TREATMENT EFFECTS THREE YEARS FOLLOWING A B.T. APPLICATION TO CONTROL WESTERN SPRUCE BUDWORM

by

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INTRODUCTION

During 1981, Cooperative Forestry and Pest Management conducted a pilot control project using Bacillus thuringiensis Berliner (B.t.) against western spruce budworm near Butte, Montana. Peformance data was obtained for two registered B.t. formulations applied at 8 billion international units (BIU) per acre for the year of application and 1 year following (1982). These results, which show significant treatment effects over 1 year later, are reported by Stipe and others (1983). Except for the larval rearing work conducted during 1982, data collected in 1983 were the same as in 1982. The 1983 samples were taken from the trees established during the initial project in 1981. The objective in 1983 was to determine if treatment effects of an 8 BIU application of B.t. would continue past the second year.

PROJECT AREA AND DESIGN

The 1981 project was conducted in western spruce budworm infested stands of Douglas-fir on portions of the Deerlodge and Beaverhead National Forests and adjacent Bureau of Land Management, State of Montana, and private lands. Block locations are shown in Appendix A. Block size, elevation and treatment are given in Table 1. Within each block 25 three-tree cluster plots were selected. Sample trees within each cluster were open-grown Douglas-fir, 35 to 60 feet tall with full crowns. Four branch samples were cut for each collection. In 1981, a single aerial application of Dipel 4L and Thuricide 16B was applied at 8 BIU per acre.

Table 1.--Size, elevation, and treatment for project blocks near Butte, Montana, 1983.

Block	Acres	Hectares	Elevation (ft)	Treatment
Grouse	2,400	972	5,785	Dipel 4L
Bald	2,000	810	5,860	Dipel 4L
Jimmie	4,200	1,701	6,590	Dipel 4L
Spire	3,650	1,478	5,920	Thuricide 16B
Coyote	2,500	1,013	6,062	Thuricide 16B
Whiskey	2,000	810	5,720	Thuricide 16B
Fish	2,000	810	6,490	Control
Divide	4,000	1,620	6,440	Control
Jerry	2,000	810	6,440	Control

SAMPLING

Sampling techniques and procedures during 1983 were in most cases the same as in 1981 and 1982. Data collected during 1983 were: budworm and other larval population density (number per 100 shoots), defoliation (percent) on 18-inch branch tip, and egg mass and egg density (number per square meter of foliage) on 30-inch branch. Four clusters were not sampled in 1983 because of fire damage. As in 1982, larvae were collected to coincide with larval development during the 1981 prespray sample. Blocks were sampled in the same sequence in which released for treatment in 1981. Larvae from the 1983 sample were removed from the foliage in the field using a portable beating apparatus, and not in the laboratory as in 1981. The number of expanding shoots were recorded

by branch tip and later used to calculate population density per 100 shoots. Larval specimens were placed in alcohol and returned to the laboratory for identification and counting. Larval rearing was not done in 1983.

Current defoliation estimates were made from 18-inch tips from four 30-inch branches per tree. From each tip, 25 new shoots were rated using the following 6-class system:

Class	Defoliation (percent)
0	0
1	>0-25
2	26-50
3	51-75
4	76-99
5	>99

Two of the four defoliation branches were bagged amd returned to the laboratory for egg mass and egg counts. Foliage examination was done using ultraviolet light (Acciavatti and Jennings 1976). Branch length and width were recorded and used to calculate foliage area. The egg mass width (number of rows) and length relationship to the number of eggs per mass developed by Washburn and Brickell was used to calculate eggs per square meter of foliage.

