

Item ID Number 00612

Author DuBridge, Leo A.

Corporate Author

Report/Article Title Statement of Dr. Leo A. DuBridge, Director, Office of Science and Technology, Senate Commerce Committee, April 15, 1970

Journal/Book Title Hearings Before the Subcommittee on Energy, Natural

Year 1970

Month/Day

Color

Number of Images 8

Description Notes Alvin L. Young filed this item under the category "Human Exposure to Phenoxy Herbicides and TCDD"; also includes document: Watershed Studies with 2,4-D, 2,4,5-T, and Picloram, p. 456-465

1970. Human
EFFECTS OF 2,4,5-T ON MAN AND THE ENVIRONMENT

HEARINGS

BEFORE THE

SUBCOMMITTEE ON ENERGY, NATURAL
RESOURCES, AND THE ENVIRONMENT

OF THE

COMMITTEE ON COMMERCE

UNITED STATES SENATE

NINETY-FIRST CONGRESS

SECOND SESSION

ON

EFFECTS OF 2,4,5-T ON MAN AND THE ENVIRONMENT

APRIL 7 AND 15, 1970

Serial 91-60

Printed for the use of the Committee on Commerce



U.S. GOVERNMENT PRINTING OFFICE

WASHINGTON : 1970

45-302

Dr. Lee DuBridge
Director, Office of Science and
Technology. 451

Senator HART. Before adjourning, I should add for the record there had been scheduled Dr. DuBridges of the Office of Science and Technology, but Mr. Bickwit advises that in the face of a 5:30 appointment, he has asked not to be heard, but instead submits his statement for the record.

(The statement follows:)

STATEMENT OF DR. LEE A. DUBRIDGE, DIRECTOR, OFFICE OF
SCIENCE AND TECHNOLOGY

SENATE COMMERCE COMMITTEE,
APRIL 15, 1970.

Mr. Chairman, Members of the Subcommittee, Let me say at the outset that I am pleased to have an opportunity to discuss with this Subcommittee certain aspects of the herbicide, 2,4,5-T. An examination of the subject illustrates a number of important issues relating to the Federal Government's involvement with pesticides. I believe that these deserve some discussion and I am glad to have the privilege of exploring them with you.

The herbicide, 2,4,5-trichlorophenoxyacetic acid is a member of a family of pesticides which have served mankind very well for a long period of time. This group of compounds, known as phenoxy or auxin herbicides, have been used since the late 1940's and resulted from research work performed during the 1940's on herbicides and defoliant for military as well as civilian use.

The toxicity of 2,4,5-T was studied in line with the requirements for its registration by the Department of Agriculture. The toxicology required for this registration of 2,4,5-T was aimed primarily at determining its acute toxicity. In this regard, it is now quite clear that the experiments performed for this purpose (almost all of which were done by or for the manufacturing industry seeking the registration) revealed that 2,4,5-T was relatively non-toxic.

This herbicide demonstrated a persistence in soil and water which was very short (on the order of three months for total disappearance). It is true also, as you heard last week, that only rare instances of 2,4,5-T residues have been discovered in the food surveys performed by the Department of Health, Education and Welfare.

As a result of these findings, plus its proved utility as an herbicide and as a defoliant, 2,4,5-T was considered a very beneficial and safe herbicide and with good reason. As evidence for this, it is plain that the demand for 2,4,5-T has risen, especially in the last several years. The production of 2,4,5-T in the United States increased from 7.9 million to 42.5 million pounds between 1960 and 1968. Domestically, it has proved its worth as a valuable adjunct in the clearing of range and pasture lands of brush, in the clearing of roadsides and rights-of-way, in the suppression of aquatic weeds, in the limited use for control of weeds in croplands, and for altering physiological responses of crops. The increase in production apparently has reflected the demand for 2,4,5-T both domestically and as a defoliant for military operations in southeast Asia. In fact, the domestically used quantities actually decreased between 1964 and 1966.

