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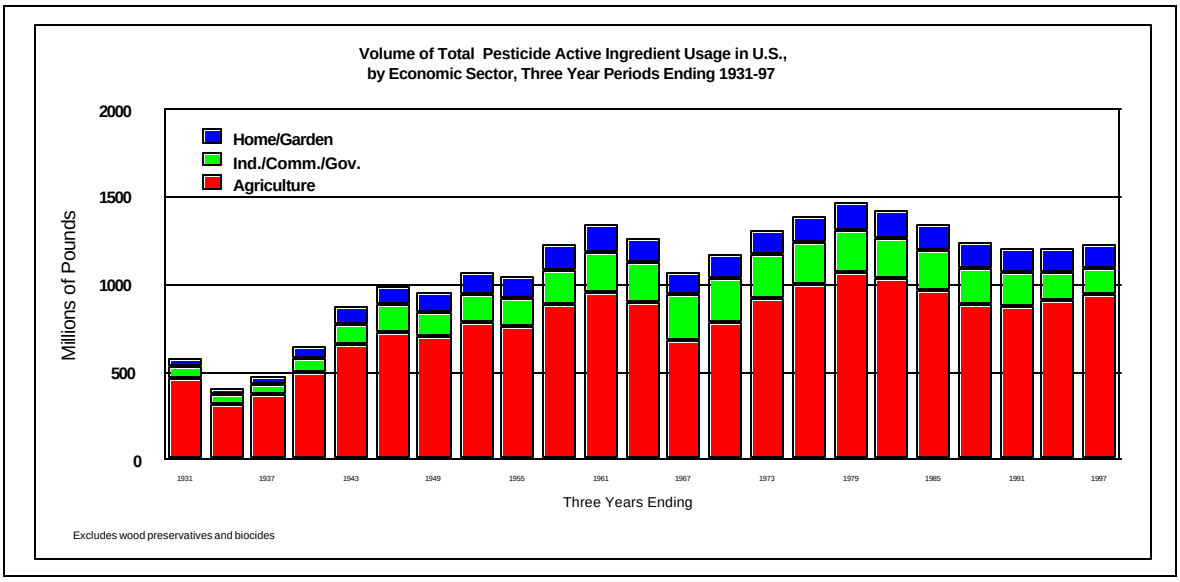
PESTICIDE USAGE IN THE UNITED STATES:

Trends During the 20th Century



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PESTICIDE USAGE IN THE UNITED STATES:

Trends During the 20th Century

by

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Finally, I would like to thank Ron Stinner, Director, Center For Integrated Pest Management for enabling the publication of this report. CIPM is a very logical outlet for this document. Pesticide usage information is very much a matter of interest to those focusing on pest management issues and programs. Thanks also go to Prof. Gerald Carlson, Agricultural Economics Department, N.C. State, for helping to make this project come to fruition.

Arnold L. Aspelin, Ph.D.
February, 2003

PESTICIDE USAGE IN THE UNITED STATES:

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PART ONE

INTRODUCTION AND SUMMARY

A. Purpose and Scope

This report presents estimates of overall pesticide usage in the U.S. covering both agricultural and non-agricultural uses, including past trends and recent usage through 1997. Focus of the report is on quantitative measures of actual pesticide use (termed "usage" in this report) rather than summarization of pesticides registered, recommended or merely available in the market for various pest control applications. The principal measure of usage is "pounds of pesticide active ingredient" rather than total volume or weight of formulated products (which includes all the other various chemicals or materials they contain, i.e., inert ingredients, as they are termed). This report presents estimates of pesticide usage per year covering roughly the most recent seven decades. It also presents historical, qualitative, background on the emergence of the use of chemical pesticides in our society going back to earliest times and their regulation in the U.S.

There is no existing previous report or source which contains a time series of comprehensive estimates of historical annual pesticide usage along with a profile of current pesticide usage. Estimates of overall annual U.S. pesticide usage, by pesticide type and economic sector, have been published going back to 1979 (Aspelin and Grube, EPA, November, 1999). That report also contains estimates of total annual usage for 1964 through 1978 but without detailed breakouts by pesticide class and sector. A partial time series of estimates for U.S. agricultural crop pesticide usage has been published for selected years covering the period from 1964 through 1995. (Barnard, C., et al., 1997) Estimates have been developed by USDA staff for selected crops and years based on USDA survey data covering the period from 1964 through 1982. (Osteen and Szmedra, September, 1989) A similar study by USDA has been published for major field crops (such as corn, soybeans, wheat, cotton and potatoes) with periodic estimates of usage for the period of 1964 through 1992. (Biing-Hwan Lin, et

al., May, 1995) Similarly, estimates of agricultural crop usage have been published only for particular years by Leonard Gianessi. (January, 1992) Basically, the project resulting in this report has been devoted to filling the void in comprehensive time series estimates, covering all sectors, for the U.S. prior to 1979.

Although principal focus of this report is on quantities of active ingredient used, quantitative information is also presented on other aspects of usage (e.g., numbers of acres, farms, homes, applicators, average application rates and user expenditures) where feasible. Breakouts of national usage estimates are provided by chemical family for each of the major pesticide types (i.e.,classes, such as fungicides). However, the breakouts by chemicals family are not extended down to the economic sector level, i.e., only national estimates for all sectors combined.

B. Organization of Report

In addition to the Introduction and Summary (Part One), the report consists of six other separate parts as follows:

- Part Two--background on history of pesticide usage and regulation;
- Part Three--profile of current overall U.S. pesticide usage;
- Part Four–long term trends in overall U.S. pesticide usage;
- Part Five--agricultural pesticide usage trends;
- Part Six--homeowner pesticide usage trends;
- Part Seven--trends in professional market applications (to industrial, commercial and government sectors, as well as to homes and gardens).
- Bibliography;
- Glossary; and
- Appendices.

Part One contains an executive summary and a more detailed summary of findings for the various Parts of the report. There are no summaries contained in the individual Parts. The individual Parts contain references to literature and other sources that are listed in the Bibliography presented at the end of the report. The Summary of Findings contained in Part One below is designed to provide a popular bullet-styled listing of key points made in the individual report Parts themselves. The summary material under each major bullet in the summary is referenced back to the Part of the report on which it is based.

Part Two provides background on the historical emergence of pesticides and their regulation in the U.S.

Parts Three and Four deal with the topics of definition (e.g., pesticide types/classes and economic/user sectors), data sources and approaches used in development of the report, which tend to

be common to the overall report. These parts set the stage for the sections dealing in detail with the three major individual user sectors.

The organizational scheme with separate Parts for the three major user sectors is used because of greatly differing histories, literature and data availabilities for the three types of applications. More detailed information is available for agricultural applications than the other sectors, particularly for the earlier years of the 20th Century. Also, large scale usage of chemicals for pest control tended to emerge first in agriculture, which continues to account for a majority of U.S. pesticide usage.

C. Approach

There are no programs at EPA or other agencies devoted specifically to estimation of the overall pesticide market in quantitative and dollar terms each year. Accordingly, values for usage in this report were developed on the basis of the best information available from the public domain and proprietary sources. Focus in upon the period from 1929 through 1997 and upon conventional pesticides and other pesticide chemicals, excluding industrial wood preservatives and biocides. These terms are defined in the Glossary and are discussed below in the Summary of Findings as well as in Part Three.

The basic approach used to develop time series (for conventional pesticides and other pesticide chemicals) was to assemble reported values for usage from all available sources and tabulate them on worksheets showing the values by particular year, type of pesticide, etc. Once all of the entries were made from available sources, efforts were made to reconcile differences and conflicts which often occurred in the reported values. Numbers were verified from their sources including data definitions. Taking into account apparent trends and relationships in the various tabulated values, estimates were developed for each year, by pesticide class and sector utilizing the best available information and judgement of the analyst. Then, three-year averages were computed for purposes of presentation in this report for the periods ending on three year intervals from 1931 through 1997. A somewhat different approach was used for the time series on active ingredient usage by chemical family. In that case, estimates were made only for conventional pesticides and for every fifth year for 1930 through 1995 and for 1997, based on best available information.

The numbers presented in this report should be considered approximate values rather than precise ones with known statistical properties. The data sources used and methods used in making the various estimates of usage are discussed in the individual Parts of the Report, particularly Parts Three and Four.

The substantive data collection, analysis and report writing on this project were concluded as of August, 2000. Work on the project since that time has been limited primarily to final editing of the report. Accordingly, the results reported should be considered current or contemporary as of about two years prior to its publication, e.g., August, 2000

D. Executive Summary

Pests of one kind or another have been problems to man since earliest times. People have struggled to control pests with a wide variety of measures, including chemicals we today call pesticides. Early history of the Orient and Biblical writings often record pest problems and efforts to deal with them. It wasn't until the 18th Century that science began to be applied to pest biology and control measures in very systematic or meaningful ways.

In the United States, chemicals (along with non-chemical controls) began to be widely accepted as control measures for pests identified by farmers, homeowners and businesses during the late 1800's and early in the 1900's. The principal quantitative indicator focused on in this report is pounds of active ingredient used per year. Figures for national quantities used began to emerge for usage of major pesticide chemicals around 1900, often for use in agriculture, which historically has accounted for a majority of U.S. pesticide usage.

In this report, historical time series of estimated U.S. usage are presented for three-year periods covering 1929/97. Economic profile information is presented for U.S. pesticide user sectors based on data for recent years (e.g., 1990's) Where data permit, breakouts are provided in the series by type of pesticide, economic sector (agriculture, home owner applications and professional non-agricultural applications) and chemical family.

Annual usage of pesticides in the U.S. (excluding biocides and industrial wood preservatives) was about one half billion pounds in the 1930's, increasing to nearly one billion pounds at the end of WWII and then peaked out at nearly 1.5 billion pounds in the late 1970's. Since then, it has declined by about 200 million pounds per year and has been quite steady in the range of 1.2 billion pounds per year during the 1990's. Usage per capita was at its highest level at the end of WWII at 7.4 pounds, has declined since, to less than 5.0 pounds during the 1990's.

- large amounts of pesticides containing arsenic, lead and other metals were also used for insects and plant diseases through the 1950's;

For last seven decades, the following general observations can be made about pesticide usage in the U.S.:

- usage of sulfur, petroleum and similar generic chemicals predominated in active ingredient usage until the mid-1960's, when new chemicals developed primarily for use as pesticides took over the lead;
- pesticide chemistry changed dramatically with the advent of synthetic organic pesticides, starting with DDT toward the end of WWII;
- there was rapid growth of synthetic organic insecticide usage during the 1940's and 1950's, followed by the dramatic adoption of herbicides in the 1960's and 1970's;
- new low-dose insecticides and herbicides introduced during the last two decades have contributed to lower overall usage of active ingredient in the U.S., along with various

integrated pest management programs and related educational efforts by agencies and industry.

E. Summary of Findings (references to text pages)

Part Two–Background and History of Pesticide Usage

! Historical Emergence of Pesticide Technology (See pages 2/1-8.)

" Pest controls can be classified broadly as: mechanical control, biological control, host/target resistance development, and chemical control. Generally speaking, the chemicals used for pest control are considered pesticides and are so regulated in the U.S. The principal focus of this report is on those chemicals which historically have been considered pesticides, which account for most pest control in the U.S. Pesticides and other controls can be used as preventatives, curatives or both and are not considered as being used wastefully if being used in line with economic thresholds., i.e., the value of pest damage avoided exceeds costs on control.

" An adequate supply of food is of fundamental importance to mankind going back to earliest times as man has struggled to obtain adequate supplies of food (and fiber) against all the elements, including pests of various sorts. Pests also cause damage by spreading disease and as nuisances by their mere presence where man does not want them.

" For hundreds of years earlier on, few noteworthy things happened in the development of pesticides. Then, during the last 100 years, especially the last 50 years, pest control has been revolutionized. The rise of the scientific method and its application to pest control helped to learn more about pests and existing chemicals as pesticides. 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. 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 and biotechnologies came forward and more will do so early in the new 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.

! Overview of Pesticide Regulatory History in the U.S. (See pages 2/9-14.)

" <u>General Regulatory Trend:</u>

- Regulation of pesticides is an integral part of the overall environment in which pesticides are developed, produced and used in the U.S. There has been a trend in national policies/laws, starting from limited objectives, primarily protection of farmers from adulterated/ineffective products, until today when there are comprehensive objectives, including human health and environmental protection, as well as pesticide user protection.

" <u>Prior to 1947:</u>

- The regulation of pesticides was given very little attention from earliest times until around the turn of the 20th 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. As the usage of pesticides began to be more common and widespread, 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.
- 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 established regulatory jurisdiction over food treated with pesticides and traded in interstate commerce. 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. 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.

-

" 1947 to 1995:

- 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. 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).
- 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. 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".
- 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.
- Responsibility for administering FIFRA, along with relevant parts of FFDCA, was transferred to EPA which was created by Executive Order of President Nixon on December 2, 1970. Pesticides were an issue at the forefront of the environmental movement leading to the establishment of EPA. 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. During the 1970's and 1980's, the amended FIFRA was used to take a number of pesticides off the market, starting most notably with the organochlorine insecticides, such as DDT, aldrin, dieldrin, chlordane, heptachlor and kepone. During the 1980's and 1990's, EPA actively pursued special reviews of problem pesticides and struggled with its mandate to reregister all old/existing pesticides.

" 1996 to Date:

- As of 1996, reregistration could not be expected to be completed until far into the next century. 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).
- Various new FQPA mandates are key features of the Pesticide Program for the foreseeable future. There also is an 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.

! Types of Pesticides Used and Why Used (See pages 2/15-20)

" What is a "Pesticide"?

- 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 term "pesticide" includes natural and genetically engineered microbials.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.

" Classes 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 (or types in some contexts). For example, those pesticides used to target fungi are called fungicides.
- Some of the principal classes or types of pesticides are herbicides, insecticides, rodenticides, and fungicides. There is some overlap between classes of pesticides identified because some pesticides control more than one type of pest.

" Why Pesticides Are Used:

- Pesticides are used because users wish to avoid some type of damage or nuisance, real or imagined. Most types of animal and plant species are capable of becoming "economic pests", in some circumstances, i.e., worth treating.
-

Part Three–Profile of Current Overall U.S. Pesticide Usage

! Overall U.S. Pesticide Usage, by General Type, 1997 (See pages 3/5-7).

" More than 4.5 billion pounds of pesticide active ingredient are used in the U.S. in a current typical year. For 1997, the estimated total for all types of pesticides was 4.63 billion pounds. The breakdown on this usage by general category of pesticides is:

-	conventional pesticides	0.97 bil. lbs.	(21%)
-	other p. chemicals	0.26 "	(6%)
-	wood preservatives	0.66 "	(14%)
-	specialty biocides	0.27 "	(6%)
-	chlorine/hypochlorites	2.46 "	(53%)
-	total	4.63 "	(100%).

" The above aggregate quantities of pesticides used can be expressed on a per capita basis, to reflect the average volume used per person in the U.S. Overall usage was about 17.3 pounds per capita for all pesticides regulated under FIFRA (about 3.6 pounds per capita for conventional pesticides).

! Volume of Conventional/Other Pesticides Used, by Class and Sector, 1997 (See pages 3/8-12.)

" The breakdown of conventional/other pesticide usage by type/class for 1997 was as follows:

-	herbicides	568 mil. lbs.	(46%)
-	insecticides/miticides	128 "	(10%)
-	fungicides	81 "	(07%)
-	fumigants/nematicides	165 "	(13%)
-	other conventional	32 "	(03%)
-	subtotal	975 "	(79%)
-	other p. chemicals	256 "	(21%)
-	grand total	1,231"	(100%).

" Agriculture dominates in usage of conventional/other pesticide chemicals as it accounts for about three-fourths of the active ingredient of such pesticides. For 1997, the sector totals were:

-	agriculture	944 mil. lbs.	(77%)
-	ind./comm./govt.	151 "	(12%)
-	home/garden	136 "	(11%)
-	total	1,231 "	(100%).

-

! Expenditures for Conventional/Other Pesticides by Type and Sector, 1997 (See pages 3/13-17.)

" The pesticide industry is quite significant in dollar terms. Annual expenditures by users of pesticides totaled about $11.9 billion in 1997 (conventional pesticides plus sulfur, etc.).

" These expenditures were distributed among pesticide types as follows:

-	herbicides	$6,846 mil.	(58%)
-	insecticides/miticides	3,553	(30%)
-	fungicides	802	(07%)
-	all other	696	(06%)
-	total	11,897	(100%).

" The U.S. total of $11.897 billion for 1997 equals about $44 per capita.

! Overview of U.S. Land Area and Pesticide Usage (See pages 3/18-23.)

" The total surface land area of the U.S. is 1,940 million acres, including 49 million acres of water areas (1992 estimates).

" Pesticides (conventional/other pesticide chemicals) are applied on an estimated 0.33 billion acres per year, which is about 17 percent of the U.S. land area.

" More than half of U.S. land area is in farmland (1.055 billion acres) and accounts for about three fourths of the use of pesticides (excluding wood preservatives and biocides).

" Forest land (559 million acres) is the second ranking land use category and is not frequently treated, e.g., less than one percent of acreage treated per year.

" Agricultural cropland for crops is quite commonly treated with pesticides. An estimated 240 million acres are treated in a given year out of a total of 337 million acres of cropland for crops.

" In approximate values, urban homes and gardens account for about 1.2 percent of U.S. land area, 2.7 percent of acreage treated and about 12 percent of total usage of active ingredient for conventional/other pesticide chemicals. Other urban land has roughly 1.7 percent of land area, 6 percent of acreage treated and 6.2 percent of active ingredient usage.

! Current U.S. Pesticide Usage Compared to the World (See pages 3/24-27.)

" The U.S. accounts for about one third of pesticide user expenditures world wide ($11.987 billion out of $37.048 billion) in 1997 for conventional and other pesticide chemicals (excluding wood preservatives and biocides).
" In terms of active ingredient volume, the U.S. accounts for 22 percent of the world total with 1.231 billion pounds out of 5.684 billion pounds.

Part Four–Long Term Trends in Overall U.S. Pesticide Usage

! Total Usage of Conventional/Other Pesticides, 1929/1997 (See pages 4/4-7.)

" Usage of conventional pesticides and other pesticide chemicals was well underway by the beginning of the 1930's. By that time, there was widespread usage of calcium arsenate, lead arsenate, copper sulfate and mercury compounds for insecticides and/or fungicides, principally to protect agricultural crops.
" There was a low point in usage in the early 1930's of about 400 million pounds per year, after which usage more than doubled the low point, continuing through WWII (to nearly one billion pounds per year). After a brief pause in growth, usage increased to a new high of about 1.3 billion pounds per year around 1960, followed by some decline in the later 1960's. Then growth occurred again until usage peaked out at nearly 1.5 billion pounds per year around the late 1970's. Since that time, usage has declined to some degree, holding about 1.2 billion pounds per year during the last decade.
" Conventional pesticide usage has exceeded other pesticide chemicals since the mid-1960's as new synthetic organic pesticides have replaced the other older chemicals such as sulfur and petroleum.
" On a per-capita basis, usage of conventional/other pesticide chemicals increased sharply until the end of WWII when it was about 7.4 pounds. There was a decline in the mid-1960's to about 5.5 pounds per capita (primarily as a result of reduced use sulfur) and a trend upward again to about 6.6 pounds per capita in 1977/79. Since then, there has been a rather consistent decline to a level of about 4.6 pounds per capita most recently.

! Usage of Conventional/Other Pesticide Chemicals, by Type of Pesticide, 1929/97 (See pages 4/14-15)

" Most of the growth in usage per year was due to the increased usage of herbicides (and PGR's) starting with the advent of the synthetic organic pesticide industry as WWII concluded) (peak of about 625 million pounds per year in early 1980's).
" There was decreased usage of sulfur/oil since the early 1960's.

" There have been rather consistent increases in usage of fumigants/nematicides for the last three decades, especially the last few three year periods.

" There has been declining usage insecticides/miticides active ingredient, as chemicals with lower application rates have been adopted during the last 15 years.

! Trends in The Types of Chemistry Being Used as Pesticides, 1930-97 (See pages 4/16-24.)

" The types of chemicals used as active ingredients in pesticides have changed greatly since the 1930's. In general, inorganic chemicals have declined in use and synthetic organic chemicals have taken over increasingly since the mid-1940's.

" Herbicides/Plant Growth Regulators (H/PGR)

- relatively small amounts of inorganics (e.g., sodium azide and sodium arsenite) were in use prior to the rapid growth of herbicide usage after 1960 and some inorganics continue to be used;
- the carboxylic acids were the first major herbicide group to emerge (largely due to the phenoxies, such as 2,4-D and 2,4,5-T) and continue to be important due to the usage of glyphosate as well as 2,4-D and others;
- the heterocyclic nitrogens, most notably the triazines, which emerged in the 1950's and 1960's, became the leading herbicide family based active ingredient, which they still are in the 1990's;
- the amides, between 1960 and 1980, became the leading herbicide family and continue to account for more than 100 million pounds of active ingredient per year; (Acetochlor is replacing alachlor within the amides.) and;
- the ureas, starting about 1955, and the phenyl ethers (about 1975), are examples of newer herbicides with small amounts of active ingredient usage, but large acreages treated due to low application rates.

" Insecticides/Miticides (I/M)

- The pattern in insecticide usage has been from dominance by inorganics until about 1950, followed by the organochlorines (led by DDT) through the mid-1970's and then organophosphates became the leading insecticide family in terms of active ingredient usage.
- arsenical insecticides (particularly calcium and lead arsenates) were already in common use by 1930 with usage of more than 150 million pounds per year and were the leading chemical family by far; their usage declined quite notably, by about 90 percent, by 1955 as the organochlorines predominated;
- DDT came on stream by 1945 and reached its maximum usage around 1960; it was essentially no longer in use by the mid-1970's; other organochlorines, such as chlordane and toxaphene, increased in usage through the mid-1970's but declined to only a few million pounds per year by 1990;
- botanicals, such as pyrethrum, nicotine and rotenone, were important insecticides already by 1930; their use along with other botanicals and biopesticides increased in usage to 28 million pounds in 1945, after which such

usage declined; botanicals/biopesticides of various types have been in use within the range of 3 to 5 million pounds per year since 1965. These figures do not reflect pesticide active ingredient generated by genetically modified organisms regulated as pesticides (GMO's);

- the organophosphates were in use by 1955 and have been the leading insecticide chemical family since 1970; their peak usage occurred around 1975 with 142 million pounds of active ingredient, after which usage has declined to some degree; usage of organophosphates was an estimated 87 million pounds in 1997.

" Fungicides (F)

- Copper sulfate has been the leading fungicide in terms of active ingredient usage most of the 20th Century. It had peak usage of 150 million pounds in 1945 and is still in use today (18 million pounds in 1997).
- copper sulfate (used with lime, known as Bordeaux mixture) was introduced as a fungicide in the U.S. by 1887 and came into large-scale application by about 1910, most often for potato and apple disease control;
- mercury based fungicides were in use from 1935 until about 1975;
- the dithiocarbamates were in use by 1950 and most of the time since have been the second ranking fungicide chemical family; and
- heterocyclic nitrogens were in use by 1955 and reached largest usage around 1975.

" Fumigants/Nematicides (F/N)

- Halogenated fungicide chemicals were in use by 1930 and since have been the leading chemical family for this class of pesticides.
- chloropicrin and carbon tetrachloride were among the first to be of importance in this class of pesticides;
- methyl bromide has been an important fumigant/nematicide since it began use around 1945; and
- the carbamates/dithiocarbamates have had expanded usage since the late 1980's to 66 million pounds in 1997.

! User Expenditures for Conventional/Other Pesticides, by Type of Pesticide and Sector, 1979/97 (See pages 4/25-27.)

" Pesticides are a significant sector of the U.S. economy as reflected by annual user expenditures for pesticides.

" Overall user expenditures have increased from about $5.3 billion in 1979 to about $11.9 billion in 1997. (nominal dollars)

" These increasing expenditures reflect changes in a number of factors including: the quantities of pesticides purchased; improved/more useful active ingredients and formulations; less use of inexpensive generic chemicals; increasing development and

regulatory costs; and general inflationary trends in the economy affecting production and transportation costs. Herbicides account for more than half of total user expenditures, followed by insecticides.

- Aggregate user expenditures in constant 1997 dollars increased less than inflation generally from 1979 through 1993, but have increased at a somewhat faster rate since that time. In other words, pesticide expenditures, in real terms, have been increasing somewhat during recent years.
- User expenditures per capita for the U.S. civilian population in constant 1997 dollars are in the same general range during recent years as they were in the 1979/84 period. As of 1997, expenditures per capita were $44.73 which is somewhat below the values for 1979 through 1984. These figures per capita are an indication as to what the average person is paying for conventional/other pesticide chemicals, whether purchased directly as a user or indirectly as part of the costs of goods and services, taking account of inflationary trends.

Part Five–Agricultural Pesticide Usage Trends

! Profile of Agricultural Applicator Sector (See pages5/1-3.)

- Agriculture is an important part of the United States in many ways. It is the source of food and fiber for the Nation and people elsewhere in the world through exports.
- There are about 1.9 million farms in the U.S. (1997 Census of Agriculture). These farms contain more than 930 million acres of land which is nearly half of the land area of the U.S. (about 1.9 billion acres). They have about 350 million acres of cropland used for crops each year, which is where most of the agricultural pesticides are applied.
- Quite remarkably, U.S. agriculture have been able to produce food and fiber to meet market needs (and even produce surpluses from time to time), with about the same amount of cropland it used many decades ago. This is due apparently to ever improving technology and efficiency in agriculture, including the use of more and more useful pesticides to control pests of various kinds.
- Pesticides of one type or another are applied on a majority of U.S. farms raising crops. In 1997, about 0.94 million of the 1.661 million farms with cropland used one or more pesticide types on at least some acres. Herbicide are used on the most farms (685,000 farms in 1997) followed by insecticides (366,000).
- As of 1997, there were 874,000 persons who had been certified under FIFRA provisions as private pesticide applicators. There is an average of nearly one certified private applicator per U.S. farm that applies pesticides in crop production (e.g, 874,000 certifications compared with 941,000 farms using pesticides in crop production in 1997).

! Principal Chemicals Available to Farmers For Pest Control Before End of WWII (See pages 5/4-5.)

" Two dramatic changes occurred starting with the latter stages of WWI, with respect to the availability of chemicals for farmers to control pests.
- The first was the discovery and commercial development of new chemical compounds which were efficacious pest controls, principally synthetic organic pesticides such as DDT and 2,4-D.
- The second major change was the emergence of an industry to produce pesticides for use by farmers. Until the new chemicals came along, basically there was no industry to efficiently produce pesticides and make them available to farmers at prices that made them cost effective. Farmers generally had to purchase raw chemicals (often crude industrial chemicals) and mix/formulate the pesticide for use themselves.

" Principal chemicals available to farmers, circa 1910-20 and early 1940's:
- For insect control, various arsenicals were important as early as 1910-20 (Paris Green containing copper metarsenite and lead arsenate) and increasingly by WWII. Various arsenicals were recommended by WWII, such as white arsenic, sodium arsenite, calcium arsenate and lead arsenate. Sulfur and petroleum were used as insecticides as were several plant-based items, including rotenone, pyrethrum, vegetable oils and nicotine/tobacco.
- Very limited chemistry was available as fungicides in 1910-20, principally Bordeaux mixture (copper sulfate/lime) and lime/sulfur. The situation had not changed much by WWII, as only mercurials were added as fungicides.
- The farmer did not have available highly useful chemicals for control of weeds until the end of WWII, starting with 2,4-D. Rather common chemicals such as sodium chloride, iron sulfate, copper sulfate, carbolic acid, sulfuric acid and petroleum were basically all that was available and they were neither very useful nor without undesired effects from usage.
- Farmers basically did not commonly use fumigants/nematicides through WWII and neither did they have available to them antimicrobials for dairy sanitation, and other purposes, as we think of such applications today.

! Agricultural Pesticide Usage Trends, Circa 1930 to Date (See pages 5/7-12.)

" As of 1929/31, about 460 million pounds of active ingredient were used in agriculture on an annual basis. Usage declined sharply during the next three-year period (ending 1934) and then increased quite consistently until after WWII (about 720 million pounds per year) when there was a slowing of growth. Then usage increased rather steadily to about 950 million pounds per year around 1960. There was a cutback in usage during the last half of the 1960's and then usage increased to a peak for the seven decades in 1977/79 at nearly 1.1 billion pounds of active ingredient per year. The above trends reflect expanded use of insecticides starting with late WWII, the growth of herbicide

usage until the late 1980's, and a drop in usage of sulfur/oil, particularly in the mid-late 1960's.

- The volume of pesticide active ingredient used in agriculture has been quite closely correlated with acres of cropland since about 1960. The association is particularly striking since 1970. Variations in crop acreage did not appear to be a major factor shaping total agricultural pesticide usage from the 1930's until about 1960, as insecticide and herbicide usage increased dramatically, regardless of crop acres.
- By 1965/67, conventional usage surpassed other pesticide chemicals and continues to do so to date.
- Conventional and other pesticide chemical usage in agriculture expressed in terms of average per U.S. crop acre can be used as a rough indicator of pesticide usage intensity in agricultural production. U.S. cropland, about 345 million acres in 1995/97 (cropland used for crops series), is where most intensively managed crops are grown and where most pesticides are used in U.S. agriculture.
- The trends in aggregate quantities of pesticides used and crop acres resulted in a rapidly increasing average rate of active ingredient used per acre of cropland-- from less than a pound per acre in the early 1930's to about 2.5 pounds during 1959/64. This was followed by markedly lower levels through about 1970 due to less use of other pesticide chemicals. This is presumed to be the result of new conventional pesticides coming on the market and replacing traditional chemicals such as sulfur and petroleum/oil.
- The highest level of usage was reached in the 1977/79 period when average usage per acre was 2.85 pounds, somewhat more than for the most recent three year period (2.76 pounds for 1995/97).

! Trends in Agricultural Pesticide Usage, by Type (Class) of Pesticide (See pages 5/13-14)

- The availability of synthetic organic herbicides toward the end of WWII led to consistent and rapid growth in the use of such chemicals in agriculture to a peak of about 500 million pounds of active ingredient in 1980/82, with some decline since.
- Insecticide usage expanded during the 1960's and 1970's, but has tended to decline since as newer, low-dose, chemicals have replaced older pesticides.
- Usage of fumigants/nematicides has been increasing steadily since the 1940's, and rather dramatically so in the 1990's (their usage is now exceeded only by herbicides/PGR’s).
- Sulfur and petroleum are still important pesticides but usage is far below levels of earlier times, e.g., three year periods ending 1943 through 1964.
- Fungicide usage has been remarkably stable at about 40-60 million pounds for several decades.

! Trends in Aggregate Active Ingredient Usage, by Crop Grouping, 1988-97 (See pages 5/15-22.)

- Trends over the 10 year period are evaluated based on three two-year periods as follows: 1988/89, 1992/93 and 1996/97.
- Corn/sorghum and fruits/nuts are by far the leading crop groups in terms of overall usage of active ingredient; they are followed at a distance by agronomic crops (which include potatoes), vegetables and soybeans.
- Herbicides are the leading pesticide type applied to major field crops such as corn/sorghum, soybeans and cereals.
- Sulfur/petroleum is used most widely on fruits/nuts, accounting for about half of usage on those crops.
- Fumigant/nematicide usage increased noticeably over the 10 years for agronomic crops, vegetables and cotton.
-

! Trends in Average Active Ingredient Usage Per Acre of Crop Grown, by Crop Grouping, 1988/97

- Fruits/nuts currently lead all other crop groups by far with about 45 pounds of active ingredient used per acre grown, followed by vegetables at about half the rate currently (more than 23 pounds).
- The most noticeable increase in usage per acre was vegetables, where usage per average acre increased from 13.4 to 23.7 pounds per acre between 1988/89 and 1996/97.
- Nematicide/fumigant usage increased sharply for vegetables and to a lesser degree for agronomic crops.
- Corn/sorghum is the only crop group for which usage per acre declined consistently per acre for the periods observed.

! Trends in Expenditures for Agricultural Pesticides, Circa 1930 to Date (See pages 5/23-27.)

- Farm expenditures for pesticides have increased from $33 million in 1929/31 to about $8.4 billion in 1995/97 in nominal dollars. When placed in constant 1997 dollars, the increase is from $296 million per year in 1929/31 to $8.5 billion in 1995/97.
- Pesticides have accounted for an increasing percentage of total farm production expenditures since WWII, when they accounted for about 0.5 percent. Since that time, pesticides have steadily increased as a percentage of total farm production expenses to a level of 4.6 percent in 1995/97.
- Another way of looking at the importance of agricultural pesticide usage is in terms of expenditures relative to the number of people in the U.S. For 1995/97, the average expenditure per capita for agricultural pesticides was $32.10.

Part Six–Home and Garden Usage by Homeowners

! Profile of Home and Garden User Sector (See pages 6/1-4)

- Home and garden pesticide applications (by homeowners and family members) account for a significant portion of total usage of conventional pesticides and other pesticide chemicals (136 million pounds of active ingredient in 1997, or 11 percent of the total for all user sectors that year). These applications were made by an estimated 123.7 million persons, of which 52.5 million were male and 71.1 million were female.
- Nearly one half of the U.S. civilian population applies pesticides, 123.7 million out of 267 million in 1997, or about 46 percent.
- There were an estimated 101 million households in the U.S. in 1997, of which 84.1 million (about 83 percent) were urban and 16.9 million rural. More than three-fourths have private lawns (80 million in 1997), but few have private swimming pools (7 million) and hot tubs (3 million). Significant proportions of households grow fruit/nut/grapes (22 million or 22 percent in 1997), grow vegetables/berries/melons (28 million or 27 percent) and grow roses (32 million or 32 percent). In 1997, an estimated 20 million households used pest control operators, which equaled about one-fifth to total U.S. households.
- Commercial lawn care service is used by about one-eighth of households and some use landscapers or other lawn care services.

! Numbers of Households Using Home and Garden Pesticides, 1990 (See page 6/5-8.)

- Pesticides are used by homeowners (and/or family members) in a majority of U.S. households, including lawns, gardens and any other outside areas. As of 1990, 69 million households used one or more types of pesticides, which equaled 81.6 percent of U.S. households that year. Insecticides and fungicides are the most commonly used conventional pesticides in homes and gardens. About 60 percent used an insecticide and about 40 percent used a fungicide. Only about four percent of households used a mulluscicide or a rodenticide. Disinfectants were used in nearly half of households and about one-fifth used insect repellents.
- In terms of application site, three fourths of U.S. households apply one or more pesticides indoors (64 million in 1990). About one-fifth have lawn pesticide applications, one-tenth, food crop applications and one-sixth, ornamentals.
- A two-way breakout of the numbers of households with homeowner pesticide applications was prepared showing numbers by both pesticide type and site of application. The leading combinations in terms of numbers of households for 1990 were: indoor insecticides (42 million), indoor disinfectants (40 million), indoor fungicides (32 million) and indoor repellents (15 million). The leading outdoor combinations were: insecticides on other outside areas, ornamentals and lawns; and herbicides on lawns.

! Numbers of Home and Garden Pesticide Applications Per Household, 1990 (See pages 6/9-11.)

" The EPA Home and Garden Survey provided estimates of the number of pesticide applications as well as numbers of households for 1990. Averages computed on basis of all U.S. households (84.6 million in 1990) were about 52 applications per household during 1990 (about one per week) for all types of applications.

" The primary living area accounted for about two-thirds of the applications. The other types of applications were much less frequent, with averages of less than 5 per year for the various types other than "outdoor areas" for which the average was 6.28 applications.

! Numbers of Home and Garden Pesticide Products in Storage, 1990 (See pages 6/12-13.)

" The EPA Home and Garden Survey found that rather large numbers of pesticide products were in storage at households. Estimates were made of the aggregate numbers of products in storage by type (class) of pesticide and use status (not used yet, used past year or used over one year ago).

" On the average, using households had 4.7 pesticides in storage, of which 0.34 were not used yet and 1.07 were used more than one year ago. Insecticides were most commonly in storage (3.38 products), followed by herbicides (2.34), while the other categories had values in the range of one and two products in storage on the average.

! Home and Garden Pesticide Usage, by Type, 1929/97 (See pages 6/14-19.)

" Conventional and Other Pesticide Chemicals, Aggregate Usage
- the usage of conventional pesticides increased quite steadily from about 10 million pounds per year in the mid-1930's to about 85 million pounds per year around 1980; since then it has declined about 10 million per year;
- other pesticide chemical usage increased from about 30 million pounds per year in the mid-1930's to a peak of about 115 million per year around 1960; since then such usage has been generally in the range of 60 to 80 million pounds per year;
- the total of conventional and other pesticide chemical usages was at a low 40 million pounds per year in 1932/34 and increased to 154 million pounds per year in 1959/61; usage was somewhat lower until around 1980 when usage returned to 150 million plus range; during the last 10 years overall home and garden usage has declined slightly, to 135 million pounds per year in 1995/97.

" Conventional and Other Pesticide Chemicals, Per Capita Usage
- Aggregate usage figures divided by U.S. civilian population place usage by homeowners on a per capita basis.
- Since 1929/31, the pattern which emerges is generally increasing levels until about 1956/61 when usage was 0.85 pounds per capita, followed by a declining trend to about one half pound per capita most recently..

" Conventional and Other Pesticide Chemical Usage, by Class

- Estimates were made of aggregates for conventional and other pesticide chemicals used by homeowners with breakouts by pesticide class for the period of 1929 through 1997.
- The following observations can be made:
  - # herbicide usage has increased steadily since WWII;
  - # insecticide/miticides usage has declined somewhat since around 1980;
  - # petroleum/oil and sulfur usage has declined since the 1960's;
  - # other pesticide chemicals, consisting largely of moth treatment chemicals, have remained at a relatively high level since the 1950's.

! Home and Garden Pesticide User Expenditures, 1979/1997 (See pages 6/20-22.)

" Aggregate user expenditures for the home and garden sector have about doubled from about $1.01 billion in 1979 to $2.01 billion in 1997. Most of the increase has occurred due to increased expenditures for herbicides and plant growth regulators, aside from inflationary trends which are dealt with below.

" When expenditures for 1979/97 are placed in constant 1997 dollars to take out the impact of inflation, the result is that expenditures have remained about the same at about $2.0 billion per year since 1979.

" When placed on a per capita basis, expenditures have declined somewhat over the period, i.e., from about $9.10 to $7.70. Home and garden pesticides are a minor part of the average household budget, and have not been increasing in real terms during the last two decades.

Part Seven–Industrial/Commercial/Governmental Usage Trends

! Profile of Professional Pesticide Applicator Sector (See pages 7/1-17.)

" Profile of Applicators and Certifications

- The industrial/commercial/governmental sector consists of applicators which apply pesticides to a very diverse set of sectors, land uses and aquatic areas. There are twelve broad categories of applicator certification of which ten generally relate to the non-farm applications. The two categories of "agricultural plant" and "agricultural animal" relate primarily to farm/ranch applications. In order to apply restricted-use pesticides, applicators must be certified as competent to apply such pesticides by meeting national standards set by EPA. The applicators are trained and certified under cooperative programs involving EPA, USDA and the State Extension Services. All states require commercial applicators to be recertified every three to five years to maintain certification.
- As of FY 1997, there were approximately 533,000 applicator certifications, involving 375,000 individual applicators. The number of certifications exceeds

the total number of applicators due to multiple certifications of many applicators.

- By far the leading categories of non-agricultural certifications are ornamental and turf (145,000) and industrial/institutional/structural and health (130,000), the latter category generally referred to as pest control operators (PCO's). The third ranking category of certifications is right-of-way (ROW) with 57,000 certifications. About 65,000 commercial applicators are newly certified each year, along with 120,000 which are recertified annually.

" Profile of Major Non-agricultural User Sectors

- The professional applicators serve a diverse set of user sectors which can be broken down into a number of categories or types which tend to follow such things as lines of business, professional disciplines, type of pesticide, economic sector and type of pest.
- Some examples of the major user segments are: turf/ornamentals (lawn care operators with 18,000 applicators; 15,000 golf courses; 15,000 parks; 22,000 landscape contractors; 42,000 nurseries and greenhouses), industrial vegetation control (3,200 utilities with 6 million miles of right of way (ROW); 39,000 government units with nearly 4 million miles of roadways;), pest control operators (14,000 pest control establishments with 17 to 18 million residences treated per year), forestry (focus on 70 million acres) and mosquito abatement districts (900 districts treating 100 million acres per year).

! History of Pesticide Applicator Industry (See pages 7/18-19.)

" The professional pesticide applicator industry we have today can be traced back to earliest times as people have struggled with pests of various sorts in the home, in industry, in commerce and in government. The history of applying pest control technology in the western world goes back to an early period of antiquity as early as 300 AD. In these early times, artisans or specialists were using various chemical and non-chemical controls for pests. Examples include apothecaries, embalmers, ship builders, and chandlers.

" During the 12th Century in Europe, itinerant peddlers provided poisons and traps for rodent control. Alchemists and others discovered improved poisons by trial and error for vermin control. Ratcatching and vermin exterminating became a livelihood for some persons as technology improved and trade expanded between Europe and the rest of the world.

" By the 18th Century, the itinerant ratcatchers had begun to settle down and operate out of regular places of business, with ads, established accounts and competition with one another over claims of control effectiveness, trade secrets, etc. About the middle of the 19th Century, some of the European exterminators emigrated to the U.S. and used available chemistry for pest control which remained quite primitive until around 1920. Arsenical and lead based chemicals became generally available for pest control, enabling growth of pest control operations.

- In the late 1920's, the more aware and ethical elements of the applicator industry began to band together to share ideas. They organized to promote regulation that would improve ethical standards and eliminate unscrupulous operators.
- The emergence of the synthetic organic pesticide industry in the 1940's manufacturing new highly effective pesticides made possible the rapid growth and expansion of the pest control industry.
- The professional pesticide market of today consists of not only the applicators for hire, but those who are professionals in entities which are not pest control firms, but engaged primarily in other activities or pursuits.
- Methods of application of pesticides in the professional market are very diverse such as, hand sprayers (dusters), ground boom and blast sprayers/dusters, directed aerosols, fumigant aerosols/canisters, fixed wing and helicopter applications, injections and others.

! Conventional and Other Pesticide Chemicals, Aggregate Usage, 1929/97 (See pages 20-24.)

- Aerial applications of pesticides began with agricultural crops in 1921/22, but probably began to be used on non-crop sites by WWII.
- The usage of conventional pesticides in the professional market increased quite steadily from about 50 to 60 million pounds per year in the early to mid-1930's to about 210 to 220 million pounds per year from the mid-1960's until around 1980; since then it has declined to just under 130 million per year;
- Other pesticide chemical usage increased from about 15 million pounds per year in the mid-1930's to a peak of about 50 million per year during 1956/1967; since then such usage has tended to decline to a level of about 20 million pounds per year during most recent years;
- The total of conventional and other pesticide chemical usages was at a low of about 50 million pounds per year in 1932/34 and increased to 267 million pounds per year in 1965/67; since then, total usage has declined to 150 million per year in 1995/97.

! Conventional and Other Pesticide Chemicals, Per Capita Usage, 1929/97

- A pattern which emerges is consistently lower levels of usage per capita since 1965/67 when usage was about 1.5 pounds per capita. For 1995/97, usage was about 0.7 pounds per capita.
- This compares with about 0.85 pounds per capita for the home and garden market and 3.57 pounds per capita for agricultural usage (based on 947 million pounds of active ingredient and 265 million population for 1995/97)

! Conventional and Other Pesticide Chemical Usage, by Class, 1929/97

- Herbicide usage emerged with significant quantities during WWII, held at about 75/85 million pounds per year through 1983/85 and has declined since to about 50 million pounds per year;

- Insecticide/miticide usage was already established by 1929/31, was in the general range of 35 to 45 million pounds per year for 1961/91 and has since declined somewhat;
- Fungicide usage expanded sharply during WWII and his remained at similar levels much of the last 50 years, showing some declines in the last decade;
- Petroleum/oil and sulfur usage has remained much the same during the last 30 years;
- Fumigant/nematicide usage expanded during WWII, leveled off during the 1960's and 1970's, and has declined to some degree during the last decade.

! Professional Market Pesticide User Expenditures, 1979/1997 (See pages 7/25-27.)

- Aggregate user expenditures have increased by about one-half from about $1.09 billion in 1979 to $1.53 billion in 1997. Much of the increase is in insecticides/miticides, for which expenditures more than doubled over the nearly 20 years. Increases for herbicides and other types of pesticides have been much more nominal.
- Estimates were made of professional market user expenditures for 1979/97 in constant 1997 dollars to take out the impact of inflation. The result was that expenditures in real terms declined from about $2.2 billion in 1979 to $1.5 billion in 1997.
- When placed on a per-capita basis, expenditures have declined rather significantly, reflecting the above aggregate trends and increasing population. On a per capita basis, expenditures declined from about $9.80 to $5.70 between 1979 and 1997. Expenditures for professional market pesticides are equal to a rather nominal amount per capita, and have been declining in real terms during roughly the last two decades.

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 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 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 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 Ennis.., p. 109

Table 2.1 Historical Time line for Pesticide-related Developments

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. 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 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

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
Conventional Pesticides		
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		
Other Pesticide Chemicals		
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		
Wood preservatives	Industrial wood preservatives	Includes water/oil borne preservatives, fire retardants, creosote, coal tar, petroleum
Specialty biocides	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
Chlorine/hypochlorites	Chems. for disinfection of potable/waste water; bleaching, disinfectant and pools	Excludes chemicals used for other purposes
GRAND TOTAL		

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PART THREE

PROFILE OF CURRENT OVERALL U.S. PESTICIDE USAGE

The purpose of this section is to present an overview of overall pesticide usage in the United States, covering the various types of pesticides regulated under FIFRA. For conventional/other pesticides, information is also presented on quantities used and user expenditures by economic sector. Overall quantities used are viewed by type of land area where applied and a comparison is made of U.S. conventional pesticide usage to World totals.

The profile information presented in this section is patterned after that already presented in the most recent "Pesticide Industry Market Report" published by the Agency which contains usage estimates through 1997. (EPA, November,1999) Most of the current numerical usage estimates and related profile information presented in this section of this report is contained in that earlier document. Presented below is a brief discussion of definitions used for pesticide types, economic sectors and sources of information. For further information on these aspects, reference is made to the latest "Market Report" (EPA, November, 1999) and the section on "Approach and Data Sources" presented in Part Four of this report.

A.. Background on Pesticide Types and Usage Sectors

Pesticides of various types are used in most sectors of the U.S. Economy. In general terms, a pesticide is any agent used to kill or control undesired insects, weeds, rodents, fungi, bacteria or other organisms. Thus, the term "pesticide" includes insecticides, herbicides, rodenticides, fungicides, nematicides, and acaricides as well as disinfectants, fumigants, wood preservatives and plant growth regulators. Pesticides play a vital role in controlling agricultural, industrial, home/garden and public health pests.

Many crops, commodities and services in the U.S. could not be supplied in an economic fashion without control of pests with chemicals or by other means. As a result of pesticide use, goods and services can be supplied at lower costs and/or with better quality. These economic benefits from pesticide usage are not achieved without potential risks to human health and the environment due to the toxicity and potency of pesticide chemicals. For this reason, the chemicals are regulated under the pesticide laws to avoid unacceptable risks. Below is an identification of the general types of pesticides regulated under FIFRA.

1. General Pesticide Categories

Five general categories of pesticides are used in this report for reporting quantities used, and related information. They are as follows:

a. conventional pesticides,
b. other pesticide chemicals,
c. wood preservatives,
d. specialty biocides, and
e. chlorine/hypochlorites.

