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WESTERN SPRUCE BUDWORM SUPPRESSION PROJECT USING *BACILLUS THURINGIENSIS* Berliner--1985

Carson National Forest
New Mexico

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ABSTRACT

In 1985, personnel from Forest Pest Management and the Carson National Forest conducted a western spruce budworm suppression project on selected areas of the Questa and Taos Ranger Districts and adjoining private ownerships. About 15,420 acres of Forest Service and private lands were aerially sprayed with the biological insecticide, Bacillus thuringiensis (Thuricide 48 LV). The project area was divided into five spray blocks. The Red River Canyon, Bobcat Pass, and Taos Ski Area spray blocks were located on the Questa Ranger District and Osha Mountain and Palo Flechado Pass spray blocks on the Taos Ranger District. Pre-suppression western spruce budworm larval population densities averaged 16.6 and 14.8 larvae per 100 buds on the Red River Canyon and Bobcat Pass spray blocks and 7.3 and 13.5 larvae per 100 buds on the Osha Mountain and Palo Flechado Pass spray blocks. The Taos Ski Area spray block was not sampled because of its steep, hazardous terrain.

Post-suppression western spruce budworm larval population densities were significantly lower on all the spray blocks 21-days after treatment. Larval densities averaged 4.7 and 7.7 on the Red River Canyon and Bobcat Pass spray blocks and 3.5 and 2.4 larvae per 100 buds on the Osha Mountain and Palo Flechado Pass spray blocks. Because of spray deposition problems and poor weather conditions encountered during this project, we hypothesize these decreases were due primarily to natural causes such as predators, parasites, and disease, etc., rather than a result of the spraying.

Defoliation averaged 60.0 and 73.8 percent on the Red River Canyon and Bobcat Pass spray blocks and 46.3 and 39.4 on the Osha Mountain and Palo Flechado spray blocks. These results are not significantly different from the control blocks which averaged 67.6 and 50.5 percent, respectively.

Egg mass densities per meter square of foliage averaged 6.0 and 8.5 on the Red River Canyon spray blocks and 10.9 and 8.4 on the Osha Mountain and Palo Flechado spray blocks. These results were similar to the controls that averaged 9.5 on the Questa Ranger District and 12.4 on the Taos Ranger District.

INTRODUCTION

In 1985, Forest Pest Management (FPM) in cooperation with the Carson National Forest (CNF), New Mexico Department of Natural Resources, Forestry Division, and the New Mexico Department of Agriculture, conducted a western spruce budworm (WSB) suppression project on selected areas of the Questa and Taos Ranger Districts (RD), Angel Fire Corporation Lands, and adjoining private ownerships in northern New Mexico. Approximately 23,230 acres of WSB-infested host types were sprayed with the biological insecticide Bacillus thuringiensis (B.t.). Of these total acres, about 15,420 acres of the CNF and adjoining lands were treated with Thuricide 48 LV (Federal lands) and 7,900 acres of Angel Fire Corporation and adjoining private ownerships were treated with Dipel 6L (Abbott Laboratories).

The purpose of this report is to document the objectives, operational aspects, sampling procedures and results of the 1985 WSB suppression project conducted on the CNF and adjoining private lands. The results of the treatments conducted on Angel Fire Corporation lands and adjoining private ownerships were previously issued by the New Mexico Department of Agriculture in December of 1985 (Johnson and Smith, 1985).

HISTORY OF THE OUTBREAK

Western spruce budworm defoliation was first sighted in lower Red River Canyon (Questa RD) and the Rio Fernando de Taos (Taos RD) drainage in 1976; the Cabresto and Rio Hondo drainages (Questa RD) in 1977; and the upper Red River Canyon and Moreno Valley and Angel Fire area (Taos RD) in 1980. Defoliation damages were particularly severe along the steep slopes and side drainages of lower Red River Canyon and in Rio Hondo Canyon.

Selected areas of the mixed conifer type on the Questa RD and adjoining private ownerships of Red River were treated with insecticides in 1981 and 1982. About 650 acres of the Bitter Creek drainage were aerially sprayed with B.t. in 1981. In 1982, 1,614 acres along Bobcat Pass and 32,594 acres of private lands in the Moreno Valley were aerially sprayed with a combination of B.t. and Sevin-4-Oil (carbaryl).

