Tom Gregg   Mounts, et al. 1978

1977 COOPERATIVE WESTERN SPRUCE BUDWORM CONTROL PROGRAM

USDA Forest Service, R-6
Washington — Oregon

Cover Photo: Helicopter spraying with observation helicopter in position for monitoring.

1977 WESTERN SPRUCE BUDWORM CONTROL PROJECT IN NORTH-CENTRAL WASHINGTON STATE

BY

JACK MOUNTS, FORESTER

ROBERT E. DOLPH, SUPERVISORY ENTOMOLOGIST

DAVID McCOMB, ENTOMOLOGIST

AND

TOMMY F. GREGG, FORESTRY TECHNICIAN

USDA FOREST SERVICE

REGION 6

PORTLAND, OREGON

JULY 1978

TABLE OF CONTENTS

ABSTRACT

On June 17, 1977, the second year of treatment began to control the western spruce budworm *(Choristoneura occidentalis)* on the Wenatchee and Okanogan National Forests and adjacent private lands in north-central Washington and the Warm Springs Indian Reservation in north-central Oregon. This cooperative project with the Washington State Department of Natural Resources (DNR) and the Bureau of Indian Affairs was planned to treat 460,000 acres of Douglas-fir and true fir timber infested to varying degrees by the western spruce budworm.

When spraying was completed on July 16, 1977, 356,661 acres had been treated with Sevin 4 OIl at the rate of 1 pound of active ingredient in ½ gallon of total formulation per acre. Over 100,000 acres originally planned for treatment were not treated due to extremely windy conditions.

In 1976, 358,000 acres in the same general areas were treated with malathion at 13 ounces of technical grade material per acre. This treatment was relatively unsuccessful since over 100,000 acres required retreatment in 1977.

The results in 1977 using Sevin 4 Oil were much better than those in 1976. The unadjusted mortality rate on the project averaged 91.7 percent. However, due to a relatively high natural mortality rate in some areas, the mortality rate adjusted by covariance analysis was only 79.4 percent.

Results of environmental monitoring conducted by the Washington State Department of Ecology, under contract to the Forest Service, and Forest Service environmental monitoring crews, indicated that very little damage was done to nontarget species with the exception of honeybees and live-box fish on Squillchuck Creek. Some honeybee losses were sustained to hives immediately adjacent to the spray areas. No losses occurred to native fish or fish installed in live-boxes for purposes of monitoring except in Squillchuck Creek. A temporary heavy aquatic insect drift occurred as expected. No dead or distressed birds were found in areas monitored for this purpose. Conclusion based on the overall environmental monitoring evaluation was that no permanent damage was done to nontarget organisms.

Total Control Project costs were about $2,386,646 or $6.69 per acre. The Federal government paid for all costs to Federal lands. Costs on State and private lands were shared by State and Federal agencies and private landowners under authority of the Forest Pest Control Act of June 27, 1947, as amended. The proportion was: Private ownerships over 500 acres, Federal 33⅓ percent, State 41⅔ percent, and private 25 percent; private ownerships under 500 acres, Federal 50 percent, State 25 percent, and private 25 percent; and State lands, Federal 25 percent and State 75 percent.

ACKNOWLEDGEMENTS

It is impossible to personally acknowledge the large number of people who made significant contributions to this Project and report. However, the following individuals were particularly helpful in assembling data, editing, and making this report possible.

Leon F. Pettinger, Entomologist, Forest Service, R-6
David R. Bridgwater, Entomologist, Forest Service, R-6
Richard Johnsey, Entomologist, Washington State Department of Natural Resources
Robert Backman, Forester, Washington State Department of Natural Resources
David A. Graham, Formerly Director, Forest Insect and Disease Management, Forest Service, R-6
John Bernhardt, Washington State Department of Ecology
Harry B. Tracy, Washington State Department of Ecology
Roberta J. Lindquist, Clerk-Typist, Forest Service, R-6
Marion Koninendyke, Supervisory Management Technician, Forest Service, R-6

I. BACKGROUND

The western spruce budworm, *Choristoneura occidentalis* Freeman, is one of the most serious and persistent defoliators of western coniferous forests. This insect has been present in outbreak numbers in the Washington Cascades since 1970.

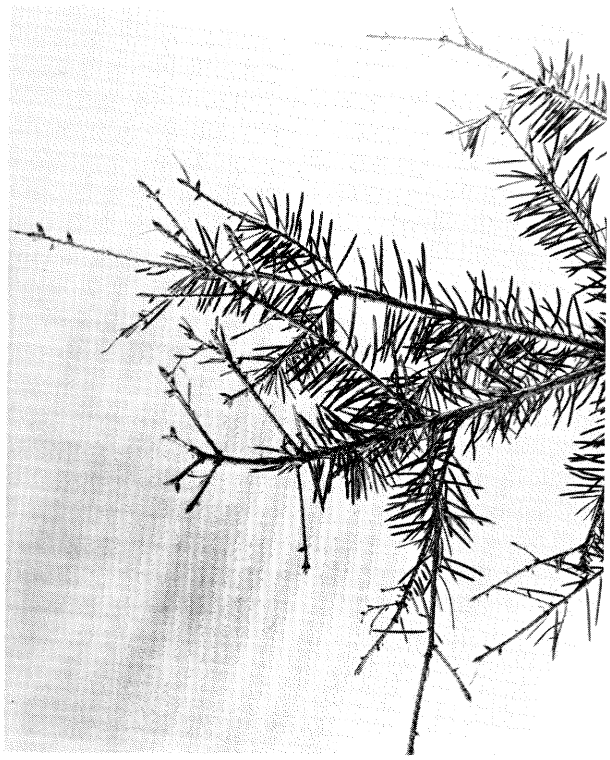


PHOTO #2: Result of heavy feeding by the western spruce budworm on current growth of Douglas-fir.

Defoliation by the spruce budworm reduces tree growth, kills the tops, and after several years of continuous defoliation, causes tree mortality. Subsequently, severely weakened trees are often attacked and killed by bark beetles. Past outbreaks have caused serious damage to stands of Douglas-fir, white fir, and grand fir, often kiiling large groups of trees in heavily infested areas.

In 1970 a patch of approximately 240 acres of western spruce budworm-damaged timber was discovered in north-central Washington. By 1971, this area had increased to about 18,000 acres, and by 1974, infested acreage had increased to almost 565,000 acres. In 1975, the infestation spread to include over 800,000 acres and in 1976 covered over 1,100,000 acres, with an additional increase predicted for 1977.

In 1975 a pilot project was conducted to determine the operational effectiveness of fenitrothion against the budworm. The material

PHOTO #3: Larvae of western spruce budworm in fifth instar, feeding on new foliage.

was applied at the rate of 3 ounces active ingredient (AI) of fenitrothion in sufficient carrier to make 20 ounces of total formulation per acre in a single application, and 2 ounces AI of fenitrothion in sufficient carrier to make 20 ounces of total formulation per acre applied twice at 7-day intervals. Spraying was carried out on the single application plots 3 days after 75 percent of the larvae were in the fifth or sixth instars. On the double application plots the first application was 3 days after 25 percent of the larvae were in the fifth or sixth instars. The second application was 7 days later. The carrier used in the formulation consisted of number 2 fuel oil and Panasol AN-3, a heavy aromatic naptha solvent. The results of these applications were disappointing. Based on the budworm population reduction obtained, both the one and two application treatments were unsuccessful. The unadjusted population reduction was 74.5 percent for the single application and 75.9 percent for the double application.

To assist in planning and coordinating control action on this infestation, a Spruce Budworm Steering Committee was formed. This committee was composed of representatives of the Wenatchee and Okanogan National

Forests, the Washington State Department of Natural Resources, Boise Cascade Corporation, Pack River Lumber Company, Burlington Northern Railway, the National Park Service, and the USDI, Bureau of Indian Affairs.

In 1976, after the 1975 fall egg mass survey and subsequent follow up surveys indicated a larger infestation in 1976, the Steering Committee recommended that an environmental statement be prepared and submitted for public review.

After reviewing the comments to the environmental statement, the Steering Committee recommended that a large-scale control project should be carried out on land of mixed ownership in north-central Washington and on the Warm Springs Indian Reservation in Oregon. Of the two chemicals registered for use against the spruce budworm, malathion and Sevin 4 Oil, the Steering Committee recommended the use of malathion since past results using both insecticides were similar and malathion provided a more favorable benefit/cost ratio. A Project Director was designated and preparations for the Project were put in motion.

Over 365,000 acres were treated on the Okanogan and Wenatchee National Forests and adjacent State and private lands as well as the Warm Springs Indian Reservation in Oregon. Of this acreage, 7,663 acres were treated with Sevin 4 Oil as a comparison with the malathion-treated area. The unadjusted mortality on the malathion-treated area averaged about 82 percent and when adjusted, mortality averaged about 64 percent. The results on the area treated with Sevin 4 Oil were considerably better, averaging 96 percent unadjusted and 92 percent adjusted mortality. The decision to use Sevin 4 Oil in 1977 was based on these results.

II. LIFE CYCLE OF INSECT

The preferred host species of the western spruce budworm are Douglas-fir, grand fir, Engelmann spruce, and Pacific silver fir. Other species that may sustain some damage when growing in association with the preferred hosts are subalpine fir, western larch, and several species of pine.

Western spruce budworm normally develops from egg to adult in 12 months, but some require 24 months to complete the life cycle. Adult moths emerge from pupal cases in July or early August. Shortly afterwards the females deposit approximately 150 eggs in egg masses averaging 25 to 40 eggs each. The eggs hatch in about 10 days, the newly hatched larvae seek hiding places among lichens or under bark scales on the host trees. They do not feed during this life stage. During their search for a hiding area the larvae molt to the second instar. After locating a hiding place, they spin silken shelters (hibernacula) and remain dormant through the winter. In the spring, larvae leave their silken shelters and move out towards the foliage where they tunnel into old needles and feed for 7 to 14 days. When the buds start to swell, the larvae leave the needles and bore into the expanding buds. Some larvae, however, move directly from hibernation to vegetative buds or male or female flowers. As new shoots unfurl, the larvae spin loose webs between needles and tips and feed on new foliage within the webs. Large larvae usually finish feeding on current needles, even though their earlier feeding may have included staminate flowers and conelets.

Larvae become full-grown in 30 to 40 days after leaving the hibernacula and pupate either in existing webs or webs they spin elsewhere on the tree. They remain in the pupal stage for 7 to 24 days before the adult moths emerge. Adult moths are sluggish fliers but may be carried great distances by air currents. Females deposit eggs within 7 to 10 days and then die.

III. BIOLOGICAL EVALUATION

Defoliation caused by the western spruce budworm was mapped during the annual aerial survey during July and August of 1976. The 1976 aerial survey indicated about 1,100,000 acres with visible defoliation which included the 365,700 acres treated with malathion or Sevin 4 Oil in 1976. Most of the damaged area occurred in north-central Washington on the Okanagan and Wenatchee National Forests, North Cascades National Park, and adjacent State and private lands. New infestation centers of 3,310 acres and 2,100 acres were detected on the Yakima and Colville Indian Reservations, respectively. Light-to-heavy defoliation was observed in Oregon on 10,800 acres on the Warm Springs Indian Reservation and 380 acres on the Malheur National Forest. A total of 865 egg mass sample plots were established in defoliated areas on State, private, National Park Service, Bureau of Indian Affairs, and Forest Service lands in north-central Washington and on the Warm Springs Indian Reservation in Oregon in September and October to evaluate egg population levels in 1976 and predict damage for 1977. Of these, 286 plots were on the 366,000 acres treated with malathion and Sevin 4 Oil in 1976.

After measuring the budworm population throughout the summer of 1976, entomologists determined that natural control factors such as parasites and predators were not sufficiently plentiful to cause the budworm population to collapse in a number of areas during 1977. Direct control was, therefore, recommended to reduce budworm populations and prevent additional tree damage.

Treatment recommendations were based on computed average egg mass densities for the sample area. Units containing an average of four or more egg masses per 1,000 square inches of foliage were recommended by the entomologists for treatment. Results of the 1976 fall egg mass survey indicated that egg mass densities met or exceeded four egg masses per 1,000 square inches of foliage on nearly 670,300 acres. Since much of this area was in wilderness and scenic areas, the final area recommended for treatment was reduced to 460,000 acres. Of the 358,000 acres treated with malathion in 1976, about 132,000 acres were recommended for retreatment in 1977. None of the 7,600 acres treated with Sevin 4 Oil needed retreatment in 1977.

IV. ENVIRONMENTAL STATEMENT

In the fall and winter of 1976-77, a "Draft Addendum to the Final 1976 Cooperative Western Spruce Budworm Management Plan" was prepared. An "addendum" rather than a complete new environmental statement was prepared because the type of insecticide application program that was planned for 1977 was essentially the same as that done during 1976. Only the acres to be treated were different and they were actually located in most cases in the same general geographic vicinity.

