CARSON - SANTA FE SPRUCE BUDWORM CONTROL

PROJECT REPORT

JUNE 1962

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11/29/62

Date

ACKNOWLEDGMENT

We are grateful for the cooperation and assistance given on the project by the Federal Aviation Agency, United States Fish and Wildlife Service, United States Weather Bureau, New Mexico Department of Game and Fish, and to United States Forest Service, Region 1, 5, and 9, who detailed specialized manpower to the job.

INTRODUCTION

The spruce budworm, Choristoneura fumiferana (Clem.), has been on a steady rise since 1956 in northern New Mexico and extreme northeastern Arizona. By 1961, 1.1 million acres of mixed conifer type were infested. Moderate defoliation characterizes this infestation, but tree killing has increased in all age groups in the last several years. Most significant is the loss of dominant and co-dominant trees which indicates that the most vigorous trees are being killed due to the cumulative effect of budworm feeding.

An aerial survey and biological evaluation, conducted by the United States Forest Service, Division of Timber Management, Pest Control Branch, in 1961, indicated that the infestation would continue at a high level in 1962, infestation boundaries would probably enlarge, and accumulative defoliation would add to the already serious nature of the infestation.

Forest pest control funds were requested to control the infestation. In January 1962, $435,000 was allocated to control the budworm infestation lying east of the Rio Grande River in the Santa Fe and Carson National Forests. Funds were deferred for the remaining infestation until F.Y. 1963.

SUMMARY

In June 1962, an aerial spraying program was conducted to control a spruce budworm infestation on approximately 445,000 acres of the Carson and Santa Fe National Forests in northern New Mexico. Involved in the project was that part of these forests, with some intermingled and adjacent private lands, that lies east of the Rio Grande River.

The control area was divided into three control units: Santa Fe Unit, 188,600 acres; Taos Unit, 118,700 acres; and Las Vegas Unit, 137,500 acres. Each unit was handled independently under the direction of a Unit Supervisor.

Spraying began June 4 on the Las Vegas Unit and was completed June 27 on the Taos Unit. Counts made 10 days after spraying showed a reduction of 97.8 percent in the budworm's population over the entire control area. A total of 444,791 acres were treated at a cost of $428,431. Of this, 88.5 acres were sprayed for the Glorietta Baptist Assembly, Glorietta, New Mexico, for which they contributed $88.50. The average cost per acre for the project was $0.96.

Three contractors were involved in the project. Arizona Agrochemical Company had the insecticide contract for supplying, storage, and transportation of the insecticide used on the entire project. Aerial Applicators, Inc., received the award for spraying the Las Vegas Unit. Cisco Aircraft, Southwest Air Contractors, was awarded the Santa Fe and Taos Units.

The insecticide contractor set up his central mixing plant at the Santa Fe County Municipal Airport. Insecticide storage tanks and control unit headquarters were set up at the Santa Fe County Municipal Airport, Santa Fe, New Mexico; Las Vegas Municipal Airport, Las Vegas, New Mexico; and the Tarleton Airstrip, Taos, New Mexico.

The insecticide used over most of the area was a solution containing one pound of DDT dissolved in 1.25 quarts of solvent and sufficient fuel oil to make one gallon of solution. In special precaution areas, near fishing streams and meadows, the amount of DDT was reduced to one-half pound. The insecticide was applied at the rate of one gallon per acre.

Four accidents involving aircraft occurred during the project. The most serious was the crash of a TBM. The pilot, though seriously injured, survived the crash, thanks to a fast, smooth rescue.

One incident of fish kill occurred on the Las Vegas Unit when a plane got off course and sprayed over a privately owned trout pond at the Rackley Ranch. This was the only report of loss or damage to fish or wildlife as a result of the spray program.

PROJECT COSTS

The total expenditure on this 444,791-acre control project was $428,431. This was an average cost of 96 cents per acre.

Project expenditures:

Function	Weighted Av. Cost per Acre	Total Cost
Insecticide	$.36	$160,421.00
Spraying	.41	183,997.00
Observation planes	.03	12,596.00
Misc. operation costs	.16	71,417.00
Total Costs	$.96	$428,431.00

INSECTICIDE

Contract Procedure

On April 6, 1962, the contracting officer of Region Three of the U.S. Forest Service extended invitations to bid on the supplying, storing, and loading of 435,000 gallons of insecticide to be used on the project. Of this amount, 348,000 gallons consisted of a solution containing one pound of DDT per gallon of fuel oil and solvent and 87,000 gallons consisted of a solution containing one pound of DDT per two gallons of fuel oil and solvent (½ pound DDT/gal.). For purpose of contract award, the low aggregate bid was determined on the basis of the following gallons delivered to the designated airports:

Bid Item	Gallons
One pound DDT per gallon solution	
1. Santa Fe County Municipal Airport	222,000
2. Las Vegas Municipal Airport	126,000
One pound DDT per two gallons solution	
3. Tarleton Airport - Taos	32,000
4. Santa Fe County Municipal Airport	43,000
5. Las Vegas Municipal Airport	12,000

Bids were opened April 30, 1962, at 2:30 p.m. at Albuquerque, New Mexico. Arizona Agrochemical Corporation of Phoenix, Arizona, was low bidder with a bid of .3735/gal. for one pound DDT and .275/gal. for ½ pound DDT. Table I is a breakdown of the bids received by bid items:

TABLE I

Bidder	Bid Price per Gallon Item* 1	2	3	4	5	Discount
Arizona Agrochemical Corp. Phoenix, Arizona	.3735	.3735	.275	.275	.275	—
Northwest Petrochemical Corp. Anacortes, Washington	.414	.414	.318	.318	.318	¼ of 1% 10 days
Herrod Aviation Co. Billings, Montana	.4295	.4374	.3136	.2957	.3036	—
Cisco Aircraft, SW Air Contractors, Deming, New Mexico	.4999	.4999	.4999	.4999	.4999	—

*Bid items described on previous page

The contracting officer made an inspection of the Arizona Agrochemical Corporation equipment in Phoenix, Arizona, on May 8, 1962, and found that it met contract specifications. On May 4, 1962, they were awarded contract No. 12-11-003-4527A.

Contractor Personnel

Mr. Joseph G. Hartsig of Arizona Agrochemical Corporation and his associates on the project were a fine group to work with. They were cooperative and did a fine job in conducting their phase of the project.

Contractor's Equipment

With the exception of some leaky storage tanks rented by the contractor, the equipment used on the project was excellent.

Insecticide Specifications

The insecticide supplied was of two solutions. The first solution was prepared using one pound of DDT to 1.25 quarts of auxiliary solvent and sufficient fuel oil to make one gallon of finished solution at 60°F, hereafter called "1 pound DDT." The second solution was prepared in the same way except sufficient fuel oil was added to make two gallons of finished solution at 60°F, hereafter called "half pound DDT."

The finished solutions were required to be free of scale, lint, silt, and other foreign matter. Each solution was required to be within a tolerance limitation of 0 to plus 10 percent for DDT content. The DDT used was Grade B-Technical, and the fuel oil Grade F.S. No. 2.