In 1964, the National Cancer Institute of the National Institutes of Health undertook on contract with the Bionetics Research Laboratories, Incorporated, a screening study of a large number of economic poisons. As you have heard, the general purpose of this study was to ascertain the potential for cancer, for genetic alteration, and the potential of producing birth defects for this long list of pesticides. All who have been concerned with this subject recognize the value of the Bionetics study as a screening mechanism for these potential hazards. 2,4,5-T was among the list of materials screened. One of the results of this study was that a particular lot of commercial grade 2,4,5-T provoked birth

defects in mice and rats if administered in sufficiently large doses at an appropriate stage of pregnancy in these animals. These results were available in 1968 and they were subsequently further analyzed statistically by the National Institute of Environmental Health Sciences.

No further action was taken on the findings of the Bionetics study after August 1968 nor was the information on teratogenesis publicly available. However, copies of the study reports did find their way to members of Congress, to journalists, and to some members of the scientific community. Coincidentally, in May or June of 1969, a number of anecdotal articles appeared in the Vietnamese press which reported an unusual incidence of congenital abnormalities and abnormalities of pregnancy in certain parts of Vietnam. In some cases, these reports were linked to defoliation operations. The evidence for this is, however, extremely doubtful.

It was with this background that I met in October of last year, in my capacity of Executive Secretary of the Environmental Quality Council, with representatives of the several Federal agencies which were most concerned with the use of this herbicide. It was the consensus of these representatives that this research information from the Bionetics study warranted serious consideration including certain restrictions on the use of 2,4,5-T. The announcement of these intended actions occurred on October 29.

One of these actions was a limitation of defoliation operations in Vietnam. The limitation, which did occur subsequently, took the form of restricting defoliation to non-populated areas. Another announced action was aimed at the Government's own use of 2,4,5-T domestically in programs of brush and weed control. These programs were mainly pursued by the Department of Agriculture and the Department of the Interior. Here the Government did restrict the application of this herbicide so as to reduce possible exposure to man. The State Department, which to some extent had been a party to the use of 2,4,5-T along our border with Canada, took steps to reduce human exposure here and make available to foreign countries technical data about the subject.

The Department of Agriculture agreed to cancel the registration of 2,4,5-T for use on food crops by the first of the year unless the Food and Drug Administration could, by that time, satisfy itself that it had enough evidence to establish a negligible tolerance limit for human exposure. The food crop uses of 2,4,5-T incidentally represented a minority of its total domestic use.

At the time of the announcement of concerted Government actions, I also assembled a panel of experts within the Office of Science and Technology to review all that is known about 2,4,5-T. This Panel has prepared a report on the subject which I expect to make available within a few weeks. During the course of this review, it became known that an impurity of 2,4,5-T was of potential importance. The impurity, a polychlorinated dioxin, was apparently very toxic and had been identified in batches of 2,4,5-T as early as 1957. It arose partly as an impurity of the chlorophenol starting material and partly as a result of the temperatures and pressures of certain of the reactions in the manufacturing process. It had provoked severe skin irritations among workers in 2,4,5-T plants in Germany and in the United States. The discovery of this industrial hazard had led one U.S. manufacturer to curtail his process until he was able to reduce the dioxin content to less than 1.0 ppm in the 2,4,5-T product. This eliminated the skin irritation problem.

Within weeks after my announcement, some additional animal experiments were begun in two laboratories simultaneously. These experiments were directed towards confirming and extending the results of the Bionetics studies. In addition, they were aimed at finding out whether the apparent teratogenic agent was 2,4,5-T itself, or a potent impurity.

Fortunately, the experiments needed to test for teratogenesis are essentially acute, short-term studies. With an expectation of meaningful results from these experiments in a fairly short period of time and in view of the potential

of the dioxin impurity, the Department of Agriculture in consultation with Interior, HEW, and my office delayed any action toward cancellation of the food crop registrations for 2,4,5-T as you heard last week.

