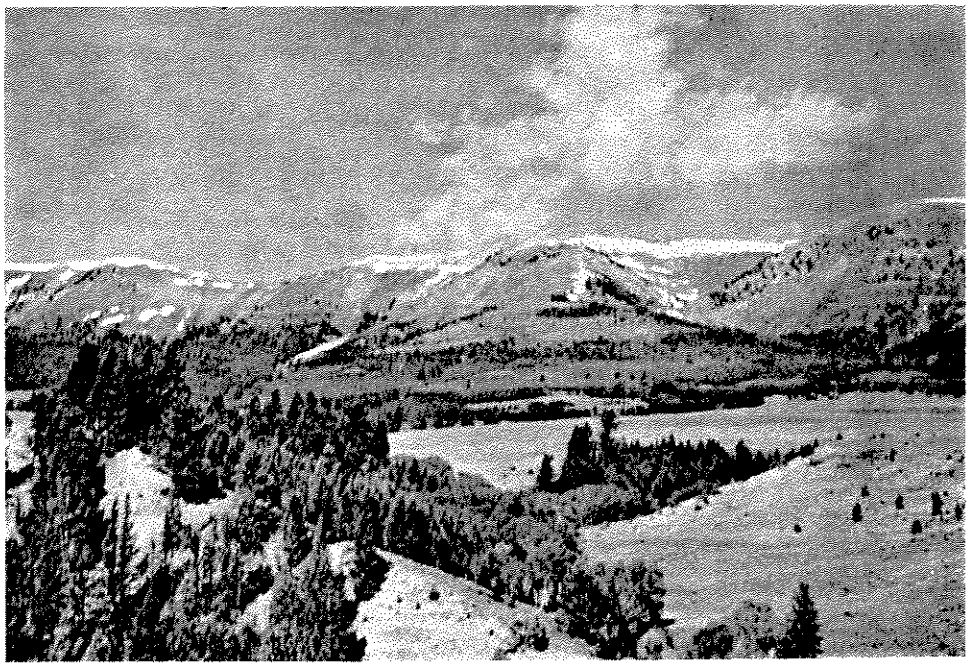
EFFECTS OF AN AERIAL APPLICATION OF DDT ON FISH & AQUATIC INSECTS IN MONTANA



FINAL REPORT

JUNE 1959

EFFECTS OF AN AERIAL APPLICATION OF DDT ON FISH AND AQUATIC INSECTS IN MONTANA

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FOREWORD

A cooperative administrative study was initiated in 1956 by the Montana State Fish & Game Department, the U.S. Fish & Wildlife Service, and the U.S. Forest Service, to facilitate comprehensive research needed in conjunction with the use of DDT spray in western forest areas. The 1956 data showed the need for additional information in 1957 on fish losses following spraying and on the population recovery of aquatic invertebrates in larger streams.

In 1957, the Montana State Fish & Game Department and the U.S. Forest Service organized a more intensive DDT-aquatic fauna relationship study for the Ruby River by placing emphasis on chemical analyses of water, sediments, vegetation, and fish and patrolling for fish mortality. Sampling of aquatic organisms and other observations were made on the Madison and Judith Rivers.

This progress report presents the data collected in 1957 and 1958 on these rivers. Richard J. Graham and David O. Scott were the coordinators for the Montana State Fish & Game Department and the U.S. Forest Service, respectively, and prepared this report.

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SUMMARY

The primary purpose of this cooperative administrative study was to obtain information on the use of DDT aerial sprays as quickly as possible for immediate use in conjunction with a current spruce budworm control program in Montana. The immediate objective was to determine the effect of the aerial application of 1 pound of DDT per acre on the fish resources and ways of minimizing any possible detrimental effect.

Most of the observations reported in this study were limited to the Ruby River. Stream shocking to determine fish abundance and stream bottom sampling to determine the amounts of fish food organisms were carried on prior to and following spraying. Chemical analyses were made on water, vegetation, sediments, and fish to determine the presence of DDT and the stream was patrolled to observe any fish mortalities.

The study data are summarized as follows:

1. Spraying adjacent to the Ruby River occurred on July 7, 1957.

2. Aerial application was made at the rate of 1 pound of DDT per acre and quantities reaching the stream ranged from 0.01 to 1.2 pounds per acre.

3. Surface water samples taken 5 minutes after spraying contained 1.35 p.p.m. (parts per million) DDT while only 0.08 p.p.m. was found in subsurface water. The amounts found decreased rapidly and 32 hours later only a trace was detected.

4. No DDT was found in water samples taken following two heavy rains subsequent to spraying.

5. DDT was found in postspray aquatic vegetation samples at least 10 miles below the spray area collected as late as September 1957.

6. No DDT was found in bottom sediments collected before or after spraying.

7. Drift samples and bottom collections showed that aquatic insects were materially reduced by the DDT spray.

8. Insect recovery was slight during 1957 but considerable during 1958.

9. High water prevented efficient prespray sampling of the fish population, but enough fish were recovered to determine that the population was primarily suckers.

10. Dead suckers began to appear within a few days after spraying. In a regularly patrolled section (about 2 miles long), the number found per day increased to 80 about 10 days after spraying. Dead suckers were found throughout the summer and fall but in smaller numbers. The mortality extended downstream for about 8 miles below the spray area.

11. No dead trout were found in the spray area during the summer, but dead brown trout were observed below the spray area in late November and early December, 1957. The extent of this die-off could not be determined but the mortality was greater than usual, even during the spawning season.

12. Fish tissues were chemically analyzed and DDT was found in all fish (dead or alive) collected following spraying. Because considerable variation in quantities was found, no conclusions were made on the amount of DDT in fish that was associated with mortalities.

13. Observations on stream bottom fauna were also made on the Madison River and Judith River. The effect of the spray on bottom organisms in these streams was similar to that for the Ruby River and to previous studies. No fish mortalities were reported on either stream.

14. A few incidental observations were made on the other areas where fish mortalities were reported following spraying. These include the Big Hole River and Deadman Lake.

INTRODUCTION

The spruce budworm, Choristoneura fumiferana (Clem.), is indigenous to western fir forests. Epidemics of this defoliator were reported as early as 1923, but these early outbreaks subsided because of natural control factors. Since 1947, however, spruce budworm infestations have become aggressively epidemic. By 1951, defoliation became so severe in many areas that timber, watershed, and recreation values were in jeopardy. Because of potential tree losses in 4 to 6 years after initial attack, the Forest Service decided to control the spruce budworm with an aerial application of 1 pound of DDT per acre. Spray projects in 1952 and 1953 established small areas of heavily infested stands as control units in order to save the annual growth loss and prevent resultant tree mortality. Three major spray projects have been completed since July 1955.

In the late fall and early winter of 1955, large numbers of dead fish were found along the Yellowstone River. Fish biologists, administrators, and sportsmen were gravely concerned over the unusual die-off. Some observers thought it to be delayed mortality related to the July 1955 aerial application of DDT spray to widespread forest areas in Yellowstone Park and the Gallatin National Forest. Investigators' conclusions varied because pre-spray populations for fish and bottom organisms were not available for most of the streams within the spray area.

By 1956, it was apparent that more information was needed on the effects of DDT spray on fish, fish-food organisms, and wildlife. This instigated a cooperative administrative study to obtain information on DDT-fish relationships as quickly as possible for immediate use in conjunction with the proposed spruce budworm control program. In 1957, followup studies were conducted on 7 of the original 13 streams studied in 1956, while another intensive study was set up on the Ruby River to obtain chemical data by analyzing water, vegetation, sediment, and fish. The Madison and Judith Rivers were also sampled for aquatic insects and limited chemical data were collected. Miscellaneous observations, the sampling of aquatic insects, and limited collections of chemical data were made on the Judith and Madison Rivers.

Acknowledgments

The authors wish to thank the many State and Federal Agencies[1/] that helped make this cooperative administrative study possible. Assistance from the Agricultural Research Service, U.S.D.A., made the services of C. H. Hoffman, Assistant Director, and Milton S. Schechter, Chemist, of the Entomology Division, available for the initial planning and preparation of guidelines used in the chemical analysis of water and fish.

1/ The Montana State Fish & Game Department's studies on the effects of DDT on fish and other aquatic life are supported by Federal aid in Fisheries Restoration Funds under Project Number F-21-R.

George Holton, Chief Fisheries Biologist, Montana State Fish & Game Department, and C. J. D. Brown, Professor of Zoology and Entomology, gave many useful suggestions. Both reviewed this report. Their contributions aided the study materially.

Elmer Frahm, Professor of Chemistry, Montana State College, made facilities available and supervised the chemical analyses. His cooperation was extremely helpful.

THE RUBY RIVER

The Ruby River is located in the Beaverhead National Forest in southwestern Montana and is a tributary of the Beaverhead River. It is approximately 65 miles long, with the upper half flowing through mountainous area and narrow valleys, and the lower half through a broad valley. Agriculture in the valleys consists mainly of hay and small grains. The Ruby Reservoir (38,850 acre-feet) is located midway along the river and about 5 miles south of Alder. Average discharge immediately above the reservoir is 162 cubic feet per second, while at the mouth of the river it is 226 cubic feet per second (map 1).