Central Mix Plant

Arizona Agrochemical Corp. set up their central mixing plant at the Santa Fe County Municipal Airport, Santa Fe, New Mexico. The plant consisted of:

1 - 20,000 gallon mixing tank (also used for storage of finished insecticide)
1 - 8,800 gallon tank to store 3 lbs. DDT in auxiliary solvent (stock solution)
10 - 8,800 gallon tanks - storage of finished insecticide
1 - 8,000 gallon tank - storage of finished insecticide
1 - 10,000 gallon tank - storage of finished insecticide

The central mix plant was powered entirely by 220 volt, 3 phase electric motors except for one small paint spray compressor used for air agitation of liquid in the central mix tank.

The central mix tank was a 20,000-gallon cylindrical tank placed in the horizontal position. The circulating pump on this mix tank was of 400 G.P.M. capacity powered by a 15 H.P. electric motor. The mix tank was rigged so liquid was pulled out at the bottom on one end and pumped back into the top at the other end of the tank. Simultaneously with the pumping circulation, the liquid was air-agitated by the small compressor mentioned above. This was accomplished by placing a perforated 1" diameter pipe inside the tank near the bottom. It ran the full length of the tank and was connected to the compressor.

Formulation

The components used in formulating the finished insecticide were: 3 lb. DDT per gallon in auxiliary solvent and No. 2 fuel oil. These two liquids were metered into the mix tank and mixed according to the contractor's formula to attain the required finished insecticide. After the insecticide was mixed in the central mix tank, a sample was pulled and tested by the contractor's chemist. After the contractor had assured himself that the mixed insecticide was within contract specifications, the insecticide was pumped into the central mix plant storage tanks and offered to the Forest Service for testing and approval.

Inspection

Samuel W. Henry, C&M Foreman, Coconino National Forest, the contracting officer's representative for the insecticide contract, pulled samples of the finished insecticide and sent them in for tests. Tests were first done by the Martin and Carlisle Laboratory in Albuquerque. Later all testing was shifted to the Industrial Laboratories Company at Denver, Colorado.

Transportation

After insecticide had been tested and approved by the Forest Service, it was either transferred via hose line and pay meter to the Santa Fe loading storage or to trucks via hose line and pay meter and sent to either Taos or Las Vegas Airport storage. All meters (pay print meter and station meters) were tested by the New Mexico State Gasoline Tax Commission.

Storage

The following loading facilities were installed at the airports by the insecticide contractor:

Airport	Station	Tanks & Capacity
Santa Fe	1 (½ lb. DDT)	2 - 8,800 gallon
	2 (1 lb. DDT)	2 - 8,800 gallon
	3 (1 lb. DDT)	3 - 8,800 gallon
Taos	1 (½ lb. DDT)	2 - 8,800 gallon
	2 (1 lb. DDT)*	1 - 8,800 gallon
		1 - 4,000 gallon

Las Vegas - Same as Santa Fe

*The insecticide contract did not call for any 1 lb. DDT to be stored at the Tarleton Airport in Taos. The aerial contractor elected to fly 1 lb. material from Taos; therefore, he negotiated with the insecticide contractor and established a 1 lb. insecticide loading station (to contract specifications) at Taos.

Aircraft Loading

The insecticide contractor hired men to operate the pumps but aircraft loading was done by the spraying contractor's personnel. Forest Service employees kept a record of the gallons of insecticide loaded into each plane.

Gallonage and Cost

Total gallonage (temperature-corrected net gallons) involved in this contract was:

366,348 gallons 1 lb. DDT	$136,831.00
85,783 gallons ½ lb. DDT	23,590.00
Total Cost	$160,421.00

SPRAYING

Contract Procedure

On April 9, 1962, the Contracting Officer of Region Three of the U.S. Forest Service extended invitations to bid on the aerial application of insecticide to approximately 435,000 acres of budworm infested timber in northern New Mexico.

The control area was divided into three control units as follows:

A. Taos Control Unit - about 97,000 acres

B. Santa Fe Control Unit - about 200,000 acres

C. Las Vegas Control Unit - about 138,000 acres

Three observation planes were required for the Taos Unit, three for the Las Vegas Unit, and four for the Santa Fe Unit.

Bidders could quote on one or more control units.

Bids were opened at Albuquerque, New Mexico, on May 1, 1962. The low bidders were: (1) Aerial Applicators, Inc., Salt Lake City, Utah, with a bid of $.254 for each acre sprayed on the Las Vegas Control Unit and $27 an hour for Forest Service use of observation planes; (2) Cisco Aircraft, Southwest Air Contractors, Deming, New Mexico, with a bid of $.4802 an acre and $27.60 an hour for observation planes for spraying the Taos Control Unit, and with a bid of $.4956 an acre and $28 an hour for observation planes for spraying the Santa Fe Control Unit.

Table II gives a breakdown of bids received on the aerial spraying contract.

It was determined that Aerial Applicators, Inc., and Cisco Aircraft, Southwest Air Contractors, had the best equipment and personnel to meet the contract requirements. Award was made to these contractors on May 16, 1962.

TABLE II

AERIAL SPRAYING BIDS

Bidder	A-1	A-2	B-1	B-2	C-1	C-2	Discount
Aerial Applicators, Inc., 1231 S. Main, Salt Lake City, Utah	No Bid	No Bid	No Bid	No Bid	.254	$27.00	-0-
Olin Mathieson Chemical Corp. Mathieson Building, Baltimore 3, Md.	No Bid	No Bid	No Bid	No Bid	No Bid	No Bid	-0-
Hillcrest Aircraft Co., Box 504, Lewiston, Idaho	.97	$40.00	.89	$36.00	.59	$36.00	3% 20 days
Johnson Flying Service, Inc., P.O. Box 1366, Missoula, Montana	.60 All or None	$35.00	.60	$35.00	.60	$35.00	-0-
Big Piney Aviation Box 551, Big Piney, Wyoming	No Bid	No Bid	.929	$35.00	No Bid	No Bid	1% 30 days
Plains Aero Service Box 988, Dalhart, Texas	No Bid	No Bid	No Bid	No Bid	.95	$35.00	1% 30 days
Rosenbalm Aviation Co. P.O. Box 1524, Medford, Oregon	.70 All or None	$28.50	.70	$28.50	.70	$28.50	1% 10 days ½% 20 days ¼% 30 days
Cisco Aircraft, SW Air Contractors Deming, New Mexico	.4802	$27.60	.4956	$28.00	.409	$27.00	-0-
Lewis Aircraft 1922 N. Faulkner, Pampa, Texas	No Bid	No Bid	No Bid	No Bid	.48	$22.50	-0-

A-1 Taos Spraying Per Acre
A-2 Taos Observation Aircraft
B-1 Santa Fe Spraying Per Acre
B-2 Santa Fe Observation Aircraft
C-1 Las Vegas Spraying Per Acre
C-2 Las Vegas Observation Aircraft

Contractors

Aerial Applicators, Inc.

This contract work was performed as a combined operation between John D. Streeter of Aerial Applicators, Inc., and Charles T. Reeder of Reeder Flying Service. These men and their associates did a fine job.

The Las Vegas Control Unit was released for spraying a week ahead of the other units because of advanced insect development. The early start was welcomed. We thought we would iron out our problems on this unit making the rest of the project easier to administer. We were wrong--Aerial Applicators ran such a smooth operation, there were few problems to deal with.

Equipment - Their equipment was in excellent condition; little time was lost due to equipment failure.

Aircraft - A total of 11 aircraft were used on the Las Vegas Unit: 8 spray planes and 3 observation planes. Five of the spray planes were Gruman TBM's. Three 450 Stearman-type aircraft were used for spraying special precaution areas. Three Cessnas were used for observation.

