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Final Report

Analytical Procedures, Methodologies, and Field Protocols to Monitor and Determine Environmental Contaminants:

Pesticide Use in California: U.S./Mexico Border Region

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Executive Summary

To assist the U.S. Environmental Protection Agency (EPA) in determining where potential pesticide exposures are occurring in children near the U.S./Mexico border, pesticide use report (PUR) data from the California Department of Pesticide Regulation (CDPR) was analyzed for the years 1991-1995 for two California border counties, San Diego and Imperial. In California, all agricultural pesticide use (pounds of product applied) is reported by growers to local and state pesticide regulatory agencies. The site of application is identified to an area of approximately one square mile. The CDPR converts pounds of pesticide product applied to pounds of active ingredient.

The quality of the pesticide use data was assessed, including evaluation of the completeness of the data and potential errors (outliers). Toxicological evaluation of the top ten pesticides by weight for each year and county was undertaken. Pesticides were classified as respiratory irritants, possible/probable human carcinogens, reproductive/developmental toxicants, and acethylcholinesterase inhibitors. Relevant animal and human literature, along with classifications by other agencies, were reviewed to classify pesticides. The top pesticides by frequency of application, and the top crops applied with pesticides were examined. Time and seasonal trends of pesticide use was analyzed by year. Locations of sites where children are likely to congregate in the two counties, including schools, day care centers, churches, migrant camps, and parks were linked to a geographic information system (GIS) for analysis. Data from the 1990 U.S. Census and updated population estimates, along with digital coverages of residential land use, were also imported into the GIS to identify population areas. Schools and census tracts were ranked by proximity to total annual volume of pesticide applications and by total annual volume of respiratory irritants.

Data quality assessment of the pesticide use data revealed that the data appear to be reasonably accurate, as the majority of the data fell in manufacturer's ranges for application rates, and the geographic distribution of pesticide use closely coincides with agricultural land use. Evaluation of the frequency of data entry and grower errors was severely limited due to the restricted availability of hard copy forms. Although outliers in application rates were found to comprise 0.1% or less of the total applications, adjustment of these large applications resulted in changes of the ranking of the top ten pesticides.

Pesticide use (number of pounds applied) in Imperial County was found to be 4-8.5 times higher than in San Diego County over the time period examined. From 1991-1995, total pesticide use increased 24% in Imperial County (from 6.5 to 8.1 million pounds), and 7% in San Diego County (from 888 to 947 thousand pounds). The top 10 pesticides by weight (in 1995) in Imperial County were metam-sodium, sulfur, methyl bromide, malathion, trifluralin, methomyl, EPTC, chlorthal-dimethyl, chlorpyrifos, and dimethoate. In San Diego County, the top 10 pesticides by weight (1995) were methyl bromide, petroleum oil, chloropicrin, mineral oil, metam-sodium, glyphosate, sulfur, potash soap, chlorothalonil, and copper hydroxide.

Geographic analysis of pesticide use and population centers showed that although the total population and population density of children is lower, heavy use of pesticides such as respiratory irritants are more likely to be applied near residential areas in Imperial County than in San Diego County. Sixty-nine percent of Imperial County census tracts had agricultural pesticide applications within their boundaries, compared to only 19% of the census tracts in San Diego County. Pesticide use near schools (within 2.8 miles) in Imperial County was approximately 10 times higher than in San Diego County (33,040 vs. 3355 pounds per public school; and 23,898 vs.

2725 pounds per private school). In Imperial County, all schools with children aged 11 years and younger had agricultural use pesticides applied within 2.8 miles of the school. In San Diego County, 55% of schools with children aged 11 and younger had pesticide applications within 2.8 miles of the school.

This analysis was limited by the lack of currentness of some of the locations of sites where children reside. Actual locations within the one square mile area where pesticides are being applied are not known. Although children may be residing or attending schools near pesticides applications, the PUR data only allowed the mapping of agricultural pesticide use, but not exposure. California has stringent regulations of the use of pesticides aimed at protecting the public. In order to determine the extent of any exposure, environmental monitoring would be required. The U.S. EPA is currently planning on conducting such monitoring in selected locations of the border area. This study may assist the EPA as a sampling frame for selecting monitoring locations.

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I Introduction

The U.S./Mexico border region, defined by the 1983 La Paz agreement as a zone 100 kms north and south of the international boundary, is an area of widespread agricultural use and rapid population growth. The California/Baja California border region is expected to continue to grow rapidly into the next century, due to sustained migration to the border region from both Mexico and the United States, and to increased employment opportunities due to the opening of the border to free trade. The two border counties in California, San Diego and Imperial, provide about 8% of the value of agricultural production in California[1] (over $2 billion in 1996), and use approximately 5% of the total statewide poundage of pesticide applications.[2]

The Environmental Health Workgroup, as part of the U.S. Environmental Protection Agency (EPA) Border XXI Program, is charged with examining the relationships between environmental exposures along the U.S./Mexico border and human health. Due to concern about potential pesticide exposures, the workgroup has initiated a five year project entitled, "Pesticide exposure and health effects in young children along the U.S.-Mexican border." The goal of this project is to "examine the risk to children from repeated exposures to pesticides via multiple sources and pathways along the U.S./Mexico border." The project is to be completed in three phases. The first phase involves review of existing data, including development of pesticide databases, the development of methodologies for environmental and biological monitoring of pesticides, and the identification of sampling areas and population centers. The second phase may involve the initial screening of children who may be exposed to pesticides, and the final phase may include follow-up screening of highly exposed children and an epidemiologic study.

The California Department of Health Services, Environmental Health Investigations Branch, has partnered with the border health departments in the other three U.S. border states (Arizona, New Mexico, and Texas), the University of Texas, and the Institute of Public Health, in Cuernavaca, Mexico, to support the pesticide exposure project and to develop a border-wide geographic information system (GIS) for environmental health. The purpose of this report is to describe the methodology and results of the assessment of California's Pesticide Use Report data for phase one of the pesticide exposure project, to identify "sensitive receptor sites" (sites where children are likely to be located such as schools, daycare centers, migrant camps, and parks) and to use GIS to overlay schools, population data, and pesticide use information to identify potential sampling areas for pediatric screening for phase two of the EPA pesticide exposure initiative.

The goals of this report are to:

- Evaluate the data quality of the Pesticide Use Reporting System of the California Department of Pesticide Regulation for two California border counties, San Diego and Imperial;

- Define and categorize pesticides used in the two counties by weight, frequency of use, toxicity, and potential health effects (i.e. carcinogens, respiratory irritants, reproductive /developmental toxicants, cholinesterase inhibitors);

- Describe time trends of top pesticide use in the two border counties;

- Define and map “sensitive receptor sites” and enumerate populations of children from schools and the U.S. Census;

- Produce a rank cross-tabulated listing of sensitive receptors and population data and pesticide use.

As an appendix to this report, the complete data documentation for the pesticide use data will be attached.

II Methods

A) Description of study area

Although the two California counties which share a common border with Mexico, San Diego and Imperial, are nearly identical in physical size (4205 sq. miles vs. 4175 sq miles), they differ in their socio-demographic profiles. Imperial County can be characterized as a young, mostly Latino agricultural population, with high fertility rates (98.4 vs. 79/1000 in San Diego county)[3], and most of the population born outside of the U.S. It has high unemployment rates, a high percentage of children in poverty, and an under-educated population. On the other hand, San Diego County is one of the wealthiest counties in the U.S.[4] San Diego County has a population that is twenty times larger than Imperial County (2,726,715 vs. 134,646, 1994 data[5]) and has lower birth rates (17.5 vs 20.2/1000) yet similar death (6.7 vs. 6.0/1000) rates of Imperial County. [3] While San Diego county grew at a faster rate than the Imperial Valley during the 1980's (3.5% vs. 1.9%/yr), the Imperial Valley grew four times faster in the first half of the 90's as the economy slowed in San Diego County and expanded in Imperial County.[4] Agricultural land use is widespread throughout the Imperial Valley (Fig. 1), while it is centered in the north-western part of the county in San Diego (Fig. 2).

B) Description of Pesticide Use Data

Data on pesticide use (e.g. type, amount applied, application date, etc.) for San Diego and Imperial Counties were obtained from the California Department of Pesticide Regulation (CDPR) Pesticide Use Report (PUR) database. Commercial agricultural users and professional applicators are legally required to report all pesticide applications to the county agricultural commissioners on a monthly basis, who in turn report annual totals to CDPR. The data are publicly available in digital tape format. Beginning with PUR year 1995, the database is on CD-ROM in standard ASCII format.

Limited reporting of agricultural pesticide use was first established around the 1950's. Beginning in 1970, the State required commercial pest control operators to report all pesticides used, as well as the date and location of application, and, in the case of agricultural applications, the crop(s) to which the pesticide was applied. In addition, anyone who used restricted materials, defined as hazardous to the public health and/or the environment, was required to file a pesticide use report with the County Agricultural Commissioner (see Appendix B for a sample copy of a pesticide use reporting form). Full use reporting began in 1990. All pesticides used for commercial agricultural purposes, as well as those used for structural and maintenance applications, must be reported. "Agricultural" uses include pesticide applications to parks, golf courses, cemeteries, rangeland, pastures, and alongside roads and railroad rights-of-way. In addition, postharvest treatments of agricultural commodities, poultry/fish production and some livestock applications are included in the reporting data. For the purposes of this report however, only agricultural applications were considered, as they are the only records linked to geographic identifiers. We defined agricultural applications as those applications applied to "acres" (unit treated="acres"), and those applications not used for structural applications (site code not equal to 10, 100001, or 100060).

Each record in the database is intended to constitute a single pesticide application. However, since the computer database registers each active ingredient as if it were a separate pesticide product, a single pesticide application would be recorded more than once in the database for products containing more than one active ingredient. In the case of a product containing 3 active ingredients applied to 20 acres, this would result in a total of 60 acres recorded as being treated instead of the 20 acres actually treated. Therefore, individual applications should not be added to determine the total area receiving pesticides applications in a county. The field ACRE_TRT refers to the number of acres upon which a particular pesticide/active ingredient was applied. The location of actual ground areas within a particular township, range, and section (TRS) cannot be distinguished without referring to hard copy records.

Each pesticide application is assigned a unique identification number at the time it is processed by CDPR. The PUR fields of primary interest for agricultural applications include: number of acres treated, chemical code, pounds of chemical used, application date, township, range, and section (geographic identifiers linked to the public land survey boundary files), site code (commodity or crop treated with pesticides), and mode of application (e.g. aerial, ground, other).