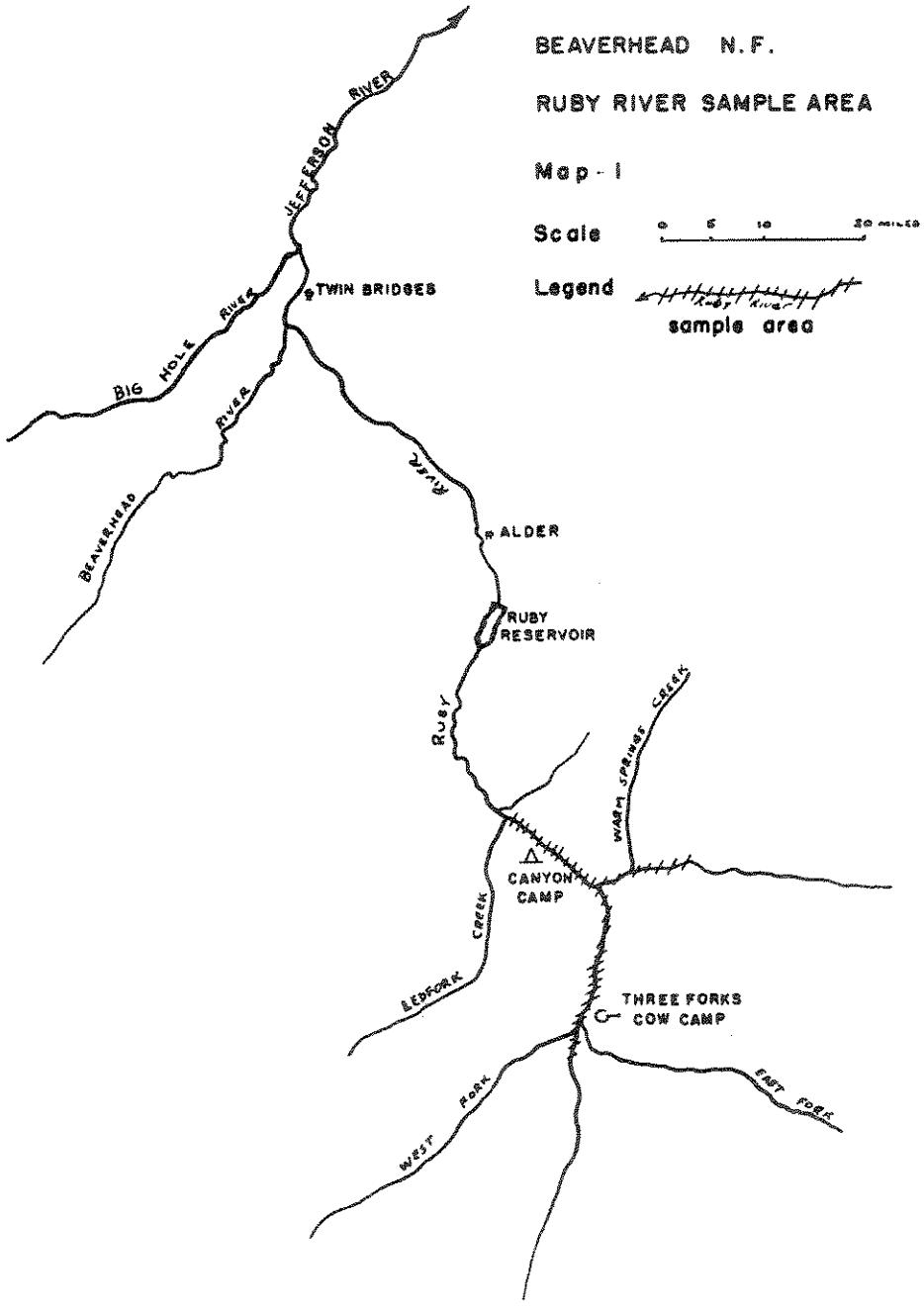
The general spray area included the headwaters of the Ruby River down to Canyon Camp (about 12 miles above the reservoir). A broad valley lies below Canyon Camp and the river meanders through a flood plain 1 to 3 miles wide. Forage crops are produced on the flood plain, while the benchlands are used mainly for grazing. Vegetative cover in the area above Canyon Camp consists of about equal portions of timber and grassland. Heaviest stands of timber occur on the north slopes of tributary streams and on the benches and steep slopes at higher elevations. (See cover.) Because the spraying of areas immediately adjacent to the river occurred between Three Forks Cow Camp and Canyon Camp (about 13 miles), this part of the stream was selected as the major study area (map 2).

Description of the Study Area

The uppermost collecting station (1) in the study area was located just above the entrance of the East and West Forks of the Ruby River and the lowest station (8) was 17 miles downstream at Ledford Bridge. From station 1 to station 5 (about 7 miles), the river flows through rolling hills and two shallow canyons. Scattered stands of timber occur along the river in this area, with heaviest stands in the canyons. Willow and alder are found along the banks where the flood plain is broad. The stream meanders considerable in this area and has widths from 10 to 30 feet and depths range from 6 inches to 6 feet. Riffles and pools are intermittent and the bottom types vary from rubble in the riffles to silt and muck in the pools.

From station 5 to station 7 (Canyon Camp) the river flows through hay meadows, but timber reaches the stream in several areas where it meanders close to steep slopes. The river meanders more in this area than above and the gradient is less. The largest tributary of the Ruby River in the study area (Warm Springs Creek) enters the river from the east midway between stations 5 and 7. Below Warm Springs Creek the river is considerably larger, with maximum width and depth reaching 65 and 10 feet respectively. (Figures 1, 2, 3, and 4)

The runoff for this drainage area generally occurs during May and June. A gaging station located near station 5 shows flows for the years 1948 to 1953 reached a maximum of 1,230 cubic feet per second on May 3, 1952, and a minimum of 6.8 cubic feet per second on November 5, 1950. The river was very turbid during the flood stage and following rain. Turbidity at station 5 during normal flows from July 8 to September 13, 1957, ranged from 2.6 to 4.6 p.p.m. On August 8, 1957, the turbidity following a rainstorm was 12.5 p.p.m. (Table 1)


BEAVERHEAD N.F.
RUBY RIVER SAMPLE AREA
Map - I
Scale
0 5 10 20 MILES
Legend
sample area
JEFFERSON RIVER
TWIN BRIDGES
BIG HOLE RIVER
BEAVERHEAD RIVER
ALDER
RUBY RESERVOIR
RUBY
WARM SPRINGS CREEK
CANYON CAMP
BEF FORK CREEK
THREE FORKS COW CAMP
WEST FORK
EAST FORK

