A PILOT PROJECT EVALUATING TRICHLORFON AND ACEPHATE for Managing Western Spruce Budworm

HELENA NATIONAL FOREST - 1976

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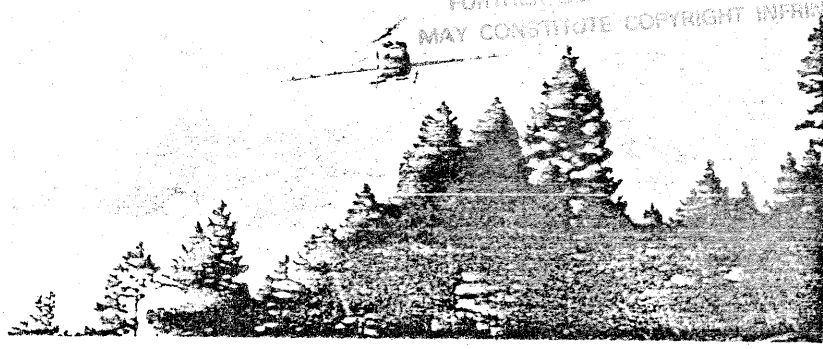

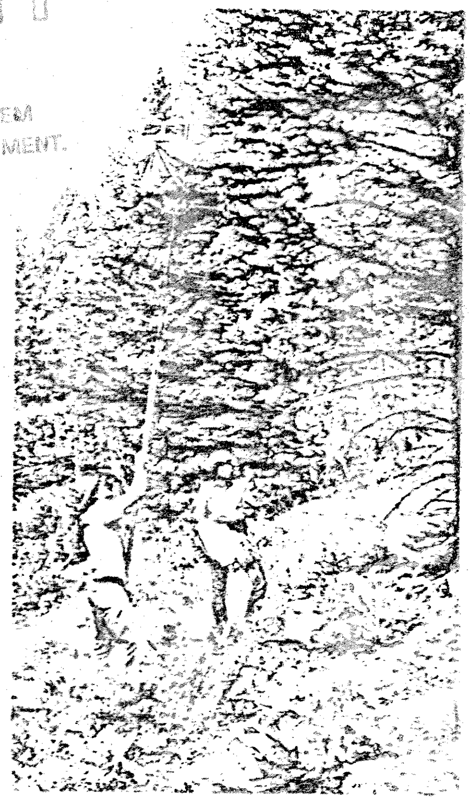

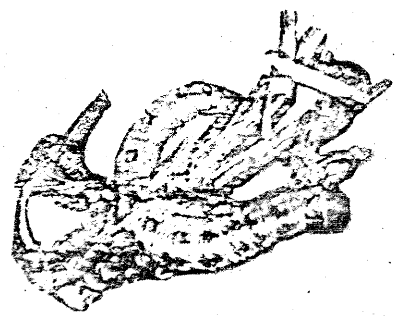

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FOREST INSECT AND DISEASE MANAGEMENT
State and Private Forestry
FOREST SERVICE · NORTHERN REGION
U.S. DEPARTMENT OF AGRICULTURE

A PILOT PROJECT EVALUATING TRICHLORFON AND ACEPHATE FOR MANAGING THE WESTERN SPRUCE BUDWORM, *CHORISTONEURA OCCIDENTALIS* FREEMAN, HELENA NATIONAL FOREST, MONTANA 1976

by

Thomas H. Flavell, Scott Tunnock, and Hubert E. Meyer

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ABSTRACT

A pilot project to evaluate trichlorfon and acephate for suppressing western spruce budworm populations was conducted on the Helena National Forest, Montana. Both insecticides were applied at 1 pound active ingredient per acre. Application was made with a Bell 205A helicopter using eight Beecomist Model 350 spray heads. Treatments and controls were replicated three times. Each replicate covered approximately 1,000 acres. Treatments were applied under a population reduction strategy.

The effects of treatments on fish and aquatic organisms and budworm parasites were monitored.

Covariance analysis of budworm larval populations 10 days after spraying showed that trichlorfon and acephate gave 59.53 and 86.86 percent control respectively. The degree of foliage protection was estimated at 13.67 percent for trichlorfon and 11.80 percent for acephate.

Treatments did not have a significant effect on budworm parasites, fish, or aquatic organisms.

INTRODUCTION

This pilot project was conducted to evaluate two insecticides, acephate (Orthene 75-S[1/]) and trichlorfon (Dylox 4) for use in combating outbreaks of the western spruce budworm, *Choristoneura occidentalis* Freeman. It was part of a nationwide effort to register environmentally safe insecticides for major forest pests in order to comply with the Federal Insecticide, Fungicide, and Rodenticide Act, as amended in 1972. This act requires pesticides to be registered with the Environmental Protection Agency for use against the target pest before it can be used. Registration is based on demonstrated effectiveness and environmental safety when used in the prescribed manner. Pilot projects are conducted by the U.S. Forest Service as a final step in the registration process. They are designed to evaluate effectiveness of insecticides used under simulated operational conditions and to identify unexpected handling or environmental problems.

The objectives of this project were to:

1. Determine effectiveness of trichlorfon and acephate against the western spruce budworm under operational conditions using a population reduction strategy.

2. Determine degree of current year foliage protection with application timed to achieve maximum larval population reduction.

1/ Mention of trade names is for information only and does not constitute endorsement by the U.S. Department of Agriculture.

3. Identify and resolve formulation, handling, application, and safety problems associated with use of these insecticides on an operational scale.

4. Determine effects of these insecticides on aquatic invertebrates and fish when used operationally.

5. Determine effects of acephate on parasites of the western spruce budworm.

MATERIALS AND METHODS

Location

Nine budworm-infested Douglas-fir areas in the Big Belt Mountain Range on the Townsend and Canyon Ferry Ranger Districts, Helena National Forest, were selected for this project (Fig. 1). Surveys made in the fall of 1975 showed a 45.2 percent increase in area infested by the budworm on this Forest. Egg mass surveys were made to locate areas with suitable budworm populations and topography for a pesticide evaluation. An egg density of at least 10 masses per 1,000 square inches of foliage was considered necessary. Access by road was also an important consideration.

The Big Belt Mountain Range runs in a northwest-southeast direction and forms the eastern border of the Helena National Forest. Elevations range from 9,504 feet at Mount Edith in the south to 7,819 feet at Hogback Mountain in the north. Streams on the western flanks of the range flow into Canyon Ferry Reservoir; those on the east flow into Smith River. Douglas-fir forests occupy rocky soils at lower elevations and south slopes and heavy, moist soils at higher elevations and north slopes. Mammals living in these mountains include elk, black bear, white-tailed and mule deer, mountain goat, pine squirrel, porcupine, golden-mantle ground squirrel, Columbian ground squirrel, and chipmunk. Birds frequenting the area include blue grouse, Franklin's grouse, red-fronted nuthatch, Canada jay, Oregon junco, mountain chickadee, Townsend solitaire, pine siskin, Audobon's warbler, western tanager, American kestrel, red-tailed hawk, sharp-shinned hawk, and goshawk.

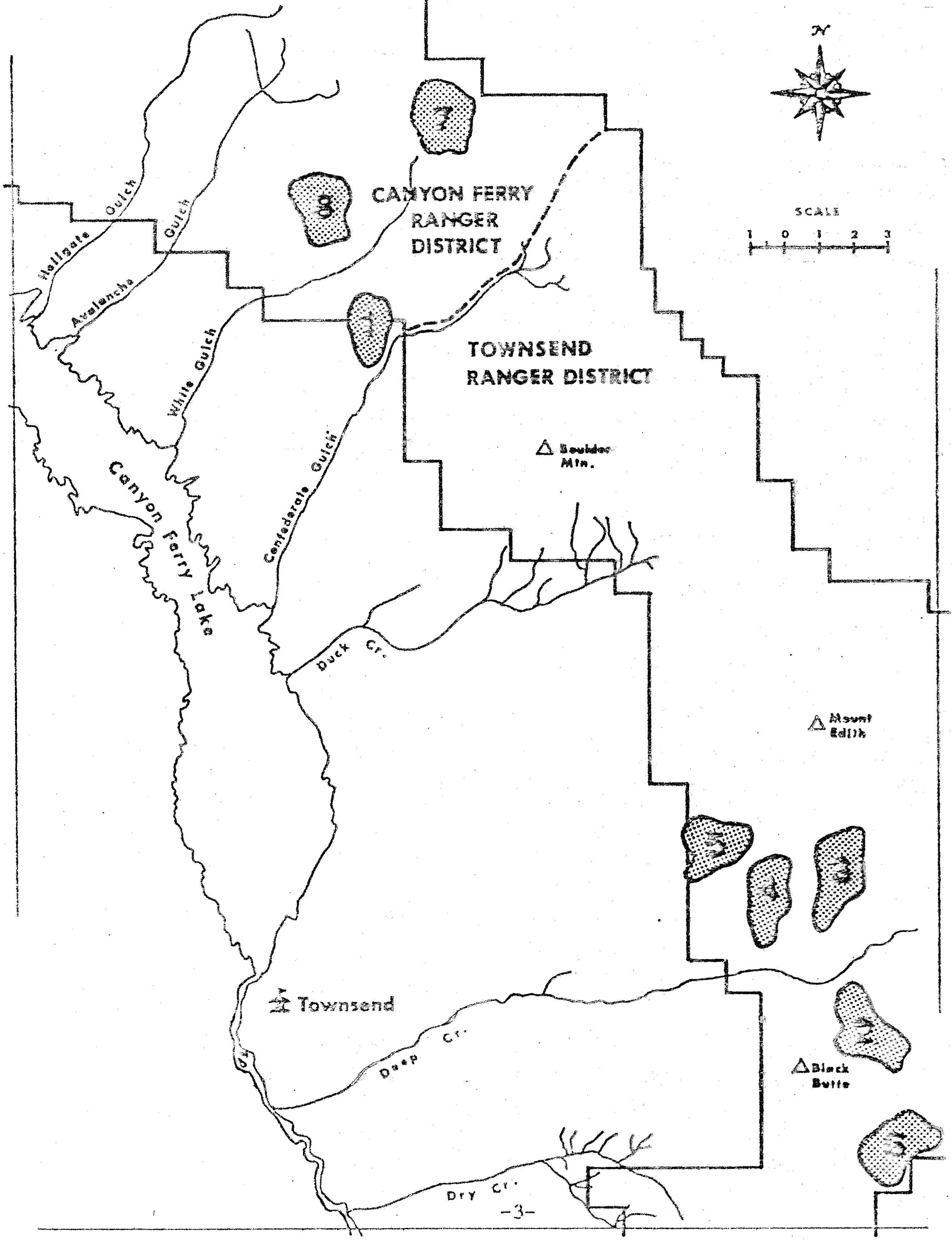
Insecticides

Dylox 4 (THFA) formulation[2/] is manufactured especially for use against forest pests. It is registered for use on gypsy moth, eastern spruce budworm in Maine, and forest tent caterpillar in Louisiana and Alabama. Tests on the western spruce budworm in Montana in 1975 were inconclusive. Although the level of budworm larval mortality achieved was lower than desired, it was felt that the pesticide's performance could be improved by using a smaller drop size and a 1:1 dilution rate of Dylox 4 in a heavy aromatic naptha. For this reason, it was included in this project.

2/ Dylox 4 formulation:

Dimethyl (2,2,2 - Trichloro-1-hydroxyethyl phosphonate 39%
Tetrahydrofurfuryl alcohol (THFA). 61%

Figure 1.--Location of treatment blocks on the Townsend and Canyon Ferry Ranger Districts, Helena National Forest, Montana.



Dylox is an organophosphate insecticide which acts as a cholinesterase inhibitor. Under experimental conditions the effects of Dylox on cholinesterase are rapidly reversed. This makes Dylox relatively safe to mammals, birds, and fish. At minimum dosage rates, Dylox is relatively nontoxic to honey bees. Although Dylox may cause a substantial impact on other beneficial insects, their populations usually return to normal in 1 to 2 weeks (1)[3/].

Dylox is relatively nonpersistent in the environment. It is most persistent in silt loam soils which retained 2.86 percent of a 20 pound/acre dose 5 weeks after application (1).

Dylox 4 was applied at a rate of 1 pound a.i. per acre in one-half gallon of final spray solution. The following spray formulation was used:

0.50	gallon Dylox 4
.48	gallon HiSOL 4-5-T
.02	gallon automate red "B" dye
1.00	gallon

As formulated, the Dylox 4 spray solution weighed 8.98 pounds/gallon (specific gravity of 1.08[4/]). The flow rate correction factor was 0.96; i.e., it flowed 96 percent as readily as water.

Orthene.--Since its recent introduction to forest uses, Orthene has been registered for gypsy moth control and has been field tested on a variety of other forest pests including both eastern and western spruce budworm. Results from a 1975 field test on the western spruce budworm showed an uncorrected mortality of 99.6 percent when Orthene was applied at 1 pound a.i. per acre when 50 percent of the larvae were in the fifth instar[5/].

Orthene is an organophosphorus insecticide which acts in both a contact and local systemic manner. About 80 percent of the active ingredient is absorbed into plant foliage within 24 hours of application. Of the absorbed material, about 5 to 10 percent is degraded to Ortho 9006 (Monitor) which is itself a highly toxic insecticide. These materials break down directly into innocuous salts. Orthene has a half-life of 5 to 10 days in plant tissue (2).

3/ Numbers in parentheses refer to corresponding numbers in Literature Cited list.

4/ Specific gravities for formulated materials used in project were calculated from data provided by manufacturers. Measurements of the specific gravity of the spray formulation by Bob Stormont, University of California at Davis, gave the following values: Dylox sp = 1.067, Orthene sp = 1.044. Dylox 4 flow rate correction factor $= \frac{1}{\sqrt{\text{sp. gr.}}} = \frac{1}{\sqrt{1.08}} = 0.96$.

5/ Personal communication with Robert Dolph, entomologist, U.S. Forest Service, Region 6, Portland, Oregon.

Orthene is highly soluble in water and because of this, moves readily through soil. It is stable to sunlight. There is no evidence suggesting bio-accumulation (2).

Orthene 75-S was formulated to contain 1 pound a.i. per gallon of final spray solution:

1.33 pounds of Orthene 75-S
.885 gallon of water (pH 7.7)
.01 pound of Rhodamine "B extra S" dye

Mixed in this manner, Orthene spray weighed 8.65 pounds/gallon (specific gravity = 1.04) with a flow rate correction factor of 0.98.

Project Design

Insecticide effectiveness was evaluated using a completely randomized design. The treatments were:

1. Orthene 75 S: 1 pound active ingredient (a.i.) in water to make 1 gallon of spray solution; applied at 1 gallon/acre to blocks 3, 5, and 8.

2. Dylox 4: 1 pound (a.i.) in HiSOL 4-5-T to make one-half gallon of final spray solution; applied at one-half gallon/acre to blocks 1, 2, and 7.

3. Controls: Blocks 4, 6, and 9.

Each treatment was replicated three times.

Nine blocks about 1,000 acres each were selected from the general budworm infestation on the basis of egg mass density, topography, and road access (Fig. 1). Treatments were randomly assigned.

Spraying was scheduled to start when 50 percent of the budworm larvae were in the fifth instar. Larval development was monitored by collecting two 40-cm branches from the midcrown of 10 single-tree plots scattered throughout the elevational range of the block. Samples were collected every other day until each block had been sampled twice. This established a development rate for each block which was then used to schedule future samples. In situations where development in two or more blocks reached the "spray criteria" simultaneously, they were scheduled for spraying in the order in which the development samples were processed.

Budworm population sampling.--Estimates of the budworm larval population density in each block were made three times during the project; i.e., (1) prespray (within 48 hours before spraying), (2) 3-day postspray, and (3) 10-day postspray. Average population density for each block was based on measurements taken on 25 clusters of three trees scattered throughout the block. (See Appendix B for cluster locations.) Cluster trees were selected from open-grown Douglas-fir trees 35 to 60 feet tall which had suffered no more than 25 percent defoliation the previous year. Trees in a single cluster were all located within 1 acre.

Prespray estimates of larval population density/cluster were made by collecting two 40-cm branches from opposite sides of the midcrown on each sample tree. A 25-foot telescopic aluminum pole pruner fitted with a nylon catch bag was used to collect sample branches (Fig. 2). Branches and the contents of the catch bag were put in separate paper bags, labeled, and taken to the field lab for examination.

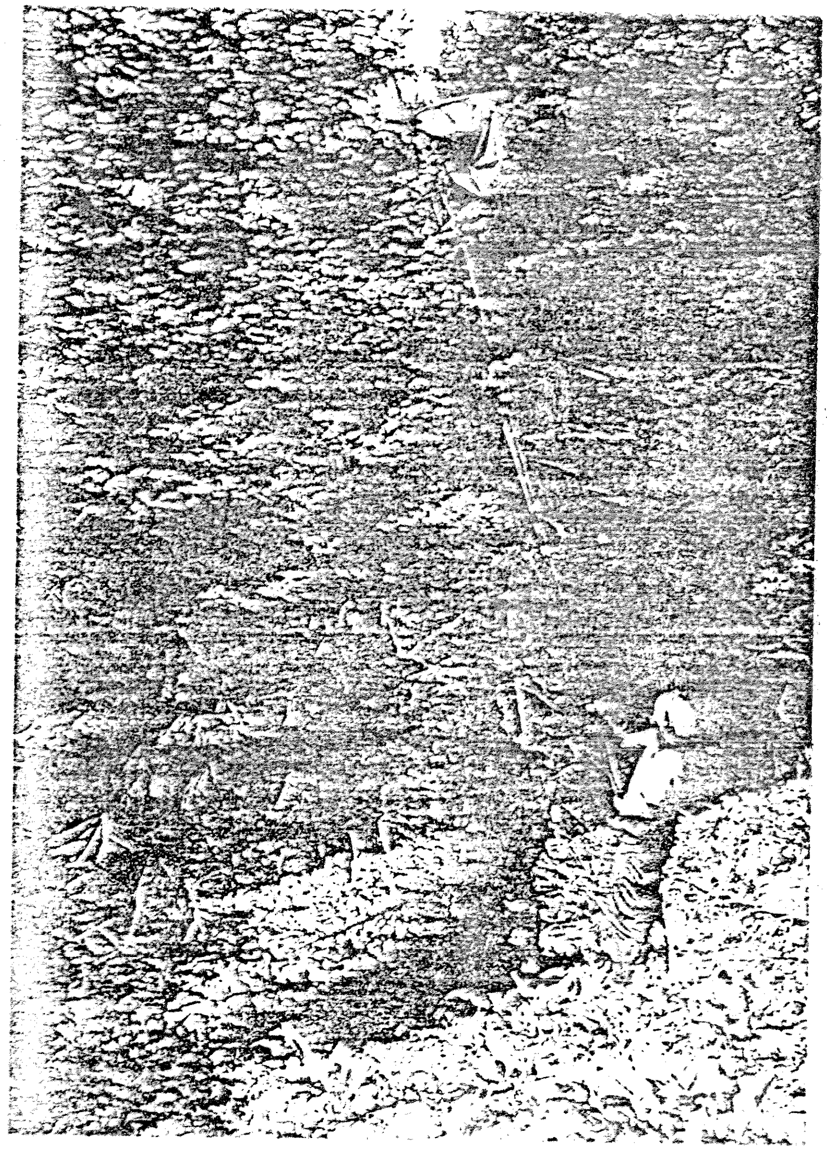


Figure 2.--Collecting 40-cm branch samples from midcrown with a telescopic pole pruner.

