Bulletin 536

PESTICIDES And The ENVIRONMENT

COOPERATIVE EXTENSION SERVICE
THE OHIO STATE UNIVERSITY

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Appendix

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1/79—20M

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Pesticides and the Environment

The Need for Pesticides

Modern pesticide chemicals have made a vivid impact on the environment in which we live; they have controlled disease-bearing insects, promoted higher crop yields, and improved the standard of living.

Millions of lives have been saved from such diseases as malaria, typhus, and yellow fever by insect vector control programs. A little over 25 years ago about 200 million people in the world were stricken with malaria annually, and 2 million died. In 1953 there were 75 million cases in India alone and life expectancy was 32 years. Through the use of DDT the number of cases was reduced by 1967 to 100,000 and life expectancy increased to 47 years. In 1950 Ceylon reported over 2 million cases of malaria and in 1963 after several years of DDT eradication program reported 17 cases. The number of malaria cases in the U.S. decreased from 60,000 in 1945 to less than 2,000 in 1950 due largely to the use of DDT.

A similar story in disease control is evident with murine typhus, which had increased in the U.S. from about 1,000 cases in 1932 to well over 5,000 cases in 1945. It rapidly dropped to less than 500 cases in 1950 and zero in 1952. DDT alone is credited with saving hundreds of millions of lives from the ravages of disease. World Health Organization leaders have said that no other chemical has done as much to control pests that carry diseases to people.

Modern pesticides have played a significant part in the increase in food and fiber crop production, and the quality of the produce. The production of milk per cow, potatoes, or tomatoes per acre has in many cases more than doubled since 1945. Yields for many other crops have increased from 20-50 percent or more. The quality of the produce has so improved that the American public has come to expect attractive, unblemished, and wholesome food on the grocery shelves. Customers will not purchase commodities of an inferior grade.

In spite of recent inflationary trends, the American public is buying better quality food for a smaller amount of its disposable income than any other nation in the world. Economists estimate that approximately 16-18 percent of the dollar in the United States is spent for food. That figure, of course, is the average of all consumers; i.e., those that may spend well over 50 percent of their income as well as those who spend less than 12 percent for food. Pesticides have also contributed greatly to the comfort and satisfactions of the homeowner in his landscaping, gardening, and leisure-time recreation.

Pesticides Called Vital to Economy

The use of chemical pesticides and their impact in the environment has been the subject of discussion and investigation for several years. A brief outline of some investigations and the resulting reports are found in the appendix. All of these reports concluded that the use of chemical pesticides is vitally important to agriculture and, hence, to the national economy. They expect these pesticides to be used extensively in the next few years; however, they emphasized that some environmental problems do exist from use of certain pesticides. Persistent pesticides, the reports suggest, should be phased out or restricted in use. This action is not in conflict with the USDA Policy on Pesticides (See page 16) as evidenced by the cancellation, suspension, review, or restriction since November 1969 of most uses of DDT and TDE except for Public Health Use and export; lindane and BHC; aldrin and dieldrin, chlordane and heptachlor; 2,4,5-T; current reviews on lindane, endrin, toxaphene, and 2,4-D and other phenoxy acid herbicides; and heavy metal products containing mercury, lead, and arsenic.

In recent years many persons and groups have argued that persistent pesticides, and in some cases, all pesticides, should be banned. In view of this controversy, let's look at possible consequences in relation to disease and food and fiber crops.

In some cases, the figures to be presented are estimates because the actual condition has not occurred, but these estimates were based on current agricultural practices, insect and disease potentials, production, and past experiences. They were presented by professional experts in science. Thus they are worth noting. Other incidents have occurred and are a matter of record.

Malaria Cases Spur Return to DDT

In the field of human disease control, perhaps the best example is that of Ceylon, as cited earlier. The use of DDT for the control of the mosquito practically eliminated the occurrence of malaria so that the insect-control program was discontinued in 1963. However, because of no mosquito control program cases of malaria again reached epidemic numbers in Ceylon within 5 years.

Data from HEW at Atlanta, Georgia (dated July 25, 1969) list the number of cases of malaria in Ceylon in 1963 as 17; in 1964, 150; in 1965, 308; in 1966, 499; in 1967, 3,466; and in 1968, more than 1,000,000, in a country about the size of West Virginia with a total population of less than 10 million. In 1969 the DDT eradication program was initiated again with prospect of facing a critical DDT shortage.

The Communicable Disease Center of the U.S. Public Health Service reported that by November 1969 the occurrence of malaria in the U.S. had climbed to 3,806 cases, many of them undoubtedly being brought back by G.I.'s returning from Viet Nam and peace corps personnel. Between 1969 and 1978 the Department of Health reported 14,519 cases of malaria in the U.S. Ohio reported 127 cases of malaria in 1970 and 376 between 1965 and 1971. Four cases were reported in 1974 and 31 cases between 1975 and 1978.

The cancellation of DDT for mosquito control has not been of serious consequence in the U.S. at present because there are other, though more costly, methods of control. But the economic aspects of mosquito control in developing countries might bring an end to the programs if DDT were no longer available. Some World Health Organization authorities have stated that such a ban would, in effect, automatically condemn millions of people to death from disease.

It is a well-known fact that the use of malathion in the nine counties of Ohio affected by summer floods in 1969 helped to curtail mosquito borne encephalitis in those counties. Cases of encephalitis in other counties in the state where the emergency spray program was not used showed the importance of good mosquito control. There were 264 reported cases of encephalitis in Ohio between 1965 and 1972. Nineteen cases were reported in 1973, 4 in 1974, and 519 from 1975 to 1978. Other incidents of control in Texas and California bear testimony to the importance of such mosquito control.

Potential Crop Losses

Estimates have been published about crop losses that could be expected with a ban on pesticides or with a partial ban, replacing the persistent organochlorines with organophosphates and carbamates. In a talk presented at the NACA Annual Meeting on September 15, 1969, former Under-Secretary of Agriculture, J. Phil Campbell, stated, "There are some 10,000 species of insects in the U.S. that are enemies of man, agriculture, and natural resources. Several hundred of these are particularly destructive. Besides insects there are 600 species of weeds, 1,500 plant diseases, and 1,500 species of nematodes and microscopic worms which are capable of causing serious economic loss. The cost of controlling these tests was estimated at more than $3 billion a year in the mid-1960's, and is more today. Even with these large expenditures to curb pests, it is estimated that insects, diseases, nematodes, and weeds cut U.S. agricultural production by about one-fourth." The 1968 estimate placed the agricultural economic loss at about $15 billion.

More recent publications have estimated the crop loss in the United States due to pests to be about 34 percent of the average annual production. An additional 9 percent is lost after harvest. Crop losses in Less Developed Countries, particularly the warmer, humid areas of the world, are estimated to be even larger. Up to 40 percent of the stored grain in India is lost to rodents, insects, and decay organisms. If one-half or even one-third of these crop and hence food losses could be avoided, the increase in food supply would be tremendous. Also the energy, supplies, and manpower used to plant, grow, and harvest the lost portion of our agricultural production would be conserved. (NYS AES 1976)

Campbell further stated that if pesticides were banned in agriculture ". . . potato production in the East could be virtually wiped out. Peaches and citrus fruit might well disappear almost completely from food markets. Total production of U.S. crops and livestock could drop by as much as 30 percent."

Agricultural losses to pests would be much greater in the United States today if it were not for the relative effect level of technology currently in use. Agricultural technology including the use of phenoxy herbicides and Hessian fly resistant varieties save millions of bushels of wheat each year. Apples could not be grown commercially without the use of insecticides, fungicides, and rodenticides. Losses on cole crops, sweet corn, tomatoes, and potatoes would be intolerable without protection from attack by disease organisms, weeds, insects, and nematodes. Problems on soybeans appear to be worsening.

Without the pesticides, fertilizers, and agricultural technology presently used, it is doubtful that adequate quantities of food and fiber could be produced on our current acreage for more than 40 percent of our present population. It is estimated by some that an additional 30 million more acres would be required under cultivation just to supply food for today's population. Another 100 million acres would be required to offset the losses in food processing, transportation and storage experienced in underdeveloped countries. A significant percentage of the population would be required to return to the farm as laborers in order to make such acreage even partially productive. Instead of spending 17 percent of our disposable income for food, we might be forced to spend 30 to 40 percent or even more for produce of inferior quality. This, of course, would cause even greater hardships to the estimated 25 million people in this country who subsist on poverty level incomes. Would millions of others whose incomes are somewhat above poverty level be dragged down into poverty? Such possibilities require careful consideration.

Scientists Say Farmers Need Pesticides

In 1969, scientists prepared a report for the governors of the five Great Lake States (Illinois, Indiana, Michigan, Minnesota, and Wisconsin), which dealt with use patterns, health considerations, related urban and industrial concerns, and economic considerations. They concluded that U.S. farmers would become less competitive and, in fact, would not be able to meet world competition, causing exports to be greatly reduced or to cease entirely if all pesticides were eliminated from U.S. agricultural operations.

Some states or regions would be affected more than others; food prices would be significantly higher, grading standards and regulatory laws would require general overhauling to compensate with lower quality. Various insect borne diseases would be more difficult to control as insect populations increased; 50 to 60 million acres of retired land would be required annually to go back into production, thus affecting wildlife and bird habitats. From a reduction in domestic food supplies of even 5 percent total, the American consumer would be faced with food costs at retail as much as 5 to 10 percent higher for a supply of much lower quality.

These scientists estimate that a pesticide ban in the five states would result in an economic loss at that time of $1.64 billion annually. If only the organochlorine insecticides were banned, the loss would be $160.5 million annually. Substituting organophosphates and carbamates for the persistent organochlorines in the control program would increase the cost of production by $23.3 million (See tables on page 18).

Dr. Edward Stroube, Extension Specialist, Weed Control at The Ohio State University, with cooperation of other scientists in the College of Agriculture and Home Economics, prepared a paper entitled "The Production of Food and Feed in Ohio in Relation to Pesticide Use." From this paper, the cash receipt value (1968) of Ohio farm income plus the percentage of several crops treated with pesticides (1969) and the estimated losses in several crops resulting from a ban on all pesticides are included on page 17. In 1969, it was estimated that a ban on pesticides would result in a $173.2 million per year loss in field crops, $35.8 million per year in greenhouse and nursery crops, and $40.2 million per year in livestock products for a total loss of some $250 million annually from Ohio agricultural production.

Federal Regulations also exert an effect on agricultural economy. In 1976 EPA published a report on the cost impacts on agriculture and industry from implementation of Amended FIFRA of 1972 (see reference listing). Among other things the report identified the types and geographic areas that would be most affected and the economic impacts solely attributable to 1972 FIFRA. The total cost pass through to the farmers is estimated at $105,470,000 per year of which $22,800,000 would be absorbed by farmers in the Corn Belt states. Increased costs to industry is estimated at 32.1 million dollars, to households at 24.2 million and to government at 3.6 million for a total of 165.4 million dollars. This figure represents only a 2.9 percent increase in pesticide costs to the farmer or an increase of 0.37 percent in crop production costs. The pass through to the consumer would be about $136.9 million or 0.1 percent increase in the national food bill, but adding the other direct impacts could total to the $165.4 million annually for the next 10 years.

Agriculture Must Feed Expanding Population

Another aspect to be considered in reviewing the needs for pesticides is the responsibility of feeding an expanding world populiaton. The prophets of doom would have us believe that we are destined for extinction; that the population will become so dense the land areas of the world cannot provide living accommodations, food, nor energy to support so many people. To avoid such catastrophies they advocate drastic control programs even to treating water and food supplies for the purpose of federal control of birth. I take a far more optimistic viewpoint in the belief that the technical knowledge of scientists will be equal to the tasks of providing food and facilities for an increasing population.

At the present rate of growth, some scientists estimate that the world population will exceed 6 billion people by the year 2,000, barring any major catastrophies such as war, or disease epidemics. To meet the needs of this population growth, they further estimate that food and fiber production will need to double in the Western World, increase three-fold overall to maintain subsistence levels in merging nations, and increase nearly six-fold in protein production to meet the needs of world population. The world is using, at various levels of efficiency, nearly 3.75 billion acres of land. The land potential available for agricultural use is estimated to be 6.25 billion acres. North America has less than 12 percent of the world's cropland, yet the United States and Canada ship nearly 80 percent of all agricultural exports and have done so for a decade or more. The present use of pesticides in food production throughout most of the world is far below that used in the U.S. Increasing intensification in agricultural production and utilization of technology indicates a continuing increased demand for pesticides.

The world food problem as noted by Phil Campbell is not primarily a population problem but an economic and distribution problem. For instance, the people of Belgium are well fed, yet the population density in Belgium is estimated to be four times that of China. People in the Netherlands have good diets, yet their density of population is twice that of India.

Campbell voiced the opinion of many agricultural scientists stating "I do not minimize the seriousness of the world food problem. But I strongly believe that research and technology have introduced an entirely new element into the food and people equation. We have developed new breeds of livestock and poultry, new crop varieties, new methods of cultivation, new machines, and many new chemicals and drugs. The result is that one hour of U.S. farm labor in 1968 produced 7½ times as much food and fiber as it did 50 years ago, 4 times as much as it did 25 years ago, and 2½ times as much as it did 15 years ago. We cannot expect such gains in nations that lack our resources and ability to develop the 'package technology.' Nevertheless, research and technology, the coming use of nuclear energy, economical processes to de-salt sea water, and other advances could be the genie which will open wide the door to more abundant food supplies. I, personally, believe that within the continental U.S. alone there are natural resources enough when combined with the coming technology to provide food and fiber for a billion people." Research and technology include the wise, prudent, and safe use of agricultural chemicals.

