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1987 WESTERN SPRUCE BUDWORM PROJECT AT RIMROCK LAKE, NACHES RD, WENATCHEE NF

PROJECT REPORT

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INTRODUCTION

Infestation of western spruce budworm, Choristoneura occidentalis Freeman, are a natural occurrence in the shade-tolerant, climax-coniferous forests of eastern Oregon and Washington. When climatic and forest-stand conditions are favorable to the insect, populations of budworm build to outbreaks proportions resulting in serious damage to host trees including; growth loss, top-kill, deformity, reduced seed production, ~~and mortality~~, ~~reduced seed production~~, and mortality. Outbreaks can increase rapidly and may cover extremely large areas of budworm host type.

Western spruce budworm has been recorded in the Pacific Northwest Region since 1914. The first evidence of budworm defoliation in Washington State, however, was noted in limited areas near Northport, Washington in 1929 (Dolph, 1980). The first full-fledged outbreak in the Pacific Northwest occurred in in 1943 where defoliation, discovered in the Methow Valley on the Okanoga National Forest, eventually grew to encompass about 200,000 acrea before the infestation collapsed from natural causes in 1948 (Dolph, 1980). The Wentachee National Forest first experienced budworm defoliation in 1950 thru 1953 with not more than 25,440 acreas defoliated in any one year. The next outbreak of budworm on the Wenatchee National Forest began in 1971 with 2,360 acreas of host type defoliated. The outbreak grew to over 793,000 acreas by 1977. Control projects were undertaken against the budworn on the Wenatchee National Forest in 1951 (DDT), 1976 (Malathion), and 1977 (Sevin 4-Oil). Since 1978, varying amounts of defoliation have been detected, including some of the formerly treated areas. Treatment of budworm has not occurred on federal lands in Washington between 1977 and this year's project on the Naches Ranger District, Wenatchee National Forest.

The western spruce budworm situation on the Naches RD apparently developed in 1982 or 1983. First reports of budworm defoliation came from District personnel in 1983, but the defoliation was not visible from the air, and was not recorded during the aerial insect detection survey for that year. The following year, however, Forest Pest Management sketch-mapped 11,510 acres of budworm defoliation on the District. The population continued to increase over the next 2 years, reaching 86,730 acres on the Rimrock and Naches Analysis Units in 1985. Most of the damage occurred around Rimrock Lake.

By 1985, the budworm problem had increased substantially ?Regionwide. An interdisciplinary team was set up to conduct an environmental analysis to determine management strategies for budworm on 2.4 million acres of federal and adjoining state and private lands. The Rimrock and Naches all were among those analyzed and identified for insecticide treatment in 1986. Competition for limited forest pest suppression dollars nationally, however, precluded any treatment of budworm in the Region during 1986.

Visual and recreational resources centered around Rimrock Lake are important to the 490 summer home occupants of the area. The local populace and others from outside the Yakima Valley frequently use the 10 campgrounds and numerous streams, trails, and other amenities offered by the area. Concern for these resources has been great, and when it became clear that federal funds would not be available to treat the budworm infested areas, summer home permittees formed an association and attempted, unsuccessfully, to raise the money to treat an infestation band around the lake, through private donations.

Spring frosts in 1986 adversely affected budworm numbers, and new defoliated areas dropped slightly from the previous year to 80,610 acres. The Rimrock and Naches Analysis Units were reanalyzed during the 1987 environmental analysis, and the Rimrock AU, with 56,274 acres, was among those Analysis Units selected for treatment with the bacterial insecticide, Bacillus thuringiensis (B.t.). Results of the 1987 western spruce budworm suppression project at Rimrock Lake are reported here.

OBJECTIVE

The objective of this project was to reduce the western spruce budworm population to residual ~~to residual~~ levels averaging less than one healthy western spruce budworm larva and/or pupa per 45cm midcrown branch tips, over the entire Analysis Unit. This population reduction strategy will have short-term effectiveness in lowering budworm population within the treated areas to levels which will result in minimal feeding damage. The resultant defoliation should be barely perceptible.

The residual population density target is calculated to produce endemic budworm levels that will allow the interaction of budworm natural enemies (parasites and predators), forest-stand conditions, and adverse weather to hold the population in check by regulating insect numbers. The budworm populations around Rimrock Lake began to increase in 1982 or 1983 because natural agents, climatic, and forest-stand conditions were favorable for budworm population growth, and parasites and predators were no longer able to limit budworm numbers. Populations rapidly increased to outbreak proportion. Historically, periods of warm, dry weather, such as the Pacific Northwest has experienced over the past several years, precede major western spruce budworm outbreaks (Fellin, 1985). Although budworm levels may be reduced by treatment with insecticides like B.t., populations could resurge again in subsequent years.

PROJECT AREA

The proposed area for treatment included the major portion of the Tieton River drainage centered around Rimrock Lake (T. 13 N., R. 13 E.), located approximately 40 miles west of Yakima along Highway 12. All land to be treated is under Forest Service ownership, and did not include classified wilderness areas. The project area was bounded, in part, by the William O. Douglas Wilderness on the north side and by the Goat Rocks Wilderness on the west side.

Spray block acreage, after completion of block boundary marking by helicopter, was calculated at approximately 53,100 treatable acres. Treatment acreage was trimmed back to 44,031 acres early on, however, due to a lower project funding allocation than originally planned.

Elevations over the project area ranged from approximately 2,320 feet to 5,490 feet. The project area was divided into 38 spray blocks ranging in size from 153 acres to 3,553 acres with average block size of 1,336 acres (SE=140.5). Spray blocks were established using three criteria. The first criterion was to hold elevational changes over a spray block to around 1,200 feet. This proved impossible to do in all but a third of the spray spray blocks, and still maintain on area of reasonable size and share that could be effectively treated by rotary aircraft. Changes in elevation of actual spray blocks ranged from a minimum of 443 feet to a maximum of 2,560 feet, because of the extremely steep terrain.

It is customary to attempt to hold elevational changes to an average of 500 feet to minimize differences in insect development. The average elevational change over project spray blocks was 1,487 feet (SE=72.4 feet). The second criterion attempted to minimize aspect changes over the spray block as much as possible. Normally, blocks are selected to allow no more than 120 degrees change in aspect. This proved difficult, however, because with rapidly changing aspects over relatively short horizontal distance. The final criterion sought to minimize working limitations (e.g., orientation and right factors, spray run lengths, turn arounds, ferrying distances, swath, widths, etc.) of application aircraft that would be used on the project. Spray block boundaries utilized district geographical features such as ridges and streams that could be readily identified from the air, as much as possible. We also attempted to match spray block acreage with the production capabilities of the aircraft by keeping spray block size down to that which each type of aircraft might be able to complete within a typical spray day or two.

Although 38 spray blocks were identified within the treatment Analysis Unit, map acres exceeded the acreage contracted by about 9,100 acres. This was in part due to literal interpretation of District R2 type maps and incorrectly interpreting areas typed as unsuitable for commercial timber production, as not containing treatable populations of budworm. Other discrepancies between mapped and contracted acres resulted from using different scaled maps and certain inaccuracies in type mapping. To correct these deficiencies, and stay within terms of the application contract, certain acreage had to be dropped from treatment. Accordingly, project overhead team and Naches Ranger District representatives prioritized acreage for exclusion from treatment based on the following:

1. Evidence of past defoliation.

2. Current budworm population levels.

3. Physical characteristics such slope, aspect, and elevation in relation to treatment requirement and difficulty.

4. Visual resource values at risk.

5. Amount of budworm non-host type.

6. Juxtaposition to other blocks as it related to reinfestation and potential population increase.

7. Current timber harvesting plans and operations.

8. Spray operation limitations.

Prioritization of spray blocks for exclusion from treatment resulted in dropping 5 blocks, as well as portions of 2 others. A total of 32 spray blocks were treated. One of the spray blocks at the west end of Rimrock Lake was left untreated as a 1/2 mile buffer zone around a bald eagle's nest.

The project area was well roaded and afforded good accessibility to nearly all spray blocks. The main roads around the lake were hard-surfaced other roads were gravelled and for the most part, well maintained. Certain roads were primitive in nature, not well maintained, or closed to traffic. These roads were not used by project personnel for safety or other reasons. At best two spray blocks were unroaded and partys of a few also lacked adequate road systems, and consequently those blocks of positions of blocks not sampled for biological information.

PROJECT FACILITIES AND EQUIPMENT

Project headquarters were located in building at the White Pass Work Center, 33 miles west of Yakima along Highway 12. The Work Center was formerly the home of the Tieton Ranger Station and consisted of a main office building, several large workshops and smaller storage buildings, a numbers of crew bunkhouses and other smaller residences, and a moderate-sized blacktopped area for parking.

The Work Center was reasonally well-suited for a project headquarters. It offered office, work, and storage space; parking space; and an adequate site to store pesticide and perform batch plant operations. In addition to providing office space for the Project and Assistant Project Directors, the main building also served the needs of Administration, Operations, and the majority of the Entomology section's work. On ocassions, both the Operations and Entomology work activities spilled over to a small house next to the main building that was intended to be used for meetings, training of temporary biological crews, and other similar activities. Although space seemed somewhat cramped, the facilities proved adequate for conducting the various activities associated with operating, administrating, and biologically evaluating a spray project. The location of the White Pass Work Center also afforded convenient access to the spray blocks, since it was situated within the Rimrock Analysis Unit.

The main building was equipped with standard office equipment, furniture and a telephone system. In addition two Data General computer terminals and a letter-quality printer were made available by the Wenatchee National Forest and Naches Ranger District for performing various administrative tasks and for creating and manipulation data files using Forest Pest Management's Western Budworm Decision Support System (WESTBUDS). Access to Fort Collins Computer Center was through the Wentachee NF computer system. Data link hardward had to be purchased and installed at the Wenatchee Computer site and the Work Center to enable communication between Work Center terminals and the Wenatchee computer. The system worked reasonally well and permitted clean data transmissions with Fort Collins. The main problem with the system was that ocassionally the datalink had to be reset at the Wenatchee computer center. When this occurred during non-business hours, such as on weekends, the computer analyst had to be called at home and asked to go to the office and reset the link. Aside from the inconvenience to the computer analyst, it resulted in delays in processing data and analyzing information needed to reach timely spray block release decisions. In the future, it would undoubtedly be beneficial to operate WESTBUDS on a personal computer. This would also avail the problem of the Fort Collins computer being down part of the time on weekends when it was needed to run WESTBUDS in order to make timely spray block release decisions.

Portable II personal computer equipped with a model PA-3000-P Pathlink Analyzes to monitor aerial application contract performance.

A total of 30 vehicles were used on the project. All vehicles were leased on contract with various vendors. Project fleet consisted of the following: One

Bronco--Project Director; one 8-passenger van--Public Information Officer; two 1/2-ton 4x4 and eleven 1/2-ton 2x4 longbed pickups--Entomology; and eleven 1/4-ton longbed and four 1/2-ton shortbed pickups--Operations.