Each chemical in the PUR Database registered as an active ingredient is assigned a unique code number (field: CHEM_CODE). The portion of the formulated product that is not identified as 'active ingredient' is consolidated into a single code for 'inert ingredient'. The identity and percent formulation of the inert ingredients of a specific pesticide are considered proprietary and are not included as part of the database. As such, inert ingredients which may be of toxicological concern were not identified/reviewed in this report.

The LBS_PRD_USED field refers to the pounds of product applied. The LBS_CHEM_USED (or LBS_CHEM) field refers to the pounds of active ingredient applied. The LBS_CHEM value is derived by CDPR by multiplying the field LBS_PRD_USED by the percent active ingredient, and then by dividing by 100. Applications are converted to pounds based on formulation (wet, dry), specific gravity, amount of product used , and the unit of measure. *(note: for the remainder of this report, the term 'pesticide' will be used to denote ' active ingredient').* All pounds reported are pounds of active ingredients.

C) Base map data

Data for the base map and road network for geocoding for San Diego County was obtained from the San Diego Association of Governments (SANDAG). The road network data was originally generated by the San Diego Data Processing Corp., a nonprofit city/county data processing consortium serving the county and municipal governments of San Diego, who in turn lease the data from Thomas Brothers. This GIS database is of 1:24,000 scale resolution.

Base map and road network data for Imperial County was obtained from Geographic Data Technology (GDT), one of the major vendors of digital data in the United States. In rural areas, original Bureau of the Census Tiger lines are used with their address ranges enhanced and corrected by GDT. In urban areas, higher resolution data is spliced in. These data are of variable resolution, up to 1:24,000 scale.

The California Public Land Survey (PLS) GIS layer is a product of the Teale Data Center, California's GIS clearinghouse. The layer was created to a 1:100,000 resolution. The original version reflected both those areas which were surveyed using the PLS system and those areas (mostly coastal) which were described under the Spanish Land Grants. A second version, used in our analysis, imposed a 'pseudo PLS grid' over the Spanish Land Grant areas for purposes of analytical consistency. These squares have no legal meaning in the description of property.

D) Description of Sensitive Receptor Sites

1) Schools

Data on schools were available from two data sources: the California Department of Education, Information Systems and Services Division, and the National Center for Education Statistics. The National Center for Education Statistics provides data on all public elementary schools from their Common Core of Data (CCD) survey, a national statistical database. Data were selected for 1995 from the public school universe component, which contains information on school location and type, and enrollment by grade. Students were enumerated for pre-kindergarten, kindergarten, and for grades 1 through 6 for each school to capture children up through age 11.

To obtain data on private schools, the California Department of Education County District School (CDC) database was accessed. Data were obtained for private schools with their 1994 enrollment. Data variables available included the name of the school, school location, type of school district, type of school, and enrollment. Since enrollment was not available by grade, the district and school type variables were used to select schools. These included schools from elementary school districts, kindergartens, elementary schools (from kindergarten through 12th) and ungraded schools (from kindergarten through 12th).

Schools were geocoded using Thomas Bros. Geofinder, Arc/Info and Arcview software. Out of 813 schools in San Diego County, 780 (96%) were successfully address-matched (linked to base map addresses), and out of 66 schools in Imperial County, 60 (90.9%) were successfully matched.

Figures 3-4 show the locations of public and private schools in Imperial and San Diego Counties.

2) Day care centers

Addresses of day care centers were obtained from the San Diego County Department of Environmental Health for San Diego County and from the Imperial County Board of Education for Imperial County. For San Diego County, all licensed daycare centers as maintained by the California Department of Social Services as of 1995 were included. Data were geocoded by San

Diego County and additionally in-house using Arc/Info. Out of 1758 day care centers in San Diego County, 1591 (91%) were successfully geocoded. For Imperial County, day care centers were geocoded using Arcview software. Out of 54 day care centers in Imperial County, 49 (90.7%) were successfully address-matched.

Figures 5-6 show the locations of day care centers in Imperial and San Diego Counties.

3) Churches

Churches in Imperial and San Diego Counties were obtained from the Pacific Bell Yellow Pages and updated from the Yahoo Yellow pages web site (URL: http://yp.yahoo.com/yahoo/yp.html). Out of 1259 churches in San Diego County, 1211 (96%) were geocoded and out of 169 churches in Imperial County, a total of 154 (91%) were successfully geocoded.

Figures 7-8 show the locations of churches in San Diego and Imperial Counties.

4) Migrant camps

Information on migrant camps in San Diego County were obtained from the County of San Diego Vector Surveillance and Control Division, Department of Environmental Health. Directions and a map to 38 camps which were active as of June, 1992 were obtained originally from a health surveillance study conducted by the Centers for Disease Control and the County of San Diego Department of Health Services.[6] Since migrant camps are highly transitory, the locations of these camps only give an indication of past settlements, but may not accurately represent current locations. Locations of camps were hand-digitized and transferred into Arcview. Figure 9 shows the locations of migrant camps in San Diego County.

Discussions with the Imperial County Agricultural Commission and the Imperial County Office of Migrant Education revealed that no migrant camps are left in Imperial County. Apparently they existed 30 years ago but at present migrant workers live in residential areas within the town limits. Therefore, no migrant camps were mapped for Imperial County.

5) Parks

Point data for parks for the two counties were downloaded from the USGS web site (URL: http://mapping.usgs.gov/www/gnis) from the Geographic Names Information system (GNIS). This information was originally taken from USGS Quad sheets of the area, from maps generated from 1968-1986. For the two counties, 158 parks were obtained for San Diego and 32 parks for Imperial (points were already geocoded). Figures 10-11 shows the parks in Imperial and San Diego Counties.

E) Description of population data

1) Population centers

For San Diego County, residential land use coverages were obtained from the 1990 inventory of generalized land use from the San Diego Association of Governments (SANDAG).[7] This database was formulated by SANDAG using digital orthophoto imagery , Thomas Bros. digital data, County Assessor's data, and other data sources.

Residential land use data for Imperial County was obtained from the Geographic Information Retrieval and Analysis System (URL: http:/www.epa.gov/nsdi/projects/giras.htm). This data was taken originally from NASA high elevation photography from the mid-70's to early 80's. With on-screen examination comparing to Tiger 1995 line work, it was apparent that the low resolution of the data resulted in some spatial inaccuracies (i.e. slight offset to the northwest). Also, from field trips to the study area, it was apparent that significant urban growth has taken place in the urban centers of El Centro, Brawley, and Calexico since this landuse layer was generated.

Since urban/suburban land uses are reasonably well delineated with roads, selected Tiger 1995 lines were brought into the landuse layer to update the urban/suburban boundaries. In areas where development had occurred and boundaries had to be expanded, some guesswork was involved. In general, residential and commercial areas were segregated by noting fine grain road network for residential areas, and larger parcels and parking lots for commercial/industrial areas.

Figures 12-13 show the population centers in Imperial and San Diego Counties.

2) Childhood age distributions

Childhood age distributions were obtained for both counties from the 1990 Census of Population and Housing, Summary Tape File 1A. Population counts were grouped into 2 categories: 0-4, and 5-11 by census tract. Population density was computed by dividing the total number of children by the square kilometers in each census tract.

Updated childhood population estimates were available from SANDAG for San Diego County for 1995. Population numbers were available for children under 5, 5-9, and 10-14. Using additional data from SANDAG, the proportion of all children in 1995 for San Diego County age 10-11 out of all 10-14 olds was computed. This percentage was multiplied by the number of 10-14 year olds in each census tract to estimate the number of 10-11 year olds.

Population estimates are computed annually by SANDAG from base year census data. SANDAG first computes postcensal census tract population estimates using the "housing unit method" which is done using data on total housing units, occupancy rates, and housing unit estimates. Population by age and ethnicity estimates are made "using a cohort-component method to model population change (natural increase and net migration) for age cohorts grouped by sex and ethnicity." (see SANDAG's web site: www.sandag.cog.ca.us for more explanation). The population by age and ethnicity estimates are then fixed to the census tract population estimates.

No updated population estimates by census tract were available for Imperial County.

Figures 14-15 show the childhood population density by census tract in Imperial and San Diego Counties.

F) Analytic procedures

Pesticide Use Report (PUR) data was obtained from the California Department of Pesticide Regulation for the years 1991 to 1995. Due to changes in reporting regulations, the data for 1990 is incomplete and therefore analysis began with PUR year 1991. Analysis was limited to agricultural pesticide applications only. The total number of pesticides/active ingredients applied in any given year in each county ranged from a low of 192 to a high of 278. Analysis was restricted to the top ten pesticides in each county each year, as this captured between 77-86% of the PUR database.

After quality assessment and data cleaning (see part III below), the total and average poundage of the top ten pesticides by weight and the method of application (e.g. air, ground) were computed for each year and county. The top ten pesticides by frequency of application, as well as the top ten crops to which pesticides were applied were also computed. A total of 22 different pesticides over the 5 PUR years (1991-1995) were identified in the top ten category by weight. These 22 substances were then assessed toxicologically according to four toxicological classifications (carcinogenicity, reproductive/developmental effects, acetylcholinesterase inhibition, and respiratory irritation; see discussion in part G) below). The time-trends were determined for county-specific overall pesticide use, the top pesticide by weight, and for the four toxicologic classifications. Seasonal trends of the top five pesticides/active ingredients for 1995 (year of best data available) was computed using the date of application.

Annual pesticide applications were summarized by township, range, and section (TRS - approximately 1 square mile area) and linked to the Public Lands Survey boundary files. The linked boundary files and summarized PUR data were imported into Arcview **(**version 3.0) in geographic projection (i.e. latitude and longitude in decimal degrees). Point and polygon layers of sensitive receptor sites (schools, day care centers, churches, migrant camps, and parks), as described above, were also imported into Arcview in geographic projection. School enrollments were linked to the school point data and census data and population estimates were linked to each census tract and stored as attribute tables in Arcview for map generation.

Geographic analysis of schools and census tract populations with summarized pesticide data at the TRS level were only conducted for the top 10 pesticides and for respiratory irritants. Respiratory irritants were selected because most pesticides applied fell into this classification. In addition, unlike the other toxicological classifications, exposure to this class of compounds could result in a fairly common acute health endpoint (i.e. asthma). This endpoint could be analyzed in an epidemiologic follow-up from small-area exposure assessments of pesticides in the border counties, as envisioned in the EPA's "Pesticides in Young Children at the Border" study. Other endpoints such as cancer are rare in children and have a longer latency.

