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The Effects of an Aerial DDT Application in the Boulder River System and Golconda Creek, near Boulder, Montana

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During the period June 29 - July 15, 1962, DDT was applied to approximately 97,000 acres in the Boulder River drainage in an effort by the U. S. Forest Service to control the spruce budworm. An investigation was made in the river and some tributaries before, during, and following the application, to determine:

1. The amount of DDT reaching the streams and in solution following spraying and how long it persists. That is, how long will it be possible to detect DDT in the waters of the drainage.

2. The residue buildup in fish following the application and how long it persists.

3. The effect on the bottom fauna population and differential species tolerances, if any.

Procedures:

Continuous water sampling was conducted at three points in the drainage during and following the application. An activated carbon filter was placed in the main Boulder River at Boulder on July 3 and removed July 9. During this period approximately 2,600 gallons of water were pumped through the filter.

Two 24-hour continuous samplers were also used. One was placed in Basin Creek above the domestic water supply intake for that community July 4 and removed July 9. The other was placed in the Little Boulder River, about 2 miles above the Boulder River, on July 3 and removed July 7. These samples represent composite samples over a 24-hour period.

The water samples were analyzed by the colorimetric test described by Irudayasamy and Nolarajan (1961).

To determine the total amount of DDT passing the sampling point during the period, it was necessary to know the stream flow. Flow measurements were taken at three water sampling points July 19 with a Gurley current meter.

Bottom samples were taken in May and again in June prior to the DDT application and in July, following the application. Two four-square foot samples were collected from each of six stations, except Station IV was not sampled in May. The four-square-foot method is described by Spindler (1959). The location of the bottom fauna and water collecting stations is shown in Figure 1.

Fish samples were collected for DDT analysis before and after the application of DDT at Stations II, III and VI. Collections of dead fish were also made during the application.

Drift samples were taken in the Boulder and Little Boulder Rivers and in Basin Creek during the aerial applications along those streams. Samples were taken with a 3- x 4-foot screen (nine meshes to the inch) held at mid-stream for a period of five minutes. The organisms were preserved in the field and sorted in the laboratory later.

Results:

The results of the water analyses are summarized in Table I. The concentrations of DDT were determined and are reported in micrograms (µg)per liter which is equivalent to parts per billion (ppb). In order to determine the total amount of DDT passing a given sampling station during a specific period of time, the volume of flow of the stream was measured and the quantity of insecticide in pounds per day was computed according to the following:

µg/l x liters in stream flow during sampling period (hrs.) ÷ µg per lb. ÷ 24 hrs. = lbs./day

It is significant to note that DDT was present in substantial quantities in Basin Creek before what was supposed to be the first application of DDT along the stream July 6. Since the writer's assistant noted considerable spraying activity in the direction of Basin July 4 and 5, it is possible some drift entered Basin Creek directly or via a tributary prior to July 6. A considerable increase in DDT over the previous day was noted in the sample collected 7:00 A.M. July 6 (when the spraying took place) to 7:00 A.M. July 7, and nearly twice that amount was noted the following day, the day after spray activities. Some reduction was noted July 8 - 9 (Table 1).

The sampler was placed in the Little Boulder River two days following completion of spray activities in that area, however, the concentration of DDT during the first 24 hour period was much higher than at any time in Basin Creek. Due to the smaller flow in the Little Boulder, the total amount of DDT coming down the stream during any day was not much greater than in Basin Creek. It is interesting to note that the DDT decreased to an undetectable amount on the sixth day following spray activities (Table 1).

It should be pointed out that these samples are composites over the period indicated and do not show the concentration range for the period. It is possible that higher concentrations than the data indicate ("slugs"), occurred during the period. Also, there was a decrease observed in the flow in the drainage from the time of spray operations until flow data was obtained. This would lead to an underestimation of the total amount of DDT coming down the water courses.