One of the sets of confirmatory studies was undertaken by the Government itself. The results of these experiments, pursued at the National Institute of Environmental Health Sciences, were made known to you by Dr. Steinfeld this morning. Essentially, these results implicated both 2,4,5-T (in the purest form available) and its dioxin impurity as potential teratogens. This story, I think you will agree, represents an example of some appropriate Government actions. As you have heard and as Dr. Steinfeld pointed out, the results of these confirmatory studies were translated into immediate actions in the form of a series of announced Government restrictions on uses of 2,4,5-T.

Let me now turn to what I believe are some important lessons to be learned from this fascinating case study. First, let me review. We have here an example of a chemical substance intentionally placed into the environment by man for the betterment of his welfare. Where the aim has been to exchange capital for labor in land and waterway management, there can be no doubt that this herbicide has proved its worth.

In view of what we have now learned, I am persuaded that we must consider some changes in our procedures and we must be willing to submit our regulatory systems for pesticides, as for other chemicals in the environment, to examination. The very excellent report of the Secretary's Commission on Pesticides, headed by Dr. Emil Mraak, will, of course, serve to point up this issue.

From a number of indications it is quite apparent that we, as a society, have relatively recently begun to ask more sophisticated questions about adverse effects on health of a variety of chemical substances. In part, this has come about because of some additional scientific knowledge and investigative tools. In part, it has arisen simply by virtue of some increased concern about the safety of environmental chemicals. For example, the realization that environmental agents may be major contributors to the incidence of cancers in the epidemiological sense is a fairly recent observation.

In brief, then, we have set our sights higher in terms of the questions we would like the scientific community to ask about pesticides. As I reminded you at the outset, the total amount of background toxicology performed on 2,4,5-T had been limited to studies of acute toxicity—performed essentially by industry as directed by the Federal Government. No one had seriously suggested that the hazards of birth defects, genetic change, or cancer be tested for in the case of 2,4,5-T, nor were there tools to screen for these diseases. The Bionetics study represented a step up in degree of sophistication of research.

Certainly this evolutionary process is a highly commendable situation and is one which is to be encouraged. There do exist some dilemmas, however. The major dilemma accrues from the fact that there is no real end point to this questioning process. The more research that is performed, the more new questions will be raised about the chemical under investigation. That is, it is quite obvious that decisions virtually always will have to be made on admittedly incomplete information. Perhaps the goal we should seek is a sufficiently flexible system to allow us to change our minds (when confronted with new information), coupled with an explicit acknowledgement of the perpetually interim state of our scientific knowledge. Again, the Bionetics study is illustrative. The

Bionetics' results were new and unexpected findings—albeit tentative findings. It is the nature of science that experimental results are always subject to further confirmation and refinement. The discovery of teratogenesis in experimental animals required confirmation and further investigation to make that finding meaningful. Fortunately, the experiments to do this were begun almost immediately, as you know, and the results have just now become available. What these results have done is to sustain our earlier concern about this herbicide. At the same time, scientific logic would dictate that we should continue to apply more research effort to better understand these findings.

Then too, the more sophisticated the scientific investigations become, the more expensive they are. The cost of the Bionetics study was approximately two and one-half million dollars. Remember, this was only a screening study. Much more extensive studies would surely be desirable.

A related question that is raised concerns the distribution of these costs. As I have noted, in the case of pesticides, the tradition has been for the Government to impose on industry the obligation of proving that a material is safe and of performing the toxicology necessary for that proof. As the cost and the time required for this background research rises, the manufacturers may be less and less inclined to pursue the development of new products of limited or uncertain marketability. Since we depend on the manufacturing industry for this development, we may be discouraging innovative and improved products. Hence, I submit that additional public investment may have to be made in the future in background research relating to health and other effects of environmental agents—including pesticides. The President's Science Advisory Committee is studying these issues presently.

Let me touch now on the subject of the translation of research findings into policy decisions and regulations. I have made the point that the heart of the Federal Government's control over pesticides resides in the process of registration with the Department of Agriculture. This registration is based, in part, on toxicological information supplied by the manufacturer. There has been relatively little thought given to the subject of how to incorporate new, unexpected information which is collected outside the registration process into the regulatory process. This was clearly demonstrated after the Bionetics study.