DATA ANALYSIS

Within each treatment, spray blocks were established as the primary sampling unit. Samples from 25 three-tree cluster points were used to calculate block means. Analyses of covariance were used to test for differences between treatments. The covariate used for each sample follows:

Sample	Covariate
Budworm larvae	1981 prespray budworm
Other larvae	1981 prespray other
Combined larvae	1981 prespray combined
Defoliation	1983 combined larvae
Egg masses	1982 budworm only
Number of eggs	1982 budworm only

RESULTS

Larval Population Density

Morphological characteristics were used to separate budworm larvae by instar. Other larvae were not counted by instar or separated by species. Budworm development for the 1983 collection was 25.0 percent second instar, 35.8 percent third instar, 35.6 percent fourth instar, 3.5 percent fifth instar, and 0.1 percent sixth instar. Larval population density per 100 shoots for budworm, other, and combined are summarized by block and treatment in Table 2. Analysis of covariance for larval population densities 3 years following treatment show no differences in any of the larval data (Appendix B).

Table 2.--Larval population density per 100 shoots for budworm, other, and combined near Butte, Montana, 1983.

Treatment/Block	Number per 100 shoots		
	Budworm	Other	Combined
Dipel			
Grouse	3.41	1.68	5.09
Bald	10.27	7.69	17.97
Jimmie	17.95	9.76	27.71
Mean	10.54	6.38	16.92
Thuricide			
Spire	5.61	3.33	8.94
Coyote	8.95	9.36	18.31
Whiskey	7.49	7.36	14.85
Mean	7.35	6.68	14.03
Control			
Fish	14.02	10.09	24.12
Divide	18.22	8.45	26.67
Jerry	16.83	4.51	21.34
Mean	16.36	7.68	24.04

Defoliation

Percent defoliation following adult emergence by treatment and block are listed in Table 3. An analysis of covariance for defoliation shows no differences between treatments (Appendix C).

Table 3.--Percent defoliation near Butte, Montana, 1983.

Block	% Defoliation	Block	% Defoliation	Block	% Defoliation
Dipel 4L		Thuricide 16B		Control	
Grouse	45.12	Spire	53.52	Fish	84.52
Bald	71.31	Coyote	71.41	Divide	91.52
Jimmie	86.95	Whiskey	65.75	Jerry	90.23
Mean	67.79	Mean	63.56	Mean	88.76

Egg Masses and Egg Density

Egg masses and number of eggs per square meter are reported in Table 4. Analysis of covariance showed no differences between treatments (Appendix D).

Table 4.--Egg masses and number of eggs per square meter near Butte, Montana, 1983.

Treatment/Block	Number per square meter	
	Egg Masses	Eggs
Dipel		
Grouse	27.19	1,371
Bald	37.74	1,894
Jimmie	25.37	1,232
Mean	30.10	1,499
Thuricide		
Spire	36.94	1,977
Coyote	34.81	1,780
Whiskey	25.83	1,261
Mean	32.53	1,673
Control		
Fish	55.27	2,750
Divide	30.13	1,427
Jerry	26.55	1,243
Mean	37.32	1,806

Data Summary for 1981, 1981, and 1983

Treatment means for all data collected during 1981, 1982, and 1983 are summarized in Table 5. Significant differences are denoted by different lower case letters (a, b).

CONCLUSIONS AND RECOMMENDATIONS

Treatment effects on population reduction following the 1981 application were as expected but below the mid 90 percent range characteristic of chemical pesticides. Adjusted mortality for Dipel and Thuricide were 79 and 91 percent, respectively. All other data except egg masses and number of eggs followed the same pattern and were significantly different following the first year. No differences were found between Dipel and Thuricide. The nonsignificant difference in egg densities might suggest that moth flights occurred from adjacent areas overcame any treatment effects. Budworm densities were not different in 1982, but defoliation differences continued. By 1983, all treatment effects were absent. At the .10 probability level all data analyses were not significant. Even though the initial response was good, these changes were of short duration (1981 and 1982). Block size (2,000-4,200 acres) was apparently too small to achieve differences in egg densities at the end of the treatment year when surrounding stands are infested. Although growth response was not measured, radial and height growth effects might go beyond the third year due to the delayed response associated with it.

Table 5-- Bt. Project treatment means for 1981, 1982, and 1983.