The first type, conventional pesticides, covers the majority of the active ingredients registered as pesticides (more than 800 out of nearly 900 active ingredients registered under FIFRA currently). These are the chemicals developed and produced primarily for use as pesticides and generally have little or no other applications or uses. The next type of pesticides, other pesticide chemicals, is for chemicals produced mostly for other purposes but which also happen to have useful applications as pesticides. Some examples of "other pesticide chemicals" are sulfur, petroleum and sulfuric acid, small fractions of overall usage which are for pesticidal purposes. These "other pesticide chemicals" are generally formulated, marketed and used in a manner similar to conventional pesticides, contrary to the other, final three, types of pesticides, as noted below.

Wood preservatives are principally used in specialized industrial plants to treat wood so it can withstand extended exposure to the outdoors, especially marine, aquatic and soil environments. The principal chemicals used are creosote/coal tar/petroleum and arsenicals. Generally, the wood preservatives are applied to wood by pressure treatment in kiln's to obtain maximum penetration. Specialty biocides is a term used for antimicrobial chemicals used as disinfectants and sterilizers, including those to treat water in swimming pools, spas and industry. Chlorine and hypochlorites are generic chemicals, some fractions of which are also used as pesticides, principally to disinfect water and for bleaching.

All of these categories of pesticides are regulated under the Pesticide Laws (principally the Federal Insecticide, Fungicide and Rodenticide Act FIFRA) administered by EPA in cooperation with other Federal Agencies (such as FDA and USDA) and the States. The separate quantities of pesticide-type chemicals regulated by FDA (and USDA) apart from EPA are not included in numbers reported in this report, e.g., quantities of specialty biocides used as hospital/medical antiseptics, food/feed preservatives and cosmetics/toiletries.

2. Pesticide Classes

Conventional pesticides are customarily grouped into classes named for the types of target pests they are designed to control. The estimates are also presented with breakouts for the various types/classes of pesticides. In this report, conventional pesticides are separated into five classes as follows: herbicides/plant growth regulators (H/PGR), insecticides/miticides (I/M), fungicides (F), fumigants/nematicides (F/N) and other conventional (OC). Other conventional (OC) includes pesticides for rodents, molluscs, aquatic areas, fish/birds, insect growth regulators and other miscellaneous pesticides. The "other pesticide chemicals" category is split into two classes as follows: sulfur/petroleum and other (which contains a number of chemicals/types as defined below Table 3-2). These particular types of classes are not used for the other general types of pesticides.

3. Economic Sectors

Quantities of pesticides used (and other parameters such as user expenditures) may be reported with separate breakouts for the economic sectors. In this report, the U.S. economy is divided into three sector categories for reporting pesticide usage as follows: (a) agriculture; (b) industrial/commercial/governmental (professional market); and (c) home and garden (homeowner applications, excluding applications to homes/gardens by professional applicators that are included in the professional category). The estimates for agriculture include those by the farmer (or farm employee) and also those done by commercial agricultural pesticide applicators (or other farmers for hire/barter). The specific definitions of the economic sectors are presented in Table 3-2 where U.S. usage of conventional pesticides and other pesticide chemicals is divided into the three economic sectors. Such breakouts are not available for the other general types of pesticides for which quantities used are presented later in this section.

B. Sources of Information

There are no programs at EPA or other agencies devoted specifically to estimation of the overall pesticide market in quantitative and dollar terms each year. Accordingly, this report is prepared based on the best information from the public domain and proprietary sources. A major effort was made to obtain information in addition to that already available in Pesticide Program files, libraries and data bases. Numerous electronic and manual literature searches were performed in 1998 and 1999, with a particular eye toward obtaining information on historical pesticide usage. Site visits were made to several Agency libraries in the Washington D.C. area including, USDA/Beltsville, USDA/ERS, USDA/South Building, Census Bureau, U.S. ITC and EPA main library. A wide variety of new literature was assembled as result of the searches, particularly on historical usage and trends.

The Agency has available a wide variety of published and proprietary information on pesticide usage. Extensive files and library materials on pesticide usage are maintained at the Pesticide Data Center, EPA/OPP/BEAD. For the agricultural sector, which accounts for a majority of use of

conventional pesticides, the Agency has available five national data bases/services including those in the U.S. Department of Agriculture plus a number of more specific and limited data sources. For the non-agricultural sector, there is a similar number of sources of information. For both the agricultural and non-agricultural estimates, use is made of proprietary data sources, with the permission of vendors. The proprietary sources used by EPA are well known organizations, which are also utilized by registrants and other private sector firms.

The methods used by the various sources of information to make estimates vary from large statistically based grower/user samples or panels (e.g., 15,000-20,000 respondents annually) to use of more limited interview/survey approaches of growers, applicators, pesticide suppliers and pest management consultants. Each source using a particular method must be considered on its merits in judging the usefulness and relevance to making usage estimates. Corroboration and cross checking are used where possible.

A brief summary of principal usage data sources available to Agency Staff is included in Appendix Three A of this report. The classification scheme for reporting usage discussed above is summarized in Appendix Three B. Also, there is further discussion of approaches used and data sources presented in Part Four of this report. In addition, text and table references are presented throughout the text and tables as needed.

The profile of U.S. pesticide usage and user sectors presented below in Part Three of this report (Tables 3-1 through 3-3) is centered on the year 1997 and is essentially as presented in the 1996/97 Pesticide Market Report published as part of the EPA series covering years 1979 through 1997. (EPA, November, 1999) A profile of U.S. pesticide usage by land-use type is presented in Table 3-4, which is an approximation based on most recent estimates of land use and pesticide usage, circa 1990's.

C. Current Overall U.S. Pesticide Usage, by General Type

More than 4.5 billion pounds of pesticide active ingredient are used in the U.S. in a current typical year. This figure is for the active ingredient only, which excludes the weight of the remainder of formulated products, i.e., the inert ingredients. Such “inerts” include a wide variety of compounds such as diluents, carriers, stickers, propellants, etc. For 1997, the estimated total for all types of pesticides was 4.627 billion pounds (Table 3-1). The breakdown on this usage by general type of pesticides is shown in Table 3-1 and Figures 3-1a and 3-1b.

Conventional pesticides and "other pesticide chemicals" (e.g., sulfur, petroleum, etc.) account for about one-fourth of the total pesticide active ingredient used in the U.S. (1.231 billion pounds or 27 percent of the total). Chlorine/hypochlorites are the leading type of pesticides in the U.S., with half of the U.S. total (2.459 billion pounds, or 53 percent of the total). Wood preservatives account for 14 percent of the total with 665 million pounds of active ingredient used in 1997. Specialty biocides are the smallest component of the total with 0.272 billion pounds, to make up the remainder of the U.S. total of 4.627 billion pounds in 1997.

The above aggregate quantities of pesticides used can be expressed on a per capita basis, to reflect the average volume used per person in the U.S. Figure 3-1c presents the results of such calculations for the U.S. for 1997. Overall usage was about 17.3 pounds per capita for all pesticides regulated under FIFRA. For conventional pesticides, the figure was about 3.6 pounds per capita. More than nine pounds per capita of chlorine/hypochlorites were used in 1997.

Table 3-1 Overall U.S. Usage of Pesticide Active Ingredient, by General Type, l997 Estimates

Type	Mil. Lbs. Active Ingredient	Percent of Total
Conventional Pesticides	975	21
Other Pesticide Chemicals Sulfur, petroleum (oil, distillates, etc.), sulfuric acid, and other misc. chemicals used as pesticides	256	6
Wood Preservatives 1	665	14
Specialty Biocides by End Use		
Swim pools, spas, ind. water treatment 2	186	4
Disinfectants and sanitizers 3	35	1
Other 4	51	1
Subtotal	272	6
Chlorine/ hypochlorites		
Disinfection of potable and waste water	1,476	32
Bleaching disinfectant and pools	983	21
Subtotal	2,459	53
Total Regulated under FIFRA	4,627	100

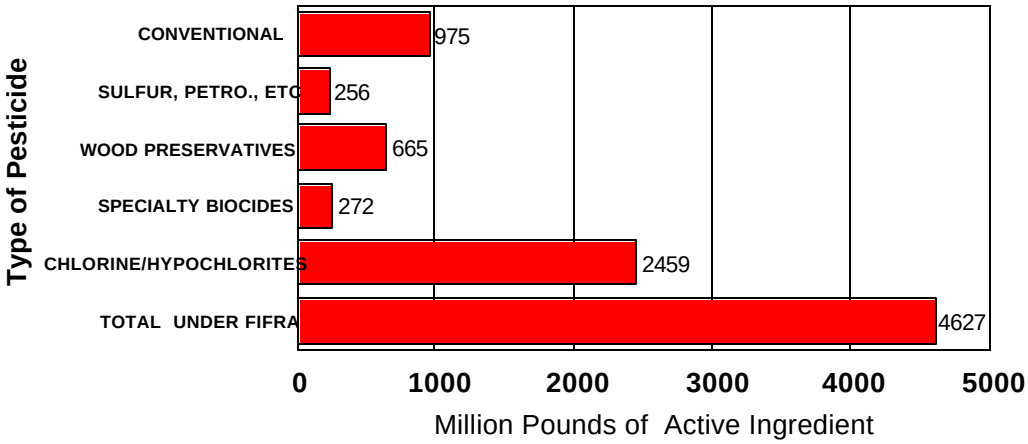
SOURCES: Wood Preservatives–EPA estimate for 1997 is projected change from AWPI reported amount for 1996; Biocides–Kline & Co. Staff input; Chlorine/hypochlorites–EPA projections forward from estimates in report by Charles River Assoc's., April, 1993.

NOTES

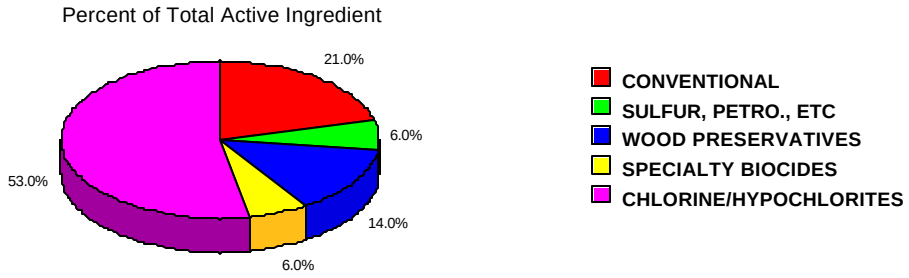
Totals may not add due to rounding.

1. Includes water and oil borne preservatives, fire retardants and creosote/coal tar/petroleum preservatives.
2. Specialty biocides only. Does not include hypochlorite or chlorine consumption, which is reported separately.
3. Includes industrial/institutional application of household products. Specialty biocides only. Does not include hypochlorite or chlorine consumption, which is reported separately.
4. Includes biocides for adhesives and sealants, leather, synthetic latex polymers, metal working fluids, paints, and coatings, petroleum products, plastics and textiles. Does not include: hospital and medical antiseptics, food and feed preservative, and cosmetics/toiletries, as they are regulated largely by FDA under the U.S. Food, Drug and Cosmetic Act, rather than FIFRA. FDA and EPA share regulatory responsibilities over some of the specialty biocides reported in the table.

Overall U.S. Usage of Pesticide Active Ingredient , by General Type, 1997 Estimates
Figure 3-1a

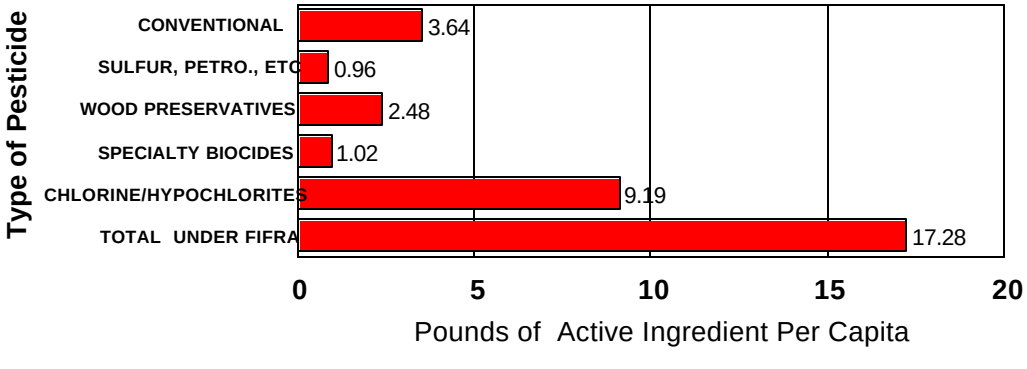


Overall U.S. Pesticide Usage, Percentage by General Type, 1997 Estimat
Figure 3-1b



SOURCE: EPA Estimates, Table 3-1

Overall U.S. Usage of Pesticide Active Ingredient Per Capita , by General Type, 1997 Estimates
Figure 3-1c



Based on civilian population estimate of 267.7 million for 1997

D. Volume of Conventional/Other Pesticides Used, by Class and Sector, 1997

The purpose of this section is to present estimates of the quantities of conventional/other pesticide chemicals used in the U.S., by economic sector and pesticide class, for the year 1997. Estimates are not available, by economic sector, for the other general types of pesticides for which quantities used were presented in Table 3-1. Quantities used are reported with separate breakouts for the three economic sectors, which are specifically defined below Table 3-2. Home and garden refers to homeowner applications only (excluding applications to homes/gardens by professional applicators which are covered the C/I/G category). The estimates for agriculture include those by the farmer (or employee) and also those done by commercial agricultural pesticide applicators (or other farmers for hire/barter). The estimates are presented with breakouts for the five classes of conventional pesticides and two classes of other pesticide chemicals. Major sources of information for the estimates of usage are noted below Table 3-2.

Agriculture dominates in usage of most classes of conventional and other pesticide chemicals as it accounted for 77 percent of active ingredient of such pesticides in 1997 (total of 944 million pounds of active ingredient). (Table 3–2) About one half of agricultural usage of pesticides is herbicides/plant growth regulators (470 million pounds out of a total of 944 million). The importance of herbicides in agriculture is a result of the widespread applications of such chemicals to the major field crops of corn, sorghum and soybeans, which are very large acreage crops. Fumigants/nematicides and sulfur/petroleum are also important in agriculture with about 140 million pounds of usage each (Table 3-2 and Figures 3-2a and 2b). They tend to be used on smaller acreage crops such as fruits, vegetables and nuts, but at higher rates of chemical application per acre..

The industrial/commercial/governmental sector had estimated usage of 151 million pounds of active ingredient in 1997, which equaled 12 percent of the U.S. total (Table 3-2 and Figures 3-2a and 2b). It's sector share was highest (about 25 percent) for insecticides/miticides and fungicides, followed by fumigants/nematicides (19 percent). Home and garden applications utilized an estimated 136 million pounds of active ingredient in 1997, which equaled 11 percent of the total, just behind the professional market (I/C/G) (Table 3-2). The largest market share for home and garden was for “other pesticide chemicals/other” pesticides due largely to use of moth treatment chemicals by homeowners.

The relative importance of pesticide usage in the various sector/class combinations can be seen graphically in Figures 3-2a and 2b. Agricultural usage is most dominant in herbicides/PGR’s, nematicides/fumigants and sulfur/oil.

Figure 3-2c depicts graphically the relative importance of “total conventional” and “other pesticide chemicals”, by sector for 1997. The professional market has the lowest share for “other” (14.6 percent), while home/garden is the highest (44.1 percent), due to extensive usage of moth proofing chemicals, to be discussed later in this report.

Table 3-2 Volume of Pesticide Active Ingredient Used in the U.S., by Type and Economic Sector, 1997 Estimates

	Sector 3			
Pesticide Type	Agriculture	Ind./Comm./ Gov't.	Home & Garden	Total
	Mil. Lbs. Active Ingredient			
Conventional Pesticides				
Herbicides/Plant Growth Regulators	470	49	49	568
Insecticides/Miticides	82	30	17	129
Fungicides	53	20	8	81
Fumigants/Nematicides	140	24	1	165
Other 1	25	6	1	32
Total Conventional	770	129	76	975
Other Pesticide Chemicals				
Sulfur/Oil	144	14	15	173
Other 2	30	8	45	83
Total Other	174	22	60	256
Total Conventional and Other	944	151	136	1,231
	Percent of Total			
Conventional Pesticides				
Herbicides/Plant Growth Regulators	83	9	9	100
Insecticides/Miticides	64	23	13	100
Fungicides	65	25	10	100
Fumigants/Nematicides	85	15	1	100
Other 1	78	19	3	100
Total Conventional	79	13	8	100
Other Pesticide Chemicals				
Sulfur/Oil	83	8	9	100
Other 2	36	10	54	100
Total Other	68	9	23	100
Total Conventional and Other	77	12	11	100

NOTES:

Totals may not add due to rounding.

Table does not cover industrial wood preservatives, specialty biocides and chlorine/hypochlorites.

1 Includes rodenticides, molluscicides, aquatic, fish/bird pesticides, insect regulators, and other miscellaneous pesticides.

2. Includes sulfuric acid, insect repellents, zinc sulfate and other misc. chemicals produced largely for non-pesticidal purposes. Moth control chemicals (e.g., paradichlorobenzine and napthaline) are included in totals presented.

3. Sector Definitions: Quantities and expenditures for pesticides in the U.S. are divided among economic sectors as follows:

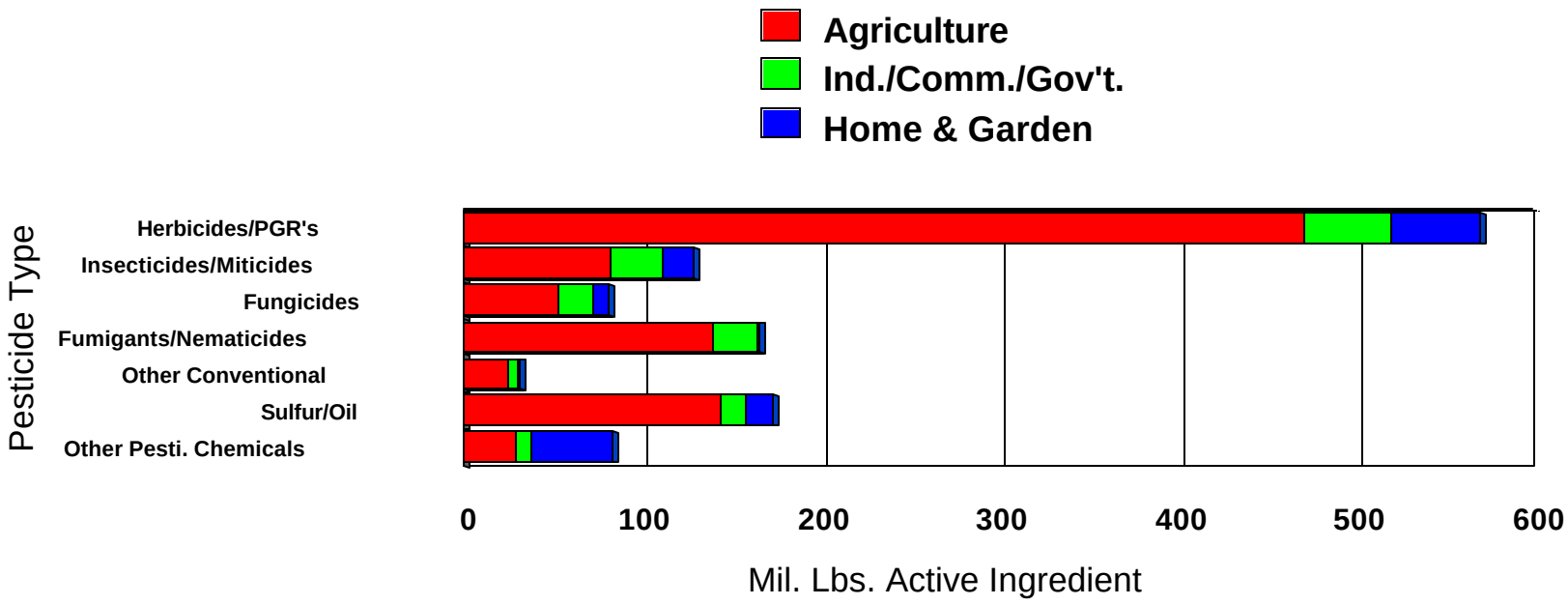
Agriculture–applications by owner/operators and custom/commercial applicators to farms and facilities involved in production of raw agricultural commodities, principally food, fiber and tobacco; includes non-crop/post harvest usage as well as crop/field usage.

Ind./Comm./Govt.–applications by owner/operators and custom/commercial applicators to industrial, commercial and governmental facilities, buildings, sites and land; plus custom/commercial applications to homes and gardens, including lawns.

Home and Garden–homeowner applications to homes and gardens, including lawns; single and multiple unit housing.

SOURCES:
Estimates based on: American Crop Protection Association (ACPA) annual surveys, USDA/NASS Survey Reports (1996/98); inputs from Kline, Doane, and SRI Consulting; and USDA/ERS estimates (Ag. Handbook 712 series and preliminary values for 1996/97).

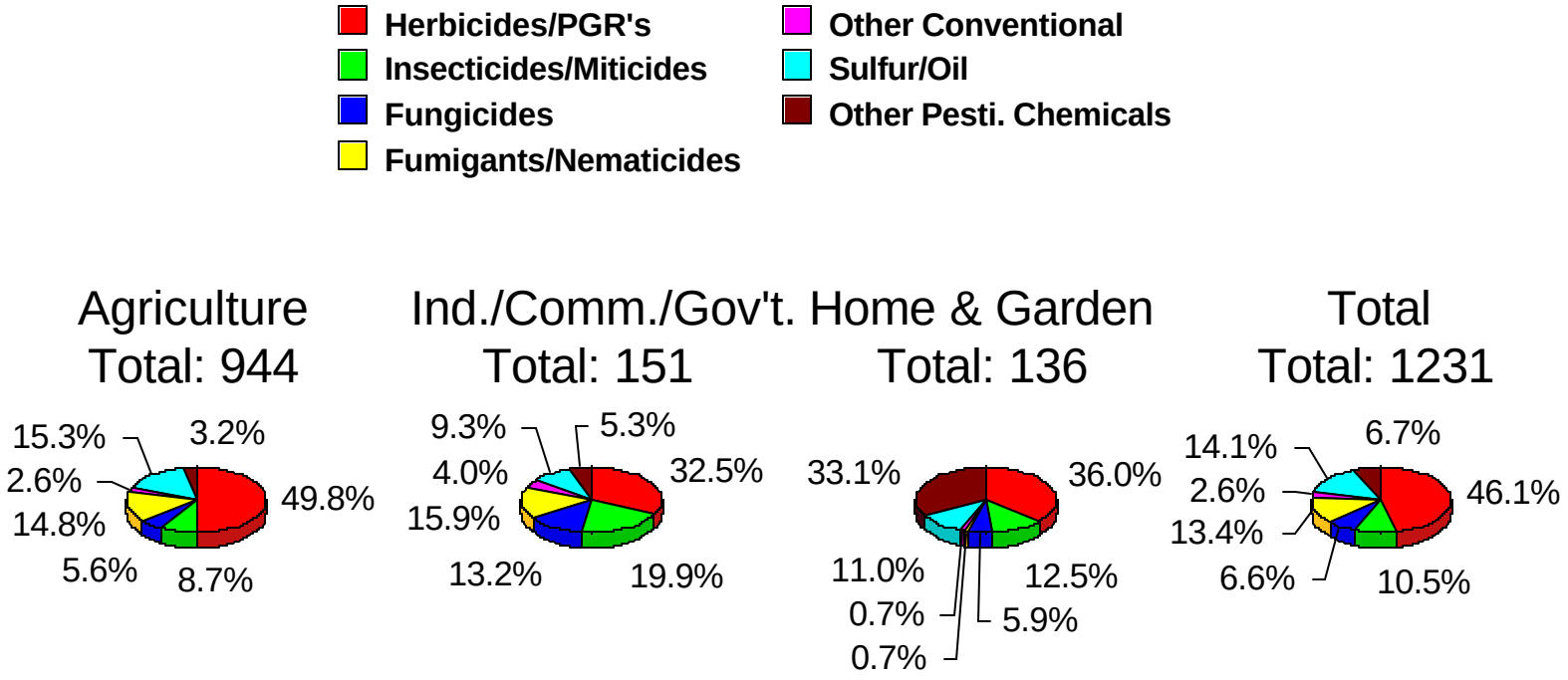
Volume of Pesticide Active Ingredient Used in the U.S., by Type and Economic Sector, 1997 Estimates
Figure 3-2a



	Herbicides/PGR's	Insecticides/Miticides	Fungicides	Fumigants/Nematicides	Other Conventional	Sulfur/Oil	Other Pesti. Chemicals
Agriculture	470	82	53	140	25	144	30
Ind./Comm./Gov't.	49	30	20	24	6	14	8
Home & Garden	49	17	8	1	1	15	45
Total	568	129	81	165	32	173	83

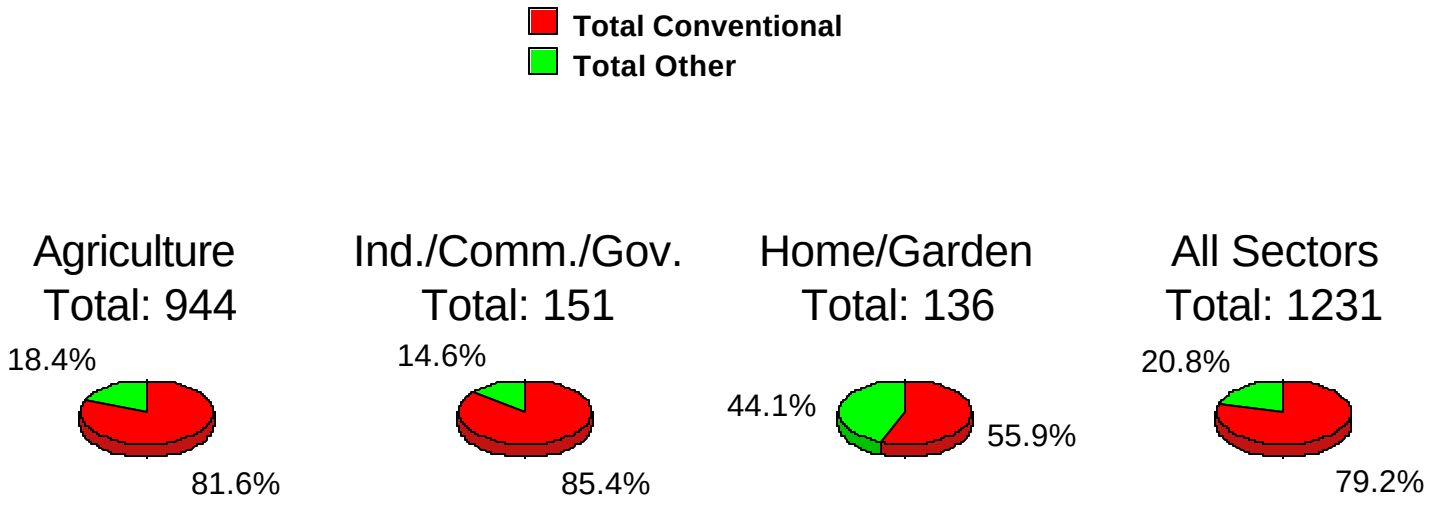
Excludes wood preservatives and biocides

Volume of Pesticide Active Ingredient Usage in U.S.
by Type and Economic Sector, 1997 Estimates
Figure 3-2b



Totals are millions of pounds active ingredient.
Excludes wood preservatives and biocides

Volume of Pesticide Active Ingredient Used in U.S., Percentage Distributions, by Type and Economic Sector, 1997 Estimates
Figure 3-2c



Totals are millions of pounds active ingredient.
Excludes wood preservatives and biocides

E. Expenditures for Conventional/Other Pesticides by Type and Sector, 1997

The pesticide industry is quite significant in dollar terms. Annual expenditures by users of pesticides totaled about $11.9 billion in 1997 (conventional pesticides plus sulfur, etc.). This estimate of total expenditures is shown in Table 3-3, with percentage breakdowns by type of pesticide (pesticide class) and economic sector. The definitions of economic sector and pesticide class are as presented below Table 3-2. This type of user expenditure information has not been developed for the other types of pesticides covered in Table 3-1 (i.e., wood preservatives and biocides). The estimates of user expenditures in Table 3-3 are based on a variety of sources, including USDA/ERS farm production expenses series (national totals only are published), ACPA annual surveys, and inputs from Kline, SRI, Doane and other sources.

Agriculture accounts for 70 percent of pesticide user expenditures as of 1997, with $8.303 billion, followed by 17 percent for home/garden ($2.061 billion) and 13 percent for industrial/commercial/governmental applications ($1.533 billion) (the I/C/G sector or "professional market" as it is often termed) (Table 3-3 and Figures 3-3a and 3b). Insecticide expenditures are relatively more important in the home and garden sector (67 percent of home and garden pesticide expenditures) because of the quantities involved (larger percentage than for other types of pesticides, as indicated in Table 3-2), small unit quantities and relatively expensive formulations, e.g., aerosols. Agriculture dominates expenditures for herbicides with 82 percent and for fungicides with 79 percent due to the large shares of active ingredient involved. (Table 3-2)

Herbicides (including plant growth regulators) lead other types in overall expenditures with 58 percent for all sectors combined, and especially for agriculture with 68 percent of its total for all types (Table 3-3 and Figure 3-3c). Insecticides (including miticides) were second in importance with 30 percent of the total for all sectors, far ahead of fungicides and other pesticides. Herbicides lead expenditures for agriculture, while insecticides/miticides lead for the other two sectors (Table 3-3 and Figure 3-3d).

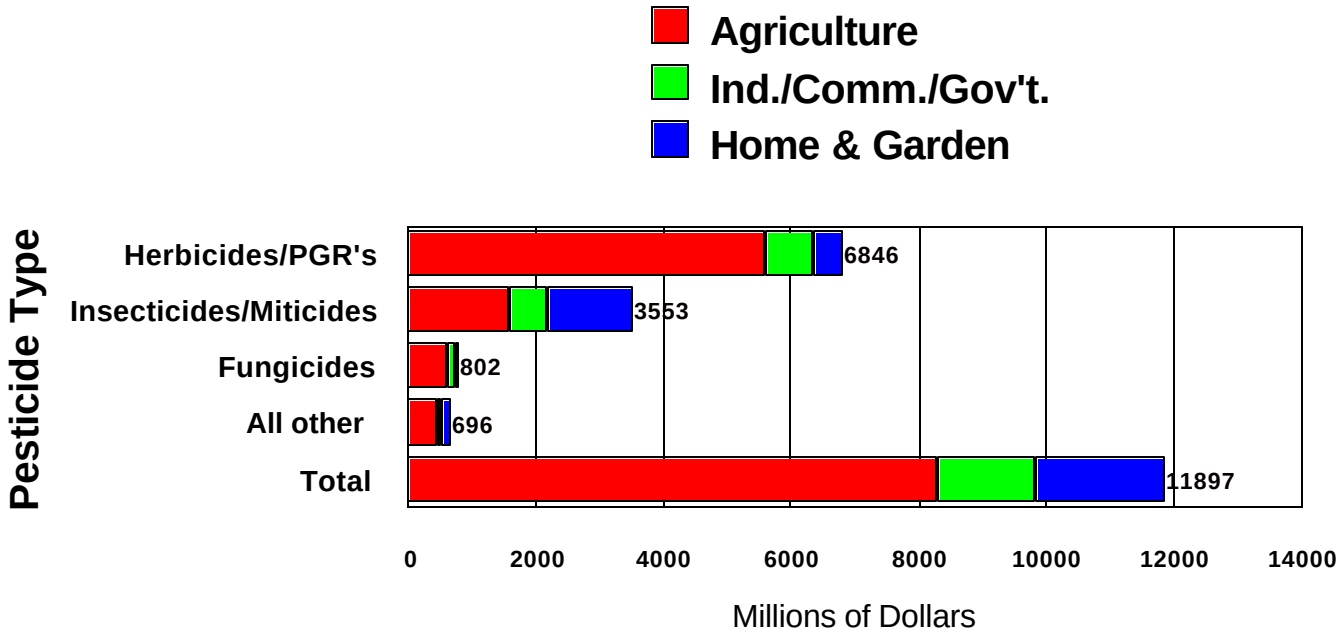
The pesticide user expenditures for agriculture (a total of $8.303 billion) equal an average of about $4,300 per farm in the U.S. for 1.925 million farms. The total for the I/C/G sector ($1.533 billion) equals about $38,000 per commercial pesticide application firm (assuming 40,000 such firms in U.S.). (There were an estimated 33,100 certified/commercial pesticide application firms in the U.S. for four major certification categories according the EPA applicator survey for 1993; EPA, August, 1995.) For homeowner applications only, a total of $2.061 billion equals about $21 per household (assuming 100 million households). (This does not include expenditures for pesticides applied to homes and gardens by others for hire.) The U.S. total of $11.897 billion for 1997 equals about $44 per capita in the U.S. (assumes about 268 million population).

Table 3-3 User Expenditures for Conventional and "Other " Pesticides in U.S., By Class and Economic Sector , 1997 Estimates

Pesticide Type	Agriculture	Ind./Comm./Gov't.	Home & Garden	Total
	Millions of Dollars			
	Agriculture	Ind./Comm./Gov't.	Home & Garden	Total
Herbicides/PGR's	$5,610.00	$743.00	$493.00	$6,846.00
Insecticides/Miticides	$1,599.00	$576.00	$1,378.00	$3,553.00
Fungicides	$632.00	$144.00	$26.00	$802.00
All other	$462.00	$70.00	$164.00	$696.00
Total	$8,303.00	$1,533.00	$2,061.00	$11,897.00
Pesticide Type	Agriculture	Ind./Comm./Gov't.	Home & Garden	Total
	Sector as Percent of Total			
Herbicides/Plant Growth Regulators	82	11	7	100
Insecticides/Miticides	45	16	39	100
Fungicides	79	18	3	100
All Other	66	10	24	100
Total	70	13	17	100
	Class as Percent of Sector Total			
Herbicides/Plant Growth Regulators	68	48	24	58
Insecticides/Miticides	19	38	67	30
Fungicides	8	9	1	7
All Other	6	5	8	6
Total	100	100	100	100

SOURCE: EPA estimates based on American Crop Protection Association (ACPA) annual surveys, USDA/ERS data series and input from Doane, Kline, and SRI Consulting. Data published in 1996/97 Market Report, EPA, November, 1999).

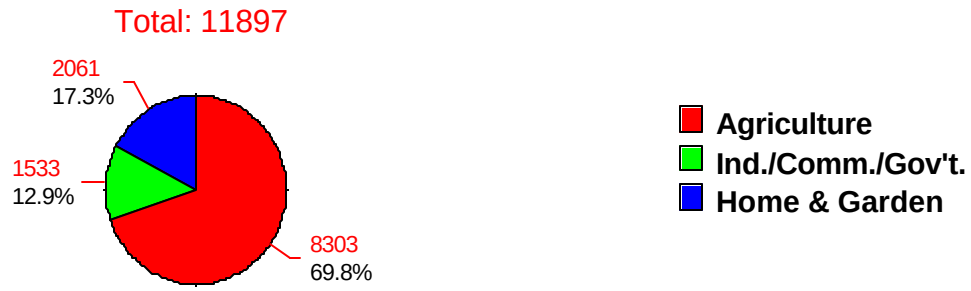
U.S. User Expenditures for Pesticides, by Class and Sector, 1997 Estimates
Figure 3-3a



	Herbicides/PGR's	Insecticides/Miticid	Fungicides	All other	Total
Agriculture	5610	1599	632	462	8303
Ind./Comm./Gov't	743	576	144	70	1533
Home & Garden	493	1378	26	164	2061
	6846	3553	802	696	11897

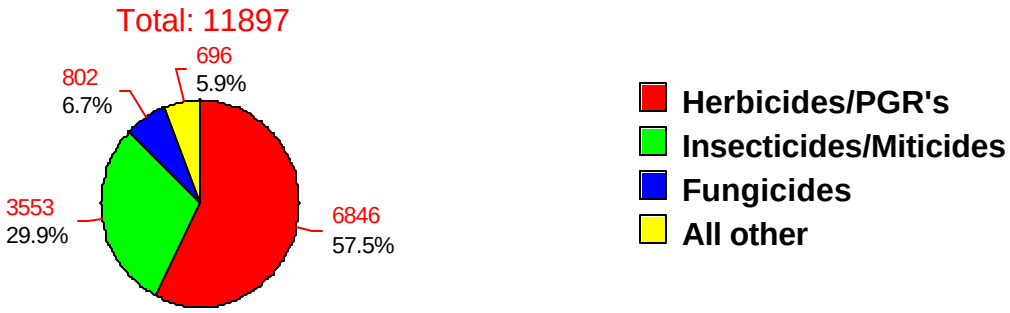
Excludes wood preservatives and biocides

U.S. Pesticide User Expenditures by Sector, 1997 Estimates
Figure 3-3b



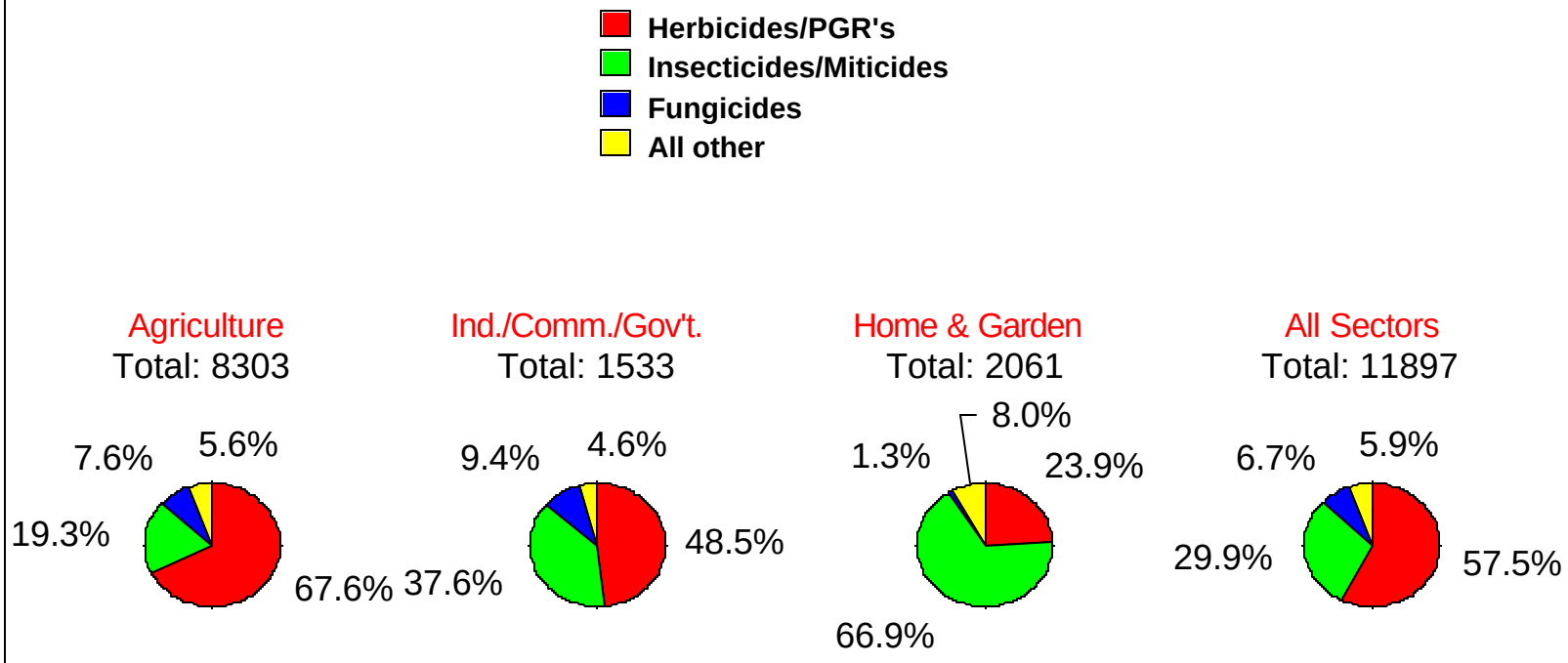
Millions of Dollars
Excludes wood preservatives and biocides

U.S. Pesticide User Expenditures by Type of Pesticide, 1997 Estima
Figure 3-3c



Millions of Dollars
Excludes wood preservatives and biocides

U.S. User Expenditures for Pesticides, by Class and Sector, 1997 Estimates
Figure 3-3d



Totals are millions of dollars.
Excludes wood preservatives and biocides

F. Overview of U.S. Land Area and Pesticide Usage

The purpose of this section is to consider the distribution of pesticide usage across the different types of land in the U.S. Estimates are made only for conventional/other pesticide chemicals because limited information exists to break out wood preservatives and biocides, by type of land use. The latest published estimates of U.S. land area by type of land use (12 types) were used (USDA/ERS, Handbook 712, July, 1997) along with estimates of water areas by Kellogg (1994). Usage of total active ingredient as estimated in the Pesticide Market Report for the latest year (1997) was used as a basis for the breakouts by land-use type. The breakouts were made primarily on the basis of the following sources of information: Doane Profile, USDA/ERS/NASS reports, particularly on percent of crops treated, and Kline Professional Market Reports. Estimates were made both for acreage treated (one or more times, i.e., base acres treated) and quantity of active ingredient used. The estimates of U.S. land area are quite precise, while those for acreage treated and quantities applied by land area should be considered as approximate values as a certain amount of judgement was involved in arriving at the figures.

The total surface area of the U.S. is 1,940 million acres, including 49 million acres of water areas (estimates for 1992) (Table 3-4). About one-fourth of U.S. land area is in cropland (460 million acres). Grassland pasture/range (589 million acres) and forest land (559 million acres) are the leading land use categories and together account for nearly 60 percent of total surface area. Urban land accounts for only about three percent of U.S. land area with 58 million acres. The urban land includes an estimated 24 million acres for urban homes and gardens, plus 34 million acres for other urban uses such as commercial, industrial and governmental (Table 3-4 and Figure 3-4a).

Conventional/other pesticide chemicals are applied to roughly one-third of a billion acres annually, as of the mid to late-1990's, which equals about 17 percent of the total surface area of 1.94 billion acres. The breakouts of acreage treated and usage of active ingredient by land-use type can be seen in Table 3-4 and Figure 3-4b.

Cropland is the leading type with 256 million acres treated, using 881 million pounds of active ingredient per year. Other types of farm land (especially grassland pasture and range) and forest land are treated with pesticides much less intensively. Miscellaneous farmland, which includes farmsteads, livestock, poultry, storage, commodity storage facilities, etc. account for an estimated 55 million pounds per year of active ingredient per year even though there are only about 5 million acres involved.

Urban homes and gardens account for about 1.2 percent of the land area, but 2.7 percent of acreage treated and 12.1 percent of active ingredient used (9 million acres treated with 148 million pounds of active ingredient) (Table 3-4). Other urban land also accounts for disproportional amounts of usage as it has about 1.7 percent of the land area, but 6.0 percent of acreage treated and 6.2 percent of active ingredient usage (20 million acres and 120 million pounds of active ingredient). Transportation land (including rights of way for electrical transmission, etc.) are quite often treated (7 million of 25 million acres each year) but relatively small amounts of active ingredient are used (only 11 million pounds active ingredient).

Agricultural cropland is the most commonly treated major land type. An estimated 300 million acres are

treated with pesticides each year (about 90 percent). (Table 3-4 and Figures 3-4a and 4b)

On the average, cropland receives about 3 pounds of active ingredient per acre, given that agricultural usage of pesticides is more than 900 million pounds per year. Urban land is often treated (25 out of 58 million acres) and has higher rates of usage than most other types of land.

Table 3-4 Overview of U.S. Land Area, by Type of Land, and Conventional/Other Pesticide Usage, Circa 1990's

Land Use Type	Total Acreage, Millions	Characterization of Site/Usage	Acreage Treated, Millions	AI Usage, Million Lbs.
Total Surface Area	1,940		333	1,231
Water Areas	49	Primarily aquatic herbicides, algaecides and mosquito controls	8	9
Total Land Area	1,891	48 states		
Total Farmland	1,055		273	944
Cropland, Total	460		256	881
Cropland for Crops	337	Accounts for majority of usage	240	870
Cropland Idled	56	Most often treated for weed control	10	7
Cropland for Pasture	67	Limited pesticide applications	6	4
Grassland Pasture & Range	589	Seldom treated	12	8
Misc. Farmland	6	Farmsteads, livestock, poultry, storage, facilities, etc.	5	55
Forest-use Land	559	Mostly herbicide treatments; a few insecticide treatments	4	4
Forest, Grazed	145			
Not grazed	414			
Urban Homes and Gardens	24	Residential, including applications by professional applicators	9	148
Other Urban/Industrial Land	34	Commercial, industrial, governmental	20	120
Transportation	25	Electrical, pipeline, rail and roadways	7	11
Other Land	194		3	5
Recreation/Wildlife	87	Often publicly owned		
National Defense areas	19			
Misc. Other Land	88	Marshes, open swamps, etc.		

NOTE: Usage does not include industrial wood preservatives and all biocides.

SOURCES:

Land areas based on USDA Agric. Handbook 712, July, 1997; EPA January 1976; and Kellogg, 1994.

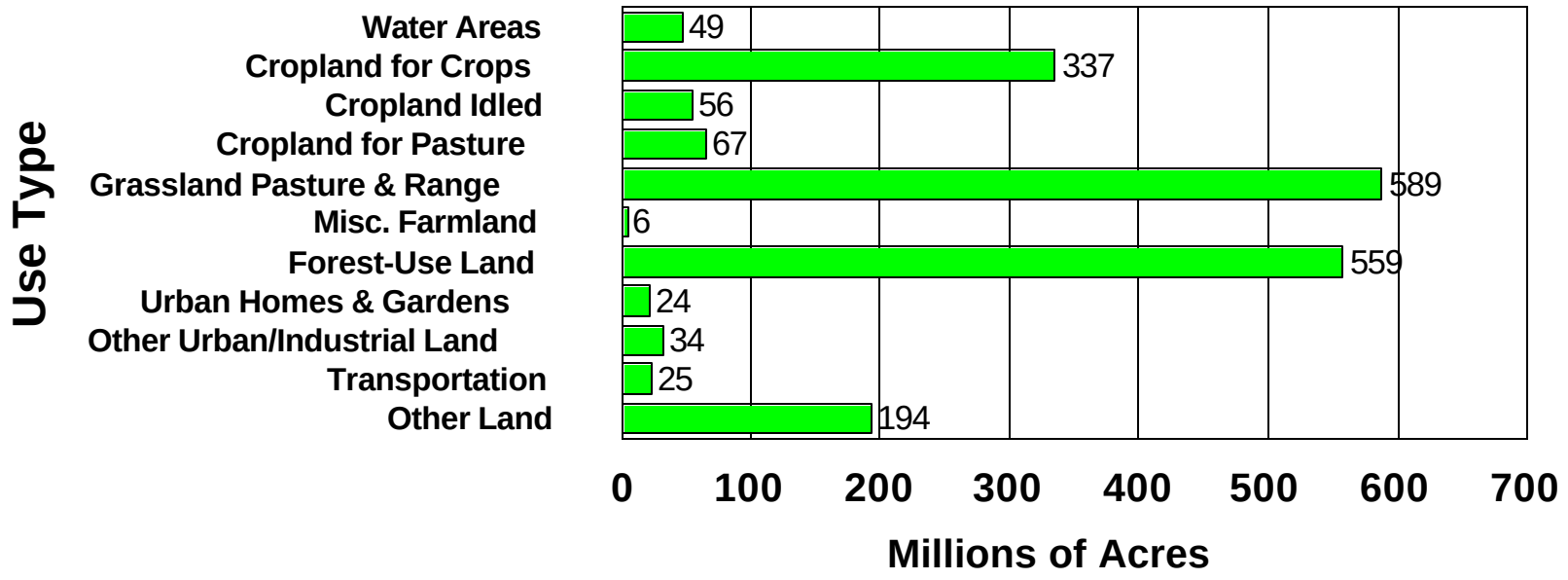
Usage estimates by land type are based on sector totals published in EPA market report for 1997 (EPA, January, 2000).

