AGRICULTURAL SOURCES OF DDT RESIDUES IN CALIFORNIA'S ENVIRONMENT

September 1985

A Report Prepared in Response
to House Resolution No. 53 (1984)

ENVIRONMENTAL HAZARDS ASSESSMENT PROGRAM

California Department of Food and Agriculture
1220 N Street
Sacramento, California 95814

Agricultural Sources of DDT Residues

in California Environment

September 1985

E R R A T U M

Page 3, lines 12-13 should read: "On the average, about half the DDTr detected is still present as DDT in the environment."

Page 31, lines 24-25 should read: "This means that on the average 49% of the detected DDT is still present as DDT."

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EXECUTIVE SUMMARY

HR 53, adopted by the Assembly on August 31, 1984, directed the Department of Food and Agriculture (CDFA) to investigate possible sources of DDT in the environment and to report findings to the Legislature within one year. This resolution was introduced in response to studies showing that, although its use was banned in 1973, DDT residues are still being found in California water, fish, shellfish, and produce samples. Additionally, the chemical composition of the DDT being found indicated that it might be from recent use. This report discusses CDFA's findings.

CDFA investigated three possible sources of contamination by DDT and/or its breakdown products (the combination of DDT and its breakdown products is called DDTr) which are agriculturally related:

1. New illegal use of DDT
2. Use of other pesticides that might be contaminated with DDTr
3. Long-lived residues from previous legal applications of DDT

The following data were analyzed in this investigation:

Field Studies

1. 1985 study, in response to HR 53, monitoring current DDTr levels in soil from agricultural areas where DDT has historically been used.
2. 1984 case study of DDT residue levels in fish and mussels in the Salinas River, Monterey County.

Ongoing Regulatory Compliance Monitoring

- product quality monitoring of pesticides for sale, including newly introduced pesticides and new uses of existing pesticides.
- monitoring for pesticide residues in fresh produce, including fruits, nuts, vegetables, eggs, honey, hay and fodder.
- monitoring of activities of all persons selling, applying, storing, or otherwise handling pesticides.
- site inspections relating to applications, mixing and loading, equipment, storage facilities, and field worker safety.

Based on all available evidence, CDFA concluded that long-lived residues from previous applications are the apparent source of DDTr residues in produce and in the environment.

Specific findings of the study include:

1. Before its ban, DDT was widely used in California in agriculture and for control of mosquitoes and other disease-carrying insects.
2. There is no evidence that there has been any illegal use of DDT since its ban. For example, in 1983, 87,000 pesticide use enforcement inspections and 3,501 investigations of possible violations were made by California County Agricultural Commissioners. None of these involved DDT. Also, in 1983, about 1300 pesticide samples were analyzed to determine what chemicals they actually contained. The results show 97.5% of these samples met registration and labeling requirements. The remaining 2.5% did not involve DDT. Even before its ban, agricultural use of DDT was declining as more insects became resistant to DDT.

3. Contamination of other pesticides by DDT can not account for the residues. There have been reports that dicofol (Kelthane^{R}) contained large amounts of DDT. Samples of dicofol sold in California examined in 1983-84 contained very low levels of DDT, usually less than 1%, too low to account for DDT residues found.

4. Detectable levels of DDT are still being found on some California produce. These levels are, in most cases, well below acceptable levels. Nearly all produce samples found with residues of DDTr have an edible portion which grows in or close to the ground, such as carrots, beets, lettuce, or spinach. DDTr residues found on produce are probably the result of contamination from soil containing DDTr.

5. On the average, about half the DDT applied is still present as DDT in the environment. However, the composition of DDT found in soil is more stable than previously thought, therefore the kinds of DDT residues present in soil do not necessarily indicate new use. DDTr residues may survive in California soil for 12-15 years or more.

6. Soil contaminated with DDTr may be moved into drains as a result of normal field work such as land leveling. Fish and shellfish pick up DDTr from the soil particles in the water.

7. DDTr residues are present in soil wherever DDT was used legally in the past. In 1985, CDFA collected 99 soil samples in 32 California counties from locations where DDT had been used in the past. All samples contained DDTr.

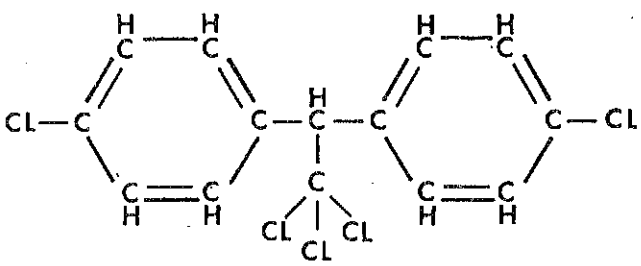
Detectable levels of DDTr are widespread in California soils 12 years after the ban of DDT. Based on analysis of historical and empirical evidence, CDFA concluded that residues from legal applications of DDT, before its use was banned, appear to be the source of this contamination.

Introduction

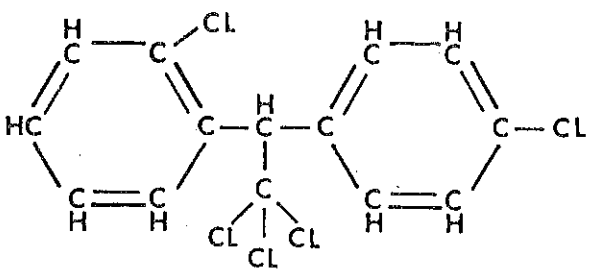
The important role that dichlorodiphenyltricholoroethane (DDT) has played in California agriculture cannot be diminished or denied. Equally important however, is the legacy of long term, widespread environmental contamination which the usage of DDT has left us. This report has been prepared as a response to the 1984 California State Assembly's Resolution Number 53 authored by Assembly Member Connelly (see Appendix I). This resolution directed the California Department of Food and Agriculture (CDFA) to conduct an investigation to ascertain the sources of DDT in the California environment and to report to the Assembly on the results of this investigation.

This report is divided into three main sections. The first section covers possible agriculturally related sources of DDT in the California environment. The second section deals with the recent soil monitoring survey conducted in agricultural areas of historic DDT usage by the California Department of Food and Agriculture. The final section presents conclusions.

There are two possible isomers or structures of DDT:



p,p' DDT



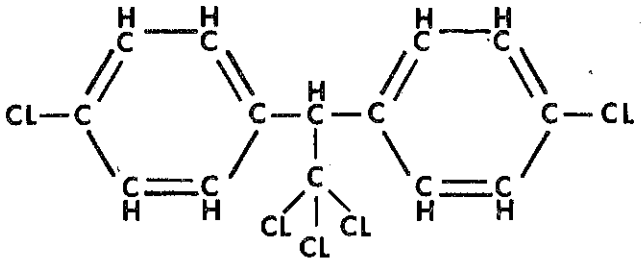
o,p' DDT

Technical grade (undiluted) DDT is usually a mixture of 70 to 80% p,p' DDT and 20 to 30% o,p' DDT[1]. The p,p' isomer of DDT exhibits the greatest efficacy against target organisms and is therefore present in the highest percentage. The o,p' isomer of DDT is formed during the manufacturing process, along with the the p,p' isomer, but is not removed from the mixture in order to keep the process costs down. DDT degrades in the environment to various other compounds including DDE and DDD (see Figure I). For the purposes of this report, the sum of all these degradation products and the parent compound DDT will be referred to as DDTr.