Chemical Pesticides To Remain In Common Use

The consensus expressed from the several reports of federally appointed scientific review committees and of the majority of agricultural scientists is that the use of synthetic organic pesticides will remain an intricate part of agricultural technology for many years and may always be a part of an integrated pest management program. In 1967, economists estimated that the use of chemical pesticides would increase at an annual rate of 15 percent over the next few years. However, because of unfavorable publicity and legislative implications, the energy crisis, lack of raw materials, and restrictions on the permitted manufacture of certain products, the production of pesticides has not increased at the rate anticipated. Pesticide use declined by 3.2 and 5.1 percent from the previous year in 1969 and 1970 respectively. Increases over the preceding year were 7.4, 8.6, 17.3, and 13.9 percent from 1971 through 1974 but declined 3.5 percent in 1975. The use demand for 1976 was expected to approach that of 1975. In 1977 it was expected to rise 5 percent and remain close to that in 1978. USDA now estimates a moderate increase in pesticide use from 1974 to 1985 projected at about 3 percent per year. Insecticide and fungicide use is expected to increase at about 1 percent per year but herbicides at 5-6 percent per year. The production of quality food in sufficient quantities to feed the population, the control of disease vectors, meeting the living standards required by the public, and the economic factors involved require use of current technology as well as the constant research for better ways.

Scientists, and also educators, involved in research, regulation, and manufacture are concerned about minimizing the environmental hazards associated with chemical pesticides. Pesticide desearch is concerned with better control and utilization of current chemical agents; the development of safer, biodegradable, and non-persistent chemicals; the integration of chemical pest control with other methods in pest management programs; the development of biological and virological controls; the development of hormones and pheromones to change specific pest behavior; the development of resistant varieties of plants and animals; male sterility, lures, traps, and other means of control. However, these techniques take years of research before becoming a practical part of the technology. In the meantime continuing education must teach people safe techniques of using current pest management tools.

Pesticides as Pollutants

As indicated previously, many committee reports that have been issued point out the problems of environmental pollution created from the use of pesticides and the need for corrective action. DDT, for instance, has been found in areas where it was never applied and has been associated with the decline and restriction of some wildlife species and the contamination of foods and feeds. The widespread occurrence of such DDT residues raised serious questions in the benefit/risk ratio. However, the situation is further complicated by the presence of PCB's (polychlorinated biphenyls—Aroclors) in the environment oftentimes mistakenly reported as DDT. A considerable percentage of the past laboratory research and hence published literature attributed to DDT residues now is questionable because of the similarity in occurrence and chemical or physical detection of PCB and DDT.

A pesticide, its metabolites and/or toxic degradation products may remain in the environment longer than required or intended, or may be transported or directed to areas other than the intended target. The result may be undesirable residues in certain food crops, waterways, and wildlife and fish. Most of the pesticide residues in the environment appears to be associated with metals such as lead, mercury and arsenic and with the persistent organochlorine-type pesticides. Consequently, these products have been under extensive scrutiny with cancellation proceedings and public hearings initiated against most of the uses (See pages 17-18). Complicating the residue evaluation is the fact that the aforementioned metals are often naturally occurring elements in the soil environment.

The organometallic, organochlorine, and inorganic pesticides generally have a long "half-life" and, under certain conditions, some may still exhibit significant residues after several years. Of course, that was one of the influential factors in the original development of the chemicals. In contrast to the persistent organochlorines, the organophosphates and carbamates are relatively non-persistent, generally lasting only for a few weeks. However, they are generally more toxic initially and may cause greater problems in application because of their potential immediate effects on the applicator and beneficial species in the environment when not used correctly.

Pesticides are introduced into the environment by various means, both intentional and unintentional. The term "intentional" as used here means only that the accepted usage of pesticides automatically results in their introduction into an environmental system. Such routes of intentional introduction include agricultural and forestry uses; aquatic uses in controlling insects, weeds, trash fires, etc.; household and garden uses; municipal and industrial uses; and public health uses.

Unintentional introduction of pesticides into the environment occurs from accidents in manufacture, handling, transportation, storage, and use; industrial and municipal wastes; agricultural wastes such as crop residues, food industry wastes, etc.; drift from application or movement by attachment to soil particles, sediments, etc.; and fires, floods, etc.

Agriculture Uses Most Pesticides

The production of pesticides in the U.S. now exceeds 1.6 billion pounds annually with approximately 68 percent of that production used domestically and the remainder exported according to 1975 data. The U.S. pesticide import amounted to 53.5 million pounds that year. Estimates on the amount of pesticides used by the different segments of our society varies but generally 15-16 percent of the market is utilized for residential including home and garden, 21-22 percent for industrial and institutional, 2-3 percent for governmental, and the remaining 59-62 percent for agricultural purposes. A 1977 USDA farm survey indicated that farmers used an estimated 675 million pounds of pesticides in 1976 in providing some kind of pest treatment for more than 60 percent of the farm acreage (excluding pasture and rangeland). Farm pesticide use increased 40 percent from 1966 to 1971 and at the end of the 1976 season had increased another 40 percent over 1971. More than 75 percent of that increase was attributed to herbicide use, in 1976 estimated to involve 56 percent of the crop acreage. The combined use of insecticides and fungicides for crop use increased only slightly during that time period.

The use of pesticides for different agricultural crops varies from year to year based largely on the acreages planted, particular pest problems and the registered products available. Recent data, including 1976 and 1978 pesticide use surveys, is limited or not yet in print. The latest data available from 1971 indicates that three crops—corn, cotton, and soybeans—received approximately 70 percent of the total quantity of herbicides and insecticides. Percent use of the total quantity of herbicides showed corn—45, soybeans—16, cotton—9, other field crops (including small grains)—7, wheat—5, sorghum—5, and other crops accounting for the balance. Insecticide use showed corn—17, soybeans—4, cotton—47, other field crops (including wheat, small grains and sorghum)—11, vegetables—7, and other crops lesser amounts. Approximately 51 percent of the fungicides were directed to use on citrus and deciduous tree fruits, 25 percent to vegetables and Irish potatoes, 11 percent to peanuts, 8 percent to small fruits and nuts, and the balance to cotton and other crops.

It is natural to assume from these percentages that the majority of environmental pollution is caused by agriculture. "That there is environmental pollution is an undisputed fact. That it stems primarily from agricultural use of pesticides and plant nutrients is not a fact. The danger is that too many uninformed people may tie the facts and non-facts together" to quote Phil Campbell. It is possible that when the facts are known, the residential areas may be major contributors to the pesticide pollution of our streams and lakes. Preliminary investigations in Michigan (Pestic. Monit. J 5:301, 1971) indicate this to be the case. Extensive spraying programs for control of insect and disease problems in municipal vegetation (DDT and Dutch Elm disease as an example) undoubtedly contributed to stream pollution. Likewise the large quantities of materials used for insect and weed control in lawns could provide significant contamination of storm sewere runoff. Data from monitoring studies in 1970 showed the pesticide levels in urban soils from 14 cities to be higher than that detected in adjacent cropland soils. (Pestic. Monit. J. 10:54, 1976) Many cases of fish kill are traced back to accidental discharge or inadequate waste disposal procedures by industry. Recent articles in Science and the Pesticide Monitoring Journal indicate industry to be the major contributors to water-borne chlorinated-hydrocarbons.

Pollution problems also arise from the misuse of pesticides, including the use of the wrong chemical; use of greater quantity than specified; not heeding the application and harvesting limitations; changing crops, either intentionally or in a rotation in a field treated with a pesticide registered for a different use or that contains residues from a previous application; and applying pesticides improperly and indiscriminately without determining prior need.

One other source of pesticide pollution is related to the disposal of unused pesticides and "empty" pesticide containers. Present disposal methods are not completely adequate. Projected into the future the problem will be greatly magnified unless research efforts can result in a satisfactory and economical method of disposal.

The Status of Pesticide Residues

The monitoring for pesticide residues in various sectors of the environment is a continuous program and considerable data has been published involving research in the 1960's and early 1970's. Residues reported generally relate to the more persistent organochlorines. The cancellation of registration of DDT, aldrin, dieldrin, heptachlor, chlordane, and most of the organomercury, lead, and arsenic pesticides will undoubtedly in due time affect pesticide residues in the environment.

1. Residues in Soils. Several monitoring programs have been in operation for several years to determine the pesticide residue levels in soils and any significant changes in residue level. USDA, through the monitoring program of the Federal Committee on Pest Control Subcommittee on Pesticide Monitoring, indicates that there has been no significant buildup in the pesticide levels in agricultural soils.

This statement was based on repeated nationwide monitoring activities. Research data shows that the repeated use of the same organochlorine chemical over several years does result in a soil residue, but the accumulated residue level never appears to be greater in concentration than that equal to one year's application except, of course, during the season immediately following the yearly application.

Some of the extensive research related to residues in soils and summaries of results are as follows:

A survey of the organochlorine insecticide residues of randomly selected soils from nine states in 1967 (Pestic. Monit. J. 2:93, 1968) showed that about half of the samples had no detectable residues. DDT was the major contaminant in the remaining samples with the DDT analogs, BHC, and aldrin contributing a more minor contamination. The soil contamination was closely associated with the value of crops being grown with soils from orchards and vegetable growing areas showing the highest DDT contamination. Soils were analyzed from Arizona, California, Idaho, Louisiana, North Dakota, Oklahoma, Texas, Washington, and Wisconsin.

Where detected, residue values of contaminated soils for total DDT, including analogs, ranged from highs of 4.56 parts per million (ppm) in a Longrie silt loam from Wisconsin and 5.81 ppm in a Pima silty clay loam from Arizona to lows of 0.015 ppm in a Burke loam from Idaho and 0.09 ppm in a Vinton sandy loam from Arizona. Dieldrin values ranged from a high of 1.52 ppm in a Vernon clay loam from Texas to 0.02 ppm in a 99 & Z loam from California. BHC, heptachlor, and aldrin residues reported with one exception were below 0.03 ppm and in most cases less than 0.005 ppm.

In another survey in 1971 involving nine states (Iowa, Kansas, Minnesota, Missouri, Nebraska, New York, North Dakota, South Dakota, and Wisconsin) only 8 percent of the samples showed pesticide residue with dieldrin the most common followed by DDTR (Pestic. Monit. J. 10:114, 1976) at maximum levels of 0.12 and 1.54 ppm, respectively.

A report published by USDA in July 1969 compiled the results of residue analysis in soils in the lower Mississippi River Delta area for 1965-67, where organochlorine and organophosphate insecticides and several types of herbicides and fungicides have been used extensively. This report gave data for pesticide residues in soil, related crops, water, fish, and wildlife. The results showed there were no significant soil residue problems even following several years of extensive pesticide use. DDT was the most frequently found contaminant, the concentration of residue related to the history of use and ranging from minute traces to common occurrences of 2-5 ppm. Residues of dieldrin, endrin, toxaphene, and trifluralin at very minute concentrations were detected occasionally in most land areas. Organophosphate insecticide and fungicide residues were not detected in soils.

In 1965 a monitoring study was conducted for pesticide residues in soils and root crops in 49 fields from the Eastern States. The results showed DDT to be present in the soil of 48 of the 49 sampling sites, ranging from 0.10 to 12.8 ppm and averaging 2.8 ppm. Residues of DDT were well below the tolerance levels in all crop samples. Dieldrin from 0.05 to 0.26 ppm was found in 28 of the fields, but no residues were found in potato tubers and only an average of 0.05 ppm in 6 of 19 composite carrot samples (Pestic. Monit. J. 1:22, 1967).

A study from 1965-1969 at a newly developed Great Plains irrigation district in Kansas provided a unique opportunity to study insecticide usage and resulting residues (Pestic. Monit. J. 5:17, 1971). The data showed no accumulative trend over the period of years with yearly repeated application of the pesticide although minute residues of organochlorines did persist from one year to the next. The infrequent trace levels of indicated insecticides demonstrated no significant contamination in any of the surface waters.

In cranberry bog soils of Massachusetts after 20 years of continued application of DDT and dieldrin, 1.88 ppm dieldrin were found one year after application and 3.57 ppm DDT were found in the top 2 inches of soil 13 years after the final application (Pestic. Monit. J. 2:172, 1968). Analysis of orchard soil, water, and fauna in New York orchards that had not been extensively sprayed with DDT since 1960 revealed total residues in the 6 inch soil layer beneath the trees in the range of 21.8 to 259 lb./acre with from 7.3 to 78.5 lb./acre in the row. However, only 0.32 ppb DDT and 0.042 ppb DDD were found in the associated water (Pestic. Monit. J. 7:200, 1974). One month after aerial application at 12 oz. of DDT per acre to an Oregon forest, 3 oz./acre was detected in the forest floor; 3 years later, the residue had decreased by more than 50 percent, and had not leached into the surface mineral soil (Pestic. Monit. J. 6:65, 1972). Water in two streams draining this area had DDT residues at 0.3 ppb and no effects were noted on the soil microbial activity.

In 1972, the Environmental Protection Agency published the report of the National Soils Monitoring Program for Pesticide Residues FY 1969 involving analysis of cropland soil involving 387 million acres in 43 states and noncropland soil in 11 of these states (see also Pestic Monit. J. 6:194, 1972). In 1974 the report for FY 1970 involving 1506 cropland sites in 35 states was published (Pestic. Monit. J. 8:69, 1974). The data for 16 of the 43 pesticides analyzed are listed in Table 4, p. 17. Residues for the remaining 24 pesticides detected (3 analyses were for DDT and metabolites and are reflected in the data for DDT total) were very infrequent and low in concentration.