OBJECTIVES

Project objectives were to: (1) Reduce WSB population to five or fewer larvae per 100 buds, and (2) reduce WSB-caused defoliation damages along the Red River and Angel Fire visual corridors.

PROJECT ADMINISTRATION AND ORGANIZATION

This project was administered by the CNF, New Mexico Department of Agriculture, New Mexico State Department of Natural Resources, Forestry Division, and Forest Pest Management, Southwestern Region (Figure 1, Appendix). Project Directors, their staffs, and field crew along with air and ground support groups were headquartered at the Angel Fire Airport, Angel Fire, New Mexico.

DESCRIPTION OF PROJECT AREA

The project area consisted of 5 treatment units totaling 15,420 acres. The Red River Canyon, Bobcat Pass, and the Taos Ski Area spray blocks were on the Questa RD and Osha Mountain and Palo Flechado Pass spray blocks on the Taos RD (Figures 2 & 3, Appendix). Total acres treated on each spray block and the dates they were sprayed are summarized in Table 1, Appendix. Treatment effects were not monitored on the Taos Ski Area spray block because of the steep, hazardous terrain.

The Red River Canyon, Bobcat Pass, and the Taos Ski Area spray blocks were characterized by very steep slopes and side drainages. Forest stand conditions within these spray blocks were varied consisting of mature and overmature mixed conifer on the middle and foreground retention areas to spruce and true firs at the higher elevations. Stand structure consisted mostly of shade tolerant host species, high stocking levels, and poor site conditions. The Palo Flechado Pass and Osha Mountain spray blocks were on slopes of less than 40 percent and consisted predominantly of mature and overmature multi-storied stands of ponderosa pine, Douglas-fir, true firs and spruce.

TIMING OF SPRAY APPLICATION

Timing of insecticide application was based on host tree foliage and WSB larval development. Spray blocks were released for treatment when 75 percent or more of the foliage shoots on Douglas-fir were flushed (foliage needles fully extended) and 50 percent of the larvae were in the third, fourth, and fifth instars (Table 2, Appendix).

MONITORING EFFECTIVENESS OF INSECTICIDE TREATMENTS

The effectiveness of the insecticide applications was measured by comparing: (1) Pre- and post-suppression larval densities sampled 21 days after treatment, (2) defoliation damages on sprayed versus non-sprayed units, and (3) egg mass densities on the sprayed versus non-sprayed units.

Pre-Suppression Versus Post-Suppression Larval Population Densities.

Western spruce budworm larval population densities on each spray block were sampled 24 to 48 hours before aerial insecticide treatment and again 21 days after treatment. The sampling design consisted of plots, each of which consisted of a three tree cluster of Douglas-fir trees averaging 30 to 50 feet in height. Plots were established along accessible road systems about 0.1 to 0.2 miles apart. Sample trees per cluster were usually within a one acre radius. Pre-suppression larval population estimates were measured by sampling two 45-cm branch tips per tree per cluster. Post-suppression larval densities were measured by sampling four 45-cm branch tips per three tree per cluster.

The plot was the primary sampling unit. Plot means were computed by averaging the larvae collected per 100 buds for each branch tip sampled and then averaging the number of larvae per 100 buds per three tree cluster. Larval means and standard errors were then calculated.

No control blocks were set up for pre- or post-suppression larval sampling.

Defoliation Damages

In late July and early August defoliation measurements were obtained from the spray blocks and two control blocks (see Figures 2 and 3). Sampling design consisted of taking two 45-cm branches cut from the mid-crowns of 3 trees sampled per plot. Twenty-five live shoots on each sample branch were then rated for defoliation (needle loss) according to the following 6-class defoliation rating system.

Rating	Percent Defoliation
0	0
1	1 - 25
2	26 - 50
3	51 - 75
4	76 - 99
5	100

Defoliation was estimated on a per cluster basis as described below:

At the branch:

$$DEF_{i,j,k} = [N^0 (0) + N^1 (12.5) + N^2 (37.5) + N^3 (62.5) + N^4 (87.5) + N^5 (100)] / [N^0 + N^1 + N^2 + N^3 + N^4 + N^5]$$

At the tree level:

$$DEF_{i,j} = \sum_{k=1}^{2} DEF_{i,j,k}/2$$

At the cluster level:

$$DEF_{i} = \sum_{j=1}^{3} DEF_{i,j}/3$$

Where: i = cluster i = 1,25
j = # of trees j = 1,3
k = # of branches k = 1,2

Egg Mass Densities

Egg mass densities were collected from the same branches rated for defoliation. Each branch rated for defoliation (two branches per tree, three trees per plot) was placed in a large plastic bag (two branches per bag, three bags per plot) along with a plot tag identifying the sample unit and plot number. These branches were taken to the laboratory where they were stored in a cooler until they could be examined.

