

MONTANA STATE DEPARTMENT OF FISH AND GAME
FEDERAL AID IN FISH RESTORATION SECTION
HELENA, MONTANA

JOB COMPLETION REPORT
INVESTIGATIONS PROJECTS

State of Montana

Name Evaluation of DDT Spraying

Project No. F-21-R-3

Title A Test Stream Study with Controlled Application of DDT to Determine Effects on Fish and Fish-food Organisms.

Job No. II

Period May 1, 1958 - April 30, 1959

Abstract:

The test stream was sprayed with DDT on August 5, 1958. Fish-food organism collections were made twice a month. Fish population censuses, a live car fish study, fish stomach content analyses, stream patrolling, water chemistry and drift sample analyses were also incorporated in the study to determine the effects of a known concentration of DDT entering a stream.

Objectives:

Extensive cooperative studies have been and are being made on trout streams by the Montana Fish and Game Department and the U. S. Forest Service to determine the effects of forest spraying with DDT on fish and fish-food organisms. To facilitate evaluation of these extensive studies it is considered necessary to conduct a detailed investigation on a single stream exposed to a known concentration of DDT. It is the objective of this job to make detailed observations of fish and fish-food organisms of a test stream before, during and after application of a known concentration of DDT.

Techniques Used:

During the 1957-58 study period a 7-mile section of Trail Creek was selected as the study area to evaluate the effects of a known concentration of DDT entering a stream. The focal point of the study area was a 200-foot riffle area which was chosen as the point where the DDT spray would enter the stream. Downstream from this point were 6 miles of accessible stream in which the various sampling stations exposed to DDT were located. The control sampling stations were located in a 1 mile upstream area from the spray point.

Fish-food Organism Collections A total of 11 fish food organism collecting stations were established in the study area. Each of the sampling stations was located on a riffle area ranging from 50 to 100 feet in length. The fish-food organism control stations were located 300 feet (I-C-2) and 1 mile (I-C-1) above the point of application. Fish-food organism sampling station (I-P-1) was located in the spray point riffle area. The spray swath covered the upstream

limit of this collecting station. The remainder of the stations located in the exposed area were 1/6 mile (I-P-2), 1/3 mile (I-P-3), 1/2 mile (I-P-4), 2/3 mile (I-P-5), 1 mile (I-P-6), 2 miles (I-P-7), 3 miles (I-P-8), and 6 miles (I-P-9) downstream from the spray point (figure 1). Fish-food organisms were collected twice a month with a Surber square foot bottom sampler, except during the spring runoff at which time sampling was impossible due to high water. A 1 square-foot sample was collected from each of the upper 10 collecting stations (two control stations and eight exposed stations) each sampling period.

A 10 square-foot bottom sample was collected from each of the eleven sampling stations one day before and six days following the application of DDT to the test stream. The six day delay in collecting the post-application 10 square-foot sample was to allow the dead and paralyzed insects to settle out. Only live insects were counted in these collections.

All collections were either field sorted and preserved in 70 per cent alcohol or placed in 10 per cent formalin until the collections could be sorted. The number and volume for each order of organisms from each station collection was determined.