Radio communications on the Rimrock Project consisted by one Forest Pest Management base station, one Boise Interagency Fir Cache set, ten King Programmable hand-held units, for a total of 27 units. Ground to ground communications was by FM King sets and BIFC packsets. Both application and observation aircraft had 9600 channel radios to communication with each other. Observations aircraft also had FM Kings to communication with personnel on the ground.

PROJECT PERSONNEL

Project personnel consisted of 60 individuals including those who functioned in advisory, liaison, or temporary capacity, and not on project payroll, as well as those directly assigned to the project. Approximately 52 people formed the project core personnel with regular project duty assignments. Two of the core personnel were Forest Service unpaid volunteers who contributed over 360 hours to the project.

All but two individuals were from within the Pacific Northwest Region. One individual was detailed from the Idaho Panhandle National Forest of the Northern Region, and one from the Boise, Idaho Forest Pest Management Field Office of the Intermountain Region, to work on the project. All personnel were

Forest Service employees except for one individual who was detailed to the project from the Bureau of Land Management.

Approximately 30 project employees were supplied by the Wenatchee National Forest, alone, including the 18 Biological Aids for the Entomology crews. The Wentachee National Forest demostrated a strong committment to the project by providing personnel and support. Numerous individuals from the Naches Ranger District, though not assigned to the project, provided valuable assistance before, ~~before~~, during, and after the operation phase of the project. The project received help from the District in the areas of administration/finance, time-keeping, procurement, information, during, driving and safety instruction for temporaries, computer assistance, and vehicle contracting maintenance. In addition the the Forest provided continuing employment opportunities for the temporaries by placing nearly all of them in other temporary jobs on the various Ranger Districts, upon completion of their entomological work on project.

APPLICATION CONTRACT

The application contract was awarded May 12, 1987 to Western Helicopter Services, Inc., of Newberg, Oregon, for $498,960 (cost includes aerial application and observation aircraft, pesticide, support equipment, and personnel provided by the contractor).

Western Helicopter Services was the prime contractor for application, and subcontracted with Cascade Helicopters, Inc., Cashmere, Washington and Transwestern Helicopters, Inc., Scappoose, Oregon to assist with application and provide all of the marking, observation and reconnaissance aircraft as well as their pilots, and support equipment and personnel.

The contract called for treatment of 44,000 acres with a <u>B</u>.<u>t</u>. product formulated in an aqueous spray suspension containing 12 billion International Units of potency (12 BIU's) at an applied rate of 96 ounce's (3/4 gallon) per acre. The agueous formulation was required due to the proximity of spray blocks to Rimrock Lake, Clear Lake, and the Tieton River and its tributaries which flow into the major river system serving the Yakima Valley with sport fisheries, irrigation, and domestic water supply. Treatment of about 153 additional acres over contracted acreage increased the total value of the completed application contract to $500,945, or $11.34 per acre applied, overall project costs to treat 44,153 acres increased the costs per acre to $18.74.

The contract specified the estimated start date to be June 1, 1987; the estimated duration to be 25 days; and an estimated 10 days of actual spraying to treat at total of 44,000 acres at a performance rate of 2,200 acres per hour.

To achieve the desired application and operate safely in the steep terrain of the project area, the application contract specified the use of helicopters. The contractor provided the following aircraft:

Year	Make/Type	Tail No.	Usage	Owner
1975	Hiller 12E Soloy Turbine	N13HA	Application	Western
1978	Hiller 12E Soloy Turbine	N545HA	Application	Western
1981	Hiller 12E Soloy Turbine	N4032Y	Application	Western
1980	Hughes 500D	N108Y	Application	Western
1974	Lama 315B	N7CH	Application	Cascade
1979	Bell 206B3	N7NU	Observation	Transwestern
1978	Hughes 500D	N58251	Observation	Transwestern
1966	Bell 47 Soloy Turbine	N2266A	Observation	Cascade
1979	Bell 206B3	N6NU	Observation	Transwestern
1970	Bell 206B3	N49573	Observation	Cascade

All observation aircraft were equipped with 9600 channel FM radios, and many were equipped with Pathlink System recorders, as well. Pathlink is a computerized recording system for collecting position information, using latitude and longitude coordinates, and switch setting data. Information recorded by Pathlink provided a permanent record of flight path and spray boom on and off intervals. Pathlink results were poor due to inadequate antenna mounting brackets and proximity of

PESTICIDE

The application contractor supplied the *B.t.* product, Thuricide 48LV, as the pesticide for budworm treatment on the Rimrock Analysis Unit. This product meet the requirements for an aqueous formulation and the formulation specification dosage, and application rate as set forth in the application contract. It was supplied in 55 gallon drums and stored at the mixing site on the Work Center campground.

Thuricide 48LV is an aqueous concentrate, biological insecticide manufactured by Yoecon Corporation. It contains a suspension of endospores and the proteinaceous crystalline parasporal bodies known as the "delta-endotoxin," of the *Bacillus thuringicusis kurstaki* serotype (designated HD-1, Dulmange, 1970). To obtain the proper dosage of 12 BIU's in 96 ounces of formulated spray, the concentrate *B.t.* suspension was diluted with water at the rate of 1 part *B.t.* to 2 parts water. Water used for the mixing was from an unchlorinated source (creek) located on the White Pass Work Center campground.

Thuricide 48LV meet all expectations in regard to mixability, flowability, atomization, and biological performance. Spray assessment was mediated by the presence of a green dye that is included as part of the Thuricide 48LV formulation, making the spray deposit relatively easy to see against the shing? white surface of the Kromekote deposit samplers used on the project for spray assessment.

PRE-PROJECT TRAINING

Prior to the start of the spray project, all project personnel (except temporaries) were required to participate in a combined Western Spruce Budworm Project training session with the Malheur project personnel. During April 13-17, approximately 110 people assembled in Eugene, Oregon to attend the training. Attendees were familiarized with organizational structure of the projects, job descriptions, project goals, project safety, administration and logistics, helicopter safety, fixed-wing safety, the operation plan, plans and intelligence, public affairs, spill management, environmental protection and monitoring, vehicle and radio use, contract review and administration, and various other project team training.

Temporaries hired for the entomological crews received a project orientation and specialized training in their areas of work, after arriving on the project. In addition, the Naches Ranger District provided temporaries with training in first aid, and in defensive and backwoods diving. All temporaries having valid state driver's licenses were required to demonstrate their driving skills to a certified instructor since they would be required to frequently drive project vehicles on back roads and, occasionally, during dark hours, in performing their work assignment.

PROJECT INFORMATION

A Public Information Officer and a Assistant PIO were assigned to the Project to inform and involve the public in the proposed spray project, and provide timely news and information reports on Project progress and accomplishments. Since the Rimrock Lake Project area is a popular recreation area with numerous summer homes and recreation sites, it was assumed there would be a high level of interest in the Project. In view of this, the Project Information section developed a program with the objective of (1) keeping the public posted on the progress of the spray project; (2) reinforce public support by emphasizing the environmental safety and effectiveness of B.t. ; (3) anticipate and answer public questions where ever possible; and (4) keep employees informed.

Through the efforts of a number of individuals, including Project personnel and Information staffs and others from the Naches Ranger District and Wenatchee National Forest, the information program was successfully implemented. A number, of means were used to implement the objective, including news releases; development of a "Fact Sheet" for local publics; Ranger District briefings; contacts with media editors; development of a recreation opportunity/area information guide for spray project employees; briefing Country Commissioners, majors, U.S. Representatives, Senators, and other political leaders; personnel contacts with homeowners and resort operators; town hall meetings; presentations to local civic groups; daily contacts with campground users and other publics in the spray area; daily media updates and a "spray day media tour" on the first operational spray day; and various other informational activities.

The information campaign paid off; the public was very receptive and supportive of the Project. Nearly all responses received from the public, prior to and during the Project, were favorable. The news media, especially, took great interest in the spray project. One Yakima television station, KNDO TV, conducted two interviews with Project personnel during spray operations, and another two follow-up interviews after spray operations were complete. In only one case did the Project receive any adverse public response. The case involved an individual who was sprayed along with others in his party at the Clear Lake Campground, while camping with family and friends. He apparently did not have prior knowledge of the spray project, having come from another town, and had not seen information signs posted in and around the campground. The Project Public Information Officer visited the campground and made personal contacts with individuals staying in the campground, but for some reason, this party had not been informed, by their account. The matter was cleared up by the Project Director writing an explanatory letter and providing information that relieved this individuals concerns.

OPERATIONS

Project Start-Up

The mild winter of 1986-87 was followed by an early spring in the Pacific Northwest. Monitoring of growing degree days in the Yakima and Wenatchee valleys indicated that plant phenology was several weeks advanced over normal years, and bud development on host trees over the project area suggested that the budworm development would likely be ahead of previous seasons, as well. Based on these observations, the Project Entomologist estimated that spraying would begin on or about June.

The Project overhead team, using the projected starting date, developed an action item list and time schedule for the Rimrock spray project. Reporting dates for personnel and a number of tasks and targets were identified, and are described in the appendix.

Project start-up officially began on May 11, with the arrival of part of the overhead team at the White Pass Work Center. The first order of business was to delineate the spray blocks so that Operations personnel could begin marking the spray block boundaries once the marking aircraft arrived at the Project. Spray block boundaries were marked using long strips of 4-inch wide fluorescent orange plasticized cloth ribbon, weighted with steel washers. The markers were thrown into tree tops along the boundaries, from slow-moving helicopters. Boundary marking was necessary to aid spray pilots in orienting the aircraft during swathing, and help avoid applying insecticide outside the target area. Spray block boundary marking was accomplished between May 22 and May 30, by two Bell 206 Jet Ranger-III helicopters. Marking took a total of 49 hours of helicopter time to complete at a cost of $17,759.

Spray block boundary marking was kept to a minimum, since the markers can stay in the treetops for many years, and may represent an adverse visual impact to some individuals who use the area for recreation. Inasmuch as possible, Operations personnel doing the marking utilized roads, highways, and geographic features such as ridges, draws, streams, and other distinguishable land forms for natural boundary identification. Artificial marking of block boundaries was done only where such features were absent or not clearly identifiable from the air.

The next major task for Operations was to select potential heliport sites for use in aircraft operations, including loading pesticide and refueling, block reconnaissance, pilot briefing, or other spray operation activities. Heliport locations were selected by project personnel and the contractor within close proximity to, or within spray blocks, so that ferrying distances to points within a spray block or among several spray blocks would be minimized. Heliports were selected that offered enough area to safely and efficiently handle all necessary spray equipment and personnel. Heliport sites had to provide adequate visibility, openness, and terrain features to permit safe take-off and landings of both application and observation aircraft, and be accessible to ground transportation. Heliport sites also had to be environmentally compatible with aircraft operations.