The mean DDT level per day shown in Table 1 for Boulder River is considerably less than that shown for the other two stations. As mentioned, an activated carbon filter was used on Boulder River whereas 24-hour continuous water samplers were used on Basin Creek and the Little Boulder. This difference in methods no doubt accounted for part of the difference in amount of DDT measured. The carbon filter does not take up all the DDT that passes through it, nor can all the DDT taken up be recovered from the filter.

Large numbers of immature and adult aquatic invertebrates were killed in the Little Boulder River, Basin Creek, the Boulder River and in Colconda and Prickley Pear Creeks (near Jefferson City) as indicated by drift samples (Table 2). Complete kills of aquatic invertebrates occurred in some sections of Basin Creek, the Little Boulder and Boulder Rivers. Several reconnaissance bottom samples following the spray operation revealed no living aquatic invertebrates in Basin Creek above the domestic water intake and less than one per sample (six to eight samples) in the Little Boulder one and one-half to two miles above the Boulder River. About three miles of the Little Boulder were affected for at least three days. The bottom substrate in the Little Boulder, two miles above the Boulder River, was covered with Trichoptera cases of the genus Brachycentrus, but the larvae inside were dead. Two weeks later these dead caddis were no longer evident.

In addition to the samples enumerated in Table 2, samples were also taken either above the affected areas or before DDT was applied to the drainage. In all cases, essentially no aquatic invertebrates were detected in stream drift in areas not affected. Samples taken by the Forest Service showed similar results.

The drift sample results are evidence that large numbers of aquatic insects were killed during the DDT application. However, evidence of a population reduction in the bottom samples (from other than natural causes) was noticeable at only one of the regular bottom sampling stations - Station IV (Figure 1 and Table 3). A reduction of 100 percent occurred at this station between June 25 and July 19. This reduction was thought to be due to DDT because of the dying aquatic insects recivered in drift samples above Station IV during spray operations (Table 2). The small amount of organisms in the drift samples at this point would be expected since they were not numerous in that area in June, prior to spray operations (Table 3).

Bottom fauna samples showed reductions of 50 and 51 percent in numbers at Stations III and V following spraying, however, this means little since reductions of 42 and 36 percent occurred at the control Stations I and II respectively as a result of seasonal fluctuations in numbers. A 93 percent reduction of Trichoptera also occurred at Station V, however, a reduction of 88 percent during the same period occurred at Station I, a control. The drift samples (Table 2) indicate that lethal amounts of DDT did not reach as far downstream as one mile above Station V on June 30.

The data indicate that complete kills of aquatic invertebrates occurred only in sections of streams rather than in entire streams. Differential tolerances of individual genera or species (the May samples were classified in detail) were not apparent in the bottom samples, however, such results were difficult to analyze due to emergence. The stations should be sampled during May and June of 1963 to determine if any group or groups of insects were seriously reduced or eliminated.

Dead fish were recovered in Basin Creek, the Little Boulder and Boulder Rivers following spray operations in those areas. Dead fish and frogs were reported in a pond in Basin that receives water from Basin Creek. Dead brook trout were observed in Basin Creek two days following spray operations. The fish had regurgitated aquatic insects and may have died from DDT ingested with the insects rather than from DDT in solution. Dead rainbow trout, brook trout and sculpins were also observed in the Little Boulder two days following spray activities.

An estimated die-off of 160 hatchery rainbow occurred in the Boulder River, between Basin and Boulder, subsequent to spray operations along Basin Creek. Also, over 150 hatchery rainbow trout planted July 3 from the same source as the hatchery fish in the river, died in a fish pond at the State Training School in Boulder. A ditch runs a constant stream of water from the Boulder River to this pond. According to personnel at the Training School, about 20 trout was the normal mortality noticed in the pond following planting in years past. Since hatchery fish are known to be more susceptible to DDT than wild fish, these kills of hatchery fish were also thought to have been caused by the insecticide.

A knowledge of the levels of DDT and metabolites in the tissues of fish, collected alive before and alive and dead after spray operations, should shed additional light on the cause of the mortalities. The analyses will be made later by the State Board of Health.

