PART TWO

# BACKGROUND ON HISTORY OF PESTICIDE USE AND REGULATION IN THE UNITED STATES

## A. Historical Emergence of Pesticide Technology

### 1. Purpose

The purpose of this section is to trace the emergence of pest control technology, with special reference to pesticides as they have been developed and come into use in our society. A table is presented which traces a time line of some of the more important or landmark developments in pest control technology, often in other nations, which led ultimately to new or changing usage of pesticides in the U.S. This section is intended to be illustrative of trends in developments, not to be exhaustive of all emerging technology.

### 2. Types of Pest Control

It may be useful to briefly note the various types of pest control, so as to place control by pesticides in proper perspective. Although controls vary greatly among the various types of pests (insects, plants, fungi, vertebrates, etc.), one can identify some basic categories of pest control such as follows:

a. Mechanical control--involving physically preventing the pest from causing the damage by removing/isolating the pest from the site of attack or by physically debilitating the pest. Includes legal control through quarantine.

b. Biological control--other organisms control pest or render harmless.

c. Host/target resistance--development of plant or animal resistance to attack by pest organism, including manipulation of genetics, etc. (can be considered a form of biological control in some cases).

d. Chemical control--use of chemical pesticide to obtain desired effect on pest.

Generally speaking, the chemicals used for pest control are considered pesticides and are so regulated in the U.S.. However, the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) [1] causes certain "biologicals or organisms" to be regulated as pesticides. The principal focus of this report is on those chemicals which are considered pesticides, which account for most of the use of chemicals for "chemical pest control" in the U.S.

Another way of looking at pest control is whether it is preventative or curative (Martin, p. 8). Preventative methods operate on or protect the host/target from anticipated or possible attack, while curative methods endeavor to stop or mitigate pest damage after there is an attack.

Pesticides can be used in either mode, such as prophylactically to prevent pest attack or after the pest is present and is expected to cause damage at economic threshold levels, i.e., where, in simplest terms, the value of the damage avoided by treatment exceeds pest control costs. Usage of pesticides by either the preventative or curative approach (or both) can be prudent (in line with economic thresholds), i.e., not wasteful. In any case, there is some uncertainty as to whether usage is justified. The uncertainty tends to be greater for preventative applications because of difficulty/costs in projecting future pest infestation/damage levels in the absence of preventative treatment. For this reason, curative treatments are often viewed as less likely to be wasteful, even though that may or may not be the case in a given situation.

## 3. Historical Time Line for Pest Control

One author has begun a book by stating: "The history of man is the record of a hungry creature in search of food."(Stakman, E. C., p.3) This is obviously a gross oversimplification, but it cannot be denied that an adequate supply of food is of fundamental importance and has been a preoccupation (if not occupation ) of mankind going back to earliest times. Man struggles to obtain adequate supplies of food (and fiber) against all the elements, including pests of various sorts which reduce the quantity and quality of output, by physical damage, disease, etc. Aside from pests interfering with production of food (also fiber, other goods and services), pests cause damage by spreading disease and as nuisances by their mere presence where man does not want them.

Through the ages, it seems, increasingly, that people find a need to minimize the existence and/or damage of pests, with the use of pesticide chemicals and by other means noted above. Some of the factors that lead to increased need for pest control are: development of succulent crops attractive to pests, e.g., high sugar content of fruits; large acreage/mass production of monoculture crops which

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[1] FIFRA originally became law on June 25, 1947 and has been amended several times since. See:EPA report published March, 1997 (730L 97001) which contains FIFRA and applicable sections of FFDCA as amended by the Food Quality Protection Act of 1996 (FQPA).

facilitates pest development; widespread incursion of people  into new areas occupied by pests not formerly interacting with man; use/development of plants/animals susceptible to pest damage; mobility of people and commerce leading to importation of pests without natural controls; expectations of people that there should be a minimum of interference from pests; and adaptation of pests to chemical and other control measures.

Presented in Table 2-1 is a listing of developments relating to pest control and pesticides in particular, ranging form prehistoric times to the present.  In looking over the listing, one realizes there has been a rapid acceleration in the rate of pest control developments as time passed.  For hundreds of years earlier on, few noteworthy things happened.  On the other hand, during the last 100  years, especially the last 50 years,  pest control has been revolutionized.

