THE EFFICACY OF EXPERIMENTAL FORMULATIONS OF FENITROTHION AND MATACIL APPLIED AERIALLY TO CONTROL *CHORISTONEURA FUMIFERANA* (CLEM.) in N.B. 1982

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INTRODUCTION

The aerial application of pesticides to control eastern spruce budworm *Choristoneura fumiferana* (Clem) in New Brunswick, Canada has, for over twenty years, been conducted amidst public concern and in some areas, opposition. In recent years, some of the emulsifying components of pesticide formulations have been suspected of being linked causally with the incidence of Reye's Syndrome, a rare and sometimes fatal disease of children.

These suspicions and the accompanying vocal opposition to the aerial spraying of pesticides prompted the Minister of Health in the New Brunswick government to commission a task force to investigate the relationships between aerial spraying of pesticides and the incidence of Reye's Syndrome in New Brunswick.

In 1982, the task force presented its report[1] which, in summary, stated that no relationship was found between the incidence of Reye's Syndrome and the aerial spraying of forests in New Brunswick. The report, however, found reason for concern over the use of the emulsifier ATLOX 3409 F® and certain insecticide solvents, some of which were currently in use. It was recommended, therefore, that the use of these products be discontinued at the earliest opportunity.

This recommendation precipitated a situation where the withdrawal of MATACIL 180F used with ATLOX 3409F® and fenitrothion with Cyclosol 63®

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[1]W.O. Spitzer - Report of the New Brunswick Task force on Reye's Syndrome (1982).

and/or shell Insecticide Diluent 585 (ID 585) was distinctly possible. The removal of these pesticides on very short notice threatened the operational control of spruce budworm in New Brunswick, since two formulations were the major insecticidal weapons used in the program.

With this in mind, the Canadian Forestry Service (CFS) initiated an action plan in May of 1982. The main objective was to register for operational use by May 1983, two more acceptable formulations of fenitrothion and Matacil, which contained no viral enhancing emulsifiers. Thus, at very short notice, the Forest Pest Management Institute (FPMI) embarked on a field program to assist in the implementation of the CFS action plan.

This report deals with the field trials which were conducted during the spring of 1982 to determine the efficacy of two new tank formulations of fenitrothion and one of MATACIL (aminocarb) flowable.

MATERIALS AND METHODS

Preparation of Blocks

The trials were conducted approximately 25 km south of the village of Charlo in Balmoral parish, Restigouche county, New Brunswick (Fig. 1). Three experimental blocks, 50 ha in area (1.0 x 0.5 km) were prepared as shown in Fig. 2. These were sited in a forest which was comprised mainly of mature balsam fir *Abies balsamea* (L.) Mill, and hardwoods. Two lines transecting each block were cleared of undergrowth to allow easy access into the block. Fifty balsam fir trees (25 per line) were randomly chosen across the width of the block and within easy access of the transects. These sample trees were cleared of neighboring trees whose canopies would

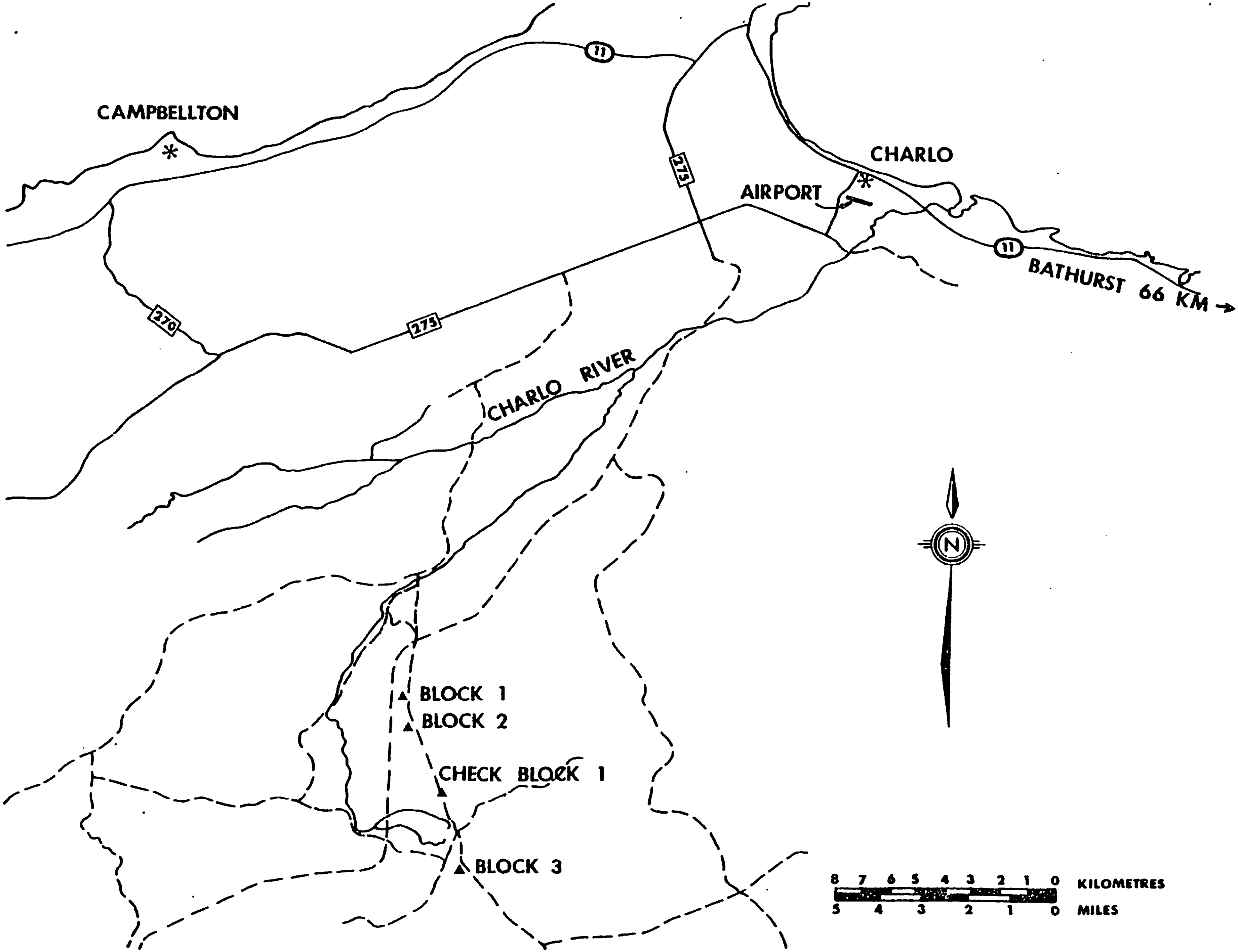

FIG. 1. Map of Research Area Showing Block Locations and Mixing/Loading Site at the airport.