Improvements to some heliport sites were required prior to their operational use. A total of 30 heliports were eventually selected and improved by cutting trees, smoothing over uneven terrain, and removing brush and other debris or obstacles that might create a hazard for aircraft and personnel working at the site. The Tieton Emergency Airstrip, located at the east end of Rimrock Lake served as a helibase site for the Project.

Prior to the arrival of the application aircraft on the project, several of the Operations staff met with the contractor at his headquarters in Newberg, Oregon, to calibrate and characterize the application ships. The helicopters were configured with the following spray systems:

Spray System	Application Aircraft: Hiller 12 E Soly	Hughes 500 D	Lama SA 315 B
Tanks	Simplex bell tank (model 4500)	Isolair saddle tank (model 3700)	Simplex saddle tank (model 4206)
Boom	Hydraulically pressurized	Hydraulically pressurized	Hydraulically pressurized
Nozzles	Beecomist model 360 rotary atomizer (4 per ship)	Beecomist model 360 rotary atomizer (6 nozzles)	Beecomist model 360 rotary atomizer (6 nozzles)

Calibration and characterization was conducted according to contract specifications. Application applied and swath widths were as follows:

Aircraft	Speed	Swath Width
Hiller 12 E Loloy	60 mph	100 ft.
Hughes 500 D	80 mph	120 ft.
Lama SA 315 B	80 mph	150 ft.

Release height during application was specified at 50 feet above the canopy. The Beecomist nozzles were adjusted to deliver 20 drops per square centimeter at ground level from the specified release height. Characterization yielded an average volume median diameter (VMD), using the D-max system (Dumbauld and Rafferty, 1977), of 83 microns. This VMD was lower than the 100 to 150 micron specified in the contract because of some confusion over the difference between stain diameter and drop diameter during spray characterization. The lower VMD did not apparently affect biological results in any measurable way, however.

In addition to insecticide label restriction for applications, spraying was not permitted or was terminated when certain environmental conditions prevailed. Operations personnel (and occasionally Spray Assessment personnel) monitored conditions closely during all phases of insecticide application, and spraying was halted or not permitted under the following conditions:

1. Wind velocity is zero (i.e., thermal inversion) or exceeds 6 miles per hour.

2. Temperature exceeds 70 or is less than 32 degrees F.

3. Rain is predicted within 12 hours after application.

4. Fog is present or visibility is poor.

5. Relative humidity is less than 50 percent.

6. The air turbulence (thermal updrafts, etc.) is so great as to seriously affect the normal application.

7. Low elevation air inversion resulting in the spray cloud hanging up or moving with the air mass.

8. Wet foliage such that drops of water form at ends of needles.

In addition to monitoring the environmental conditions during spray operations, insecticide that was not used up during the application for which it was batched, had to be monitored by the Operations section. Thuricide 48LV, once diluted with water, could not be allowed to remain in tanks for more than 72 hours, and still be usable. Diluted sprays on the Rimrock Project were always used up prior to the 72-hour limitation, and the contractor was never required to dispose of "old batch material."

Spraying Operations

Entomological monitoring resulted in the first three spray blocks being released for treatment on May 31, 1987. Operations had 48 hours to complete treatment on a block, starting the day after the release date, otherwise the block would have to be resampled to determine if the budworm population had developed past a treatable stage. Since releases usually were made near the end of a work day, the released blocks could not be treated until the following morning. Frequent and timely communication with the contractor was necessary to inform him of what blocks were released for treatment the following morning, to allow time for batching insecticide and movement of equipment to the proper heliport for the next morning's operation.

Application of B.t. to 2 of the first 3 blocks released, began June 1, 1987. Spray blocks were released for treatment at an average of 2.3 blocks per day (SE=0.4) over the course of the Project. All blocks were released with a 14-day period. Spraying of the final three blocks was completed on June 12, 1987, 12 days after treatment first began.

The number of spray blocks released for treatment each day were probably close to ideal from an operational standpoint. The contractor had the right number of application ships to treat the blocks in a timely manner, as they were released. The contractor kept up with spray block releases, and usually had blocks treated within a day or two of release. Conversely, insect development occurred in such a manner over the Analysis Unit, that no blocks were seriously delayed in being released, so as to cause the contractor to wait for blocks to open before continuing. Also, working to our advantage was the factor of favorable spray weather and conditions which permitted the timely application as blocks were released. Examination of release and treatment data from the

Project support these conclusions. The time from block release to the start of spraying of blocks averaged 0.78 days (SE=0.13), over the Project area. The average time from start of spraying blocks until completion was 09.72 days (SE=0.15).

Daily operations started with Ground Observers taking temperature, relative humidity, and wind speed measurements, one hour before sunrise, at various locations within the spray block designated for treatment. This information was reported to Application Team Leaders every 15 minutes. Weather parameters measured during spray operations, and the reasons for shutting down daily spray operations are summarized in the appendix. Pilot briefings, aircraft loading and fueling, and other last-minute preparations for flight were taken care of during the first hour before sunrise, as well. Spraying began at approximately 30 minutes before sunrise. The earliest recorded application of the day began at 0434 hours. The latest start of any day (in the case, due to unfavorable weather--wind and precipitation), was at 0735 hours. Spray operations would continue throughout the morning, as long as spray weather and application conditions were favorable. Spray cutoff times varied from between 0459 and 0934 hours for any particular application ship working a spray block during the 12 days of spraying. Unusually low relative humidities over the Project area on June 5--relative humidities between 33 and 58 percent were recorded--essentially prohibited any spraying from taking place that day. The contractor was able to spray only 217 acres on June 5, before being shut down by the low humidity.

Following completion of morning's spray operations, the Operations section marked the daily spray accomplishment boundary on a master Project spray map.

When a spray block was completed, that block would be colored in, entirely on the Project Map.

Average start-up and shut-down times were computed using data from flight records and daily reports for all application ships over the course of project spray operations. Start-up (or take-off) time averaged 0502 hours (SE=0006) and shut-down time averaged 0716 hours (SE=0010). Using these averages, the average daily application time was calculated at 2 hours and 14 minutes. An examination of the reasons for terminating daily spray operations (see appendix) reveals that, for the most part, operations were stopped each day because of exacerbating conditions for spraying. In one case, an application ship was out of spray mix and could not continue after completing a block. There was not time to mix another batch before spray conditions would become unfavorable. In two other cases, application ships had to be temporarily shot down because of mechanical failures, but these were quickly fixed. The problems were relatively minor, and the resultant delays did not seriously hamper spray operations.

Prior to the start of spraying, ground checking of the areas to be treated revealed that much of the summer home sites and campgrounds located primarily around Rimrock Lake, were characterized as having a fairly dense overstory canopy, with smaller fir trees in the understory. The understory trees frequently provided a natural vegetation screen between adjacent summer homes. These small trees were also experiencing moderate to heavy defoliation by budworm. This host type-predominated band around the lake received the heaviest recreational use, and was noted as the District's greatest concern and priority for treatment.

To effectively treat this crucial 500 acres of host-type and prevent further damage by budworm, the spray deposit would have to penetrate the thick vegetative cover, and reach all canopy levels, especially the understory. Project overhead team were not confident that a 12 BIU per acre application would result in satisfactory deposit over this area, so a heavier application on about 500 acres around Rimrock Lake, including summer homes, organizational camps, and campgrounds, was proposed. This was accomplished by decreasing the application helicopter's flight speed over this area. The decreased flight speed resulted in increasing the volume of spray applied per acre; hence, increasing the dosage from 12 BIUs to 16 BIUs per acre. This rate was consistent with the registered label rates for western spruce budworm. The slower speed also allowed for a more downward direction of the spray material which should have provided greater penetration of the overstory canopy. Our assumption was that more material would reach the understory, in this manner.

During the application, spray deposit samplers were placed in several of the resort areas to monitor the application, including Indian Creek Campground, Silver Beach Resort, Bear Cover Cabins, 12-West Resort, and Rimrock Lake Grocery. The average deposit from these locations was 7.03 drops per square centimeter (SE=2.2) Although this density is lower than the overall Project's average, it should not be viewed as an absolute measure of the application efficiency or potential efficacy of treatment. The droplet density nearly shows how much deposit filtered through the canopy openings and made it to the ground where deposit samplers were placed. What we cannot measure is the amount of spray material that was filtered out by the canopy and impringed on the foliage. Our post-treatment evaluation sampling design for budworm on the

Analysis Unit was not statistically designed to estimate any population parameters for sampling stages smaller than the Analysis Unit as a whole. Therefore, it would be statistically inaccurate to apply block or plot budworm densities to specific areas such as the summer home sites and resort areas. Suffice it to say, without providing any empirical data, that budworm populations were reduced from these areas of concern as a result of the heavy B.t. application. Causal observations suggests that budworm densities--had they been properly evaluated at these specific sites, rather than generally for the entire Analysis Unit--would have measured less than one budworm for 45 cm branch. Budworm feeding was curtailed following application, and damage around these resort areas was minimized. Budworm populations are expected to remain low. Reports received back from the Naches Ranger District indicate that summer home and resort owners are pleased with the results of the application. The remainder of the Project area received normal treatment of 12 BIUs per acre, as per contract specifications.

A final tally of gallons applied and acres treated was made at the completion of the spray operations on June 12. Results indicated that approximately 33, 115 gallons of Thuricide 48LV spray mix had been applied to 44, 153 acres. The daily production rate was 2,759.6 gallons per day (SE=526.6) or 3,679.4 acres per day (SE=701.8).

Weather Monitoring and Forecasts

The National Weather Service, by way of an Interagency Agreement with the Forest Service, provided special weather forecasts for the 1987 Western Spruce Budworm Suppression Project. Forecasts for the Rimrock Lake Project were generated at the weather office in Yakima. Weather forecast reports were prepared by the meteorologist and provided information such as high and low temperature, relative humidity range, windspeed, and expected precipitation, for the 0400 to 0900-hour period when spraying would take place each morning. The forecast also included a long-range (5-day) forecast. Weather forecasts were made twice daily; once at 0500 hours and again at 1700 hours. In addition, the meteorologist was available for consultation and to provide more detailed forecast information, as needed. The forcasts were quite accurate

Environmental Monitoring

The Project monitoring objective was to monitor the effects of an aerial application of B.t. on domestic water supplies, flowing streams, and bald eagles. Direct application to surface waters were avoided during the Project, even though the U.S. Environmental Protection Agency has no such requirements for B.t. A number of mitigation measures were implemented to ensure environmental objectives were met, including:

(1) Designating all Class I, II and II streams on Project maps and alerting Application Team Leaders of specific environmentals concerns in each spray block on a daily basis;

(2) Spray blocks containing open waterways such as the main Tieton River, South Fork Tieton River, North Fork Tieton River, Rimrock Lake, Wildcat Creek, and Indian Creek, would be treated utilizing a flight pattern parallel to the waterway while spraying next to or in the proximity of the waterway;

(3) Domestic water supplies subject to contamination would be marked with flagging or balloons so that direct application could be avoided;

(4) Open springs used for domestic water supply would be covered with plastic, where feasible; and

(5) The bald eagle nest site would be protected with a one-half mile radius buffer zone in which no spray application or aircraft flight would be allowed.