In the laboratory, the length and width of the branches were measured in centimeters and then examined under ultraviolet light and the absence or presence of egg masses recorded. Needles with WSB egg masses were classed according to current and previous year's foliage. All egg masses on the current year's foliage were classes as new and used as a basis of comparison for those egg masses found on the previous year's foliage.

WEATHER FORECASTING AND MONITORING

Local weather forecasts were provided daily to the project director. Meteorological information was collected from each spray block before treatment and telephoned to the National Weather Service Office in Albuquerque, New Mexico. National Oceanic and Atmospheric Administration meteorologists interpreted the weather information collected and adjusted their forecasts for the local situations.

INSECTICIDE APPLICATION

Thuricide 48 LV was applied diluted at a 1:1 ratio with water at 48 ounces per acre (12 BIU's per acre).

Aerial application aircraft and observation helicopter services were obtained jointly with the New Mexico Department of Natural Resources, Forestry Division and New Mexico Department of Agriculture. Two Marsh Turbo-thrush turbine powered, single engine agricultural low-winged monoplanes were used to apply the pesticide. Each aircraft was equipped with an air driven pump and a two-inch diameter equivalent trailing edge airfoil boom to which 8 Micronair AU5000 rotary atomizers were attached.

Two turbine powered standard factory equipped helicopters, a Bell 206 "Jet Ranger" and a Hughes 500D "Loach" were used for observing and directing the spray aircraft. Service vehicles and attending personnel were provided by the helicopter contractor.

CHARACTERIZATION AND CALIBRATION

Characterization and calibration trials took place on June 19 and 20, 1985, at the Angel Fire Airport. Each aircraft was flown at about 140 miles per hour and at 50 feet over a Kromekote card field. Cards were collected and analyzed after each pass. The results of the characterization trials were negative. The spray mixture evaporated before depositing onto the Kromekote card field. This problem was never resolved.

SPRAY DEPOSIT ASSESSMENT

A spray deposit assessment was conducted using Kromekote cards placed in plastic card holders. Rhodamine dye was added to the spray formulation for assessment. Two cards were placed in openings at each sample plot before treatment and collected immediately after treatment. The purpose of this assessment was to determine if the insecticide was successfully deposited.

RESULTS

Spray Deposit Assessment

The results of the spray assessment portion of this project were negative. No significant spray deposition was found on the Kromekote cards placed at the plot sites. These results were similar to those obtained during the characterization trial and show the insecticide applications did not reach the ground and may not have reached the tree canopy(ies).

Larval Population Densities

Western spruce budworm pre-suppression larval population densities, sampled 24 hours before insecticide treatments, averaged 16.6 and 14.8 on the Red River Canyon and Bobcat Pass spray blocks and 7.3 and 13.5 larvae per 100 buds on the Osha Mountain and Palo Flechado Pass spray blocks. Twenty-one days after treatment, post-suppression larval densities were significantly lower. Larval numbers averaged 4.7 and 7.7 larvae per 100 buds on the Red River Canyon and Bobcat Pass spray blocks and 3.5 and 2.4 on the Osha Mountain and Palo Flechado Pass spray blocks. These results show treatment objectives, reducing larval populations to 5 or fewer larvae per 100 buds, were successfully met in 3 of the four spray blocks treated. No control blocks were sampled at this time. Unfortunately, without "check units," we cannot be sure if these post-suppression larval densities were due to the insecticide application or another phenomenon such as inadequate foliage, predators, parasites, or disease. We suspect the latter due to difficulties encountered during the characterization trials and negative spray assessment results. The pre- and post-suppression results are summarized in Tables 3 and 4, Appendix, along with the number of plots sampled and range of larvae per 100 buds sampled.