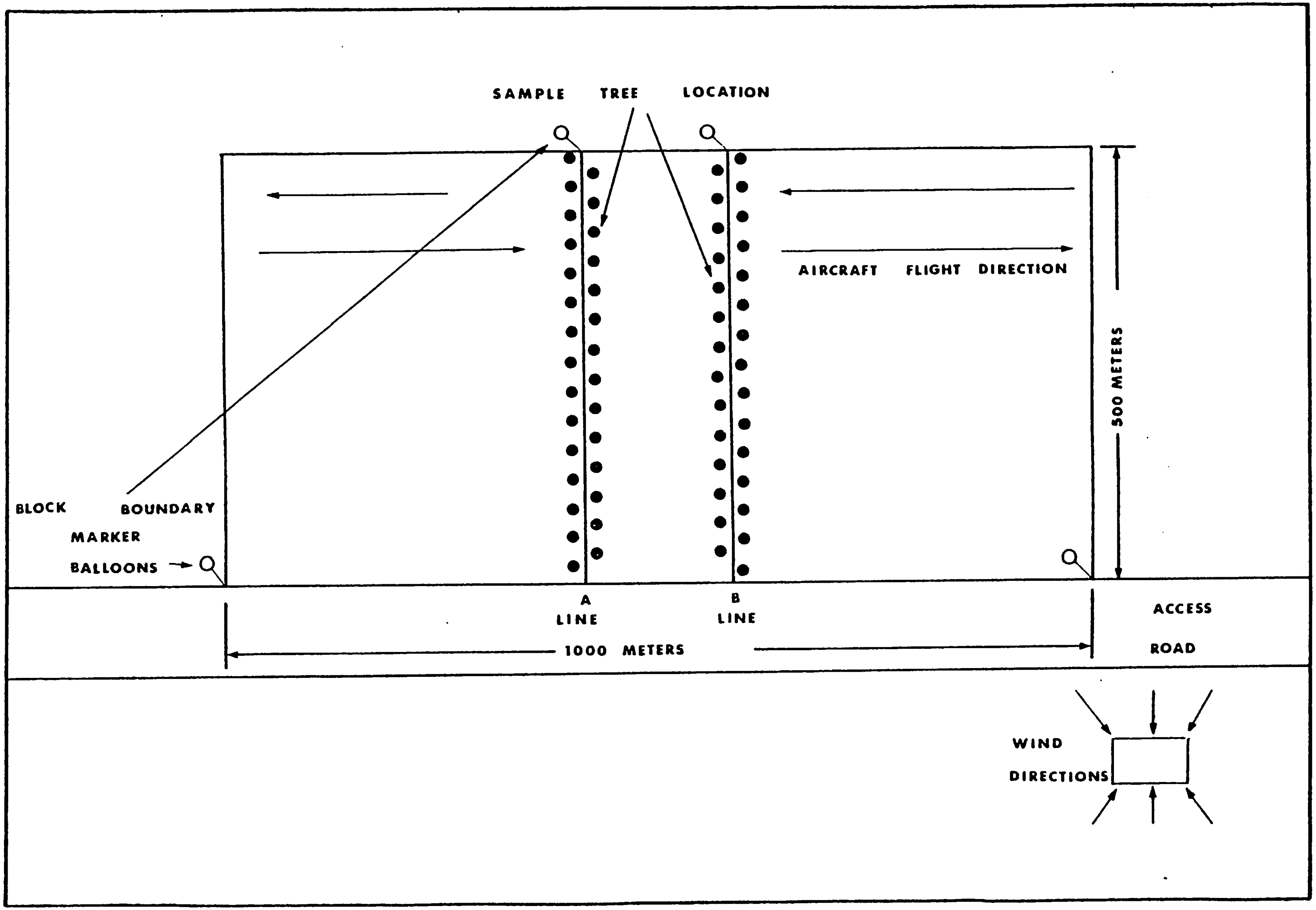

FIGURE 2 ; DESIGN OF EXPERIMENTAL BLOCK, SHOWING LOCATION OF SAMPLE LINES, MARKER BALLOONS, HYPOTHETICAL SAMPLE TREE POSITION AND PREFERRED WIND DIRECTION.

have obstructed or intercepted spray droplets from impinging on samples. At the same time [redacted] ground clearings were created around the sample trees.

Fifty balsam trees were also selected in an unsurveyed area (approximately 20 ha) and remained untreated. This block was used to determine the reduction of spruce budworm population due to factors other than insecticidal treatment and to compare this reduction with those in blocks treated with the formulations.

Formulations and Mixing

From preliminary laboratory testing the formulation section of FPMI determined the new formulations. Three formulations, hereafter referred to as formulation #1, #2, and #3, and detailed in Table 1, were studied during these trials. All were aqueous and contained various volumetric percentages of Triton X-100®, which was being investigated as the replacement for ATLOX 3409F.

The formulations were mixed in a trailer-mounted insecticide mixing-loading unit (Armstrong 1978). The ingredients were added in the order listed in Table 1 and after adding each ingredient, the mixture or solution was circulated and stirred for 10 min. The tank mixes were all dyed with Rhodamine W.T. dye to facilitate chemical and physical analysis of the spray droplets.

Weather

The study was conducted during a period of unusual weather. The plots were prepared during a spell of warm weather with the daily maximum temperature surpassing 20°C on three out of seven days but the actual sprays were applied in cooler weather with the mean maximum temperature of

Table 1. Spray formulations mixed at Charlo, N.B. 1982.

Formulation no.	Block no.	Ingredients or materials	% (vol.)	*Volume mixed per application (litre)	Formulation: Viscosity (c.p.)[1]	Formulation: Density (g/ml)[1]
1	1	Fenitrothion conc.	10.9	12.3	6.82 a	0.996 a
		Triton X100	3.0	3.6	6.69 b	0.997 b
		Cyclosol 63	24.0	27.3		
		Water	61.1	69.3		
		Rhodamine dye	1.0	1.1		
2	2	Matacil 180F	26.7	30.3	6.91 a	0.979 a
		Triton X100	3.0	3.4	10.30 b	0.962 b
		Water	69.3	78.7		
		Rhodamine dye	1.0	1.1		
3	3	Fenitrothion conc.	10.9	12.3	6.65 a	0.995 a
		Triton X100	10.7	12.1	3.45 b	1.016 b
		Water	77.4	88.0		
		Rhodamine dye	1.0	1.1		

Ingredients of each formulation are listed in the order in which they were mixed.