Spray deposit cards were used along open domestic water supplies to determine if direct application to the water system occurred. Spray deposit samples did not show any evidence of spray material being deposited in flowing surface waters, according to the water monitoring report prepared by the Project Monitoring Leader (see appendix). The monitoring report also states that there were no domestic water sources that were subject to contamination since none were exposed. In only one case, Goose Egg Spring, was the water source exposed. This spring was covered over with plastic prior to treatment of the surrounding area with _B.t._

Water samples taken from 13 locations or time periods showed that surface waters within the spray area remained largely uncontaminated with _B.t._ The monitoring report indicates that _B.t._ was detected in only 2 out of 13 water samples collected. The amount of _B.t._ detected was extremely low; 1 colony per liter of sample in one instance, and 6 colonies per liter of sample in the other. To express this in terms of how much formulated spray material, 1 or 6

_B.t._ colonies per liter of sample represents a calculation was made using the number of viable spores contained per International Unit of activity of product (1,500 viable spores per International Unit of activity, based on the 48LV labelled potency). Since each _B.t._ colony results from the germination of only one viable _B.t._ spore, and, by calculation from the label, we are applying 1.8 X 10^{13} viable spores in 96 ounces of formulated spray per acre, the quantity of formulated spray contained in each liter of sample water required to produce 1 _B.t._ colony is 5.33 trillionths of an ounce (=5.33 X 10^{-12} ounces). Likewise, it would take 3.20 hundred-billionths (3.20 X 10^{-11} ounces) of an ounce of the formulated spray material per each liter of stream water sampled, to yield 6 _B.t._ colonies per liter of sample. It is apparent that only trace amounts of spray material reached the surface water, and that spray which did reach the water was quickly diluted by the large volume of flowing surface water. Since toxicity of pathogenicity to nontarget organisms has not been demonstrated with _B.t._, spray drift and residues in surface waters or on food crops do not present a health hazard. The U.S. Environmental Protection Agency has granted _B.t._ products such as Thuricide 48LV exemption from the requirements of tolerance on all registered crops. _Bacillus thuringiensis_ is commonly found in natural settings where susceptible ledidopterous hosts are present.

The fate of _B.t._ in water has not been thoroughly investigated, but it is believed that the presence and activity of _B.t._ in water is short-lived. Studies of water monitoring for _B.t._ during aerial applications of Thuricide to forest stands in Canada, indicate that viable _B.t._ spores detected in river water immediately after spraying, were not detectable after thirty days (Buchner, 1974, cited in Lassaman, 1987).

Observations were made on the pair of bald eagles during spray application of blocks located adjacent to the bald eagle's nest. A report from the monitoring team (see appendix) indicates that the bald eagles apparently are not disturbed by the presence of application and observation aircraft within a radius of one-half mile of the nest. These observations are consistent with other observations made of bald eagles on other insect suppression or eradication projects, such as the 1985 Oregon Gypsy Moth Eradication Project.

Accidents, Injuries, Incidents, and Spills

Need to mention the use of the Project area by the military Aircraft — No incidents occurred.

A summary prepared by the Project Safety Officer (see appendix) documents the safety record of the Project. As pointed out in this summary, an insect spray project, by the nature of it's activities, brings together several elements with varying amounts of associated hazards and risks. Even with the best preparation, training, personnel, and equipment, these hazards and risks can lead to accidents that result in personal injury or a fatality, and damage or destruction of equipment and property. The need to remain alert; to not take unnecessary risks; to diligently apply established regulations and operating procedures; and to avoid shortcuts to save time or money, when taking them compromise safety to individuals and equipment, cannot be over emphasized on a spray project.

Another measure of the success of a spray project is it's safety record. In the case of the Rimrock Project, the safety record was excellent. We had no accidents nor injuries requiring medical treatment beyond the normal first aid care provided to individuals on the Project. The minor Project injuries included cut fingers, debris in the eye, scraped and bruised skin, dog bites, and other injuries of similar nature. Continuous safety awareness and attitude on the part of all individuals--Government employees and contractor, alike--and frequent safety briefings for crews and pilots, paid off in terms of accomplishing a safe, accident-free project.

Only one aircraft incident was documented during the Project. That incident involved a helicopter used during spray block boundary marking, in which the N2 gauge stopped working during flight. The helicopter set down, and an inspection revealed that a sensor wire connection had vibrated loose. The wire was reconnected and the gauge began working again--the flight was resumed. Other minor occurrences that could have become aircraft incidents, include:

1. A helicopter left helibase in the wrong direction after receiving clearance to take off. Pilot was briefed on proper approach and departure from helibase.

2. An observation helicopter failed routine power checks. Use of aircraft was suspended until deficiencies were corrected and aircraft passed additional power checks.

3. A helicopter started to leave helibase without aircraft warning lights switched on. Pilot notified by radio, and turned lights on.

Air Operations personnel kept these events from becoming Aircraft Incidents by being alert and responsive, acting in accordance with established procedures, and applying sound judgment.

Several other items which proved to be minor annoyances to Operations personnel, pilots, and the contractor were noted in the Contract Daily Diary reports. These include problems with internal communication systems and radios, cracked plexiglass on the helicopter, malfunctioning air speed indicators, dead batteries, malfunctioning Hobb's meters, difficulty in starting aircraft on cold mornings, tripping circuit breakers on spray systems, leaking Beecomist nozzles, and leaking spray system pumps. These kinds of problems are notyunexpected on spray projects; but, stopping to deal with them during application waters valuable spray time.

Mechanical or Electrical Problems

Mechanical or electrical problems with the Project fleet were minimal. A few of the pickups had brakes overheat and start to seize up. Others had minor fluid leaks. No Project vehicle was involved in an accident or sustained damage, other than one vehicle's windshield cracked when a spring-loaded, tilt-forward seat struck it, after it was released. The worse problem with vehicles occurred when wiring to provide lights for a pickup canopy was improperly installed over one trucks driveline. The wire became entangled in the driveline and broke a hydraulic line to the clutch. This allowed hydraulic fluid to be sprayed onto the hot engine, resulting in a small fire. Quick action by the driver extinguished the fire. The hydraulic line had to be replaced.

A few minor spills occurred during the Project. While refueling a helicopter with jet fuel during block boundary marking, a pipe near the meter box on a truck began leading, and spilled 4 or 5 gallons of Jet fuel onto a dirt heliport landing. The operation was shut down for the day while the contractor got parts to repair the leak. The site where the aviation fuel leaked onto the ground was trenched around the spill and covered over with dirt. The aviation fuel did not get into any surface water. A couple of B.t. spills occurred when application aircraft were being loaded with batch. In both cases, the aircraft were overfilled because the batch truck pump pressure was too high. Approximately 4 gallons were spilled during the first overfill, and 2 gallons were spilled during the second overfill. The spills were covered over with soil, in accordance withe the Project Spill Plan.

ENTOMOLOGICAL ANALYSIS

Sampling Design and Procedures

The Entomological Plan described the operating procedures for the Entomological section during the Project. The Plan was designed with three objectives in mind; namely:

1. to insure that the Analysis Unit qualified with a high enough budworm population density to justify treatment;

2. to insure that spray blocks within the qualifying Analysis Unit are released for treatment at the appropriate time to maximize treatment effects against the budworm stages present; and

3. to achieve budworm population reductions that average less than one budworm larva or pupa per 45 cm branch tip.

Early Larval Density Sampling

The purpose of this sample was to qualify the Analysis Unit for treatment. To qualify, the Analysis Unit had to average four or more larval per 45 cm branch tip. The design of Early Larval Density Sampling used multiple-stage sampling statistics to crease a three-staged design. The three stages of the sampling design are:

1. sample plots for the first-stage sampling unit;

2. trees within plots for the second-stage sampling unit; and

3. branches within trees for the third-stage sampling unit.

The results of a computer analysis for Multi-Stage Sampling (MUST, see Hazard and Stewart, 1974), using larval densities from the 1985 Budworm Operational Evaluation to provide estimates of variances and costs, indicated that 40 plots, with 3 trees per lots and 1 branch per tree, would be required to estimate early larval density at a precision of 15 percent sampling error (S.E.) and 95 percent probability that the true mean would fall within the sampling error (P=0.05). A total of 46 early larval density sample plots were distributed over the 38 blocks. Five of the plots were located on blocks that were not treated, but were sampled anyway. Each block contained at least one Early Larval Density Plot.

The sample at each plot consisted of three Douglas-firs or three true firs. The trees were open grown host trees with bud-bearing branches in the midcrown, 20 to 30 ft. tall so the midcrown could be reached with a poleprunner, and open grown. An apical branch sample 45 cm long was clipped from the midcrown region of each sample tree using a poleprunner equipped with a cloth catch-basket. Each branch, plus any larvae that fell in the basket, was placed in a paper bag along with a label identifying the sample and plot location, and the bag sealed to prevent escape of larvae. After collecting all samples, the bags of foliage were returned to the laboratory for processing.

At the lab, foliage samples were held in a walk-in cooler at 40^{o}F. until they could be examined. During examination, current year's buds were counted and dissected to remove larvae, and all foliage carefully inspected for larvae. All larvae were placed into glass vials containing 95 percent ethyl alcohol, and later examined to determine species and instar. Larval density data were entered in the Data General computer and analyzed with WESTBUDS. The Western Spruce Budworm Decision Support System (WESTBUDS) consists of a number of FORTRAN computer program modules that evaluate and summarize entomological and spray assessment data collected during a suppression project into a report. Information from the report assists the Project Entomologist in making decisions and recommendations regarding qualification of Analysis Units for treatment and spray block release timings. The System also helps the Project

Entomologist evaluate the treatment efficacy and organize results into a report.

Larval Development Sampling

In order to properly time the application of B.t. to spray blocks to achieve the desired budworm population reduction, budworm development plots were established and sampled every 2 or 3 days initially, and everyday when development on a spray block was nearing time of release for treatment. Blocks were released for treatment with respect to the progression of larval development within each block. The Project Entomologist released spray blocks when measurements and observations on development plot sample trees and other locations in a block indicated that approximately 95 percent of all buds unfurled and approximately 50 percent or more budworm larvae were in the 5th instar or later.

A selection of three sampling locations for budworm development plots was based on the ability of the plot locations to best characterize the range of both elevational and aspect differences within the block, and the degree to which plots locations would be accessible by road or trail. In a couple of cases, access to the spray blocks was nonexistent. In these situations, additional development plots were established in adjacent blocks at the same elevation and aspect as the sites on the inaccessible block which budworm development information was needed to release the block. We assumed that larval development on the inaccessible block would be similar to sites on an adjacent block, at the same elevation and aspect.