For each school in the database, the total pounds of pesticides applied (from the top 10 pesticides and for respiratory irritants for 1995) in the TRS unit in which the school was located, and the adjacent 8 TRS units were summed. Since each TRS unit is one square mile, pesticide use "near the school" was defined as use in these 9 TRS units. An actual field with pesticide application could be up to 2.8 miles away from the school location. All the schools were ranked by pounds of pesticides applied near the school. For each county, census tracts were also ranked by the total number of pounds of pesticides and respiratory irritants which were applied to TRS units in which more than half of their area lies within the census tract boundary. Population data from the 1990 U.S. census was used for Imperial County and available 1995 population estimates were used for San Diego County for this analysis**.**

All GIS layers were checked for accuracy by verifying current city/town attribution by overlaying municipal boundaries and by performing a 5% random check of addresses in each data layer. The quality assurance information for each GIS layer can be found in Appendix C. SAS statistical software (SAS Institute Version 6.12, Cary, N.C.) and Arcview software (Version 3.0) were used for all analyses.

G) Toxicological Classification Methods

There are a number of ways in which a pesticide can be classified as to its toxicological potential. They include classification by target organ, effect (e.g. cancer), by poisoning potential, and by general categories such as irritants or corrosives. A preliminary review of the literature by the EPA (see "Pesticides in Young Children" workplan; U.S. EPA) revealed that health conditions including certain cancers and developmental defects were associated with childhood/prenatal exposure to pesticides. Chemicals toxic to the reproductive system may inflict genetic damage to the parent germ cells, leading to developmental effects. In addition, respiratory irritation is an important and appropriate endpoint for consideration as young children in general spend more time out-of-doors, and have a higher rate of breathing than adults. Finally, pesticides classified as acetylcholinesterase (AcHE) inhibitors, due to their action on the central nervous system, are another important category as they are the most common pesticides involved in pesticide poisonings. For the purposes of this report, it was therefore decided to focus on these four toxicological endpoints: carcinogenic potential, reproductive/developmental effects, respiratory irritation, and AcHE inhibition.

Pesticides comprising the top ten (by weight) categories for each of the 5 study years in San Diego and Imperial Counties were assessed toxicologically according to the four classifications. Health effects information for the pesticides/active ingredients was culled from a variety of sources including federal/state governmental agencies and other authoritative bodies, research databases, and the open scientific literature. A partial list of databases searched include the Integrated Risk Information System (IRIS), Toxnet, Hazardous Substances Database (HSDB), Reprotext, Reprotox, Registry of the Toxic Effects of Chemical Substances (RTECS), and Medline. Information for every active ingredient for each classification was not available**.**

The US Environmental Protection Agency (USEPA) carcinogen classification scheme[8] was used to designate carcinogenicity class (i.e. A, B1, B2, C). Any pesticide/active ingredient which had been evaluated by the US EPA for carcinogenic potential and was listed as either a known human carcinogen (Group A), a probable human carcinogen (groups B1 or B2) or a possible human carcinogen (class C) was designated a carcinogen for the purposes of this report.

The primary resource for developmental/reproductive effects information came from CDPR's toxicological summaries. CDPR critically reviews pertinent animal toxicological studies with birth defect and/or reproductive endpoints and summarizes the data for each endpoint as follows: possible adverse effect, no data gap; possible adverse effect, data gap; no adverse effect, data gap; no adverse effect, no data gap; and none (i.e. no study on file). For the purposes of this report, these CDPR designations were assigned a number of 1-4 (respectively); "none" (i.e. no study on file) was listed as none. A 'data gap' results when a toxicological study evaluating a specific endpoint (i.e. birth defect or reproductive effect) is either, a) of poor scientific quality, and/or b) the assay was not carried out using one of the recommended animal models (rat or other rodent species), or was tested in only one species, where testing in two or more different species was required for that endpoint**.** Summaries on individual pesticides are revised by CDPR on a continual basis as new information comes available.

Information used to classify chemicals as acetylcholinesterase inhibitors and/or respiratory irritants was derived from the above mentioned databases and the open literature (see Appendix F). Acetylcholinesterase (AChe) inhibitors are pesticides which exert their toxic action on living organisms by affecting the central nervous system (CNS). By inhibiting AChe, AChe inhibitors cause the chemical transmitter of nerve impulses - acetylcholine - to accumulate in the CNS. Pesticides which exhibit this capacity belong to the chemical classes organophosphate and carbamate, and are generally, insecticides. A pesticide was listed as a respiratory irritant if toxicological/ epidemiological information was available that showed: a) it was an acetylcholinesterase inhibitor, and/or, b) exposure resulted in constriction of the airways and/or other physiological responses such as damage to the cells lining the airway and edema. Literature evaluated for respiratory irritant classification included both animal and occupational exposure studies.

III Quality Control assessment of Pesticide Use Data

A) Quality Control Methods

The PUR database is comprised of several million records per year (statewide). CDPR conducts up to 50 validity checks on the data against the permit files prior to releasing the information as an annual report. In addition, each county is also responsible for verifying the initial data received from the grower/applicator prior to forwarding the information to CDPR. Most of the 50 error checks that comprise CDPR's Loader Program Validations consist of integer, numeric or character field verification, as well as checks on unit of measure conversions.

Further checks were conducted on the PUR database by examining the completeness of critical fields and by looking for outliers in the number of pounds applied in the top 10 pesticides/active ingredients by weight. The following database fields (variables) were searched for missing/miscoded values for each year (1991-1995): application date, chemical code, township range section, crop/commodity, number of pounds of pesticide applied , and mode of application.

Outliers in the distribution of the total pounds applied for each of the top ten pesticides were examined for PUR years 1991-1995. Since there was a large variability in application volume for a particular pesticide, it was decided to compute the application <u>rate</u> (i.e. number of pounds applied per acre) for each of the top ten pesticides.

The following 4 criteria were employed to identify outliers in the number of pounds of pesticides applied per application. Any value which (1) exceeded the pesticide-specific application rate plus two standard deviations, and in which (2) the number of pounds of active ingredient applied was equal to or greater than 100 pounds, and (3) the application rate was equal or greater than 10 pounds/acre, and in which (4) the number of pounds applied looked "unreasonable" (i.e. exceeded the *manufacturer's* application rate) was defined as an outlier. The "unreasonable" criterion was included because certain applications which met the first three criteria were in actuality within the acceptable application range for that particular pesticide ("acceptable" application ranges for a particular pesticide can be found by looking at the manufacturer's fact sheet for that pesticide). Suggested manufacturer application rates are determined by many different factors (e.g. the product formulation, crop, and mode of application).

Verification of outliers in the number of pounds of pesticides applied required site visits to the individual county agricultural commissioner's offices in San Diego and Imperial Counties to obtain copies of the original grower/applicator forms. Agricultural commissioners are only required to maintain the original paper forms for the latest two years for which the CDPR PUR database is available. Consequently, suspect applications for PUR years 1991-1994 could not be verified against the original PUR forms.

B) Quality Control Results

Outliers in the number of pounds of pesticides applied which were found for PUR year 1995 (the only year for which hard copy forms were available) were checked against hard copy grower/applicator forms at the agricultural commissioners offices in San Diego and Imperial Counties (n=21). There were a total of only four outliers (2 for each county) in which grower/application forms could be found and the values on the hard copy form did not match the values in the PUR database. These errors were of 2 types: key data entry errors and grower errors. Key data entry errors consisted of misplaced decimal points, incorrect units of measure entered and/or incorrect number of acres reported. Grower errors consisted of incomplete/inaccurate information (e.g. dilution of formulation indicated but percent dilution not provided, wrong units checked, etc.). The re-computed pounds of pesticides were set to the corrected value in the revised database.

For eight additional outliers in which hard copy forms could be found in San Diego County, the information contained on the grower/applicator form matched the information found in the PUR database, but the number of pounds applied and/or application rate (lbs. pesticide/acre) reported to CDPR exceeded (at times grossly) the manufacturer's application rate. Discussions with the local agricultural commissioner office indicated that due to the high cost of pesticides and other factors such as compliance history, these large outliers were most likely reporting errors and did not reflect the actual application. As mentioned previously, outliers were defined as applications greater than 100 pounds and applied at a rate exceeding 10 lbs/acre, and therefore did not include relatively small exceedences from the manufacturer's application rate.

For these reporting errors and for the remaining outliers in which forms could not be found (n=11), along with identified outliers in the number of pounds of pesticides applied for 1991-1994 data, the 1995 statewide mean application rate was multiplied by the number of acres treated for that specific pesticide application. This resulting value was imputed in the number of pounds of pesticides applied field for each outlier. There were a total of 108 values changed in the corrected dataset (n=75 for San Diego County and n=33 for Imperial County; see Appendix D). PUR year 1995 was chosen as the standard because the data from that year were considered to be the most reliable and complete. While the total number of corrected values were few in number (0.1% of the total applications for the top ten pesticides for San Diego County and 0.03%

for Imperial County), the magnitude of these few outliers was such that the pesticides comprising the top ten (by weight) category for each year were appreciably effected (i.e. pesticides in the top ten by weight were dropped/added or shifted in rank for both counties).

Evaluation of completeness for mode of application found a total of 420 missing values (0.3% of top 10 pesticide applications) for both counties for 1991-95. There were no missing values for application date, chemical code, or crop/commodity. There were 139 (0.09% of applications) missing values identified in the township, range, and section (TRS) field. For miscoded values, in place of the standard spatial descriptive parameters designating a physical site, "00 00 00" was entered in the TRS field by CDPR. For these values, it was confirmed that these were actual pesticide applications in which the physical site had not been coded to the TRS system. They were determined not likely to be either structural or fumigation applications but rather more likely to be applications to industrial/institutional areas.

In addition to these missing/miscoded TRS values, an additional number of TRS values could not be linked to the public land survey layer. From the top ten pesticide applications, we found a total of 6 applications where the survey section number could not be linked in San Diego County boundary files, and 9 applications which could not be linked in Imperial County boundary files. Examination of these applications revealed that mislinkage occurred due to out of county sections, and sections in which no survey section number in the public lands survey boundary file could be found. These latter errors are probably due to farmer/key entry errors or inaccuracies in the boundary files.