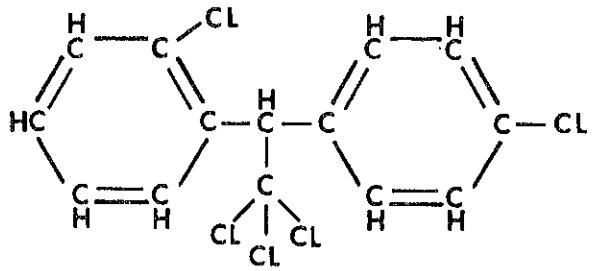
I. AGRICULTURALLY RELATED SOURCES OF DDT

Background

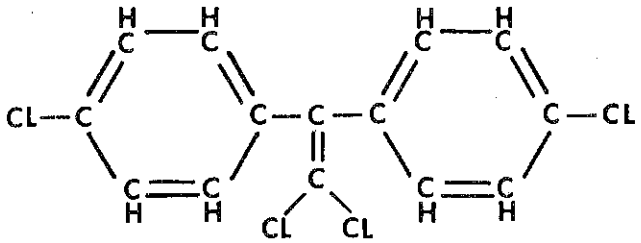
DDT was first synthesized by Zeidler in 1874[2]. In 1939, Dr. P. Muller working for the J.R. Geigy Chemical Company discovered the insecticidal properties of DDT[3]. Muller received the Nobel Prize in 1948 for this work. DDT's first full-scale uses were as the main agent for the control of insect vectors of an impressive list of diseases, including malaria, Chagas' disease, plague, typhus, yellow fever, dengue/haemorrhagic fever, encephalitis, filariasis, African trypanosomiasis, onchocerciasis and leishmaniasis[4]. In fact, even today DDT is still the main agent for control of these diseases in developing countries. Starting in 1944, DDT found widespread acceptance as a nearly universal insecticide for agricultural as well as residential, commercial and public health applications. In the late 1960's, DDT use in the United States and California reached its peak. Increasing problems with DDT resistance from a large number of insects, the development of more specific pesticides and the rising concern for environmental contamination caused a marked drop in DDT use in the United States generally, and



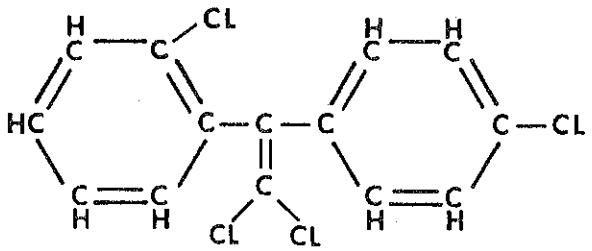
p,p' DDT



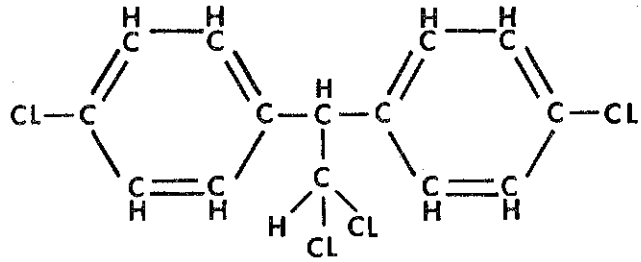
o,p' DDT



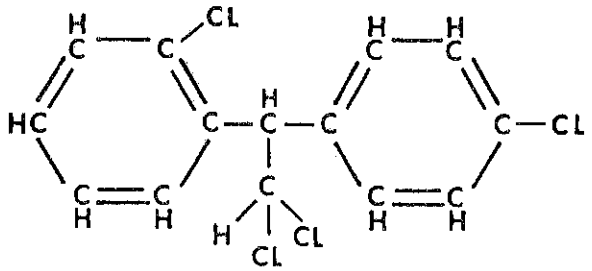
p,p' DDE



o,p' DDE



p,p DDD



o,p' DDD

Figure I
Structure of Various DDTr Species

in California in particular. In August, 1971, the United States Environmental Protection Agency (EPA) instituted official hearings on the problems caused by the continued use of DDT. These hearings continued until February 1972. The results of these hearings were given legislative backing with the elimination of use of DDT for all domestic purposes as of December 31, 1973.

The history of DDT usage in California began around 1944. DDT found wide acceptance in California as it did in the rest of the United States and the world. The uses of DDT in California ranged from control of agricultural pests to control of cockroaches in residences and mosquito abatement in neighborhoods. DDT was declared a restricted material by the California Department of Food and Agriculture in 1963. The last year in which substantial amounts of DDT were applied to California crops was 1970. Table I gives the use of DDT and DDD from 1970 to 1980. DDD is included because it too was registered for use as a pesticide.

Table I - DDT Use in California from 1970 to 1980[a]

Year	Pounds Used	Main Use
1970	1, 164,699	agricultural
1971	111,058	agricultural
1972	80,800	agricultural
1973[b]	NUR[b,c]	-
1974	160	residential pest control (SLN)
1975-1980	less than 200 lbs per year	Vector control (SLN)

a. 1970 was the first year in which the amount of restricted pesticides used in California was reported. In 1980, the introduction of new pesticides replaced the need to use DDT for vector control.

b. Year all use banned except for special local needs (SLN)

c. NUR - no use reported

Table I (cont'd)

DDD Use in California From 1970-1980

Year	Pounds Used	Main Use
1970	7,929	agricultural
1971	5,601	agricultural
1972	NUR[c]	-
1973[b]	NUR	-
1974	NUR	-
1975-1980	NUR	-

a. 1970 was the first year in which the amount of restricted pesticides used in California was reported. In 1980, the introduction of new pesticides replaced the need to use DDT for vector control.

b. Year all use banned except for special local needs (SLN)

c. NUR - no use reported

Statement of the Problem

The current renewed interest in environmental DDTr levels arising from agricultural sources is the result of continued monitoring of California's environment and agricultural products. Ongoing studies by the State Water Resources Control Board (SWRCB)[5] have found DDT and its metabolites in fish samples taken from selected rivers in California. The levels of DDT found in these samples were higher than expected by the SWRCB for a compound whose last major usage was fifteen years ago. Additionally, the SWRCB felt the isomeric composition of the DDT found in these samples may have been due to newly mobilized DDT residues. The SWRCB, in cooperation with the Department of Food and Agriculture conducted an intensive study of the possible sources of DDTr in

one of these rivers, the Salinas, in Monterey County. The full report and results of this study will be issued by the SWRCB in late 1985, but findings are briefly discussed later in this report.

The Pesticide Residue and Monitoring Program conducted by CDFA provides for the continuing inspection and sampling of farm commodities including fruits, nuts, vegetables, eggs, honey, hay and fodder. This program continues to find very low levels of DDTr on some California grown produce. However, these levels of DDTr are, in most cases, well below established, acceptable levels for the respective commodity. The CDFA policy on detectable levels of pesticides on commodities for which no tolerance for that pesticide has been established, or on which an over-tolerance level has been found, is to review and investigate each find on a case by case basis.

The main question that arises from the data on DDTr levels in produce is the source of these DDTr residues. The concentrations have remained low but are still being found some twelve years after use of the DDTr compounds was banned. Possible sources considered for these DDTr residues in the environment are: previous legal use; new, illegal use; or the use of other DDTr containing pesticides. This report will present data on the agricultural sources of DDTr in the California environment.

Other Pesticides as a Source of DDT

The one pesticide of major interest as a source of DDTr residues is dicofol. Dicofol is marketed under the trade name Kelthane®. Dicofol is used to control mite pests on various commodities grown throughout the state. In order to understand the concern surrounding the use of dicofol, one must first look at the manufacturing process for

dicofol. The starting material from which dicofol is made is DDE. The DDE used to make dicofol will contain some DDT as a result of its own manufacturing process. The DDE is then reacted with chlorine to form a product one can describe as "chlorinated DDE." This "chlorinated DDE" is then reacted further to give dicolfol. The final product, dicofol, therefore can contain levels of DDT and "chlorinated DDE"[6,7]. Dicofol itself does not breakdown in the environment to DDT. However, there is evidence that the "chlorinated DDE" species will dechlorinate back to DDE in the environment.[8] This means that dicofol can be a direct source of both DDT and DDE in the environment.

