Note: This report was based on best available information from the California Department of Pesticide Regulation (DPR) sales and use data. Since the release of this report, DPR discovered an error in its internal database that caused the pesticide sales data it provides to the public to be incorrect. These data are the basis for the calculations that UP3 Project estimates of urban pesticide use. DPR notified the UP3 Project of the error and has supplied revised sales figures for some pyrethroids (most notably beta-cyfluthrin) These corrected data were presented to the UPC at its September 2006 meeting (see update). The UP3 Project is working with DPR to obtain updated information and will make it available.

tdc environmental

Pesticides in Urban Surface Water

Urban Pesticides Use Trends Annual Report 2006

Prepared for the
San Francisco Estuary Project

June 2006

PREFACE

This is a report of research performed by TDC Environmental, LLC for the San Francisco Estuary Project. This report was prepared for the San Francisco Estuary Project to fulfill the annual reporting requirements in Task 2.2.2 and 2.2.5 of its grant agreement with the State Water Resources Control Board (Agreement Number 04-076-552-0) for the Urban Pesticides Pollution Prevention Project (UP3 Project). Views or information expressed in this report may not necessarily reflect those of the funding agencies.

ACKNOWLEDGEMENTS

The author appreciates the information and assistance provided by many organizations that have assembled and made public data on pesticide use. Pesticide sales and use data from the California Department of Pesticide Regulation were particularly useful in the preparation of this report.

TDC Environmental thanks the following reviewers for their assistance with completing this report:

- Dave Tamayo, Sacramento County Stormwater Quality Program
- Armand Ruby, Armand Ruby Consulting
- Glenn Brank, California Department of Pesticide Regulation
- Cheryl Wilen, University of California Statewide IPM Project
- Geoff Brosseau, California Stormwater Quality Association

Thanks are also due to Laura Speare for technical editing. The author also wishes to acknowledge the grant management team—San Francisco Estuary Project (SFEP) UP3 Project Manager Laura Speare and SFEP Project Manager Marcia Brockbank—who provided invaluable assistance to TDC Environmental with this project.

REPORT PREPARER

TDC Environmental, LLC
4020 Bayview Avenue
San Mateo CA 94403
www.tdcenvironmental.com

Project Manager: Kelly D. Moran, Ph.D.

Pesticides in Urban Surface Water
Urban Pesticides Use Trends Annual Report 2006

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

Page

Figures (Continued)

1.0 INTRODUCTION

1.1 Background

The presence of pesticides in urban surface water and the environmental effect of pesticides that are found in water bodies are topics of great interest to research scientists, regulatory agencies, municipalities, and the general public. Future trends in water quality depend, in part, on trends in use of urban pesticides. This report is intended to assist California water quality agencies—including municipalities—by analyzing urban pesticide use trends.

This is one of three reports prepared annually by the Urban Pesticide Pollution Prevention (UP3) Project. (The other two reports are a review of California water quality agencies' urban pesticide water quality regulatory activities and a summary of recent scientific findings that are relevant to urban surface water quality management activities). The purpose of the UP3 Project is to provide education, outreach, and technical assistance for implementation of the Diazinon and Pesticide-Related Toxicity in Bay Area Urban Creeks Water Quality Attainment Strategy and Total Maximum Daily Load (WQAS/TMDL) (Johnson 2005).[1] The project is structured to mirror the three major elements of the WQAS/TMDL Implementation Strategy: Outreach and Education, Science (Research and Monitoring), and Proactive Regulation. The San Francisco Estuary Project (SFEP) has been awarded California water bond grant funds from the State Water Resources Control Board to implement the UP3 Project through March 2007. TDC Environmental is providing technical support for the project.

1.2 Scope of This Report

This is the second annual urban pesticide sales and use trends report prepared by the UP3 Project. It presents the results of the project's analysis of data and reports relevant to urban pesticide use trends for pesticides that have the potential to cause adverse effects in urban surface waters. While much of the information in the report is relevant throughout California, the report focuses on the San Francisco Bay Area and on pesticides that may be released to urban creeks, as the UP3 Project is designed specifically to support the San Francisco Bay Area urban creeks WQAS/TMDL. This report considers not only sales and use patterns, but also potential for adverse effects on urban surface waters in its analysis, with the intent of making it a more complete and useful resource than reports that simply address pesticide market availability or pesticide use patterns.

As explained in the UP3 Project *Annual Research and Monitoring Update 2006* (TDC Environmental 2006), use of pyrethroid insecticides in Northern California urban areas is causing adverse effects in aquatic ecosystems receiving urban runoff. This report includes a section (Section 2.5) that focuses on how pyrethroids are used in urban areas to assist water quality managers and their colleagues with their response to this problem.

Based on previous analysis of pesticide sales and use (TDC Environmental 2005c) and pesticide retail shelf surveys (most recently in the summer of 2005; see TDC Environmental, 2005b) the following pyrethroids are included in this analysis: bifenthrin, cyfluthrin (including beta-cyfluthrin), cypermethrin, deltamethrin, esfenvalerate, lambda-cyhalothrin, permethrin, and tralomethrin. This report also includes information relevant to the other pesticides of concern for water quality identified in the UP3 Project *Annual*

[1] References are in Section 7.

Research and Monitoring Update 2006—carbaryl, malathion, polyhexamethylene biguanadine (PHMB), and fipronil—and information about two pesticides associated with recent (now believed to be past) urban water quality problems—the organophosphorous pesticides diazinon and chlorpyrifos. Together, the pesticides above are called the "study list." (Note that all but one of the study list pesticides is an insecticide, which is why the remainder of the report focuses primarily on insecticides.)[2] Table 1 lists the study list pesticides and their other commonly used names for these substances.

Table 1. Study List Pesticides and Their Common Names

Name	Synonyms and Trade Names (Examples)
Pyrethroids	
Bifenthrin	Biphenthrin, Bifenthrine, Biflex, Brigade, Capture, Onyx, Talstar
Cyfluthrin	Baythroid, Tempo, Cykick, Renounce
Beta-Cyfluthrin	Tempo Ultra, Cylence
Cypermethrin	Ammo, Cynoff, Demon, Cymbush
Deltamethrin	Decamethrin, Deltadust, Deltaguard, Suspend SC
Esfenvalerate	(S)-Fenvalerate, Asana
Lambda-Cyhalothrin	Scimitar, Demand
Permethrin	Ambush, Nix, Pounce
Tralomethrin	Saga
Organophosphorous Pesticides (OPs)	
Chlorpyrifos	Dursban, Lorsban
Diazinon	Diazol
Malathion	Cythion, Carbophos, Fyfanon
Other	
Carbaryl	Sevin
Fipronil	Termidor, Maxforce FC, Frontline, Chipco Choice
PHMB	Baquacil, Revacil, Vantocil, Chlorine Free Splashes Sanitizer, Clear Comfort Sanitizer, Clorox Readymop Advanced Floor Cleaner, Free, Soft Soak Sanitizer

Source: DPR Product/Label database.

This report builds on previous related work, particularly last year's urban pesticide sales and use trends annual report (TDC Environmental 2005c), the UP3 Project *Annual Research and Monitoring Update 2006* (TDC Environmental 2006) and a 2003 review of the water quality implications of the shift in urban insecticide use patterns resulting from the phase out of most urban uses of diazinon and chlorpyrifos (TDC Environmental 2003). The recommendations in this report specifically address how new scientific and pesticide use information can be used to improve the effectiveness of California water

[2] Pesticide-related surface water problems in urban areas have historically been most commonly linked to insecticides (rather than herbicides or fungicides). USGS National Water Quality Assessment data suggest that insecticides are more likely than herbicides to be linked to pesticide-related toxicity in urban surface waters (see *Pesticides in Urban Surface Water: Annual Research and Monitoring Update 2005* [TDC Environmental 2005d] for more information).

quality agency efforts to prevent pesticide-related toxicity in surface waters, urban runoff, and municipal wastewater discharges.

For purposes of this report, the San Francisco Bay Area is defined to include the nine Bay Area counties: Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Sonoma, and Solano Counties.

1.3 Data Sources

This report is based on a review of information relating to trends in urban use of pesticides. Information in this report was obtained from a variety of sources:

- Pesticide sales and use data collected by the California Department of Pesticide Regulation (DPR);
- Pesticide retail shelf surveys;
- Pesticide product labels;
- Pesticide use surveys conducted by universities and government agencies; and
- Interviews with agency staff and researchers.

Since it builds on previous reports, the focus of this report is on the most recently available information (*i.e.*, information that became available in 2005 and early 2006).

1.4 Report Organization

This report is organized as follows:

- *Section 1* (this section) provides the background and scope of the report.
- *Section 2* provides estimates of the California and San Francisco Bay Area use of pesticides most likely to threaten urban surface water quality and looks at trends in the use of these pesticides.
- *Section 3* gives this report's conclusions on the sales and use trends for pesticide of interest for urban surface water quality.
- *Section 4* provides recommendations to improve urban pesticide toxicity reduction activities. These recommendations are based not only on this report, but also on the UP3 Project's *Annual Research and Monitoring Update 2006* (TDC Environmental 2006) and annual update on improving pesticide regulatory activities to protect water quality (TDC Environmental 2005a).
- *Section 5* lists the references cited in the body of the report.

2.0 ESTIMATED URBAN USE OF STUDY LIST PESTICIDES

2.1 Background

The only public source of quantitative data about California pesticide use is DPR. Using DPR data, it is possible to develop gross estimates of pesticide use statewide and in the San Francisco Bay Area. The estimation process uses pesticide sales data, reported pesticide use data, and a calculation of unreported use as described below. To ensure consistency with other pesticide data, this analysis follows DPR's convention of describing pesticide use in terms of pounds of pesticide "active ingredient." Pesticides in this section are grouped by chemical families—pyrethroids, organophosphorous pesticides (OPs), and other pesticides.

2.2 Pesticide Sales

While not all pesticides sold are used (some are stored indefinitely or disposed of), over the long term, there is likely to be a correlation between pesticide sales and pesticide use. The State of California annually compiles statewide pesticide sales volumes, by amount of active ingredient, based on the payment of a fee that provides the majority of DPR's funding. DPR sales data are based on a fee paid by the pesticide manufacturer when products are shipped. Data are generally released 10 to 12 months after the end of the reporting year. The most recent data available are for calendar year 2004 (DPR 2006b).

These sales data are available only as annual aggregate data; no time of year information or regional breakdowns are publicly available. Prior to 2005, data were only made public for pesticides for which more than three companies ("registrants") had registered products during the calendar year for which sales are reported (these data included about 90% of the quantity of pesticide active ingredients sold). In 2005, DPR adopted new regulations that will make statewide pesticide sales volumes available for all pesticide active ingredients, starting with year 2005 data. Since 2003, sales data have been made public for all study list pesticides.

Aside from the DPR data, sales data from specific pesticide manufacturers, distributors, and retailers are usually considered confidential and are generally unavailable to water quality agencies. Occasionally, individual retailers and distributors have disclosed specific sales figures, but such disclosure is unusual. Although market data firms do occasionally sell such data, the price has proven prohibitive for water quality agencies.

Table 2 (on the next page) presents California statewide sales of study list pesticides from 1999-2004 (the most recent data available). These data include all pesticide sales, whether for urban or agricultural use. Note that sales of pyrethroids, fipronil, and PHMB have generally increased since 1999, while sales of diazinon and carbaryl have generally decreased in that time period. The recent rapid increase in fipronil sales is particularly notable.

