B3

RESULTS OF A TEST TO EVALUATE THE EFFECTIVENESS OF FORAY 48B^{R} AGAINST THE WESTERN SPRUCE BUDWORM IN OREGON IN 1988

By

Paul E. Buffam and Jon David Buffam

PESTECHON, INC.

3080 Lake Osborne Drive

Lakeworth, Florida 33461

September 16, 1988

RESULTS OF A TEST TO EVALUATE THE EFFECTIVENESS OF FORAY 48B[R] AGAINST THE WESTERN SPRUCE BUDWORM IN OREGON IN 1988

By

Paul E. Buffam and Jon David Buffam[1]

The present western spruce budworm (Choristoneura occidentalis) outbreak in the Pacific Northwest was first detected in 1980 in the Blue Mountains of Oregon. Since then, budworm-caused tree defoliation has occurred on over six million acres of forested land in Eastern Washington and Eastern and Central Oregon.[2]

The short term approach to preventing resource losses over large areas during a budworm outbreak is to apply safe, effective aerial sprays. Aerial suppression projects were carried out in 1982 on 179,000 acres and in 1983 on 524,000 acres on and adjacent to the Umatilla and Malheur National Forests in Eastern Oregon. In 1982, carbaryl (Sevin 4-Oil[R]) was used on most areas, and acephate (Orthene Forest Spray[R]) was used adjacent to critical streams with Chinook salmon habitat. In 1983, carbaryl was used on most of the project area. However, mexacarbate (Zectran DB[R]) and Bacillus thuringiensis (Thuricide 32LV[R]) were evaluated on 10,000 and 12,000 acre blocks, respectively.

In recent years, Bacillus thuringiensis (B.t.) has been selected for use because of its safety margin against non-target organisms and its proven efficacy against a variety of forest lepidopteran pests. In 1985, several formulations of B.t. were tested in an operational evaluation on 40,000 acres

---

[1]Consulting Forest Entomologist and Forest Entomology Technician, respectively, 7270 S.W. Wilson Avenue, Beaverton, Oregon 97005.

[2]USDA - Forest Service, Pacific Northwest Region. 1988. Environmental Assessment, Western Spruce Budworm Management in Oregon and Washington during 1988, January 1988.

on the Malheur National Forest. Operational projects were carried out on 40,000 acres on the Wenatchee National Forest in Washington and on over 90,000 acres on the Malheur National Forest in Oregon in 1987. B.t. was selected for both projects. Thuricide 48LV^{R} was used exclusively on the Wenatchee National Forest project. Dipel 6L^{R} was chosen for the Malheur National Forest project. However, this material thickened significantly during mixing and caused problems in handling and spraying. Therefore, its use was dropped midway through the project, and Thuricide 48LV^{R} was used on the remainder of the project. Dipel AF^{R} was tested on 2,000 acres on the Malheur National Forest in 1987. A large-scale aerial spray operation was carried out in 1988 in and adjacent to the Umatilla, Wallowa-Whitman and Mt. Hood National Forests and Warm Springs Indian Reservation in Oregon. Thuricide 32LV^{R} and Dipel 6L^{R} were selected for the operational program. However, several other formulations of B.t. were pilot tested including Thuricide 48LV^{R} and Dipel 6AF^{R}.

Past results with B.t. have been variable especially with the western spruce budworm. The 1985 evaluation showed that B.t. can reduce budworm populations to one or less larva per branch tip--the USDA-Forest Service's goal. The 1987 operational project on the Wenatchee National Forest was very successful. However, results on the 1987 Malheur National Forest project were not entirely satisfactory due to mixing and application problems and spray evaporation because of low humidities.

Due to the increasing demand for biological insecticides like B.t., many pesticide and/or pharmaceutical companies, especially those with expertise in fermentation technology, are investigating the market place. In 1988, Novo Laboratories, Inc. of Danbury, Conn. introduced a new aqueous (water-based) formulation of B.t. to the forestry market--Foray 48B.

This report summarizes the results of insect and spray sampling on a test near Sisters, Oregon evaluating the effectiveness of an undiluted application of Foray 48B^{R} in reducing western spruce budworm populations to non-damaging levels.

THE STUDY AREA

Both the sprayed and unsprayed (check) plots were located on land owned and managed by Willamette Industries, Inc. The plots were about 9 air miles northwest of Sisters, Oregon. The sprayed area was in the south half of Sec. 1, T.14S.; R.8E. and the check area in the southwest quarter of Sec. 31; T.13S.; R.9E. The northeast corner of Sec. 1 (sprayed area) and the southwest corner of Sec. 31 (check area) touched, so the plots were less than 1 mile apart. The sprayed area had an elevation of about 3,600 feet with a slight northern exposure, while the check area was at an elevation of 3,450 feet with a slight eastern exposure. Slope was gentle at both sites.