*Includes surplus to optimise flow rate--only 75 L were applied.

[1]For 10°C supplied by Dr. A. Sundaram.
a = 1st application
b = 2nd application

15.3°C over 5 days. The thermometer did not surpass 20°C on any day during that period and the temperatures at mixing time remained around the 4°C mark. The weather which prevailed during the actual spray applications was monitored using a Heathkit weather computer, Model 4001, attached to a vehicle. This mobile system made it possible to monitor the weather conditions at the individual blocks. Temperatures at two profiles (18 m and 2 m), relative humidity (R.H.), and wind speed and direction at 18 m were recorded at 5.0 min. intervals. These readings were taken from one hour before the spray until 50 minutes after it and are summarized in Table 2.

Communications

During the spray applications, a communication link by radio was maintained between the airport, where the mixing and loading were conducted, and the treatment blocks. Since no very high frequency (V.H.F.) radio was available, radio contact with the aircraft was not possible. The pilots were, therefore, briefed thoroughly prior to take-off and the aircrafts were dispatched only after the blocks were made ready. Helium filled red balloons were tethered just above the tree canopy in the treatment blocks (Fig. 2). They marked the boundaries of the blocks and assisted the pilot in applying the predetermined number of swaths.

Aircraft and Application

The experimental formulations were applied by two Cessna 188 Ag-trucks, each equipped with four Micronair AU-3000 atomizers. The aircraft operational data are summarized in Table 2. The first sprays were applied on June 12, when the new shoots were 1.69 ± 0.48 cm long (n = 400) and the budworm population, calculated from 1000 larvae, comprised of 6.3% 3rd

Table 2. Summary of field data for research sprays conducted near Charlo, N.B. 1982.

	BLOCK 1		BLOCK 2		BLOCK 3	
	*	**	*	**	*	**
Date	12/6/82 -	17/6/82	12/6/82 -	17/6/82	12/6/82 -	17/6/82
Spray Time	2100 hrs.	0745 hrs.	2050 hrs.	0715 hrs.	0735 hrs.	0655 hrs.
Block Size	50 ha		50 ha		50 ha	
Applic. Rate	1.5 L/ha		1.5L/ha		1.5 L/ha	
Diluent	Water		Water		Water	
Insecticide	Fenitrothion		Aminocarb 180F		Fenitrothion	
Amount Active	210 g/ha		70 g/ha		210 g/ha	
	CESSNA		188 C			
Aircraft Data						
Speed (km/hr)	160		160		160	
Height[2] (m)	30		30		30	
Equipment	AU 3000 Micronairs		AU 3000 Micronairs		AU 3000 Micronairs	
No. of Units	4		4		4.	
Emission Rate	23.7 L/min.		23.7 L/min.		23.7 L/min.	
	*	**	*	**	*	**
Weather Data						
Wind Speed (km/hr)[1]	3 ± 2	3 ± 1	3 ± 2	5 ± 3	3 ± 2	3 ± 1
Temp. °C[1]	15.5	11.1	16.1	11.1	13.3	11.7
R.H. %[1]	71	75	62	81	80	87
Inversion	Inv 1.0°F	Inv 1.0°F	Inv 1.0°F	Inv 2.0°F	Inv 3.0°F	Inv 4.0°F

[1]Mean

[2]Approximate mean flying altitude above ground.

*1st application

**2nd application.

instar (L_3), 17.8% 4^{th} instar (L_4), 40.6% 5^{th} instar (L_5) and 35.0% 6^{th} instar (L_6). The second spray was applied 5 days later, but the budworm population, because of sustained cool temperatures, had only advanced to 1.4% prepupa, 39.8% L_6, 38.8% L_5, 17.1% L_4, and 2.9% L_3.

Biological

To assess the budworm populations one prespray and four postspray samples were taken in the treatment blocks. Similarily dated samples were taken in the untreated area. On each sample date two 46-cm branch tips were cut from the midcrown of each sample tree with pole pruners having baskets attached. The branches were placed in 16.0 kg paper bags which were then placed in larger plastic bags and transported to a laboratory-counting mill, in Bathurst. The number of viable buds and, or shoots counted from each 46 cm branch, as well as the living insects which were classified according to instar, made it possible to assess population changes on a per branch, as well as a per bud, basis. Budworm populations in the insecticide blocks were corrected for natural mortality using a computerized adaption of Abbotts (1925) formula. A graphical curve was generated to fit the population decline in the untreated block, and from this equation, the corrected percent mortalities were calculated for the treated blocks.

Defoliation

The warm weather which preceded the sprays accelerated budworm development at an unusual rate, causing substantial defoliation prior to the application of the formulations. This prespray damage was not evaluated. Hence, no conclusive assessments of the influence of the formulations on defoliation were made. However, visual defoliation evaluations of the sample trees (Sanders, 1980) were conducted after the budworm larvae had all pupated.

Spray Assessment

Spray droplet samples were collected to assist in determining the efficacy of the formulation. Units described by Randall (1980) were placed approximately 8 cm above ground level in the *"clearings"* mentioned in the section *"preparation of blocks"*. The units were put into position 0.5 hours before the spray and retrieved approximately 1 hour after the spray was completed, thus allowing time for the droplets to settle. The sample units were stored in dry containers and transported to FPMI. Subsequently the kromekote cards were sent to National Aeronautical Establishmenet (NAE) in Ottawa where they were analyzed by a Flying Spot Scanner (Drummond 1979). The spray deposit on the glass slides was elutriated with a solvent and the dye content analyzed using a Bausch & Lomb spectronic 100 spectrophotometer. By comparing the dye taken from a glass slide with that from a tank-mix standard it was possible to estimate the volume of the spray recovered at ground level.

RESULTS AND DISCUSSION

Mixing

The three tank formulations were difficult to mix at cold ($< 8°C$) temperatures. Greaselike precipitate adhered to the bottom of the mixing tank and plugged the filtering system. Removal of this precipitate from the mixes changed the viscosity, density (Table 1) and possibly the active ingredient (A.I.) of the sprayed material. Consequently, the efficacy observed could have been significantly influenced by such removal. Formulation #1 exhibited the least mixing problems followed by #2. Mixing of #3 for the 1st application was very difficult. Hence the AI content and general composition of its emitted spray were somewhat suspect. Generally, the formulations for the second application mixed more readily than those for the first.