Table 2.1 Historical Time line for Pesticide-related Developments

| CIRCA/YEAR | PESTICIDE DEVELOPMENT | REMARKS | REFERENCE |
|---|---|---|---|
| ----BC | Early stone tablets said to have referred to red squill as a rat poison | | Shepard, p.4 |
| 12000BC | First records of insects in human society | | Jones, p. 309 |
| 8000BC | Beginnings of agriculture | Cereals provide staple diet, storage from one harvest to next, established villages | Jones., pp., 309-10 |
| 2500 BC | Ancient Sumarians use sulfur to control mites/insects | | Jones, p. 321 |
| 1200 BC | Biblical armies sowed conquered fields with salt and ashes to make land unproductive | Probably first non-selective pre-emergent herbicide | |
| ---- BC | Romans applied hellebore for control of rats, mice and insects | One of earliest poisons | Shepard, p. 4<br>Frear, p. 41 |
| 1000 BC | Homer refers to the use of sulfur compounds | | Shepard, p. 4 |
| 324 BC | Chinese use ants in citrus groves to control caterpillars | Early use of biocontrol or IPM | Shepard, p. 4 |
| AD------------ | | | |
| 70 | Pliny the Elder notes the use of gall from green lizard to protect apples from worms and rot | Early use of organic chemical | |
| 900 | Chinese use arsenic to control garden insects | Early use of inorganic stomach poison as pesticide | Shepard, p. 4 |
| 1300 | Marco Polo writes of the use of mineral oil against mange in camels | | Shepard, p. 4 |
| Circa 1300 | Marco Polo is claimed to have brought Pyrethrum to Europe as a wondrous compound of secret origin | Pyrethrum biological extract still in use; inspired modern synthetic pyrethroids | Mrak, p. 44 |
| Several centuries | South American natives use sabadilla plant preparations as louse powders | | Mrak, p. 44 |
| 1669 | Earliest use of arsenic as insecticide in Western World | Honey ant bait | Shepard, p. 4 |
| 18th century | Petroleum, kerosene, creosote and turpentine introduced as insecticides | | Frear, p. 120<br>Mrak., p.44 |
| As early as 1763 | Ground tobacco recommended in France to kill aphids | | Mrak, p. 44 |
| 1787 | Soap mentioned as insecticide and turpentine emulsion recommended to kill/repel insects | | Shepard, p. 4 |
| 1809 | Nicotine discovered in France to kill aphids | | Mrak, p. 44 |

Table 2.1 Historical Time line for Pesticide-related Developments

| | | | |
|---|---|---|---|
| 1825 | BHC produced by Michael Faraday | But insecticidal properties not known | Ordish, p. 131 |
| As early as 1848 | Rotenone used as insecticide | Usage not common until 1920's, expanding greatly in 1930's | Mrak, p. 45 |
| 1867 | Unknown inventor discovers that the dye Paris Green killed insects | For chewing insects | Shepard, p. 4 |
| 1860's | Paris Green (arsenical) used to control Colo. potato beetle in Rocky Mountain Region, as inorganic chemicals emerge as pesticides | | Shepard, p. 6 |
| 1873 | DDT first made in a laboratory (Otto Ziedler) | But insecticidal properties not discovered until 1939 | Ordish, p. 152 |
| 1882 | Bordeaux mixture discovered in France to control plant diseases | Mostly copper sulfate; became mainstay for many years | Shepard, p. 5 |
| 1883 | John Bean invents pressure sprayer to apply pesticides, leading to fire engine mfg. by FMC | Key development leading to efficient applications to crop surfaces | |
| 1877/78 | Kerosene emulsified in soap developed to kill sucking insects | Prof. John Cook, Mich. Ag. College. | Perkins, p. 5 |
| 1886 | Inorganic lime sulfur washes introduced to control scale insects in California; also fumigation with hydrogen cyanide introduced | Hydrogen cyanide led to one of first instances of insect resistance to a chemical | Shepard, p. 5 |
| 1892 | Lead arsenate discovered as control for gypsy moth in Massachusetts | F.C. Moulton, MA State Bd. of Ag. | Perkins, p.5 |
| 1893/1906 | Lead arsenate found to be effective against many insects and usage of home-made preparation expands | Widely accepted by home gardeners | Perkins, pp. 5-6 |
| 1894/1900 | Steam/mechanical/horse driven spray equipment developed | Permitted larger-scale field applications | Ordish, p. 118 |
| 1901<br><br>1908 (Revised version) | USDA issues Farmer Bulletin 127 containing recommendations for preparation and use of arsenicals (Paris Green, copper arsenite, arsenite of lime, London purple, lead arsenate) for chewing insects. | For sucking insects, it recommended soaps, pyrethrum, tobacco decoction, sulfur and petro. oils. Resin and lime-sulfur was for scale. | USDA F. Bul. 127 |
| 1907/1911 | Chemical industry begins production of lead arsenate; home manufacture no longer recommended | Usage reaches 40 mil. lbs. by 1934 | Perkins, p. 6 |
| 1910's/1920's | USDA tests/recommends chemicals for animal dips and disinfectants | Chemicals include carbolic acid, chloride of lime, sulphur, pet. oils, nicotine, creosote and arsenicals | Whitaker, pp.72/72 |
| 1921/22 | First airplane field application of insecticides (cotton, La., 1922) | Ohio experiments in 1921 | Shepard, p. 5 |
| 1913/1915 | Organic mercury compounds introduced in U.S. from Germany as seed treatments | Mercurial fungicides were widely adopted for fungi/disease control by late 1920's. | Frear, p. 170<br>Ennis.., p. 109 |