The forest stands in both areas had been selectively logged. Large overstory ponderosa pine and Douglas-fir had been removed. The present stands consist of sawtimber-sized ponderosa pine, Douglas-fir and grand fir as well as seedling, sapling and pole-sized ponderosa pine, Douglas-fir, grand fir and Pacific silver fir. Open-grown host trees from 20-50 feet in height were abundant in both areas. These made excellent sample trees.

TREATMENTS

A single application of Foray 48B^{R} was applied to about 300 acres of forested land at the rate of 1/3 gallon (43 fluid ounces) or 16 B.I.U.s per acre. A dye, Erio Acid Red XB 400, was added to the spray at a concentration of 0.2% by weight to aid in spray deposit assessment. A similar, adjacent area was left unsprayed to serve as a check. This area was far enough away from the sprayed area to prevent spray drift from reaching the sample trees.

DEVELOPMENT SAMPLING

Branch tips were removed from the mid crown of several trees within both the sprayed and check areas at four times from May 26 - June 17 to determine budworm larval development and host tree bud/shoot development. The branch tips were cut from the mid-crown with the aid of a pole pruner with attached basket. Samples were lowered to the ground where the number of open and closed buds were counted and recorded. Budworm larvae were then removed and separated into stage of development, and the number of larvae in each stage was recorded. Data were separated by tree species as bud/shoot development and perhaps insect development are usually more advanced on true firs than on Douglas fir. To be most effective, spray should be applied when most of the buds have opened and most of the larvae are in the 4th and 5th instars.

SPRAY ASSESSMENT

Spray deposit was evaluated by two different methods -- (1) droplet counts on spray cards and (2) mid-crown foliage. Immediately before spraying, three

to four 4 1/4" X 5 1/2" white kromekote cards were tacked to the top of 35" long cedar stakes that had been driven into the ground on the open sides of each tree in the sprayed area. The cards were labeled and collected within 3 hours after spraying. Each card was later examined using a binocular microscope with 14X magnification. The number of droplets in the center square centimeter of each card was counted and recorded. No attempt was made to stratify droplet numbers by droplet size. Subsequently, the spray cards were analyzed by an Optomax Image Analyzer at the USDA-Forest Service laboratory at Hamden, Connecticut. The results of both analyses are included in this report.

Within 1 - 3 hours after spraying, a 45 cm. branch tip was cut from the mid-crown of each sample tree in the sprayed area. This sample was taken from the immediate proximity where pre-spray sample number 1 was taken. Samples were lowered to the ground, placed in individual paper bags, stapled, and transported to Dr. Charles Wiesner's microscopy laboratory in Pendleton, Oregon for examination. Results of the latter spray assessment study will be summarized in a separate report by Dr. Wiesner.

PRE- AND POST-SPRAY SAMPLING

Mid-crown branch tip samples were taken within 3-5 days of spraying and at 14-17 days after spraying in the spray area and within 1-3 days before spraying and at 12-14 days after spraying in the check area. A total of 61 trees - 31 Douglas-firs and 30 true firs - were located, selected and tagged in each area. Each of the sample trees met the following selection criteria:

1. Open grown on at least 3 sides
2. 20-50 feet tall
3. New buds or shoots in mid-crown

4. At least 75 feet from the nearest well-traveled road

5. 150 feet or more inside the exterior plot boundary (sprayed plot only)

6. Some evidence of defoliation in 1987

7. Some evidence of budworm population in 1988.

At the time of the pre-spray sample, two 45 cm. branch tips were cut from the mid-crown of each sample tree on opposing sides. A 5-section pole pruner with basket was used in the sampling. This allowed us to sample a height of from 10-25 feet above ground level. Samples were lowered to the ground, placed on a white muslin ground cloth and cut into small pieces. The number of buds/shoots was counted and recorded. Also the number of live budworm was counted and recorded. Other Lepidopterous larvae were also counted and recorded.

During the post-spray sample, four 45 cm. branch tips were cut from the mid-crown of each sample tree. The number 1 sample was always taken from the same area as the number 1 pre-spray sample and post-spray droplet assessment foliage sample. This sample was lowered to the ground and placed in a brown paper bag. Any live insects in the pole pruner bag were placed in the paper bag for counting. Samples 2, 3 and 4 were taken on the same sides as spray cards 2, 3 and 4, if possible. These samples were clipped from the mid-crown and lowered to the ground where they were placed in another paper bag. Again any live budworms in the bottom of the pole pruner bag were placed in the paper bag.

Both paper bags were carried a short distance to a portable table and chairs that were used as an outdoor laboratory. Muslin sheeting had been taped to the top of the table to aid in observing. Each branch tip was removed one at a time from the paper bags, examined by the senior author and assigned a

defoliation estimate. The number 1 sample was given to the junior author who counted the number of buds/shoots and budworms. We then examined the other three branch tips.

