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Department of Conservation
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I. INTRODUCTION

One of the registered insecticides for spruce budworm suppression in Maine is Sevin 4 Oil (carbaryl). The registered application rate is one pound active carbaryl diluted with eight fluid ounces of number 2 fuel oil, to make 40 fluid ounces of formulation, per acre, applied aerially.

In 1976, the Maine Bureau of Forestry, in cooperation with U.S.D.A., Forest Service, compared the efficacy of 1 lb. per acre with a reduced application rate of 3/4 lb. per acre. Spray application was monitored by use of spray deposit cards. Efficacy was based upon budworm larval survival and foliage preservation.

II. METHODS

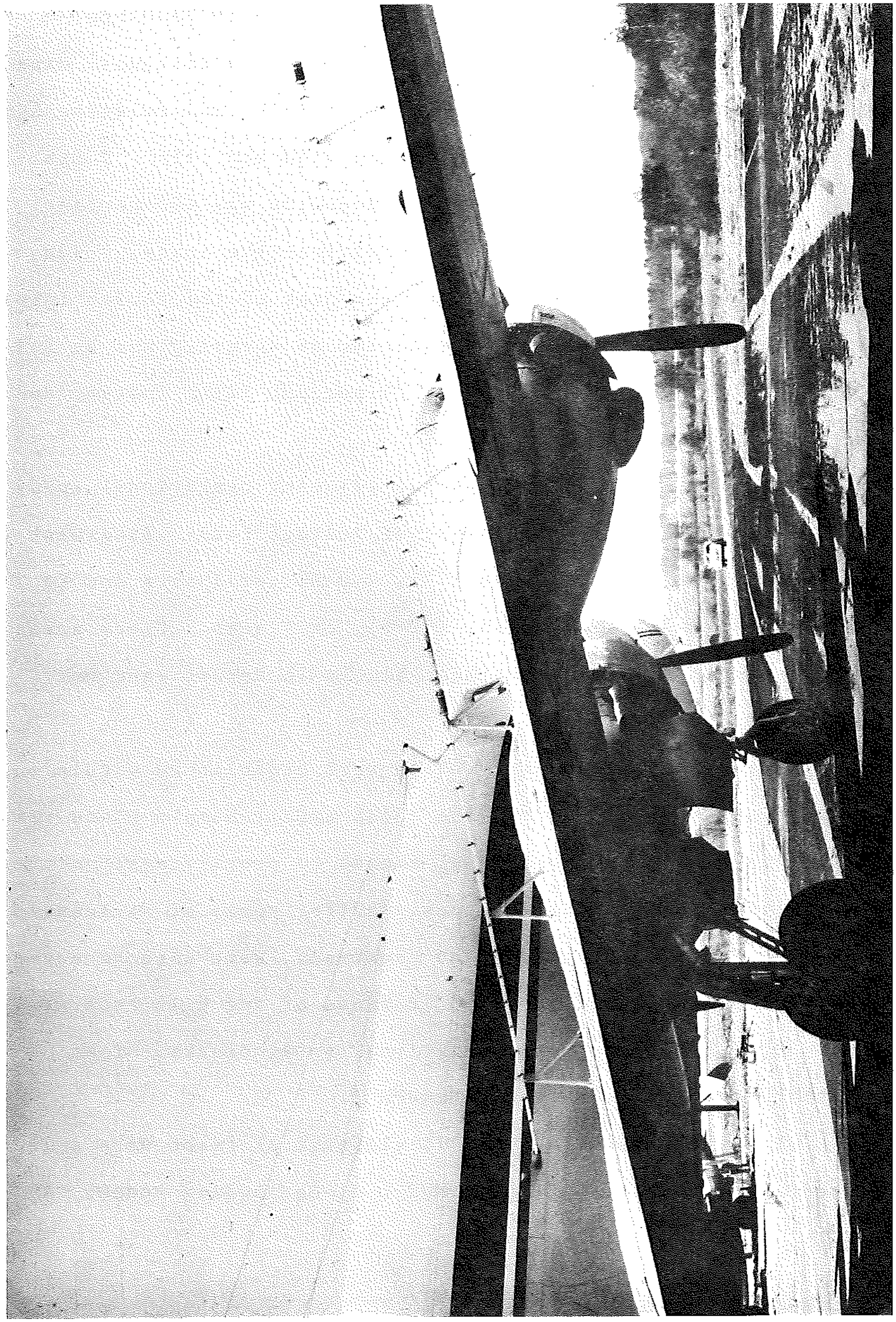
Insecticide was applied by two pairs of C-54 aircraft. The C-54 is a four-engine military transport plane which was adapted for spray aircraft use. Spray booms were located above the trailing edge of the wings with nozzles directed upwards (Figure 1). The two application rates were derived by applying different volumes of diluted Sevin 4 Oil per acre. The 1 lb/acre rate contained 32 fl. oz. of Sevin 4 Oil and 8 fl. oz. of number 2 fuel oil, a total of 40 fl. oz./acre. Aircraft carried 88 nozzles for this rate. The reduced rate contained 24 fl. oz. of Sevin and 6 fl. oz. of fuel oil, a total of 30 oz/acre. The aircraft carried 64 nozzles. All nozzles were 8015 Tee-Jet.