<u>Uncertainty</u>

Since DPR sales data are based on fees from pesticide sellers, they have been generally considered by researchers to be relatively accurate, as it is reasonable to assume that most pesticide sellers comply with state fee requirements. Errors are known to come from the following sources:

- <u>Failure to pay required fees</u>. A 2004 audit of Long's Drugs sales data suggested that sales data may understate actual sales, particularly for urban products (DPR

Table 2. Sales of Study List Pesticides in California, 1999-2004 (Pounds of Pesticide Active Ingredient)

Pesticide	1999	2000	2001	2002	2003	2004
Pyrethroids						
Bifenthrin	NR[a]	NR	31,626	32,179	70,759	109,119
Cyfluthrin	30,579	47,338	46,610	50,525	44,567	46,184
Beta-Cyfluthrin	NR	NR	NR	NR	41,779	184,423
Cypermethrin	43,757	50,436	49,690	64,596	81,840	77,897
Deltamethrin	2,103	8,326	3,189	4,386	4,926	3,852
Esfenvalerate	41,163	43,011	35,972	43,478	53,580	57,221
Lambda-Cyhalothrin	NR	NR	NR	24,061	27,892	25,689
Permethrin	290,714	437,901	276,144	427,960	480,572	479,216
Tralomethrin	1,922	1,924	34,438	175,383	63,897	151,096
OPs						
Chlorpyrifos	2,316,601	2,347,494	1,977,141	1,697,022	1,951,083	2,318,731
Diazinon	1,539,574	1,430,665	1,361,507	916,438	751,376	809,813
Malathion	1,501,547	1,054,078	1,124,940	1,018,961	1,662,673	1,550,897
Other						
Carbaryl	639,600	563,605	412,635	421,528	329,782	388,236
Fipronil	NR	1,857	19,002	32,191	913,530[b]	1,250,790
PHMB	NR	27,179	NR	NR	55,863	35,693

Source: DPR Sales data reports (DPR 2000a, 2001a, 2002a, 2003a, 2005a, 2006b)
[a]NR = Not Reported. Sales of products with fewer than four registrants are not disclosed to the public.
[b]The accuracy of this value was confirmed with DPR.

2004; Brank 2006). Based on this audit, DPR estimates that its past sales data are at least 10% below actual total pesticide sales, not including unregistered products (Brank 2005). The understatement of sales data is believed to apply primarily to non-agricultural products. DPR has estimated that prior to its 2004-2005 enforcement activities, non-agricultural pesticide retail sales may have been underestimated by an average of 20%, based on a limited number of individual audits (Brank 2006). This is an aggregate error estimate—the error in the data for the specific pesticides on the study list is not known. Relative errors in pesticide sales data are likely to differ among pesticides, since this error is based on non-compliance by particular categories of retailers (e.g., “big box” stores) and since the non-agricultural sales fractions differ among pesticides.

This error may extend beyond the non-professional sector for some pesticides. For example, as explained below, reported sales of cypermethrin and deltamethrin averaged less than 50% of the reported use of these pesticides between 1999 and 2004. This error cannot be explained readily except by non-payment of fees.

Since the error associated with non-payment of fees is systematic, it is not expected to affect evaluation of past trends. Stepped up enforcement of sales and registration requirements in 2005 and subsequent years may affect evaluation of trends that include data prior to and after 2005.

- Data errors. Prior to releasing its annual report, DPR does a quality assurance review of the data, with the intent of eliminating major data errors (e.g., errors in data entry or units) (Owen 2006).
- Shipment timing. Pesticide shipment scheduling practices and tax payment timing may cause sales to appear to fluctuate in a manner that does not reflect use patterns. (For example, the spike in permethrin sales in 2000 may reflect timing of sales that would actually have occurred in 1999 or 2001, as this data point is inconsistent with the 10 year trend in permethrin sales). Sales may be higher than use in situations where purchasers are stockpiling products (e.g., those where manufacturing is phasing out but existing product sales and/or use may continue until a later date or until existing stocks are exhausted). Evaluation of multiple years of sales data is necessary to ensure that apparent trends are meaningful. It is also important to recognize that pesticide use depends on environmental factors—such as the weather—making year-to-year variations normal for the data set.

2.3 Pesticide Use Reports

Certain pesticide applications[3] are required to be reported to the County Agricultural Commissioner, who, in turn, reports the data to DPR. In general, the pesticide uses that require reporting are agricultural uses or urban applications done by licensed pest control operators (who are called "professionals" in this report). DPR prepares annual summary reports on the basis of these data. While the required reporting and the annual summary reports lack the detail necessary to allow a detailed tally of reported urban pesticide applications, they are sufficiently detailed to allow selection of "urban" categories (like structural pest control and landscape maintenance) to create an estimate of the urban portion of the reported pesticide use.[4] Required reporting includes the registration number of the product that was applied and the month it was applied; these data are available from an Internet database of pesticide use reports that is maintained by DPR.[5] The structural pest control reporting category includes aboveground applications (e.g., spraying around a building to control ants), indoor applications, and underground injection (e.g., injection of pesticides into holes drilled into the ground to control termites).

Table 3 (on the next page) summarizes statewide reported use of study list pesticides in 2004 (the most recent data available). Table 4 (on page 8) presents reported *urban* use of study list pesticides in 2004 for the San Francisco Bay Area.[6] Note that the majority of pyrethroid and fipronil reported use was for structural pest control.

---

[3] The following pesticide uses must be reported: pesticide uses for the production of any agricultural commodity, except livestock; for the treatment of post-harvest agricultural commodities; for landscape maintenance in parks, golf courses, and cemeteries; for roadside and railroad rights-of-way; for poultry and fish production; any application of a restricted material; any application of a pesticide designated by DPR as having the potential to pollute ground water when used outdoors in industrial and institutional settings; and any application by a licensed pest control operator must be reported.

[4] For purposes of this analysis, the following categories of use from DPR's annual compilation reports were defined as urban uses: landscape maintenance, public health, regulatory pest control, rights of way, structural pest control, vertebrate control, uncultivated non-agricultural sites, and food processing plants. Some typically agricultural categories may include some applications in urban areas (*e.g.*, nurseries, greenhouses, sod/turf), so this "urban" estimate is likely to understate actual reported use in urban areas.

[5] DPR's California Pesticide Information Portal (CalPIP) database is accessible on the Internet: http://calpip.cdpr.ca.gov/cfdocs/calpip/prod/main.cfm

[6] An examination of San Francisco Bay Area pesticide use data found that less than 10% study list pesticide use was agricultural (Moran 2005).

Table 3. California Study List Pesticides Reported Use, 2004
(Pounds of Pesticide Active Ingredient)

Pesticide	Total (Agricultural and Urban)	Total (Urban Only)	Structural Pest Control	Landscape Maintenance
Pyrethroids				
Bifenthrin	61,882	44,266	40,952	2,867
Cyfluthrin	48,549	33,306	32,606	656
Beta-Cyfluthrin	16,602	15,944	4,962	10,960
Cypermethrin	205,731	201,644	188,980	7,008
Deltamethrin	12,607	12,499	12,132	327
Esfenvalerate	30,823	105	98	6
Lambda-Cyhalothrin	36,613	16,431	16,324	105
Permethrin	461,152	330,629	302,167	19,191
Tralomethrin	136	131	131	<1
OPs				
Chlorpyrifos	1,775,828	129,746	120,487	4,728
Diazinon	492,050	23,672	19,860	3,675
Malathion	492,308	85,106	41,522	2,728
Other				
Carbaryl	240,071	34,956	5,288	29,387
Fipronil	49,950	49,950	49,828	116
PHMB	0	0	0	0

Source: DPR's California Pesticide Information Portal (CalPIP) database (DPR 2006a).
Note: Only malathion had significant reported urban uses other than structural pest control and landscaping: 30,055 pounds for regulatory pest control, 9798 pounds for use for public health protection, and 946 pounds for rights of way. Less than 10% of the total volume of other study list pesticides was reported for urban uses not listed in the table.

Uncertainty

Pesticide use reports are generally considered relatively reliable as compared to other data sources. DPR's reporting requirements and DPR's and County Agricultural Commissioners' enforcement systems are intended to ensure that most pesticide applications that require reporting are reported. Potential sources of error include:

- Non-compliance with reporting requirements. An unknown amount of non-reporting certainly occurs. Because DPR has never completed a field verification of the pesticide use reporting system, a quantitative estimate of non-reporting is not available. A 2004 Pesticide Action Network (PAN) analysis suggested that non-reporting may be significant for some pesticides. PAN compared four years of reported sales and reported use for 5 pesticides for which all uses are reportable, finding reporting rates from 9% to 138% (PAN 2004). DPR completed a similar analysis for a larger group of pesticides (though still a small subset of all pesticides), also finding a rather large variation in reporting among pesticides (Wilhoit 2005). In this analysis, DPR found that on average about 90% of the sales of the analyzed pesticides (for which all uses are reportable) was reported as used over a 5 year period; however, since there was a large variation in results for individual pesticides, this average is very uncertain (Wilhoit 2005; Brank 2006). The error rate for individual pesticides—and for urban

Table 4. San Francisco Bay Area Study List Pesticides Reported Urban Use, 2004 (Pounds of Pesticide Active Ingredient)

Pesticide	Total	Structural	Landscaping	Rights of Way	Public Health
Pyrethroids					
Bifenthrin	8,532	7,107	1,425	0	0
Cyfluthrin	3,504	3,366	138	<1	0
Beta-Cyfluthrin	1,062	572	490	0	<1
Cypermethrin	22,300	16,115	6,184	<1	0
Deltamethrin	1,104	943	161	0	<1
Esfenvalerate	3	3	<1	0	0
Lambda-Cyhalothrin	333	323	9	0	0
Permethrin	24,262	10,237	14,022	3	<1
Tralomethrin	2	2	0	<1	0
OPs					
Chlorpyrifos	893	357	531	<1	<1
Diazinon	2,084	1,433	647	5	0
Malathion	2,736	1,365	1,371	0	0
Other					
Carbaryl	4,416	1,303	3,106	6	<1
Fipronil	3,938	3,895	43	<1	0
PHMB	0	0	0	0	0

Source: DPR's California Pesticide Information Portal (CalPIP) database (DPR 2006a).
Note: Use of less than 5 pounds of one or more study list pesticides was also reported for: vertebrate pest control, regulatory pest control, uncultivated non-agricultural sites, and food processing plants.

reportable uses (which could not be explored separately from agricultural uses with this analytical method)—may differ significantly from the underreporting average suggested by this DPR analysis.

- Data handling errors. Prior to releasing its annual report, DPR does a quality assurance review of the data, which should eliminate data entry errors that are likely to have a significant effect on the data from the water quality perspective. After a 2001 audit of the data management system (Wilhoit et al. 2001), DPR implemented error handling processes that are believed to keep errors to less than 1-2% (Wilhoit 2002; Wilhoit 2005).

2.4 Quantitative Pesticide Use Estimates

Using data from DPR, it is possible to develop gross quantitative estimates of pesticide use statewide and in the San Francisco Bay Area. The estimates use pesticide sales data, reported pesticide use data, and a calculation of pesticide use that does not require reporting. Assuming all pesticides sold are used within a particular year, pesticide use that does not require reporting ("unreported pesticide use") can be estimated to be approximately equal to the difference between statewide pesticide sales and statewide reported pesticide use. Since sales data are only available on a statewide basis, estimates of unreported pesticide use are usually extrapolated to a smaller region (e.g., the San Francisco Bay Area) on a per-capita basis.

The main assumption behind this urban pesticide use estimation method is that all unreported pesticide use occurs in urban areas. The primary exceptions to California's pesticide use reporting requirements are home and garden use and most industrial, commercial, and institutional pesticide applications not made by professional applicators.[7] Because these activities occur primarily in urban areas—and all agricultural use requires reporting—the assumption that essentially all unreported uses of the study list pesticides are urban is reasonable.

Uncertainty

Errors in source data. Estimates of unreportable urban use made in this manner combine uncertainties in the reporting and sales data described above. Since both sales and use data are believed to be underreported by about the same fraction, these errors may—on average—be relatively less important than other sources of error (because, on average, these errors offset each other). The effect of errors in the source data is variable, depending on the pesticide. For example, for a few pesticides, reported use has exceeded reported sales for at least 5 years (see below). Since the primary identified errors in pesticide sales and reported use data are systematic, they affect quantitative estimates more than they affect trends. These uncertainties must be kept in mind while reviewing this section, as errors for individual pesticides are unknown and may differ significantly from these average estimates.