Samples were stored in a refrigerated truck at about 4° C. until examined the following day.

The same procedure was followed for both postspray samples except that four branches were taken per tree; i.e., one at each cardinal direction.

In the laboratory, the number of buds/branch and the number of budworm larvae/branch were counted. The area of foliage (m^2) per branch was estimated by clipping all twigs and laying them on a grid. Budworm population density/cluster estimates were based on the average number of larvae per 100 buds for the 6 or 12 branch samples. Larval density per m^2 was also calculated, but not used in the statistical analysis because the variance was smaller for larvae/100 buds.

Aquatic monitoring.--The effects of Orthene and Dylox on the aquatic ecosystems in five streams were evaluated in July 1977 by the U.S. Forest Service Eastside Zone fisheries biologist. All streams monitored had flows less than 20 cfs at the time of spraying. Monitoring was done in blocks 2, 3, 5, 7, and 8.

Natural fisheries were present in only two streams. Trout and insects caught in nearby streams were held in live cars in the remaining streams. Two eastern brook trout, *Salvelinus frontinalis*, and five rainbow trout, *Salmo gairdneri*, less than 7 inches long, and six each of the aquatic insects, *Duira* spp., *Ephermerella* spp., and *Neureclipsis* spp., were placed in each live car (Fig. 3). A Hess sampler (1 ft^2) was used to collect

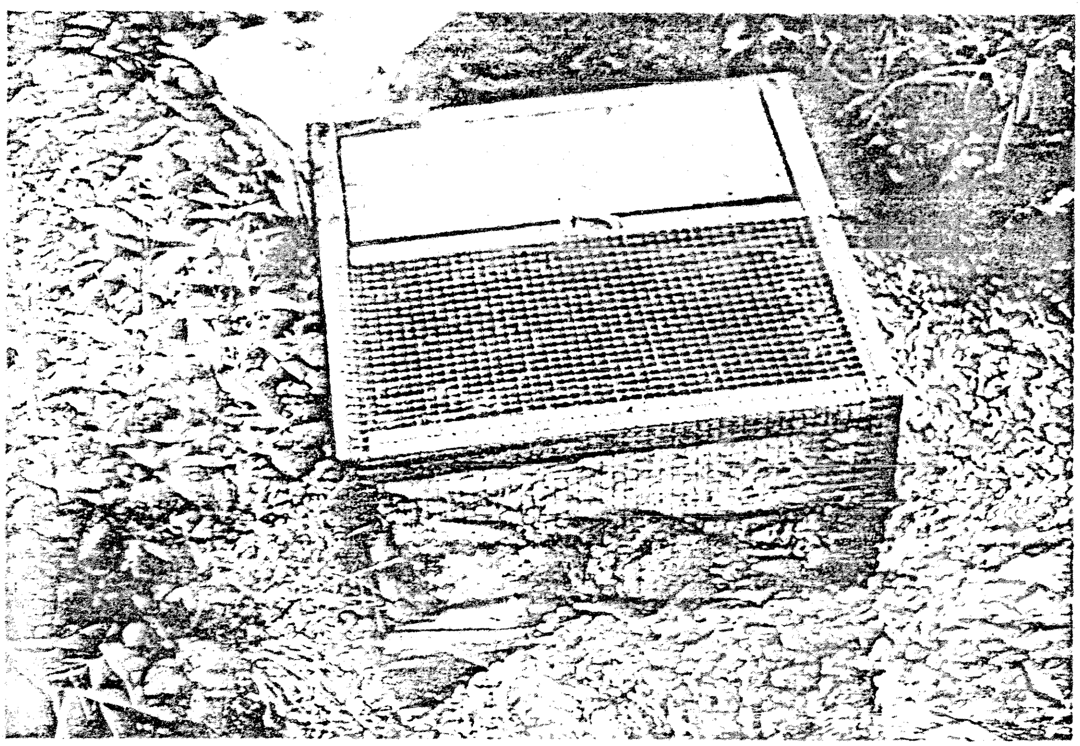


Figure 3.--Live cars in which trout (large cage) and insects (small cage in lower left) were exposed to insecticides during project.

aquatic bottom fauna from each stream. Drift nets (12- by 8-inch opening, #40 mesh) were set for several 1-hour intervals beginning just before spraying and for several hours after. Net contents were removed at hourly intervals and preserved in 10 percent formalin (Fig. 4). Water samples were collected from creeks in Orthene spray blocks using an Isco R Model 1680 sampler (Fig. 5). Approximately 300 ml of water were collected every 30 minutes while the spray was being applied and for several hours after.

Figure 4 (left).--Collecting aquatic insects to evaluate effects of spraying an insect drift.

Figure 5 (right).--Isco R Model 1680 automatic water sampler in position beside stream.

All macroinvertebrates were identified to genus or species and counted. Water, fish, and insect samples were analyzed for Orthene and Monitor residues by personnel at the U.S. Forest Service Insecticide Evaluation Project, Berkeley, California. Residue analysis for Dylox was not done.

Spray deposit monitoring.--Kromekote spray deposit cards (16.9- by 11-cm) (Fig. 6) were used to measure spray deposit at ground level for each cluster, along streams, and in open areas. Deposit on clusters was measured by placing a card at each cardinal direction around the drip line of each sample tree. Cards were placed directly on the ground in a cleared spot 3 to 5 feet in diameter. Average deposit on these 12 cards was used as the estimate of deposit for the cluster for analytical purposes.

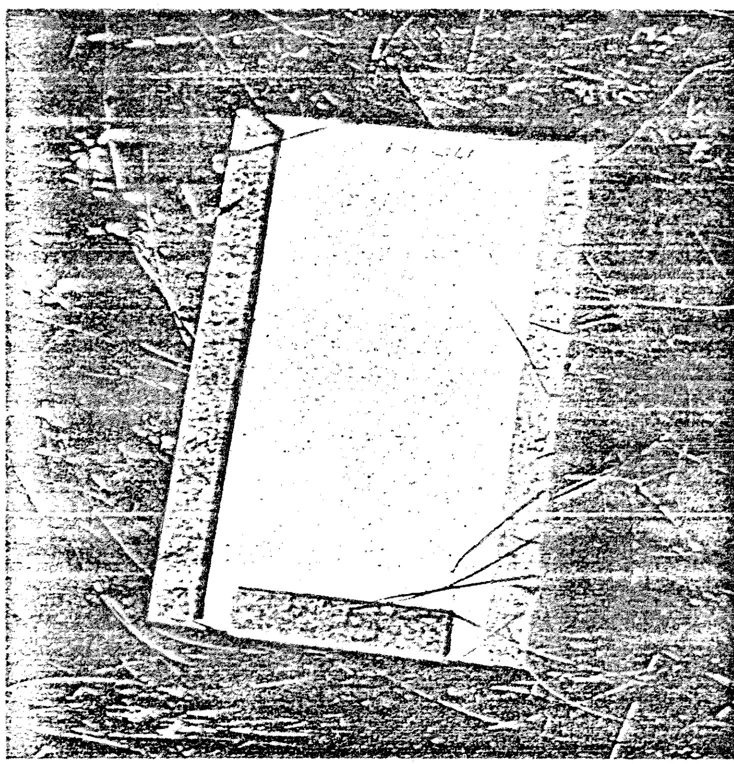


Figure 6.--Kromekote spray deposit card and plastic cardholder.

Since larval population estimates were made by sampling the midcrown at each cardinal direction, it was hoped that a closer correlation could be established between spray deposit and insect mortality.

Amount of insecticide entering streams was estimated by a card line along streams in selected blocks.

A line of about 50 cards, 20 feet apart, was placed in each block to estimate amount of insecticide reaching the ground when it was uninterrupted by the forest canopy. Cards were set out prior to spraying and picked up about 4 hours after it was completed.

All cards except those from Block 5 were analyzed with a Quantimet image analyzer by personnel at Los Alamos Scientific Laboratory, New Mexico. Cards from Block 5 were hand read because of insufficient dye content in the spray solution. Data from the cards were analyzed for drop size, drop number, and mass deposit by the U.S. Army ASCAS and personnel from the U.S. Forest Service Methods Application Group at Davis, California.

Meteorological support.--Local weather forecasts were provided to the project by a meteorologist from the Department of Commerce, National Weather Service, with a fire weather mobile station. A forecast for the spray area was provided each evening during the project.

During characterization and spraying, onsite meteorological conditions were monitored using a Contel Corporation Model 150-800 Metro-Sonode system, a Beckman and Whitney 2-meter wind set, a Climatronics Electronic Weather Station (2-meter wind set), and a hot film anemometer (Fig. 7).

Figure 7.--Meteorological monitoring station showing Metro-Sonode system (KyToon) and 2-meter wind set.

The Metro-Sonode system provided data on temperature, relative humidity, wind speed and direction to 700 meters above the surface. This instrument malfunctioned during spraying so that only temperature data before and after spraying to altitudes of 97.5 meters were collected. Surface wind data were collected using the Beckman and Whitney 2-meter wind set and

Climatronics Electronic Weather Station. These instruments were set up in each spray block the evening before treating and run until spraying was completed next day. Wind speed 15 meters above the forest canopy was measured with a hot film anemometer suspended from a mylar balloon. Data were recorded on a chart recorder while spray was in progress. Brief interruptions occurred when the balloon was lowered to avoid the spray aircraft (see Appendix E).

Field formulation of insecticides.--Dylox was mixed in two custom-made 500-gallon stainless steel tanks mounted on a 5-ton truck (Fig. 8). Tanks were connected by a 2-inch chemical grade hose so material could be moved readily from one tank to the other for mixing. Pumping between tanks and to the aircraft was done with a centrifugal pump powered by a 4-hp engine. The aircraft spray system was loaded at about 90 gpm through a 2-inch chemical grade hose coupled to a 2-inch Neptune flow meter.

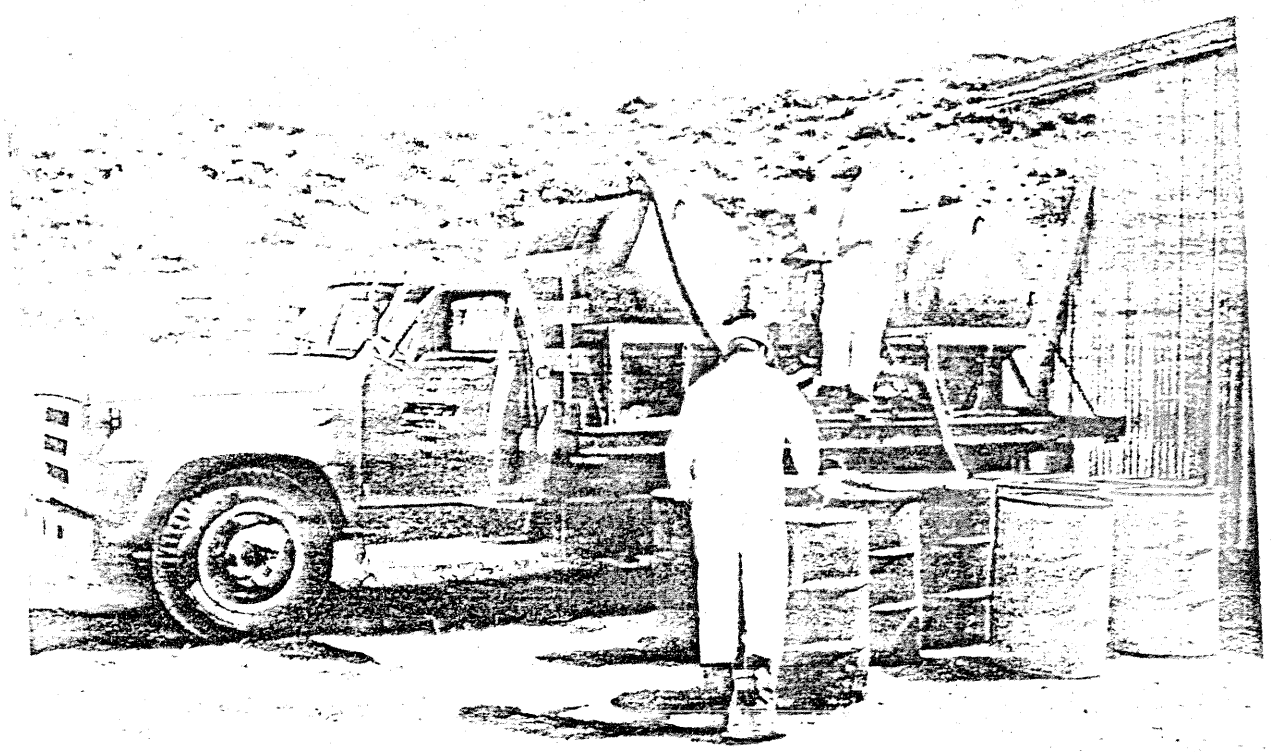


Figure 8.--Dylox 4 being pumped from 55-gallon drums into 500-gallon stainless steel mixing tank.

Dylox concentrate and diluents were pumped from 55-gallon drums into mixing tanks using a positive displacement pump driven by a 9-hp engine.

A 2,000-gallon tanker (Fig. 9) with internal agitation was used for mixing Orthene 75 S. The tank was divided into two 1,000-gallon compartments by

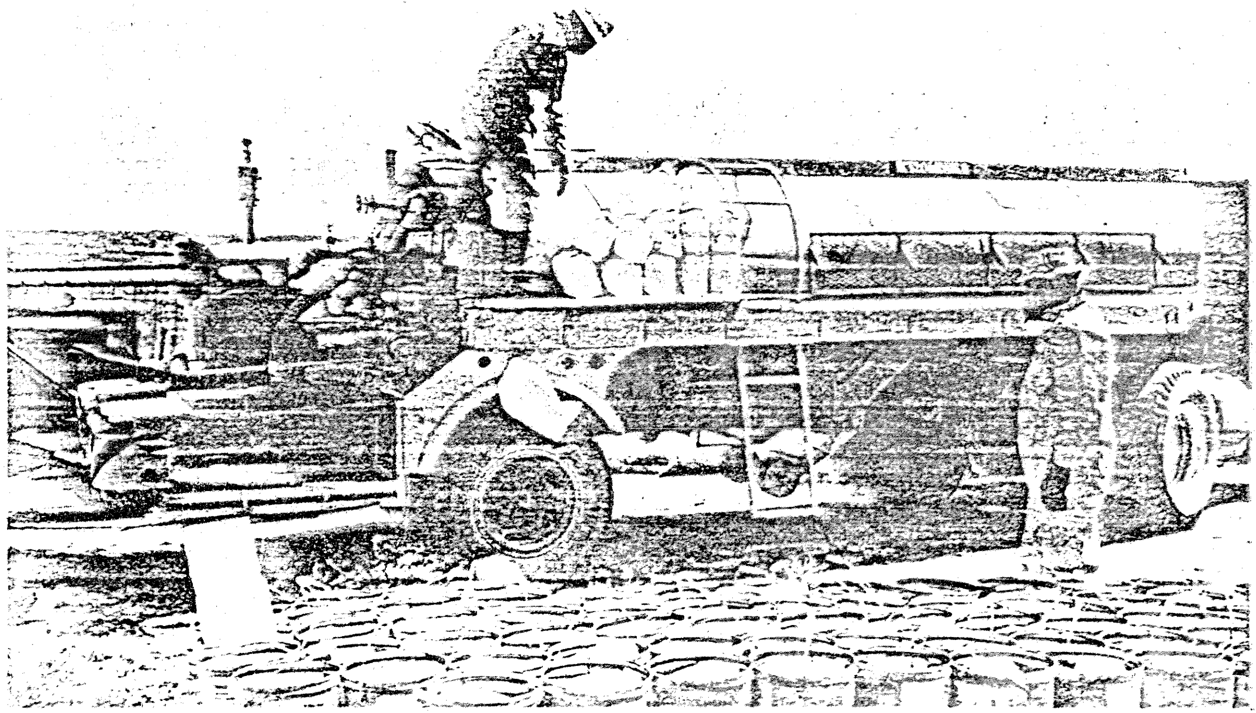


Figure 9.--Orthene 75 S wettable powder was mixed in a 2,000-gallon tanker.

a central bulkhead. Both the agitators and a rotary piston positive displacement pump used to load the aircraft were powered by a 20-hp, 4-cylinder engine located at the rear of the tanker. This system was capable of pumping 80 gpm.

Orthene was mixed by adding it and the dye to the desired quantity of water with the agitators operating. Water used for mixing Orthene had a pH of 7.7.

Spray system.--A Bell 205 A-1 medium turbine helicopter (Fig. 10) was used to apply both pesticides through eight Beecomist Model 350 spray heads equipped with 80-100 μ wettable powder sleeves. The aircraft was calibrated to apply the specified dose at 90 mph with a 200-foot swath. A 400-gallon fiberglass tank was fitted in the aircraft. The pesticide was delivered to the spray booms through a centrifugal pump driven by a gas engine. An electrically operated three-way ball valve controlled the flow of pesticide.

Spray booms extended 24 feet from each side of the helicopter. Four Beecomist spray heads were mounted on top of each boom so that the spray would clear the boom support structure (Fig. 11). The spray heads were positioned at 4, 10, 16, and 20 feet from the inboard end of the boom.

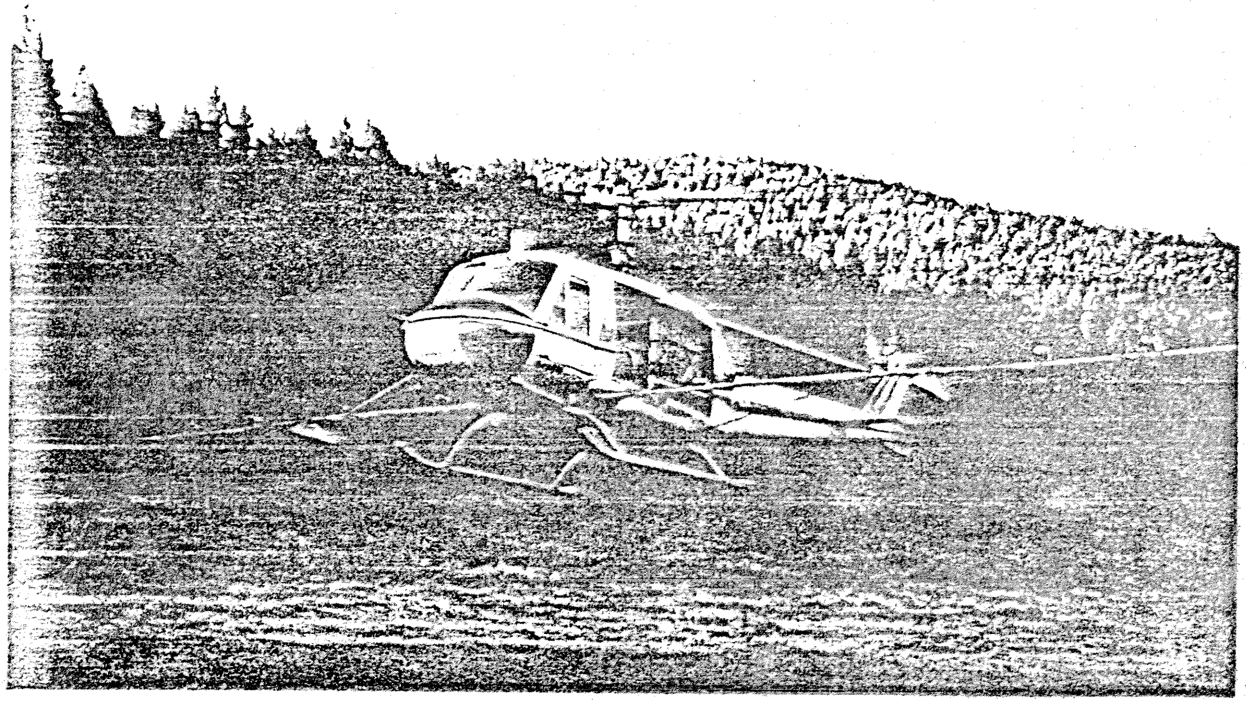


Figure 10.--Bell 205 A helicopter fitted with eight Beecomist spray heads.