Subsequent exercises showed that these mixing difficulties could be reduced substantially or eliminated by thoroughly mixing the AI and emulsifier prior to adding the water.

Spray Deposit

The droplet spectra of the 3 tank formulations did not differ substantially (Table 3). All three exhibited spectra which shifted towards the small end of the scale with #1, #2, and #3 having NMD of 17, 15 and 23 m respectively. During the 1st application the greatest percentage of cards received 1 to 5 drops/cm^2 for all 3 formulations (Table 4). Table 3 shows that the spectra resulting from the 2nd application shifted slightly towards the larger end of the scale with the 3 formulations showing larger VMD and D max and #3 exhibiting a significant increase in droplet density. NMD of 25, 22, and 57 m were calculated for #1, 2 and 3 respectively.

These findings indicate that considering the mixing problems the three tank formulations atomized and deposited satisfactorily.

Biological Responses

Spruce Budworm. The two methods of assessing the population decline of larval budworm populations produced fairly similar results. Table 3 and Figs. 3 and 4 show the larval

Table 3. Spray deposit and spruce budworm population responses. Charlo, N.B. 1982.

Block No.	Treatment (Formulation No.)	1st Application 82-06-12				2nd Application 82-06-17				Spruce budworm larval densities* (mean)				
		Deposit				Deposit				Sampling dates				
		Drops/cm^2 ($\bar{X}$) ± SD	L/ha ($\bar{X}$)	VMD (μm)	Dmax (μm)	Drops/cm^2 ($\bar{X}$) ± SD	L/ha ($\bar{X}$)	VMD (μm)	Dmax (μm)	June 8	June 15	June 19	June 24	June 27
1	Fenitrothion (Novathion) (1)	4.3 ± 2.6	0.042	43	122	5.3 ± 2.7	0.036	56	137	17.0 0.148	13.4 0.112	8.1 0.075	9.3 0.087	7.9 0.071
2	Matacil 180F (2)	3.3 ± 2.7	0.054	43	90	2.8 ± 2.3	0.047	94	201	20.8 0.194	12.0 0.119	6.8 0.071	5.6 0.066	3.5 0.050
3	Fenitrothion (Novathion) (3)	4.4 ± 4.7	0.040	66	154	15.0 ± 10.2	0.074	108	232	37.5 1.390	17.5 0.554	8.6 0.387	9.3 0.361	5.6 0.265
C_1	Untreated									29.4 0.378	27.2 0.397	24.1 0.354	16.9 0.246	10.9 0.152

*Upper numbers are larvae/branch; lower ones are larvae/bud (shoot).

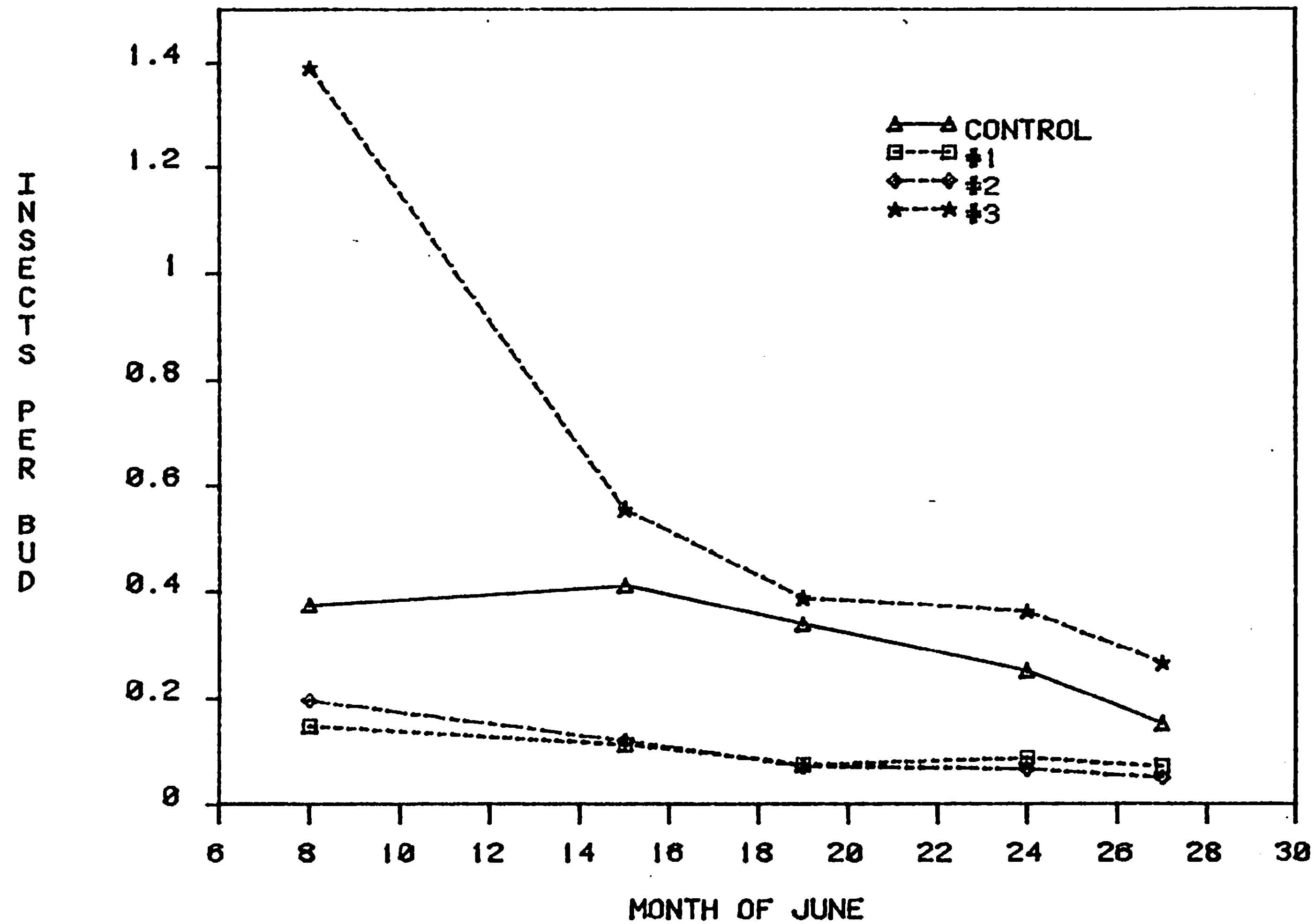

FIG. 3. Larval spruce budworm densities (bud^{-1}) recorded in the 3 treatment and control blocks. Charlo, N.B. 1982.