Literature Cited

Irudayhsamy, Arokiasamy and A. R. Natarajan. 1961.
Spot test microdetermination of DDT and its related compounds in biological material. Analytical Chemistry. Vol. 33.

Spindler, John C. 1959.
An extensive chemical, physical, bacteriological, and biological survey (1957 studies) Montana State Board of Health, Water Pollution Control Report No. 59-1 : pg 44.

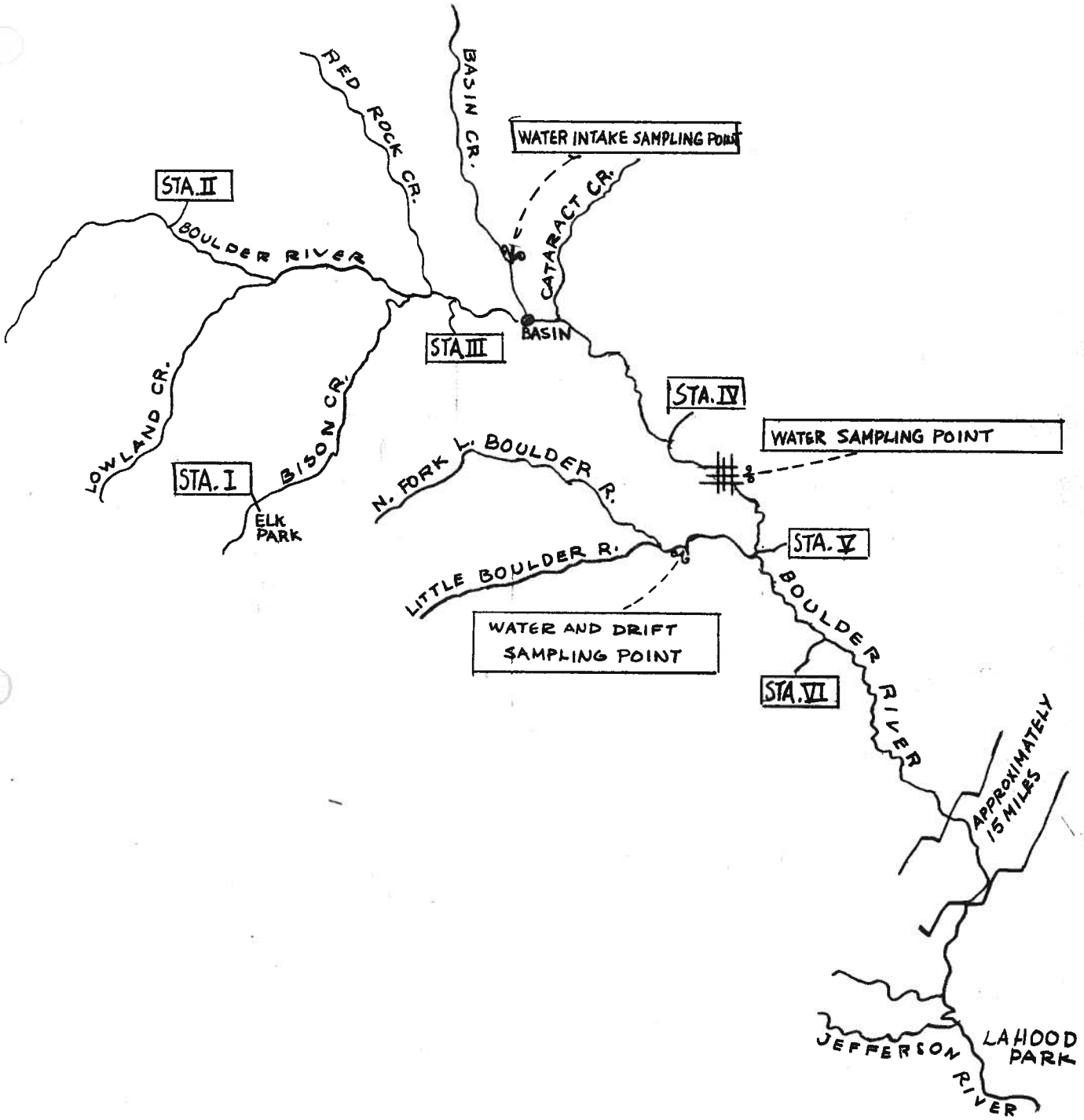

Figure 1. The Boulder River drainage showing established bottom sampling stations (Roman numerals) and other water and drift sampling points during the spruce budworm control program, June 29 to July 15, 1962.

Table 1. Results of DDT (and metabolites) analyses in water samples collected from the Boulder River drainage, July 3 - 9, 1962.

Basin Creek above Basin water supply intake
flow = 19.6 cfs 7/19/62.
Some spraying in area 7/ 4 and 5, but along stream 7/6.

Date	Hours Sampled	µg/l (ppb) Composite	Lbs. of DDT
7/4 - 7/5/62	1200 - 0930 (21.5)	5	.4735
7/5 - 7/6/62	0930 - 0700 (21.5)	3	.2841
7/6 - 7/7/62	0700 - 0700 (24.0)	7.5	.7929
7/7 - 7/8/62	0700 - 1000 (27.0)	12	1.4271
7/8 - 7/9/62	1000 - 0700 (21.0)	12	1.1100
Total	115.0		4.0876

mean = .853 lbs. DDT/day

Little Boulder River 1.5 miles above Ranchotel.
Area sprayed 6/29 - 30 and 7/1
flow = 13.2 cfs 7/19/62

Date	Hours Sampled	µg/l (ppb) Composite	Lbs. of DDT
7/3 - 7/4/62	0800 - 0800 (24)	20	1.4242
7/4 - 7/5/62	0800 - 0800 (24)	10	.7121
7/5 - 7/6/62	0800 - 1000 (26)	5	.3857
7/6 - 7/7/62	1000 - 0900 (23)	0	.0000
Total	97		2.5220

mean = .62 lbs. DDT/day

Boulder River at Boulder
flow = 69.5 cfs 7/19/62