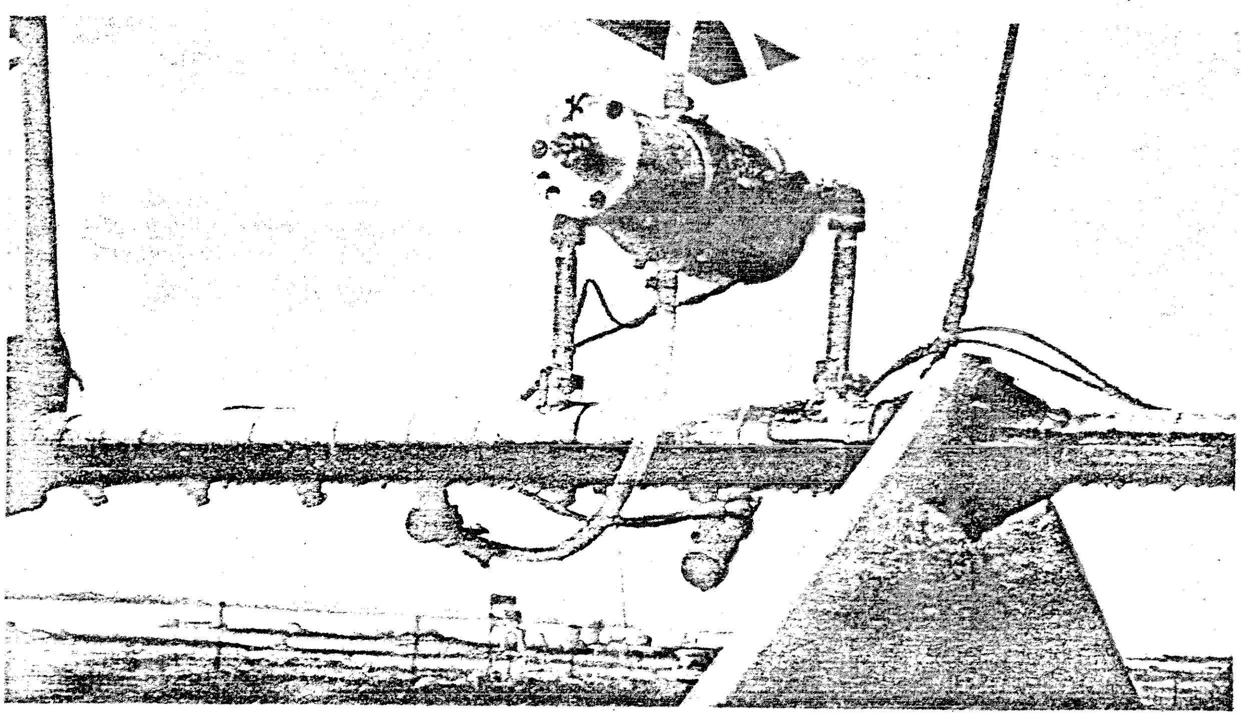


Figure 11.--Beecomist spray head installation.

They were positioned on the boom so that they would be parallel to the air stream in flight. Each spray head was wired using No. 10 wire to a separate switch on the pilot's control console. The boom was not used for grounding. A 200-ampere circuit breaker was used in the main power supply line.

Each spray head was tested for no-load rpm with a stroboscope prior to mounting. In addition, one unit was tested for instantaneous current draw to insure an adequate electrical supply. The no-load rpm of new spray heads averaged 11,700 (range 10,200 to 12,500) at 28 volts d.c. for the eight units. Instantaneous no-load current draw was 30 amperes at 28 volts d.c. Because of this high start-up current requirement, the spray heads were started in sequence, one at a time. When spraying, the electric motors in the spray heads ran continuously.

Two 3/8-inch I.D. polyethylene hoses were used to supply each spray head with insecticide. No. 6135 Spray Systems Company diaphragm check valves with a 50-mesh screen were used to regulate the flow of insecticide to the spray heads. Teflon diaphragms were placed behind the standard neoprene ones to prevent the swelling frequently caused by Dylox.

The amount of insecticide flowing to the spray heads was regulated by the pump pressure and an orifice plate in the diaphragm check valve. Pump pressure was controlled by the pump engine rpm which could be set either at the engine or from a throttle control on the pilot's console. A pressure guage was mounted on the boom. Boom pressure was set and maintained at 41 psi throughout this project. A Spraying Systems Company No. 4916-140 orifice plate was used in both lines when applying 1 gallon per acre. One line was blocked off with a blank plate when applying one-half gallon per acre.

Spray system calibration.--Calibration of the spray system was done with water. Since the flow rates of Dylox (0.96) and Orthene (0.98) were so close, an average flow rate correction factor of 0.97 was used to calibrate the system.

Calibration was made easier because the spray system could be operated independently of the aircraft. First, the tank was filled with water and the pump run until flow ceased. Then, without changing the position of the aircraft, a metered amount of water was added to the tank. The time required to pump this water through the spray heads was then determined and the flow rate calculated. The average flow rate for three trials was used for determining the flow rate.

The flow rate of the pesticides in this system was then determined (average flow rate correction factor x g.p.m. of water = pesticide flow rate) to be 36.28 g.p.m. versus a desired flow rate of 36.36 g.p.m. This was considered adequate for the purpose of this project.

Spray System Calibration

Water (gallons)	Spray time (minutes)	Flow rate (gpm)	Indicated boom pressure (psi)
150.3	4.03	37.26	41
150.1	4.00	37.53	41
150.3	4.02	37.42	41
Average		37.40	

Aircraft characterization.--Characterization of the aircraft for swath width and drop size was done by spraying each insecticide over a line of Kromekote spray deposit cards. Swath width tests were made into the wind flying at 90 mph 50 feet above the surface. Air speed was checked from the ground with a handheld traffic control "radar gun" and was maintained between 90 and 94 mph during characterization. The average minimum effective swath was estimated by two methods. The first method set the effective swath width limits at a drop density of 20 drops/cm^2. A second method defined swath width on the basis of deposit; i.e., 110 mg/m^2 (16 ounces/acre) for Orthene and 50 mg/m^2 (7 ounces/acre) for Dylox. In five trials with Beecomist spray heads, the average minimum swath width for Orthene was: method 1, 140 feet; method 2, 198 feet. Four trials with Dylox gave minimum swath widths of 182 feet and 167 feet for the two methods respectively. These figures were uncorrected for slight variations in wind direction with respect to the card line. It was, therefore, assumed that the 200-foot swath width recommended for this system was appropriate for this project. The drop volume median diameter (VMD) during characterization trials was determined to be 212μ for Orthene and 106μ for Dylox.

Application.--Insecticides were applied when about 50 percent of the budworm larvae reached the fifth instar (Fig. 12). Spraying was completed within 24 hours of the prespray sample.

Application was made under the assumption that the spray aircraft flew, on the average, at 90 mph, 50 feet above the canopy. The validity of these assumptions for mountainous terrain is open to serious question.

Information on the aerial application of each insecticide is presented in Appendix A. Swaths made by the spray aircraft were plotted on aerial photographs by the aerial observer (Appendix B).

Problems encountered when spraying centered around the spray heads and dirt in the spray system. Drooling from the spray heads was a problem throughout the project. Inline and 50-mesh nozzle strainers were cleaned repeatedly during each day's spraying, but this did not eliminate the problem. After the first load had been applied to block 3 (Orthene), a field wire broke in the electric motor on one spray head. Rather than abort the spraying and lose the block (some clusters had been sprayed), the spray head was pulled and the aircraft slowed to 79 mph to compensate for the lower flow rate.

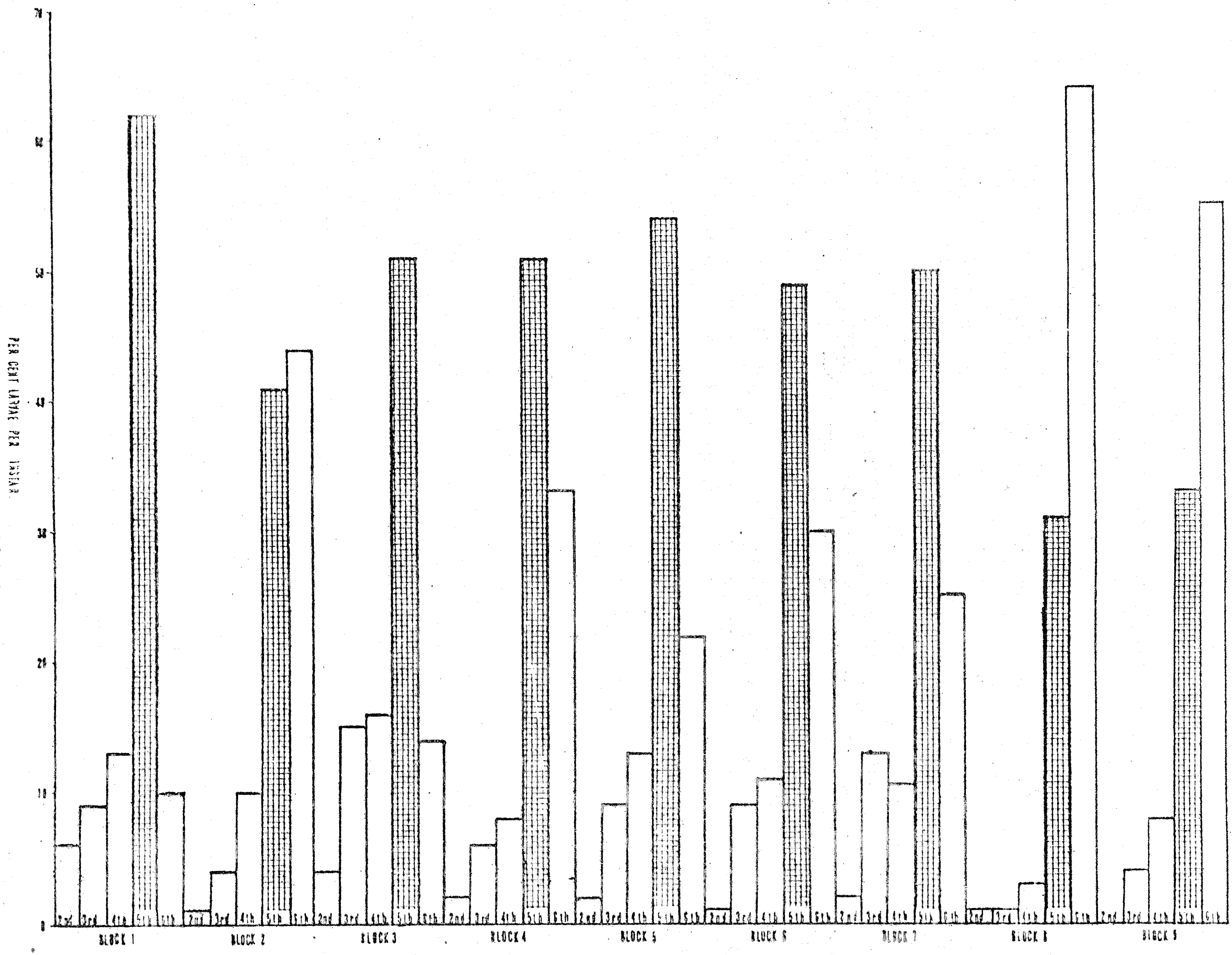


FIGURE 12. BUDWORM LARVAL DEVELOPMENT AT TIME OF PRE-SPRAY SAMPLE.

A spray head switch on the pilot's console shorted out during spraying of block 5 (Orthene), requiring two spray heads to be controlled from one switch.

After the second day's spraying, cracks were found in the spray head support brackets on all but one unit (Fig. 13). All supports were replaced. At the same time, the rear seal in the sleeve assembly was found to be broken and loose in all but one unit. All of these seals were removed. No replacements were available. No cracks were found in the support brackets for the rest of the project.

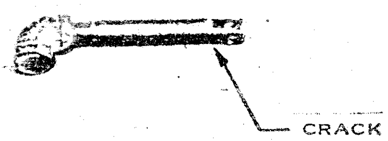


Figure 13.--Beecomist mounting bracket.

Defoliation estimation.--Estimates on the degree of foliage protection achieved were made by visually rating 25 apical shoots on each sample branch on a scale of 1 to 4 for prespray and 10-day postspray samples.

Percent defoliation	Rating
0-25	1
26-50	2
51-75	3
76-100	4

The defoliation class for each cluster per sample period was determined by calculating the mean rating and multiplying it by 25 to set the upper class limit. The class midpoint was determined by subtracting 12.5 from the upper class limit. This figure was used to estimate foliage protection by covariance analysis. Using this method, there is a theoretical maximum point estimate of 87.5 percent defoliation.

Sampling for budworm parasitism.--Treatment effect on parasitism was evaluated by collecting 10 fourth and fifth instar larvae from branch samples from the prespray and 10-day postspray sample. Larvae from each cluster were placed in 100 x 200 mm Petri dishes with about 15 g of modified McMorran's[7/] (3) budworm diet replenished as needed (Fig. 14).

7/ A synthetic diet for the spruce budworm, modified by substitution of wheat germ for wheat embryo and chlorotetracyline for aureomycin.

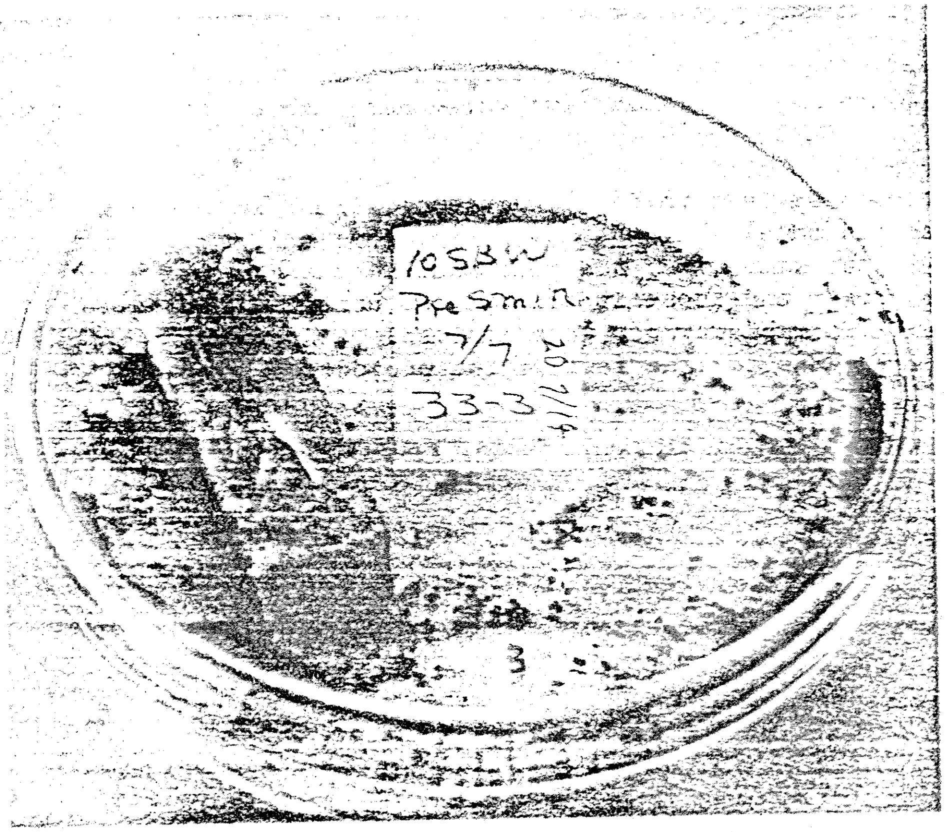


Figure 14.--Budworm larvae reared on modified McMorran's diet for parasite evaluation.

Petri dishes were examined every other day for parasite emergence. Adult parasites were placed indivudually in a No. 000 gelatin capsule and held for identification.

Data analysis.--Data analysis originated at the field laboratory where insect densities at the cluster level were calculated using a programable calculator. The original data sheets were then brought to Missoula where the data was recorded on magnetic tape for computer processing. Insect densities were then verified with field processing and correction made when differences occurred. Only a few errors were found, and most of those were due to illegible handwriting. These were corrected by referring back to the responsible laboratory examiner.

An analysis of covariance in a completely random experiment was used to test differences between block means. The covariance model was as follows:

$Yij = U + Ti + B(Xij\ X) + lij$, where:

- lij is the experimental error between blocks
- X is the overall experimental mean of the covariate (prespray population mean)
- Xij is the value of the covariate for the j^{th} replication and the i^{th} treatment
- B is the overall regression coefficient
- Ti is the effect due to treatments
- U is the overall mean, and
- Yij is the value of the dependent variable for the j^{th} replication in the i^{th} block.

Example of Covariance Analysis Table

Source	Degree of freedom	Sum of squares	Mean square	F	Tail area probability
Analysis of covariance - 3-day postspray data					
Adjusted treatment means	2	132.5212	66.2606	--	0.0050
Zero slope	1	27.3703	27.3703	7.6380	.0400
Error	5	17.9178	3.5836	--	--
Equality of slopes	2	12.5886	6.2943	3.5430	.1620
Error	3	5.3293	1.7764	--	--
Analysis of covariance - 10-day postspray data					
Adjusted treatment means	2	42.9228	21.4614	--	.0029
Zero slope	1	.7965	.7965	.8722	.3932
Error	5	4.5663	.9133	--	--
Equality of slopes	2	1.7630	.8815	.9434	.4810
Error	3	2.8033	.9344	--	--

RESULTS AND DISCUSSION

Pesticide efficacy.--Treatment effect on the budworm larval population is shown in Table 1. Percent larval mortality 3 and 10 days after treatment is presented using three commonly used methods of calculations to aid in comparing these results with those of others. The covariance analysis is the official result. Larval population densities in each block before and 3 and 10 days after spraying are shown in Table 2. Mean budworm larval population densities for each treatment at the 3 and 10-day observation are shown in Table 3.