Finally, let me raise the question of the latitude available for regulation of pesticides. Under the existing Federal Insecticide, Fungicide and Rodenticide Act (which law regulates pesticides), the burden of proof of safety resides with the manufacturer. In the case of an existing registration, the options for action available to the Government, however, are relatively few. These are cancellation or suspension of the registration. Both of these are relatively drastic actions and are not supposed to be entered into capriciously. If a registration is cancelled (which was the suggestion made for 2,4,5-T), the decision may be appealed by the manufacturer and it then befalls the Government to prove that a hazard exists, rather than the industry to establish its safety. In short, there does not exist a mechanism whereby the Government may exercise prudent and unequivocally effective restraint temporarily on the receipt of new, unexpected information, and while awaiting more definitive results.

There are now under discussion a series of proposed amendments to the Federal Insecticide, Fungicide, and Rodenticide Act. These matters are seriously being considered in these discussions before your Committee.

Watershed Studies with 2,4-D, 2,4,5-T, and Picloram¹

Description of Watersheds

The two experimental watersheds are located in the southern Appalachian near Waynesville, North Carolina. Watershed 1 contains 4.64 acres, and watershed 2 contains 3.66 acres. The slopes of both watersheds averaged about 35 to 40 percent. The predominant soil is Halewood clay loam. The watersheds are delineated and enclosed so that no surface or subsurface flow can enter. Each is equipped with a weir installed to bedrock, and total flow from the watersheds is measured. Three 0.05-acre plots with catchment devices for surface runoff determination are superimposed on watershed 2. The vegetative cover was a mixed grass sward containing discontinuous infestations of herbaceous weeds and small woody plants.

Experimental Procedure

The map of watershed 1 (Figure 1) shows the nine 0.05-acre plots sprayed in 1967 and the three large plots (1.16 acres) sprayed in 1968 and 1969. There are three replications of three treatments in 1967. Large plots A, C, and D were sprayed with the same herbicides in 1968 and 1969. The application rate was 2 lb/A. When large plots were used, there was one replication per watershed. The map of watershed 2 (Figure 2) shows the small plots sprayed in 1967 and 1968. The plots were sprayed as shown in 1967. In 1968 herbicide treatments were rotated so that each plot received a different herbicide. The application rate was 2 lb/A in 1967 and 1968. In 1969 the large plots were sprayed at a rate of 4 lb/A. The treatments were adjusted so that the herbicide assigned to each surface runoff plot had not been applied to that plot in 1967 or 1968. There were three replications of treatments when small plots were used. Treatments on large plots were unreplicated within a watershed.

The chemical and common names of the herbicides were 3,6-dichloro-o-anisic acid [dicamba], 2,4-dichlorophenoxyacetic acid [2,4-D], 2,4,5-trichlorophenoxyacetic acid [2,4,5-T], and 4-amino-3,5,6-trichloropicolinic acid [picloram].

The herbicides were applied in September, 1967 and in August, 1968 and 1969. All applications were made with a Knap-sac sprayer. The herbicidal formulations were as follows:

dicamba (dimethylamine salt)
2,4-D (alkanolamine salts)
picloram (potassium salt)
2,4,5-T (propylene glycol butyl ether ester in 1968)
2,4,5-T (triethylamine salt in 1969).

For several months after spraying, grab samples of water were collected at the flumes during storms, and runoff samples were removed from the surface-runoff tanks at the end of each rain storm. Water and soil samples were shipped to Raleigh for analysis. Soil samples were frozen before shipment. Water samples were shipped as soon as possible after collection and were stored at 4°C on arrival in the laboratory. Usually, analysis of water samples began within 3 to 4 days after collection.

An electron-capture gas chromatographic method was developed for simultaneously measuring residues of the four herbicides. Low limits of detection of 2,4-D in water was 0.002 to 0.003 ppm; for picloram, 2,4,5-T, and dicamba the limit was 0.0005 to 0.001 ppm.