RESULTS

WEATHER

The weather in early June was cool and damp with temperatures at the USDA-Forest Service Ranger Station in Sisters ranging from highs of 53-60 degrees F. to lows of 29-45 degrees F. About mid-June, a warming trend moved into Central Oregon with highs at Sisters in the mid-80's to low 90's and lows in the mid 30's to high 40's. It was during this period that budworm and tree development escalated. The weather was hot and dry from about June 13 until June 25 -- the day of spraying. A cooling trend lasted from June 25 until about July 7. A trace of rain was recorded in Sisters on June 25 and June 29, but no rain occurred on the plot on June 25. We could find no sign of rain between June 25 and our next visit to the area on July 6.

APPLICATION

Foray 48B^{R} was applied to approximately 300 acres on June 25 by a Bell 206 helicopter equipped with six Beecomist model 361 rotary atomizers and an on-board flow monitoring system calibrated to apply 1/3 U.S. gallon per acre. The aircraft was calibrated, dye incorporated into the batch formulation and loaded at Madras, Oregon. On the morning of spraying, the aircraft ferried to the plot near Black Butte Ranch. The helicopter was calibrated for an effective swath width of 120 feet with a spray speed of 75 m.p.h. and flow rate of 6.1 gallons per minute.

Spraying began on June 25th at 5:32 a.m. under typical operational parameters - acceptably high humidity (absolute relative humidity unavailable),

57 degrees F., and calm conditions. The first load was completed at 5:48 a.m., and the pilot, Jack Sinton of Delano, California reported an inability to achieve the pre-established flow rate determined by calibration.

Spraying of the second load continued from 6:15 a.m. to 6:28 a.m.; humidity remained high, temperature increased to 59 degrees F. and a slight breeze developed near the end of the application period. Due to the inability to achieve the required flow rate, pump pressure was decreased to maintain the flow rate at 50% calibration, with the area flown twice to achieve the desired application rate. The second application was conducted at right angles to the first to help ensure adequate coverage of the spray area.

Although the Model 361 Beecomists rotate at 9400 rpm under load, the altered viscosity of the Foray 48B may have reduced the rotational speed even more resulting in less than an ideal droplet spectrum. Further investigations may be required to determine if the droplets produced were too large for maximizing efficacy.

BUDWORM AND TREE DEVELOPMENT

The first development samples were taken on May 26 and 27. All larvae were in the 3rd and 4th instars at this time and no bud burst had occurred although bud swelling was prevalent (Table 1). Only one 5th instar was found through June 8, undoubtedly because of the cool, wet weather in late May and early June. However, with the advent of warm weather in mid-June, both insect and tree development proceeded rapidly. Sixth instar larvae began appearing in our samples on June 19 in the check area and June 20 in the spray area. Bud burst was complete on all host species by June 20. Insect development was more advanced in the check area than in the spray area probably because of the slightly lower elevation and eastern exposure of the check area. About 90 percent of the budworms sampled in the spray area at 3-5 days before spraying

were in the 3rd, 4th and 5th instars with 54 percent in the 5th instar or peak of the 5th instar. Some advancement in development probably occurred from June 20-22 until the spray date (June 25), but the majority of budworms were still in the 5th instar at the time of spraying. No pupae were found in either the spray or check areas even though the last counts in the check area were made the day before spraying.

Samples taken in the check area on July 6-9 (12-15 days after spraying) indicate the effects of the cool weather on development. By this time, only 11.5 percent pupation was found. Only 9 pupae were found in the post-spray samples in the spray area. This amounts to 2.5 percent of the survivors in the spray area. Very few 3rd and 4th instar larvae were seen at post-spray sample time.

We found larvae that ranged in color from brown to green indicating that both the western spruce budworm and Modoc budworm (C. viridis) as well as hybrids of the two species were present in the area.

SPRAY ASSESSMENT

A total of 223 spray cards were used during the project. Spray deposit averaged 18.91 (23.58)[3] drops per square centimeter (Tables 2 and 4) and ranged from 1 to 63 (4.5 to 64.3) drops per square centimeter (Tables 3 and 4). Average spray deposit per tree ranged from 3.3 to 45.5 (7.5 to 49.8) drops per square centimeter. Sixteen (5) trees had spray deposits averaging 10 or less drops per square centimeter, while 23 (34) trees had deposits averaging more than 20 drops per square centimeter (Figure 1). Of particular note is the fact that several trees had excellent deposit on 2 or 3 sides but poor deposit on the remaining side(s). For example, tree number 60 had deposits of 25 and 32 (43 and 54) drops per square centimeter on sides 1 and 3, respectively, but only 4 (21) drops per square centimeter on side 2. Tree 52 had deposits of 13

[3]The first number in this section refers to counts obtained with the microscope and the numbers in parentheses refer to counts obtained by Optomax analysis.

and 19 (23 and 33) drops per square centimeter on sides 2 and 3, respectively, but only 3 and 3 (8 and 7) drops per square centimeter on sides 1 and 4, respectively. Some of this variation around a tree may have been due to screening. However, we think that most was due to variation in application either from the flying pattern, flow rate problems or lack of wind during the application of the first load. It should be noted that due to the double application procedure with the second passes at 90 degrees to the first, it is difficult to correlate deposition (or lack thereof) to flight paths and spraycloud trajectory/tree shading. Deposit cards were installed around sample trees to maximize the recording of spray deposit and not in any particular compass orientation.

