

Field Test of Bacillus thuringiensis Against
the Western Spruce Budworm in 1987

(A Progress Report)

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INTRODUCTION

The microbial, Bacillus thuringiensis Berliner (BT), is frequently the pesticide used in forest spraying because of its host selectivity, its high degree of environmental safety and general public acceptance. Success in the past has been varied; however, new formulations have increased the efficacy of the microbial making it practical to use against specific forest defoliators. The aerial application of undiluted BT in low volume sprays has had some success in eastern North America against the spruce budworm, Choristoneura fumiferana (Clemens). The undiluted application, however, has not been adequately tested under western conditions against the western spruce budworm, C. occidentalis Freeman. The general weather patterns, topography, and stand characteristics are completely different from those in the East; therefore, undiluted materials must be tested before general operational use.

OBJECTIVE

The primary objective was two-fold; (1) To compare the efficacy of a commercial formulation of BT at two different dosages and, (2) To compare a diluted formulation against an undiluted one (Neat) at the higher dosage.

METHODS

The field evaluation was a cooperative effort between Forest Pest Management, R-6, and Research Work Unit 4502 of the Pacific Northwest Research Station. The research study was conducted entirely on the Burns Ranger District, Malheur National Forest in eastern Oregon. The study site was located in the vicinity of King Mountain about 30 km northeast of Burns, OR.

Twelve 16-hectare plots were selected within the area to be included in the BT evaluation (Fig. 1). A buffer strip of at least 0.33 km separated each plot. The general elevation of the plots was between 1524 m and 1829 m. The plots contained primarily grand fir, Abies grandis (Dougl.) Lindl. with Douglas-fir, Pseudotsuga menziesii (Mirb.) Franco at the lower elevations. A scattered overstory of tall ponderosa pine, Pinus ponderosa Dougl. ex Loud., was common throughout the test sites.