Results

Water samples collected from flumes at the base of each watershed during and after rain storms in 1967 contained 2,4-D, but concentrations of picloram and dicamba were below the limits of detection. The highest concentration of 2,4-D (0.028 ppm) occurred shortly after peak runoff of the first storm after application. The level decreased with each subsequent storm and was below the limit of detection in samples taken between September 27, 1967 and June 17, 1968 when sampling was discontinued until the 1968 application.

Although one-fourth of watershed 1 was sprayed with each of three herbicides in 1968, neither 2,4,5-T nor picloram was detected in flume water, and only low concentrations of apparent 2,4-D (0.003 to 0.005 ppm) occurred sporadically (Table 1). A small interference peak with a retention time in the gas chromatograph equal to that of 2,4-D raises some doubt about the authenticity of 2,4-D values in the 0.002 to 0.004 ppm range (Tables 1 and 2).

Concentrations of the herbicides in flume water samples collected in 1969 from watershed 1 were below the detection limit in all cases (Table 3).

After the 1969 applications, 2,4,5-T was detected in water samples taken at the base of watershed 2 during the first and second storms (Table 4). The highest concentration was 0.048 ppm in a sample collected while runoff was increasing during the second storm. The concentration was less in other samples and decreased to less than 0.001 ppm when flow returned to normal. Low concentrations of picloram were detected in flume samples during the second storm also. The maximum concentration was 0.003 ppm in a sample collected while flow rate was decreasing. Picloram was detected at 0.002 ppm in the first base-flow sample taken after the storm, but levels were less than 0.001 ppm in all samples thereafter.

Residues of 2,4-D, 2,4,5-T, and picloram in soil at several times after application are shown in tables 5, 6, and 7, respectively. The 2,4-D disappeared rapidly from soil. Although picloram persisted for several months, none was detected 1 year after application. A very small amount of 2,4,5-T was present in the 0 to 6-inch soil depth at 3 and 7 months after application, but none was found 12 months after.

¹ A contribution of the North Carolina State University Agricultural Experiment Station. This research was supported by the U. S. Department of Agriculture under Contract No. 12-14-100-8938(34).

Table 1. Concentrations (ppm) of 2,4-D, 2,4,5-T, and picloram in water from the flume of watershed 1 over a 4-month period after application of 2 lb/A of each herbicide to 25% of the watershed area on August 21, 1968.

Date	Flow condition	2,4-D (ppm)	2,4,5-T (ppm)	Picloram (ppm)
8-25-68	Peak	<0.002	<0.0005	<0.0005
	Base	<0.002	<0.0005	<0.0005
8-31-68	Peak 1	<0.002	<0.0005	<0.0005
9- 1-68	Half-down	<0.002	<0.0005	<0.0005
	Peak 2	<0.002	<0.0005	<0.0005
	Peak 3	<0.002	<0.0005	<0.0005
	Base	<0.002	<0.0005	<0.0005
9- 6-68	Base	<0.002	<0.0005	<0.0005
9-13-68	Base	<0.002	<0.0005	<0.0005
10- 3-68	Half-down	0.005	<0.0005	<0.0005
	Base	0.002	<0.0005	<0.0005
10- 6-68	Half-down	0.004	<0.0005	<0.0005
	Base	0.003	<0.0005	<0.0005
10-16-68	Base	<0.002	<0.0005	<0.0005
10-24-68	Base	<0.002	<0.0005	<0.0005
11- 6-68	Base	0.002	<0.0005	<0.0005
12- 1-68	Peak	<0.002	<0.0005	<0.0005
12-13-68	Peak 1	<0.002	<0.0005	<0.0005
	Peak 2	<0.002	<0.0005	<0.0005
	Peak 3	<0.002	<0.0005	<0.0005
12-14-68	Base	<0.002	<0.0005	<0.0005
12-20-68	Base	<0.002	<0.0005	<0.0005
12-22-68	Peak 1	<0.002	<0.0005	<0.0005
	Peak 2	<0.002	<0.0005	<0.0005
12-24-68	Half-down	<0.002	<0.0005	<0.0005
12-26-68	Base	<0.002	<0.0005	<0.0005

Table 2. Concentrations (ppm) of 2,4-D, 2,4,5-T, and picloram in water from the flume of watershed 2 over a 4-month period after application of 2 lb/A of each herbicide to 4% of the watershed area on August 20, 1968.