The Draft Addendum proposed suppression of the spruce budworm infestation on 670,380 acres of the total infestation of 1,100,020 acres, by aerial application of carbaryl (Sevin 4 Oil). Alternative solutions proposed included treating all areas except those in designated wildernesses, National Recreation Areas, and National Parks; treating only those entomological units with favorable benefit/cost ratios; treating only portions of entomological units on the basis of specific land management objectives and resource values; not treating any areas that were treated in 1976; treating only young stands or overmature stands with an existing manageable understory; postponing

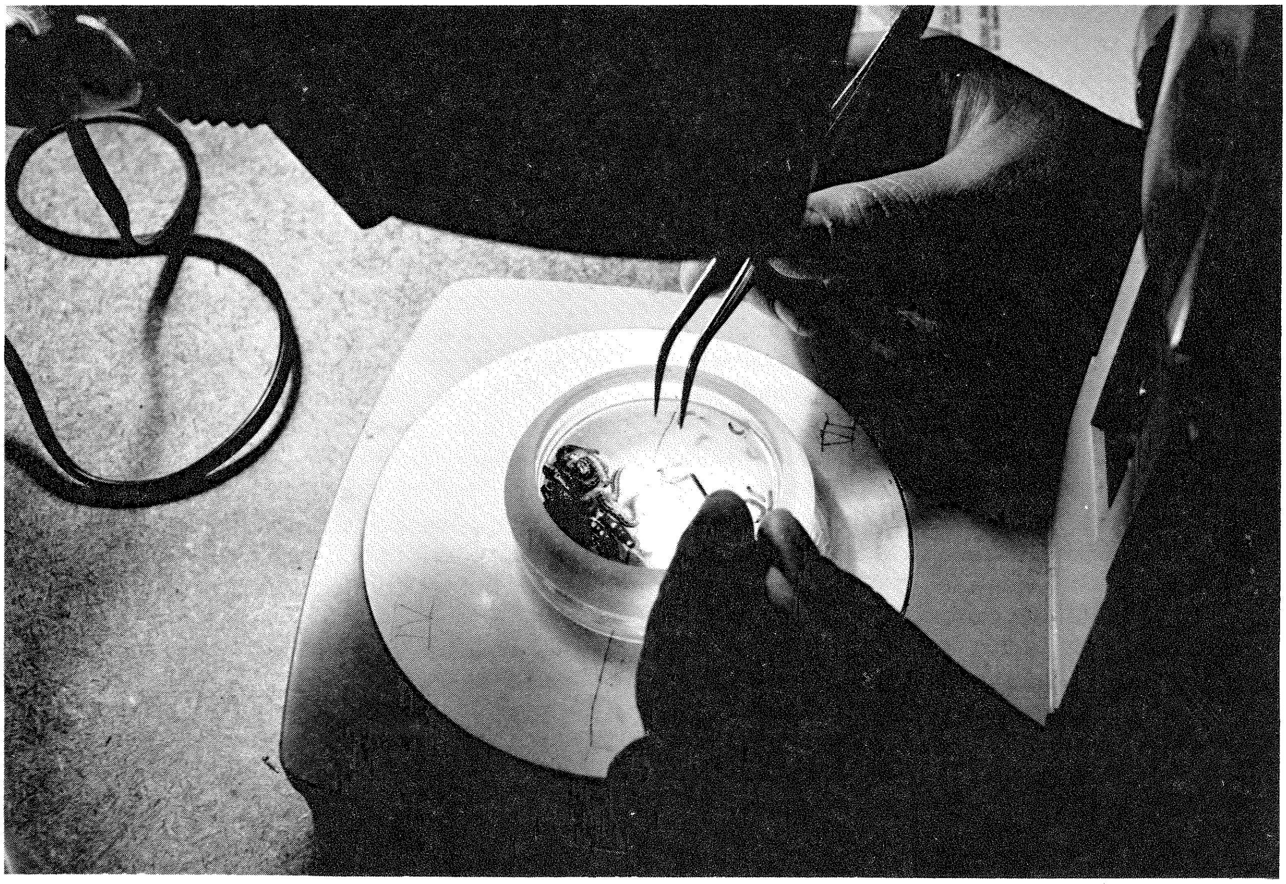


PHOTO #4: Entomologists determined spray timing by stage of insect development.

treatment for one more year; reimbursing small private landowners for actual dollar losses; using malathion, zectran, fenitrothion, Dylox 4, pyrethrins, DDT, Orthene, matacil, dimethoate, phosphamidon, naled, parasites, virus, cultural methods; and no action.

The Draft Addendum was filed with the Council on Environmental Quality on February 7, 1977. A total of 54 responses to the proposed action was received during the review period which was completed on April 8, 1977.

The Final Environmental Statement was designated as an "Addendum to the Final 1976 Cooperative Western Spruce Budworm Pest Management Plan" for the reasons previously given. The "Final Addendum" proposed to treat western spruce budworm on 460,000 acres by aerial application with carbaryl (Sevin 4 Oil). Areas eliminated from the 670,380 acres proposed for treatment in the Draft Statement were primarily wilderness, National Recreation Areas, and National Park areas that were not considered as a threat to treated areas outside of their boundaries.

The Final Environmental Statement was filed with the Council on Environmental Quality on May 4, 1977.

V. PROJECT PLANNING AND PREPARATION

A. OPERATIONAL PLANS

Since the 1977 western spruce budworm control project was in the same general vicinity as the 1976 project, it was decided to use the same basic three Units and the same headquarters sites as in 1976. These were Twisp, Cashmere, and Ellensburg, Washington, for control Unit Headquarters, and Cashmere for Project Headquarters. As in 1976, the Warm Springs Indian Reservation was handled as a subunit from the Ellensburg Control Unit. However, unlike the 1976 project, the Ellensburg Control Unit was administered by the Forest Service rather than the Washington State Department of Natural Resources. Operations on the three Control Units were directed and coordinated by the Project Director and his staff from Cashmere, Washington. The administrative organization of each Control Unit and the Project Headquarters is shown in the Organization Charts in the Appendix.

1. Personnel

A total of 116 positions were filled on the Project by Forest Service and DNR personnel. Because of the difficulty in getting some personnel for the full period of the Project, some positions were filled by more than one person during the Project. This was true of the Project Safety Officer, Project Information Officer, and Insecticide Inspector.

Also, approximately 71 contractor personnel were involved in the Project, including pilots, tank truck drivers, fuel truck drivers, chemical company representatives, insecticide mixing personnel, and environmental monitoring personnel. Many other people were involved at least part-time on the Project. This included personnel from the U.S. Weather Service in Wenatchee and recreation and fire prevention guards on the Ranger Districts who notified forest users of the spraying.

2. Equipment

A total of 11 light to medium spray helicopters were used on this Project. These consisted of four Bell 205-A's, three Alouette Lamas, two Bell 206-B's, and two Hiller 12E's. An additional 14 light turbine helicopters were used for observation or spraying reconnaissance, boundary marking, and other general administrative flying. These consisted of two Hughes 500-C's, two Hiller FH 1100's, and ten Bell 206-B's.

Each spray helicopter was serviced by an insecticide tank truck and a fuel truck, and each observation helicopter was serviced by a fuel truck.

The insecticide mixing contractor provided a truck and trailer with a capacity of 5,500 gallons to service satellite insecticide tanks at Twisp and Cle Elum, Washington.

A total of about 70 vehicles was utilized on the Project. Contracts were awarded for 58 of these by the Wenatchee National Forest. These included compact pickups, suburban carryalls, 4-wheel drive pickups, and stake trucks. Several regular Forest Service vehicles were used, and some personnel used their personal vehicles on a mileage basis. This total does not include vehicles used by contractor personnel.

B. CONTRACTING

Separate contracts were awarded in May and June for the following items or services:

1. Insecticide;

2. Formulation, storage, and transportation of insecticide;
3. Application of insecticide by helicopter;
4. helicopter services (observation, reconnaissance, etc.);
5. Environmental monitoring of fish, aquatic organisms, and water;
6. Laboratory analysis of environmental monitoring samples; and
7. Rental of vehicles.

Union Carbide Corporation was awarded the contract for insecticide (Sevin 4 Oil). A total of 30,000 gallons was delivered in railroad tank cars early in the Project. The balance of 59,620 gallons was delivered in tank trucks because of time constraints, at the Company's request. Cost of the insecticide was $8.37 per gallon for a total cost of $750,119.40.

Chempro of Oregon, Incorporated, was awarded the contract for insecticide formulation, storage, and transportation. The contractor was required to set up a central mixing plant and satellite storage tanks at Twisp and Cle Elum, Washington. Both central mixing plant and satellite tanks had mixing capability. The contractor was also required to provide transportation of the mixed material to the satellite tanks and maintain a minimum of 5,000 gallons on hand at all times in each tank. He also furnished all the number 2 fuel oil for mixing with the insecticide. Bid prices for this contract varied by Unit Location. Total gallonage mixed was 179,923 at a total cost of $151,318.60 or an average of $.841 per gallon.

A small business set aside contract was negotiated with High Life Helicopters, Incorporated, a minority contractor, for application of insecticide to 95,000 acres on the Okanogan Control Unit. The negotiated price was $1.62 per acre. The actual acreage treated under this contract was 96,862 for a total cost of $155,226.84. The amount earned was reduced by $1,689.60 for insecticide spillage. A contract for the remaining 365,000 acres to be treated was advertised and awarded by Control Units as follows:

Okanogan Unit — 75,000 acres,
Wenatchee Unit — 152,000 acres, and
Ellensburg Unit — 138,000 acres.

Evergreen Helicopters, Incorporated, of McMinnville, Oregon, was the successful bidder on all three Control Units. Bids by Control Units were Okanogan, $1.44/acre; Wenatchee, $1.22/acre; and Ellensburg, $1.33/acre.

Because weather conditions reduced spraying time in several areas and the insects had pupated before spraying was accomplished, two out of the three Control Units did not meet the minimum acreage requirements. As a result, the prices for treatment had to be renegotiated with the contractor. Negotiated prices and acreage treated by Control Units are as follows:

Okanogan Unit —	
29,680 Acres @ $2.2523 =	$ 66,848.26
Wenatchee Unit —	
132,907 Acres @ $1.22 =	$162,146.54
Ellensburg Unit —	
97,212 Acres @ $1.3832 =	$134,463.64
Total	$363,458.44

After reductions for spillage and discount for early payment, the total cost of this contract was $358,998.42 or $1.382 per acre. A summary of application contracts is found in Table 8, Appendix.

Helicopter service contracts for observation and administrative flying were also awarded on the basis of competitive bidding. Bids were awarded for three light turbine helicopters on each Control Unit except the Okanogan Unit which had four, and two light turbine helicopters at Project Headquarters. One of the project Headquarters' helicopters was contracted without pilot since it was for the use of the Project Air Officer who is a helicopter pilot. Eight bidders were successful on these contracts. One contractor was defaulted during the Project for nonavailability of aircraft because of mechanical defects.

Flying time for helicopters was paid at $150 per hour for all helicopters except for the helicopter without pilot, which was $135 per hour. Bidding was on the basis of daily availability, which ranged from $347 to $539 per day and averaged about $450 per day.

Total cost for all 14 observation helicopters was $273,482 or $.76678 per acre.

A summary of helicopter service contracts is found in Table 9, Appendix.

A contract for environmental monitoring of fish, aquatic organisms, and water was awarded to the Washington State Department of Ecology. Significant objectives of this work were to:

1. Determine the incidence of Sevin 4 Oil in the aquatic environment through sample analysis;
2. Assess the impacts, if any, of Sevin 4 Oil on aquatic organisms, including, but not limited to, benthic invertebrates and fish;
3. Provide samples of certain nontarget organisms to the Department of Social and Health Services Pesticide Laboratory, Wenatchee, Washington, for analysis; and

4. Provide results of these investigations to the Forest Service in the form of a final report.

The total bid price for this contract was $45,537 or about $.128 per acre.

A contract was awarded to the Washington State Department of Social and Health Services for laboratory services in analyzing environmental samples. The negotiated rate was $55 per sample with a minimum of 325 samples. Total number of samples analyzed was 454 at a total cost of $24,970 or about $.07 per acre.

A contract for 58 Project vehicles was added to the regular Wenatchee National Forest vehicle contract. Contract bids ranged from $198.52 to $399.10 per month, depending on the number and type of vehicle and period of use. The Forest Service was required to furnish gas and oil for the vehicles. Any repairs not the fault of the Forest Service were to be furnished by the contractor.

C. TRAINING

Because a preliminary decision to spray was not made until April 8, 1977, selection and training of personnel was later than desirable. A preliminary meeting of top overhead was held on May 17, 1977, to discuss the Project and set goals. A session on entomological monitoring for the entomology crews was held on May 16. On June 2 a training session on contracts and spray operations was held for the Unit Supervisors, Spray Operations Officers, Unit Safety Officers, and Administrative Assistants. On June 7, all Project personnel were given a general orientation to the Project and safety training. On June 8 a calibration training session was held for Spray Operations Officers and Heliport Managers. Also on June 8 a helicopter safety training session was held for Spray Operations Officers, Aerial Observers, and Heliport Managers. On June 9 a general helicopter safety training session was held for all Project personnel. On June 10 a training session on environmental monitoring and spray deposit assessment was given to Unit Entomologists, spray deposit crews, and Environmental Monitoring Coordinators.

Although much time and effort were spent on training on this Project, more time would have been beneficial because of the lack of experience of most project personnel.

VI. SPRAY OPERATIONS

A. ADJUSTMENT OF EXTERNAL SPRAY BOUNDARIES

External treatment area boundaries were located from helicopters early in June. Mapped Control Unit boundaries were adjusted to easily recognizable topographic, timber type, and infestation boundaries. Boundaries not easily recognizable from the air were marked with highly visible fluorescent orange streamers.

B. INTERNAL SPRAY BLOCK BOUNDARIES

Spray blocks were laid out on aerial photos or U.S.G.S. topographic quadrangle maps on the basis of elevation and aspect. The objective was to minimize elevational and aspect differences so that insect development would be at approximately the same rate in each spray block. In many cases contour lines were used as the dividing line between several spray blocks.

Interior spray block boundaries were marked in the same manner as the exterior boundaries where marking was necessary.

C. DEVELOPMENT AND EVALUATION PLOTS

In order to determine when the insects were at the stage of development when they were most susceptible to the insecticide (40 percent in the fifth instar or larger), insect development plots were located in each spray block that was reasonably accessible.

Release of the block for spraying was based on the results of data collected from periodic examination of these plots. Generally, one development plot was located in each spray block. Blocks with a large difference in elevation might have more than one plot. In some cases, where access was a problem, a block might not have any development plots. In this case, development was interpolated from the nearest plot of similar elevation and aspect.

Insect development plots were sampled by cutting two 15-inch, bud-bearing branches from opposite sides at mid-crown of each sample tree. The number of open and unopened buds were counted from each sample. All budworm larvae were collected and the instar determined by an entomologist or other well-trained personnel. The percentage of insects that had reached the fifth or sixth instar was calculated. The Unit Entomologist released blocks for spraying when at least 40 percent or more larvae had reached the fifth instar or larger, including pupae, and the buds had unfurled. Where data appeared to be questionable or inadequate, the Unit Entomologist and/or his assistant made on-the-ground examinations before releasing the block for treatment.

If a block reached 5 percent or more pupation before it could be treated, that block was eliminated from the Project. This occurred on numerous blocks in the 1977 Project.