CDFA, together with the California Department of Fish and Game (CDFG) has analyzed samples of technical (undiluted) and formulated (diluted) dicofol and Kelthane® for DDT. CDFA drew a total of 27 samples in 1982 and 1983. Twenty-one were from registrants' formulated products and six were EPA samples of 98% technical material. Analyses revealed that one of the 21 registrants' formulated products contained under 0.1% DDT, and one of the six technical material samples contained 0.27% DDT. All the other samples contained no detectable DDT at a detection level of 0.08%. The CDFA and CDFG conducted a joint analysis of a sample of technical product in 1984 and both agencies found less than 0.1% DDT in the sample.

The manufacturer of Kelthane®, Rohm and Haas, has announced that the current levels of DDT related impurities in Kelthane®, will be reduced to a total of 2.5% by 1986 and to 0.1% by 1987.[9] This reduction will mean the sum of DDT, DDE, DDD and "chlorinated DDE" will not exceed 0.1% after 1987. A level of 0.1% for the DDT

related impurities in Kelthane will significantly reduce the contribution of Kelthane to DDTr levels in the environment.

Possible Illegal Use Of DDT And DDD

California's regulatory program of pesticide use enforcement sampling, inspection, and surveillance is administered by the Pesticide Enforcement Branch of the CDFA and the County Agricultural Commissioners. This regulatory program provides lines of defense and safeguards against illegal pesticide use and residues which may occur on agricultural commodities or in the environment. These safeguards consist of field activities involving pesticide product quality sampling and inspections, pesticide residue sampling and monitoring, and pest control site inspections, as well as pest control record reviews by the County Agricultural Commissioners.

The following is an overview of field enforcement activities:

1. CDFA Pesticide Product Quality Program

The program's goal is to ensure that pesticide products offered for sale in California meet label guarantees, are registered for use in California and are unadulterated. Unregistered, adulterated or misbranded products may be quarantined from sale or use, and parties responsible for the violation may be cited or prosecuted. None of the pesticides found out of compliance in 1983 contained DDT or DDD.

The program's activities and workload consist of taking about 1,300 pesticide samples for analysis annually, primarily at dealer and user locations, and conducting about 4,000 pesticide inspections annually. Samples taken in the field are submitted to the CDFA laboratories for analysis.

"Inspection call" activities include: review of labels for compliance with labeling requirements; premise and product inspection to ensure that products are handled and packaged safely in undamaged containers; verification that products offered for sale have both current California and EPA registration; and verification that pesticide handlers hold the required licenses.

In addition, producers' establishment inspections, import inspections, and experimental use inspections are conducted by the CDFA under an enforcement agreement/grant from the U.S. Environmental Protection Agency (EPA). The breakdown of the workload and measure of effectiveness for the calendar year 1983 are shown below:

1983 WORKLOAD

Type of Activity	Number of Samples Collected
Market Surveillance	1,101
Producer Establishments	247
Inspection Calls	
Market Surveillance	3,975
Producer Establishments	194
Experimental Use Inspections	10
Import Samples & Inspections	3
Quarantine Actions	106
Notice of Warnings	66
Unregistered Product Reports	39

1983 MEASURE OF EFFECTIVENESS

Percentage of pesticides found in field inspections that are properly registered and labeled	97.5%
Percentage of pesticide formulations found in field inspections that meet the label guarantee	95.2%
Percentage of pesticide labels found in field inspections with labels in compliance with labels on file with the Department	99.2%

2. CDFA Pesticide Residue and Monitoring Program

The primary goal of this program is to protect the public and the California environment from possible harmful effects of pesticides. This goal is accomplished by two methods. The first is a produce sampling program to assure the consumer that California produce is within the legal pesticide residue tolerances established by EPA for health and safety. The second method of accomplishing this goal is through the monitoring of newly introduced pesticides, as well as new uses of existing pesticides and special local need uses of canceled pesticides to determine that they are not creating a residue problem or having a detrimental effect on public health, wildlife, crops or the environment.

Produce inspections are primarily carried out at large wholesale markets and chain store receiving docks. Roadside stands and retail stores are inspected through

periodic surveys that are conducted in a given area. Hay and fodder are usually sampled in the areas of production. Analyses of the samples are performed by CDFA laboratories located in Sacramento, Berkeley, Fresno, and Anaheim. For special problems in growing, packing and marketing areas, a mobile laboratory is available for conducting numerous residue tests rapidly in the field.

All the pesticide residues found on these samples are entered into a data processing program that keeps a continuous record of all pesticides found in all crops. With this information, CDFA can monitor the total pesticide residue found on produce, the average level of pesticides found on produce, whether the levels are going up or down year by year, what the average percentage of residue compared to tolerance is for each pesticide and crop, and could calculate what the average intake in a person's diet would be based on individual food intake. These data may also trigger the need for reevaluation of pesticide residue data that was presented at the time the pesticide was registered for use in California.

Table II gives a summary of information on the number of produce samples with detectable DDT and DDE residues from 1981 to 1984. No DDD was detected in any samples. If illegal usage of DDT on crops were occurring in California, the Residue Program would have detected increased residues on the target crops. This has not been the case. Residue levels have remained low and have been confined to crops which either have edible portions which grow in the soil, have fruit which rests on the soil, or have an irregular leaf or fruit surface which readily traps soil particles.

Table II - DDT and DDE Concentrations in Produce Samples Collected from 1981-84

1981 - Total of 6410 produce samples analyzed[a]

Commodity	# w/residue	Residue Found (ppm)[b]	Tolerance (ppm)[c]
1981 DDT			
Carrots	1	0.13	3.5
Parsley	1	0.03	NTE
Lettuce	1	0.02	7.0
Spinach	4	0.01-0.30	1.0
1981 DDE			
Beets	11	0.01-0.30	1.0
Carrots	10	0.01-0.80	3.5
Leeks	2	0.01-0.02	NTE[d/]
Onions (green)	4	0.01-0.08	NTE
Parsley	8	0.01-0.06	NTE
Parsnip	1	0.24	1.0
Oriental vegetables	1	0.01	NTE
Celeriac	1	0.02	NTE
Cabbage (Napa)	1	0.23	NTE
Cilantro	1	0.01	NTE
Spices	1	0.02	NTE
Anise	1	0.03	NTE
Radish	12	0.01-0.22	1.0
Sweet Potato	2	0.01-0.10	1.0
Turnip	3	0.01-0.02	1.0
Potato	6	0.10-0.15	1.0
Lettuce(leaf)	5	0.02-0.05	7.0
Endive	2	0.01-0.40	1.0
Beans, green	1	0.02	7.0
Turnip greens	1	0.06	1.0

Table II (cont'd)

Commodity	#w/residue	Residue Found (ppm)	Tolerance (ppm)
Cauliflower	1	0.30	1.0
Collard	8	0.01-0.10	1.0
Kale	4	0.01-0.10	1.0
Mustard	4	0.02-0.05	1.0
Celery	5	0.01-0.20	1.0
Escarole	1	0.10	1.0
Lettuce, romaine	2	0.01-0.70	7.0
Cucumber	2	0.01-0.05	0.5
Zucchini	4	0.01-0.03	0.5
Peppers	1	0.10	NTE
Orange	1	0.02	3.5
Apples	1	0.02	0.5
Broccoli	1	0.01	1.0
Spinach	32	0.01-0.14	1.0

1982 - Total of 7631 produce samples analyzed

1982 DDT

Spinach	1	0.05	1.0
Carrot	1	0.11	3.5
Radish	2	0.01-0.07	1.0
Parsley	1	0.02	NTE

Table II (cont'd)