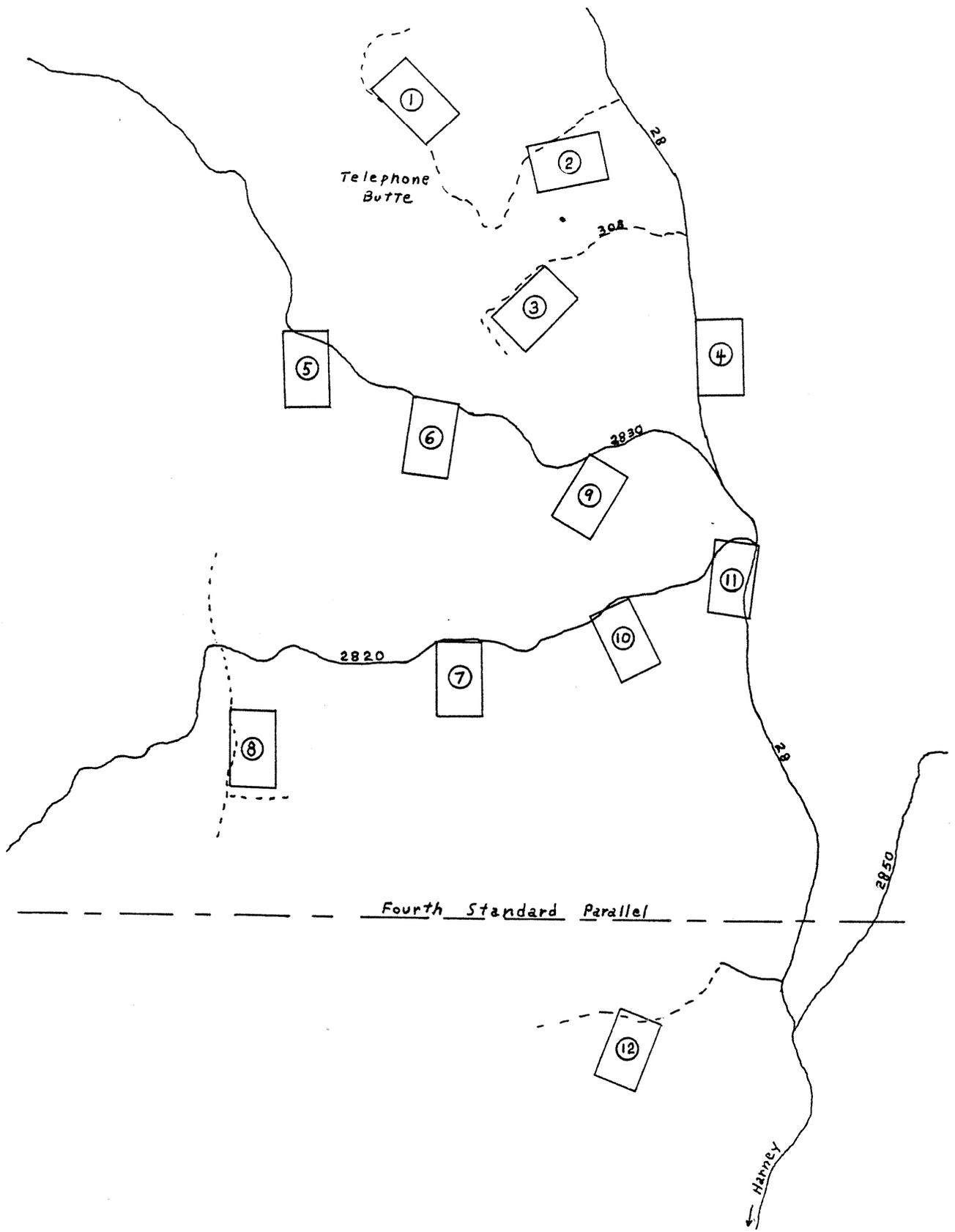


Fig. 1. Plot locations for the 1987 BT test, Burns Ranger District, Malheur National Forest, Oregon

The sites varied from flat benches to fairly steep slopes and were often relatively open to allow thorough spray coverage and facilitate sampling. Some of the areas had been previously logged, leaving much of the slash on the ground. The 12 test plots were laid out in 3 blocks; each block consisted of a randomized selection of all treatments and a check. A single block was treated on any one day so that all treatments were under the same general weather conditions (Table 1). The diluted spray was applied at 7.0 liters per hectare; the undiluted material was applied at 3.1 liters per hectare. The BT used was Dipel 6L containing "Day-Glo" which allowed seeing spray deposit on detection cards.

A Hiller-Saloy turbo helicopter equipped with four Beecomist rotary atomizers on a standard spray boom was used to apply the test materials. Prior to spraying, the helicopter was calibrated to meet the following parameters: swath width--25+ meters; Air Speed--100 kilometers per hour; VMD--100 - 150 microns. Flight altitude would be 16 m above the forest canopy for safety; this often put the altitude much higher than the target trees because of the large ponderosa pines in the stands.

The spray application began after the new shoots had expanded sufficiently for adequate impingement of the spray droplets. At the time of spraying, most of the larvae were 4th - 6th with a few in the 3rd instar. Block 1 was sprayed on June 16; Block 2 on June 19; and, Block 3 on June 20. Temperatures were about 1°, 5°, and 9°C for Blocks 1, 2, and 3 respectively; humidity was generally above 80%. Adverse weather delayed the start of the test and interrupted the sequence between Blocks 1 and 2. Kromekote cards were laid in a line perpendicular to the intended spray on the morning of the spray application. In addition, cards were placed on two sides of each of fifteen tagged trees that would be used for the foliage bioassay.

Sampling : Foliage samples were obtained from 30 trees per plot within 72 hours before spraying and 14 days after spray application to determine population reduction. One 45-cm branch per tree was used in the prespray sample; two branches per tree was used for the postspray sample because of normal population reduction and the effect of the treatment. All western spruce budworm larvae were counted and removed over drop-cloths in the field. One hundred larvae per plot were collected and reared in individual petri dishes to determine mortality factors. Foliage samples were also taken immediately after spraying from 15 tagged trees per plot. They were placed in paper bags and returned to the laboratory where they were kept in cold storage for eventual needle washings to determine deposition by BT.

