of these process animals, nor be able to define what they do; but it is important to ecosystem integrity - to the smooth function of resource productive processes - that all these obscure animals be present in appropriate numbers most of the time. Good forest management requires that toxic chemicals should not harm the long-term availability of resource animals, nor stress the ecological function of process animals. The third class is the ***pest animal***. Pests are resource or process animals that become a nuisance above a certain population threshold i.e. a function of the damage they do. Above that threshold - in the case of spruce budworm, around one million per hectare - pest reduction by chemicals is usually ecologically acceptable, as well as desirable for resource protection.

There is a difference between ***ecological effects*** and ***environmental damage***. Although these terms are sometimes used interchangeably, they are not the same thing. Every aerial spray of insecticide brings an immediate array of ecological effects - selective reduction of vulnerable animals, mostly insects, and a later array of interactions or adjustments of numbers of dependent organisms, such as in predator - prey relations; such stresses can be visualized as sharp or gentle tugs on affected threads in the trophic web of life in an ecosystem. Eventually, some weeks, months, or even years after the immediate impact of the spray, populations of this or that species settle back to the carrying capacity of the habitat. The fact is that most animals, especially insects, have a generous capacity to reproduce, which allows populations to rapidly recuperate once the poison has dissipated.

Immediate insecticidal mortality of a proportion of a species population is not necessarily important in seasonal dynamics. The mechanism of density-dependent compensation generally accords a population lowered by insecticides the capacity to fare relatively well in terms of subsequent survival rate. Both fecundity and mortality run high in natural systems. Since we are ignorant of the key factors regulating most species populations, we can only speculate on the additive influence of mortality induced by insecticides. Conceivably, mild chemical toxicity in spring could compound such natural stresses as migration, winter starvation, incipient disease, or the demands of territorial assertion. Monitoring is thus needed every spray year because of the possibility of a unique combination of factors leading to sharp changes in population densities.

Typically, adverse effects from forest insecticide practice are short-lived and absorbable. Unquestionably, environmental damage does occur in ecosystems where insecticide pressure is much more severe, causing a perennial maladjustment of dependent organisms in the trophic web. This kind of damage through excessive use of insecticides is well demonstrated by pesticide resistance, secondary pest irruption and biocontrol failure in the cotton farmlands of western United States of America and Mexico. But there is no evidence of any such drastic perturbation from spraying in the forests of New Brunswick, where insecticides are applied infrequently at any one locale, and always at low dosage. The general record of environmental surveillance, so far, reads as the continuing normality of species abundances and relationships, not as a perennial series of ecological upsets.

It is possible that subtle adjustments in mortality rates due to insecticides might cause slow adverse changes in the productivity of forest systems. We have no way of testing that hypothesis except by the accumulative records of species abundance and process function over time. The early records before insecticide was widely applied become the baselines against which current abundance of a given species is measured. A further measure of change is to compare animal abundance in an area that has no or little history of treatment with abundance in perennially-treated areas. Both methods of census are costly and imperfect both technically and statistically, but there is no better way at present; New Brunswick is as far ahead in this scientific field as any region of North America.

Impact of spray regimes used in 1977

Fenitrothion In spite of recognized gaps in scientific accountability of fenitrothion mobility and environmental toxicology, the accumulated knowledge of its chemistry and ecological effects make it an outstandingly well-documented insecticide (NRC Symposium, 1977).

New Brunswick experience in 1977, when the principal regime was two applications of fenitrothion at 210 g/ha, confirms the general environmental safety of the treatment, within the limits of our foresight and data gathering to this time. Mortality of songbirds, if any, was minor and restricted to few species. In stream studies, there were no apparent effects on fish, and only light mortality of invertebrates which fish eat; new data give no support to the hypothesis that spray operations are adverse to fish productivity. In the context of hazard to kinglets and warblers and to stream insects, the margin of safety of fenitrothion at the 210 g/ha dosage is not broad. Although the immediate effects of fenitrothion on the abundance of terrestrial insects are frequently harsh, the long-term effects on predatory and parasitoid arthropods appear to be slight, but there are some reservations concerning the survival of pollinators. The contamination of coastal shellfish is also a matter of concern.

It is encouraging that in Quebec where 730 000 ha were sprayed with oil-formulated fenitrothion in 1977, monitors[10] observed similar ecological responses (birds, mammals, stream fauna), and similarly concluded that fenitrothion spraying using conventional tactics was environmentally acceptable. On the other hand, monitors in Newfoundland, on limited experience, concluded that fenitrothion spraying has considerable potential for ecological damage in streams.[11]

Aminocarb Aminocarb (Matacil R) has been used in Canadian forests since 1971, culminating in the spraying of 500 000 ha in New Brunswick and 1 400 000 ha in Quebec in 1977. In January 1977, it was fully registered under the Pest Control Products Act for forest use against spruce budworm. Thus, it has run the gamut of close environmental and laboratory scrutiny for safety and efficacy over several years.