Each Control Unit was composed of three to six entomological units or subunits. A total of 26 evaluation plots were installed in each subunit for determining the effectiveness of the treatment. Each plot consisted of three trees, 30 to 50 feet tall, with some recent defoliation. Evaluation plots were scattered throughout the subunit on a random basis where access permitted.

Prespray plots were read within 3 days of planned treatment. If treatment was not carried out on a block within 3 days of prespray samples, the block was resampled.

Postspray sampling was carried out 14 days after each block was treated.

D. TREATMENT

Of the 460,000 acres recommended for treatment, a total of 356,661 acres were treated with Sevin 4 Oil at the rate of 1 pound in ½ gallon of formulated material per acre. Unusually windy conditions were encountered in the Twisp, Taneum, Teanaway, Entiat, and Warm Springs Subunits which prevented treatment on about 103,000 acres before pupation occurred. Fortunately, it was possible to block them up in such a way as to have a minimum of reinvasion potential on adjacent treated areas.

The area treated within each of the Control Units and their subunits is shown in Table 7 and illustrated maps. A breakdown by ownership is shown in Table 3, Appendix.

Spraying started on June 17, 10 days earlier than in 1976, as insect development was much faster than in previous years. The long period of drought and extremely dry conditions in the area were believed to be the factors that favored the rapid development of the budworm. This allowed less time than planned to complete spraying and caused pupation to take place before some areas could be treated when windy conditions slowed production.

The first blocks treated were on the Okanogan Unit on June 17. Spraying commenced on the other two Control Units on June 18. Although very few days were completely lost to spraying because of weather factors, the average number of hours in a given day that were available for spraying was considerably less than in past years. Final spraying on the Project was completed on July 16 on the Wenatchee Unit. The Okanogan Unit finished on July 4 and the Ellensburg Unit on July 6.

PHOTO #5 Larvae drop down on silken-like threads immediately after spraying.

Topographical features on the three Control Units varied from moderately to extremely rough ridges and canyons. Elevations ranged from 2,500 feet to 7,000 feet above sea level.

Heliports were located in natural openings such as meadows, open ridgetops, clearcuts, rock outcrops, log landings, or roadways that were accessible to tank trucks.

Each contract helicopter was inspected by the Project Air Officer for airworthiness, contractual specifications, and suitability for the work. The qualifications and proficiency of pilots were also checked.

Approximately 449 aircraft hours were available for insecticide application on the three Control Units. The average production per available hour for the Project was 794 acres.

PHOTO #6: Helicopters were loaded with insecticide from large tank trucks at heliports in the spray area.

Available hours included all the time that would have been available for spraying had there been no equipment failures or other contractor delays.

The greatest production occurred on July 3 when 33,341 acres were treated in the three Units. The greatest daily Unit production was on July 3 when 13,795 acres were treated in the Okanogan Unit with four helicopters.

Observation and administrative aircraft flew a total of 917 hours for observation of treatment, ferrying crews into evaluation plots, marking boundaries, and other administrative flying. Field sampling crews were dependent on helicopters for getting them into otherwise inaccessible areas to install and sample plots. Observation aircraft use summaries are shown in Table 9, Appendix.

E. PESTICIDE SPILLS

Seven accidental insecticide spills occurred on the project. In addition, one accidental spraying of private land outside the spray boundary occurred. A summary of spills is as follows:

Date	No. of Gallons	Control Unit	Cause	Environmental Effects
6/18	193	Okanogan	Dump valve release	All fell on dry ridge, no water
6/18	330	Wenatchee	Dump valve release	All fell on dry ridge, no water
6/19	100	Okanogan	Dump valve release	All fell on dry ridge, no water
6/24	11	Wenatchee	Overflow while pumping between compartments on tank truck	At heliport, cleaned up and hauled away
7/3	230	Wenatchee	Accidental trip of dump valve after broken filter cap	All at heliport, cleaned up and hauled away
7/4	35	Wenatchee	Broken filter cap	All fell on dry ridge, no water
7/7	6	Wenatchee	Broken seal in spray system	All fell on dry ridge, no water

All ships were grounded immediately after spills until mechanical defects were repaired. In one case this involved grounding one 205-A for a period of 3 days while the spray system was completely rebuilt.

On June 29, an accidental overspray occurred on private land outside the spray boundaries. This occurred when the regular aerial observer had been given the day off, his replacement who had flown over and been briefed on the spray area became ill the morning of spraying and a third observer was assigned who had not been properly briefed. Three land ownerships were accidentally sprayed, including a house and an organic garden. Steps were immediately taken to prevent any further occurrences of this nature.

A total of 905 gallons of insecticide was accidentally spilled on the Project. No spills occurred in the vicinity of water except for the accidental overspray. All spills were investigated by qualified Unit personnel, and necessary actions taken to prevent them from happening again to the same aircraft. A faulty method of installation of dump valves on the Lamas was immediately corrected, and no further spills occurred with those aircraft. The spray system in one 205-A kept breaking filter caps due to vibration. This system had to be completely rebuilt to correct the problem, and several days of production were lost while it was being rebuilt.

All spills were reported promptly to the EPA Regional Office in Seattle and the Washington State Department of Health and Social Services in Wenatchee.

F. SAFETY

As in previous projects, safety was heavily emphasized on the Project. The headquarters staff included a Project Safety Officer whose primary job was safety and who directed the safety program for the entire project. In addition, a Helicopter Operations Officer specialized in air safety.

Each Control Unit had a safety officer who implemented the safety plan on his Unit. All Safety Officers were well qualified by training and/or experience for this job.

All Project personnel attended safety meetings of various kinds, including driver training for temporary employees. All Project personnel also attended special safety sessions for working around and riding in helicopters. Special attention was given to location and construction of safe heliports by Project personnel. A new position of Supervisory Heliport Manager was installed on each Control Unit. These positions were filled by extremely well-qualified helicopter managers who had received special training for the position. Safety was one of the major thrusts of this position.

The extra time, expense, and effort that went into the safety program paid off in terms of fewer and less serious accidents and injuries.

Over 1,350 hours were flown by all aircraft on the Project without an accident. Several aircraft incidents occurred which, had the aircraft not been shut down immediately until the problem was corrected, could have lead to serious accidents. Immediate action by spray operations and safety personnel prevented accidents.

Preliminary inspections of all aircraft by the Project Air Officer and approval of their use only after all deficiencies had been corrected, were instrumental in preventing accidents.

One serious vehicle accident occurred on the Project when excessive speed on a curve caused a vehicle to go off the road with heavy damage to the vehicle. The driver was not hurt. In addition to this accident, six other minor vehicle accidents occurred. Also a helicopter bubble was cracked when a clipboard was dropped on it accidently

Two minor personal injuries occurred on the Project. One of these was a bruised jaw sustained from the tailgate of a truck. The other was a result of cleaning up an insecticide spill at a heliport when the employee got some insecticide on her pant's leg and it caused a minor rash, probably from the diesel fuel in the formulation rather than the insecticide.

Considering the number of man hours worked, hours flown, and miles driven on rough forest roads, this is an excellent safety record.

VII. PUBLIC INFORMATION

A full-time Public Information Officer was assigned to the Project to cover the informational and public relations aspects of the Project. Because of the difficulty in getting a person for this position for the entire period of the Project, one person was assigned for the intial 2 weeks and another for the balance of the Project.

All landowners within the proposed spray area boundaries were notified by letter of the Project in advance and were provided with an estimate of costs to them for the treatment. News releases were sent out to newspapers and wire services throughout the States of Washington and Oregon, with information about the Project including approximate spray dates.

Public notices describing the Project were posted in post offices, public buildings, campgrounds, and other areas likely to be visited by the general public.

Printed fact sheets with updating amendments were provided to public agencies, private landowners, news media, and other interested persons and organizations. These sheets were also provided as handouts for the general public at key locations such as Ranger Stations, Forest Supervisors' Offices, Project offices, and other outlets.

While the Project was in progress, daily contact was made with news media personnel, both newspapers and radio stations. Contacts were made with television stations; however, since there had been projects for several years in a row, the television stations were not as interested in coverage as they had been in previous years.

News releases on current status of the Project were sent out several times during the Project. Show-me-trips were made for several newspaper reporters and photographers, including one Canadian newspaper reporter who was interested because of a proposed spray project in British Columbia.

A special 3-day show-me-trip was also held for nine Canadian Foresters who are considering a similar project in 1978.

Signs were posted the day before spraying at all forest roads entering treatment areas. In addition, all forest users were contacted personally by forest recreation and fire prevention patrolmen who explained the Project, effects of the chemical, time and date of treatment, and other general information about the Project.

Daily status and progress reports were sent to news media, all National Forests in the Region, Regional Office, Washington Office, Washington State Department of Natural Resources, Bureau of Indian Affairs, and other interested groups and individuals.

VIII. ENVIRONMENTAL MONITORING

A plan for monitoring effects of the insecticide on nontarget organisms during this Project was developed in cooperation with various Federal and State agencies and universities. The objectives of this monitoring plan were to:

1. Insure that the insecticide was applied safely and restricted to the target areas; and
2. Determine the biological effects, or their absence, on selected nontarget species in the forest environment.

Due to the fact that Sevin 4 Oil has been monitored extensively on other projects, monitoring on the Project was limited to aquatic organisms, fish, water, birds, and domestic bees.

A wildlife biologist was assigned to the Project as Environmental Monitoring Coordinator. His principal duties were to coordinate and direct the environmental monitoring effort on all Control Units, as well as action on any accidental spills that might occur. A Unit Environmental Monitoring Coordinator was also assigned to each Control Unit to carry out the monitoring plan.

A. AQUATIC MONITORING

All phases of aquatic monitoring were contracted to the Washington Department of Ecology. Their formal report is listed in the references section of this report.

1. Methods

a. Sampling Locations

Biological impact and chemical residue sampling were conducted on two index streams in each of the three Control Units, one buffered and one nonbuffered. Control streams were designated on each Unit during the prespray sampling. Three sampling stations were established on each stream monitored. The first station was located within the spray area boundary, the two remaining stations were established below the boundary at approximately 1-mile intervals.

b. Sampling Schedule

The prespray sample was taken within 1 week prior to spray application. Sampling on spray day began at midnight and continued for 12 to 14 hours thereafter. On most index streams postspray sampling was completed within 48 hours after spray day.

c. Sampling Procedures

Sampling methods addressed four aspects of environmental sampling: Residue and biological sampling, stream surveys, and water quality chemistry. The water quality, biological, and residue samples were collected at the highest and lowest stations.

2. Conclusions of Aquatic Monitoring

Pesticide residues showed a slight increase on all streams except Squillchuck Creek. This small stream was designated as a non-buffered stream in which the residues increased sharply from 0 to 121 parts per billion of carbaryl.

Drift insect counts increased slightly on three of the index streams, moderately on two streams, and sharply on Squillchuck Creek, shortly after spraying. Counts on all streams returned to prespray levels within the sampling period of 48 hours.

There was no mortality to fish in live-boxes except on Squillchuck Creek where 50 percent mortality was observed. No mortality occurred in native fish populations.

No significant adverse impact occurred due to spraying on any stream except Squillchuck Creek. Since Squillchuck Creek was very comparable to Beaver Creek which showed very little impact from spraying, it is felt that Squillchuck Creek must have received a much heavier application of Sevin 4 Oil than other index streams. This impact was temporary as the residue levels returned to normal within 48 hours of treatment.

For more detailed information on methods used and results of pesticide residue and impact monitoring on the aquatic environment, refer to the Department of Ecology Monitoring Report in the list of references.

B. BIRD AND BEE MONITORING

Monitoring for effects of Sevin 4 Oil on birds and honeybees was carried out by Project personnel under the direction of Project and Unit Environmental Monitoring Coordinators.

1. Methods and Results

Survey lines for bird monitoring were laid out in small drainages with some water flow and consisted of a U-shaped transect line intersecting the stream at right angles and with each leg of the transect measuring 10 chains in length. The survey strip consisted of an area of 4 feet on each side of centerline. All ground in the strip was carefully examined for dead or distressed birds. Arrangements were made to pack any birds found in dry ice and ship them immediately by air to the University of California at Davis for analysis.

Observers spent at least 2 hours examining other areas in the vicinity of the transect on each visit. Visits to the transects were made 12 to 24 hours before treatment, on the day of treatment, 24 hours after treatment, and 48 hours after treatment. In addition, all Project personnel were instructed to watch for dead or distressed birds in spray areas and report the location of any found.

The monitoring plan called for collection of six specimens of the same species of bird as any found dead or distressed as a control. However, this did not become necessary since no dead or distressed birds were found.

The honeybee monitoring required counts of dead bees at hives that were within 3 miles of the spray areas. Counts were made within 24 to 48 hours prior to spraying to determine the normal death rate. Postspray counts were made at

1, 3, and 5 days to determine losses due to the insecticide.

A diligent search to locate bee hives was carried out by Project personnel. When hives were found, an attempt was made to locate the owners, who were then advised to remove their hives from near the spray areas. Unfortunately, most owners did not remove their hives from spray areas and as a result bee mortality was high in some areas. It was extremely difficult to determine the cause of death in some cases because of use of other insecticides to spray apple orchards in the vicinity and the occurrence of mortality due to disease. Claims for loss of bees, hives, and honey production from five beekeepers are now being processed.

IX. TREATMENT EFFECTIVENESS

The effectiveness of the 1977 Western Spruce Budworm Project was determined by three methods. Standards to be attained if the Project was to be considered successful were established for each method in the work plan (USDA 1977) for the Project.

The first method was a measurement of the budworm population density present in treated areas 14 days after insecticide application. Budworm counts of less than three larvae or 1 pupae per 100 new shoots were to be considered adequate control. This population is below any that has been previously recorded where resurgence to epidemic numbers followed a control project.

The second method of measuring effectiveness was a determination of the percent of population reduction between prespray and postspray population counts. A 90 percent unadjusted population reduction was to be considered satisfactory control, 95 percent good, and 98 percent or greater excellent.

The third method was a determination of the new budworm egg masses deposited in the control area during the fall following treatment. Control was to be considered adequate if the egg mass density did not exceed four per 1,000 square inches of foliage.