The Optomax data should be superior to that obtained with the microscope as the former obtains counts on five fields per card and the latter only one. There is some question as to whether the Optomax Analyzer can discern spray droplets from dust particles, honey dew and other particles or stains. Never-the-less, droplet counts with the Optomax were highly correlated with those counted by microscopic means ($r=0.921$ with 60 d.f.).

The cards installed near sample trees 1 through 17 indicate poorer coverage than other stations; these trees are located in the northwest side of the plot. In all probability, the application problems and the in-air flow rate fluctuations resulted in less than the desired application rate in this sector. Also, the calm conditions (no wind) at the very beginning of the applications may have exacerbated the application problems as the small droplets produced, especially with such a low application volume, are best deposited with a slight, mixing breeze. The foliar deposition analysis by Dr. Wiesner may provide further insight into this problem. If the data from trees 1 through 17 are excluded from the analysis, the average spray deposit is 22.6 drops per square centimeter.

PRE- AND POST-SPRAY SAMPLING

Pre-spray budworm populations averaged 12.5 larvae per branch tip (14.1 per 100 buds) in the sprayed area and 9.8 larvae per branch tip (10.6 per 100 buds) in the check area (Table 2). The spray area had a significantly higher population at time of pre-spray sampling than the check area ($t=3.19$ with 120 d.f.; $p=< 0.50\%$). Post-spray populations averaged 1.5 larvae and pupae per branch tip (1.86 per 100 buds) in the spray area and 4.7 larvae and pupae per branch tip (5.5 per 100 buds) in the check area. The spray area had a significantly lower population at the time of post-spray sampling than the check area ($t=8.32$ with 120 d.f.; $p=< 0.10\%$). Population reduction between the pre- and post-spray counts averaged 88.0 percent in the spray area and 49.3 percent in the check area.

Survival was less in the true fir plot trees than in the Douglas-fir plot trees in the spray area (1.1 larvae per branch tip vs. 1.9 larvae per branch tip) (Table 5). This difference might be explained by more spray deposit on the true firs than on the Douglas-firs (21.8 drops/cm^2 vs. 16.1 drops/cm^2). The difference in deposits between species is significant at $p=0.05$ ($t = 2.01$ with 59 d.f.). Twelve of the 17 trees in the sector that received the lightest spray deposit (see preceeding section) were Douglas-firs. This undoubtedly resulted in more survival on Douglas-firs than on white firs. In the spray area, pre-spray populations in Douglas-firs and true firs were about the same (12.2 and 12.8 larvae per branch tip, respectively), while pre-spray populations in the check area were different (7.9 larvae per branch for true firs and 11.5 larvae per branch tip for Douglas-firs).

In all cases, the average number of buds/shoots per branch tip was less at the post-spray count than the pre-spray count. This was probably because shoots were more difficult to see after two weeks more of defoliation.

Post-spray defoliation in the spray area ranged from 4 to 69 percent and averaged 24.7 percent. In the check area defoliation ranged from 6 to 89 percent and averaged 32.9 percent. This difference, although small, was significant at P=< 2.5% (t=2.51 with 120d.f.). Therefore, the spray treatment significantly reduced defoliation even though the pre-spray population levels were significantly lower in the check area than in the spray area.

Most trees had been heavily defoliated in 1987. However, the cool, moist spring weather in 1988 allowed shoot development to progress more rapidly than budworm development. The lush shoot development masked the effects of defoliation, so that little damage could be seen from long distance.

Population reduction and survivorship in the spray area were significantly related to spray droplet density at P = 0.01, i.e. the higher the droplet counts the higher the population reduction and lower the survival (r = 0.42 with 60 d.f. for population reduction and r = -0.43 with 60 d.f. for survival based on number of budworms per branch tip).[4] The same relationship existed if number of budworms per 100 buds was used for the analysis except that the correlation coefficients are smaller (r = 0.38 with 60 d.f. for droplet density vs. population reduction and r = -0.40 for droplet density vs. survival). To obtain a survival rate of 1.0 larva/pupa per branch tip, spray deposit would have to average 20.7 drops/cm^2 using the data obtained with the microscope ($\bar{Y}x = 18.91 + (-3.62)(x-\bar{x})$. To obtain 98 percent population reduction, droplet density would have to average 21.9 drops/cm^2 ($\bar{Y}x = 18.91 + (-2.37)(x-\bar{x})$. Certainly both of these rates are attainable under operational conditions.