Date	Flow condition	2,4-D (ppm)	2,4,5-T (ppm)	Picloram (ppm)
8-25-68	Half-up	<0.002	<0.0005	<0.0005
	Peak	0.002	<0.0005	<0.0005
	Half-down	<0.002	<0.0005	<0.0005
8-31-68	Peak 1	<0.002	<0.0005	<0.0005
9- 1-68	Half-down	<0.002	<0.0005	<0.0005
	Peak 2	<0.002	<0.0005	<0.0005
	Peak 3	<0.002	<0.0005	<0.0005
	Base	<0.002	<0.0005	<0.0005
9- 6-68	Base	<0.002	<0.0005	<0.0005
10- 3-68	Half-down	<0.002	<0.0005	<0.0005
	Base	<0.002	<0.0005	<0.0005
10- 6-68	Half-down	0.003	<0.0005	<0.0005
	Base	<0.002	<0.0005	<0.0005
10-16-68	Base	<0.002	<0.0005	<0.0005
10-24-68	Base	<0.002	<0.0005	<0.0005
11- 6-68	Base	0.003	<0.0005	<0.0005
12- 1-68	Half-up	<0.002	<0.0005	<0.0005
12-13-68	Peak 1	<0.002	<0.0005	<0.0005
	Peak 2	<0.002	<0.0005	<0.0005
	Peak 3	<0.002	<0.0005	<0.0005
12-14-68	Base	<0.002	<0.0005	<0.0005
12-20-68	Base	<0.002	<0.0005	<0.0005
12-22-68	Peak 1	<0.002	<0.0005	<0.0005
	Peak 2	<0.002	<0.0005	<0.0005
12-24-68	Half-down	<0.002	<0.0005	<0.0005
12-26-68	Base	<0.002	<0.0005	<0.0005

Table 3. Concentrations (ppm) of 2,4-D, 2,4,5-T, and picloram in water from the flume of watershed 1 over a 4-month period after application of 2 lb/A of each herbicide to 25% of the watershed area on August 13, 1969.

Date	Flow condition	2,4-D (ppm)	2,4,5-T (ppm)	Picloram (ppm)
8-16-69	Half-down	<0.003	<0.001	<0.001
	Base	<0.003	<0.001	<0.001
8-22-69	Peak	<0.003	<0.001	<0.001
	Half-down	<0.003	<0.001	<0.001
	Base	<0.003	<0.001	<0.001
8-29-69	Base	<0.003	<0.001	<0.001
9- 5-69	Half-down	<0.003	<0.001	<0.001
	Base	<0.003	<0.001	<0.001
9-12-69	Base	<0.003	<0.001	<0.001
9-19-69	Half-down	<0.003	<0.001	<0.001
	Base	<0.003	<0.001	<0.001
9-23-69	Peak 1	<0.003	<0.001	<0.001
	Peak 2	<0.003	<0.001	<0.001
	Half-down	<0.003	<0.001	<0.001
9-24-69	Base	<0.003	<0.001	<0.001
10- 1-69	Base	<0.003	<0.001	<0.001
10- 2-69	Base	<0.003	<0.001	<0.001
10- 8-69	Base	<0.003	<0.001	<0.001
11-28-69	Base	<0.003	<0.001	<0.001
12- 7-69	Peak	<0.003	<0.001	<0.001
	Half-down	<0.003	<0.001	<0.001
	Base	<0.003	<0.001	<0.001
12-10-69	Peak	<0.003	<0.001	<0.001
	Half-down	<0.003	<0.001	<0.001
	Base	<0.003	<0.001	<0.001
12-17-69	Base	<0.003	<0.001	<0.001
12-29-69	Base	<0.003	<0.001	<0.001

Table 4. Concentrations (ppm) of 2,4-D, 2,4,5-T, and picloram in water from the flume of watershed 2 over a 2-month period after application of 4 lb/A of each herbicide to 25% of the watershed area on August 14, 1969.