Table 2.1 Historical Time line for Pesticide-related Developments

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|---|---|---|---|
| 1920's/mid-1930's | Calcium arsenate dust developed by USDA found to be effective against boll weevil, but chemical is toxic to many plants | Usage quickly adopted for usage in cotton, potatoes and tomatoes, plants that would tolerate its toxic properties. Usage reaches approx. 30 mil. lbs. by 1934 | USDA Yearbook, 1920, pp. 241 ff.<br><br>Perkins, p. 6 |
| 1928 | Sodium chlorate tested at rates of 200 lbs. per acre to control Johnson grass | Landowners desperate for controls of the pest in South | Harper, p. 417 |
| 1928 | Ethylene oxide patented as insect fumigant | | Shepard, p. 6 |
| 1930 | Yearbook of Agriculture recommends poisoning lawns with lead arsenate for beetle/grub control | Use 100 lbs. lead arsenate for 3,000 sq. ft., 3 inches deep | USDA, 1930, pp. 348-49 |
| 1932 | Methyl bromide first used as fumigant (France) | | Shepard, p. 6 |
| 1932/39 | Search by Swiss firm, Geigy, (Dr. Paul H. Mueller) for insect controls/seed disinfectants results in discovery of DDT | Compound had extraordinary killing power and duration outdoors, exposed to weather; Mueller won Nobel prize. | Perkins, p. 169<br><br>Perkins, p. 10 |
| 1940 | BHC insecticidal properties discovered in France and England | | Jones, p. 322 |
| 1941/42 | DDT used on crops and for human lice control in Switzerland | Geigy makes DDT available to other countries | Perkins, p. 11 |
| 1942 | Liquefied gases used for aerosol propellant for pesticide application | | Shepard, p. 6 |
| 1942/45 | DDT made available for use in U.S., military use first; civilian and agricultural use by July, 1945; prevented typhus plague in war-torn Europe | USDA and War Production Board controlled the chemical's introduction | Perkins, p. 20 |
| 1944 | Phenoxy acetic acids discovered as first selective herbicides, typified by 2,4-D | Followed discovery of selective herbicidal activity of certain dinitro dye compounds in France in 1930's; revolutionized broad leaf weed control in U.S. | Ennis.., p. 107 |
| 1946 | Organic phosphate insecticides of German invention made available to American producers | | Shepard, p. 6 |
| 1945/53 | Numerous important synthetic organic insecticides come on U.S. market (two dozen chemicals or more) | Chemicals included chlordane, BHC, toxaphene, aldrin, dieldrin, endrin, heptachlor, parathion, m. parathion and TEPP, leading to widespread soil applications as well as broadcast/aerial | EPA registration files |
| 1949 | Captan, first dicarboximide fungicide introduced | | |
| 1940's | D-D mixture discovered to have value as nematicide | Much more cost effective than other chemicals, leading to expanded usage | OPP registration files |
| 1950's/60's | Formulation developments, particularly granulars (along with numerous new chemicals) lead to adoption of soil applications of insecticides and herbicides on major crops | Corn, sorghum, soybeans and cotton become major users of pesticides rather than fruits/vegetables | |

Table 2.1 Historical Time line for Pesticide-related Developments

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|---|---|---|---|
| 1965 | Atrazine registered as herbicide (heterocyclic nitrogen type) | Break through in control of broad leaf and grassy weeds in corn/sorghum and other crops | OPP registration files |
| 1969 | Alachlor registered as herbicide (amide type) | Mainly for grass control | “ |
| 1972 | Bacillus thuringiensis (Berlinger) (Bt), a biological, registered as an insecticide | Led way toward more related Bt registrations and biologicals more generally | “ |
| 1974 | Registration of glyphosate as herbicide | Important because first modern systemic non-selective herbicide with quick inactivation in soil | “ |
| 1979 | First of synthetic pyrethroids registered as insecticides (fenvalerate and permethrin) | Greatly reduced application rates, replacing older chemicals with regulatory and resistance problems | “ |
| 1985 | Registration of urea-based herbicides, including sulfonylureas | High efficacy at lower application rates by an order of magnitude. | “ |
| 1994 | Registration of imidacloprid as first of nicotinoid insecticides | Nicotine based insecticides have great potential | “ |
| 1990's | Accelerated registration of biologicals and safer pesticides | 50 percent or more of new AI’s registered in mid to late- 1990's | OPP Annual Reports, recent years. |
| 1997 | Fipronil registered as systemic insecticide of fiprole type | Likely to be important type of insecticide in 2000 and beyond | OPP registration files |

Pests were identified as problems going back to 2500BC and earlier, leading to chemical controls, or pesticides as we now refer to them. In these earliest times, pests were not well understood and controls were quite crude, if effective at all. There was some usage of chemicals, along with mechanical and biological methods. Existing chemicals, such as arsenic, plant extracts, sulfur and mineral oil were identified as useful in pest control. Ritual, religion and magic were also engaged. (Ordish, 1976, pp.28 ff.) From time to time, church officials took actions such as excommunication or banishment of pests to deal with pest problems of the day. This is understandable, given some of the Bible stories about pestilence attributed to God, such as visitation of locust plagues upon the Egyptians.

Science was not used in any organized or rigorous manner to address pest control problems until the rise of the scientific method (generally associated with Francis Bacon), and its application particularly by the beginning of the 18th Century. More was learned about pests and chemicals resulting in identification of petroleum, turpentine, nicotine and rotenone as pesticides. BHC (benzine hexachloride) was produced as a chemical (Faraday, France, 1825), later to be discovered to have broad application as an insecticide (1941/42). Apparently, knowledge of pests and control technology took a remarkable step forward with the publication of a book entitled “Farm Insects” in 1860, written by John Curtis (Ordish, 1976, p.5), which ushered in a new period in pest control.

From about 1860 until the advent of DDT in 1942, there was widespread identification of inorganic and natural organic chemicals for control of insects and plant diseases (fungi). Little progress occurred in chemical control of weeds. The chemistry of arsenicals was further exploited to control insects (Paris Green). Bordeaux mixture (copper sulfate and lime) was found to be very useful in the control of plant diseases leading to widespread usage. The pressure sprayer (hand and power driven) was invented, making efficient large scale application of pesticides feasible and economical. Aerial application was also invented (early 1920's) leading to expanded applications in agriculture.