Another study in 1969 (Pestic. Monit. J. 6:126, 1972) showed that arsenic, DDTR, dieldrin and chlordane residues were generally much higher in concentration in urban soils than in cropland soils adjacent to the city. Other monitoring studies included analysis following a Japanese Beetle control program in Michigan (Pestic. Monit. J. 1:30, 1968), and analyses of soils and alfalfa in Arizona (Pestic. Monit. J. 2:129, 1968; 4:21, 1970; 5:276, 1971).

In order to determine the levels of organochlorine pesticides residue in the Corn Belt region of the U.S.A., 400 sites were sampled in 12 states in 1970 (Pestic. Monit. J. 6:367, 1973). Cropping and pesticide use records were obtained at all sites for 1970 and for the previous 5 years. Forty-five percent of the soil samples analyzed contained residues of one or more of 11 pesticides and/or metabolites (Table 4, p. 17). The residue results from this study for Ohio with 29 sampling sites are also shown in Table 4. Pesticide residues found in Ohio soils from 69 sites in Ohio in 1969 and another 69 sites in 1970 (Pestic. Monit. J. 6:196, 1972; and Laboratory Analyses Report, G. Wiersma, Monitoring Section Laboratory Services Branch, PRD, EPA) associated with the National Soils Monitoring Program are also shown in Table 4. The occurrence of arsenic in almost all of the samples from all studies is attributed to the fact that arsenic is a natural ingredient of most soils and thus is not necessarily due to pesticide use.

Analyses of soils and sediments from Ohio fields and rivers conducted by the Cooperative Extension Service Pesticide Analytical Laboratory during the last several years have detected the presence of some pesticides, dieldrin and DDT generally the most frequent, in very minute concentrations in many of the samples. The significance of such residue concentrations has not been evaluated. However, in some cases, we have noted very low concentrations (parts per billion range and lower) of residues detected in crops such as soybeans grown subsequently on some of those soils.

Pesticides residue occurrence in soils as observed from a nationwide pilot study in 1965 67 showed the direct relationship with use (Pestic. Monit. J. 4:145-166, 1970). Where no pesticides had been used, no residues were detected. The concentration of residues currently in soils does not generally cause illegal residues in subsequent crops. Some exceptions to that fact do occur, however, as illustrated by an endrin contamination a few years ago in carrot shipments, originating from a farm in Arizona, that had been treated five years previously (unknown to the current owner).

2. Residue in Water. The major routes of pesticide residues in the water environment occurs from direct application to surface waters and from run off from adjacent watersheds. Analysis of rainwaters indicates only extremely minute concentrations removed from natural air of the order of low parts per trillion (ppt). Several monitoring studies have been initiated to determine residue content in our national waterways. Twenty western streams in a U.S. Geological Survey program for monitoring pesticides are being studied for the occurrence of pesticide residues. The results for the period 1965-1971 are reported in the Pestic. Monit. J. 1:38-46, 1967; 3:1-7 and 124-127, 1969; and 7:73-84, 1973. DDT was the most frequently occurring insecticide and 2,4,5-T the most common herbicide. The maximum amounts observed were very low at 0.46 ug/1 for DDT and 0.99 ug/1 for 2,4-D during that period of time. The maximum residue level found in the latter 3 years of this current study were well below the permissable limits established for public water supplies by the National Technical Advisory Committee to the Secretary of Interior. Most of the residues found were in the range of .01-.05 ug/1 (ppb) and many samples gave no indication of any pesticide residue.

Studies of organochlorine pesticide content of sediments in water from the lower Mississippi River area and its tributaries in 1964 67 gave no evidence of general buildup due to agricultural use of pesticides (Pestic. Monit. J. 3:8-66, 1969). Residues were detected from both agricultural and non-agricultural sources, but the two areas of significant pesticide contamination were associated with pesticide manufacturing plants. The data indicated that large amounts of organochlorine pesticides applied to the crops in the Mississippi River Delta had not created widespread contamination of the water and sediments in that area.

A survey of water, seston, and sediment from the Upper Great Lakes involving PCB, 15 organochlorines, and 17 organophosphates indicated low concentrations of PCB and DDT and traces of dieldrin in sediment and seston but no detection of any pesticide chemicals in the water (Pestic. Monit. J. 10:61, 1976). In this case the source of DDT and dieldrin contamination could not be documented.

The Ohio Department of Health conducts a pesticide monitoring program on major streams in Ohio. During 1966 only one occurrence of a pesticide residue was reported; that being a concentration of 0.2 ppb DDT in the Sandusky River in July. Six pesticide residues of the 15 analyzed for during 1967 were found at six sampling sites; the highest being 0.007 ppb DDT in the Miami River in November. Six stations reported seven residues in 1968. Parathion was reported at 0.11 ppb in the Maumee River in May; the highest residue level reported for 1968. All eight stations reported residues in 1969 with the highest concentration being malathion at 0.31 ppb on the Mad River at Dayton in October. In 1970, 5 stations of the 8 sampled reported pesticide residue present in the water with the highest at 0.09 ppb of malathion on September 4th in the Mad River and BHC as the most frequent residue (4 occurrences in 9 sampling periods). In 1971, 4 of 10 stations reported pesticide residue in the water at concentrations generally lower than in 1970. The highest concentration reported was 0.07 ppb of parathion on Aug. 8th in the Little Miami River and aldrin or dieldrin occurred most frequently (4 occurrences in 8 sampling periods). During the years of monitoring, the occurrence of pesticide residues has been very infrequent and has always been well below the permissible limits set by the Federal Water Quality Control Administration. (Report from the Ohio Department of Health.)

There are some problems associated with the analysis of pesticide residues in water. Most pesticides are not readily soluble in water and tend to adhere strongly to soil particles sediments, algae growth, etc. Thus to get a correct picture of the amount of pesticides in run-off from watersheds, it is important to analyze the sediments and other materials.

Between 1972 and 1975 EPA cancelled the sale and prohibited most uses of the persistent insecticides DDT, aldrin, dieldrin, chlordane, and heptachlor. Monitoring studies by the Council for Environmental Quality on 60 sites in heavy pesticide use areas of Texas, Louisiana, and Oklahoma (1968-1976) showed a dramatic decline of residues in both water and sediment following the restriction on use of the persistent organochlorines. However, significant residues of some materials still persisted in the sediment at several locations during the period indicating the importance to analyze sediment as an accurate assessment of pesticide contamination. Organophosphate insecticide and phenoxy herbicide residues varied in accordance with local use and known persistence properties of the chemicals (Environ. Quality 8th Ed., pp. 236-245).

Our Cooperative Extension Service Pesticide Analytical Laboratory has completed two major pesticide residue studies (one for EPA and the second for Shell Chemical Company) on water, bottom sediment, and fish or fresh water clam samples at various sites on five major rivers of northern Ohio and the bay areas of Lake Erie. The occurrence of residues was very infrequent and at very insignificant concentrations (EPA Report-660/2-74-032, April 1974 and formal report to Shell Chemical Co., Oct. 1973). The sources of pesticide contamination and the relation to soil characteristics and cultural practices were inconclusive. It was noted that the most significant residues in the water associated with agricultural areas occurred following periods of rainfall soon after the particular pesticide was probably applied to the fields. In studies in Utah and Canada (Pestic. Monit. J. 6:166-170, 1972; 363-368, 1973), it was noted that seasonal variations in organochlorine pesticide residues in lake and river water generally correspond to the application periods. This phenomena was confirmed in studies of dieldrin residues in the Des Moines River in Iowa following application of aldrin to corn fields (Pestic. Monit. J. 9:186, 1976). Other studies in Iowa concerned with atrazine, DDT, and dieldrin residues in surface waters (Pestic. Monit. J. 9:118, 1975) indicated some contamination in all watersheds with the concentration of atrazine being the highest. This was not surprising because of the extensive use of atrazine on corn in Iowa and its relatively high water solubility. The occurrence of DDE provided additional evidence of the great persistence of DDT and its metabolites. Pesticide residue concentrations were directly associated with runoff as related to rainfall periods and the time of pesticide application.

An important consideration in determining the significance of minute traces of pesticides in water is the effects on fish. A minute trace of pesticide residue in water may seem relatively insignificant, but when it becomes an integral part in the food chain, the residue may become greatly magnified in the bodies of higher species of life. Examples of this problem as recorded in the publication "Organochlorine Pesticides in the Environment" include such cases as: (1) Mud samples in the Green Bay area of Lake Michigan contained 0.014 ppm DDT and its metabolites; crustaceans that were principal fish food contained 0.41 ppm; alewives taken from herring gulls averaged 3.4 ppm; and 12 seemingly healthy gulls taken from nesting islands had 99 ppm in the breast muscles and 2441 ppm in the fat. (2) In two watersheds in Pennsylvania where residues in soils and sediments were generally a few parts per billion, the residues in brook trout were 20 to 100 times greater and in white suckers 6 to 15 times greater than the trout. (3) Trout that died after 17 to 23 days of exposure to water containing 2.3 ppb dieldrin had muscle residues 3300 times the water concentration. Croakers exposed to 0.1 ppb DDT in water for five weeks accumulated concentrations 20,000 times greater.

As a part of the nationwide monitoring program, nine estuaries were sampled in California during 1966-67. Shellfish were used as sampling organisms because of their ability to concentrate low levels of pesticide residues. Lindane, heptachlor, aldrin, heptachlor epoxide, DDT, dieldrin, and endrin were among the pesticides found. DDT, DDE, DDD, dieldrin, and endrin were found in concentrations from 0.010 to 3.6 ppm with high levels of DDT, DDD, DDE observed in the offshore King Crab at 2.74 ppm and ova of Cape Salmon at 0.668 ppm. The pesticide levels in estuaries geographically isolated from agricultural areas seldom exceeded 0.1 ppm. In contrast, residues in estuaries receiving run-off from agricultural and urban areas sometimes exceed 11.0 ppm in shellfish, such as in the Sacramento-San Jaoquin drainage basin. However, in most cases, including this basin emptying into San Francisco Bay, the high levels in run-off were adequately diluted by the ocean waters in the bay areas to diminish the problem (Pestic. Monit. J. 3:1-8, 1969). Sediment particles in the water influence significantly the concentration of pesticide contamiants absorbed by fish and a strong seasonal variation in residue concentration is related to the time of pesticide application and the amount of sediment in the water due to runoff (Pestic. Monit. J. 11:138, 1978).

The National Pesticide Monitoring Program reported the occurrence of organochlorine pesticide residues detected in mollusks from estuaries of 15 coastal states from 1965-72. DDT occurred in 63 percent of the samples and dieldrin in 15 percent (Pestic. Monit. J. 6:328-362, 1973). Additional monitoring reports are published in the Pesticide Monitoring Journal of 1975 and 1976. The concentration of DDT residue peaked in 1968 and has declined markedly since 1970. Research evaluating DDT levels in 12 species of fauna in a New Jersey salt marsh revealed a decrease of 84-99 percent in nine species between 1967 and 1973 (Pestic. Monit. J. 10:149, 1977).

The public has been led to believe that cases of extraordinary fish and wildlife fowl kill are due to pesticide residues. It is true that some cases have occurred, but when considered as a part of the total kill, the percent due to pesticides in water is relatively small. The 1968 Fish Kill Report stated that 15,236,000 fish perished as a result of water pollution. Eighty-eight percent of these kills were caused by municipal and industrial pollution (6.952,000) from 122 incidents and 6,398,000 from 177 incidents, respectively. In 1969, water pollution killed 41 million fish in 45 states. Insecticides in agricultural operations were the source of 80 incidents resulting in a 5,982,877 total fish kill, 78 percent of which were non-game species. The fish kill census from 1960-1969 indicates that over 140 million fish perished in 4200 separate accidents. Agricultural pollution generally ranks third in the cause of fish kills, accounting for 16 percent or less of the loss. Exact figures, averaging about 3 percent, for pesticide-related fish kills can be obtained from the annual reports. Fish kills in Ohio attributed to pesticides for the period 1970 to 1975 are as follows: 1970 (11,819), 1971 (3,403), 1972 (414), 1973 (36,859), 1974 (4,384), and 1975 (4,836) (Publication No. 7, Ohio Dept. of Natural Resources, 1976).

3. Residues in Air

The presence of pesticide residues in the air is a function of the chemical nature, the physical state, the method of application, and atmospheric conditions. Residues occur from evaporation, spray drift, dust particles, wind blowing, etc. The use of aircraft over a good percentage of the area of pesticide application contributes greatly to air contamination.

At the present time the research is rather limited on the occurrence of pesticide residues in the atmosphere. Work that has been reported indicates that atmospheric contamination is very closely associated with agricultural operations (and urban also). At Barbados, an area remote from agricultural use of pesticides, the residue ranged from 13×10^{-6} nanograms per cubic meter of air to 380×10^{-6} ng/m^3. By contrast the air at LaJolla, California, an area adjacent to agricultural areas where pesticides were used, contained an average of 7×10^{-2} ng/m^3. It appears thus that pesticides are universally present in the air and their distribution is associated with application sites, prevailing wind patterns, and rates of fallout (Secretary's Commission on Pesticides Report).