Each of the three development plots per spray block consisted of either 2 Douglas-fir or 2 true fir trees per plots. Sample trees had abundant foliage with new buds in the lower crown, which could easily be reached from ground level. Sample trees were open-grown, dominant host species. Plots were established so that both Douglas-fir and true fir were represented, where blocks contained mixed budworm host types.

Development sampling was done in a manner similar to that described by Williams, et al. (1985). Samples were obtained by clipping two 45 cm branches containing new buds and shoots from sample trees, and cutting it in small segments into a paper sack. A slip containing sampling plot and location information was placed in the bag, the bag stapled shut, and transported to the lab for processing.

Budworm development foliage samples were placed in a walk-in cooler at 40°F. at the lab, until they could be examined. Each sample was examined within 24 hours after collection. Every attempt was made to examine foliage the day it was collected, but due to the laborious job of going through foliage and dissecting larvae from buds that were not opened, this proved impossible. All larvae were removed and put into glass vials containing 95 percent ethyl alcohol. The larvae were examined by qualified individuals to determine instars. Instar determinations, along with bud-burst data were analyzed at the Ft. Collins Computer Center using WESTBUDS. Percent fifth-instar or greater results were plotted on a leistegram chart??? , but spray block at each sampling period, to follow the progression of budworm development on each block over time.

Post-Treatment Budworm Density Sampling

Budworm populations on spray blocks were sampled at the beginning of pupation to determine the effectiveness of the B.t. treatment in reducing budworm populations below an average density of 1.0 healthy larva and/or pupa per 45 cm branch tip over the Analysis Unit. Post-treatment evaluation utilized a multiple-stage sampling design similar to the early larval density design to determine the optimum allocation of sampling resources to the three sampling stages; plots, trees, and branches. Based on the 1985 Project data using a precision of 30 percent sampling error and 90 percent probability (P=0.90), the analysis indicated that 40 plots with 3 trees per plot and 2 branches per tree would be required. To increase the level of precision in estimating the residual budworm population mean, the Project Entomologist choose to increase the sampling intensity by including more plots. A total of 91 plots were established over the treated portion of the Analysis Unit. In addition, 12 post-treatment density plots were established on the untreated spray blocks.

The evaluation plots were distributed throughout the samplable host-type. Plots were a minimum of 1/4 mile inside the spray block boundary to avoid edge effect of spray application. A District Transportation map was used to record the plot locations for a permanent record. The plots will be revisited the year following treatment to assess current defoliation levels.

The sample trees conformed to the same criteria as described for the Early Larval Density Sample. Evaluation plot trees were distributed within an area approximately 1 acre in size. Branches 45 cm in length were clipped from the midcrown of each sample tree on the plots using a poleprunner equipped with a cloth collection basket. The branch and any larvae that had fallen off into the basket were carefully deposited onto a white cotton table cloth spread open on the ground near the sample trees. All larvae, pupae, and pupal exaviae were counted and collected for rearing (larvae and pupae) or examination (exaviae) by the Entomology staff. All live larvae and pupae were placed individually into plastic petri dishes and returned to the lab for rearing.

The larvae and pupae were reared to determine the amount of latent _B.t._ infection and parasitism in the residual population. Insects were reared on artificial diet until either death or adult emergence occurred. A portion of those individuals which died from causes other than parasitism, were sent to the Forestry Sciences Laboratory at Corvallis, Oregon, for culturing, to determine if death resulted form latent _B.t._ infection. Results of bacteriological studies were not available at the time of this writing. Rearing data was analyzed using WESTBUDS.

Post-Treatment Defoliation Estimates

Post-treatment defoliation estimation was done to establish a baseline defoliation level with which to compare subsequent year's of defoliation against, as a measure of long-term effectiveness of _B.t._ treatment. Midcrown branch samples collected for determining post-treatment budworm densities, were used to make estimations of 1987 defoliation levels. Defoliation was rated for a total of 20 new (current year's) buds on each branch. A defoliation index which places each shoot or bud into one of six discrete classes of defoliation, was used to rate current foliage for each branch. The following scheme was used:

Defoliation Index	Percent Defoliation
1	0
2	1-25
3	26-50
4	51-75
5	76-99
6	100

Defoliation data as analyzed using WESTBUDS.

Adult Trapping

To provide additional measurements of the post-treatment residual budworm population, and to predict levels of defoliation that may occur in 1988, adult trapping of western spruce budworm was conducted on the Rimrock Analysis Unit. Adult male western spruce budworm moths were trapped using milk carton (delta-type) sticky traps baited with the synthetic sex attractant or pheromone, of the female moth. The bail consisted of a PVC pellet impreguated with a 92:8 mixture of E-11 and Z-11 tetradecenal, at a strength of 0.0001 percent by weight. One trap was placed on each spray block, including those blocks which were untreated (i.e., block nos. 16, 24, 27, 35, 36, and 37). The traps were also placed on the untreated Naches Analysis Unit, for comparison with the treated Rimrock AU. The traps were placed in the AU beginning on June 23 (Naches AU), and June 29 (Rimrock AU), and collected from both AUs beginning on August 3. Both the placement and collection of traps took about 3 days for both AUs. All adult trapping data was entered into a database on the Data General computer and analyzed by WESTBUDS at Ft. Collins.

Spray Assessment Sampling

Spray assessment sampling was used to monitor the overall quality of the spray application over the treated portion of the Analysis Unit. Spray deposit data were analyzed to determine:

1. if the treatment reached the intended target area;

2. if the treatment coverage was uniform over the treated area; and,

3. whether the contractor achieved the "acceptable" application density as measured by droplet density on randomly placed deposit sampler lines.

The spray deposit results were also used to provide timely information to Application Team Leaders and/or Aerial Observers for making on-site corrections of application deficiencies.

White Kromekote-coated cards were used as deposit samplers. Cards were placed in wire card holders designed to hold deposit samplers off the ground and above ground vegetation to prevent damage from ground moisture, animal damage, and other factors (Maksymink, 1959). A design which employed 45 cards over a distance of 450 ft. in a meandering line or equilateral triangular pattern, similar to that used for characterizing aircraft spray (Dumbauld and Rafferty, 1977), was used to place cards in openings, as much as possible. An attempt was made to place two cardlines or cardgrids (triangles) in every treated spray block. This was not always possible, however, due to limited accessibility or some spray blocks. Cards were placed prior to commencement of spray operations on each block, usually well before daylight. By the time the application of *B.t.* had been completed on 32 spray blocks, 51 cardlines or cardgrids had been placed to evaluate spray deposit.

In addition to the cardlines and cardgrids, spray deposit cards were placed around evaluation plot sample trees on 17 of the 32 blocks treated. Deposit samplers were placed around sample trees in each cardinal direction, approximately 10 feet out from the dripline of the tree. All cards were picked up approximately 1/2 hour after the block was treated, to allow time for the fine spray droplets to settle out.

Spray assessment crews estimated spray deposit on each card, and twenty percent of the cards were counted under a magnifier or microscope to verify estimates. Data was analyzed in WESTBUDS using statistical procedures for double sampling data. The analysis computed a linear regression equation that provides an estimate of the average droplet density per square centimeter on each spray block, based on the regression of the counted droplets with the estimated droplets.

Results and Discussion

Early larval density sampling began May 21, 1987, and was completed and analyzed by May 26, 1987. The Project Director was notified that the Rimrock Analysis Unit qualified for treatment with a mean population density of 5.5

larvae per 45 cm branch tip. After adjusting treatment areas by dropping low or zero population spray blocks to bring Project treatment acreage in line with contract acreage, the early density data was reanalyzed for the Rimrock AU. The results of the analysis indicated that the early larval density on the treated blocks was actually 5.9±0.82 larvae per 45 cm branch. Densities on the 6 plots representing the spray blocks dropped from treatment, averaged 2.3±1.10 larvae per 45 cm branch (see appendix). Early density data for the untreated Naches Analysis Unit were not obtained.

The density estimate for the untreated blocks on the Rimrock Analysis Unit should be viewed with less confidence than the treated blocks, due to the very small sample size and low precision of the estimate (i.e., percent standard error). Also, comparisons between treated blocks and untreated blocks should be made with considerable discretion. These untreated blocks were never intended to be untreated control or check area for use in comparing with treated blocks or statistical hypothesis testing of treatment effects. These data on untreated block densities are included merely for information, since the data were available.

The Entomological Plan called for spray blocks to be released for treatment when 50 percent or more of the larvae were 5th-instar or greater, and when approximately 59 percent of all buds had unfurled. Monitoring of insect and bud development indicated that lower elevational blocks and those with southerly or easterly exposures would be released for treatment first. In general, the lowest elevation blocks within the Analysis Unit (i.e., those south of and adjacent to Rimrock Lake were released first. The last blocks to be released were high elevation sites, and nearly all located south of Rimrock

Lake. A review of the block release and treatment dates (see appendix) indicates that insect development progressed rapidly over the Analysis Unit. All blocks were released within 13 days.

Data on inset and bud development indicate that block releases were timed about right in the Entomological Plan. Figures and (see appendix) depict the budworm development and budburst results, respectively, for spray blocks at the time of release. Averaged over all treated blocks on the AU, insect development shows that blocks were released when 57.3 percent (SE=1.63) of the budworm were 5th instar or larger; whereas, budburst averaged 99.1 percent (SE=.27) blocks when released for treatment. The average budworm instar for each block when released for treatment is depicted in Figure _______(see appendix). Averages ranged from 4.2 to 5.1.

The block frequencies of average instar at the time of release for treatment are described by Figure ______(see appendix). The overall average budworm instar at the time of block release was 4.5 ± 0.04.

Spray blocks were released for treatment at the appropriate time in nearly all cases. In a few instances, blocks could have been released somewhat earlier, had more development plots been taken over the range of elevations represented across the blocks. In these instances, insect development sampling led to incorrect estimates of budworm development over the blocks, either because of the small numbers of insects found in the sample, or the plots were located at elevations which did not accurately represent the true range in development of the insect over the block, even though an attempt was made to distribute the three development plots over each block to characterize elevational change.

This led to delaying the release of the block until development over the block was actually further advanced than that indicated by the development measured on plots. However, this did not appear to result in any measurable loss of efficacy of the treatment due to the somewhat more advanced age of larvae at time of treatment.