Pesticides sold but not used. Generally, it is reasonable to assume that pesticide use correlates with pesticide sales. Market factors may, however, cause this to not be the case. For example, pesticides newly introduced into the market may be sold in one calendar year, but not applied until the next year. When allowable pesticide uses are changed, sometimes users stockpile pesticides with the "old" label, which are generally allowed to be applied for the previously allowable use until stocks with labels allowing this use are exhausted.

Extrapolation. Extrapolation of statewide pesticide data to the San Francisco Bay Area creates highly uncertain pesticide use estimates. Extrapolation is reasonable in that the target pests for the study list pesticides are reported by consumers to be similar throughout the state. Argentine ants are the most common target pest for insecticide use in the state's most populated areas (Southern California, the Central Valley, and the Bay Area) (Wilen 2001; Wilen 2002; Flint 2003). Extrapolation is also reasonable in that sales are anticipated to correlate with use, even though all pesticides sold are not applied (some are disposed as hazardous waste or garbage). Extrapolated estimates do not account for climate, lot size, regional pest problems or other reasons that pesticide use per person might vary across the state.

To reflect the uncertainties in the quantitative estimates in this section, this report utilizes significant figures when presenting estimates. While sales and use data from DPR are presented as reported by DPR, estimates based on calculations are rounded to provide the appropriate number of significant figures.

Statewide Study List Pesticides Urban Pesticide Use Estimates

In 2004, DPR reports indicate that 704,898,069 pounds of pesticide active ingredient were sold (DPR 2006b) and 180,272,161 pounds of pesticide active ingredients were used in manners requiring reporting (DPR 2006c). Assuming that on average, an amount equivalent to pesticide sales is used each year, about 74% of California

[7] Pesticides incorporated into consumer products (e.g., treated wood, pet collars, insecticidal clothing) are often unreported, or reported as applied at the product manufacturing site rather than at the site where the products are used. Use of biocides to treat drinking water and wastewater are also usually not reported.

pesticide use in 2004 did not require reporting.[8] For 2004, the sum of unreported pesticide use and reported urban use is about 500,000,000 pounds, about 76% of total use. Given the uncertainties in the data sources, this estimate is not exact; nevertheless, it certainly indicates that at least half of California pesticide use occurs in urban areas.

Reported urban pesticide use, however, comprises only a small fraction of all reported pesticide use. According to DPR, 13,000,000 pounds of pesticide active ingredient were applied for reported urban uses in 2004 (DPR 2006c). This represented about 7.6% of all reported pesticide use in 2004.

Table 5 (on the next page) provides statewide sales, reported use, estimated unreported use, and the fraction of the use that is unreported for study list pesticides in 2004. For several pesticides, specific factors should be considered when reviewing Table 5 and subsequent tables:

- Organophosphorous pesticides. The low percentage of reported use (versus total estimated use) of OPs could reflect professionals and consumers stocking up on OPs prior to phase out of many allowable uses. It could also reflect under-reporting of the agricultural and urban uses of these pesticides, which have lost popularity since the U.S. EPA released risk information about them in 1999 and 2000. The chlorpyrifos unreported use estimates are very unlikely to represent actual urban use, because sales of products for almost all non-reportable urban uses ended in December 2001. Retail sales of diazinon products for urban use were intended to phase down in 2004; sales ended in December 2004.
- Cyfluthrin, Cypermethrin, Deltamethrin and Lambda-Cyhalothrin. For all four of these pesticides, statewide reported use exceeded statewide reported sales; therefore, unreported use was assumed to be approximately zero. Annual variations in sales data can cause these data anomalies to occur; however, cypermethrin and deltamethrin are notable in that reported sales averaged less than 50% of reported use between 1999 and 2004. Since all four were found in a few products in 2004 retail shelf surveys (TDC Environmental, 2004) the unreported use was almost certainly not zero. These data should be interpreted to suggest that retail sales for non-professional uses were probably not a significant part of the use of these pesticides.
- Carbaryl and Permethrin. Unreported use estimates for these pesticides rely on the differences between rather large sales and reported use values. Relatively small errors in sales and/or reported use values would significantly change the unreported use estimate.

Total estimated statewide urban pesticide use is the sum of urban reported use (see Table 3 above) and estimated unreported use. Table 6 (on page 12) presents an estimate of the total urban use of study pesticides in the California in 2004. These data should be interpreted with the understanding that the margin of error in the estimates may be more than 10%.

[8] Note that most use of biocides like chlorine (sales of almost 123 million pounds in 2004) and sodium hypochlorite (sales >142 million pounds in 2004) do not require reporting. These two biocides are used in large quantities to treat drinking water and wastewater. Sodium hypochlorite is also sold over the counter in bleach, which is registered as a pesticide.

Table 5. California Study List Pesticides Unreported Use, 2004
(Pounds of Pesticide Active Ingredient)

Pesticide	Sales	Reported Use	Unreported Use[a]	% of Use That Is Unreported
Pyrethroids				
Bifenthrin	109,119	61,882	50,000	43%
Cyfluthrin	46,184	48,549	Limited[b]	0%
Beta-Cyfluthrin	184,423	16,602	170,000	91%
Cypermethrin	77,897	205,731	Limited	0%
Deltamethrin	3,852	12,607	Limited	0%
Esfenvalerate	57,221	30,823	30,000	46%
Lambda-Cyhalothrin	25,689	36,613	Limited	0%
Permethrin	479,216	461,152	20,000	4%
Tralomethrin	151,096	136	150,000	100%
OPs				
Chlorpyrifos	2,318,731	1,775,828	500,000	23%
Diazinon	809,813	492,050	300,000	39%
Malathion	1,550,897	492,308	1,100,000	68%
Other				
Carbaryl	388,236	240,071	150,000	38%
Fipronil	1,250,790	49,950	1,200,000	96%
PHMB	35,693	0[c]	40,000	100%
All Pesticides	***704,898,069***	***180,272,161***	***500,000,000***	***74%***

Source: DPR sales data (DPR 2006b), pesticide use reports (DPR 2006a) and TDC Environmental calculations.
[a] Total estimated use values reflect 1 or 2 significant figures, assuming that sales data have an error of about 10% and reported urban use values are accurate to two significant figures. Totals may not add up due to rounding.
[b]When reported use exceeds sales, unreported use is assumed to be relatively limited.
[c]This pesticide is only registered for urban uses that do not require reporting.

In Table 7 (on page 13), pesticide sales and reported agricultural pesticide use data are used to estimate the fraction of the total statewide use of each study list pesticide that occurs in agricultural and in urban areas. Note that most pyrethroids are used primarily in urban areas, as is most malathion, fipronil, and PHMB.

San Francisco Bay Area Study List Pesticides Urban Use Estimates

Pesticide use estimates specific to the urbanized portions of the San Francisco Bay Area can be developed using a methodology similar to the methodology used above. Total estimated San Francisco Bay Area urban pesticide use is the sum of Bay Area reported urban use (see Table 4 above) and estimated unreported use. Unreported use can be estimated on the basis of an extrapolation from the statewide unreported use estimates in Table 5. The extrapolation was made on the basis of population, using population data from the California Department of Finance (DOF 2006).

Table 8 (on page 14) presents an estimate of the urban use of study list pesticides in the San Francisco Bay Area in 2004. These data should be interpreted with the understanding that the margin of error in the estimates may be greater than 10%.

Table 6. California Study List Pesticides Estimated Urban Use, 2004 (Pounds of Pesticide Active Ingredient)

Pesticide	Reported Urban Use	Estimated Unreported Urban Use[a]	Total Estimated Urban Use[b]
Pyrethroids			
Bifenthrin	44,266	50,000	90,000
Cyfluthrin	33,306	Limited[b]	33,000
Beta-Cyfluthrin	15,944	170,000	200,000
Cypermethrin	201,644	Limited	200,000
Deltamethrin	12,499	Limited	12,000
Esfenvalerate	105	30,000	30,000
Lambda-Cyhalothrin	16,431	Limited	16,000
Permethrin	330,629	20,000	350,000
Tralomethrin	131	150,000	150,000
OPs			
Chlorpyrifos	129,746	?[c]	?[c]
Diazinon	23,672	*300,000*[d]	*300,000*[d]
Malathion	85,106	1,100,000	1,100,000
Other			
Carbaryl	34,956	150,000	200,000
Fipronil	49,950	1,200,000	1,200,000
PHMB	0	40,000	40,000

Source: TDC Environmental calculations based on data in Tables 3 and 5.
[a]Unreported use values reflect only 1 significant figure to reflect uncertainty in these values.
[b]Total estimated use values reflect 1 or 2 significant figures, assuming that reported urban use values are accurate to two significant figures. Totals may not add up due to rounding.
[c]Estimates made according to the methodology (700,000 pounds) are very unlikely to represent actual urban use, as they are based primarily on estimated retail sales of chlorpyrifos, which were essentially prohibited. Therefore, values have not been included in the table. Please see the discussion in the text above.
[d]Estimated unreported use of diazinon is very likely a significant overestimate as it is based almost entirely on estimated retail sales of diazinon, which were phasing out. Please see the discussion in the text above.

Table 7. California Study List Pesticides Urban Usage Percentages, 2004 (Pounds of Pesticide Active Ingredient)

Pesticide	Sales	Reported Agricultural Use	% of Use that is Agricultural	% of Use that is Urban
Pyrethroids				
Bifenthrin	109,119	17,616	16%	84%
Cyfluthrin	46,184	15,243	33%	67%
Beta-Cyfluthrin	184,423	658	<1%	Almost 100%
Cypermethrin	77,897	4,087	5%	95%
Deltamethrin	3,852	108	3%	97%
Esfenvalerate	57,221	30,718	54%	46%
Lambda-Cyhalothrin	25,689	20,182	79%	21%
Permethrin	479,216	130,523	27%	73%
Tralomethrin	151,096	5	<1%	Almost 100%
OPs				
Chlorpyrifos	2,318,731	1,646,082	71%	*29%*[a]
Diazinon	809,813	468,378	58%	*42%*[a]
Malathion	1,550,897	407,202	26%	74%
Other				
Carbaryl	388,236	205,115	53%	47%
Fipronil	1,250,790	0	0%	100%
PHMB	35,693	0	0%	100%

Source: TDC Environmental calculations based on data in Table 2 and DPR's compilation of statewide pesticide use reporting data (DPR 2006c).
[a]These estimated percentages are likely to substantially overstate actual values, as they are based largely on estimated retail sales of diazinon and chlorpryifos, which were phasing out (diazinon) or essentially prohibited (chlorpyrifos). Please see the discussion in the text above.

Table 8. San Francisco Bay Area Study List Pesticides Estimated Urban Use, 2004 (Pounds of Pesticide Active Ingredient)

Pesticide	Reported Bay Area Urban Use	Estimated Bay Area Unreported Urban Use[a]	Total Estimated Bay Area Urban Use[b]
Pyrethroids			
Bifenthrin	8,532	9,000	20,000
Cyfluthrin	3,504	0	3,500
Beta-Cyfluthrin	1,062	30,000	30,000
Cypermethrin	22,300	0	22,000
Deltamethrin	1,104	0	1,100
Esfenvalerate	3	5,000	5,000
Lambda-Cyhalothrin	333	0	330
Permethrin	24,262	3,000	30,000
Tralomethrin	2	30,000	30,000
OPs			
Chlorpyrifos	893	?[c]	?[c]
Diazinon	2,084	*60,000*[d]	*60,000*[d]
Malathion	2,736	200,000	200,000
Other			
Carbaryl	4,416	30,000	30,000
Fipronil	3,938	200,000	200,000
PHMB	0	8,000	8,000

Source: TDC Environmental calculations based on data in Tables 4 and 5 and the Bay Area fraction of the state population (19.3%) (DOF 2006).

[a]Unreported use values reflect only 1 significant figure to reflect uncertainty in these values.