---

[4]These correlation coefficients were calculated using droplet counts obtained with the aid of a microscope. Comparable analyses using Optomax data showed the following results: r=0.42 with 60 d.f. for reduction and r=-0.48 with 60 d.f. for survival.

Achieving uniform deposit is extremely important. This would eliminate the problem mentioned in the spray assessment section. It became obvious during our post-spray sampling by observing survivors that some sides of some trees did not receive adequate spray deposit while the other sides received adequate deposit. For example, branch tip 4 of tree 53 had 4 survivors, while branch tips 1, 2, and 3 combined had only 1 survivor. The cards around this tree had 16, 10 and 5 droplets/cm^2 (microscope counts). Tree 52 which was previously mentioned had 15 surviving larvae on only 1 branch tip. Nineteen trees had one or more sides with a deposit of 5 or less drops/cm^2. If these were not used in the analysis, survivors per branch tip would average 1.01. If data from trees 1 through 17 in the northwest sector were excluded from this analysis, survival would also average 1.01 larvae/pupae per branch tip.

We found dead or dying larvae and pupae in both the check area and the spray area. However, we found less than 50 dead larvae in the check area and these showed the characteristics of being parasitized. We collected several specimens and parasite larvae -- primarily of Apanteles sp. and Glypta sp. -- emerged from each of them. We found so many dead larvae in the spray area, that we decided to keep a count. These larvae and pupae were usually black and desiccated although we found a few dead pupae that were filled with a gray-black liquid. Dead larvae and pupae averaged 3.43 per branch tip and ranged from 0 to 11 per branch tip. The quality of the survivors in the spray area looked poorer than those in the check area. We did not find many large, healthy 6th instar larvae in the spray area like we did in the check area. We suspect that many of the survivors in the spray area will not reach the moth stage due either to latent B.t. effect or parasitism.

We sampled trees 1 through 8 on July 12, 3 days after the first post-spray sample, to see if survivorship decreased significantly in just 3 days. The first post-spray count averaged 3.2. budworms per branch tip and the second count averaged 2.0 budworms per branch tip. Although this difference was not statistically significant at the 5% level ($t = 2.06$ with 7 d.f.), it may indicate that mortality was continuing after the inital post-spray sample.

As mentioned previously, pre- and post-spray samples number 1 were cut from the trees and examined separately for Dr. Wiesner to use. We also analyzed these data separately. Results of this analysis compared with that of all four samples are:

Attribute	Sample 1 Only	All 4 Samples
	-------Average-------	
Pre-Spray Budworms/Branch Tip	11.49	12.48
Pre-Spray Budworms/100 Buds	12.30	14.13
Post-Spray Budworms/Branch Tip	1.49	1.50
Post-Spray Budworms/100 Buds	1.69	1.86
Percent Reduction/Branch Tip	86.8	88.0
Percent Reduction/100 Buds	83.7	86.8
Percent Defoliation	17.6	24.7
Spray Drops/CM^2	19.0	18.9

As you can see, results were very similar except, perhaps, for defoliation. The relationship between spray droplet density and population reduction was significant ($r = 0.42$ with 60 d.f. using budworms per branch tip and $r = 0.38$ with 60 d.f. using budworms per 100 buds). These correlation coefficients are less than those obtained by utilizing all four samples.

We found several other species of Lepidopterous larvae and pupae as well as sawfly larvae in both the spray and check areas. Dioryctria sp. was the most abundant defoliator followed by Argyrotaenia sp., a geometrid, another budworm and a Neodiprion sp. The following is a summary of other defoliator counts:

Treatment	Pre-Spray Insects/ Branch Tip	Post-Spray Insects/ Branch Tip
Unsprayed	0.62	0.61
Sprayed	1.19	0.52

As you can see, no change occurred between pre- and post-spray numbers in the unsprayed area. A significant reduction (at P = 0.01) was found in the sprayed area.

MAJOR FINDINGS

1. Cool, wet weather in late May and early June slowed budworm development.
2. A majority of larvae were in the 5th instar when sprayed. Tree bud burst was complete at the time of spraying. Both the budworm and trees were in optimum development at the time of spraying.
3. Spray deposit averaged 18.9 drops per square centimeter. However, deposit was variable and 16 of the 61 sample trees had less than 10 drops per square centimeter.
4. The Foray 48B^{R} treatment reduced budworm populations from 12.5 to 1.5 budworms per branch tip while populations in the unsprayed area dropped from 9.8 to 4.7 budworms per branch tip. This difference in budworm population reduction between the treated and untreated areas was significant.