Breakouts of non-agricultural acreage treated and usage of active ingredient are based largely on Kline Professional Market reports for mid to late 1990's.

Agricultural breakouts based on Doane Profile estimates.

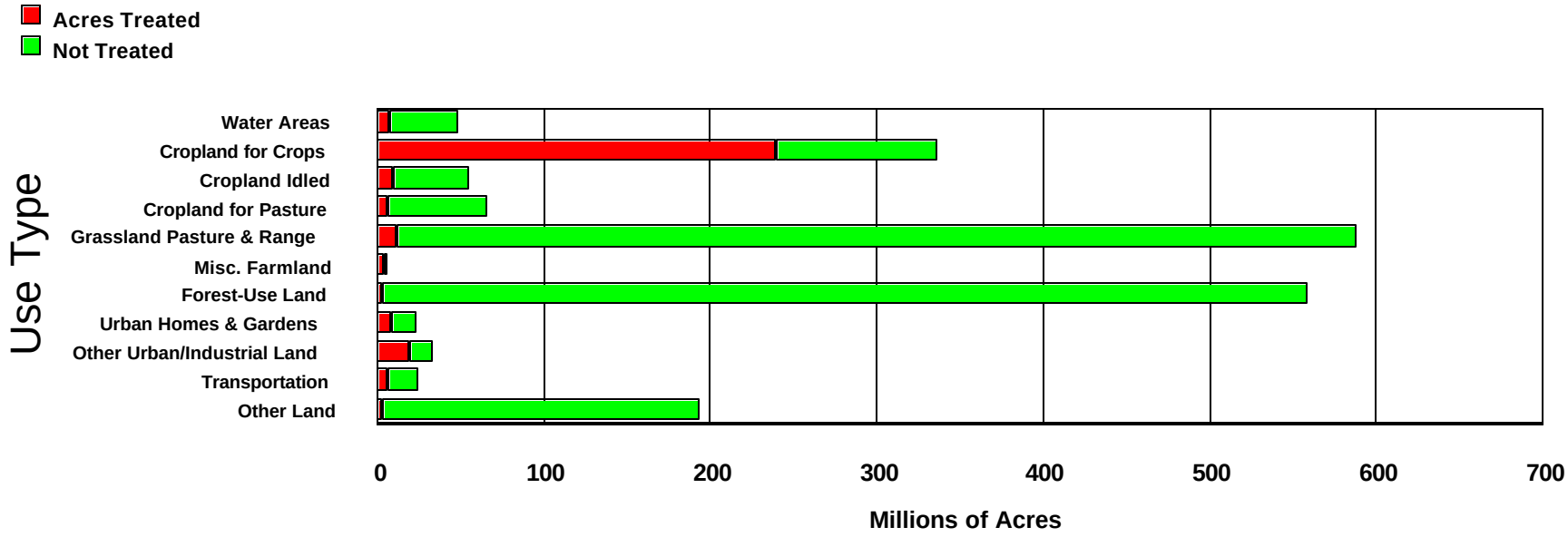
U.S. Land Area, Acreage by Type of Land Use, Circa 1990's

Figure 3-4a



SOURCE: See Table 3-4.

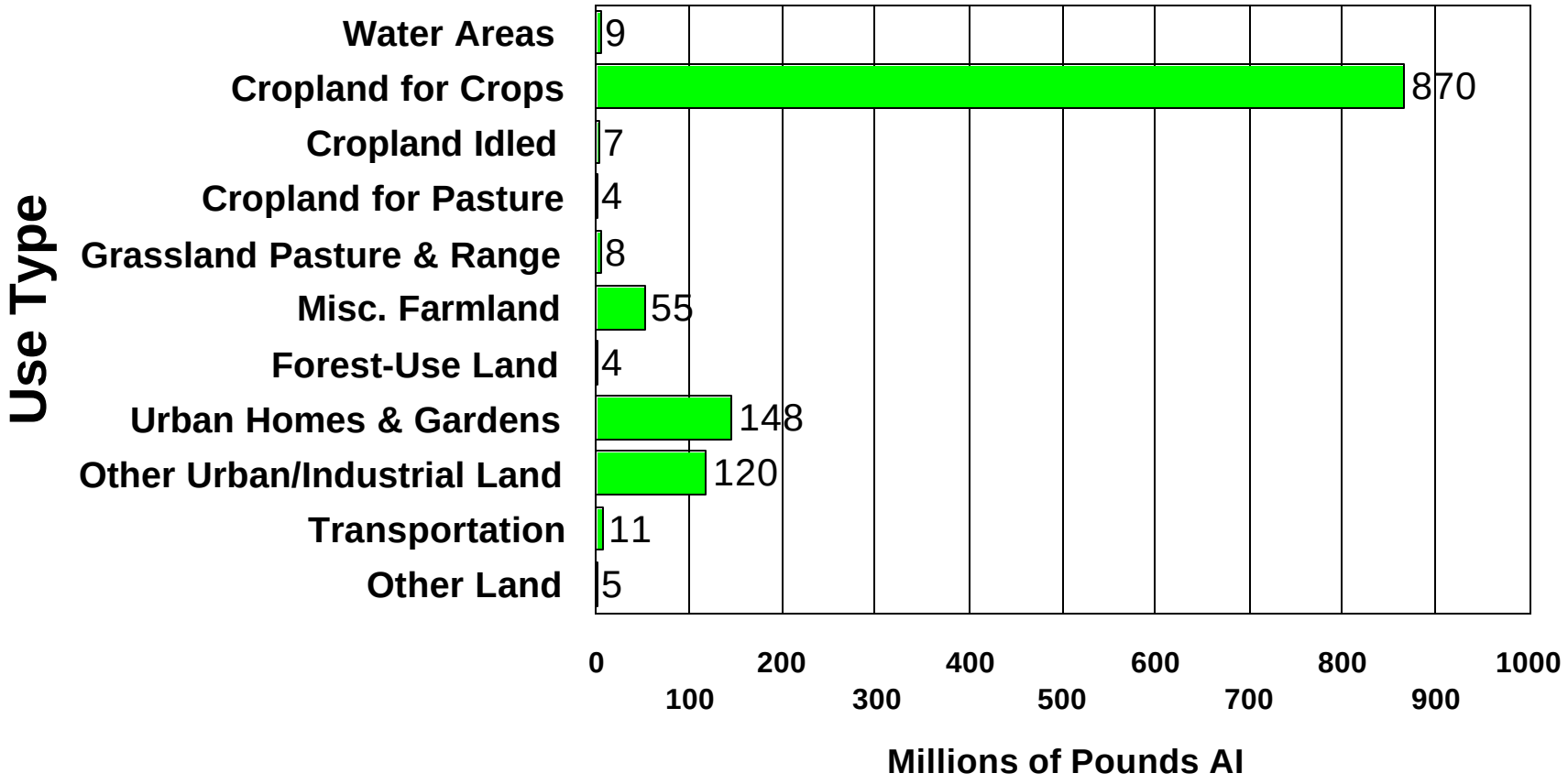
U.S. Surface Acreage Treated with Conventional/Other Pesticides, Circa 1990's
Figure 3-4b



	Water Areas	Cropland for C	Cropland Idle	Cropland for P	Grassland Pas	Misc. Farmlan	Forest-Use Lai	Urban Homes	Other Urban/I	Transportatior	Other Lanc
Acres Treat	8	240	10	6	12	5	4	9	20	7	3
Not Treatec	41	97	46	61	577	1	555	15	14	18	191
Total	49	337	56	67	589	6	559	24	34	25	194

NOTE: Excludes wood preservatives and biocides
SOURCE: See Table 3-4.

Volume of Conventional/Other Pesticide Active Ingredient Usage, by Land-Use Type, Circa 1990's
Figure 3-4c



NOTE: Excludes wood preservatives and biocides.
SOURCE: See Table 3-4.

G. Current U.S. Pesticide Usage Compared to the World

The U.S. is a major factor in the world market for pesticides. The U.S. accounts for about one third of pesticide user expenditures world wide ($11.987 billion out of $37.048 billion) in 1997 for conventional and other pesticide chemicals (excluding wood preservatives and all biocides) (Table 3-5). The highest market share for the U.S. was for herbicides/plant growth regulators (41 percent) and the lowest was for fungicides (13 percent).

In terms of active ingredient volume, the U.S. accounts for 22 percent of the world total with 1.231 billion pounds out of 5.684 billion pounds (Table 3-5). The U.S. accounts for 25 percent of herbicides used, but only 9 percent of the insecticides, world wide.

The relative importance of U.S. user expenditures and active ingredient used in 1997 is depicted in Figures 3-5a, b and c.

Table 3-5 U.S. and World Pesticide Sales at User Level, 1997 Estimates

Pesticide Class	U.S. Market		World Market		U.S. % of World Market
	Million	%	Million	%	
User Expenditures (Millions of $)					
Herbicides	$6,846	58%	$16,886	46%	41%
Insecticides	$3,553	30%	$11,592	31%	31%
Fungicides	$802	7%	$6,037	16%	13%
Other 1	$696	6%	$2,533	7%	27%
Total	$11,897	100%	$37,048	100%	32%
Volume of Active Ingredient (millions of lb)					
Herbicides	574	46%	2.254	40%	25%
Insecticides	133	11%	1.47	26%	9%
Fungicides	82	7%	539	9%	15%
Other 1	458	37%	1.421	25%	32%
Total	1,247	100%	5.684	100%	22%

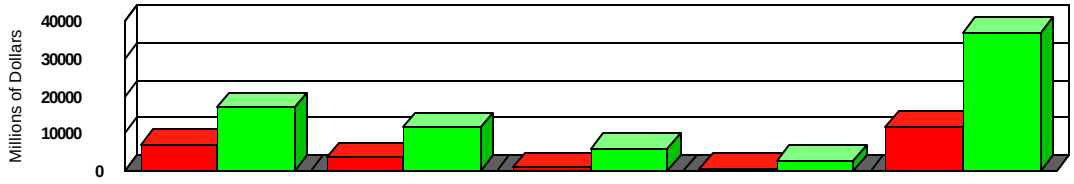
SOURCES: See sources for Tables 3-1 and 3-2.

NOTES:

1 Other includes all other conventional pesticides and other pesticide chemicals as defined in Table 3-2. Wood preservatives and biocides are not included.

U.S. and World Pesticide Sales at User Level, 1997 Estimates

Figure 3-5a

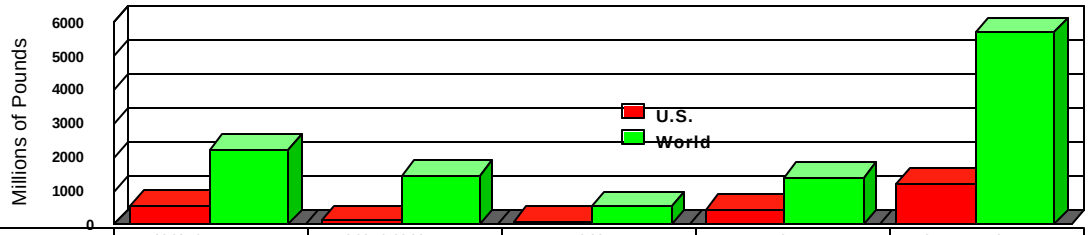


	Herbicides/PGR's	Insecticides/Miticides	Fungicides	Other	Total Conv. & Other
U.S.	6846	3553	802	696	11897
World	16886	11592	6037	2533	37048

Excludes wood preservatives and biocides

U.S. and World Pesticide Active Ingredient Usage, 1997 Estimates

Figure 3-5b

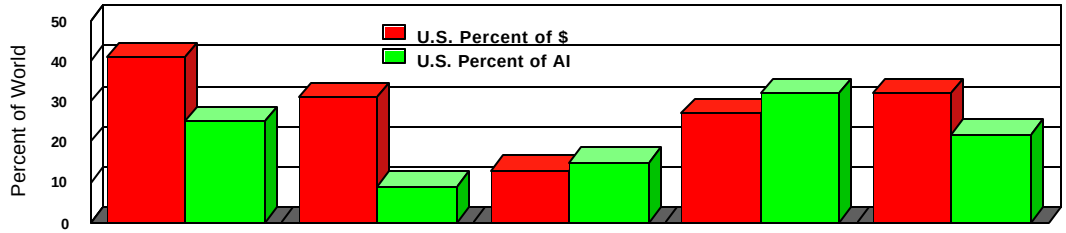


	Herbicides/PGR's	Insecticides/Miticides	Fungicides	Other	Total Conv. & Other
U.S.	574	133	82	458	1247
World	2254	1470	539	1421	5684

Excludes wood preservatives and biocides

U.S. Percentage of World Pesticide Active Ingredient Usage and User Expenditures, 1997 Estimates

Figure 3-5c



	Herbicides/PGR's	Insecticides/Miticides	Fungicides	Other	Total Conv. & Other
U.S. Percent of $	41	31	13	27	32
U.S. Percent of AI	25	9	15	32	22

PART FOUR

LONG TERM TRENDS IN OVERALL U.S. PESTICIDE USAGE

The purpose of this section is to present information on trends in overall pesticide usage in the U.S. during roughly the last seven decades. Estimates of active ingredient usage are presented for conventional pesticides and other pesticide chemicals for three year periods, starting with the period ending with 1931 and concluding with the period ending in 1997. Totals are presented along with separate breakouts by economic sector and type (class) of pesticide chemicals. Also, a separate series was developed showing conventional pesticide usage broken down by chemical family (type of chemistry of active ingredient) for each class of pesticides for every fifth year, 1930 through 1995, and 1997. Annual estimates are presented for user expenditures for pesticides for the period of 1979 through 1997. Estimates could not be made for years prior to 1979 for lack of information on non-agricultural pesticide expenditures for the earlier years

A. Approach and Data Sources

Information has been assembled on quantities of pesticide active ingredient used in U.S. going back as far as possible in time so as to be able to make comprehensive usage estimates for earliest possible years. This was done as part of a long term effort on the part of the author as well as specific research for this report. The result has been the location of enough information to make estimates of overall usage of conventional pesticides and other pesticide chemicals back to 1929. In this section, estimates are presented for conventional/other pesticide usage based on annual estimates starting with 1929. The year 1929 was selected as the first year of the data series because it was the first year of usage reported in a study for EPA by Battelle which contained estimates of usage from 1929 through 1971 (Battelle, Feb., 1975). Estimates of usage by class and sector already have been published by the Agency in the "Pesticide Market Series" (most recent edition for 1996/97) for each year from 1979 through 1997 (EPA, November, 1999). Basically, a major thrust of this project has been to take the coverage of the existing series for 1979/97 series back to1929.

The approach used was to assemble reported values for usage from all available sources and tabulate them on a worksheet showing the values by particular year and type of pesticide (along with sector, chemical family, etc. as available from the particular source). Once all of the entries were made from available sources, efforts were made to reconcile differences and conflicts which often occurred in the reported values. Numbers were verified from their sources, with due consideration to data definitions. Taking into account apparent trends and relationships in the various tabulated values, estimates were developed for each year, by pesticide class and sector utilizing the best available information and judgement of the analyst. Then, three-year averages were computed for purposes of presentation in this report for the periods ending on three year intervals from 1931 through 1997. This

was done to condense the volume of data for reporting and to avoid false precision suggested by annual estimates over the nearly 70 year period. The resulting data series is reported variously in this report, showing usage of active ingredient per year by class and sector for three year periods covering 1929/97.

Estimates of active ingredient usage by chemical family were developed for each fifth year for the period 1930 through 1995 and for 1997 based on best available information on individual chemicals and chemical groupings or families. Such breakouts were made only for the four major conventional pesticide classes (herbicides/PGR, insecticides/miticides, fungicides and fumigants/nematicides). In other words, chemical family breakouts were not developed for conventional "other pesticide chemicals" and "other pesticides" as defined in Part Three of this report (especially pages 1 through 3 and Table 3-2).

The numbers presented in this report should be considered approximate values rather than precise ones with known statistical properties. The author believes the numbers are reasonable approximations and representative of trends over time. The presentation of the results in this section is primarily with reference to charts, which contain essential values from the basic tables that are included as referenced appendices to this report.

A wide variety of sources was utilized in developing the estimates covering the years 1929 through 1997. Some of the principal sources were: Battelle study covering 1929-1971 (1975); annual reports of the commissioner of agriculture going back to as early as 1865 and yearbooks of agriculture for more recent years; USDA “Agricultural Statistics” reports which replaced the yearbook of agriculture as a reporting medium for agricultural statistics in the mid-1930's; US Bureau of the Census reports and those of the U.S. Tariff Commission, often summarized in the USDA “Agricultural Statistics Reports” from 1936 on; periodic USDA surveys, particularly those of a comprehensive nature conducted in the 1960's and early 1970's; SRI Chemical Economics Handbook estimates covering the period since 1965; SRI contract study for CEQ covering period from 1950 to 1970; RVR Consultants estimates of usage for various years 1972 through 1986; Doane Market Research reports and data base covering late 1960's through 1997 (particularly the last 15 years); periodic reports on agricultural pesticide usage by the National Center for Agricultural Policy (1980's and early 1990's, funded by EPA and others); USDA/ERS estimates of comprehensive crop use of pesticides based on extrapolations of USDA’s survey results to all crop acres; and EPA/OPP staff estimates published for the period from 1979 through 1997 in the latest "Pesticide Market Report" (Aspelin and Grube, EPA, November, 1999).

Other key sources included: USDA/Commodity Stabilization Service (later ASCS) Pesticide Situation reports (starting with 1953/54) and related Pesticide Reviews which were published through 1980; a book by Harold H. Shepard which contains reported/estimated values for most pesticides as of about 1950, and earlier years (Shepard, 1951); (Shepard's work contained estimates by crop and non-crop use in many instances, which helped in making sector breakouts of usage; an article by R.C.

Roark, also as noted below (May, 1935); a book by Donald E.F. Frear on the chemistry of insecticides and fungicides (1942); an EPA-funded study report by ICF containing an economic profile of the pesticide industry, including long term statistics on pesticide usage by chemical) (ICF, August, 1980); and EPA-sponsored surveys of pesticide usage (mid 1970's, all sectors), late 1980's (comm. applicators), 1990 (home and garden) and 1992 (certified/commercial applicators).

The same basic sources of information used for development of the estimates for usage for the three year averages covering 1929/97 were used for developing the breakouts of usage by chemical family for 1930-95 and 1997. The Chemical Economics Handbook Series by SRI published variously from the 1970's to date, was particularly useful for the years 1965 through 1997. (SRI, various editions, 1970-99) The pesticide market studies by RvR Consultants covering usage for 1974 through 1986 contained usage estimates by chemical/chemical family or class, as did the study for the Council for Environmental Quality by SRI in 1972, which contained estimates for the years 1950 through 1970. (SRI, April, 1972) The USDA Pesticide Situation Reports and Reviews coving the years from 1952/53 (with estimates back to the late 1940's in some instances) through 1980 were quite useful. Profiles of pesticide usage, by chemical/chemical family were developed by USDA staff for 1934 (R.C. Roark, Industrial and Chemical Engineering, May, 1935), and for 1936, 1941 and 1944 as published in USDA Agricultural Statistics (1938, page 525; 1942, page 690; and 1945, page 468). EPA registration data bases and the Merck Index were used to check on when chemicals were developed or patented as pesticides in some cases.

A data base was developed to compute net usage of pesticides, by chemical or family, based on data developed by the U.S. Tariff Commission and by the U.S. Bureau of Census as reported directly by those agencies and also as summarized in the U.S. Agricultural Statistics reports covering the years 1919 through the early 1960's. After that time, the reported numbers increasing do not permit detailed breakouts by chemical or family as was the case for earlier years.

The bibliography to this report contains a comprehensive listing of sources, some of which are not discussed or noted above.

Time series resulting from the above noted approach are contained in Appendix 4 (usage estimates by class and sector, three year periods ending 1931-97, all conventional/other pesticide chemicals). Usage estimates by class and chemical family or group, stated fifth years 1930-95 and 1997, conventional pesticides only are presented in Figures 4-7/10.

B. Total Usage of Conventional/Other Pesticides, 1929/1997

1. Aggregate Usage Trends

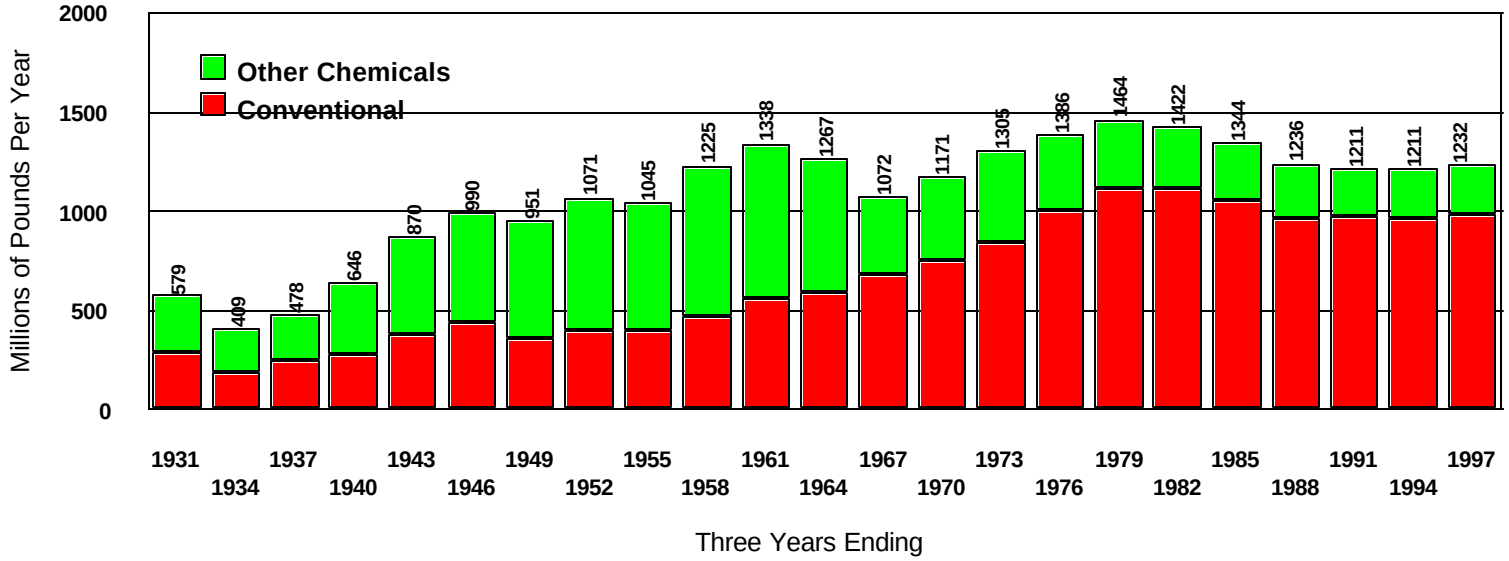
Usage of conventional pesticides and other pesticide chemicals was well underway by the beginning of the 1930's. By that time, there was widespread usage of calcium arsenate, lead arsenate, copper sulfate and mercury compounds for insecticides and/or fungicides, principally to protect agricultural crops, as will be discussed further in part Five of this report. Estimated usage of conventional/other pesticide chemicals was 579 million pounds per year by 1929/31. (Figure 4-1) Usage then declined markedly during the next three year period (to 409 million pounds per year), no doubt due to the economic collapse of the Great Depression. (Figure 4-1) Following the low point in the early 1930's, usage increased very significantly to more than double the low point, continuing through WWII and the latter 1940's (to just under 1.0 billion pounds per year). There was a rather steady increase until around 1960 to a level of about 1.3 billion pounds, followed by some decline by 1965/67. Then growth occurred again until usage peaked out at nearly 1.5 billion pounds per year by 1977/79. Since that time, usage has declined to some degree, holding at about 1.2 billion pounds per year during the last decade. The changes in usage by sector and pesticide class which are behind these changes will be discussed below.

2. Trends for Conventional and Other Pesticide Chemicals Separately

Figure 4-1 depicts trends separately for conventional pesticides and other pesticide chemicals over the seven decades. Conventional pesticide usage was generally in the 200-400 million pound range until the latter 1950's at which point it expanded consistently to a peak in the late 1970's/early 1980's at about 1.l billion pounds per year. Since the mid-1980's, conventional pesticide usage declined somewhat and has been holding slightly under 1.0 billion pounds.

Usage of other pesticide chemicals generally equaled or exceeded conventional pesticides during the period from 1940 through 1964, with usage generally in the range of 500 to 750 million pounds of active ingredient per year. Since that time, such usage has generally declined and has held at a level of about 250 million pounds per year during the last decade. The sharp decline in the usage of other pesticide chemicals was due to greatly reduced use of sulfur in agriculture between 1964 and 1967, as is noted further below in this section.

Volume of Pesticide Active Ingredient Usage in U.S., Conventional and Other Pesticide Chemicals, With Total All Economic Sectors, Three Year Periods Ending 1931-97
Figure 4-1



	1931	1934	1937	1940	1943	1946	1949	1952	1955	1958	1961	1964	1967	1970	1973	1976	1979	1982	1985	1988	1991	1994	1997
Conventional	289	185	247	282	380	442	354	400	401	468	558	589	684	755	839	1006	1112	1113	1059	965	968	965	986
Other Chemicals	290	224	230	365	491	547	597	670	644	757	780	678	388	416	465	380	352	309	285	271	243	246	246
Tota	579	409	478	646	870	990	951	1071	1045	1225	1338	1267	1072	1171	1305	1386	1464	1422	1344	1236	1211	1211	1232

Excludes wood preservatives and biocides

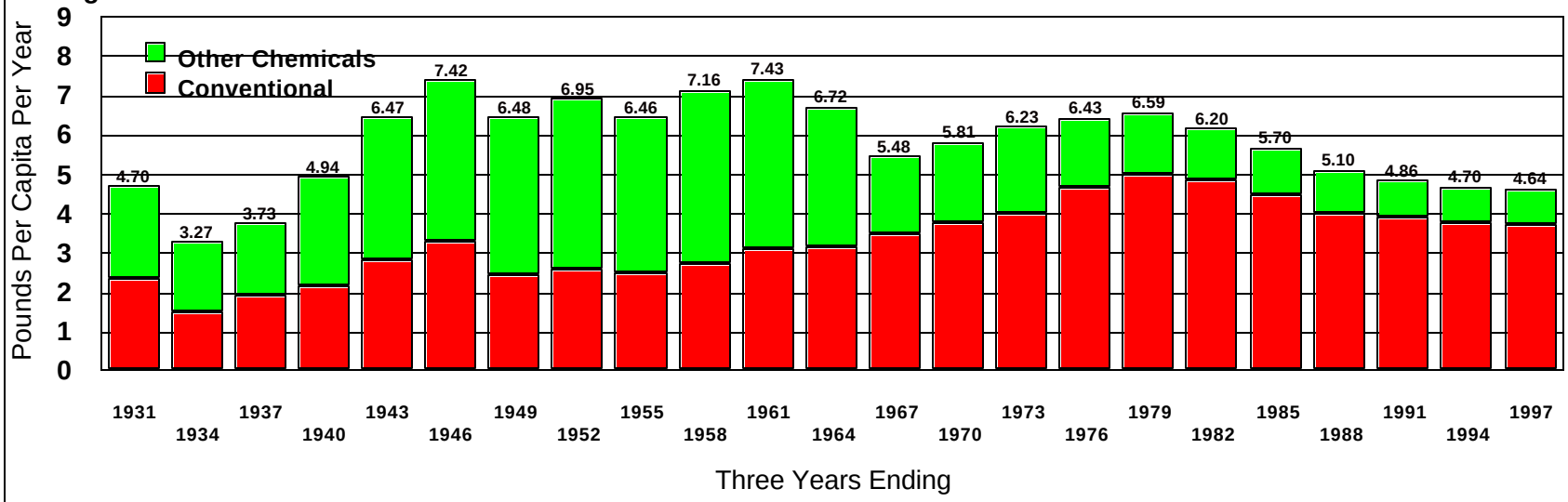
3. Trends in Conventional/Other Pesticide Usage Per Capita

One way to place trends in pesticide usage into perspective is to relate them to the growth in population by computing usage per capita. Aggregate usage of active ingredient divided by total population provides an average amount of pesticide active ingredient used to meet chemical pest control needs in general without regard to the distribution among the various types of users. Figure 4-2 contains a set of per-capita usage figures for the seven decades based on the aggregate number presented above in this section and U.S. Bureau of Census estimates of civilian population.

Figure 4-2 shows the following:

- that usage per capita for conventional/other pesticide chemicals increased sharply until the end of WWII when it was about 7.4 pounds, and held somewhat below that until 1959/61;
- there was a decline in the mid-1960's to about 5.5 pounds per capita (primarily as result of reduced sulfur usage) and a trend upward again to about 6.6 pounds per capita in 1977/79;
- and since then, there has been a rather consistent decline to a level of about 4.6 pounds per capita most recently.

Volume of Pesticide Active Ingredient Usage Per Capita in U.S., Conventional and Other Pesticide Chemicals with Tota
All Economic Sectors, Three Year Periods Ending 1931-97
Figure 4-2



Con	2.35	1.48	1.93	2.15	2.82	3.32	2.41	2.60	2.48	2.73	3.10	3.13	3.50	3.75	4.01	4.67	5.00	4.85	4.49	3.98	3.88	3.74	3.72
Othe	2.36	1.79	1.80	2.78	3.65	4.10	4.07	4.35	3.98	4.42	4.33	3.60	1.98	2.06	2.22	1.76	1.59	1.34	1.21	1.12	0.97	0.95	0.93
Tota	4.70	3.27	3.73	4.94	6.47	7.42	6.48	6.95	6.46	7.16	7.43	6.72	5.48	5.81	6.23	6.43	6.59	6.20	5.70	5.10	4.86	4.70	4.64

Excludes wood preservatives and biocides

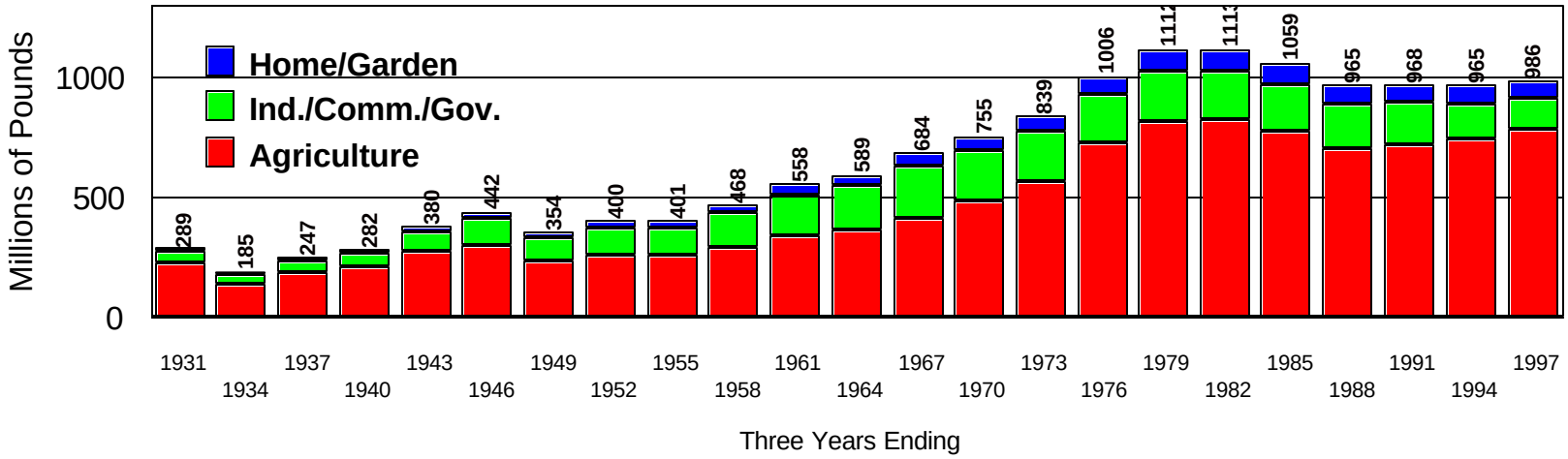
C. Usage of Conventional/Other Pesticides by Sector, 1929/97

Separate charts are presented in this section to depict trends for conventional pesticides, other pesticide chemicals and the total of these.

1. Conventional Pesticides

Conventional pesticide usage, which currently accounts for four-fifths of the total including other pesticide chemicals (as defined in Part Three of this report), has increased from a low of about 185 million pounds per year in the early 1930's to a high of about 1.1 billion pounds per year during the late 1970's/early 1980's. (Figure 4-3) Most of the growth was as result of increased usage for agricultural purposes between 1960 and 1980, although usage also increased for the I/C/G sector and H/G sector. Agricultural usage of conventional pesticides declined briefly after WWII to about 230 million pounds per year and then increased rather steadily to more than 800 million pounds per year around 1977/82. After that it generally has been in the range of 700 to 800 million pounds, with some slight trend upward most recently.

Volume of Conventional Pesticide Active Ingredient Usage in U.S., by Economic Sector, Three Year Periods Ending 1931-97
Figure 4-3



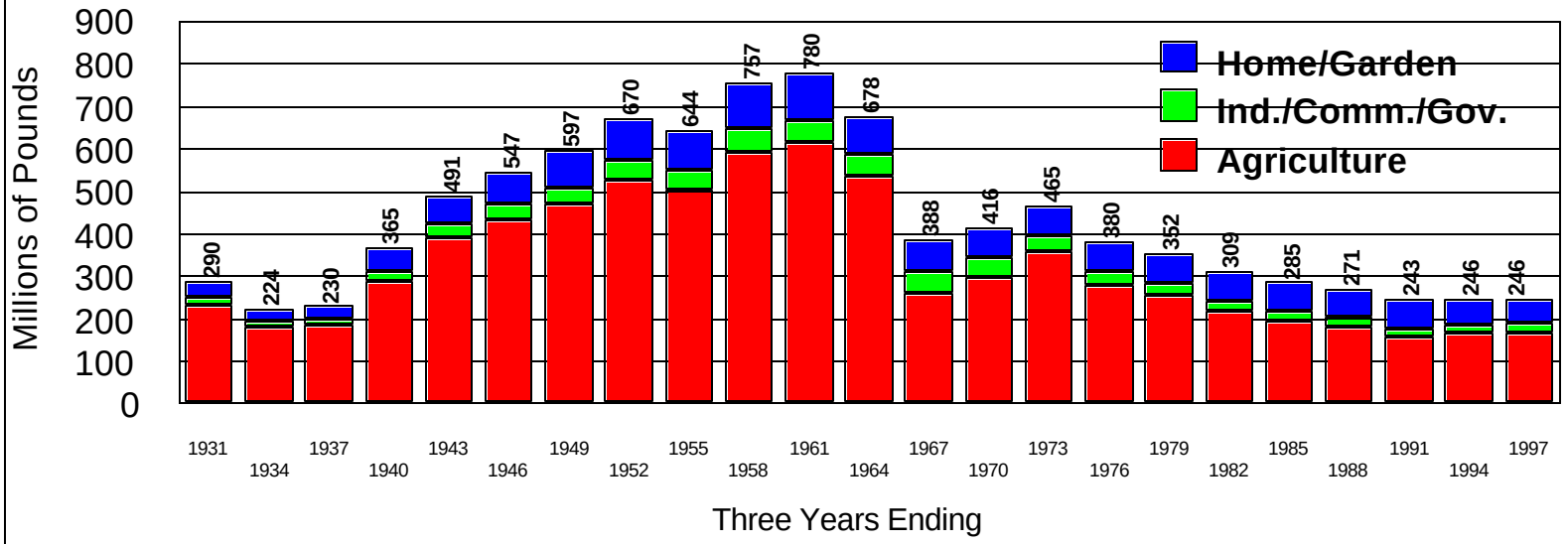
	1931	1934	1937	1940	1943	1946	1949	1952	1955	1958	1961	1964	1967	1970	1973	1976	1979	1982	1985	1988	1991	1994	1997
Agriculture	230	140	188	208	270	297	230	262	256	292	341	362	413	482	570	723	817	821	777	704	722	742	782
Ind./Comm./Gov.	47	36	47	59	86	115	100	111	117	140	173	182	219	217	208	209	212	207	198	182	169	148	128
Home/Garden	13	9	12	15	24	30	24	27	28	35	44	45	52	56	62	73	83	86	84	79	77	74	75
Total	289	185	247	282	380	442	354	400	401	468	558	589	684	755	839	1006	1112	1113	1059	965	968	965	986

Excludes wood preservatives and biocides

2. Other Pesticide Chemicals

The trend in usage of other pesticide chemicals primarily reflects changes in the use of sulfur and petroleum. (Figure 4-4) Usage of other pesticide chemicals increased notably until about 1960 (when about 780 millions pounds per year were used) and then declined rapidly by the mid-1960's when about half the former amounts were used (e.g., 388 million pounds). Since that time, usage has declined further, to about 250 million pounds per year during most recent years. No doubt the declines over the years since the 1960's are due to the replacement of sulfur/oil and other such basic chemicals with modern conventional pesticides.

Volume of Other Pesticide Chemicals Active Ingredient Usage in U.S., by Economic Sector, Three Year Periods Ending 1931-97
Figure 4-4



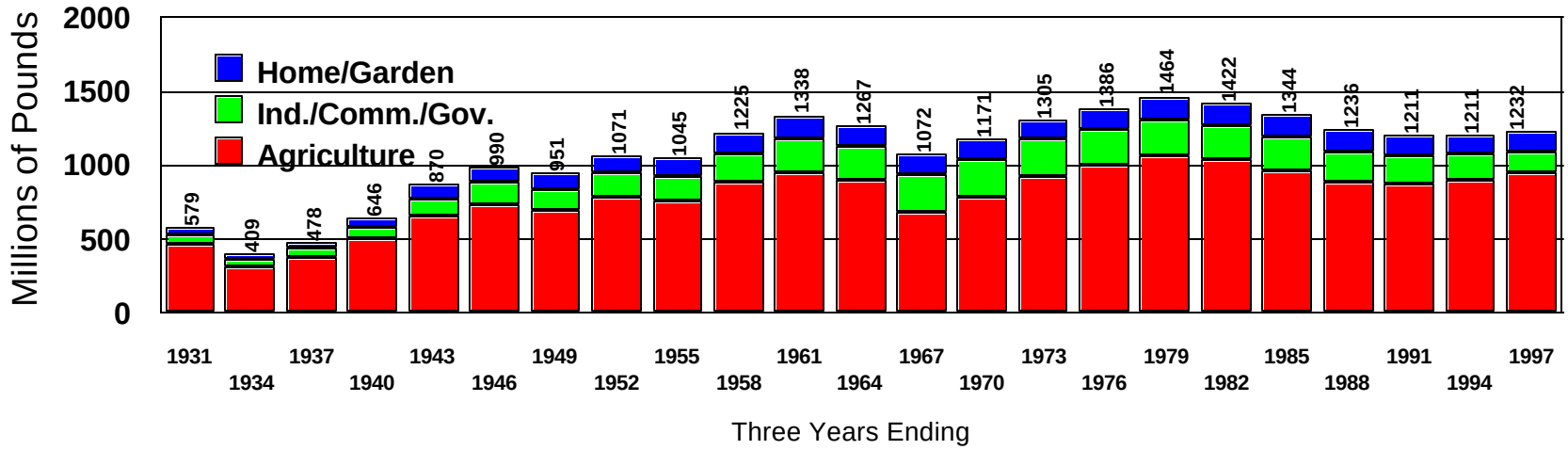
Agriculture	234	178	185	290	389	434	469	527	506	595	614	536	262	299	356	276	254	216	194	182	155	163	165
Ind./Comm./Gov.	17	14	14	23	31	35	40	45	43	51	52	48	48	42	38	34	29	24	23	22	22	20	22
Home/Garden	39	31	31	52	70	78	88	99	95	112	114	93	77	74	71	70	70	68	67	67	66	62	60
Total	290	224	230	365	491	547	597	670	644	757	780	678	388	416	465	380	352	309	285	271	243	246	246

Excludes wood preservatives and biocides

3. Conventional Plus Other Pesticide Chemicals, by Economic Sector

Figure 4-5 contains the total of conventional and other pesticide chemical usage for the 1929/97 period as discussed above for the two individual components. Notable features of the figure are the dip in agricultural usage during the late 1960's (to a level of 675 million pounds per year) followed by increases to about 1.1 billion pounds per year by around 1980, with somewhat lower levels since. Ind./comm./gov. usage per year has declined rather consistently since the late 1970's.

Volume of Total Pesticide Active Ingredient Usage in U.S., by Economic Sector, Three Year Periods Ending 1931-97
Figure 4-5



	1931	1934	1937	1940	1943	1946	1949	1952	1955	1958	1961	1964	1967	1970	1973	1976	1979	1982	1985	1988	1991	1994	1997
Agriculture	463	318	374	498	659	731	700	789	761	887	954	898	675	781	926	999	1071	1037	971	886	877	906	947
Ind./Comm./Gov.	64	50	61	82	118	150	139	156	160	191	225	231	267	259	246	243	240	231	221	205	191	169	150
Home/Garden	52	40	43	67	93	108	112	126	123	147	158	139	129	130	133	143	153	154	151	146	143	136	135
Total	579	409	478	646	870	990	951	1071	1045	1225	1338	1267	1072	1171	1305	1386	1464	1422	1344	1236	1211	1211	1232

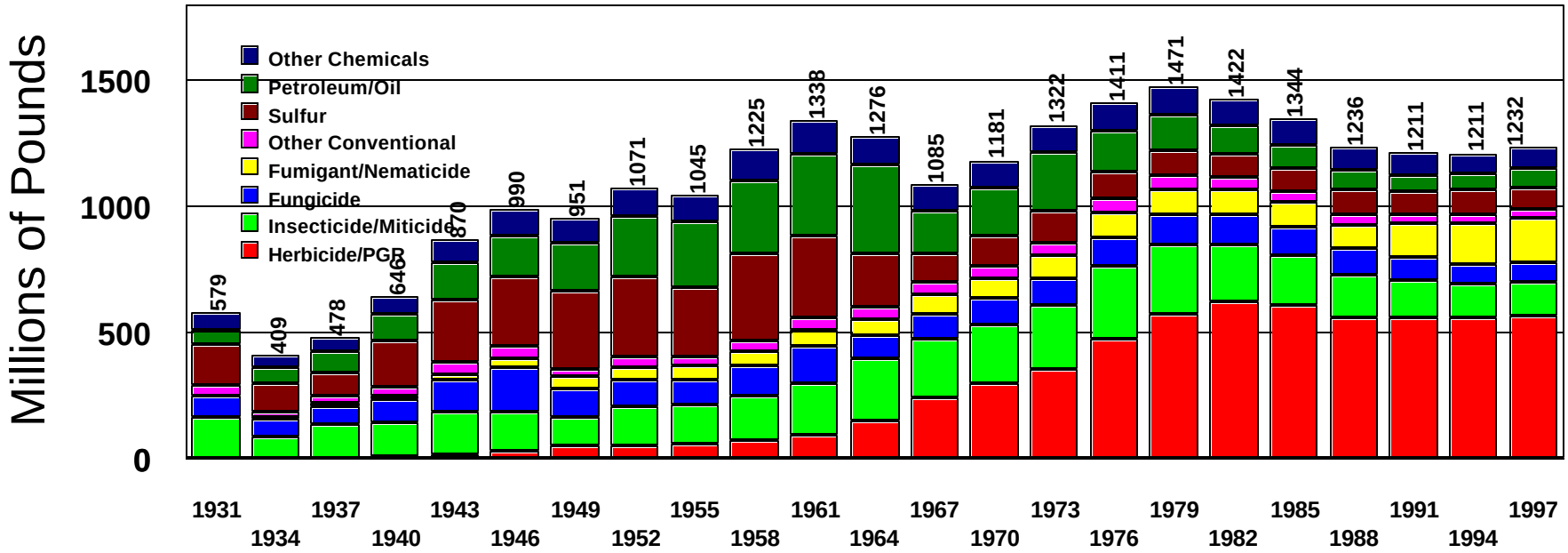
Excludes wood preservatives and biocides

D. Usage of Conventional/Other Pesticide Chemicals, by Type of Pesticide, 1929/97

Figure 4-6 presents a breakdown of conventional/other pesticide usage by pesticide type (class) for the period since 1929, in three year periods. The following observations can be made:

- most of the growth in usage per year was due to the increased usage of herbicides (and PGR's) starting with the advent of the synthetic organic pesticide industry (as WWII concluded); (there was a peak of about 625 million pounds per year in early 1980's);
- decreased usage of sulfur/oil occurred since the early 1960's;
- there were rather consistent increases in usage of fumigants/nematicides for the last three decades, especially the last few three year periods; and
- there was declining usage of insecticides/miticide active ingredient, as chemicals with lower application rates have been adopted during the last 15 years.

Volume of Pesticide Active Ingredient Usage in U.S., All Economic Sectors, by Type of Pesticide, Three Year Periods Ending 1931-97
Figure 4-6



	1931	1934	1937	1940	1943	1946	1949	1952	1955	1958	1961	1964	1967	1970	1973	1976	1979	1982	1985	1988	1991	1994	1997
Herbicide/PGR	1	1	2	8	17	27	46	47	60	70	93	149	240	298	353	472	576	624	606	560	559	555	567
Insecticide/Miticide	161	84	134	138	167	157	117	156	152	177	207	246	233	235	257	287	266	219	198	167	148	137	132
Fungicide	85	70	69	86	127	172	112	109	99	120	146	88	101	103	105	114	121	120	111	103	92	80	79
Fumigant/Nematicide	5	8	12	17	26	39	45	49	54	58	63	68	76	80	89	102	99	100	98	97	135	161	175
Other Conventional	37	23	30	33	43	47	34	39	37	42	49	48	48	50	52	56	57	50	45	39	34	32	32
Total Conventional	289	185	247	282	380	442	354	400	401	468	558	589	684	755	839	1006	1112	1113	1059	965	968	965	986
Sulfur	165	116	95	184	246	279	308	320	278	346	328	213	114	116	126	107	104	94	88	99	88	103	87
Petroleum/Oil	56	61	81	109	151	165	193	241	262	289	321	349	167	193	230	159	137	111	98	77	65	59	78
Other Chemicals	69	47	55	72	94	103	96	109	104	122	130	115	106	107	109	114	111	104	99	94	90	84	82
Total Non-conventional	290	224	230	365	491	547	597	670	644	757	780	678	388	416	465	380	352	309	285	271	243	246	246
Grand Total	579	409	478	646	870	990	951	1071	1045	1225	1338	1267	1072	1171	1305	1386	1464	1422	1344	1236	1211	1211	1232

Excludes wood preservatives and biocides

E. Trends in The Types of Chemistry Being Used as Pesticides, 1930-97

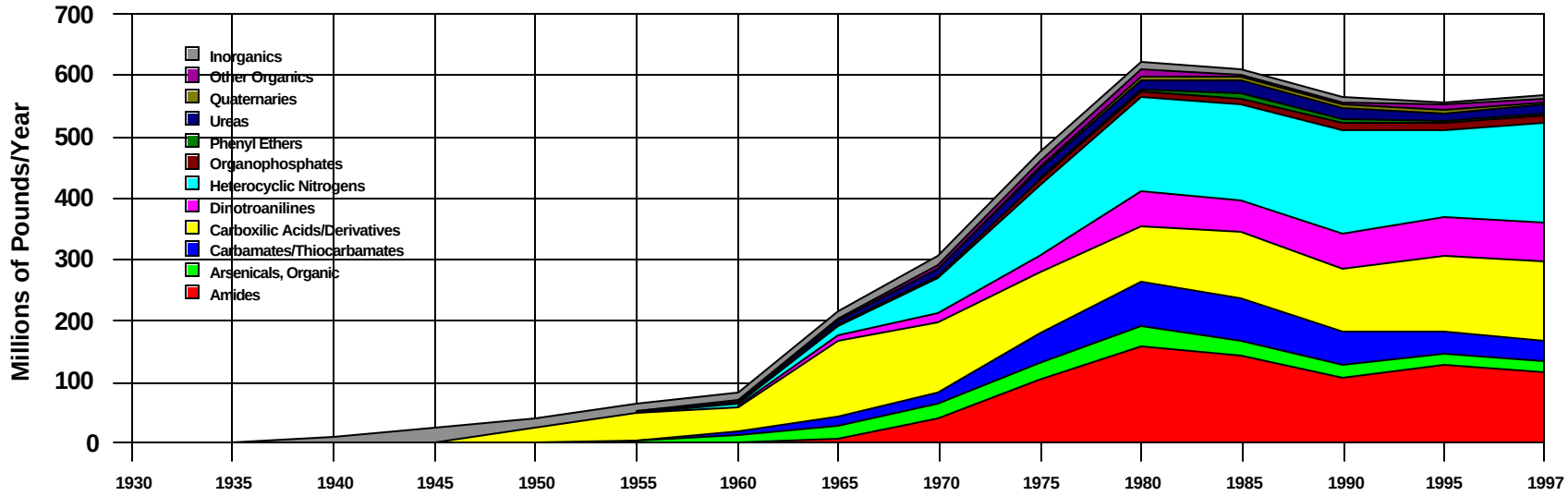
The types of chemicals used as active ingredients in pesticides have changed greatly since the 1930's. In general, inorganic chemicals have declined in use and synthetic organic chemicals have taken over increasingly since the advent of the synthetic organic chemical industry starting in the mid-1940's. In this section, separate charts are presented showing trends in conventional pesticide usage in the U.S., by chemical family, for each of the four major classes of pesticides, since 1930. The designated Figures which contain the charts are based on Appendix Table 4-B, which shows the principal chemical active ingredients included in the various chemical families or groups, along with estimated usage volume. The principal chemicals in each family noted in Appendix 4-B are listed in alphabetic order, not necessarily in order of importance or usage within the family or group. Also, readers should be cautioned that the values presented are only in terms of volume (weight) of active ingredient used. Accordingly, they do not reflect the relative importance of the pesticides with low volume application rates, which are common with many of the newer herbicides and insecticides. Unfortunately, it is beyond the scope of this study to develop other indicators to deal with this aspect, such as acre treatments or dollar expenditures, by pesticide family.