[b]Total estimated use values reflect 1 or 2 significant figures, assuming that reported urban use values are accurate to two significant figures. Totals may not add up due to rounding.

[c]Estimates made according to the methodology (100,000 pounds) are very unlikely to represent actual urban use, as they are based primarily on estimated retail sales of chlorpyrifos, which were essentially prohibited. Therefore, values have not been included in the table. Please see the discussion in the text above.

[d]Estimated unreported use of diazinon is very likely a significant overestimate as it is based almost entirely on estimated retail sales of diazinon, which were phasing out. Please see the discussion in the text above.

2.5 Pyrethroids Urban Use

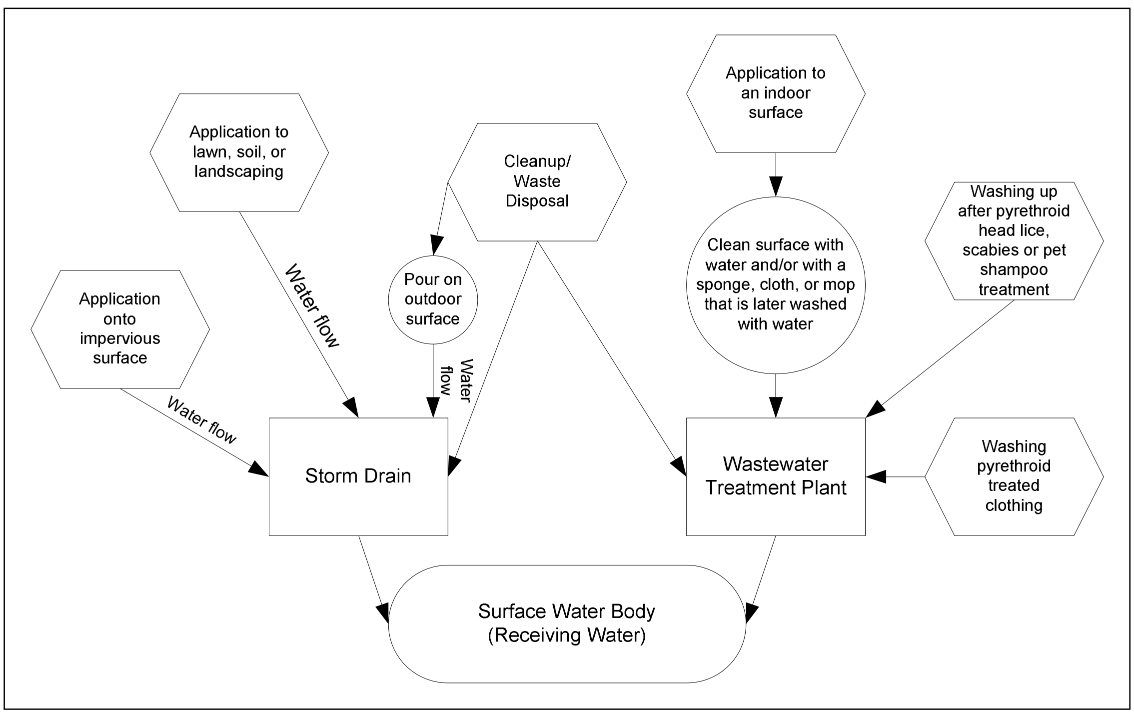
As explained in the UP3 Project *Annual Research and Monitoring Update 2006* (TDC Environmental 2006), use of pyrethroid insecticides in Northern California urban areas is causing adverse effects in aquatic ecosystems receiving urban runoff. Ending this toxicity is a priority for California water quality agencies. Understanding how pyrethroids are used in urban areas will help agencies develop management strategies to respond to this problem. This section explores how pyrethroids are used in urban areas.

Background

All uses of pyrethroids are as pesticides. Pyrethroids are not formed by decomposition of other chemicals in the environment. Because pyrethroids are not very volatile and because urban uses comprise a very significant fraction of all pyrethroids use, air transport of pyrethroids from agricultural areas into urban areas is unlikely to be a significant source of pyrethroids in urban runoff. Most Northern California urban creeks do not receive agricultural runoff. Thus, it is reasonable to assume that the only significant source of pyrethroids in most Northern California urban creeks is urban pesticide use.

A 2001 report prepared for DPR explores how pesticides used in urban areas can flow to surface waters (TDC Environmental 2001). Figure 1, below, summarizes the connections between common pyrethroid uses and surface waters.

Figure 1. Primary Pathways for Pyrethroids to Flow to Urban Surface Waters



Source: TDC Environmental summary based on TDC Environmental 2001 and pyrethroid use data.

When it rains (or when water is discharged for other reasons in urban areas), urban runoff flows through storm drains into urban creeks. (In almost all of California, stormwater does not receive any type of treatment before it is discharged.)[9] Urban

[9] A few areas, like most of the city of San Francisco, have combined sewer systems that flow to municipal wastewater treatment plants. Innovative stormwater treatment projects and requirements to treat runoff from new development sites provide treatment for a very small fraction (<5%) of California's urban runoff.

runoff carries pollutants from urban surfaces into storm drains and creeks. These pollutants may be dissolved in the rain or attached to fine particles that flow with the water through the storm drain system (given pyrethroids low solubility, the latter is the most likely pathway for pyrethroid transport). Only a small fraction of the total quantity of pesticides that are applied outdoors wash off. Washoff fractions from pesticide applications to impervious surfaces appear (on the basis of limited data) to be significantly higher than washoff fractions from "pervious" surfaces like lawns and landscaped areas (see TDC Environmental 2003 for more information).

In California, wastewater treatment plants discharge to rivers, bays, or the ocean, but normally not to urban creeks. None of the urban creeks where pyrethroid-related sediment toxicity has been found receives wastewater treatment plant discharges (Amweg et al. 2006; Weston et al. 2005). Because there is not a direct link between wastewater discharges and the identified toxicity, this analysis focuses on outdoor pyrethroids use.

<u>Permethrin Equivalents</u>

The pyrethroids are a family of pesticides with similar mechanisms of toxicity. They are believed to have additive effects on aquatic organisms (Weston et al. 2004). To understand the environmental importance of the pyrethroids, it is necessary to look at them as a group. Simply adding up the total quantity of pyrethroids is not sufficient, because the aquatic toxicity of pyrethroids differs among the individual pesticides—some are more than twenty times more toxic than others. Toxicity differences among pyrethroids must be taken into account to understand potential for pyrethroids to cause aquatic toxicity. To address their toxicity, pyrethroids can be summed on the basis of "permethrin equivalents," which are calculated based on the toxicity of each pyrethroid, as explained below.

Toxicity to the sediment-dwelling organism *Hyalella azteca* is an important environmental endpoint (Weston et al. 2004; Amweg et al. 2005). Comparing toxicity to *Hyalella azteca* of various pyrethroids is a convenient method of expressing their toxicity differences. Table 9 summarizes the average sediment 10-day LC50s (lethal concentration to 50% of organisms) for pyrethroids toxicity to *Hyalella azteca*. The table also shows the relative toxicity of the pyrethroids, expressed as the ratio of the toxicity of each pyrethroid to the toxicity of permethrin. The number of "permethrin equivalents" is

Table 9. Toxicity of Pyrethroids to *Hyalella azteca*

Pyrethroid	Average sediment 10-Day LC50 (µg/g organic carbon)	Ratio to Permethrin LC50
Bifenthrin	0.52	21
Cyfluthrin	1.08	10
Beta-Cyfluthrin	1.08*	10*
Cypermethrin	0.38	29
Deltamethrin	0.79	14
Esfenvalerate	1.54	7.03
Lambda-Cyhalothrin	0.45	24
Permethrin	10.83	1.00
Tralomethrin	*	*

Source: Maund et al. 2002 (cypermethrin); Amweg et al. 2005 (all others).
*No data available. Because it is a subset of Cyfluthrin isomers, Beta-cyfluthrin was assumed to have the same toxicity as cyfluthrin. Based on relative toxicity to other aquatic species, Tralomethrin was assumed to have the same toxicity as permethrin.

calculated by multiplying the quantity of a pyrethroid by the listed “Ratio to Permethrin LC50” listed in Table 9.

California and San Francisco Bay Area Pyrethroid Use

Figures 2 and 3 provide an overview of how pyrethroids are used in California. These two figures are based on the data in Tables 6 and 7. Figure 2 is based on the total quantity of pyrethroids applied, without consideration of the toxicity of the individual pyrethroids. By comparing Figure 2 to Figure 3 (which uses permethrin equivalents to account for the toxicity of each pyrethroid), it is apparent that the specific pyrethroids applied for agricultural and unreported urban uses are less toxic to aquatic life (as represented by *Hyalella azteca*) than those applied by professionals for urban use.

Figure 2. California Study List Pyrethroids Use, 2004
(Pounds of Pesticide Active Ingredient)

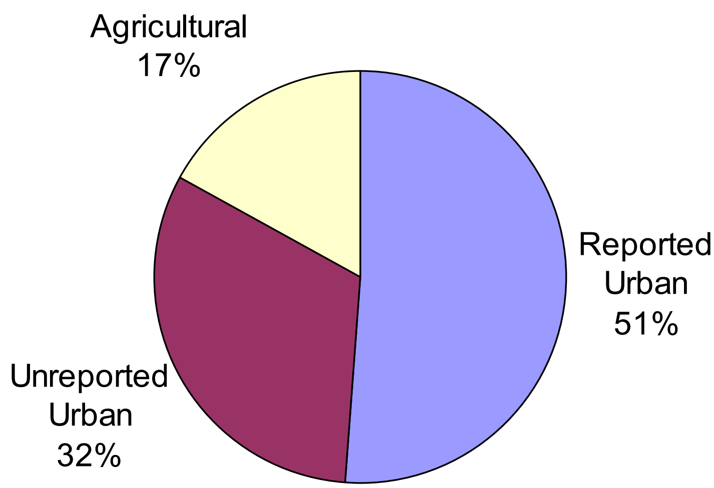
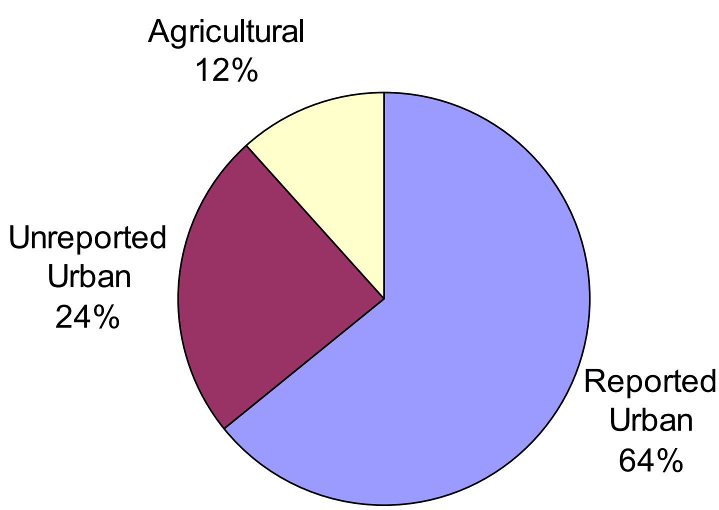


Figure 3. California Study List Pyrethroids Use, 2004
(Permethrin Equivalents)



Figures 4 and 5 (which are based on data in Tables 3 and 6 and the factors in Table 9) provide an overview of urban pyrethroids use. Comparing Figures 4 and 5 shows that the pyrethroids in unreported urban uses are less toxic to aquatic life (as represented by *Hyalella azteca*) than those applied for structural pest control. When reviewing Figures 4 and 5, it is important to remember that some pyrethroids applied for structural pest control are applied by underground injections—and therefore relatively unimportant for urban surface water quality (this topic is explored further later in this section).