Its use in oil formulations in New Brunswick in 1977 demonstrated high efficacy against budworm and low environmental costs. The 70 g/ha dosage, in two applications, appears to have no lethal effect on songbirds, small mammals, or fish. Its effects on populations of terrestrial and aquatic invertebrates appear to be generally light with a few exceptions such as heavy mortality of spiders. Its influence on the dynamics of bee survival may even be benign.

However, there are three technical drawbacks to be considered. First, the analytical methodology is still weak so that at present it is difficult and expensive for monitors to reliably determine deposit or residues in soil, water, air, plants, and animals. Secondly, the pathways of breakdown and the nature and toxicities of degradation products are little known, so that monitors cannot adequately account for its persistence or disappearance. Thirdly, we have little experience of its potential long-term biological effects, since it has not yet been used repeatedly in any one location. Thus, our knowledge of the chemistry and effects of aminocarb is not nearly so well based as of fenitrothion.

Solutions to these problems may soon be found. A consortium of Canadian and American chemists is organizing further research on methodology and environmental accountability. Monitors can best acquire experience on the basis of continuing operational usage of the insecticide.

The Quebec experience - where all regimes incorporated one treatment with aminocarb - strengthens our confidence and optimism in usage of the insecticide. Monitors in that province reported virtually no lethal effect of aminocarb on birds, small animals, fish, or aquatic invertebrates.

Trichlorfon Trichlorfon has been extensively used during the 1960's and 1970's in the United States and around the world for a great variety of pest control situations. It is registered in both Canada and the United States for forest protection. Residues with insecticidal properties persist on foliage for several days after application, but its environmental persistence is generally rated as low, and its environmental safety record is very good. It has been used in New Brunswick since 1970 and has been particularly employed in forests in blueberry growing districts, because bee sensitivity to trichlorfon is low. While it has the usual quality of cholinesterase inhibition in vertebrate animals, there is no evidence that approved dosages produce mortality of birds, small mammals or fish. However, our regional experience of its effect on non-target arthropods, whether in aquatic or terrestrial habitats, is limited.

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[10] Unpublished report: Sarrazin, R. (Ed.) 1977. Environmental effects of spruce budworm spray program in Quebec - 1977. Submitted to Forest Pest Control Forum, Ottawa December 1977.

[11] Anon (1977) Limited insecticide spray program to control the spruce budworm. Interim Rpt. Nfld. Dept. Consumer Affairs and Environment.

Experience in New Brunswick is that trichlorfon applied twice at 560 g/ha, with a 4-day interval, is environmentally acceptable. Nevertheless, its efficacy and cost-competitiveness in killing budworm in conventional regimes appear to be inferior to either fenitrothion or aminocarb. The possibility of replacing trichlorfon with aminocarb should be explored.

Phosphamidon Formerly used as a budworm larvicide at 140 g/ha or higher dosages, phosphamidon had acquired a reputation for toxicity to songbirds in New Brunswick and elsewhere. However, used at repeated 70 g/ha dosages in July, application proved to be harmless to songbirds and aquatic fauna. More exploration of effects on non-target insects is desirable if moth suppression practices become operational.

Looking forward

Evidently in New Brunswick in 1977, the perceived immediate, short-term, and long-term effects of insecticidal contamination of faunal habitats were of marginal importance to populations of resource and process animals. Further, the collective overview of the monitoring committee is that the current insecticidal strategy does not appear to have had unacceptable adverse effects on faunal dynamics across the Province, over the decade during which organophosphate insecticides have been predominant. Taking the broad view, most stands have suffered only brief periods of contamination at sporadic intervals, such that population recuperation and redistribution have mitigated immediate adverse effects. This Province's forests have not suffered and are not now suffering the "Silent Spring" of Rachel Carson's imaginative insecticide scenario. Certainly the organophosphates and carbamates now in use lack the qualities of extreme mobility, persistence, biological concentration, lipid storage and remobilization which earned DDT its international censure.

It may be argued that the ecological hazard of continued spray usage may yet lie in those effects that monitors are not able to perceive. Certainly, the monitoring committee recognizes the limitations of survey capacity to undertake an overview of faunal responses to insecticides across New Brunswick's forests. There is a possibility that our methods of measuring change in faunal density, resource availability, and process function may be too insensitive to detect subtle long-term deterioration. Consequently, we risk being lulled into complacency by the succession of spot investigations reporting "little or no effect".