5. Population reduction and survival rates in the spray area were correlated with droplet density. If data from trees receiving light spray deposit like those in the northwest sector were deleted from analysis, budworm survival would be only 1.01 larvae per branch tip which is very close to the USDA-Forest Service's goal of 1.00 larva per branch tip.
6. Shoot defoliation was significantly lower in the spray area than in the unsprayed area even though the pre-spray population in the sprayed area was significantly higher than that in the unsprayed area.
7. The quality of the surviving budworm population in the sprayed area seemed to be quite poor compared with that in the unsprayed area. Larvae seemed to be smaller and less healthy than those survivors in the unsprayed area.
8. It is surmised that the application problems (inconsistent flow rate) are attributable to the incorporation of the dyestuff into the formulation; this caused a significant change in the physical characteristics of the liquid and undoubtedly contributed to the deposition results.

ACKNOWLEDGEMENTS

We thank Mo Bergman and Tucker Williamson, Willamette Industries, Inc., for allowing the use of the study area and for supplying maps, aerial photographs and advice during the project; to LeRoy Kline, Oregon Department of Forestry, for locating the study area; to Roy Mask and Andy Egletis, USDA-Forest Service for providing technical advice; to Roy Beckwith, USDA-Forest Service, Pacific Northwest Research Station, for loan of equipment; to personnel of the Sister's Ranger District, Deschutes National Forest for supplying information and advice during the project; and to Alan Jackson, Altair, Inc. for providing liaison between the spray application and us.

TABLE 1.
SUMMARY OF DEVELOPMENT SAMPLING OF SPRAY AND CHECK AREAS IN 1988

Treatment	Date Sampled	Tree Species	Stage of Development (Instar) 3rd & 4th No.	3rd & 4th %	5th No	5th %	6th No.	6th %	Pupae No.	Pupae %	% Buds Open
Sprayed	May 26	TF	95	100	0	0	0	0	0	0	0
	May 31-June 2		95	100	0	0	0	0	0	0	50
	June 6		178	100	0	0	0	0	0	0	90
	June 16-17		481	76	155	24	0	0	0	0	97
	June 20-22		280	36	400	52	89	12	0	0	100
	July 9-12 *		3	2	28	21	97	72	6	5	100
	May 26	DF	23	100	0	0	0	0	0	0	0
	May 31-June 2		58	100	0	0	0	0	0	0	0
	June 6		104	100	0	0	0	0	0	0	20
	June 16-17		366	87	54	13	0	0	0	0	67
	June 20-22		265	35	424	56	65	9	0	0	100
	July 9-12 *		1	1	76	33	151	65	3	1	100
Check	May 27	TF	97	100	0	0	0	0	0	0	0
	June 8		40	98	1	2	0	0	0	0	100
	June 19		14	35	22	55	4	10	0	0	100
	June 22-24		63	13	219	47	186	40	0	0	100
	July 6-9		6	1	73	16	330	73	45	10	100
	May 27	DF	22	100	0	0	0	0	0	0	0
	June 8		15	100	0	0	0	0	0	0	0
	June 19		28	72	11	28	0	0	0	0	95
	June 22-24		89	12	376	53	250	35	0	0	100
	July 6-9		4	1	130	19	475	68	87	12	100

* Post Spray Samples

TABLE 2. SUMMARY OF PRE- AND POST-SPRAY SAMPLING BY TREATMENT

	AVERAGE NO. OF LIVE BUDWORMS--PRE-SPRAY		AVERAGE NO. OF LIVE BUDWORMS--POST SPRAY		PERCENT POPULATION REDUCTION			
TREATMENT	PER BRANCH TIP	PER 100 BUDS	PER BRANCH TIP	PER 100 BUDS	BRANCH TIP	100 BUDS	PERCENT DEFOLIATION	AVERAGE DROPS/CM^2
CHECK	9.75±0.55	10.58±0.84	4.72±0.32	5.53±0.45	49.31±2.95	44.20±3.20	32.85±2.49	---
SPRAYED	12.48±0.66	14.13±0.91	1.50±0.21	1.86±0.29	88.00±1.99	86.84±2.15	24.65±2.12	18.91±1.31

TABLE 3. SUMMARY OF SPRAY DEPOSIT DATA OBTAINED FROM MICROSCOPIC ANALYSIS

Tree No.	Card No.	Drops/CM^2
1	1	13
	2	10
	3	13
2	1	9
	2	15
	3	19
	4	11
3	1	4
	2	3
	3	3
4	1	8
	2	1
	3	5
	4	10
5	1	7
	2	8
	3	1
6	1	12
	2	9
	3	14
7	1	4
	2	6
	3	9
	4	4
8	1	12
	2	6
	3	9
	4	3
9	1	8
	2	3
	3	12
	4	7
10	1	11
	2	14
	3	6
	4	5
11	1	13
	2	20
	3	10
	4	15
12	1	2
	2	5
	3	8
13	1	5
	2	19
	3	10
	4	8