Foliage Bioassay: Small branch samples were obtained from each of fifteen permanently tagged trees at periodic intervals (.25-, 1-, 3-, 5-, 7-, and 14-days) to determine persistence of the test materials. The new growth was placed in small cups and fed to clean laboratory stock for seven days to determine mortality due to BT. All dead larvae were examined by a compound microscope to confirm the presence of the bacillus.

Spore Counts: Viable spore counts were made from the needle washings by using a standard technique. Twenty needles per tree (5-trees per plot) were washed in distilled water that had been autoclaved to kill all bacteria. The washings were diluted 10^6 ; 1 ml of the dilutant was added to 10 mls of Tryptic Soy Agar which was allowed to cool and stand inverted for 48 hours. The washings were made in triplicate to get an average per tree. The BT colonies were counted by using a Spencer A/O Grid Counter.

RESULTS

The mean number of living western spruce budworm larvae collected during the pre and 14-day postspray sample are shown in Table 2. Although there was a general reduction following spray, none of the treatments reduced the population below the one larva per branch that was considered successful by FPM-Region 6.

The foliage bioassay also produced poor results in that the greatest percent mortality at 0-hour was only 31.7 using the diluted material at 40 BIU's/ha (Table 3). The mortality decreased over time similar to that found by Beckwith and Stelzer (1987). This indicates very poor coverage as verified by the percentage of cups that produced no mortality (Table 3, in parentheses) by BT.

A total of 2252 western spruce budworm larvae were individually reared on a standard artificial diet to determine general mortality factors. Mortality attributed to BT was 0 in all the prespray collections and from the postspray untreated check plots (Table 4). The postspray collections from the treated plots contained low BT mortality indicating that the applications were not successful. The hymenopterous parasitoids were about normal for budworm populations with the early larval parasitoids Apanteles fumiferanae Viereck and Glypta fumiferanae (Viereck) being the most prevalent. The dipterous parasitoids were more common in the postspray collections because earlier collections were made before the normal attack period of the adult flies.

The number of viable BT colonies obtained by washing the needles in the laboratory varied from a mean of 4.1 for the undiluted application to 16.4 at the 40 BIU/ha application of diluted spray (Table 5). The percentage of plates containing no BT colonies was high showing lack of proper impingement on the foliage and/or poor spore viability.

CONCLUSIONS

The 1987 experimental spraying produced poor results as far as meeting the objectives of the field test. The major problem appeared to be the lack of proper coverage and impingement of the spray droplets on the target foliage. The low mortality caused by BT at 0-hour of the foliage bioassay (Table 3) shows the lack of proper coverage. Some cups produced 100% mortality; however, many cups had 100% survival of the larvae showing that no BT was present on the new growth in those cups.

The Dipel 6L gave problems in the undiluted dosage especially at the low temperatures experienced in the early morning hours when the humidity and wind conditions were right for spraying. The undiluted material was loaded into the aircraft the night before the first-days spray to save time in the early morning. This was a mistake as the temperature dropped quite low (.5°C at 0430 hours) that night. The aircraft had difficulty in forcing the material through the system in a trial run requiring drainage of the entire boom and spray pump. In draining, the formulation formed small piles rather than flowing out level as would be expected of a liquid. Possibly using an aircraft equipped with a gear-driven pump would help alleviate the problem of getting the material through the system.

The helicopter pilot also said that the fine droplets appeared to "hang in the air" the first two days of spray application. Western weather patterns can cause inversions which would produce conditions that tend to prevent fine droplets from hitting the target. The rapid change in relative humidity accompanied by convection currents is quite common in eastern Oregon.

ACKNOWLEDGEMENTS

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APPENDIX

Table 1. Description and treatment of 16 hectare plots near King Mountain on the Malheur National Forest, 1987.