Aircraft were calibrated for the following operational specifications:

1. Ground speed of aircraft - 180 mph.
2. Effective swath width - 1200 feet.
3. Flight altitude - 150 feet.
4. Boom pressure - 40 psi.

The insecticide was mixed with Automate Red-B^R dye (Morton Chemical Co.) at the rate of 1 gallon dye per 100 gallons mixed chemical to aid in electronic machine analysis of spray deposit cards.

Figure 1. Spray nozzle arrangement on C-54 aircraft. Spruce Budworm Operational Test, Maine, 1976.



Spraying began June 9, 1976 from 1900 to 2100 hrs., and was completed on the following day from 0500 to 0800 hrs.

Weather conditions in the evening were as follows: Wind decreasing from 5 to 3 mph, temperature 75^0F, and relative humidity 35 percent. In the morning the wind was calm - 3 mph, temperature was 51^0F, and relative humidity was 100 percent.

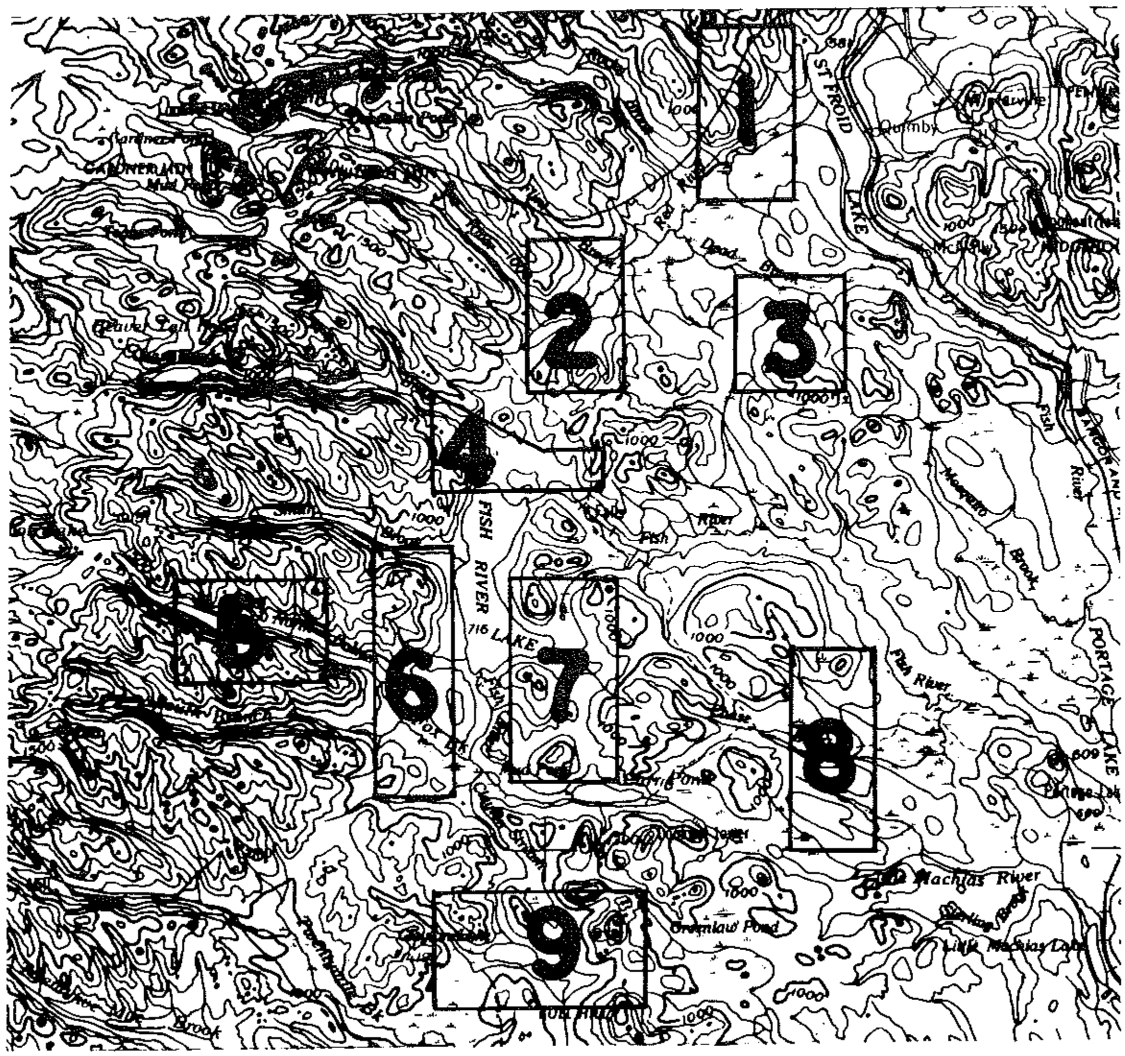
Due to unfavorable weather conditions the spraying was delayed beyond the targeted date, the peak of the fourth instar. Spruce budworm development at the time of spraying was as follows: 24 percent fourth instar, 74 percent fifth instar, and two percent sixth instar.