Defoliation Damages

Defoliation (needle loss) to current year's foliage was moderate to heavy on all of the blocks sampled. Defoliation averaged 60.0 and 73.8 percent on the Red River Canyon and Bobcat Pass spray blocks and 46.3 and 39.4 on the Osha Mountain and Palo Flechado Pass spray blocks. These results were similar to those of the control blocks that averaged 67.6 and 50.5 percent, respectively. Although we believe the insecticide never reached the targeted tree canopy, these results (summarized in Table 5, Appendix) are consistent with those of past suppression projects using B.t. That being, there is generally no significant foliage protection achieved with B.t. during year of treatment (Ragenovich, 1983 and Rogers, Chavez, and Linnane, 1984).

Egg Mass Densities

No significant differences were found between the WSB egg mass densities collected from the spray blocks and control blocks. Egg mass densities (per square meter of foliage) averaged 6.0 and 8.5 on the Red River Canyon and Bobcat Pass spray blocks and 8.5 and 10.9 on the Osha Mountain and Palo Flechado Pass spray blocks. On the untreated Cabresto Canyon and Taos Canyon units, egg mass densities averaged 9.5 and 12.4, respectively. These results, summarized in Table 6, Appendix, along with their respective standard errors, show WSB insect populations on the spray blocks and control blocks were similar. Had the insecticide treatments been successful, we would expect WSB population densities (egg mass densities) to have been significantly lower in the spray blocks.

CONCLUSIONS

The results obtained during this project indicate that application difficulties minimized the amount of the insecticide that reached the targeted foliage. We hypothesize that the reduction in WSB larval population densities 21 days after treatment resulted primarily from natural causes such parasites, predators, diseases, or a lack of feeding material (foliage), rather than the B.t. application.

PROJECT COSTS

Total project costs incurred during the 1985 WSB aerial suppression project conducted on the CNF amounted to $148,615.12 or $9.64 per acre. A breakdown of the project costs by item is summarized below.

ITEM	ITEM COST	TOTAL COST
Application		$ 84,300.00
Insecticide	9,680.00	
Spray Aircraft (2)	73,620.00	
Helicopters (2)		
Addition Claims	1,000.00	
Supplies		16,230.62
Overhead (salaries, overtime, travel, etc.)		47,179.63
Carson National Forest	35,730.00	
Forest Pest Management	11,449.63	
Characterizations		907.87
TOTAL PROJECT COST		$148,618.12

REFERENCE

1. Johnsen, John O. and Anthony H. Smith. 1985. Western spruce budworm Bacillus thuringiensis (B.t.) suppression project--1985 State of New Mexico and Angel Fire Corporate and homeowner lands. New Mexico Department of Agriculture, Forest Pest Management. 18 pp.

2. Ragenovich, I.R. 1983. Pilot project to evaluate the operational use of Bacillus thuringiensis against the western spruce budworm in northern New Mexico. Progress Report No. 1., USDA Forest Service, Southwestern Region. R-3 84-1. 62 pp.

3. Rogers, T.J. 1985. Western spruce budworm biological evaluation, Carson National Forest, New Mexico. USDA Forest Service, R-3 86-3. 19 pp

4. Rogers, T.J., Chavez, J.M., and James P. Linnane. 1985. Western spruce budworm suppression project using Bacillus thuringiensis--1984, Carson National Forest, New Mexico. USDA Forest Service, R-3 85-6. 15 pp.

5. Telfer, William G. and James P. Linnane. 1984. Western spruce budworm suppression project--1983, Carson National Forest, New Mexico. USDA Forest Service, R-3 84-14. 17 pp.

6. Telfer, William G., Linnane, James P., and James H. Davis. 1983. Western spruce budworm suppression project--1982, Carson National Forest, New Mexico. USDA Forest Service, R-3 84-12. 36 pp.

7. USDA Forest Service Final Environmental Impact Statement, Western Spruce Budworm Management Program for Portions of the Carson National Forest, New Mexico. 1985. 300 pp.