IV Results

A) Top 10 pesticides by weight

Table 1 shows the top 10 pesticides and/or active ingredients (by weight) applied to agricultural crops/commodities in Imperial County for years 1991 to 1995. The top 10 pesticides account for between 78-86% of all pesticides used by weight each year in Imperial County. Sulfur was the top pesticide applied in 1991-1993, and metam-sodium was the top pesticide used for the last two years of the study period (years 1994-1995). With the exception of metam-sodium in PUR year 1991, use of sulfur and metam-sodium exceeded a million pounds per year. Metam-sodium is a broad-spectrum biocide, and is used as an insecticide, nematacide, herbicide, fungicide, and soil fumigant. Elemental sulfur is used to control a variety of plant diseases and its primary use is as a fungicide/acaricide (control of mites).

The other pesticides making up the top ten active ingredients by weight ranged from approximately 72,000 to 303,000 pounds per year. Chlorothalonil and methyl bromide, like sulfur, are fungicides applied to a wide range of foodstuffs; methyl-bromide (MeBr) is also employed as a pre-plant soil fumigant and is used for insect/rodent control in space/commodity fumigation. Because MeBr is an odorless gas, during soil fumigant applications, the soil fumigant chloropicrin is applied in tandem with MeBr as a warning agent or odorant. Chlorpyrifos, dimethoate, endosulfan, methomyl, and malathion, like metam-sodium and methyl bromide, are insecticides with activity against a wide variety of sucking/chewing insects. Chlorthal dimethyl (dacthal), EPTC (S-ethyl dipropylcarbamate), and trifluralin (treflan) are, like metam-sodium, largely pre-emergence herbicides and are used on a wide variety of fruits/vegetables, ornamentals and turf to control weeds/perennial grasses.

The primary mode of pesticide application for the top ten pesticides in Imperial County is by air. For PUR year 1995, there are approximately twice as many air applications as ground applications (13,697 by air vs. 6,622 by ground). This choice of application mode may be facilitated in part by the fact that Imperial County is largely agricultural with large contiguous tracts of cropland. Amongst this top ten subgroup of the PUR data, the top four pesticides with the highest number of
applications over the 5 year study period are methomyl, dimethoate, chlorpyrifos, and malathion. All of these compounds are insecticides. The latter three are organophosphates while methomyl is a carbamate. These compounds require frequent re-application as they are rapidly degraded by sunlight. All four of these insecticides are applied via both air and ground, although application by air is the predominant method of application in each case. Chlorothalonil, chlorthal-dimethyl, EPTC, metam-sodium and methyl bromide are all almost exclusively applied by ground.

Table 2 shows the top 10 pesticides applied by weight to agricultural crops/commodities in San Diego County for years 1991 to 1995. The soil fumigant methyl bromide was the pesticide applied in greatest volume, with between 300,000 to approximately 500,000 pounds applied each year. Other pesticides comprising the top ten category ranged in use from 7,000 to 252,000 pounds per year, and included the soil fumigant chloropicrin and the multi-use pesticide metam-sodium; the fungicides chlorothalonil, sulfur, and copper hydroxide; the herbicides, simazine, glyphosate, and petroleum and mineral oils; and the insecticides/acaracides dienochlor, propargite, and potash soap - a non-systemic miticide. Petroleum oil and mineral oil may be used as insecticides and/or herbicides, and may also be used as an adjuvant to boost the efficacy of fungicides.

In contrast to Imperial County, the predominant mode of pesticide application in San Diego County for the top ten pesticides is via ground application. For PUR year 1995, there were 9,636 applications by ground as opposed to only 673 by air. The use of ground applied pesticides may be driven in part by the fact that San Diego County is largely residential/industrial with isolated tracts of agricultural lands and/or hot houses for growing ornamental flowers, etc. Amongst this top ten subgroup of the PUR database, the organophosphate herbicide glyphosate has the highest number of pesticide applications in each of the 5 study years, followed by chlorothalonil and potash soap. All three are almost exclusively applied via ground application. Glyphosate is the only top ten (by weight) organophosphate pesticide applied in San Diego County and, as stated previously, organophosphates require frequent re-application due to thermal degradation. Chlorothalonil is employed as a fungicide and potash soap is used as an insecticide. For PUR years 1994-1995, potash soap replaces chlorothalonil as the second most frequently applied pesticide in the top ten (by weight) subgroup. Potash soap, an irritant potassium salt, is considered to have low systemic toxicity.

Table 1. Top Ten Pesticides (by weight) Applied in Imperial County, 1991-1995

1991

Pesticide	Total lbs	Average lbs (per appl)
Sulfur	2,489,596.6	1,528.3
Metam-sodium	983,421.6	5,258.9
Trifluralin	303,811.2	119.2
EPTC*	257,528.9	167.9
Malathion	257,352.5	78.6
Chlorthal-dimethyl	220,471.3	233.3
Dimethoate	144,548.2	23.4
Endosulfan	143,111.7	34.5
Chlorpyrifos	140,437.8	41.7
Methomyl	138,546.9	24.0

1992

Pesticide	Total lbs	Average lbs (per appl)
Sulfur	2,464,944.0	1,530.1
Metam-sodium	1,755,878.9	9,754.9
Malathion	179,730.0	80.4
EPTC*	164,003.3	181.2
Chlorthal-dimethyl	145,947.9	224.5
Methyl bromide	137,625.5	5,734.4
Trifluralin	132,552.5	105.0
Chlorpyrifos	94,500.4	40.3
Methomyl	76,394.1	25.0
Chlorothalonil	74,286.6	62.5

1993

Pesticide	Total lbs	Average lbs (per appl)
Sulfur	2,121,162.6	1,629.2
Metam-sodium	1,115,498.0	7,290.8
Malathion	169,188.9	81.7
Chlorthal-dimethyl	157,515.6	217.0
Trifluralin	149,661.4	108.1
EPTC*	143,652.5	167.2
Methomyl	100,637.8	23.1
Chlorpyrifos	94,150.8	39.8
Methyl bromide	75,432.1	7,543.2
Chlorothalonil	72,261.7	58.7

1994

Pesticide	Total lbs	Average lbs (per appl)
Metam-sodium	1,906,802.0	8,706.9
Sulfur	1,724,271.0	1,473.7
Trifluralin	217,380.4	121.1
Malathion	204,819.6	94.5
Methyl Bromide	199,586.4	4,868.0
EPTC*	157,259.0	167.8
Chlorthal-dimethyl	129,842.1	213.2
Methomyl	114,922.8	25.2
Chlorpyrifos	107,144.6	41.2
Dimethoate	79,083.2	21.1

1995

Pesticide	Total lbs	Average lbs (per appl)
Metam-sodium	3,184,583.6	10,407.1
Sulfur	2,401,681.3	1,651.8
Methyl Bromide	268,962.1	3,404.6
Malathion	267,254.5	98.6
Trifluralin	250,446.6	121.5
Methomyl	148,174.4	25.4
EPTC*	147,870.5	157.0
Chlorthal-dimethyl	134,561.7	230.8
Chlorpyrifos	110,520.0	39.3
Dimethoate	78,092.7	21.0

*EPTC = S-ethyl dipropylthiocarbamate

Table 2. Top Ten Pesticides (by weight) Applied in San Diego County, 1991-1995

1991

Pesticide	Total lbs	Average lbs (per appl)
Methyl Bromide	376,317.0	1,154.4
Petroleum Oil	104,559.4	184.1
Chloropicrin	91,532.4	304.1
Mineral Oil	70,073.3	3,503.7
Glyphosate	31,490.9	7.2
Chlorothalonil	27,187.9	24.2
Sulfur	24,512.8	58.5
Simazine	10,676.5	14.2
Potash Soap	8,721.4	8.2
Dienochlor	7,187.6	7.2

1992

Pesticide	Total lbs	Average lbs (per appl)
Methyl Bromide	499,281.3	922.9
Petroleum oil	169,872.8	207.2
Chloropicrin	132,004.3	1,157.9
Mineral Oil	96,984.5	2,552.2
Sulfur	75,807.5	115.0
Glyphosate	31,719.6	7.4
Chlorothalonil	26,915.8	20.8
Metam-sodium	10,407.5	116.9
Simazine	8,825.5	11.3
Propargite	8,160.4	173.6

1993

Pesticide	Total lbs	Average lbs (per appl)
Methyl Bromide	474,855.9	871.3
Petroleum Oil	252,900.0	320.1
Mineral Oil	173,139.3	2,748.2
Chloropicrin	100,467.4	772.8
Sulfur	81,091.6	81.8
Metam-sodium	50,111.2	432.0
Glyphosate	30,855.8	6.5
Chlorothalonil	26,874.3	20.2
Propargite	25,191.7	124.1
Potash Soap	10,911.0	8.4

1994

Pesticide	Total lbs	Average lbs (per appl)
Methyl Bromide	434,215.5	1,233.6
Petroleum oil	209,761.4	202.9
Chloropicrin	99,827.6	612.4
Mineral Oil	80,378.5	3,494.7
Sulfur	49,972.1	85.3
Metam-sodium	43,812.3	339.6
Chlorothalonil	28,339.0	22.5
Glyphosate	28,254.8	6.8
Propargite	25,229.6	116.3
Potash Soap	24,087.1	11.2

1995

Pesticide	Total lbs	Average lbs (per appl)
Methyl Bromide	328,928.8	1,364.8
Petroleum Oil	165,859.5	208.6
Chloropicrin	98,912.9	760.9
Mineral Oil	61,784.0	4,118.9
Metam-sodium	49,927.7	567.4
Glyphosate	31,583.7	7.8
Sulfur	26,583.9	40.6
Potash Soap	23,113.3	8.7
Chlorothalonil	22,811.9	20.4
Copper Hydroxide	7,161.2	13.0

B) Top 10 pesticides by frequency

Since the number of times a particular pesticide/active ingredient is applied in any given year may increase the potential/severity of exposure, pesticides were also ranked by frequency of application for each year without regard to their total volume (pounds) of application (Tables 3-4). In Imperial County, phosphoric acid is the most frequently applied substance out of all pesticides applied each year for four out of the five years examined. The bulk of the fourteen chemicals which comprise the top ten most frequently applied pesticides over the 5 year study period are insecticides; most belong to the chemical class organophosphate.