Spray block 38 is one such case in point. Budworm development was first measured on this block on May 26. The samples from three plots contained a total of 25 budworm larvae; none of which were over fourth instar, and the mean instar was 3.6. The block was sampled again 2 days later, and only 13 larvae were found, distributed 31 percent as second-instars, 46 percent as third-instars, and 23 percent as fourth-instars. The mean development stage of the sample was 2.9. The drop in mean development over the earlier sample was a result of sampling error from the small sample size (non-representative sample). Since the insects were all fairly small, and weather conditions over the following days gave no reason to suspect rapid growth of the insect, the next sample of the block was not scheduled until June 2. The June 2 sample did not indicate any significant change in development from the previous. However, only 4 larvae were found in this sample. The mean instar was 3.2. The block was sampled again the following day because the small numbers of larvae in the previous day's sample did not foster confidence in the data. Only 10 larvae were taken in this sample, and they were distributed 10 percent third-instar; 50 percent fourth-instar, and 40 percent fifth-instar. The mean development was 4.3. The block was next sampled on June 5. No larvae were found in any of the three plots sampled on this date. We sampled the block again the following day and found only 2 larvae--one fifth-instar and one sixth-instar. Again, the small sample size made the reliability of the data suspect, especially after taking another sample the following day. The June 7 sample revealed a total of 12 larvae distributed 25 percent in the third-instar, 25 percent in the fourth-instar, 33 percent in the fifth-instar, and 17 percent in the sixth-instar. The mean instar was 4.4. Rather than release the block for treatment, the Project Entomologist opted to sample the next day to see if the development measured on the plots was, indeed, ready to release. The sample of June 8 showed that the four larvae that were found were distributed equally across instars 3 through 6. This still didn't indicate a change from the 50 percent in fifth-instar or greater measured the day before, and the small numbers of insects taken in the sample left the data open to question. It was decided that sampling should be done more intensively, and at lower elevations, closer to Clear Lake. The sampling of nine development plots on June 9, revealed some startling information about the budworm population on block 38. We found 208 larvae and 1 pupa (0.5 percent of total in pupal stage). Almost 74 percent of the budworm were in the fifth-instar or greater; the average instar was 4.9. Block 38 was immediately released for treatment.

The experience on block 38 points up the need to intensify sampling efforts early on when it is suspected that, due to extreme range in elevations over a block or lack of an adequate sample size, the development data do not reflect the true development of budworm over the block. Had more intensive sampling at additional--especially lower elevations--sites been done earlier, spray block 38 would probably have been released for treatment 3 or 4 days sooner.

Each spray block on the Rimrock Project was readily treated within a day or two, and no block approached a point of insect development where it had to be withdrawn, or even considered for withdrawal, from treatment. Adverse weather did not cause undo delays in treating blocks, nor did development of the budworm advance so rapidly that the contractor couldn't keep up with block releases. Even if conditions had occurred to cause delays, the contractor would probably still have had adequate time to treat blocks released for treatment before the insects get too old to treat. It seems that in the case of the Rimrock Project, the spray window defined by the parameters .50 percent in the fifth-instar or greater, and less than 5 percent pupation, provided a realistic and operable window within which treatment could occur. Although the Rimrock Project did not experience untoward delays due to adverse application conditions, it is not known to what extent the spray window might have become operationally limiting, if significant delays had occurred. This question may take on greater importance in larger projects where application equipment may also become a limiting factor in achieving adequate and timely treatment of spray blocks with B.t.

Post-treatment Densities

Analysis of post-treatment budworm sampling results yielded an average residual density over the Analysis Unit of 0.89 ± 0.10 budworm per 45 cm branch tip, unadjusted for latent B.t. mortality (table ____ in appendix). The B.t. treatment, in reducing the population of budworm to less than 1.0 larva or pupa per branch over the AU, achieved the Project population reduction objective, and resulted in a successful and effective operational treatment for budworm. Budworm levels are expected to remain low and undamaging during the course of the present outbreak. The extant budworm populations adjacent to the Rimrock Analysis Unit were either extremely low or non-existent because the perimeter of the AU was mostly located at high elevations where budworm host-type became limiting. Sites where host trees are few in number typically harbor low and limited populations in comparison to sites where budworm hosts are abundant. Accordingly, migrating larvae or adult moths from these areas into the treated unit, are not expected to cause the population to increase to damaging levels again soon. Budworm natural enemies should be able to regulate the insect's numbers over the long-run, both within and outside the treated Analysis Unit.

Results from sampling untreated spray blocks on the Rimrock Analysis Unit, showed populations of budworm had declined from early larval density samples taken prior to eliminating these areas from treatment. It is difficult to conclusively prove what caused the decline in insect numbers on these untreated areas because mortality rates in field-collected and reared larvae were extremely low, as will be shown later. One possible explanation might be that predation from ants, birds, spiders, or other animals caused a reduction in budworm numbers. Ants seemed to be abundant on certain sample trees. It was not uncommon, for example, to find ants carrying off budworm larvae from foliage samples collected to monitor development, prior to post-treatment density sampling. The extent of predation and its impact on budworm population levels on the Rimrock Analysis Unit for both treated and untreated blocks is unknown and was not measured.

Samples of larvae which died during the rearing phase were sent to a laboratory for diagnosis and culturing to determine whether B.t. produced latent mortality in these individuals. Since those larvae that were sent had not been parasitized, we assumed that detection of B.t. in the cadavers from culturing on bacteriological media would indicate latent B.t. mortality once microscopic examination eliminated virus or microsporidia as etiologic agents. These diagnostic results had not been received by the time of this writing, however,

A small amount of sampling for budworm occurred on the Naches Analysis Unit in order to establish relative population levels. This Analysis Unit had been considered in the Environmental Assessment for budworm during 1987, but was not selected for treatment. Sampling was conducted to estimate budworm densities just prior to commencement of post-treatment density sampling or the Rimrock AU. Although not sampled as intensively as the Rimrock, the Naches Analysis Unit displayed budworm levels comparable to those found on the Rimrock AU during the early larval density sampling. Budworm densities averaged 5.22 ± 1.06 larvae or pupae per 45 cm branch on the Naches AU. Initial population levels on the Naches AU, undoubtedly, would have been higher, but natural mortality factors reduced budworm numbers to the current density.

Post-treatment Budworm Rearings

A total of 486 budworm were reared from 88 plots on the treated portion of the Rimrock Analysis Unit, and 17 budworm were reared from 11 plots located on the untreated portion of the unit. In addition, 366 budworm were reared from 16 plots located on the Naches Analysis Unit. The larvae that died within these rearing groups were segregated in an analysis, by their mortality or survivorship status.

The Rimrock unit rearings showed that approximately one-half of the post-treatment larvae survived to adulthood on the treated (47.8 percent) and untreated (57.7 percent) portions of the AU, respectively. The proportion of survivors on the Naches Analysis Unit was 62.1 percent (table_____ in appendix). The remaining proportion of reared larvae were found to have been parasitized by braconid or ichaeumonid wasps, tachinid flies, or died from other unidentified causes, including latent _B.t._ infection in the treated portion. Parasitism accounted for approximately 29 percent of mortality of reared larvae on the treated portion of the Rimrock AU, and 15 percent on the untreated portion. In the later case, however, the results were based on only 3 observations, and may not be accurate. The Naches Analysis Unit, on the other hand, showed the same rates of parasite-caused mortality as found on the treated Rimrock AU. In this case, approximately 29 percent of the reared larvae had been parasitized. These results confirm those of Thompson, et al. (1977) and Nieva et al. (1987) where nearly identical rates of parasitism of larvae not killed by _B.t._ were found in treated and control plots, alike. Thompson et al. (1977) suggest that these results indicate the environmental compatibility of _B.t._ treatments with budworm insect parasites. In some instances, budworm parasites can become infected with _B.t._ from their hosts, although this percentage is quite small. Nieva et al. (1987) concluded that application of _B.t._ to control western spruce budworm is not detrimental to the associated parasite species.

The category of "other" mortality of budworm identified from the rearings was very similar on the Rimrock treated and untreated areas (although number of observations were limited for untreated block), but quite different for the untreated Naches Analysis Unit (table____). This unknown mortality includes injuries from handling and latent _B.t._ infections, as well as other unidentified components. Unknown mortality, however, has not been quantified by specific cause, except for sub-samples used to diagnose _B.t._ Rates of other mortality reported here are within the range of unknown mortality causes reported elsewhere for treatment of budworm with B.t. (cf Beckwith et al., 1984).

The measurement of this unknown mortality is important in determining final population density as a result of treatment effects. Field tests and laboratory studies with B.t. have shown that application of B.t. can have persistent residual activity that may extend over time, the prevalence of the disease in the budworm population. In a study on the persistence of two B.t. formulations applied in the field against western spruce budworm, for example, Beckwith and Stelzer (1987) found that for 12 BIU per acre applications, the half-life of B.t. exceeded 10 days from the time of treatment. On one of their treated blocks, they found extended B.t. activity on foliage 20 days after spraying. The number of budworm larvae that succumb to the bacterial entomopathogen increases over time due to the deaths of those larvae harboring latent infections or which acquired the disease sometime after treatment with B.t., because of the extended half-life of B.t. residues. We attempted to capture the latent effects of B.t. on budworm population, as well as initial mortality, by:

1. scheduling the post-treatment density sample at the first signs of pupation (sampling late);

2. rearing budworm to determine amount of mortality in the unknown category which would include latent B.t. mortality; and,

3. verifying diagnostically, either by microscopic examination or culturing on bacteriological medium, the presence of B.t. in those individuals which died from unknown causes.

Results of the foregoing provide justification for adjusting post-treatment budworm densities by that proportion of "other" mortality attributable to B.t., based on diagnostic evaluation results. Our new final treatment-caused budworm population reduction mean on the treated portion of the Rimrock Analysis Unit, after adjusting for latent B.t. mortality, becomes _______ budworm per 45 cm branch tip. As shown in table ____, we can also expect further reductions in budworm numbers from parasitism, as well as predation and other unaccounted for factors. In the final analysis, to fully evaluate treatment effects, latent B.t. infections resulting in budworm mortality need to be measured because they contribute to the overall treatment-caused reduction of the budworm population. Beckwith and Stelzer (1987) emphasized the importance of residual effects of B.t., based on their findings, by concluding that the persistence of B.t. on treated foliage is important to total mortality of budworm and its impact on the forest resource.

Defoliation

Western spruce budworm defoliation occurring in 1987 was compared with defoliation from 1986 in figure _______. Although some proportion of the evaluation plots on spray blocks had defoliation distributed across all defoliation classes in 1987, the highest frequency of plots (65.4±2.0 percent) fill into the "no-defoliation" (0-percent) class. The majority of the remaining plots were found in the 1 to 25 percent defoliation class, and only

minor proportions of the total plots had 26 percent or more budworm-caused defoliation (figure ____ and table ______).
Defoliation from the previous year was more severe. Less Than 25 percent of the evaluation plots had no defoliation, and a greater number of plots had higher levels of defoliation in 1986 than in 1987 (cf. figure ____ and table ____). Although foliage protection was not a stated objective for the 1987 Budworm Suppression Project at Rimrock Lake, it appears that some measure of foliage protection did result from the *B.t.* treatment.

Adult Moth Trapping

Adult moth captured in pheromone-baited sticky traps represent another measure of the residual budworm population following treatment. Table ______ shows the mean numbers of moths trapped on the treated and untreated portions of the Rimrock Analysis Unit, and on the untreated Naches Analysis Unit, for comparison.

