PESTICIDES USED IN AGRICULTURE: ECONOMIC CONSIDERATIONS AND ENVIRONMENTAL CONSEQUENCES

by

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CHAPTER I

INTRODUCTION

As a result of the harnessing of inanimate energy a chain of events developed that has resulted in a reduction in the need for man to engage in hard physical labor. At the same time the use of inanimate energy allowed greater and greater division of labor. It also made modern transportation possible, which, in turn, has greatly increased the supply of land available for use in an economic sense. The development of transportation made it easier for different cultures to come into contact with one another. In fact, it has been said that modern transportation has made people more alike, while at the same time it has strengthened the differences between places.[1] The result of all these rapid developments has been turmoil on a scale never before witnessed in the history of mankind.

This turmoil has created problems for mankind, many of which are nowhere near solution. For example, the possibility of rapid cultural interaction through modern transportation has been responsible for rapid acculturation in many areas of the world by many diverse cultures. In some cases the speed and amount of accommodation by subordinate cultures have caused cultural shock, for too many changes took place too rapidly for adequate adjustment to occur. Some feel that this is the basic cause of the wars that have occurred during the twentieth century.[2]

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[1] Edward Ullman, "The Role of Transportation and the Bases of Interaction," Man's Role in Changing the Face of the Earth, ed. William L. Thomas, Jr. (Chicago: University of Chicago Press, 1956), p. 863.

[2] Preston E. James, A Geography of Man (Boston: Ginn and Company, 1951), p. 13.

This harnessing of inanimate energy has been responsible for the rapid expansion of technology. When modern technological innovations are made available, problems arise. For example, one of the major complaints aired in academic communities today is that technological developments are applied before sufficient time has elapsed to evaluate properly their net results. Pesticides serve as a good specific example of this. They are made available in large quantities before their effects on the environment are known.[3] And later when their effects have been studied, it is determined that the damage caused is so severe that the benefits derived from their use are outweighed by the damage done to the environment.

The upshot of the foregoing is simply that although man has made tremendous scientific progress in a relatively short period of time, sufficient time has not passed for his economic, social, and political institutions to adjust to his new powers to control and make use of his environment.

STATEMENT OF THE PROBLEM

With these points in mind, the problem that is the subject of this paper can now be stated. Actually it is a three part problem. What are the problems associated with pesticide use? What economic considerations are involved in pesticide use? And finally, what are the environmental consequences of pesticides used in agriculture?

JUSTIFICATION OF THE PROBLEM

Such a study is justified by the comments on the definition and

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[3]Robert Sherrill, "Real Villains," Nation, September 14, 1970, pp. 208-12.

functions of geography as stated by James and Hartshorne.[4] Essentially it amounts to this: Geography is concerned with studying the areas of the earth according to their causally related differences. Such a study begins with the understanding provided by the systematic sciences. But, geography, as opposed to the systematic sciences, cannot be defined by its subject matter; rather, geography is a "system of procedures."[5]

(1) It applies the theories of the systematic sciences to real situations and extends knowledge by showing how theories are modified by or invalidated by real conditions.

(2) It allows the testing of concepts derived by the systematic sciences.

(3) It is the basis for a realistic appraisal--essential in decision making--of conditions that differ from place to place.

This particular study is concerned with the third function mentioned above. This is accomplished by considering the history of pesticides, their benefits and harmful aspects from a geographer's point of view, to provide insight into needs for the future of pesticide use.

The final justification of this study is the most important. That is, because man is bound to this planet and its resources for some time to come, he must strive to live in harmony with nature, and must not push nature beyond her capacity, or he will not long survive on this earth. An example of this is the decline of the Mayan Civilization. In a fairly short period of time an area that had been supporting dense populations suffered a drastic

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[4]Preston E. James, "Geography," Encyclopaedia Britannica (1970), X, 145. Also see Richard Hartshorne, The Nature of Geography (Lancaster: The Association of American Geographers, 1939), Abstract.

[5]Ibid.

population reduction because the soil was overworked and became exhausted of various important nutrients and minerals. As a result the yields per acre were reduced drastically. This, of itself, is not enough to lead to the demise of a civilization, but due to the primitive nature of the transport methods available, the Mayans could not expand their area of production sufficiently to make up for the decrease in fertility, consequently the civilization declined.

Along these lines it is hoped that the work presented in this paper will shed light on the implications of the problem, and what alternative courses of action are available to man to rectify or to prevent environmental damage while keeping within the parameters set by political and economic feasibility.

METHOD OF APPROACH

In order to obtain information pertinent to the problem, the subject must first be put in historical perspective. The role of the government must then be considered since regulation and control of pesticides and their use lie within the authority of the federal government. This is followed by a look at the nature of the current research of the various agencies responsible for pesticide research. Attention is then turned to consideration of the most basic aspects of pesticide economics, and finally, the environmental aspects are presented and conclusions are enumerated.

CHAPTER II

BACKGROUND AND NATURE OF THE PROBLEMS ASSOCIATED WITH PESTICIDE USE

IMPORTANT DEFINITIONS

In order to communicate one's ideas to other people it is first necessary that the various parties involved understand the meanings of the important terms under consideration. To that end, it is helpful to define several terms as they will be used throughout this paper. First, the term, pesticide. A pesticide is in reality an economic poison. That is, according to the United States Department of Agriculture (USDA), a pesticide is "any substance or mixture of substances intended for preventing, destroying, repelling or mitigating any insects, rodents, nematodes, fungi, weeds, and other forms of plant or animal life or viruses, except viruses on or in living man or animals, which the Secretary of Agriculture shall declare to be a pest." That is the primary definition of a pesticide; secondarily, it is "any substance or mixture of substances intended for use as a plant regulator, defoliant or dessicant."[6] Thus, an insecticide is but one possible type of pesticide.

Secondly, the terms, persistent and non-persistent, need to be defined. The word, persistent, when used in conjunction with pesticides means that long after its application to a specific type of plant it retains much of its strength and remains as a residue in the soil. Additional applications of this compound can result in dangerously high residue build-up in

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[6] U.S., Department of Agriculture, Report on Pesticides and Related Activities, 1968 (Washington: U.S. Government Printing Office, 1969), p. 1.

the soil. Non-persistent, then, refers to a chemical compound that breaks down rapidly after its initial application.

PESTICIDE USE PRIOR TO THE TWENTIETH CENTURY

Pesticides, whether persistent or non-persistent, are not new. In fact, as long ago as 70 A.D. Plinius recommended arsenic as an insecticide. Also, there are references to the use of arsenic sulfide by the Chinese in the late sixteenth century.[7] Non-persistent pesticides such as pyrethrum, rotenone, and nicotine sulfate, are more recent additions. Nicotine sulfate has been in use at least 300 years and pyrethrum was developed in 1828.[8] Edwards says the following about early pesticides.

> The earlier insecticides included various inorganic compounds which contained lead, antimony, arsenic, mercury, selenium, sulfur, thallium, zinc, and fluorine as active ingredients. These compounds, although not very toxic to insects, were very persistent; so sprayed crops sometimes retained sufficient arsenical residues to be potentially harmful to the consumers, and crops were sometimes damaged by residues which accumulated in soils.[9]

However, during the period of time in question the use of pesticides was quite limited and so were the problems of soil residue build-up that accompanied the use of persistent pesticides.

PESTICIDE DEVELOPMENT AND TRENDS, 1900-1944

The gains in scientific thinking and knowledge that came during the nineteenth century had a tremendous impact on chemistry, turning it from a

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[7] K. A. Hassall, World Crop Protection, Vol. 2 (Cleveland: The Chemical Rubber Company, 1969), p. 1.

[8] Ibid.

[9] C. A. Edwards, Critical Reviews in Environmental Control, Vol. I:I (Cleveland: The Chemical Rubber Company, February, 1970), p. 7.

black magic art into one of the first of the quantitative sciences. Nowhere is that more visible than in Germany, the home of modern chemistry. It was here in the year 1874[10] that the most famous, now turned infamous, pesticide--DDT--was first formulated. However, its usefulness as a pesticide was not discovered until 1939. The discovery was made by Dr. Paul Mueller, an employee of J. R. Geigy, Inc., a Swiss chemical company. His discovery was not met with much fanfare at the time; however, DDT went into commercial use in 1943 and gained a world-wide reputation after 1944 when DDT was used to control an epidemic of typhus fever in Naples, Italy.

Within a few years DDT was extensively used throughout the world and was being heralded as evidence of man's control over his environment. It was during the time when this thinking prevailed that Dr. Mueller was awarded the Nobel prize for medicine in 1948.

After the first years of the use of DDT passed, it became a fact of life and was regarded as a savior compound that could help insure man's survival. In recent years this idea has been reversed and DDT has been banned from some uses, while a complete ban in this country is being considered.