Date	Flow condition	2,4-D (ppm)	2,4,5-T (ppm)	Picloram (ppm)
8-16-69	Half-down	<0.003	<0.001	<0.001
	Base	<0.003	0.019	<0.001
8-22-69	Half-up	<0.003	0.048	<0.001
	Peak 1	<0.003	0.031	<0.001
	Peak 2	<0.003	0.006	0.002
	Half-down	<0.003	0.003	0.003
	Base	<0.003	<0.001	0.002
8-29-69	Base	<0.003	<0.001	<0.001
9- 5-69	Half-down	<0.003	<0.001	<0.001
	Base	<0.003	<0.001	<0.001
9-12-69	Base	<0.003	<0.001	<0.001
9-19-69	Peak	<0.003	<0.001	<0.001
	Half-down	<0.003	<0.001	<0.001
	Base	<0.003	<0.001	<0.001
9-23-69	Half-up	<0.003	<0.001	<0.001
	Peak 1	<0.003	<0.001	<0.001
	Half-down	<0.003	<0.001	<0.001
	Peak 2	<0.003	<0.001	<0.001
	Peak 3	<0.003	<0.001	<0.001
9-24-69	Base	<0.003	<0.001	<0.001
10- 1-69	Base	<0.003	<0.001	<0.001
10- 2-69	Base	<0.003	<0.001	<0.001
10- 8-69	Base	<0.003	<0.001	<0.001

Table 5. Residues of 2,4-D (lb/A) in soil at 0 to 3 months after application of 2 lb/A August 20, 1968 to Watershed 2.

Soil depth (inches)	Months after application		
	0	1.5	3.0
0-3	0.79	0.03	0.02
3-6	-	<0.02	<0.02
6-12	-	<0.04	<0.04
12-18	-	<0.04	<0.04
18-24	-	<0.04	0.04
Total	0.79	0.03	0.06

Table 6. Residues of 2,4,5-T (lb/A) in soil at 0 to 12 months after application of 2 lb/A August 20, 1968, to Watershed 2.

Soil depth (inches)	Months after application				
	0	1.5	3.0	7.0	12.0
0-3	1.14	0.15	0.03	0.04	<0.01
3-6	-	0.01	<0.01	<0.01	<0.01
6-12	-	0.04	<0.02	<0.02	<0.02
12-18	-	0.08	<0.02	-	-
18-24	-	0.02	<0.02	-	-
Total	1.14	0.30	0.03	0.04	<0.04

Table 7. Residues of picloram (lb/A) in soil 0 to 12 months after application of 2 lb/A August 20, 1968 to Watershed 2.

Soil depth (inches)	Months after application				
	0	1.5	3.0	7.0	12.0
0-3	1.27	0.52	0.37	0.08	<0.02
3-6	-	0.11	0.08	0.06	<0.02
6-12	-	0.18	0.04	0.06	<0.04
12-18	-	0.10	0.06	-	-
18-24	-	0.04	0.06	-	-
Total	1.27	0.95	0.61	0.20	<0.08

WATERSHED 1
MOUNTAIN RESEARCH STATION
WAYNESVILLE, N.C.