Test areas were chosen as two adjacent operational spray blocks (D245 and D246) northwest of Portage Lake. Treatment in block D245 (52054 ac) was 1 lb. (40 fl. oz.)/acre and in block D246 (54214 ac) 3/4 lb. (30 fl. oz.)/acre. Check areas were selected near the treatment blocks in forest land not scheduled for treatment.

Three replicated sample plots were established within each treatment block and in the check area. Sample plots were arranged within the operational blocks to provide maximum variation of topographic conditions. Buffer zones of at least one mile, sprayed with the same treatment, were used to separate test plots. Unsprayed buffer zones of one mile separated check plots from test and operational spray blocks. Test plot arrangement is shown in Figure 2.

Within each sample plot, 15 clusters of trees were selected approximately 0.1 miles apart along logging roads. A

Figure 2. Location and arrangement of spray blocks. Spruce Budworm Operational Test, Maine, 1976.



Key to Block Treatments

1 lb :	2, 6, 7
3/4 lb:	1, 3, 8
Check :	4, 5, 9

cluster was composed of three dominant or co-dominant balsam fir trees that were no more than 100 feet apart.

Prespray samples were collected two days before treatment. Samples were collected using pole pruners equipped with nylon sample bags designed to contain the branch and dislodged budworm larvae. Two 18-inch branch tips were cut from the mid-crown of each sample tree. Branch tips were bagged and taken to laboratories where the budworm were counted.

Postspray samples were collected using the same method as prespray samples. Postspray samples were taken three, seven, and fourteen days after spraying. Most survivors had pupated by the 14-day sample.

Budworm population levels were compared by analysis of variance, fixed effect model (P=0:05). Data were transformed using $X' = \log (X+1)$ to correct for inherent heteroscedasticity of the budworm population. Duncan's multiple range test was used to determine significant differences between treatments.

Unadjusted mortality was assessed for each treatment at each sampling period. Spray-induced mortality was determined for the 14-day sample by the method of Simmons and Chen (1975).

A defoliation index was determined for each of the twigs collected at prespray and postspray periods. This determination consisted of an estimate of the percentage defoliation on three expanding terminal shoots on each twig. Defoliation categories are listed below:

Percent Defoliation	Category
0	0
1- 10	1
11- 20	2
21- 30	3
31- 40	4
41- 50	5
51- 60	6
61- 70	7
71- 80	8
81- 90	9
91-100	10

Defoliation data were analyzed using a Kruskal-Wallis test and a nonparametric multiple range test (P=0:05) (Zar, 1974). Intertreatment defoliation indexes were compared for prespray levels. Because there were significant differences between the check and treated blocks before spray treatment, the intertreatment postspray defoliation indexes were not compared between treatments and check areas. The 3/4 lb./acre and 1 lb./acre treatments were directly compared for the 3-day prespray and the 14-day postspray sampling periods.

To further analyze the effect of spray treatments, defoliation estimates were compared for intratreatment differences between each of the four sampling periods.

The amount of foliage protection was determined by comparison of the change in defoliation in the treated blocks vs. the check blocks. Using the relative increase in defoliation in the check blocks, an expected defoliation value was computed for each treatment. The difference between the expected defoliation value and the observed defoliation value was the amount of foliage saved due to the treatment.

Four deposit cards in plastic holders were placed at cardinal directions at the dripline of each sample tree. Additional cards were placed at 100 foot intervals along roads and trails adjacent to the sampling locations. Cards were placed about two hours before spraying began and collected about one hour after spraying had ceased for the spray period. In check areas cards were placed along roads before spraying in adjacent areas.

Spray deposit cards were analyzed by the Quantimet particle analyzer at the Los Alamos Scientific Laboratory. Cards which were not suitable for automatic analysis were hand counted under supervision of the Methods Application Group, State and Private Forestry, Davis, California.

Spray recovery was summarized as a function of application rate and as a function of volume median diameter and drops/square centimeter.