Commodity	# w/residue	Residue Found (ppm)	Tolerance(ppm)
1982 DDE			
Limes	1	0.01	3.5
Squash, summer	1	0.03	0.5
Collards	6	0.01-1.0	1.0
Ginger	1	0.02	NTE
Green Onion	2	0.03	NTE
Parsley root	2	0.02	NTE
Parsley	2	0.05-0.06	NTE
Beets	6	0.01-0.1	1.0
Carrots	15	0.01-1.0	3.5
Parsnips	3	0.05-0.1	1.0
Peppers, bell	2	0.01-0.0	7.0
Radish	26	0.01-0.10	1.0
Potatoes	3	0.02-0.06	1.0
Spinach	25	0.01-0.30	1.0
Swiss chard	1	0.04	1.0
Cauliflower	1	0.10	1.0
Celery	1	0.03	1.0
Kale	5	0.01-0.10	1.0
Mustard	3	0.01-0.05	1.0
Tomatoe	1	0.02	7.0
Oriental vegetables	1	0.03	NTE
Turnip greens	1	0.01	1.0

Table II (cont'd)

Commodity	# w/residue	Residue Found (ppm)	Tolerance (ppm)
Yams	1	0.02	1.0
Cucumbers	2	0.02-0.03	0.5
Oranges	1	0.35	3.5
Artichokes	1	0.03	1.0
Broccoli	1	0.01	1.0

1983 - Total of 7695 produce samples analyzed[a]

1983 DDT

Radish	1	0.10	1.0
Tomatoe	1	0.16	7.0
Cilantro	1	0.07	NTE
Endive	1	0.17	1.0

1983 DDE

Carrot	4	0.06-0.12	3.5
Endive	1	0.05	1.0
Kale	2	0.10	1.0
Lettuce (head)	1	0.02	7.0
Lettuce (leaf)	3	0.04-0.20	7.0
Mustard	1	0.05	1.0
Green Onions	1	0.11	NTE
Orange	1	0.06	3.5
Parsley	1	0.07	NTE
Parsnip	1	0.04	1.0
Radish	8	0.04-0.15	1.0

Table II (cont'd)

Commodity	# w/residue	Residue Found (ppm)	Tolerance (ppm)
Spinach	11	0.04-0.10	1.0
Turnip	1	0.04	1.0
Zucchini	1	0.02	0.5
Sweet potatoes	1	0.03	1.0
Cilantro	1	0.10	NTE

1984 - Total of 7243 produce samples analyzed[a]

1984 DDT

Celeriac	1	0.08	NTE
Radish	1	0.07	1.0
Spinach	2	0.14-0.18	1.0
Tomatillos	1	0.16	NTE

1984 DDE

Beets	4	0.03-0.14	1.0
Carrots	18	0.01-0.10	3.5
Celeriac	1	0.05	NTE
Cilantro	2	0.04-0.10	NTE
Escarole	2	0.01-0.05	1.0
Lettuce (leaf)	3	0.02-0.08	7.0
Lettuce (Romaine)	2	0.03-0.18	7.0
Mustard	1	0.06	1.0
Parsley	2	0.05	NTE
Radish	15	0.02-0.15	1.0
Salsify	1	0.06	NTE
Spinach	13	0.02-0.07	1.0

Table II (cont'd)

Commodity	# w/residue	Residue Found (ppm)	Tolerance (ppm)
Squash (summer)	2	0.03-0.03	0.50
Turnip	1	0.03	1.0

a. No DDD detected on any samples.
b. For more than one sample analyzed, the range of results is listed.
c. Tolerances are established for DDT, DDD, and DDE either separately or as the sum of all three for each year listed.
d. NTE - No tolerance established.

3. County Agricultural Commissioner Pesticide Enforcement Program

Each county in California has a Department of Agriculture managed by a County Agricultural Commissioner. The Commissioners enforce California laws and regulations pertaining to pest control and pesticides. The Commissioners are responsible for local administration of the enforcement program. CDFA is responsible for overall statewide enforcement through the issuance of policy and procedures, and by providing assistance in training, laboratory services, investigations of pesticide product quality and pesticide residues, and by providing program uniformity and coordination.

The County Agricultural Commissioners' Pesticide Enforcement Program includes: county registration of Pest Control Operators (PCO), Pest Control Advisers (PCA), aircraft pilots, and structural pest control operators (SPCO); issuance of restricted material use permits; record inspections relating to employer headquarters and PCO, pesticide dealers, PCA, and certified applicator certification records; site inspections relating to application, mixing and loading, application equipment, storage facilities, and field worker safety; and episode investigations relating to human, environment, crop and property damage, and employee and general public complaints.

During the fiscal year 1983-84, County Agricultural Commissioners expended a total of 375,274 enforcement hours. Over 87,000 pesticide use enforcement inspections were made to check compliance, and a total of 3,501 episode investigations were conducted. Administrative and judicial actions taken by the County Agricultural Commissioners were: 1470 notice of violations, 48 cease and desist orders, 72 permit actions, 3 actions against private applicator certifications, 13 county registration actions, notice to appear and 18 criminal complaints. None of these actions involved the use of DDTr pesticides.

4. Pesticide Episode Reporting and Investigative Program Via Cooperative Agreements

Vital to the effectiveness of the CDFA and the County Agricultural Commissioners pesticide enforcement programs is the establishment of cooperative agreements between other county, state, and federal agencies which have interest in regulation of pesticides. CDFA and the County Agricultural Commissioners have entered into coooperative agreements with the U.S. Environmental Protection Agency (Region IX), the California Department of Industrial Relations and the California Department of Fish and Game. CDFA also maintains close communications and cooperation with the U.S. Fish and Wildlife Service, the Federal Food and Drug Administration, the California Department of Water Resources, the Regional and State Water Quality Control Boards, the Air Resources Board, and the Structural Pest Control Board.

The above mentioned cooperative agreements have, in the past, been useful for detecting and investigating illegal pesticide usage, but have never detected any evidence of illegal DDT or DDD usage.

Likely Sources of DDTr Contamination from Agricultural Sources

Aquatic Environment Contamination

As mentioned earlier in this report, in 1984 the SWRCB and the CDFA conducted an in-depth study of the Salinas River in Monterey County, in an attempt to identify the source of DDTr residues found in fish and mussel samples collected there. Additional cooperators in this study were the Monterey County Agricultural Commissioner, the Central Coast Regional Water Quality Control Board and the Bodega Marine Laboratory of the University of California. Initial sampling by the SWRCB and the Central Coast Board had pinpointed the source of DDTr residues as the Blanco Drain located just southwest of the city of Salinas, California. The drain collects water from adjacent farm land along its nine mile length, for later pumping into the Salinas River. A detailed report of this study will be issued by the SWRCB later this year, so only a brief presentation of the results will be made here. This study found that:

1. The DDTr residue level in soils from fields adjacent to the Blanco Drain averaged 2.6 parts per million (10/23/84 sampling). Values varied from 1.2 to 5.0 ppm.

   The DDTr residue level in sediment from the Blanco Drain averaged 2.1 ppm (10/23/84 sampling). Values varied from 0.22 ppm to 6.3 ppm.

2. DDT residues averaged 70% of all DDTr residues in soils from fields adjacent to the Blanco Drain (10/23/84 sampling). Values varied from 35% to 81%.

   DDT residues averaged 51% of all the DDTr residues in sediment from the Blanco Drain (10/23/84 sampling). Values varied from 19% to 79%.

3. The average percentage of o,p' DDT to the sum of o,p' DDT + p,p' DDT in soils from fields adjacent to the Blanco Drain is 19% (10/23/84 sampling). Values varied from 12% to 27%.