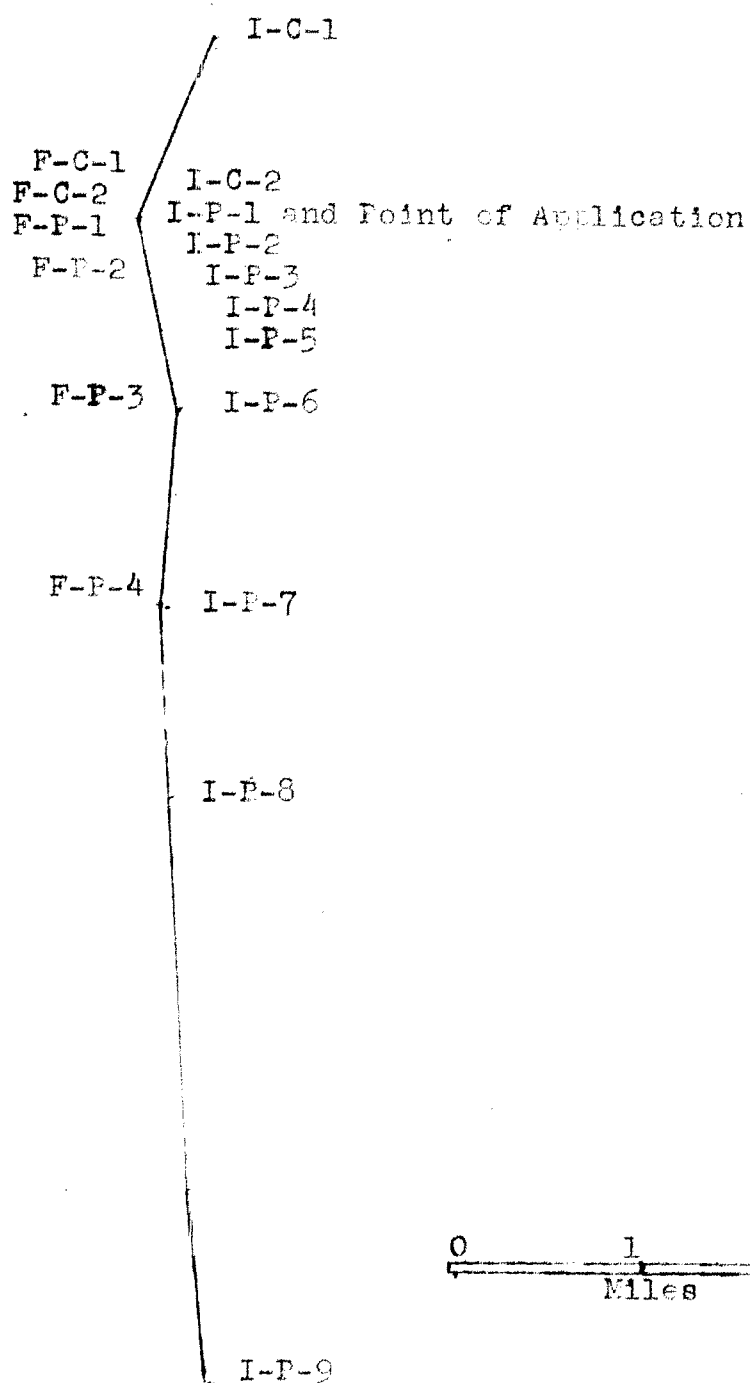
Fish Population Census. Six 300-foot fish population census stations were established in the study area. The control sections were located 20 feet (F-C-2), and 600 feet (F-C-1) above the spray point. The four stations exposed to DDT were located 1/16 mile (F-P-1), 1/2 mile (F-P-2), 1 mile (F-P-3) and 2 miles (F-P-4) downstream from the spray point (Figure 1). Each station was sampled five days before and one month following the application of DDT. A 110-volt AC shocker was used during the collections. The length and species were recorded for all fish collected in each section.

Fish Live Car Study. During the two weeks following the application of DDT, rainbow and brown trout were held in live cars at (F-C-2), (F-P-1), (F-P-2), (F-P-3), and (F-P-4) fish census stations. The fish used in the live cars were collected by shocking from streams in the Bozeman vicinity. The fish were transported from the collecting streams to the test stream by a hatchery planting tank. The pens of the live cars were made of nylon bobbinnetting to reduce injury to the fish. Three days following the application of DDT the fish held in the live cars were reduced to five fish per live car. The surplus from each live car were measured, fin clipped, and then released in the fish census station.

Drift Sample Collections. Drift samples were collected at stations located 300 feet, 1/2, 1, 2, and 3 miles below the point of application. During the day DDT was applied to the test stream, a 5-minute pre-spray sample was collected from each station. After the spray solution reached the drift stations a 5-minute sample was collected at 30-minute intervals. Four samples were the maximum collected at any one station. The samples were collected by using a Surber square foot bottom sampler held so the top bar was submerged 3 inches below the surface of the stream. This was to prevent the collection of adult insects which were floating on the water surface. The collections were preserved in 10 per cent formalin.