RECENT TRENDS IN OUTPUT AND USE OF PESTICIDES

The discovery of the qualities that DDT possessed as an insecticide in 1939 led to its introduction into the commercial market in the United States in 1945. This has had a considerable impact on pesticide production in the United States since that time. The major trends are:

1. The introduction of DDT resulted in a considerable decline in both

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[10]Don Widener, Timetable for Disaster (Los Angeles: Nash Publishing, 1970), p. 1.

the production and domestic use of arsenic compound insecticides. (See Tables 1 and 2.) The pre-war totals for these compounds show them to have been the dominant group of insecticides before the advent of DDT.

2. The once widely used naturally occurring organic substances derived from various plants have also undergone a considerable decline. Of the three major insecticides in this category, two -- pyrethrum and rotenone -- are insignificant when compared to the total amount of synthetic insecticides. And a third, nicotine sulfate, has all but disappeared from use in the United States.

3. Not only has the introduction of synthetic organic pesticides resulted in the partial or complete replacement of older, once widely used substances, it has resulted in a rapid increase in the total quantity of pesticides sold, despite the fact that a pound of the newer compounds can do more than a pound of one of the older compounds. Sales of synthetic organic pesticides increased from 279 million pounds in 1954 to 634 million pounds in 1962.[11] This documents the rapid adoption of the new compounds.

4. Of all the compounds available, the most popular are the chlorinated hydrocarbons. In 1961 these constituted 85 per cent of total insecticide and rodenticide sales by weight. A scant four years prior to that time chlorinated hydrocarbons accounted for only 63 per cent by weight. In recent times this high percentage of total sales has been cut into by organophosphates, which are generally less persistent in the environment, but more dangerous to handle.

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[11] U.S., Department of Agriculture, Agricultural Stabilization and Conservation Service, The Pesticide Situation for 1962-63 (Washington: U.S. Government Printing Office, September, 1963).

TABLE 1

PRODUCTION OF SELECTED PESTICIDES IN THE UNITED STATES FOR SELECTED YEARS

PRODUCT	1939	1945	1950	1955	1960	1963
Calcium Arsenate	41,349	25,644	45,348	3,770	6,590	N.A.
Lead Arsenate	59,569	70,522	39,434	14,776	10,062	N.A.
White Arsenic	44,686	48,698	26,546	--	--	--
Copper Sulfate	134,032	251,000	174,600	156,176	116,000	83,272
Aldrin-Toxaphene group*	--	--	--	77,025	90,671	105,986
Benzine Hexachloride	N.A.	N.A.	70,698	56,051	37,444	6,776
DDT	N.A.	33,243	78,150	129,693	164,180	178,913
Methyl Bromide	--	--	--	9,222	12,659	17,394
Methyl Parathion	--	--	--	--	11,794	15,999
Parathion	--	--	N.A.	5,168	7,434	N.A.
Nabam	--	--	--	--	2,978	2,420
2, 4-D Acid	N.A.	971	14,156	34,516	36,185	46,312

(Figures in million pounds)

*Aldrin, Dieldrin, Endrin, Chlordane, Heptachlor, and Toxaphene.

Adapted from: The Pesticide Problem: An Economic Approach to Public Policy (Baltimore: The John Hopkins Press, 1967), p. 7.

PROBLEMS ASSOCIATED WITH PESTICIDE USE

For all intents and purposes, there were no problems associated with pesticide use prior to the twentieth century. There were many compounds in use as pesticides, as has already been mentioned, and some of these were very

TABLE 2

DOMESTIC CONSUMPTION OF SELECTED PESTICIDES
FOR THE UNITED STATES FOR SELECTED YEARS

PRODUCT	1950-51	1953-54	1958-59	1960-61	1961-62	1962-63
Aldrin-Toxaphene group	N.A.	N.A.	73,331	78,260	82,125	79,275
Benzene Hexachloride	9,600	7,610	4,276	4,577	2,404	1,299
DDT	72,688	45,117	78,682	64,068	67,245	61,165
Parathion	4,670	3,975	N.A.	N.A.	N.A.	N.A.
Calcium Arsenate	39,583	3,190	N.A.	4,874	4,541	3,960
Copper Sulfate	122,449	74,054	84,230	78,220	80,815	80,599
Lead Arsenate	30,174	16,000	N.A.	8,976	7,957	6,954
Pyrethrum	7,098	7,679	N.A.	N.A.	N.A.	N.A.
Rotenone	7,027	6,428	4,827	3,888	3,598	3,336
2, 4-D (Acid Equivalent)	23,494	26,483	34,102	31,067	35,903	33,199

(Figures in million pounds)

Adapted from: U.S., Department of Agriculture, Agricultural Stabilization and Conservation Service, The Pesticide Situation (Washington: U.S. Government Printing Office, selected years).

persistent. However, these compounds were only used on a limited scale, and in general the applications were not closely spaced chronologically because the amount of money necessary to purchase and use pesticides was generally not available to the farmer. As agricultural methods improved, the number of subsistence farmers decreased, and the size of the average farm increased. It became necessary to reduce crop losses significantly in order to compete successfully.. To do this farmers began to apply more and more pesticides to

more and more land. When DDT and other modern pesticides became available, they were rapidly adopted because the cost of purchasing and applying them was more than justified by the returns, for the application of pesticides resulted in both an increase in the yield per acre and an improvement in the quality of crop.

Several problems resulted from the rapid widespread adoption of pesticides. First, chlorinated hydrocarbons were known to be persistent, but at first there was little concern over the possibility of residue build-up in soil to levels sufficient to cause harm to the crops being grown. During the late 1950's and early 1960's evidence was accumulated that indicated the presence of pesticides in the bottom of streams as well as in the soils to which they were applied.

A second problem that developed was a rapid proliferation of chemicals for use as pesticides. These were widely adopted and put to many uses before any significant research was done on their long term effects on the environment.

A third problem is the fact that each of the three major types of pesticides carries with it its own particular kind of hazard. The chlorinated hydrocarbons, of which DDT is the most famous member, was the first group to be developed. They are relatively safe to handle but are very persistent. The organophosphates, which are recent additions to the lineup of pesticides, are quite varied in their properties. They are much less persistent than the chlorinated hydrocarbons but are more dangerous to handle because they can enter the body through contact with the skin.

The newest class of pesticidal chemicals is the carbamates. They represent a search for chemicals which are relatively nontoxic to warm-blooded animals with little residue accumulation in animal tissues. The main

hazard from some of these chemicals is their growth regulating effect on plants.

The fourth problem is the matter of insect resistance to pesticides over time. The basis of this problem is easy enough to understand. The lifetime of insects is quite short in relation to man, usually measured in days, weeks, or months. As a result they are able to develop resistance to some pesticides in a short time through mutations as the generations pass. Some observers see this as an indication that biological means rather than chemical tools will become necessary in the future.

The last major problem associated with pesticide use is the matter of spillover hazards. However, discussion of this problem is deferred until the end of this chapter.

AREAS TREATED WITH PESTICIDES IN THE UNITED STATES ACCORDING TO LAND USE

The data pertinent to this topic are summarized in Table 3. Only 5 per cent of the total area under consideration is treated annually with insecticides. Of all the categories represented on the table, cropland and cropland pasture constitute three-fourths of the area treated. The next largest category is urban or built-up areas which account for 16 per cent of the total area treated. Of the cropland and cropland pasture category, the largest treated area is accounted for by grains. One statistic not presented in Table 3 below is also worthy of mention. That is, the United States Department of the Interior (USDI) estimated in 1963 that 75 per cent of the land area of the conterminous states had never been treated with insecticides.[12]

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[12]U.S., Department of the Interior, Fish and Wildlife Service, Pesticide-Wildlife Studies, Circular 167 (Washington: U.S. Government Printing Office, June, 1963), p. 3.

TABLE 3

AREAS TREATED ANNUALLY WITH INSECTICIDES
IN THE UNITED STATES, 1962
(excluding Hawaii and Alaska)

LAND USE	Million Acres in Category	Acreage on Which Insecticides Applied (Million)	Area Treated as Percentage of Category
Forest Land	640	1.8	0.28
Grassland Pasture	630	1.6	0.25
Desert, Swamps, Dunes, and Wildland	77	2.5	3.24
Water Areas	32.6	0	---
Cropland and Cropland Pasture	457	68.6	15.00
Fruits, Nuts	2.8	2.3	80
Cotton	15.8	11.9	75
Vegetable	4.1	2.1	50
Grains	216.6	32.5	15
All Other Crops	217.6	19.9	9
Urban or Built-up Areas	53.0	15.0	28.3
Nonforested Parks, Wildlife Refuges, Duck Reserves, National Defense Sites	43	---	---
Total U.S. Acreage	1,934.6	89.5	4.6

It is possible to look at the areas treated with pesticides in the United States from other points of view. For example, it is possible to determine the single most important group of pesticide users and then consider the regional distribution of pesticide application for that group. Table 4 shows the percentages of various types of pesticides used by the most important group of pesticide users.