The average percentage of o,p' DDT to the sum of o,p' DDT + p,p' DDT in sediment from the Blanco Drain is 19% (10/23/84 sampling). Values varied from 14% to 42%.

The following conclusions can be drawn from the study findings:

1. The fairly uniform distribution of DDTr throughout the Blanco Drain area soils rules out the possiblity of new, illegal usage. The relatively low variability and the similarity in composition from site to site is consistent with a pattern of residues from past applications.

2. DDTr and in particular o,p' DDT and p,p' DDT species have a very long life time in Salinas clay soils.

3. The similarities between the DDTr levels in the Blanco Drain sediment and the DDTr levels in soil from fields adjacent to the drain, points to soil erosion from the fields into the drain as the source of DDTr in the Blanco Drain.

The above conclusions were also reached in a SWRCB funded study of the Blanco Drain area conducted by the Bodega Marine Laboratory of the University of California.[10] This study was independent of the SWRCB, CDFA, CCRWQCB, and Monterey County Agricultural Commissioner's joint study.

The photographs in Figures 2-7 were taken at the Blanco Drain in late 1984. All the photographs were taken on the same day at various locations along the Blanco Drain. Figures 2 to 7 show that during post-harvest operations most fields adjacent to the drain are plowed, leveled and furrowed right up to the edge of the drain or its tributaries. After cultivation, road ways are re-established through the freshly worked ground next to the drain. During the cultivation process, excess soil is allowed to fall directly into the drain or its tributaries. Subsequent flooding of the drain or its tributaries carries this DDTr-laden soil down the Blanco Drain to the Salinas River where it can enter the food chain of fish, mussels and other animals. This process does not occur at all points along the drain, however. Figure 7 shows an example of a grower who follows best soil management practices. The old, established roadway along the tributary was undisturbed during the cultivation operation which prevented direct movement of excess soil into the tributary. The Monterey County Agricultural Commissioner is currently informing growers in the Blanco Drain area of the results of these studies and encouraging growers to prevent soil from spilling into drains during cultivation.

This is a case study of only one of the rivers in California in which the SWRCB has found DDTr levels. How this case study and new data collected by the CDFA relates to other rivers in California will be discussed in the conclusion section of this report.

Agricultural Produce Contamination

The Blanco Drain case study which was just discussed above serves as an excellent example for the discussion of DDTr levels in California produce. The study found that the average DDTr level in soils adjacent to the Blanco Drain is 2.6 ppm. CDFA collected samples of crops from fields in the Blanco Drain area in April and July,

Figure 2.

Figure 3.

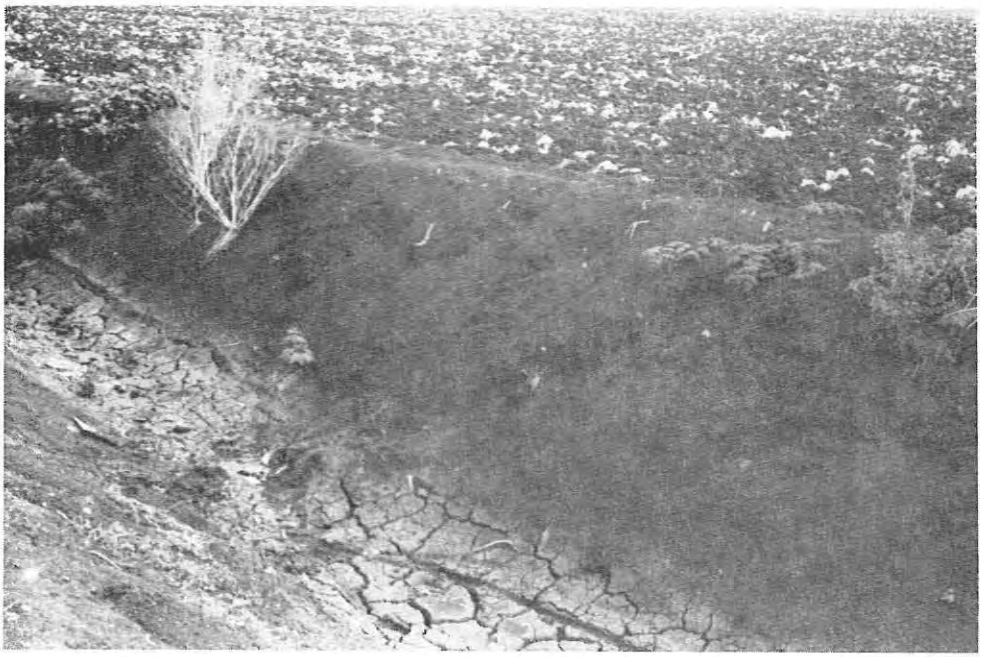


Figure 4.

Figure 5.

Figure 6.

Figure 7.

1985. The crops sampled included cauliflower, broccoli, kale, leaf lettuce, green onions, Napa cabbage, Romaine lettuce, celery, Bok Choy, and head lettuce. No residues of DDT, DDE, or DDD were found on any of the samples at a detection limit of 0.02 to 0.03 ppm. Apparently not all produce grown in soil where low DDTr levels exist will have residues of DDTr. What about the produce in Table II which did show detectable levels of DDTr? If the DDTr found in the analysis were from DDTr incorporated into the commodity during growth, one would expect that residues of DDTr would always be found in every sample which had been grown in DDTr-laden soil, and that residues would be at much higher levels than actually observed. The fact that produce grown in the DDTr-laden soils of the Blanco Drain do not always have DDTr residues, and that when these residues occur, they are at very low concentrations, implies that the source of DDTr residues must be located somewhere other than in the flesh of the commodity. As discussed earlier, DDTr residues have been found on crops which either have edible parts growing in the ground, have fruit which rests on the ground, or have an irregular leaf, stem or stalk structure which will trap soil particles. The commodities listed in Table II all fall into this category. The guidelines for analysis of these products published by the U.S. EPA under Title 40, Code of Regulations, requires that soil particles which would normally be present on the commodity when it is sold not be removed before analysis. It is possible that very small amounts of DDTr-containing soil trapped on the commodity, in the curly leaves of parsley for example, would give a detectable level on analysis but would probably be removed by the consumer during washing prior to consumption. Further investigative work is needed to confirm this hypothesis.

II. 1985 CALIFORNIA SOIL MONITORING SURVEY FOR DDTr

The specific objective of this monitoring study was to collect soil samples from areas in California's agricultural basins, where historic use of DDT was confirmed, in order to establish the range of ratios of DDT to total DDTr and the

range of ratios of o,p' DDT to total DDT. The Agricultural Commissioner in each county located in the agricultural basins was contacted and with the help of information provided by his or her staff members, the degree of known use of DDT in a county was determined. If little or no DDT had been used, or the Agricultural Commissioner could not supply the needed information, soil in the county was not sampled.

For counties that had a history of moderate to high DDT use, the Agricultural Commissioner's staff was asked to provide maps or coordinates that would locate particular fields or general areas where the applications were known to have been made. This information was later used to locate sampling sites.

After the information for all selected counties had been reviewed, a decision was made to collect either two or four soil samples in a county based on the intensity of agriculture, the probable historical use of DDT, and the total land area. When more sites than required were identified in a county, an attempt was made to select sites that were most widely spaced within the county.

Soil samples were collected from individual fields with a known history of DDT application or from fields located in areas known to have had historic widespread and repeated applications of DDT. The fields selected for sampling were all under cultivation although many did not have a crop present at the time sampling was conducted. A total of 99 samples in 32 counties were collected. A generalized map of sampling locations throughout the state appears in Figure 8.