1. Budworm Population Counts

Prespray and postspray budworm populations measured within 14 days after application are shown in Table 1. Population estimates were based on counts of budworm larvae or pupae per 100 buds. Covariance analysis was used to account for natural mortality. Results using Abbotts formula are included for comparison.

The average number of larvae or pupae per 100 buds surviving 14 days after insecticide application was well within the standard of three larvae or one pupae established as necessary for successful control on all areas treated.

2. Budworm Population Reduction

The percentage of reduction in the budworm population during the 14-day period following treatment as shown in Table 1, reached the acceptable level on two out of the three Control Units and was very close to acceptable on the third Control Unit at Wenatchee. The average for all areas was 91.7 percent which is within the acceptable limits.

Table 1. — Changes in budworm populations on treated and untreated study plots during a 14-day period following aerial application of insecticide.

	[1] Budworm Per 100 Buds		Percent Budworm Mortality		
Unit	Prespray	Postspray	Unadjusted	Covariance	Abbotts
Okanogan	18.5	1.1	94.1	91.0	88.2
Ellensburg	18.1	1.8	90.1	59.2	63.5
Wenatchee	17.0	2.0	88.2	56.6	74.8
All Areas	18.0	1.5	91.7	79.4	79.1
Checks	20.6	8.2	59.0	—	—

[1] Very few pupae were found on samples with the exception of the last plots treated.

3. Egg Mass Surveys

A budworm egg mass survey was made on treated and untreated areas during the fall of 1977. Average egg mass counts on all treated areas were less than four egg masses per 1,000 square inches of foliage and considerably less than counts on the same areas in 1976.

Egg mass survey counts indicated that populations were low on all treated areas and no treatment would be needed in 1978 on any areas treated in 1977.

Using all three methods above, the Project can be considered a success since the primary objective of reducing the population to a level which would not cause significant damage to the timber resource was met.

Table 2. — Comparison of 1976 and 1977 fall egg mass survey results — egg masses per 1,000 square inches of foliage.

Unit	Entomological Unit	No. Egg Masses (Mean) 1976	1977
Okanogan	Twisp	6.9	0.6
	Buzzard	9.8	0.2
	Loup Loup	4.6	0.2
	Pearrygin	5.1	0.3
	Thompson	5.0	0.3
	Mazama	5.9	0.1
Ellensburg	Teanaway	9.0	1.8
	Swauk	9.8	1.1
	Cle Elum	8.3	1.3
Wenatchee	Tronsen	7.2	0.2
	Tumwater	8.8	0.4
	Entiat	5.5	0.4

X. COSTS

Total Project control costs were $2,386,646 or $6.692 per acre. A detailed summary of costs is shown in Table 4 of the Appendix. Costs were shared by State and Federal agencies and private landowners under authority provided in the Forest Pest Control Act of June 25, 1947, as amended.

The Federal government paid the full control costs on Federal land and Indian Reservation land, 50 percent on private land ownerships under 500 acres, 33⅓ percent on private land ownerships over 500 acres, and 25 percent on State lands. The State of Washington and the private landowners shared the remaining costs.

XI RECOMMENDATIONS FOR FUTURE PROJECTS

A critique was held by Project personnel when the Project was completed. Some of the major recommendations that were brought out in the critique are as follows:

1. If possible, more time should be allocated for training, boundary marking, heliport location, etc.
2. A real effort should be made to complete the environmental statement earlier in order to make it possible to proceed through the review process earlier and thereby obtain funding earlier.
3. A Supervisory Aerial Observer should be designated similar to the Supervisory Heliport Manager on each Control Unit.
4. The Project Director should be delegated authority similar to a Fire Boss to authorize administrative leave for safety reasons.
5. Hiring the temporary personnel and field purchasing authority should be delegated to individual Control Units.
6. Because of the heavy workload on a project of this nature and the need for expertise, there should be one inspector for pilots and another for aircraft.
7. Aerial markers made from less durable material should be used so they will decompose rapidly.
8. When treating sensitive areas, a ground observer with a radio should be utilized as well as an aerial observer.
9. Rental vehicles should be equipped with AM radios to help keep drivers alert during early morning hours.
10. Ski goggles rather than regular safety goggles should be worn at heliports, to prevent dust from getting in through holes on sides of goggles.

11. Should acquire the use of more radio frequencies, both Forest Service and VHF, to prevent interference between units.

12. Formulation contract should include complete cleanup of storage sites when project is completed.

13. Observation contracts should provide for dust abatement for their aircraft.

14. Spray contractors should be required to furnish extra batch trucks to permit quick changes in heliport locations when weather precludes spraying in some areas.

15. Beekeepers should be required to sign liability release statements if they choose not to move or cover their hives during spraying.

XII. REFERENCES

Bernhardt, John, Joseph, Paveza, and Harry Tracy
1978. Aquatic monitoring of the 1977 spruce budworm, Sevin 4 Oil, aerial spray project in Washington State. Washington State Dept. of Ecology. DOE 78-4. March. 22 pp.

Carolin, V.M. and W.K. Coulter
1971. Trends of western spruce budworm and associated insects in Pacific Northwest forests sprayed with DDT. J. Econ. Entomol. 64:291-297. Illus.

Carolin, V.M. and W.K. Coulter
1972. Sampling populations of western spruce budworm and predicting defoliation on Douglas-fir in eastern Oregon. Forest Service, Research Paper PNW-149.

Mounts, Jack and David McComb
1975. Pilot project of fenitrothion for control of western spruce budworm. Insect and Disease Management, State and Private Forestry, Forest Service, USDA, Region 6, Portland, Oregon. 18 pp. plus appendix. Illus.

USDA
1976. Cooperative western spruce budworm control project Washington - Oregon. Forest Service, USDA, Region 6, Portland, Oregon. 18 pp. plus appendix. Illus.

USDA
1977. USDA final environmental statement, addendum to the final 1976 cooperative western spruce budworm pest management plan. Forest Service. May. 113 pp. plus appendix.

USDA
1977. Project plans for the 1977 spruce budworm control project. Forest Insect and Disease Management, State and Private Forestry, Region 6, Portland, Oregon. May. 99 pp.

XIII. APPENDIX

Table 3. — Acreage treated by ownership.

Ownership	Acres	Percentage
WASHINGTON		
National Forest		
Okanogan	116,015	
Wenatchee	177,795	
Subtotal	293,810	82.4
State of Washington	12,407	3.5
Private (over 500 acres)	43,550	12.2
Private (less than 500 acres)	6,206	1.7
Total Washington	355,973	
OREGON		
Warm Springs IR	688	0.2
Total Oregon	688	
GRAND TOTAL	356,661	100.0

Table 4. — 1977 Spruce Budworm Control Project Cost Estimate (8/19/77)

		Cost/Acre
Insecticide	$ 750,119	2.103
Mixing, Storage, and Transportation	151,319	0.424
Application	514,225	1.442
Observation and Administrative Aircraft	273,482	0.767
Salaries — FS Personnel	309,984	0.869
Per Diem — FS Personnel	76,000	0.213
Vehicle Use	63,948	0.179
Supplies, Materials, and Freight	44,205	o.124
Rents, Communications, and Utilities	9,331	0.026
State Personnel Salaries and Per Diem (estimated)	42,715	0.120
Environmental Monitoring	45,537	0.128
Laboratory Analysis, Environmental Samples	24,970	0.070
Miscellaneous Expenditures (includes report, data analysis, printing, etc.)	22,423	0.063
Overhead Costs	58,388	0.164
GRAND TOTAL	$2,386,646	6.692

$$\text{Cost/Acre} = \frac{\$2,386,646}{356,661 \text{ acres}} = \$6.692/\text{acre}$$

Table 5. — Control Project Personnel

Location	USFS and WDNR Personnel	Contracting Personnel	DOE Monitoring Personnel	Total Personnel
Project Headquarters	11	5	—	16
Okanogan Unit	39	23	3	65
Wenatchee Unit	31	17	3	51
Ellensburg Unit	31	17	3	51
TOTALS	112	62	9	183

Table 6. — Accident Summary Chart

Control Unit	Personal Injuries	Motor Vehicle Accidents	Aircraft Accidents	Aircraft Incidents
Project Headquarters	0	0	0	0
Okanogan	1	2	0	4
Wenatchee	1	5	0	6
Ellensburg	0	1	0	1
TOTALS	2	8	0	11

Table 7. — Treatment Summary

Date	Okanogan	Wenatchee	Ellensburg	Totals for Day	Comulative Acres Total
6/17	2,426	—	—	2,426	2,426
6/18	1,762	400	3,424	5,586	8,012
6/19	3,879	3,040	3,100	10,091	18,031
6/20	4,738	708	360	5,806	23,837
6/21	11,404	2,780	1,608	15,792	39,629
6/22	12,816	5,134	1,280	19,230	58,859
6/23	5,312	4,648	3,280	13,240	72,099
6/24	7,393	7,934	3,684	19,011	91,110
6/25	4,195	6,620	1,908	12,723	103,833
6/26	5,419	7,858	1,756	15,033	118,866
6/27	3,966	3,070	3,618	10,654	129,520
6/28	13,426	3,726	7,172	24,324	153,844
6/29	12,670	4,148	7,632	24,450	178,294
6/30	8,514	7,520	8,364	24,398	202,692
7/1	5,512	7,094	7,362	19,968	222,660
7/2	1,473	928	0	2,401	225,061
7/3	13,795	10,670	8,876	33,341	258,402
7/4	7,842[1]	11,544	10,472	29,858	288,260
7/5	—	7,700	7,318	15,018	303,278
7/6	—	4,092	5,438[1]	9,530	312,808
7/7	—	5,856	—	5,856	318,664
7/8	—	5,870	—	5,870	324,534
7/9	—	2,450	—	2,450	326,984
7/10	—	3,413	—	3,413	330,307
7/11	—	944	—	994	331,341
7/12	—	0	—	0	331,341
7/13	—	7,380	—	7,380	338,721
7/14	—	7,892	—	7,892	346,613
7/15	—	5,546	—	5,546	352,159
7/16	—	4,502[1]	—	4,502	356,661
TOTALS	126,542	143,467	86,652	—	356,661
		-10,560[2]	+ 10,560[2]		
	126,542	132,907	97,212		356,661

[1] Unit completed.

[2] Acreage done on Ellensburg Unit by Wenatchee crew.

Table 8. — Applicator Contract Summary Chart

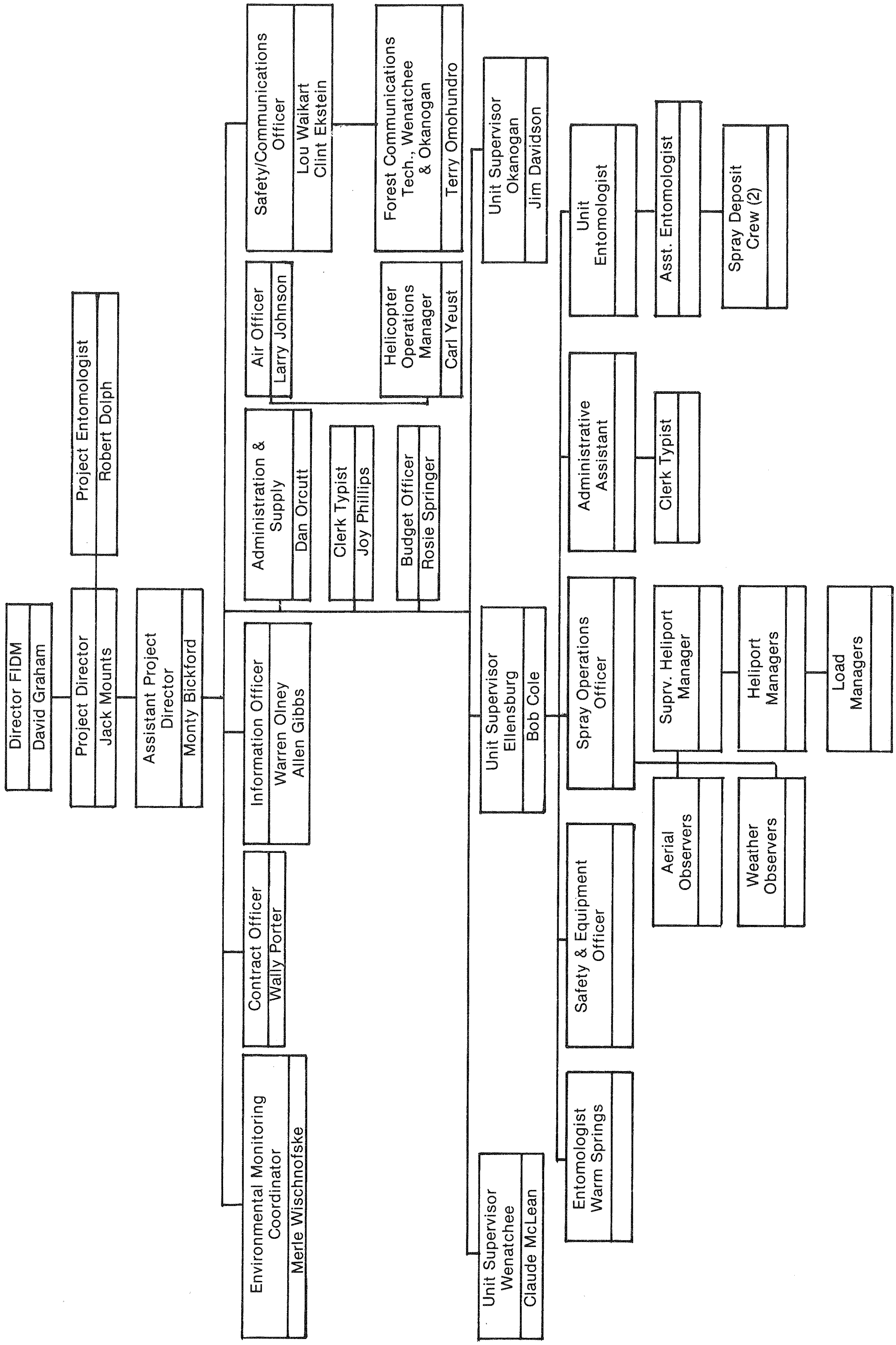
Control Unit	Contractor	Bid Quantity (Acres)	Bid Price[1]	Negotiated Price	Actual Acres	Performance Payment
Okanogan	High Life Helicopters	95,000	—	$1.62[2]	96,862	$156,916.44
	Evergreen Helicopters	75,000	$1.44	$2.2523[3]	29,680	66,848.26
Wenatchee	Evergreen Helicopters	152,000	$1.22	—	132,907	162,146.54
Ellensburg	Evergreen Helicopters	138,000	$1.33	$1.3832[3]	97,212	134,463.64
	Less spillage and time payment discount					— 6,149.61
TOTALS		460,000	$1.37	$1.44	356,661	$514,225.27

[1] Original bid prices on advertised contracts.
[2] Price negotiated with S.B.A. for High Life Helicopters under Section 8A.
[3] Prices on Okanogan and Ellensburg Units negotiated with Evergreen Helicopters because of having less than 75 percent of contracted acres available for treatment.