Fish Stomach Content Analyses. Stomach samples from trout were collected in the fall and spring following the application of DDT. These collections were made in the control area and three miles below the point of application. The stomach sample collections were not taken closer than 1/2-mile from a fish census station. This was to prevent alteration of the fish populations at the census areas. The samples were preserved in 10 percent formalin.

Figure 1. Test Stream Study Area



Stream Patrolling. The study area was patrolled daily for two weeks following the application of DDT and then at various times through the fall and winter when fish-food organisms were sampled.

General Physical and Chemical Water Data. Chemical water analysis included determinations of dissolved oxygen, pH, and total alkalinity. The turbidity was analyzed on the day of application. Maximum-minimum thermometers were used to record the water temperature for a two week period following the application of DDT.

Application of DDT. On August 5, 1958 the DDT solution was applied to a 3-foot swath at the point of application. The length of time the spray was allowed to enter the stream was calculated on the time it would require for a 5-mile section of the stream to flow passed a given point. The rate of application was based on the average width of the stream and the surface acres of a 5-mile section upstream from the point of application. The average stream surface velocity was determined by the floating chip method at four 100-foot sections. The average stream velocity was 1.9 feet per second. The average stream width was 15 feet, based on the average of 10 randomly selected points upstream from the point of application. From this it was determined that 5 miles of the streams surface was 9.09 acres. The DDT spray solution used during this study was obtained from the U. S. Forest Service. The spray contained 1 pound of DDT dissolved in 1.25 quarts of hydrocarbon solvent and diluted in fuel oil to make a gallon of spray. The spray was administered at the rate of 148 c.c. per minute for 232 minutes.

A centrifugal water pump was used to pump the DDT spray solution into the stream. The water was drawn into the pump by a 2-inch intake hose from a point upstream from where the spray solution was entering the stream. The intake hose was connected to a tee at the suction connection of the pump. A 1-hole rubber stopper was placed in the vertical portion of the tee and a 1 liter burette inserted in the hole. The flow from the burette was controlled by a petcock. The vacuum created by the pump drew in the water and a calibrated amount of the DDT solution which were mixed by the action of the pump and forced under pressure through a 3/4-inch plastic discharge pipe. The plastic pipe was suspended across the stream one foot above the waters surface. Small holes were cut at 2-foot intervals in the bottom of this pipe. When in operation a 3-foot swath was sprayed across the stream with the DDT solution and water. During the 232 minutes that the DDT was being applied to the stream one person was continuously stationed at the pump and by use of a stop watch continually measured the calculated rate of 148 c.c. per minute of DDT entering the stream.

FINDINGS:

Fish-food Organism Collections. The data in Table 1 indicate a 99 per cent reduction in the number of insects collected at the nine exposed sampling stations following the application of DDT. The pre-application 10 square-foot samples for individual stations in the exposed area had a range of 347 to 1,511 insects. The post-application samples had a range from 1 to 17 insects. The control sampling stations showed an increase in the number of insects collected. The Tricoptera collected in the exposed area during the post-application sample were in the pupa stage. The five insect orders found in the test stream showed a similar reduction in number following the application of DDT. The drifting DDT was toxic to insects at the sampling station I-P-9 located 6 miles downstream from the point of application. Nine miles downstream from the point of application the entire flow of water

from the test stream is diverted into an irrigation ditch. Observations made at this point indicate that the drifting DDT was still toxic to insects by quantitative data is lacking.

Data in Tables 2 and 3 denote the recovery trend in the insect populations following the application of DDT. The drift of insects from an unsprayed area into a sprayed area is very slow during normal fall and winter stream flows.

Nineteen days following the application of DDT, 52 insects per square foot were collected at I-P-1. This would indicate that the residual toxic effect of DDT in water is less than 19 days.