The treated and untreated blocks on the Rimrock Analysis Unit were very similar in adult captures (2.32 vs 2.67 moths per trap, respectively). This similarity is not unexpected since ending populations on both treated and untreated units were similar. A very different adult population density was found on the untreated Naches Analysis Unit, however. The Naches AU had moth catches 10 times higher than the Rimrock Lake side (table ____). This result is also characteristic of the trends found by comparing the evaluation plot results for Rimrock and Naches AUs in table _____.

Sartwell (1987)1/ has shown that defoliation trends during the following season can be reliably predicted from pheromone-baited sticky trap catches of western spruce budworm adult male moths. Based on his estimates, the Rimrock Analysis Unit is predicted to have no budworm-caused defoliation that will be visible from the air in 1988. This is not to say that defoliation will not be visible from the ground during 1988, however. We would expect some minor amount of ground visible defoliation--though probably very slight--to result from budworm feeding during 1988, since there is a residual budworm population left at Rimrock Lake. The minor amount of defoliation in 1988 will be of no consequence to visual, recreational, or timber and other values represented by the area. Moreover, it is doubtful that any defoliation will be visible to the casual observer.

The Naches Analysis Unit, on the other hand, will experience high levels of defoliation in 1988, than that predicted for the Rimrock AU. With an average capture rate of 26.90 ± 2.50 moths per trap, the Naches AU is predicted to have relative levels of defoliation falling within the "light" category, during 1988. Certain areas within this AU that have been characterized as having light defoliation in 1986 or 87 may become classed as "moderate" in 1988, if budworm populations remain high or increase.

1/ Personal communication with Charles Sartwell, Pacific Northweset Research Station, Forestry Sciences Laboratory, Corvallis, Oregon.

Spray Deposit Assessment

Spray Assessment crews placed spray deposit samplers on 29 of the 32 blocks sprayed with B.t. The three unsampled spray blocks lacked adequate access or sampling location to install sufficient spray deposit samplers to represent the application over these spray blocks. Crews installed over 2,400 Kromekote cards on 52 cardlines over the treated Project area, and placed an additional 216 cards on 18 evaluation plot grids around evaluation plot sample trees on 17 of the 32 blocks treated.

Spray deposit results were variable from block to block, and seemed to be mostly dependent upon the interaction or influences of the filtering of spray by the tree canopy; temperature, wind, and relative humidity; height of spray release over the canopy; and direction of aircraft flight relative to the cardline. By both estimating and counting deposit within one-square centimeter marked on each spray deposit card prior to treatment, we were able to use double-sampling statistics to compute a correction for estimated means based on a least-squares linear regression fit of estimated deposit data with actual counted data from a random sample of twenty percent of the cards. The raw sample means for the estimated and counted deposit were 13.12 ± 0.82 and 12.09 ± 0.71 drops per cm^2, respectively (n=311 paired observations). The regression equation fitting a line to these data was $y=1.2168 \pm 0.8286x$ ($R^2=0.9281$); the Analysis of variance yielded a very highly significant 4-value for the regression of 4001.21 ($p<0.001$), indicating that the slope differ significantly from zero. The average deposit estimated from all spray deposit cards was 11.87±1.53 (ranging from 1.93 to 35.85). After adjusting the estimates based on the regression with the counted cards, the spray deposited on cards averaged 11.05±1.27 drops per cm^2, overall (range=2.82 to 30.92).

Clearly, mean drop density for the overall project averaged less than the 20 drops per cm^2 specified in the contract. Only 21.6 percent of the cards actually contained densities of 20 drops per cm^2 or more on the cards. Project overhead team members were very concerned at the beginning of spray operations, that adequate spray material was being deposited on the foliage. A number of discussions revolving around spray deposit results occurred during daily Project Overhead Team meetings. Ground and air observation indicated that during most of the periods of application, spray material was reaching the targeted needle surface. Poor applications were noted and the contractor was stopped when deposit density and spray cloud behavior indicated that conditions for spraying had deteriorated. Certain portions of at least two blocks were retreated due to inadequate coverage on spray deposit cards, and from ground and air observations.

The consensus of Project Overhead Team members was that droplet density on spray deposit cards should not be viewed as the absolute measure of application success, but rather as another tool to help do the best job possible of applying the pesticide in the right place, and at the correct rate per acre. There is a fallacy in thinking that because the aircraft were calibrated and characterized to deliver 20 drops per cm^2 should be expected at the ground level within openings in the canopy. Spray behavior is clearly different under the two conditions. Filtering out of spray material by the canopy, air disturbances and turbulence created by the "rough" surface of surrounding trees, and various other factors operate to limit the amount of spray material reaching deposit samplers at or near the ground, within stand openings. As the spray application progressed, Project personnel became more at ease with spray deposit results, and interpreted and used the results in a meaningful way to make application adjustments and insure that the treatment reached the target and was uniformly applied over each block.

Not all spray cards contained deposits of spray material. Portions of cardlines showed "skips" either because the spray swath missed part of the line (did not overlap with other swaths) or the spray drifted off and missed the intended target. This occurred infrequently, however, in that only 9.36 percent of the total cards had no deposit whatsoever. Although skips during spray application were not entirely unavoidable, the minor amount of skips occurring on the Rimrock Project were probably not serious enough to significantly influence biological results, and were not worth requiring retreatment of the block (except in the few instance mentioned above).

The results of placing cards around evaluation plot trees yielded higher drop densities than over the Project blocks as a whole. The evaluation plot cardgrids averaged 17.30 ± 4.08 drops per cm^2. The large standard error indicates a fair amount of sampling error associated with the estimate of the mean density. This suggest that the mean is probably less reliable as an estimate of actual deposit within the block than the mean derived for the overall Project. A linear regression "least-squares fit" using the evaluation plot data was performed to examine the relationship between survivorship or mortality with spray drop density. Variation in spray drop density could only explain 9 percent of the variation in budworm survival or mortality ($R^2=0.09$, N=17), indicating that variability in population densities between spray blocks was so great that mortality or survivor densities were independent of spray drop density. On one spray block, for example, we measured 0.0 percent survival on evaluation plot trees that had only 2.5 drops per cm^2 on the spray deposit cards around those same trees. On another block, however, we ended with 0.0 percent survival and 39.4 drops per cm^2 on the spray deposit cards around the same trees. The beginning populations on these two blocks were 7.7 larvae per 45 cm branch in the first case, and 0.7 larvae per branch in the second. These kind of data point out the difficulty in trying to analyze treatment effects when population densities are so variable between blocks. In addition, the sample size is too small to estimate mean deposit without considerable sampling error.

Overall, spray deposit assessment was useful in indicating areas skipped during application, which could help to explain erratic results. It was also useful in providing immediate feedback to Aerial Observers and Application Team Leaders, so that adjustment could be made by the contractor to improve application, including the retreatment of spray blocks or portions of block, if necessary.

APPENDICES

SPRAY BLOCK NO.	HIGHEST ELEVATION (FEET)	LOWEST ELEVATION (FEET)	ELEVATION CHANGE (FEET)	ASPECT	MAP[1/] ACRES
1	3920	2930	990	SW	1325
2	4080	2930	1150	S	1413
3	5320	3600	1720	SW	1183
4	5240	3840	1400	E	654
5	5152	4120	1032	N-NE	1168
6	4520	3400	1120	SE	824
7	5200	3200	2000	S-SW	3301
8	4020	2520	1500	S-SE	3108
9	4240	2320	1920	E	216
10	4400	2480	1920	N	1825
11	4440	2594	1846	NE	855
12	4440	2800	1640	E	1079
13	4440	2930	1510	SE	1416
14	5360	2989	2371	N	1295
15	4480	2930	1550	N	3556
16	3373	2930	443	N	NO SPRAY (EAGLE)
17	4080	2930	1150	S	583
18	4128	2930	1198	N-NE	564
19	4480	2930	1550	SE	775
20	4440	2360	2080	N	1109

21	4532	2960	1572	NW	1991
22	4000	2930	1070	NW	1376
23	4200	3000	1200	SE	1377
24	5020	4420	600	N	NO SPRAY
25	4960	3400	1560	E-SE	1300
26	4720	3200	1520	NW	1552
27	5440	3720	1720	N-NE	NO SPRAY
28	4160	3080	1080	E-SE	671
29	4360	3350	1010	N	634
30	4400	3120	1280	E	2208
31	5400	2840	2560	N-NW	705
32	5440	3400	2040	N	1481
33	5200	3600	1600	NW	1218
34	5492	3620	1872	W-SW	2010
35	5280	3680	1600	W	NO SPRAY
36	4580	3540	1040	W	534
37	5120	3520	1600	E	NO SPRAY
38	4480	2989	1491	SE	1681

1/ NO SPRAY BLOCKS WERE NOT TREATED BECAUSE OF BALD EAGLE'S NEST (BLOCK 16) OR EXTREMELY LOW OR NON-EXISTENT WESTERN SPRUCE BUDWORM POPULATIONS. NOTE THAT MAP ACRES DIFFER FROM TREATMENT ACRES.

1987 WESTERN SPRUCE BUDWORM SUPPRESSION PROJECT - RIMROCK LAKE

BUDGET SUMMARY

BUDGET ELEMENT	TOTAL AMOUNT	ACCOUNT PER ACRE
APPLICATION CONTRACT	$500,945	$11.34
SALARIES	190,900	4.32
MONITORING	500	.01
VEHICLES	51,200	1.16
TRAVEL AND PER DIEM	40,300	.91
SUPPLIES AND EQUIPMENT		
MATERIALS AND SUPPLIES	8,500	.19
RENTS AND UTILITIES	7,200	.16
ADP AND FLIPS	5,800	.13
OTHER		
MARKING CONTRACT	17,800	.40
HELIPORT CONSTRUCTION	1,500	.03
PROJECT CLOSE-OUT	5,000	.11
TOTALS	$829,645	$18.79

+ 7.42 = 18.76

Appendix ______

Action Items and Dates for the

1987 Western Spruce Budworm Suppression Project

at Rimrock Lake

Date	Action Item
April 13-17	Spray Operations training and project orientation at the Shilo Inn, Eugene, oregon.
April 15	Recruitment Notice for Temporary positions on the entomology crew classes.
April 27	Spray contract bids are opened in the RO.
May 7	Marking contract bids are opened in the RO.
May 11	Second Recruitment Notice for temporary positions on the entomology crew opens.
May 11	Leased vehicles for project scheduled to arrive at Naches RS.

May 11	Project Director, Assistant Project Director, Operations Managers, Project Entomologist, Assistant Project Entomologist, and Safety/Fleet Officer report to the Project.
May 12-13	Project Entomologist, Assistant Project Entomologist, and Operations Manager check budworm host typing and develop spray block map. Early development check by Entomology.
May 13	Second Recruitment Notice for temporary positions on the Entomology crews closes.
May 13	Remaining Project Overhead Team arrives on Project including Assistant Operations Chief, Plans Manager, Application Team Leaders, Administrative Officer, and Project clerk/typist.
May 13-14	Set up office and work areas.
May 18	Assistant Public Information Officer, Entomology Crews (temporaries), and Aerial Observers report to the Project.
May 18-20	Temporary crew training.