In early August, an egg mass sample was made consisting of one whole branch from the mid-crown of each sample tree. Branches were measured for length and width at the midpoint and then cut into small segments and placed in paper bags for delivery to the laboratories. At the laboratories, the branch segments were searched for new, viable egg masses. The total number of egg masses for each three-tree cluster was divided by the total surface area of the three branches to determine egg mass density, which was expressed as egg masses per 100 sq. ft. of foliage. The cluster value was used to approximate the sequential method currently used in Maine (Morris, 1954). Mean egg mass values for each treatment were compared by analysis of variance (P=0:05).

III. RESULTS

The spray deposit cards were examined for evidence of poor treatment before any of the analysis of efficacy were done. Block 4, a check block, received some spray deposit evidently due to drift. Block 6, a 1 lb./acre block, contained an area which did not receive any spray, apparently due to an error in the aerial application.

Exclusion of these areas in blocks 4 and 6 from analysis did not change the results of either the analysis of budworm survival or defoliation and all data were incorporated into these analyses. The data from block 4 were excluded from the determination of adjusted mortality.

The mean numbers of budworm/18 inch branch tip for each plot are shown in Table 1, and graphically represented in Figure 3. An analysis of variance compared the three plots in each of three treatments for each of the four sampling periods. An F test (P=0:05) and Duncan's multiple range test showed that:

1. At 2 days prespray, there was no difference in budworm numbers/18 inch branch between treatments.
2. At 3 days postspray, there was no difference between carbaryl treatments, but the check area budworm population was significantly higher than the 1 lb./acre population. Check populations were not different from the 3/4 lb./acre population.

Table 1

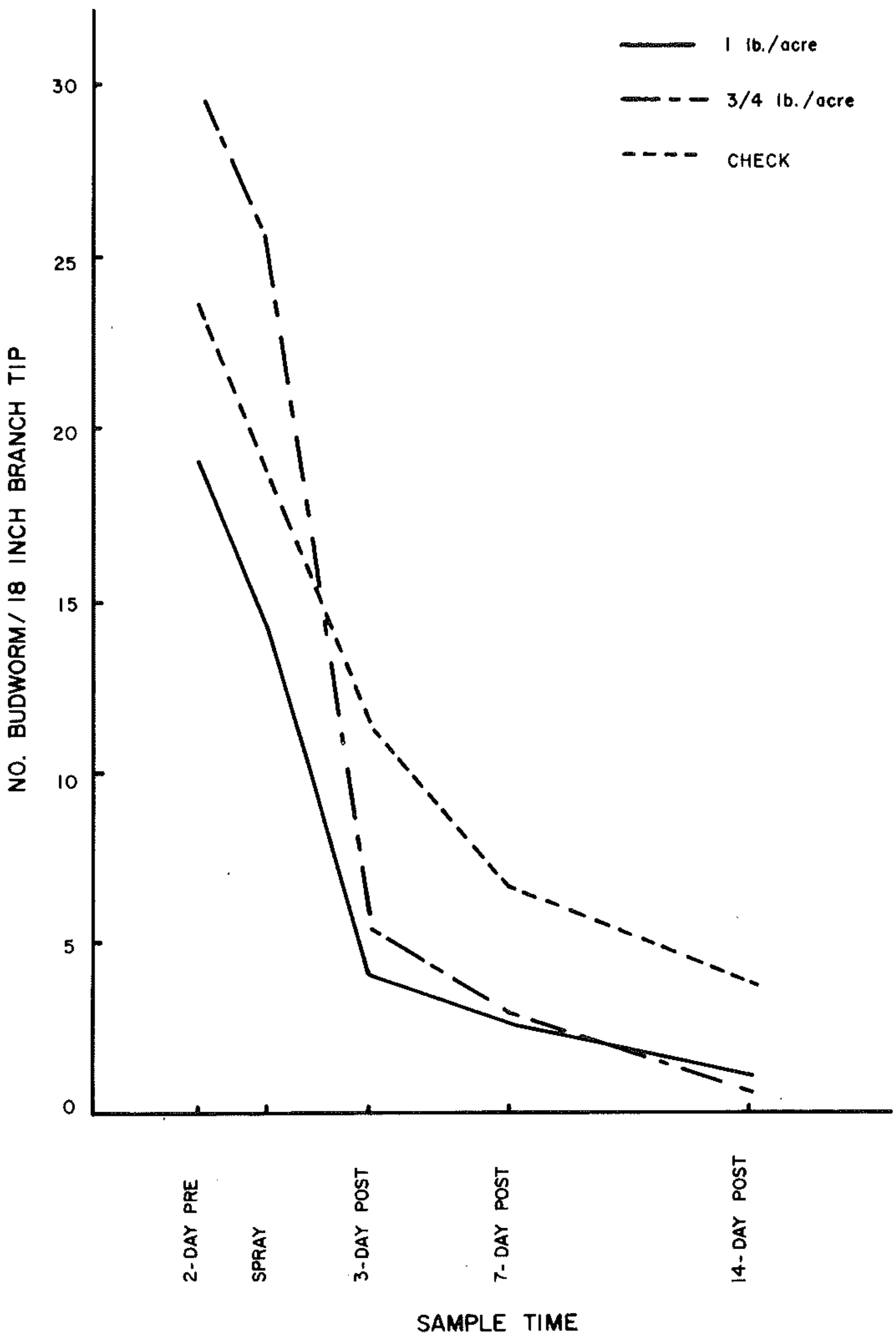
Mean Number of Budworm/18" Branch Sample