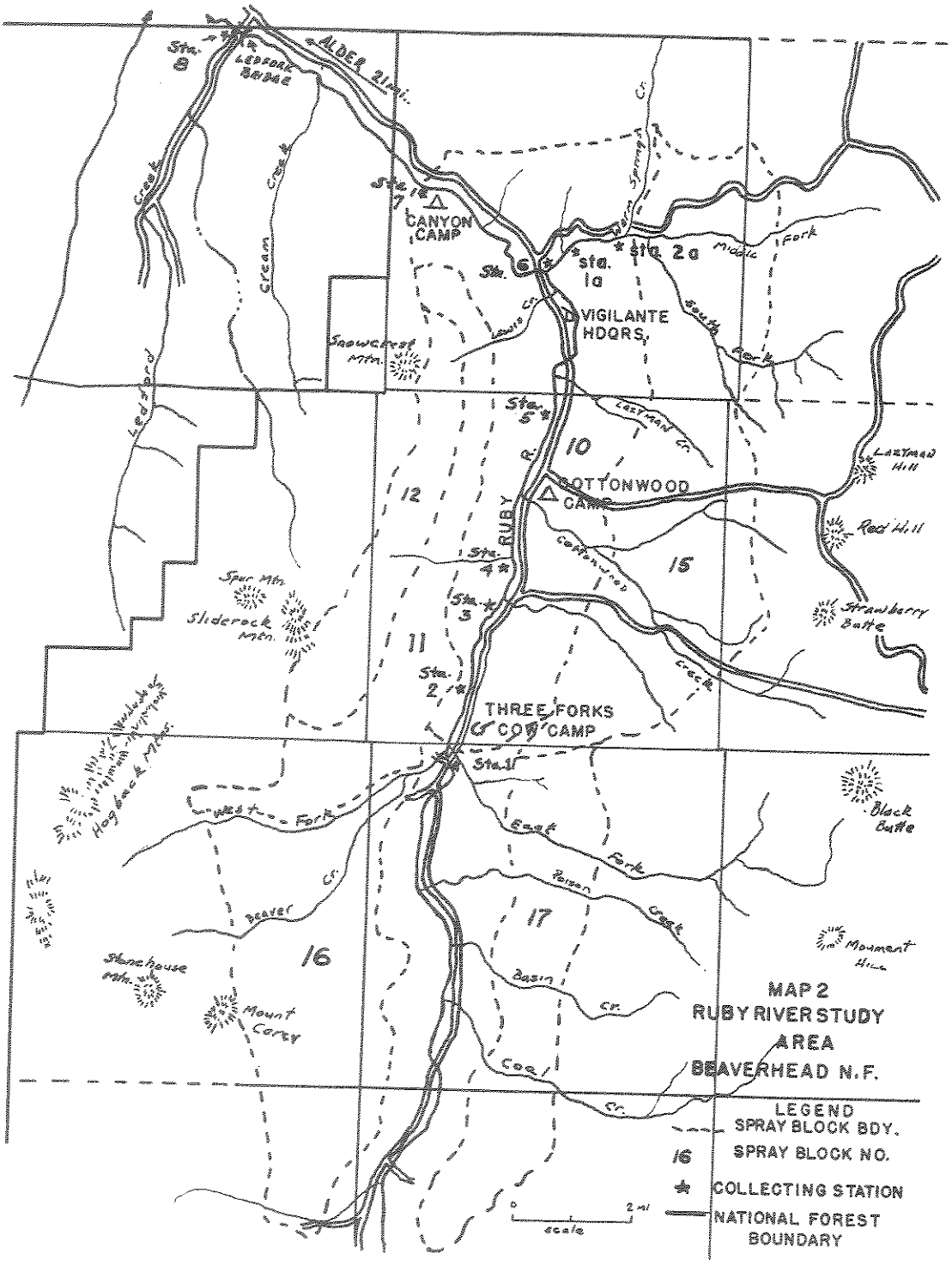

ALDER 21 mi.
Sta. 8
LEDFORD BRIDGE
Ledford Creek
Cream Creek
Sta. 7
CANYON CAMP
Sta. 6
sta. 1a
sta. 2a
VIGILANTE HDQRS.
Middle Fork
South Fork
Lewis Cr.
Snowcrest mtn.
Sta. 5
Eastman Cr.
Eastman Hill
10
COTTONWOOD CAMP
12
RUBY R.
Red Hill
Sta. 4
Cottonwood
15
Sper Mtn.
Sliderock mtn.
Sta. 3
11
Strawberry Butte
Sta. 2
THREE FORKS CG & CAMP
Creek
Sta. 1
Hogback Mtns.
West Fork
East Fork
Black Butte
Beaver Cr.
Poison Creek
17
16
Stonehouse mtn.
Mount Carey
Basin Cr.
Monument Hill
Coal Cr.
MAP 2
RUBY RIVER STUDY AREA
BEAVERHEAD N.F.
LEGEND
SPRAY BLOCK BDY.
16 SPRAY BLOCK NO.
COLLECTING STATION
NATIONAL FOREST BOUNDARY
0
2 mi
scale

Figure 1. Station 6 and view down Ruby River. Warm Springs Canyon enters Ruby River in center foreground.

Figure 2. Station 6 and aerial view up Ruby River Canyon. Warm Springs Canyon enters on left just above station 6.

Figure 3. Aerial view of Warm Springs Canyon. Ruby River in center of picture.

Figure 4. Aerial view of the Ruby River at Lazy Man Creek just below station 5.

Table 1--Prespray and postspray physical and chemical conditions of the Ruby River in 1957

Station	Hour	Flow c.f.s.	Velocity f.s.	Turbidity	pH	Temperature (°F.)	M.O. alk.	Phen. alk.
			Prespray 7/3 to 7/6					
1	9:00 a.m.	30	3	M[1]	8.1	50	164	T[3]
2	3:00 p.m.	90	3	M	8.3	52	170	T
3	10:30 a.m.	90	3	M	8.2	52	170	T
4	2:00 p.m.	114	3-4	M	8.2	56	170	T
5	11:30 a.m.	150	3	C[2]	8.2	54	160	T
6	1:30 p.m.	250	3	M	8.0	53	160	T
7	4:00 p.m.	---	2½	M	8.0	54	160	T
8	2:30 p.m.	---	2	M	8.0	55	160	T
			Postspray 7/26					
1	9:00 a.m.	21	2-3	T[3]	8.4	55	170	16
2	10:00 a.m.	53	2	C	8.5	54	176	16
3	11:00 a.m.	60	3	C	8.5	54	176	16
4	11:00 a.m.	60	3	C	8.5	54	176	16
5	1:00 p.m.	58	2	C	8.5	62	176	16
6	2:00 p.m.	140	2	C	8.3	67	168	16
7	2:30 p.m.	140	2	C	8.3	66	168	T
8	3:15 p.m.	130	2	C	8.3	64	168	0
			Postspray II, 8/20 to 8/21					
1	9:00 a.m.	10	2	C	8.2	55	182	T
2	10:30 a.m.	40	21 sec.	C	8.4	56	182	6
3	11:15 a.m.	40	2	C	8.4	56	180	6
4	11:00 a.m.	37	2-3	C	8.4	55	180	8
5	10:00 a.m.	42	2	C	8.4	53	180	16
6	2:30 p.m.	100	3	C	8.2	--	170	12
7	2:00 p.m.	100	2-3	C	8.2	--	178	12
8	3:00 p.m.	100	2	C	8.2	--	162	T
			Postspray III, 9/11 to 9/12					
1	10:00 a.m.	---	--	C	8.3	--	208	8
2	12:00 a.m.	---	--	C	8.4	--	190	10
3	2:00 p.m.	---	--	C	8.4	--	190	10
4	4:00 p.m.	---	--	C	8.4	--	190	8
5	8:50 a.m.	33	1	C	8.2	50	190	8
6	10:00 a.m.	---	--	C	8.2	61	188	T
7	2:15 p.m.	---	--	C	---	60	---	--
8	4:20 p.m.	---	--	C	8.2	58	190	4

1/ M - moderate
2/ C - clear
3/ T - trace

Application of Insecticide

A C-82 airplane (flying boxcar) was used to disperse the DDT spray over the timber stand within the study area (block 10) on July 7 (map 2). Long parallel runs were made with many shutoffs for open or grass areas. No special instructions were given the pilot as the Ruby River was to be sprayed by the best practical method for control of the spruce budworm. General instructions included shutoffs over large streams, lakes, or openings over 120 acres in size.

The spray consisted of 1 pound of DDT dissolved in 1.25 quarts of hydrocarbon solvent and diluted in sufficient oil to make 1 gallon of insecticide. Sensitized cards that collected the spray showed varying amounts of DDT reached the ground and water surfaces. (Figure 5)

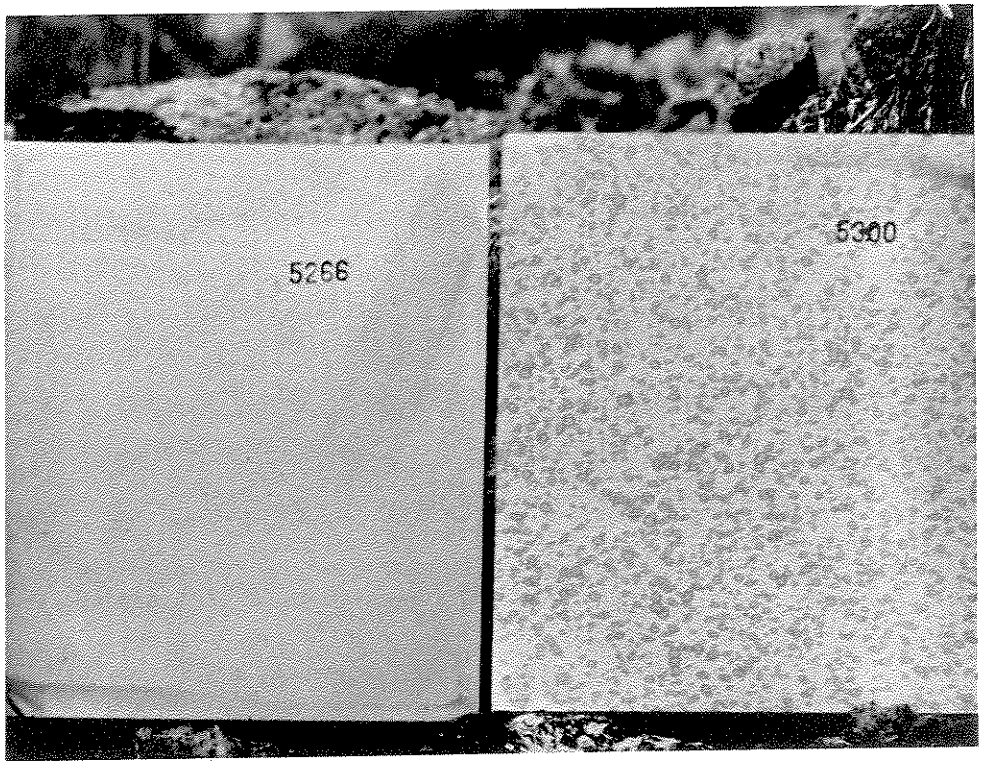


Figure 5. Sensitized cards - aerially sprayed with DDT (5300) and unsprayed card (5266).