Plot No.	Location			Elevation (m)	Treatment	Dosage (BIU/Ha)	Spray Date
	T (S)	R (E)	S				
1	20	32	13	1786	Undiluted	40	6/16/87
2	20	33	18	1652	Check	--	--
3	20	32/33	24/19	1737	Diluted	40	6/16/87
4	20	33	19	1664	Diluted	30	6/16/87
5	20	32	24	1768	Check	--	--
6	20	32	24	1786	Diluted	40	6/19/87
7	20	32	25/36	1768	Diluted	30	6/19/87
8	20	32	35	1798	Undiluted	40	6/19/87
9	20	33	19/30	1682	Diluted	40	6/20/87
10	20	33	30	1707	Diluted	30	6/20/87
11	20	33	29/30	1670	Check	--	--
12	21	32.5	5/6	1725	Undiluted	40	6/20/87

Table 2. Number of western spruce budworm larvae per branch during population sampling before and after spraying with Bacillus thuringiensis.

30 BIU		40 BIU		"Neat"		Untreated Check	
Pre	Post	Pre	Post	Pre	Post	Pre	Post
4.6	3.1	4.2	2.8	8.5	3.1	6.1	6.9
7.1	3.8	3.5	3.8	5.6	4.1	5.8	5.6
7.1	2.4	3.7	2.4	10.1	3.5	4.5	3.5
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* 6.2	3.1	3.8	3.0	8.1	3.6	5.5	5.4

* Mean of 3 Plots (90 branches)

Table 3. Mean percent kill obtained from foliage bioassay at six time-intervals after spray application with Bacillus thuringiensis.

Interval	30 BIU	40 BIU	Neat ¹	Untreated Check
0-hr	21.2 (42) ²	31.7 (18)	25.5 (27)	0.0 (100)
1-day	22.8 (29)	22.9 (31)	23.6 (29)	0.0 (100)
3-day	12.3 (56)	17.5 (42)	10.4 (56)	0.0 (100)
5-day	8.0 (69)	16.5 (47)	10.3 (71)	0.0 (100)
7-day	6.1 (76)	11.4 (62)	6.3 (82)	0.0 (100)
14-day	1.4 (93)	5.6 (84)	1.4 (98)	0.0 (100)

¹ Applied at 40 BIUs per hectare

² Number in () represents the % of 0s in a 15-tree sample; one branch per tree.

Table 4. Survival and percent mortality in rearings of western spruce budworm larvae collected before and after aerial application of B. t.

Treatment	Total Reared	Adults	MORTALITY FACTORS			
			Hymenop. Par.	Diptera	<u>B. t.</u>	Other
NEAT	296 ¹	188 (64) ²	87 (29)	1 (<1)	0	20 (7)
PRE- SPRAY						
40 BIU	294	159 (54)	99 (34)	0	0	36 (12)
30 BIU	296	174 (59)	90 (30)	1 (<1)	0	31 (10)
CHECK	292	165 (56)	82 (28)	2 (1)	0	43 (15)
POST SPRAY						
NEAT	275	117 (43)	105 (38)	15 (5)	7 (3)	31 (11)
40 BIU	223	115 (52)	71 (32)	16 (7)	5 (2)	16 (7)
30 BIU	294	133 (45)	90 (31)	35 (12)	3 (1)	33 (11)
CHECK	282	126 (45)	88 (31)	48 (17)	0	19 (7)

¹ Numbers

² Percent rounded to whole number

Table 5. Bacillus thuringiensis colony count¹ obtained from branch samples collected immediately after spraying².

Treatment	Mean Number ₃ of Colonies ³	Standard Error of Mean
NEAT	4.1 (64) ⁴	1.84
40 BIU	16.3 (29)	4.90
30 BIU	6.6 (42)	2.01

1 10² dilution

2 33% sample of 15 trees per plot; washing of 20 needles per branch

3 Spore count per needle obtained by multiplying by 100

4 Percent of plate counts showing no BT colonies.