APPENDIX

WESTERN SPRUCE BUDOWRM CONTROL PROJECT
ORGANIZATION

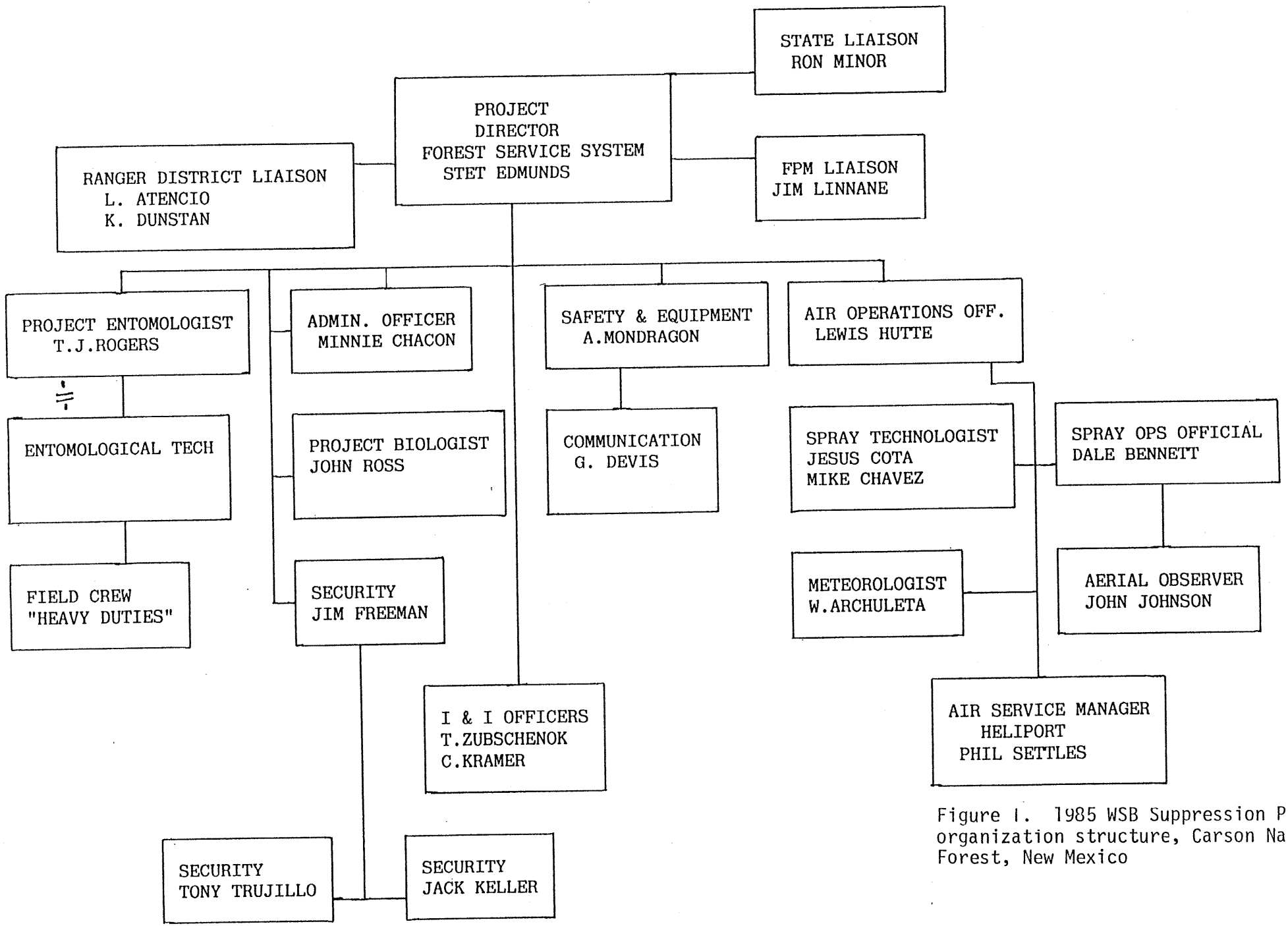

Figure 1. 1985 WSB Suppression Project organization structure, Carson National Forest, New Mexico