The availability of DDT, starting in 1945 for civilian/agricultural usage, opened a new era of pest control, leading to not only its extensive usage, but the development of numerous other synthetic organic insecticides, e.g., organophosphates (1946). About the same time (1944), selective synthetic organic herbicides were discovered, starting with 2,4-D which revolutionized weed control in agriculture and elsewhere. Also, synthetic organic fungicides (metal based) were developed as effective controls of plant diseases (and for other applications). During the 1950's and 1960's, granular pesticide formulations were developed, which led to large expansions of pesticide usage on the major field crops.

Prior to the advent to DDT ( and other organic pesticides which rapidly followed), most pesticides used in agriculture were applied to protect high value/small acreage crops, principally fruits, vegetables and cotton. This however, this changed dramatically starting in the 1950's, as major field crops, ( e.g., corn, sorghum, grains and soybeans) quickly came to account for a majority of pesticide usage.

By the 1960's, some very important new families of chemicals were discovered as herbicides (e.g., triazines, acetanilides and dinitroanilines). In the 1970's, the synthetic pyrethroids came on to replace much of the insecticide chemistry developed during the previous 20 years. During the 1980's, imidazolinone and sulfonylurea herbicides came on to dramatically lower application rates for weed control.

During the 1990's, new, powerful, chemistries have come forward and more will do so by the Millennium. There is heavy emphasis in industry, user groups and at EPA in the registration and usage of biologicals and "safer" pesticides, along with enhanced stewardship in use of available pesticides.

B. Overview of Pesticide Regulatory History in the U.S.

1. Purpose

This section provides a brief survey of national policies and laws which have been involved in the social regulation of pesticides in the U.S. during the last century. Regulation of pesticides is an integral part of the overall environment in which pesticides are developed, produced and used in the U.S. The paragraphs below chart a trend in national policies/laws starting from limited objectives, primarily protection of farmers from adulterated/ineffective products, and ending today with comprehensive objectives, including human health and environmental protection, as well as pesticide user protection.

2. Prior to 1947

The regulation of pesticides was given very little attention from earliest times until around the Turn of the Century. The pesticide chemicals in use were old chemicals with which people were quite comfortable (e.g., sulfur, petroleum, lime, arsenicals) and there did not seem to many concerns with the chemicals requiring regulation, other than from the point of view of consumer (user) protection. Reports of the Commissioner of Agriculture (today's equivalent to the Secretary of Agriculture) going back to the immediate Post-Civil War do not reveal regulatory attention to pesticide chemicals other than checking them for chemical content and development of recommendations for their use in pest control, the latter being done extensively.[2] For example, the Commissioner of Agriculture in 1865, Isaac Newton, reported to His Excellency Andrew John son, President, the following:

> "The field open for chemical science never was so great as the present time. Chemistry being indeed the life and soul of an intelligent, rational agriculture, the governments of Europe--

[2] The U.S. Department of Agriculture is the logical agency in the Federal government to be concerned with pesticides, as it was so designated early in the 20th Century, until 1970, when EPA was formed and agriculture early on (and now) accounts for a majority of pesticide usage in the U.S.

> Germany, taking the lead-- impressed with this unquestionable fact, have established experimental stations, consisting of an experimental garden and complete analytical laboratory. The chemist, provided with assistants, institutes on the spot, such original experiments, and tests such theoretical problems in reference to agriculture as seem most prolific of benefit to the farming community and the world at large... Thus every one may gradually be prepared to receive and profit by the rich stores of science open to every intelligent farmer." (page 7)

He goes on to highlight the progress along these lines in Germany (page 7), which no doubt was a factor (if not model) in setting up the Land Grant University system in the U.S. under legislation passed on July 2, 1862 (noted on page 140). The report (and others issued in later years) focuses heavily on efforts to improve agricultural crop production and control of pests including a section on weeds. (Commissioner's Report, 1865)

Toward the end of the 19th Century, the usage of pesticides began to be more common and widespread and Congress became alarmed at developments leading to the passage of the Insecticide Act in 1910. This Law was aimed at helping protect farmers against fraud as they purchased insecticides, often by mail or from itinerant dealers. At that time, many of the pesticides were actually prepared (formulated) by the farmer for use. The pesticide industry, as we now know it, did not begin to emerge until later. The Insecticide Act of 1910 appears to be the beginning of serious pesticide regulation in the U.S. although the Food and Drug Act of 1906 establishes jurisdiction over food treated with pesticides and traded in interstate commerce (NAS, p. 95)

Passage of the Food and Drug Act of 1906 occurred as public concerns for the wholesomeness of food supplies took a major turn when Upton Sinclair's book, "The Jungle", was published the previous year. It highlighted problems with the safety of the food supply, particularly that produced by the meat packing industry and wholesomeness as related to sanitation, product quality and handling practices. Pesticide residues were not an apparent major concern at the time. Nevertheless, the Insecticide Act of 1910 provided for establishment of tolerances for specific insecticides, which was done later by regulation, primarily for arsenic and lead on apples and pears. (Odom, p.293) The principal chemicals regulated were Paris green, pyrethrin and Bordeaux mixture. (Kenaga, p. 189) Other types of pesticides were not covered, e.g., chemicals used as fungicides, which were quite common by that time.