Pilots and Ground Crews - Twelve pilots had their logs checked and were approved for flying under this contract. Charles T. Reeder was appointed Chief Pilot. The contractor supplied one licensed aircraft mechanic to maintain his aircraft.

Cisco Aircraft, Southwest Air Contractors

Spraying of the Santa Fe and Taos Control Units was a joint venture between Mr. Zack C. Monroe of Cisco Aircraft, Burbank, California, and Mr. Jack R. Smith of Southwest Air Contractors, Deming, New Mexico.

Equipment - These contractors provided more than enough equipment to meet the minimum daily spray output as required by the contract. But due to faulty equipment the minimum daily output was seldom met. The contractors didn't have enough mechanics to keep ahead of equipment breakdown. An unusual amount of supervision by our Air Officer and Unit Supervisor was necessary to see that the equipment was kept in operating condition. Figure 1 illustrates one of the equipment problems--leaky tanks.

Insecticide Leaking From Tank on TBM

A total of 16 spray aircraft and 4 observation planes were used on the Santa Fe Control Unit. The spray planes included 5 TBM's, 2 B-25's, 1 F7F, 1 FBY, and 7 Stearman-type aircraft. The observation planes were Cessnas.

Nine spray aircraft and four observation planes were used on the Taos Control Unit. The spray planes included 5 TBM's and 4 Stearman-type aircraft. The observation planes were Cessnas.

Pilots and Ground Crews - A total of 33 pilots had their logs checked and were approved for flying under this contract. John H. Bowman and later Zack C. Monroe were designated Chief Pilots for the Santa Fe Control Unit. Jack Smith was the Chief Pilot for the Taos Control Unit. The contractors supplied three licensed aircraft mechanics to maintain their planes.

PRE-WORK CONFERENCES

Prior to the start of spray operations, work conferences were held with each contractor involved in the project. The meetings were conducted by Don Williamson, Contracting Officer, and attended by key Forest Service personnel involved in the administration of the contracts.

At these meetings the project was explained, the contract read, and any points in question were cleared up. The pre-work conferences were a valuable part of the project.

PROJECT PERSONNEL

The following is a list of Forest Service personnel who worked on the project. There were many others who helped but were not assigned to the project.

Branch Chief, Pest Control - F. M. Yasinski
Project Leader - D. A. Pierce
Contracting Officer - D. L. Williamson
Contracting Specialist - R. M. Yates
Regional Air Officer - E. G. Scholz
Regional Communication Officer - R. R. Busby
Project Entomologist - D. T. Jennings
Formulation Checker - S. W. Henry
Project Air Officer - G. Ruth
Assistant Project Air Officer - J. Wemple
Fisheries Biologist - H. J. McKirdy

Santa Fe Unit

Unit Supervisor - L. O. Hill

Ass't Unit Super. - M. E. Richards

Safety Officer - H. W. Moody

Communications Off. - F. Campbell

Adm. Officer - K. L. Brudos

Clerk - D. Cearly

Aerial Observers - G. Cargill
J. Holtet
J. Stephenson
M. Oehlerich

Weather Observers - J. Guck
E. Barker
A. Trujillo

Radio Operators - B. Ingham
R. Mathias
J. Melandez

Load & Flight Checkers - A. Hinds
E. Harrold
J. Shank

Larval Checkers - C. Campbell
M. Langenbruner
C. Brainard
D. Zamora
I. Mathews
B. Carroll

Unit Biologist - I. Garcia

Biologist Helpers - A. Trujillo
T. Vigil
S. Gonzales

Watchman - J. Thompson

Las Vegas Unit

Unit Supervisor - D. E. Jirsa

Ass't Unit Super. - J. L. Perry

Safety Officer - B. Brainard

Communications Off. - D. G. Dalton

Adm. Officer - B. Hood

Clerk - J. Lopez

Aerial Observers - L. Prichard
J. Holtet
M. Oehlerich
E. Blann

Weather Observers - J. Duran
J. Washburn

Radio Operators - B. Denton
F. Quintana

Load & Flight Checkers - J. Hutt
B. Ingham
B. Wallingford

Unit Biologist - G. E. Moore
T. Garcia

Biologist Helpers - E. Martinez
R. Corrales
C. Corrales
S. Lavato

Watchman - J. Thompson

Taos Unit

Unit Supervisor - W. B. Metcalf

Ass't Unit Super. - G. P. Tune

Safety Officer - B. W. Schulle

Communication Off. - T. J. Holmes

Adm. Officer - F. LaFave

Clerk - E. Leyba

Aerial Observers - G. Janssen
J. Valdez
F. Galley
J. Holtet
M. Oehlerich

Weather Observers - M. Romero
B. Dominguez

Radio Operator - F. Miera

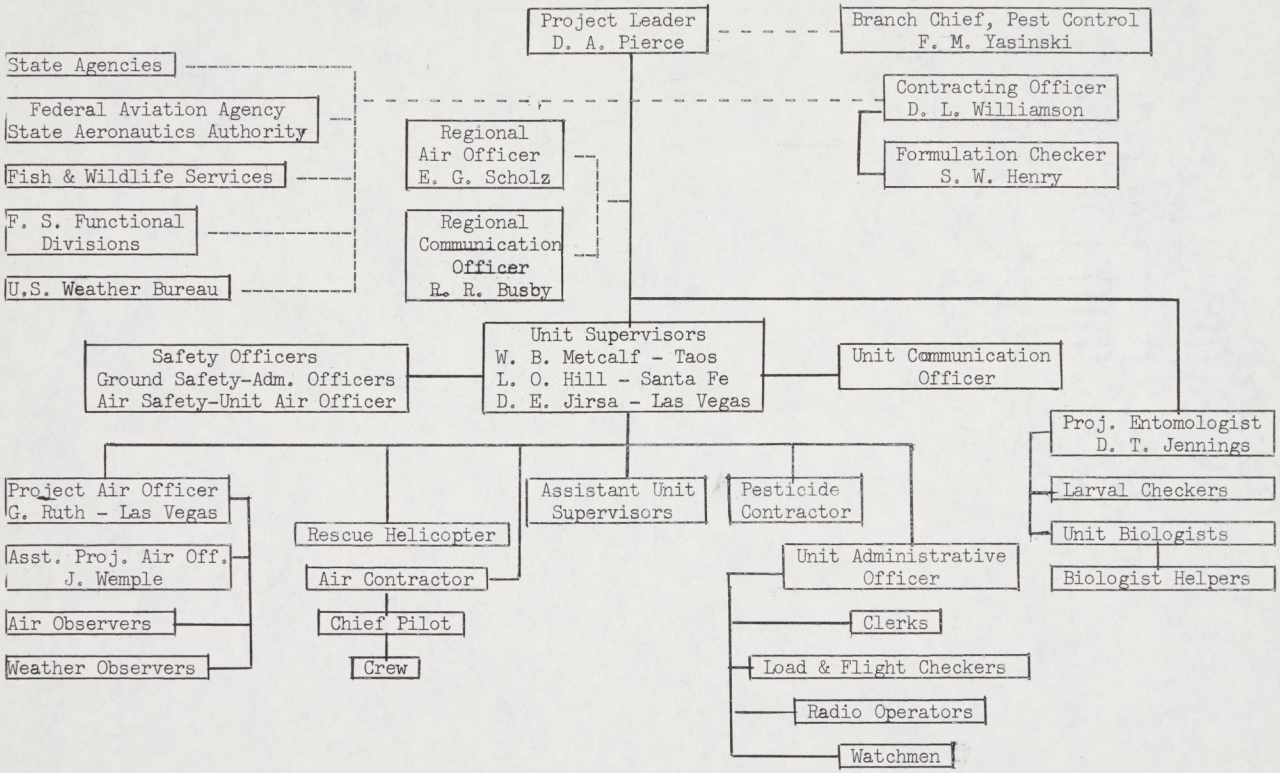
Load & Flight Checkers - D. Cruz
C. Garcia