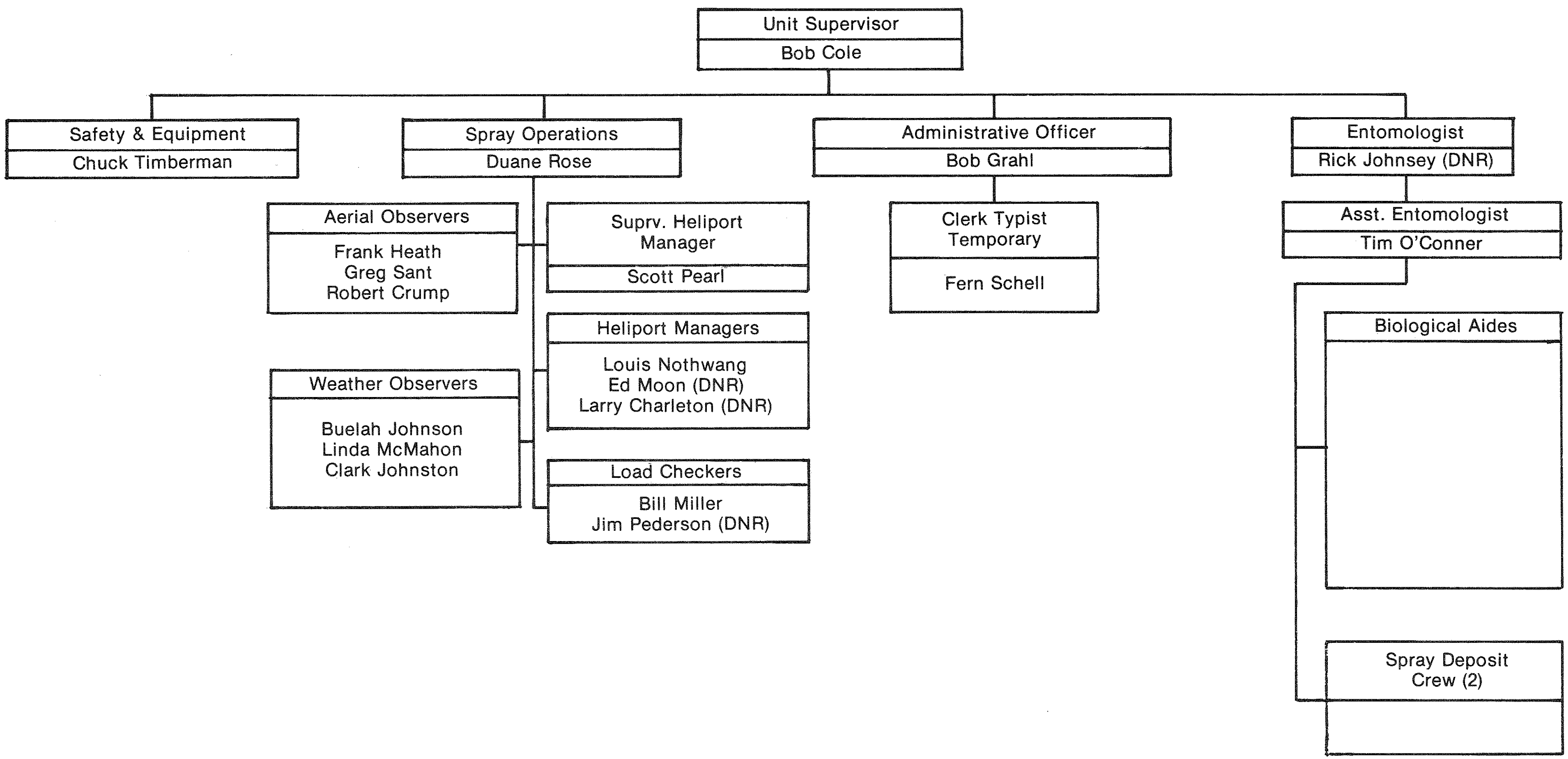
Table 9. — Summary of service helicopter contracts

Helicopters	Contractor	Days Guar.	Unit Price	Days	Hours	Final Payment
2 light turbine-powered	Mountain Air Helicopters	30	$495/day $150/hr	47	128.33	$42,515
2 light turbine-powered	Snake River Helicopters	30	$534/day $150/hr	35	104.4	34,350
2 light turbine-powered	Olympic Helicopters, Inc.	30	$347/day $150/hr	48	130.0	36,154
2 light turbine-powered	Mid Valley Helicopters, Inc.	30	$450/day $150/hr	45	166.7	45,255
1 light turbine-powered	Corvallis Aero Service, Inc.	15	$435/day $150/hr	6[1]	23.1	6,075
1 light turbine-powered	Henderson Aviation	15	$539/day $150/hr	42	143.4	44,148
1 light turbine-powered	Henderson Aviation[2]	0	$539/day $150/hr			
1 light turbine-powered	Cascade Helicopters, Inc.	15	$398/day $150/hr	46	157.7	42,133
1 light turbine-powered	Cascade Helicopters, Inc.[2]	0	$398/day $150/hr			
1 light turbine-powered (W/O pilot)	Aero Copters, Inc.	15	$395/day $135/hr	35	63.7	22,380
TOTALS		180		304	917.33	$273,010

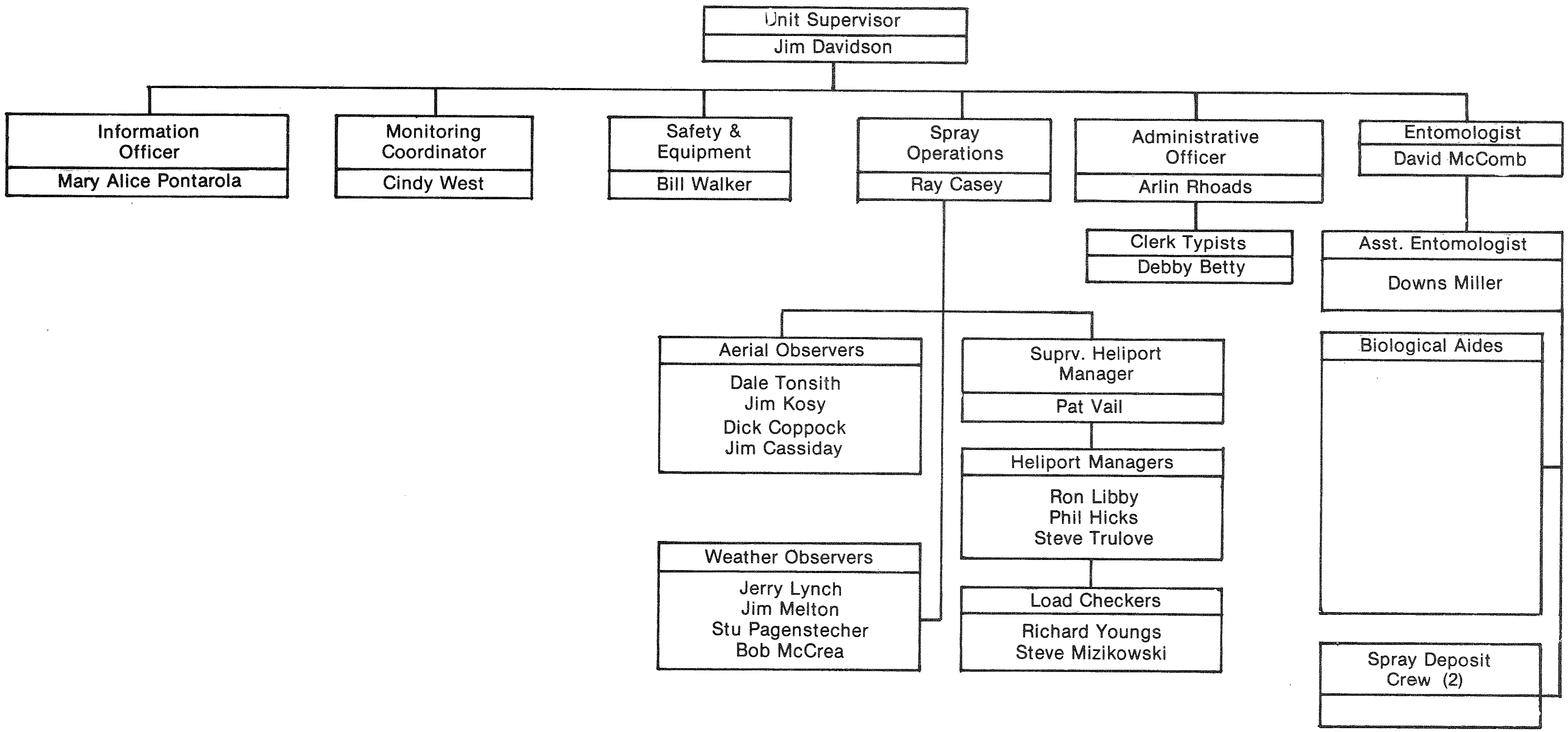
[1] Defaulted because of mechanical difficulties.
[2] Brought in second aircraft under same contract.


Director FIDM
David Graham
Project Director
Jack Mounts
Project Entomologist
Robert Dolph
Assistant Project Director
Monty Bickford
Environmental Monitoring Coordinator
Merle Wischnofske
Contract Officer
Wally Porter
Information Officer
Warren Olney
Allen Gibbs
Administration & Supply
Dan Orcutt
Clerk Typist
Joy Phillips
Budget Officer
Rosie Springer
Air Officer
Larry Johnson
Helicopter Operations Manager
Carl Yeust
Safety/Communications Officer
Lou Waikart
Clint Ekstein
Forest Communications Tech., Wenatchee & Okanogan
Terry Omohundro
Unit Supervisor Wenatchee
Claude McLean
Unit Supervisor Ellensburg
Bob Cole
Unit Supervisor Okanogan
Jim Davidson
Entomologist Warm Springs
Safety & Equipment Officer
Spray Operations Officer
Administrative Assistant
Clerk Typist
Unit Entomologist
Asst. Entomologist
Spray Deposit Crew (2)
Suprv. Heliport Manager
Heliport Managers
Load Managers
Aerial Observers
Weather Observers

ELLENSBURG CONTROL UNIT



OKANOGAN CONTROL UNIT



WENATCHEE CONTROL UNIT

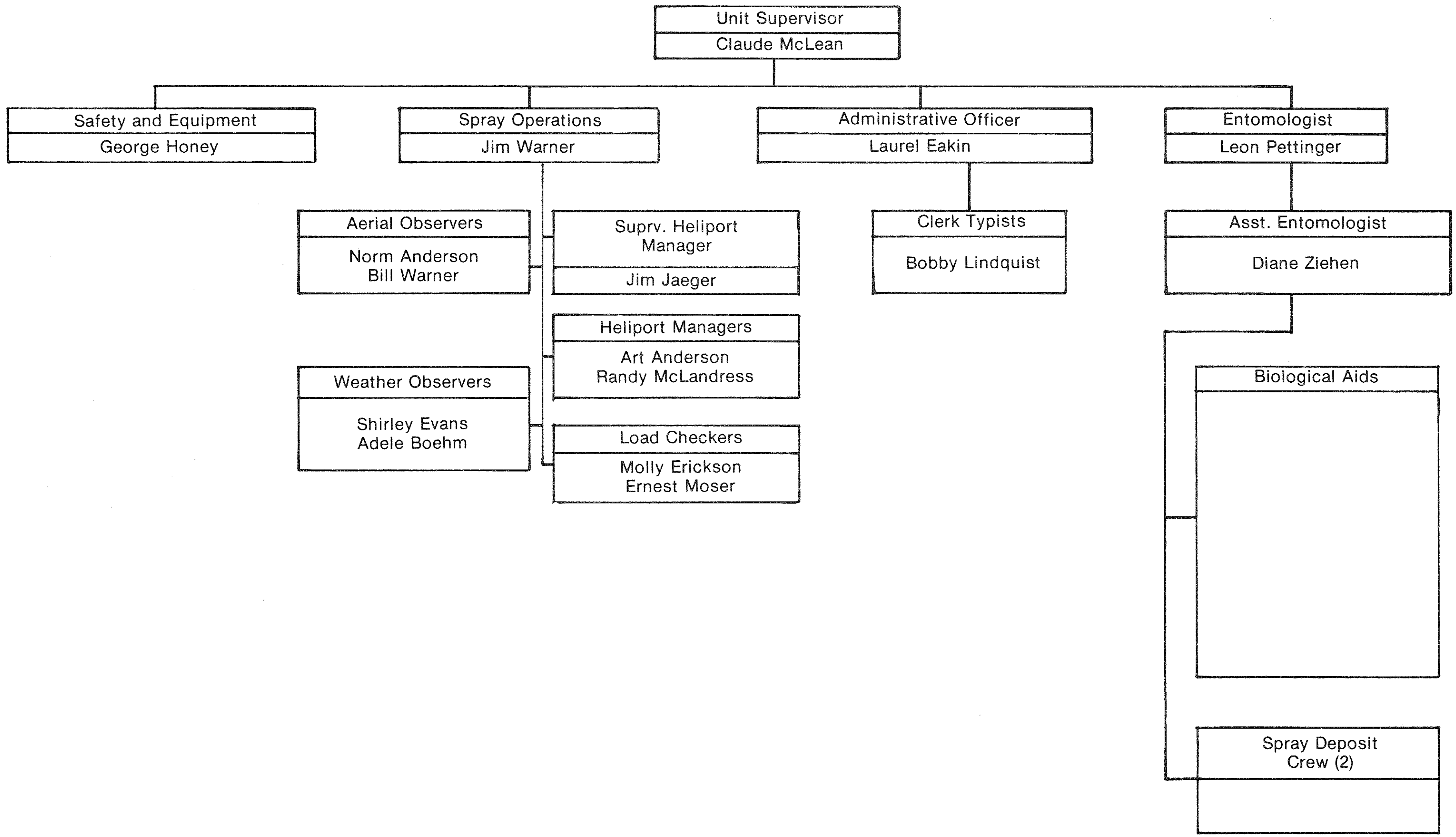


Table 10. — Budworm populations and mortality estimates by control unit and subunit