Figure 4. California Study List Pyrethroids Urban Uses, 2004
(Pounds of Pesticide Active Ingredient)

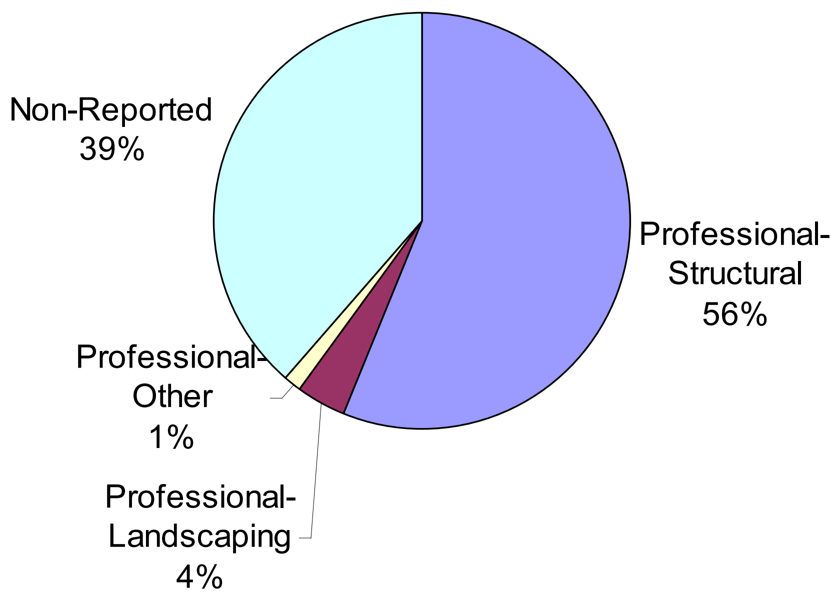
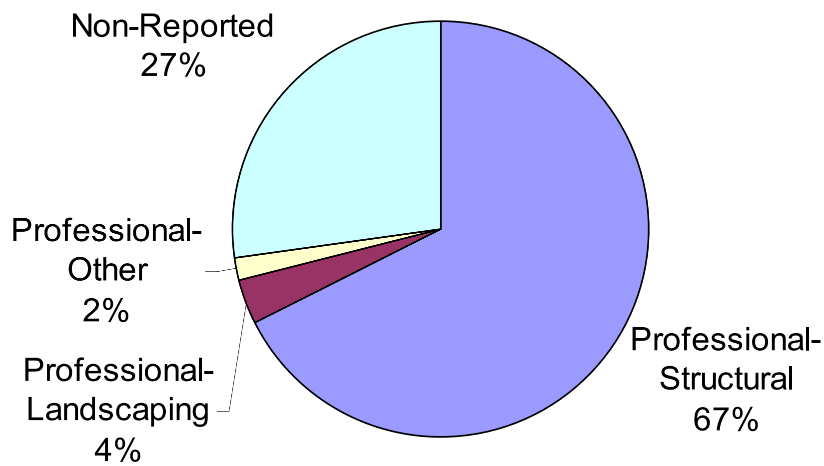


Figure 5. California Study List Pyrethroids Urban Uses, 2004
(Permethrin Equivalents)



Figures 6 and 7 (which are based on Tables 6 and 8 and the factors in Table 9) show that three pyrethroids—cypermethrin, cyfluthrin (including beta-cyfluthrin) and bifenthrin—contain about 90% of the pyrethroid-related toxicity (expressed in permethrin equivalents) that is used in California urban areas and in the San Francisco Bay area. These same three pyrethroids—particularly bifenthrin—have been most commonly found to contribute to toxicity in urban creeks (Amweg et al. 2006; Weston et al. 2005). Where reviewing these figures, keep in mind that usage quantity alone does not determine contributions to aquatic toxicity. Other factors—such as application location and environmental degradation rates—must also be considered.

Figure 6. Study List Pyrethroids Used in California Urban Areas, 2004 (Permethrin Equivalents)

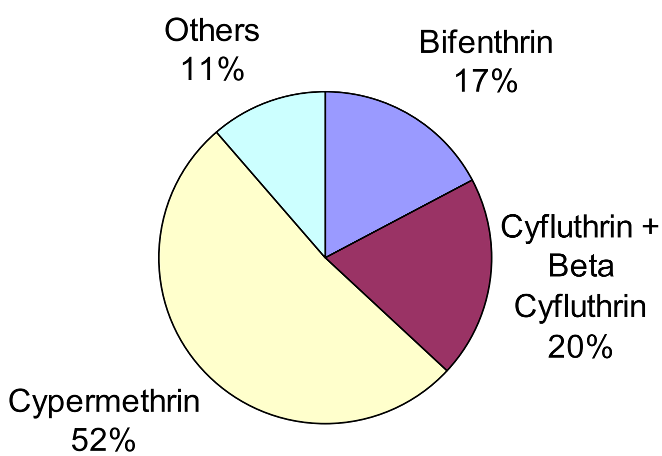
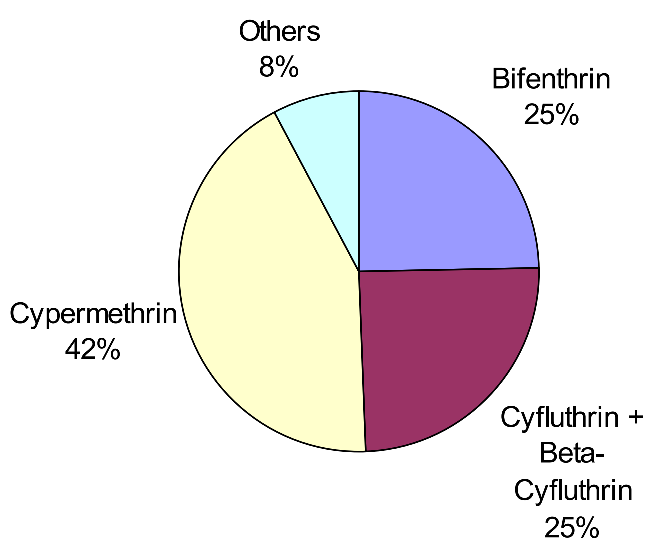


Figure 7. Study List Pyrethroids Used in the San Francisco Bay Area, 2004 (Permethrin Equivalents)



Figures 8 and 9 (which are based on data in Tables 4 and 8 and the factors in Table 9) show how considering the toxicity of the pyrethroids can change the interpretation of pesticide use data. As shown in Figure 8, about a quarter of estimated urban pyrethroid use (on the basis of pounds of active ingredient) is by professional pest control operators for structural pest control. However, the pyrethroids selected by structural pest control operators are, on average, more toxic than those used for non-reported uses. As Figure 9 shows, professional pest control operator applications of pyrethroids for structural pest control comprise almost half of the amount of toxicity in pyrethroids used in the San Francisco Bay Area. This conclusion should be viewed with caution, as a potentially significant fraction of professional structural pest control applications of pyrethroids may be applied underground and thus may be relatively unimportant for water quality.

Figure 8. San Francisco Bay Area Study List Pyrethroids Urban Uses, 2004 (Pounds of Pesticide Active Ingredient)

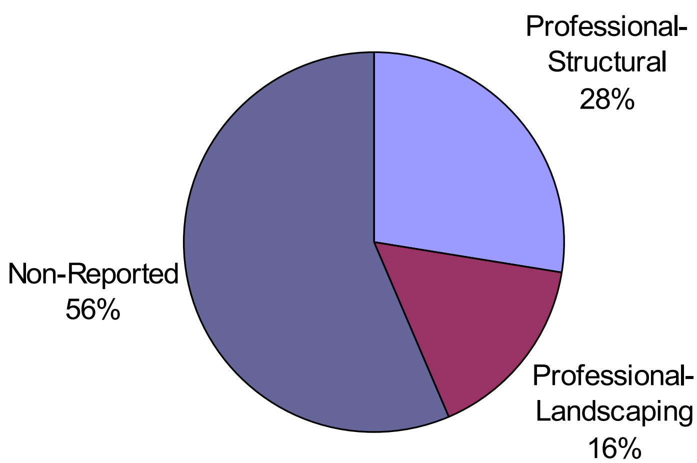
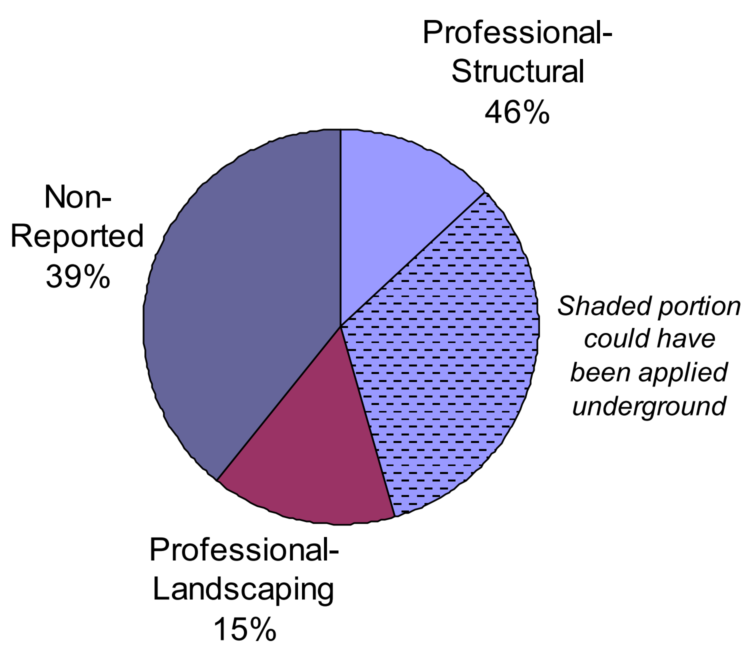


Figure 9. Toxicity of San Francisco Bay Area Study List Pyrethroids Urban Uses, 2004 (Permethrin Equivalents)



Underground Applications

The pesticide reporting forms used in California for structural pest control applications does not provide a way to distinguish among applications above ground (e.g., around buildings to control ants), indoors (e.g., baseboard sprays and flea foggers), and those made by underground injection (e.g., to control termites). Because applications by underground injection are unlikely to contribute significantly to aquatic toxicity—and applications indoors would affect sewer discharges rather than urban runoff—it would be preferable to be able to distinguish among these applications.

Pesticide application reports require applicators to identify the specific pesticide product that was applied. Assuming that professionals use products according to their label directions, it is possible to identify potential application types (outdoor, indoor, underground) based on a review of the labels for the applied products. Copies of product labels are available on the Internet in the U.S. EPA's Pesticide Product Label System (PPLS). PPLS labels may differ slightly from California-approved labels; however, differences are not common (because California cannot control pesticide labels directly) and are expected to be unusual for urban uses of pyrethroid products (because DPR does not normally examine urban uses in detail during its registration process).

The PPLS labels for more than 99% of the quantity of study list pyrethroid products reported used for structural pest control in the San Francisco Bay Area in 2004 were reviewed to determine whether allowable uses included aboveground outdoor uses, indoor uses, and/or underground injection applications. Where multiple labels were in the database, the label applicable in 2004 was selected. All products were found to allow application aboveground outdoors for structural pest control. Nearly all products (except granular formulations) allowed indoor applications. Only a portion of the products were labeled for underground injection—these included some bifenthrin products, one cypermethrin product, and all permethrin products. No cyfluthrin, beta-cyfluthrin, deltamethrin, esfenvalerate, lambda-cyhalothrin, or tralomethrin product labels allowed underground injection applications.

One-third (33%) of the quantity of bifenthrin, 92% of the quantity of cypermethrin, and 99% of the quantity of permethrin reported applied for structural pest control applications in the San Francisco Bay Area in 2004 were from products where labels allow underground injection. Overall, 71% of the total quantity of study list pyrethroids that were applied (also 71% of the permethrin equivalents) were of products where labels allow underground injection. While it is unlikely that all of this was applied underground, this analysis method identifies the minimum (0%) and the maximum (71%) fraction of the Bay Area reported structural pest control pyrethroids use that could have been applied underground. The actual fraction of underground applications is likely between these two extremes. The maximum fraction that could have been applied underground is designated by shading in Figure 9.

