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JOB COMPLETION REPORT
INVESTIGATIONS PROJECTS

State of Montana

Project No.: F-21-R-2 Name Evaluation of DDT Spraying

Job No.: I Title Investigation of the Effects of Forest Spraying Operations on Fish Populations.

Period Covered: June 1, 1957-April 30, 1958

Abstract: Observations on bottom organisms and fish populations were made on seven streams sprayed with DDT in 1956. (Project F-21-R-1, Job I). By the end of the summer volumes on one of the streams exceeded prespray volumes. On five streams, quantitative recovery had progressed considerably but did not equal prespray volumes, while the seventh stream recovery was practically absent. Game fish reductions of 70 percent and 80 percent occurred on two of the seven streams. Observations were made on four rivers and one lake in conjunction with the 1957 spray program. Fish mortalities were observed on two of the rivers and the lake.

Objectives: A cooperative study began in 1956 by the Montana Fish and Game Department, U.S. Fish and Wildlife Service and the U.S. Forest Service to facilitate comprehensive research needed in conjunction with the use of DDT aerial sprays in western forest areas. The primary purpose of the study was to obtain information as quickly as possible on the effects of DDT on the fish resources and ways of minimizing possible detrimental effects.

Techniques and Findings:

Although the presence of the spruce budworm was reported in Montana as early as 1923, only since 1947 has the infestation continued to spread from several foci to become aggressively epidemic. The infestation became so severe by 1951 that a decision was made to attempt chemical control. Aerial application of DDT at the rate of one pound per acre was initiated in the summer of 1952 on 12,000 acres within the Bitterroot National Forest. This project was followed by similar "hot-spot" spray programs on the Helena and Nezperce National Forests and Yellowstone Park in 1953. In 1955 a control project of 132,856 acres was completed in and adjacent to Yellowstone National Park, this was part of a 292,000 acre control program in Montana that year.

During October 1955 following the spraying, the Montana Fish and Game Department received reports of fish dying in the Yellowstone River. Observations of fish mortality were made all along the river system from Gardner to Big Timber, Montana, approximately 91 road miles.

Float trips on the Yellowstone River conducted by biologists indicated the mortality was predominately whitefish, followed by brown trout and suckers. During these observations a density of 600 dead fish in approximately 250 yards in the Emigrant area was noted.

During December 1955, aquatic insects were sampled in sprayed and unsprayed areas in the drainage and comparison showed a noticeable absence of mayflies, stoneflies and caddis flies in the sprayed areas. Aquatic insect sampling conducted by personnel from the Agricultural Experiment Station, Montana State College, revealed a decided drop in quantity of aquatic insects between prespray and postspray samples.

Attempts to collect adipose tissue from dying fish for chemical analysis failed because of their emaciated condition. DDT was found in brain, liver and kidney tissues on a sample of sick whitefish.

In attempting to explain this unusual mortality, fishery biologists looked to the spruce budworm control program carried out in July, as it was the only apparent activity in the area that was different from other years. Considerable controversy ensued, particularly because of the time lapse between spraying and fish mortality.

A review of literature revealed conflicting results on effects of DDT to fish. A major portion of the research was not applicable as it was confined to warm water fish and bio-assays in aquaria. Very little was known about the long-range effects in streams.

Because of the inadequate information on the effects of DDT on cold water fish, a study was initiated to determine the effects of future spray operations on several trout streams.

Fish shocking operations to determine indices of fish abundance and bottom sampling to determine amounts of fish food were carried on prior to and following spraying on 13 mountain streams in 1956. Two streams (Canyon Creek and Trapper Creek) were studied more intensively than the others. Seven of these streams were resampled in 1957 to observe any delayed effects on fish and recovery rates of bottom organisms. Trout populations were sampled using an electric shocking device. Numbers of fish for all streams are based only on fish with total length of at least three inches.

Extensive Stream Studies

I. Fish Food Organisms on Canyon Creek and Trapper Creek.

The DDT reaching the ground on sprayed sections ranged from 0.01 to 0.32 pounds per acre for Canyon Creek and from 0.10 to 0.19 pounds per acre for Trapper Creek.

Comparison of volume of predominant bottom organisms before spraying on Canyon Creek and Trapper Creek show a material reduction caused by the DDT aerial spray. One week following spraying the volume of aquatic organisms had decreased by about 90 percent on sprayed sections of both streams. Samples of drifting insects of 5 minute duration were collected before and during spraying. One hour following spraying the volume of drifting insects in Canyon Creek increased from 1.5 cc. to 150 cc. and in Trapper Creek from 0.2 cc. to 21.5 cc. The effect on organisms one and one-half miles below the spray areas was considerably less.