In San Diego County, the herbicide glyphosate, and isopropyl alcohol are the two most frequently applied pesticides/active ingredients for the years 1991-1994. **.** Although a member of the organophosphate class, glyphosate does not inhibit AcHE. Isopropyl alcohol and its biotransformation product, acetone, potentiate the toxicity of a number of other chemicals. As is the case with Imperial County, the majority of the top ten pesticides/active ingredients applied most frequently in San Diego County are insecticides. Pyrethrins among the most frequently applied class of active ingredients for years 1994/1995, are botanical insecticides derived from the chrysanthemum flower. Human exposure to pyrethrum has been associated with contact dermatitis, asthma-like attacks and anaphylactic reactions**.**[9] Rotenone is another example of a botanical insecticide derived from plant extracts; it is highly irritating to eyes, skin, and upper respiratory tract. Fluvalinate, a synthetic pyrethroid derived from the natural pyrethrins is a restricted use pesticide. As a class, synthetic pyrethroids have been associated with a large number of acute pesticide poisionings.[10,11,12,13] Piperonyl butoxide, an insecticide synergist, is frequently used in conjunction with pyrethrins and fluvalinate to potentiate toxicity. Acephate is an organophosphorus insecticide with the capacity to inhibit AcHE in insects and mammals. Strychnine, a rodenticide, is an intensely toxic vertebrate poison with a lethal dose of a few milligrams per kilogram of body weight for most animals. Iprodione, a dicarboximide, metalaxyl, a benzenoid, and thiophanate-methyl are fungicides; iprodione is a restricted use pesticide.

Table 3. Ten Most Frequently Applied Pesticides in Imperial County, 1991-1995

1991

Pesticide	# of appl	Frequency of Application (%)
Dimethoate	6,169	6.2
Phosphoric Acid	5,868	5.9
Methomyl	5,764	5.8
Isopropyl Alcohol	4,337	4.4
Endosulfan	4,151	4.2
Permethrin	3,645	3.7
Chlorpyrifos	3,369	3.4
Malathion	3,273	3.3
*	3,135	3.2
Diazinon	2,989	3.0

1992

Pesticide	# of appl	Frequency of Application (%)
Phosphoric Acid	3,055	5.4
Methomyl	3,050	5.4
Isopropyl Alcohol	2,445	4.3
Dimethoate	2,370	4.2
Chlorpyrifos	2,344	4.1
Malathion	2,236	3.9
Diazinon	2,162	3.8
Permethrin	2,075	3.7
Sulfur	1,611	2.8
Esfenvalerate	1,606	2.8

1993

Pesticide	# of appl	Frequency of Application (%)
Phosphoric Acid	4,953	6.6
Isopropyl Alcohol	4,533	6.0
Methomyl	4,350	5.8
*	2,870	3.8
Permethrin	2,840	3.8
Dimethoate	2,734	3.6
Chlorpyrifos	2,368	3.2
Diazinon	2,234	3.0
Malathion	2,070	2.8
Esfenvalerate	1,880	2.5

1994

Pesticide	# of appl	Frequency of Application (%)
Phosphoric Acid	8,168	9.7
Isopropyl Alcohol	6,139	7.3
*	4,820	5.7
Methomyl	4,570	5.4
Dimethoate	3,756	4.5
Permethrin	3,230	3.8
Chlorpyrifos	2,598	3.1
Carbofuran	2,370	2.8
Esfenvalerate	2,315	2.8
Malathion	2,168	2.6

1995

Pesticide	# of appl	Frequency of Application (%)
Phosphoric Acid	8,662	9.0
Isopropyl Alcohol	6,706	7.0
Methomyl	5,824	6.1
*	5,457	5.7
Permethrin	3,979	4.1
Dimethoate	3,717	3.9
Chlorpyrifos	2,810	2.9
Malathion	2,711	2.8
Poly-I-Para Menthene	2,386	2.4
Esfenvalerate	2,299	2.4

* Alkylaryl-polyoxyethylene Ethanol

Table 4. Ten Most Frequently Applied Pesticides/Active Ingredients in San Diego County, 1991-1995

1991

Pesticide	# of Appl	Frequency of Application (%)
Glyphosate	4,362	6.6
Isopropyl Alcohol	2,919	4.4
Acephate	2,410	3.6
Strychnine	2,380	3.6
Iprodione	2,364	3.6
*	2,286	3.5
Metalaxyl	2,071	3.1
Avermectin	2,033	3.1
Chlorpyrifos	1,684	2.6
**	1,599	2.4

1992

Pesticide	# of Appl	Frequency of Application (%)
Glyphosate	4,310	5.6
Isopropyl alcohol	3,412	4.4
Iprodione	3,178	4.1
Acephate	3,116	4.0
Metalaxyl	2,642	3.4
*	2,492	3.2
**	2,471	3.2
Avermectin	2,348	3.0
Chlorpyrifos	1,881	2.4
Fluvalinate	1,832	2.4

1993

Pesticide	# of Appl	Frequency of Application (%)
Glyphosate	4,724	6.0
Isopropyl alcohol	2,896	3.7
Iprodione	2,797	3.6
**	2,786	3.5
Acephate	2,743	3.5
Metalaxyl	2,273	2.9
Avermectin	2,180	2.8
Styrchnine	2,098	2.7
Thiophanate-methyl	2,062	2.6
Fluvalinate	1,999	2.5

1994

Pesticide	# of Appl	Frequency of Application (%)
Isopropyl Alcohol	4,410	5.6
Glyphosate	4,145	5.3
Pyrethrins	4,042	5.1
Avermectin	2,630	3.3
Acephate	2,373	3.0
Potash Soap	2,157	2.7
**	2,149	2.7
Rotenone	2,057	2.6
Piperonyl butoxide	2,057	2.6
Iprodione	1,985	2.5

1995

Pesticide	# of Appl	Frequency of Application (%)
Glyphosate	4,058	5.3
Pyrethrins	3,784	4.9
Isopropyl Alcohol	3,213	4.2
Potash Soap	2,658	3.4
Avermectin	2,294	3.0
**	2,284	3.0
Acephate	2,271	3.0
Piperonyl Butoxide	2,058	2.7
Piperonyl Butoxide (other)	2,058	2.7
Iprodione	1,941	2.5

* Alkylaryl-polyoxyethylene glycol
** Modified phthalic glycerol alkyd resin

C) Toxicological classifications

A total of 22 pesticides/active ingredients were identified in the top ten category (by weight) applied to agricultural crops/commodities in San Diego and Imperial Counties for years 1991 through 1995 (Table 5). Each of these 22 pesticides was assessed for its potential toxicity in the following 4 toxicity classes: acetylcholinesterase inhibition, carcinogenicity, respiratory irritation, and reproductive/developmental effects.

Acetylcholinesterase Inhibitors

A total of six compounds, chlorpyrifos, diazinon, dimethoate, EPTC (S-ethyl dipropylthiocarbamate), malathion and methomyl, were classified as acetylcholinesterase (AChe) inhibitors. Of these, four belong to the class of pesticides known as organophosphates: chlorpyrifos, diazinon, dimethoate and malathion, and two, EPTC and methomyl, are carbamates. Appendix E shows toxicity category designations based on oral, inhalation, or dermal toxicity, as well as on eye and skin effects data derived from short-term animal bioassays. Toxicity Categories (I-IV) refer to the level of toxicity of a chemical substance, and the EPA has published regulations for use of human hazard signal words on pesticide labels. For example, any pesticide with an oral LD50 $\leq$ 50 mg/kg, and/or any of the following, an inhalation LC50 $\leq$ 0.2 mg/liter, a dermal LD50 $\leq$ 200 mg/kg, corrosive corneal opacity not reversible within 7 days, or skin corrosivity, meets the criteria of Toxicity Category I.

Based on these toxicity categories, Methomyl is considered to be the most acutely toxic of the six AChe inhibitors as it carries a Toxicity Category I designation (Table 5), followed by dimethoate and chlorpyrifos (Toxicity Category II), diazinon (Toxicity Category II or III), and finally malathion and EPTC (Toxicity Category III). All of the acetylcholinesterase inhibitors are insecticides, with the exception of EPTC, an herbicide. Acetylcholinesterase inhibition results in an accumulation of acetylcholine in the central nervous system, which could lead (in high doses) to symptoms such as slurred speech, tremor, weakness, ataxia, convulsions, and depression of respiratory and circulatory centers. As a toxicity class, AChe inhibitors have been the pesticides most frequently involved in human poisonings. Studies in laboratory animals have shown that continuous or prolonged exposure to high doses of acetylcholinesterase inhibitors leads to marked blood and nervous tissue cholinesterase activity inhibition, as well as elevated levels of acetylcholine in brain tissue[14-15]. The long-term effects of exposure to AChe inhibitors in humans are not known.

Carcinogenicity

Among the top ten pesticides evaluated over the 5 year study period, there were no EPA Group A carcinogens (i.e. known human carcinogens). Chlorothalonil, metam-sodium and propargite are listed by EPA as group B2 carcinogens (probable human carcinogen - sufficient evidence in animals, inadequate evidence in humans). Diemethoate, simazine and trifluralin are listed by EPA as group C carcinogens (possible human carcinogen - no human, limited animal studies). These six compounds comprise widely divergent chemical classes and include insecticides, acaracides, herbicides and fungicides. Ten of the 22 compounds which make up the top ten pesticides
applied by weight have not been evaluated by US EPA or any other authoritative body for their carcinogenic potential.

Respiratory Irritants

Fourteen out of 22 of the pesticides comprising the top ten are known respiratory irritants, affecting the lungs and/or other mucous membranes of the nasal passages (see Appendix F for references). Two of the most severe respiratory irritants in the top ten are chloropicrin, a soil fumigant, and metam-sodium, also a fumigant, whose break-down product, MITC (methyl isothiocyanate), causes eye and throat irritation, dizziness and shortness of breath at low levels. Both of these pesticides have a Toxicity Category I designation for acute effects (Table 5). Chloropicrin is a strong lacrymator and exposure to airborne concentrations > 0.15 ppm (1 mg/m^3) cause tearing and eye irritation.[16] It is frequently applied in conjunction with the fumigant gas methyl bromide as a warning agent or odorant. Prolonged inhalation exposure to airborne concentrations of chloropicrin in excess of 1 ppm may cause irritation of the airways, shortness of breath and/or tightness in chest, and difficulty breathing.