Unit Biologist - B. D. Cowan
R. T. Lewis

Biologist Helpers - E. Martinez
T. Valerio
G. Gonzales

SPRUCE BUDWORM CONTROL PROJECT ORGANIZATION

Carson - Santa Fe, 1962



BIOLOGICAL PHASE

Pre-spray

The winter of 1961-62 was an unusually cold one in New Mexico. We thought that the extreme temperatures could have reduced the over-wintering budworm population to a point where control would not be necessary. During January 1962, Dan Jennings, entomologist, brought bolts of fir from the infestation area into the laboratory and placed them in the rearing room. From the large number of budworm that emerged it was clear that it would be necessary to go ahead with control plans.

From past records of spruce budworm development in New Mexico, it was decided to begin collecting larvae (to watch their development) the last week in May. From field checks of larval development made on May 15 and 16 it was found that the larvae had already broken hibernation and were in the buds. Plans were quickly changed and larval development sampling was started May 21. By May 25 the first sixth instar budworm larvae showed up. These were from foliage collected on May 24 from the lower elevations of the Las Vegas Control Unit.

We set up our sampling headquarters in Santa Fe, New Mexico, in a warehouse provided by the Santa Fe National Forest. This warehouse came to be known as the "bug house."

Four local women were hired to work in the "bug house" as larval checkers. On May 22 they began collecting larvae from foliage brought in by the biologist helpers. Four women could not examine all the foliage so on May 25 two additional women were hired.

Nine men were hired as biologist helpers. Three men were assigned to each control unit under the direction of a unit biologist. The biologist helpers made daily foliage collections from development plots established by the unit biologists. Each evening the unit biologists brought the foliage back to the "bug house" for examination.

Having the unit biologists return to Santa Fe each night worked fine. It was useful for getting work coordinated for the next day. The unit biologists were also available at night to aid other entomologists in separating larvae into instars.

The following standards of control established by the Pacific Northwest Experiment Station[1] were used as a guide to determine the effectiveness of this project.

Class	Percent Larval Mortality
Excellent Control	(98-100%)
Good Control	(95-97%)
Marginal Control	(90-94%)
Poor Control	(Below 90%)

1/ Report of the 1955 Oregon Spruce Budworm Control Project, p. 41. U.S.D.A. Forest Service P.N.W.F.&R. Exp. Sta. Portland Oregon. April 1956.

Checking of Spray Deposit

To determine if the insecticide dosage had been sufficient to cause adequate budworm kill in a given area, the unit biologists and helpers used three types of measurements.

Prior to the spraying of each block, oil-sensitive dye cards were placed at two-chain intervals on a spray check line running at right angles to the spray swaths. Examination of these cards was made after completion of the spraying to get an indication of the amount of insecticide reaching the ground.

On lines where the cards showed little or no spray deposited, a second examination of the area was made for foliage "burning" caused by oil in the spray. In addition, the presence of dead larvae and larval webbing was noted. These examinations were made when spray cards were collected.

THE CONTROL OPERATION

Special Spraying Precautions

In addition to the usual steps taken to insure a safe spray program, a list of special precautions was issued from Washington on March 7, 1962. These precautions were applied on the project.

Precautions which made it necessary to modify our preliminary contracts and control plans were:

1. Strips will be left unsprayed along lake shores and large streams to the extent consistent with effective control.

2. Use helicopters or small Stearman-type aircraft for spraying near important fishing waters and meadows, and to fly as close to tree tops as safety permits to better control spray drift.

3. Amount of DDT will be halved for spray operations near open waterways and meadows.

All important fishing streams and meadows were clearly indicated on maps and photo mosaics. The area 100 feet on either side of the streams was left unsprayed. The next 2,000 feet back from the streams were sprayed by Stearman-type aircraft--no helicopters were used for spraying on this project. This 2,000-foot strip was sprayed with $\frac{1}{2}$ pound DDT per gallon of fuel oil per acre.

Approximately 86,000 acres of this 445,000-acre project were treated with $\frac{1}{2}$ pound DDT using Stearman-type aircraft.

Unit Release

On May 25, written notice was given to the Contracting Officer that parts of the Las Vegas Unit would be ready for spraying on June 4, 1962.

On June 1, notice was given that parts of the Santa Fe and Taos Units would be ready for spraying on June 10.

In all control units the first blocks to be released were all at 9,500 feet in elevation or below. Above 9,500 feet blocks were not ready for spraying due to delayed insect and foliage development. This development change at about 9,500 feet was well defined.

Las Vegas Control Unit

Unit Headquarters and Airport - Headquarters for the Las Vegas Control Unit were set up at the Las Vegas Municipal Airport, Las Vegas, New Mexico.

The Unit headquarters consisted of:

1. Two trailers - one for an office and one for communications.
2. Two tents - one for briefing room. The other tent was not used.
3. Washing and drinking facilities
4. Two chemical toilets
5. Bulletin board for public information
6. Parking area

The insecticide storage tanks and loading stations were set parallel to the taxi strip. The area around the tanks and loading pit was roped off and no-smoking signs posted.

Spraying - Spraying on the Las Vegas Control Unit started the morning of June 4 and was completed on June 16. A total of 137,485 acres was treated, 12,000 acres of which were treated with half pound DDT.

The area up to 9,500 feet in elevation was completed in 5 days. Because of delayed insect development above this elevation, spraying operations were stopped until the morning of June 13. This four-day delay was unfortunate for the contractor but he understood the problem and gave us his full cooperation.

Effectiveness of Spray - Larval mortality lines, to determine the effectiveness of spray, were established in all but one block of the Las Vegas Control Unit. The average percent of larval mortality on the lines due to spraying this unit was 98.8. This is classed as excellent control.

The following table gives the percent of larval mortality on the Las Vegas Unit by blocks and lines.

TABLE III

Spruce Budworm Larval Mortality
Las Vegas Control Unit

Block	Percent Mortality by Line						Percent Mortality of Block
	1	2	3	4	5	6	
L-1	No lines established						--
L-2	96.4	--	--	--	--	--	96.4
L-3	99.3	99.4	97.6	96.7	100.0	99.6	98.7
L-4	100.0	99.6	98.5	99.6	100.0	--	99.5
					Average		98.8

Santa Fe Control Unit

Unit Headquarters and Airport - Headquarters for the Santa Fe Control Unit were set up at the Santa Fe County Municipal Airport, Santa Fe, New Mexico. Facilities at this headquarters were essentially the same as at Las Vegas. The only noticeable difference was in the number of insecticide tanks. Since both the Santa Fe Unit insecticide storage and the Central Mix Plant were here, the place resembled an oil refinery.