Nine locations (urban and rural) in the U.S. were selected to determine atmospheric contamination by pesticides. The sites were Baltimore, Maryland; Buffalo, N. Y.; Dothan, Ala.; Fresno, Calif.; Iowa City, Iowa.; Orlando, Fla.; Riverside, Calif.; Salt Lake City, Utah; and Stoneville, Miss. Only DDT was found at all localities and the highest concentrations were in the agricultural areas of the South (likely associated with DDT application to cotton fields). The lowest level of detection of pesticides was 0.1 ng/m^3 and ranged to as high as 1560 ng/m^3 p,p'-DDT, 2520 ng/m^3 toxaphene and 465 ng/m^3 parathion. The highest concentration levels were found when spraying was reported to have occurred just prior to sampling (which would be expected) and the kinds and levels of residue varied with the agricultural activity and the season in a given area. Residue studies of DDTR in air in the Mississippi Delta showed a decrease of 88 percent between 1972 and 1974 and an additional decrease of 36 percent between 1974 and 1975, thus totalling a 92 percent decrease in 3 years following the cancellation of DDT registrations (Pestic. Monit. J. 10:168, 1977).

Even the highest levels of air contamination were below those encountered by the general population from other sources. Food analyzed from 12 restaurant and 17 household meals, based on the food in the meals analyzed, gave a mean daily intake of 1.99×10^{-1} mg. of DDT. This concentration was 20 times the exposure by the daily inhalation of air contaminated at the highest DDT level indicated above; such air contamination amounting to approximately 0.000286 percent of the quantity of DDT required by intravenous injection theorized to cause death in humans.

Pesticides and Wildlife

A considerable amount of research has been and is being done on the effects of pesticide residues on fish, birds, and wildlife with a major percentage concentrating on birdlife. Patuxent Wildlife Research Center at Laurel, Maryland, has been concerned directly with the problems and has published much of the available literature. Pesticidal residues are creating problems in the life and habitat of some of our bird species. Here is a brief glance at some of the problems encountered.

Quantities of pesticides in wild birds are related to their food habits and are a reflection of the contamination of the food supply. Fish eating birds such as bald eagles, peregrine falcons, osprey, brown pelicans, grebes, etc., have much higher organochlorine residues than the plant-eating species, such as ducks, geese, pheasants, or those that eat a combination of carrion and plant, such as the golden eagle and crow. Alaskan peregrines, which feed primarily on birds, contain far higher residue levels than small birds in the area. Several of the bird species are declining. These include the bald eagle, osprey, peregrine falcon, and brown pelicans, whereas other species such as the red winged blackbird, starling, quail, pheasant and robin (in spite of public emotion to the contrary) are increasing in population and health.

Pesticides May Speed Bird Decline

Pesticides probably have been a contributing factor to the recent decline in some bird species, but it must be remembered that these same species have been on the decline for years prior to the use of pesticides. Perhaps pesticides have accelerated the rate of decline. It is entirely erroneous, however, to automatically attribute the death of a bird to pesticide contamination even though analysis of tissues shows residues present. On the other hand, pesticide residues in bird tissues (particularly the brain) can cause death at lower concentrations than normally expected due to stress and other contributing factors of the environment. Diagnosis of mortality caused by pesticide residue is extremely difficult because of all the factors involved even with individual members of the same species.

Research has produced evidence that pesticides have affected and are affecting the reproduction in some species, both in egg laying and in the thickness of the egg shell. Egg shell thickness has been reduced about 13 to 19 percent in the species where reproductive trends have been on a downward slope. However, not all members of the particular family of hawks, owls, eagles, and other carnivorous birds show the same reproductive failures; this complicates the picture. The egg shell effects are generally attributed to the pesticide causing a change in the calcium metabolism. The most widely observed species susceptible to thin egg shell and consequent decline in species has been the peregrine falcon. Research has been conducted on field populations as well as laboratory specimens of bird species, and it now appears that DDT and its metabolites may have caused widespread and significant reductions of peregrine falcon populations. Other factors for consideration in the decline of certain species, however, include contamination from polychlorinated biphenyls (PCB), heavy metals, shooting by hunters and researchers, encroachment of human civilization into nesting areas, and constant disruption by some well-meaning biologists in nesting and breeding areas. Refusal to permit scientists to hover helicopters or to land on Anacapa Island off the southern California Coast by the National Park Service in 1971 resulted in dramatic recovery of nesting and hatching of Brown Pelicans contrasted to relatively few in 1970 (Dr. J. Gordon Edwards, San Jose State College).

Pesticides Are Often Beneficial to Wildlife

In many cases, the effects of pesticides have been beneficial to wildlife. Dr. Donald A. Spencer of National Agricultural Chemical Association, in a talk to orchardists in Michigan, pointed out the increase in numbers and health of game animals, birds, and fur bearing animals due partially to improvements of their habitats and control of pests and disease. In 1930 the wild turkey was on the brink of extinction in the U.S., but in 1967 hunters were able to harvest 118,844 birds.

The mourning dove in 1942 produced about 11 million in the harvest as contrasted to 42 million in 1967. The annual harvest of deer, elk, caribou, and other big game animals has shown a constant increase over the 20-year period, 1948-1967, of pesticide use. Dr. Spencer likewise reports that the catch by commercial fisheries from the Great Lakes has made tremendous increases. After a temporary set-back due to mercury contamination from industrial dumping in Lake St. Clair and Western Lake Erie, the commercial catch from these areas again is significantly upward.

As has been discussed, part of the problems with pesticide contamination is focused on the accumulation and concentration of residues in the food chain. Data shows that insignificant residues in water or feeds can become very significant in a species of fish, bird, or animal farther up the food chain. Our appraisal of the effects of pesticide residues in fish, birds, and wildlife is further complicated in that only 1 percent of the total species has been investigated, and it thus appears rather vague and unscientific to apply the findings and conclusions to the other 99 percent.

Pesticides and Human Health

Man is naturally concerned about the purity and quality of the food he eats, and the Federal Government is likewise concerned that he have a safe food supply. During the past few years the Food and Drug Administration (FDA) has conducted research called Market Basket Surveys in which researchers went into supermarkets in selected cities in our country, bought groceries enough to feed a 16- to 19-year-old male for two weeks, prepared and cooked the food, and then analyzed the food for pesticide residue. (Pestic. Monit. J. 1:2-7, 1968; 2:140-152, 1969; 4:89-105, 1970; 5:73-212, 1971; 5:313-341, 1972; 8:110-124, 1974; 9:94-105, 1975; 9:157-169, 1976; 10:134-148, 197; and 11:116-131, 1977). The kinds and frequency of organochlorine pesticide residues have not differed significantly from 1964 through 1970 being detected in approximately 45-74 percent of the samples. From 1970 through 1975 detection was in approximately 48-54 percent of the samples. The incidence of organophosphates has increased slightly from 7 to 20 percent during the six year period and increased to 28, 31, 28, and 25 percent in the surveys from 1971 through 1975 respectively. Incidence of herbicides has remained low throughout the period and after a dramatic decline in 1970 has been detected subsequently very infrequent. Carbamate pesticide residue incidences were too limited for consideration between 1964 and 1971 but since that time Carbaryl was found in approximately 6, 1, 3, 2, and less than 1 percent of the composites in the respective years analysis. Arsenic, mercury, lead, cadmium and other metallic pesticide residues, although fluctuating because of variation in natural occurrence, remained very low. Pesticide residues present in a high consumption well-balanced diet have generally been substantially below the limits established for acceptable daily intakes by FAO-WHO (Food and Agricultural Organization-World Health Organization) and the United Nations Committees. Levels on raw agricultural products grown in the U.S. are generally much lower than the safe tolerance levels established by FDA with only 3 percent exceeding such guidelines. FDA reports that the residue levels detected in food in commercial channels is far below the level considered to be the "safe acceptable daily intake" and thus the **food produced for the American public is the purest and most wholesome in the world.**

Labels Explain Safe Pesticide Use

Agriculture and the American public have a good record from the labelled use of pesticides. No human death has been recorded from eating produce that was treated with pesticides, harvested, and processed according to label directions. Fatalities are very infrequent in the manufacturing of pesticides and formulations where safety procedures are a vital concern and part of the operation. There are, however, some fatalities in the U.S., usually children, attributed to acute poisoning—a one time heavy dose. Some of these cases are accidental while others are intentional such as the parathion poisonings and deaths in Mexico and Columbia due to improper transportation; the deaths of family members in Florida due to intential parathion poisoning by the father; mercury poisoning in New Mexico from the consumption of pork from a herd that had been fed mercury treated milo seed; deaths in North Carolina due to improper use of parathion in tobacco fields, transportation, cleanup, etc.; deaths in Turkey due to contamination of grain used in breadmaking from pesticide leakage during ship transport; suicide attempts from drinking paraquat and other pesticides; and several other incidents attributed to accidental consumption of a pesticide formulation. California lost 13 commercial applicators in 1969 probably from inadequate protection when using parathion. With the substitution of the more toxic organophosphates for the persistent but less toxic organochlorines, the need for adequate protection during application and immediately afterwards becomes more critical.

Human errors are the major source of pesticide poisonings. Accidents have been reported attributed to (a) use of the wrong chemical, (b) use of more than specified amounts, (c) improper storage and disposal, (d) accidents in transportation, and (e) dumping of industrial wastes.

Practices that could also result in illegal residues on commodities include (a) indiscriminate, unwise use not specified on the label, (b) not heeding application and harvesting limitations, (c) changing crops, etc., in a field treated with a pesticide registered for a different use. Some of the principles and regulations of the Amended FIFRA of October 1972 are intended to provide control over illegal and unsafe practices in pesticide handling that could cause significant human and environmental hazards.

Seventy percent of the accidental poisonings from pesticides reported from poison control centers in the U.S. occur in children under five years of age and another 7 percent in children from 5 to 14 years of age. The data prove conclusively that the problems are due to improper transportation, storage, and disposal—not to the labelled registered use of the material.

Part of the present concern in environmental pollution is the long-term chronic effects from daily exposure to trace amounts of pesticide residues. There are some who would advocate that no pesticide be marketed until it has been proven, without doubt, to be absolutely free of chronic effects in man. This would involve observation from two or three generations of people requiring a waiting period of 30 to 60 years before making the pesticide available for public use. This is rather impractical because of the time period involved, the need of pest control measures at the time the pest problem occurs, and the availability of generations of people who would serve as test personnel. It is true that all the answers on long-time exposure are not known and are likely not going to be known with our present or foreseeable methods of research. Those who research and manufacture pesticides would not remain in the business if such a long time span were involved.

Most of the published pesticide residue data associated with human populations concern DDT and metabolites, dieldrin, chlordane, and heptachlor epoxide. Of considerable interest, also, are the non-pesticide polychlorinated biphenyls (PCB's) which resemble DDT in many chemical characteristics. Dr. Deyland J. Hayes, formerly chief toxicologist at the HEW residue laboratories in Athens, Georgia, stated, following the incidence of DDT residues in Coho salmon in Lake Michigan, that a man could eat Coho with 19 ppm DDT in the tissue morning, noon, and night every day of the year for at least 19 years without harmful effects of DDT poisoning.

In feding studies conducted by Dr. Hayes with volunteers from a penitentiary, a daily diet of up to 600 ppm of DDT over a period of many months caused no significant illness or poisoning. Men who have worked in DDT manufacturing plants for 20 years show no indications of ill effects from the constant exposure and daily intake of 17.5 milligrams per man compared to the average of 0.04 mg per man per day for the general population. Adipose tissue levels of residue for these men ranged from 36 to 647 ppm compared to 8 ppm in the normal population. These men have less incidence of cancer, respiratory, circulatory, and digestive diseases than a comparative group not daily exposed to DDT in manufacture.

Ohio DDT Residues Are Below Average

In recent years the public has become concerned over the level of DDT and dieldrin in human tissues and the chronic effects of such residues. DDT and dieldrin residue levels as determined in 1968 from various states in the U.S. are shown on page 22. Ohio rated in the low category at 5.08 and 0.09 ppm of total DDT and dieldrin respectively in the adipose tissue of the white population and 7.65 and 0.13 ppm respectively in the black population. The U.S. average for DDT from 5 to 15 ppm, which had remained relatively constant since 1951, contrasts to that of India with 25 ppm. The variation in pesticide residue levels in human tissues is directly related to the location and exposure index as indicated in a Michigan study (Pestic. Monit. J. 11:111, 1977). With the decline in DDT usage culminating in the cancellation of all registration except public health use as authorized by EPA in 1972, the DDT residue content of human adipose tissue in most areas has continuously decline. The average dieldrin residue in the U.S. population in 1968 was 0.13-0.14 ppm. Average residue concentrations increased somewhat in subsequent years. Tissue samples taken by EPA during therapeutic surgery or autopsy in 1970 revealed that 96.5 percent had detectable dieldrin residues averaging 0.27 ppm in adipose tissue. In 1971, the percentage was 99.5 percent with average residue of 0.29 ppm. In the years subsequent to the restriction and registration cancellations of aldrin and dieldrin in 1973-75 it is logically assumed that dieldrin residues in human tissue has significantly declined.

The concern for human exposure to persistent organochlorine pesticides has been spurred by emotional appeal sometimes to the obscuring of scientific fact. Alarm over reported DDT residues in human mother's milk caused many to avoid breast feeding based upon propaganda that they would poison their babies. Medical authorities and the La Leche League International (LLLI), an organization devoted to promoting good mothering the world over, have assured mothers that the benefits of breast feeding far outweigh the dangers from DDT and concur with the scientific committees appointed by the Environmental Protection Agency (EPA) that DDT does not constitute "an immient hazard to the public and human health" (Report of the DDT Advisory Committee), although it is considered a substantial threat to the quality of the environment as a serious pollutant.