Table 1.--Budworm larval population reduction by treatment, observation period, and method of analysis. Covariance analysis is the official result

	3-day postspray percent control			10-day postspray percent control		
Treatment	Covariance (percent)	Abbotts formula (percent)	Population reduction* (percent)	Covariance (percent)	Abbotts formula (percent)	Population reduction* (percent)
Dylox	68.23	71.24	75.16	59.53	68.32	81.77
Orthene	90.63	86.06	87.96	86.86	89.26	93.82
Check			13.63			42.46

*Not corrected for natural mortality

Table 2.--Spruce budworm population density by sampling period and spray block

	Budworm/100 buds		
	Means		
Treatment	Prespray ± S.E.*	3-day postspray ± S.E.*	10-day postspray ± S.E.*
Dylox 1	20.700 ± 2.749	5.454 ± 0.826	3.405 ± 0.506
Dylox 2	16.816 ± 1.614	2.314 ± .332	1.518 ± .227
Dylox 7	9.062 ± .920	3.803 ± .676	3.567 ± .545
Orthene 3	17.249 ± 1.232	1.543 ± .331	.558 ± .219
Orthene 5	15.885 ± 1.357	2.240 ± .379	.891 ± .226
Orthene 8	19.476 ± 2.269	2.552 ± .590	1.802 ± .538
Check 4	19.606 ± 1.299	15.233 ± 1.075	7.891 ± .616
Check 6	6.888 ± .889	7.518 ± .924	5.818 ± .664
Check 9	8.523 ± .777	7.491 ± .650	6.441 ± .565

*S.E. = 1 standard error

Table 3.--Mean budworm larval population densities/100 buds by treatment and observation period

3-day postspray				
Treatment	Prespray	3-day	Adjusted* 3-day	Standard error
Dylox	15.526	3.857	3.612	1.097
Orthene	17.537	2.112	1.066	1.157
Check	11.672	10.081	11.371	1.188

10-day postspray				
Treatment	Prespray	10-day	Adjusted* 10-day	Standard error
Dylox	15.526	2.830	2.788	0.554
Orthene	17.537	1.084	.905	.584
Check	11.672	6.669	6.889	.600

*Adjusted by covariance analysis.

Covariance analysis of the 10-day postspray data indicates larval population reductions of 59.53 percent and 86.86 percent for Dylox and Orthene respectively. There was a significant difference between treatments and checks at the 99 percent C.I. level and between treatments at about the 94 percent ($p = 0.0638$) C.I. level.

Unusually high mortality in check block 4 had a strong influence on the covariance analysis and accounts for the decline in effectiveness of the insecticides between 3- and 10-day postspray samples. Starvation was the apparent cause of this mortality.

The average level of defoliation by the treatments is given in Table 4. Dylox and Orthene are estimated to have saved 13.67 percent and 11.80 percent of the new growth respectively.

Table 4.--Douglas-fir foliage saved by aerial application of Dylox 4 Oil and Orthene 75-S, Townsend, Montana

Treatment	Mean prespray larval population density/100 buds	Mean percent defoliation	Adjusted* mean	Defoliation class	Percent foliage saved
Dylox 4 Oil	15.52	30.44	29.76	17.26-42.26	13.67
Orthene 75-S	17.53	34.55	31.62	19.12-44.12	11.81
Check	11.67	39.82	43.43	30.93-55.93	

*Adjusted by covariance analysis.

Spray deposit analysis.--Spray deposit was measured under the drip line of sample trees and in open areas within the spray blocks. Table 5 summarizes data collected from these two sources. A subjective analysis of spray deposit was made by classifying the average deposit (drops/cm^2) for each cluster as negative, light, medium, or heavy. This information is presented in Table 6 and Appendix B, along with data on average uncorrected larval mortality observed on clusters in each deposit class. If the medium deposit class is considered optimum, it would appear that application of Orthene 75-S was slightly better than Dylox 4 (52 percent vs. 42.67 percent of clusters in medium deposit class). Percent recovery (Table 7) was also better for Orthene than Dylox.

Regression analysis of larval mortality on spray deposit was done to estimate the deposit (drops/cm^2 and gallon/acre) on "tree cards" required to achieve a given level of larval mortality (Fig. 15a and b). Based on this analysis, it is estimated that, on the average, Dylox required a deposit on "tree cards" of 0.22 gallon/acre (24 drops/cm^2 with a VMD of 121-140) to cause 95 percent uncorrected larval mortality. Similarly, Orthene would be expected to cause 95 percent mortality where deposit on "tree cards" reached 0.21 gallon/acre (8.5 drops/cm^2 with a VMD of 236-245). The above deposit/mortality figures are presented to serve as rough guides in evaluating spray coverage. Because deposit was measured at ground level and larval mortality at midcrown, these are not true measures of the deposit/mortality relationship. Deposit at ground level should be viewed as an "index" to expected mortality.

Table 5.--Summary of spray deposit analysis

Block	Card location	Application rate GPA	VMD (μm)		Drops/cm²		Deposit - GPA		Percent recovery		Total sample cards
			Tree	Open	Tree	Open	Tree	Open	Tree	Open	
			Dylox 4								
1. Jimmy Creek	Tree	0.5	147	--	13	--	0.06	--	12	--	281
	Open		--	151	--	24	--	0.14	--	28	50
2. Sulphur Bar Creek	Tree	0.5	127	--	10	--	.03	--	6	--	280
	Open*		--	139	--	23	--	.08	--	16	6
	Open		--	76	--	16	--	.02	--	4	50
	Open		--	117	--	17	--	.05	--	10	28
7. Vermont Gulch	Tree	0.5	146	--	8	--	.04	--	8	--	286
Mean		0.5	140	121	10	20			9	15	
			Orthene 75-S								
3. East Fork Cabin Gulch	Tree	1.0	259	--	11	--	0.35	--	35	--	298
	Open		--	260	--	11	--	.38	--	38	47
	Open*		--	272	--	18	--	.94	--	94	10
	Open		--	289	--	23	--	1.02	--	102	69
5. Holloway Gulch	Tree	1.0	229	--	10	--	.26	--	26	--	300
	Open*		--	194	--	9	--	.18	--	18	3
8. Spring Gulch	Tree	1.0	221	--	14	--	.36	--	36	--	300
	Open		--	220	--	19	--	.59	--	59	27
	Open		--	267	--	20	--	.95	--	95	50
	Open*		--	238	--	27	--	.91	--	91	7
	Open		--	216	--	20	--	.54	--	54	24
Mean		1.0	236	245	12	18			32	69	

*Cards along stream.

Table 6.--Summary of spray deposit (drops/cm^2) and larval mortality for sample clusters

Treatment	Negative 0	Light 1-7	Medium 8-19	Heavy 20	Grand total
	Distribution of clusters by spray deposit class - drops/cm^2				
Dylox 4 (Block 1)	1	6	13	5	25
(Block 2)	0	11	12	2	25
(Block 7)	1*	15	7	2	25
Total	2	32	32	9	75
% of grand total	2.67	42.67	42.67	12.00	100
Average mortality**	48.60	65.57	82.89	95.87	
Orthene 75-S (Block 3)	0	9	14	2	25
(Block 5)	0	9	16	0	25
(Block 8)	1	8	9	7	25
Total	1	26	39	9	75
% of grand total	1.33	34.67	52.00	12	100
Average mortality**	18.50	85.76	97.03	98.70	

*Missing cards
**Uncorrected mortality

Table 7.--Summary of spray deposit data

Treatment	Tree cards			Open cards		
	VMD	Drops/cm^2	% recovery	VMD	Drops/cm^2	% recovery
Dylox 4	140µ	10	9	121µ	20	15
Orthene 75-S	236µ	12	32	245µ	18	69

FIGURE 15a. Orthene 75 S. Data and regression analysis of Larval mortality on spray deposit. 1976 Western Spruce Budworm Pilot Project, Helena National Forest, Montana.

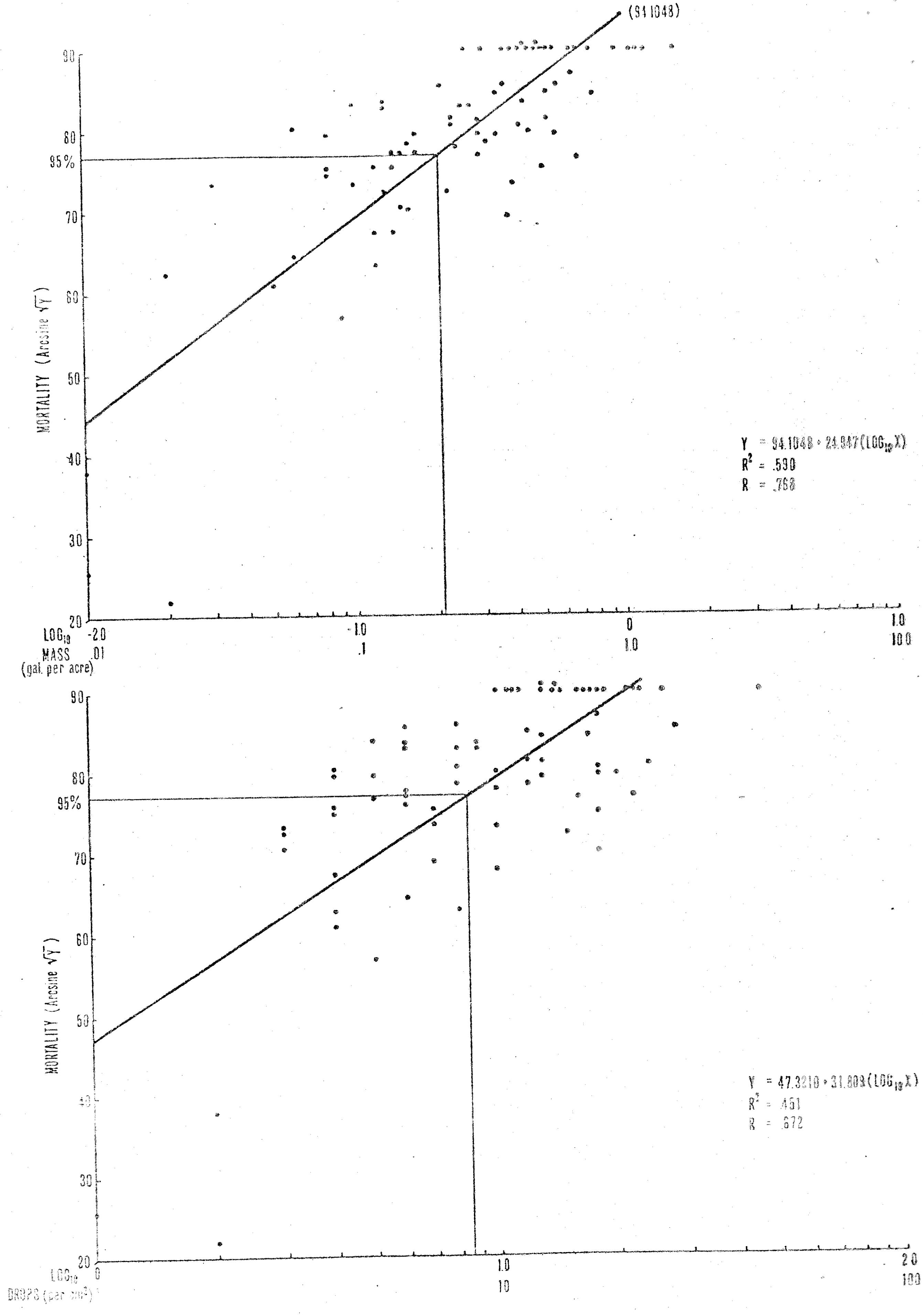
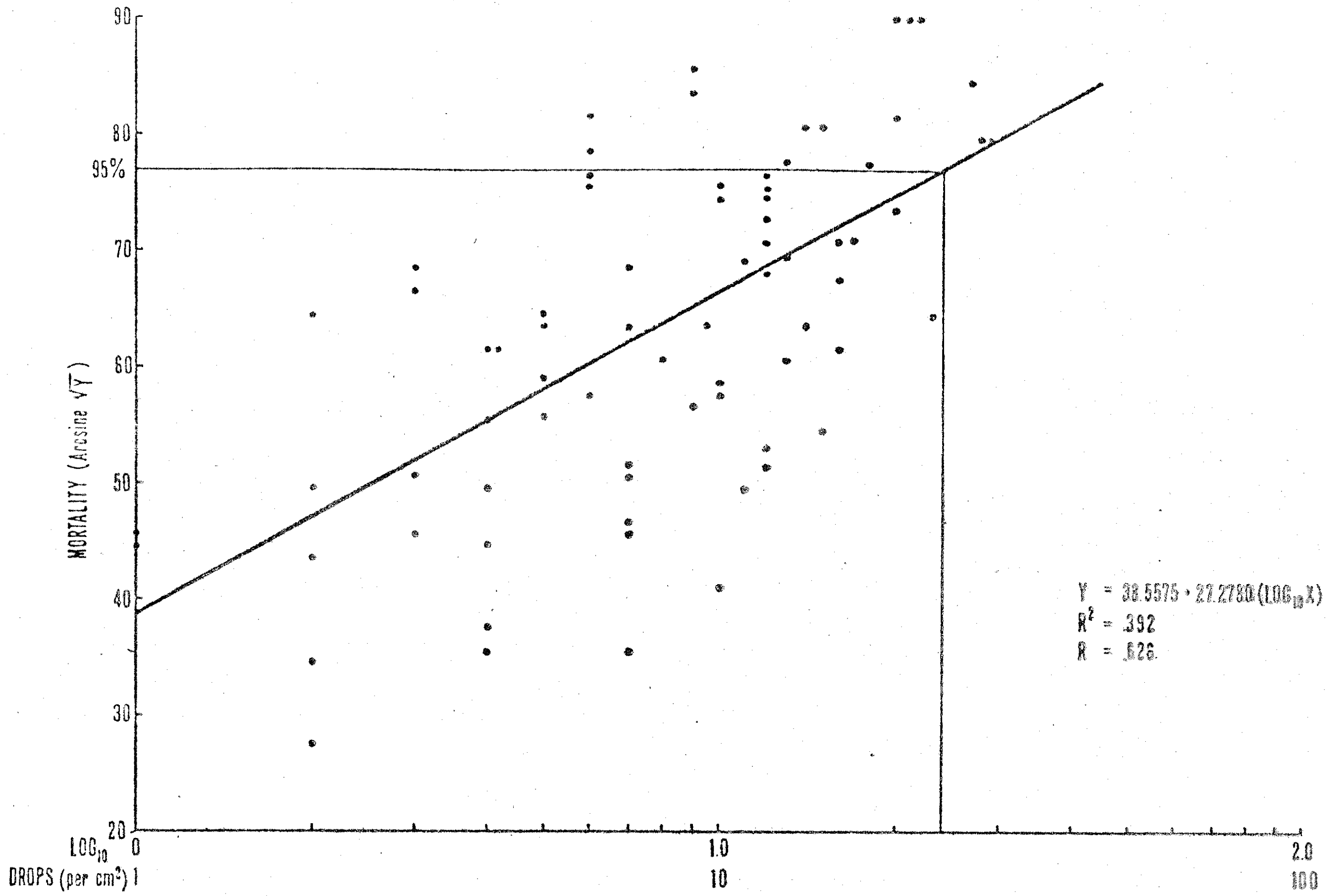
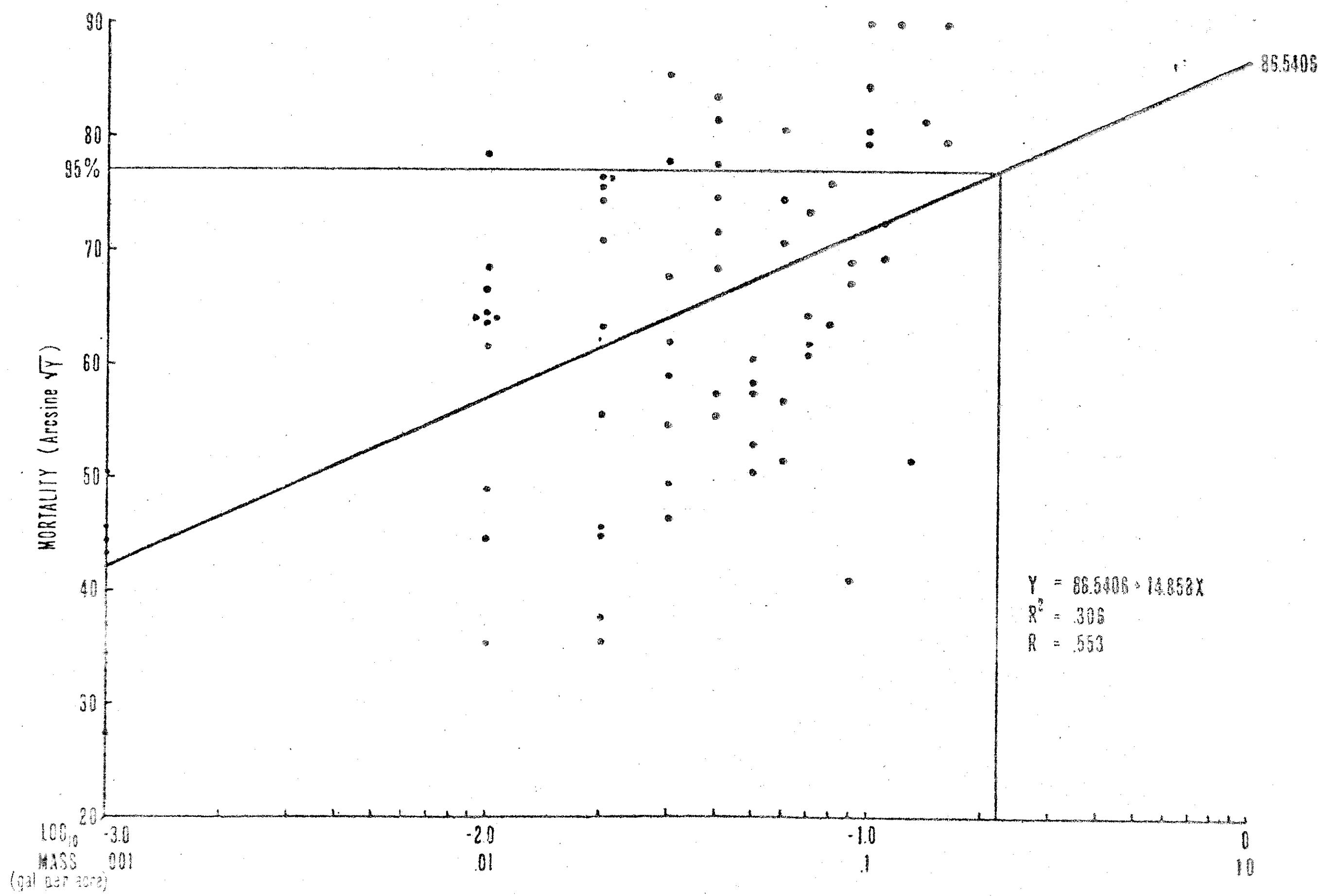


FIGURE 15b. Dylox 4. Data and regression analysis of Larval mortality on spray deposit. 1976 Western Spruce Budworm Pilot Project, Helena National Forest, Montana.