UNIT SUBUNIT	SAMPLE SIZE	LARVAE[1]				EGG MASSES[2]		LARVAE MORTALITY				
		PRESPRAY		POSTSPRAY		POSTSPRAY		UNADJUSTED	ADJUSTED[3]			
		MEAN	SE	MEAN	SE	MEAN	SE	MORTALITY	MORTALITY (ABBOTTS)	MEAN (COVARIANCE)	SE (COVARIANCE)	MORTALITY (COVARIANCE)
ELLENSBURG												
Teanaway	22	23.9	3.2	3.1	1.0	1.8	.8	.870	.468	2.5	.7	.538
Swauk	24	12.3	1.9	1.3	.3	1.1	.4	.894	.567	2.1	.7	.596
Cle Elum	21	18.1	1.7	1.1	.3	1.3	.7	.939	.751	1.2	.7	.769
Mean	3	18.1	3.3	1.8	.6	1.4	.2	.901	.592	1.9	.4	.635
Check	21	24.2	4.1	5.9	1.2	1.2	.4	.756	—	5.2	.7	—
WENATCHEE												
Tronsen	27	15.0	1.8	1.3	.3	.2	.1	.913	.814	1.8	.6	.660
Tumwater	3	19.5	5.4	1.1	.4	.4	.2	.944	.879	1.1	1.9	.793
Entiat	13	16.5	3.8	3.7	.7	.4	.2	.776	.519	4.0	.9	.245
Mean	3	17.0	1.3	2.0	.8	.3	.1	.882	.748	2.3	.9	.566
Check	10	8.8	2.9	4.1	1.3	.2	.1	.534	—	5.3	1.1	—
OKANOGAN												
Twisp	18	12.6	3.5	.9	.3	.6	.2	.929	.859	1.7	.8	.873
Buzzard	25	34.4	3.9	1.2	.4	.2	.1	.965	.931	-.6	.7	1.000
Loup Loup	22	22.1	4.1	1.6	.7	.2	.1	.928	.857	1.2	.7	.910
Pearrygin	26	9.6	1.2	1.2	.3	.3	.1	.875	.753	2.3	.7	.828
Thompson	13	20.6	3.0	1.2	.3	.3	.1	.942	.885	1.0	.9	.925
Mazama	26	11.6	1.7	.5	.1	.1	.05	.957	.915	1.4	.7	.896
Mean	6	18.5	3.8	1.1	.2	.3	.07	.941	.882	1.2	.4	.910
Check	26	28.9	3.7	14.6	1.7	2.8	.7	.495	—	13.4	.7	—

[1] Number of budworm larvae per 100 buds.
[2] Number of egg masses per 1,000 sq. in. of foliage.
[3] Postspray larvae density adjusted to a common prespray density, 18.9 larvae per 100 buds, all Units combined.

Table 11. — Budworm populations and adjusted mortality for all units combined

TREATMENT	LARVAE PER 100 BUDS SAMPLE PERIOD			MORTALITY[3]		
				UNCORRECTED	CORRECTED	
	PRE	POST	EGG[1]		ABBOTTS	COVARIANCE
SPRAY	~~1.8~~ 18.0 ± 2.0	1.5 ± .3	4.03 ± .40	.917	.791	.794
CHECK	20.6 ± 6.1	8.2 ± 3.2	6.17 ± 1.96	.590		
F^2	~~129~~ .29 ns	19.22**	3.22 ns			

[1] Calculation of larvae per 100 buds based on linear regression of larval density in buds on egg mass density; $y = 2.54 + 2.5908x$ (Carolin 1972).

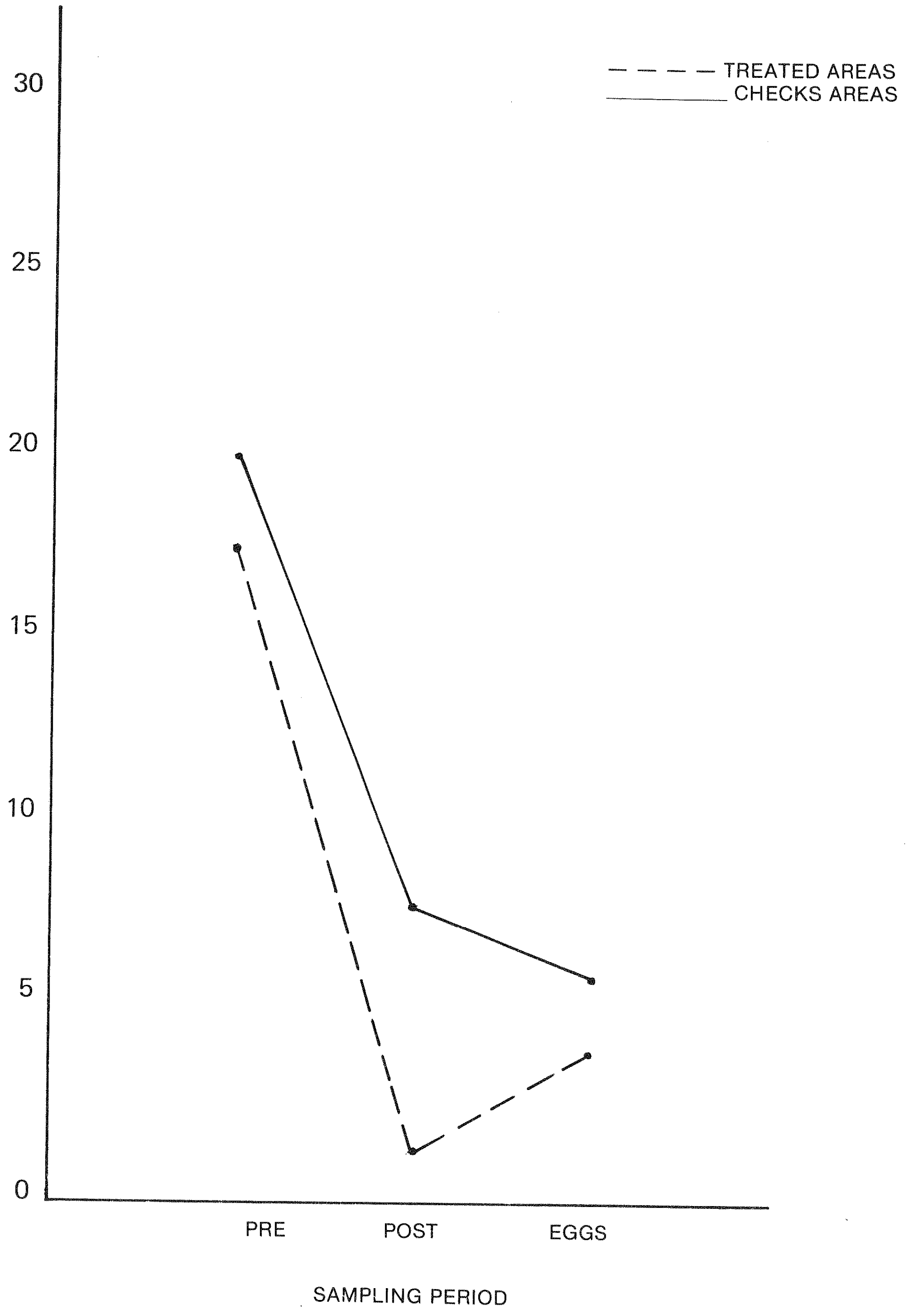
[2] F is the normal test statistic to test for equality of plot means; ns implies nonsignificance;** implies significance at .99 percent level.

[3] Unadjusted mortality $= 1 - \dfrac{\text{Postspray}}{\text{Prespray}}$

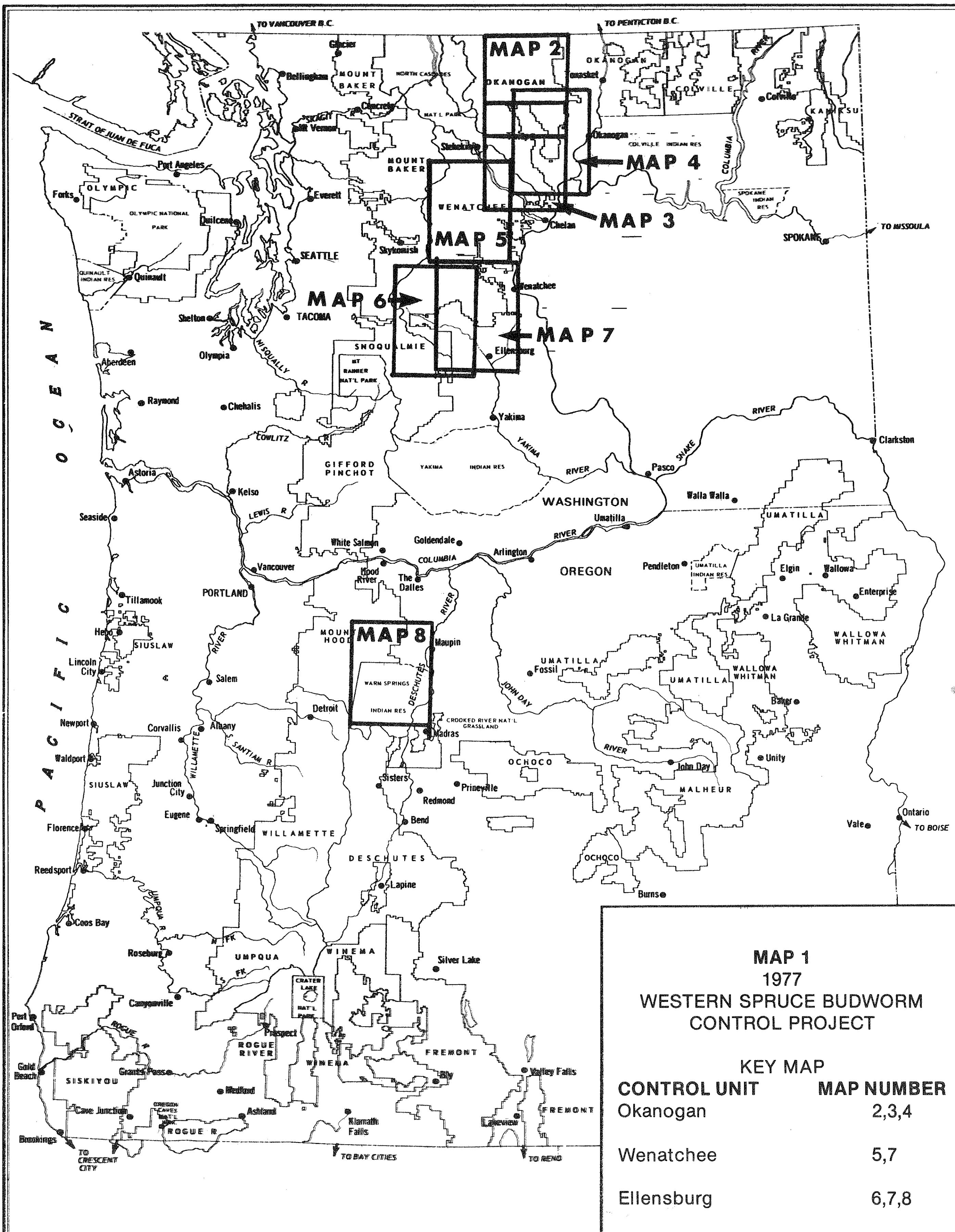
$$\text{Adjusted mortality by Abbott} = 1 - \left[\frac{\text{Post (Treat)}}{\text{Pre (Treat)}}\right] \bullet \left[\frac{\text{Pre (Check)}}{\text{Post (Check)}}\right]$$

$$\text{Adjusted mortality by Covariance} = 1 - \frac{\text{Adj. Postspray Treatment}}{\text{Adj. Postspray Check}}$$

Figure 1. BUDWORM LARVAE PER 100 BUDS ESTIMATES FOR THREE SAMPLE PERIODS: PRESPRAY, POSTSPRAY, AND EGG MASS[1]