Date	Hours Sampled	µg/l (ppb) Composite	Lbs. of DDT
7/3 - 7/9/62	144	.105	.24

mean = .04 lbs. DDT/day

TABLE 2

Boulder River and Prickley Pear Creek
Drainage Aquatic Insect Drift Samples (5 minute with 4 ft. screen)
Collected During June and July, 1962

Station	Date	Time		Ephemeroptera	Plecoptera	Trichoptera	Coleoptera	Diptera	Total
Little Boulder	6/29	0830	Immature	69	7	363	4	8	451
2 mi. above Boulder R.			Adult	2	58	5	74	104	243
Little Boulder	6/29	0930	Immature	43	4	143	1		191
1.5 mi. above Boulder R.			Adult				33	6	39
Little Boulder	6/29		Immature	5		11		1	17
5 mi. above Boulder R.			Adult		1	1	3	27	32
Little Boulder	6/29		Immature	1		1			2
Bridge 1 mi. above			Adult						0
Boulder River									
Prickley Pear	6/29	1100	Immature	225	15	35	21	5	301
above Colconda Cr.			Adult					6	6
Colconda Creek	6/29	1115	Immature	794	109	259		57	1219
above Prickley Pear			Adult				2	11	13
Little Boulder	6/30	0825	Immature	13	1	21	2		37
2½ mi. above Boulder R.			Adult	3	5	1	30	48	87
Little Boulder	6/30	0855	Immature	23		42	10		75
2½ mi. above Boulder R.			Adult	4	7	8	49	72	140
Little Boulder	6/30	0925	Immature	65	4	88	4	9	170
2½ mi. above Boulder R.			Adult	7	7	5	258	45	322
Little Boulder	6/30	0955	Immature	50	3	49	6	8	116
2½ mi. above Boulder R.			Adult		2	6	52	31	91
Little Boulder	6/30		Immature	19	5	97	2	1	124
2 mi. above Boulder R.			Adult	1	5	2	29	30	67
Little Boulder	7/1	0850	Immature	5	1	11	4	1	22
2½ mi. above Boulder R.			Adult				20	25	45
at West Creek									
Boulder R. ½ mi.	7/1	1030	Immature	18	2	4		22	46
above Sta. 4			Adult				25	13	38
Boulder R. ½ mi.	7/1		Immature	3		3		2	8
above truck stop			Adult	1	2		2	18	23