TABLE 4

TOTAL USE OF SELECTED PESTICIDES AND PERCENTAGE USED BY FARMERS IN THE UNITED STATES, 1963

Type of Pesticide	Total Use in United States (Million pounds of active ingredients)	Percentage Used by Farmers in 48 States
Fungicides	125	27
Herbicides		
2,4-D and 2,4,5-T	85	48
Other Herbicides	142	59
Total Herbicides	227	55
Insecticides		
DDT	50	54
Aldrin-Toxaphene	78	68
Others	201	54
Total Insecticides	329	57
Total Pesticides	681	51

Adapted from: U.S., Department of Agriculture, Economic Research Service (Agricultural Economic Report No. 179), Quantities of Pesticides Used by Farmers in 1966 (Washington: U.S. Government Printing Office, April, 1970), p. 6.

Table 4 shows that in 1963 farmers used 51 per cent of all pesticides. Table 5 shows the regional breakdown of the percentages of the various kinds of pesticides used by farmers.

SPILLOVER HAZARDS

In a previous section of this chapter (Problems Associated with Pesticide Use) one of the major problems of pesticide use was deliberately omitted. The reason for that deletion is simple. It was first necessary to

TABLE 5

REGIONAL PERCENTAGES OF PESTICIDES USED ON FARMS FOR CROPS, 1964 AND 1966

Region	Fungicides (Per Cent)		Herbicides (Per Cent)		Insecticides (Per Cent)	
	1964	1966	1964	1966	1964	1966
Southeast	27	17	4	4	24	26
Delta States	1	2	7	5	19	16
Corn Belt	12	18	22	32	10	15
Southern Plains	1	6	8	7	15	12
Appalachian	18	11	6	5	10	8
Pacific	12	9	9	12	9	7
Northeast	21	22	10	6	5	5
Mountain	0.5	1	11	6	3	5
Lake States	7	11	11	10	3	3
Northern Plains	1	3	12	13	2	2

Adapted from: U.S., Department of Agriculture, Economic Research Service (Agricultural Economic Report No. 179), Quantities of Pesticides Used by Farmers in 1966 (Washington: U.S. Government Printing Office, April, 1970), pp. 11, 16, 21.

show the extent of pesticide use before the spillover hazard would be significant to the reader. The spillover hazard is an economic hazard. That is, it is concerned with cost-benefit distribution and resource allocation problems.

Considering first cost-benefit distributions, one finds that it is possible that certain people or groups of people are bearing costs when they do not share in the benefits. One possible example of this concerns pollution

problems arising from pesticide use. It is also possible that certain persons or groups of persons may be sharing the benefits without bearing the costs. In both of these cases action must be taken to see that there is a proper redistribution of costs and benefits.

Considering resource allocation problems, one finds two alternatives. (1) It is possible for too many resources to be pressed into use for the production of pesticides. (2) It is also possible for too few resources to be utilized in the production of pesticides. This implies that there is also a third alternative, that is, to strive for optimal resource use which will be a point of equilibrium somewhere between the two extremes.

CHAPTER III

GOVERNMENT RESEARCH AND PESTICIDE CONTROL IN THE UNITED STATES

In the United States the agency charged with the responsibility to control pesticide registration and use is the Pesticides Regulations Division (PRD) of the Agricultural Research Service of the USDA. As the agency was set up in 1947, its purpose was to protect the country from pesticides that produce more harmful effects than beneficial effects. But basically the primary and most direct concern of the PRD is, from a practical point of view, that a pesticide contains what its manufacturers claim it contains and that it does what its manufacturers claim it will do. In the years since its establishment the PRD has registered nearly 65,000 pesticides. Of this number some 40,000 still remain on the PRD books.

As of 1970, the PRD had thirty-one inspectors under five supervisors who actively collected pesticide samples for testing to determine if a specific sample contained what its manufacturers claimed it contained and to determine if it served its intended purpose. If a pesticide is to be marketed in the United States, it must be registered with this agency, but to be registered by the PRD it must only meet the two criteria mentioned above.

POWERS TO REGULATE AND REMOVE PRODUCTS FROM MARKET

If tests show that a duly registered pesticide is a dangerous product, or that it has been mislabeled, two courses of action are available to the PRD. First, the registration of the product may be cancelled. This lesser

of the two powers makes it possible for the company to continue to market the product until a series of hearings and appeals are heard. The outcome of these hearings will determine if the product will continue to appear on the market or if it is to be removed.

A second power held by the PRD is more effective against a dangerous or mislabeled product. This power gives the PRD the authority to suspend the registration because continued sale of the product creates a hazard to public safety. If and when this power is evoked, distribution of the product must be stopped immediately. Also, the PRD has the power to seize all products that may be suspended. According to one observer's count, the PRD has only used its suspension power three times in its 24 year history, one of them coming after considerable bad publicity for the pesticide in question.[13]

Because other government agencies -- notably the Department of Health, Education and Welfare (HEW) and the USDI -- have interests that concern the registration and use of pesticides, the PRD has arranged to send copies of applications for registration to these departments to see if they have objections. In 1969, 185 pesticides were registered even though one or more agencies in HEW objected.[14] The reason for such action is to be found in political and economic pressures that have been brought to bear on the PRD.

PESTICIDE RESEARCH PROGRAMS

For regulation and control of pesticides to reflect the latest thinking on the subject, the agency involved must be supplied with the

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[13]Robert Sherrill, "Real Villains," Nation, September 14, 1970, p. 209.

[14]Ibid.

necessary research data. For the purposes of this paper one arm of the federal government is most important, in that it not only is charged with research, it also is responsible for regulation and control as well as making information available to the public. Table 6 shows the various USDA agencies which deal in any way with pesticides. Eleven major USDA agency names appear in that table, these containing a total of twenty-three sub-agencies. A total of sixteen agencies or sub-agencies appearing in that table have research and service responsibilities. From the table one observes that the primary agency for regulation itself has no research responsibilities. Depending upon the levels of coordination and cooperation among the various responsible agencies, this may or may not cause problems. And yet, there is reason to believe that not only could improvement be made among the agencies of the Department of Agriculture, the responsibilities and linkages among the USDA, HEW, and USDI should be more clearly defined and strengthened if the interests of the public are to be properly served.[15]

Nevertheless, the USDA has many agencies involved in pesticide research. A look at the names of the agencies participating in pesticide research (Table 6) shows that all points from the economics of pesticide use to the effects of pesticides on human nutrition are considered by one or more agencies.

The best and most concise statement of the goals of the various pesticides research programs carried out by the USDA is provided by a list of the

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[15]U.S., Department of Health, Education and Welfare, Report of the Secretary's Commission on Pesticides and Their Relationship to Environmental Health, Parts 1 and 2 (Washington: U.S. Government Printing Office, December, 1969), p. 30.

TABLE 6

PARTICIPATING USDA SERVICES AND AGENCIES
Pesticides and Related Activities

Organizational Unit	Activity						
	Research and Surveys	Education	Information	Regulation	Control	Monitoring	
Agricultural Research Service							
Agricultural Engineering Research	X						
Animal Disease and Parasite Research	X						
Animal Husbandry Research	X						
Animal Health					X		
Crops Research	X						
Entomology Research	X						
Human Nutrition Research	X						
Information			X				
Market Quality Research	X						
Northern Utilization Research and Development	X						
Pesticides Regulation				X			
Plant Pest Control					X	X	
Plant Quarantine					X		
Soil and Water Conservation Research	X						
Agricultural Stabilization and Conservation Service							
Policy and Program Appraisal	X						
Farmer Programs					X		
Cooperative State Research Service	X						
Forest Service							
Forest Pest Control					X		
Forest Protection Research	X						
Information and Education		X	X				
Timber Management Research	X						
Watershed, Recreation & Range Res.	X						
Federal Extension Service		X					
Economic Research Service	X						
Consumer and Marketing Service							
Livestock Slaughter Inspection						X	
Processed Meat Inspection						X	
National Agricultural Library		X					
Office of Information			X				
Office of the General Counsel				X			
Research Program Development and Evaluation Staff	X						

Source: U.S., Department of Agriculture, Report on Pesticides and Related Activities, 1968 (Washington: U.S. Government Printing Office, 1969), Appendix A-1.

targets the USDA has set for its pesticides programs.[16]

I. To gain knowledge of the taxonomy, biology, ecology, physiology, pathology, metabolism, and nutrition of pests and host plants and animals.