Treatment Effect on Parasitism

Results.--Before treatment, the most abundant parasite was *Glypta* sp., and the second most abundant was *Apantales* sp. They parasitized 5.7 and 4.8 percent respectively of all the western spruce budworm larvae reared from the three check and six spray plots. Parasitism ranged from 3.2 to 25.5 percent on the nine plots and was highest on plot 8, which was to be treated with Orthene. Total parasitism by all species before treatment for all nine plots was 12.6 percent (Table 8).

Ten days after treatment, *Glypta* sp. was again the most abundant parasite, causing 3.5 percent parasitism. *Apantales* sp. numbers decreased, but *Tachinid* flies increased to second in abundance by parasitizing 0.8 percent of the budworm reared. Parasitism on the nine plots ranged from 5.6 to 19.4 percent, and the highest was again on an Orthene plot (No. 3). Overall, total parasitism decreased from 12.6 percent before treatment to 6.7 percent 10 days after (Table 9).

Average parasitism decreased on the check and spray plots from before treatment to after treatment. The highest reduction in parasitism was 47.8 percent in the three check plots (Table 10).

This indicates the insecticides were not responsible for any great reduction in parasitism.

Table 8.--Percent budworm parasitism before treatment*, Western Spruce Budworm Pilot Project, Helena National Forest, Montana, July 1976

Insect	Plots 1 Dylox No.	%	2 Dylox No.	%	7 Dylox No.	%	3 Orthene No.	%	5 Orthene No.	%	8 Orthene No.	%	4 Check No.	%	6 Check No.	%	9 Check No.	%	Total	%
Apanteles	2	0.8	26	10.4	8	3.3	6	2.5	7	2.9	22	8.9	16	6.6	2	0.8	16	6.6	105	4.8
Glypta	4	1.6	17	6.8	16	6.6	10	4.2	14	5.8	31	12.5	13	5.4	10	4.3	10	4.1	125	5.7
Phaeogenes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Meteorus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Unidentified Hymenoptera	1	.4	0	0	1	.4	0	0	1	.4	2	.8	1	.4	0	0	0	0	6	.3
Tachinids	0	0	0	0	0	0	0	0	0	0	0	0	1	.4	0	0	0	0	1	0
Unrecognizable	1	.4	6	2.4	5	2.0	1	.4	5	2.1	8	3.2	2	.8	4	1.7	7	2.9	39	1.8
Total parasites	8		49		30		17		27		63		33		16		33		276	
Total budworm reared	252		249		244		235		240		247		242		234		243		2,186	
% parasitism in plot		3.2		19.7		12.3		7.2		11.2		25.5		13.6		6.8		13.6		
	Total percent parasitism before treatment																			12.6

*Prespray samples were taken from July 3 to July 9, 1976.

Table 9.--Percent budworm parasitism 10 days after treatment*, Western Spruce Budworm Pilot Project, Helena National Forest, Montana, July 1976

Insect	Plot 1 Dylox No.	Plot 1 Dylox %	Plot 2 Dylox No.	Plot 2 Dylox %	Plot 7 Dylox No.	Plot 7 Dylox %	Plot 3 Orthene No.	Plot 3 Orthene %	Plot 5 Orthene No.	Plot 5 Orthene %	Plot 8 Orthene No.	Plot 8 Orthene %	Plot 4 Check No.	Plot 4 Check %	Plot 6 Check No.	Plot 6 Check %	Plot 9 Check No.	Plot 9 Check %	Total	%
Apanteles	0	0	0	0	1	0.5	0	0	2	1.8	0	0	0	0	1	0.4	0	0	4	0.2
Glypta	8	3.6	6	3.7	6	2.9	10	13.9	1	.9	7	5.6	4	1.6	12	4.8	3	1.2	57	3.5
Phaeogenes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	.4	1	.1
Meteorus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	.4	1	.1
Unidentified Hymenoptera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tachinids	1	.4	0	0	2	.9	1	1.4	1	.9	0	0	7	2.8	0	0	2	.8	14	.8
Unrecognizable	4	1.8	5	3.1	5	2.4	3	4.2	2	1.8	1	.8	0	0	6	2.4	7	2.8	33	2.0
Total parasites	13		11		14		14		6		8		11		19		14		110	
Total budworm reared	219		160		204		72		110		124		248		251		249		1,637	
% parasitism in plot		5.9		6.9		6.9		19.4		5.4		6.4		4.4		7.6		5.6		
Total percent parasitism 10 days after treatment																				6.7

*Postspray samples were taken 10 days after treatment from July 14 to July 20, 1976.

Table 10.--Average percent parasitism before and 10 days after treatment, Western Spruce Budworm Pilot Project, Helena National Forest, 1976

Treatment	Plot No.	Percent parasitism: Prespray	Percent parasitism: 10 days after spraying	Percent reduction
Dylox	1	3.2	5.9	
Dylox	2	19.7	6.9	
Dylox	7	12.3	6.9	
	Average	11.7	6.6	43.6
Orthene	3	7.2	19.4	
Orthene	5	11.2	5.4	
Orthene	8	25.5	6.4	
	Average	14.6	10.4	28.8
Check	4	13.6	4.4	
Check	6	6.8	7.6	
Check	9	13.6	5.6	
	Average	11.3	5.9	47.8

Aquatic Monitoring

Results of the aquatic monitoring program are published in a separate report: "Effects of Orthene and Dylox on the Aquatic Ecosystem of Five Small Trout Streams in the Helena National Forest, Montana," by Gordon N. Haugen, 1976. The summary of this study is presented here. Residue analyses were done by the U.S. Forest Service Insecticide Evaluation Project, Berkeley, California.

Summary

1. The effects of Dylox and Orthene on the aquatic ecosystem were evaluated in five small streams on the Townsend and Canyon Ferry Ranger Districts in July 1976.

2. Prespray monitoring characterized the aquatic insect life of all streams as being represented by a clean water fauna.

3. Trout were indigenous in Sulphur Bar Creek, North Fork of Deep Creek, and Holloway Gulch.

4. Increases in drift during the spray application were recorded at some stations. *Baetis bicaudatus* and *Dugesia* sp. appeared to comprise the greatest part of the increase in drift.

5. Prespray and postspray bottom samples secured by the use of a Hess sampler suggest that only a short-term impact occurred as a result of the insecticide application.

6. Orthene concentrations in water samples secured during application did not exceed 1 p.p.m.

7. Caged and/or wild trout were observed not to be affected by the insecticide during the study period.

Tables 11 and 12 present data on Orthene and Monitor residues in water and fish and aquatic insects respectively.

Table 11.--Analysis for Orthene and Monitor residues in fish and insects collected from the 1976 Western Spruce Budworm Pilot Project, Helena National Forest, Montana

	Fish				Insects		
		P.p.m.				P.p.m.	
Sample	Wt. g	Monitor	Orthene	Total Orthene*	Wt. g	Monitor	Orthene
1. Cabin Gulch Sta. B Trib.	51.58	0.0104	0.0417	0.0521	0.7244	0	0.025
2. N. Fork Deep Cr., Sta. A	57.10	.0065	.0192	.0257	.9875	0	.046
3. Spring Gulch, Sta. A	58.59	.0085	.0157	.0242	.7220	0	.107
4. Cabin Gulch, Sta. A	56.56	.0250	.1140	.1390	.9300	0	0
5. Holloway Gulch, Sta. B	43.56	.0096	.0765	.0861	.4800	0	0

*Total Orthene = Monitor and Orthene. These figures have not been corrected for percent recovery of spiked samples.

Table 12.--Concentrations of Orthene found in water samples taken at one-half hour intervals from streams within spray blocks during day of application

	Time	P.p.b.* Monitor	P.p.b.* Orthene
North Fork of Deep Creek			
1	0730	1.64	163.03
2	0800	1.07	31.99
3	0830	1.35	230.46
4	0900	.39	10.75
5	0930	2.39	233.54
6	1000	1.29	132.32
7	1030	.76	77.88
8	1100	1.06	43.84
9	1130	.66	27.25
Spring Gulch			
0	0500	.24	9.88
1	0530	.18	9.92
2	0600	0	2.55
3	0630	4.44	961.64
4	0700	2.29	349.31
5	0730	1.07	379.01
6	0800	1.47	262.24
7	0830	.56	419.40
8	0900	1.18	146.67
9	0930	1.46	185.42
10	1000	.29	124.15
11	1030	1.07	149.68
12	1100	3.67	285.85
Holloway			
1	0530	1.15	4.14
2	0600	1.38	199.72
3	0630	2.01	194.71
4	0700	1.33	192.53
5	0730	1.78	228.41
6	0800	1.66	119.53
7	0830	1.11	65.76
8	0900	.54	117.60
9	0930	.24	30.09
10	1000	.65	34.67
Cabin Creek			
1	0545	0.72	19.91
2	0615	.52	77.65
3	0645	.45	38.66
4	0715	.36	44.27
5	0745	.29	19.16
6	0815	.47	14.21
7	0845	1.11	232.84
8	0915	2.86	471.28
9	0945	1.54	265.98
10	1015	1.85	218.25
11	1045	1.86	174.81
12	1115	1.09	124.54
13	1145	1.14	108.39
14	1215	1.24	81.48
15	1245	2.01	136.01
16	1315	.95	124.44
17	1345	.56	89.94
18	1415	1.13	80.81
19	1445	.98	57.00
North Fork of Cabin Creek			
1	0600	.04	9.27
2	0630	0	2.78
3	0700	.01	31.00
4	0730	.94	159.91
5	0800	0	146.15
6	0830	.50	68.09
7	0900	.14	57.80
8	0930	1.18	385.43
9	1000	1.03	440.87
10	1030	2.40	254.47
11	1100	1.07	211.36
12	1130	.58	147.65
13	1200	.53	79.97
14	1230	.26	70.28
15	1300	.31	58.98
16	1330	1.04	50.18
17	1400	.49	42.27
18	1430	.53	32.31
19	1500	.73	46.33

*Parts per billion.

Recovery of Orthene from spiked water samples was 85 percent. All figures have been corrected by this percentage.

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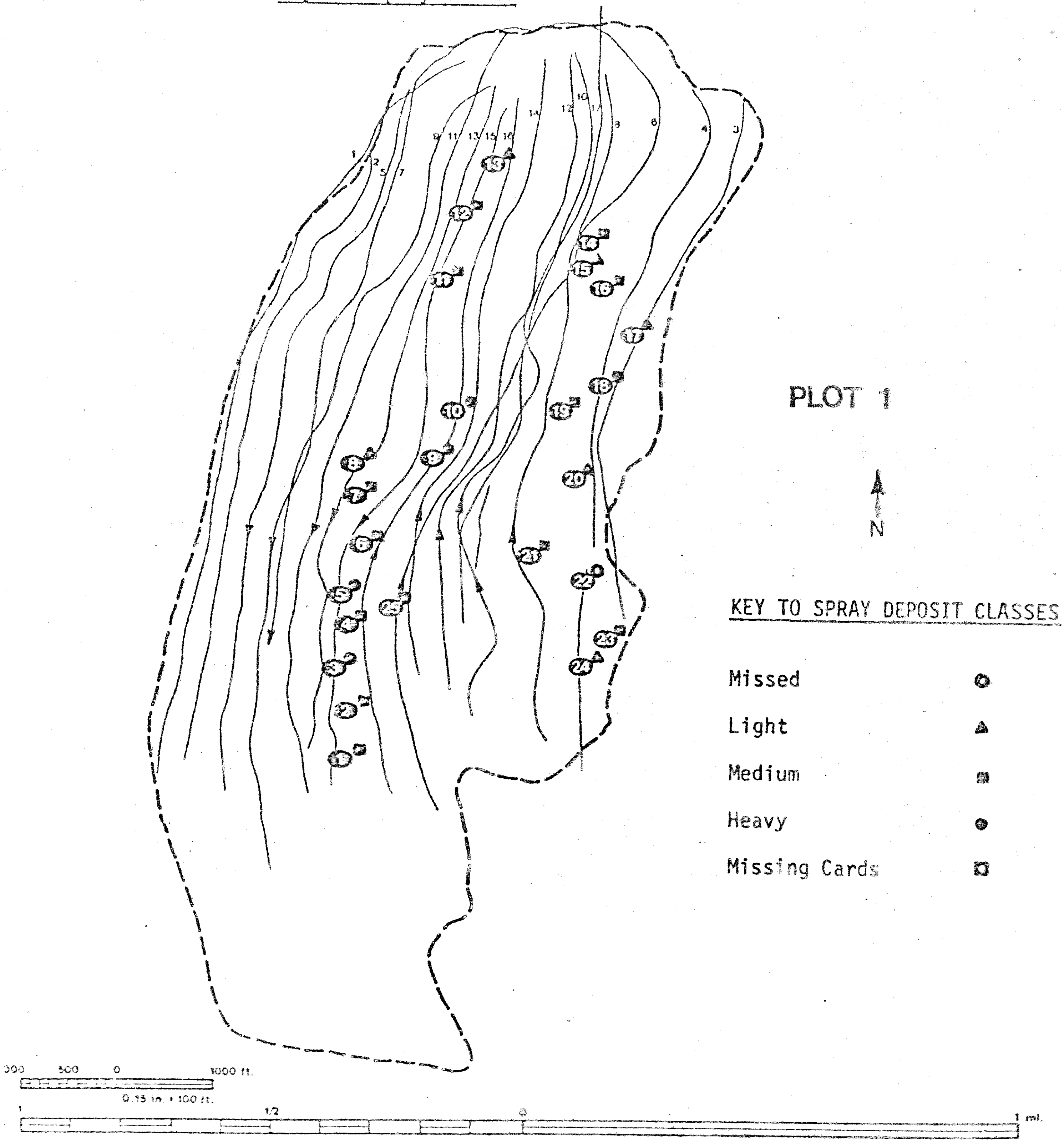
Appendix A.--Summary of data on the aerial application of Orthene 75-S and Dylox 4 for control of western spruce budworm

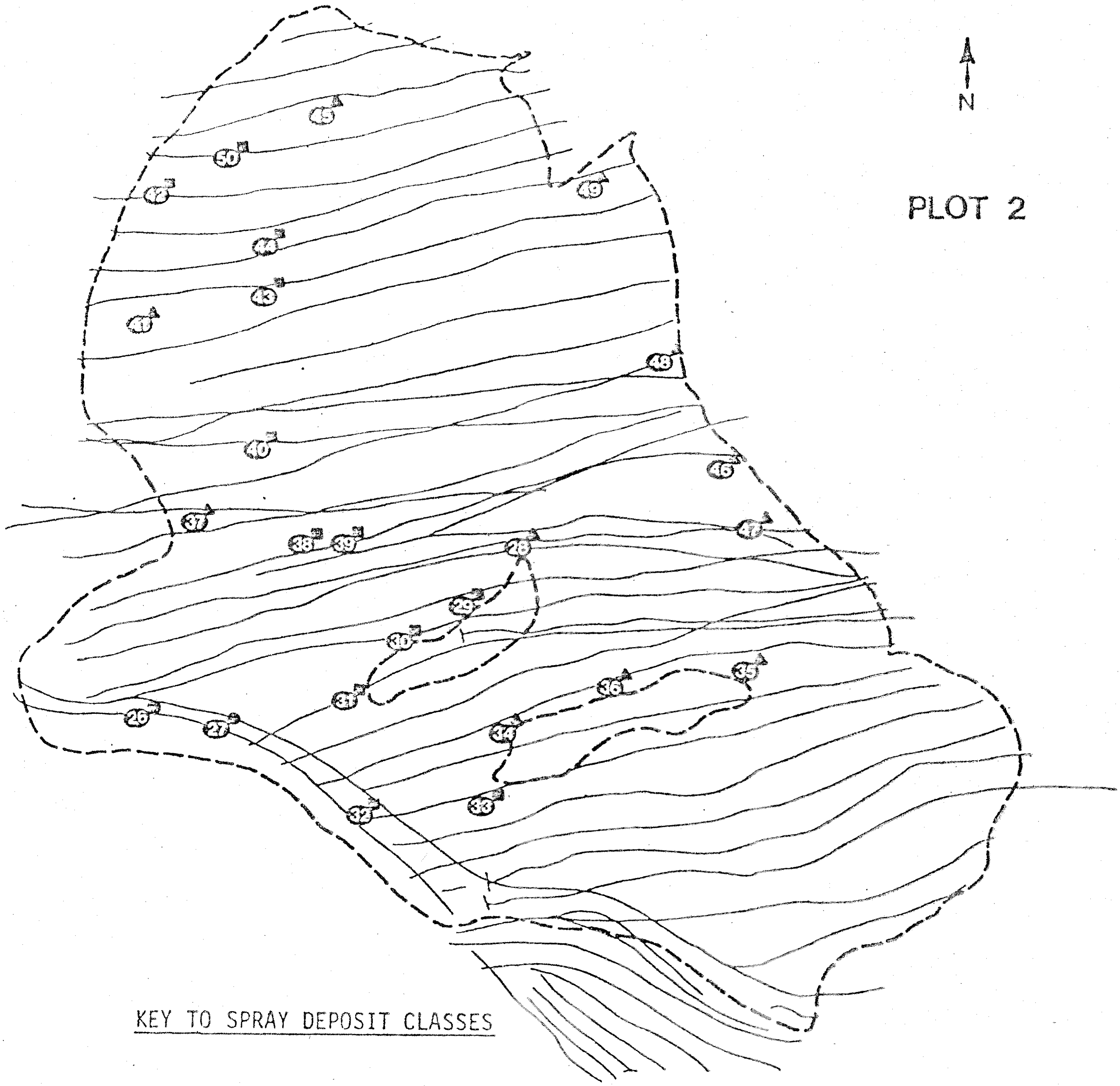
Block	Treatment	Acres	Date treated	Time treated	Actual spray time	Refueling and loading time (number)	System "down time"	Comments
1. Jimmy Creek	Dylox	798	7/3/76	0554-0646	44 min.	(1) 5 min.	3 min.	Pump malfunction
2. Sulphur Bar Creek	Dylox	1,300	7/7/76	0543-0750	1 hour 22 min.	(2) 25 min.[1/]	20 min.	Nozzle malfunction
3. East Fork Cabin Gulch	Orthene	1,000	7/5/76	0555-0913	1 hour 27 min.	(3) 35 min.	1 hour 16 min.	Nozzle malfunction
5. Holloway Gulch	Orthene	830	7/6/76	0542-0727	1 hour 3 min.	(2) 9 min.	33 min.	Switch malfunction
7. Vermont Gulch	Dylox	986	7/8/76	0541-0707	49 min.	(3) 33 min.	4 min.	Pump malfunction
8. Spring Gulch	Orthene	1,194	7/9/76	0540-0731	1 hour 21 min.	(5) 30 min.[2/]	0	
Total		6,108		11 hours 19 min.	6 hours 46 min.	2 hours 17 min.	2 hours 16 min.	

Acres sprayed/hour = 900.44
Average turnaround time = 8.56 min./stop[3/] = 22.43 min./1,000 acres
Spray system "down time" = 22.10 min./1,000 acres.

1/ Approximately 15 min. waiting for monitoring aircraft to clear area.
2/ Approximately 8 min. waiting for monitoring aircraft to clear area.
3/ Uncorrected for time required for monitoring aircraft to clear area.