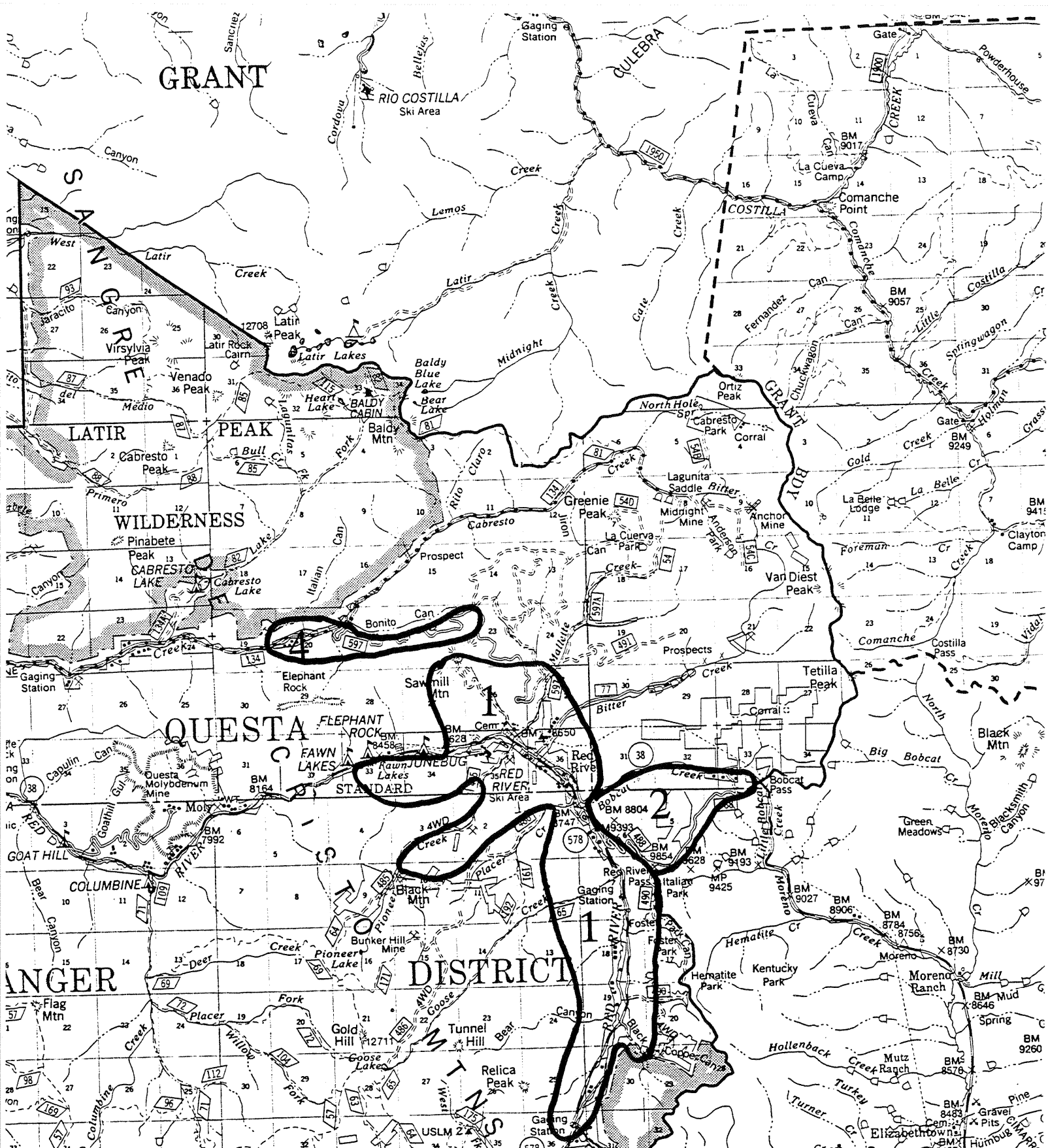

Figure 2. 1985 WSB Suppression Project Area, Questa RD, CNF

1. Red River Canyon Spray Block
2. Bobcat Pass Spray Block
3. Taos Ski Area Spray Block
4. Control

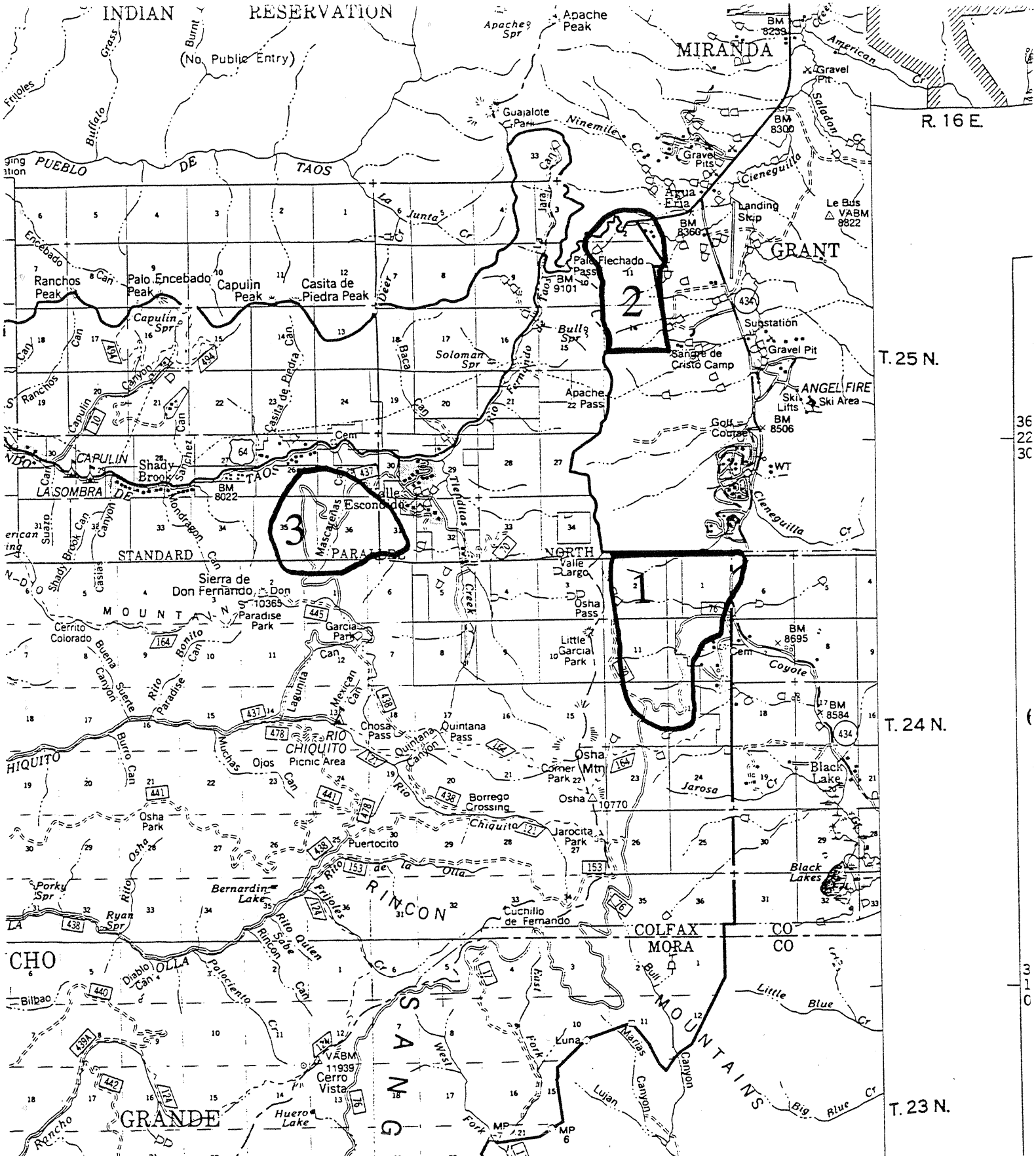

Figure 3. 1985 WSB Suppression Project Area, Taos RD, CNF

1. OSHA Mountain Spray Block
2. Palo Flechado Pass Spray Block
3. Control

TABLE 1. 1985 Western spruce budworm project spray blocks showing acres treated and dates sprayed.

SPRAY BLOCKS	ACRES SPRAYED[1]	DATES SPRAYED
Questa Ranger District		
Red River Canyon	9,460[2]	June 21, 22, and 23
Bobcat Pass	960	June 22 and 23
Taos Ski Area	760	June 23
Total area sprayed	11,180	
Taos Ranger District		
Osha Mountain	2,570	June 23 and 24
Palo Flechado Pass	1,670	June 23 and 24
Total area sprayed	4,240	

1 Acres estimate by dot grid method.

2 Initially this spray block was divided into three individual blocks averaging 4,153 acres in size. However, because all three blocks were sprayed at once and pre-suppression larval densities were similar and not significantly different, they were combined.