	1981[1]			1982[1]			1983[1]		
	Dipel	Thuricide	Control	Dipel	Thuricide	Control	Dipel	Thuricide	Control
Prespray population per 100 shoots									
Budworm	7.8a	7.8a	9.5a	4.3a	3.5a	12.6a	10.5a	7.3a	16.3a
Other[2]	3.9a	5.8a	3.2a	2.6a	4.3b	4.4b	6.3a	6.6a	7.6a
Combined[2]	11.8a	13.7a	12.9a	7.0a	7.8a	17.0b	16.9a	14.0a	24.0a
7-Day Post population per 100 shoots									
Budworm	5.2a	4.7a	10.3b						
Other	3.0a	3.6a	4.1b						
Combined	8.3ab	8.3a	14.4b						
14-Day Post population per 100 shoots									
Budworm	4.9a	3.9a	10.5b						
Other	2.5a	2.9a	5.1a						
Combined	7.4a	6.8a	15.6b						
21-Day Post population per 100 shoots									
Budworm	4.0a	3.0a	7.0b						
Other	1.9a	2.0a	4.4b						
Combined	6.0a	5.0a	11.5b						
Larval Parasitism									
Percent[3]	21.5a	19.8a	26.0a	5.1a	8.6a	7.3ab			
Rearing Survival									
Percent	22.3a	15.4a	53.6b						
Residual Population per									
100 shoots	1.3a	0.8a	6.2b						
Defoliation									
Percent	29.8a	36.9a	47.0b	28.9a	29.2a	67.8b	67.7a	63.5a	88.7a
Egg Masses per									
Sq. Meter	18.3a	17.6a	38.5a	44.5a	39.7a	78.6a	30.1a	32.5a	37.3a
Number Eggs per									
Sq. Meter	583a	577a	1708a	2120a	1959a	4374a	1499a	1673a	1806a
Female Pupae %				60.0a	59.3a	47.4b			
Pupal Wt. mg				121a	113a	126a			
Female Adults %				61.4a	62.0a	52.4b			

[1] Treatment means followed by the same letter (a) are not significantly different (probability at least .10 or better). This notation does not apply between years.

[2] 1982 means for other and combined are revised.

[3] 1981 data are for combined larvae; 1982 data are only for budworm larvae.