II. To improve and develop means of controlling pests by nonpesticidal methods.

III. To develop safer and more effective pesticide use patterns, formulations, and methods of application; and improve methods for detecting, measuring and eliminating or minimizing pesticide residues in plants, animals, and their products, and in other parts of the environment.

IV. To study the toxicity, pathology and metabolism of pesticides and investigate levels, effect, and fate of their residues in plants, animals, and their products, and other parts of the environment.

V. To study economic aspects of pest control and its impact on the environment; determine the supply, requirements and use of pesticides; and give assistance to control agencies and industries in emergencies.

VI. To control pests and protect the environment during and after control operations.

VII. To monitor the presence and distribution of pesticides in plants, animals, and their products, and in other parts of the environment.

VIII. To administer the regulatory statute -- the Federal Insecticide, Fungicide and Rodenticide Act -- to assure properly labeled pesticides, with guidelines for their safe and effective use, and to prevent the marketing of harmful, adulterated or misbranded products.

IX. To educate and inform the public about the importance of pesticides and pest control and the need for safe and proper use of pesticides; maintain a Pesticides-Information Center; coordinate and review pesticide and pesticide-related activities of the U.S. Department of Agriculture and coordinate them with other Federal, State, and private organizations.

POLITICAL PRESSURES ON PESTICIDE USE AND REGISTRATION

Agricultural and agriculture-related business in the United States is large and extremely diversified, ranging from small individually owned farm

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[16]U.S., Department of Agriculture, Report on Pesticides and Related Activities, 1968 (Washington: U.S. Government Printing Office, June, 1969), pp. 3-6.

centers to gigantic corporations whose various subsidiaries produce machinery, chemicals, or petroleum products, all for farm consumption. Such a wide range of businesses and industries employs a large number of Americans whose livelihood depends to a considerable degree on the fortunes of American agriculture. A group such as this, when acting in its own self-interest, can be and in reality is capable of generating considerable political pressure. Small wonder it is that governmental agencies and congressional committees come under such pressure.

Much time could be devoted to examples of this political pressure, but for the purposes of this paper such detail is not necessary. However, one example should be cited as a lead-in to the economic and, even more important to this paper, the environmental considerations, both of which will be treated in the following chapters.

In the United States in 1966, insecticides played their most important role in cotton production. The Economic Research Service of the USDA sums up the situation with respect to cotton with the following:

> Their (insecticides) use on cotton accounted for 64.9 million pounds, or 47 per cent of the insecticide materials used by farmers in 1966. Insecticide use on cotton was down somewhat from 1964, when 78.0 million pounds were used. However, planted cotton acreage in 1966 was down about a third from 1964. Leading products used on cotton were toxaphene, DDT, and methyl parathion. These three products accounted for over 80 per cent of the insecticides used on cotton.[17]

DDT, the oldest and best known of the organochlorines, had for years been a major pesticide used for the protection of cotton. Also, for years researchers had been carefully collecting evidence of the hazards associated

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[17]U.S., Department of Agriculture, Economic Research Service, Agricultural Economic Report No. 179, Quantities of Pesticides Used by Farmers in 1966 (Washington: U.S. Government Printing Office, April, 1970), p. 19.

with the use of DDT.[18] Because of the hazards many scientists had been pressing for sharp reductions in the use of DDT. The various congressional farm committees to which these pleas were directed were reticent to direct the USDA to act because many committee members were from major cotton producing areas and were having pressure applied by farmers and agri-business groups. When such vested interest groups are to be denied their way, considerable public pressure must be brought to bear for some time before change can be achieved.

Conservation and environmental groups have developed within the last few years to raise their collective voices against many practices, programs, and products. Pesticides have not gone without attack. In a few years the strength of such groups has risen to the point that they have been able successfully to challenge larger vested interest groups. The future ability of these groups to halt the use of potentially dangerous programs and products depends upon their ability to present relevant and accurate information to support their contentions. The willingness of environmental groups to present accurate information to achieve their ends has been challenged by some observers who contend that these groups have relied upon scant or misleading evidence and the highly emotion-charged atmosphere of the times to achieve their goals.[19] However, their presence as political pressure groups is necessary to call attention and take action against programs and products that stand as environmental hazards.

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[18] C. A. Edwards, Critical Reviews in Environmental Control, Vol. I:I (Cleveland: The Chemical Rubber Company, February, 1970), pp. 8-11.

[19] Robert M. Bleiberg, "Nature-Lover's New Breed," Barron's, June 14, 1971, p. 7.

CHAPTER IV

ECONOMIC CONSIDERATIONS IN PESTICIDE USE

From the first, the basic reason for using pesticides has been a matter of economics. For mankind as a whole it is selecting the best alternative method or methods that will make it possible to have abundant, high quality fibers, foods (including livestock products), and feed grains to insure the survival of the earth's population.[20] For the subsistence farmer it is producing enough to meet the needs of his family. For the commercial farmer it is a matter of maximizing output with a minimum of inputs to that a profit can be made to justify the enterprise financially.

To meet the basic goal of producing sufficient agricultural products to sustain mankind from a physical land base of limited dimensions makes it necessary to strive for greater quantities of agricultural products with a higher quality from a total land area with only limited possibilities for expansion. This calls for increased inputs per acre or per farmer. It also places a premium on reducing crop losses from pests and climatic variation.[21] At the present time man can exert little control over the latter, but he has at his disposal considerable technology for pest control. Since technical ability is not uniformly distributed over the earth, some countries can control pests to a greater degree than others.

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[20] U.S., Department of Agriculture, Economic Research Service, Economic Research on Pesticides for Policy Decisionmaking (Washington: U.S. Government Printing Office, April, 1970), p. 21.

[21] Losses from pests annually amount to more than nine billion dollars. Joseph D. Brown, "Adoption and Purchasing of Agricultural Pesticides," in University of Georgia, College of Agriculture, Experiment Station, Research Bulletin 39, June, 1968, p. 1.

The United States because of its great economic strength has been a large consumer of pesticides, particularly since the late 1940's. When a farmer is introduced to pesticides, he asks himself several questions before he considers a given pesticide for use. (1) Will the returns from using this product exceed the costs of using it? (2) If so, are there other pesticides that serve the same purpose and produce greater returns? (3) Can this product be handled and applied easily and safely? (4) What other returns can be expected for the money?

The answers to questions one and two are yes or the volume of pesticides used would be much smaller and the variety of pesticides would be much more restricted than it is today. Question three is not a matter of economics, but rather of personal safety. Question four evokes a threefold answer. Pesticide use can result in higher yields per acre while improving the quality of the crop as well as reducing production uncertainties.[22] These are important considerations in view of the many problems that farmers in the United States face. These problems include increased labor costs, increased costs of machinery, reduced crop acreages, increasing demand for food due to increasing population, climatic variations, rapid change in prices paid for agricultural products, and increased foreign competition for certain items. These problems discriminate against the small farm, which means that today the trend is increasingly toward larger and larger farms. This creates the need for amounts of capital never before seen in American agriculture. One result of this is the appearance of corporate farms.

Implied in the foregoing is a fifth question which was not asked until a small group of concerned scientists did so recently. That question is:

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[22] Ibid.

What other costs are incurred through pesticide use? The answer has been difficult to ascertain because little work has been done to place values on the environmental hazards resulting from pesticide use. However, more is being done along these lines and some preliminary ideas are available. Discussion of these will be deferred until the various environmental consequences are considered.

BENEFICIAL EFFECTS OF PESTICIDE USE

Yield increases have been an important positive result of pesticide use. As a means of showing this, percentage increases are presented in Tables 7 and 8 for two selected crops or groups of crops. For cotton the apparent effectiveness of synthetic organic pesticides is well demonstrated by a comparison of the figures for the years before and since 1945. In comparing these figures it should be remembered that not all the credit for increased cotton yields can go to pesticides, for improved cotton varieties were developed and the use of fertilizer was expanded.[23] In 1958, 66 per cent of the total cotton acreage was treated with insecticide. By 1961 this figure had increased to 80 per cent, at a total cost for chemical control of $12.00 per bale.[24]

Table 8 shows yield increases attributable to the use of parathion on small grains after infestation with greenbugs and aphids.

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[23] J. C. Headley and J. N. Lewis, The Pesticide Problem: An Economic Approach to Public Policy (Baltimore: The Johns Hopkins Press, 1967), p. 62.

[24] U.S., Department of Agriculture, Economic Research Service, Extent and Cost of Using Chemicals in Cotton Production (Washington: U.S. Government Printing Office, March, 1964), p. 7.