A serious consideration in the exposure to synthetic pesticide chemicals is the possibility of causing human cancer. This factor has been of vital importance in restricting the use and/or cancelling the registration of pesticide products in recent years. It is also the most common trigger used by EPA in its current RPAR (Rebuttable Presumption Against Registration) process of review of pesticides prior to reregistration or cancellation procedures. Other triggers are teratogenicity, mutagenicity, fetotoxicity, metabolic effects, reproductive effects, neurotoxicity effects, environmental hazards and effects, and history of high toxicity and poor safety record. A USDHEW report printed in the Journal of the National Cancer Institute indicated that DDT was a carcinogen on the basis of producing tumors in certain strains of mice. Mice receiving a daily dosage of 46.4 mg/kg body weight over an 18 month period developed cancerous tumors. The conclusion was that DDT was carcinogenic even though the dosage used in the research was exceedingly far beyond that which would be encountered in the environment. In rebuttal, Dr. Weyland J. Hayes stated that tumors can be produced from such excessively heavy dosage feeding and that the report did not publish observations of similar studies where the tumors disappeared upon withdrawal of DDT from the diet. Recent research reported by the National Cancer Institute in 1978 casts serious doubt on the validity of the conclusion that DDT was carcinogenic although it did conclude that DDT was a significant environmental pollutant and had affected the health status of several wildlife, fish and bird species. Strong emphasis must be placed on using scientific principles in assessing pesticide effects. A maximum tolerable dosage to produce symptoms is not adequate criteria in determining long-range health factors in view of the fact that even table salt in excessive quantities can cause serious illness and death.

In public hearings relative to aldrin-dieldrin in 1973-75, carcinogenicity, along with other toxicological defects related to birth, learning capabilities, and reproduction, were the major points of contention by those advocating the cancellation of registration. However, in contrast to the research reported above for DDT, the dietary dosages reported to cause effects were as low as 0.1 ppm in the diet. The result of those hearings was the cancellation of aldrin and dieldrin registrations for agricultural purposes based upon the conclusion that the chemicals were oncogenic. Cancellation proceedings for chlordane and heptachlor resulted in a similar conclusion and action in 1978 but with a phase out period permitted for certain uses.

It is important that we be able to determine the significance of pesticide residue levels in body tissues. Likewise, we need more precise parameters in extrapolating results of animal and rodent studies to man. In most cases, the minute concentrations of exposure to pesticide residues is insignificant and the probability of inducing cancer in man at such low exposure levels perhaps is remote. However, we do not have the necessary answers to the question of longtime low level exposure. Our instruments are capable now of detecting down to the parts per trillion concentration levels of pesticides. When you consider that 1 ppm is one inch in 16 miles, then 1 ppb is one inch in 16,000 miles and 1 ppt is one inch in 16,000,000 miles. Thus, one part per billion is not really very much (see page 17). The question is, "Is it or isn't it significant?"

It is important that the public realize the safety factors involved in registering a pesticide chemical. Such compounds are not dumped indiscriminately on the American public. In the 5 to 8 years of research, costing an average of $1,000,000 per year by the company in developing a pesticide (see page 23), concurrent studies determine the chemical's performance and usefulness, toxicity to plants and animals including the triggers for RPAR as indicated above, the identification and fate of metabolites in the environment, safe procedures for use including dosage and limitations, sensitive accurate analytical techniques for detecting residues in treated crops, soils, water and animals, and data showing residues encountered in commodities upon use of the chemical.

During the process of investigation, EPA closely scrutinizes all data and performs research of its own to assure the usefulness and the safety of the material to the public (see page 24). Tolerances that will not harm the human population are set on the permissable residue. These are set at a minimum of at least 100 times less than the pesticide concentration that produces noticeable effects in test animals. Chemicals are tested for their effects on cancer inducement, teratogenicity, etc. The constant surveillance of the environment and the readjustments of guidelines, when found necessary, further insure the safety and health of the American public.

What Is To Be Done?

The answer to pesticide contamination in the environment is not to be found in the banning of chemical pesticides as some factors of society would advocate. Nor is the answer found in unwise, unnecessary legislation. Instead we should direct our effort to major areas of research and education including:

1. Evaluation of the nature, extent, significance, and impact of pesticides in the ecosystem, including (a) long-term ecological significance; (b) long-term exposure to sub-lethal levels of pesticides in producing ecological changes that are not immediately apparent or considered health hazards; (c) immediate toxic effects to plants, animals, and mankind; and (d) monitoring the extent, sources, and movement of pesticide residues in soils, water, and air; and the subsequent transport and significance in the food chain.

2. Reducing the amount of hazardous pesticides in the environment.

3. Research and evaluation of integrated control measures including development of biological, enzyme and hormone manipulation, and mechanical controls resulting in pest management concepts.

4. Treating, controlling, or removing pesticide residues from commodities, production animals, soils, air, and receiving waters.

5. Disposal of pesticide wastes in a manner least detrimental to the environment.

6. Development and improvement of analytical methodology in determining residue levels and the significance of residual effects.

7. Establishment of effective regulatory and legislative programs.

8. Education of the public in environmental and economical aspects of pest control with particular emphasis on safe use of all control agents.

Although it appears that much of the effort is directed toward long-range goals, we must likewise consider these efforts directed toward current needs. It must be a continuing program to use pesticides safely and thus eliminate hazards and pollution. Much can be done through individual effort in reading and following label directions including the important aspects of transportation, storage, use, and disposal (see page 20).

Wise pesticide legislation can be an asset to agriculture and the environment, but any restrictions or regulations must be based upon well founded scientific facts and not upon the quirks of public emotion. The use or restriction of any pesticide must thoroughly evaluate the benefit/risk ratio and that ratio must be adjusted as circumstances and data require. In some cases, even though the risks may be significant, the benefits may be far more important. We should be careful that unfounded public emotion or political pressures are not the factors that enact legislation or determine the fate of chemical pesticides. Urban populations and legislators should be adequately informed so that in the decision making process agriculture and the small minority engaged in providing the essential foods and fibers are not the victims of irrational thought.

If we are to maintain a satisfactory benefit/risk ratio, use pesticides safely, and help control the pollution of the environment thus keeping the good faith of our neighbors and quelling unfounded public emotion, we must select pesticides carefully, use them correctly, store them properly, and dispose of excess pesticides and empty containers promptly and safely.

List of Some References:

Note: *This list is by no means all inclusive The reader is encouraged to review other publications and summaries that may be available to enlarge his knowledge on the subject of pesticides and environmental relationships.*

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APPENDIX

SUMMARY OF SOME IMPORTANT DEVELOPMENTS IN PESTICIDE REGULATIONS

May 1963: President's Science Advisory Committee Report entitled, "Use of Pesticides." Recommended an orderly reduction in the use of persistent pesticides with their elimination being the goal.

Environmental Pollution Panel of the President's Service Advisory Commmittee entitled, "Restoring the Quality of Our Environment." Expressed concern over the persistence of pesticides in the environment and recommended more stringent controls.

Nov. 1966: National Research Council at suggestion of USDA appointed a committee to appraise the significance of residues from the standpoint of their effects on the environment. The committee submitted its report in May 1969 and recommended that immediate attention be given to the problem of buildup of persistent pesticides in the total environment.

Nov. 1969: The Commission on Pesticides and Their Relationship to Environmental Health, appointed by Secretary of Health, Education, and Welfare. The Mrak report recommended that all uses of DDT be eliminated except those uses essential to the preservation of human health. Subsequent to this recommendation USDA cancelled registration of all uses of DDT except those essential uses where no adequate substitute was available or those deemed necessary from the public health viewpoint.

February 19, 1970: USDA suspended all uses of ethyl and methyl mercury chemical fungicides for seed treatment. On April 8, 1972, EPA issued notices of cancellation of registration for all mercury-based pesticides.

December 2, 1970: The Environmental Protection Agency became law and had transferred to it much of the regulatory aspects of pesticides formerly in USDA, USDI, USDHEW, and FDA.

January 1971: The Ohio Pesticide Use and Applicator Law became effective. The law authorizes the Director of Agriculture to adopt a list of restricted use pesticides, requires notices of pesticide applications to outside structures, requires a permit to apply restricted pesticides, requires examination and licensing of all commercial pesticide applicators and operators, establishes regulations on pesticide use, and permits inspection of establishments and records. Regulations have been modified as required since that time and the law has been rewritten to conform to the requirements of FIFRA Amended.

March 1971: EPA initiated administrative cancellation of DDT, Aldrin, Dieldrin, and 2,4,5-T in order to initiate review of current registrations and evaluate critical and essential needs in view of public health and environmental pollution.

September 1971: Report of the DDT Advisory Committee to EPA concluded that present use of DDT does not constitute "an imminent hazard to human health" but does to human welfare as a serious environmental pollutant. They recommended that the use of DDT in the U.S. be reduced at an accelerated rate with the goal of virtual elimination of any significant amounts to the environment; that immediate suspension was not warranted nor wise from the Public Health viewpoint.

April 25, 1972: Conclusion of the consolidated DDT Hearings with recommendations from the Hearing Examiner that pertinent registrations, corrected to indicate the essential uses defined in the action, should be restored to the same force and effect each carried just prior to the notices of cancellation—PR 71-1, 71-3, and 71-5; that evidence did not show that present uses of DDT caused an unreasonable adverse effect on the environment; that there is a present need for the essential uses of DDT; that efforts are being made to provide a satisfactory replacement for DDT; and that a cooperative program of surveillance and review can result in a continued lessening in the risks involved.

June 3, 1972: Order signed by William D. Ruckelshaus, Administrator of EPA, providing for the general banning of DDT after December 31, 1972; after which date registrations would exist only for public health and quarantine uses and three minor crop uses—green peppers, onions, and sweet potatoes (in storage) for which there appeared to be no effective alternatives. (Since Dec. 31, 1972, petitions to retain DDT registration for green peppers and onions have been dropped.)

June 26, 1972: EPA Determination and Order to affirm the cancellation of all registered uses of aldrin and dieldrin, except those involving dipping of roots or tops of nonfood plants, subsurface ground insertions for termite control, and mothproofing in manufacturing processes in a closed system. Shell Chemical Company requested a formal hearing August 25, 1972, which commenced in late 1973 with a decision scheduled for early spring 1975. In August 2, 1974, EPA issued a notice of intent to suspend the registration and prohibit the production of aldrin and dieldrin for the 1975 season pending the results of the aldrin-dieldrin cancellation proceedings. This suspension in manufacture was upheld October 1, 1974 following a public hearing.

Oct. 21, 1972: Federal Environmental Pesticide Control Act of 1972 (FEPCA) signed by President Nixon to become Public Law 92-516. The Act completely revises the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) and, in brief, includes the following major provisions: (1) Establishes requirements and procedures for federal registration of all pesticides; (2) Prohibits the use of any pesticide inconsisitent with its labeling and thus prevents any injury to man or any unreasonably adverse effects on environmental values; (3) Requires pesticides to be classified for general or restricted use; (4) Provides for certification of applicators to apply restricted use pesticides; (5) Strengthens judicial review, administration, and enforcement by EPA on registration of pesticides and pesticide producing establishments, record keeping, cancellation, suspension, and stop sale and use of pesticides; (6) Provides for civil and criminal penalties for violation of unlawful acts; (7) Provides for necessary cooperation between EPA, USDA, States, and Cooperative Extension Service; (8) Authorizes payment of indemnities to persons holding quantities of pesticides if finally canceled or otherwise withdraw from registration; (9) Authorizes establishment of packaging standards, pesticide and container disposal, experimental permits, research on pesticides and alternatives, and monitoring pesticide use and presence in the environment; (10) Establishes a series of effective dates in order that the Act will become completely effective by Oct. 21, 1976. Many provisions of the Act, now referred to as "FIFRA Amended," have been enacted, whereas, the regulations for other sections are still being developed. Emphasis in early 1975 was directed toward state legislation to conform to the federal law, state plans for certification and training, and the classification of pesticides.

June 10, 1974: EPA Health and Safety Standards for Farm Workers Dealing with Pesticides became effective which establishes re-entry and safety standards related to field application of pesticides. Such standards are subject to continuing review and revision as warranted.

Nov. 18, 1974: EPA issued a notice of intent to cancel registrations of certain pesticide products containing Heptachlor or Chlordane involving all uses except subsurface ground insertion for termite control and the dipping of roots or tops of non-food plants. Veliscol Chemical Company requested a public hearing to defend all registered uses of the pesticides. The hearing commenced early in 1975.

May 27, 1975: Accelerated decision by EPA Chief Administrative Law Judge to cancel all registrations of aldrin and dieldrin for domestic use except ground insertion for termite control, dipping of non-food roots and tops, and mothproofing by manufacturing processes in a closed system. Order reaffirmed on June 30, 1975.

Nov. 1975: Amendments to FIFRA–1972 requiring EPA coordination with USDA prior to issuing registration cancellation and restriction action and proposed and final regulations, changes in the certification requirements of private applicators, reviews by Congressional and Scientific Advisory Committees of proposed regulations prior to final action, provisions on issuing Experimental Use Permits, and procedures for determining compensation payments for data in pesticide registrations.

Spring 1976: EPA began its process of pesticide registration review under the RPAR (Rebuttable Presumption Against Registration) program. However, the proposed schedule of review and evaluation of the Benefits/Risk analysis has not been maintained and as of October 1978 the only decisions that have been finalized involve Kepone and DBCP.