Table 5: Toxicologic Classifications of pesticides applied to agricultural crops/commodities in San Diego and Imperial Counties, 1991-1995

Pesticide Name	CAS NO.	Chemical Class	Toxicity Class (acute effects)	AChe Inhibition	EPA Cancer Classification	Repro/Dev. Effects	Respiratory Irritation
Chloropicrin	76-06-2	CCl3NO2	I (eye)			X	X (severe)
Chlorothalonil	1897-45-6	Nitrile	I		B2		X
Chlorpyrifos (Dursban)	2921-88-2	OP	II	X			X
Chlorthal-dimethyl	1861-32-1	Phthalate	IV				
Copper Hydroxide	20427-59-2	metal	III				X
Diazinon	333-41-5	OP	II or III	X		X	X
Dienochlor	2227-17-0	organochlorine	II				
Dimethoate	60-51-5	OP	II	X	C	X	X
Endosulfan	115-29-7	Chlorinated HC*	I				
EPTC	759-94-4	Carbamate	III	X		X	X
Glyphosate (Roundup)	1071-83-6	OP**	I (eye)				X
Malathion	121-75-5	OP	III	X			X
Metam-sodium	137-42-8	Carbamate	I		B2	X	X(severe-MITC product)
Methomyl	16752-77-5	Carbamate	I	X			X
Methyl Bromide	74-83-9	Alkyl bromide	I			X	X
Mineral Oil (petroleum)	8012-95-1	Mixture of HC					X
Petroleum Oil		Mixture of HC					X
Potash Soap	61790-44-1	***					
Propargite	2312-35-8	Sulfite ester	I		B2	X	
Simazine	122-34-9	Triazine	IV		C		
Sulfur	7704-34-9	elemental sulfur	IV				X
Trifluralin	1582-09-8	Dinitroaniline	I, II or III		C		

Key:

AChe = acetylcholinesterase

EPTC = S-ethyl dipropylthiocarbamate

MITC = methyl isothiocyanate

OP = organophosphate

* = sulfurous acid ester of chlorinated cyclic diol (cyclodiene subgroup)

** = an OP compound (a phosphanoglycine) but not an OP ester (does not inhibit AChe)

*** = potassium salt of tall oil fatty acids

B2 = probable human carcinogen; C = possible human carcinogen

Six out of 14 of the pesticides listed as respiratory irritants - chlorpyrifos, diazinon, dimethoate, EPTC, malathion and methomyl - are AChe inhibitors, and it is via this toxic mechanism that they cause a general depression of the respiratory and circulatory centers. Signs and symptoms of respiratory irritation following exposure to these compounds may include: tightness in the chest, wheezing, increased bronchial secretions, and dyspnea (difficulty breathing). In addition, contaminants which are often present in the formulation of these pesticides include sulfur-containing compounds which are irritating to the respiratory tract. Mineral and petroleum oils are irritating to airway passages and, like other low viscosity solvents, present a risk of aspiration and development of chemical pneumonia.

Reproductive/Developmental Effects

For the reproductive/developmental effects category, a total of 7 out of the 22 pesticides listed in the top ten by weight category carry a category 1 designation (possible adverse effect, no data gap) for at least one endpoint (see Appendix G). These 7 pesticides include the fumigants methyl bromide and chloropicrin, the organophosphate insecticides diazinon and dimethoate, the acaricide propargite, and the carbamates metam-sodium and EPTC (an herbicide). Based on the animal evidence accumulated thus far, methyl bromide appears to be the most hazardous pesticide from a reproductive/developmental standpoint. For all the endpoints listed, birth defects in two species, and reproductive effects in one, methyl bromide carries a category 1 designation (possible adverse effect, no data gap). Methyl Bromide is also listed under California's Proposition 65 as a chemical known to the State of California to cause reproductive toxicity.

MITC, the break down product of the multi-use pesticide metam-sodium, carries a category 2 designation (possible adverse effect, data gap) for reproductive endpoints. Metam-sodium, its parent compound, has been shown to have no adverse effects on reproduction (category 4) but is listed as a category 1 for birth defects in two separate non-human species. Eight pesticides in the top ten carry a category 4 designation (no adverse effect, no data gap). It is important to acknowledge that all of the data comprising the CDPR toxicological summaries result from controlled laboratory animal studies, and that no comparable findings exist for any of these pesticides concerning adverse reproductive/developmental effects in humans. Conversely, negative findings (category 4) in animal studies do not mean that adverse reproductive/developmental effects may not occur in humans. For five of the pesticides, sulfur, potash soap, petroleum and mineral oil, and dienochlor, no reproductive/developmental studies were available for review.

D) Time trends of pesticide use

Figure 16 shows the time-trends of total pesticide use in pounds for the two California border counties from 1991 to 1995. Pesticide use in Imperial County is high relative to San Diego County, with over 5 million pounds applied annually each year. In 1995, over 8 million pounds of the pesticides were applied in Imperial County, a 24% increase from 1991. Although they are similar in geographic area, pesticide use was 4-8.5 times higher in Imperial than San Diego County over the time period. It is not known what caused the apparent drop in pesticide use in 1993 in Imperial County. In San Diego County, total pesticide use increased 7% over the time period, with annual pesticide use averaging 1.12 million pounds.

The time trends of the pesticides used in the greatest volume for 1995 in the 2 counties, metam-sodium, for Imperial County, and methyl bromide, for San Diego County, is shown in Figure 17. Except for the dip in use in 1993, it is apparent that use of metam-sodium in Imperial County increased rapidly, from 980,000 pounds annually in 1991 to over 3 million pounds in 1995, a 224% increase. In contrast, methyl bromide use in San Diego County, following trends in overall pesticide use in that county, appears to be relatively constant.

Figures 18 and 19 show the trends over time of the top ten pesticides by the four toxicity classes (acetylcholinesterase inhibitors, reproductive/developmental toxicants (animal data), respiratory irritants, and possible/probable human carcinogens) in Imperial and San Diego. In Imperial County, the largest amount of pesticide use by weight is for the class of respiratory irritants. Use of this class increased 49% (from 4.4 to 6.6 million pounds) from 1991 to 1995. Reproductive/developmental toxicant and carcinogen use was similar; they increased 165% and 145% over the time period, respectively (from approximately 1.4 to 3.6 million pounds). Use of pesticides which were acetylcholinesterase inhibitors decreased 20% (from approximately 940 to 752 thousand pounds).

Respiratory irritants and reproductive/development toxicants were the top 2 toxicological classes by weight from the top 10 pesticides for San Diego County, showing a peak in use in 1993. While use of reproductive toxicants showed only a 2% increase in use from 1991 to 1995 (from

468 to 478 thousand pounds), use of respiratory irritants increased 9% (from 726 to 794 thousand pounds). Use of pesticides classified as possible/probable human carcinogens increased 92% (from 38 to 73 thousand pounds).

E) Top crops treated with pesticides

The distribution of all pesticides (not just the top 10 by weight) applied on the top 10 crops treated with pesticides was used for this analysis. Carrots, sugarbeets, and alfalfa were the top three crops/commodities which are treated with pesticides in Imperial County in 1995 (Table 6). Carrots are primarily treated with metam-sodium (94% of total poundage of pesticides applied on carrots in 1995) and sugarbeets are primarily treated with sulfur (86% of total poundage). Sulfur is also the primary compound used on bermuda grass (#7 crop/commodity), accounting for 73% of the total poundage. Alfalfa is treated with numerous pesticides, but mostly sulfur (23%), trifluralin (18%), and malathion (18%). Cantaloupes (#4 crop) are treated mostly with metam-sodium (57%) and sulfur (33%); while watermelons (#9 crop) are treated mostly with methyl bromide (55%) and metam-sodium (32%). Metam-sodium is also the top pesticide used on potatoes (#8 crop), accounting for 85% of total pesticide poundage, while methyl-bromide is the top pesticide used on peppers (#10 crop), accounting for 75% of total poundage. Numerous pesticides are used on lettuce (#5 crop). Only three account for over 10% of the total poundage of pesticides: methomyl (19%), methyl bromide (13%), and metam-sodium (12%). Chlorthal-dimethyl accounts for a quarter of the total poundage of pesticides used on onions (#6 crop), along with metam-sodium (19%), and chlorothalonil (14%).

Citrus fruits, tomatoes, strawberries, and cut flowers are among the top crops which are treated with pesticides in San Diego County (Table 6). Several crops are primarily treated with methyl bromide along with chlorpicrin. They include the top crop, tomatoes, (65% of total pounds for methyl bromide and 18% of total pounds for chlorpicrin); the number 4 crop, outdoor grown cut flowers (64% and 19% of total pounds, respectively) and the number 5 crop, strawberries (62% and 25%, respectively). Nursery-greenhouse grown cut flowers/greens (#7 crop) are also treated with methyl bromide (37%) and chlorpicrin (17%), but also potash soap (16%). Oranges and lemons (crops 2 and 3) are primarily treated with petroleum and mineral oils (54% and 33%, respectively for oranges, and 69% and 18%, respectively, for lemons). Nursery- outdoor grown container/field grown plants (#6 crop) are treated with numerous pesticides, but primarily petroleum oils (18%) and glyphosate (10%). Avocados (#8 crop) are treated with glyphosate (35%), sulfur (31%), and petroleum oils (24%). The number 9 and 10 crops, cucumbers and potatoes, are primarily treated with metam-sodium (76% and 81%, respectively).

F) Seasonal trends

Figure 20 shows the distribution by month of the top five pesticides in Imperial County using 1995 data. Sulfur applications take place mainly in the late winter and spring, with approximately 800,000 pounds being applied in March. Metam-sodium is primarily applied in the late summer and early fall, peaking in September, the month that school begins, with over 1.3 million pounds being applied. Total poundage applied of methyl bromide, malathion, and trifluralin is small compared to sulfur and metam-sodium. Use of the top five pesticides is lowest in the months of June, July, and November through January.

August is the peak month for application of the top five pesticides in San Diego County (Fig. 21). Methyl-bromide comprises the bulk of the applications for that month, with approximately 55,000 pounds. Methyl-bromide is used every month, with use peaking in May and August. Petroleum oil use is also highest in August, with over 42,000 pounds used. The seasonal distribution of chloropicrin follows that of methyl-bromide, as they are often used in combination. Use of the top five pesticides is lowest from November to January in San Diego County.

G) Geographic distribution of pesticide use (1995 data)

Use of the top 10 pesticides is ubiquitous throughout the Imperial Valley, with heaviest use to the south-west of the Salton Sea, in the northern part of the valley near Calipatria, in the north-west near Westmorland, and in the south-east near Holtville (Figure 22). Other pockets of high use exist throughout the Valley, such as south of El Centro. The distribution of respiratory irritants (Fig 23) is similar, as most of the top 10 pesticides are also respiratory irritants.