May 21	Begin early larval density sampling and development sampling with Entomology crews.
May 22	Begin spray block boundary marking by helicopter.
May 25	Environmental Monitoring Team report to the Project.
May 26	Load Checkers report to the Project.
May 28	Ground Observers report to the Project.
May 30	Complete spray block boundary marking.
June 1	Start spraying.
June 12	Finish spraying. Operations personnel released from Project.
July 10	Vehicle turn in date for all rigs except those assigned to the Entomology crew.
July 10	Release temporary personnel on Entomology crews from Project.
July 31	Turn in date for the Entomology crew vehicles.

SUMMARY OF RELEASE AND TREATMENT DATES FOR 1987

WESTERN SPRUCE BUDWORM SUPPRESSION PROJECT,

RIMROCK LAKE, WENATCHEE NATIONAL FOREST

SPRAY BLOCK NO. 1/	RELEASE DATE	SPRAY START DATE	SPRAY FINISH DATE	ACRES TREATED 2/
1	JUNE 6	JUNE 6	JUNE 8	1,440
2	JUNE 5	JUNE 6	JUNE 6	1,367
3	JUNE 9	JUNE 11	JUNE 11	1,195
4	JUNE 9	JUNE 11	JUNE 11	674
5	JUNE 12	JUNE 12	JUNE 12	1,168
6	JUNE 9	JUNE 11	JUNE 11	814
7	JUNE 7	JUNE 8	JUNE 8	3,025
8	MAY 31	JUNE 1	JUNE 4	3,040
9	JUNE 1	JUNE 2	JUNE 2	153
10	JUNE 1	JUNE 3	JUNE 4	1,825
11	JUNE 2	JUNE 4	JUNE 5	855
12	JUNE 7	JUNE 7	JUNE 7	1,027
13	JUNE 5	JUNE 6	JUNE 7	1,373
14	JUNE 7	JUNE 8	JUNE 9	1,200
15	JUNE 6	JUNE 6	JUNE 9	3,553
17	MAY 31	JUNE 1	JUNE 1	583
18	MAY 31	JUNE 2	JUNE 3	591

19	JUNE 3	JUNE 4	JUNE 5	801
20	JUNE 4	JUNE 4	JUNE 6	1,109
21	JUNE 6	JUNE 6	JUNE 7	2,054
22	JUNE 6	JUNE 6	JUNE 6	1,376
23	JUNE 8	JUNE 9	JUNE 9	1,367
25	JUNE 8	JUNE 8	JUNE 9	1,281
26	JUNE 11	JUNE 11	JUNE 12	1,725
28	JUNE 2	JUNE 3	JUNE 4	876
29	JUNE 9	JUNE 9	JUNE 10	693
30	JUNE 9	JUNE 9	JUNE 9	2,193
31	JUNE 9	JUNE 9	JUNE 9	705
32	JUNE 8	JUNE 8	JUNE 9	1,481
33	JUNE 11	JUNE 12	JUNE 12	1,200
34	JUNE 10	JUNE 11	JUNE 12	2,011
38	JUNE 10	JUNE 11	JUNE 11	1,507
			TOTAL	44,262

1/ SPRAY BLOCKS 16, 24, 27, 35, 36, AND 37 NOT TREATED.

2/ ACRES TREATED BASED ON GALLONS APPLIED (INCLUDES HEAVY APPLICATION AREAS AROUND SUMMER HOME SITES, CAMPGROUNDS, AND ORGANIZATIONAL CAMPS, AND PORTIONS OF BLOCKS RETREATED DUE TO LIGHT INITIAL APPLICATION OR SKIPS).

Appendix ________

Summary of Reasons for Terminating Spray

Operations for the Day

Condition or Circumstance 1/ for Terminating Spray Operations	Frequency (Days)
Low Humidity	2
Poor Weather (spray rising)	7
Poor Weather (lost weather)	6
Poor Weather (spray hanging)	1
Poor Weather (wind and/or precipitation)	3
Block Completed (lost spray weather)	5
Block Completed (ran out of spray)	1
Mechanical Failure (malfunctioning pump seal)	1
Mechanical Failure (Hobb's meter failed)	1

1/ All reasons cited in daily reports by Application Team Leaders and Aerial Observers for terminating spray operations for the day are listed. Termination of spray operations on a given day may have been for more than one reason, and have therefore been counted in two or more places in the list above. Also, categories such as "low humidity" may also be included in "poor weather (spray rising)," through not specifically identified as such by operations personnel. It was not possible to identify specific reasons for shut-down in the category listed as "Poor weather (lost weather)", because Operations personnel did not provide specific reasons other than "lost weather," in their daily reports on the days recorded.

Summary of Weather Parameters Recorded

During Spray Operations

	Take-off 1/	Shut-down 2/
Daily Ambient Block Temperature (^{o}F)		
Range	32-59	32-59
Mean $\pm$ SE	44.8 $\pm$ 0.9	44.8 $\pm$ 1.0
Daily Spray Block Relative Humidity (%)		
Range	41-92	33-90
Mean $\pm$ SE	74.4 $\pm$ 1.5	66.5 $\pm$ 1.8
Daily Spray Block Wind Speed (MPH)		
Range		0-7
Mean $\pm$ SE		1.4 $\pm$ 0.3

1/ Values reflect measurements taken at the time each application aircraft lifted off the heliport for the morning.

2/ Values represent measurements taken at the time each application aircraft completed treatment on its last block for the morning, or when the application Team Leader terminated spray operations for the due to poor weather or spray conditions.

WATER MONITORING RESULTS

SPRUCE BUDWORM SPRAY PROJECT

RIMROCK UNIT

After initial survey of the treatment area it was determined that there were no domestic water sources that were subject to contamination. All the domestic supplies for the Rimrock area are either from wells or covered spring boxes. The only exposed water source, Goose Egg Spring, is used by recreationists and were taken from several flowing streams in the area to determine if contamination had occurred. Spray cards were placed along some of the streams to determine if the flight paths parallel to the stream were successful in limiting water contamination.

Water sampling results were the following:

Sample Date	Time	Location	Colonies B.t. per liter
6-2-87	0745	Soup Creek at Hwy.	none detected
6-3-87	0600	Jumpoff Creek at Rd. 1201	none detected
6-3-87	0700	Jumpoff Creek at Rd. 1201	none detected
6-4-87	0700	Wildcat Creek at Hwy.	none detected
6-4-87	0810	Wildcat Creek at Hwy.	none detected
6-6-87	0515	Indian Creek at Hwy.	none detected
6-6-87	0630	Indian Creek at Hwy.	none detected
6-9-87	0730	Grey Creek at Rd. 1000	1/liter
6-9-87	0745	South Fork Tieton at Spruce Cr.	none detected

6-9-87	0800	South Fork Tieton at Rd. 1010	none detected
6-10-87	0800	Wildcat Creek at Hwy.	none detected
6-11-87	0800	North Fork Tieton at Rd. 1200	none detected
6-11-87	1000	North Fork Tieton at Rd. 1200	6/liter

Spray card assessment did not show that any chemical was being deposited in flowing surface waters.

William Garrigues

Hydrologist

1987 SPRUCE BUDWORM SPRAY PROJECT BALD EAGLE MONITORING REPORT

I met with Jim Michaels of the USF&W on Tuesday morning June 2, at 0430. We observed the Bald Eagle Nest on the south side of Rimrock Lake during the spray of unit 18. Spraying started about 0530. At first it looked as though there was no activity at the nest site. No adults were seen and there was not activity at the nest. As the helicopters approached the 1/2 mile buffer limit we noticed that there was movement in the nest. As the sun rose the male eagle finally flew in, it seemed from the direction of Indian Creek, where we concluded that he probably had a night roost.

The eagles recognized that the helicopters were present by turning their heads and looking at them, but the female never got up on the edge of the nest, and the male just sat on his perch and looked around. The 1/2 mile buffer appears to be a good buffer distance for this pair of eagles.

After visiting the osprey nests on the west side of Rimrock and around Clear Lake, we returned to a different observation point to look at the eagle nest again. The sun was on the nest at that time and the female was sitting on a snag next to the nest. The male was about a 1/4 mile away in another snag.

SUSAN STEPNIEWSKI

Range Conservationist

Rimrock Spray Project

Safety Summary

June 12, 1987

The following is a summary of the number of days worked, hours flown, and general comments concerning this project.

Man days worked: 1,157

Hours flown: 347

Number of vehicles: 30

Miles driven: 24,000

When one reads this statement it should be noted that the above totals are extremely important, if you consider the uniqueness of this project. A spray project comes with built-in risks and hazards that are seldom found in most other Forest Service projects they include: flying helicopters at very low levels, numerous helicopters in air at one time, large trucks, long work hours over day or weeks, including weekends. The folks also come from throughout the Pacific Northwest and have left families that remain a concern to them. Most of the hours worked start in the wee hours (0200) in the morning and carried well into a normal day.

The project has had no serious injuries, in fact four CA 1's have been filed, with none of them requiring any further medical attention.

It is my opinion that the time spent at the beginning, that provided sessions in defensive driving, rig care and first aid, has contributed to the excellent safety record. The Naches Ranger District also provided assistance.

I would like to credit the Entomology and Application crews for their dedication to give solid tailgate safety sessions. Their awareness of safety made my job much easier than expected. Two people, Charlotte Campbell and Dave Ritz need to be commended for holding morning safety briefings and documenting discussions.

The application section accomplished a professional handling of heliports and spraying of blocks. Lori Osterstock and Doug Ledgerwood provided the direction needed to have an uneventful project from the point of view of Safety. I also attribute some of their success to a quality contractor, who had excellent equipment and was cooperative in doing a good job.

In conclusion, I think the success of the safety aspect on this project rests with quality of folks involved in the project.

Earl Brown

Safety Chief

RIMROCK SPRAY PROJECT--1987

WENATCHEE NATIONAL FOREST

WESTERN SPRUCE BUDWORM EVALUATION PLOT SUMMARY

Treatment Status Sample Status	No. of Plots	Average Density (budworm per 45 cm branch + SE)	Percent Standard Error
Treated blocks (Rimrock AU)			
Early density	41	5.90 ± 0.82	13.95
Post-treatment density (Unadjusted for latent *B.t.* mortality)	91	0.89 ± 0.10	11.23
Untreated blocks (Rimrock AU)			
Early density	6	2.33 ± 1.10	47.21
Post-treatment density	12	0.28 ± 0.08	28.57

Untreated Analysis Unit

(Naches AU)

Early density	N/T	N/T	N/T
Post-treatment density	23	5.22 ± 1.06	20.36

N/T = not taken

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