TABLE 7

PERCENTAGE INCREASE IN COTTON YIELDS
ON INSECTICIDE-TREATED OVER UNTREATED PLOTS

Location	Years	All Years	Per Cent Increase in Yields Pre-1945	Since 1945
Florence, South Carolina	1928-58	40.6	23.6	53.9
Tallulah, Louisiana	1920-56	31.6	26.4	41.3
Waco, Texas	1939-58	41.8	34.0	53.0

Source: U.S., Congress, Senate, Interagency Coordination in Environmental Hazards (Pesticides), Hearings before Subcommittee on Reorganization and International Organizations of the Committee on Government Operations, 88th Congress, March 1, 1965 (Washington: U.S. Government Printing Office), p. 64.

These four examples are not the only ones to be drawn from agriculture; in fact, pesticide use has contributed significantly to all phases of agricultural production, even milk production. In Illinois, during the years 1955 to 1957, butterfat production of dairy cows treated for control of stable flies was found to be from 6.5 per cent to 29.8 per cent higher than that of untreated cows.[25]

Pesticides have been found to have significant positive effects on the quality of agricultural products. While these effects are seen in varying degrees for many crops and products, they are best shown in fruit and in vegetables, to the point that pesticide use can mean the difference between

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[25] W. P. Bruce and G. C. Decker, "The Relationship of Stable Fly Abundance to Milk Production in Dairy Cattle," Journal of Economic Entomology, Vol. 51, No. 3, pp. 269-74.

TABLE 8

YIELD INCREASES IN SMALL GRAIN
FOLLOWING GREENBUG CONTROL WITH PARATHION

Crop	Year	Location	Yields in Pounds per Acre		Per Cent Increase Due to Treatment with Parathion
			Untreated	Treated	
Wheat	1951	Oklahoma	54	666	1,133
	1952	Oklahoma	762	1,242	63
	1952	Oklahoma	546	1,398	156
	1956	Texas	804	1,254	56
	1956	Texas	1,380	2,134	54
Oats	1951	Oklahoma	976	1,214	24
	1952	Oklahoma	227	1,308	476
	1954	Oklahoma	68	1,361	1,901
Barley	1951	Oklahoma	58	566	876
	1954	Oklahoma	379	1,373	262

Source: R. C. Dahms and E. A. Wood, "Evaluation of Greenbug Damage to Small Grains," Journal of Economic Entomology, Vol. 50, 1957, pp. 443-46, and N. E. Daniels et al., "Greenbugs and Some Other Pests of Small Grains," Texas Agriculture Experiment Station Bulletin No. 845, 1956, p. 14.

being able to market a crop and having to destroy it since insect damaged crops cannot be legally marketed.[26]

Input savings also accrue as a result of pesticide use. Consider, for example, the case of herbicides. Harris[27] and Holstein[28] describe the reduction of labor requirements by 20 hours per acre on one million acres of

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[26]Robert L. Rudd, Pesticides and the Living Landscape (Madison: The University of Wisconsin Press, 1964), p. 45.

[27]V. C. Harris, "Weed Control in Cotton over a Ten Year Period by Use of the More Promising Materials and Techniques," Weeds, Vol. 8, 1960, pp. 616-24.

[28]G. T. Holstein, Jr., et al., "Weed Control Practices, Labor Requirements and Costs in Cotton Production," Weeds, Vol. 8, 1960, pp. 232-42.

cotton land in Mississippi with an improvement in both lint quality and harvesting operations. Another example is provided by Bureau of Reclamation information.[29] In this instance the use of herbicides to control aquatic weeds in irrigation canals reduced costs from $330.31 to $38.11 per mile.

PESTICIDES AND THE ORGANIZATION OF AGRICULTURE

The use of pesticides has had a profound effect on agriculture. Effective control of certain pests has allowed the development of certain specialized types of agriculture, notably the production of specialized fruits and vegetables. In addition the development and use of pesticides has allowed the principle of comparative advantage to develop more fully in this country, thus promoting "monocultures" and more efficient resource use.

Headley and Lewis have broken the role of pesticides in the technological revolution in agriculture into three related aspects:[30] The insurance function, the substitution of pesticides for other inputs, and the contribution of pesticides to interregional shifts in agricultural production.

In the case of the first of these, pesticides offer the farmer not only higher quality crops, but more production than is possible without the use of pesticides. Their use can, therefore, be thought of as a form of chemical insurance against crop damage. Thus, with yields at higher levels and more assured, efficiency of resource use may be increased by allowing economies of scale.

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[29] U.S., Department of the Interior, Bureau of Reclamation, Annual Regional Weed Control Report for 1962 (Salt Lake City, Utah).

[30] Headley and Lewis, op. cit., p. 74.

The second of these aspects, the substitution of pesticides for other inputs, has been dealt with earlier in the chapter, and only one more comment should be made at this point. Large-scale crop production operations that have become economically feasible through such technological developments as improved farm machinery add to the uncertainties associated with the use of seasonal labor and tend, as a result, to promote the use of chemicals as a substitute for labor in weed control.

The two factors just discussed have combined to account for changes in the regional distribution of the production of several major crops. Most notable among these crops is cotton, which has been extended farther and farther westward.

PESTICIDE RESIDUES IN INTERNATIONAL TRADE

Because pesticides are used in nearly all the world's countries, international trade may be adversely affected. This stems from the fact that there are, at present, no international standards for pesticide residue tolerances in food. Dormal and Hurtig observe, "These growing difficulties are being regarded with increasing apprehension as a hindrance to the free international movement of food and are causing fear in some quarters that, unscrupulously employed, they may be used as barriers to restrict trade."[31]

Some form of international standardization of permissible pesticide residue levels would seem desirable. However, several factors would seem to make such a goal impractical. First, climatic conditions vary widely and, second, population pressure on food supplies also varies widely. Third, and

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[31] S. Dormal and H. Hurtig, "Principles for the Establishment of Pesticide Residue Tolerances," Residue Reviews, Vol. 1, 1962, pp. 140-51.

perhaps most important, diet varies so widely that the proportions of consumption of the various agricultural commodities entering international trade would cause considerable difficulties, because what would be an acceptable level in one area could be dangerously high for continued consumption in another area of the world.

CHAPTER V

ENVIRONMENTAL CONSEQUENCES OF PESTICIDE USE

Man has for centuries tried to exert control over his surroundings so that his life could be easier and more secure. Man's efforts with regard to control of his environment have been summed up by Rudd.

> Man has been termed an ecological dominant--a creature capable of molding his environment to his will, yet independent of it. Biblical allegory reinforces this belief that he was apart from, not part of, the naturalistic world.
>
> But his dominance is not so firmly based. The living fabric of the earth's surface is of delicate and complicated weave. Nature is quite as capable of preventing fulfillment of our aspirations if mistreated as of rewarding us if understandingly managed. Sustained dominance can come only through genuine understanding of the natural forces we have set about to guide and of which we are an integral part. Concomitance--living with natural forces--rather than dominance is the only route to enduring self-interest.[32]

AGRICULTURAL CONSEQUENCES OF PESTICIDE USE

Individual researchers have been amassing evidence of the consequences of the agricultural use of pesticides for at least two decades. Yet, in that time only the most readily detectable consequences of pesticide use have been studied, and these only on a limited scale. The United States government has been monitoring pesticide residues in soil and water since 1964. Since that time work done along these lines has been expanded considerably by government researchers as well as by private researchers. Although much research has been done, much of it merely substantiates earlier work. Little has been

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[32]Robert L. Rudd, Pesticides and the Living Landscape (Madison: The University of Wisconsin Press, 1964), pp. 3-4.

discovered in terms of the more long run deleterious effects that no doubt exist from constant exposure to low level pesticide pollution. This is partly due to the fact that many aspects of the known effects are not completely understood, and because pesticide pollution has only been a subject for general public concern since 1965.

Research to date has shown four kinds of agricultural pollution resulting from pesticide use: (1) Soil; (2) Water, including surface water and groundwater; (3) Residues in crops; and (4) Air pollution. The remainder of this section will be devoted to these four aspects of the agricultural consequences of pesticide use.

(1) Pesticide Residues in Soil. Researchers found evidence of pesticide residue accumulation in soils within a few years of the appearance of pesticides on the U.S. market. Many of these early researchers believed that such an accumulation posed no environmental hazard because residues were not absorbed by plants, and because they would be decomposed by microbes in the soil. A major contradiction of the latter of these beliefs came in 1965 from Alexander.[33] And Bruce[34] in 1966 showed that pesticides could be taken up by plants, thus making it possible for excessively high soil residues to damage or destroy crops. It is possible to avoid soil residue build-up if pesticides can be applied at low concentrations or if they need be applied infrequently. This, however, is difficult to manage with some treated crops as they are grown perennially. Apples and other fruits serve as examples of this.