1. Herbicides/Plant Growth Regulators (H/PGR's)

Figure 4-7 shows the limited usage of herbicides through1945, some growth by 1960 and then dramatic increases until about 1980. Additionally, the following can be observed:

- relatively small amounts of inorganics (e.g., sodium azide and sodium arsenite) were in use prior to the rapid growth of herbicide usage after 1960 and some inorganics continue to be used;
- the carboxylic acids were the first major herbicide group to emerge (largely due to the phenoxies, such as 2,4-D and 2,4,5-T) and continue to be important due to the usage of glyphosate as well as 2,4-D and others;
- the heterocyclic nitrogens, most notably the triazines, which emerged in the 1950's and 1960's, became the leading herbicide family based active ingredient, which they still are in the 1990's;
- the amides, between 1960 and 1980, became the leading herbicide family and continue to account for more than 100 million pounds of active ingredient per year; (Acetochlor is replacing alachlor within the amides.) and;
- the ureas, starting about 1955, and the phenyl ethers (about 1975), are examples of newer herbicides with small amounts of active ingredient usage, but large acreages treated due to low application rates.

Volume of Conventional Herbicide/Plant Growth Regulator Active Ingredient Usage in U.S., All Economic Sectors, by Chemical Family or Group, Stated Years, 1930-97
Figure 4-7



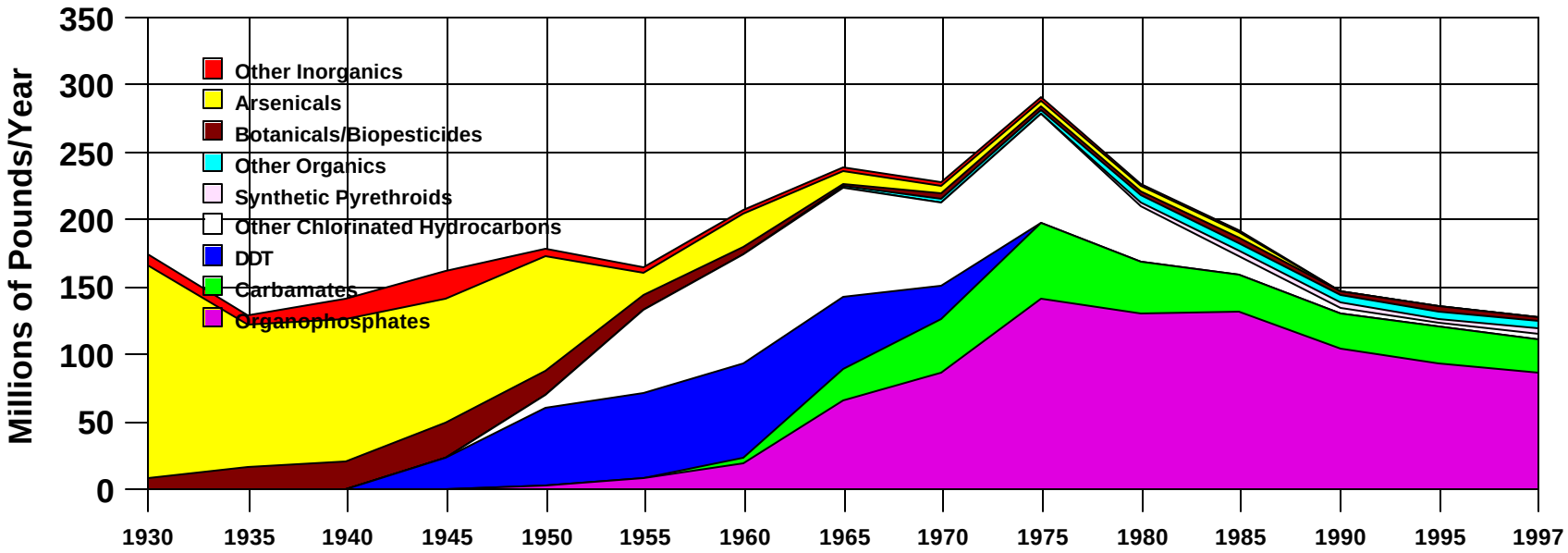
	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	1997
Amides							2	9	42	105	158	142	108	131	119
Arsenicals, Organic					2	6	11	21	23	28	33	27	20	17	17
Carbamates/Thiocarbam						1	5	14	18	48	74	67	55	35	32
Carboxilic Acids/Derivati				1	25	44	42	125	116	97	91	110	103	126	130
Dinotroanilines							1	6	15	30	55	52	56	63	62
Heterocyclic Nitrogens						2	6	17	53	114	153	154	169	141	163
Organophosphates							1	3	7	9	10	11	10	10	11
Phenyl Ethers										1	4	9	7	5	6
Ureas						1	2	5	10	17	14	20	18	12	11
Quaternaries							1	1	2	3	5	7	6	6	6
Other Organics						1	1	3	4	9	12	4	5	5	6
Inorganics	1	2	12	25	14	10	12	13	15	15	12	8	6	5	5
Total	1	2	12	26	41	64	84	217	306	475	622	611	564	556	568

2. Insecticides/Miticides (I/M)

Figure 4-8 shows trends I/M usage between 1930 and 1997 by chemical family in terms of active ingredient used. The pattern in insecticide usage has been from dominance by inorganics until about 1950, followed by the organochlorines (led by DDT) through the mid-1970's and then organophosphates became the leading insecticide family in terms of active ingredient usage. The following can also be noted:

- arsenical insecticides (particularly calcium and lead arsenates) were already in common use by 1930 with usage of more than 150 million pounds per year and were the leading chemical family by far; their usage declined quite notably, by about 90 percent, by 1955 as the organochlorines predominated;
- DDT came on stream by 1945 and reached its maximum usage around 1960; it was essentially no longer in use by the mid-1970's;
- other organochlorines, such as chlordane and toxaphene, increased in usage through the mid-1970's but declined to only a few million pounds per year by 1990;
- botanicals, such as pyrethrum, nicotine and rotenone, were important insecticides already by 1930; their use along with other botanicals and biopesticides increased in usage to 28 million pounds in 1945, after which such usage declined; botanicals/biopesticides of various types have been in use within the range of 3 to 5 million pounds per year since 1965. These figures do not reflect pesticide active ingredient generated by genetically modified organisms regulated as pesticides (GMO's);
- synthetic pyrethroids, which were in common use by 1980, account for a limited share of active ingredient due to their low application rates;
- the organophosphates were in use by 1955 and have been the leading insecticide chemical family since 1970; their peak usage occurred around 1975 with 142 million pounds of active ingredient, after which usage has declined to some degree; usage of organophosphates was an estimated 87 million pounds in 1997; and
- carbamate insecticide usage in 1997 (26 million pounds) was about one half its peak amount of 55 million in 1975.

Volume of Conventional Insecticide/Miticide Active Ingredient Usage in U.S., All Economic Sectors, by Chemical Family or Group, Stated Years, 1930-97
Figure 4-8



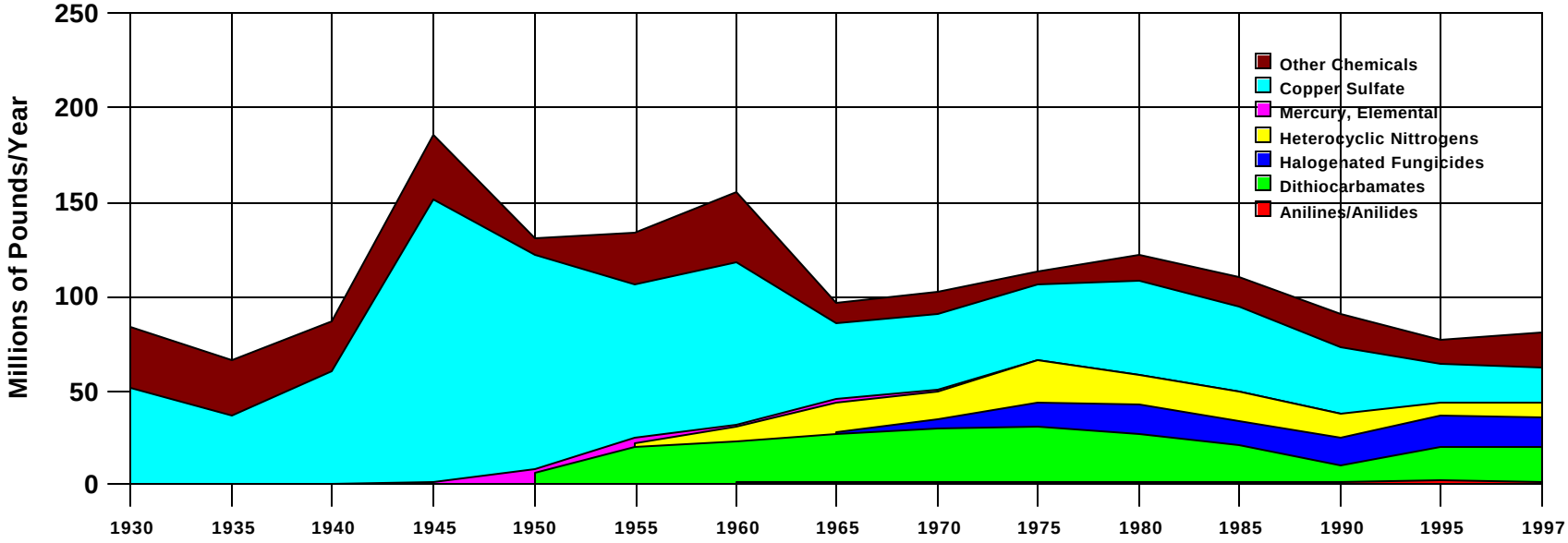
	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	1997
Organophosphat	0	0	0	0	3	10	20	66	87	142	131	132	104	94	87
Carbamates	0	0	0	0	0	0	4	24	39	55	38	27	27	27	26
DDT	0	0	0	23	58	62	70	53	26	1	0	0	0	0	0
Other Chlorinatec	0	0	0	0	10	62	81	81	62	80	41	15	4	3	3
Synthetic Pyrethr	0	0	0	0	0	0	0	0	0	0	2	3	3	4	4
Other Organics	0	0	0	0	0	0	0	1	2	3	6	5	5	6	5
Botanicals/Biopes	9	17	21	28	18	11	6	4	4	3	3	5	4	4	4
Arsenicals	158	106	106	91	85	16	24	8	7	6	5	4	0	0	0
Other Inorganics	8	8	15	20	5	4	3	3	3	2	1	1	0	0	0
Total	175	131	142	162	179	164	208	239	229	292	228	193	148	137	129

3. Fungicides (F)

Trends in the usage of fungicide active ingredient are shown in Figure 4-9. Copper sulfate has been the leading fungicide in terms of active ingredient usage most of the 20th Century. It had peak usage of 150 million pounds in 1945 and is still in use today (18 million pounds in 1997). The following can also be stated:

- copper sulfate (used with lime, known as Bordeaux mixture) was introduced as a fungicide in the U.S. by 1887 and came into large-scale application by about 1910; (Shepard, pp. 72-80), most often for potato and apple disease control;
- mercury based fungicides were in use from 1935 until about 1975;
- the dithiocarbamates were in use by 1950 and most of the time since have been the second ranking fungicide chemical family; and
- heterocyclic nitrogens were in use by 1955 and reached largest usage around 1975.

Volume of Conventional Fungicide Active Ingredient Usage in U.S., All Economic Sectors, by Chemical Family or Group, Stated Years, 1930-97
Figure 4-9



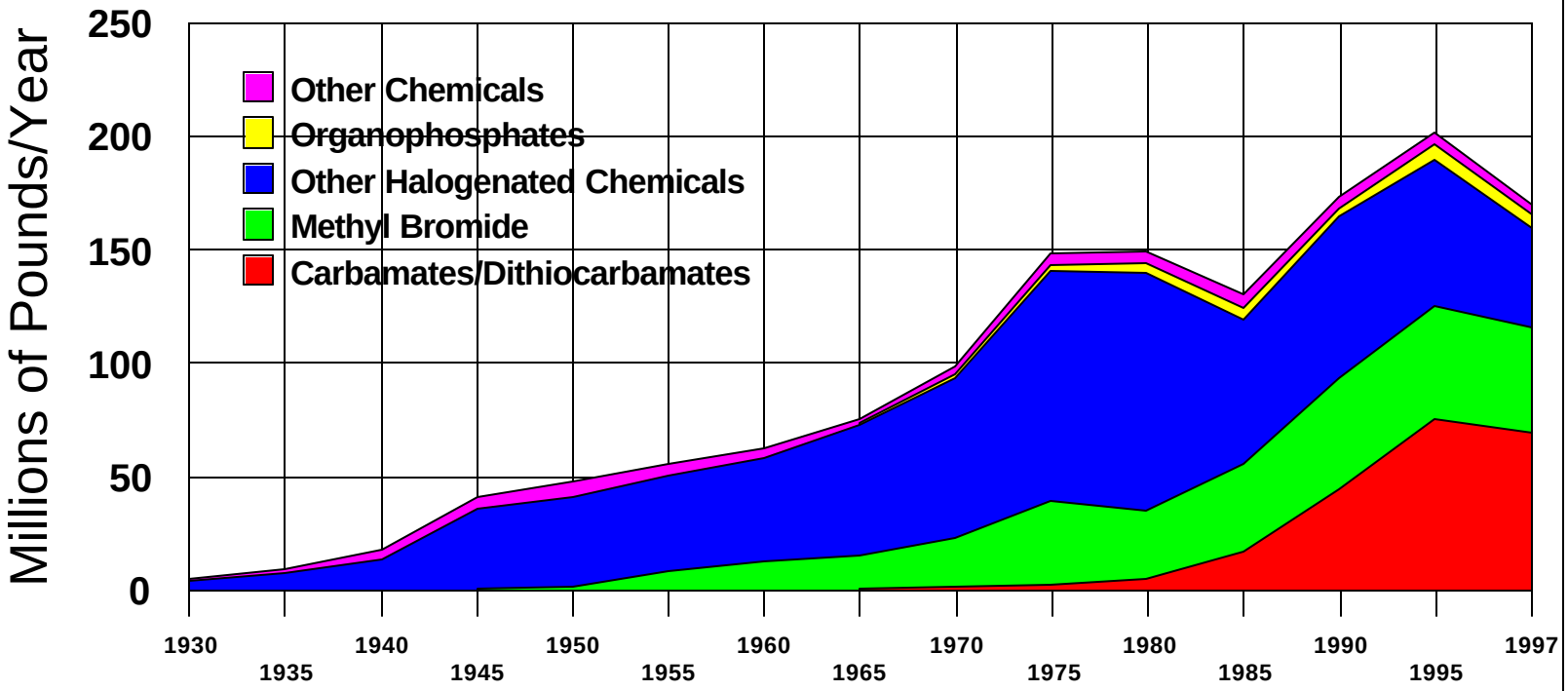
	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	1997
Anilines/Anilides							1	1	1	1	2	2	2	2	2
Dithiocarbamates					6	20	22	26	29	30	24	19	9	18	18
Halogenated Fun								1	5	13	16	14	14	16	16
Heterocyclic Nittr						2	8	16	15	22	16	16	13	8	8
Mercury, Element	0	1	1	1	2	3	1	2	1	1	0	0	0		
Copper Sulfate	52	36	60	150	114	81	86	40	41	40	50	45	35	20	18
Other Chemicals	32	30	26	35	9	28	38	11	11	8	13	15	18	13	19
Total	84	66	87	186	131	134	156	96	102	114	122	110	91	77	81

4. Fumigants/Nematicides (F/N)

Figure 4-10 shows trends in usage of fumigants/nematicides from 1930 through 1997. The halogenated chemicals were in use by 1930 and since have been the leading chemical family for this class of pesticides. The following can also be stated:

- chloropicrin and carbon tetrachloride were among the first to be of importance in this class of pesticides;
- methyl bromide has been an important fumigant/nematicide since it began use around 1945; and
- the carbamates/dithiocarbamates have had expanded usage since the late 1980's to 66 million pounds in 1997.

Volume of Conventional Fumigant/Nematicide Active Ingredient Usage in U.S., All Economic Sectors, by Chemical Family or Group, Stated Years, 1930-97
Figure 4-10



	1930	1935	1940	1945	1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	1997
Carbamates/Dithioc								1	2	3	5	17	45	76	70
Methyl Bromide				1	2	9	13	14	21	36	30	39	49	49	46
Other Halogenated	4	8	14	35	40	42	46	58	71	102	105	64	71	65	44
Organophosphates								1	2	3	4	4	4	7	6
Other Chemicals	1	2	4	6	6	5	4	2	3	4	5	6	5	5	5
Total	5	10	18	42	48	56	63	76	99	149	150	131	174	202	171

F. User Expenditures for Conventional/Other Pesticides, by Type of Pesticide and Sector, 1979/97

Pesticides are a significant sector of the U.S. economy as reflected by annual user expenditures for pesticides. This section presents user expenditures for conventional pesticides and other pesticide chemicals on an annual basis for the period of 1979 through 1997. The figures are as previously published by the Agency in the EPA "Pesticide Market Series" last published for 1979 through 1997. (ASPELIN and Grube, EPA, November, 1999) The annual user expenditures are broken down by class of pesticide in current dollars. They also are converted to constant 1997 dollars to remove the influence of general inflationary trends in the U.S. economy, based on the U.S. gross domestic product (GDP) deflator published by the Department of Labor.

1. Trends in Aggregate Expenditures, 1979/97

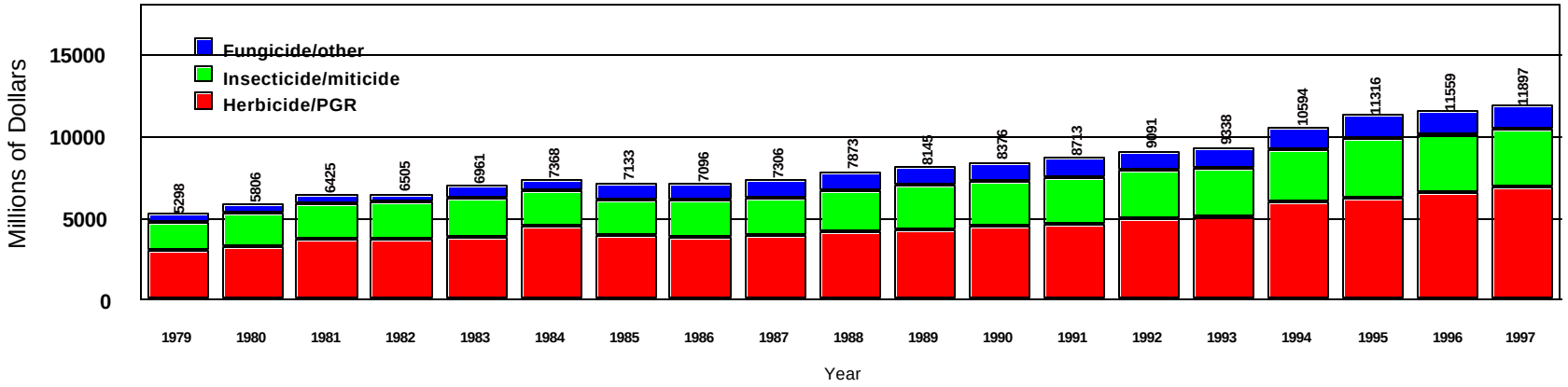
Overall user expenditures have increased from about $5.3 billion in 1979 to about $11.9 billion in 1997. (Figure 4-11) These increasing expenditures reflect changes in a number of factors including: the quantities of pesticides purchased; improved/more useful active ingredients and formulations; less use of inexpensive generic chemicals; increasing development and regulatory costs; and general inflationary trends in the economy affecting production and transportation costs. Herbicides account for more than half of total user expenditures, followed by insecticides.

Aggregate user expenditures in constant 1997 dollars are presented in Figure 4-12 for the 18 year period, 1979/97. Those estimates show that expenditures increased less than inflation generally from 1979 through 1993, but have increased at a somewhat faster rate since that time. In other words, pesticide expenditures in the aggregate have been increasing somewhat during recent years.

2. Trends in User Expenditures, Per Capita of U.S. Population

Figure 4-12 indicates that user expenditures per capita for the U.S. civilian population are in the same general range during recent years as they were in the 1979/84 period. As of 1997, expenditures per capita were $44.73 which is somewhat below the values for 1979 through 1984. These figures per capita are an indication as to what the average person is paying for conventional/other pesticide chemicals, whether purchased directly as a user or indirectly as part of the costs of goods and services, taking account of inflationary trends.

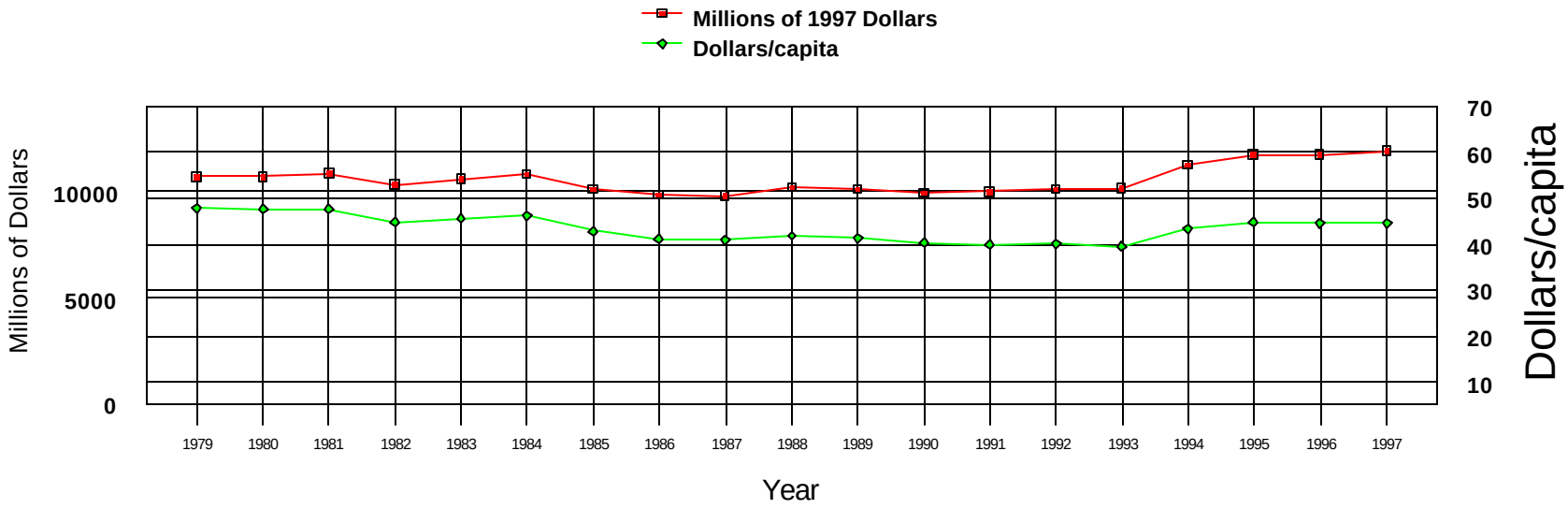
Expenditures for Pesticides Applied in U.S., 1979-97
All Economic Sectors,
Figure 4-11



	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Herbicide/PGR	3026	3310	3738	3772	3870	4488	3920	3858	3973	4121	4305	4473	4682	5004	5094	5944	6276	6599	6846
Insecticide/miticid	1783	2037	2151	2193	2360	2172	2250	2271	2284	2562	2699	2732	2808	2904	2985	3242	3552	3439	3553
Fungicide/other	489	459	536	540	731	708	963	967	1049	1190	1141	1171	1223	1183	1259	1408	1488	1521	1498
Total	5298	5806	6425	6505	6961	7368	7133	7096	7306	7873	8145	8376	8713	9091	9338	10594	11316	11559	11897

Excludes wood preservatives and biocides.
Current/nominal dollars

Expenditures for Pesticides Applied in All Economic Sectors, U.S., 1979-97
Total Expenditures and Per Capita, Constant 1997 Dollars
Figure 4-12



	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Millions of 1997 D	10702	10737	10860	10343	10616	10828	10134	9825	9814	10203	10129	9984	9989	10143	10150	11247	11743	11774	11897
Dollars/capita	48.00	47.59	47.67	44.97	45.74	46.25	42.90	41.21	40.80	42.02	41.32	40.30	39.88	40.02	39.60	43.43	44.90	44.60	44.73

Excludes wood preservatives and biocides.

PART FIVE

AGRICULTURAL PESTICIDE USAGE TRENDS

The purpose of Part Five of this report is to present comprehensive historical trend information on the extent of pesticide usage in the agricultural sector of the U.S., by types of chemicals used. In this section, estimates are presented for overall agricultural pesticide usage starting with 1929. Limited quantitative information has been found on agricultural pesticide usage prior to the 1930's. For the period prior to 1929, information of a qualitative nature in presented on agricultural pesticide usage, i.e., primarily the types of chemicals that were available and recommended. For most recent times, e.g., the last decade, more detailed information is presented, such as quantities used by crop or crop grouping. Information is presented on dollar expenditures and acreages treated where data are available, as well as quantities of active ingredient used, which is the principal focus of reporting in this section.

A. Profile of Agricultural Applicator Sector

Agriculture is an important part of the United States in many ways. It is the source of food and fiber for the Nation and people elsewhere in the world through exports. Table 5-1 contains a brief profile of the U.S. agricultural sector, circa the 1980/90's, with some historical comparisons, with particular reference to pesticide applications.

There are about 1.9 million farms in the U.S. (1997 Census of Agriculture). These farms contain more than 930 million acres of land which is nearly half of the land area of the U.S. (about 1.9 billion acres as shown in Table 3-4 earlier in this report). They have about 350 million acres of cropland used for crops each year, which is where most of the agricultural pesticides are applied.

The relative importance of the agriculture sector in the U.S. economy has changed greatly over the last several decades. In recent times, agriculture (farm sector) has accounted for about 1.0 percent of the gross domestic product in the U.S. (1.1 percent in 1997) and has about 1.5 percent of U.S. population (1997 estimate). This compares with earlier times such as 1930 when it accounted for 10.6 percent of the GDP and 24.8 percent of population. (Table 5-1) In 1910, agriculture accounted for 16.7 percent of the GDP and about 35 percent of the population. The percentage of U.S. land in farms was as low as 16 percent before the Civil War (1850) and was as high as about 60 percent in the mid-1950's. (Table 5-1)

Since 1910, the average size of farm has increased from 140 acres to nearly 500 acres (491 acres in 1992). Despite these various trends, the amount of land farmed most intensively has been much more stable. During the 1980's and 1990's, cropland used for crops was generally in the range of 330 to 380 million acres, compared with 330 million acres in 1919.

Table 5-1 Profile Overview of U.S. Agriculture Pesticide User Sector, Circa 1980/90's, with Some Historical Comparisons

Reporting Item	Units	1997	1992	1987	1982	Historical Comparisons
No. farms, total	Thousands	1,912	1,925	2,088	2,241	Peak of 6.8 mil. circa 1935
No. farms, with cropland	Thousands	1,661	1,697	1,849	2,011	
No. farms with harvested cropland	Thousands	1,411	1,492	1,644	1,810	
Land in farms, total	Million Acres	932	945	964	987	
Average land acreage/farm	Acres	487	491	461	440	Low of about 140 acres in 1910
Cropland, total	Million Acres	431	435	443	445	Over 500 mil. acres in 1925
Cropland, used for crops	Million Acres	353	337	331	383	330 mil. acres in 1919
Cropland, harvested	Million Acres	309	296	282	326	
Total land area of U.S.	Million Acres	1,891	1,894	1,896	1,896	
Percent of U.S. land in farms	Percent	49.3	49.9	50.1	52.1	16 pct. in 1850; high 60 pct. in mid '50's
Percent of U.S. land in harv. cropland	Percent	16.3	15.6	14.9	17.2	
Population						
U.S. total population	Millions	268	255	243	232	123 mil. in 1930; 92 mil. in 1910
Farm population	1,000	4,020	4,665	4,986	5,397	30.5 mil. in 1930; 32 mil. in 1910
Farm population as percent of U.S.	Percent	1.5	1.9	2.1	2.4	24.8% in 1930; 35% in 1910
Gross Domestic Product						
U.S. economy	Billion $	8,111	6,244	4,692	3,242	507 in 1959
Agriculture Sector	Billion $	90	81	65	65	19 in 1959
Agriculture as percent of U.S.	Percent	1.1	1.3	1.4	2.0	3.7 %in 1959; 10.6% in 1930 and 16.7% in 1910
Farms using chems. for:						
Insects on hay/crops	1,000 Farms	366	480	554	530	584 in 1978
Nematodes	1,000 Farms	43	54	66	77	103 in 1978
Diseases on crops/orchards	1,000 Farms	113	121	129	128	129 in 1978
Weeds/grass/brush	1,000 Farms	685	757	914	872	960 in 1978
Defoliation/fruit thinning	1,000 Farms	51	65	75	74	82 in 1978
Any or all of above, or lime	1,000 Farms	941	1,093	1,263	1,125	1,439 in 1978
Acreage treated with chems. for:						
Insects on hay/crops	1,000 Acres	61,520	62,592	68,823	72,848	75,888 in 1978
Nematodes	1,000 Acres	6,465	6,555	5,931	7,533	8,805 in 1978
Diseases on crops/orchards	1,000 Acres	13,315	11,642	10,467	11,685	11,415 in 1978
Weeds/grass/brush	1,000 Acres	184,195	178,991	171,288	176,871	164,415 in 1978
Defoliation/fruit thinning	1,000 Acres	11,473	11,024	9,497	9,322	9,267 in 1978
No. of private applicators registered	1,000 Persons	874	963	955		

Sources: U.S. Census of Agriculture for 1997, 1992, 1987, 1982 and 1978; U.S. historical statistics, biennial edition for earlier times; DOC estimates of GDP; USDA/ERS, Ag. Handbook 712, July, 1997; Economic Report of President for 1999; farm population estimate for 1997 developed by author based on personal communication with Calvin Beale, USDA/ERS, May, 2000; U.S. Census of Population.

The percentage of U.S. land area in farms was as high as 60 percent in the mid-1950,s but has declined to about 50 percent in recent years. Quite remarkably, U.S. agriculture have been able to produce food and fiber to meet market needs (and even produce surpluses from time to time), with about the same amount of cropland it used many decades ago. This due apparently to ever improving technology and efficiency in agriculture, including the use of more and more useful pesticides to control pests of various kinds. Agriculture accounts for a disproportional share of pesticides (compared to shares of GDP and population) due to the vulnerabilities of crops to pests, e.g., it accounts for about three-fourths of the U.S. total usage of conventional pesticides and other pesticide chemicals (See Table 3-3 presented earlier.).

Pesticides of one type or another are applied on a majority of U.S. farms raising crops. In 1997, about 0.94 million of the 1.661 million farms with cropland used one or more pesticide types on at least some acres. (Table 5-1) Herbicides are used on the most farms (685,000 farms in 1997) followed by insecticides (366,000). The numbers of farms using pesticides has declined generally since the 1987 Census of Agriculture, particularly those using insecticides, herbicides and defoliant/plant regulators. The declining numbers of farms using the various pesticides seems to be the result of the chemicals being used on more acres per farm, because acreages treated have not tended to decline in the same proportion (and have increased in some cases). (Table 5-1) The acreages treated for each of the pest treatment categories in the 1997 and 1992 census years were higher than in 1987 for all of the categories except treatment of insects on hay/crops.

As of 1997, there were 874,000 persons who had been certified under FIFRA provisions as private pesticide applicators. This figure is down somewhat from 963,000 in 1992 according to Agency records. (Figure 5-1) There is an average of nearly one certified private applicator per U.S. farm that applies pesticides in crop production (e.g, 874,000 certifications compared with 941,000 farms using pesticides in crop production in 1997).

B. Principal Chemicals Available to Farmers For Pest Control Before End of WWII

Two dramatic changes occurred by the latter stages of WWII, with respect to the availability of chemicals for farmers to control pests. The first was the discovery and commercial development of new chemical compounds which were efficacious pest controls, principally synthetic organic pesticides such as DDT and 2,4-D. These new chemistries were far superior to the older traditional chemicals which often worked because of very crude, gross animal toxicity characteristics, were dangerous to use and frequently had undesired features. The new chemicals were more specifically developed to take advantage of the particular vulnerabilities of insect, plant and other pests, based on emerging scientific knowledge of chemistry and biology. The second major change was the emergence of an industry to produce pesticides for use by farmers, making use of the newly developed pesticide chemistry.

Until the new chemicals came along, basically there was limited industry to efficiently produce pesticides and make them available to farmers at prices that made them cost effective. Farmers generally had to purchase raw chemicals (often crude industrial chemicals) and mix/formulate the pesticides for use themselves because ready-to-use/formulated pesticide products were not available.

This brief section of the report highlights the types of active ingredients that were available and generally recommended for use prior to the advent of DDT and 2,4-D, near the end of WWII.

Table 5-2 summarizes the principal chemicals that were available to farmers for pest control in two periods as follows: circa 1910-20 and early 1940's. The table is prepared on the basis of published references which are thought to be representative of the guidance being followed by farmers during those periods. This qualitative information is being presented as a supplement to the quantitative information presented later in this section, which is somewhat limited, especially for the early part of the 20th Century.

For insect control, various arsenicals were important as early as 1910-20 (Paris Green containing copper metarsenite and lead arsenate) and increasingly by WWII. Various arsenicals were recommended, such as white arsenic, sodium arsenite, calcium arsenate and lead arsenate. Sulfur and petroleum were used as insecticides as were several plant-based items, including rotenone, pyrethrum, vegetable oils and nicotine/tobacco.

A limited spectrum of chemistry was available as fungicides in 1910-20, principally Bordeaux mixture (copper sulfate/lime) and lime/sulfur. The situation had not changed much by WWII as mercurials were added as fungicides.

Table 5-2. Principal Chemicals Available to Farmers for Pest Control Prior to Synthetic Organic Pesticide Revolution, Circa 1910-20 and Early 1940's

	Circa 1910-20	Early 1940's
Insecticides	Paris Green (copper metarsenite/acetate)	London Purple (arsenic, lime, acids, etc.)
	Lead arsenate	White arsenic, sodium arsenite, calcium arsenate
	Hellebore (root of veratrum album)	Lead arsenates (various normal and basic compounds, plus mixtures)
	Lime sulfur	Flourine compounds
	Kerosene/soap	Rotenone
	Linseed oil	Elemental sulfur and inorganic sulfur compounds
	Tobacco extract	Petroleum oils (crude, kerosene, various other weights); coal tars
	Pyrethrum	Pyrethrum
	Carbolic acid	Vegetable/animal oils
	Whale oil	Nicotine/tobacco
Repellants	Slaked lime/talc	New chemicals added such as methyl phthalate, hexanediol & indalone.
	Tobacco dust	
	Naphthaline	
	Creosote/essential oils/citronella	
Fumigants/nematicides	Chemicals not recommended for farm use other than green houses	Paradichlorobenzene, chloropicrin, carbon disulfide; treatments most commonly for stored commodities and green houses.
Fungicides	Bordeaux mixture (copper sulfate/lime)	Bordeaux mixture
	Lime/sulfur	Lime/sulfur
		Burgundy mixture and other compounds related to Bordeaux mixture
		Mercuric chloride
		Organic mercurial compounds
Herbicides	Common salt (sodium chloride)	About the same chemicals available for herbicides
	Copperas (Green vitriol or iron sulfate)	as 1910-20.
	Bluestone (blue vitriol or copper sulfate)	Weeds still mostly controlled by cultural/mechanical means in crops.
	Carbolic acid (phenol)	
	Caustic soda (sodium hydrate or hydroxide)	Sodium chlorate
	Oil of vitriol (sulfuric acid)	
	Corrosive sublimate (bichloride of mercury)	
	Kerosene/crude petroleum	
	Arsenite of soda	
Antimicrobials	Not thought of as pesticides	

Sources: Frear, 1942; Georgia, 1914; O'Kane, 1915; Shepard, 1951.

The farmer did not have available highly useful chemicals for control of weeds in crops until the end of WWII, starting with 2,4-D. Rather common chemicals such as sodium chloride, iron sulfate, copper sulfate, carbolic acid, sulfuric acid and petroleum were basically all that was available and they were neither very useful in crop production nor without undesired effects from usage.

Farmers basically did not commonly use fumigants/nematicides in crop production through WWII and neither did they have available to them antimicrobials for dairy sanitation, and other purposes, as we think of such applications today.

C. Approach and Information Sources, Circa 1930 to Date

Information has been assembled on quantities of pesticide active ingredient used in U.S. agriculture going back as far as possible in time so as to be able to make comprehensive usage estimates for earliest possible years. The sources and approach used in making the estimates were discussed above in Parts Three and Four of this report.

The estimates of overall agricultural pesticide usage discussed in this section are based on Appendix 4 (estimates of active ingredient usage, by type of pesticide, three year periods ending 1931-97). The presentation focuses on a series of charts (Figures) showing levels and trends graphically, but with tables included below the charts, based on Appendix 4. Total agricultural usage of conventional and other pesticide chemicals is covered by the data series, including non-crop usage of pesticides usage--on all types of "farms," such as ranches, as covered by the Census of Agriculture. The usage figures do not include industrial wood preservatives and biocides, as was discussed in Part Four of this report.

A second time series is presented for average agricultural pesticide usage per crop acre, by three year periods ending 1931 through 1997. This series was developed by simply dividing the estimates of overall usage noted above by national estimated acreages used for crops (USDA's series entitled "acres of cropland used for crops." This series gives an indicator for trends in intensity of pesticide chemical usage in food and fiber production, recognizing that not all pesticides used on farms are used on cropland (by the vast majority is).

A third time series is presented on expenditures for agricultural pesticides in the U.S., for the 1929/97 time frame. The series is three-year averages covering the 69 year period, utilizing annual estimates of pesticide expenditures from USDA for 1929 through 1978 and the EPA series published in the EPA "Pesticide Market Series" for 1979 through 1997. (Aspelin and Grube, EPA, November, 1999, Table 16) The expenditures are expressed in both nominal values and in constant 1997 dollars (based on the Gross National Product Deflator series). The constant dollar series was divided by U.S. civilian population estimates to develop an indicator for expenditures per capita for pesticides used to produce food and fiber.

The other major portion of this Part on agriculture is a data set dealing with changes in pesticide usage in crop production between 1988/89, 1992/93 and 1996/97, by crop grouping and type of pesticide. Values were developed for aggregate usage of active ingredient and for average pounds of active ingredient per acre of crop grown (by type/class of pesticide and crop grouping as explained later in this section of the report). The estimates of usage by class and crop grouping are aggregate usage

estimates from the EPA Market Report Series, apportioned across crop groupings based on estimates prepared by Doane Market Research staff from the Doane Profile for years indicated.

Various work tables used to develop data series presented on agricultural pesticide usage presented in this section are included in Appendix 5.

D. Overall Conventional/Other Pesticide Usage and Crop Acreage, 1929/97

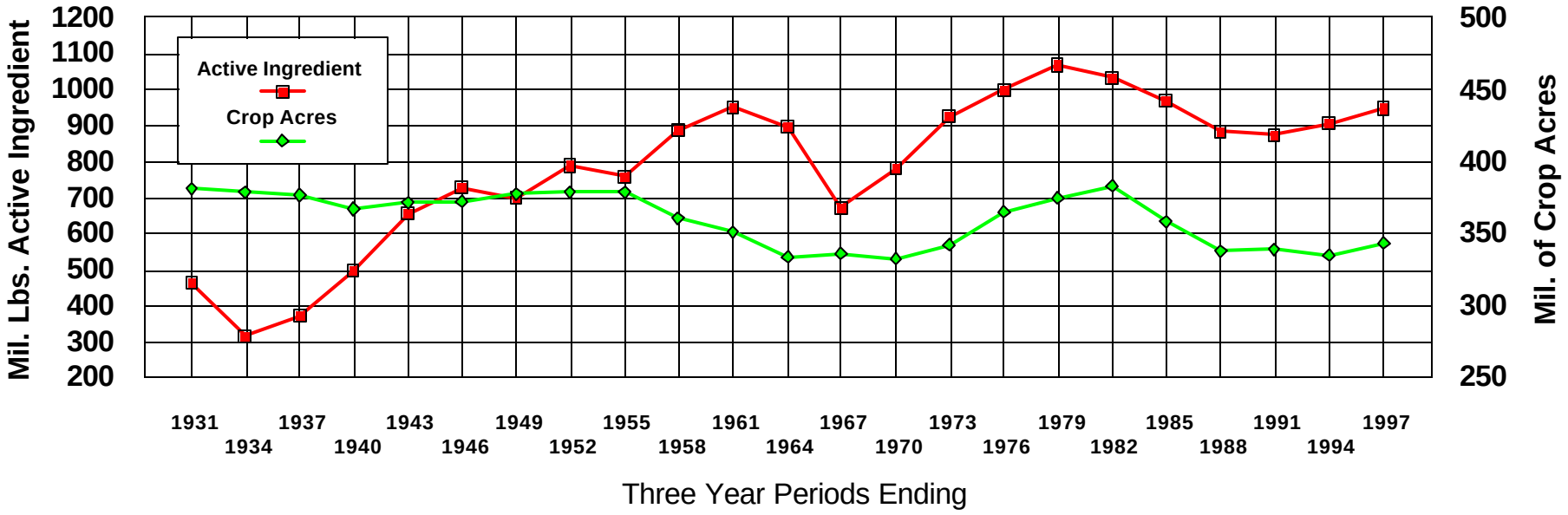
Presented in Figure 5-1 are estimates of the volume of pesticide active ingredient used in agriculture (conventional pesticides plus sulfur/petroleum and other chemicals) for three year periods for 1929 through 1997 (annual figures representative of each period). These are simply values for total active ingredient used without breakouts for different types/classes of pesticides as are presented later in this section and in Appendix Table 3 A. Also data are presented on total acres of U.S. cropland for the periods indicated.

As of 1929/31, about 460 million pounds of active ingredient were used in agriculture on an annual basis. (Figure 5-1) Usage declined sharply during the next three-year period (ending 1934) to about 318 million pounds per year, as the Nation was in the Great Depression. Following that low point, usage increased quite consistently until after WWII when there was a slowing of growth. Then usage increased rather steadily to about 950 million pounds per year around 1960. There was a brief cutback in usage during the mid-1960's and then usage peaked out for the seven decades in 1977/79 at nearly 1.1 billion pounds of active ingredient per year. As will be discussed later, where more detailed data are presented by type of pesticide usage, the above trends reflect expanded use of insecticides starting with late WWII, the growth of herbicide usage until the late 1980's, and a drop in usage of sulfur/oil, particularly in the mid-late 1960's.

Total acreage used for cropland was remarkably stable at 370/380 million acres from 1930 through the early 1950's and then declined to a low of 333 million acres around 1968/70. Then it increased to a peak of about 380 million acres in 1980/82, followed by a decline to about 335-345 million acres where it has been during the last decade. (Acreages in this paragraph are from USDA “cropland used for crops” series.)

The volume of pesticide active ingredient used in agriculture has been quite closely correlated with acres of cropland since about 1960, as can be seen in Figure 5-1. The association is particularly striking since 1970. Variations in crop acreage did not appear to be a major factor shaping total agricultural pesticide usage from the 1930's until about 1960, as insecticide and herbicide usage increased dramatically, regardless of crop acres. Obviously changes in cropland acreage available for cropping do not totally explain changes in aggregate pesticide usage. Other key factors are at work including changes in crop selection, acreages treated (percent), numbers of applications, application rates, government programs/policies and economic factors e.g., pesticide/commodity cost/price relationships. Also, there are non-crop uses of pesticides in agriculture (e.g., post-harvest commodity storage and livestock/poultry) and uses of pesticides on non-cropland such as range, forests, fence rows and rights of way.