Spraying - Spraying on the Santa Fe Control Unit started on June 10 and was completed June 23. A total of 188,616 acres was sprayed, of which about 47,000 acres were sprayed with half pound DDT.

The area up to 9,500 feet in elevation was sprayed first. When everything up to this elevation was completed, the remaining area was released. No delay was encountered on this Unit because of insect development. Lost time due to faulty equipment, two days of wind, and one non-work day allowed the insects to develop at the higher elevations before the contractor completed lower elevations.

Effectiveness of Spray - Larval mortality lines, to determine the effectiveness of spray, were established in all but one block of Santa Fe Control Unit. The average percent of larval mortality on the lines due to spraying this Unit was 96.7. This is classed as good control.

The following table gives the percent of larval mortality on the Santa Fe Unit by blocks and lines.

TABLE IV

Spruce Budworm Larval Mortality
Santa Fe Control Unit

Block	Percent Mortality by Line 1	2	3	4	5	6	7	Percent Mortality of Block
S-1	95.3	90.9	99.3	95.4	100.0	--	--	96.2
S-2	100.0	93.5	97.7	--	--	--	--	97.1
S-3	No Lines Established							
S-4	91.8	100.0	97.8	93.7	100.0	96.3	98.7	96.9
						Average		96.7

Taos Control Unit

Unit Headquarters and Airport - Headquarters for the Taos Control Unit were set up at the Tarleton Airport, a privately owned strip, about 5 miles north of Taos, New Mexico. Arrangements for the use of this strip were made by the aerial spraying contractor and not by the Forest Service. Maintenance of the airstrip was the duty of the contractor. The headquarters for this Unit were housed in two large trailers. One trailer served for communications and as an office. The other trailer was used for briefing and map work. A tent would have served better for briefing--the trailer was cramped for space. The remaining facilities for this Unit were similar to the other units.

Spraying - Spraying of the Taos Control Unit started the morning of June 10 and was completed the morning of June 27. A total of 118,690 acres was treated on this Unit of which approximately 26,000 acres were treated with half pound DDT.

As with the other control units, the area up to 9,500 feet elevation was released and sprayed first.

Effectiveness of spray - Larval mortality lines to determine the effectiveness of spray were established in all blocks of the Taos Control Unit. The average percent of larval mortality on the lines due to spraying this Unit was 97.6. This is classed as excellent control.

The following table gives the percent of larval mortality on the Taos Control Unit by blocks and lines.

TABLE V

Spruce Budowrm Larval Mortlaity
Taos Control Unit

Block	Percent Mortality by Line 1	2	3	4	5	Percent Mortality of Block
T-1	96.0	--	--	--	--	96.0
T-2	99.4	--	--	--	--	99.4
T-3	96.8	--	--	--	--	96.8
T-4	95.1	99.6	99.2	99.4	100.0	98.7
T-5	93.8	100.0	96.7	99.2	--	97.4
T-6	98.7	--	--	--	--	98.7
T-7	96.1	--	--	--	--	96.1
				Average		97.6

PROBLEMS

Accidents

Four accidents involving aircraft occurred during the project.

1. Las Vegas Unit. On June 6 an observation plane (Lockheed 60) piloted by E. Kanell made a long landing, ending up in rough area at the end of the strip. The nose wheel collapsed causing the plane to nose down. No one was injured.

2. Taos Unit. On June 10 an N3N piloted by L. R. Scott did a ground loop while landing. The pilot suffered a broken finger.

3. Taos Unit. On June 24, a TBM piloted by W. McDonnell crashed into the mountains while making an uphill spray run. The pilot was saved by an efficient rescue operation conducted by Air Officer G. Ruth, Smokejumpers J. Holtet and M. Oehlerich, and Helicopter Pilot W. Heuber.

4. Taos Unit. On the last day of spraying, June 27, an N3N piloted by L. R. Scott ground looped on take-off (Fig. 2). The pilot was not injured.

Fig. 2

N3N After Ground Loop on Take-Off

Dust

Santa Fe Control Unit - With all the planes that were based at the Santa Fe Unit, dust in the loading area was a real problem. No one realized how great a problem it would be until the planes pulled into the loading stations on the first day. Air Officer Ruth and the contractor declared the loading area unsafe. The fear was that the dust would cause engine wear and possible failure. A one-base oil coat was laid down in the loading area at a cost of about $1,000. This coat served the purpose but broke up badly towards the end of the project.

Air Officer Ruth explained that aside from the abrasive quality of the dust, it contained metal particles that melt in the hot engine, shorting spark plugs. Fig. 3 illustrates the problem of the metallic dust.

Fig. 3

(a) (b)

Magnet before (a) and after (b) it was dragged through dust at the Santa Fe Airport. Black rings are metal particles.

Taos Control Unit - The Tarleton Airport was a dirt strip. The dust problem was bad. When planes pulled into the loading pit or were prepared to take off, the dust reduced the visibility to zero. The contractor had a water truck sprinkling the area during the spraying operations but this did little to settle the dust. Fig. 4 illustrates the dust problem.

Fig. 4

TBM kicking up the dust at Tarleton Airport

Loading Station Area

Aside from the dust problem at the loading stations, there were other problems.

Santa Fe Unit - The loading stations were set up so planes would leave the taxi strip for loading. Just parallel to the taxi strip there was a shallow drainage ditch that planes had to cross to reach the loading station. The aerial spray contractor's representative objected to the planes having to cross this ditch. He maintained that it would break the nose wheel mechanism on the larger planes. To appease the contractor, the ditch was filled with gravel at two points and landing mat laid over the fill. This made an adequate crossing but at considerable expense to the Forest Service. It appeared that the expense was hardly justified when pilots often ignored the crossing points, driving across the ditch with no apparent harm to the planes.

Las Vegas Unit - It was found that the ground at the Las Vegas loading pit was too soft to allow the planes to leave the taxi strip for loading. A coat of road sealer was applied that partially remedied the situation. The planes still had to be loaded with their front wheels on the taxi strip. Some damage to the taxi strip resulted from this operation and repairs were made by the Forest Service.

Size of Planes

Cisco, Southwest Air Contractors, used several large planes on the Santa Fe Unit; e.g., 2 B25's, an F7F, and a PBY. The B25's and F7F were too fast and too hard to maneuver in this mountainous terrain to be classed as good spray ships. They require large flat areas with long spray runs if they are to operate economically. It was a constant problem to Unit Supervisor Hill to assign areas for these ships to spray. The PBY is a good spray plane but is designed for working close to sea level--we didn't have any areas on this project at that elevation.

Fish Kill

In spite of the precautions taken to protect fish, there was one incident of fish kill on the Las Vegas Unit. It occurred on June 6 when it was reported that two planes sprayed over a trout pond belonging to John W. Rackley, Sapello, New Mexico. This pond was outside of the spray boundary and clearly marked on the map as an area to avoid. The pilots apparently got off course.

The incident was investigated by members of Denver Research Lab., United States Fish and Wildlife Service, New Mexico Department of Game and Fish, and the United States Forest Service. Dead fish taken from the pond were

sent to the Denver Research Laboratory for analysis. The laboratory reported that the fish contained relatively high amounts of DDT that suggest exposure to heavy doses of the insecticide.

Mr. Rackley estimated that 3,600 trout were killed by the spray and submitted a claim for $1,141 to the Forest Service. This claim has been referred to Aerial Applicators, Inc.