TABLE 2 (Continued)

Station	Date	Time		Ephemeroptera	Plecoptera	Trichoptera	Coleoptera	Diptera	Total
Boulder R. ½ mi. above truck stop	7/2	0630	Immature	10		6		9	25
			Adult			1	9 + 30-40	3	42
Boulder R. ½ mi. above Sta. 4	7/2	0700	Immature	31		20	4	39	94
			Adult		2		47	4	53
Little Boulder 2½ mi. above Ranchotel at West Creek	7/3	1010	Immature			6	1	1	8
			Adult				3	4	7
Basin Creek above intake	7/4		Immature			1			1
			Adult					3	3
Boulder River ½ mi. above sta. 4	7/4	1245	Immature	2	2	11		254	269
			Adult			2	22	22	46
Basin Creek above water intake	7/6	0650	Immature	27	30	29	1	7	94
			Adult			1	172	30	203
Basin Creek above water intake	7/6	0845	Immature	2932	412	512	4	44	3904
			Adult				472	16	488

Table 3. Numbers and percent composition of the representative orders of bottom fauna sampled in the Boulder River drainage during May, June and July, 1962.

Station	Date Mo.	Day	Year	No. Square Feet Sampled	Ephemer-optera	Plecop-tera	Trichop-tera	Coleop-tera	Diptera	Oligoch-aeta	Other	Total	Percent Sensitive
I	5	10	62	8	171 63%		48 18%	3 1%	49 18%		1 1%	272	81%
I	6	25	62	8	158 47%	1	81 24%	2 1%	93 28%			335	71%
I	7	19	62	8	66 38%		10 6%	5 3%	94 53%			175	39%
II	5	10	62	8	41 38%	2 2%	17 16%	10 10%	30 29%		4 4%	104	56%
II	6	25	62	8	130 46%	13 5%	111 39%	16 6%	14 4%			284	90%
II	7	19	62	8	52 28%	12 7%	33 18%	29 16%	54 29%	4 2%		184	55%
III	5	11	62	8	33 17%		15 7%	31 15%	117 49%	3 2%		199	24%
III	6	25	62	8	124 21%	3 1%	249 43%	100 17%	89 18%	1		566	67%
III	7	19	62	8	16 6%	5 2%	49 18%	20 7%	192 67%	1		283	26%
IV				No Sample									
IV	6	25	62	8	9 45%		3 15%		8 40%			20	60%
IV	7	19	62	8	No organisms								

Table 3. (Continued)

Station	Mo.	Day	Year	No. Square Feet Sampled	Ephemer-optera	Plecop-tera	Trichop-tera	Coleop-tera	Diptera	Oligoch-aeta	Other	Total	Percent Sensitive
V	5	11	62	8	63 15%	23 6%	210 53%	78 17%	36 9%			410	74%
V	6	25	62	8	56 17%	12 4%	207 63%	18 5%	30 9%	5 2%		328	84%
V	7	19	62	8	35 22%	39 24%	15 9%	6 4%	60 37%	6 4%		161	56%
VI	5	11	62	8	34 20%	56 33%	35 18%		49 29%			174	71%
VI	6	25	62	8	5 13%	5 13%	19 47%	1 2%	10 25%			40	72%
VI	7	18	62	8		11 30%	7 19%		18 51%			36	53%