Volume of Pesticide Active Ingredient Usage In Agriculture, and Acres Used for Cropland, U.S., Three Year Periods Ending, 1931-97
Figure 5-1



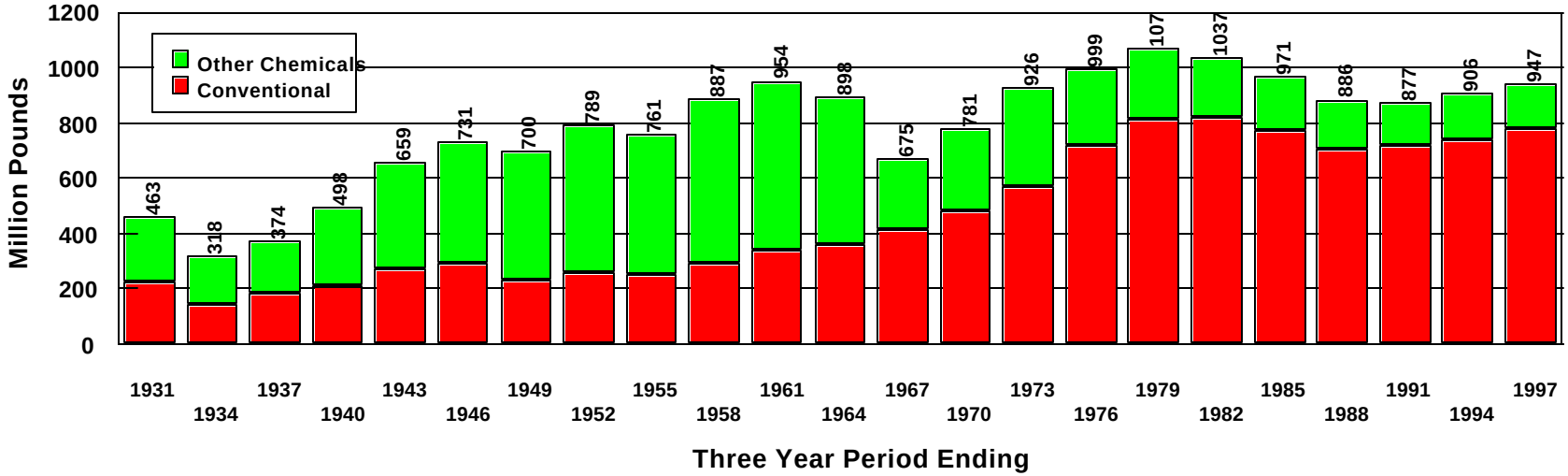
	1931	1934	1937	1940	1943	1946	1949	1952	1955	1958	1961	1964	1967	1970	1973	1976	1979	1982	1985	1988	1991	1994	1997
Active Ingre	463	318	374	498	659	731	700	789	761	887	954	898	675	781	926	999	1071	1037	971	886	877	906	947
Crop Acres	382	379	377	368	371	373	379	379	379	361	351	334	336	333	342	365	375	384	359	338	340	335	344

E. Agricultural Pesticide Usage by Type, Conventional and Other Chemicals, 1929/97

Presented in Figure 5-2 are estimates of aggregate agricultural pesticide usage over the period from 1929 through 1997, with a breakout for conventional pesticides, separate from other pesticide chemicals (based on the definitions discussed earlier in Parts Three and Four of this report). The following observations can be made about the data depicted in Figure 5-2:

- from 1929/31 until the mid-1950's, conventional pesticide usage was quite stable in the range of 150 to 250 million pounds per year and there was growth in usage of other pesticide chemicals to a peak of about 600 million pounds around 1960;
- by 1965/67, conventional usage surpassed other pesticide chemicals and continues to do so to date;
- since 1971/73, usage of other pesticide chemicals has generally declined and is far below peak levels achieved around 1959/61; and
- conventional pesticides currently account for about 80 percent of total agricultural pesticide usage, i.e., 782 million out of 947 million for 1995/97.

Volume of Pesticide Active Ingredient Usage in U.S. Agriculture by Type of Pesticide, Three Year Periods Ending 1931-97
Figure 5-2



	1931	1934	1937	1940	1943	1946	1949	1952	1955	1958	1961	1964	1967	1970	1973	1976	1979	1982	1985	1988	1991	1994	1997
Conventional	230	140	188	208	270	297	230	262	256	292	341	362	413	482	570	723	817	821	777	704	722	742	782
Other Chemica	234	178	185	290	389	434	469	527	506	595	614	536	262	299	356	276	254	216	194	182	155	163	165
TOTAL	463	318	374	498	659	731	700	789	761	887	954	898	675	781	926	999	1071	1037	971	886	877	906	947

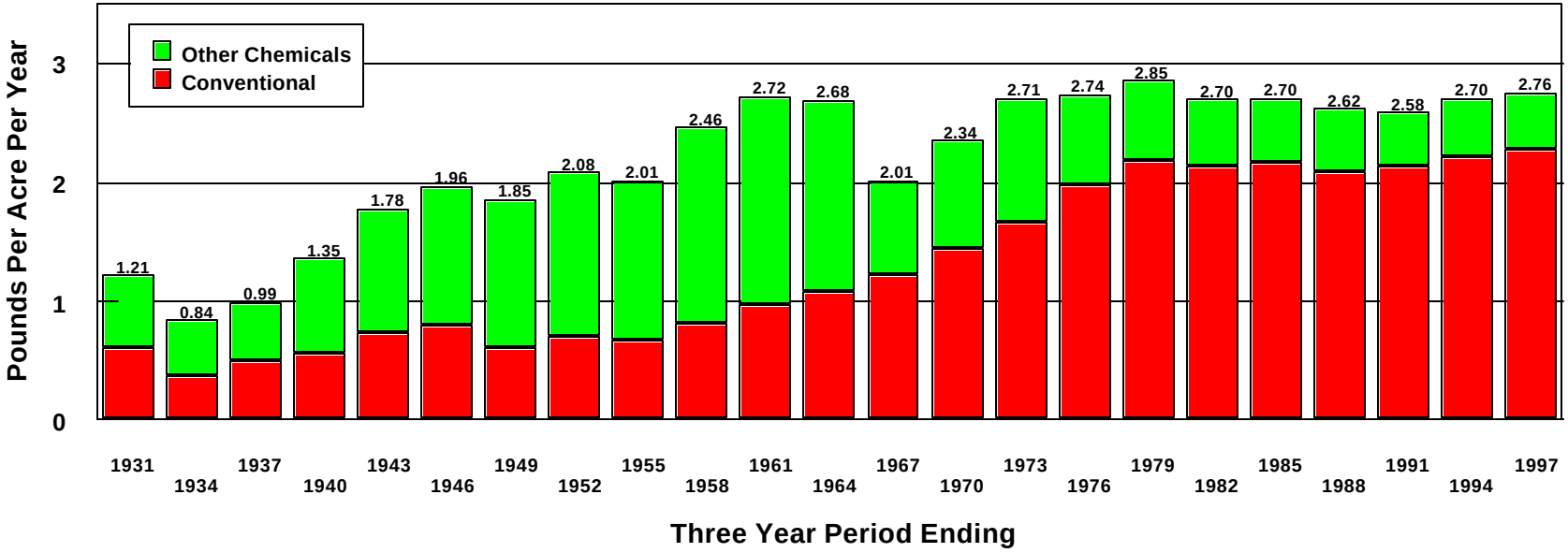
Excludes wood preservatives and biocides

F. Average Pesticide Usage Per Crop Acre, 1929/97

Presented in Figure 5-3 are estimates of conventional and other pesticide chemical usage in agriculture expressed in terms of average per U.S. crop acre. The aggregate usage figures presented above (pounds of pesticide active ingredient) have been divided by total U.S. crop acreage in an effort to develop a rough indicator of pesticide usage intensity in agricultural production. U.S. cropland, about 345 million acres in 1995/97 (USDA's "cropland used for crops" series), is where most intensively managed crops are grown and where most pesticides are used in U.S. agriculture. This cropland accounts for just under one-fifth of total U.S. land in farms of 1.9 billion acres. The pesticides not used on cropland are used for other land uses such as range and forests and for non-land uses such as livestock and poultry production, commodity storage, etc. Also, not all cropland is treated with one pesticides. Abstracting from these considerations, the calculated average usage per crop acre (pounds of active ingredient) can still provide a general indicator or proxy for trends in intensity of pesticide usage in agriculture.

The trends in aggregate quantities of pesticides used and crop acres resulted in a rapidly increasing average rate of active ingredient used per acre of cropland-- from less than a pound per acre in the early 1930's to about 2.7 pounds during 1959/64. (Figure 5-3) This was followed by markedly lower levels through about 1970 due to less use of other pesticide chemicals. This is presumed to be the result of new conventional pesticides coming on the market and replacing traditional chemicals such as sulfur and petroleum/oil. The highest level of usage was reached in the 1977/79 period when the rate per acre was 2.85 pounds, somewhat more than for the most recent three year period (2.76 pounds for 1995/97). Basically, there has not been a consistent long term trend up or down during the last 25 years, as usage has tended to equal about 2.6 to 2.7 pounds per acre. However, there has been a slight tendency for the rate per acre to increase during the 1990's.

Volume of Pesticide Active Ingredient Usage in U.S. Agriculture by Type of Pesticide, Per Acre of Cropland, Three Periods Ending 1931-97
Figure 5-3



	1931	1934	1937	1940	1943	1946	1949	1952	1955	1958	1961	1964	1967	1970	1973	1976	1979	1982	1985	1988	1991	1994	1997
Conventional	0.60	0.37	0.50	0.56	0.73	0.80	0.61	0.69	0.67	0.81	0.97	1.08	1.23	1.45	1.66	1.98	2.18	2.14	2.16	2.08	2.13	2.21	2.28
Other Chemicals	0.61	0.47	0.49	0.79	1.05	1.16	1.24	1.39	1.33	1.65	1.75	1.60	0.78	0.90	1.04	0.76	0.68	0.56	0.54	0.54	0.46	0.49	0.48
TOTAL	1.21	0.84	0.99	1.35	1.78	1.96	1.85	2.08	2.01	2.46	2.72	2.68	2.01	2.34	2.71	2.74	2.85	2.70	2.70	2.62	2.58	2.70	2.76

Excludes wood preservatives and biocides

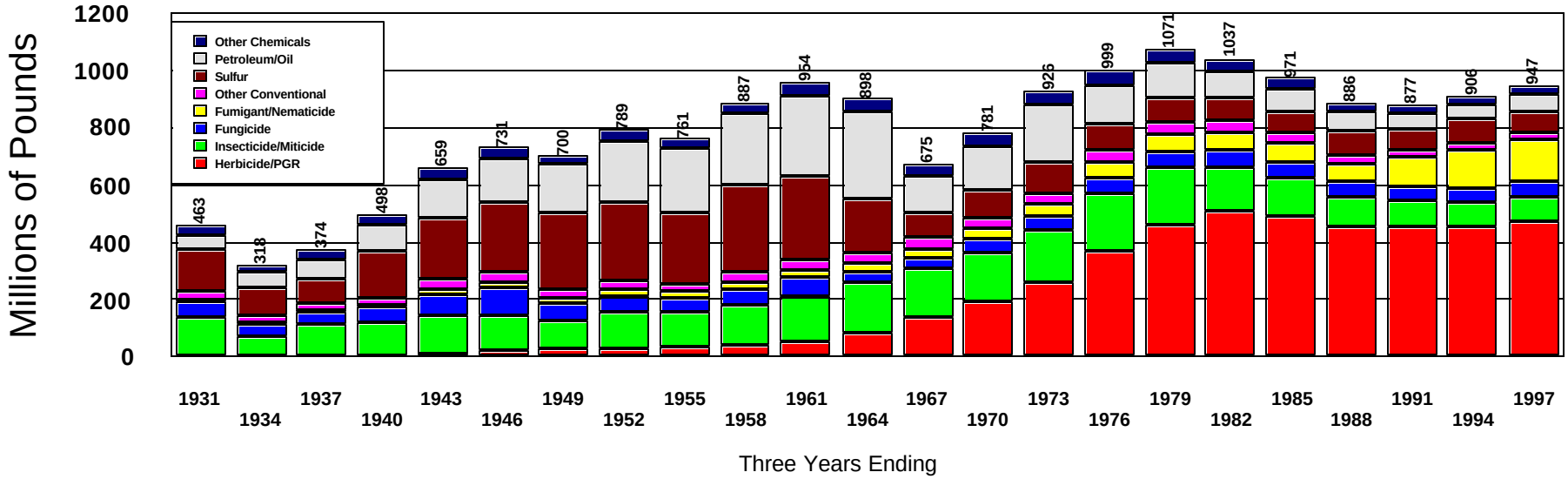
G. Agricultural Pesticide Usage, by Type (Class) of Pesticide, 1929/97

Some rather notable changes have occurred in the types of pesticide chemicals that have been used in agriculture since 1929/31. Figure 5-4 contains estimates of overall agricultural usage of active ingredient broken down into seven different types of pesticides for the three year periods covering 1929 through 1997. Conventional pesticides are reported separately for five types and other pesticide chemicals are split into three types. (Figure 5-4)

The following observations can be made:

- the advent of synthetic organic herbicides by about 1945 led to consistent and rapid growth in the use of such chemicals in agriculture to a peak of about 500 million pounds of active ingredient in 1980/82, with some decline since;
- insecticide usage expanded during the 1960's and 1970's, but has tended to decline since as newer, low-dose, chemicals have replaced older pesticides;
- usage of fumigants/nematicides has been increasing steadily since the 1940's, and rather dramatically so in the 1990's (their usage is now exceeded only by herbicides/PGR's);
- sulfur and petroleum are still important pesticides but usage is far below levels of earlier times, e.g., three year periods ending 1943 through 1964; and
- fungicide usage has been remarkably stable at about 40-60 million pounds for several decades.

Volume of Pesticide Active Ingredient Usage in U.S. Agriculture, by Type of Pesticide, Three Year Periods Ending 1931-97
Figure 5-4



	1931	1934	1937	1940	1943	1946	1949	1952	1955	1958	1961	1964	1967	1970	1973	1976	1979	1982	1985	1988	1991	1994	1997
Herbicide/PGR	1	1	2	6	12	18	30	30	36	41	52	80	138	191	257	372	463	507	491	452	452	453	471
Insecticide/Miticide	135	69	110	112	135	126	93	123	119	138	159	180	165	172	181	197	193	152	130	104	90	87	86
Fungicide	57	45	43	52	73	96	60	56	48	56	65	37	40	46	48	53	56	60	58	55	50	47	51
Fumigant/Nematicide	3	4	6	8	12	17	20	21	22	23	25	26	32	35	42	56	61	63	64	65	105	132	150
Other Conventional	34	21	28	30	38	40	28	32	30	35	40	39	37	39	41	45	45	38	34	29	25	24	25
Total Conventional	230	140	188	208	270	297	230	262	256	292	341	362	413	482	570	723	817	821	777	704	722	742	782
Sulfur	144	101	83	161	214	244	269	279	243	302	286	186	88	95	109	90	87	78	73	83	73	86	71
Petroleum/Oil	49	53	71	95	131	144	168	210	228	252	280	305	131	158	199	133	115	93	82	65	53	50	64
Other Chemicals	40	24	32	35	44	47	32	38	35	41	47	46	43	46	48	53	52	45	39	33	29	28	29
TOT NONCON	234	178	185	290	389	434	469	527	506	595	614	536	262	299	356	276	254	216	194	182	155	163	165
Grand Total	463	318	374	498	659	731	700	789	761	887	954	898	675	781	926	999	1071	1037	971	886	877	906	947

H. Active Ingredient Usage, by Crop Grouping, 1988/97

The purpose of this section of the report is to present information on the usage of pesticide active ingredient in U.S. crop production, by crop grouping and class (type) of pesticide, covering the 10 year period ending in 1997. This is done by using data for two year periods at the beginning, middle and end of the 10 year period, i.e., 1988/89, 1992/93 and 1996/97. The raw data for individual years were merely averaged to get the two-year period averages. The goal of the effort is to show trends in usage for the various crop groups as well as to show the relative importance of the various crop groups, along with figures on U.S. acreages grown of the crops. The crop acreages are those used by Doane in its profile program, which rather closely track with USDA contemporary estimates and U.S. Census of Agriculture estimates. The crop groupings used are those adopted by Doane in its Profile (crop groupings are presented below tables in this section).

The estimates of usage by crop grouping presented in this section are a disaggregation of national totals published by EPA in the latest published market report (Aspelin and Grube, EPA, November, 1999). Doane estimates of usage by crop grouping were used to apportion the published EPA national totals to the various crop groupings. The classes of pesticides assumed to be used in crop production from the EPA report were four types of conventional pesticides (herbicides/PGR, insecticides/miticides, fungicides, nematicides/fumigants) and sulfur/oil. Aggregate estimates of usage are presented first in this section of the report followed by comparable figures on average usage of active ingredient per acre of crop grown by crop grouping.

The resulting break-outs of aggregate active ingredient usage are shown in Table 5-3 and Figure 5-5. Some observations which can be made about the data set are:

- Corn/sorghum and fruits/nuts are by far the leading crop groups in terms of overall usage of active ingredient; they are followed at a distance by agronomic crops (which include potatoes), vegetables and soybeans;.
- Herbicides are the leading pesticide type applied to major field crops such as corn/sorghum, soybeans and cereals;
- Sulfur/petroleum is used most widely on fruits/nuts, accounting for about half of all pesticide usage on those crops;
- Consistent increases occurred in usage on cotton, agronomic crops, fruits/nuts and vegetables over the decade, for the two-year periods presented; and
- Fumigant/nematicide usage increased noticeably over the 10 years for agronomic crops, vegetables and cotton.

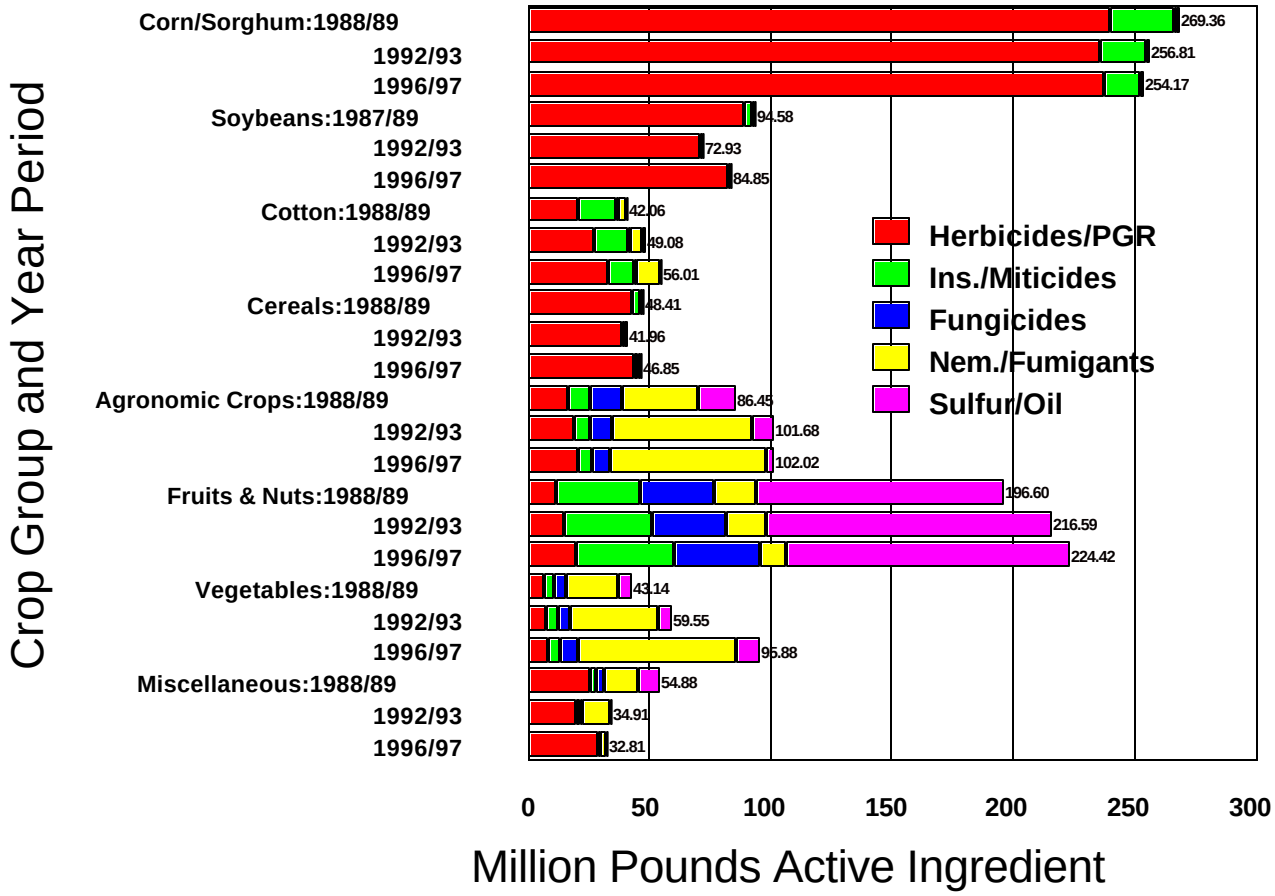
Table 5-3 Pounds of Pesticide Active Ingredient Used in U.S. Crop Production, by Crop Group and Type of Pesticide Along with Total Acres Grown, Two Year Periods, 1988-97

		Acres Grown	**Pounds of active ingredient in thousands**					
Crop Group	Years	(000)	Herbicides/PGR	Ins./Miticides	Fungicides	Nem./Fumigants	Sulfur/oil	Total
Corn/Sorghum	1988/89	80,877	240,222	26,727	122	214	2,079	269,364
	1992/93	88,349	236,115	19,299	113	101	1,182	256,810
	1996/97	91,687	237,635	15,466	43	34	991	254,169
Soybeans	1988/89	59,459	89,637	3,499	342	201	898	94,578
	1992/93	59,123	70,963	662	231	610	468	72,935
	1996/97	67,575	82,783	924	75	399	673	84,853
Cotton	1988/89	11,297	21,085	15,527	992	3,269	1,185	42,058
	1992/93	13,495	27,922	13,583	755	4,808	2,007	49,076
	1996/97	14,060	32,785	11,604	624	10,337	661	56,011
Cereals	1988/89	92,769	43,299	3,139	1,641	30	297	48,407
	1992/93	88,135	39,228	1,415	947	0	367	41,958
	1996/97	89,582	43,818	1,901	711	25	397	46,852
Agronomic Crops	1988/89	9,451	17,119	8,425	13,699	30,966	16,242	86,452
	1992/93	10,305	19,846	6,583	8,432	57,890	8,933	101,684
	1996/97	10,964	20,945	5,982	7,260	64,659	3,170	102,016
Fruits & Nuts	1988/89	4,458	11,447	34,885	30,871	17,051	102,343	196,597
	1992/93	4,616	15,061	37,051	29,954	16,653	117,867	216,585
	1996/97	5,126	20,103	40,439	35,608	10,703	117,563	224,416
Vegetables	1988/89	3,212	6,798	4,555	5,347	20,718	5,719	43,136
	1992/93	3,818	7,903	4,930	4,727	37,123	4,862	59,545
	1996/97	4,048	8,385	5,482	7,505	64,339	10,165	95,876
Miscellaneous	1988/89	643,611	25,393	2,776	3,733	13,838	9,143	54,883
	1992/93	639,670	20,461	1,478	841	11,315	812	34,907
	1996/97	611,451	29,047	1,203	173	2,004	381	32,808

All Crops	1988/89	902,571	455,000	97,500	54,000	76,500	137,500	820,500
	1992/93	821,821	437,500	85,000	46,000	128,500	136,500	833,500
	1996/97	894,491	475,500	83,000	52,000	152,500	134,000	897,000

Cereals: Wheat, Barley, Oat, Rye, Rice
Agronomic Crops: Dry Beans/Peas, Peanut, Potato, Sugarbeet, Sugarcane, Sunflower, Tobacco
Fruits & Nuts: Berries, Grapes, Fruit Trees, Citrus, Nut Trees
Vegetables: Sweet Corn, Tomato, Eggplant, Pepper, Melons, Coles, Curcurbits, Lettuce, Other Leafy Vegetables, Veg. Beans/Peas, Bulb Crops, Roots/Tubers, Other Vegetables
Miscellaneous: ACR, CRP, Fallow, Flax, Pasture/Rangeland, Other Pasture/Rangeland

Pesticide Active Ingredient Used for Crops, Millions of Pounds, by Crop Group, Two Year Periods (1988/97) and Type of Pesticide, U.S.
Figure 5-5



Presented in Table 5-4 and Figure 5-6 are averages for active ingredient usage per acre derived from the above aggregates, by crop grouping spanning the 10 year period. Some observations can be made as follows:

- The average for all crops was 1.0 pounds per acre for 1996/97, somewhat higher than for 1988/89 (0.91), but down slightly from 1.1 pounds in 1992/93;
- Fruits/nuts currently lead all other crop groups by far with about 45 pounds of active ingredient used per acre grown, followed by vegetables at about half the rate in 1996/97 (more than 23 pounds);
- The most noticeable increase in usage per acre was vegetables, where usage per average acre increased from 13.4 to 23.7 pounds per acre between 1988/89 and 1996/97;
- Nematicide/fumigant usage increased sharply for vegetables and to a lesser degree for agronomic crops; and
- Corn/sorghum is the only crop group for which usage per acre declined consistently in both 1992/93 and in 1996/97.

Figures 5-7a and 7b, respectively, show aggregate and per acre usage of pesticide active ingredient by crop grouping for the most recent two year period, 1996/97. The importance of overall usage by corn sorghum and fruits/nuts is again evident. Similarly, the highest rates of usage per acre are evident for fruits/nuts, followed by vegetables and agronomic crops respectively.

Figures 5-8 a, b and c provide profiles of usage per acre by crop group for each of the three two-year periods.

Table 5-4 Average Pounds of Pesticide Active Ingredient Used Per Acre in U.S. Crop Production, by Crop Group and Type of Pesticide, Along with Total Acres Grown, Two Year Periods, 1988-97

Crop Group	Years	Acres grown	**Pounds of active ingredient**					
		(000)	Herbicides/PGR	Ins./Miticides	Fungicides	Nem./Fumigants	Sulfur/oil	Total
Corn/Sorghum	1988/89	80,877	2.97	0.33	0.00	0.00	0.03	3.33
	1992/93	88,349	2.67	0.22	0.00	0.00	0.01	2.91
	1996/97	91,687	2.59	0.17	0.00	0.00	0.01	2.77
Soybeans	1988/89	59,459	1.51	0.06	0.01	0.00	0.02	1.59
	1992/93	59,123	1.20	0.01	0.00	0.01	0.01	1.23
	1996/97	67,575	1.23	0.01	0.00	0.01	0.01	1.26
Cotton	1988/89	11,297	1.87	1.37	0.09	0.29	0.10	3.72
	1992/93	13,495	2.07	1.01	0.06	0.36	0.15	3.64
	1996/97	14,060	2.33	0.83	0.04	0.74	0.05	3.98
Cereals	1988/89	92,769	0.47	0.03	0.02	0.00	0.00	0.52
	1992/93	88,135	0.45	0.02	0.01	0.00	0.00	0.48
	1996/97	89,582	0.49	0.02	0.01	0.00	0.00	0.52
Agronomic Crops	1988/89	9,451	1.81	0.89	1.45	3.28	1.72	9.15
	1992/93	10,305	1.93	0.64	0.82	5.62	0.87	9.87
	1996/97	10,964	1.91	0.55	0.66	5.90	0.29	9.30
Fruits & Nuts	1988/89	4,458	2.57	7.83	6.93	3.83	22.96	44.10
	1992/93	4,616	3.26	8.03	6.49	3.61	25.54	46.93
	1996/97	5,126	3.92	7.89	6.95	2.09	22.93	43.78
Vegetables	1988/89	3,212	2.12	1.42	1.66	6.45	1.78	13.43
	1992/93	3,818	2.07	1.29	1.24	9.72	1.27	15.60
	1996/97	4,048	2.07	1.35	1.85	15.90	2.51	23.69
Miscellaneous	1988/89	643,611	0.04	0.00	0.01	0.02	0.01	0.09
	1992/93	639,670	0.03	0.00	0.00	0.02	0.00	0.05
	1996/97	611,451	0.05	0.00	0.00	0.00	0.00	0.05
All Crops	1988/89	902,571	0.50	0.11	0.06	0.08	0.15	0.91
	1992/93	821,821	0.53	0.10	0.06	0.16	0.17	1.01
	1996/97	894,491	0.53	0.09	0.06	0.17	0.15	1.00

SOURCE: Figures calculated by dividing aggregate usage estimates in Table 5-3 by total U.S. acres grown as estimated by Doane also shown above.

Crop Groupings

Cereals: Wheat, Barley, Oat, Rye, Rice

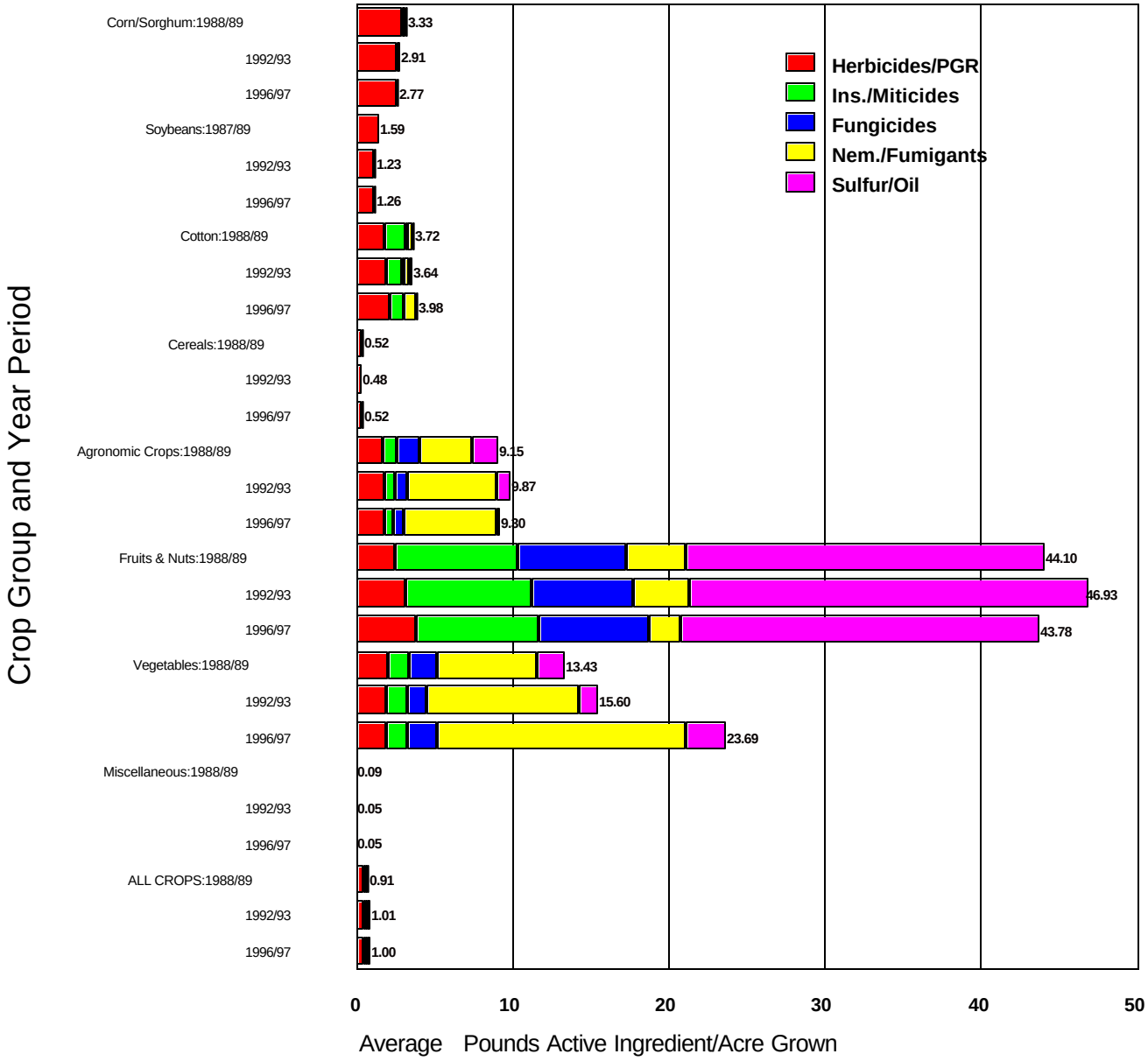
Agronomic Crops: Dry Beans/Peas, Peanut, Potato, Sugarbeet, Sugarcane, Sunflower, Tobacco

Fruits & Nuts: Berries, Grapes, Fruit Trees, Citrus, Nut Trees

Vegetables: Sweet Corn, Tomato, Eggplant, Pepper, Melons, Coles, Curcurbits, Lettuce, Other Leafy Vegetables, Veg. Beans/Peas, Bulb Crops, Roots/Tubers, Other Vegetables

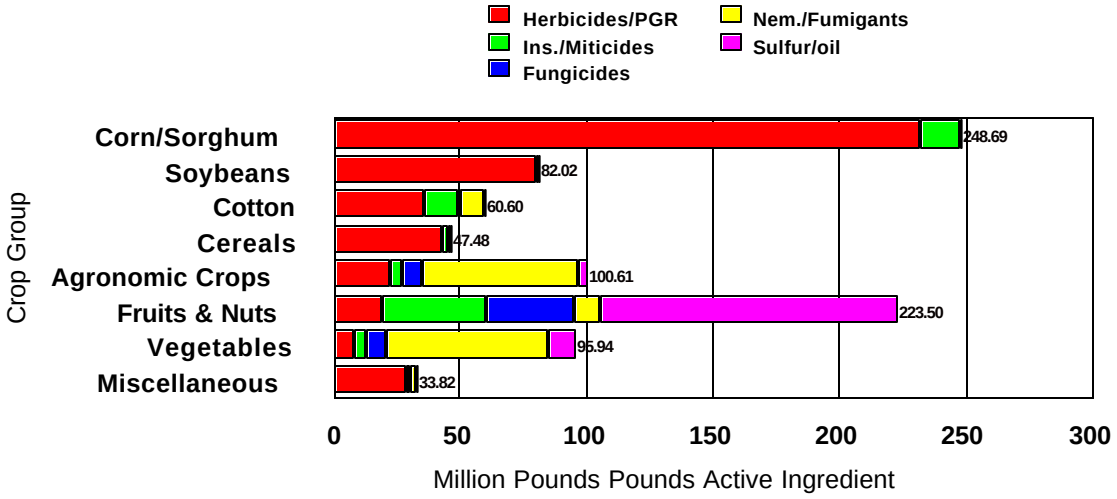
Miscellaneous: ACR, CRP, Fallow, Flax, Pasture/Rangeland, Other Pasture/Rangeland

Average Pesticide Active Ingredient Per Acre of Crop Grown, by Crop Group, Two Year Periods (1988/97) and Type of Pesticide, U.S.
Figure 5-6

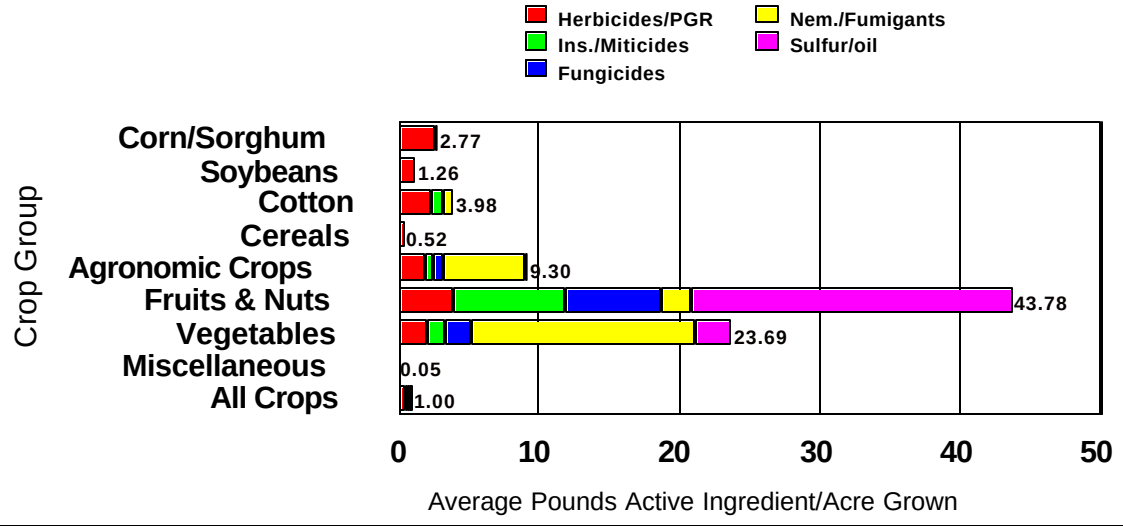


SOURCE: Table 5-4 .
NOTE: Figures calculated by dividing aggregate usage estimates in Table 5-3 by total U.S. acres grown as estimated by Doane also shown in Table 5-3.

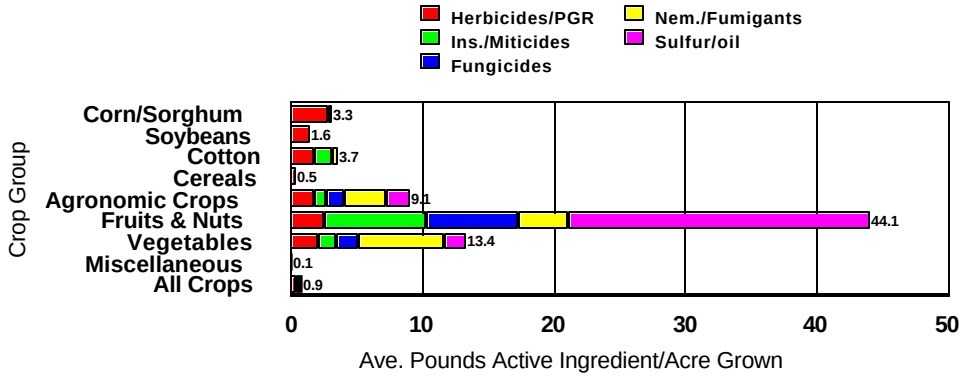
Pesticide Active Ingredient Used for Crops,
Millions of Pounds, by Type of Pesticide, U.S., 1996/97
Figure 5-7a



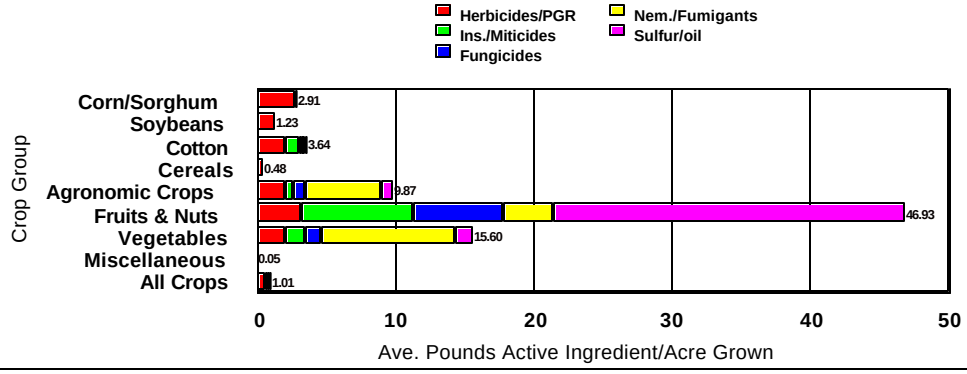
Pesticide Active Ingredient Per Acre of Crop Grown,
by Type of Pesticide, U.S., 1996/97
Figure 5-7b



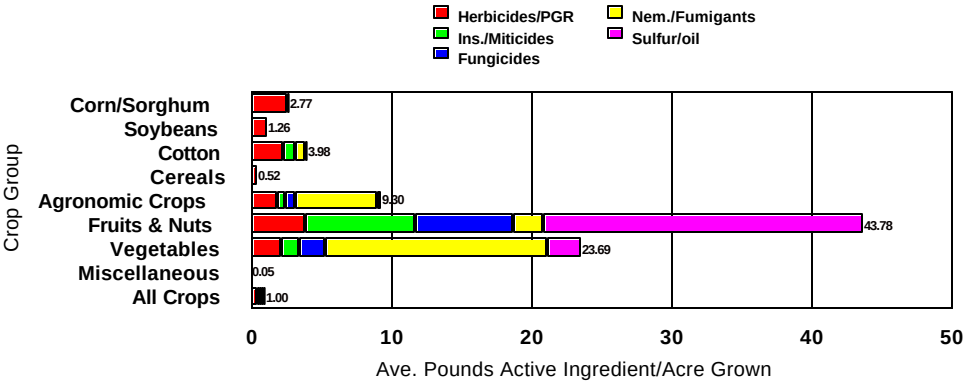
Pesticide Active Ingredient Per Acre of Crop Grown, by Type of Pesticide, U.S., 1988/89
Figure 5-8a



Pesticide Active Ingredient Per Acre of Crop Grown, by Type of Pesticide, U.S., 1992/93
Figure 5-8b



Pesticide Active Ingredient Per Acre of Crop Grown, by Type of Pesticide, U.S., 1996/97
Figure 5-8c



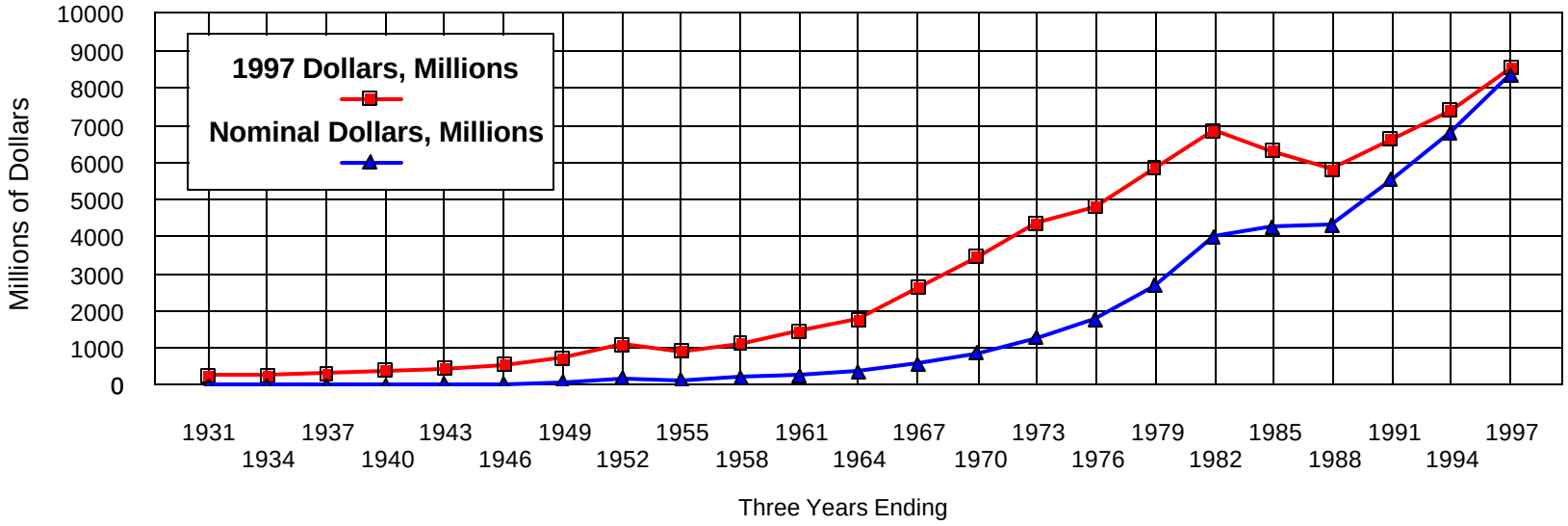
I. Expenditures for Agricultural Pesticides, 1929/97

USDA maintains data series on total farm production expenditures and with break-outs for components, including pesticides. The series goes back to 1910. This section shows trends starting with 1929 utilizing USDA/ERS's expenditure series through 1978 and EPA's series for 1979 through 1997. Separate series for expenditures are presented for nominal dollars and constant 1997 dollars based on the U.S. GDP deflator published by the U.S. DOL.

Farm expenditures for pesticides have increased greatly over the last seven decades due to trends in the general level of prices in the U.S. economy and more importantly due to expanded usage of pesticide chemicals, including more complex and costly pesticide products. Farm expenditures for pesticides have increased from $33 million in 1929/31 to about $8.4 billion in 1995/97 in nominal dollars. (Figure 5-9) When placed in constant 1997 dollars, the increase is from $296 million per year in 1929/31 to $8.5 billion in 1995/97. As can be seen in Figure 5-9, the correction for inflationary price trends explains only a minor part of increasing levels of expenditures over the roughly seven decades. Some of the factors which relate to the increasing expenditures for pesticides include:

- more than three times as much conventional pesticide active ingredient usage in 1996/97 than in 1929/31 (230 vs.782 million pounds);
- declining relative importance of other pesticide chemicals such as sulfur and petroleum, which are less expensive than conventional pesticides; and
- trends in conventional pesticides away from rather crude/inexpensive chemicals such as arsenicals, lead and coppers and toward sophisticated, potent, convenient and pest-specific/targeted products more valuable to users.

Agricultural Pesticide Expenditures, Nominal and Constant 1997 Dollars, U.S., Three Year Periods Ending 1931-97
Figure 5-9



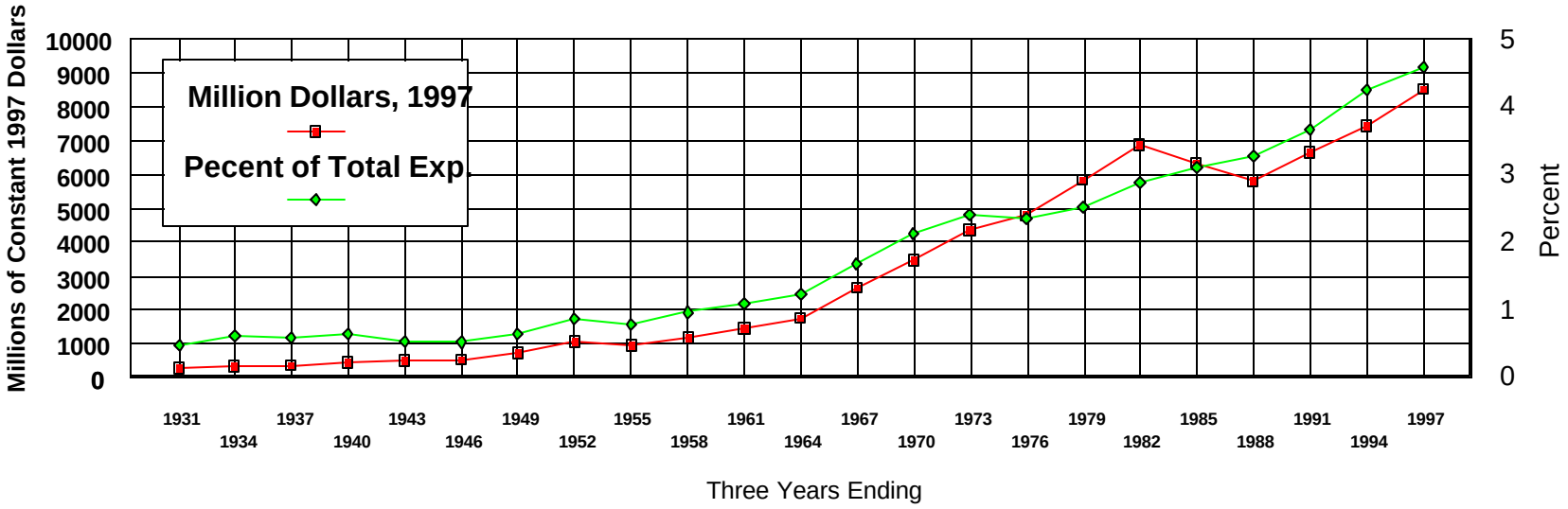
	1931	1934	1937	1940	1943	1946	1949	1952	1955	1958	1961	1964	1967	1970	1973	1976	1979	1982	1985	1988	1991	1994	1997
1997 Dollars,	296	312	348	428	476	549	745	1090	950	1159	1449	1770	2645	3457	4351	4837	5857	6852	6325	5805	6644	7406	8517
Nominal Doll	33	28	33	41	52	69	118	188	174	230	302	383	609	898	1308	1801	2677	4007	4297	4328	5565	6806	8360

One way of considering the importance of pesticides in agriculture is to measure their relative importance in dollar terms among all farm inputs. Pesticides have accounted for an ever increasing percentage of total farm production expenditures since about 1945, when they accounted for about 0.5 percent. (Figure 5-10) Since that time, pesticides have steadily increased as a percentage of total farm production expenses to a level of 4.6 percent in 1995/97. Increases in this percentage have been rather pronounced during the 1990's. Apparently agricultural producers are depending on pesticide chemicals to carry an increasingly heavy pest management load and are willing to pay for it.