Bottom samples taken in October 1956 on both streams showed an increase in volume of aquatic insects in sprayed areas. However, at that time the volume of insects taken at sprayed stations on Canyon Creek was only one-fourth the volume before spraying. Samples from control stations (unsprayed) showed a fourfold increase during the same period.

The volume of insects in the sprayed stations of Canyon Creek was still low in June 1957 but by September had increased to nearly the volume of the prespray samples of 1956. On Trapper Creek the September 1957 volume was greater than the 1956 prespray volume.

The quantitative recovery of fish food organisms on these streams started during the summer of spraying, continued through the following summer, and nearly equaled or exceeded the prespray volumes by the end of the second summer. Whether recovery was qualitative as well as quantitative could not be determined by the methods used.

II. Fish on Canyon Creek and Trapper Creek

Comparison of populations before and after spraying could not be made as both streams were in flood stage during the prespray sampling. More fish were taken during post-spray sampling than during prespray sampling as lowered water levels made more efficient recovery of fish possible.

A total of 158 trout were held in live cages in the two streams during spraying. None of these died during spray day or during the three days following spraying. No fish mortality was observed on either stream during 1956, but no regular patrolling was conducted.

To determine over-wintering effects on the populations, samples were taken again in August of 1957. The total number of trout in sprayed sections in 1956 was 140 for Canyon Creek and 324 for Trapper Creek. The populations of both streams were primarily small brook trout. In 1957 the numbers were 106 and 289 respectively. Although

there is a decline in numbers for both streams, the decrease could have been the result of normal population fluctuations. Numerous yearling brook trout were collected from Trapper Creek in 1957 showing a survival of young-of-the-year fish of 1956. Condition factors of trout (length-weight relationship) were better in 1957 than in 1956.

III. DDT Analysis of Water and Fish from Canyon Creek and Trapper Creek

A water sample taken on Canyon Creek immediately after spraying contained 0.10 ppm (parts per million) of DDT and one-half hour later a water sample contained 0.33 ppm. In less than 27 hours there was no measurable amount of DDT in the water. No DDT was detected in the water following a 1.2 inches of rain 36 hours after spraying.

Chemical analyses were made on 8 samples of trout tissues collected just after spraying and during the summer. DDT was commonly located in visceral fat. The amount of DDT varied so greatly in the samples that no conclusions could be drawn.

An analysis of whole fish was made on only one sample (2 trout from Canyon Creek on August 16, 1956) and the concentration of DDT in dry flesh was 1 ppm. On November 7, 1957 six live brook trout were collected from the 1956 sprayed area on each of the two streams. The concentration of DDT in the sample from Trapper Creek was 0.3 ppm and from Canyon Creek was 3.3 ppm. The fish retained DDT in their bodies for at least 16 months following spraying.

IV. Other Stream Studies

In addition to Canyon Creek and Trapper Creek, prespray and postspray samples of fish populations and food organisms were taken on 11 other streams during 1956.

Data collected on bottom organisms from these streams substantiate the findings on Canyon Creek and Trapper Creek. The DDT spray caused a marked loss of aquatic insects in sprayed sections.

Results of fish population studies on these 11 streams were similar to those for Canyon Creek and Trapper Creek. High water prevented efficient prespray sampling. The only decline in numbers of fish in the postspray sampling occurred on one study section of the Musselshell River, here trout numbers decreased from 235 to 134 or about 43 percent.

Five of these streams were selected for study in 1957 in order to observe any delayed effects on fish and the recovery rate of bottom organisms. On three streams, the numbers of fish collected in 1957 equaled or exceeded those taken in 1956. The recovery of aquatic insects on these three streams was similar to that of Canyon Creek and Trapper Creek.

On the fourth stream (Musselshell River) the aquatic insect recovery was good but trout numbers were considerably less. The total number of trout (all brook trout) taken from the two study sections on July 31, 1956 was 253. On August 15, 1957 only 75 were recovered. This decline (about 70 percent) is more than would be expected in normal population fluctuations. Although the number of trout 3 inches and larger decreased considerably, numerous living 1- and 2-inch fish were still observed.

Five study sections were established on the fifth stream (Sheep Creek) in 1956. The upper 3 sections were in the spray area and the lower two were several miles below the spray boundary. The average volume per square foot of aquatic insects for the 5 stations before spraying was 3.37 cc. while about one month after spraying (August 2, 1956) it was 0.33 cc. On August 14, 1957 the average volume per square foot for the lower sections was 0.66 cc. but for the upper 3 sections it amounted to only 0.02 cc.