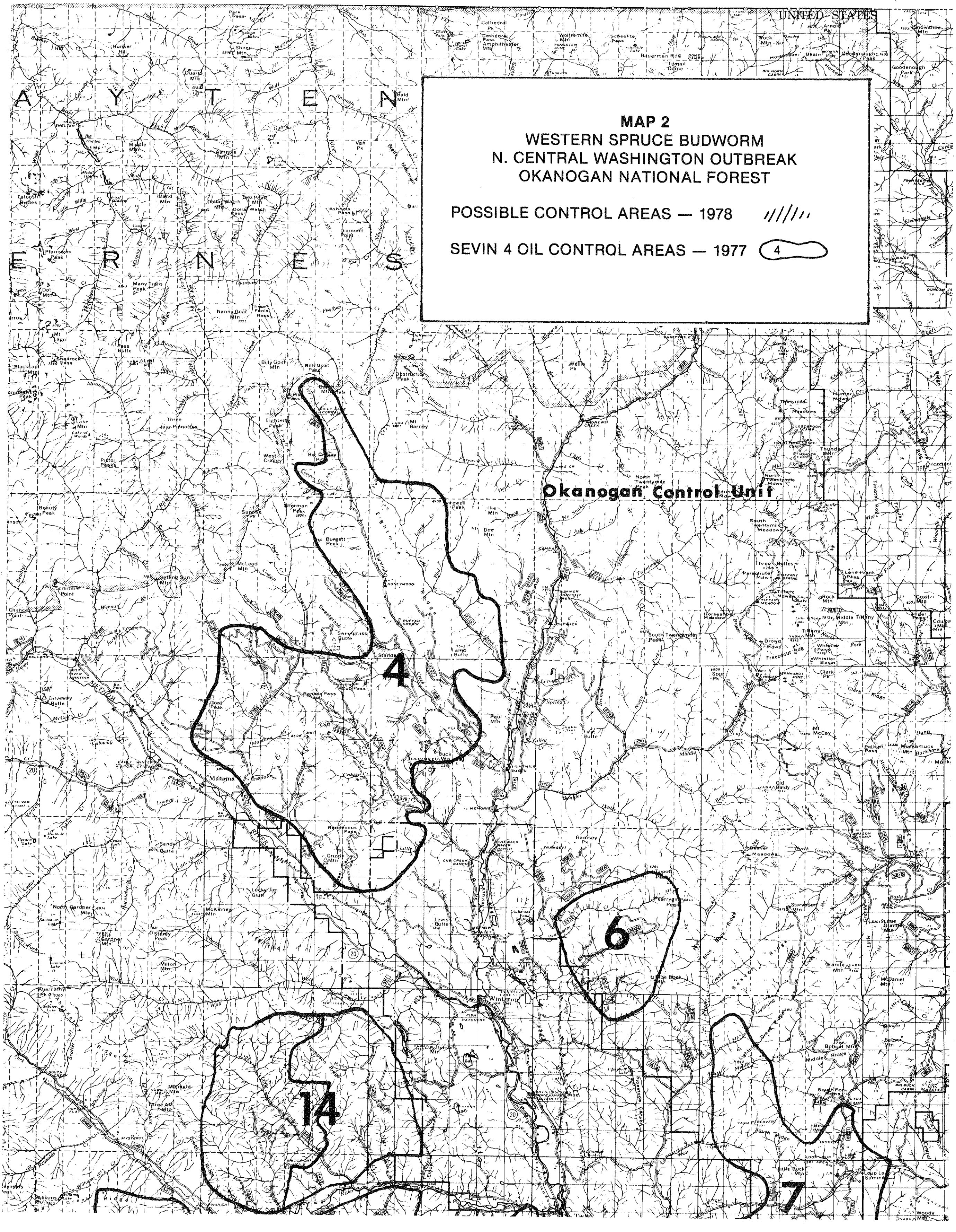
[1] Egg mass densities converted to larvae per 100 buds using $Y = 2.54 + 2.5908x$ (Carolin).

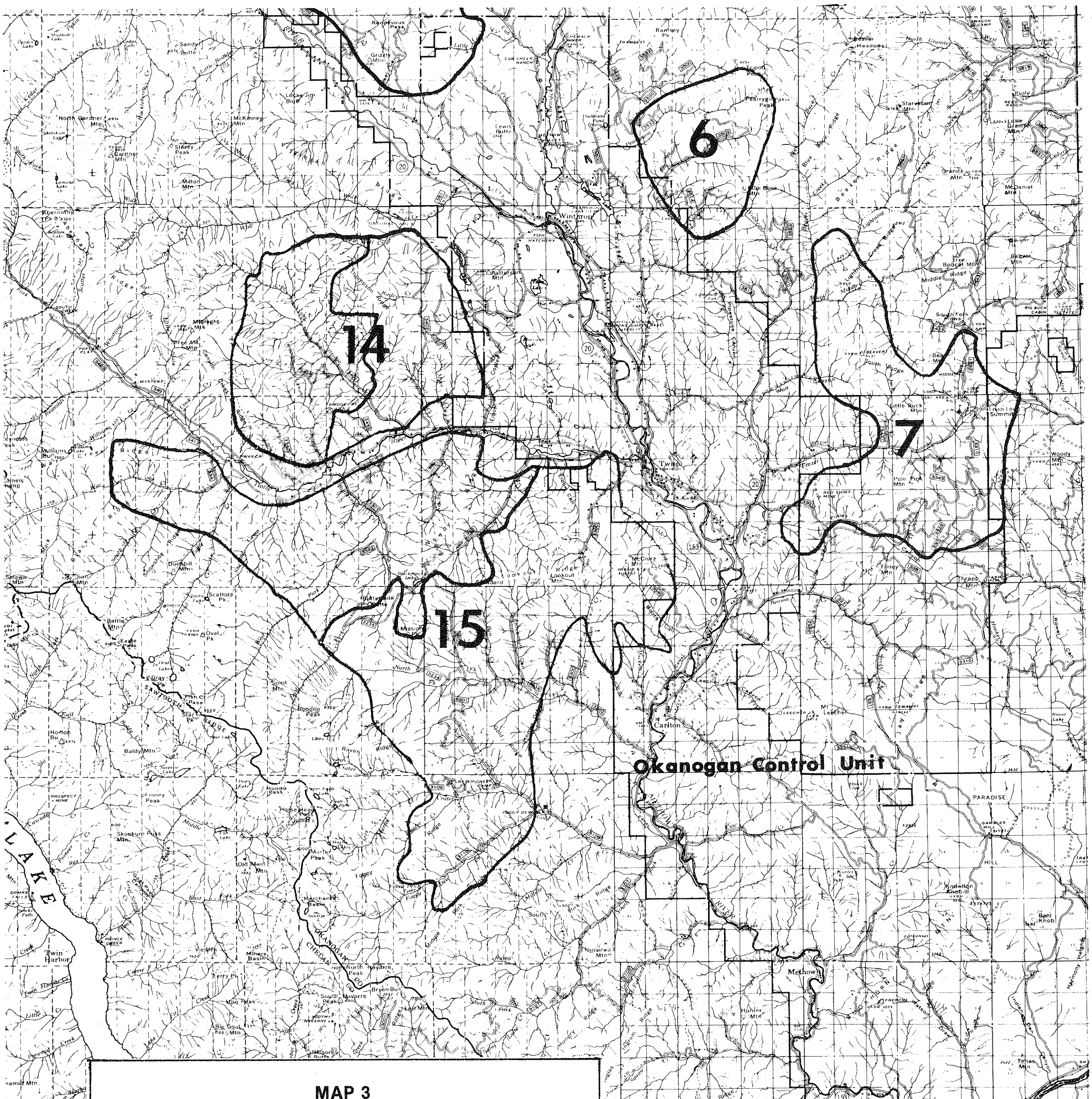


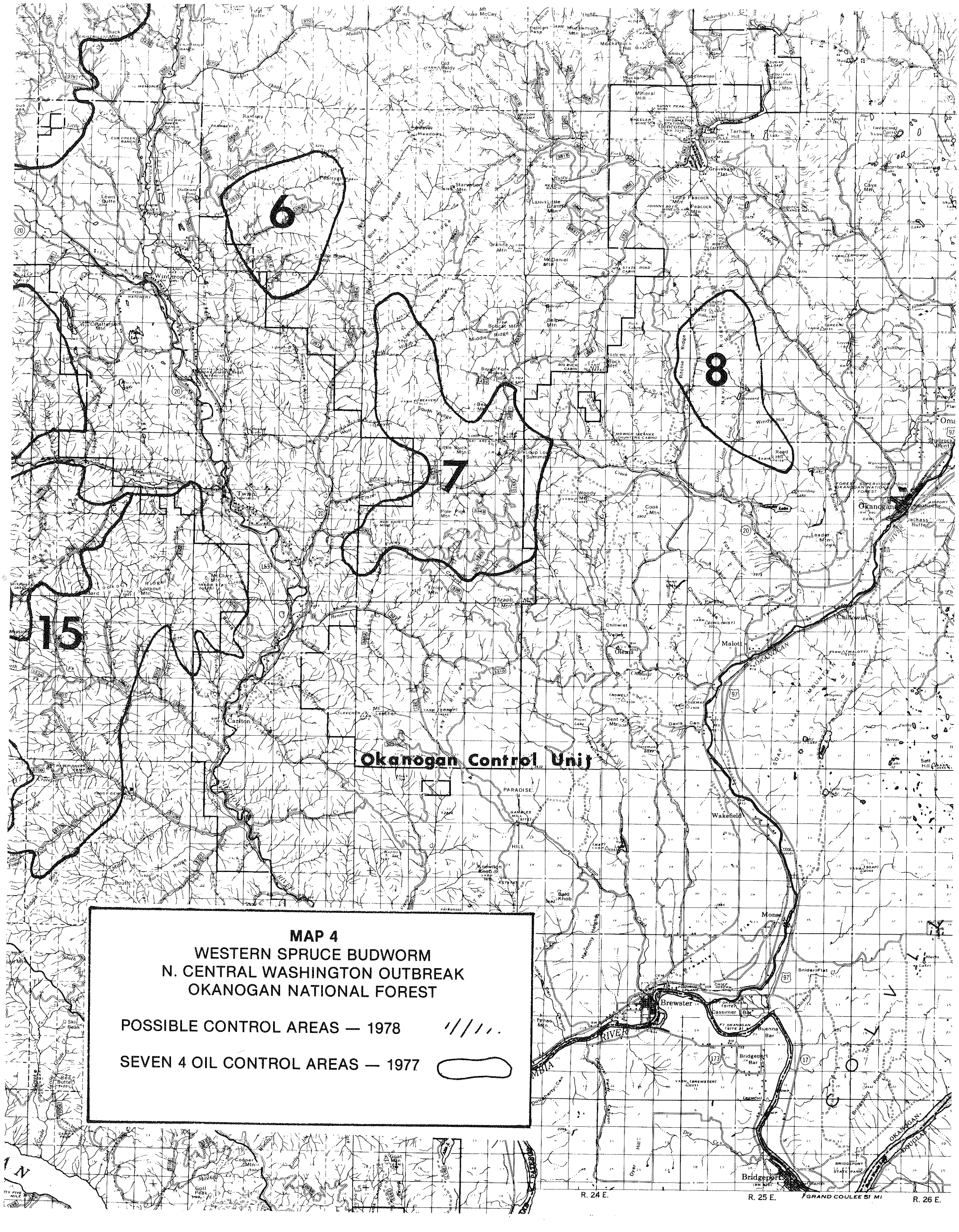
MAP 1
1977
WESTERN SPRUCE BUDWORM
CONTROL PROJECT