Spray cards were placed along the Ruby River from station 1 to station 5, (map 2). This area was selected for spray deposit checking, because scattered patches of Douglas-fir timber extended to the river's edge in many places. The upper 7 miles of the study area was sectionalized to facilitate card laying. Sixty-two cards were placed approximately 500 feet apart along the stream in 6 sections. Section 1 was treeless for a distance of 500 feet, then a mixture of juniper, limber pine, and Douglas-fir extended to the river's edge on the west side of the Ruby River. Section 2 was a continuation of the mixed timber type. Sections 3, 4, and 5 were in open areas with only willow and alder growing along the stream. Section 6 had timber on both sides of the river for about one half mile.

The data from the sensitized cards are presented in tables 2 and 3. Nine sensitized cards failed to reveal any spray deposit, while one card showed 1.2 pounds of DDT per acre reached the river's edge. Side drift occurred in the treeless sections. (Table 3)

Table 2--Amounts of DDT collected on sensitized cards (pounds per acre)

Sections					
1	2	3	4	5	6
0.00	0.20	0.03	0.01	0.01	0.20
0.01	1.00	0.01	0.01	0.01	0.06
0.00	1.00	0.03	0.01	0.02	0.03
0.00	0.20	0.01	0.00	0.01	0.09
0.00	0.20	0.01	0.00	0.00	0.20
0.01	1.20	0.04	0.00	0.01	0.01
0.01	0.50	0.04	0.08	0.01	0.01
	0.08	0.02	0.08	0.01	0.01
	0.07	0.01	0.07	0.01	0.07
	0.09	0.01	0.07	0.01	0.50
	0.13	0.01		0.02	
		0.00		0.02	

Table 3--Summary of stream sections (regrouped by timbered and open sections) (pound DDT per acre)

Miles	Range	Average	Tree cover
.7	0.00-0.01	.01	Open
1.1	0.07-1.2	.63	Moderate
.8	0.01-0.05	.02	Open
2.6	0.00-0.08	.02	Open
1.0	0.01-0.5	.18	Moderate

Forty additional sensitized spray cards were placed at right angles to the river. A line of 20 cards extended a mile on each side of the stream. The spray deposit averaged 0.17 of a pound per acre. An average of 0.15 to 0.20 of a pound per acre is needed to obtain satisfactory spruce budworm mortality.

Chemical Analyses of Water

Numerous water samples were collected, but time and expense limited analyses. Initial results from selected samples determined which samples were analyzed.

Water samples were collected during and after spraying to determine the concentration of DDT in the water and the length of time it remained after spraying. (Figure 6) Two samples of 1 gallon each were collected for each sampling period. Surface water was sampled by immersing half the mouth of the jug, and then moving it back and forth across the stream. Subsurface water was collected in the main current with the entire mouth submerged. For some analyses, surface and subsurface samples were combined. The water samples were acidified to prevent decomposition of DDT in storage.

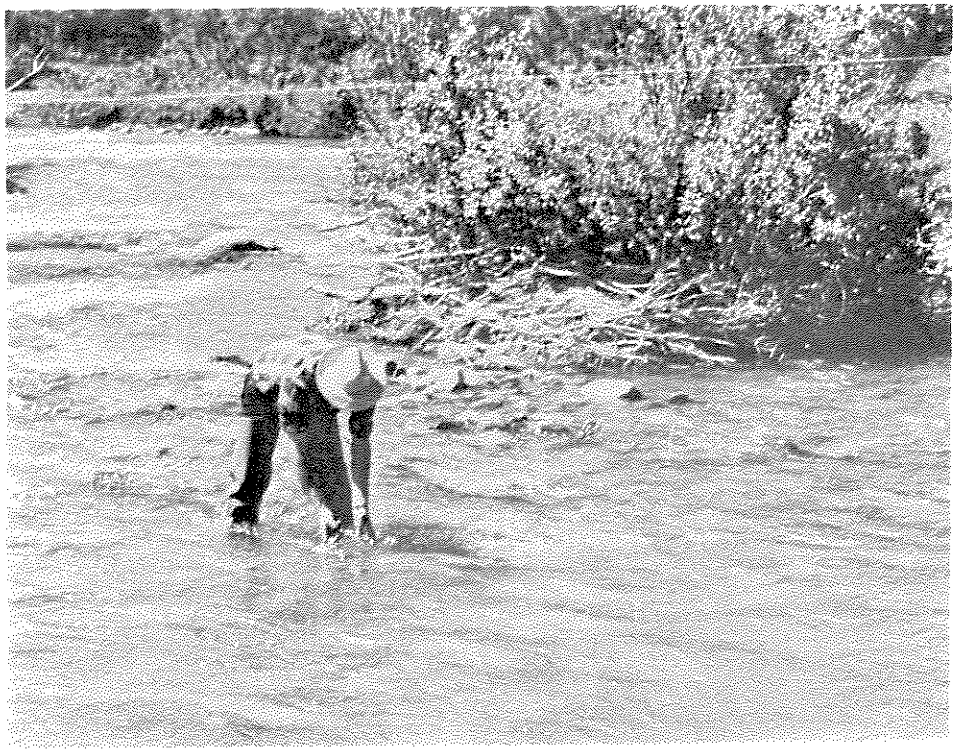


Figure 6. Water samples were collected during and after spraying.

Analyses were made by the Chemistry Department, Montana State College. The extraction procedures used are described by Berck, 1953. Interfering substances were removed, using the chromotographic method developed by Davidow, 1950. Determination of DDT followed the method described by Schechter and Haller, 1945. A recovery curve was made for Ruby River water before spraying.

No DDT was found in prespray water samples. Initial spraying occurred upstream from station 5 at 6:30 a.m. One hour later, a sample of surface water contained 0.03 p.p.m. DDT, while subsurface water contained 0.04 p.p.m. Spraying over station 5 occurred at 8:35 a.m. The quantities of DDT found in samples of surface and subsurface water taken five minutes after this spraying were 1.35 p.p.m. and 0.08 p.p.m. respectively. (Table 4)

Table 4--Results of analysis of water samples collected at station 5, Ruby River

Time after spraying	Type	DDT (p.p.m.)
5 minutes	Surface	1.35
5 minutes	Subsurface	0.08
30 minutes	Surface	0.01
30 minutes	Subsurface	0.01
1 hour	Surface	0.05
1 hour	Subsurface	0.01
2 hours	Surface	T
2 hours	Subsurface	0.01
4 hours	Surface	0.01
4 hours	Subsurface	0.01
10 hours	Surface	0.01
10 hours	Subsurface	0.01
24 hours	Surface	0.01
32 hours	Surface	T
48 hours	Combined	0.00
80 hours	Combined	0.00

Within 2 hours after spraying, the amounts detected decreased to about 0.01 p.p.m. and remained at this level for at least 24 hours. Thirty-two hours following spraying, only a trace could be detected. No DDT was found in water samples taken after this time, even though two were taken following heavy rains.1/

A combined water sample taken 24 hours after spraying and about 4 miles below the spray area (station 8) contained 0.01 p.p.m. DDT.

1/ In 1957, water samples were collected from the Ruby River after .34- and .85-inch rainfalls. One sample was collected 12 days after the initial spraying on July 7, while the other was taken a month after the entire drainage had been sprayed. There was no measurable DDT in the samples.

Chemical Analyses of Aquatic Vegetation

Aquatic vegetation (mostly filamentous algae) was sampled before and after spraying at several stations.

A sample consisted of about 1 pound of material, stored in a plastic bag and frozen. This material was dried and ground so as to pass through a 20-mesh sieve. Ten-to-twenty grams were extracted in a soxhlet with ether for 6 to 8 hours. Analyses were made at Montana State College and followed the procedures used for water.

Results presented in table 5 are on a dry-weight basis and therefore are considerably concentrated compared to wet weights. No DDT was found in prespray samples, but it was found in all samples collected after spraying. Some of these samples were taken at least 10 miles below the spray area and about 2 months following spraying. It is interesting to note that DDT was found on the late summer vegetation which had considerable more growth than at the time of spraying.

Table 5--Results of analysis of aquatic vegetation collected from the Ruby River, 1957

Date collected	Location	DDT (p.p.m.)
July 9	Station 6	6.8
July 30	Station 6	1.5
July 30	10 miles below spray area	0.9
September 6	Station 6	0.5
September 10	10 miles below spray area	0.7

Chemical Analysis of Bottom Sediment

A thin layer of bottom sediment (coarse and fine silt) was collected and acidified to prevent the decomposition of DDT in storage. Analyses were made at Montana State College following the procedures used for water.

Collections corresponded to aquatic vegetation sampling as to time and place. No DDT was found in the bottom sediments collected before or after spraying.

Drift Samples

Under normal condition small quantities of aquatic insects are carried downstream. However, when a DDT oil solution is sprayed on streams the bottom organisms are affected soon after application, come to the surface and float downstream. A 5-minute drift sample is adequate to show this movement of dead and dying insects.