The numbers of fish collected from the lower two sections in August 1956 were 84 rainbow and cutthroat trout and 32 whitefish. In 1957 there were 87 and 66 respectively. In the upper sections, 60 brook trout, 26 rainbow and cutthroat trout and 94 whitefish were taken in 1956. These numbered 5, 10 and 14 respectively in August 1957. While the numbers of game fish remained about the same between 1956 and 1957 in the lower sections, numbers in the upper sections decreased about 84 percent. Many sculpins were observed in the upper sections in 1956 but none were seen in 1957.

Ruby River Studies, 1957

The Ruby River was added to the cooperative study in 1957. The investigation on this stream embodied all aspects of the previous study with additional effort placed on periodic sampling of water, fish, aquatic vegetation, and bottom sediment for chemical analysis to determine the presence of DDT. Also, sprayed areas were regularly patrolled to observe fish mortality.

Spraying was to be conducted on six miles of the river with no attempt made to keep spray out of the stream. Observations on spray day (July 7) revealed that less than three miles of the river received the expected amount of spray. A sample of surface water taken five minutes after spraying contained 1.35 ppm (parts per million) DDT while sub-surface water contained 0.08 ppm. One hour after spraying the quantities detected were 0.05 ppm and 0.01 ppm respectively. Twenty-four hours following spraying 0.01 ppm DDT was found in the water but at 32 hours, only a trace could be detected. No DDT was found in any water samples taken after this time even though two were taken following heavy rains. A water sample taken 24 hours after spraying and 5 miles below the spray area contained 0.01 ppm DDT.

The effect of DDT spray on bottom organisms was very similar to that observed in previous studies.

High water again prevented efficient prespray sampling of the fish population but enough fish were recovered to conclude that the population was primarily suckers. The average number of trout per section was six and these were mostly rainbow trout.

Six miles of the Ruby River (within spray boundaries) were patrolled on spray day (July 7) and no dead fish were found. On the following day one dead sucker was found on the river. A two mile section in the lower part of the spray area (below the entrance of a warm-spring tributary) was selected for regular patrolling. Three suckers were found in this area on July 9, 9 suckers were found on the 10th, and 13 on the 11th. The numbers of dead suckers found in this area increased to 80 on July 17 (10 days after spraying). Periodic checking in this section of the river resulted in the recovery of 345 dead suckers by the end of July. Dead suckers were found throughout the summer and fall but in smaller numbers. Float trips on the river indicated that the sucker mortality occurred for approximately eight miles below the spray boundary.

A portion of the river about 5 miles below the spray boundary was patrolled in December. This portion of the river was too large to census the fish population electrically but observations indicated that trout were more abundant here than in the sprayed area. Thirty dead brown trout and three suckers were found in a two mile stretch of river in this 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. This trout mortality is greater than usual, even when following the spawning season.

Analysis of tissue for DDT was made on suckers, rainbow trout and brown trout. No DDT was found in samples collected prior to spraying but it was found in all fish (dead or alive) collected following spraying. The amounts contained in tissues varied from 0.27 ppm to 6.2 ppm but in many cases, more DDT was found in live fish than in dead fish. The inconsistency of the results invalidate these figures as criteria for determining the amount of DDT in tissues necessary to kill fish. The analyses did show a slight trend towards greater amounts of DDT accumulating in tissues as the season progressed.

Aquatic vegetation in the Ruby River was sampled until September 10, 1957. DDT was found in all samples collected following spraying and some of these were taken at least 10 miles below the spray area.

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

Miscellaneous Observations

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 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 each day for one mile above the pumping station 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 2-3 rainbow trout, 5-6 whitefish and some sculpins. The Big Hole River was patrolled for a distance of five 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 more fish mortality had occurred up to that time. A microscopic examination of dead suckers was made and no bacteria or parasite which might have caused the mortality was found. DDT (2.39 ppm) was found in a sample of the dead suckers.

Deadman Lake:

A reported fish mortality on this small mountain lake was investigated a few days following spraying in 1957. A total of 60 dead cutthroat trout were found along the shoreline. On the day the last of these fish were collected, live fish were observed in the lake. The smell of DDT spray and the presence of an oil film on the water surface was reported on spray day. A sample of dead fish was analyzed and 2.91 ppm DDT was found.

Judith River:

Spraying of inaccessible head waters of the Judith River occurred over a period of two weeks. Samples of bottom organisms and water were collected below the spray area and near where the river is formed. No DDT could be found in water samples taken every other day throughout the spray period. In spite of this, there was a marked reduction in bottom organisms. The volume per square yard of aquatic insects dropped from 2.0 cc. before spraying (July 1, 1957) to 0.2 cc. after spraying (July 23, 1957). It is possible that DDT was present in the water in such small quantity that it could not be detected by the method used. Studies have shown that exposure to small dosages for a long period may be just as fatal as exposure to large dosages for a short period. No fish mortality for this area has been reported but patrolling was not conducted.