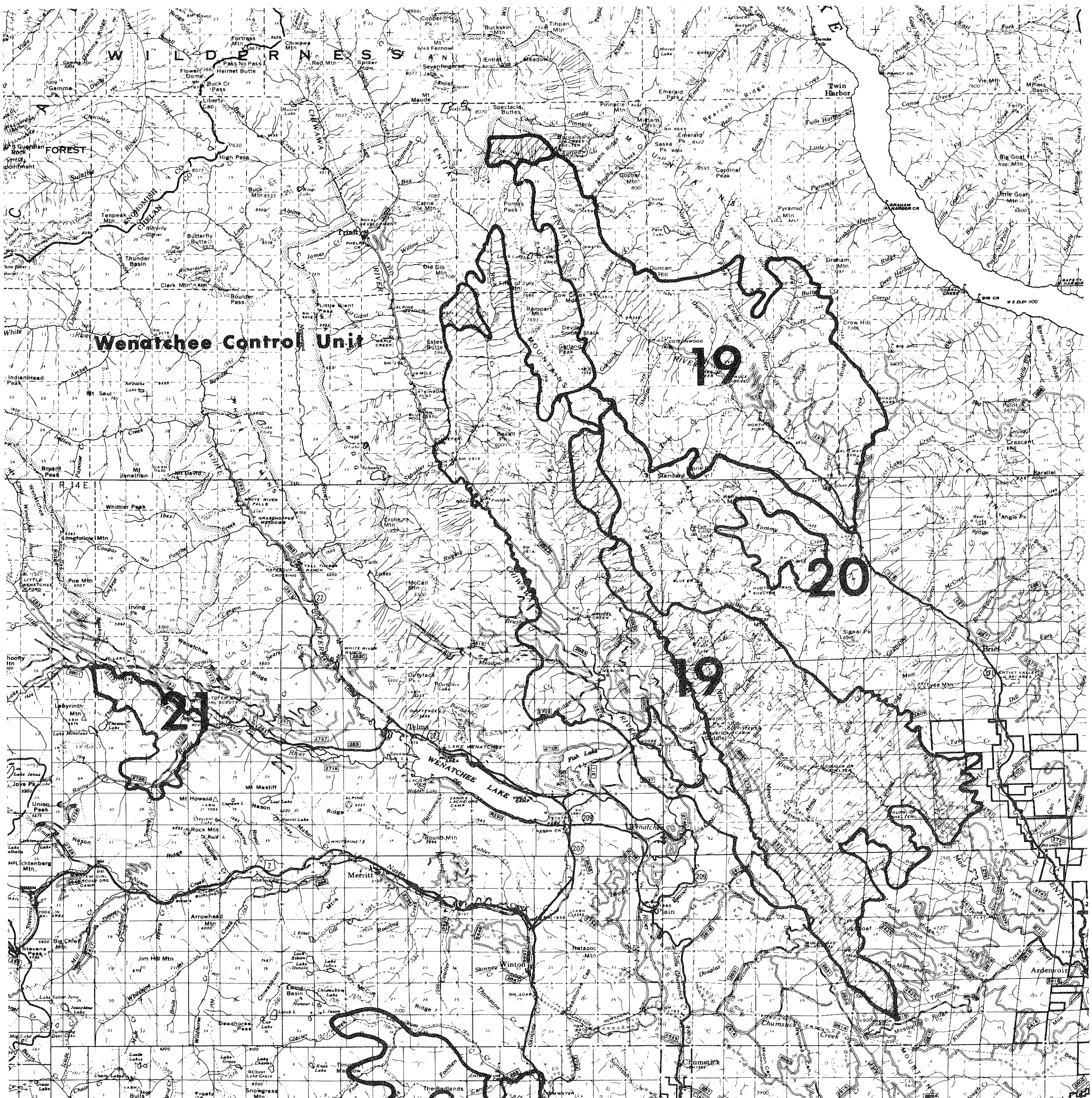
KEY MAP

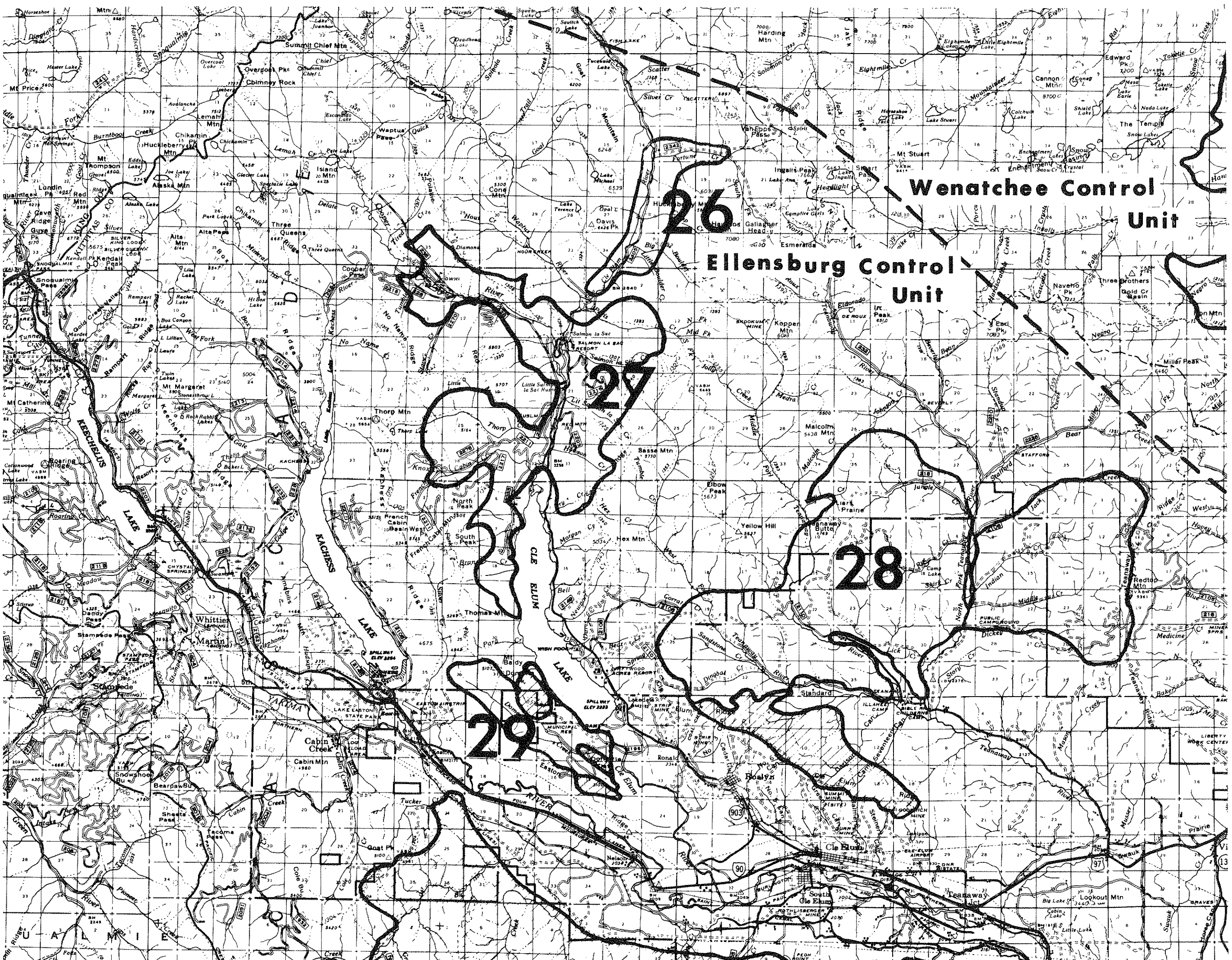
CONTROL UNIT	MAP NUMBER
Okanogan	2,3,4
Wenatchee	5,7
Ellensburg	6,7,8

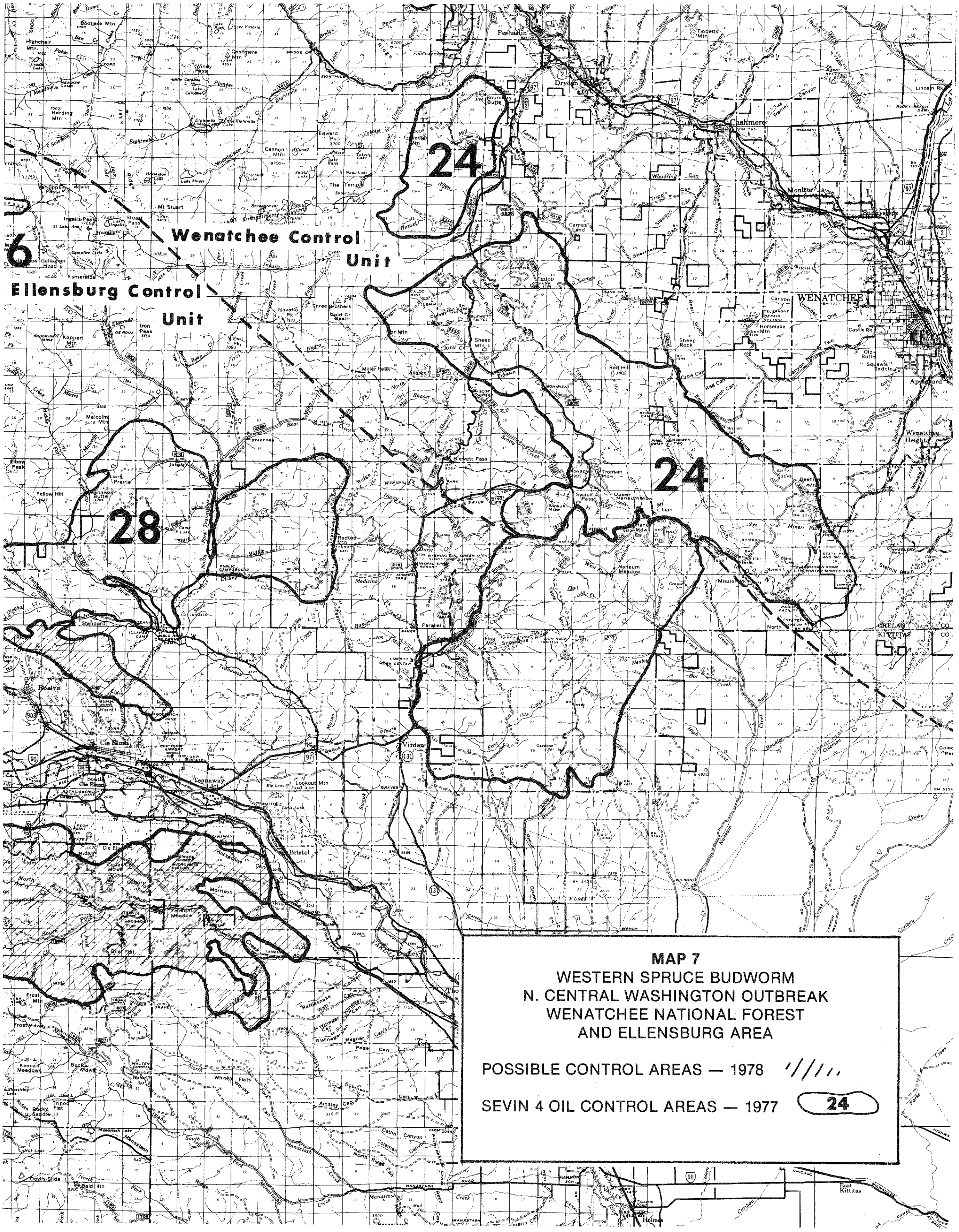

MAP 2
WESTERN SPRUCE BUDWORM
N. CENTRAL WASHINGTON OUTBREAK
OKANOGAN NATIONAL FOREST
POSSIBLE CONTROL AREAS — 1978
SEVIN 4 OIL CONTROL AREAS — 1977
4
Okanogan Control Unit
4
6
14
7
UNITED STATES
Mazama
Winthrop

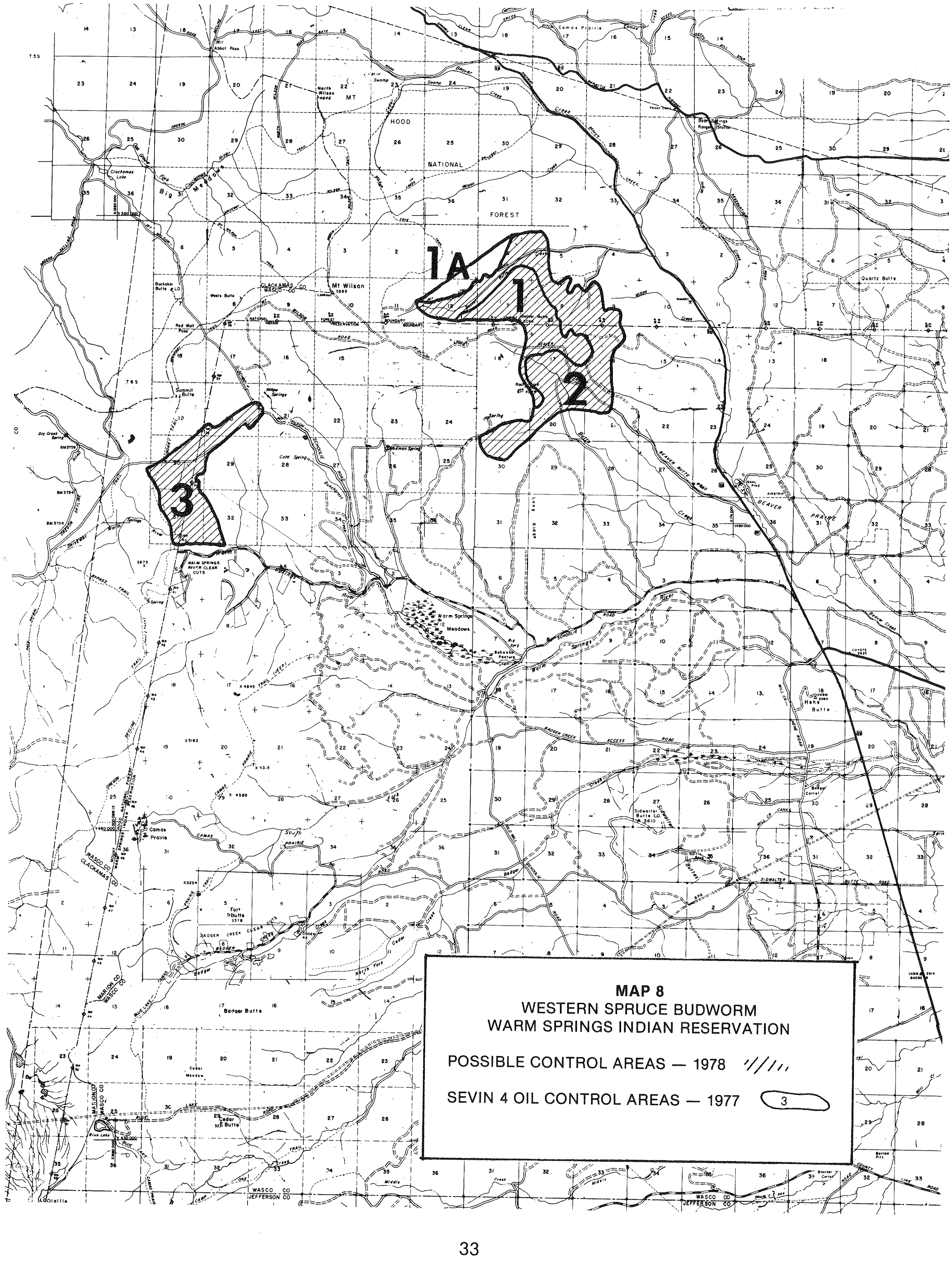

MAP 3
WESTERN SPRUCE BUDWORM
N. CENTRAL WASHINGTON OUTBREAK
OKANOGAN NATIONAL FOREST
POSSIBLE CONTROL AREAS — 1978
SEVIN 4 OIL CONTROL AREAS — 1977
15
6
14
7
15
Okanogan Control Unit
Winthrop
Twisp
Carlton
Methow
Pateros
COLUMBIA
LAKE
Okanogan
Chelan


6
7
8
15
Okanogan Control Unit
MAP 4
WESTERN SPRUCE BUDWORM
N. CENTRAL WASHINGTON OUTBREAK
OKANOGAN NATIONAL FOREST
POSSIBLE CONTROL AREAS — 1978
SEVEN 4 OIL CONTROL AREAS — 1977
R. 24 E.
R. 25 E.
R. 26 E.


WILDERNESS
Wenatchee Control Unit
19
20
21
22
23
MAP 5
WESTERN SPRUCE BUDWORM
N. CENTRAL WASHINGTON OUTBREAK
WENATCHEE NATIONAL FOREST
POSSIBLE CONTROL AREAS — 1978
SEVIN 4 OIL CONTROL AREAS — 1977
19
WENATCHEE LAKE
Leavenworth
Chumstick
Peshastin
Dryden
Merritt
Ardenvoir
Twin Harbor


Wenatchee Control Unit
Ellensburg Control Unit
26
27
28
29
30
MAP 6
WESTERN SPRUCE BUDWORM
N. CENTRAL WASHINGTON OUTBREAK
ELLENSBURG AREA
POSSIBLE CONTROL AREAS — 1978
SEVIN 4 OIL CONTROL AREAS — 1977
29
CLE ELUM LAKE
KACHESS LAKE
KITTITAS CO
YAKIMA CO


MAP 7
WESTERN SPRUCE BUDWORM
N. CENTRAL WASHINGTON OUTBREAK
WENATCHEE NATIONAL FOREST
AND ELLENSBURG AREA
POSSIBLE CONTROL AREAS — 1978
SEVIN 4 OIL CONTROL AREAS — 1977
24
Wenatchee Control Unit
Ellensburg Control Unit
24
24
28
6
WENATCHEE
Cashmere
Peshastin
Dryden
Monitor
Cle Elum
Virden
Bristol



MAP 8
WESTERN SPRUCE BUDWORM
WARM SPRINGS INDIAN RESERVATION

POSSIBLE CONTROL AREAS — 1978 //////

SEVIN 4 OIL CONTROL AREAS — 1977 (3)

Forest Service · USDA
Pacific Northwest Region