Sampling Plan

For smaller fields (about 10-30 acres), the person collecting the samples walked approximately 50 feet in from the edge, moved in a line diagonally across the

Figure 8. Generalized map of the sampling locations.

field, and collected ten 1-pint soil samples at intervals along the line. Larger fields were sampled at ten points around the perimeter of the field with each sample collected about 50 feet in from the edge. A precleaned trowel was used to remove the top 6 inches of soil from a small area and place it into a clean 1-pint jar. Whenever possible, the soil was taken from a raised planting bed. Soil from the ten jars was combined in a clean three gallon stainless steel pail and thoroughly mixed using the trowel. Two 1-quart jars were then filled with soil, capped with aluminum foil-lined lids and stored at 4°C until analyzed. Each sample was accompanied by a chain of custody form which documented the county, location and date of collection. All samples were collected during April and May, 1985. One quart jar from each sampling site was analyzed by the CDFA laboratory in Sacramento for o,p' DDT, p,p' DDT, o,p' DDD, p,p' DDD, o,p' DDE, p,p' DDE and percent moisture. As a quality control measure, the second jar from 14 randomly chosen sites was also analyzed. As a quality assurance measure , the second jar from five randomly chosen sites was analyzed by the Fish and Game Wildlife Water Pollution Control Laboratory of the California Department of Fish and Game. All results from the quality control and assurance samples showed good agreement with the analysis by the CDFA laboratory. The results of this survey are listed in Table III.

Examination of Table III shows several interesting features. The first is that contamination of agricultural soils in California by DDTr is statewide. All sites sampled had DDTr residues in the soil. The second feature is found on examination of the ratio of o,p' DDT + p,p' DDT to all DDTr species. The ratio varies from 0 to 100 but is 49% on the average (see Figure 9). This means that on the average 49% of the applied DDT is still present as DDT. This figure does not take into account the small amounts of DDD applied as a pesticide. These results are not unexpected. The values listed in scientific literature for the lifetime

TABLE III

Data From 1985 Soil Monitoring Survey for DDTr

County Name	Site No.	% Moisture	o,p' DDT[a]	p,p' DDT[a]	o,p' DDD[a]	p,p' DDD[a]	o,p' DDE[a]	p,p' DDE[a]	Ratio[b] o,p' DDT / (o,p'+ppp')DDT	Ratio[c] DDT / DDTr
Alameda	1	10	8	41	3	3	0	27	13	59
	2	9	202	862	92	210	24	471	19	57
Colusa	1	22	7	35	3	4	2	70	17	35
	2	32	2	9	1	2	3	38	18	20
Contra Costa	1	13	484	2,123	162	376	100	3,750	19	37
	2	1	81	431	9	97	24	465	16	46
Fresno	1	9	50	190	14	36	11	156	21	53
	2	11	20	50	3	7	6	94	29	39
	3	15	47	186	14	34	14	190	20	48
	4	9	195	717	24	NA	40	49	21	39
Glenn	1	22	32	228	25	NA	21	275	12	–
	2	10	15	54	4	10	2	93	22	39
Imperial	1	4	21	83	20	14	8	343	20	21
	2	4	12	32	17	15	5	165	27	18
		(4)[d]	(19)	(36)	(15)	(17)	(4)	(182)	(35)	(20)
	3	7	0	11	2	2	1	21	0	30
	4	1	6	21	4	3	4	97	22	20
Kern	1	8	463	1,586	79	162	68	2,269	23	44
		(8)	(463)	(1,586)	(79)	(162)	(68)	(2,269)	(23)	(44)
	2	6	37	40	0	4	2	51	48	57
	3	5	4	2	0	0	2	3	67	55
	4	6	7	52	0	4	10	76	12	40
Kings	1	2	0	2	0	0	0	2	0	50
	2	13	15	35	2	11	9	89	30	31
Los Angeles	1	10	713	4,168	50	249	34	1,078	15	78
	2	4	2,326	13,740	459	629	654	9,553	14	59
	3	3	2,634	14,566	445	536	642	12,214	15	55
Madera	1	6	1	10	0	0	2	35	9	23
	2	8	0	1	0	0	0	0	0	100
	3	6	2	10	0	0	0	8	17	60
	4	8	26	224	3	25	3	58	10	74
		(8)	(35)	(255)	(5)	(27)	(3)	(69)	(12)	(74)

TABLE III (continued)

County Name	Site No.	% Moisture	o,p' DDT	p,p' DDT	o,p' DDD	p,p' DDD	o,p' DDE	p,p' DDE	Ratio o,p' DDT / (o,p'+ppp')DDT	Ratio DDT / DDTr
Merced	1	5	99	535	18	53	24	1,082	16	35
	2	7	8	30	1	3	1	46	21	43
	3	8	3	12	0	0	0	18	20	45
	4	12	276	1,281	29	168	31	689	18	63
Monterey	1	16	508	1,285	85	186	37	1,116	28	56
	2	11	379	1,303	63	131	35	976	23	58
	3	10	262	926	41	198	16	717	22	55
		(10)	(289)	(1,059)	(36)	(146)	(14)	(719)	(21)	(60)
	4	16	247	879	37	187	26	823	20	58
		(15)	(282)	(911)	(40)	(148)	(16)	(643)	(24)	(58)
Napa	1	11	173	803	133	172	32	1,224	18	38
	2	10	233	1,607	185	179	26	1,046	13	56
Orange	1	7	159	809	74	143	20	538	16	56
		(7)	(150)	(829)	(76)	(124)	(18)	(558)	(15)	(56)
	2	7	23	149	9	25	3	112	13	54
		(6)	(44)	(161)	(11)	(37)	(2)	(114)	(21)	(56)
	3	4	444	1,227	63	284	34	906	27	56
Placer	1	6	405	2,569	62	201	43	2,330	14	53
	2	18	14	129	0	7	0	11	10	89
Riverside	1	1	59	378	12	17	8	581	14	41
		(1)	(52)	(309)	(11)	(21)	(7)	(568)	(14)	(37)
	2	4	63	163	35	20	24	1,219	28	15
	3	2	17	24	9	23	2	60	41	30
	4	0	28	81	7	7	12	311	26	24
Sacramento	1	10	19	83	2	12	1	67	19	55
	2	8	0	0	0	0	0	1	19	0
San Benito	1	23	49	177	7	19	13	214	22	47
	2	15	150	482	31	71	20	693	24	44
	3	16	64	574	52	107	6	518	10	45
	4	18	20	125	4	8	3	215	14	39

TABLE III (continued)

County Name	Site No.	% Moisture	o,p' DDT	p,p' DDT	o,p' DDD	p,p' DDD	o,p' DDE	p,p' DDE	Ratio o,p' DDT / (o,p'+ppp')DDT	Ratio DDT / DDTr
San Bernardino	1	1	3	10	0	0	0	15	23	45
	2	4	58	227	16	25	6	442	21	37
		(5)	(59)	(257)	(9)	(21)	(7)	(442)	(19)	(40)
	3	12	6	44	19	32	6	158	12	19
		(12)	(154)	(880)	(17)	(49)	(13)	(477)	(15)	(65)
	4	4	11	49	23	40	7	221	18	18
		(5)	(142)	(836)	(10)	(47)	(14)	(461)	(15)	(65)
San Diego	1	8	153	976	23	96	10	314	14	72
	2	4	7	31	2	4	1	33	18	49
	3	2	26	90	2	5	2	136	22	44
		(1)	(24)	(87)	(5)	(5)	(2)	(137)	(22)	(43)
	4	0	21	73	7	8	2	120	22	41
San Joaquin	1	4	50	511	26	97	8	289	9	57
	2	5	3	15	0	1	0	19	17	47
San Luis Obispo	1	5	72	322	13	41	7	258	18	55
	2	9	144	605	21	82	10	384	19	60
	3	21	606	2,661	124	370	52	1,686	19	59
	4	15	680	3,484	220	455	105	3,326	20	52
Santa Barbara	1	2	289	1,602	35	166	11	494	15	75
	2	2	444	2,121	47	179	11	627	17	75
		(2)	(361)	(1,706)	(34)	(133)	(15)	(516)	(17)	(75)
	3	8	19	101	2	5	2	84	16	56
		(6)	(21)	(116)	(2)	(10)	(2)	(94)	(15)	(56)
Santa Cruz	1	20	830	3,802	170	719	55	1,340	18	67
	2	18	910	3,438	96	411	44	1,446	21	69
	3	19	1,658	4,766	248	852	104	3,019	26	60
	4	14	129	989	98	159	12	758	12	52
Solano	1	9	22	93	5	12	4	168	19	38
	2	11	1	6	0	0	0	4	14	64
Sonoma	1	13	2	15	3	6	0	23	12	35
	2	7	154	853	563	247	31	516	15	43