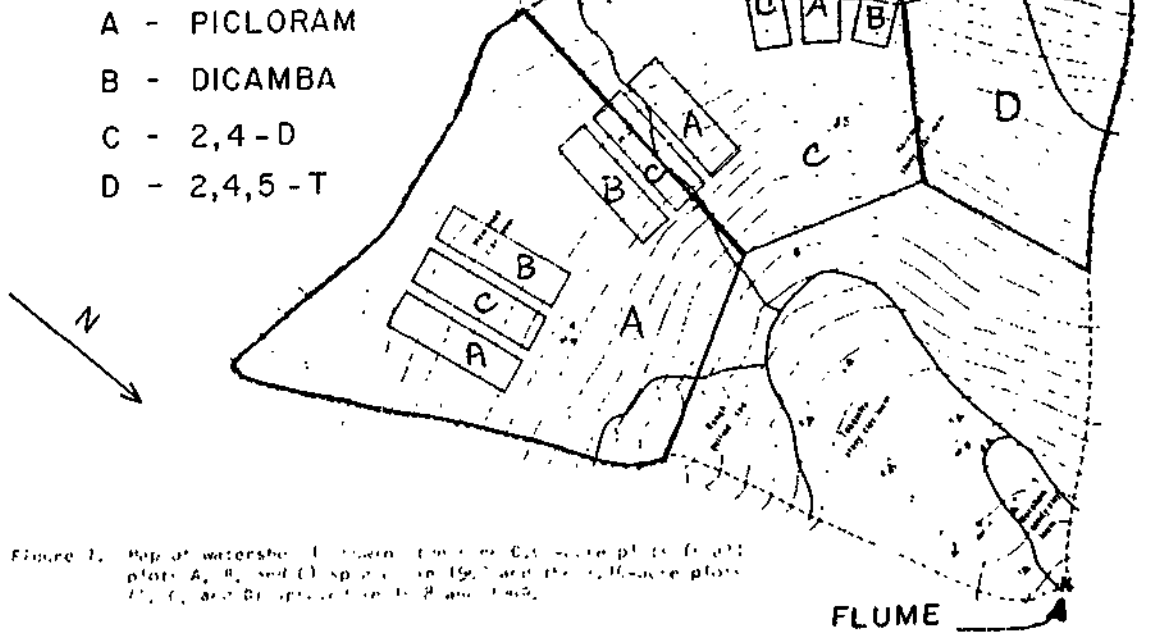


Figure 1. Map of watershed 1 showing the nine 0.2-acre plots sprayed in 1967 and 1968 and the 1-acre plots sprayed in 1967 and 1968.

404

WATERSHED 2
MOUNTAIN RESEARCH STATION
WAYNESVILLE, N.C.

- A - PICLORAM
B - DICAMBA
C - 2,4-D
D - 2,4,5-T

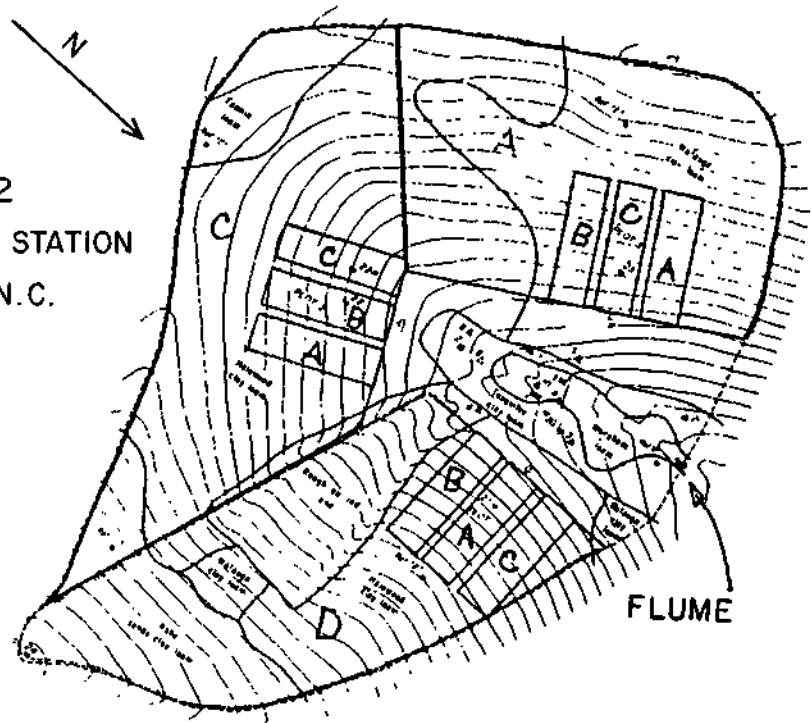


Figure 2. Map of watershed 2 showing the nine 0.2-acre plots sprayed in 1967 and 1968 and the 1-acre plots sprayed in 1967.

405