Drift samples were taken periodically at one location (station 5) to aid in evaluating the results of the bottom sampling. Prespray samples did not produce measurable volumes of insects. On July 7, 1957 (spray day), samples indicated an insect loss 45 minutes after the plane passed over a small section of stream in the upper end of the spray block. Another pass

(over station 5) at 8:30 a.m. increased the loss, and by 8:50 a.m. it reached 110 cc., of which 70 percent were mayflies. The volume of drifting insects began to decrease within 2 hours after spraying. Twenty-four hours later only 3 cc. were collected. (Table 6) Four days after spray day no insects were taken in the drift samples.

Table 6--Drift samples: Volumes of insects collected in 5-minute drift samples at station 5

Date	Time	Volume cc.	Predominant forms	Remarks
7-7	7:15	40	Black flies, 95%	Spray day
	7:45	46	Black flies, 85%	Postspray
	8:50	110	Mayflies, 70%	Postspray
	9:50	110	Mayflies, 70%	Postspray
	10:45	95	Mayflies, 95%	Postspray
	1:00	70	Mayflies, 95%	Postspray
	2:50	20	Mayflies, 95%	Postspray
	5:00	15	Mayflies, 70%	Postspray
	6:45	5	Mayflies, 60%	Postspray
7-8	8:45	3	Caddisflies, 50%	Postspray
7-9	9:00	0.3	Stoneflies, 30%	Postspray
7-10	9:00	0.1	Miscellaneous	Postspray
7-11	0		---	---
7-12 to 7-14	0		---	---

Spraying in the upper section of the West Fork of the Ruby River (block 16, map 1) on July 17, 1957, did not produce a measurable volume of drift insects. A 5-minute sample taken at 3:30 p.m. showed only about 100 small mayflies. Two drift samples taken at 9:30 a.m. and 4:00 p.m. on July 18 failed to reveal any change in the number of mayfly nymphs floating downstream. A .34-inch rain the night of July 18 made the river turbid, but a drift sample taken at near peak flow (8:30 a.m.) was still considered to be normal. Apparently the run-off did not carry sufficient DDT to cause insect mortality.

Stream Bottom Sampling

Eight stream bottom sampling stations were established from one half mile above the confluence of the East Fork and West Fork tributaries of the Ruby River (station 1) to Ledford Bridge (station 8). This is a road distance of about 17 miles. (Map 2)

Station 1 was not in timber type and, therefore, was not in the spray area. Spraying on tributaries above this station precluded its use as a control station. The next station down the river (station 2) was established at the mouth of Elk Creek. There a mixture of limber pine, juniper, and Douglas-fir timber formed a continuous band for about 0.2 of a mile on the west side of the Ruby River.

Both station 3 at the mouth of Burnt Creek and station 4, near the entrance of Bear Creek were out of type (no Douglas-fir trees were immediately adjacent to the stream).

Station 5 was located below a small canyon, with half mile of mixed type on each side, which required the immediate shoreline to be sprayed. Because the stream gradient changed and the timber type was farther away from the stream below station 5, this station was selected for intensive water sampling.

Stations 6, 7, and 8 were established in the more open areas of a meandering stream at Marshall Bridge, Canyon Camp, and Ledford Bridge, respectively.

High water during the prespray sampling period prevented the use of the Surber square-foot sampler; therefore, a square-yard sampling method was adopted. This sampler consists of a metal frame (3 feet square) to outline the unit area to be sampled, and a collecting net made of common window screen fastened to two portable, upright wooden pole handles. (Figure 7) Agitation within the boundary of the metal frame loosened the bottom invertebrates, and they were collected on this net at the lower edge of the frame. Care was exercised to prevent side drift and over-the-top losses. Then the screen was cleaned over a plastic sheet and the bottom organisms were separated from the debris and placed in vials containing alcohol. (Figure 8)

In 1957, two square-yard bottom samples were taken four times during the summer season at each of the eight stations on the Ruby River. These 64 samples were preserved and identified to order (except dipterous material, which was identified to family).

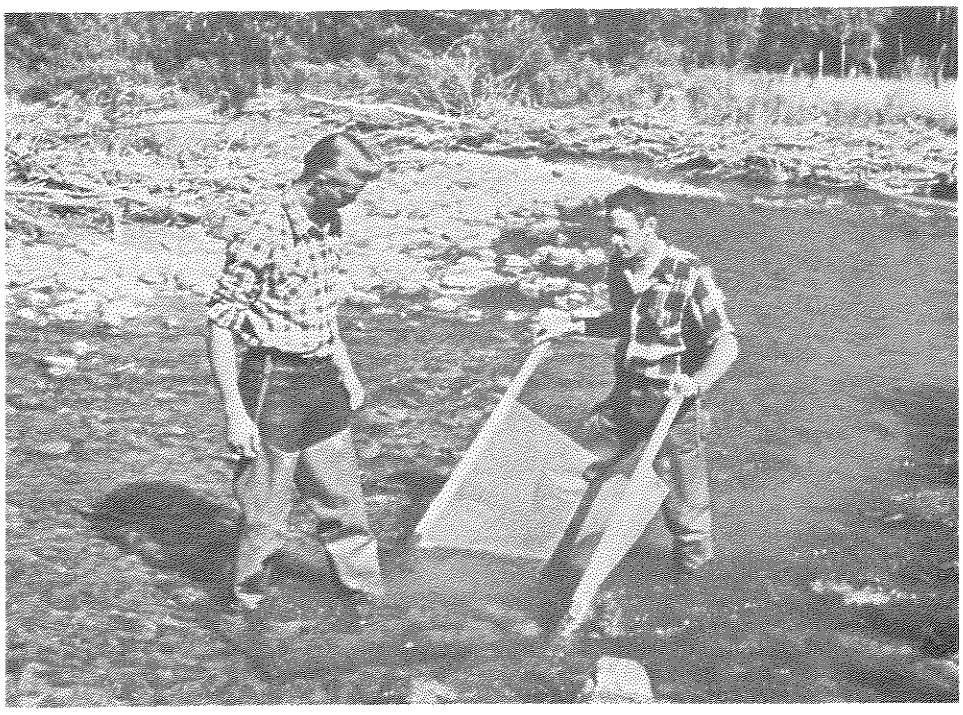


Figure 7. Square-yard samples. Note metal frame outlining unit to be sampled.

Figure 8. Bottom organisms, separated from debris, are placed in collecting vials.

In table 7, prespray samples show that mayflies and caddisflies made up 85.9 percent of the population and 44.4 percent of the volume of the aquatic insects collected. Stoneflies comprised only 5.6 percent of the insect population, they represented 44.4 percent of the volume. Postspray samples (taken 20 days after spraying), show mayflies and caddisflies to be only 10.2 percent of the population and 1.7 percent of the volume. Stoneflies were less affected by the DDT spray and increased in number and volume by July 26. On September 11, postspray samples show a slight recovery in numbers and volume of caddisflies and mayflies.

The Ruby River was resampled during the 1958 season in order to determine the length of time required to reach a near normal aquatic bottom fauna population. The term "near normal," as used here, means the recovery of the predominant forms which produce the bulk of the trout food. No attempt was made to establish the rate of recovery of individual species.

In comparing July 1958 postspray samples with July 1957 prespray samples, the mayflies recovered favorably, but the number of caddisflies was still only a small percentage of the original prespray number.

However, by September 1958, the aquatic insect population had increased to near normal numbers with the exception of the caddisfly population. The combined volume, however, was well below normal. September 1958 volumes of mayflies and caddisflies did not equal July prespray (1957) volumes; whereas, in a normal population a substantial increase in volume would be expected by September.

Of the four major insect orders present in the Ruby River, population reductions appeared to be most severe in Trichoptera (caddisflies) and Ephemeroptera (mayflies). The Plecoptera (stoneflies) seemed to be less affected than the Diptera (true flies) when all species were considered. However, horse flies (Diptera) apparently were not affected by the spray.

These data do not support the reports of other studies that have classed the Plecoptera highly susceptible. It may be that the species, Pteronarcys sp., that comprises the bulk of the Plecoptera in this study are less susceptible.

Considerable variation may be noted in the samples taken at various stations. (Table 8) This may be due to insufficient samples, low populations, and that sampling dates did not consider cyclic development of the aquatic insects.