The increasing expenditures for pesticides are reflected in higher average expenditures per pound of active ingredient. For example, over the twenty one years between 1974/76 and 1995/97, the average expenditure per pound of active ingredient nearly doubled— from $4.84 per pound in 1974/76 ($4,837 mil. for 999 mil. pounds) to $8.99 ($8,517 mil. for 947 mil. pounds) (numbers from Figure 5-10 and 5-2 respectively). Over the years, pesticides have become effective at lower dosage rates and often have features or functions that earlier chemicals did not have, all of which cost to develop but are valuable to the grower or other user.

Another way of looking at the importance of agricultural pesticide usage is in terms of expenditures relative to the number of people in the U.S. One can calculate the average or pro-rata level of expenditures for pesticide used to produce food and fiber per capita. This has been done in Figure 5-11 which shows agricultural pesticide expenditures in total and per capita, for U.S. civilian population over the last seven decades (1997 constant dollars). There are three rather distinct periods as follows---before 1960; 1961/1982 and 1983/97. Following the rather low levels prior to 1960, expenditures increased quite rapidly and consistently through 1982; and then they have varied, at levels generally at or below 1980/82. For the most recent period, 1995/97, the average expenditure per capita for agricultural pesticides was $32.10 (Figure 5-11).

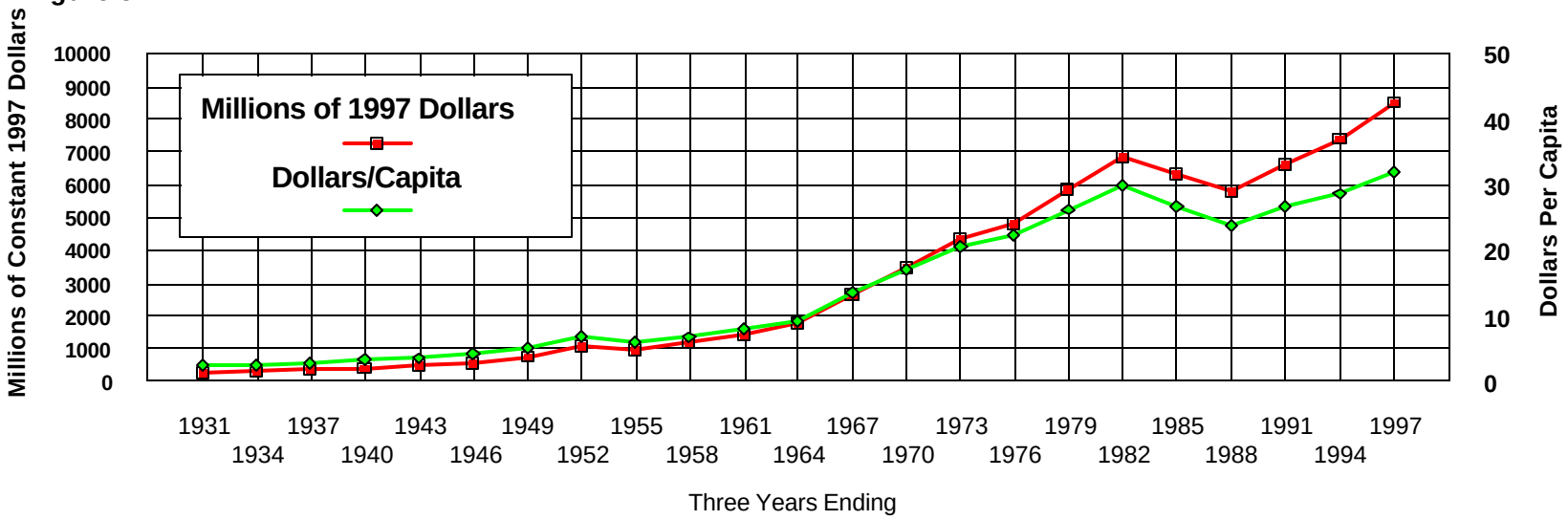
Agricultural Pesticide Expenditures, Total and as Percent of Total Farm Production Expenses, U.S., Three Year Periods Ending 1931-97
Figure 5-10



	193	193	193	194	194	194	194	195	195	195	196	196	196	197	197	197	197	198	198	198	199	199	199
Million Doll	29	31	34	42	47	54	74	109	95	115	144	177	264	345	435	483	585	685	632	580	664	740	851
Pecent of T	0.4	0.6	0.5	0.6	0.5	0.5	0.6	0.8	0.8	0.9	1.0	1.2	1.6	2.1	2.4	2.3	2.5	2.8	3.1	3.2	3.6	4.2	4.6

SOURCE: USDA data series for total expenditures and for pesiticides, 1929-78.
Percentage computed from nominal dollars; dollars computed from nominal dollars converted to 1997 dollars, using GDP deflator

Agricultural Pesticide Expenditures,
Total and Per Capita, U.S., Three Year Periods Ending 1931-97
Figure 5-11



	1931	1934	1937	1940	1943	1946	1949	1952	1955	1958	1961	1964	1967	1970	1973	1976	1979	1982	1985	1988	1991	1994	1997
Millions of 1997 Do	296	312	348	428	476	549	745	1090	950	1159	1449	1770	2645	3457	4351	4837	5857	6852	6325	5805	6644	7406	8517
Dollars/Capita	2.40	2.50	2.72	3.27	3.54	4.11	5.08	7.08	5.87	6.77	8.05	9.39	13.52	17.16	20.79	22.44	26.37	29.86	26.82	23.96	26.64	28.73	32.10

Includes conventional pesticides and other pesticide chemicals;
Excludes wood preservatives and biocides.

PART SIX

TRENDS IN HOME AND GARDEN USAGE BY HOMEOWNERS

The purpose of Part Six of this report is to present comprehensive historical trend information on homeowner applications of pesticides to homes and gardens, including lawns, by types of pesticides used. Estimates of usage per year are presented for three year periods covering the time from 1929 through 1997. The coverage of chemicals is conventional pesticides and other pesticide chemicals, but does not include biocides and wood preservatives, following the same definitions and reporting scheme used in Part Five of this report.

The definition of the home and garden sector is as provided in Part Three of this report and excludes applications to homes and gardens by professional applicators, which are included under the industrial/commercial/government sector for pesticide applications. The applications to homes and gardens by pest control operators, lawn services, arborists, etc., are included in Part Seven of this report. The professional applicator sector is sometimes referred to as the certified/commercial applicator sector and will be discussed further in Part Seven.

A. Profile of Home and Garden User Sector

Home and garden pesticide applications (by homeowners and family members) account for a significant portion of total usage of conventional pesticides and other pesticide chemicals. As was shown earlier in Table 3-2, home and garden applications accounted for 136 million pounds of active ingredient in 1997, or 11 percent of the total for all user sectors that year. These applications were made by an estimated 123.7 million persons, of which 52.5 million were male and 71.1 million were female. (Table 6-1) These figures are based on estimates developed in the EPA Home and Garden Pesticide Use Survey. (EPA, 1992) That study provided estimates of numbers of persons applying pesticides and many other aspects, for the year 1990. Table 6-1 in this report contains the estimates derived from the EPA study for 1990, and extrapolations forward to 1997, using the same proportions (e.g., percentages of households and population). The user profile information presented in the subsection is from that EPA study, unless otherwise noted.

Nearly one half of the U.S. civilian population applies pesticides, 115.2 million out of 249.4 million in 1990, or about 46 percent.(Table 6-1) Females tend to apply pesticides more commonly than males as 66.3 million females applied pesticides compared with 48.9 million males in 1990.

There were an estimated 84.6 million households in the U.S. in 1990, of which 70.5 million (about 83 percent) were urban and 14.1 million rural. (Table 6-1) About three-fourths

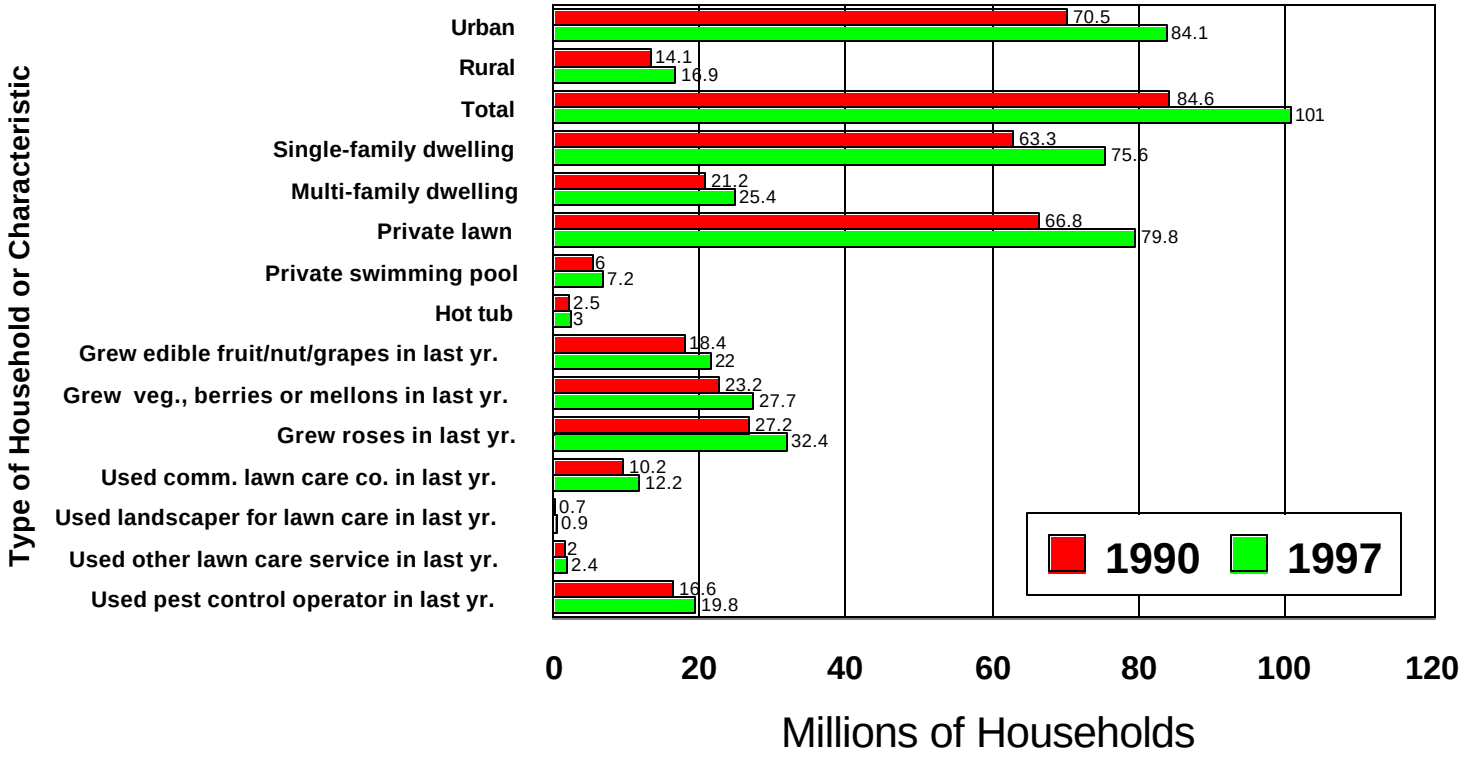
Table 6-1 Profile Features of U.S. Home and Garden Pesticide Application Sector, 1990 and 1997					
Profile Feature	1990		1997 Projected		
	Millions	Percent of U.S. Total	Millions		
U.S. civilian population	249.4	100.0	267.9		
No. U.S. households					
Urban	70.5	83.3	84.1		
Rural	14.1	16.7	16.9		
Total	84.6	100.0	101.0		
No. U.S. households with:					
Single-family dwelling	63.3	74.9	75.6		
Multi-family dwelling	21.2	25.1	25.4		
Private lawn	66.8	79.0	79.8		
Private swimming pool	6.0	7.1	7.2		
Hot tub	2.5	3.0	3.0		
No. U.S. households that:					
Grew edible fruit/nut/grapes in last year	18.4	21.8	22.0		
Grew veg., berries or mellons in last year	23.2	27.4	27.7		
Grew roses in last year	27.2	32.1	32.4		
U.S. Home lawn acrege	23.3	100.0	26.0		
No. U.S. households using :					
Comm. lawn care co.	10.2	12.1	12.2		
Landscaper for lawn care	0.7	0.9	0.9		
Other lawn care service	2.0	2.3	2.4		
Pest control operator for insects, etc	16.6	19.6	19.8		
No. of resident persons applying pesticides during year					
Male	48.9	42.5	52.5		
Female	66.3	57.5	71.2		
Total	115.2	100.0	123.7		
SOURCES: EPA Home and Garden Pesticide Use Survey, March 1992 for numbers and percent 1990 except for population and lawn acreage. Percentages for 1990 used to extrapolate for 1997.					
Population estimates from Census of Population					
1990 home lawn acreage from Economic Profile Estimates for Turf Insecticides, by DPRA for EPA, Jan., 1993; 1997 home lawn acres based on Kline Briefing, May 6, 1999.					

of U.S. households have single-family dwellings (63.3 million in 1990), leaving one-fourth to have multi-family dwellings. More than three-fourths have private lawns (66.8 million in 1990), but few have private swimming pools (6 million) and hot tubs (2.5 million). Significant proportions of households grow fruit/nut/grapes (18.4 million or 22 percent in 1990), grow vegetables/berries/melons (23.2 million or 27 percent) and grow roses (27.2 million or 32 percent). The EPA survey estimated that 16.6 million households used pest control operators, which equaled about one-fifth to total U.S. households. (Table 6-1)

Commercial lawn care service is used by about one-eighth of households and some use landscapers or other lawn care services. (Table 6-1) As of 1990, there was an estimated total of 23.25 million acres of home lawns in the U.S. (Table 6-1), which equals an average of 0.34 acres per household with private lawn (66.8 million households). The estimated acreage of lawn per household remained about the same in 1997, based on new estimates of turf acreage and assuming the same proportion of households with private lawns, as estimated in the EPA Survey for 1990.
(Table 6-1)

A graphic version of the key user-profile data presented on the home and garden pesticide usage sector is presented in Figure 6-1.

Numbers of Households in Home and Garden Pesticide Usage Sector, with Specified Charateristics, U.S., 1990 and 1997
Figure 6-1



SOURCE: EPA Home and Garden Pesticide Use Survey, 1990

B. Quantitative Characteristics of Home and Garden Usage, 1990

The EPA home and garden pesticide use survey developed estimates of numbers of households using pesticides by type (class) of pesticide and site of application, along with numbers of applications. It also developed estimates of numbers of pesticide products in storage by type of pesticide and when used. A detailed table summarizing some of the key results of the survey are presented in Appendix Table 6 A, which provides the basis for a series of charts on home and garden use patterns for 1990 presented in this section. That study did not undertake to estimate quantities of pesticide active ingredient (or formulated product) used because of inherent difficulties involved in obtaining an entire year's worth of applications from selected households without a much more ambitious survey involving multiple contacts during the enumeration year and record keeping. So far, since that time, such a more ambitious national survey of home and garden usage has not been undertaken by EPA to derive estimates of quantities used. Accordingly, this report is based on other available secondary reports and sources as concerns quantities of pesticides used in the home and garden sector.

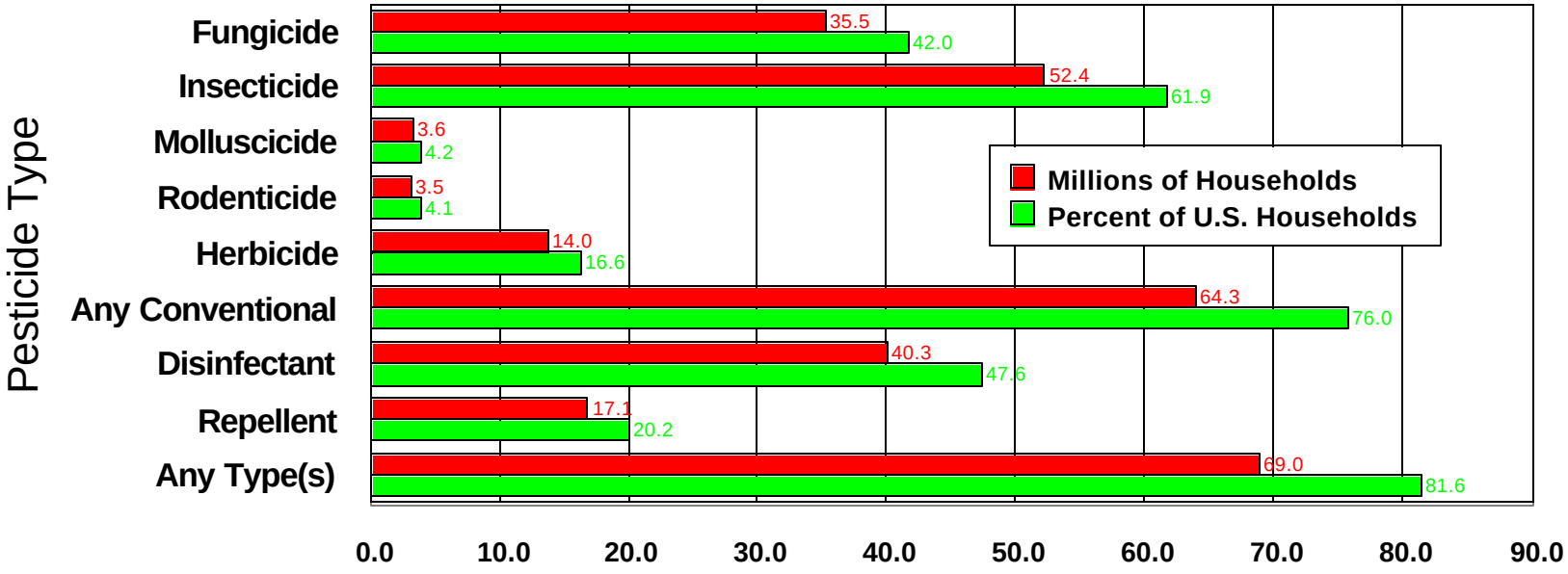
1. Numbers of Households Using Home and Garden Pesticides, 1990

Pesticides are used by homeowners (and/or family members) in a majority of U.S. households, including lawns, gardens and any other outside areas. As of 1990, 69 million households used one or more types of pesticides, which equaled 81.6 percent of U.S. households that year. (Figure 6-2) In other words, about one-fifth of households did not use any pesticides. Insecticides and fungicides are the most commonly used conventional pesticides in homes and gardens. About 60 percent used an insecticide and about 40 percent used a fungicide. Only about four percent of households used a molluscicides or a rodenticide. (Figure 6-2) Disinfectants were used in nearly half of households and about one-fifth used insect repellents.

In terms of application site, three fourths of U.S. households apply one or more pesticides indoors (64 million in 1990). (Figure 6-3) About one-fifth have lawn pesticide applications, one-tenth, food crop applications and one-sixth, ornamentals. Other outside areas, such as outbuildings were treated with one or more pesticides by homeowners in 1990 (25 million households or 29 percent of the total).

Figure 6-4 contains a two-way breakout of the numbers of households with homeowner pesticide applications showing numbers by both pesticide type and site of application. The leading combinations in terms of numbers of households were: indoor insecticides (42 million), indoor disinfectants (40 million), indoor fungicides (32 million) and indoor repellents (15 million). The leading outdoor combinations were: insecticides on other outside areas, ornamentals and lawns; and herbicides on lawns.

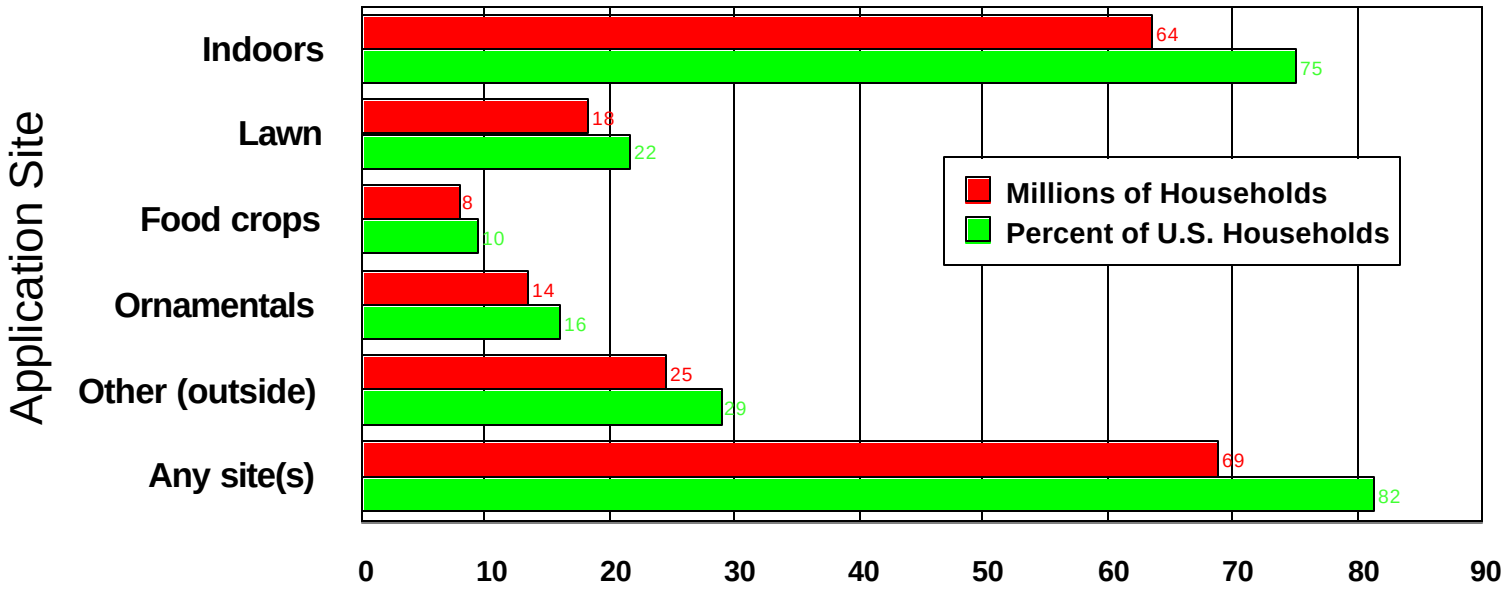
Numbers and Percentages of Households Using Home and Garden Pesticides, by Type of Pesticide, All Sites of Application, U.S., 1990
Figure 6-2



	Fungicide	Insecticide	Molluscicide	Rodenticide	Herbicide	Any Conventiona	Disinfectant	Repellent	Any Type(s)
Millions of Hou	36	52	4	3	14	64	40	17	69
Percent of U.S	42.0	61.9	4.2	4.1	16.6	76.0	47.6	20.2	81.6

SOURCE: EPA Home and Garden Survey, 1990

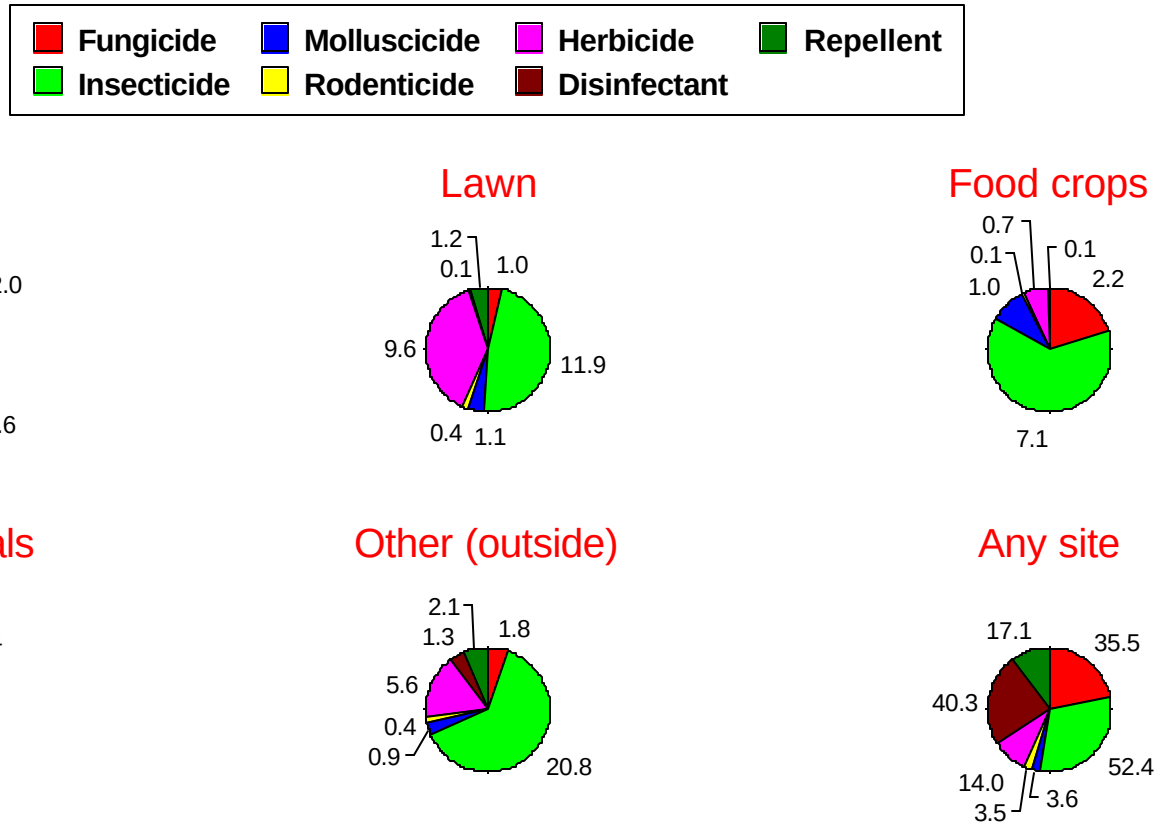
Numbers and Percentages of Households Using Home and Garden Pesticides, by Application Site, All Types of Pesticides, U.S., 1990
Figure 6-3



	Indoors	Lawn	Food crops	Ornamentals	Other (outside	Any site(s)
Millions of Household	64	18	8	14	25	69
Percent of U.S. Hou	75.3	21.8	9.6	16.2	29.1	81.6

SOURCE: EPA Home and Garden Survey, 1990

Numbers of Households Using Home and Garden Pesticides, by Type of Pesticide and Site of Application, U.S., 1990
Figure 6-4



SOURCE: EPA Home and Garden Use Survey, 1990
NOTE: Millions of Households

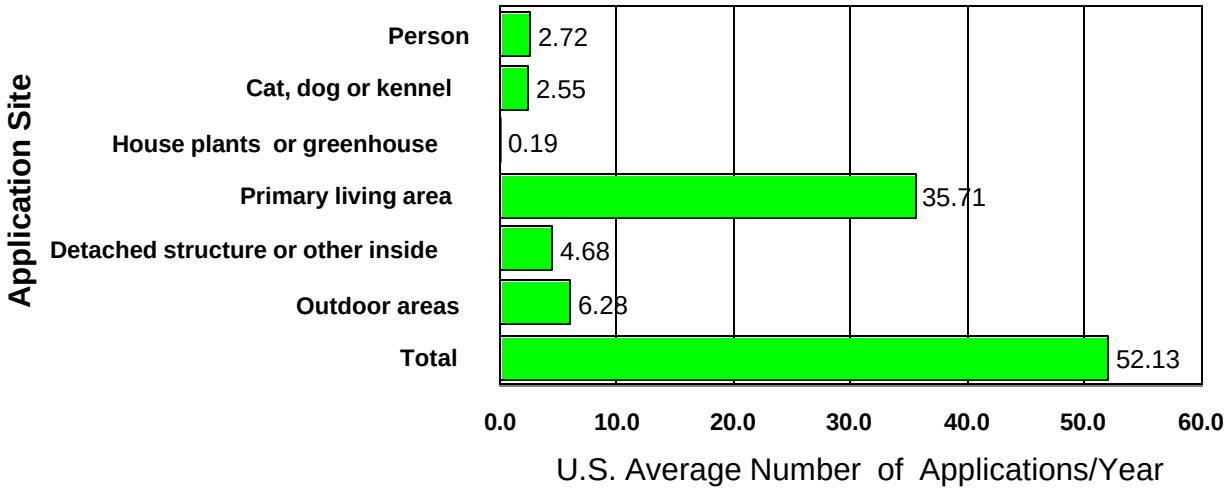
2. Numbers of Home and Garden Pesticide Applications Per Household, 1990

The EPA Home and Garden Survey provided estimates of the number of pesticide applications as well as numbers of households, as summarized in Appendix Table 6A, which also contains computations of the average numbers for applications per household, for 1990. Averages were computed in two alternative ways, one based on all U.S. households (84.6 million in 1990) and the other based only the number of households making the particular type of application.

Figure 6-5 contains estimates of average numbers of applications for all U.S. households by application sites, in different terms than presented above, e.g., person, animal/kennel, and primary living area. The average was about 52 applications per household during 1990 (about one per week) for all types of applications. The primary living area accounted for about two-thirds of the applications. The other types of applications were much less frequent, with averages of less than 5 per year for the various types other than "outdoor areas" for which the average was 6.28 applications.

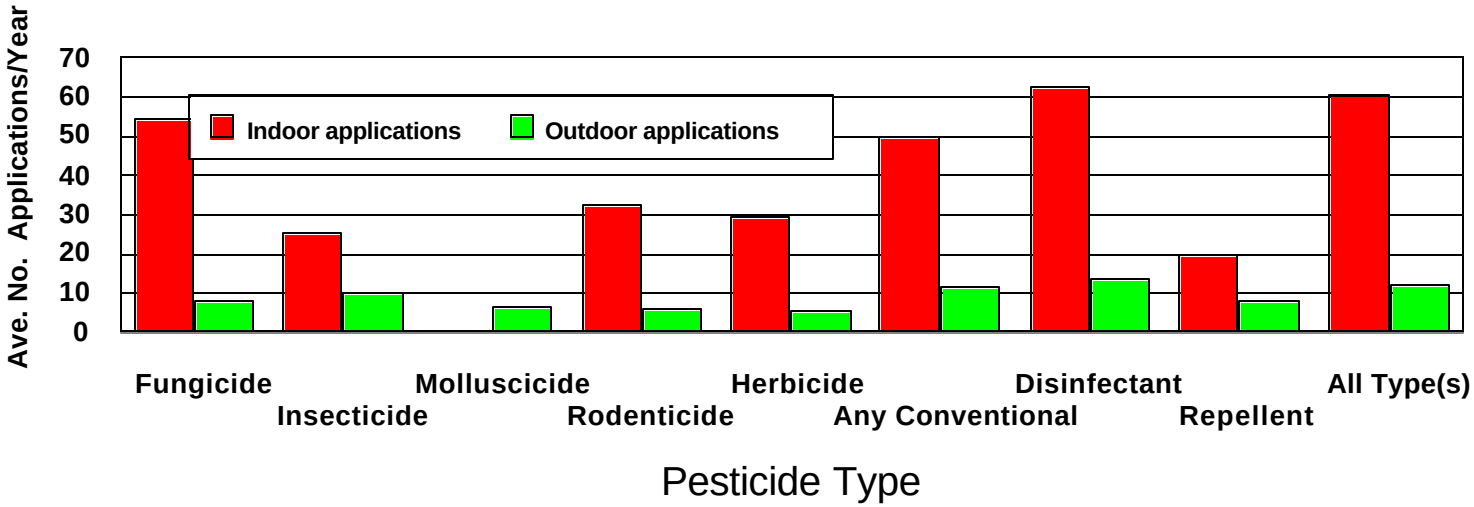
The alternative set of calculations for the average number of applications per household is summarized in Figure 6-6, with separate breakouts for type of pesticide and indoor vs. outdoor applications. As indicated in the Figure, the values for indoor applications are computed directly from aggregate estimates of applications and households published in the study, while the values for outdoor applications are mid-range estimates, assuming the midpoint of possible households making particular types of indoor applications. For any and all types of pesticides used indoors, the average was 60.89 applications per year for using households. The highest indoor averages were for disinfectants (62.66), fungicides (54.13) and rodenticides (32.69). For outdoor applications, the average for any and all types of pesticides was 11.87 applications per using household. The leading pesticide types were: disinfectants (13.25 applications), insecticides (10.19) and fungicides (7.56).

Numbers of Home and Garden Pesticide Applications, by Site of Appplication, U.S., 1990
Average Number of Applications Per U.S. Household During Year
Figure 6-5



NOTE: Average computed from EPA Survey, 1990
using all U.S. households in divisor, i.e., 84.6 million.

Numbers of Home and Garden Pesticide Applications Indoors and Outside, by Type of Pesticide, U.S., 1990
Average Numbers of Applications for Households Using Specified Pesticide Type
Figure 6-6



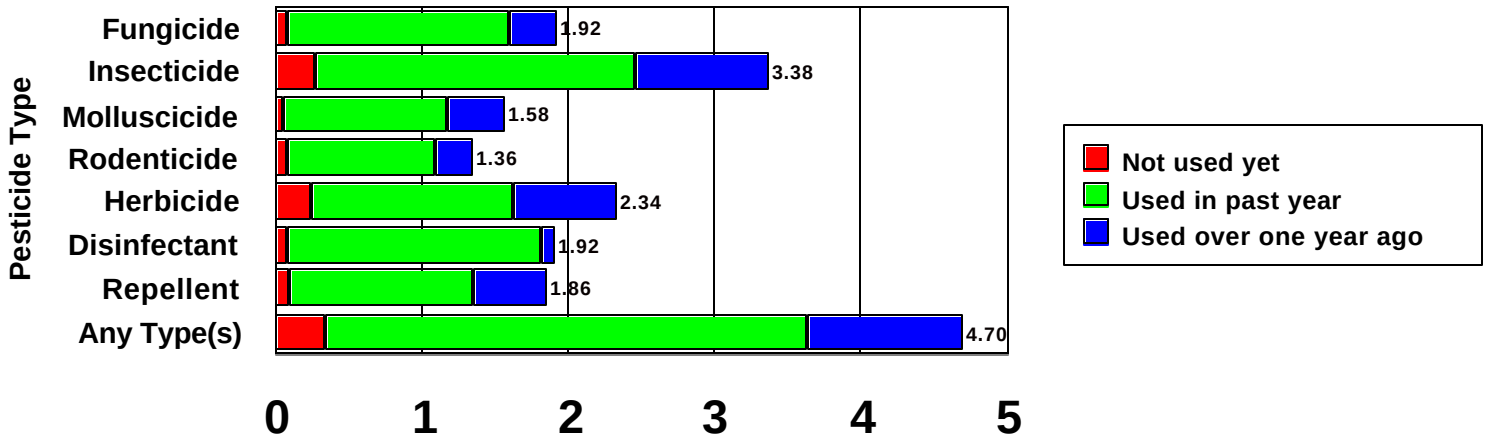
	Fungicid	Insecticide	Molluscicid	Rodenticide	Herbicide	Any Convention	Disinfectan	Repellen	All Type(s
Indoor ap	54.13	25.66		32.69	29.55	49.97	62.66	19.77	60.89
Outdoor a	7.56	10.19	6.47	6.04	5.29	11.59	13.25	8.38	11.87

NOTE: Outdoors estimates computed directly from aggregages in EPA Home/Garden Report
Indoor figures are imputed mid-point estimates based on same EPA Survey Report. (See Appendix Table 6 A.)

3. Numbers of Home and Garden Pesticide Products in Storage, 1990

The EPA Home and Garden Survey found that rather large numbers of pesticide products were in storage at household. Estimates were made of the aggregate numbers of products in storage by type (class) of pesticide and use status (not used yet, used past year or used over one year ago). The numbers of products in storage are shown in Appendix Table 6 A. There also, are calculated averages for numbers of products in storage, based on numbers of households reporting use of the specified type of pesticide. They are also summarized and presented in Figure 6-7. On the average, using households had 4.7 pesticides in storage, of which 0.34 were not used yet and 1.07 were used more than one year ago. Insecticides were most commonly in storage (3.38 products), followed by herbicides (2.34), while the other categories had values in the range of one and two products in storage on the average.

Numbers of Home and Garden Pesticide Products in Storage, by Type and When Used, Average Numbers per Household Using Specified Type of Pesticide, U.S., 1990
Figure 6-7



	Fungicide	Insecticide	Molluscicide	Rodenticide	Herbicide	Disinfectant	Repellent	Any Type(s)
Not used	0.09	0.27	0.06	0.09	0.23	0.09	0.11	0.34
Used in p	1.52	2.19	1.13	1.01	1.38	1.74	1.25	3.30
Used ove	0.32	0.91	0.39	0.26	0.73	0.10	0.50	1.07
Total	1.92	3.38	1.58	1.36	2.34	1.92	1.86	4.70

NOTE: Total products in storage divided by number of households using specified type of pesticide based on results of EPA Home and Garden Survey for 1990.

C. Home and Garden Pesticide Usage, by Type, 1929/97

1. Approach and Data Sources

The approach used in this section to report home and garden usage trends tracks with the presentations made in Parts Three, Four and Five earlier in the report. Reference can be made to those sections concerning reporting definitions, e.g., sectors and pesticide classes, along with principal data sources/methods for the time series of three-year periods covering the years 1929 through 1997. Appendix 4 A contains master tables for the home and garden sector usage (along with other sectors reported separately) covering the 1929/97 period.

The sector breakouts for home and garden applications presented in this section are approximations based on best available information and judgement of the author. Firm, precise, figures were particularly limited for the earlier years of the period from 1929 through 1997. Estimates of active ingredient usage (and user expenditures) on an annual basis for the home and garden sector have been previously published in the EPA Pesticide Market Series for 1979 through 1997. (Aspelin and Grube, EPA, November,1999) Those figures were adopted for computing the three year averages presented in this section. Reference was made to; the SRI Chemical Handbook Series, which has estimates going back as far as 1965; RvR Consultants Pesticide Market Studies for alternate years from 1974 through 1986; Kline Consumer Markets studies covering alternate years during the 1980's and 1990's; EPA home and garden pesticide studies for 1976/77, 1985 and 1990; DPRA study of impacts from FIFRA as amended in 1972 (DPRA, December, 1975); SRI study for CEQ covering 1950/70 with inferences about the relative sizes of homeowner and other market shares of U.S. pesticide usage (SRI, April, 1972); USDA Pesticide Situation and Pesticide Reviews, which have various estimates of home and garden, professional and agricultural usage (by chemical or groupings), going back as far as the 1940's in some cases (USDA, most years, 1952/53 through 1980); a study on usage of major pesticides by sector for CEQ by von Rumker and Lawrence (1974); a contract study for EPA presenting a profile of pesticide usage, with long term statistical series on production and usage by sector for numerous pesticides (ICF, August, 1980) and USDA annual Agricultural Statistics editions, which from time to time have information that can be used to apportion national usage to usage sectors, covering years as early as 1919.

Many other sources were consulted including: a book by Shepard containing valuable information on quantities of the older pesticides, by use site, going back to 1900 and earlier (Shepard, 1951); a book on spraying, dusting and fumigating of plants (Mason, 1928); a rather comprehensive book on chemistry and use of pesticides by Frear (1942 and 1955 editions); USDA homeowner and farmer bulletins starting as early as 1908 (Marlatte, M.S., 1908); an early manual on control of weeds by chemical and other means (Mason, 1933); a manual on tree and shrub insects and their control (Felt, 1924); a 1920's manual on vegetable garden insects (Crosby, 1918); an early book on how to identify and control injurious insects (O'Kane, 1915). Based on the above noted sources and others, estimates were made of usage in the home and garden sector. The resulting estimates for three year periods are thought by the author to be representative

of general levels of usage and trends over time.

2. Conventional and Other Pesticide Chemicals, Aggregate Usage

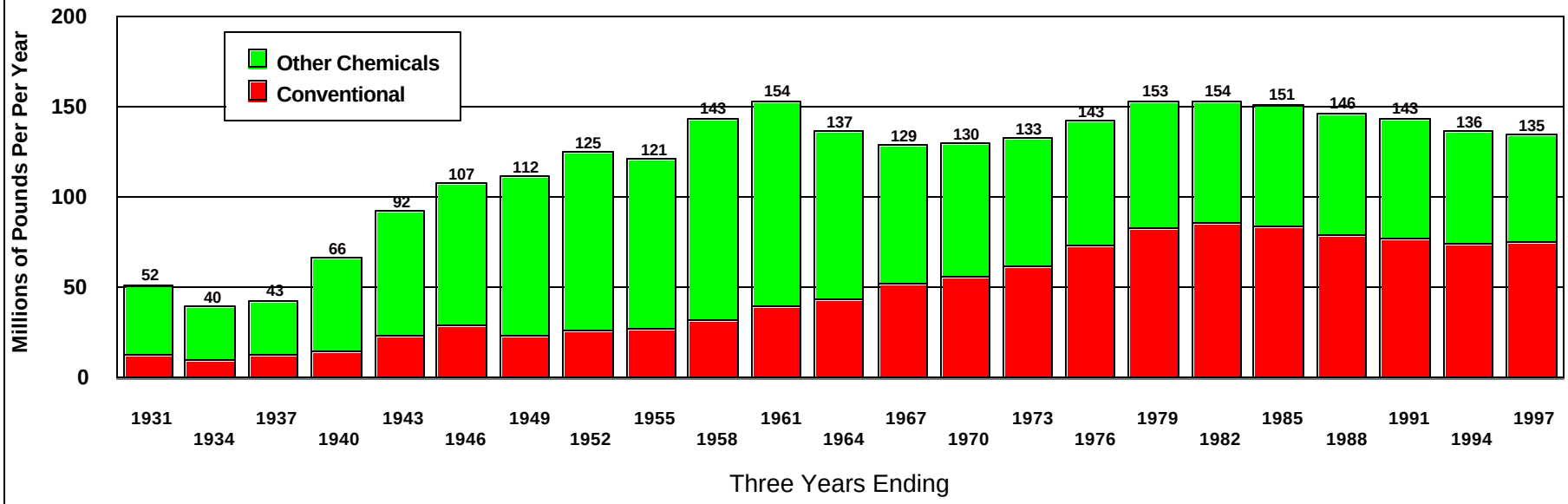
Presented in Figure 6-8 are estimates of conventional pesticide usage, other pesticide chemicals, and the total of these, for the home and garden sector covering the 1929/97 period. The values are averages per year for three year periods. The following observations can be made:

- the usage of conventional pesticides increased quite steadily from about 10 million pounds per year in the mid-1930's to about 85 million pounds per year around 1980; since then it has declined to75 million in the most recent period;
- other pesticide chemical usage increased from about 30 million pounds per year in the mid-1930's to a peak of about 115 million per year around 1960; since then such usage has been generally in the range of 60 to 80 million pounds per year;
- the total of conventional and other pesticide chemical usages was at a low 40 million pounds per year in 1932/34 and increased to 154 million pounds per year in 1959/61; usage was somewhat lower until around 1980 when usage returned to 150 million plus range; during the last 10 years overall home and garden usage has declined slightly, to 135 million pounds per year in 1995/97.

3. Conventional and Other Pesticide Chemicals, Per Capita Usage

The above aggregate usage figures have been divided by U.S. civilian population to place usage by the home and garden sector on a per capita basis. The results are shown in Figure 6-9, graphically, along with a table. A pattern which emerges is generally lower levels of usage since 1959/61 when usage was 0.85 pounds per capita, especially rather consistently since 1977/79 to a 1995/97 level of about one half pound per capita.

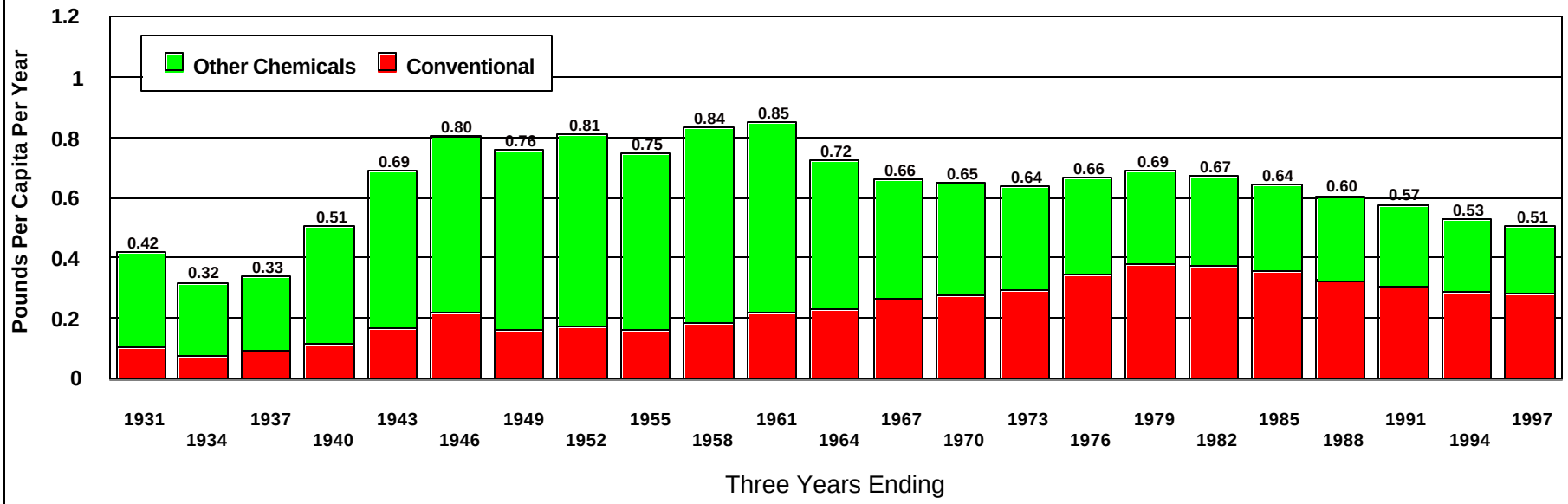
Volume of Pesticide Active Ingredient Usage in U.S., Conventional and Other Pesticide Chemicals with Total, Home and Garden Sector, Three Year Periods Ending 1931-97
Figure 6-8



	1931	1934	1937	1940	1943	1946	1949	1952	1955	1958	1961	1964	1967	1970	1973	1976	1979	1982	1985	1988	1991	1994	1997
Conven	12	9	12	15	23	29	23	26	26	31	40	43	52	56	62	73	83	86	84	79	77	74	75
Other C	39	31	31	52	70	78	88	99	95	112	114	93	77	74	71	70	70	68	67	67	66	62	60
Total	52	40	43	66	92	107	112	125	121	143	154	137	129	130	133	143	153	154	151	146	143	136	135

Excludes wood preservatives and biocides

Volume of Pesticide Active Ingredient Usage Per Capita in U.S., Conventional and Other Pesticide Chemicals with Total, Home and Garden Sector, Three Year Periods Ending 1931-97
Figure 6-9



	1931	1934	1937	1940	1943	1946	1949	1952	1955	1958	1961	1964	1967	1970	1973	1976	1979	1982	1985	1988	1991	1994	1997
Conve	0.10	0.07	0.09	0.11	0.17	0.22	0.16	0.17	0.16	0.18	0.22	0.23	0.27	0.28	0.29	0.34	0.38	0.37	0.36	0.33	0.31	0.29	0.28
Other	0.32	0.25	0.24	0.39	0.52	0.59	0.60	0.64	0.59	0.65	0.63	0.49	0.39	0.37	0.34	0.32	0.31	0.30	0.28	0.28	0.27	0.24	0.22
Total	0.42	0.32	0.33	0.51	0.69	0.80	0.76	0.81	0.75	0.84	0.85	0.72	0.66	0.65	0.64	0.66	0.69	0.67	0.64	0.60	0.57	0.53	0.51

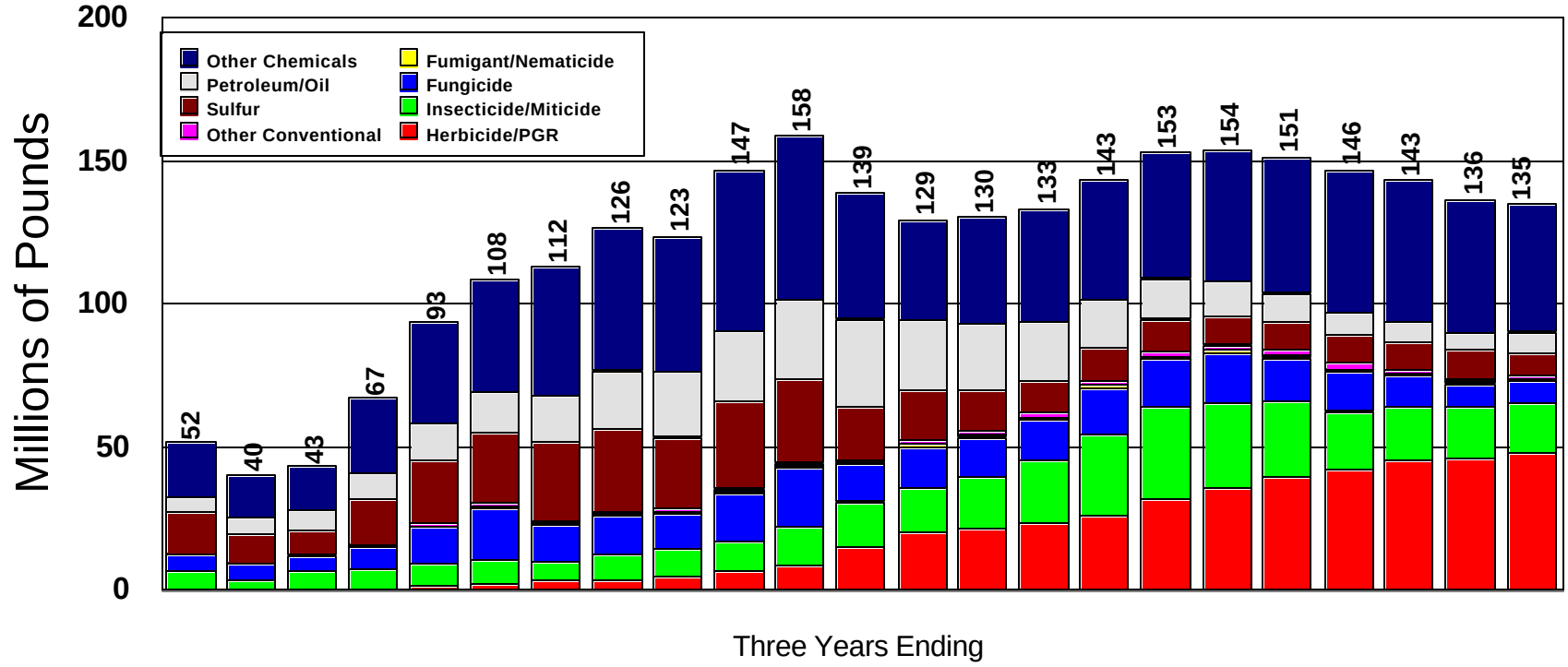
Excludes wood preservatives and biocides

4. Conventional and Other Pesticide Chemical Usage, by Class

The estimates of aggregates for conventional and other pesticide chemicals used by homeowners are presented in Figure 6-10 with breakouts by pesticide class for the period of 1929 through 1997. The following observations can be made:

- herbicide usage has increased steadily since WWII;
- insecticide/miticide usage has declined somewhat since around 1980;
- petroleum/oil and sulfur usage has declined since the 1960's;
- other pesticide chemicals, consisting largely of moth treatment chemicals, have remained at a relatively high level since the 1950's.