Reports received to date on the effect of DDT spray on fish are included in the appendix. No reports on the studies of spray effects on wildlife have been received.

Maps and Mosaics

From this project we leamed that nearly everyone is an expert on maps. From the comments received on the maps we provided, it was obvious that they were poor. These comments were all volunteered after the maps were completed--not before.

Forest pest control funds were appropriated for the project in mid-January. Map work started immediately. In early February, a man from the Pest Control Branch visited the Forests and Ranger Districts to use the timber-type maps and get help in mapping type boundaries, streams, and meadows. The final control maps were made using the information received.

The maps used on the project were 1" planimetric maps. Block boundaries and special precaution areas were marked with various colors. It would have been better to have used some system of cross-hatching with ink so the maps could have been reproduced by machine rather than by hand.

Photo mosaics were available for use by the pilots and Forest Service personnel on each control unit. Block boundaries and special precaution areas were clearly indicated on the photos. It is doubtful if the amount of use these mosaics received warranted the cost and effort of making them.

RECOMMENDATIONS

The following recommendations have been made by various personnel who were involved in the project.

Insecticide Contract

1. Set up a Forest Service Laboratory for testing insecticide at the Central mix plant. This would speed up the approval of finished insecticide, a bottleneck in administration of the contract. The

laboratory technician could assist the COR in checking loads, computing net gallonages, etc. This would free the COR for more contract administration at other airports.

2. Do not allow the contractor to use the central mix tank as part of the central mix plant storage.

3. Change from 15-lb. CO^2 fire extinguishers to either 3- to 5-lb. CO^2 or 3- to 5-lb. dry chemical extinguishers at each required position. On the one occasion where an extinguisher was used, the 15-lb. CO^2 was too heavy to handle while climbing onto the airplane.

4. Prior to start of spraying operations, a fire drill should be required with all Forest Service, insecticide contractor, and aerial contractor personnel participating.

5. The airport locations be arranged for and all tank locations and loading stations staked out prior to advertisement of the contract. This would solve the problem of unknown quantities of pipeline, loading station tank placement, etc., for the contractor.

6. Require a calibrated gauge on all tanks.

7. Require a meter between the central mix tank and central mix plant storage tanks.

8. Allow for enough extra gallonage in the contract to fill one storage tank. This fluid could be pumped from tank to tank to check for leaks prior to their use. The fluid could then be pumped into the airplane tanks and allowed to stand overnight, thus checking for leaks. This fluid could then be used to check spray patterns and calibrate the spray nozzels.

9. Require one of the contractors (aerial or insecticide) to prepare the loading pit area for dust control or have the Forest prepare the site prior to operations--consider the possibility of landing mat for the entire loading pit-ramp area.

10. Stipulate a cut-off nozzle at the end of the loading hose at each loading station to avoid spillage on the loading areas or taxiways.

11. Delete Section 8, Item 2a(1), through (6), page 18 of the insecticide contract. Require all finished insecticide to be placed in airport loading station storage and then metered into the airplanes.

12. Have COR assigned to the job and become familiar with the sites even prior to award.

13. Change wording in insecticide supply contract to provide for minimum gallon-per-minute pumping capacity to permit contractor to use equipment which does not tie him to 2½-inch supply lines. This is an unusual size and difficult to obtain.

14. Truck load tickets were not received by consecutive numbers. In these cases, the ticket should bear a notation of the reason.

Aerial Spray Contract

1. Require crystal-controlled radios for all aircraft--spray, observer, and rescue.

2. Put limit on aircraft, size and speed, that will be acceptable. The terrain and elevation to be sprayed will determine this.

3. Do not require so much acreage along streams to be sprayed with Stearman-type aircraft. Just use Stearman-type to spray one or two passes along stream to straighten spray run. Use TBM's with one-half pound DDT to do rest of special precaution area.

4. The Stearman-650 with the Swathmaster spray boom was an excellent machine. The cockpit-controlled system lead to over-application on several occasions. This control should be sealed so as to yield a 20 to 30 gallon-per-minute flow at normal airspeeds.

5. Stearman-450 aircraft are not suitable for high elevation spraying in rough country. They cannot carry enough payload of insecticide.

6. Some penalty should be imposed on the contractor if the minimum number of aircraft do not spray some minimum time each day, barring bad weather.

7. For each fast spray plane (TBM, B-25, etc.) there should be an observation plane. This observation plane could handle two or three such spray planes if the latter worked together. The plane could also handle one or two Stearman-type working in the same vicinity.

8. Maintain absolute control over use of observer planes and other light aircraft. This can be done by making it compulsory that the "Daily Flight Record" be initialed and approved for each flight by the Unit Supervisor or a designated person, and returned to office after each flight.

9. The responsibility of contractor and the Forest Service should be clearly stated regarding the condition of the airfield and particularly the loading area.

10. Orientation of spray pilots including cost of "birddog" aircraft should be spelled out in the contract. The mere orientation of the chief pilot with the expectation that he will properly train his spray pilots in the location of block boundaries is not satisfactory.

11. The contract should be more explicit in wastage as caused by defective aircraft and equipment. Spillage, leakage, drops, and other wastage should be clearly defined as to responsibility. The contract should be written in such a manner that a reasonable number of emergency dumps are allowed per aircraft; however, the contractor should be penalized for an excessive number of dumps because of poorly maintained equipment.

12. The contract should provide for a thorough and adequate check of all spray planes. To do this the following is proposed:

a. Require all spray planes and pilots to be available at least four days in advance of the start of spraying. Set up spray cards on a portion of the treatment area in sufficient numbers to give an actual check under project conditions for all planes.

b. Load all spray planes with goop and allow to stand at least 12 hours to check for leaks.

c. Have planes spray test pattern over cards at which time equipment checks and calibration should actually be field checked.

d. During this four-day period, all spray pilots and observers should be properly orientated from the air in project block and sub-block unit boundary locations.

Airport

1. Loading areas, if bare soil, should be oiled at least one week in advance of spraying. This not only protects aircraft engine but prevents accidents due to flying dust, rocks, etc.

2. Loading pits should be at least 100 feet apart to give better maneuverability for spray planes.

3. Provide for immediate "washing down" or dilution facilities for insecticide accidentally spilled on the ground.

Communications

1. Have radios manned by qualified operators having special training in radio technique.

2. Place communication facilities in view of the runways and loading pits.

3. Assign separate air-ground frequency to each unit when possible.

4. Devise a code for each unit such as was used on this project.

Maps and Mosaics

1. Determine from other regions the most common type and size of map and/or mosaic used by spray pilots.

2. Unit blocks should be divided and subdivided into small enough areas to allow treatment in not over two days.

3. Set up blocks on the basis of elevation and aspect in anticipation of the time at which the insect will develop to a stage of readiness for treatment.

Organization

1. Have an air officer assigned to each unit.

2. The ground-safety officer should "ride herd" on all unit vehicles to insure that preventative maintenance, service, and care is exercised.

3. Use air observers who are thoroughly familiar with the country. Use local Ranger, Assistants, GDA's or former Rangers or Assistants.

4. Review and change individual job descriptions to make them function better; e.g., do not tie down the Unit Supervisor with the responsibility of daily progress-map maintenance. This job can better be done by the Assistant Unit Supervisor working with the air observers.