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[33] M. Alexander, "Persistence and Biological Reactions of Pesticides in Soils," Soil Science Society of America Proceedings, Vol. 29, 1965, p. 1.

[34] W. P. Bruce, G. C. Decker, and J. G. Wilson, "The Relationship of the Levels of Insecticide Contamination of Crop Seeds to their Fat Content and Soil Concentration of Aldrin, Heptachlor, and their Epoxides," Journal of Economic Entomology, Vol. 59, pp. 179-81.

Lichtenstein[35] showed results of DDT applications on orchard soils. In this particular study, the author recorded the DDT equivalent of 197 pounds per acre. This amounted to 82 per cent of all DDT applied to the area from 1946 to 1955. Fortunately, fruits, especially apples and peaches, are the most intensively treated of all crops on which pesticides are used.[36] Residues in soils of other crops need not reach such levels unless the pesticides involved are misused or some type of accident occurs. Build-ups are alarming but are not believed to cause serious threats to persons consuming fruits produced on such land. Residual build-ups, however, serve as a primary source for pesticides found in water.

(2) Pesticide Residues in Water. Once a pesticide has been applied and has entered the soil, it can be transported by the geomorphic agents operational on the earth's surface. Many of the pesticides used in the United States are not soluble in water. Hence, they are not transported directly in solution by runoff. Likewise, leaching by water percolating into soils has been proved an insignificant agent for pollution by pesticides. Eye[37] concluded in his studies of dieldrin that several hundred years are necessary for that pesticide to move through the top twelve inches of soil. This leaves the erosive action of runoff as a major transporting agent. The same applies to flooding; however, runoff occurs more frequently and on

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[35] E. P. Lichtenstein, "A Survey of DDT Accumulation in Midwestern Orchard and Crop Soils Treated Since 1945," Journal of Economic Entomology, Vol. 50, pp. 545-47.

[36] N. C. Brady, Agriculture and the Quality of our Environment (American Association for the Advancement of Science, 1966), p. 316.

[37] J. D. Eye, "Aqueous Transport of Dieldrin Residues in Soils," Journal of Water Pollution Control, Federal Supplement 40, 1968, pp. 316-32.

all land, while flooding only has local significance. Nevertheless, the volume of pesticide-laden sediment eroded by flood waters can be considerable.

As mentioned earlier, most pesticides are insoluble in water. They tend to move in water by suspension either bound to some other particle such as silt, algae, or dead organic matter, or as large particles of the chemical itself. Thus, they may travel hundreds or thousands of miles from their source areas, e.g., treated fields, contaminating streams, ponds, lakes and rivers, and ultimately entering the ocean in presently unknown quantities. The fact that pesticides travel in suspension while attached to other particles means that bodies such as ponds, lakes, and oceans serve as reservoirs for any sediment that may settle out. Fish and other organisms living in these waters may eat contaminated nutrients or may obtain pesticide residues indirectly by eating organisms which have ingested contaminated nutrients and concentrated the residues to levels many thousands of times greater than the residual level in the water from which they obtained the pesticide.

The water itself is not contaminated during the movement of pesticides; only the matter it carries is affected. As long as such material is removed from water supplies for human consumption, no threat to humans exists from this source. The residue, however, remains attached to the sediment in an active state. This sediment may remain in a stream bed or lake bed with the constant possibility of ingestion by some organism which may then pass it up the food chain. If the sediment should be deposited on agricultural land, it can be taken up by plant root systems and enter the food chain in that manner, ultimately winding up in the fatty tissues of humans who consume it.

It would appear from the conclusion drawn by Eye that pesticides would be uncommon in groundwater; however, such is not necessarily the case. Natural processes are not the only means of creating pollution hazards from

pesticide use. Man-made accidents have been the primary mode of pesticide entry into groundwater.[38] This is cause for alarm since groundwater recharge rates are slow, and contamination would thus persist for a long time. Continuing tests of groundwater supplies indicate more widespread contamination of groundwater than was previously realized. The concentrations revealed by these studies have been quite low, however.[39]

(3) Pesticide Residues in Crops. All crops treated with pesticides take some of the chemical in through the root system. The amount taken in varies tremendously, depending on the pesticide itself, the method of application, the time between application and harvest, the nature of the crop itself, and the amount of processing it undergoes before consumption. The implications for man depend upon the specific crop under consideration. Fibers pose the least hazard for man unless the specific pesticide is capable of entering the body through the skin. Many pesticides can enter in this way, and little is available to suggest the magnitude of any hazard that may exist from this source.

(4) Air Pollution from Pesticides. A study conducted by Cohen and Pinkerton[40] in 1965 proved that pesticides may be transported over long distances when attached to particles of dust in the air. Risebrough and his

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[38] J. E. McKee and H. W. Wolf, Water Quality Criteria (ed. 2), State Water Quality Control Board Publication 3A (Sacramento: Water Resources Agency of California, 1963), p. 157.

[39] U.S., Department of Health, Education and Welfare, Report of the Secretary's Commission on Pesticides and Their Relationship to Environmental Health, Parts 1 and 2 (Washington: U.S. Government Printing Office, December, 1969), p. 117.

[40] J. M. Cohen and C. Pinkerton, "Widespread Translocation of Pesticides by Air Transport and Rain-Out," in R. F. Gould, Organic Pesticides in the Environment, Advances in Chemistry Series (Washington: American Chemical Society, 1966), pp. 173-76.

associates[41] concluded that pesticides are ubiquitous in the air, though in varying concentrations. They also concluded that the distance traveled from source areas depended upon wind patterns and rates of fallout. Again, information on health hazards is scarce as detailed study has just recently begun.

DISTRIBUTION OF PESTICIDES IN SURFACE WATER

Beginning in 1964 the Federal Water Pollution Control Administration of the USDI conducted an annual survey for evidence of chlorinated hydrocarbons in the surface water of the United States. The purpose of this continuing surveillance is to make known the quantities and trends of pesticides in waters. The samples that are taken for this survey are collected in September of each year when stream flows are minimal. Samples are taken at approximately 100 different sites in all of the major river basins in the United States. (See Maps 1 and 2 for specific locations.) Samples in this survey are currently limited to nine pesticides from the chlorinated hydrocarbon group. Weaver et al.[42] and Breidenbach et al.[43] estimated that the nine pesticides considered represented 60 per cent of all chlorinated hydrocarbons consumed as pesticides.

Maps 1 and 2 show the findings of the survey for 1964 for two selected

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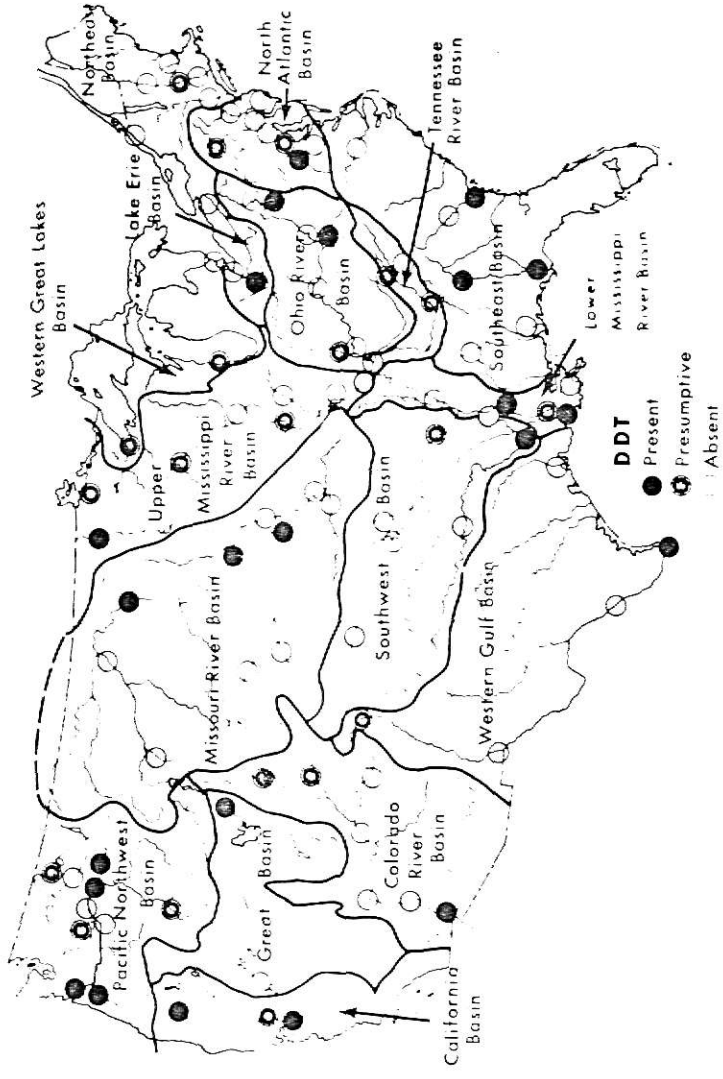
[41] R. W. Risebrough, R. J. Huggett, J. J. Griffin, and E. D. Goldberg, "Transatlantic Movements in the Northeast Trades," Science 159, 1968, pp. 1233-36.