The next major development was passage of the Federal Food, Drug and Cosmetic Act (FFDCA) in 1938, which provided for tolerances to be established for chemicals including pesticides, primarily arsenicals such as lead arsenate and Paris green. The Act required that color be added to the formulations to prevent their misuse and set tolerances for residues in food where these materials were necessary for production of the food supply. (Grodner, p. 3) The protection of the wholesomeness of food supplies dates back many centuries in the Western World. For example, Ms. Grodner makes the point by the following piece in her paper:

With a sword to his neck, King John of England signed the Magna Carta in June 1215AD but it was not until 1265AD that the first Parliament was elected. Prior to the election of the Parliament, Guilds made the rules necessary for a civilized society. In about 1236 AD, a rule was passed that forbade the addition of anything to the food supply which was "not wholesome". This was probably the first rule regulating the food supply, especially food additives. (Grodner, p. 2)

3. 1947 to Date

The 1910 and 1938 Acts did relatively little but set the stage for passage of the Federal Fungicide, Insecticide and Rodenticide Act (FIFRA) in 1947, as the synthetic organic pesticide industry was in its take off stages. Dramatic increases in production and usage of such chemicals as DDT, BHC, dithiocarbamic fungicides and 2,4-D were occurring and it was apparent there was a need to update pesticide regulation. FIFRA replaced the Federal Insecticide Act of 1910. Among other things it expanded coverage to all pesticides (not just insecticides) and required that all pesticides be registered with the U.S. Department of Agriculture (which had responsibility for pesticide regulation, going back to the 1910 Act).

FIFRA maintained the function of protecting against ineffective or dangerous products from a farmer or other user's standpoint and labels were to be approved by USDA before products were sold. Products were to be safe when used as directed by the label. The 1947 Act was primarily a labeling act, providing no sanctions for misuse, no authority for immediate stop-sale orders against dangerous pesticides and limited penalties for companies selling such products. (Briggs, p. 279) Also, a company could obtain a "protest registration" and sell the product even if USDA would not register it, which was done for a number of products. (Briggs, p. 279) These were major defects in FIFRA and were changed by amendments in later years (Miller, p. 435) FIFRA was later amended to add federal registration number as part of registration of pesticides (1959), include warnings on labels (1961) and remove safety claims from labels (1964).

Meanwhile, there was legislative action amending FFDCA during the 1950's related to pesticides. The Miller act (1954) amended FFDCA to give FDA responsibility for monitoring food for residues and provided a new mechanism for setting tolerances of pesticidal residues in foods.. Then, in 1958, the Delaney Clause was passed by Congress, amending FFDCA to prohibit any pesticide additives "found to induce cancer when ingested by man or animal". The purpose of the 1954/58 amendments to FFDCA was to give FDA authority to condemn raw agricultural commodities, processed foods and animal feeds if they contained any pesticide which had not been approved for use or in amounts above tolerance. The 1958 amendment (Delaney Clause) was quite controversial, as it essentially set a zero tolerance for any chemical with cancer activity. This basically was in conflict with FIFRA starting with its 1972 amendments (discussed below), which provided for "risk/benefit balancing" under the "unreasonable adverse effects criterion", and ultimately led to amendments in 1996, repealing the Delaney Clause.

Pesticides were not a major concern during the 1950's and early 1960's; and USDA was under limited pressure to tighten regulation of pesticides. USDA lost a pesticide fraud case and was successful in persuading Congress in 1964 to allow denial of registrations (or cancellation) for reasons of safety or effectiveness, with the burden of proof switched to the registrant rather than USDA, as under the original FIFRA. Despite the new authorities, USDA's Pesticide Regulation Division was not prepared for the job of dealing with pesticides as their numbers and usage expanded and as there were increasingly vocal demands from the public for enhanced protection of human health and the environment. The result was that the responsibility for administering FIFRA was transferred to EPA which was created by Executive Order of President Nixon on December 2, 1970. (Miller, p. 435-36)

Pesticides were an issue at the forefront of the environmental movement leading to the establishment of EPA. The publication of Rachel Carson's book "Silent Spring" in 1962 dramatized the risks of DDT (and other pesticides) and helped crystallize the publics' concerns in general about chemicals contaminating the air, water, wildlife and food supplies (and as found as residues in human tissues). In 1963, the President's Science Advisory Committee issued a report entitled "The Use of Pesticides" which called for reduced use of pesticides, especially the persistent ones. Similarly, in 1969, the HEW Secretary's Commission on Pesticides and Their Relationship to Environmental Health ("Mrak Commission", as it was known) issued its report recommending elimination of DDT and DDD usage (except essential public health uses) due to their adverse effects and restricting other persistent pesticides to "essential uses" which create no known hazard to man or the environment. (Mrak, pp. 8-9) ( See also, NAS, p. 96)

Congress responded to heightened concerns about pesticides and amended FIFRA in 1972, changing it to an environmental protection statute, addressing human health and environmental protection aspects, as well as maintaining the traditional role of protecting the user from unsafe/ineffective products, dating back to the 1910 Act. The 1972 amendments were a major rewriting of FIFRA. Among other things, they strengthened enforcement provisions, provided greater flexibility in controlling dangerous chemicals, extended scope of federal law to cover intrastate registrations, set up categories of registrations (e.g., general, restricted use), streamlined administrative appeals processes, dealt with trade secrets/data sharing issues and called for reregistrations for old pesticides.