Table 7--Summary of combined stations of stream insects collected in the Ruby River, 1957, volume in cc. per square yard of immature insects with number predominant forms shown

Insects	Prespray, July 3 to 6				Postspray, July 26				Postspray, August 20				Postspray, September 11			
	No.	Percent	Volume	Percent	No.	Percent	Volume	Percent	No.	Percent	Volume	Percent	No.	Percent	Volume	Percent
Mayflies	498	49.3	5.8	18.0	13	8.3	.1	.6	2	1.0	.1	.4	21	7.4	.2	.7
Caddisflies	369	36.6	8.5	26.4	3	1.9	.2	1.1	2	1.0	--	--	11	3.9	.3	1.1
Stoneflies	56	5.6	14.3	44.4	43	27.6	12.0	66.7	98	50.5	24.2	92.4	76	26.8	22.2	80.1
Horse flies	79	7.8	2.9	9.0	94	60.3	5.1	28.3	89	45.9	1.9	7.2	139	48.9	4.6	16.6
Other	7	.7	.7	2.2	3	1.9	.6	3.3	3	1.6	T	--	37	13.0	.4	1.5
Totals	1,009		32.2		156		18.0		194		26.2		284		27.7	

Table 8--Stream insects collected in the Ruby River, 1957, volume in cc. per square yard of immature insects with number predominant forms shown

Station	Insects	July 3 to 6, prespray		July 26 postspray 1		August 20 and 21, postspray 2		September 11 and 12, postspray 3	
		No.	Volume	No.	Volume	No.	Volume	No.	Volume
1	Mayflies	43	0.8	2	--	--	--	9	0.1
	Stoneflies	20	4.2	16	2.6	37	9.0	21	2.8
	Caddisflies	120	3.1	--	--	--	--	8	0.3
	Midges	--	--	--	--	--	--	2	--
	Black flies	--	--	--	--	1	--	2	--
	Horse flies	9	0.2	10	0.6	15	0.3	33	0.8
	Totals	192	8.3	28	3.2	53	9.3	75	4.0
2	Mayflies	57	0.7	2	--	1	0.1	2	.1
	Stoneflies	2	0.8	4	1.6	10	2.1	13	5.8
	Caddisflies	64	1.2	1	--	--	--	1	--
	Midges	--	--	--	--	1	--	2	--
	Beetle larva	1	--	--	--	--	--	--	--
	Black flies	--	--	--	--	--	--	1	--
	Horse flies	11	0.5	17	0.9	12	0.2	39	1.1
	Totals	135	3.2	24	2.5	24	2.4	58	7.0
3	Mayflies	37	0.3	--	--	--	--	--	--
	Stoneflies	6	2.6	8	2.0	7	2.4	8	3.4
	Caddisflies	14	0.6	1	0.1	--	--	1	--
	Horse flies	7	0.3	9	0.5	10	.1	4	.4
	Dragonflies	--	--	--	--	--	--	--	--
	Totals	64	3.8	18	2.6	17	2.5	13	3.8
4	Mayflies	58	0.8	--	--	--	--	2	--
	Stoneflies	7	3.4	5	2.1	10	4.6	6	2.0
	Caddisflies	36	0.6	--	--	1	--	1	--
	Midges	--	--	--	--	--	--	1	--
	Black flies	--	--	--	--	--	--	1	--
	Horse flies	15	0.5	26	1.4	12	.2	19	0.5
	Totals	116	5.3	31	3.5	23	4.8	30	2.5

Table 8--Stream insects collected in the Ruby River, 1957--Continued

Station	Insects	July 3 to 6, prespray		July 26 postspray 1		August 20 and 21, postspray 2		September 11 and 12, postspray 3	
		No.	Volume	No.	Volume	No.	Volume	No.	Volume
5	Mayflies	46	0.4	1	--	--	--	1	--
	Stoneflies	6	0.7	6	3.5	5	1.2	9	2.7
	Caddisflies	35	0.5	--	--	1	T	--	--
	Horse flies	22	0.8	12	0.9	12	0.3	21	0.6
	Totals	109	2.4	19	4.4	18	1.5	31	3.3
6	Mayflies	56	0.7	--	--	--	--	1	--
	Stoneflies	5	1.8	4	0.2	27	4.9	15	4.8
	Caddisflies	51	1.2	1	0.1	--	--	--	--
	Beetle larva	1	--	--	--	--	--	--	--
	Horse flies	12	0.5	19	0.8	27	0.8	18	1.0
	Dragonflies	--	--	--	--	--	--	--	--
	Totals	125	4.2	24	1.1	54	5.7	34	5.8
7	Mayflies	110	1.3	2	--	--	--	4	--
	Stoneflies	4	0.1	--	--	1	T	2	0.3
	Caddisflies	24	0.8	--	--	--	--	--	--
	Midges	--	--	--	--	--	--	8	--
	Black flies	--	--	--	--	--	--	4	--
	Crane flies	--	--	--	--	--	--	2	0.2
	Horse flies	--	--	--	--	--	--	3	0.1
	Beetle larva	1	--	--	--	--	--	--	--
	Dragonflies	--	--	2	0.4	--	--	1	0.1
	Totals	139	2.2	4	0.4	1	T	24	0.7
8	Mayflies	91	0.8	6	0.1	1	T	2	--
	Stoneflies	6	0.7	--	--	1	0.1	2	0.4
	Caddisflies	25	0.5	--	--	--	--	--	--
	Midges	2	--	--	--	--	--	13	--
	Beetle larva	--	--	--	--	--	--	1	--
	Crane flies	1	0.6	--	--	--	--	1	0.1
	Horse flies	3	0.1	1	--	1	T	2	0.1
	Dragonflies	1	0.1	1	0.2	--	--	--	--
	Totals	129	2.8	8	0.3	3	0.1	21	0.6

Table 9--Summary of combined stations of stream insects collected in the Ruby River, 1958, volume in cc. per square yard of immature insects with number predominant forms shown

Insects	Postspray, July 15				Postspray, August 19				Postspray, September 23			
	No.	Percent	Volume	Percent	No.	Percent	Volume	Percent	No.	Percent	Volume	Percent
Mayflies	340	41.9	3.85	19.6	287	26.3	0.96	3.8	522	47.4	3.35	9.6
Stoneflies	52	6.4	9.85	50.1	175	16.0	18.05	71.1	234	21.3	26.20	74.7
Caddisflies	70	8.6	2.55	13.0	89	8.1	1.80	7.1	200	18.2	2.05	5.9
Black flies	295	36.3	1.95	9.9	462	42.3	2.20	8.6	15	1.4	0.05	0.1
Horse flies	35	4.3	1.45	7.4	64	5.9	1.85	7.3	105	9.5	2.43	6.9
Other	20	2.5	0	0	16	1.4	0.55	2.1	24	2.2	1.00	2.8
Totals	812		19.65		1,093		25.41		1,100		35.08	

Table 10--Stream insects collected in the Ruby River, 1958, volume in cc. per square yard of immature insects with number predominant forms shown

Station	Insects	July 15, postspray		August 19, postspray		September 23, postspray	
		No.	Volume	No.	Volume	No.	Volume
1	Mayflies	20	0.20	4	T	75	0.30
	Stoneflies	2	0.25	21	3.20	34	3.20
	Caddisflies	36	1.30	18	0.65	15	0.50
	Black flies	1	T	15	.05	0	0
	Horse flies	10	0.20	30	.65	52	1.05
	Other	2	T	3	0.55	5	0.20
	Totals	71	1.95	91	5.10	181	5.25
2	Mayflies	53	1.05	65	0.13	142	1.20
	Stoneflies	4	0.65	10	1.70	31	3.95
	Caddisflies	12	0.65	5	0.15	45	0.30
	Black flies	135	1.25	119	0.40	0	0
	Horse flies	12	0.60	16	0.45	23	0.85
	Other	1	T	4	T	3	0.05
	Totals	217	4.20	219	2.83	244	6.35
3	Mayflies	36	0.40	76	0.30	108	0.60
	Stoneflies	5	1.25	12	3.95	29	3.05
	Caddisflies	8	0.30	1	T	37	0.20
	Black flies	133	0.65	138	0.45	0	0
	Horse flies	8	0.40	6	0.30	10	0.03
	Other	2	T	2	T	8	0.55
	Totals	192	3.00	235	5.00	192	4.43
4	Mayflies	29	0.45	75	0.35	76	0.55
	Stoneflies	10	5.10	10	1.30	26	2.20
	Caddisflies	3	0.10	0	0	23	0.15
	Black flies	0	0	15	0.10	0	0
	Horse flies	2	0.10	7	0.20	10	0.40
	Other	0	0	1	T	3	0.20
	Totals	44	5.75	108	1.95	138	3.50

Table 10--Stream insects collected in the Ruby River, 1958--Continued

Station	Insects	July 15, postspray		August 19, postspray		September 23, postspray	
		No.	Volume	No.	Volume	No.	Volume
5	Mayflies	15	0.20	28	0.10	58	0.45
	Stoneflies	4	0.90	25	4.95	97	13.15
	Caddisflies	3	0.05	2	0	43	0.20
	Black flies	3	0	84	0.45	0	0
	Horse flies	1	0.05	3	0.20	9	0.10
	Other	1	0	3	0	1	0
	Totals	27	1.20	145	5.70	208	13.90
6	Mayflies	115	0.65	31	0.08	1	0
	Stoneflies	4	1.10	21	0.90	2	0.40
	Caddisflies	6	0.15	63	1.00	35	0.65
	Black flies	3	0	15	0.05	0	0
	Horse flies	2	0.10	1	0.05	0	0
	Other	14	T	3	0	4	0
	Totals	144	2.00	134	2.08	42	1.05
7	Mayflies	7	0.10	4	T	28	0.10
	Stoneflies	0	0	1	T	1	T
	Caddisflies	1	T	0	0	2	0.05
	Black flies	20	0.05	76	0.70	6	T
	Horse flies	0	0	0	0	0	0
	Other	0	0	0	0	0	0
	Totals	28	0.15	81	0.70	37	0.15
8	Mayflies	65	0.80	4	T	34	0.15
	Stoneflies	23	0.60	75	2.05	14	0.25
	Caddisflies	1	T	0	0	0	0
	Black flies	0	0	0	0	9	0.05
	Horse flies	0	0	1	T	1	0
	Other	0	0	0	0	0	0
	Totals	89	1.40	80	2.05	58	0.45

Fish Population

The fish population was sampled with a 500-watt, 240-volt electric shocker. Three-hundred-foot sections of the stream were selected and blocked at both ends with nets. Each section was shocked three times during a sampling period. Stunned fish were captured with dip nets and were anesthetized in a 0.5 percent solution of urethane before measuring. Total lengths were taken to the nearest 0.1 of an inch. Only fish over 3 inches long were used in population index numbers, since fish smaller than this could not be efficiently collected.