TABLE III (continued)

County Name	Site No.	% Moisture	o,p' DDT	p,p' DDT	o,p' DDD	p,p' DDD	o,p' DDE	p,p' DDE	Ratio o,p' DDT / (o,p'+ppp')DDT	Ratio DDT / DDTr
Stanislaus	1	5	26	79	5	NA	13	65	25	36
	2	5	90	208	0	0	13	185	30	60
	3	8	41	252	7	36	11	250	14	49
	4	4	3	8	0	0	7	11	27	38
Sutter	1	17	0	2	1	2	0	4	0	22
	2	16	2	13	16	13	3	54	13	15
Tehama	1	12	68	267	10	42	14	185	20	57
	2	13	6	155	3	NA	8	61	4	-
Tulare	1	6	3	33	1	3	1	48	8	40
	2	7	14	132	6	15	1	104	10	54
	3	9	17	84	6	10	3	187	17	32
	4	12	27	131	7	7	18	35	17	70
Ventura	1	4	321	1,347	40	160	29	828	19	61
	2	2	182	466	30	99	10	379	28	56
		(2)	(184)	(445)	(27)	(89)	(9)	(367)	(29)	(56)
	3	5	230	1,384	87	301	24	842	14	60
		(5)	(277)	(1,688)	(88)	(340)	(27)	(716)	(14)	(63)
	4	2	322	1,093	25	99	22	847	23	59
Yolo	1	11	9	20	5	4	4	112	31	19
	2	4	13	90	5	11	4	17	13	74

a. all values in parts per billion (dry weight)

b. all values times 100 (in percent)

c. ratio of sum of DDT isomerrs (o,p' + p,p') to sum of DDT + DDD + DDE isomers (o,p' + p,p') times 100 (in percent)

d. values in parentheses are from analysis of duplicate sample collected at same site

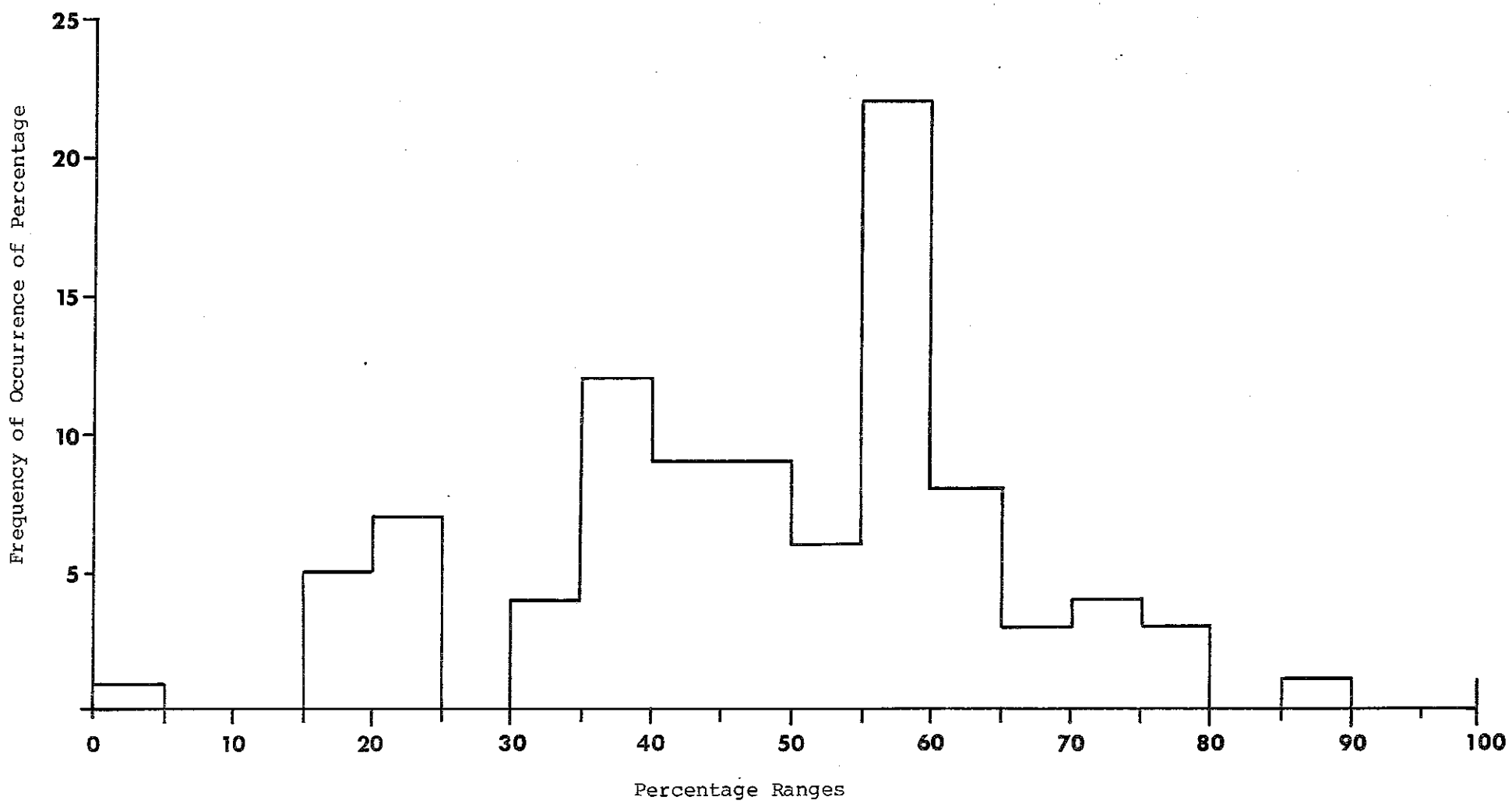


Figure 9. Percentage of o,p' and p,p' DDT in Total DDTr Residues for All Counties Sampled.

of DDTr species in soil vary greatly but are usually 15 or more years.[11] The third feature is found when one examines the ratio of o,p' DDT to o,p' DDT + p,p' DDT. As stated earlier, this ratio was usually from 20 to 30% when the DDT was applied. Examination of Table III shows that, for most sites sampled, this ratio is still close to the value on application. The average value for this ratio is 19% in this survey (see Figure 10). These levels of o,p' DDT are not unexpected for soils. The scientific literature shows that the o,p' isomer of DDT can be, and often is, longer lived than the p,p' isomer in the environment of soil.[12] The same scientific literature also shows that the o,p' isomer seems to be shorter-lived in the aquatic environment than the p,p' isomer. The argument has been made by some that a comparison of the ratios of the concentrations of various DDTr isomers could be used to show how recently an application of DDT had been made. Clearly with both extremes occurring, o,p' and p,p' DDT long-lived in soil and short-lived in aquatic sediment, and with all the possible combinations of these extremes which can occur, such use of these ratios is tenuous at best. Additionally, since values of the o,p' isomer in soil of around 19% were the norm and not the exception, if illegal use of DDT is occurring it is on a statewide scale occurring everywhere at once. Such widespread illegal use could not occur without detection.