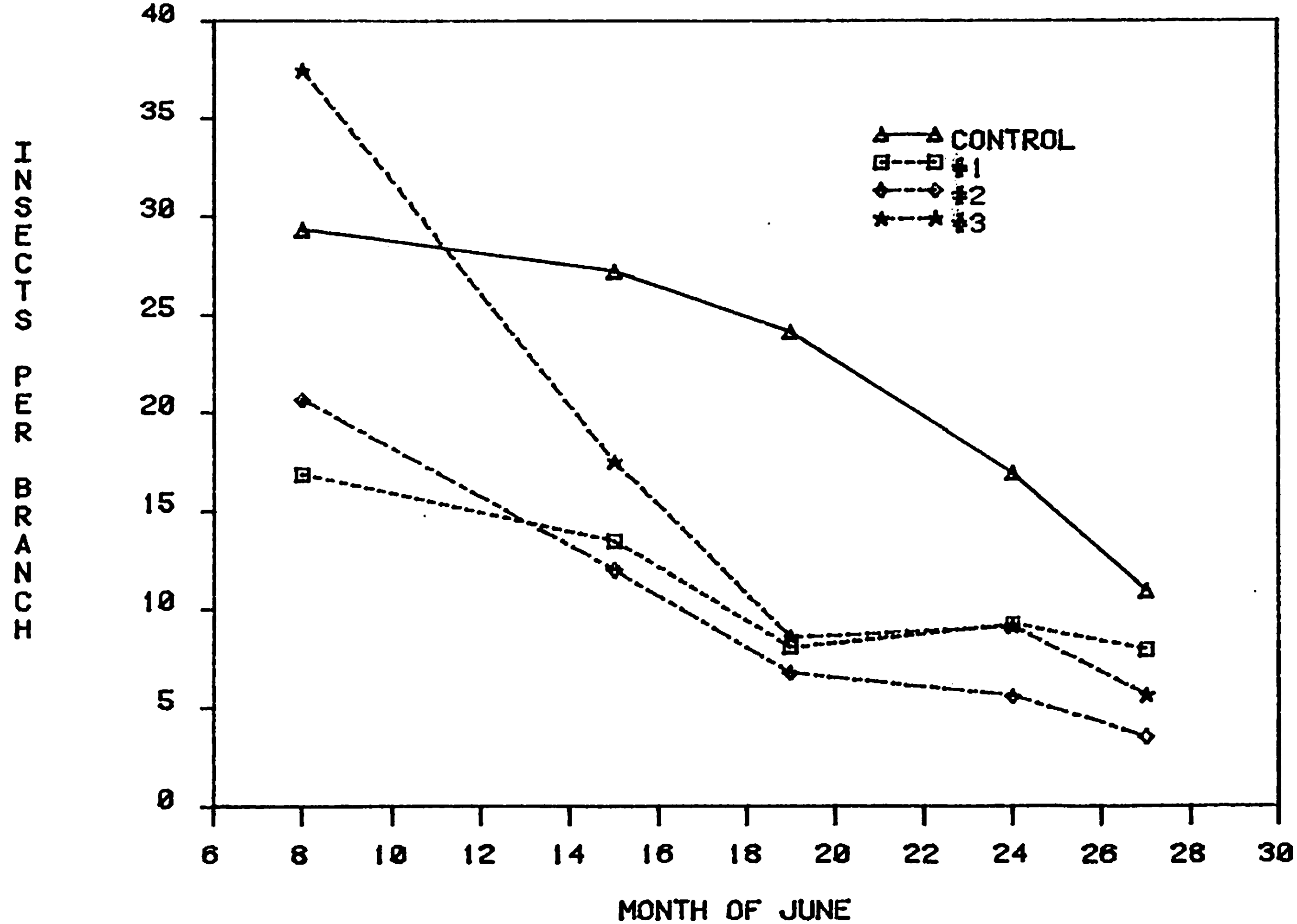

FIG. 4. Larval spruce budworm densities (branch^{-1}) recorded in the 3 treatment and control blocks. Charlo, N.B. 1982.

densities recorded using the two methods. They both infer that the residual populations, i.e., those surviving to repopulate the following year, were higher than desirable.

The uncorrected mortalities are shown in Figs. 5 and 6. Those corrected for the natural mortality occurring in the control block are shown in Table 5 and Figs. 7 and 8. We postulate that the unusually high final mortality of ∿ 60% observed in the untreated population (Figs. 5 and 6) so influenced the calculations of the final assessments of the "corrected" data (June 27, Table 5) that these figures might be misleadingly low.

Defoliation. The levels of defoliation shown in Table 5 should not be interpreted definitively as assessments of the efficacy of the formulations because considerable defoliation, not measured due to logistic problems had occurred prior to the sprays. However, it was observed that there was very good foliage protection in block #2 and severe defoliation in block #3.

Spray Deposit-Biological Relations. A good relationship was observed between droplet density, volume of spray deposited on glass slides and population reduction. Table 4 shows that 1 drop cm^{-2} on kromekote cards at ground level caused no mortality but ∿ 5 to 20 cm^{-2} consistently gave the most effective results for each of the 3 formulations.

No phytotoxic effects or unusual impact on non-target insect populations was seen in any of the blocks.