Spruce Budworm Operational Test, Maine, 1976

Treatment	Blocks	Prespray	Post Spray		
		2 days	3 days	7 days	14 days
1 lb/acre	2	25.87	1.91	0.90	0.12
	6	19.92	7.72	4.10	1.67
	7	11.79	2.66	2.76	1.37
Average		19.20	4.10	2.76	1.05
3/4 lb/acre	1	43.28	3.09	2.17	0.90
	3	24.82	8.22	4.37	1.15
	8	20.74	5.45	2.80	0.35
Average		29.61	5.53	3.11	0.80
Check	4	33.26	11.68	5.67	2.61
	5	28.09	15.35	9.57	5.78
	9	9.34	7.04	5.05	3.50
Average		23.56	11.19	7.31	4.64

FIG. 3

MEAN NUMBER OF BUDWORM PER 18 INCH TIP BY TREATMENT AND SAMPLING PERIOD. SPRUCE BUDWORM OPERATIONAL TEST, MAINE, 1976.



3. At 7 days postspray, the differences remained as they were at 3 days postspray.
4. At 14 days postspray, the population in the sprayed areas did not differ, but those in the check areas were significantly higher.

Values are shown in Table 2.

Unadjusted mortality was determined for each treatment for each of the four sampling periods (Table 3). Also, for the 14-day postspray sample, an assessment of spray induced mortality was calculated by the Simmons and Chen (1975) four sample method (Table 3). Because some of check block 4 was treated, it was excluded from the calculations of adjusted mortality.

Prespray defoliation levels between the treatments and the checks were significantly different (Kruskal-Wallis, nonparametric multiple range test, P=0:05) and, therefore, not directly comparable. Because there was no significant difference in prespray defoliation levels between the 3/4 lb./acre and the 1 lb/acre treatments, those postspray defoliation levels were directly comparable. At the 14-day postspray sampling period there was no significant difference in the amount of defoliation between the 3/4 lb/acre and the 1 lb/acre treatments.

Intratreatment comparisons between sampling periods show that:

1. There were no differences in the percentage defoliation in any of the sampling periods for the 1 lb/acre

Table 2

Summary of Mean Number of Budworm Per 18" Tip

For Each Treatment at Each Sampling Time

Spruce Budworm Operational Test, Maine, 1976

Sampling Time	Treatment		
	1 lb/acre	3/4 lb/acre	check
2 days prespray	19.20	29.61	23.56*
3 days post spray	4.10	5.53	11.19
7 days post spray	2.76	3.11	7.31
14 days post spray	1.05	0.80	4.64

* A common line denotes no significant difference in population means. (Duncan's multiple range rest, (P=0:05).

Table 3

Budworm Mortality By Treatment at Sampling Periods

Spruce Budworm Operation Test, Maine 1976

	Unadjusted Mortality			Adjusted Mortality[1]
Treatment	3 Days	7 Days	14 Days	14 Days
	Percent	Percent	Percent	Percent ± C.I.
1 lb/acre	78.6	85.6	94.5	88.62 ± 4.78
3/4 lb/acre	81.4	89.4	97.3	94.47 ± 2.16
Check	51,8	71.2	83.2	

1. Simmons and Chen, 1975.

treatment.

2. There were no differences in the percentage defoliation in any of the sampling periods for the 3/4 lb/acre treatment.

3. There were significant increases in the percentage defoliation between each of the sampling periods for the check areas.

4. The defoliation levels for each of the sampling periods are shown graphically in Figure 4.

Based on the percentage defoliation at the 2-day prespray and the 14-day postspray sampling periods (Table 4), the 3/4 lb/acre treatment and the 1 lb/acre treatment saved 28.63 percent and 32.10 percent of the total foliage complement, respectively. When these values are correlated to the amounts of foliage available at the prespray sampling period, foliage protection was 59.37 percent for the 3/4 lb/acre treatment and 69.83 percent for the 1 lb/acre treatment.

The volume median diameter (vmd) values of spray droplets for each spray block are shown in Table 5. The average vmd for the 3/4 lb and 1 lb/acre application rates were both 143 um. The vmd was determined from analysis of all 1977 spray deposit cards.