III. CONCLUSIONS

Based on all evidence examined, the following conclusions can be made about agriculturally-related DDTr residues in the California environment.

1. DDTr residues can still be detected in California soils some thirteen years after the last use of DDT and DDD on those same soils.

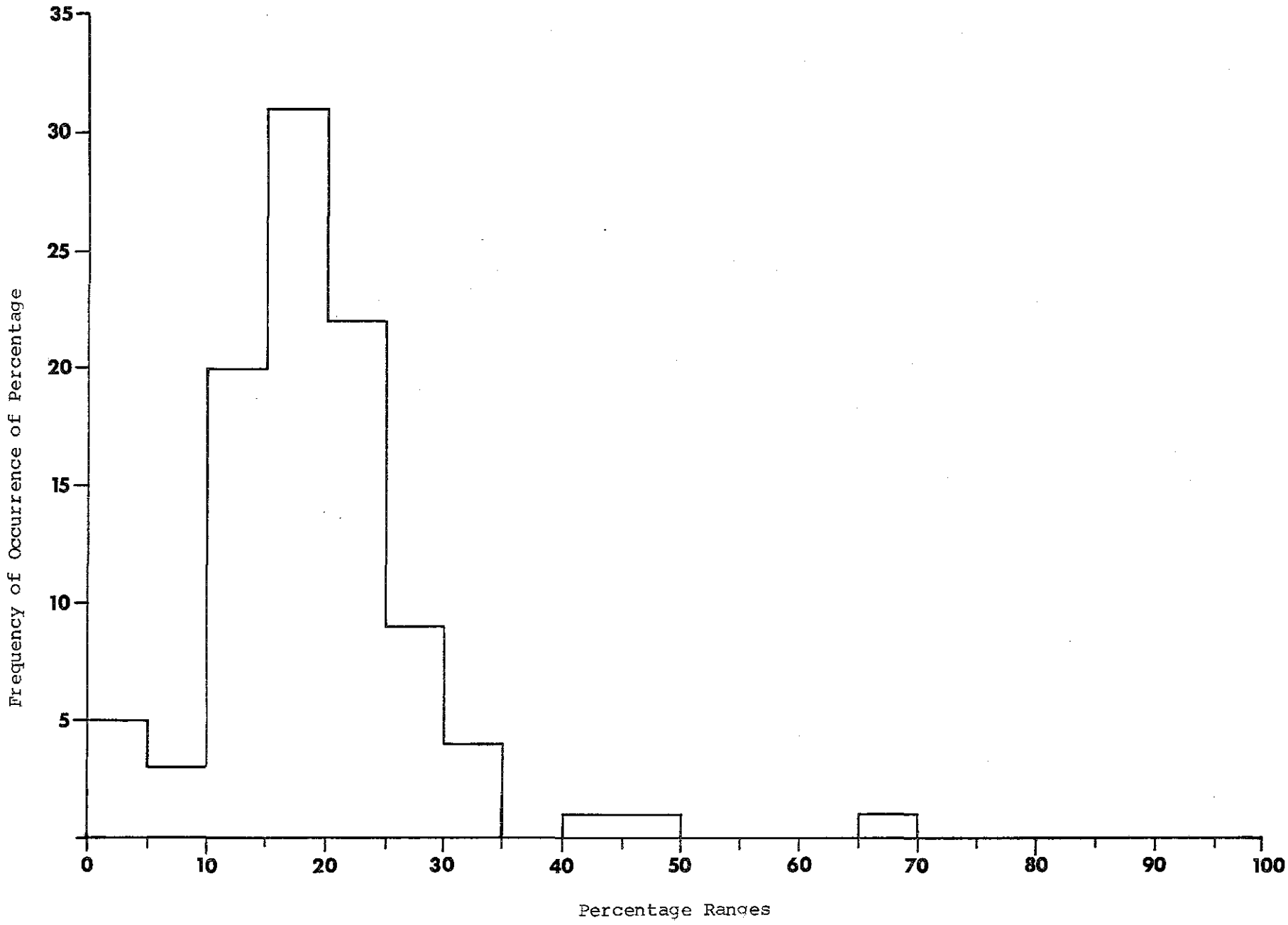


Figure 10. Percentage of o,p' DDT in Sum of o,p' DDT and p,p' DDT For All Counties Sampled.

2. The presence of DDTr residues is widespread throughout California in soils with a history of DDT usage. Every one of the 99 sites in 32 counties tested showed detectable levels of some DDTr species.

3. Continuing surveillance and monitoring by the CDFA and the California Agricultural Commissioners has found no evidence of new, illegal usage of DDT or DDD.

4. Dicofol usage in California is not a significant source of DDT residues. Further reductions in DDTr contamination levels by the manufacturer, targeted for 1987, will further reduce the contribution of dicofol to DDTr levels.

5. An examination of the percentage of DDT to total DDTr in the soil samples collected from 32 California counties shows that the average is 49% with the largest number of samples having values below 60%. This distribution is consistent with a pattern of residuals from past applications. If DDT were being used now in these areas, the distribution would be shifted towards higher percentages.

6. An examination of the percentage of o,p' DDT isomer to total DDT in the soil samples collected from 32 California counties confirms the findings of the Blanco Drain/Monterey County study. The lifetime of o,p' DDT in the soil environment of California is at least equal to, and in some cases greater than, the lifetime of the p,p' DDT isomer in the same soil. This conclusion is confirmed by results in the scientific literature which show that indeed o,p' DDT has a longer lifetime than p,p' DDT in some cases.

7. The most likely source of DDTr levels in fish samples collected by the SWRCB from the Salinas River is erosion or mechanical movement of DDTr laden soil particles into the waterway. The DDTr in these soil particles then moves into the fish via food chain or direct entrapment of soil particles in the gills. A similar mechanism may be responsible for DDTr levels in fish in other rivers around the State.

8. The most likely source of DDTr residues found in California produce is the long lived residues from past applications to the soil in which the produce is grown.

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APPENDIX I

House Resolution No. 53

By Assembly Member Connelly:

Relative to pesticides.

WHEREAS, The pesticide dichloro-diphenyl-trichloroethane (D.D.T.) is an extremely toxic substance which accumulates in human fatty tissues, which is highly toxic to aquatic life, and which is linked to the severe thinning of eggshells of marine bird species, including some endangered species; and

WHEREAS, D.D.T. persists in the environment once it is released; and

WHEREAS, Data released over the past five years by the State Water Resources Control Board shows D.D.T. continuing to be found in fish in California waterways; and

WHEREAS, Levels of D.D.T. found by the board exceed public health action levels and guidelines for fish and wildlife protection in at least one state waterway; and

WHEREAS, An independent study of pesticides in food, released in March 1984, found D.D.T. residues in fruits and vegetables; and

WHEREAS, D.D.T. has been banned in the Uned States since 1972; and

WHEREAS, State officials are uncertain of the source of D.D.T. currently in the environment; and

WHEREAS, D.D.T. now in the environment could be residue from its pre-1972 use, could be entering the United States environment from Mexico or other foreign sources, or could be the result of past illegal disposal sites or illegal use of the substance; now, therefore, be it

Resolved by the Assembly of the State of California, That the Department of Food and Agriculture immediately begin an investigation to ascertain the source of D.D.T. in the environment; and be it further

Resolved, That the department report to the Assembly on the results of the above investigation within one year from the date this resolution is approved.