Volume of Pesticide Active Ingredient Usage in U.S. Home and Garden Sectors, by Type of Pesticide, Three Year Periods Ending 1931-97
Figure 6-10



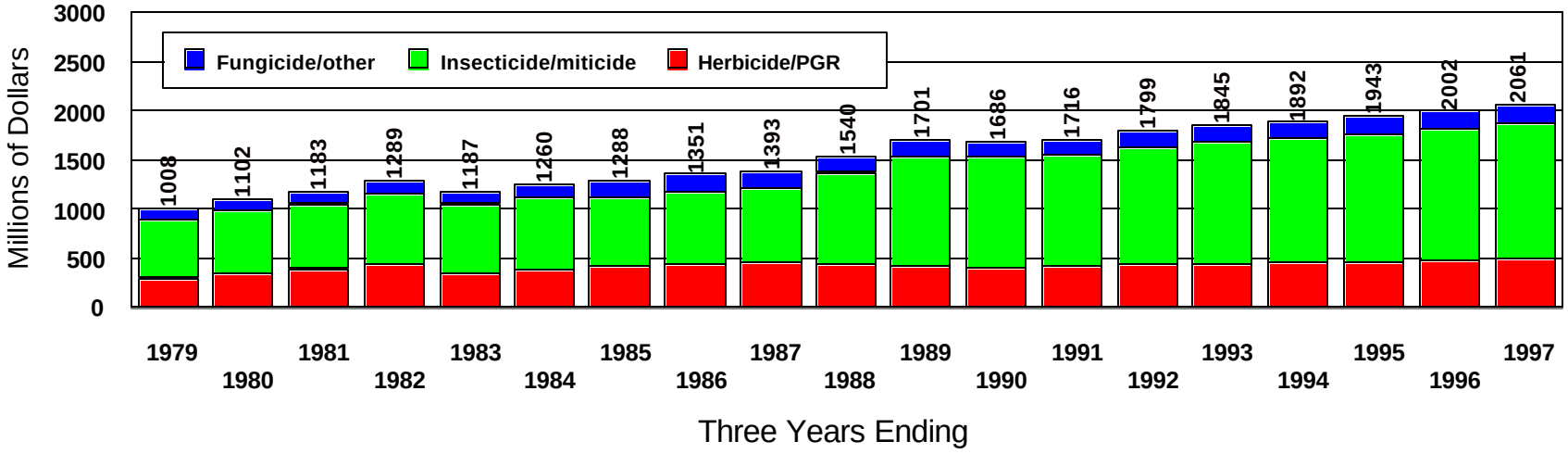
	1931	1934	1937	1940	1943	1946	1949	1952	1955	1958	1961	1964	1967	1970	1973	1976	1979	1982	1985	1988	1991	1994	1997
Herbicide/PGR	0	0	0	1	1	2	4	4	5	6	9	15	20	22	23	26	32	36	39	42	45	46	48
Insecticide/Miticide	7	4	6	7	8	8	6	9	9	11	13	16	15	17	22	29	32	29	27	21	19	18	17
Fungicide	6	6	6	8	13	18	13	13	13	16	21	13	14	15	14	16	16	17	15	14	11	8	8
Fumigant/Nematicide	0	0	0	0	0	0	0	0	1	:	1	:	1	:	1	:	1	:	1	1	1	1	1
Other Conventional	0	0	0	0	1	:	1	:	1	:	1	:	1	:	1	2	2	2	2	2	1	1	1
Total Conventional	13	9	12	15	24	30	24	27	28	35	44	45	52	56	62	73	83	86	84	79	77	74	75
Sulfur	15	10	8	16	22	25	27	29	25	31	29	19	18	14	11	11	11	10	9	10	9	10	8
Petroleum/Oil	5	5	7	9	13	14	17	21	23	25	28	30	24	23	21	17	15	12	10	8	7	6	7
Other Chemicals	20	16	15	26	35	39	44	49	47	56	57	44	35	37	39	42	44	46	47	50	50	47	45
Total Other P. Chems.	39	31	31	52	70	78	88	99	95	112	114	93	77	74	71	70	70	68	67	67	66	62	60
Grand Total	52	40	43	67	93	108	112	126	123	147	158	139	129	130	133	143	153	154	151	146	143	136	135

D. Home and Garden Pesticide User Expenditures, 1979/1997

Aggregate user expenditures are presented in Figure 6-11 for the home and garden sector for the years of 1979 through 1997. These are as previously published in the EPA market report and are in nominal dollars. Expenditures have about doubled from about $1.01 billion in 1979 to $2.01 billion in 1997. Most of the increase has occurred due to more expenditures for herbicides and plant growth regulators, aside from general price trends which are dealt with below.

Figure 6-12 contains home and garden pesticide usage expenditures for 1979/97 in constant 1997 dollars to take out the impact of inflation. The result was that expenditures have remained about the same at about $2.0 billion per year since 1979. When placed on a per capita basis, expenditures have declined somewhat over the period, i.e., from about $9.10 to $7.70. Obviously, home and garden pesticides are a minor percentage of the average household budget, which has not been increasing during the last two decades.

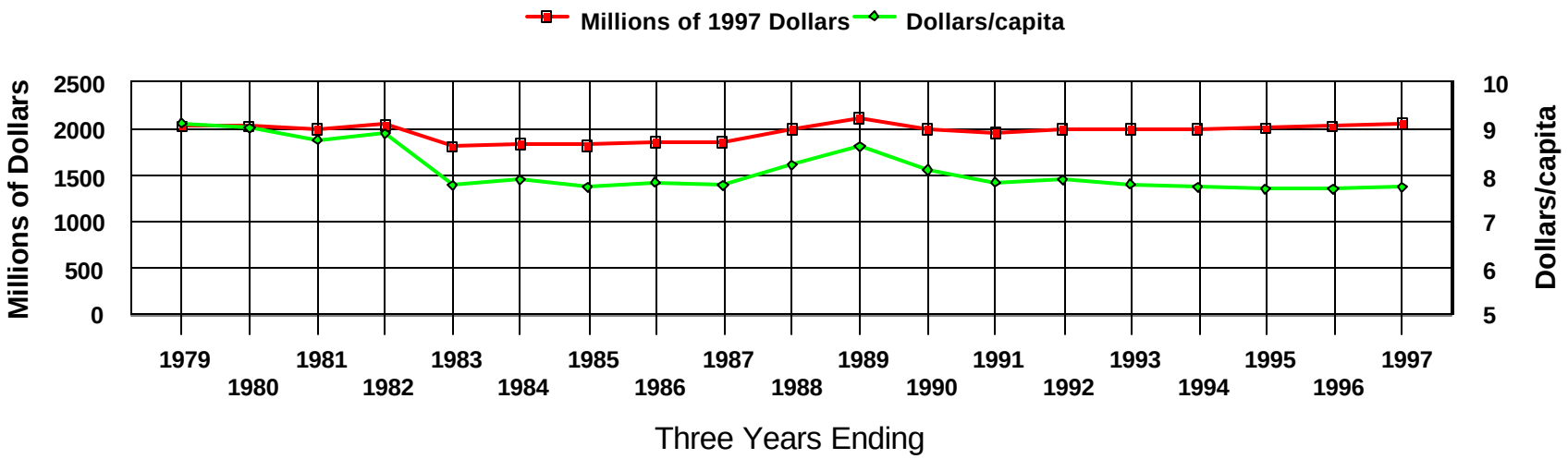
Expenditures for Pesticides Applied by Homeowners to Homes and Gardens, U.S., 1979-97
Figure 6-11



	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Herbicide/PGF	294	350	392	445	350	378	420	441	462	441	420	417	423	441	446	456	465	479	493
Insecticide/mi	595	630	665	714	700	742	700	735	742	924	1120	1109	1131	1190	1225	1261	1299	1338	1378
Fungicide/othe	119	122	126	130	137	140	168	175	189	175	161	160	162	168	174	175	179	185	190
Total	1008	1102	1183	1289	1187	1260	1288	1351	1393	1540	1701	1686	1716	1799	1845	1892	1943	2002	2061

Excludes wood preservatives and biocides.
Current dollars

Expenditures for Pesticides Applied by Homeowners to Homes and Gardens, U.S., 1979-97
Total Expenditures and Per Capita, in 1997 Dollars
Figure 6-12



	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Millions of 199	2036	2038	2000	2050	1810	1852	1830	1871	1871	1996	2115	2010	1967	2007	2006	2009	2016	2039	2061
Dollars/capita	9.13	9.03	8.78	8.91	7.80	7.91	7.75	7.85	7.78	8.22	8.63	8.11	7.85	7.92	7.82	7.76	7.71	7.72	7.75

Excludes wood preservatives and biocides.
Constant 1997 dollars

PART SEVEN

INDUSTRIAL/COMMERCIAL/GOVERNMENTAL USAGE TRENDS

The purpose of Part Seven of this report is to present comprehensive trend information on the extent of pesticide usage in the industrial/commercial/governmental sectors of the U.S., by types of chemicals used. As has been discussed earlier in this report, notably in Part Three, the industrial/commercial/governmental pesticide usage sector is often referred to as the "professional market." In general, it covers applications of conventional pesticides and other pesticide chemicals by certified and/or professional applicators in the non-agricultural sectors of the U.S. economy, including applications to homes and gardens by professionals. The professional market includes applications by pest control operators, lawn services, arborists, exterminators, public health applicators, animal care professionals and many other types of professionals who apply pesticides, which may be for-hire or be part of a firm, business or agency. Personnel with federal agencies such us Animal Health and Protection Service (of USDA) apply pesticides as do staff/contractors of state/local agencies/governments.

A brief profile is presented of the professional pesticide applicator sector, followed by historical information and trends on the quantities of pesticides used, by type, covering about 70 years, using the same approach and data sources used in preceding sections. Information is also presented on pesticide expenditures for applications by professional applicators in the non-agricultural sectors. The same basic approach and data sources were used in Part Seven as in the earlier parts of this report.

A. Profile of Professional Pesticide Applicator Sector

1. Profile of Applicators and Certifications

The industrial/commercial/governmental sector consists of applicators which apply pesticides to a very diverse set of sectors, land uses and aquatic areas. The diversity is suggested by the categories which are used for certifying applicators for application of restricted-use pesticides under FIFRA sec. 3 and 40 CFR 171. There are twelve broad categories of applicator certification of which ten generally relate to the non-farm application sectors (Table 7-1 and Figure 7-1). The two categories of "agricultural plant" and "agricultural animal" relate primarily to farm/ranch applications. In order to apply restricted-use pesticides, applicators must be certified as competent to apply such pesticides by meeting national standards set by EPA. The applicators are trained and certified under cooperative programs involving EPA, USDA and the State Extension Services. Commercial applicators are required in all states to be recertified every three to five years to maintain certification (See: Pesticide Applicator Certification and Training Program, information sheet, EPA/OPP, 1999)

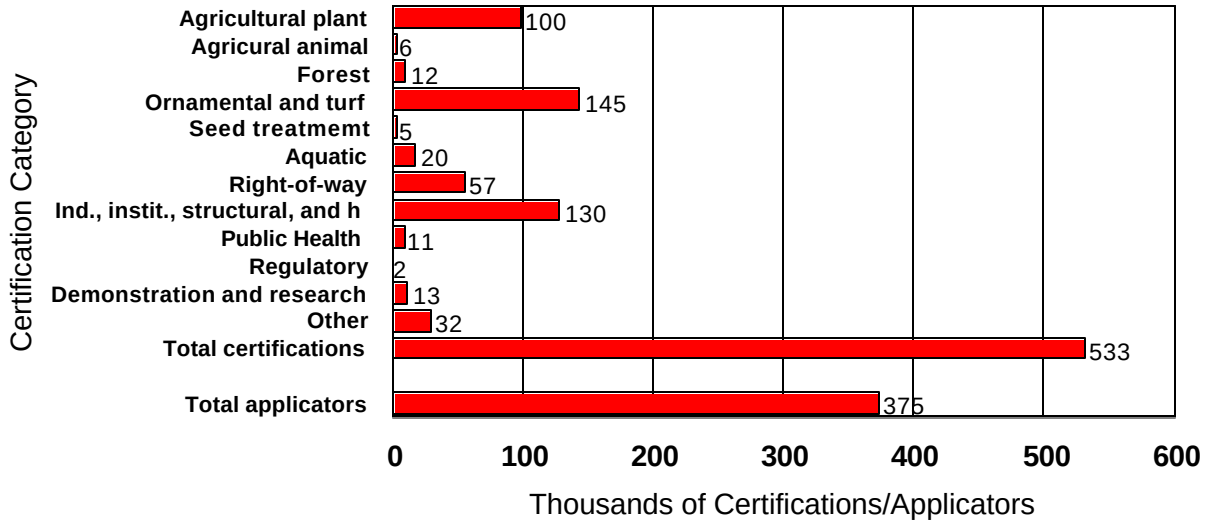
Table 7-1 Number of Pesticide Applicator Certifications by Certifcation Category and Total Number of Applicators with Certifications,, U.S., FY97

Certification Category	No. (000)	Percent
Agricultural plant	100	18.8
Agricultural animal	6	1.1
Forest	12	2.3
Ornamental and turf	145	27.2
Seed treatment	5	0.9
Aquatic	20	3.8
Right-of-way	57	10.7
Ind., instit., structural, and health	130	24.4
Public Health	11	2.1
Regulatory	2	0.4
Demonstration and research	13	2.4
Other	32	6.0
Total certifications	533	100.0
Total applicators	375	

NOTE: Total of certifications exceeds number of applicators due to multiple certifications. Numbers are for individuals certified under FIFRA sec. 23c and Regulation 40 CFR 171 under state/federal program.

SOURCE: EPA/OPP pesticide applicator files, Michael Walsh, 7/20/99

Number of Pesticide Applicator Certifications by Certification Category and Total Number of Applicators with Certifications, U.S., FY97
Figure 7-1



SOURCE: EPA/OPP applicator certification files, FY97

As of FY 1997, there were approximately 533,000 applicator certifications, involving 375,000 individual applicators. The number of certifications exceeds the total number of applicators due to multiple certifications of many applicators. By far the leading categories of non-agricultural certifications are ornamental and turf (145,000) and industrial/institutional/structural and health (130,000), the latter category generally referred to as pest control operators (PCO's). The third ranking non-agricultural category of certifications is right-of-way (ROW) with 57,000 certifications. About 65,000 commercial applicators are newly certified each year, along with 120,000 which are recertified annually.

The above certifications of applicators are separate from the certifications of individuals as "private applicators", which in general is for farmers/ranchers applying pesticides to their own operated land or that of neighbors. As of FY 1997, there were about 875,000 certified private applicators in the U.S. (See Table 5-1 of this report.)

Limited profile information is available about the overall certified/commercial pesticide application sector. EPA conducted a study of five major certification categories for the year 1993. (EPA, May 30, 1995). (This study is commonly referred to as the certified/commercial pesticide application study, C/CPAS.) The categories covered were turf/ornamental, ROW, aquatic, structural (industrial., institutional., structural and health-related) and public health. These categories account for a majority of the certifications for non-agricultural pesticide applications. EPA conducted a related, more limited, study for the year 1981, covering turf, tree and structural applications. (EPA, July, 1985) Presented below is profile information primarily from the EPA the study for 1993, C/CPAS

In the C/CPAS study, it was estimated that there were 165,500 certified applicators in the five major categories in 1993, of which 69,800 were for hire (42 percent) and 95,700 were not for hire. The estimates of totals for the five broad categories are broken down into 11 mutually exclusive subcategories. (Table 7-2 and Figure 7-2a). Turf/ornamental only and structural only were the leading categories. The third ranking category was ROW only, with 17,200 applicators, most of which were not for hire.

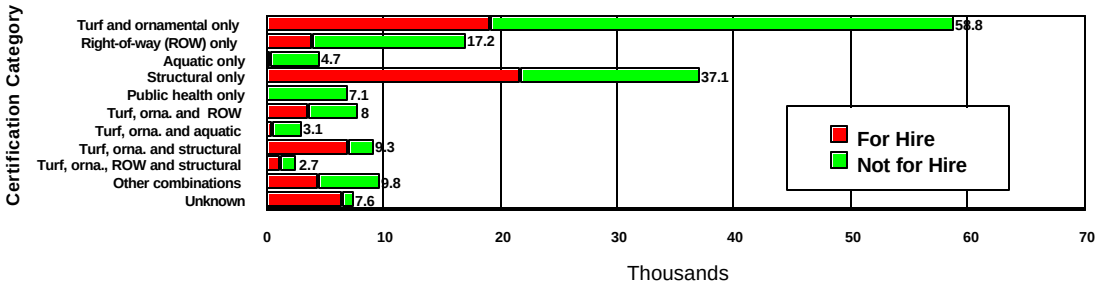
The C/CPAS study also estimated that there were 29,500 commercial applicators for hire which were not certified. These applicators, along with the 165,500 certified, bring the total of certified and not certified for hire to about 195,000 for the five major certification categories. The applicators for hire (certified 69,800 and not certified 29,500) were associated with a total of 33,100 businesses, of which turf/ornamental only and structural only were the most common, accounting for about two-thirds of the total. (Table 7-2 and Figure 7-2b)

Table 7-2 Number of Non-agricultural Pesticide Applicators by For-hire and Certification Status and Number of Businesses in U.S., 1993, Covered by Five Major Non-agricultural Certification Categories (Turf/Ornamental, ROW, Aquatic, Structural and Public Health)

Certification Category	For Hire, Certified (000)	Not For Hire, Certified (000)	Certified, Total (000)	Not Certified, for Hire (000)	No. of Businesses (000)
Turf and ornamental only	19.3	39.5	58.8	5.4	11.2
Right-of-way (ROW) only	4	13.2	17.2	4.8	0.6
Aquatic only	0.5	4.2	4.7	0.3	0.2
Structural only	21.9	15.2	37.1	5.2	10.2
Public health only	0.2	6.9	7.1	0.1	0.1
Turf, orna. and ROW	3.8	4.2	8.1	0.4	1.3
Turf, orna. and aquatic	0.6	2.5	3.1	0.1	0.2
Turf, orna. and structural	7.1	2.2	9.3	9.1	3.1
Turf, orna., ROW and structural	1.3	1.4	2.7	0.4	0.7
Other combinations	4.5	5.3	9.8	1.1	1.4
Unknown	6.5	1.1	7.6	2.7	4
TOTAL	69.8	95.7	165.5	29.5	33.1

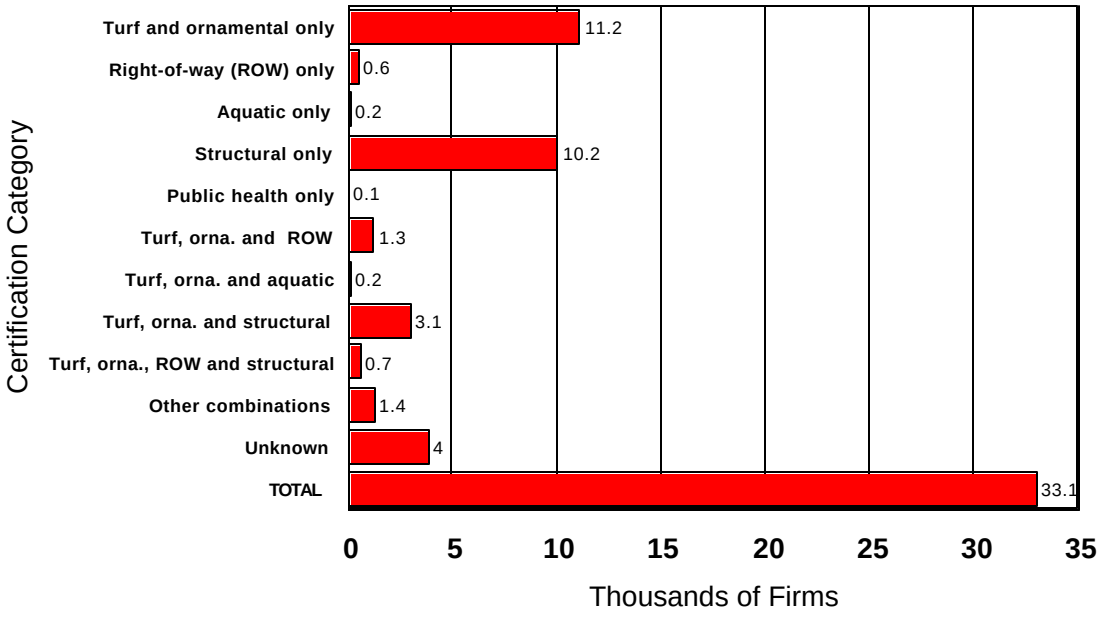
NOTE: Total of certifications exceeds number of applicators due to multiple certifications. Numbers are for individuals certified under FIFRA sec. 23c and Regulation 40 CFR 171 under state/federal program.
SOURCE: Certified/Commercial Pesticide Applicator Survey (C/CPAS), EPA/OPP, 5/95, Tables 2 and 6.

Number of Certified Non-agricultural Pesticide Applicators by For-hire Status and Certification Category, U.S., 1993, Covered by Five Major Non-Agricultural Certification Categories
Figure 7-2a



	Turf and ornamenta	Right-of-way (ROW	Aquatic only	Structural only	Public health onl	Turf, orna. and RO	Turf, orna. and aquat	Turf, orna. and struc	Turf, orna., ROW ar	Other combinatio	Unknow
For Hire	19.3	4	0.5	21.9	0.2	3.8	0.6	7.1	1.3	4.5	6.5
Not for Hire	39.5	13.2	4.2	15.2	6.9	4.2	2.5	2.2	1.4	5.3	1.1
Tota	58.8	17.2	4.7	37.	7.1	8	3.1	9.3	2.7	9.8	7.6

Number of Pesticide Application Businesses by Certification Category, U.S., 1993
Five Non-agricultural Certification Categories Only
Figure 7-2b



Certified applicators not-for-hire (a total of 95,700 in FY97) are most commonly with the public sector (31,700) followed by golf courses (11,100). Many persons holding certifications are not actually applying pesticides (33,100), based on the C/CPAS. (Table 7-3 and Figure 7-3)

Table 7-4 presents the distribution of certified applicators covered in the C/CPAS study by for-hire status and certification category (see also Figure 7-4), along with the numbers of corresponding certifications. There were an estimated 165,500 applicators having one or more certifications, with a total of 208,600 certifications. Turf/ornamental was the most common category for applicators and certifications, followed by structural.

Table 7-5 and Figure 7-5 present a summary of for-hire pesticide applicators by certification status and certification type. More than twice as many applicators are certified than not certified (69,800 compared with 29,500 not certified). Turf/ornamental and structural are the leading categories in terms of applicator numbers and a majority of these applicators are certified, e.g., more than three-fourths certified.

Table 7-3 Numbers of Not-For-Hire Certified Pesticide Applicators by Employers' Type of Business, U.S.,1993, Covered by Five Major Certification Categories

Employers business	No. applicators (000)	Percent
Golf course	11.1	11.6
Nursery	3.4	3.6
Public/gov't.	31.7	33.1
Utility	2.5	2.6
Trans./ind./other comm.	4.9	5.1
Other/unknown	8.9	9.3
No application	33.1	34.6
TOTAL	95.7	100.0

NOTE: Five non-agricultural certified/commercial applicator categories are turf/ornamental, ROW, aquatic, structural, and public health.
Numbers are for individuals certified under FIFRA sec. 23c and Regulation 40 CFR 171 under state/federal program.
SOURCE: Certified/Commercial Pesticide Applicator Survey (C/CPAS), EPA/OPP, 5/95, Table 7.

Numbers of Not-For-Hire Certified Non-agricultural Pesticide Applicators by Employers' Type of Businesss, U.S.,1993
Five Non-agricultural Certification Categories Only
Figure 7-3

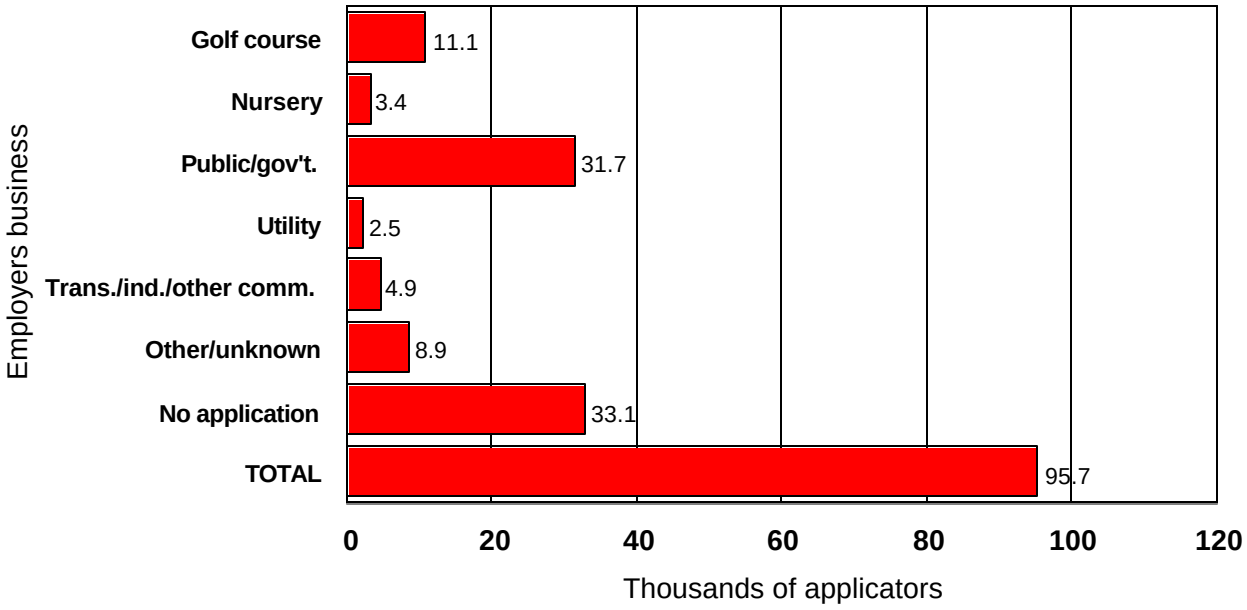


Table 7-4 Numbers of Certified Pesticide Applicators and Certifications, by For-hire Status and Certification Type, Five Major Non-agricultural Certification Categories, U.S., 1993

NUMBER OF APPLICATORS

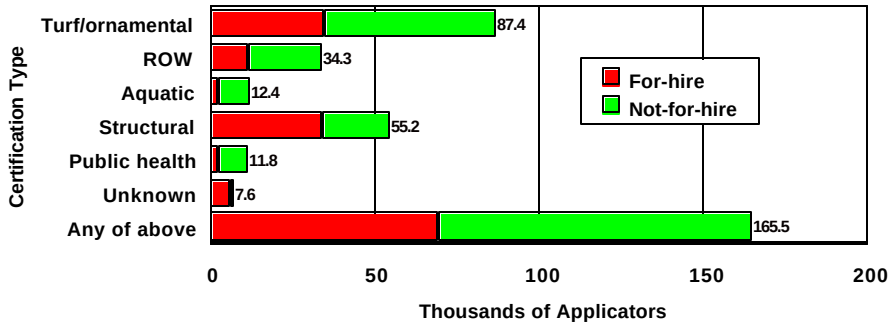
Certification Type	For-hire (000)	Not-for-hire (000)	Total (000)
Turf/ornamental	35.0	52.4	87.5
ROW	11.4	22.9	34.2
Aquatic	2.5	9.9	12.4
Structural	33.9	21.3	55.2
Public health	2.7	9.1	11.8
Unknown	6.5	1.1	7.6
Any of above	69.8	95.7	165.5

NUMBER OF CERTIFICATIONS

Certification Type	For-hire (000)	Not-for-hire (000)	Total (000)
Turf/ornamental	55.4	70.5	125.8
ROW	22.1	37.6	59.6
Aquatic	6.0	19.1	25.1
Structural	49.9	31.4	81.4
Public health	7.2	13.1	20.3
Unknown	6.5	1.1	7.6
Any of above	92.0	116.6	208.6

NOTE: Numbers are for individuals certified under FIFRA sec. 23c and Regulation 40 CFR 171 under state/federal program.
SOURCE: Certified/Commercial Pesticide Applicator Survey (C/CPAS), EPA/OPP, 5/95, Table 4.

Number of Certified Non-Agricultural Pesticide Applicators, by Certification Category and and For-Hire Status, U.S., 1993, Five Non-agricultural Certification Categories Only
Figure 7-4



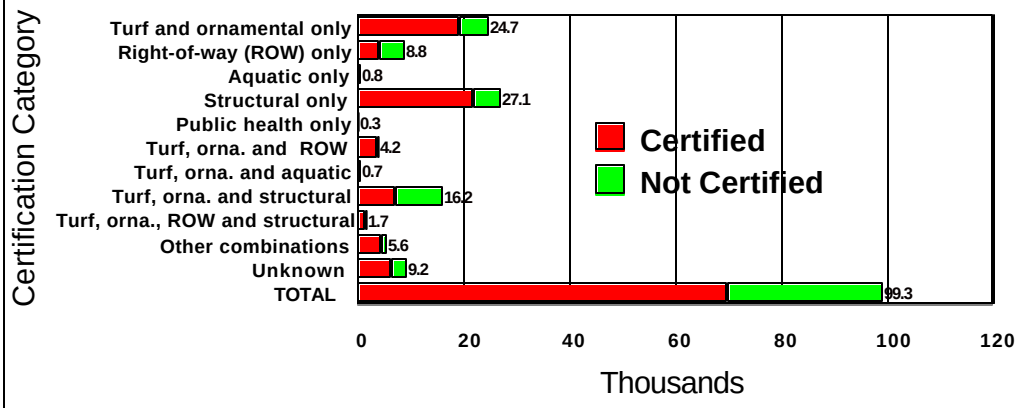
	Turf/ornamental	ROW	Aquatic	Structural	Public health	Unknown	Any of above
For-hire	35	11.4	2.5	33.9	2.7	6.5	69.8
Not-for-hire	52.4	22.9	9.9	21.3	9.1	1.1	95.7
Total	87.4	34.3	12.4	55.2	11.8	7.6	165.5

Table 7-5 Number of Pesticide Applicators for Hire, by Certification Status and Type for Five Major Certification Categories, U.S., 1993

Certification Type	Certified (000)	Not Certified (000)	Total (000)
Turf and ornamental only	19.3	5.4	24.7
Right-of-way (ROW) only	4	4.8	8.7
Aquatic only	0.5	0.3	0.8
Structural only	21.9	5.2	27.1
Public health only	0.2	0.1	0.3
Turf, orna. and ROW	3.8	0.4	4.3
Turf, orna. and aquatic	0.6	0.1	0.7
Turf, orna. and structural	7.1	9.1	16.2
Turf, orna., ROW and structural	1.3	0.4	1.7
Other combinations	4.5	1.1	5.6
Unknown	6.5	2.7	9.2
TOTAL	69.8	29.5	99.3

NOTE: Numbers are for individuals certified under FIFRA sec. 23c and Regulation 40 CFR 171 under state/federal program.
SOURCE: Certified/Commercial Pesticide Applicator Survey (C/CPAS), EPA/OPP, 5/95, Table 6.

Number of For-hire Non-Agricultural Pesticide Applicators, by Certification Category and Certification Status, U.S., 1993
Figure 7-5



	Turf and orna	Right-of-way	Aquatic only	Structural on	Public health	Turf, orna. a	Turf, orna. a	Turf, orna. a	Turf, orna., I	Other combi	Unknown	TOTAL
Certified	19.3	4	0.5	21.9	0.2	3.8	0.6	7.1	1.3	4.5	6.5	69.8
Not Certi	5.4	4.8	0.3	5.2	0.1	0.4	0.1	9.1	0.4	1.1	2.7	29.5
Total	24.7	8.8	0.8	27.1	0.3	4.2	0.7	16.2	1.7	5.6	9.2	99.3

2. Profile of Major Non-agricultural User Sectors

As has been noted above, the professional market involves numerous applicators which can be broken down into a number of categories or types which tend to follow such things as lines of business, professional disciplines, type of pesticide, economic sector and type of pest. There is no limit to the various breakouts that could be made of the applicator/user sector in the professional market. An example of profile information is presented in Table 7-6, which shows some of the major segments covering turf/ornamentals, industrial vegetation control, structural and others. The identification of segment/categories is as used in general terms by one of the leading pesticide market research firms. It is not intended to be complete or exhaustive of the professional market and the numbers presented are rough approximations, for recent years, e.g., circa 1995/99.

Table 7-6 Profile Information on Selected Non-agricultural Pesticide Applicator Segments	
Market Segment/Category	Description/Characterization
TURF AND ORNAMENTALS	
Lawn care operators	18,000 professional applicators of pesticides to residential and commercial lawns; include lawn mowing and landscaping
Golf courses	15,000 public and private golf courses
Institutional turf	15,000 identifiable state, county and municipal parks, and park systems; 3,700 colleges; 15,000 local school districts; 7,000 actively maintained cemeteries.
Landscape contractor	22,000 professional landscapers who also apply pesticides to lawns and gardens; low pesticide usage per establishment.
Nursery and greenhouse	42,000 growers of ornamental plants; includes all outdoor and under cover growing.
Turf farms	1,800 growers of commercial turf for use in residential or commercial lawns, who also belong to national association.
INDUSTRIAL VEGETATION CONTROL	
Electric utilities	3,200 investor owned, rural coop, and muni. utilities which maintain over 6 million miles of ROW for power lines
Roadways	39,000 muni., county, state, and federal governing bodies maintaining nearly 4 million miles of roads in U.S.
Railroads	12 Class I railroads that maintain 182,000 miles of track, 85% of the total track miles in U.S.
Industrial facilities	over 14,000 facilities involved in petroleum, chemicals, bulk storage and primary metals that may require weed control.
Pipelines	20 largest pipeline co's. accounting for over 1 million miles of pipelines in U.S., most of which need vegetation control.

STRUCTURAL PEST CONTROL	
Pest control operators (PCO's)	14,000 PCO establishments who apply pesticides to residential and other sites; 17 to 18 million residences treated per year.
OTHER	
Aquatic areas	Public and private end users, including professional applications
Forestry	Public and private forest lands, mostly weed control, focused on private holdings totaling 70 million acres out of total of about 600 million acres.
Mosquito abatement districts	Mosquito control products applied by applicators at direction of over 900 mosquito control districts; acres available for treatment total 103 million out of total of 690 million.
NOTE: Listing is not intended to be exhaustive or cover all non-ag sectors; numerical values are rough approximations.	
SOURCE: Kline & Company, Inc., Briefing document by Mancur Cyr, May 6, 1999	

B. Brief History of Pesticide Applicator Industry

The professional pesticide applicator industry we have today can be traced back to earliest times as people have struggled with pests of various sorts in the home, in industry, in commerce and in government. According to Snetzinger (1983), the history of applying pest control technology in the western world goes back to an early period of antiquity, e.g., 300 to 400 AD. (p. 245) In these early times, artisans or specialists were using various chemical and non-chemical controls for pests. Examples include apothecaries, embalmers, ship builders, and chandlers. Its history can be traced through five other somewhat overlapping ages including: Middle Ages/Renaissance (1200-1700 A.D.); the industrial revolution (1750-1930); professionalization (1933-1960+); modern chemical pesticides (1940-1975+); and environmental concern and regulation (1962 and later). The first three periods were of long duration, with serious pest problems, and limited knowledge of technology/science about pests. (Snetzinger, p. 245)

During the 12th Century in Europe, itinerant peddlers provided poisons and traps for rodent control. Alchemists and others discovered improved poisons by trial and error for vermin control. Ratcatching and vermin exterminating became a livelihood for some persons as technology improved and trade expanded between Europe and the rest of the world. By the 18th Century, the itinerant ratcatchers had begun to settle down and operate out of regular places of business, with ads, established accounts and competition with one another over claims of control effectiveness, trade secrets, etc. About the middle of the 19th Century, some of the European exterminators emigrated to the U.S. and used available chemistry for pest control which remained quite primitive until around 1920. Arsenical and lead based chemicals became generally available for pest control, enabling growth of pest control operations. In the late 1920's, the more aware and ethical elements of the applicator industry began to band together to share ideas. They organized to promote regulation that would improve ethical standards and eliminate unscrupulous operators. Eventually, there was reluctant support from USDA, Fish and Wildlife Service, land grant colleges and universities as the applicators professionalized. (Snetzinger, p. 246/47)

An example of the timing and growth of professionalism in pest control is provided by the history of the current Pest Control Operators of California, Inc. and predecessor organizations. (http:///www.pcoc/org) This history document indicates that 60 years ago, the pest control operators in California were "an unregulated industry" and "many consumers were being bilked by itinerant pest control impostors." In 1932, a number of pest control operators in California joined together to promote industry standards and regulation. In 1935, California passed the nation's first state structural pest control act directly focused on pest control operators.

The emergence of the synthetic organic pesticide industry in the 1940's manufacturing new highly effective pesticides made possible the rapid growth and expansion of the pest control industry. Simultaneously, the demand for pest control increased dramatically with the end of the Depression, WWII and ensuing economic growth, which has continued to date. People have increasingly demanded freedom from pestilence in the home, industry and elsewhere, in an ever more urban society. The result has been a growing role for the pest control operator, both for hire and as a part of businesses, organizations, industry, institutions and government agencies at various levels.

The professional pesticide market of today consists of not only the applicators for hire, but those who are professionals in entities which are not pest control firms, but engaged primarily in other activities or pursuits. As was noted above in this section of the report, the C/CPAS survey indicated that there were more not-for hire certified applicators than for hire (95,700 compared with 69,800 for hire as of 1993). (Table 7-4) Turf/ornamental, ROW and structural are the principal types of applicators that are not for hire. (Table 7-4)

Methods of application of pesticides in the professional market are very diverse such as, hand sprayers (dusters), ground boom and blast sprayers/dusters, directed aerosols, fumigant aerosols/canisters, fixed wing and helicopter applications, injections and others. This diversity of application equipment types and methods has evolved as influenced by emergent pest control needs, chemicals, user industry structure/characteristics and regulations.

Aerial applications of pesticides began with agricultural crops in 1921/22, but probably began to be used on non-crop sites by WWII. Interestingly enough, Delta Air Lines history started with founding of the worlds first aerial crop dusting organization—Huff Daland Dusters in 1924. This firm was founded to dust cotton in Georgia and its parent firm (Huff Daland Mfg., Co) soon designed aircraft specifically for pesticide application. It acquired a fleet of aircraft and diversified operations to include applications to crops in Peru to take advantage of the opposite seasons south of the equator.

At this point, data are not at hand as to the extent of pesticide application by aerial or other methods of application in the professional market. No doubt aerial applications account for significant shares of the professional market such as for ROW for pipelines, utilities, forestry, etc.

C. Professional Market Pesticide Usage, by Type, 1929/97

1. Approach and Data Sources

The approach used in this section to report trends for professional market usage (industrial/commercial/governmental sector) is in line with the presentations made in the preceding Parts Three through Six. Reference can be made to those sections concerning definitions, e.g., sectors and pesticide classes, along with the principal data sources/methods for the time series of three-year periods covering 1929 through 1997. Appendix Table Three A contains master tables for the professional market covering three-year periods for 1929 through 1997. In addition to active ingredient usage, estimates of user expenditures for the professional market are presented on an annual basis for 1979 through 1997. Estimates of user expenditures for the professional market (and aggregate active ingredient usage) have been previously published in the EPA Pesticide Market Series for 1979 through 1997 on an annual basis (rather than three year averages as presented in this report). (Aspelin and Grube, EPA, November, 1999)

2. Conventional and Other Pesticide Chemicals, Aggregate Usage

Presented in Figure 7-6 are estimates of conventional pesticide usage, other pesticide chemicals, and the total of these, for the professional market covering the 1929/97 period. The values are averages per year for three year periods. The following observations can be made:

- the usage of conventional pesticides increased quite steadily from about 50 to 60 million pounds per year in the early to mid-1930's to about 210 to 220 million pounds per year from the mid-1960's until around 1980; since then it has declined to just under 130 million per year;
- other pesticide chemical usage increased from about 15 million pounds per year in the mid-1930's to a peak of about 50 million per year during 1956/1967; since then such usage has tended to decline to a level of about 20 million pounds per year during most recent years;
- the total of conventional and other pesticide chemical usages was at a low of about 50 million pounds per year in 1932/34 and increased to 267 million pounds per year in 1965/67; since then, total usage has declined rather steadily to150 million per year in 1995/97.