Sept. 1, 1976: Ohio Pesticide Law, involving modifications of all previous pesticide laws in conformance with Amended FIFRA and EPA regulations and providing for certification of private and commercial applicators, became effective.

Feb. 1978: EPA published its first list of "restricted use" pesticides consisting of 23 active ingredients. Application of "restricted use" pesticide products requires certification of the applicator or supervisor in charge. EPA gave notice of 38 additional pesticides for review in consideration of the "restricted use" classification.

Mar 6, 1978: Notice from EPA relative to acceptance of a settlement of the consolidated cancellation proceedings for chlordane and heptachlor which cancelled all registrations of the Nov. 1974 notice; permitted phase out of certain uses from October 1978 to July 1983 and established the quantities of technical materials that can be manufactured for the phased-out uses.

Sept. 19, 1978: Congress passed the Federal Pesticide Act that provides for 1978 amendments to FIFRA. Among other things the amendments provide for more state participation in the registration of pesticides particularly for local needs, resolve some of the difficulties in ascertaining company trade secrets and information related to pesticide product registration, require EPA to validate the triggers and consult the producer prior to issuing an RPAR, permit "generic" registration of compounds, make provisions for conditional registration of pesticides, remove the restrictions of use less than label amounts and against pests not on the label when use on the host target is registered, and other improvements to make the Amended FIFRA more workable and EPA more accountable.

On Sept. 30th President Carter signed the law which now is known as FIFRA of 1978.

SECRETARY'S MEMORANDUM NO. 1799
(USDA Policy on Pest Control, Feb. 1, 1973)

(Supersedes Memorandum No. 1666 — October 29, 1969)

It is the policy of the Department of Agriculture to practice and encourage the use of those means of practicable, effective pest control which result in maximal protection against pests, and the least potential hazard to man, his animals, wildlife, and the other components of the natural environment.

Nonchemical methods of pest control, biological or cultural, will be used and recommended whenever such methods are economically feasible and effective for the control or elimination of pests. When nonchemical control methods are not tenable, integrated control systems utilizing both chemical and nonchemical techniques will be used and recommended in the interest of maximum effectiveness and safety.

Where chemicals are required for pest control, patterns of use, methods of application and formulations which will most effectively limit the impact of the chemicals to the target organisms shall be used and recommended. In the use of these chemicals, the Department has a continuing concern for human health and well-being and for the protection of fish and wildlife, soil, air, and water from pesticide contamination.

In keeping with this concern, persistent pesticides will not be used in Department pest control programs when an equally safe and effective nonresidual method of control is judged to be feasible. When persistent pesticides are essential to combat pests, they will be used in minimal effective amounts, and applied only to the infested area at minimal effective frequencies.

In carrying out its responsibilities, the Department will continue to:

- —Conduct and support cooperative research to find new, effective biological, cultural, and integrated pest control materials and methods;
- —Seek effective, specific, nonpersistent pesticides and methods of application that provide maximal benefits and are least hazardous to man and his environment;
- —Cooperate with other public and private organizations and industry in the development and evaluation of pest control materials and methods, assessment of benefits and potential hazards in control operations, monitoring for pesticide residues, and dissemination of pesticide safety information.

All users of pesticides are strongly urged to heed label directions and exercise constant care in pesticide applications, storage, and disposal for the protection of people, animals, and our total environment.

The Department commends this policy to all who are concerned with pest control.

THE PURPOSE OF THE ENVIRONMENTAL PROTECTION AGENCY

The Environmental Protection Agency became law December 2, 1970. William D. Ruckelshaus issued the following statement outlining the purposes of EPA:

"EPA is an independent agency. It has no obligation to promote agriculture or commerce; only the critical obligation to protect and enhance the environment. It does not have a narrow charter to deal with only one aspect of a deteriorating environment; rather it has a broad responsibility for research, standard-setting, monitoring and enforcement with regard to five environmental hazards; air and water pollution, solid waste disposal, radiation, and pesticides. EPA represents a coordinated approach to each of these problems, guaranteeing that as we deal with one difficulty we do not aggravate others.

As we work toward pollution abatement, we shall also strive to provide information and leadership; to enhance the environmental awareness of all of the people and all of the institutions of this society. A clean and healthy environment is up to all of us. So we shall be an advocate for the environment with individuals, with industry, and within government.

The job that must be done now to restore and preserve the quality of our air, water, and soil can only be accomplished if this new Federal agency works closely with industry and with other levels of government. The technology which has bulldozed its way across the environment must now be employed to remove impurities from the air, to restore vitality to our rivers and streams, to recycle the waste that is the ugly, by-product of our prosperity. And municipal and state governments must do more than curb pollution where it occurs now; they must plan for healthy and balanced and pollution-free growth in the future."

To enable EPA to work closely with industry and all levels of government, Ruckelshaus established 10 regional offices, covering the entire nation, set up to work with state and local officials and private organizations to insure maximum participation in environmental programs.

"Our hopes for this agency are high. We know all environmental problems will not be solved this year or next. But if we remain flexible in approach and firm in our commitment, we believe we will live up to the President's challenge that 'the 1970's absolutely must be the years when America pays its debt to the past by reclaiming the purity of its air, its water, and its living environment.' "

William G. Ruckelshaus
Administrator, EPA
December 16, 1970

Persistent Pesticide

Defined as a pesticide which may be found to exist in its original or a closely related form longer than one season after it was initially applied. The chlorinated hydrocarbon insecticides are generally considered to be persistent.

The following insecticides are chlorinated hydrocarbons and are persistent pesticides under certain uses:

1. aldrin
2. benzene hexachloride (BHC)
3. chlordane
4. DDT
5. dieldrin
6. endrin
7. heptachlor
8. lindane
9. toxaphene

Relationship of the Quantity Parts Per Million (PPM)

1 PPM is:

1 ounce of sand in 31¼ tons of cement
1 inch in 16 miles
1 gram needle in a 1 ton haystack
1 minute in 1.9 years
1 ounce of dye in 7,530 gallons of water
1 square inch in 1/6 acre of land
1 pound in 500 tons
1 penny in $10,000
1 ounce of salt in 62,500 pounds of sugar
1 book 1/16 inch thick in a stack 1 mile high

GREAT LAKE REPORT

(Report to Governors of Illinois, Indiana, Michigan, Minnesota, and Wisconsin)

TABLE 1—Value of Agricultural Production or Marketings

Item	Wisconsin	Illinois	Minnesota	Michigan	Indiana	5 States Total
			Million Dollars			
Forage crops	1,243.0	1,073.8	1,278.5	453.9	745.5	4,794.7
Field grains	266.0	135.5	438.2	117.2	54.4	1,011.3
Vegetables	256.5	1,551.1	770.7	232.8	707.4	3,518.5
Fruit	82.1	25.7	46.8	65.7	21.1	241.4
Specialty crops	15.2	7.7	2.2	85.3	6.2	116.6
Forest products	26.2	39.0	3.0	165.8	30.5	264.5
Livestock and poultry	47.3	1.5	2.1	175.0	3.5	229.4
Total by states	1,936.3	2,834.3	2,541.5	1,295.7	1,568.6	10,176.4

TABLE 2—Economic Loss in Value of Production Without Chemical Pesticides

Item and State	Forage Crops	Field Crops	Vege-tables	Fruit	Specialty Crops	Livestock and Poultry	Total by States
				Thousand Dollars			
Insects:							
Wisconsin	12,222	13,500	26,958	7,582	704	64,402	125,368
Indiana	3,714	32,082	7,847	5,151	7,971	69,413	126,181
Minnesota	16,460	45,735	12,682	1,405	30	72,813	149,125
Illinois	772	81,745	5,060	5,094	11,700	25,787	130,158
Michigan	21,158	15,506	23,994	81,322	38,000	39,700	219,680
Total insect loss							**750,512**
Plant disease:							
Wisconsin	5,304	13,586	30,873	6,915	530	—	56,938
Indiana	—	2,611	5,447	6,237	371	—	14,666
Minnesota	2,602	59,670	3,140	1,366	9	—	66,787
Illinois	—	6,115	7,437	5,901	12,000	—	31,453
Michigan	4,290	9,718	16,679	45,406	2,778	—	78,871
Total plant disease loss							**248,715**
Weeds:							
Wisconsin	16,371	52,367	17,473	1,231	2,233	—	89,675
Indiana	1,125	59,437	5,359	1,501	3,094	—	70,516
Minnesota	20,640	168,679	3,748	15	150	—	193,232
Illinois	559	225,326	2,625	732	—	—	229,242
Michigan	4,230	24,782	8,508	20,202	1,104	—	58,886
Total weed loss							**641,551**

TABLE 3—Economic Loss in Value of Production without Persistent Chlorinated Hydrocarbons[1]

Item	Wis.	Illinois	Minn.	Mich.	Indiana	5 States Total
			Thousand Dollars			
Forage crops....	2,500	—	—	—	—	2,500
Field grains....	4,660	37,400	15,500	1,200	31,000	89,760
Vegetables	8,900	100	10,300	—	3,700	23,000
Fruit	—	—	13,700	200	—	13,900
Specialty crops..	100	11,800	—	1,800	4,500	18,200
Forest products..	1,000	—	—	—	—	1,000
Livestock and poultry	1,000	7,500	1,400	—	2,200	12,100
Total by states..	18,160	56,800	40,900	3,200	41,400	160,460

[1] Persistent Chlorinated Hydrocarbon Insecticides listed on page 12. Figures are not complete for all states. However, the table is shown to exhibit a trend.

TABLE 4—Additional Cost When Substitute Materials Used For 9 Persistent Chlorinated Hydrocarbons[1]

Item	Minn.	Ind.	Mich.	Ill.	Wis.	5 States Total
			Thousand Dollars			
Forage crops....	—	—	—	—	—	—
Field grains.....	599	4,046	25	9,250	160	14,080
Vegetables	1,015	169	—	2	548	1,734
Fruit	—	71	625	22	—	718
Specialty crops..	—	373	1,620	1,180	313	3,486
Forest products..	—	—	—	—	—	—
Livestock and poultry	721	1,408	227	606	283	3,245
5 states total......						23,263

[1] Estimate not complete for all states, however, totals shown to exhibit trend. In some cases, production would be impossible without persistent pesticides (see text).

PRODUCTION OF FOOD AND FEED IN OHIO IN RELATION TO PESTICIDE USAGE

The following tables regarding the possible economic loss to Ohio's agriculture that could result from a ban on pesticides are taken from a paper prepared by Dr. Edward W. Stroube, Dept. of Agronomy with assistance from Drs. E. K. Alban, Dept. of Hort., B. D. Blair, W. F. Lyon and R. L. Miller, Dept. of Entomology, and B. F. Janson, Dept. of Plant Pathology all of the Ohio State Univeristy. The complete report may be obtained from Dr. Stroube. Ohio farm income is shown in Table 1.

TABLE 1—Cash Receipts of Ohio Farm Income, 1968[a]

Commodity	Cash Receipts	Percentage of Total Receipts
	—Thousand Dollars—	
Livestock and Livestock Products	704,269	57.6
Grain Crops[b]	205,294	16.7
Soybeans	142,916	11.7
Vegetables	74,951	6.1
Fruits and Nuts	12,883	1.1
Other Crops	83,267	6.8
Total	1,223,580	100.0

[a] 1968 Ohio Farm Income, Department Series AE440 (Nov. 69), OARDC, Wooster, Ohio

[b] A large amount of the grain production in Ohio is fed to livestock therefore is not reflected in cash receipts.

The estimated percentage of acreage of several crops treated by pesticides is shown in Table 2. It is not possible to have a valid estimation of the amount of specific pesticide used in Ohio. The manufacturer of a pesticide is about the only reliable source for this information and generally this information is confidential.

TABLE 2—Estimated Percentage of Several Crops Treated with Pesticides in Ohio in 1969

Crop	Percentage Treated with		
	Herbicides	Insecticides	Fungicides
Field Corn	82	65	100[a]
Soybeans	57	2	—
Wheat	12	5	100[a]
Alfalfa	8	90	—
Sugar Beets	90	10	100[a]
Apples	—	100[b]	100[b]
Peaches	—	100[b]	100[b]
Strawberries	75	10	100[b]
Onions	100[b]	100[b]	100[b]
Carrots	100[b]	50	50
Sweet Corn	75	100[b]	100[a]
Tomatoes	65	100[b]	100[b]

[a] All commercially produced seed are seed treated with a fungicide.

[b] Essentially 100% of commercial acreage is treated with pesticides. The production of untreated acreage is insignificant to the total production.

Table 3 is an estimation of the effect of using no pesticides on the production of specific crops in Ohio. It is reasonable to believe that losses would increase as time elapsed and would require a few years of using no pesticides before a climax situation of pests would occur.

Estimated losses for crops listed in Table 3 account for 32 percent of the 1969 value of these crops. Applying this 32 percent also potentional loss to greenhouse and nursery crops, turf areas, tobacco and minor vegetable and fruit crops would account for another 35.8 million dollars. Using the Great Lakes Pesticide Report as a basis, a 5.7 percent loss in livestock and poultry production would account for another 40.14 million dollars. The grand total loss to the agricultural economy in Ohio would approximate 250 million dollars.