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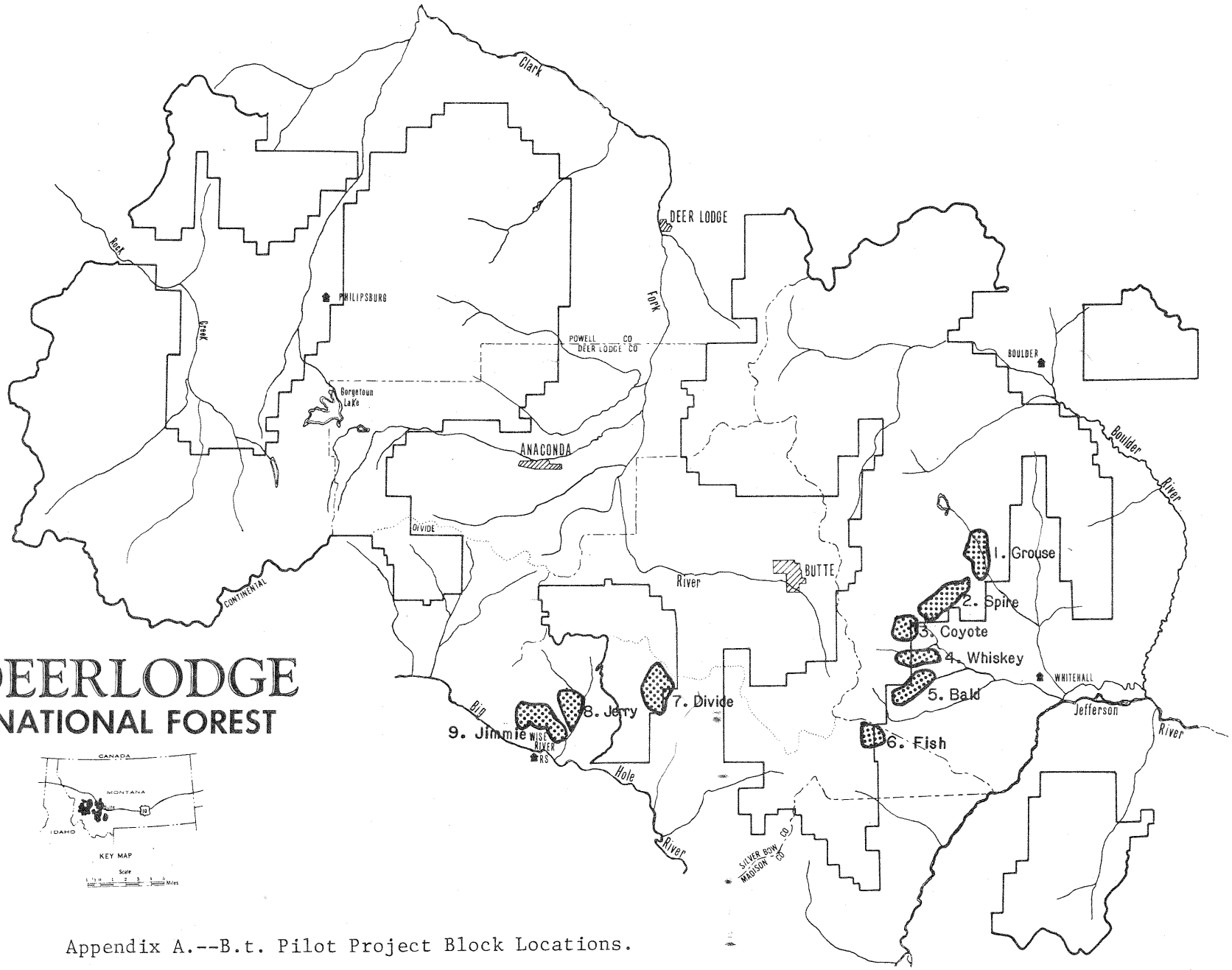
APPENDIX



Appendix A.--B.t. Pilot Project Block Locations.

Appendix B.--Analyses of covariance on larval density for budworm, other, and combined larvae, 1983.

	Df	SS	MS	F	P
BUDWORM					
Total	8	245.69			
Bet. trt.	2	96.52	48.26	2.25	> .10
Within	5	107.48	21.50		
Covariate	1	41.69			

Dipel a Thuricide a Control a

OTHER					
Total	8	73.35			
Bet. trt.	2	2.03	1.01	0.07	> .10
Within	5	69.58	13.92		
Covariate	1	1.74			

Dipel a Thuricide a Control a

COMBINED					
Total	8	475.83			
Bet. trt.	2	159.62	79.81	1.26	> .10
Within	5	316.21	63.24		
Covariate	1	00			

Dipel a Thuricide a Control a

Note: Treatments followed by the same letter (a) are not significantly different.

Appendix C.--Analysis of covariance on percent defoliation, 1983.

	Df	SS	MS	F	P
Total	8	2180.66			
Bet. trt.	2	85.88	42.94	3.11	> .10
Within	5	69.10	13.82		
Covariate	1	2025.68			

Dipel	a	Thuricide	a	Control	a

Note: Treatments followed by the same letter (a) are not significantly different.

Appendix D.--Analysis of covariance on egg masses and number of eggs per square meter of foliage, 1983.

	Df	SS	MS	F	P
EGG MASSES					
Total	8	729.55			
Bet. trt.	2	212.42	106.21	1.04	> .10
Within	5	509.28	101.86		
Covariate	1	11.85			

Dipel a Thuricide a Control a

NUMBER OF EGGS					
Total	8	2,012,081			
Bet. trt.	2	469,887	234,943	0.79	> .10
Within	5	1,481,918	296,383		
Covariate	1	60,275			

Dipel a Thuricide a Control a

Note: Treatments followed by the same letter (a) are not significantly different.