Table 6 Top Ten Agricultural Crops/Commodities Treated with Pesticides in 1995 in Imperial and San Diego Counties*

Imperial County				San Diego County		
Crop/ Commodity	**Total Applied Pesticides (lbs)**	**Average per application (lbs)**		**Crop/ Commodity**	**Total Applied Pesticides (lbs)**	**Average per application (lbs)**
Carrots, general	2,500,805.9	1,115.9		Tomato	286,068.2	80.3
Sugarbeet	1,711,791.5	196.2		Orange	112,647.2	41.6
Alfalfa (forage)	1,207,907.0	45.1		Lemon	103,407.8	31.9
Cantaloupe	592,066.1	187.7		Nursery-Outdr Grwn cut flowers or greens	101,839.4	11.6
Lettuce, head	287,492.2	18.1		Strawberry	83,933.7	84.0
Onion	275,623.0	43.8		Nursery-Outdr container/field grwn plants	49,129.8	4.5
Bermudagrass	221,720.0	143.1		Nursery-grnhs grwn cut flowers/greens	40,274.7	4.9
Potato	213,223.6	297.4		Avocado	38,859.4	14.8
Watermelons	181,123.4	226.1		Cucumber	32,157.7	34.9
Peppers	147,216.4	345.6		Potato	23,536.0	240.2

(Source: CA Dept. of Pesticide Regulation 1995 Pesticide Use Report)

Concentration of top 10 pesticide use in San Diego County is highest in the north-west part of the county, from Encinitas to Fallbrook (Fig. 24). Again, the distribution of pesticides which are respiratory irritants are similar to the distribution of all top 10 pesticides, as most of the top 10 were respiratory irritants (Fig. 25).

H) Rank order of schools and pesticide use

Imperial County

Out of 52 public schools in Imperial which were geocoded, 33 (64%) had grades from kindergarten through the 6th grade. All 33 of these schools had pesticide use within 2.8 miles of the school location. There was a total of 16,516 students enrolled in these schools. The smallest school had 67 students and the largest 1566, with an average of 500.5 students per school. There was a total of 1,090,352 pounds of the top ten pesticides applied in the nine survey sections surrounding these schools in 1995, or 33,040 pounds per school.

Table 7 shows the top 10 public schools in Imperial County ranked by proximity to the top 10 pesticides and respiratory irritants for 1995. The school identification number, lowest and highest grade, total enrollment, number of children enrolled (kindergarten to 6th grade) and pesticide factor (in pounds) is shown for each school. The most numerous schools with high proximity to pesticides were in El Centro and Holtville.

Out of 8 private schools which were geocoded in Imperial County, 7 (88%) met the criteria of elementary school district location, kindergartens, or schools with grades K through 12. All 7 had pesticide use within 2.8 miles of the school location. Six of the schools were in elementary school districts, and one was a K to 12th grade school. A total of 1323 students were enrolled in these schools, with a minimum of 38 and a maximum of 648, and an average of 189 students per school. There was a total of 167,283 pounds of the top ten pesticides applied in the surrounding survey sections in 1995, or 23,898 pounds per school. The ranking of proximity of pesticides to private schools in Imperial County is shown in Table 8. One private school in Holtville was the highest in terms of pesticide proximity for all top 10 pesticides and for respiratory irritants, yet this school only had 38 children enrolled.

San Diego County

Out of 511 public schools in San Diego County which were successfully geocoded, 389 (76%) had students in grades kindergarten through 6th grade. Out of these 389 schools, 216 (55%) had pesticide use within 2.8 miles of the school location. There were a total of 138,628 children in these schools. The minimum number of students was 13, and the maximum was 1420, with an average of 641 students per school in these schools. There was a total of 724,698 pounds of the top ten pesticides applied in the surrounding survey sections in 1995, or 3355 pounds per school. This average amount is ten-fold lower than that for schools in Imperial County. Most of the top 10 public schools which were ranked by proximity to pesticides were in Oceanside (Table 9). However, one school in Rancho Santa Fe and Escondido were at the top of the lists for schools ranked by proximity to the top ten pesticides and respiratory irritants.

Out of 269 private schools which were successfully geocoded in San Diego County, 253 (94%) met the criteria of elementary school district location, kindergartens, or schools with grades K through 12. Out of these 253 schools, 135 (53%) had pesticide use within 2.8 miles of the school location. Twenty percent of these schools were kindergartens, 29% were K through 12th grade schools, and 51% were in elementary school districts. A total of 14,506 children were enrolled, with a minimum of 6 to a maximum of 697 children per school, an average of 107.5 children per school. There was a total of 367,983 pounds of the top ten pesticides applied in the surrounding survey sections in 1995, or 2725 pounds per school.

Most of the top 10 private schools ranked by proximity to pesticides were in Encinitas (Table 10). The top private school with the highest pesticide usage up to 2.8 miles away was in Escondido, with a total of 97,543 pounds of the top 10 pesticides applied in 1995. This school was also the highest for pesticide proximity for respiratory irritants. There are 154 students enrolled at this school.

Table 7: Top 10 public schools in Imperial County ranked by top ten pesticides and respiratory irritants, 1995.

School ID Number	City	Lowest Grade	Highest Grade	Total Enrollment	Children Enrolled (Pre to 6)	Aggregate of Top 10 Pesticides in Proximity to School (Pounds)	Respiratory Irritants (pounds)
13632306008650	Westmorland	KG	8	514	387	138,170	130,213
13631986008619	El Centro	KG	8	519	397	123,412	119,950
13632066008627	Brawley	KG	8	92	67	116,940	107,660
13631806008593	El Centro	KG	8	538	421	97,103	89,081
13631496008510	Holtville	KG	5	761	761	70,245	68,254
13631496008528	Holtville	6	8	403	121	70,245	68,254
13631236008411	El Centro	KG	4	528	502	64,479	58,115
13631076008395	Calipatria	5	8	355	169	60,365	57,249
13631076103535	Calipatria	KG	4	434	434	60,365	57,249
13631496008536	Holtville	KG	8	190	156	54,713	50,986

Table 8: Private schools in Imperial County ranked by pesticide groupings, 1995

School ID Number	City	California Department of Education School Ownership Description	Total Enrollment	Aggregate of Top 10 Pesticides in Proximity to School (Pounds)	
				All	Respiratory Irritants
13631496933907	Holtville	Elementary schools (any of grades K to 8)	38	70,245	68,254
13631236967764	El Centro	Elementary schools (any of grades K to 8)	268	43,171	40,591
13631647037740	Imperial	Elementary schools (any of grades K to 8)	104	22,279	16,900
13630736970685	Brawley	Elementary schools (any of grades K to 8)	142	20,899	16,336
13631646933915	Imperial	K to 12 (at least one elementary & one secondary)	53	5,974	3,218
13631236955306	El Centro	Elementary schools (any of grades K to 8)	70	4,695	3,555
13630996968226	Calexico	Elementary schools (any of grades K to 8)	648	20	20

Table 9: Top 10 public schools in San Diego County ranked by pesticide groupings, 1995

School ID number	City	Lowest Grade	Highest Grade	Total Enrollment	Children Enrolled (Pre to 6)	Aggregate of Top 10 Pesticides in Proximity to School (Pounds)
						All
37683536040331	Escondido	KG	8	264	198	97,406
37683126039051	Rancho Santa Fe	KG	6	478	478	51,109
37735696038855	Oceanside	KG	6	721	710	46,966
37735696088991	Oceanside	KG	6	819	810	45,199
37735696070916	Oceanside	KG	6	513	482	41,858
37735696106546	Oceanside	KG	6	896	896	41,858
37684526110407	Vista	KG	5	644	644	41,478
37735516099352	Carlsbad	KG	6	542	542	27,771
37684456106124	Valley Center	KG	3	874	874	27,361
37680806066989	Encinitas	KG	6	557	557	17,617
						Respiratory Irritants
37683126039051	Rancho Santa Fe	KG	6	478	478	51,109
37683536040331	Escondido	KG	8	264	198	48,526
37735696038855	Oceanside	KG	6	721	710	44,218
37735696088991	Oceanside	KG	6	819	810	39,533
37735696070916	Oceanside	KG	6	513	482	39,110
37735696106546	Oceanside	KG	6	896	896	39,110
37684526110407	Vista	KG	5	644	644	38,416
37684456106124	Valley Center	KG	3	874	874	27,361
37735516099352	Carlsbad	KG	6	542	542	25,891
37680806095046	Encinitas	KG	6	748	748	15,126

Table 10: Top 10 private schools in San Diego County ranked by pesticide groupings, 1995

School ID Number	City	California Department of Education School Ownership Description	Total Enrollment	Aggregate of Top 10 Pesticides in Proximity to School (Pounds)
				All
37681066939342	Escondido	K to 12 (at least one elementary & one secondary)	154	97,543
37684457051949	Valley Center	K to 12 (at least one elementary & one secondary)	16	27,361
37680806999353	Encinitas	Elementary schools (any of grades K to 8)	11	26,036
37680806913800	Encinitas	Elementary schools (any of grades K to 8)	240	25,835
37680807077217	Encinitas	Elementary schools (any of grades K to 8)	52	25,835
37735696930499	San Luis Rey	Elementary schools (any of grades K to 8)	109	21,655
37680807051360	Encinitas	Elementary schools (any of grades K to 8)	65	17,494
37680807008238	Encinitas	Kindergarten	12	16,052
37680807051352	Encinitas	Elementary schools (any of grades K to 8)	49	16,052
37735517077332	Rancho La Costa	Kindergarten	15	12,148
				Respiratory Irritants
37681066939342	Escondido	K to 12 (at least one elementary & one secondary)	154	48,664
37684457051949	Valley Center	K to 12 (at least one elementary & one secondary)	16	27,361
37680806913800	Encinitas	Elementary schools (any of grades K to 8)	240	24,910
37680807077217	Encinitas	Elementary schools (any of grades K to 8)	52	24,910
37680806999353	Encinitas	Elementary schools (any of grades K to 8)	11	22,018
37735696930499	San Luis Rey	Elementary schools (any of grades K to 8)	109	20,505
37680807008238	Encinitas	Kindergarten	12	15,126
37680807051352	Encinitas	Elementary schools (any of grades K to 8)	49	15,126
37680807051360	Encinitas	Elementary schools (any of grades K to 8)	65	13,236
37735517077332	Rancho La Costa	Kindergarten	15	10,465

I) Rank order of population data and pesticide use

Imperial County

There were 20 census tracts in Imperial County (out of 29 total tracts or 69%) which had pesticide use within the census tract boundary. There were a total of 14,354 children in these tracts (1990 estimates) and an average of 288 children per tract aged 0 to 4 and an average of 430 children aged 5 to 11. There was an average of 329,766 pounds per tract applied in 1995. Table 11 shows the top 10 census tracts rated by pesticide use. The census tract number, along with the counts and population density of children, are also listed in this table. Census tract 108 was the number one census tract for overall use of the top 10 pesticides, with over 1.5 million pounds applied in 1995. There were only 269 children aged 0-11 in this tract (and a population density of 0.93 children per square kilometer), according to the 1990 census. Census tract #103 was a close second, also with over 1.5 million pounds applied in 1995. The tract with the highest pesticide use and the highest population density of children was tract #113, with approximately 470,000 pounds of pesticides applied and 9.1 children aged 0-11 per square mile. This tract also had the highest pesticide use and the highest population density of children for respiratory irritants.