Both Matacil and Fenitrothion have previously given consistently good results (Cadogan 1981, Brown 1978, Hildahl and DeBoo, 1978) and

Table 4. The relationships between droplet density, volume of spray recovered and budworm population reduction[1] resulting from three experimental tank formulations (Charlo, N.B. 1982)

Block No.	Formulation[2] or treatments	Spray dates	1st Application (12-6-82) Deposit drops/cm^2	L/ha	No. of samples	Population reduction (%)	Cumulative 1st and 2nd applications Deposit drops/cm^2	L/ha	No. of samples	% Population reduction at day 2*	day 6*	day 10*	Defoliation (%)
	#1		<1	0.02	4	0	<1	-	0	--	--	--	
1	Fenitrothion	12-6-82	1.1-5	0.03	62	19	1.1-5	0.05	10	9	0	0	
	(Novathion)		5.1-10	0.06	32	23	5.1-10	0.06	52	35	5	0	48
		17-6-82	12.1-15	0.10	2	40	10.1-15	0.08	28	54	37	0	
			15.1-20		0	--	15.1-20	0.15	10	71	54	0	
	#2		<1	0.02	8	0	<1	-	0	--	--	--	
2	Matacil 180F	12-6-82	1.1-5	0.03	70	32	1.1-5	0.06	42	55	42	36	25
		17-6-82	5.1-10	0.10	18	63	5.1-10	0.11	46	69	74	73	
			10.1-15	0.30	4	56	10.1-15	0.19	12	78	76	76	
	#3		<1	0.02	20	42	<1	-	0	--	--	--	
3	Fenitrothion	12-6-82	1.1-5	0.02	56	54	1.1-5	0.24	8	33	19	12	
	(Novathion)	17-6-82	5.1-10	0.08	8	40	5.1-10	0.12	38	76	57	58	
			10.1-15	0.11	10	44	10.1-15	0.09	24	69	67	75	
			15.1-20	0.15	6	53	15.1-20	0.25	2	84	59	1	90
							20.1-25	0.16	12	63	52	59	
							25.1-30	0.18	4	73	86	63	
							30	0.23	12	60	55		
C_1	Untreated				100								93

[1]Based on larvae/branch

[2]See Table 1 for details.

*Days after 2nd application.

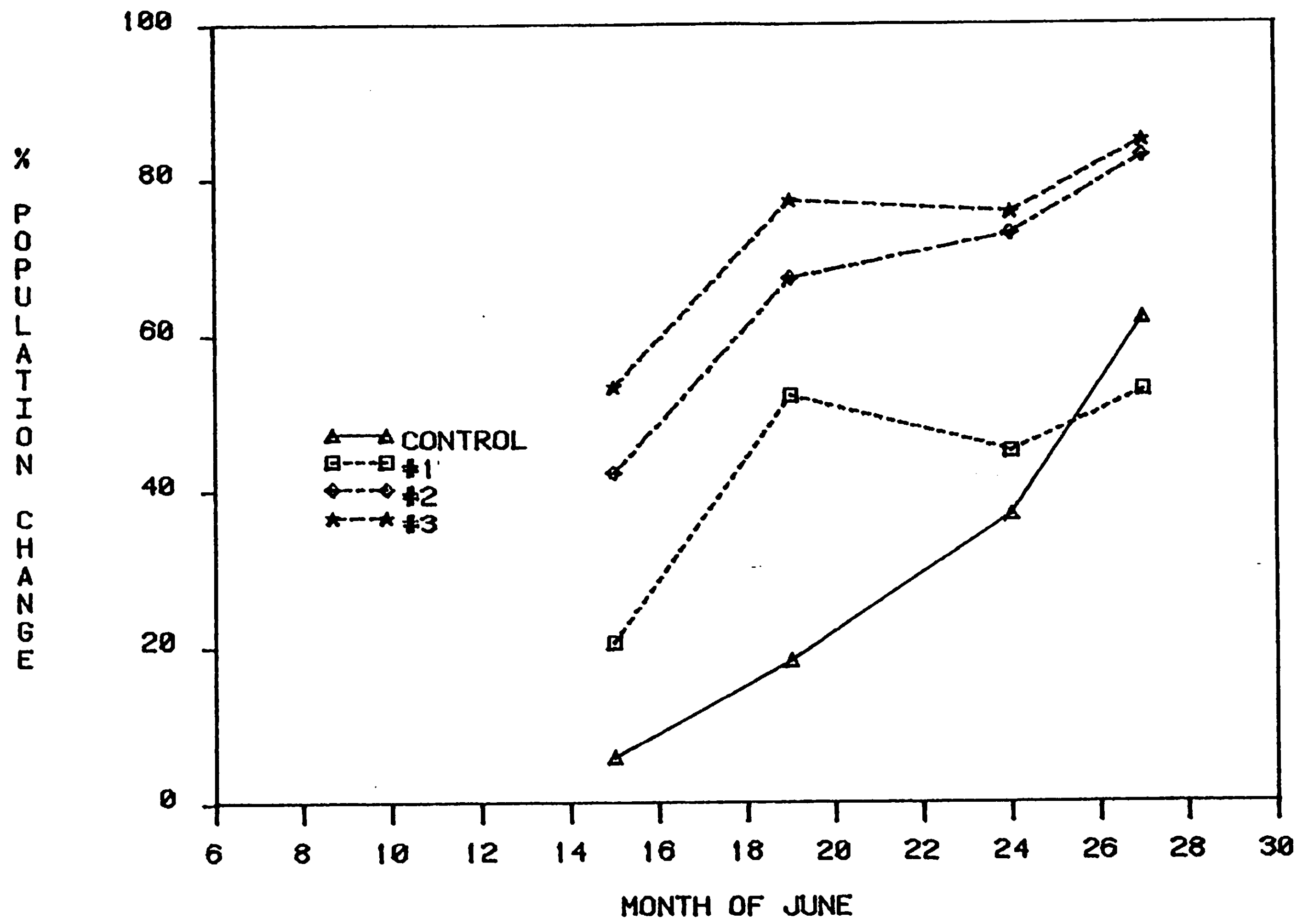

FIG. 5. Uncorrected spruce budworm population reducitons assessed using insects bud^{-1} in the 3 treatment and untreated control blocks. Charlo, N.B. 1982.