3. Conventional and Other Pesticide Chemicals, Per Capita Usage

The above aggregate usage figures have been divided by U.S. civilian population to place usage in the professional market sector on a per capita basis. The results are shown in Figure 7-7, graphically, along with a table. A pattern which emerges is consistently lower levels of usage per capita since 1965/67 when usage was about 1.5 pounds per capita. For 1995/97, usage was about 0.7 pounds per capita. This compares with about 0.5 pounds per capita for the home and garden market (Figure 6-9) and 3.6 pounds per capita for agricultural usage (based on 947 million pounds of active ingredient from Figure 5-2 and 265 million population for 1995/97)
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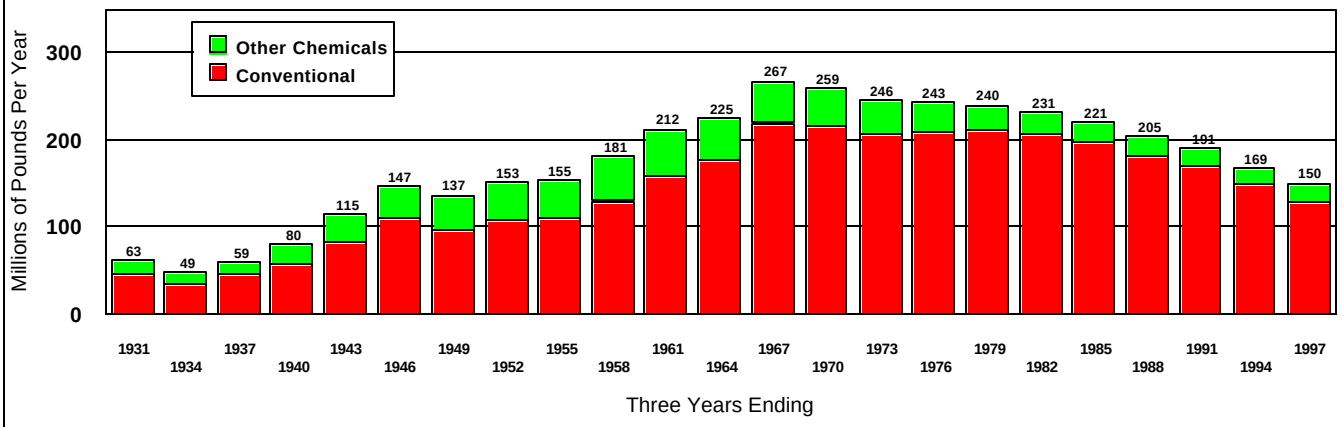
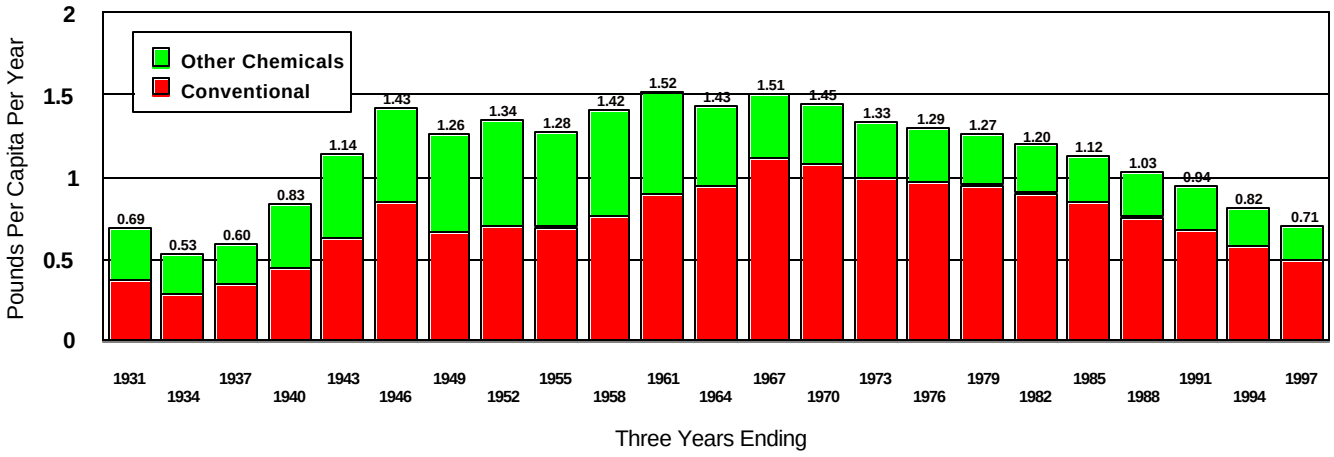
Volume of Pesticide Active Ingredient Usage in U.S., Conventional and Other Pesticide Chemicals with Total, Industrial/Commercial/Governmental Sector, Three Year Periods Ending 1931-97
Figure 7-6



	193:	1934	1937	194(	1943	1946	1949	1952	1955	1958	196:	1964	1967	1970	1973	1976	1979	1982	1985	1988	1991	1994	1997
Convent	45	35	45	57	84	112	97	108	112	13:	160	177	219	217	208	209	212	207	198	182	169	148	128
Other Cl	17	14	14	23	31	35	40	45	43	51	52	48	48	42	38	34	29	24	23	22	22	20	22
Tota	63	49	59	80	115	147	137	153	155	18:	212	225	267	259	246	243	240	231	221	205	19:	169	150

Excludes wood preservatives and biocides
Includes applications by professionals to homes and gardens

Volume of Pesticide Active Ingredient Usage Per Capita in U.S., Conventional and Other Pesticide Chemicals, With Total, Industrial/Commercial/Governmental Sector, Three Year Periods Ending 1931-97
Figure 7-7



	1931	1934	1937	1940	1943	1946	1949	1952	1955	1958	1961	1964	1967	1970	1973	1976	1979	1982	1985	1988	1991	1994	1997
Convent	0.37	0.28	0.35	0.43	0.62	0.84	0.66	0.70	0.69	0.76	0.89	0.94	1.12	1.08	0.99	0.97	0.95	0.90	0.84	0.75	0.68	0.58	0.48
Other Cl	0.32	0.25	0.24	0.39	0.52	0.59	0.60	0.64	0.59	0.65	0.63	0.49	0.39	0.37	0.34	0.32	0.31	0.30	0.28	0.28	0.27	0.24	0.22
Tota	0.69	0.53	0.60	0.83	1.14	1.43	1.26	1.34	1.28	1.42	1.52	1.43	1.51	1.45	1.33	1.29	1.27	1.20	1.12	1.03	0.94	0.82	0.71

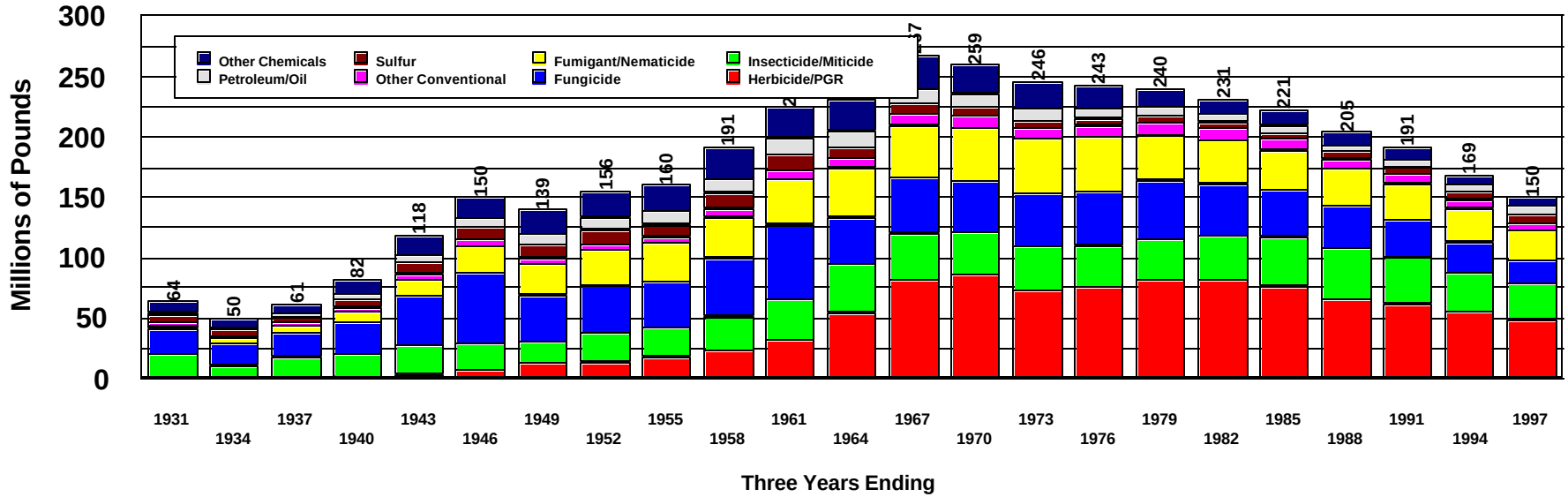
Excludes wood preservatives and biocides
Includes applications by professionals to homes and gardens

4. Conventional and Other Pesticide Chemical Usage, by Class

The estimates of aggregates for conventional and other pesticide chemicals used in the professional market are presented in Figure 7-8 with breakouts by pesticide class for the period of 1929 through 1997. The following observations can be made:

- herbicide usage emerged with significant quantities during WWII, held at about 75/85 million pounds per year through 1983/85 and has declined since to about 50 million pounds per year;
- insecticide/miticide usage was already established by 1929/31, was in the general range of 35 to 45 million pounds per year for 1961/91 and has since declined somewhat;
- fungicide usage expanded sharply during WWII and his remained at similar levels much of the last 50 years, showing some declines in the last decade;
- petroleum/oil and sulfur usage has remained much the same during the last 30 years; and
- fumigant/nematicide usage expanded during WWII, leveled off during the 1960's and 1970's, and has declined to some degree during the last decade..

Volume of Pesticide Active Ingredient Usage in U.S. Industrial/Commercial/Governmental, Sector, By Type of Pesticide, Three Year Periods Ending 1931-97
Figure 7-8



	1931	1934	1937	1940	1943	1946	1949	1952	1955	1958	1961	1964	1967	1970	1973	1976	1979	1982	1985	1988	1991	1994	1997
Herbicide/PGR	0	0	0	2	4	7	12	14	18	23	32	55	82	85	73	75	81	82	76	66	62	55	49
Insecticide/Miticide	19	11	17	19	23	23	17	24	24	29	34	40	39	36	36	35	34	37	41	43	39	32	29
Fungicide	22	19	20	26	41	58	40	40	38	48	61	38	46	42	43	45	49	43	38	34	31	25	20
Fumigant/Nematicide	3	4	6	9	14	21	25	28	31	34	37	41	42	44	45	45	37	36	33	31	30	28	24
Other Conventional	3	2	3	3	5	6	5	6	6	7	8	8	10	10	10	9	10	10	9	9	8	7	6
Total Conventional	47	36	47	59	86	115	100	111	117	140	173	182	219	217	208	209	212	207	198	182	169	148	128
Sulfur	6	4	4	7	9	11	12	12	11	13	13	8	8	7	6	6	6	5	5	6	6	7	7
Petroleum/Oil	2	3	3	5	6	7	8	10	11	12	13	14	12	12	11	9	8	6	6	5	5	4	7
Other Chemicals	9	7	7	12	16	18	20	22	22	25	26	26	28	24	22	19	15	13	12	11	11	9	8
Total Other P. Chem	17	14	14	23	31	35	40	45	43	51	52	48	48	42	38	34	29	24	23	22	22	20	22
Grand Total	64	50	61	82	118	150	139	156	160	191	225	231	267	259	246	243	240	231	221	205	191	169	150

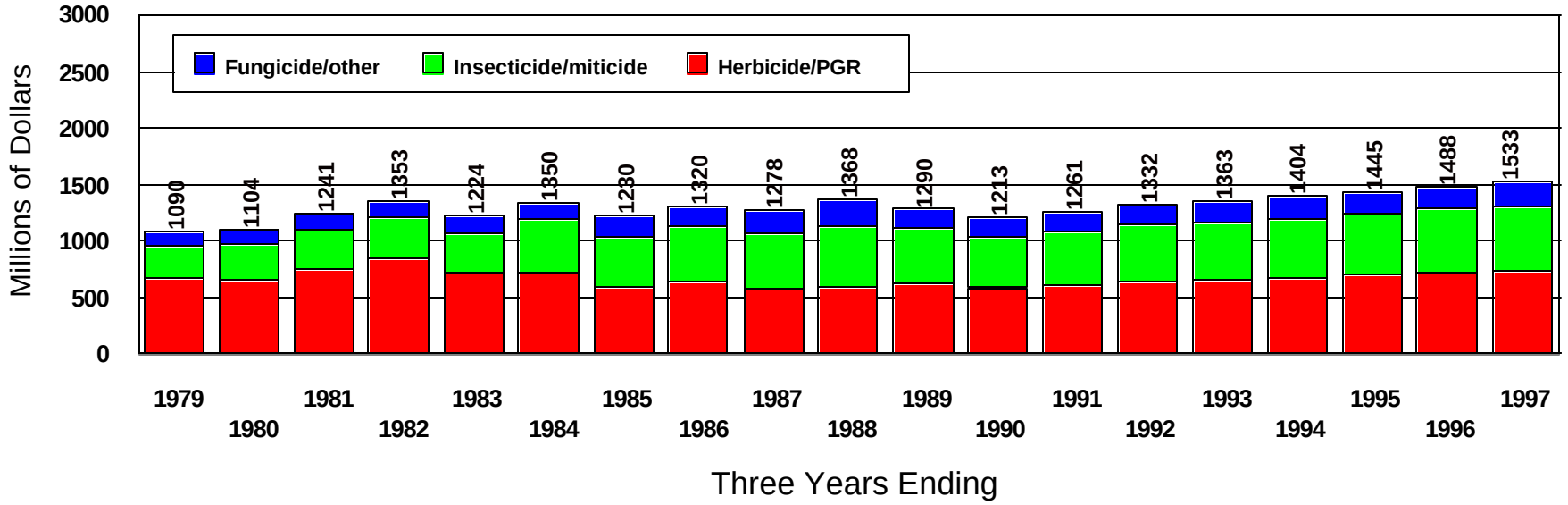
Includes pesticides applied by professionals to homes and gardens

D. Professional Market Pesticide User Expenditures, 1979/1997

Aggregate user expenditures are presented in Figure 7-9 for the professional market for the years of 1979 through 1997. These are as previously published in the EPA market report and are in nominal dollars. Expenditures have increased by about one-half from about $1.09 billion in 1979 to $1.53 billion in 1997. Much of the increase is in insecticides/miticides, for which expenditures more than doubled over the nearly 20 years. Increases for herbicides and other types of pesticides have been much more nominal.

Figure 7-10 contains estimates of professional market user expenditures for 1979/97 in constant 1997 dollars to take out the impact of inflation. The result was that expenditures in real terms declined from about $2.2 billion in 1979 to $1.5 billion in 1997. When placed on a per capita basis, expenditures have declined rather significantly, reflecting the above aggregate trends and increasing population. On a per capita basis, expenditures declined from about $9.80 to $5.70 between 1979 and 1997. Professional market pesticides equal a minor percentage of the average household budget, and have been declining in real terms during roughly the last two decades.

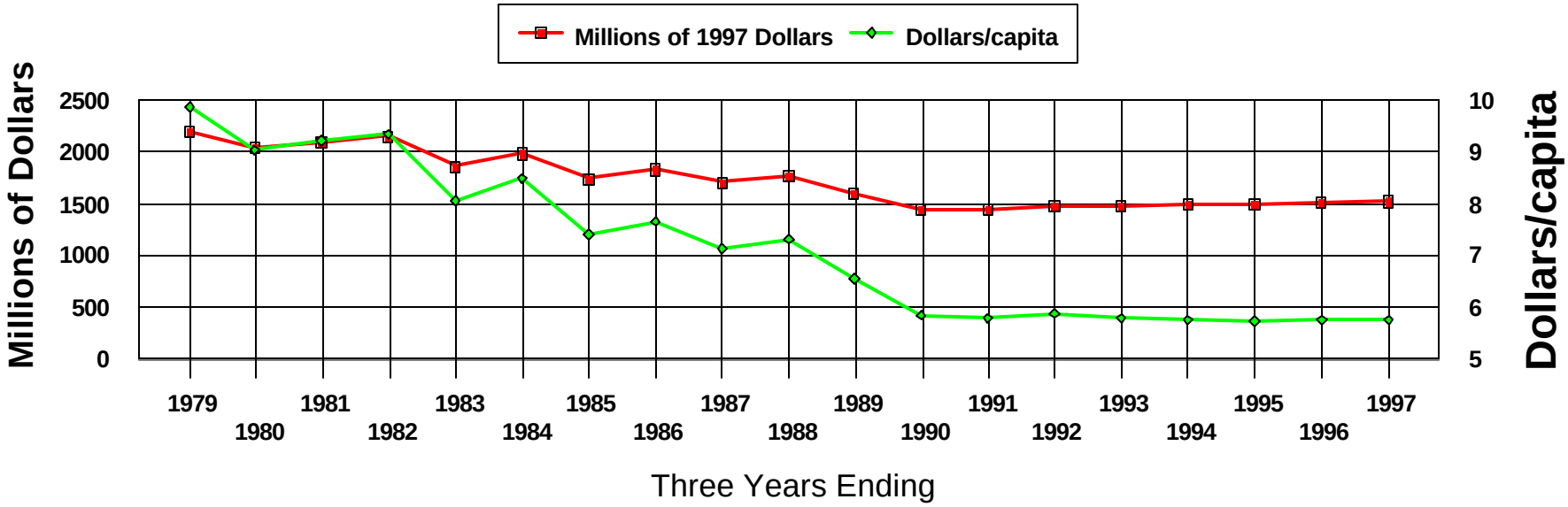
Expenditures for Pesticides Applied by Industrial/Commercial/Governmental Sector, U.S., 1979-97
Including Applications by Professionals to Homes and Gardens
Figure 7-9



	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Herbicide/PGR	672	660	756	852	720	720	600	642	576	600	630	593	616	648	660	679	700	721	743
Insecticide/miticide	288	312	347	359	360	480	450	486	492	528	480	451	469	498	512	528	543	559	576
Fungicide/other	130	132	138	142	144	150	180	192	210	240	180	169	176	186	191	197	202	208	214
Total	1090	1104	1241	1353	1224	1350	1230	1320	1278	1368	1290	1213	1261	1332	1363	1404	1445	1488	1533

Excludes wood preservatives and biocides.
Current dollars

Expenditures for Pesticides Applied by Industrial/Commercial/Governmental Sector, U.S., 1979-97
Total Expenditures and Per Capita, Including Applications by Professionals to Homes and Gardens in 1997 Dollars
Figure 7-10



	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Millions of 1997 Do	2202	2042	2098	2151	1867	1984	1747	1828	1717	1773	1604	1446	1446	1486	1482	1491	1500	1516	1533
Dollars/capita	9.88	9.05	9.21	9.35	8.04	8.47	7.40	7.67	7.14	7.30	6.54	5.84	5.77	5.86	5.78	5.76	5.73	5.74	5.76

Excludes wood preservatives and biocides.

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GLOSSARY

ACTIVE INGREDIENT (A.I.): The chemical or substance component of a pesticide product that can kill, repel, attract, mitigate or control a pest or that acts as a plant growth regulator, desiccant, or nitrogen stabilizer. The remainder of a formulated pesticide product consists of one or more "inert ingredients" (such as water, solvents, emulsifiers, surfactants, clay and propellants), which are there for reasons other than pesticidal activity.

AGRICULTURAL USER SECTOR (OR MARKET): Pesticides applied by owner/operators and custom/commercial applicators to farms and facilities involved in production of raw agricultural commodities, principally food, fiber, and tobacco; includes non-crop and post-harvest use as well as crop/field applications.

CERTIFIED APPLICATOR: A person who is authorized to apply "restricted-use" pesticides as result of meeting requirements for certification under FIFRA-mandated programs. Applicator certification programs are conducted by states, territories and tribes in accordance with national standards set by EPA. "Restricted use pesticides" may be used only by or under the direct supervision of specially trained and certified applicators.

COMMERCIAL APPLICATOR: A person applying pesticides as part of a business applying pesticides for hire or a person applying pesticides as part of his or her job with another (not for hire) type of business, organization or agency. Commercial applicators often are certified, but need to be so only if they use restricted-use pesticides.

CONVENTIONAL PESTICIDES: Pesticides that are chemicals or other substances developed and produced primarily or only for use as pesticides. The term is generally used in reference to active ingredients. An example is DDT, which was developed and used almost exclusively as a pesticide.

ECONOMIC USER SECTORS (OR MARKETS): In this report, estimates of quantities used and user expenditures for pesticides are broken out separately for the three general economic user sectors (or markets) as follows: agriculture, industrial/commercial/governmental, and home/garden. These three sectors/markets are defined elsewhere in this glossary.

FDA: U.S. Food and Drug Administration, which is involved in regulation of pesticides in the U.S., particularly enforcement of tolerances in food and feed products.

FFDCA: Federal Food, Drug, and Cosmetic Act is the law which controls pesticide residues in food and feed, along with FIFRA.

FIFRA: Federal Insecticide, Fungicide, and Rodenticide Act is the law which generally controls pesticide sale and use.

HOME AND GARDEN USER SECTOR (OR MARKET): Involves pesticides applied by homeowners to homes and gardens, including lawns; single and multiple unit housing. Does not include pesticides for home/garden applications by professional applicators.

INDUSTRIAL/COMMERCIAL/GOVERNMENTAL USER SECTOR (OR MARKET): Involves pesticides applied by professional applicators (by owner/operators/employees and custom/commercial applicators) to industrial, commercial and governmental facilities, buildings, sites, and land; plus custom/commercial applications to homes and gardens, including lawns. May also be referred to as "professional market" for pesticides.

NON-AGRICULTURAL SECTORS: General term which refers to a combination of home/garden and industrial/commercial/governmental sectors.

OTHER PESTICIDE CHEMICALS: Chemicals registered as pesticides but which are produced and marketed mostly for other purposes, i.e., multi-use chemicals. Notable examples are sulfur, petroleum products (e.g., kerosene, oils and distillates), salt and sulfuric acid.

PESTICIDE: May be used to refer to an active ingredient (as defined above) or formulated pesticide product registered under FIFRA.

PESTICIDE TYPE/CLASS: Grouping of conventional pesticides used for a certain target pest category. In this report, the types/classes generally used are: herbicides/plant growth regulators, insecticides/miticides, fungicides, fumigant/nematicides and other miscellaneous pesticides (e.g., rodenticides, molluscicides and fish or bird pesticides).

PESTICIDE USER EXPENDITURES: Dollar value of purchases by persons or businesses applying pesticides, such as farmers, commercial pesticide applicators and homeowners. Reported numbers are nominal values for the years indicated, i.e., not adjusted or indexed for inflation.

PESTICIDE USAGE: Refers to actual applications of pesticides, generally in terms of quantity applied or units treated.

PRIVATE APPLICATOR: A category of applicator certification for farmers and/or employees such that they can legally apply restricted use pesticides or supervise others doing so who are not certified.

PROFESSIONAL MARKET: Sales of pesticides for application to industrial/commercial/governmental sectors, homes and gardens by certified/commercial applicators.

SAFER PESTICIDES: Pesticides designated as "safer" (or "reduced-risk") by EPA due to favorable characteristics affecting health or environmental risks, resistance management and integrated pest management. Safer pesticides may be conventional pesticides posing less risk or be biopesticides with unique modes of action, low use volume, lower toxicity, target species specificity or natural occurrence.

SPECIALTY BIOCIDES: In this report, estimates are provided for end uses as follows: swimming pools, spas and industrial water treatment (excludes chlorine/hypochlorites which are reported separately); disinfectants and sanitizers (including industrial/institutional applications and household cleaning products); and other specialty biocides (including biocides for adhesives and sealants, leather, synthetic latex polymers, metal working fluids, paints and coatings, petroleum products, plastics and textiles). These are categories of end usage which are covered by FIFRA. There are other end uses of specialty biocides which are regulated under FFDCA and are not covered in this report. (such as hospital/medical antiseptics, food/feed preservatives and for cosmetics/toiletries).

TOLERANCE: The maximum amount of a pesticide allowable in a food or feed product before it is considered adulterated, usually specified in parts per million.

USDA: U.S. Department of Agriculture

WOOD PRESERVATIVES: Pesticide active ingredients used in treatment of wood to protect it from insects, fungi and other pests. In this report, a total is presented for usage of wood preservative chemicals in industrial plants, the bulk of which is for pressure treatment. The major categories of pesticide chemicals included in this report as industrial wood preservatives are water borne preservatives (primarily arsenicals), oil borne preservatives (such as copper naphthenate and pentachlorophenol), creosote, creosote-coal tar and creosote petroleum.

APPENDIX THREE A

Major Pesticide Industry Profile and Usage Data Sources Available To EPA Staff

Source	Brief Description	Remarks
American Crop Protection Association	Annual surveys of U.S. pesticides production, sales and usage, 1960's to date	Survey of industry participants/members by independent accounting organization
Directed Research Inc.	National estimates of U.S. usage and sales of pesticides, by market segment, ag and non-ag (proprietary)	Industry interviews, data gathering,, etc..
Doane Market Research	Reports and interactive data base on U.S. agricultural/crop usage of pesticides, covering all land in farms, by geographic area (proprietary AgroTrak/Profile Service)	Comprehensive data base on quantities used, acres/farms treated and expenditures, 1987 to date; selected reports for earlier years back to late 1960's; estimates based on responses of grower panel with about 17,000 members
EPA/OPP Usage Surveys	User surveys of home/garden applications (1990) and commercial applicators (1992)	Large sample design surveys conducted by interview by Research Triangle Institute
FIFRA Section 7 Data	Summaries of reports by pesticide producers on quantities of individual pesticides produced and distributed annually, including imports/exports	Individual reports are confidential business information (cannot be released)
Freedonia Group	Pesticide Industry/Market profile, by market segment (sector/class), selected past years to 1997 (proprietary)	Estimates based on Freedonia market research, interviews, publicly available data, etc.

Source	Brief Description	Remarks
Frost and Sullivan	Pesticide industry profile and biocides studies, 1990's; usage and market estimates by segment (proprietary)	Frost & Sullivan market research, interviews
Kline & Co.	Profiles of home/garden and professional usage on alternate years, by class/market segment, chemical; selected years, 1974 to date; biocides profile starting in 1970's (proprietary)	Kline user surveys and interviews of suppliers/applicators
Landell Mills/Produce Studies Ltd.	International crop usage data base covering more than 60 nations, including U.S.; electronic data for 1991-date (proprietary)	Current service was preceded by Battelle international data base starting in 1980's
Maritz Marketing Research	Reports and interactive data base, with estimates of U.S. usage by pesticide and crop, 1991-95; also reports for some earlier years (proprietary)	Maritz became part of Doane in 1998; estimates based on responses from large scale panel/survey approach
Mike Buckley Marketing Research	Reports of usage on variety of crops, by chemical and geographic area, 1995/97 (proprietary)	Buckley surveys, interviews of growers, applicators, crop consultants, suppliers
National Center for Food and Agricultural Policy	Reports and data base on U.S. usage, by chemical, crop, geographic area; data circa 1987 and 1992	Estimates based on best available information from registrants, growers, consultants, etc. and published reports
Seehusen and Associates	Reports of market research on selected fruits, vegetables and non-ag usage (i.e., mosquito control) since 1980's (proprietary)	Seehusen interviews of growers, applicators, etc.

Source	Brief Description	Remarks
SRI Consulting/International	Chemical Economics Handbook Reports containing usage estimates (and sales) by class/chemical and sector (proprietary)	Estimates cover overall production, trade and usage from 1965 to date
State Surveys and Data	Extensive file of surveys by Land Grant Universities and USDA/NASS state offices conducted primarily since the mid-1980's; also, usage data from state regulatory programs, e.g., California	Agricultural primarily, but some of home/garden market; National Agricltural Pesticide Impact Assessment Program funded many state surveys
U.S. Department of Agriculture (NASS/ERS)	Reports based on annual surveys for field crops and alternate years for fruits and vegetables, in major states, 1990 to date; some results available in electronic form	Estimates of quantities used/acres based on interviews of large scale samples of growers , e.g., 20,000
U.S. Census of Agriculture	Acres/no. farms using pesticides, by type, census years, e.g., 1992	
U.S. Dept. of Commerce	Periodic reports on pesticide industry and annual industry outlook	Including reports by U.S. International Tariff Comm.

Prepared by: Arnold L. Aspelin
10/22/98
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APPENDIX FOUR

Pesticide Usage Per Year in U.S., Three Year Periods, 1931-97.

APPENDIX FOUR A -1 Volume of Pesticide Active Ingredient Usage Per Year in U.S., by Sector, Conventional Pesticides, Other Pesticide Chemicals and Total, Three Year Periods Ending 1931-97

Three Years Ending	Conventional Pesticides				Other Peticide Chemicals				Total Conventional and Other			
	Agriculture	Ind./Comm./Gov.	Home/Garden	All Sectors	Agriculture	Ind./Comm./Gov.	Home/Garden	All Sectors	Agriculture	Ind./Comm./Gov.	Home/Garden	All Sectors
1931	221	45	12	279	232	17	39	289	453	63	52	568
1934	132	35	9	175	177	14	31	222	309	49	40	398
1937	179	45	12	236	184	14	31	229	363	59	43	465
1940	195	57	15	266	288	23	52	362	482	80	66	629
1943	253	84	23	360	387	31	70	488	640	115	92	848
1946	279	112	29	420	431	35	78	544	710	147	107	964
1949	216	97	23	337	467	40	88	595	683	137	112	932
1952	246	108	26	381	524	45	99	667	770	153	125	1,048
1955	226	112	26	365	501	43	95	639	727	155	121	1,003
1958	240	131	31	402	586	51	112	748	826	181	143	1,150
1961	275	160	40	475	602	52	114	768	877	212	154	1,243
1964	333	177	43	553	531	48	93	673	864	225	137	1,226
1967	413	219	52	684	262	48	77	388	675	267	129	1,072
1970	482	217	56	755	299	42	74	416	781	259	130	1,171
1973	570	208	62	839	356	38	71	465	926	246	133	1,305
1976	723	209	73	1,006	276	34	70	380	999	243	143	1,386
1979	817	212	83	1,112	254	29	70	352	1,071	240	153	1,464
1982	821	207	86	1,113	216	24	68	309	1,037	231	154	1,422
1985	777	198	84	1,059	194	23	67	285	971	221	151	1,344
1988	704	182	79	965	182	22	67	271	886	205	146	1,236
1991	722	169	77	968	155	22	66	243	877	191	143	1,211
1994	742	148	74	965	163	20	62	246	906	169	136	1,211
1997	782	128	75	986	165	22	60	246	947	150	135	1,232

APPENDIX FOUR A-2 Derivation of Per Capita Consumption of Pesticides in U.S., Three Year Periods Ending 1931-97							
Three Years Ending	Usage/Capita			Usage of Active Ingredient, All Sectors, Mil. Lbs.			U.S. Civilian Population Mils.
	Conventional	Other Chemicals	Total	Conventional	Other Chemicals	Total	
1931	2.27	2.34	4.61	279	289	568	123.1
1934	1.40	1.78	3.18	175	222	398	125.0
1937	1.85	1.79	3.63	236	229	465	128.0
1940	2.03	2.77	4.80	266	362	629	131.0
1943	2.67	3.62	6.30	360	488	848	134.6
1946	3.15	4.08	7.23	420	544	964	133.4
1949	2.30	4.05	6.35	337	595	932	146.7
1952	2.47	4.33	6.81	381	667	1,048	154.0
1955	2.25	3.94	6.20	365	639	1,003	161.9
1958	2.35	4.37	6.72	402	748	1,150	171.2
1961	2.64	4.27	6.91	475	768	1,243	180.0
1964	2.93	3.57	6.50	553	673	1,226	188.5
1967	3.50	1.98	5.48	684	388	1,072	195.6
1970	3.75	2.06	5.81	755	416	1,171	201.4
1973	4.01	2.22	6.23	839	465	1,305	209.3
1976	4.67	1.76	6.43	1,006	380	1,386	215.5
1979	5.00	1.59	6.59	1,112	352	1,464	222.1
1982	4.85	1.34	6.20	1,113	309	1,422	229.5
1985	4.49	1.21	5.70	1,059	285	1,344	235.8
1988	3.98	1.12	5.10	965	271	1,236	242.3
1991	3.88	0.97	4.86	968	243	1,211	249.4
1994	3.74	0.95	4.70	965	246	1,211	257.8
1997	3.72	0.93	4.64	986	246	1,232	265.3

APPENDIX FIVE

Various Work Tables on Annual Agricultural Pesticide Usage, Three-Year Period Averages, 1931-97

VOLUME OF PESTICIDE ACTIVE INGREDIENT USED IN U.S. AGRICULTURAL SECTOR, BY TYPE, THREE YEAR PERIODS ENDING 1931 TO DATE.

APPENDIX FIVE-A

	CONVENTIONAL PESTICIDES						OTHER PESTICIDES				
	MILLIONS OF POUNDS										
THREE YRS ENDING	HERB/PGR	INS/MITE	FUNG	FUM/NEM	OTHER CONV	TOT. CONV.	SULFUR	PETRO/OIL	OTHER CHEMS	TOT NONCON	GR TOTAL
1931	1	128	57	3	33	221	144	49	39	232	453
1934	1	63	45	4	19	132	101	53	23	177	309
1937	2	103	43	6	26	179	83	71	31	184	363
1940	6	102	52	8	28	195	161	95	32	288	482
1943	12	121	73	12	35	253	214	131	41	387	640
1946	18	111	96	17	37	279	244	144	43	431	710
1949	30	82	60	20	25	216	269	168	30	467	683
1952	30	110	56	21	30	246	279	210	35	524	770
1955	36	94	48	22	26	226	243	228	30	501	727
1958	41	93	56	23	27	240	302	252	31	586	826
1961	52	104	65	25	30	275	286	280	35	602	877
1964	80	156	37	26	35	333	186	305	40	531	864
1967	138	165	40	32	37	413	88	131	43	262	675
1970	191	172	46	35	39	482	95	158	46	299	781
1973	257	181	48	42	41	570	109	199	48	356	926
1976	372	197	53	56	45	723	90	133	53	276	999
1979	463	193	56	61	45	817	87	115	52	254	1071
1982	507	152	60	63	38	821	78	93	45	216	1037
1985	491	130	58	64	34	777	73	82	39	194	971
1988	452	104	55	65	29	704	83	65	33	182	886
1991	452	90	50	105	25	722	73	53	29	155	877
1994	453	87	47	132	24	742	86	50	28	163	906
1997	471	86	51	150	25	782	71	64	29	165	947

APPENDIX FIVE B WORK TABLES FOR AGRICULTURAL USAGE DATA PRESENTED IN PART 5														
THREE YRS ENDING	AI USAGE	CROP ACRES	LBS AI/ACRE	PEST EXP	PEST EXP% TOT EX[	TOT EXP	THREE YRS ENDING	PEST EXP	TOTAL LBS AI/ACRE	CONVENTIONAL LBS AI/ACRE	OTHER P. CHEMS.)	TOT. CONV.	OTHER P CHEMS	AI USAGE
1931	453	382	1.19	33	0.49	6,715.6	1931	33	1.19	0.58	0.61	221	232	453
1934	309	379	0.81	28	0.61	4,518.9	1934	28	0.81	0.35	0.47	132	177	309
1937	363	377	0.96	33	0.59	5,645.7	1937	33	0.96	0.48	0.49	179	184	363
1940	482	368	1.31	41	0.65	6,348.8	1940	41	1.31	0.53	0.78	195	288	482
1943	640	371	1.72	52	0.54	9,809.7	1943	52	1.72	0.68	1.04	253	387	640
1946	710	373	1.90	69	0.52	13,298.3	1946	69	1.90	0.75	1.15	279	431	710
1949	683	379	1.80	118	0.66	17,934.7	1949	118	1.80	0.57	1.23	216	467	683
1952	770	379	2.03	188	0.88	21,531.0	1952	188	2.03	0.65	1.38	246	524	770
1955	727	379	1.92	174	0.80	21,815.3	1955	174	1.92	0.60	1.32	226	501	727
1958	826	361	2.29	230	0.96	24,066.0	1958	230	2.29	0.67	1.62	240	586	826
1961	877	351	2.50	302	1.09	27,714.0	1961	302	2.50	0.78	1.72	275	602	877
1964	864	334	2.58	383	1.23	31,229.7	1964	383	2.58	1.00	1.59	333	531	864
1967	675	336	2.01	609	1.67	36,112.3	1967	609	2.01	1.23	0.78	413	262	675
1970	781	333	2.34	898	2.13	42,030.0	1970	898	2.34	1.45	0.90	482	299	781
1973	926	342	2.71	1308	2.42	54,449.7	1973	1308	2.71	1.66	1.04	570	356	926
1976	999	365	2.74	1801	2.35	76,255.0	1976	1801	2.74	1.98	0.76	723	276	999
1979	1071	375	2.85	2677	2.51	105,146.0	1979	2598	2.85	2.18	0.68	817	254	1071
1982	1037	384	2.70	4007	2.88	137,629.7	1982	3818	2.70	2.14	0.56	821	216	1037
1985	971	359	2.70	4297	3.11	138,069.0	1985	4641	2.70	2.16	0.54	777	194	971
1988	886	338	2.62	4328	3.29	132,054.7	1988	4675	2.62	2.08	0.54	704	182	886
1991	877	340	2.58	5565	3.68	151,077.1	1991	5456	2.58	2.13	0.46	722	155	877
1994	906	335	2.70	6806	4.24	160313.4	1994	6462	2.70	2.21	0.49	742	163	906
1997	947	344	2.76	8360	4.60	181665.0	1997	7999	2.76	2.28	0.48	782	165	947

APPENDIX FIVE C WORK TABLES FOR AGRICULTURE SECTOR PRESENTATION IN PART 5									
					MULT				
					97=100	97=100			exp/cap
THREE YRS ENDING	PEST EXP	PEST EXP%TOT EX[		Three Yr. Period Ending		PEST EXP	Mils. of 1997 Dollars	us civ pop/mil	Exp./Capita
1931	33	0.49		1931	9.05	296	296	123.1	2.40
1934	28	0.61		1934	11.15	312	312	125.0	2.50
1937	33	0.59		1937	10.43	348	348	128.0	2.72
1940	41	0.65		1940	10.43	428	428	131.0	3.27
1943	52	0.54		1943	9.10	476	476	134.6	3.54
1946	69	0.52		1946	7.91	549	549	133.4	4.11
1949	118	0.66		1949	6.29	745	745	146.7	5.08
1952	188	0.88		1952	5.80	1090	1090	154.0	7.08
1955	174	0.80		1955	5.46	950	950	161.9	5.87
1958	230	0.96		1958	5.05	1159	1159	171.2	6.77
1961	302	1.09		1961	4.80	1449	1449	180.0	8.05
1964	383	1.23		1964	4.62	1770	1770	188.5	9.39
1967	609	1.67		1967	4.34	2645	2645	195.6	13.52
1970	898	2.13		1970	3.85	3457	3457	201.4	17.16
1973	1308	2.42		1973	3.33	4351	4351	209.3	20.79
1976	1801	2.35		1976	2.69	4837	4837	215.5	22.44
1979	2677	2.51		1979	2.19	5857	5857	222.1	26.37
1982	4007	2.88		1982	1.71	6852	6852	229.5	29.86
1985	4297	3.11		1985	1.47	6325	6325	235.8	26.82
1988	4328	3.29		1988	1.34	5805	5805	242.3	23.96
1991	5565	3.68		1991	1.19	6644	6644	249.4	26.64
1994	6806	4.24		1994	1.09	7406	7406	257.8	28.73
1997	8360	4.60		1997	1.02	8517	8517	265.3	32.10

APPENDIX 5C WORK TABLES FOR AGRICULTURE SECTOR PRESENTATION IN PART 5									
					MULT				
					97=100	97=100			exp/cap
THREE YRS ENDING	PEST EXP	PEST EXP%TOT EX[		Three Yr. Period Ending		PEST EXP	Mils. of 1997 Dollars	us civ pop/mil	Exp./Capita
1931	33	0.49		1931	9.05	296	296	123.1	2.40
1934	28	0.61		1934	11.15	312	312	125.0	2.50
1937	33	0.59		1937	10.43	348	348	128.0	2.72
1940	41	0.65		1940	10.43	428	428	131.0	3.27
1943	52	0.54		1943	9.10	476	476	134.6	3.54
1946	69	0.52		1946	7.91	549	549	133.4	4.11
1949	118	0.66		1949	6.29	745	745	146.7	5.08
1952	188	0.88		1952	5.80	1090	1090	154.0	7.08
1955	174	0.80		1955	5.46	950	950	161.9	5.87
1958	230	0.96		1958	5.05	1159	1159	171.2	6.77
1961	302	1.09		1961	4.80	1449	1449	180.0	8.05
1964	383	1.23		1964	4.62	1770	1770	188.5	9.39
1967	609	1.67		1967	4.34	2645	2645	195.6	13.52
1970	898	2.13		1970	3.85	3457	3457	201.4	17.16
1973	1308	2.42		1973	3.33	4351	4351	209.3	20.79
1976	1801	2.35		1976	2.69	4837	4837	215.5	22.44
1979	2677	2.51		1979	2.19	5857	5857	222.1	26.37
1982	4007	2.88		1982	1.71	6852	6852	229.5	29.86
1985	4297	3.11		1985	1.47	6325	6325	235.8	26.82
1988	4328	3.29		1988	1.34	5805	5805	242.3	23.96
1991	5565	3.68		1991	1.19	6644	6644	249.4	26.64
1994	6806	4.24		1994	1.09	7406	7406	257.8	28.73
1997	8360	4.60		1997	1.02	8517	8517	265.3	32.10

APPENDIX 5D WORK TABLES FOR PART 5, AG RICULTURAL USAGE									
	AGRIC USAGE, MILLIONS			POUNDS PER CAPITA				AG P. EXPENDITURES	
Three Yr. Period Ending	Conventional	Other Chemicals	Total	Conventional	Other Chemicals	Total	Three Yr. Period Ending	Mils. of 1997 Dollars	Exp./Capita
1931	221	232	453	1.80	1.89	3.68	1931	296	2.40
1934	132	177	309	1.05	1.42	2.47	1934	312	2.50
1937	179	184	363	1.40	1.44	2.84	1937	348	2.72
1940	195	288	482	1.49	2.20	3.68	1940	428	3.27
1943	253	387	640	1.88	2.87	4.75	1943	476	3.54
1946	279	431	710	2.09	3.23	5.32	1946	549	4.11
1949	216	467	683	1.47	3.18	4.66	1949	745	5.08
1952	246	524	770	1.60	3.40	5.00	1952	1090	7.08
1955	226	501	727	1.40	3.09	4.49	1955	950	5.87
1958	240	586	826	1.40	3.42	4.82	1958	1159	6.77
1961	275	602	877	1.53	3.34	4.87	1961	1449	8.05
1964	333	531	864	1.77	2.82	4.58	1964	1770	9.39
1967	413	262	675	2.11	1.34	3.45	1967	2645	13.52
1970	482	299	781	2.39	1.48	3.88	1970	3457	17.16
1973	570	356	926	2.72	1.70	4.42	1973	4351	20.79
1976	723	276	999	3.36	1.28	4.64	1976	4837	22.44
1979	817	254	1071	3.68	1.14	4.82	1979	5857	26.37
1982	821	216	1037	3.58	0.94	4.52	1982	6852	29.86
1985	777	194	971	3.29	0.82	4.12	1985	6325	26.82
1988	704	182	886	2.91	0.75	3.65	1988	5805	23.96
1991	722	155	877	2.89	0.62	3.52	1991	6644	26.64
1994	742	163	906	2.88	0.63	3.51	1994	7406	28.73
1997	782	165	947	2.95	0.62	3.57	1997	8517	32.10

APPENDIX 5-E Volume of Pesticide Active Ingredient Usage in U.S. Agricultural Sector, Conventional Pesticides, Other Pesticide Chemicals and Total, Three Year Periods Ending 1931-97

	MILLIONS OF POUNDS		
Three Years Ending	Conventional	Other Chemicals	Total
1931	221	232	453
1934	132	177	309
1937	179	184	363
1940	195	288	482
1943	253	387	640
1946	279	431	710
1949	216	467	683
1952	246	524	770
1955	226	501	727
1958	240	586	826
1961	275	602	877
1964	333	531	864
1967	413	262	675
1970	482	299	781
1973	570	356	926
1976	723	276	999
1979	817	254	1071
1982	821	216	1037
1985	777	194	971
1988	704	182	886
1991	722	155	877
1994	742	163	906
1997	782	165	947

APPENDIX FIVE F VOLUME OF PESTICIDE ACTIVE INGREDIENT USED IN U.S. AGRICULTURAL SECTOR, BY TYPE, 1929 TO DATE.

YEAR	CONVENTIONAL PESTICIDES						OTHER PESTICIDES				
	MILLIONS OF POUNDS										
	HERB/PGR	INS/MITE	FUNG	FUM/NEM	OTHER CONV	TOT. CONV.	SULFUR	PET OIL	OTHER	TOT NONCON	GR TOTAL
1929	1	173	65	2	43	284	156	52	50	258	543
1930	1	140	56	2	35	235	143	47	41	231	466
1931	1	70	49	3	21	145	134	48	25	207	351
1932	1	59	47	3	19	129	99	47	22	168	297
1933	1	53	46	4	18	122	97	62	21	181	302
1934	1	75	43	4	21	145	107	51	25	183	327
1935	2	102	42	5	26	175	95	61	30	186	362
1936	1	95	45	6	25	172	86	71	29	187	359
1937	2	112	42	7	28	190	67	80	32	179	369
1938	4	105	53	7	28	197	113	77	33	224	420
1939	5	96	52	8	27	188	192	102	31	324	512
1940	9	103	52	8	28	200	177	105	33	315	515
1941	11	102	64	10	30	217	207	115	35	358	574
1942	11	136	86	11	40	284	213	129	47	389	673
1943	14	126	70	13	35	259	223	149	41	413	672
1944	17	117	86	16	36	272	243	136	43	422	693
1945	18	114	104	18	39	292	238	151	46	435	727
1946	20	102	98	18	36	274	250	144	42	436	710
1947	24	109	55	19	30	237	254	152	35	440	677
1948	33	67	66	19	24	209	269	169	28	466	675
1949	34	68	58	20	23	203	285	183	26	494	697
1950	26	132	68	20	36	283	300	231	42	573	856
1951	26	111	71	21	33	261	302	195	38	535	796
1952	37	87	29	21	21	195	235	205	24	464	660
1953	35	93	33	22	23	205	224	222	26	472	678
1954	35	89	47	22	25	219	224	226	29	479	698
1955	38	99	64	23	29	254	280	236	34	551	805
1956	37	145	49	23	35	288	291	245	41	577	865
1957	39	78	61	23	25	226	291	248	29	568	794
1958	47	58	57	24	21	206	325	264	24	613	819
1959	53	79	70	24	27	252	308	274	31	613	865
1960	47	100	69	25	30	271	292	278	35	605	876
1961	55	133	56	25	34	303	259	289	39	588	891
1962	66	111	39	26	27	268	227	294	31	552	820
1963	75	190	33	26	40	365	194	307	47	548	913
1964	98	166	39	26	37	366	137	313	43	493	859
1965	122	170	37	30	37	396	100	200	43	343	740
1966	136	165	42	34	37	414	80	92	43	215	630

1967	156	161	42	33	37	429	85	100	43	228	656
1968	173	168	44	34	38	457	90	125	45	260	717
1969	191	178	47	34	41	491	95	150	47	292	783
1970	208	169	46	37	39	499	100	200	45	345	844
1971	228	173	48	39	40	528	112	222	46	380	908
1972	257	189	46	41	42	575	110	200	49	359	935
1973	286	182	50	47	42	607	105	175	49	329	935
1974	341	198	53	51	45	688	100	150	53	303	991
1975	375	198	54	57	45	729	90	125	53	268	997
1976	399	196	53	60	45	753	80	125	52	257	1010
1977	435	198	56	59	46	794	90	120	53	263	1057
1978	461	192	54	62	44	813	85	115	52	252	1065
1979	492	188	57	62	44	843	85	110	51	246	1090
1980	504	163	59	60	40	826	80	100	47	227	1053
1981	513	152	62	65	39	831	80	90	45	215	1045
1982	503	142	59	65	36	805	75	90	42	207	1012
1983	455	135	59	65	35	749	70	85	41	196	945
1984	516	129	56	67	33	801	75	80	39	194	995
1985	501	126	59	61	33	780	75	80	39	194	974
1986	481	121	59	62	32	755	80	70	38	188	943
1987	425	90	52	65	26	658	85	65	30	180	837
1988	450	100	54	67	28	699	85	60	32	177	876
1989	460	95	54	86	27	722	70	60	31	161	883
1990	455	90	50	108	25	728	80	55	29	164	893
1991	440	85	47	120	24	716	68	44	28	140	855
1992	450	90	45	126	24	735	82	51	28	161	897
1993	425	80	47	131	23	706	91	48	27	166	872
1994	485	90	48	138	25	786	84	50	29	163	949
1995	461	91	49	145	25	771	84	54	30	168	939
1996	481	84	51	165	25	806	62	62	28	152	958
1997	470	82	53	140	25	770	68	76	30	174	944

APPENDIX FOUR A-3 Volume of Pesticide Active Ingredient Used Per Year in U.S., All Economic Sectors, by Type of Pesticide, Three Year Periods Ending 1931-97

THREE YRS ENDING	Conventional Pesticides						Other Pesticides				
	Millions of Pounds										
	HERB/PGR	INS/MITE	FUNG	FUM/NEM	OTHER CONV	TOT. CONV.	SULFUR	PETRO/OIL	OTHER CHEMS	TOT NONCON	GR TOTAL
1931	1	152	85	5	36	279	165	56	67	289	568
1934	1	75	70	8	21	175	116	61	45	222	398
1937	2	125	69	12	29	236	95	81	53	229	465
1940	8	124	86	17	31	266	184	109	70	362	629
1943	17	150	127	26	41	360	246	151	92	488	848
1946	27	138	172	39	44	420	279	165	100	544	964
1949	46	102	112	45	31	337	308	193	94	595	932
1952	47	139	109	49	36	381	320	241	106	667	1,048
1955	60	120	99	54	32	365	278	262	99	639	1,003
1958	70	120	120	58	34	402	346	289	112	748	1,150
1961	93	135	146	63	39	475	328	321	118	768	1,243
1964	149	205	88	68	43	553	213	349	110	673	1,226
1967	240	220	101	76	48	684	114	167	106	388	1,072
1970	298	225	103	80	50	755	116	193	107	416	1,171
1973	353	240	105	89	52	839	126	230	109	465	1,305
1976	472	262	114	102	56	1,006	107	159	114	380	1,386
1979	576	259	121	99	57	1,112	104	137	111	352	1,464
1982	624	219	120	100	50	1,113	94	111	104	309	1,422
1985	606	198	111	98	45	1,059	88	98	99	285	1,344
1988	560	167	103	97	39	965	99	77	94	271	1,236
1991	559	148	92	135	34	968	88	65	90	243	1,211
1994	555	137	80	161	32	965	103	59	84	246	1,211
1997	567	132	79	175	32	986	87	78	82	246	1,232