Appendix B.--Maps of Spray Swaths

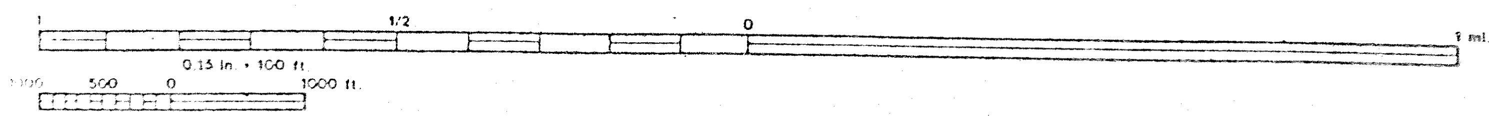


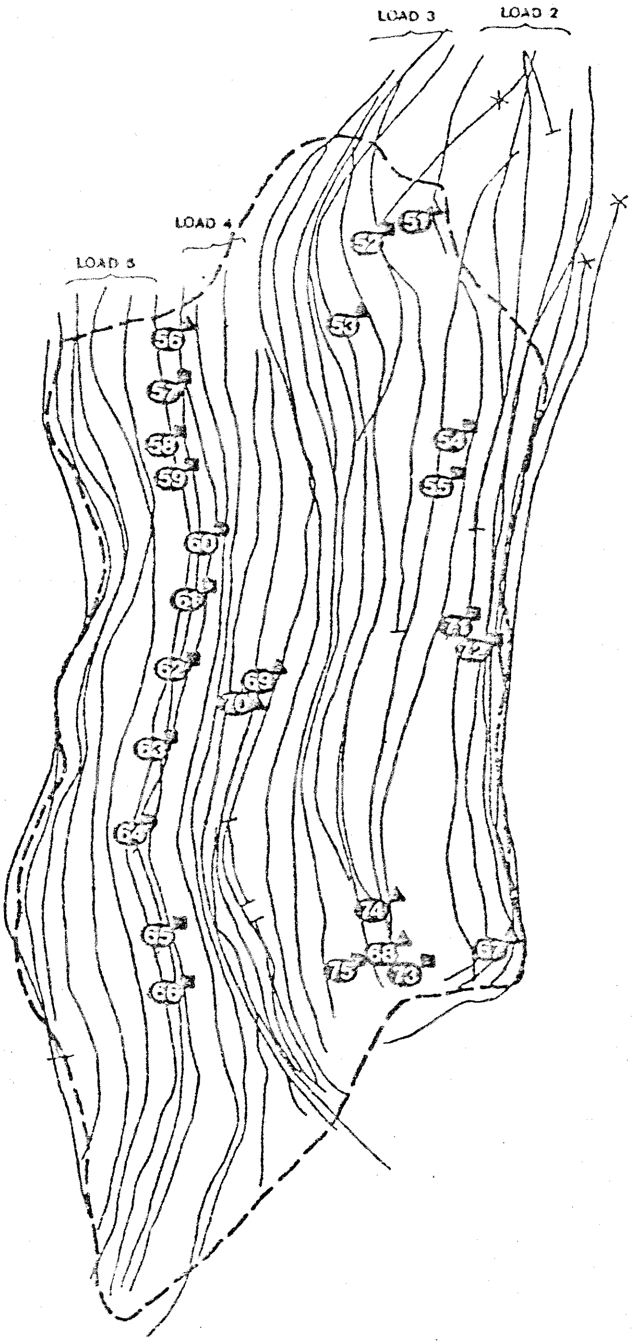


PLOT 2

KEY TO SPRAY DEPOSIT CLASSES

Missed	◎
Light	▲
Medium	■
Heavy	●
Missing Cards	□





N

PLOT 3

KEY TO SPRAY DEPOSIT CLASSES

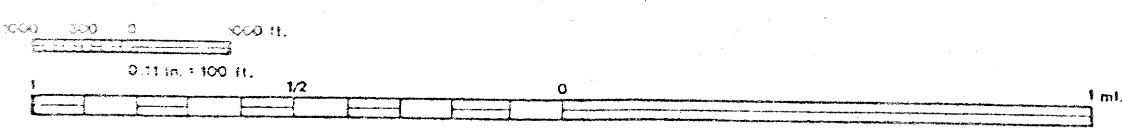
Missed

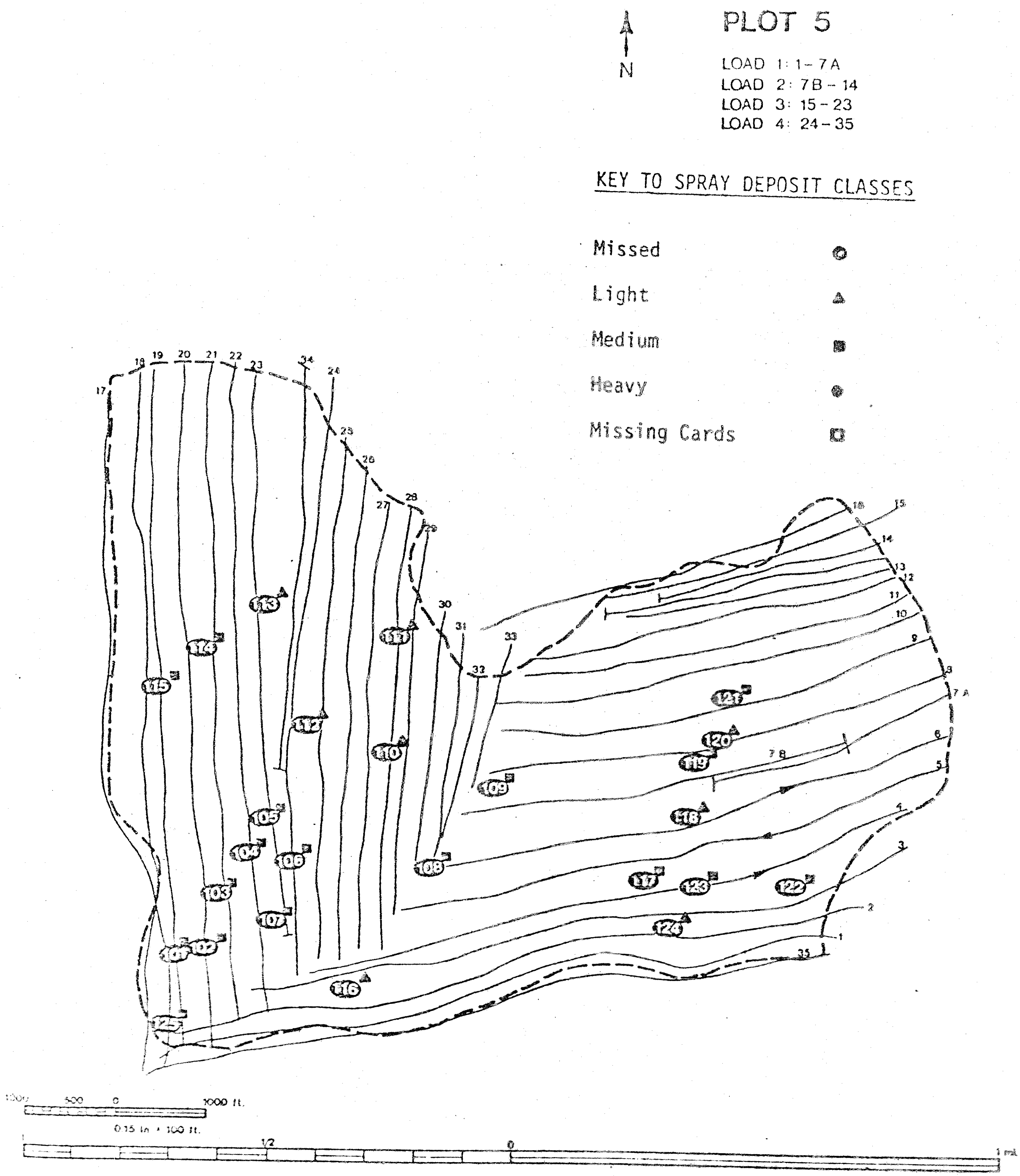
Light

Medium

Heavy

Missing Cards




PLOT 5
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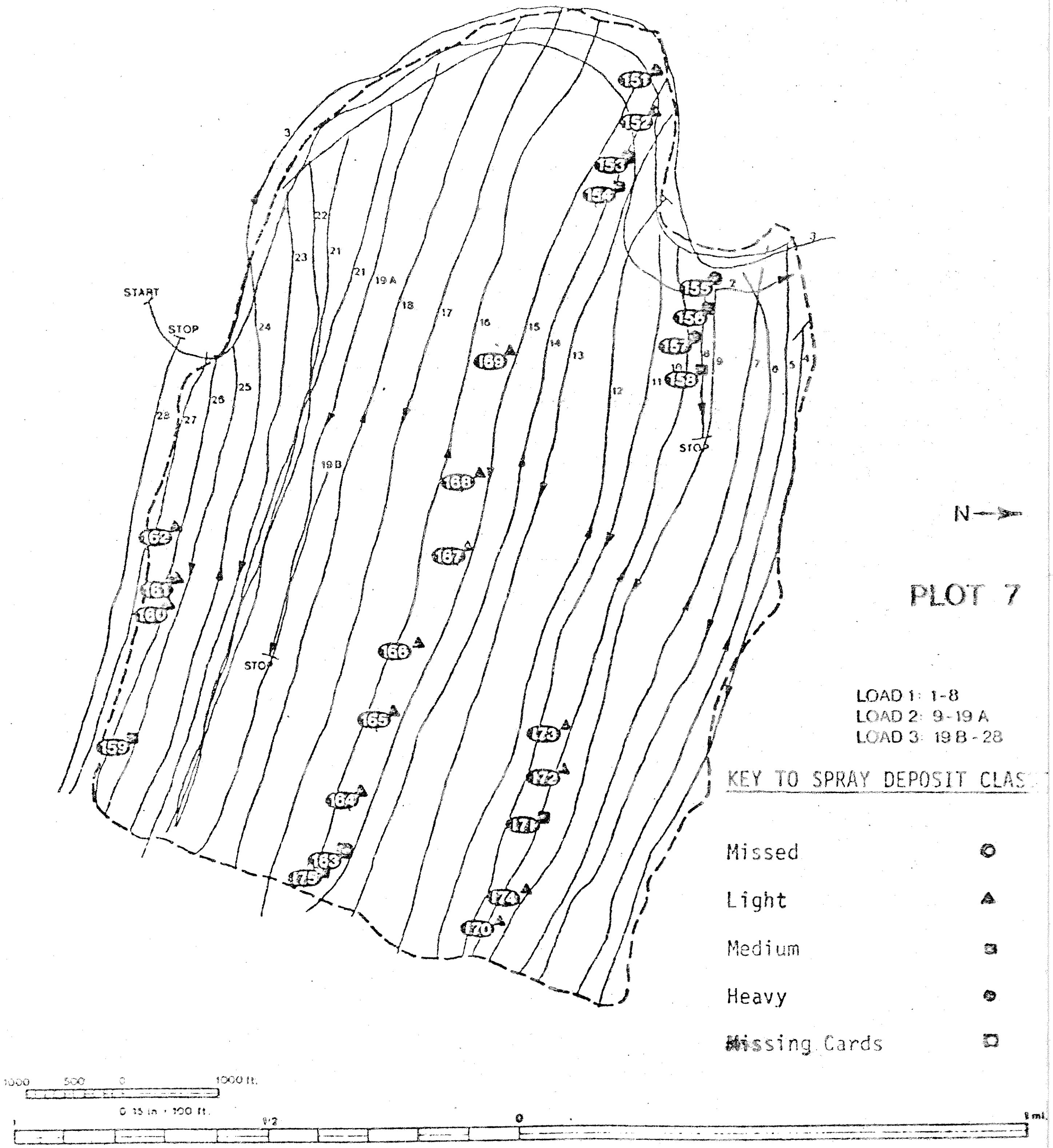
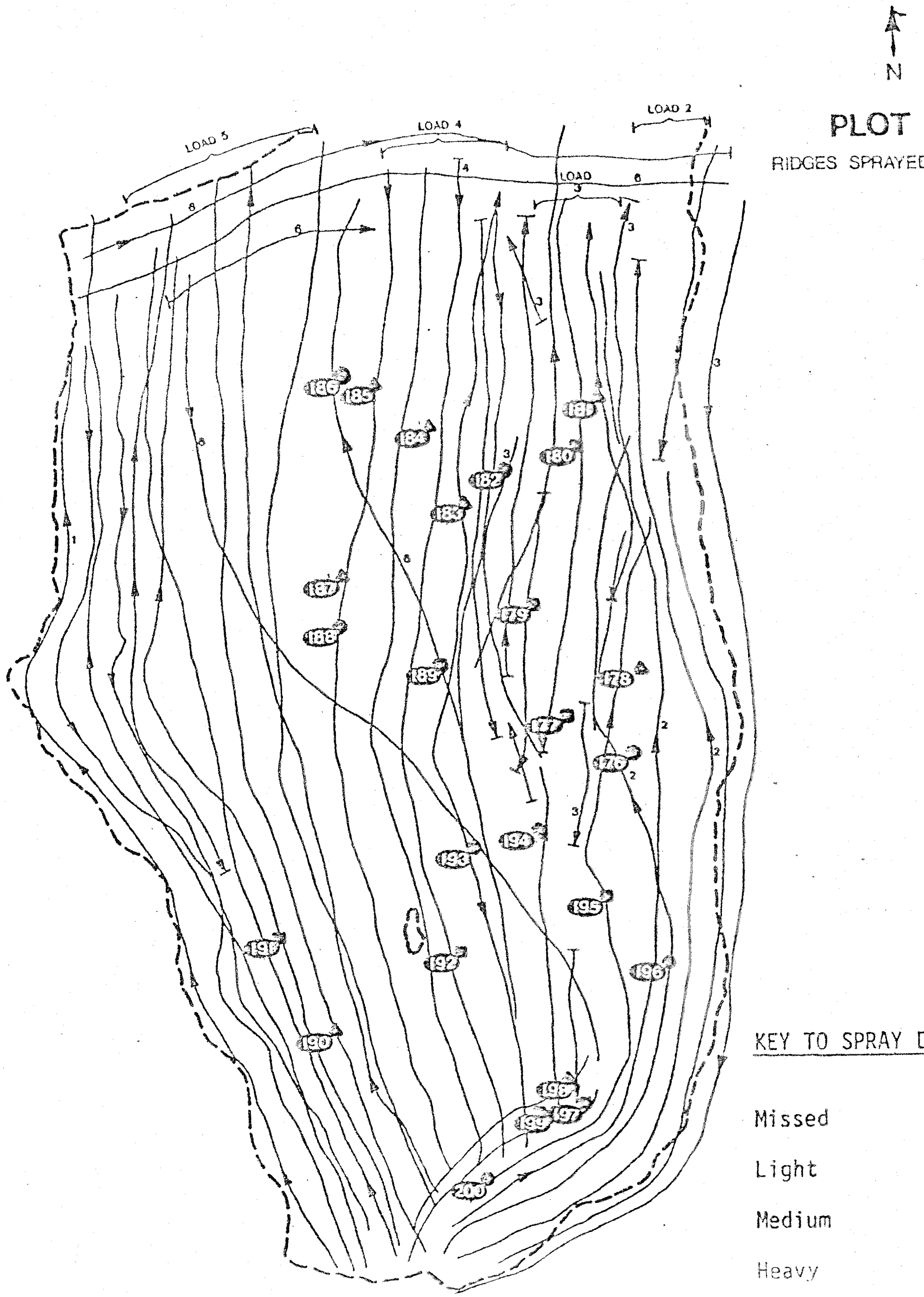
LOAD 1: 1 - 7A
LOAD 2: 7B - 14
LOAD 3: 15 - 23
LOAD 4: 24 - 35
KEY TO SPRAY DEPOSIT CLASSES
Missed
Light
Medium
Heavy
Missing Cards
1000 500 0 1000 ft.
0.15 in = 100 ft.
1/2
0
1 mi.


START
STOP
STOP
STOP
N
PLOT 7
LOAD 1: 1-8
LOAD 2: 9-19 A
LOAD 3: 19 B - 28
KEY TO SPRAY DEPOSIT CLAS
Missed
Light
Medium
Heavy
Missing Cards
1000 500 0 1000 ft.
0.15 in = 100 ft.
1 1/2 0 1 mi.



PLOT 8

RIDGES SPRAYED WITH LOAD 1

KEY TO SPRAY DEPOSIT CLASSE

Missed	○
Light	△
Medium	■
Heavy	●
Missing Cards	◘

1000 500 1000 ft.

0.15 in. = 100 ft.