The data in Table 3 presents a comparable winter sampling period before and after the application of DDT. Plecoptera, Tricoptera and Coleoptera recovery was lacking at collecting stations below I-P-1. Ephemeroptera had regained to the pre-application numbers 1/2 mile below the point of application, but to lesser extent below this point. There was a one and one-half times greater number of Diptera collected at the exposed sampling stations in the post-application samples than in the pre-application samples. The repopulation of Diptera occurred at a uniform rate at all exposed sampling stations within a month period.

Fish Population Census. Shocking data in Table 3 indicate very little difference between the pre and post application sampling periods. Shocking conditions during the post-application period were more favorable accounting for the slight increase in the number of fish collected. The pre-application shocking period was hindered by high turbidity which made recovery more difficult.

Fish Live Car Study. A total of 127 rainbow and brown trout were held in live cars during and for two days following the application of DDT. No mortality was recorded for the control fish. In the live cars exposed to DDT 3 rainbow and 1 brown trout died at F-P-1 located 300 feet below the point of application.

The retention of 5 fish per live car for two weeks following the application of DDT resulted in the mortality of one rainbow trout at F-P-4 located two miles below the point of application.

Stream Patrolling. Stream patrolling started on August 5, a few hours after the application of DDT to the test stream. On August 5th one 9.0 inch cutthroat trout was observed dying. This fish showed symptoms of DDT poisoning similar to those fish that died during the DDT bio-assays. Two days following the application of DDT, 2 trout and 1 longnose sucker were found dead in a 2-mile section below the point of application. A dead trout was picked up on August 8th and one on August 14th. All fish picked up were under 3 inches in length. The turbid condition of the test stream during the two-week patrolling period made it difficult to recover fish from the deep holes. The small number of fish collected would indicate that there was not a large die-off during the two weeks following the application of DDT. On a patrol conducted October 24th, five pair of brown trout were observed spawning in a 1/2 mile section below the point of application. During this patrol, three dead brown trout were collected. The size range of the trout was 11.0 to 12.1 inches.

Drift and Stomach Samples. Analysis of this data has not been completed.

Recommendations:

That the test stream study be continued to study insect recovery and changes in fish populations.

Table 1. Test Stream Insect Populations

The number of insects by Order in a 10 square-foot bottom sample collected one day before and six days following the application of DDT.

Station	<u>Ephemeroptera</u>		<u>Plecoptera</u>		<u>Tricoptera</u>		<u>Coleoptera</u>		<u>Diptera</u>	
	Pre Sample	Post Sample	Pre Sample	Post Sample	Pre Sample	Post Sample	Pre Sample	Post Sample	Pre Sample	Post Sample
I-C-1	458	453	17	25	367	349	66	59	188	346
I-C-2	142	286	9	23	130	215	44	52	204	341
I-P-1	361	1	39	0	307	2	101	2	61	0
I-P-2	247	0	22	0	39	1	23	1	15	1
I-P-3	574	1	25	0	165	0	102	1	46	0
I-P-4	323	0	16	0	180	1	75	0	42	0
I-P-5	491	0	29	1	145	7	151	9	47	0
I-P-6	327	0	37	0	42	2	122	0	28	1
I-P-7	604	0	54	1	152	2	135	0	202	1
I-P-8	722	0	28	0	140	2	293	1	333	3
I-P-9	76	0	26	1	113	2	170	4	455	1

Table 2. Test Stream Insect Populations

Average number and volume per square foot bottom collection
Two collections were made at each station each month