Spray drops recovered beneath the sample trees in the blocks ranged from three to eight drops per cm^2 and in the open eight to 20 drops per cm^2. There was no detectable difference in the percent of spray recovered between the two application rates. About two to three times more drops were observed in

FIG. 4

MEAN PERCENTAGE DEFOLIATION BY TREATMENT AND SAMPLING PERIOD. SPRUCE BUDWORM OPERATIONAL TEST, MAINE, 1976.

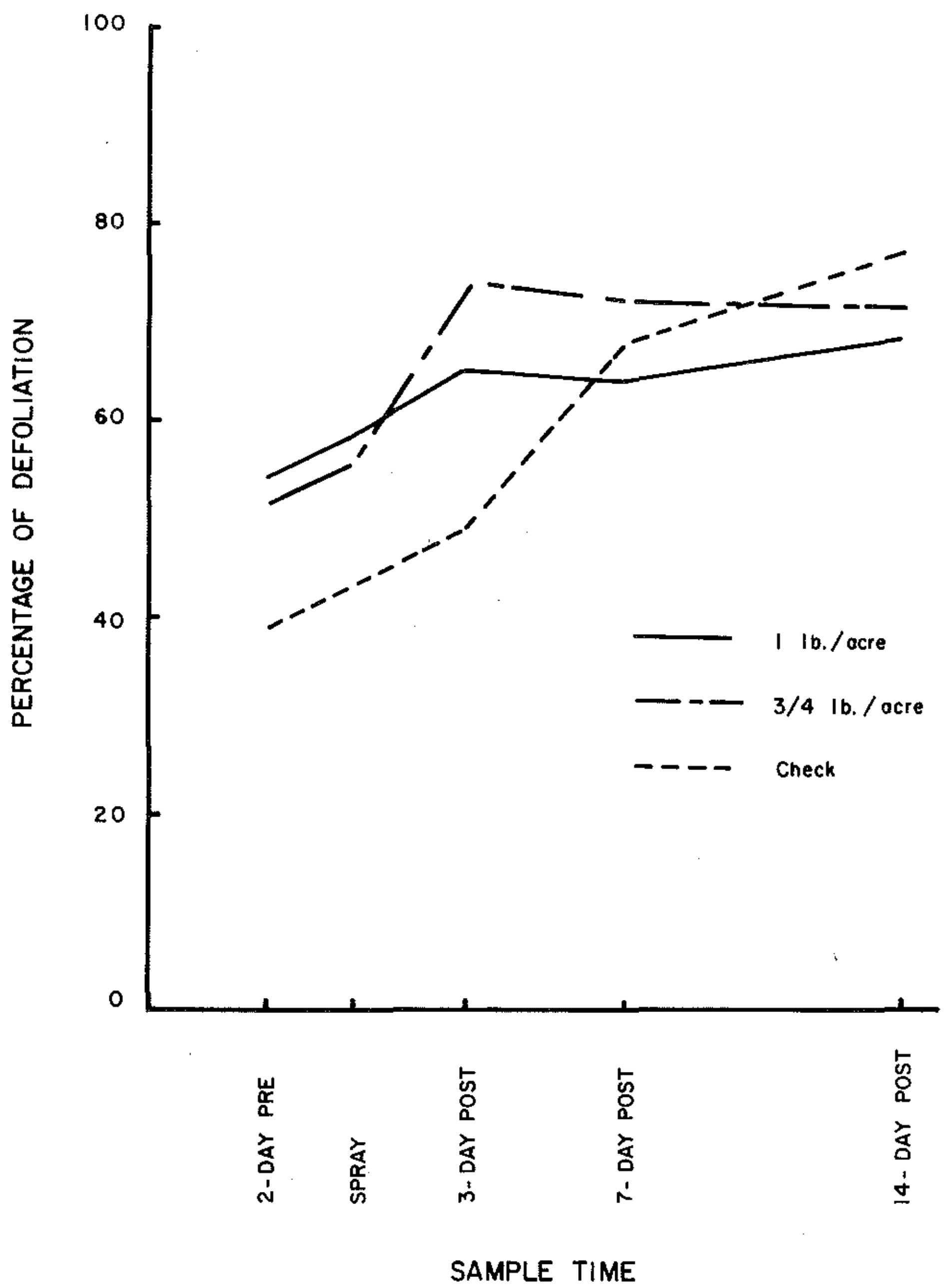


Table 4

Percent Defoliation at the 2-day Prespray

and

The 14-day Postspray Sampling Period

and

Determination of Amount of Foliage Saved

Spruce Budworm Operational Test, Maine, 1976

Treatment	Percentage Defoliation			Percentage Total Foliage Saved [2].
	2-day Prespray	14-day post spray observed	expected [1].	
Check	39.07	75.77	75.77	
3/4 lb/acre	51.78	71.38	100.42 (100)	28.63
1 lb/acre	54.03	67.90	104.78 (100)	32.10

1. Expected defoliation equals prespray percentage x C, with C being the ratio of increase in the check; 75.77/39.07= 1.939.