PESTICIDE RESIDUES IN AGRICULTURAL SOILS

TABLE 4—Pesticide Residue Detection in Selected Monitoring Studies

Pesticide	Percent Occurrence in Samples and Average Mean Residue in PPM									
	Nat'l. Soils Monitor FY 1969		Corn Belt		Ohio Corn Belt		Ohio Monitoring 1969		Ohio Monitoring 1970	
Arsenic	99.3	(6.4)	88.3	(3.19)	100.0	(6.41)	100.0	(11.23)	100.0	(7.73)
Aldrin	10.9	(0.02)	17.0	(0.05)	13.8	(0.03)	14.7	(0.03)	24.6	(0.09)
D eldrin	27.8	(0.03)	39.0	(0.05)	24.1	(0.04)	27.9	(0.02)	37.7	(0.14)
Chlordane	8.7	(0.04)	9.0	(0.07)	0.0		4.4	(0.01)	21.7	(0.37)
Toxaphene	4.2	(0.07)	...		...		...		...	
DDT (Total)	26.0	(0.31)	3.0	(0.02)	0.0		16.2	(0.08)	10.1	(0.08)
Heptachlor	3.9	(<0.01)	5 0	(0.01)	0.0		2.9	(<0.01)	8.1	(0.14)
Heptachlor Epoxide	8.0	(<0.01)	9.5	(<0 01)	0.0		1.5	(<0.01)	13.0	(0.02)
Isodrin	0.6	(<0.01)	1.0	(<0.01)	0.0		2.9	(0.01)	2.9	(0.05)
Lindane	0.0	(<0.01)	...		..		1.5	(0.01)	0.0	
Ethyl Parathion	10.6	(0.06)	...		...		...		..	
Malathion	3.0	(<0.01)	...		...		...		...	
Diazinon	3.0	(0.01)	...		...		...		...	
Atrazine	14.1	(0 01)	...		...		...		...	
2,4-D	1.6	(<0.01)	...		...		...		...	
Trifluralin	3.5	(<0.01)	3.5	(<0.01)	3.4	(<0.01)	1.5	(<0.01)	2.9	(0.05)

TABLE 3—Estimated Effect of Producing Several Crops in Ohio Without Pesticides

Crop	Loss in Value Without[a] Herbicides	Insecticides	Fungicides	Total Loss[b]	Loss in Value[c] (Dollars)
	Percent	Percent	Percent	Percent	1000
Field Corn	10	10	10	30	87,567
Soybeans	15	1	—	16	25,015
Wheat	5	2	40	47	21,524
Alfalfa	8	60	—	68	15,249
Sugar Beets	20	5	20	45	3,713
Apples	[d]	50	80	100[e]	9,870
Peaches	[d]	30	75	100[e]	2,366
Strawberries	15	5	40	60	695
Onions	20	10	15	50	427
Carrots	25	10	15	50	226
Sweet Corn	15	40	10	65	2,290
Tomatoes	10	15	50	75	4,226
				Total loss in value	$173,168

[a] Loss in value includes direct loss from pests and also loss from increased production costs and decrease in quality.
[b] Total loss cannot be assumed to be the sum of the three figures of the three classes of pesticides, however it is most difficult to calculate the combined effect. In some instances it would be a greater loss than the sum and in some instances less than the sum.
[c] Calculated from data from USDA Crop Production 1969 Annual Summary (Dec. 19, 1969)
[d] Herbicides have little direct effect on apple and peach production, however they are important in eliminating poison ivy in tree fruit and in reducing rodent nesting places.
[e] See footnote page 6 of Dr. Stroube's report.

TABLES TAKEN FROM THE PESTICIDE REVIEW—1969 TO 1976

TABLE 1—Organochlorine Insecticides: Producers' Domestic Disappearance of Selected Kinds of Crop Year, U.S., 1955-75

Crop Year[1]	Aldrin-toxaphene[2] Group	DDT	BHC	Total
	1,000 pounds	1,000 pounds	1,000 pounds	1,000 pounds
1955	54,400	61,800	7,800	124,000
1956	61,570	75,000	9,450	146,020
1957	52,500	71,000	6,600	130,100
1958	78,834	66,700	5,500	151,034
1959	73,331	78,682	4,276	156,289
1960	75,766	70,146	5,111	151,023
1961	78,260	64,068	4,577	146,905
1962	82,125	67,245	2,404	151,774
1963	79,275	61,165	1,299	141,739
1964	83,161	50,542	[3]	133,703[4]
1965	80,568	52,986	[3]	133,554[4]
1966	86,646	46,672	[3]	133,318[4]
1967	86,289	40,257	[3]	126,546[4]
1968	38,710	32,753	[3]	71,463[4]
1969	89,721	30,256	[3]	119,977[4]
1970	62,282	25,457	[3]	87,739[4]
1971	85,005	18,234	[3]	103,239[4]
1972	105,980	23,546	[3]	129,526[4]
1973	89,362	1,100		90,462[4]
1974	77,822	"5"		"5"
1975	"5"	"5"		"5"

"5" Data not available—withheld to avoid disclosure.

[1] Ends September 30 through 1968; December 31 for 1967-72.
[2] Includes aldrin, chlordane, dieldrin, endrin, heptachlor, Strobane and toxaphene.
[3] Not published separately to avoid disclosure, but probably less than in 1963.
[4] Includes only the aldrin-toxaphene group and DDT.

TABLE 2—Synthetic Organic Pesticides: Production and Sales, U.S., 1959-75[1]

	Quantity	Increase Over Previous Year	Value	Increase Over Previous Year
	1,000 pounds	Percent	1,000 dollars	Percent
		Production		
1959	585,446	8.5	268,532	12.1
1960	647,795	10.6	307,293	14.4
1961	699,699	8.0	361,983	17.8
1962	729,718	4.3	427,373	18.1
1963	763,477	4.6	456,068	6.7
1964	782,749	2.5	481,955	5.7
1965	877,197	12.1	582,899	20.9
1966	1,013,110	15.5	727,772	24.9
1967	1,049,663	3.6	963,639	32.4
1968	1,192,360	13.6	1,066,775	7.0
1969	1,104,381	-7.4	953,592	-7.3
1970	1,034,075	-6.4	1,058,389	11.0
1971	1,135,717	9.8	1,282,630	21.2
1972	1,157,698	1.9	1,344,832	4.8
1973	1,288,952	11.3	1,492,700	11.0
1974	1,417,158	9.9	1,984,794	33.0
1975	1,609,121	13.5	2,918,088	47.0
		Sales (domestic and export)		
1959	502,852	7.7	225,469	14.9
1960	570,397	13.4	261,789	16.1
1961	611,917	7.3	302,955	15.7
1962	633,962	3.6	346,301	14.3
1963	651,471	2.8	369,140	6.6
1964	692,355	6.3	427,111	15.7
1965	763,905	10.3	497,066	16.4
1966	822,256	7.6	583,802	17.4
1967	897,363	9.1	787,043	34.8
1968	959,631	6.9	849,240	7.9
1969	928,663	-3.2	851,166	0.2
1970	880,914	-5.1	870,314	2.2
1971	946,337	7.4	979,083	12.5
1972	1,021,565	8.6	1,091,708	11.5
1973	1,198,568	17.4	1,343,581	23.1
1974	1,365,214	13.9	1,815,433	35.1
1975	1,317,320	-3.5	2,358,842	29.9

[1] Includes a small quantity of soil conditioners.
[2] Calculated from production and unit sales value, manufacturers' level.

TABLE 3—DDT: Production, Exports, and Producers' Domestic Disappearance U.S. 1944-76

	Production[1]	Exports[1]	Domestic Disapperance-
	1,000 pounds	1,000 pounds	1,000 pounds
1944	9,626	n.a.	n.a.
1945	33,243	n.a.	n.a.
1946	45,651	n.a.	n.a.
1947	49,600	n.a.	n.a.
1948	20,240	n.a.	n.a.
1949	37,904	n.a.	n.a.
1950	78,150	7,898	57,638
1951	106,139	n.a.	72,688
1952	99,929	32,288	70,074
1953	84,366	31,410	62,500
1954	97,198	42,329	45,117
1955	129,693	53,252	61,800
1956	137,659	57,194	n.a.
1957	124,545	64,096	71,000
1958	145,328	70,111	66,700
1959	156,741	74,987	78,682
1960	164,180	98,964	70,146
1961	171,438	94,616	64,068
1962	167,032	123,378	67,245
1963	178,913	101,955	61,165
1964	123,709	84,627	50,542
1965	140,785	90,414	52,986
1966	141,349	90,914	46,672
1967	103,411	81,828	40,257
1968	139,401	109,148	32,753
1969	123,103	82,077	30,256
1970	59,000	66,000	25,457
1971	:	45,100	18,234
1972	:	35,424	23,546
1973	"3"	73,712	"3"
1974	"3"	56,376	"3"
1975	"3"	47,228	"3"
1976	"3"	25,433	"3"

[1] Year ends December 31.
[2] Year ends September 30.
[3] Figure on U.S. production and use withheld to avoid disclosure as confidential statistical data.

(Production) Tariff Commission. (Exports) Bureau of the Census Report FT 410.

(Disappearance) Calculated from production, export, and producers' inventory data.

SAFE USE OF PESTICIDES
(READ THE LABEL)

Selection of Pesticides

1. Identify the pest to be controlled. If in doubt consult the Cooperative Extension Service or other agricultural authority.
2. Select the pesticide that is recommended by competent authority for the particular pest problem. Consider the effects of pesticide residues that may persist on crops grown in following seasons.
3. Make sure that the label on the pesticide container is current including the directions for use and precautionary procedures.
4. Purchase only the quantity of material that is needed for a single season.

Transportation of Toxic Chemicals

1. Material of hazardous nature should be marked in a conspicuous manner on the outside of the container.
2. Generally transport in an open-type vehicle—never transport volatile pesticides or chemicals that give off noxious or poisonous fumes in a closed vehicle.
3. Protect pesticides from rain, from puncturing or tearing of containers.
4. Make sure containers are tightly closed.
5. Accidents can happen—*be prepared.*

Handling and Mixing Pesticides

1. Read the label directions and current Cooperative Extension Service recommendations carefully before mixing.
2. Wear the appropriate protective clothing and equipment as specified on the label. Some organophosphate and carbamate pesticides are highly toxic and should be used only by persons thoroughly familiar with their hazards and equipped to follow the required precautions.
3. Handle pesticides in a well ventilated area. Avoid dusts and splashing when opening containers or pouring formulations into the spray apparatus. Do not mix or use pesticides on windy days.
4. Measure the quantity of pesticide required accurately using proper equipment.
5. Don't mix pesticides in areas where a chance of spills or overflows will get into any water supply.
6. Clean up spills immediately. Wash pesticides off skin promptly with plenty of soap and water. Change clothes immediately if they become contaminated.

Applying Pesticides

1. Wear the appropriate protective clothing and equipment as required for toxic materials.
2. Make sure the equipment is calibrated correctly and is always in a satisfactory condition.
3. Apply pesticides only at the rate recommended. To minimize drift apply only on a calm day and do not work through any clouds or drifts of unsettled dusts or sprays. Do not contaminate livestock and food and water supplies.
4. Avoid damage to beneficial and pollinating insects by not spraying during periods when such insects are actively working in the spray area. Notify neighboring beekeepers as required by legislative regulations at least 24 hours before using the pesticide so that they may take precautionary measures.
5. Keep pesticides out of mouth, eyes, and nose. Do not use mouth to blow out clogged lines or nozzles.
6. Observe precisely the waiting periods specified between pesticide use and harvesting and/or entry into a treated area. Post the treated area when required and keep all people and animals out of treated areas as designated on the label.
7. Clean all equipment used in mixing and applying pesticides according to recommendations. Do not use the same equipment in applying insecticides that was formerly used for herbicides.
8. After handling pesticides bathe skin thoroughly with soap and water, and change clothing.
9. Keep complete and accurate records of the use of pesticides.
10. If symptoms of poisoning occur during or shortly after the use or exposure to a pesticide, call the physician and/or get the patient to the hospital immediately. Take the pesticide label with you. It is wise to alert family members and the family physician before using highly toxic pesticides in the event that an accident might occur.

Storage of Pesticides

1. All pesticide rooms, cabinets, or sheds should be locked.
2. Do not store pesticides where food, feed, seed, or water can be contaminated.
3. Store in a dry, well-ventilated place, at temperatures above freezing, or as directed on the label.
4. Mark all entrances to storage area clearly *"Pesticides stored here —Keep Out."*
5. Keep pesticides in their original containers. Make sure they are closed tightly and plainly labelled.

6. Examine containers of pesticides periodically for leaks and tears. Dispose of leaking and torn containers immediately. Clean up spilled or leaked material promptly.
7. Where possible, a sink for washing should be located in or near storage.
8. Keep an inventory and eliminate all outdated materials. Date containers when purchased.
9. Take precautions of potential fire hazards.