Some of the unreported pyrethroids use may involve applications by "trenching," which is the typical non-professional method for applying termite-control pesticides. This method, if properly implemented, would cause most of the pesticide to be applied below the ground surface and thus not be subject to runoff. The fraction of unreported applications of pyrethroids made in this manner is not known, but is anticipated to be relatively small, as pesticide applications to control termites by residents (rather than a professionals) appear to be rare based on surveys of consumer pesticide use (Wilen 2001; Wilen 2002; Flint 2003).

Indoor Applications

Professional structural pest control applications can be made indoors. As mentioned above, nearly all study list pyrethroid products reported applied for structural pest control (except granules, only a few percent of reported use) allow indoor application. Neither reporting nor labels provide a means to estimate quantitatively the fraction applied indoors. Consumer surveys can, however, provide a qualitative indication of the extent of indoor applications. Available surveys cover residents, but not businesses, and thus may not fully reflect application patterns.

In 2002-2003, the University of California Integrated Pest Management program (U.C. IPM) completed detailed telephone surveys of residents in the San Francisco Bay Area and the Central Valley (Sacramento and Stockton areas) (Flint 2003). These surveys, which were designed to collect representative samples of residents in each region, included a question about how professional pest control operators hired by the resident applied pesticides. Only 4% of San Francisco Bay Area respondents who hired professional pest control applicators said that the professional applied pesticides indoors. For the surveyed Central Valley regions, indoor applications by professionals were reported by fewer than 6% of respondents who hired professionals.

In 2000 and 2001, U.C. IPM conducted similar surveys in Southern California (in the San Diego Creek and Delhi Channel areas of Orange County and in the Chollas Creek watershed of San Diego County) (Wilen 2001; Wilen 2002). These surveys also found that indoor pesticide applications were relatively uncommon, but perhaps slightly more common than in Northern California. In these surveys, fewer than 2% of respondents reported hiring a professional pest control company to apply pesticides indoors; however, 10-16% said that a building manager handled pest control, including any indoor applications that might be needed.

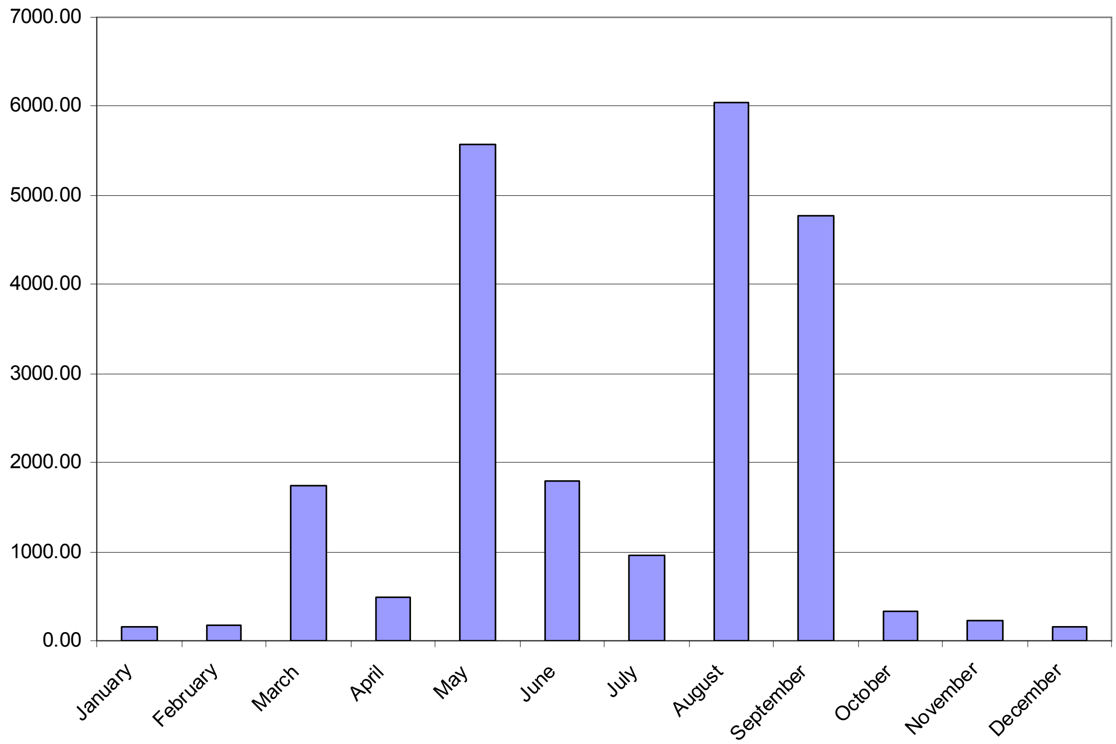
Based on these survey data, it is reasonable to assume that indoor applications by professionals occur, but that these applications represent a relatively small fraction of the pyrethroids applied for structural pest control. This small quantity falls in the range of the error of the estimates. Omitting consideration of indoor applications of study list pyrethroids by professional structural pest control applicators should have little effect on interpretation of pesticide use data.

For unreported applications, the surveys do not provide a clear basis for estimating the fraction of pyrethroids use that occurs indoors. Although the Northern California surveys did not address indoor self-applications, the Southern California surveys did ask residents if they applied pesticides indoors. About 60% of respondents to these surveys reported indoor pesticide applications by household members (in contrast, only about 25% to 45% reported outdoor pesticide applications by household members). More than half of these applications were aerosols sprays, which generally contain very small quantities of pesticide active ingredients. However, formulations that might have more meaningful quantities of pyrethroid active ingredients (ready-to-use pump sprays, other liquids, concentrates, and powders) were used indoors by more than 20% of respondents in the Delhi Channel area of Orange County and the Chollas Creek watershed of San Diego County (the only regions where this question was asked).

Pyrethroid Application Timing

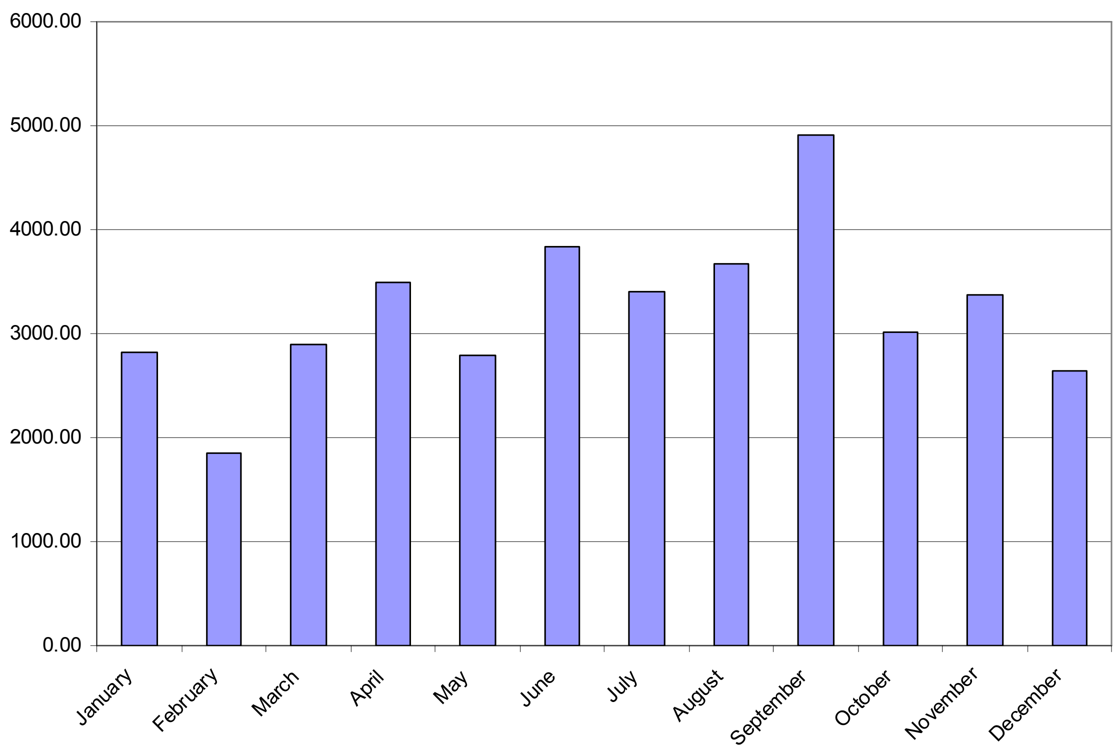
Urban pyrethroids applications occur at all times of the year. As shown in Figure 10 (on the next page), in 2004, professional applications of study list pyrethroids for landscape maintenance experienced spring and fall peaks and were low during the winter, which is the rainy season. In contrast, professional structural pest control application quantities were more consistent throughout the year, as Figure 11 (on the next page) shows.

Figure 10. San Francisco Bay Area Study List Pyrethroids Reported Landscape Maintenance Applications by Month in 2004 (Pounds of Active Ingredient)



Source: Pesticide use reports (DPR 2006a).

Figure 11. San Francisco Bay Area Study List Pyrethroids Reported Structural Pest Control Applications by Month in 2004 (Pounds of Active Ingredient)



Source: Pesticide use reports (DPR 2006a).

2.6 Trends

Table 10 (on the next page) shows the trends in estimated San Francisco Bay Area urban use (both reported and unreported) of study list pesticides from 1999-2004. This reflects the most recent available data (2004) and most of the time period during which the market was transitioning in response to U.S. EPA's year 2000 announcements of the termination of most urban uses of diazinon and chlorpyrifos. Until data are available to reflect the period after the final end of sales of diazinon urban use products (December 2004) and chlorpyrifos termiticide products (December 2005), the effect of the transition may not be fully understood.

To evaluate the effect of the transition, it is necessary to look at the trend between 2001 (the first reporting year after the phase-out announcements) and 2004 (the most recent year for which data are available). The data in Table 10 show the following trends between 2001 and 2004:

- Use of pyrethroids, malathion, and fipronil increased. Three individual pyrethroids did not exhibit the trend of the group: lambda-cyhalothrin and permethrin (no meaningful change) and cyfluthrin (sales appear to be shifting to the beta form).
- Use of diazinon decreased.

These data suggest that pyrethroids, fipronil, and perhaps malathion are replacing diazinon and chlorpyrifos in the urban pesticide use market. Estimating how this shift affects urban runoff is not simple, as some of the previous uses of diazinon and chlorpyrifos and the new uses of these products are not outdoor surface applications.

The following recent changes are notable:

- Fipronil sales increased significantly in 2003 and 2004. Fipronil is a relatively new insecticide—it was first registered in California in the late 1990s. Fipronil is available in professional products and in containerized baits and pet flea control products for consumers. Fipronil is labeled for underground injection to control termites, which colloquial information suggests was its primary initial use. The label was amended in 2003 to allow for application around structures to control ants, which could expose it to runoff.
- Tralomethrin use increased significantly between 2000 and 2003. It was first observed in multiple non-aerosol products intended for applications around structures and on landscaping (liquid ready to use and granule formulations) in 2003. While this involved a relatively small number of products from one supplier, sales data suggest that the application quantity has the potential to be meaningful, if these new products—rather than aerosols—comprise a significant fraction of the quantity of active ingredient sold.
- Beta-cyfluthrin use appeared to grow significantly. Sales data for beta-cyfluthrin, which is a refined form of cyfluthrin that is more concentrated in the most toxic isomers, first became public in 2003. If beta-cyfluthrin sales for prior years correlate with reported use, total use has increased significantly.
- Bifenthrin use grew significantly in 2004. Between 2003 and 2004, reported applications (primarily for above ground structural pest control) doubled—and unreported use increased by about 500%.