2. Percentage foliage saved equals the expected defoliation minus the observed defoliation.

Table 5

Summary of Volume Median Diameter (VMD)

and

Drops/cm^2 On Spray Deposit Cards

Spruce Budworm Operational Test, Maine, 1976

Application Rate	Block	VMD (um)		Drops/cm^2	
		Trees	Open	Trees	Open
3/4 lb	1	140	157	6	13
	3	149	157	6	12
	8	131	127	3	9
1 lb	2	141	134	7	19
	6	137	171	8	20
	7	128	147	4	8

the open as compared to under the trees. These data are summarized in Table 5.

Spray recovery by spray block, expressed in ounces/acre as a function of total material applied, ranged from five percent to 14 percent beneath the sample trees and 14 percent to 45 percent in the open area. These data are summarized in Table 6.

A spray with a vmd of 143 um, as observed in this project, appears to insure that all of the foliage is subjected to the spray.

The mean egg mass density/100 sq. ft. was calculated for each of the test blocks (Table 7). An analysis of variance (P=0:05) showed no significant difference in egg mass density between the 1 lb/acre, 3/4 lb/acre and check treatments.

Table 6

Summary of Spray Recovery Data In Ounces/Acre

and

Recovery as A Percent of Material Applied

Spruce Budworm Operational Test, Maine, 1976

Application	Block	Ounces/Acre		Recovery Percent	
		Trees	Open	Trees	Open
3/4 lb	1	3.88	11.53	13	38
	3	4.59	11.32	15	38
	8	1.42	5.16	5	17
1 lb	2	5.19	14.88	13	37
	6	4.58	17.94	12	45
	7	1.83	5.56	5	14

Table 7

Egg Mass Density/100 Sq. Ft. Branch Surface

Spruce Budworm Operational Test, Maine, 1976

Treatment	Block	Number egg masses/100 sq. ft.
1 lb/acre	2	121.47
	6	115.53
	7	48.20
		95.07
3/4 lb/acre	1	49.40
	3	100.67
	8	76.40
		75.49
Check	4	89.20
	5	151.20
	9	57.40
		99.27
Average		89.94

IV. DISCUSSION

Since prior to spray treatment there was no significant difference in budworm population levels between the different treatments (Table 2), barring the effect of spray treatment, the successive population levels should not be significantly different. As shown in Table 2, there was no significant difference between the 3/4 lb/acre and the 1 lb/acre treatments at any sampling period. This result indicates that there is no difference in the efficacy of the two rates for controlling budworm.

Both the 3/4 lb/acre and the 1 lb/acre treatments suppressed budworm populations below the level of the check areas (Table 2). However, it appears that the 1 lb/acre rate may kill more quickly than the 3/4 lb/acre rate. With extreme populations this difference could affect the amount of foliage saved.

Analysis of the spray deposit cards indicates that a section of Block 6 (1 lb/acre treatment) was not sprayed. Analysis of the data, excluding these samples, while lowering the survival rate in that block, did not alter the results sufficiently to show any difference between the 3/4 lb/acre and the 1 lb/acre treatments.

Population levels at pupation (14-day postspray) were about one budworm/18 inch branch in the sprayed areas (Table 1). Although this level is not sufficiently low to be considered endemic, it is significantly lower than the population in the check areas (Table 2). There was further mortality from late larval-pupal parasites. Surveys (Trial and Struble, 1977) showed an average late larval-pupal parasitism rate of 23.79% in the test areas; reducing budworm populations well below one budworm/18 inch branch in the treated areas.

Total mortality was 97.3 percent in the 3/4 lb/acre treatment and 94.5 percent in the 1 lb/acre treatment (Table 3). Based on the 4-sample method of Simmons and Chen (1975) the spray-induced mortality was 94.47 percent in the 3/4 lb/acre treatment and 88.62 percent in the 1 lb/acre treatment. These mortality rates are not significantly different and are acceptable spray objectives.

Since there are significant differences in the amounts of prespray defoliation between the treated and check blocks, the amount of foliage protection afforded by the spray was determined by indirect methods. The increase in the amount of defoliation in the check blocks from the 2-day prespray sample to the 14-day postspray sample was used as a measure against which the results from the treated blocks were compared. We assumed that, barring any outside influence, the defoliation in all treatments would increase as a function of the starting percentage defoliation.

Considering that the spray treatment was delayed beyond the optimum timing due to weather, the foliage protection values are quite acceptable.

Since defoliation was assessed only on terminal twigs, the values may not be indicative of the whole tree due to overestimation of defoliation. However, since this bias was constant, the relative defoliation values and the amounts of foliage saved due to treatment are an accurate portrayal of the situation.