Four sections were selected on the Ruby River from station 1 to just below station 5. The river below the entrance of Warm Springs Creek was too large to be efficiently sampled by the method used. High water prevented sampling all sections except station 1 prior to spraying. Results obtained from shocking as soon after spraying as streamflow permitted (table 11) indicate that over 75 percent of the fish in the area were suckers. The average number of trout per section was less than 6 and nearly all of these were rainbow. Sampling between the entrance of Warm Springs Creek and Canyon Camp indicated that the species composition and relative abundance was similar to the above. Creel census and sampling below Canyon Camp showed that brown trout were more common, but abundance could not be determined.

Table 11--Number of fish collected by shocking, Ruby River, 1957

Species	Number and average length	Section and date shocked: 1 8/26	2 7/29	3 7/29	4 8/2	Total
Rainbow trout	Number	6	6	3	6	21
	Average length	7.7	9.2	10.7	9.9	
Brown trout	Number	1	--	--	1	2
	Average length	20.7	--	--	19.2	
Whitefish	Number	--	--	2	--	2
	Average length	--	--	10.5	--	
Longnose sucker	Number	1	29	11	38	79
	Average length	6.1	12.6	10.1	13.6	
Common sucker	Number	--	4	2	--	6
	Average length	--	6.8	11.7	--	

The number of fish captured from section 1 (located above spray area) the day before spraying (July 6) were 2 rainbow trout and 30 longnose suckers. On August 26, 1 brown trout, 6 rainbow trout, and only 1 sucker were collected. The large number of suckers present on July 6 were considered to be spawners that had migrated upstream to the area and by August 26 they had moved back downstream.

Spraying along Warm Springs Creek was limited to one side of a mile-long canyon area. (Figure 3) The lower part of this canyon is about 1 mile above the stream's entrance into the Ruby River. Three shocking sections were established on Warm Springs Creek. Sections 1 and 2 were in the canyon and section 3 was in the meadow below. Results obtained from shocking 1 week prior to spraying and 7 weeks following spraying are presented in table 12. Sculpins and dace were numerous but numbers were not recorded. Game fish (mostly rainbow trout) comprised less than 15 percent of the fish recorded. No significant reduction of the fish population between sampling periods was noted. No young trout less than 3 inches long were observed on either stream. No observations were made in 1958.

Table 12--Number of fish collected by shocking, Warm Springs Creek, 1957

Species 1/	Number and average length	Before spray, June 25 and 26 Sections 1	2	3	Total	After spray, August 27 Sections 1	2	3	Total
Rb and CT	Number	7	8	7	22	5	6	5	16
	Average length	9.4	8.4	9.2	--	7.6	8.5	10.0	--
LL	Number	1	1	0	2	0	0	0	0
	Average length	15.7	14.3	--	--	--	--	--	--
FSu	Number	19	37	12	68	17	40	4	61
	Average length	9.6	12.4	10.5	--	7.3	8.9	9.6	
CSu	Number	3	10	2	15	9	28	2	39
	Average length	10.5	8.7	9.3	--	6.9	5.8	3.9	
JSu	Number	10	25	15	50	3	54	12	69
	Average length	7.3	5.7	6.8	--	5.3	6.2	5.6	
Stonecat	Number	--	--	36	36	--	3	16	19
	Average length	--	--	4.5	--	--	4.7	4.6	

1/ Rb and CT - rainbow trout, cutthroat trout and hybrids
LL - brown trout
FSu - longnose sucker
CSu - common sucker
JSu - mountain sucker

Fish Mortalities

The portion of the Ruby River between stations 1 and 5 and the canyon and meadow areas of Warm Springs Creek were intensively patrolled by 9 men on spray day and the day following. No dead fish were found on spray day, but on the day after, 3 longnose suckers and 1 mountain sucker were recovered from the meadow on Warm Springs Creek. Patrolling on July 9 was conducted along 2 miles of the river near station 5, 1 mile of the river above Canyon Camp (station 7) and the lower part of Warm Springs Creek.

Dead fish found included 3 dace from Warm Springs Creek and 3 suckers and 1 rainbow trout from the section above Canyon Camp. The rainbow trout appeared to have suffered a mechanical injury.

On July 10, a section of the river (approximately 2 miles) above Canyon Camp (station 7) was selected for periodic patrolling. The numbers of dead suckers found in this area increased from 9 on July 10 to 80 on July 17. By the end of July, a total of 345 were recovered. Dead suckers were found throughout the summer and fall (patrolling in this area ended November 29), but in smaller numbers. Only 1 dead brown trout and 1 whitefish were found in this area.

No dead fish were found in the river above station 5, but irregular patrolling revealed some sucker mortality between station 5 and the entrance of Warm Springs Creek. Float trips made in late July showed that the sucker mortality occurred for approximately 8 miles below the spray boundary.

On November 29, 1957, 5 dead and 1 sick brown trout were found in several hundred yards of the river near Ledford bridge. Thirty dead brown trout and 3 suckers were found in a 2 mile stretch of the river in ths area on December 4. Two weeks later, dead fish recovered from this section included 31 brown trout, 2 whitefish, and 16 suckers. Heavy brush cover, muck bottom, and pools 8 to 10 feet deep prevented efficient patrolling, and it is doubtful if more than 25 percent of the dead fish were found. Considering the relatively poor productivity of the upper Ruby River as indicated in bottom sampling, shocking, and creel census, this trout mortality is greater than usual, even when following the spawning season. No patrolling was done in 1958.

Chemical Analysis of Fish

Fish samples were analyzed to determine the amount of DDT accumulating in tissues following spraying. It was thought that by analyzing both live and dead fish, the results might indicate the amount of DDT that would cause mortalities. Determining the amount of DDT in vital organs would have been more desirable, but it was not possible to collect enough of this material so entire fish were used.

A sample consisted of from 1 to 6 fish. After collection, the sample was refrigerated, ground in a meat grinder, hand blended, and the composite was frozen for storage. The stomach contents were removed from all fish before grinding. Only dead fish with red gills, and therefore quite fresh, were considered in these results. Analysis was made on 50 to 100 grams of the sample following procedures described by Davidow, 1950, and Schechter and Haller, 1945.

No DDT was found in samples collected just prior to spraying, but it was found in all fish (dead or alive) collected following spraying. The amounts detected varied from 0.10 p.p.m. in a sample of dead suckers to 6.20 p.p.m. in a sample of sick suckers (table 13). Quite often more DDT was found in live fish than in dead fish. Some of this variability was

probably due to the fact that the entire sample was not analyzed. Since DDT concentrates in fatty tissue, a disproportionate amount of fat in the sample extracted for analysis would give a high result. The results of fish analyses were not received until late in the year so the techniques could not be modified to limit this variability. Inconsistent results due to methods of treating samples were partly verified when analysis was made on two portions extracted from the last sample submitted (number 13). The amounts found in these portions were 5.0 p.p.m. and 0.6 p.p.m.

The Chemistry Department at Montana State College was unable to continue analysis, so the remaining work was done at the Wisconsin Alumni Research Foundation, and similar methods were used. The remainder of sample 13 was divided into two parts and sent to Wisconsin. The amounts detected for these parts were 5.02 p.p.m. and 6.75 p.p.m.

Table 13--Results of analysis of fish samples collected between stations 6 and 8, Ruby River

Sample	Date collected	Sample Number	Sample Species	Condition	DDT (p.p.m.)
1	July 8	1	Rainbow trout	Dead	1/1.06
2	July 9	2	Suckers (f.s.) 2/	Dead	0.07
3	July 10	5	Suckers (f.s.)	Dead	0.10
4	July 10	4	Suckers (f.s.)	Dead	0.39
5	July 11	2	Suckers (f.s.)	Dead	0.27
6	July 30	6	Suckers (f.s.)	Live	2.31
7	July 30	6	Rainbow trout	Live	3.19
8	September 13	6	Rainbow trout	Live	1.90
9	September 14	4	Brown trout	Live	1.30
10	September 14	2	Suckers (c.s.) 3/	Live	4/5.80
		1	Sucker (f.s.)	Live	
11	November 12	2	Suckers (f.s.)	Sick	6.20
12	November 12	1	Brown trout	Sick	3.70
13	December 4	5	Brown trout	Dead	(5.00
					(0.60
					1/(5.02
					1/(6.75

1/ Analyzed by Wisconsin Alumni Research Foundation.
2/ Longnose suckers.
3/ Common suckers.
4/ Appreciable amounts of DDE, a metabolite of DDT, were found only in sample 10 (1.1 p.p.m.) and sample 12 (0.4 p.p.m.).