Madison River:

The canyon area of the Madison River below Hebgen Lake was sprayed July 12-15. Extreme caution was used in spraying this area. Sensitized spray cards and water samples showed that some DDT was introduced into the river and tributary streams. Insect drift samples and bottom samples indicated aquatic insect mortality, but not as severe as observed on other streams. A sample of live brown trout collected from this area on November 10, 1957 contained 1.8 ppm DDT. No fish mortality has been reported on the Madison River.

Summary and Conclusions

Studies conducted on several trout streams in Montana show that aquatic bottom organisms are materially reduced by DDT spray. Reductions of over 90 percent of the volume were common. By fall, insect recovery on these streams represented only a small fraction of the normal volume. Bottom organisms on seven streams were sampled for two summers. By the end of the second summer, volume recovery on one of these streams exceeded prespray volumes. On five of the streams, quantitative recovery by the end of the second summer had progressed considerably but did not equal prespray volumes. On the seventh stream (one of the richest in bottom fauna) only a trace of aquatic organisms in sprayed sections was found in the second summer.

Fish population on seven streams were censused with an electric shocker during the summer of spraying and again the following year. This census did not reveal any fish mortality during the summer of spraying. In the second summer, fish populations on five of the streams approximated those of the previous year. On two streams, game fish reductions in sprayed sections of 70 percent and 80 percent occurred between the summer of spraying and the following year. The stream with a game fish reduction of 80 percent was also the stream where aquatic insect recovery was practically absent.

The limited data collected on young fish populations in streams did not show that they were more susceptible to DDT than older fish, however, bio-assays conducted in a hatchery showed this to be true.

In addition to the two streams listed above, fish mortality following spraying have been observed in the following areas: Yellowstone River (in 1955), Big Hole River (in 1957), Ruby River (in 1957), and Deadman Lake (in 1957). On two of these streams, brown trout mortality occurred several months following spraying.

Game fish comprising the bulk of observed mortalities were brown trout, brook trout and whitefish. All of these are fall spawners. On the two rivers where heavy sucker mortality was observed in 1957, indications were that most of the suckers had completed

spawning just prior to spraying. It is possible that physiological stress and poorer condition due to spawning may result in stored DDT becoming lethal. Bio-assays conducted during 1957 substantiate this view.

The effect of various physical, chemical and biological factors on mortalities in streams could not be evaluated since the concentration of DDT in the water and length of exposure was not accurately determined. Bio-assays showed that an increase in water temperatures of 3 degrees F. resulted in an immediate increase in the mortality rate of test fish.

Information collected this far indicate that forest spraying with DDT at the rate of one pound per acre will result in some fish kills, some of which will be serious. Extreme caution in spraying near streams and lakes will reduce the hazard to fish and aquatic organisms. Repeated spraying within 3 or 4 years will not give affected bottom organisms and fish populations a chance to recover adequately.

Observations also show that delayed mortalities occur, particularly where fall spawning fish are present. The delayed mortalities appeared to be more serious than those occurring immediately following spraying. The data also show that fish die-offs can occur and not be reported by sportsmen or local residents. No reports of fish mortalities were received for Sheep Creek, North Fork Musselshell River, or Ruby River.

Studies on the effects of DDT conducted thus far reflect many conflicting results. Even though DDT has been studied more than any other insecticide, there remain many questions to be answered. Many new pesticides have been developed since DDT and some of these chemicals are far more toxic. Each year wildlife biologists are confronted with a bewildering array of new chemicals whose field effects are largely unknown. The concern over widespread use of crop protection chemicals was reflected at a seminar on biological problems in water pollution held at the Robert A. Taft Sanitary Engineering Center in 1956. A report by O. Lloyd Meehan of the U.S. Fish and Wildlife Service stated: "A type of pollution that has become one of our most pressing problems is that resulting from the increased use of insecticides, herbicides and fungicides. It is estimated that farmers, home gardeners, and government organizations charged with control of noxious insects and plants now purchase 700 million pounds of these basic materials each year. This represents about 3 billion pounds of finished pesticides that are sprayed or dusted annually on millions of acres of the nation's crop, forest, range and marsh lands."

The need for adequate studies on the effect of pesticides on fish, wildlife and public health becomes more pressing each year.

Recommendations:

It is recommended that observations on bottom organisms and/or fish populations continue for one more year on Trapper Creek, Canyon Creek, Sheep Creek, North Fork Musselshell River and Ruby River. Observations should also be made in the Deep Creek area (near Townsend) if a pesticide to controll the spidermite is used with DDT.

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