Table 10. San Francisco Bay Area Study List Pesticides Estimated Urban Use 1999-2004[a]
(Pounds of Pesticide Active Ingredient)

Pesticide	1999	2000	2001	2002	2003	2004
Pyrethroids						
Bifenthrin	*600*	*1,400*	2,000	5,000	6,000	20,000
Cyfluthrin	5,400	7,000	5,300	7,900	4,800	3,500
Beta-Cyfluthrin	0	<1	*73*	*360*	8,000	30,000
Cypermethrin	11,000	12,000	9,500	10,000	15,000	22,000
Deltamethrin	400	1,000	600	1,200	1,400	1,100
Esfenvalerate	2,000	2,000	2,000	3,000	4,000	5,000
Lambda-Cyhalothrin	*540*	*650*	*530*	740	600	330
Permethrin	30,000	40,000	10,000	30,000	30,000	30,000
Tralomethrin	300	200	7,000	10,000	10,000	30,000
OPs						
Chlorpyrifos	100,000	100,000	80,000	60,000	?[b]	?[b]
Diazinon	200,000	100,000	100,000	90,000	50,000	**60,000**[c]
Malathion	200,000	100,000	100,000	80,000	200,000	200,000
Other						
Carbaryl	50,000	40,000	30,000	70,000	30,000	30,000
Fipronil	*1*	310	3,000	5,000	200,000	200,000
PHMB	*0*	5,000	*0*	*0*	10,000	8,000

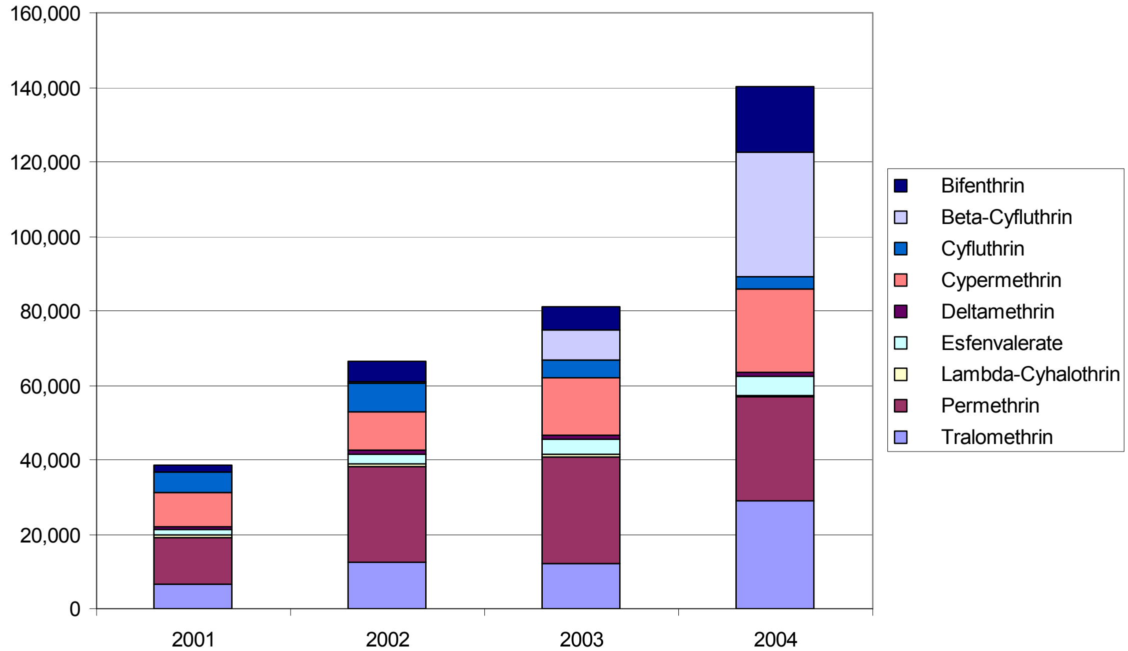
Source: TDC Environmental calculations based on DPR sales (DPR 2000a, 2001a, 2002a, 2003a, 2005a, 2006b) and reported use data (DPR 2000b, 2001b, 2002b, 2003b, 2005b, 2006a) and the Bay Area fraction of the state population (DOF 2006).
[a]Values in italics do not include any estimate of unreported use, as sales data were not available (sales of products with fewer than four registrants are not disclosed to the public.).
[b]Estimates of chlorpyrifos urban use made according to the methodology are very unlikely to represent actual urban use, as they are based primarily on estimated retail sales of chlorpyrifos, which were essentially prohibited. Therefore, values have not been included in the table. Please see Section 2.4.
[c]Estimated use of diazinon is very likely a significant overestimate as it is based almost entirely on estimated retail sales of diazinon, which were phasing out. Please see the discussion in the text in Section 2.4.
Notes: Uncertainties are discussed in Section 2.4. Values reflect one or two significant figures, depending on the accuracy of the input data.

Trends in Pyrethroids Use

While the total quantity of pyrethroids estimated used in 2004 (about 140,000 pounds) is lower than the total quantity of diazinon and chlorpyrifos estimated used in 1999 (about 295,000 pounds), comparing quantities is not sufficient to gain an understanding of the potential surface water quality impact of pesticide use. In general, pyrethroids are significantly more toxic to the most sensitive aquatic species than diazinon and chlorpyrifos (see TDC Environmental 2003), which means that much lower concentrations—and therefore much lower use rates—can adversely affect surface water quality.

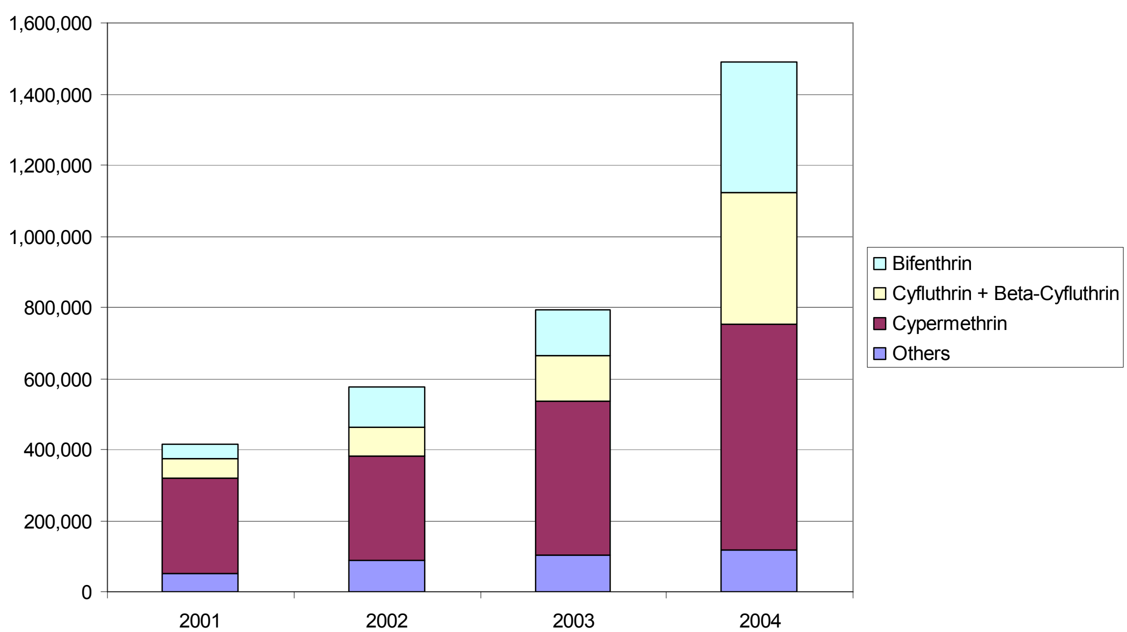
Figures 12 and 13 summarize pyrethroid use trends from 2001-2004 (the time period of the phase out of most urban uses of diazinon and chlorpyrifos). Figure 12 shows the total use of the study pyrethroids based on pounds of active ingredient. Between 2001 and 2004, use more than tripled. Figure 13 presents these data on the basis of permethrin equivalents, adjusting for the aquatic toxicity of each pyrethroid using the data from Table 7. In 2004, pyrethroid applications comprised the equivalent of the application of almost 1,500,000 pounds of permethrin, more than 3.5 times the use in 2001. Figure 12 shows that the most heavily used pyrethroids are permethrin and cypermethrin. Figure 13 shows that cypermethrin, cyfluthrin (including beta-cyfluthrin) and bifenthrin applications contain the most toxicity.

Figure 12. San Francisco Bay Area Study List Pyrethroids Estimated Urban Use 2001-2004 (Pounds of Active Ingredient)



Source: Table 10.

Figure 13. San Francisco Bay Area Study List Pyrethroids Estimated Urban Use 2001-2004 (Permethrin Equivalents)

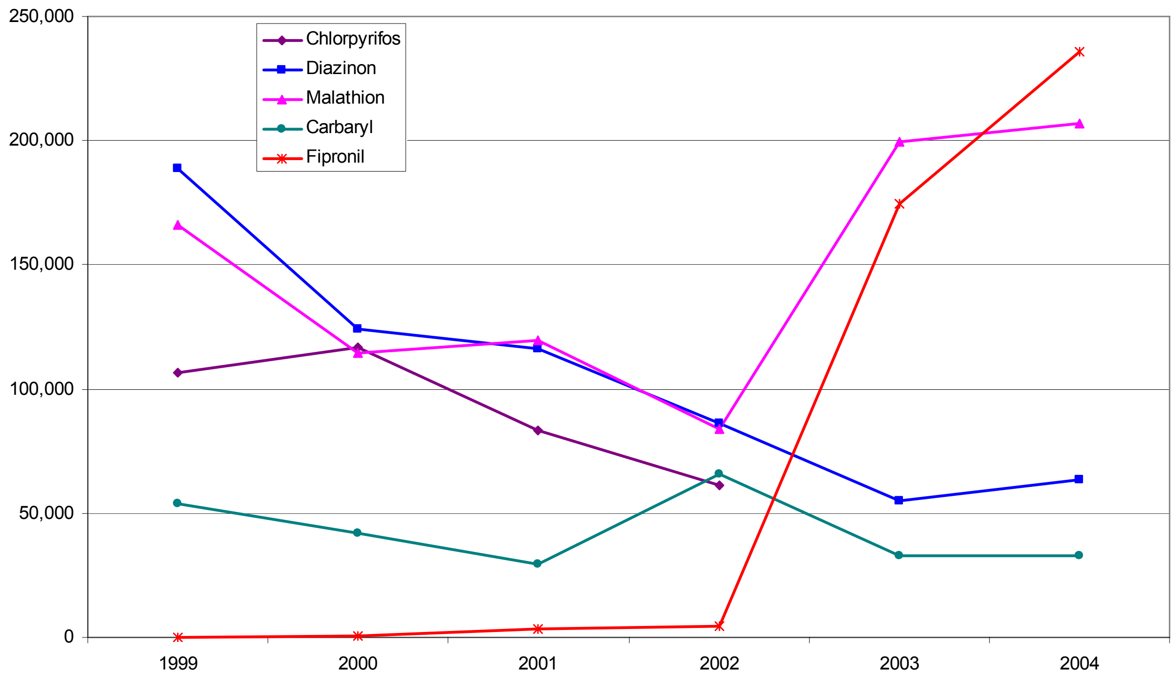


Source: Table 10, adjusted for the relative aquatic toxicity of each pyrethroid with values in Table 9.

<u>Trends in Use of Other Study List Pesticides</u>

Figure 14 shows recent trends in estimated urban use of selected other study list pesticides in the San Francisco Bay Area from 1999 through 2004. As explained above, Figure 14 shows the decline in diazinon use and the recent increase in fipronil and malathion use. As explained in Section 2.4, the small increase in estimated diazinon use is likely to reflect something other than real increased use in 2004, because diazinon sales were phasing out.

Figure 14. San Francisco Bay Area Study List Organophosphorous Pesticides, Carbaryl and Fipronil Estimated Urban Use 1999-2004 (Pounds of Active Ingredient)



Source: Data used to generate Table 10.
Notes: Values in Table 10 are rounded to reflect the appropriate number of significant figures (in most cases one significant figure). Values in this figure do not reflect the rounding. Chlorpyrifos values for 2003 and 2004 are omitted as explained in Table 10.