Tree No.	Card No.	Drops/CM^2
14	1	14
	2	10
	3	3
15	1	15
	2	17
	3	13
16	1	8
	2	15
	3	13
	4	14
17	1	4
	2	15
	3	3
	4	10
18	1	10
	2	22
	3	20
19	1	22
	2	12
	3	25
	4	13
20	1	28
	2	11
	3	20
21	1	13
	2	9
	3	23
	4	24
22	1	27
	2	15
	3	32
	4	20
23	1	7
	2	12
	3	9
	4	13
24	1	13
	2	22
	3	16
	4	17
25	1	16
	2	33
	3	22
	4	18
26	1	27
	2	20
	3	23
27	1	17
	2	15
	3	9
	4	34

Tree No.	Card No.	Drops/CM^2
28	1	48
	2	13
	3	33
	4	40
29	1	16
	2	13
	3	44
30	1	46
	2	34
	3	54
	4	42
31	1	33
	2	32
	3	34
	4	34
32	1	60
	2	28
	3	32
	4	62
33	1	6
	2	6
	3	4
34	1	13
	2	15
	3	17
35	1	12
	2	29
	3	21
36	1	22
	2	29
	3	16
	4	34
37	1	37
	2	46
	3	43
	4	38
38	1	28
	2	18
	3	27
	4	20
39	1	60
	2	26
	3	63
	4	25
40	1	16
	2	13
	3	17
	4	15
41	1	16
	2	15
	3	8
	4	16

Tree No.	Card No.	Drops/CM^2
42	1	14
	2	15
	3	10
43	1	23
	2	24
	3	14
	4	9
44	1	28
	2	38
	3	27
	4	24
45	1	38
	2	50
	3	37
46	1	37
	2	21
	3	39
	4	23
47	1	21
	2	29
	3	20
	4	26
48	1	29
	2	37
	3	51
49	1	17
	2	12
	3	16
50	1	42
	2	23
	3	38
	4	31
51	1	9
	2	20
	3	21
52	1	3
	2	13
	3	19
	4	3
53	1	16
	2	10
	3	5
54	1	4
	2	15
	3	11
	4	10
55	1	21
	2	29
	3	35
	4	21

Tree No.	Card No.	Drops/CM^2
56	1	5
	2	11
	3	5
	4	8
57	1	9
	2	2
	3	14
	4	13
58	1	8
	2	7
	3	12
	4	3
59	1	27
	2	37
	3	28
	4	21
60	1	25
	2	4
	3	32
61	1	39
	2	34
	3	25

TABLE 4. SUMMARY OF SPRAY DEPOSIT DATA OBTAINED FROM OPTOMAX ANALYIS

SUMMARY DATA FROM SPRAY DEPOSIT CARDS

OCATION: SISTERS OREGON **SPRAY DATE:6-25-88**
ATERIAL: FORAY 48B
TREATMENT: UNDILUTED @16 BIU/ACRE @ 43OZ/ACRE
QUIPMENT: SINTON HELICOPTERS, CA
BELL 206 JET RANGER WITH BEECOMIST 360
ROTARY ATOMIZER NOZZLES (6)

ALIBRATION: (75 MPH x 120 FT SWATH)/(495 X 0.33 G.P.ACRE) = 6.1 G.P.M

TREE #	# SAMPLES	V-10	V-50	V-90	N-90	#/CM2	# FIELDS	# DROPLETS
1	3	105.02	189.59	285.52	206.69	15.79	15.00	159.00
2	4	102.70	162.08	216.52	189.89	14.60	20.00	196.00
3	3	105.29	192.77	295.13	206.80	10.13	15.00	102.00
4	4	97.12	160.74	250.75	173.71	9.16	20.00	123.00
5	3	102.10	217.02	299.68	202.43	7.45	15.00	75.00
6	3	85.22	134.65	194.80	149.78	13.40	15.00	135.00
7	4	93.47	144.18	216.47	158.68	9.01	20.00	121.00
8	3	92.44	155.37	218.18	174.36	14.20	15.00	143.00
9	4	97.57	169.92	224.06	189.33	12.66	20.00	170.00
10	4	95.55	154.79	238.68	159.67	11.39	20.00	153.00
11	4	100.06	173.58	270.70	185.58	18.32	20.00	246.00
12	3	81.40	131.30	206.11	142.18	8.74	15.00	88.00
13	4	90.22	159.92	274.35	155.61	11.84	20.00	159.00
14	5	86.56	146.51	250.42	151.84	11.92	15.00	120.00
15	3	80.18	141.38	290.88	137.14	13.70	15.00	138.00
16	4	83.48	142.39	246.84	150.10	13.18	20.00	177.00
17	4	116.06	193.80	348.45	201.58	11.99	20.00	161.00
18	3	80.92	119.40	159.91	140.64	19.96	15.00	201.00
19	4	84.27	144.57	270.51	148.54	23.23	20.00	312.00
20	4	83.29	140.55	267.54	150.50	20.75	15.00	209.00
21	4	88.96	159.63	267.27	163.73	19.88	20.00	267.00
22	4	76.04	128.97	249.15	136.14	23.31	20.00	313.00
23	4	81.30	178.05	222.51	172.81	10.95	20.00	147.00
24	4	90.58	166.07	289.22	161.18	23.46	20.00	315.00
25	4	91.21	190.02	304.10	176.72	23.38	20.00	314.00
26	3	86.26	154.78	308.78	152.97	28.30	15.00	285.00
27	4	112.09	190.72	352.80	200.34	30.23	20.00	406.00
28	4	72.95	122.47	202.41	136.66	38.58	20.00	518.00
29	3	86.39	147.29	332.85	153.34	24.92	15.00	251.00
30	4	90.28	160.23	265.29	160.50	45.87	20.00	616.00
31	4	87.11	168.20	276.76	160.00	37.23	20.00	500.00
32	4	90.10	150.68	288.48	157.69	48.85	20.00	656.00
33	3	103.39	209.50	408.71	163.67	12.41	15.00	125.00
34	3	114.63	206.90	308.92	209.50	20.85	15.00	210.00
35	3	94.66	195.70	310.37	171.37	24.72	15.00	249.00
36	4	102.19	156.01	229.71	177.60	30.83	20.00	414.00
37	4	94.45	154.03	221.46	170.50	48.18	20.00	647.00
38	4	102.30	169.95	271.58	183.78	33.44	20.00	449.00
39	4	83.93	157.93	259.62	153.40	37.98	20.00	510.00