The key operative criterion of the Amended FIFRA is "unreasonable adverse effects on the environment", which is defined as "any unreasonable risk to man or the environment, taking into account the economic, social and environmental costs and benefits of the use of the pesticide". This broad, flexible, mandate was used successfully to take many pesticides off the market during the 1970's and 1980's starting most notably with the organochlorine insecticides, such as aldrin, dieldrin, chlordane, heptachlor and kepone. (EPA, Feb., 1990) The cancellation of DDT was taken (January, 1971) and finalized (July, 1972) under FIFRA prior to the 1972 amendments which were in October, 1972.

In the years 1975, 1978, 1980 and 1981, there were amendments to FIFRA which amounted to refinements to the basic law. They related primarily to enhanced penalties for misuse, pesticide classification, registration/inspection of pesticide plants and scientific evidence proving performance and safety of pesticides.

During the 1980's and 1990's, EPA actively pursued special reviews of problem pesticides resulting in a number being removed from the market. The Agency struggled mightily with its mandate to reregister all old/existing pesticides by particular target dates (as early as 1976). But as of the late 1980's and again in 1996, reregistration could not be expected to be completed until far into the Millennium according to available schedules. Amendments in 1988 helped some by providing fee revenue to enhance resources available to EPA to fund the Pesticide Program and by related measures. But reregistration was still not proceeding at a rapid rate. Largely as a result of this, Congress passed the Food Quality Protection Act of 1996, which was designed to expedite the reregistration process, and at the same time, pay particular attention to protecting the safety of food supplies for all identifiable groups (such as infants and children). Among other things, FQPA provides for:

- A new safety standard for all pesticide residues in food (reasonable certainty of no harm), considering exposure from all sources, including drinking water which eliminates the problems with the Delaney Clause;
- Special protections for infants and children and attention to endocrine disruptor chemicals;
- Comprehensive application of the new safety standard to tolerance assessment and reassessment of all tolerances within 10 years;
- Particular attention to minor pesticide uses and coordination with related/interested parties;
- New emphasis on right to know about pesticides by consumers;
- Facilitated registration of reduced-risk pesticides;
- Speed up reregistration and renew registrations after 15 years;
- Enhanced antimicrobial program (speed registration and ensure efficacy).

The listing of FQPA mandates summarized above will be key features of the Pesticide Program for the foreseeable future. There also will be emphasis upon communication with affected/interested parties in general and upon voluntary programs to reduce risks of pesticides (and unnecessary usage) under pesticide environmental stewardship programs initiated in recent years. OPP is working closely with USDA to implement FQPA with involvement of the Vice President.

4. Other Regulatory Aspects

Although pesticides in the U.S. are regulated principally under the Federal Statute, FIFRA, which incorporates certain parts of FFDCA, other laws apply to them in one way or another. Some of the applicable laws are as follows:

- Clean Air Act, which can be used to regulate a pesticide if it is a hazardous air pollutant (which has been done with methyl bromide in the 1990's);
- Federal Water Pollution Control Act, can be used to regulate effluent from pesticide production/formulation facilities and certain other aspects, e.g., non-point pollution;
- Waste Disposal Acts, e.g., RCRA, may be used to deal with pesticide disposal problems;
- Occupational Safety and Health Act, administered by the Department of Labor. This Act overlaps with FIFRA and the two agencies have worked out a sharing of responsibilities such as with protection of farm workers from pesticide exposure.
- Endangered Species Act, administered by the Department of Interior, relates to pesticides and EPA works with DOI in this regard.

So far in this discussion, no mention has been made of regulation other then at the national or federal level. Actually, FIFRA provides for substantive involvement of the states under a federal/state regulatory approach. Federal regulation has primacy in this scheme, but the states, along with The Indian Tribes, are heavily involved, particularly in applicator certification/training and enforcement, under agreements with EPA. In addition, there are county/city/local statutes and programs which impact on pesticides in many instances across the Nation.

Finally, there are international aspects of the regulation of pesticides. The U.S. works as closely as possible with other nations and international bodies to deal with pesticide matters. An example is support of the Codex Alimentarius Commission which sets recommended maximum residues in food to protect consumers (while avoiding unnecessary interruption of foreign trade). A joint committee comprised of the Food and Agriculture Organization (FAO) and the World Health Organization (WHO) produces the Codex Alimentarius -- an authoritative guide for the global food market. (See FAO Codex A. Home Page)

In addition, cooperative U.S./Canada efforts on pesticides regulatory harmonization were expanded in 1996 to include Mexico through the new North American Free Trade Agreement's (NAFTA's) Technical Working Group (TWG) on Pesticides. The goal of the TWG is to develop a coordinated pesticides regulatory framework among NAFTA partners to address trade irritants, build national regulatory/scientific capacity, share the review burden, and coordinate scientific and regulatory decisions on pesticides. This work has already begun to pay dividends by addressing specific trade irritants, often caused by national differences in Maximum Residue Limits (MRLs or tolerances), developing a better understanding of each regulatory agency's assessment practices, working to harmonize each country's procedures and requirements, and encouraging pesticide registrants (product owners) to make coordinated data submissions to the three NAFTA countries to facilitate joint reviews.

C. Types of Pesticides and Why Used

1. Purpose

In order to deal with the scope of pesticide usage and trend in the U.S., it is necessary to have in mind the various types of pesticides that there are and what they are used for. Definitions are presented for the data series to be presented later in the report.