1/2 0

Appendix C.--Financial Statement

Aircraft		
Spray helicopter		
Spraying 6,108 acres @ 2.89/acre		$17,652.12
Mounting 8 Beecomist nozzles		738.78
Calibration, characterization, & flushing		4,946.65
Chase helicopter - 27.6 hrs. @ $175/hr.		4,830.00
	Subtotal	$28,167.55
Pesticides		
Dylox 4		$9,812.50
HI SOL 4-5-T		1,155.00
Orthene 75-S (purchased 2,000 lbs. @ $4.50/lb.)		9,000.00
Automate Red B dye		984.00
Shipping (est.)		1,700.00
	Subtotal	$22,651.50
Rentals		
Pickup trucks & carry-all		$7,618.00
Tractor for pesticide tanker		871.74
Office & storage facilities		1,120.00
Forklift		200.00
	Subtotal	$9,809.74
Equipment & Supplies		
Field & lab equipment		$5,433.34
Vehicle operation		1,796.19
Budworm diet		106.00
Beecomist spray heads (8)		2,920.00
Aquatic monitoring (equip. retained by FIDM)		4,914.50
	Subtotal	$15,170.03
Personnel		
I&I officer		$2,856.00
Air Operations officer		2,895.00
Heliport manager		1,220.00
Asst. Heliport manager		807.00
Lab. crew leader (est.)		900.00
3 field crew leaders (est.)		3,319.00
9 field crew members (est.)		10,667.00
20 lab. crew members (est.)		16,120.00
3 spray deposit crew members (est.)		2,555.00
Administrative assistant (est.)		3,500.00
	Subtotal	$44,839.00

Administrative travel (est.)		$2,485.00
Overtime pay for administrative personnel		$1,621.29
Services		
Aquatic monitoring - Gallatin NF		
Salaries		$11,265.00
Vehicles		1,000.00
Per diem		2,500.00
Equipment & supplies		1,000.00
Overhead (Gallatin NF)		4,729.50
	Subtotal	$20,494.50
Missoula Equipment & Development Center		
Meteorology & spray deposit		$1,790.00
Insecticide mixing & loading		7,211.00
Coordination		1,465.00
	Subtotal	$10,466.00
National Weather Service		
Mobile fire weather unit		$1,588.00
Methods Application Group		
Spray deposit card analysis		$3,424.00
Insecticide Evaluation Project		
Residue analysis		$5,000.00
Overhead Charges		
Helena NF (50% overhead)		$8,219.00
Regional Office (7% overhead)		$22,174.00
	GRAND TOTAL	$196,109.61

Appendix D.--Meteorological data

BLOCK 1 JIMMY CR

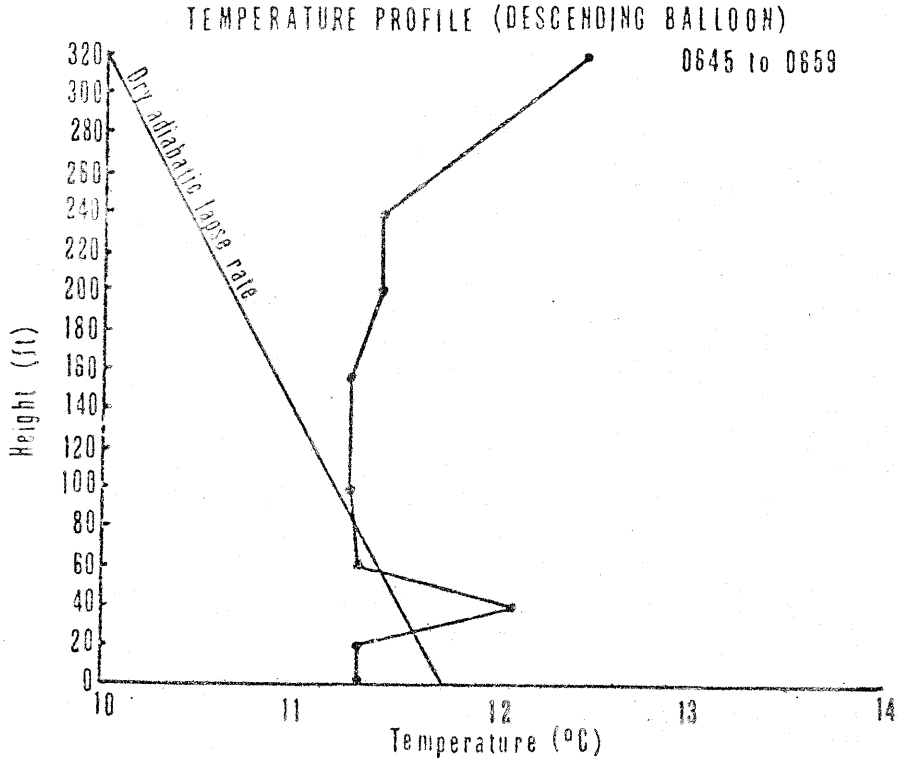
Treatment - Dylox 4

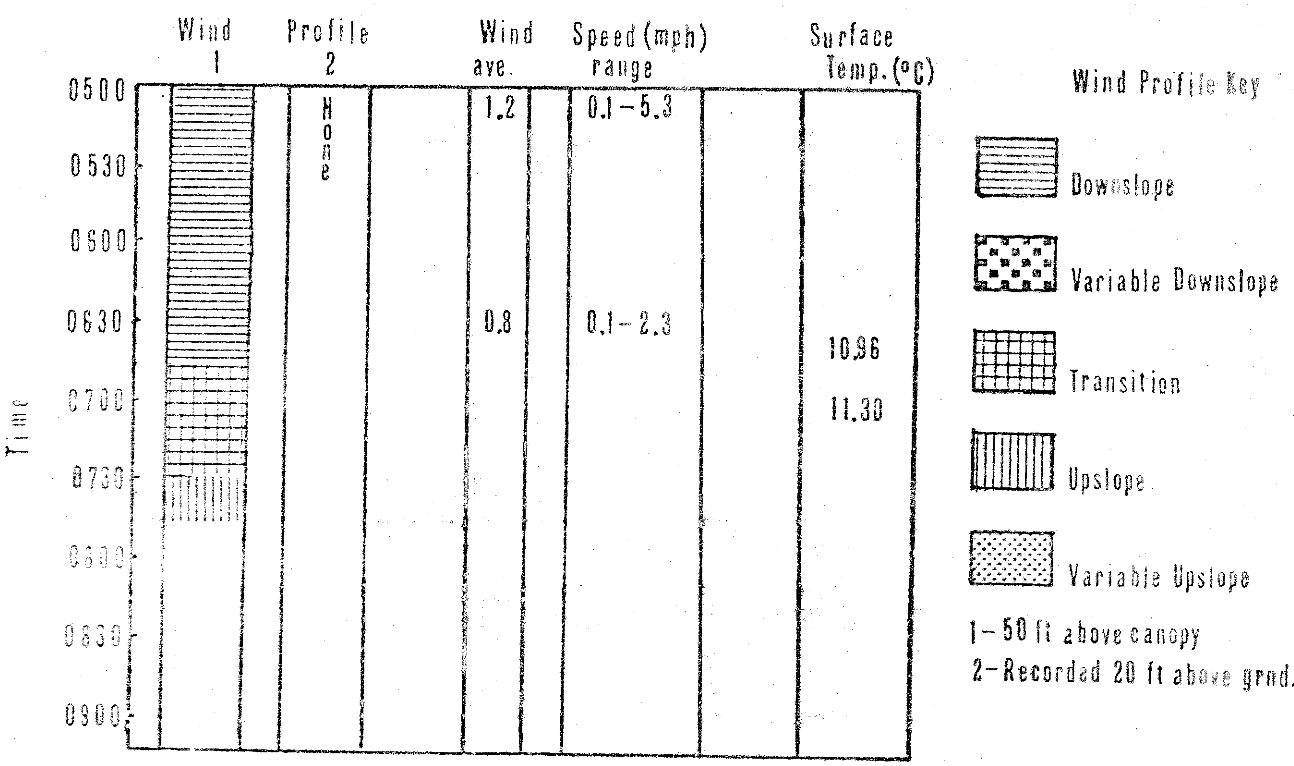
Plot Altitude - 4800 to 6000 ft.

Meteorological Monitoring Site Elivation - 5800 ft.

Spray Date - 7/3/76

Spray Time - 0554 to 0820



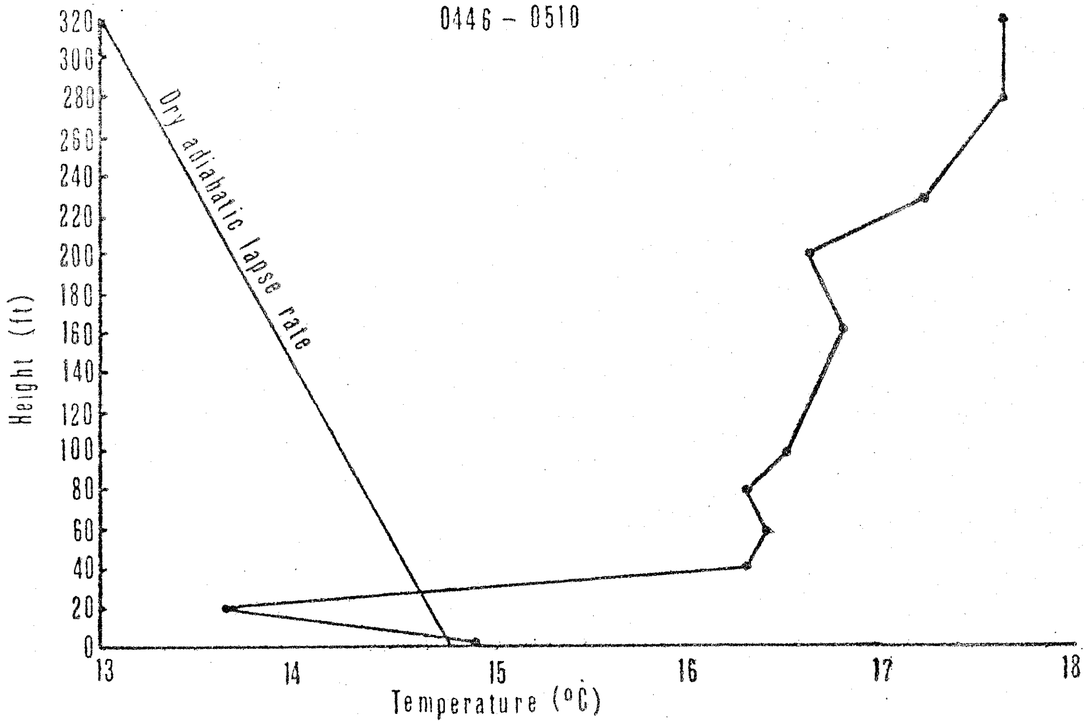


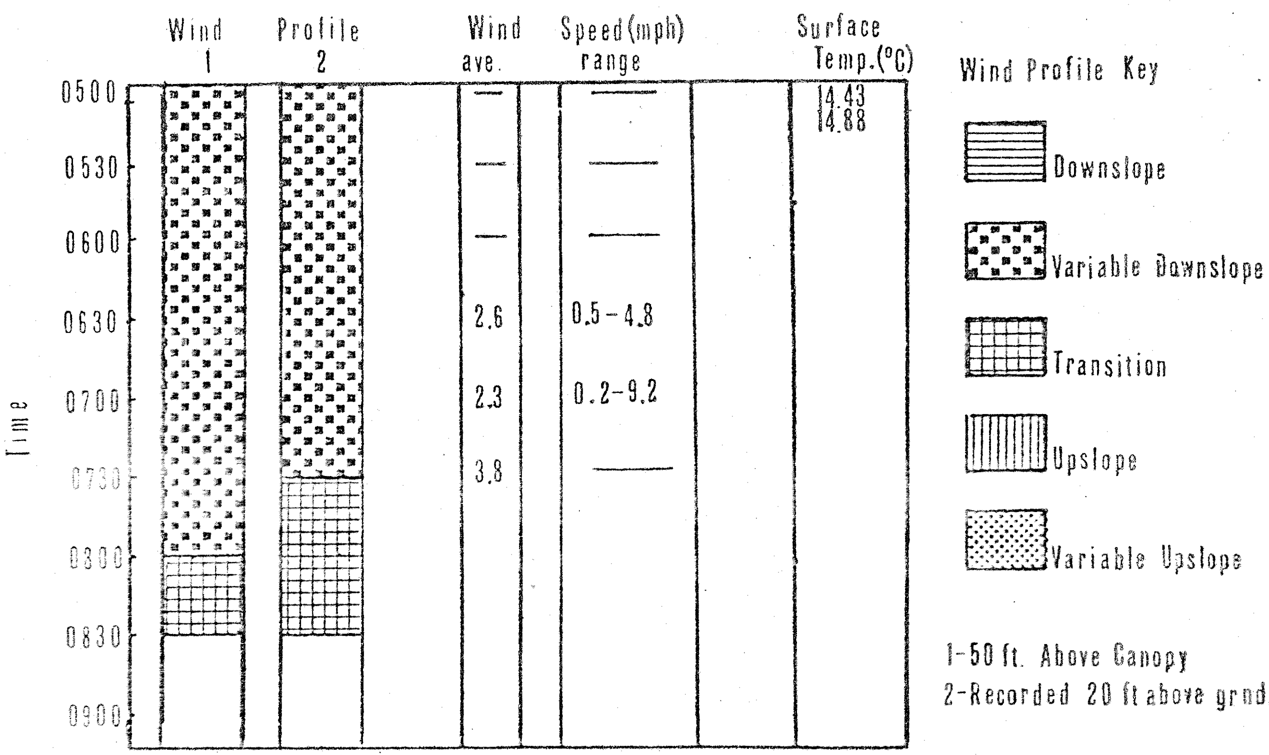
BLOCK 2 SULPHUR BAR CR

Treatment – Dylox 4
Plot Altitude – 5280 to 6280
Meteorological Monitoring Site Elivation – 5710, 5750, 5800 ft.

Spray Date – 7/7/76
Spray Time – 0543 to 0750

TEMPERATURE PROFILE (DESCENDING BALLOON)
0446 – 0510



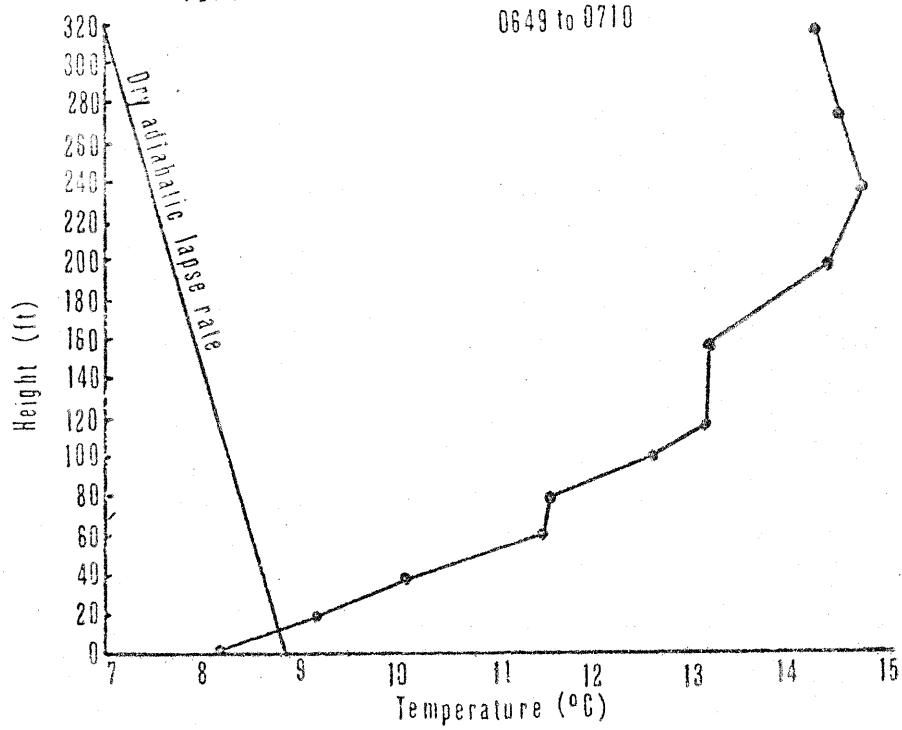


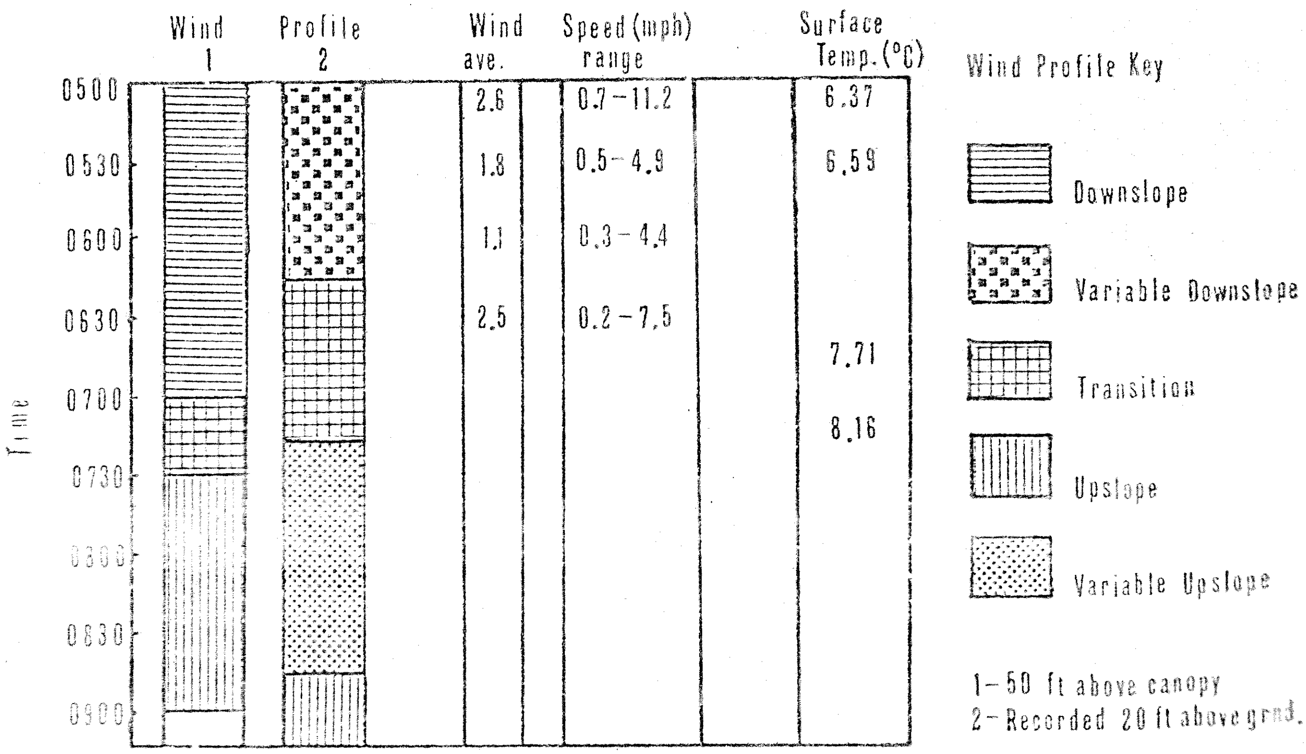
BLOCK 3 EAST FK DEEP CR

Treatment – Orthene
Plot Altitude – 5250 to 6720 ft
Meteorological Monitoring Site Elivation – 6013, 6050, 5950 ft