Based on the results of the intratreatment analysis between sampling periods, it is apparent that spray treatment halted defoliation. Since both the 3/4 lb/acre and the 1 lb/acre treatments had no significant difference in defoliation levels between the 2-day prespray and any of the postspray samples, it appears that there is no difference in the effectiveness of either of the two dosages. This is further supported by the comparison of the defoliation results of the 14-day postspray sampling period where there was no difference between the 3/4 lb/acre and the 1 lb/acre application rates.

The assessment of the spray deposit cards indicates that the technique used to reduce dosage (reduction of the number of nozzles) had no effect on the spray spectrum. Since there is no detectable difference in the percent recovery (Table 6) between the 3/4 lb/acre and the 1 lb/acre treatments, apparently the amount of spray intercepted by the foliage is directly proportional to the amount of spray applied.

The results of the egg mass deposit analysis showed no difference between the treatments and the check areas. The average deposit (Table 7) was well below the level which is considered to be a "trigger" for treatment. This general reduction in deposit and lack of difference between treatments is a reflection of the relatively small size of the test blocks and checks within a large treated area. The mobility of the budworm moths precludes drawing any conclusions on next generation population control.

To study the effect of pesticide upon the N+1 generation it would be necessary to halt any dispersal to or from the test area or increase the size of the test blocks such that net migration would be negligible. Since neither was done, the egg mass level can only be assumed to be a reflection of the overall operational treatment of the entire region.

While there were no differences in the effectiveness in regards to larval reduction, defoliation levels, or spray spectrum between the 3/4 lb/acre and the 1 lb/acre treatments, it is possible that, with extremely high budworm populations, foliage protection would be better with the 1 lb/acre rate than with the 3/4 lb/acre rate. During this operational test such differences were not noted.

The environmental aspects of reducing the dosage are quite clear; lowering the dosage by 25 percent reduces the pesticide load on the environment. Examination of the late larval-pupal parasite collections in the test areas (Trial and Struble, 1977) reveals no detectable differences in the spectrum of budworm parasites between treatments, but subtle or long term changes in the biosphere are a real concern.

The lowering of the dosage from 1 lb/acre to 3/4 lb/acre, based on fuel oil and insecticide prices for 1977, represents a cost saving of 50 cents/acre. Additional savings are provided by the greater acreage/load possible at the reduced dosage leading to better utilization of available spray time, but conversion into specific per acre estimates is difficult. Viewed another way, the reduction in dosage permits treatment of 1/3 more acreage with a given budget for insecticide.[1]

1. Personal communication Lloyd C. Irland, Forest Insect Manager, Maine Forest Service.

V. CONCLUSIONS

There is no difference between the 3/4 lb/acre and the 1 lb/acre application rates in controlling budworm population levels.

There is no difference between the 3/4 lb/acre and the 1 lb/acre application rates in controlling defoliation levels.

Both the 3/4 lb/acre and the 1 lb/acre rates reduce budworm density and defoliation percentage below levels found in the check areas.

There is no difference in spray droplet spectrum between the two application rates.

There are significant savings in pesticide and cost resulting from 3/4 lb/acre treatment vs. the 1 lb/acre treatment.

Registration and application of Sevin 4 Oil at 3/4 lb and 30 oz/acre would result in reduced biological load and cost savings while maintaining efficacy against spruce budworm equal to the 1 lb and 40 oz/acre application rate.

VI. REFERENCES CITED

Morris, R.F. 1954. A sequential sampling technique for spruce budworm egg surveys. Can. J. Zool. 32:302-313.

Simmons, G.A. and C.W. Chen, 1975. Approaches to assessing insecticide efficiency in spruce budworm (Lepidoptera: Tortricidae) control programs. Can. Ent. 107:1205-1209.

Trial, H., Jr. and D. Struble, 1977. The spruce budworm in Maine: 1976. 1976 spray project and projected situation for 1977. Maine Forest Service, Dept. of Conservation.

Zar, J. H., 1974. Biostatistical Analysis. Prentice-Hall, Inc. Englewood Cliffs, N.J.

TECHNICAL REPORT SERIES

1. LaBonte, G.A., The Saddled Prominent Outbreak of 1970-1971 and its Damages. March, 1978.
2. Dearborn, R.G., Trial, Jr., H., Struble, D., Devine, M., The Saddled Prominent Complex in Maine with Special Consideration of Eastern Maine Conditions. March, 1978.
3. Maine Forest Service, Entomology Division, Spruce Budworm in Maine: 1977. March, 1978.
4. Devine, M.E., Trial, Jr., H., Kotchian, N.M., Assessment of Spruce Budworm Damage in the Moosehorn National Wildlife Refuge. August, 1978.