TABLE 2. Percent western spruce budworm larval development by instar at time of treatment, 1985 western spruce budworm project, Carson National Forest.

SPRAY BLOCKS	II	III	IV	V	VI	PUPAE
Questa Ranger District						
Red River Canyon	0	11	33	45	11	0
Bobcat Pass	2	10	33	40	15	0
Taos Ski Valley	No data collected					
Taos Ranger District						
Osha Mountain	0	7	18	56	19	0
Palo Flechado Pass	0	0	5	69	23	3

TABLE 3. Average pre-suppression budworm larval population densities, 1985 western spruce budworm suppression project, Carson National Forest.

SPRAY BLOCKS	AVERAGE LARVAE PER 100 BUDS AND S.E.[1]	N	RANGE	DATE SAMPLED
Questa Ranger District				
Red River Canyon	16.6 ± 1.3	41	4.5 - 39.2	6/17/85
Bobcat Pass	14.8 ± 1.2	12	5.2 - 21.5	6/19/85
Taos Ski Valley	No data collected			
Overall average	16.2 ± 1.0			
Taos Ranger District				
Osha Mountain	7.3 ± 1.1	16	3.2 - 156	6/22/85
Palo Flechado Pass	13.5 ± 1.9	14	4.5 - 30.6	6/22/85
Overall average	10.9 + 1.3			

[1]Standard error.

TABLE 4. Average post-suppression larval population densities (unadjusted), 1985 western spruce budworm suppression project, Carson National Forest.

SPRAY BLOCKS	AVERAGE LARVAE PER 100 BUDS AND S.E.[1]	N	RANGE	DATE SAMPLED
Questa Ranger District				
Red River Canyon	4.7 ± 0.4	33	0 - 12.7	7/11/85
Bobcat Pass	7.7 ± 1.1	12	0 - 13.3	7/11/85
Taos Ski Valley	No data collected			
Overall average	5.4 ± 0.5			
Taos Ranger District				
Osha Mountain	3.5 ± 0.6	16	1.2 - 9.7	7/10/85
Palo Flechado Pass	2.4 ± 0.3	14	0.6 - 4.16	7/10/85
Overall average	3.0 + 0.4			

[1]Standard error.

TABLE 5. Average percent defoliation (Six Class System) on spray blocks treated with B.t. and untreated check areas, 1985 Western Spruce Budworm Suppression Project

AREA	AVERAGE PERCENT DEFOLIATION	N	RANGE
Questa Ranger District			
Spray Blocks			
Red River Canyon	60.0 ± 3.2	30	27.3 - 94.4
Bobcat Pass	73.8 ± 4.3	12	54.2 - 94.6
Taos Ski Valley	No data collected		
Overall average	64.0 ± 4.0		
Control Block			
Cabresto Canyon	67.6 ± 4.0	12	42.3 - 88.2
Taos Ranger District			
Spray Blocks			
Osha Mountain	46.3 ± 7.8	16	13.0 - 90.4
Palo Flechado Pass	39.4 ± 4.3	14	15.2 - 73.3
Overall average	42.9 ± 4.7		
Control Block			
Taos Canyon	50.5 + 4.0	27	18.6 - 93.8

TABLE 6. Average egg mass densities on spray blocks treated with B.t. and untreated check areas, 1985 western spruce budworm suppression project, Carson National Forest

AREA	EGG MASS DENSITIES PER M^2 OF FOLIAGE	N	RANGE
Questa Ranger District			
Spray Blocks			
Red River Canyon	60.0 ± 1.4	30	0 - 37.4
Bobcat Pass	8.5 ± 1.9	11	1.6 - 21.4
Taos Ski Valley	No data collected		
Overall average	6.7 ± 1.2		
Control Block			
Cabresto Canyon	9.5 ± 1.2	12	1.0 - 16.0
Taos Ranger District			
Spray Blocks			
Osha Mountain	10.9 ± 1.6	16	0 - 16.3
Palo Flechado Pass	8.4 ± 1.1	14	1.9 - 22.6
Overall average	9.2 ± 1.0		
Control Block			
Taos Canyon	12.4 + 1.7	36	0 - 42.5