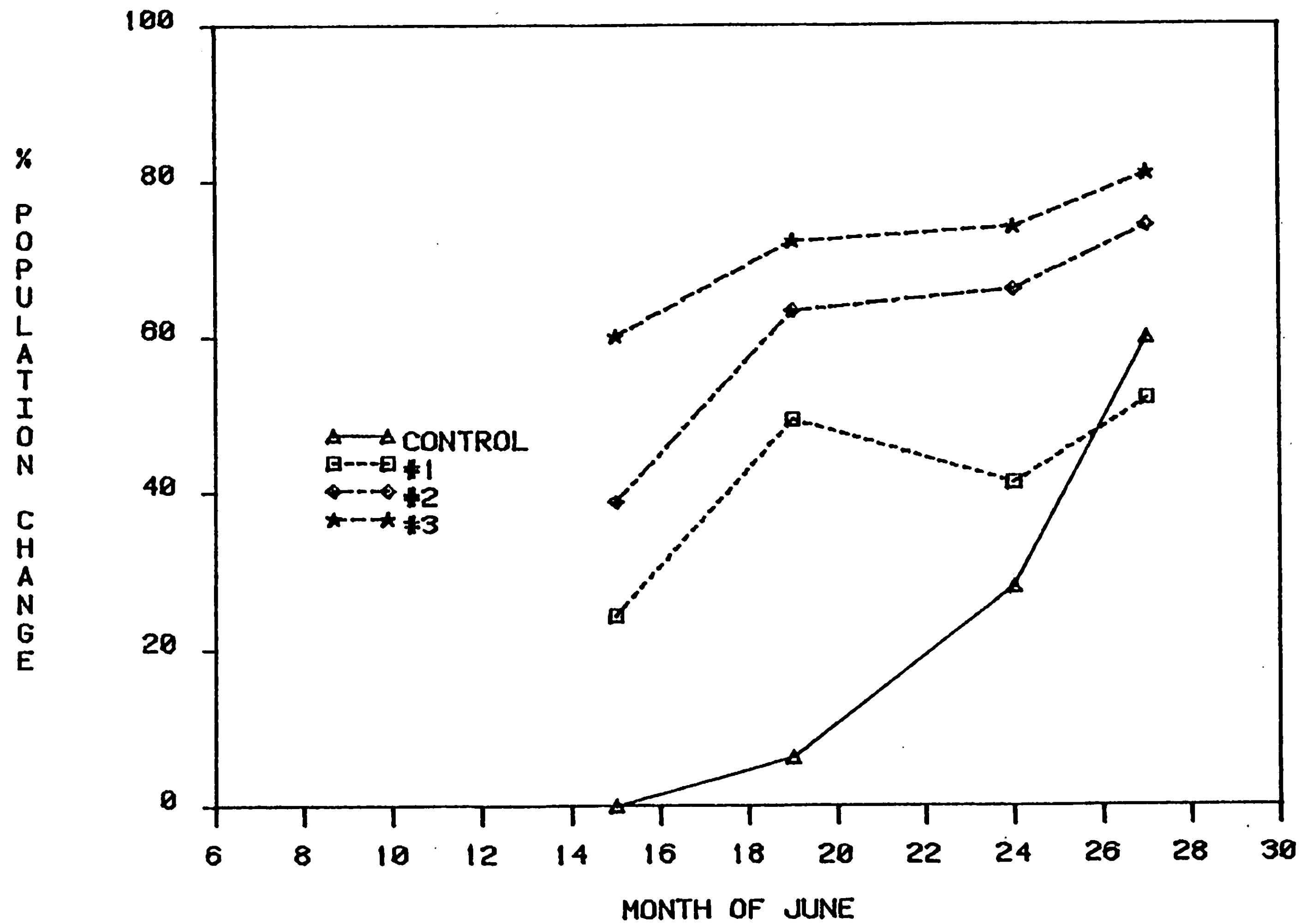

FIG. 6. Uncorrected spruce budworm populations ($branch^{-1}$) in the 3 treatment and control blocks. Charlo, N.B. 1982.

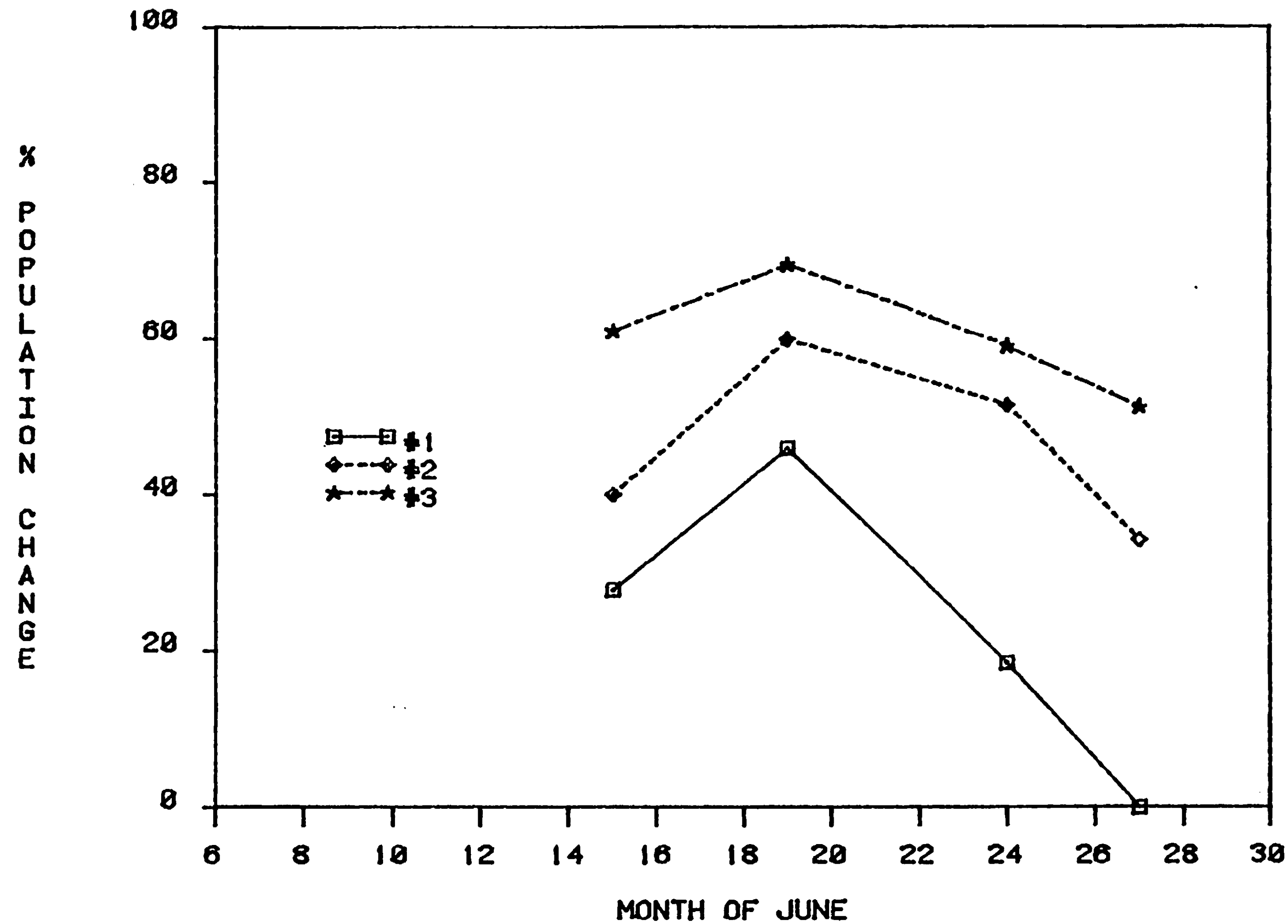

FIG. 7. Spruce budworm population reductions assessed by insects bud^{-1} (and corrected for natural mortality) in the 3 treatment blocks. Charlo, N.B. 1982.