2. What is a "Pesticide"?

In this section of the report, the term "pesticide" has been used without any particular attention to what it means for regulatory purposes, to the average American or historically. For current regulatory purposes, FIFRA (Sec. 2) defines a pesticide as:

> "(1) any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest, (2) any substance or mixture of substances intended for use as a plant regulator, defoliant or desiccant, and (3) any nitrogen stabilizer"... (except that the term "pesticide" shall not include any article that is a new animal drug under FFDCA and certain other biocides/devices also covered by FFDCA).

The full scope of this definition can be better understood by considering the definition of the term "pest" in FIFRA, which is:

> "(1) any insect, rodent, nematode, fungus, weed, or (2) any other form of terrestrial or aquatic plant or animal life or virus, bacteria, or other micro-organism which the Administrator declares to be a pest"....(except viruses, etc. on or living in man/animals, which are generally regulated by FFDCA)

The term "pesticide" includes natural and genetically engineered microbials. Certain microorganisms, such as bacteria, are effective as pesticide active ingredients. As a class, natural microbial pesticides tend to work without adversely affecting other organisms and do not leave harmful residues. For this reason, these "safer" pesticides often are not subject to the same stringent registration requirements as chemical pesticides. Similarly, biochemicals, which are naturally occurring chemicals (or identical to them), can often be treated as "safer" pesticides and receive expedited registration because of their natural environmental compatibility.

Obviously, the pesticide concept, from a regulatory perspective, has changed markedly in the last 100 years. At the turn of the last century, the "pesticide" law covered only "insecticides", which were the principal type of pesticides in use at the time. By 1947, the new pesticide law was based on a much broader definition of the term, e.g., covering chemicals used against fungi, rodents and weeds. However, under the original 1947 FIFRA, the chemicals were generally regulated as "economic poisons", not as pesticides as we think of them today. This was changed in a major way in the 1972 FIFRA amendments in line with the definition shown above for current FIFRA (except for some clarifications v.z. FFDCA and addition of nitrogen stabilizers). Today EPA, in practice, uses a broader term for pesticides than a decade or two ago , particularly because of including the microbials and biochemicals as pesticides (even though the definition in FIFRA has remained quite similar since 1972).

It seems fair to these authors to say that many people tend to think "insecticide" when the term "pesticide" is used. Very often you hear people use the term "pesticides and herbicides", implying they are not aware of the broader scope of the term "pesticide". That is in line with the evolution of our laws as well. The Insecticide Act was the principal pesticide act we had as a Nation from 1910 to 1947. The dictionary is quite consistent with FIFRA . Funk and Wagnalls Standard Dictionary defines pesticide as: "a chemical or other substance used to destroy plant and animal pests".

This report is intended to cover the usage of pesticides utilizing the current FIFRA definition noted above. This means that inorganic, synthetic organic and organic chemicals (biochemicals) are covered along with microbials as data permit. In some cases, data are not available or very meaningful for biochemicals and microbials.

3. Particular Types of Pesticides and User Benefits

One may ask, what types of pesticides are used and why? Presented in Table 2.2 is a listing of various rather specific types of pesticides that are used and a key word statement as to the kinds of benefits that inspire the user to employ the pesticides. As to the types of pesticides, over the years, pesticide producers, regulators, researchers and users have developed a set of terms for identifying pest control chemicals that tend to follow the target pests for which they are to be used. They are commonly referred to as pesticide classes as well as types. For example, those pesticides used to target fungi are called fungicides in industry parlance. Often there is some overlap between types or classes of pesticides identified because some pesticides control more than one type of pest. Also, some of the type categories are intentionally defined to be broader in scope than a particular listing may provide for. This listing in intended to be quite inclusive of the pesticides regulated by FIFRA. The use types in Table 2.2 are the basis for explaining the definitions for categories of pesticides that are used in reporting usage in this report, as developed below.

Pesticides are used for an amazingly broad range of pests. It seems that most every facet of the home, garden, industry, commerce, government and agriculture are subject to possible infestation such that a pesticide may be applied at least at times. When pesticides began to be used in the U.S., focus first was generally on a few insects and plant diseases as discussed earlier in the section). But as time has gone by, applications have been developed for a very broad range of use sites in our society and for practically every type of plant or animal species. Most types of animal and plant species are capable of becoming "economic pests", in some circumstances. This means that users judge it would be prudent or worthwhile to incur the cost of using a pesticide because of perceived benefits of such

Table 2.2 Types of Pesticides, Target Pests and Nature of User Benefits from Pest Control usage.