The monitoring committee cannot assure the public of absolute environmental safety from chemical tactics. In all human activity relative to exploitation of renewable resources, "safe" has to be a relative term meaning that the risks have been estimated and can be accepted in expectation of perceived benefits. It is in this sense that the monitoring committee judges the spray tactics of 1977 to have been environmentally safe. It is up to legislators and resource managers to decide whether forest conservation and estimated socio-economic benefits from the protection policy are worth the known spray budget and environmental costs. The public can help management by a well-informed reasonable response to these benefits and costs. Problems in environmental effects should be viewed in the perspective of the whole budworm policy issue. We live in a risk-benefit world.

Looking forward, the requirements for adequate environmental surveillance in the future are:

1) continued monitoring of ecological effects and residue persistence;
2) regional research into long-term effects on faunal population and productivity in a systematic framework;
3) improved survey and technical methods,
4) development of experimental capacity in environmental toxicology;
5) improved capacity in insecticide accountability;
6) more attention to formulation toxicology;
7) adequate funding and coordination at regional and national levels.

RECOMMENDATIONS

A consensus of opinion of the EMOFICO committee.

Recommendations are made with a view to improving the acquisition of knowledge and reducing environmental hazards in the 1978 spray program in New Brunswick. It is recommended: -

(1) that the spray agencies persist with regimes involving not more than 210 g/ha of fenitrothion or 70 g/ha of aminocarb in any single application.

(2) that the operational plan, from a monitoring point of view, should be as simple as possible, and that only one insecticide should be employed in any one regime. In this respect the announced plan for 1978 is commendable.

(3) that close liaison between monitoring agencies, resource managers, and spray operators be continued under the umbrella of a monitoring committee (EMOFICO).

(4) that the effects of aminocarb be monitored as a first priority, and that efforts to improve its chemical technology be supported by all research agencies.

(5) that the effects of oil formulation on insecticide mobility and biological activity be studied by the research agencies. The dispersion of oil aerosols over the landscape, in lieu of water, brings another environmental pollutant.

(6) that the research agencies study the feasibility of modelling and monitoring long-distance transport and redistribution of insecticides by wind, rain, and drainage systems. The vagaries of insecticide occurrence in untreated areas are disturbing to scientists concerned with insecticide accountability.

(7) that research on insecticide deposit assessment within and adjacent to spray blocks be conducted by a national agency. Monitors and researchers have continuing difficulty in establishing cause-effect relationships and in advising how to reduce deleterious effects because of the lack of a cheap, effective way to measure deposits in relevant habitats.

(8) that a shellfish monitoring survey be instituted in coastal waters to check the possibility of insecticide contamination.

(9) that monitoring and research funding by all agencies should not be weakened in 1978. It is recognized that the 1977 level of support will not bring all the answers to valid questions. Spray ecology is a national, as well as a provincial responsibility, so investigations on many monitoring and research problems should be more strongly coordinated by a national agency.

(10) that public information be expanded. Monitoring and research agencies should spend a greater proportion of their time in explaining the significance of their work through news media that reach a broad public. It is evident from press reports and letters that pesticide fallacies and unfounded fears are commonplace in the populace.

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ABBREVIATIONS USED IN TEXT

DFE = Department of Fisheries and Environment Canada

FPMI = Forest Pest Management Institute, CFS, DFE (Sault Ste Marie, Ont)

MFRC = Maritimes Forest Research Centre, CFS, DFE (Fredericton)

IWD = Inland Waters Directorate, DFE (Moncton)

DREE = Department of Regional Economic Expansion

CFS = Canadian Forestry Service, DFE

CWS = Canadian Wildlife Service, DFE (Fredericton, Sackville)

FMS = Fisheries and Marine Service, DFE (Halifax)

EPS = Environmental Protection Service, DFE (Halifax)

CCIW = Canada Centre for Inland Waters, (Burlington, Ont)

CDA = Canada Department of Agriculture, (Fredericton, Sackville)

FPL = Forest Protection Ltd., (Fredericton)

UNB = University of New Brunswick, (Fredericton)

U Monc. = University of Moncton

U of T = University of Toronto

NB Env = New Brunswick Department of the Environment

NBNR = New Brunswick Department of Natural Resources

EMOFICO = Committee for Environmental Monitoring Of Forest Insect Control Operations.

Note: throughout the text these initials designate agencies.