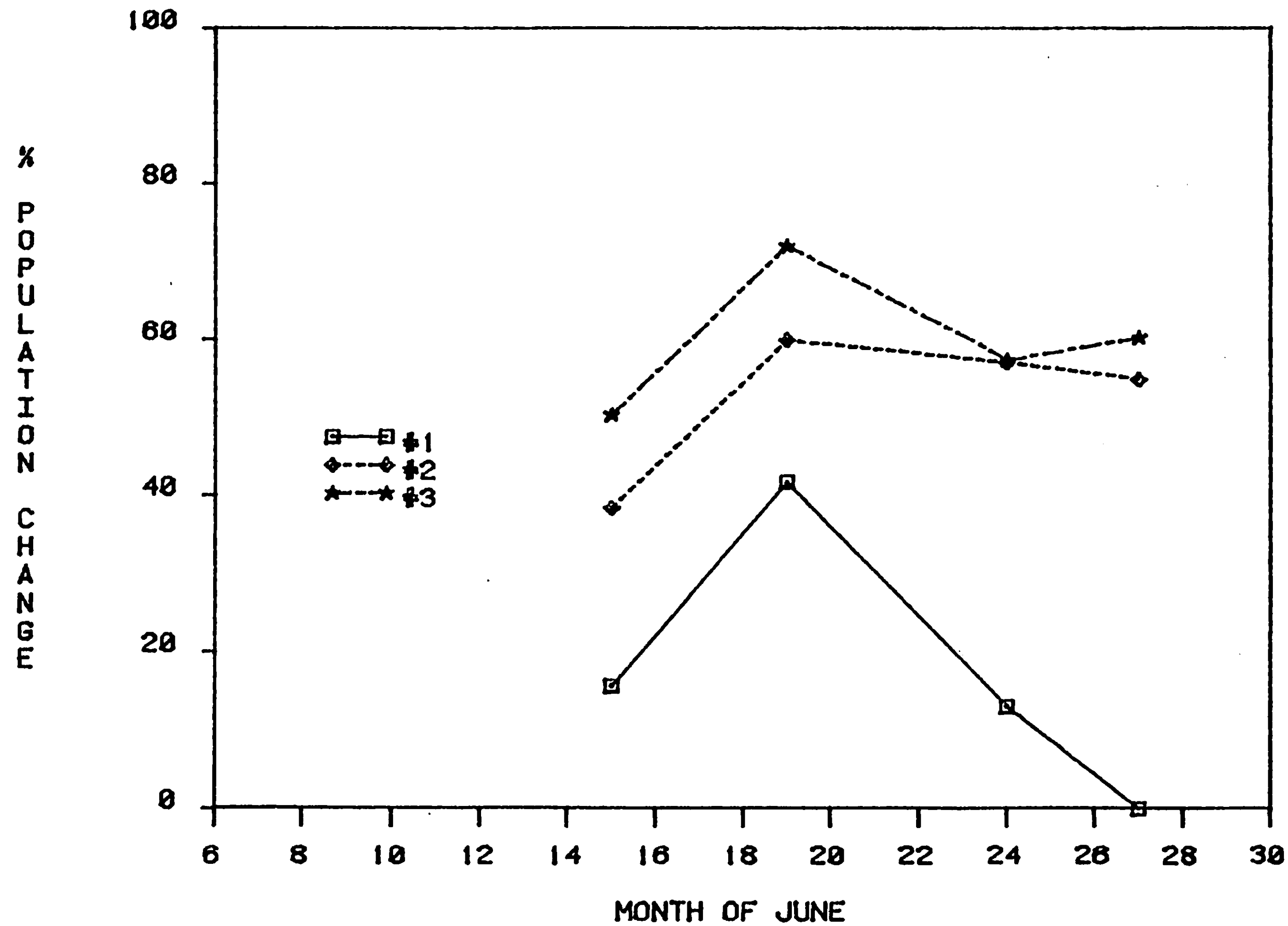

FIG. 8. Spruce budworm population reducitons assessed by insect branch^{-1} (and corrected for natural mortality) in the 3 treatment blocks. Charlo, N.B. 1982.

Table 5. Spruce budworm corrected population reduction (using two methods) in balsam fir blocks treated with experimental tank formulations. (Charlo, N.B. 1982).

Block and Formulation	No. of Samples Per Date	*Corrected Larval Reduction (%)[1]				% Defoliation
		June 15	June 19	June 24	June 27	
#1	100	15	42	14	0	48
		28	46	18	0	
#2	100	38	61	58	55	25
		40	60	52	34	
#3	100	50	72	61	60	90
		61	70	59	51	
C_1 Untreated	100					93

1st Application 12.06.82

2nd Application 17.06.82

1 - Upper numbers denote Larvae/branch method
- Lower numbers denote Larvae/bud (shoot)

*Using a computerized adaptation of Abbott's (1925) formula although the results from this trial are not as impressive, it is believed that this was primarily due to the mixing difficulties. Since these have been corrected the three tank formulations applied aerially under good conditions should be equally as efficaceous as their predecessors against spruce budworm.

ACKNOWLEDGMENT

The authors would like to thank Drs. G.W. Green and J.A. Armstrong for their considerable inputs throughout the project. Formulation data were supplied by Dr. A. Sundaram. We are grateful to Mr. H.J. Irving and Forest Protection Ltd. who provided the aircraft, airport facilities and services. Our thanks are also due to Mr. Ed Kettella who coordinated the field aspects of the 'action plan' and to Larry Smith, FPMI; Gerry Davidson, Sault College and Peter Ebling, Sir Sandford College for their assistance in the field.

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ERRATA

P. 3, line 2 - should read "At the same time ground clearings were created ...."

Figs. 5, 6, 7, 8 - the "y" axis should be labelled "% Population Reduction"

Figs. 5, 8 - "reducitons" should read "reductions"

Fig. 6 - The Title should read uncorrected spruce budworm population reductions (branch^{-1}) in the 3 treatment and control blocks Charlo, N.B. 1982.