San Diego County

There were 83 census tracts in San Diego County (out of 445 total tracts or 19%) which had pesticide applications within the census tract boundary. There were a total of 109,646 children in these tracts (1995 estimates), with an average of 683 children aged 0 to 4 and 638 children aged 5 to 11 per tract. There was an average of 8447 pounds of the top ten pesticides applied per tract in 1995. Census tract #186.05 had the highest pesticide use (132,000 pounds in 1995) and the highest population density of children (48.5 children per square kilometer using 1995 population estimates) (Table 12). There is an estimated total of 1494 children in this census tract. This tract also had the highest pesticide use and child density for respiratory irritants. Tract #171.05 was the second highest in terms of childhood population density (20.3 children per sq. km). This tract ranked 9th in pesticide use (18,730 pounds of the top 10 pesticides [all respiratory irritants] used in 1995).

Table 11: Top 10 census tracts in Imperial County ranked by top 10 pesticides and respiratory irritants, 1995

Census Tract Number	Total Population	Population of Children Age 0 to 4	Population of Children Age 5 to 11	Population Density of Children Age 0 to 4 (per sq. km.)	Population Density of Children Age 5 to 11 (per sq. km.)	Aggregate of Top 10 Pesticides Contained in Census Tract (Pounds)
						All
0108.00	1,396	116	153	0.40	0.53	1,586,830
0103.00	1,151	90	171	0.19	0.37	1,572,731
0102.00	1,902	156	278	0.83	1.48	933,978
0101.00	4,901	444	657	0.73	1.08	884,567
0119.00	2,587	197	298	0.88	1.33	470,626
0113.00	5,445	490	676	3.81	5.25	468,917
0111.00	3,021	241	395	1.20	1.96	207,369
0110.00	5,571	550	714	3.05	3.96	194,470
0123.02	1,953	75	108	0.46	0.66	180,343
0124.00	1,543	38	69	0.00	0.01	149,624
						Respiratory Irritants
0108.00	1,396	116	153	0.40	0.53	1,515,825
0103.00	1,151	90	171	0.19	0.37	1,414,361
0102.00	1,902	156	278	0.83	1.48	869,356
0101.00	4,901	444	657	0.73	1.08	797,528
0113.00	5,445	490	676	3.81	5.25	443,116
0119.00	2,587	197	298	0.88	1.33	436,573
0123.02	1,953	75	108	0.46	0.66	174,032
0111.00	3,021	241	395	1.20	1.96	171,303
0110.00	5,571	550	714	3.05	3.96	169,766
0124.00	1,543	38	69	0.00	0.01	141,050

Table 12: Top 10 census tracts in San Diego County ranked by top 10 pesticides and respiratory irritants, 1995

Census Tract Number	Total Population	Population of Children Age 0 to 4	Population of Children Age 5 to 11	Population Density of Children Age 0 to 4 (per sq. km.)	Population Density of Children Age 5 to 11 (per sq. km.)	Aggregate of Top 10 Pesticides Contained in Census Tract (Pounds)
						All
0186.05	9,093	741	753	24.07	24.46	131,885
0207.03	6,402	415	418	3.12	3.14	100,958
0187.00	34,077	3,973	2,829	7.31	5.20	77,850
0191.01	5,073	420	505	1.69	2.03	50,953
0171.06	5,275	169	249	5.58	8.22	41,790
0191.03	4,902	312	348	4.98	5.56	38,922
0188.03	4,080	266	254	5.41	5.17	27,650
0209.01	5,800	250	333	0.17	0.23	20,956
0171.05	6,333	488	538	9.65	10.64	18,730
0190.00	7,031	436	471	2.09	2.26	16,648
						Respiratory Irritants
0186.05	9,093	741	753	24.07	24.46	126,188
0187.00	34,077	3,973	2,829	7.31	5.20	73,715
0191.01	5,073	420	505	1.69	2.03	50,571
0207.03	6,402	415	418	3.12	3.14	50,540
0171.06	5,275	169	249	5.58	8.22	41,790
0191.03	4,902	312	348	4.98	5.56	36,696
0188.03	4,080	266	254	5.41	5.17	22,242
0209.01	5,800	250	333	0.17	0.23	20,956
0171.05	6,333	488	538	9.65	10.64	18,730
0190.00	7,031	436	471	2.09	2.26	16,281

V Discussion/Conclusions

We examined pesticide use, as self-reported by growers, in two California border counties, San Diego and Imperial, from 1991-1995. Over the time period examined, we found that pesticide use was 4 to 8.5 times higher in Imperial County than in San Diego County. Over 8 million pounds of pesticides were applied in the last year examined, 1995, in Imperial County. Out of the top 10 pesticides applied in that county, the largest amount of use by weight was for the class of respiratory irritants. Although the total population and population density of children is much lower in Imperial than in San Diego County, visual inspection of mapped pesticide use in Imperial County shows that heavy use of pesticides of concern, such as respiratory irritants, directly surround residential areas. In contrast, the majority of the population in San Diego County resides in the urban southern part of the county, where pesticide use is low. Although there are significant population centers in northern San Diego County, the potential for exposure to higher levels of pesticides near residential areas may be higher in Imperial County.

One goal of this report was to describe the time-trends of pesticide use in the two counties. Increases in overall pesticide use may be due to greater compliance with reporting or due to substitution of less hazardous pesticides for more toxic compounds.[2] However, although we found pesticide use to be increasing in Imperial County, we found pesticide use to be relatively stable over the years 1991-1995 in San Diego County. Further, although total pesticide use increased moderately (24%) over the time-period in Imperial County, certain classes of pesticides have increased more rapidly, such as respiratory irritants, possible/probable human carcinogens and reproductive/developmental toxicants (out of the top 10 pesticides). In San Diego County, use of respiratory irritants and potential carcinogens have also increased at rates more rapidly than overall pesticide use. These data suggest that, in the future, as residential development extends into agricultural land, the opportunity for exposure will increase.

We analyzed the proximity of public and private schools to public land survey sections which had pesticide applications in the two counties in 1995. We found that there were approximately 150,000 children aged 0-11 in San Diego County attending schools with pesticide use up to 2.8

miles away, compared to approximately 18,000 children in Imperial County. However, all schools with children in Imperial County had pesticide use within 2.8 miles of the school location, compared to 55% of schools in San Diego County. These pesticide applications within 2.8 miles of schools were about 10 times greater in Imperial County than in San Diego County. Analysis of census tract population data showed that San Diego County had more children which live in census tracts with pesticide use (7.6 times more than Imperial County), but pesticide use per census tract was much higher in Imperial County.

In Imperial County, the region near the communities of Holtville and Brawley have the highest pesticide use, from inspection of the pesticide use maps and the census tract analysis. The region near Heber has the highest pesticide use and childhood population density. Areas with high pesticide use which should be considered for monitoring in San Diego County should include agricultural areas near Oceanside, areas east of Carlsbad, areas east of Chula Vista, and the Bonsall area.

There are several limitations to the use of this data. The pesticide use report information is self-reported by the farmer, and although quality control measures have been implemented, both grower and data entry errors occur. We were unable to assess the extent of these errors, due to the limited availability of hard copy forms. Furthermore, since the township, range, and section information is self-reported, it could not always be linked to the public land survey boundary files due to errors. This limits the utility of the geographic analysis. However, the data appear to be reasonably accurate as the bulk of the data fell in manufacturer's ranges for application rates, and the geographic distribution of pesticide use closely coincides with agricultural land use.

We used a crude measure, the aggregate of pesticides in the resident and surrounding eight public land survey sections, as a measure of pesticide use proximity to schools. The precise location of where within the one square mile area that pesticides are actually being applied is unknown. Therefore, this measure should be used as a rough guide for ranking pesticide use near schools.

Although pesticides are being applied in these areas, the degree to which children are actually being exposed is unknown. We did not assess exposures to children which may occur inside schools or homes. Actual exposure to agriculturally applied pesticides is determined by a number of factors, including regional fate and transport of pesticides, and available route of exposure (inhalation, dermal, ingestion). We did not conduct any risk assessment modeling which would address these factors, such as the incorporation of toxicological potency, or simulation of hydrologic and air drift models. As active ingredients were classified together toxicologically, the relative potency of the compounds taken together is unknown. Data on carcinogens and reproductive/developmental toxicants were based on laboratory animal studies and it is not known whether the effects described occur in humans.

The data quality on schools and other sensitive receptor sites varies by source. Some of the datasets, such as schools and churches, are the most accurate as current address information was available. Robust base maps allowed us to have high success rates of address matching, so these data should be deemed close to complete. Other data, such as migrant camps and parks, are less accurate due to the transitory nature of migrant camps and the older quad sheet source data for parks. Placement of the exact location of point data is also subject to error by the geocoding software, which estimates locations from an address range along a street segment.

The primary purpose of this report was to assist the EPA in determining where the likely areas in the two California border counties are in which children aged 11 and younger may potentially be exposed to pesticides. Identification of these areas will allow the EPA to direct their sampling protocols in selecting homes and individuals for environmental and biologic sampling for their proposed phase 2 of the *Pesticides in Young Children* initiative.

Appendix A: Figures

Appendix D:
Table of changed values for Pesticide Use Data

Appendix E:
EPA Toxicity Categories

Appendix H:
Data documentation for
CDPR Pesticide Use Data

Appendix B:

Copy of Pesticide Use Reporting Form

Appendix I:
Data documentation for
cleaned Pesticide Use datasets

Appendix C:
Quality Assurance Data for GIS coverages

Appendix F:
Respiratory Irritant References

Appendix G: Reproductive/developmental Toxicants References

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