A group of live fish was collected from the Ruby River on June 17, 1958, to test variability due to blending materials and chemical methods. These analyses were made at the Wisconsin Alumni Research Foundation. Samples of fish were subsampled, considering various tissues and methods of blending. Results are presented in table 14.

Table 14--Analysis of fish collected between station 6 and 8, Ruby River, June 17, 1958

Sample	Subsample		DDT p.p.m.
	Material	Mixture	
No. 1, 7 longnose suckers	Whole fish	Hand blend	2.90
	Whole fish	Hand blend	2.86
	Whole fish	Mechanical blend	2.12
	Whole fish	Mechanical blend	1.62
No. 2, 12 common suckers	Viscera	Mechanical blend	1.50
	Viscera	Mechanical blend	2.20
	Flesh (fillet)	Mechanical blend	0.95
	Flesh (fillet)	Mechanical blend	0.25
	Flesh (fillet)	Mechanical blend	1.11
	Flesh (fillet)	Mechanical blend	1.00
No. 3, 5 rainbow trout	Flesh (fillet)	Mechanical blend	0.54
No. 4, 20 rainbow trout	Viscera	Mechanical blend	0.45
No. 5, 4 brown trout	Flesh (fillet)	Mechanical blend	0.67
No. 6, 5 whitefish	Flesh (fillet)	Mechanical blend	3.00

The flesh of 12 suckers (sample 2) was removed, ground in a meat grinder, hand blended, divided into 4 subsamples, and frozen for shipping. Before analysis, these subsamples were mechanically blended so that samples extracted were homogeneous. The amount of DDT found in one subsample was four times greater than in another, indicating that some of the variability may be due to chemical procedures.

Because of the inconsistent results, no conclusions are made on the amount of DDT in fish that might indicate mortality due to spraying with DDT. In any case, the effect of a particular concentration of DDT would vary considerably, depending on environmental conditions and the physical condition of the fish. Bio-assays conducted by the Montana Fish and Game Department have shown that an increase in water temperature of 3 degrees F. resulted in an immediate increase in the mortality rate of test fish.

MISCELLANEOUS OBSERVATIONS

Madison River

About 6 miles of the canyon area of the Madison River below Hebgen Lake was sprayed July 12 to 15, 1957. Extreme caution was used in spraying this area. Spray cards placed along the stream indicated that only a small amount of DDT was introduced into the river, but tributary streams received normal dosages (.15 to .20 pounds per acre). Trace amounts of DDT were found in water samples collected from the river below the canyon on the mornings of July 12 and 15.

Numerous drifting insects were observed in Beaver Creek (a tributary to the river in the canyon area) on July 13, the day this drainage was sprayed. One 5-minute drift sample contained 6.45 cc. of drifting insects. The next day the volume had decreased to 1.65 cc. The amounts collected in drift samples from Cabin Creek, another tributary of the Madison, increased from 0.4 cc. on July 13 to 3.3 cc. on July 15, the day this drainage was sprayed.

A drift sample collected from the Madison River about 2 miles below the canyon on July 11 contained 0.3 cc. volume of insects. On July 12, this increased to 1.8 cc. and remained at about this level through July 14. On July 15, 0.3 cc. were found. Most of these drifting insects were extremely small mayflies. Over 2,000 were found in one sample, with a volume of 1.9 cc.

Bottom insects were sampled at 3 stations within the spray area and at 3 stations below. Two square-yard samples were collected for each sample except at station B where 3 square-yards were sampled. Results are presented in table 15.

Aquatic insects were reduced in sprayed areas and for at least 2 miles below. Mayflies and caddisflies showed the greatest reduction, and true flies (Diptera) were affected the least. The bulk of the flies were horse flies. Whereas fall volumes in control stations on other streams show increases of 3 to 4 times over June samples, the fall volumes on this stream are 3 to 4 times less. Affects on stations E and F (8 and 25 miles) below the spray area were considerably less.

Although insects were materially reduced, no fish mortalities were reported from this area of the river.

Table 15--Volume and number per square yard of bottom insects collected in Madison River, 1957

Station	Insects	June 11 to 23 Number	June 11 to 23 Volume	September 23 to 29 Number	September 23 to 29 Volume
A - upper end spray area	Mayflies	495	8.3	65	0.9
	Caddisflies	63	2.0	24	0.2
	Stoneflies	4	0.3	2	0.6
	Flies	503	12.3	106	3.5
	Totals	1,065	22.9	197	5.2
B - middle of spray area	Mayflies	258	4.8	34	0.1
	Caddisflies	34	1.5	21	0.1
	Stoneflies	6	1.0	5	0.1
	Flies	116	5.3	130	3.6
	Totals	414	12.6	190	3.9
C - lower end spray area	Mayflies	765	10.0	114	1.0
	Caddisflies	15	0.3	26	0.4
	Stoneflies	42	1.9	5	0.6
	Flies	30	1.4	54	1.4
	Totals	852	13.6	199	3.4
D - 2 miles below spray area	Mayflies	801	6.1	55	0.1
	Caddisflies	104	1.6	34	0.5
	Stoneflies	67	7.0	7	0.3
	Flies	69	2.3	63	1.2
	Totals	1,041	17.0	159	2.1
E - 8 miles below spray area	Mayflies	298	2.6	16	0.1
	Caddisflies	23	0.2	44	0.6
	Stoneflies	32	0.1	12	0.2
	Flies	27	1.0	16	2.4
	Totals	380	3.9	88	3.3
F - 25 miles below spray area	Mayflies	133	2.0	4	---
	Caddisflies	124	2.3	175	3.1
	Stoneflies	52	4.8	44	4.3
	Flies	14	0.3	23	0.2
	Totals	323	9.4	246	7.6

Judith River

The inaccessible headwaters of the Judith River were sprayed over about a 2-week period (July 8 to 23, 1957). The drainage area is fan-shaped and samples were collected at the base of the fan where the river is formed.

No DDT was found in water samples collected every other morning from July 11 through July 25.

The square-yard samples were taken at 3 stations below where the river is formed, on July 1, 11, and 23, 1957. Results are presented in table 16.

Table 16--Volume and number per square yard of bottom insects collected in Judith River, 1957

	July 1		July 11		July 23	
Station	Number	Volume (cc.)	Number	Volume (cc.)	Number	Volume (cc.)
1	149	2.1	31	0.8	2	0.1
2	206	2.8	41	1.4	6	0.4
3	102	1.2	20	1.1	3	0.2
Totals	457	6.1	92	3.3	11	0.7

The number and volume of aquatic insects was materially reduced between July 1 (prespray) and July 23 (postspray) samples. It is possible that DDT was present in the water in such small quantity that it could not be chemically detected by the method used. Although insect reductions occurred, no fish mortalities were reported for this area.

Big Hole River

On July 18, 1957, a reported fish mortality in the Big Hole River at the Butte Water Commission Pumping Station was investigated. The station operator stated that DDT spraying in the immediate area occurred on about July 5, 1957, but the smell of spray was strong each morning from July 7 through July 9. The Forest Service reported that on one of these mornings, airplane trouble resulted in spraying closer to the river than planned. The operator of the pumping station first noticed dead suckers on July 10 but did not become concerned until July 14, when he removed about 60 suckers in a distance of 200 yards. He patrolled a 1-mile section above the pumping station each day after July 14 but did not record the number of dead fish removed. On July 17, he did remove at least 125 suckers from this section of the river. Also removed during the die-off were 2 rainbow trout, 5 whitefish, and some sculpins. The Big Hole River was patrolled for a distance of 5 miles below the pumping station on July 22 and dead fish recovered included 119 suckers, 2 whitefish, 1 ling, and 1 sculpin. The mortality at the pumping station decreased rapidly and had dwindled to nothing by July 25. On December 3, the operator stated that no additional fish mortality had occurred up to that time. A careful examination of dead suckers was made and no bacteria or parasites which might have caused the mortality were found. DDT (2.39 p.p.m.) was found in a sample of the dead suckers.

A reported fish die-off on the Big Hole River between the Butte Pumping Station and Melrose (about 10 miles downstream) was investigated on March 20, 1958. Dead fish were first observed in late February when the ice began to break up, but the mortality was apparently over at the time of the investigation.

Interviews with local residents revealed the species composition of the die-off to be mostly suckers, some whitefish, and a few trout. Three deep sections of the river near Melrose were patrolled and 53 dead suckers and 2 dead whitefish were counted.

Deadman Lake

About 30 dead cutthroat trout were found along the shore of this small mountain lake on the day spraying occurred below the lake. The smell of DDT spray and the presence of an oil film on water surface was reported. Six days following spraying the shore was patrolled and only 15 dead fish were found. Trout were observed swimming in the lake on this day and live sculpins, caddisflies, and stoneflies were found in the stream above and below the lake. A sample of dead fish was analyzed for DDT and 2.91 p.p.m. were found.

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