Safety

1. Have coffee available at all times.

2. All pilots should log their total flying hours whether it be on the contract or other off-hours flying.

3. Have a helicopter and smokejumpers available for reserve work.

4. Load and flight checkers should wear brightly colored hunting vests.

General

1. Provide more time for training personnel prior to start of spraying.

2. Review and revise present systems of record keeping to make them more workable.

C O P Y

UNITED STATES
DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE
Bureau of Sport, Fisheries and Wildlife
Fish-Pesticide Research Laboratory
Building 45 - Denver Federal Center
Denver 25, Colorado

July 18, 1962

Mr. Fred H. Kennedy, Regional Forester
U.S. Forest Service Service
517 Gold Ave., S.W.
Albuquerque, New Mexico

Dear Mr. Kennedy:

Attached here are some results of chemical analysis done in our laboratory in connection with the spruce budworm spray program on the Santa Fe National Forest. All available water samples have been completed, and the fish samples from Rackley's Pond in the Sapello drainage have been done. Other samples will be run as they become available.

It appears to us from these data that the amounts of DDT found in the water samples are very small and probably not sufficient to cause acute mortality in trout. The amounts of DDT found in the fish from Rackley's Pond are relatively high, and suggest exposure to heavy doses of the insecticide.

Sincerely yours,

/s/ Oliver B. Cope
Chief

cc: N.M. Game & Fish
Regional Office

COPY

Results of Analysis for DDT in Samples
from Santa Fe National Forest

FISH

Collected dead in Rackley's Pond, Sapello drainage, on June 7, 1962 after airplane spray with DDT.

R-1 2 rainbow, 50 and 82 grams, 13.9 and 9.9 ppm of DDT complex
R-2 3 rainbow, 36, 26, and 14 grams, pooled sample with 11.1 ppm
R-3 2 rainbow, 78 grams, 190 mm and 45 grams, 160 mm, 38.8 and 37.0 ppm of DDT complex

WATER

Lower Pecos

P-111-0	Before spray	ND (No detectable DDT)
P-111-1	4 hrs. after second spray	ND

Rio La Junta

L-0	Before spray	ND
L-2	30 min. after first spray	1.9 ppb(parts per billion)
L-3	2 hrs. "	2.7 ppb
L-4	1 hr. after second spray	ND
L-5	2 hrs. "	ND
L-6	4 hrs.	ND
L-7	6 hrs. "	ND
L-8	1 hr. after third spray	ND
L-9	3 hrs. "	ND
L-10	6 hrs. "	ND

COPY

STUDY OF AERIAL DDT TREATMENT OF THE PECOS RIVER DRAINAGE
SANTA FE NATIONAL FOREST, NEW MEXICO
JUNE 11 - 23, 1962

Introduction:

In order to control a heavy infestation of the spruce budworm in the Carson and Santa Fe National Forests of New Mexico, it became necessary to spray the area with DDT. A study area was set up to evaluate the effects of the DDT spray on the fish and aquatic insect life within the spray area. This study area consisted of the Pecos River and its tributaries, north of Indian Creek, and covered approximately 100,000 acres. (See map) This river, along with its numerous clear water streams, is considered to be one of the finer trout fishing areas in the State. Also located in the Santa Fe National Forest on the Pecos River is the Lisbon Fish Hatchery owned and operated by the New Mexico Game & Fish Department.

The sampling stations were located as follows:

Station #1 - Twp. 16N, Rge. 12E, Sec. 16 on the Pecos River near the Lisbon State Fish Hatchery.

Station #2 - Twp. 18N, Rge. 12E, Sec. 15 on the Pecos River above the confluence of the Pecos-Mora Rivers.

Station #3 - Twp. 18N, Rge. 12E, Sec. 14 on the Mora River above the campground.

The size of the drainage, the great fishing pressure and the hatchery location were all factors in locating the study in this area. Another study area was located on the Rio Pueblo - La Junta streams near Tres Ritos; this part of the report will be authored by the Fish Pesticide Research Lab of the U. S. Fish & Wildlife Service in Denver.

Procedure & Location of Sites:

Under the guidance and direction of Mr. W. R. Bridges of the Fish Pesticide Research Lab of the U. S. Fish & Wildlife Service, the following procedure and sites were gathered: Prior to the spray job, three sampling stations were located (see map). At each of these sites live fish were placed in live-cars. These fish were used as control fish during the spray period. Insect drift samples and water samples were also taken prior to the spray period. These pre-spray samples are to be analyzed for amounts of DDT residue before spray with the 5 minute drift sample to be used as an indicator to the abundance of aquatic insects prior to spraying.

During the actual spraying operations, the stations were manned to determine the effects of the DDT on the control fish, to evaluate the peak period of insect kill and to determine amounts of DDT residue in the water, insect and fish samples collected.

Field Findings:

As added safety precautions to protect the Fisheries in the entire spray area, strips or buffer zones of approximately 100 feet on either side of the streams were left unsprayed. Adjacent to the unsprayed strip and for a distance of approximately 1000 feet on either side, (this covered most or all of the Pecos Area) the amount of DDT used was .5 pound per acre. Small biplanes (stearman) were used in the canyons with larger planes (TBM & B-25) covering the ridges and higher elevations. To minimize the spray drift, the operations were stopped when the wind velocity reached six miles per hour.

The actual period of spray began on June 11 and was completed on June 23rd. (Referring to Pecos study area only). Of the 12 days in this period, 8 days of actual spray operations took place. The actual time of spray during these days was confined to periods between 4:30 AM and 9:00 AM.

The waters of the Pecos River during this study period flowed clear with a velocity range of 4-6 feet per second. The water temperatures ran from a low of 46°F on Holy Ghost, Panchuela and Windsor Creeks to a high of 66°F on the Mora. Temperatures on the main Pecos ranged from 53°F at the upper station to 59°F at the lower station.

Other chemical make-up was as follows:

Methyl Orange alkalinity ranged from 50 to 85 PPM.
Phenolphthalein alkalinity found only on Willow Creek of 15 PPM.
PH values ranged from 7.1 on Windsor Creek to 8.1 on the upper Pecos.

The bottom of the streams of the Pecos Drainage consist of large boulders, rock and gravel with a very small amount of silt. Some moss is scattered throughout with sparse growth of algae. The most abundant type of insect found during the pre-spray and spray period was the Stonefly, followed by the Caddis, Diptera species and Mayfly.

Twenty control fish (from live-cars) were taken at various intervals during the spray period. These fish were placed in plastic bags and frozen. They will be analyzed at a later date, for DDT residue by the Denver Fish & Wildlife Research Lab. Additional fish will be collected at 10 day, 30 day and 60 day intervals after spray. These too, will be sent to Denver for analysis. An effort will be made to collect insect residue samples at the 10 day after spray period.

Conclusions:

These conclusions are based only from the actual field studies and observations. Final conclusions will not be available until such time as the water, insect and fish samples are analyzed. The spray period was spread out over a long period of time which made field studies more difficult. The instar stages of the spruce budworm were ready for spraying in the lower Pecos much sooner than in the upper reaches. At no time during this spray period were any dead fish observed or reported dead in this area. Only two of the forty fish in the live-cars were dead at the end of the spray period. These fish were held for sixteen days and were showing visual signs of prolonged confinement.