[42] L. Weaver, et al., "Chlorinated Hydrocarbon Pesticides in Major U.S. River Basins," Public Health Report, 80 (Washington: U.S. Government Printing Office, 1965), p. 482.

[43] A. W. Briedenbach, et al., "Chlorinated Hydrocarbon Pesticides in Major River Basins, 1957-65," Public Health Report, 82 (Washington: U.S. Government Printing Office, 1967), pp. 139-56.

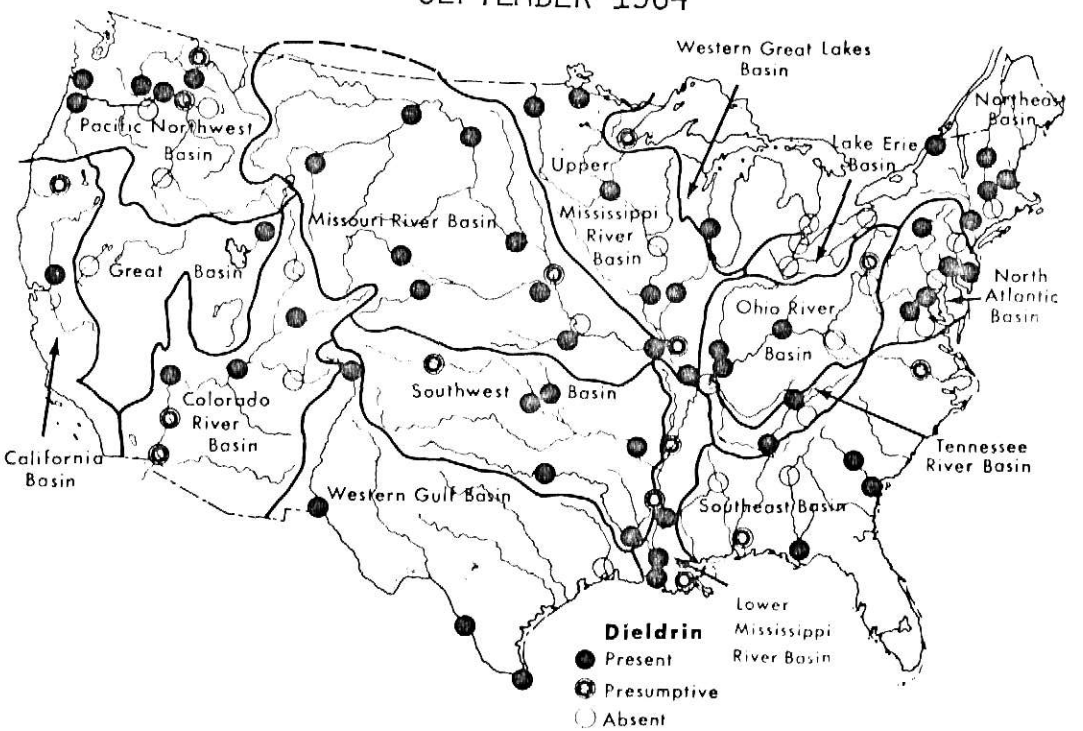
MAP 1

OCCURRENCE OF DDT IN MAJOR RIVER BASINS,
SEPTEMBER 1964



Source: L. Weaver, et al., "Chlorinated Hydrocarbon Pesticides in Major U. S. River Basins," Public Health Report, 80, June 1965, p. 488.

OCCURRENCE OF DIELDRIN IN MAJOR RIVER BASINS, SEPTEMBER 1964



Source: L. Weaver, et al., "Chlorinated Hydrocarbon Pesticides in Major U. S. River Basins," Public Health Report, 80, June 1965, p. 487.

MAP 2

pesticides, DDT and dieldrin. These two were chosen for this paper because dieldrin was found to be the most widespread of all those considered, and DDT has had the longest history of use in the United States.

At this stage in the study of pesticides in surface waters no geographic relationship has been noted to account for the widespread occurrence of dieldrin, which is consumed in amounts only 20 per cent as large annually as DDT.[44]

A tentative explanation is available, however, to account for the occurrence of DDT in water in the western states even though Map 3 shows that the consumption of DDT in those areas is limited. Weaver et al.[45] cite the basic reason for its presence in the western states as being its close association with irrigation agriculture. In the south and southeast DDT is common in water because of its extensive use, for many years, in conjunction with cotton production. Based on the persistent nature of DDT, its long history of use, and its extensive use in these two areas, DDT would be present in water samples from these areas even after a complete ban on its use.

The areas showing DDT consumption at less than two million pounds on Map 3 are misleading. DDT use may be much smaller in these areas than in the south and southeast; nevertheless its use is limited to the areas of irrigation agriculture which make up but a small fraction of the total area of the western states.

OTHER GEOGRAPHICAL RELATIONSHIPS IN PESTICIDE USE

Currently available information shows that few definite geographical relationships are known to exist between pesticide use and environmental

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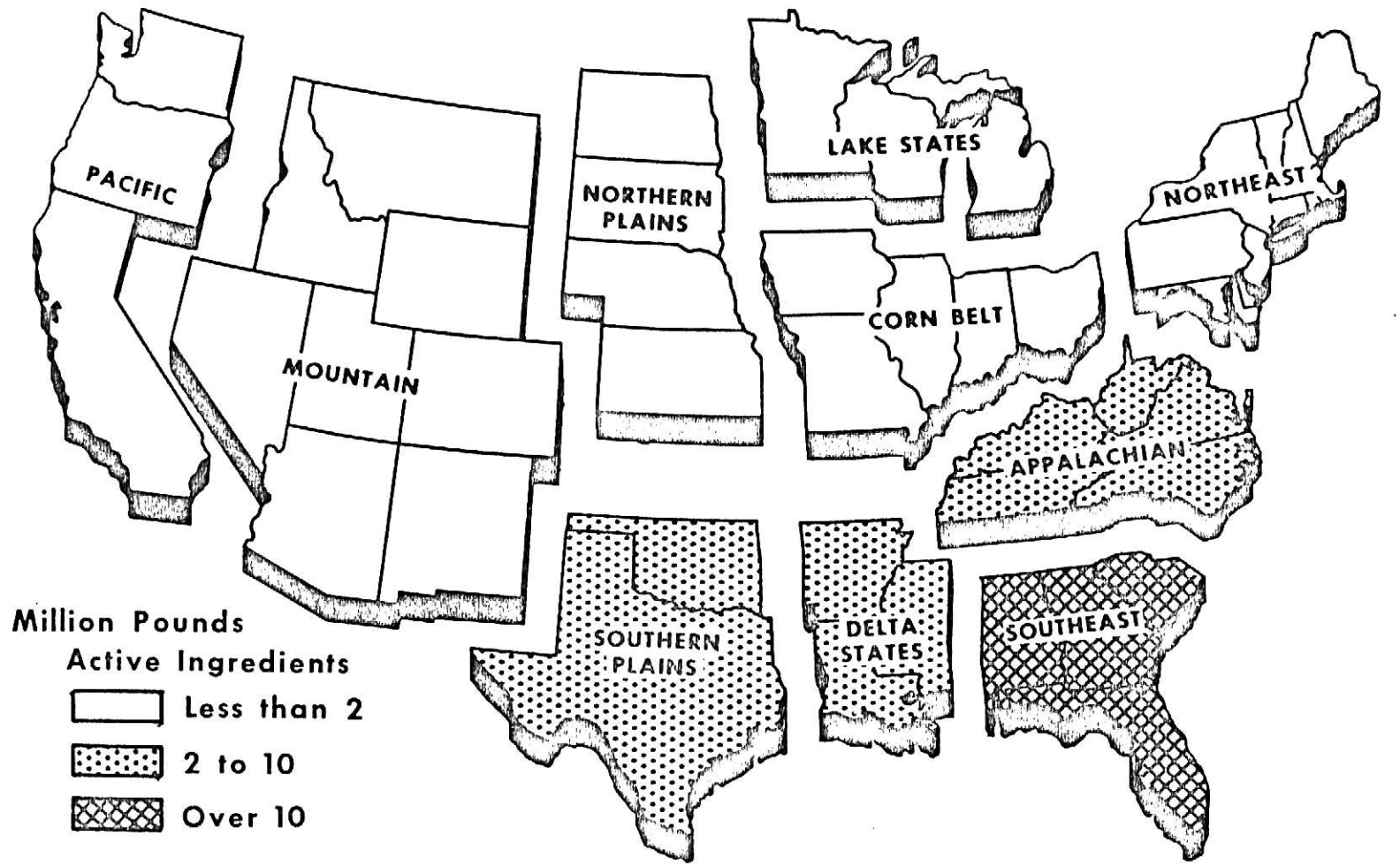
[44] Weaver, op. cit., p. 483.