	40	4	91.08	214.78	299.84	156.25	17.87	20.00	240.00
	41	4	80.01	136.72	278.67	136.87	21.37	20.00	287.00
	42	3	96.15	182.53	294.91	157.35	20.06	15.00	202.00
	43	4	91.52	159.43	263.49	159.39	22.19	20.00	298.00
	44	4	92.05	159.65	273.86	157.00	32.17	20.00	432.00
	45	3	89.18	143.46	215.47	155.11	46.77	15.00	471.00
	46	4	85.23	143.29	223.11	151.67	34.11	20.00	458.00
	47	4	85.08	150.72	282.28	151.24	23.01	20.00	309.00
	48	3	93.35	162.31	280.25	168.04	39.82	15.00	401.00
	49	3	86.94	157.77	271.56	150.12	19.76	15.00	199.00
	50	4	89.80	159.62	278.63	156.58	36.49	20.00	490.00
	51	3	83.35	149.68	278.72	148.85	23.63	15.00	238.00
	52	4	90.24	211.39	378.54	158.74	16.90	20.00	227.00
	53	3	126.48	193.46	284.84	212.55	12.21	15.00	123.00
	54	4	83.67	166.05	246.31	151.11	13.11	20.00	176.00
	55	4	82.36	179.39	281.37	162.00	29.79	20.00	400.00
	56	4	101.46	230.82	319.43	187.72	11.77	20.00	158.00
	57	4	103.04	177.37	294.64	177.84	24.12	20.00	310.00
	58	4	105.41	173.72	269.92	159.22	24.04	20.00	309.00
	59	4	106.74	167.01	285.52	170.21	44.19	20.00	568.00
	60	3	105.60	164.38	300.16	162.36	40.46	15.00	390.00
	61	3	97.64	150.63	258.93	158.11	49.80	15.00	480.00
)TAL	61	222	5677.92	10075.80	16555.94	10085.28	1438.43	1105.00	17546.00
MEAN		3.64	93.08	165.18	271.41	165.33	23.58	18.11	287.64

TABLE 5. SUMMARY OF PRE- AND POST-SPRAY SAMPLING BY TREE SPECIES AND TREATMENT

	SPECIES	NO. TREES	AVERAGE NO. OF LIVE BUDWORMS PRE-SPRAY PER BRANCH TIP	AVERAGE NO. OF LIVE BUDWORMS PRE-SPRAY PER 100 BUDS	AVERAGE NO. OF LIVE BUDWORMS POST-SPRAY PER BRANCH TIP	AVERAGE NO. OF LIVE BUDWORMS POST-SPRAY PER 100 BUDS	AVERAGE NO. OF BUDS/SHOOTS PRE-SPRAY	AVERAGE NO. OF BUDS/SHOOTS POST-SPRAY	DROPS CM^2
CHECK	TF	30	7.92	8.43	3.80	4.41	106.60	101.04	
SPRAY	TF	30	12.82	13.99	1.12	1.40	103.32	94.85	21.75
CHECK	DF	31	11.53	12.65	5.61	6.61	99.89	88.36	
SPRAY	DF	31	12.16	14.26	1.87	2.31	102.79	94.62	16.11

FIGURE 1. LOCATION OF PLOT TREES BY SPECIES AND SPRAY DEPOSIT SUMMARY ON SPRAY PLOT