| PESTICIDE TYPE | TARGET PEST(S) | USER BENEFIT FROM PEST CONTROL |
|---|---|---|
| Acaricides/ miticides | Mites | Stop pests sucking juices from plants or liquids from animals, incl. nuisance |
| Algicides | Algae, marine plants, scum | Kill algae in desired locations |
| Avicides | Birds | Avoid nuisance and physical damage of birds |
| Bactericides | Bacteria | Kill bacteria in desired locations |
| Defoliants & desiccants | Plants | Removal of leaves/foliage of plants or completely kills plant immediately, to facilitate harvest |
| Disinfectants/ biocides/antimicrobials | Microorganisms of various types, viruses | Kill/eliminate microbes from target area, e.g., disinfection, sterilization, sanitization |
| Fumigants | Nematodes, weed seeds, fungi, insects, etc | Kill undesired species from soil, commodities or space |
| Fungicides | Fungi | Kill fungi causing plant diseases, nuisance or physical damage/problems |
| Herbicides | Undesired plants (weeds) | Elimination of visual or other nuisance of weeds or economic damage due to use of water, nutrients and light by weeds |
| Insecticides/ins. Growth regulators | Insects | Eliminate nuisance/disease threats to humans and animals, contamination/destruction of commodities/premises |
| Moluscicides | Invertabrates, e.g., snails, slugs | Eliminate nuisance or economic damage of invertebrates to valued plants or crops |
| Piscicides | Fishes | Removal of undesired fish from target waters |
| Plant growth regulators | Plants/fruits/seeds | Control growth/development of plant or plant parts to obtain desired effect, e.g., ripening, storage life, etc. |
| Repellents | Various insect and other animal forms | Dissuades/deters animal from being on protected object or in protected area. |
| Rodenticides | Rodents | Eliminate nuisance and disease to humans and damage to commodities/premises |
| Silvicides | Woody plants/weeds in forestry/ornamental production | Eliminate damage to by undesired species of trees |
| Slimicides | Various lower plant/animal forms, microbes | Prevent development of slime in aquatic/aqueous environments |
| Wood preservatives | Fungi & other life forms that attack wood | Prevent decay and destruction of wood products exposed to the elements |

The "user benefits" may be very tangible, such as avoided loss in quantity (or quality) of a farmer's crop yield, improved physical condition of a homeowner's lawn or elimination of a pest-induced public health problem. Conversely, user-benefits may be purely intangible such as avoidance of the mere existence of a pest where it is not desired, i.e., nuisance benefit. The benefits to the user may be real or imagined and may or may not turn out to be realized after the application, for one reason or another. The purpose here is not to address this topic of economic thresholds rigorously or the social wisdom of applying pesticides. It is merely to present background as to why pesticides are used in our society and who makes those decisions, i.e., users of various kind who ultimately pay for such applications.

4. Categories for Reporting Usage

Unfortunately comprehensive detailed data are not available for each of the pesticide use types (rows) identified in Table 2.2. Neither would it be within the scope of this project to report such detailed data even if it were available (which it is in some cases). Data however are available to present estimates for general categories of usage. A framework for developing usage estimates is presented in Table 2.3. Overall estimates of U.S. usage are presented only for those usage categories. Breakouts (disaggregated data or market segments, e.g., by crop or economic sector) are presented where feasible and within the scope of reporting in this document.

"Conventional pesticides" is the first listed category shown in Table 2.3. These are the chemicals (active ingredients) developed and produced primarily for use as pesticides and the ones that have historically occupied much of the focus of Federal regulation (due to their inherent biological potency, use in food production, quantities used). There are "other pesticide chemicals" used much like conventional pesticides for which estimates are also presented , e.g., sulfur and petroleum items. The focus of this report is upon these first two general categories of pesticides. Only national summary data are presented on the other three categories: wood preservatives, specialty biocides and chlorine/hypochlorites. The wood preservatives are used in industrial plants to treat wood against microbial and other pest damage. The other two categories are also antimicrobial chemicals used for a broad range of applications as suggested in Table 2.3. Further discussion of the usage categories can be seen in a report summarizing U.S. pesticide usage for 1996 and 1997. (Aspelin, 1998) In this report, focus is upon estimating and reporting usage of pesticides regulated by EPA, apart from those only regulated by other agencies such as FDA and USDA. In some cases, EPA and FDA have joint responsibility for regulating certain pesticides and those are include in totals reported herein.

Table 2.3 Types of Pesticides Included in General Categories for Summarizing Usage in the U.S. Usage

| GENERAL PESTICIDE CATEGORY/TYPE | COVERAGE | REMARKS |
|---|---|---|
| **<u>Conventional Pesticides</u>** | | |
| Herbicides/plant growth regulators | Herbicides, plant growth regulators, dessicants, defoliants | |
| Insecticides/miticides | Insecticides, acaracides (miticides) | |
| Fungicides | Fungicides only | |
| Fumigants/nematicides | Fumigants, nematicides | Control some pests other than nematodes and insects |
| Other conventional pesticides | Rodenticides, mulluscicides, aquatics, fish/bird controls, insect regulators, & other misc. | Aquatic herbicides included |
| Total conventional | | |
| **<u>Other Pesticide Chemicals</u>** | | |
| Sulfur/oil | Inorganic sulfur; kerosene, distillates | Generally used control of ins./mites or as fungicide |
| Other chemicals | Sul. acid, repellents, z. sulfate, and misc. chems. produced largely for non-pesticidal purposes | Moth crystals, etc. not included |
| Total other pesticide chemicals | | |
| Total conv. and other chemicals | | |
| **<u>Wood preservatives</u>** | Industrial wood preservatives | Includes water/oil borne preservatives, fire retardants, creosote, coal tar, petroleum |
| **<u>Specialty biocides</u>** | Chems. for pools, spas, water treatment, disinfectants, sanitizers; ind./inst./household cleaning products with pesticidal claims | Excludes hospital & med. antiseptics, food/feed preservatives & cosmetics/toiletries |
| **<u>Chlorine/hypochlorites</u>** | Chems. for disinfection of potable/waste water; bleaching, disinfectant and pools | Excludes chemicals used for other purposes |
| **<u>GRAND TOTAL</u>** | | |

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