[45] Ibid.

DDT USED IN FARM PRODUCTION, 1966



Source: U. S. Department of Agriculture, Economic Research Service, DDT Used in Farm Production, Washington: U. S. Government Printing Office, April 1969, p. iv.

MAP 3

pollution. If the recent expansion in research on pesticides is any indication, this situation will be changing every day. The literature used in the preparation of this chapter suggested only two such relationships. First, 80 per cent of all insecticides now in use in this country are used to control the 100 most serious insect pests.[46] The Secretary of HEW recommended the application of a vigorous program to concentrate on controlling these specific pests by nonchemical means as a way to greatly reduce environmental pollution from pesticides. Second, the same report concludes that a marked geographical stratification of DDT residues exists in the population of the United States. DDT residue levels in people living in the cooler areas of the country are only one-half the values for people living in the warmer areas. The report also states that these findings do much to dispel the belief that food is the main source of DDT in the human body.[47]

Relationships such as these pose interesting problems for geographical analysis. However, as the report states, such undertakings are impossible at present, due to "the paucity of our knowledge in this area."[48]

PESTICIDES AND HUMAN HEALTH

The effects of pesticides can be classed as either beneficial or detrimental. Their use has produced two beneficial results. First, pesticides offer the possibility of producing more and higher quality food than ever before. They permit better and longer storage of foodstuffs than was previously possible, and better storage coupled with faster, more efficient,

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[46] U.S., Department of Health, Education and Welfare, op. cit., p. 30.

[47] Ibid., p. 36.

[48] Ibid., p. 35.

and low cost transportation makes it possible for certain foods to be available for longer periods of time during the year. This means that, other things being equal, the nutritional standards of Americans are higher than ever before. Second, pesticides have contributed significantly to the control of many insect-borne diseases. Deaths from many of these diseases have been reduced significantly, as shown by Table 9.

TABLE 9

DEATHS FROM SELECTED INSECT-BORNE DISEASES IN THE UNITED STATES

Year	Malaria	Rocky Mountain Spotted Fever	Tularemia
1940	1,442	83	189
1945	443	128	122
1950	76	31	15
1955	18	8	9
1960	7	11	4

Adapted from: J. C. Headley and J. N. Lewis, The Pesticide Problem: An Economic Approach to Public Policy (Baltimore: The Johns Hopkins Press, 1967), p. 82.

Not all the effects of pesticides on human health are beneficial. The presence of toxic chemicals in the air, water, and food poses problems that must be solved. At present, the effects of long-run low level exposure on man are not known. However, not all people are subjected to low level exposure. Agricultural workers and persons engaged in manufacturing and packaging pesticides are exposed to concentrations of pesticides that can be lethal or cause serious illness if improperly handled. Each year deaths and illnesses occur. Steps are being taken to reduce such events, but that does little to aid the situation of low level exposure.

CAUSES OF ENVIRONMENTAL PROBLEMS

The causes of the pollution hazards created by pesticides are numerous. Excessive use, poor handling, and accidents account for many specific incidents. Yet, the fact remains that vast quantities of pesticides are concentrated in the soil, water, and to a lesser extent in the air. Seven major causes have been cited as the basic reasons for environmental pollution resulting from pesticides.[49] These are important for consideration here. Of the seven, none is truly the most or least significant since problems arise as a result of complicated interplay of all these contributing factors.

(1) Misplaced economic incentives are the first of the causes. Basically two points are involved. Only now are pollution and the means necessary to abate it being considered as costs of production and included in the production function. This concept must be expanded and all industries and types of agriculture must include social costs in their respective production functions if real progress is to be made.

In addition, the incentive is to produce "broad spectrum" pesticides which handle many pests and can be used on many crops. What incentive is there to encourage private industry to develop specific pesticides for specific pests, as the market for such products would be quite limited, based on present circumstances?

(2) Values in American society are the second cause. Here society is demanding vast amounts of consumer goods without thinking about the costs of pollution, resources consumed, and the consequences of resource misallocation.

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[49] Council on Environmental Quality, Environmental Quality (Washington: U.S. Government Printing Office, 1970), p. 12.

This system of values is a twentieth century holdover from the expansionist attitude that prevailed during the nineteenth century when resources were believed to be unlimited.[50]

(3) Population constitutes the third of the seven causes. The various densities of population contribute to environmental problems, and a large and growing total population presses for efficient food production.

(4) Technology, which is the fourth cause, has resulted in rapid innovation in western society. It has given us many new ways to solve problems, and it presents us with new problems. This has occurred because the rate of technological innovation has exceeded the scientific and regulatory capability of industry and government.[51]

(5) Mobility contributes to environmental pollution by allowing the free time to travel to national parks, national forests, and other public areas where insecticides are used to remove insect pests.

(6) Limitation of government units contributes to pollution from pesticides. Agencies set up to control pollution are too limited in scope to control problems adequately.

(7) Lack of information contributes significantly to pollution resulting from pesticide use. Many of the accidental spills of pesticides result from a lack of proper handling of information. Over-application of pesticides can also result from lack of information concerning pesticides.

All of these causes have geographical implications and will provide room for future geographical inquiry.

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[50] J. I. Bergman and Sergei Lenormand, The Pollution Paradox (Washington: Spartan Books, 1966), pp. 2-3.

[51] Council on Environmental Quality, op. cit., p. 15.

CHAPTER VI

CONCLUSIONS

Much more in the way of research and monitoring needs to be done before the full effects of pesticides on the environment will be known. As a result, only tentative conclusions can be stated.

(1) Much of the pollution resulting from the use of pesticides comes from three sources. Inadequate information about the seriousness of the threat from the pests that are to be controlled, accidental contamination during handling, and improper use of the pesticide in question. Usually the improper use of pesticides amounts to applying a pesticide at too high a concentration, which means that more pesticide is present than is actually necessary.

(2) The amounts of the various pesticides consumed in the United States could be reduced considerably by finding nonchemical means to control the 100 most serious pests, as the Secretary of the Department of Health, Education and Welfare has suggested.

(3) Pollution resulting from pesticides, even if used in increasing amounts as the current trend suggests, could be reduced by carefully controlling the amount used on lands of differing slopes. Of the four classes of land suitable for cultivation, according to the Land Use Capability Survey as set up by the Soil Conservation Service, class I land could receive pesticides in both greater quantity and concentration than class IV land should receive.

(4) As with many other problems, much could be done to reduce pollution from pesticide use with an expanded program to educate people and to make new information available.

(5) Finally, if the problems of pollution from pesticides are to be solved, economic incentives to industry must be changed to promote the solution to those problems.

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PESTICIDES USED IN AGRICULTURE: ECONOMIC CONSIDERATIONS AND ENVIRONMENTAL CONSEQUENCES

by

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Man's ability to solve complex problems with far-reaching ramifications has resulted in a high rate of technological innovation. Such innovation of itself creates other problems which, in turn, must be solved. One example of technological innovation is the development of synthetic organic pesticides. This development has occurred since 1939. Various pesticides were used for centuries before 1939, but problems associated with pesticide use have only developed since that date. Currently, five problems are associated with pesticide use. These are: (1) The possibility of soil residue build-up from continuous use of persistent pesticides. (2) Many kinds of pesticides are available, but little is known of the environmental consequences of their use. (3) The hazards associated with the use of each of the three major types of pesticides are quite different. (4) The possibility of the development of insect resistance to specific pesticides over time. And (5) pesticide use creates complex cost-benefit distribution and resource allocation problems. These problems have developed because of a combination of the nature of the pesticides themselves, the vast quantities used, and the social, political, and economic make-up of American society.

Government is responsible for registration and control of pesticides in this country, but the information provided by government research is infinitely limited in relation to the vast quantities of pesticides manufactured and used in this country. Because of the recent public concern over all types of pollution, the efforts of government agencies are being increased and more specific programs are being designed and implemented.

Because the research into the nature of pesticides and the consequences of their use has lagged behind the use and proliferation of pesticides, the environmental consequences are only partly known. Years will pass

before the implications for men are known. This is not a condemnation of pesticides, for they have benefited man tremendously; it is merely a call for careful evaluation and use of pesticides as well as re-evaluation of the economic incentives behind pesticide production and use.