Spray Date – 7/5/76
Spray Time – 0555 to 0913

TEMPERATURE PROFILE (DESCENDING BALLOON)
0649 to 0710



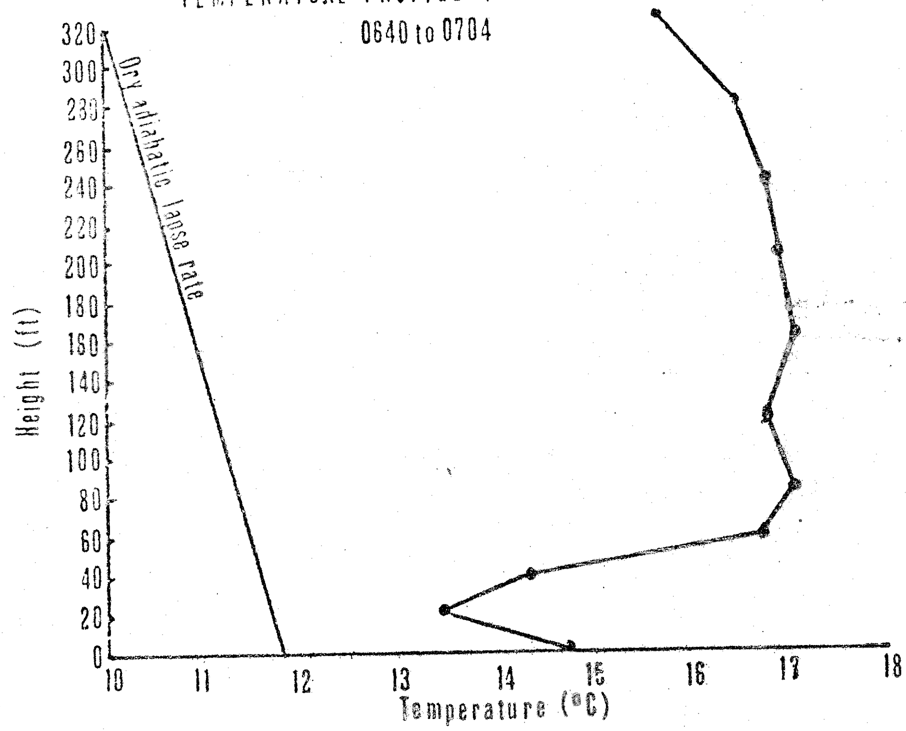


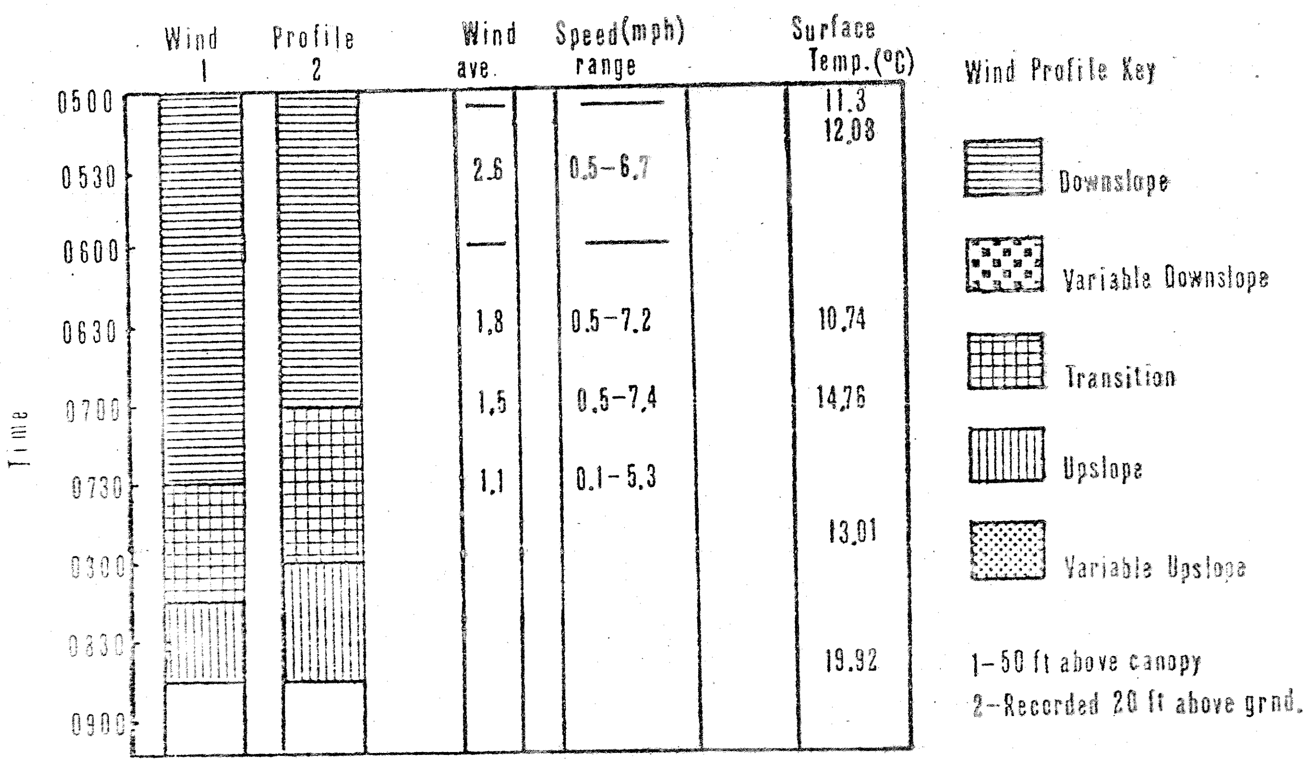
BLOCK 5 HOLLOWAY GULCH

Treatment – Orthene
Plot Altitude – 5480 to 6280
Meteorological Monitoring Site Elivation – 5920, 6000, 6080

Spray Date – 7/6/76
Spray Time – 0542 to 0727

TEMPERATURE PROFILE (DESCENDING BALLOON)
0640 to 0704





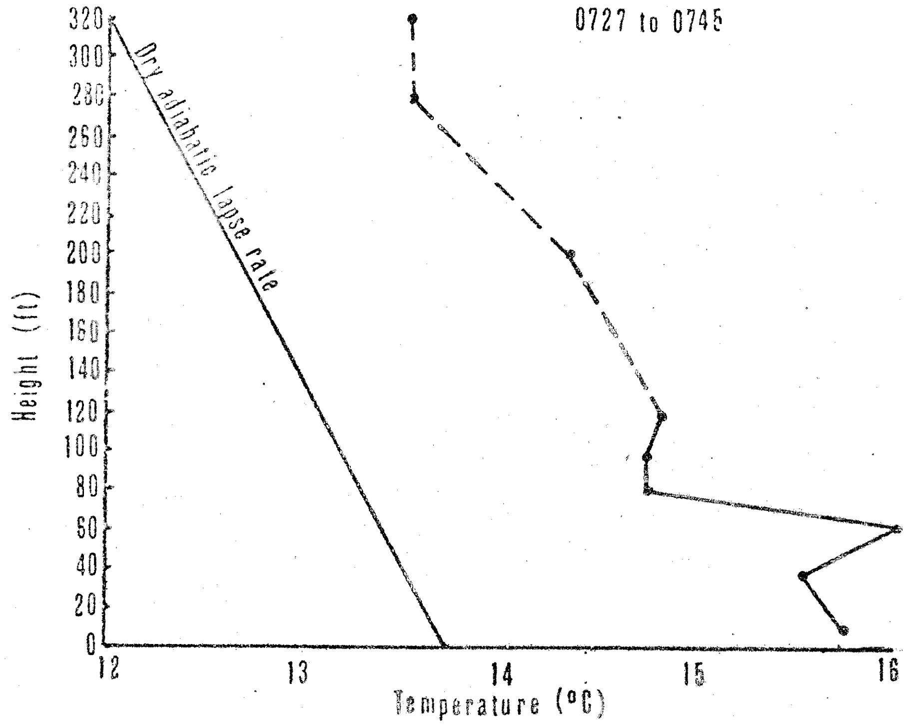
BLOCK 7 VERMONT GULCH

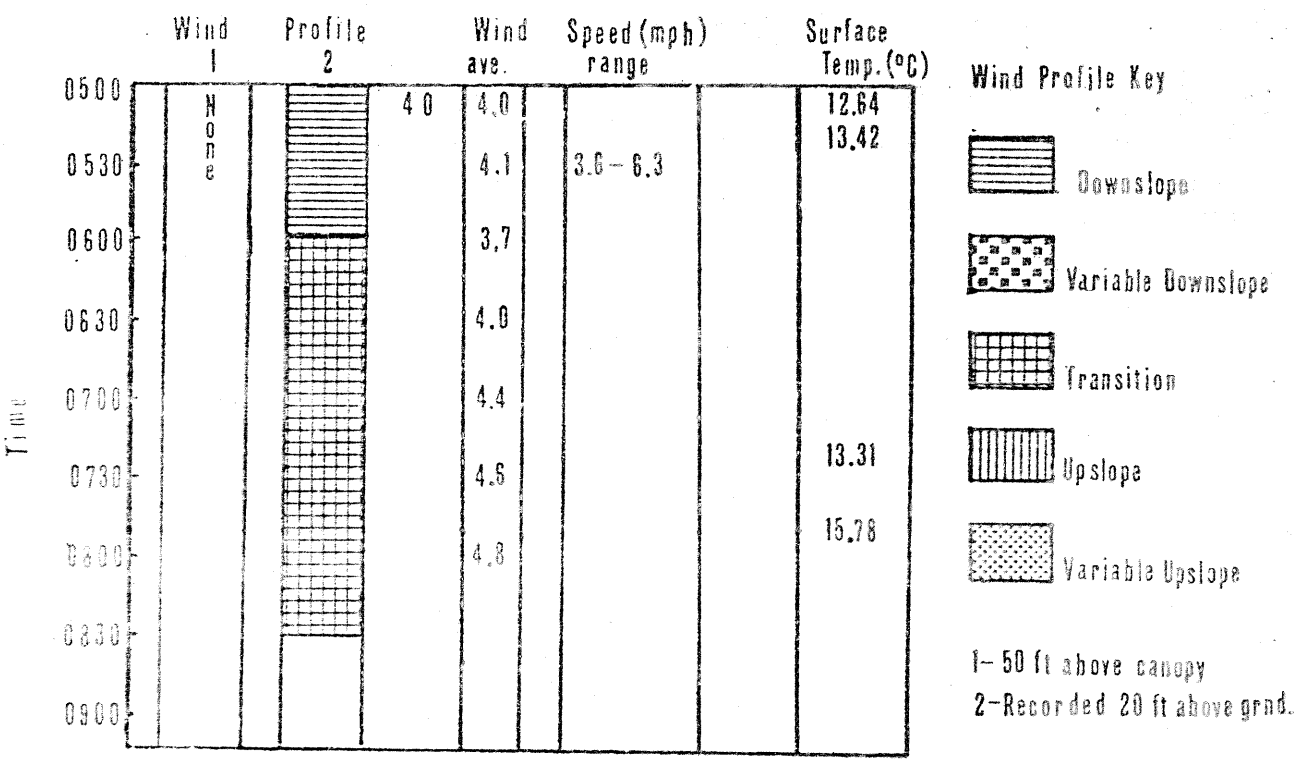
Treatment - Dylox 4
Plot Altitude - 5600 to 6693
Meteorological Monitoring Site Elivation - 6300, 6550

Spray Date - 7/8/76
Spray Time - 0541 to 0707

TEMPERATURE PROFILE (DESCENDING BALLOON)

0727 to 0745



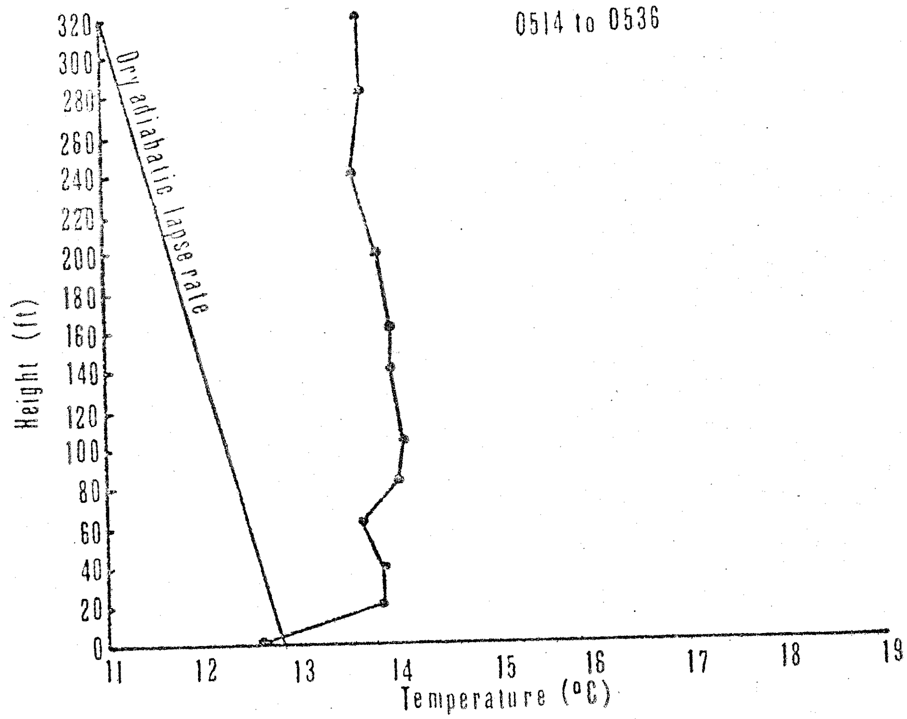


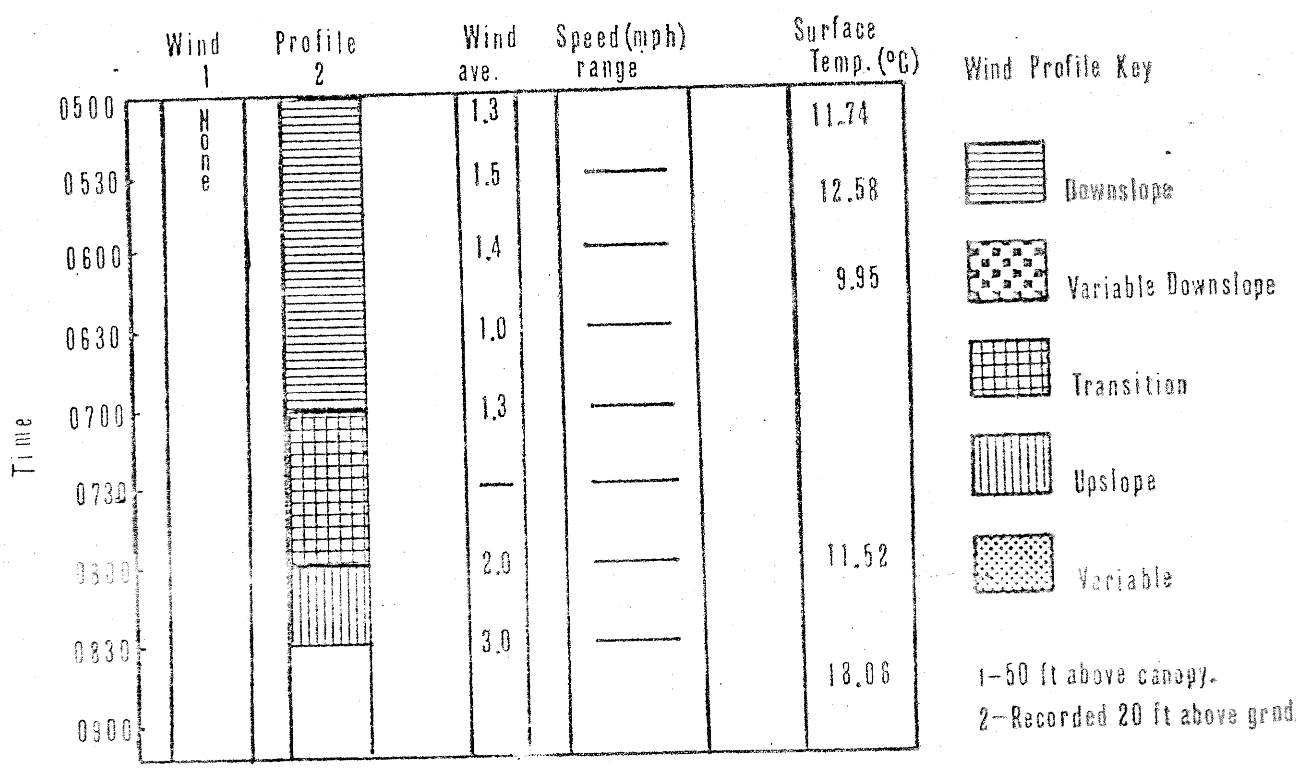
BLOCK 8 SPRING GULCH

Treatment – Orthene
Plot Altitude – 5080 to 7300
Meteorological Monitoring Site Elivation – 5870, 5890, 5920

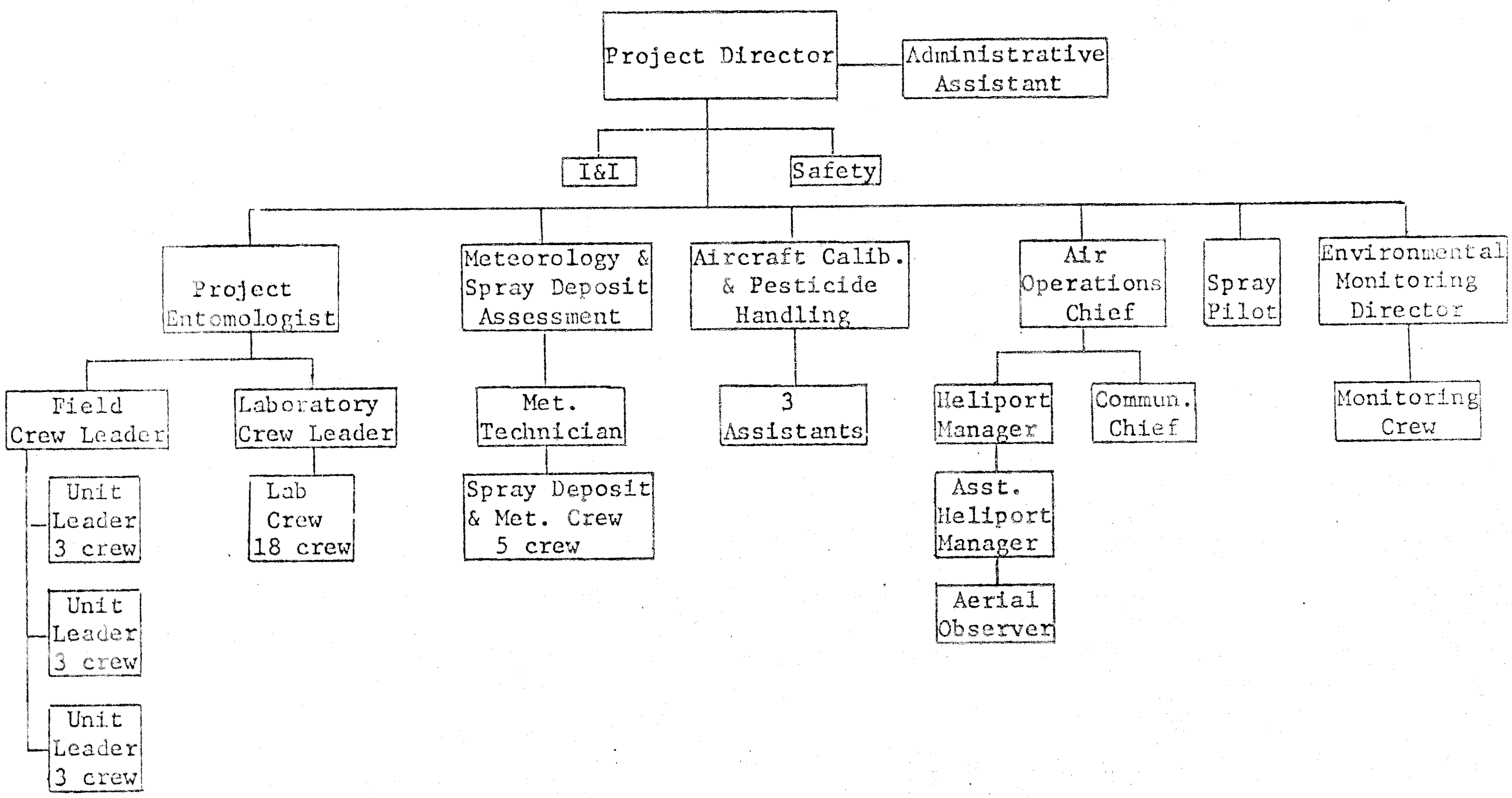
Spray Date – 7/9/76
Spray Time – 0540 to 0731

TEMPERATURE PROFILE (DESCENDING BALLOON)





Appendix E.--Organization of 1976 pilot project to evaluate Dylox 4 and Orthene 75-S for controlling western spruce budworm



ACKNOWLEDGMENTS

So many people were involved in the planning and successful completion of this project that it is impossible to mention all their names. Let it suffice to say everyone carried out his assigned responsibilities in a highly professional manner.

I would like to extend special thanks to some whose advice I found especially helpful in conducting this project:

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Fred Mellgren, Contracting Officer
Fred Andres, Project Air Operations Chief
Phil Schlamp, Project I&I Officer
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