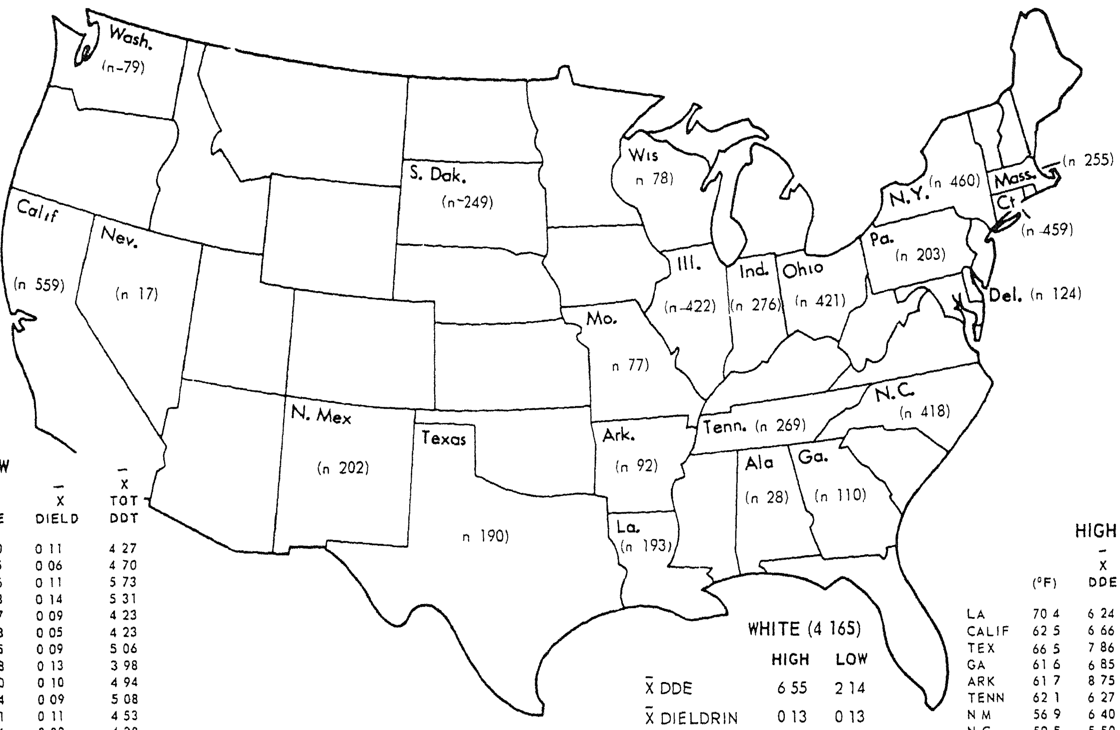
Disposal of Unused Pesticides and Empty Containers

"Empty" containers are *never completely empty.*

Always read and follow the directions and precautions on the label of the container. Become familiar with disposal guidelines recommended by EPA based upon type and classification of pesticides and containers (Federal Register 39; 85 Part II, May 1, 1974).

1. Use surplus pesticide for a labelled use whenever possible. If material cannot be used, the order of preference in disposal of organic pesticides is (a) incineration, (b) burial in a specially designated landfill, (c) chemical degradation and burial in an isolated area away from all water supplies, and (d) temporary storage. Small quantities of certain pesticides may be burned by the user in the field where state and local regulations are acceptable.
2. Metallo-organic pesticides (except heavy metals) should be treated to recover the metals and then disposed of as other pesticides. Organic mercury, lead, cadmium, arsenic, and all inorganic pesticides should be chemically deactivated and treated to recover the heavy metals and then disposed of. Non-treated pesticides in this category should be encapsulated and buried in designated landfills.
3. Do not re-use the container. Destroy all containers that cannot be recycled through authorized channels.
4. Combustible containers (except those having contained organic mercury, lead, cadmium, or arsenic) should be disposed of by (a) incineration or (b) burial in a designated landfill. Small quantities of such containers can be burned in the field according to local and state burning regulations.
5. Non-combustible containers (except those having contained organic mercury, lead, cadmium, or arsenic) should be triple-rinsed and then (a) recycled to the manufacturer, or (b) punctured and destroyed and then recycled as scrap or buried in a sanitary landfill. Small quantities, after triple rinsing, can be buried in the field by the user of the pesticide.
6. All containers having contained mercury, lead, cadmium or arsenic and all inorganic pesticides should be triple rinsed, punctured, and disposed of in a sanitary landfill.
7. Pesticide related wastes (such as rinses, etc., when not used) and unrinsed containers should be disposed of in the same manner as the surplus pesticide.
8. Extreme caution should be exercised when burning materials to keep humans and desirable plants and animals out of the smoke and to prevent volatilization of herbicides that can cause undesirable effects downwind and/or wherever the smoke drifts.
9. Bathe thoroughly and change to clean clothing after contact with pesticides.

ADIPOSE RESIDUES OF DDT AND DIELDRIN IN UNITED STATES



WHITE (4 165)

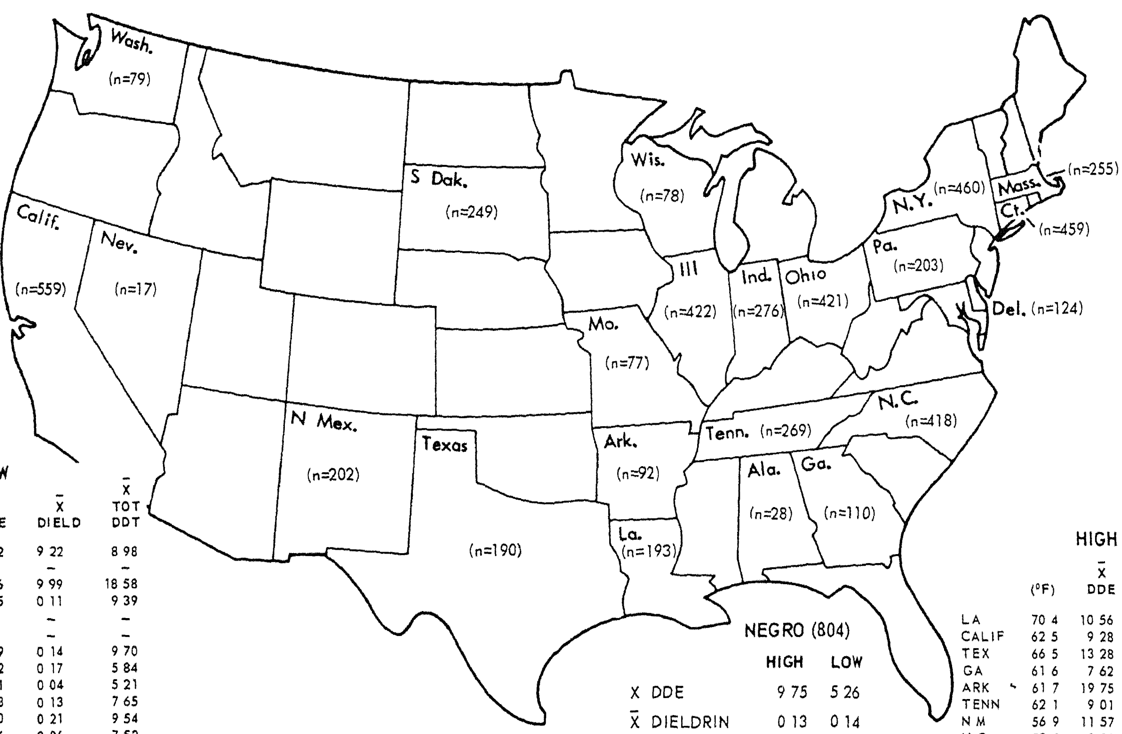
	HIGH	LOW
X̄ DDE	6 55	2 14
X̄ DIELDRIN	0 13	0 13
X̄ TOTAL DDT	9 21	4 85

LOW

	(°F)	X̄ DDE	X̄ DIELD	X̄ TOT DDT
MO	56 0	2 90	0 11	4 27
WASH	53 2	2 95	0 06	4 70
S D	45 7	3 66	0 11	5 73
CONN	49 3	3 48	0 14	5 31
MASS	51 4	2 97	0 09	4 23
NEV	48 8	2 98	0 05	4 23
IND	52 1	3 45	0 09	5 06
ILL	50 9	2 78	0 13	3 98
N Y	54 5	3 50	0 10	4 94
OHIO	55 2	3 44	0 09	5 08
PA	54 6	3 11	0 11	4 53
DEL	54 1	2 96	0 09	4 38
WISC	45 1	3 97	0 15	5 53

HIGH

	(°F)	X̄ DDE	X̄ DIELD	X̄ TOT DDT
LA	70 4	6 24	0 10	8 55
CALIF	62 5	6 66	0 16	9 35
TEX	66 5	7 86	0 21	10 73
GA	61 6	6 85	0 18	9 68
ARK	61 7	8 75	0 21	13 23
TENN	62 1	6 27	0 17	9 28
N M	56 9	6 40	0 14	8 50
N C	59 5	5 50	0 11	7 73
ALA	67 2	4 90	0 01	5 92



NEGRO (804)

	HIGH	LOW
X DDE	9 75	5 26
X̄ DIELDRIN	0 13	0 14
X̄ TOTAL DDT	14 37	7 86

LOW

	(°F)	X̄ DDE	X̄ DIELD	X̄ TOT DDT
MO	56 0	5 82	9 22	8 98
WASH	53 2	–	–	–
S D	45 7	14 56	9 99	18 58
CONN	49 3	6 85	0 11	9 39
MASS	51 4	–	–	–
NEV	48 8	–	–	–
IND	52 1	6 39	0 14	9 70
ILL	50 9	3 92	0 17	5 84
N Y	54 5	3 31	0 04	5 21
OHIO	55 2	5 13	0 13	7 65
PA	54 6	6 50	0 21	9 54
DEL	54 1	5 06	0 06	7 52
WISC	45 1	4 26	0 20	6 11

HIGH

	(°F)	X̄ DDE	X̄ DIELD	X̄ TOT DDT
LA	70 4	10 56	0 06	14 75
CALIF	62 5	9 28	0 16	12 76
TEX	66 5	13 28	0 27	18 64
GA	61 6	7 62	0 19	11 70
ARK	61 7	19 75	0 10	28 86
TENN	62 1	9 01	0 08	14 14
N M	56 9	11 57	0 38	15 15
N C	59 5	8 29	0 11	13 21
ALA	67 2	10 20	0 00	11 36

(Reprinted from Report of the Secretary's Commission on Pesticides and their Relationship to Environmental Health—U S Department of Health, Education and Welfare, December 1969)

Reprinted from **N A.C. News** and Pesticide Review, December 1968

A Typical
Research and Development Program
Agricultural Chemical Manufacturer

TIME — **COSTS UP TO**

From planned synthesis of new structures, plus numerous intermediates of chemical manufacturing come candidate pesticides.

The larger manufacturers routinely screen these chemicals for biological and pesticidal activity—on plants, seeds, insects, fungi, fish, birds, and mammals.

1 YEAR — **$1,000,000**

From among some 4,000 candidate chemicals only about 40 merit further study after the above screening tests. The data from the other 3,960 compounds are filed for future reference.

More extensive laboratory, greenhouse, and small field plot tests using larger numbers of plant and animal species, reduce the 40 candidates to one or two.

2 YEARS — **$1,000,000-$2,000,000**

Introductory field studies on the manufacturer's own farms at several locations about the United States will require a minimum of two years' study.

Chemical process research and pilot plant production.

The pesticide under investigation is now offered to Government laboratories and agricultural experiment stations for independent evaluation.

Concurrently as the most promising compounds emerge four important programs must be undertaken.

Chemical analytical techniques must be developed to detect residues of the parent compound and all toxic metabolites in treated crops and in meat and milk products derived from animals consuming treated crops.

Toxicology studies involving 90-day and 2-year feeding studies on two or more appropriate test animals; studies on reproduction, teratogenesis, mutagenesis, and carcinogenesis; actual and probable effects on fish, shellfish, birds, primates, and humans.

4 YEARS — **$2,000,000-$4,000,000**

Metabolism studies in animals and plants and in humans when possible.

Environmental factors involving stability, movement, spectrum, and accumulation.

If the Data are still favorable then application is made to the EPA Pesticides Regulation Division for a temporary permit (1-year) to allow field trials under a variety of geographic and faunal conditions.

6-8 YEARS — **$4,000,000-$8,000,000**

Finally, armed with 5-8 years of cumulative studies, the *one compound* out of the initial 4,000 that has survived is presented for registration. It has taken a combined effort of chemists, agricultural scientists, toxicologists, and environmental biologists.

Originally Reprinted from **N.A.C. News** and **Pesticide Review,** December 1968.
Revised by bulletin author 1975.

Pesticide Safety—
from Research to Application

Many Scientists Are Involved in the Research, Evaluation, Registration, and Regulation of Pesticides To Insure Safety to the Consumer and His Environment.

RESEARCH AND DEVELOPMENT

Chemical Companies

USDA

Universities and Experiment Stations

SCIENTISTS INVOLVED

Chemists, Biologists, Botanists, Entomologists, Plant Pathologists, Toxicologists, Agronomists, Veterinarians, Horticulturists, and other Plant and Animal Specialists.

EVALUATION FOR REGISTRATION AND REGULATION

ENVIRONMENTAL PROTECTION AGENCY

Federal Water Quality
Pesticide—Wildlife Div.
Sport Fisheries Laboratory
} Formerly in USDI

National Air Pollution Control
Bureau of Solid Waste Management
FDA—Research & Tolerance for Pesticides
} Formerly in USDHEW

Ecological Research—Formerly in Environmental Quality

Pesticide Regulation Division
Pesticide Monitoring Branch
} Formerly USDA

STATE DEPARTMENT OF AGRICULTURE

Toxicologists; Entomologists; Plant Pathologists, Bacteriologists; Chemists; Veterinarians; Biochemists; Pharmacologists; Physicians; Mammalogists; Ornithologists; Biologists; Wildlife, Aquatic, Marine, and Plant Biologists.

CONTINUING RESEARCH, MONITORING, AND EVALUATION

Environmental Protection Agency
USDA, USDI, USDHEW, National Research Council, and other Federal Agencies
State Departments of Agriculture, Health etc.
Universities and Experiment Stations

Same type of scientists as above.