Station	1958		March-April		May-June		July-August		Sept.-Oct.		Nov.-Dec.		1959	
	<u>Jan.-Feb.</u> No. Vol. (cc.)		<u>March-April</u> No. Vol. (cc.)		<u>May-June</u> No. Vol. (cc.)		<u>July-August</u> No. Vol. (cc.)		<u>Sept.-Oct.</u> No. Vol. (cc.)		<u>Nov.-Dec.</u> No. Vol. (cc.)		<u>Jan.-Feb.</u> No. Vol. (cc.)	
I-C-1	301 2.33		160 1.61		81 1.1		171 1.23		175 1.10		430 3.15		185 1.41	
I-C-2	140 1.33		115 0.91		48 0.42		45 0.48		165 1.53		151 1.32		215 1.50	
I-P-1	343 2.78		187 1.27		71 1.02		61 0.72		74 0.44		192 0.51		83 0.95	
I-P-2	118 0.85		62 0.46		8 0.07		40 0.30		4 0.06		12 T*		151 0.90	
I-P-3	62 0.15		116 1.26		25 0.65		70 0.76		9 0.07		43 0.09		14 0.13	
I-P-4	42 0.40		171 .94		2 0.10		32 0.25		15 0.04		8 T		40 0.07	
I-P-5	64 0.33		178 1.22		31 0.37		57 0.45		5 T		2 T		13 0.07	
I-P-6	143 0.76		59 0.82		18 0.20		52 0.32		6 0.04		2 T		5 0.02	
I-P-7	154 0.86		247 1.63		45 0.90		109 0.77		4 T		6 0.02		6 T	
I-P-8	342 2.25		3.57 1.69		45 0.62		146 0.80		1 0.10		4 0.02		16 0.06	

T* Trace

Table 3. Test Stream Insect Populations

The average number of Insects Classified to Order Per Square Foot Bottom Collection for January-February collecting period in 1958 and 1959. Four collections were made at each station each year during January and February. Spray was applied August 5, 1958

Station	<u>Ephemeroptera</u>		<u>Plecoptera</u>		<u>Tricoptera</u>		<u>Coleoptera</u>		<u>Diptera</u>	
	1958	1959	1958	1959	1958	1959	1958	1959	1958	1959
I-C-1	181	144	43	14	47	21	11	5	18	8
I-C-2	68	121	6	10	37	57	14	24	4	2
I-P-1	207	47	40	19	73	5	14	1	8	11
I-P-2	72	104	7	0	32	0	5	0	2	48
I-P-3	35	8	9	0	9	0	10	0	2	5
I-P-4	22	37	3	0	15	0	2	0	0	2
I-P-5	48	9	6	0	5	0	4	0	0	4
I-P-6	107	2	24	0	7	0	8	0	1	3
I-P-7	96	1	16	0	25	0	13	0	4	10
I-P-8	206	0	6	0	74	0	30	0	22	16

Table 4. Test Stream Fish Populations Before and After Application of DDT

Pre-Application Fish Population					Post-Application Fish Populations				
July 31, 1958					September 6, 1958				
Station	Species	Number	Size Range	Average	Species	Number	Size Range	Average	
F-C-1	Ct.	13	3.9 - 9.8	6.6	Ct.	27	2.8 - 7.6	6.4	
	Rb.	0			Rb.	3	7.6 - 9.9	9.0	
	LL	1	5.8	5.8	LL	2	4.9 - 6.4	5.6	
F-C-2	Ct.	19	4.1 - 10.2	7.2	Ct.	25	1.9 - 8.4	5.0	
	Rb.	4	5.3 - 11.3	6.5	Rb.	7	5.1 - 11.4	8.7	
	LL	5	6.2 - 10.0	7.0	LL	8	3.2 - 12.7	6.8	
F-P-1	Ct.	11	4.3 - 7.6	5.8	Ct.	12	2.6 - 10.0	6.8	
	Rb.	0			Rb.	1	7.9	7.9	
	LL	4	4.7 - 9.9	7.3	LL	6	3.2 - 10.1	6.9	
F-P-2	Ct.	5	6.3 - 8.1	7.4	Ct.	6	2.6 - 8.4	6.2	
	Rb.	0			Rb.	2	8.5 - 9.4	8.9	
	LL	5	5.8 - 11.0	7.9	LL	8	2.6 - 11.5	7.7	
F-P-3	Ct.	15	4.1 - 9.1	6.6	Ct.	19	4.9 - 8.8	6.7	
	Rb.	0			Rb.	0			
	LL	10	2.4 - 10.8	4.7	LL	33	2.7 - 10.2	3.4	
F-P-4	Ct.	12	2.1 - 7.2	5.8	Ct.	9	4.3 - 7.8	5.9	
	Rb.	0			Rb.	0			
	LL	8	8.0 - 12.0	9.6	LL	13	3.0 - 12.0	7.7	

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