Five minute drift samples taken throughout the spray period showed a steady decrease of aquatics as the area was sprayed. No insects were taken in the five minute drift sample in several of the streams; however, a 30 minute drift would produce a very limited number. There were not enough insects to collect for residue during the last few days of spray. It appears that the insects were hit fairly hard. Many Caddis worm houses were observed still attached to rocks and apparently unharmed by the spray. Conclusions from the above observations and field collections would indicate no adverse effects were made on the fish populations of the Pecos River and tributaries from the DDT spraying. The 10 day, 30 day and 60 day checks of the area will give us an indication as to the length of time before the insect populations will come back.

Realizing the importance of this control job, it presently appears that the proper precautionary measures were taken and carried out correctly. The fish food seems to have suffered quite extensively; however, due to the rapidity in which insects come back, it is likely that the food chain will be back to normal in a short time. Without the timber, the fish habitat would soon be depleted and with it the fish. The spray job was carried out with every consideration given to the fish species and at the same time to do the job of controlling the spruce budworm infestation.

Accumulative results of the DDT residue over a period of time are not presently known; however, results from the field studies of the control fish appear to indicate very little, if any, mortality of fish species.

Personnel:

Mr. W. R. Bridges of the Denver Research Lab of the U.S. Fish & Wildlife Service spent considerable time (June 4-15) and effort in setting up these stations and directing the sampling techniques. Due to other commitments,

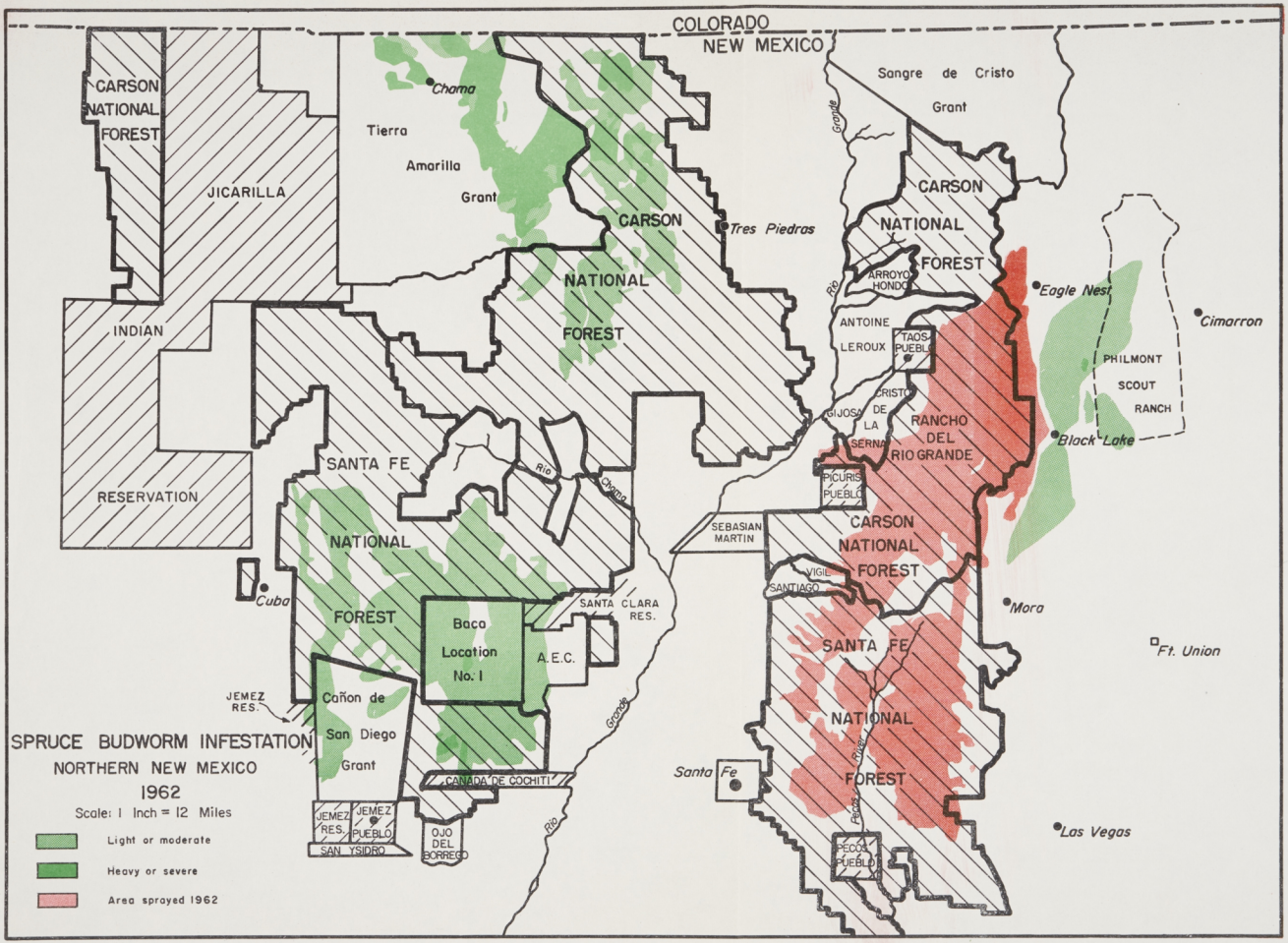
he had to leave on June 15th. Mr. James Harrison and his assistant of the Fishery Division of the New Mexico Game and Fish Department assisted with sampling and equipment from June 4 until June 14th. Mr. Harrison will attempt to get the post-spray samples necessary to evaluate the accumulative residue of the stream fishes. Mr. H. J. McKirdy spent from June 4 to June 23 on the project.

The use of the walk-in freezer at the Lisbon Hatchery of the Game & Fish Department for storage of the specimens, is much appreciated.

Submitted by:

H. J. McKirdy
Fishery Biologist
U. S. Forest Service
Albuquerque, New Mexico

cc: Santa Fe N.F.
New Mexico Game & Fish Dept.
Timber Mgmt.
Denver Research Lab.
U. S. Fish & Wildlife Serv.


COLORADO
NEW MEXICO
CARSON NATIONAL FOREST
JICARILLA
INDIAN
RESERVATION
Chama
Tierra Amarilla Grant
CARSON NATIONAL FOREST
Tres Piedras
SANTA FE NATIONAL FOREST
Rio Chama
Cuba
Baca Location No. 1
A.E.C.
SANTA CLARA RES.
JEMEZ RES.
Cañon de San Diego Grant
CANADA DE COCHITI
JEMEZ RES.
JEMEZ PUEBLO
SAN YSIDRO
OJO DEL BORREGO
Rio Grande
Sangre de Cristo Grant
Rio Grande
CARSON NATIONAL FOREST
ARROYO HONDO
ANTOINE LEROUX
TAOS PUEBLO
CRISTOBAL DE LA SERNA
RANCHO DEL RIO GRANDE
PICURIS PUEBLO
SEBASIAN MARTIN
CARSON NATIONAL FOREST
VIGIL SANTIAGO
SANTA FE NATIONAL FOREST
Pecos River
PECOS PUEBLO
Santa Fe
Las Vegas
Eagle Nest
Cimarron
PHILMONT SCOUT RANCH
Black Lake
Mora
Ft. Union
SPRUCE BUDWORM INFESTATION
NORTHERN NEW MEXICO
1962
Scale: 1 Inch = 12 Miles
Light or moderate
Heavy or severe
Area sprayed 1962