3.0 CONCLUSIONS

Conclusion 1: *Urban use of diazinon decreased from 2001 to 2004.* Phase out of most urban uses of diazinon in response to U.S. EPA agreements with manufacturers is evident.

Conclusion 2: *Urban use of pyrethroids, malathion, and fipronil increased from 2001 to 2004. Pyrethroids, fipronil, and (to a lesser extent) malathion are replacing diazinon and chlorpyrifos in the urban pesticide use market.* Estimating how this shift affects water quality is not simple, as the primary aquatic toxicity endpoints are different and some of the previous uses of diazinon and chlorpyrifos and the new uses of substitute products involve underground applications and containerized baits, neither of which are likely to be important for surface water quality. While the total quantity of pyrethroids estimated used in 2004 (about 140,000 pounds) is lower than the total quantity of diazinon and chlorpyrifos estimated used in 1999 (about 295,000 pounds), these applications have greater potential to be environmentally relevant, as pyrethroids are significantly more toxic to aquatic species than diazinon and chlorpyrifos.

Conclusion 3: *No single user category dominates urban use of pyrethroids that could be transported to surface water.* Both professionals and non-professionals apply pyrethroids outdoors. Professionals apply pyrethroids to control pests in and around structures and in landscaped areas (including lawns). Non-professionals (probably primarily residents) also apply pesticides around buildings and in landscaped areas. Although the majority of pyrethroid use statewide is for structural pest control, it is unclear what fraction of these applications involves underground injection (which is not a major concern for water quality). In the San Francisco Bay area, the relative fraction of pyrethroids applications for structural pest control is estimated to be lower than it is statewide.

Conclusion 4: *Three pyrethroids—cypermethrin, cyfluthrin (including beta-cyfluthrin) and bifenthrin—contain about 90% of the pyrethroid-related toxicity (expressed in permethrin equivalents) that is used in California*. These three pyrethroids are the ones that have most often been found to be significant contributors to pyrethroid-related toxicity to sediment dwelling organisms in Northern California urban creeks.

Conclusion 5: *Fipronil use is increasing very rapidly.* It is uncertain what fraction of this use is for underground injection and containerized baits (which are not a major concern for water quality) and what fraction involves above ground applications, such as the recently allowed use around structures to control ants.

Conclusion 6: *Professionals have generally moved away from older pesticides.* Professionals used only a small fraction of the diazinon, chlorpyrifos, malathion, and carbaryl sold in 2004.

Conclusion 7: *A significant fraction of the pyrethroids reported applied by professionals for structural pest control may be injected underground, where they cannot be transported readily to surface water.* As much as 71% of the study list pyrethroids applied by professionals in the San Francisco Bay Area for structural pest control could have been applied underground. The actual fraction of underground applications is likely less than 71%, but greater than zero. Based on consumer surveys, it is unlikely that a meaningful fraction of unreported pyrethroid use involves underground applications.

Conclusion 8: *Indoor applications are unlikely to comprise a significant fraction of professional structural pest control use of study list pyrethroids, but may comprise a meaningful fraction of unreported pyrethroid use*. Omitting consideration of indoor use of study list pyrethroids by professional structural pest control applicators should have little effect on interpretation of pesticide use data.

Conclusion 9: In 2004, at least half of California pesticide use was in urban areas. Although only about 8% of reported pesticide use is urban, about 74% of pesticide use is not reported. Almost all pesticide uses that do not require reporting are urban. The total of urban reported use and unreported use was about three-fourths of pesticide sales in California in 2004.

Conclusion 10: Malathion, fipronil, PHMB, and most pyrethroids are used primarily in urban areas. Of the study list pesticides, only diazinon, chlorpyrifos, carbaryl and the pyrethroids lambda-cyhalothrin and esfenvalerate are used more in agricultural areas than in urban areas. More than 80% of the use of study list pyrethroids occurred in California urban areas in 2004.

Conclusion 11. Urban pyrethroids applications occur at all times of the year. In 2004, landscaping applications by professionals peaked in the spring and early fall. Professional structural pest control applications did not vary significantly by season.

4.0 MITIGATION IMPROVEMENT RECOMMENDATIONS

The following are recommendations to improve urban pesticide toxicity reduction activities. These recommendations are not only based on this report—they are also based on the information in the UP3 Project's recent regulatory and research and monitoring updates (TDC Environmental 2005a and 2006). This section includes a set of general recommendations, followed by specific recommendations for outreach and education, monitoring and research, regulatory activities, and funding. The recommendations below are not directed only at California water quality agencies—U.S. EPA, DPR, and others should play a significant (if not leading) role in their implementation.

Recommendation 1: *Target outdoor, above ground use of pyrethroids in pesticide toxicity reduction programs.* Any outdoor use of pyrethroids that is subject to storm water (or other water) runoff could contribute to the pyrethroid-related toxicity that has been identified in Northern California urban creeks.

Recommendation 2: *Seek to change the way Argentine ants are kept out of buildings in California.* Argentine ant control around buildings is the most common urban insecticide application in California. Surfaces around buildings are often impervious surfaces, from which meaningful fractions of pesticides can wash off when it rains (or when non-rainwater discharges occur). Spraying pesticides on and around buildings to control Argentine ants has historically been among the most problematic pesticide uses for water quality. Shifting Argentine ant control methods away from perimeter sprays and to IPM-based methods that minimize pesticide releases to surface waters (e.g., use of containerized baits and barriers like caulking) may be an important element in ending recurring surface water quality problems from urban insecticide use. Consideration should also be given to identifying building methods, materials, and landscaping practices that can reduce Argentine ant problems inside buildings.

Recommendation 3: *Avoid recommending against or terminating use of a particular insecticide without promoting or requiring a less environmentally problematic substitute.* History continues to show that simply substituting one group of pesticides for the previous one creates new environmental problems. In the near term, this recommendation will be particularly important in developing management strategies for pyrethroid-related sediment toxicity and copper releases from marine antifouling paint.

Recommendation 4: *Recognize that widespread use of any pesticide in an urban watershed can have significant adverse cumulative impacts on surface waters receiving runoff and wastewater treatment plant discharges*. Adverse effects of pesticides on water quality involve a combination of pesticide toxicity and the quantity of pesticide used in manners that lead to releases to surface water bodies. Developing and implementing pest control and pesticide application methods that provide effective pest control while minimizing pesticide runoff (e.g., mechanical controls, containerized baits, restriction of urban outdoor pesticide applications to spot treatments) would reduce the potential for pest control to create water quality problems.

Recommendation 5: *Continue to focus programs intended to prevent urban pesticide-related surface water toxicity on insecticides*. U.S. Geological Survey (USGS) data show that insecticides are more likely to be associated with surface water toxicity in urban areas than herbicides. (The USGS study only compared insecticides and herbicides; it did not address disinfectants, fungicides, or any other class of pesticides).

Outreach and Education

The highest priorities for outreach and education are Recommendations 1 through 5 above. The additional recommendations below focus on potential hazards of specific insecticides to aquatic life. An excellent set of recommendations addressing all priorities for outreach and education to urban pesticide users (particularly non-residential users) to reduce water quality impacts has been prepared by the University of California in the report *Tracking Non-Residential Pesticide Use in Urban Areas of California* (Wilen et al. 2005).[10]

Recommendation 6: *Continue to discourage use of pyrethroids, carbaryl, and malathion as replacements for urban uses of diazinon and chlorpyrifos.* Instead, encourage IPM-based insect control methods that minimize pesticide releases to surface waters (e.g., use of containerized baits and barriers like caulking).

Recommendation 7: *Continue to exercise discretion with recommendation of alternative pesticides for urban outdoor applications, particularly imidacloprid, pyrethrins, and fipronil.* Because containerized baits are unlikely to release significant quantities of pesticide active ingredients into runoff, it is not necessary to avoid fipronil in containerized baits (however, above ground outdoor application of uncontainerized fipronil products should be avoided).

Monitoring and Research

Recommendation 8: *Support activities to improve chemical analytical and toxicity testing capabilities for pesticides in surface water (water column and sediment), urban runoff, and municipal wastewater treatment plant effluent*. The suggested near-term priority that is not currently being addressed is development of chemical analysis methods with environmentally meaningful detection limits for PHMB and fipronil (and fipronil degradates). Creating methods that are feasible for commercial laboratories is particularly important, since contractors (rather than agency or university laboratories) perform the chemical analysis of most surface water quality samples collected in California.

Recommendation 9: *Conduct surveillance monitoring of California urban surface waters, including sediment, for toxicity and for specific pesticides that have the potential to cause adverse effects in aquatic ecosystems (e.g., currently used pyrethroids[11], carbaryl, malathion, PHMB, and fipronil and its degradates).* A long-term surveillance monitoring program is needed. Specific monitoring recommendations are as follows:[12]

- Toxicity monitoring should be conducted with standard aquatic toxicity test species and should (in the near term) include the standard test species most sensitive to pyrethroids (water column—*Oncorhynchus mykiss* and *Ceriodaphnia dubia*; sediment—*Hyalella azteca)*.
- Pyrethroids monitoring should include bifenthrin, cyfluthrin (including beta-cyfluthrin), cypermethrin, deltamethrin, esfenvalerate, lambda-cyhalothrin, permethrin, and tralomethrin.

[10] Available on the Internet: http://www.up3project.org/documents/dpr_ucipm_non-residential_pesticide_use.pdf or http://www.ipm.ucdavis.edu/PDF/PUBS/ucdavisrep.pdf.
[11] The pyrethroids of greatest interest for urban surface water quality are bifenthrin, cyfluthrin (including beta-cyfluthrin), cypermethrin, deltamethrin, esfenvalerate, lambda-cyhalothrin, permethrin, and tralomethrin.
[12] Toxicity test species and detection limit recommendations are based on aquatic toxicity data and (where available) water quality criteria (see section 4, TDC Environmental 2003 and Oros and Werner 2005) and best professional judgment. The pyrethroids selection is based on evaluation of urban pesticide use (see TDC Environmental 2006).

- Monitoring of pyrethroids in sediments is a higher priority than monitoring for them in the water column. Because pyrethroid toxicity is inversely correlated with organic carbon concentration, when monitoring for pyrethroids in sediments, organic carbon concentrations should also be measured.
- Recommended detection limits are:
  - Each individual pyrethroid in water—as close to 1 nanogram/liter as available
  - Each individual pyrethroid in sediment—1 nanogram/gram (dry weight)
  - Carbaryl in water—0.5 micrograms/liter
  - Malathion in water—0.1 micrograms/liter
  - PHMB in water—10 micrograms/liter
  - Fipronil and degradates in water—0.1 micrograms/liter
  - Fipronil and degradates in sediment—30 nanogram/gram (dry weight)

The Clean Estuary Partnership designed a monitoring program that—if implemented—would fulfill these recommendations for the San Francisco Bay Area (Ruby 2006). Monitoring programs should be adjusted every few years to reflect pesticide market changes.

Recommendation 10: *Compile pesticide-related water quality monitoring data in one readily accessible location.* The compilation could be regional (e.g., by Water Board region) or statewide. All monitoring reports for pesticides in surface water should be submitted to DPR for inclusion in its surface water database.[13] Creating an Internet site that contained monitoring plans and final reports would be extremely useful to pesticide and water quality researchers, managers, and regulators. The UP3 Project has compiled some information on its web site[14] and in its reports; however, the budget necessary to compile and update a complete Internet site that includes all water quality monitoring plans, data, and reports exceeds current UP3 Project resources.

Recommendation 11: *Encourage publication of pesticide monitoring data in professional journals.* Data that have been published in professional journals are more broadly accessible and have more credibility for use by regulatory agencies (particularly pesticide regulatory agencies). Since one year's worth of a single program's data may be insufficient for complete interpretation, preparation of regional data reviews every few years is recommended (e.g., a multi-year version of the recent Clean Estuary Partnership Analysis of Bay Area Urban Creeks Monitoring, 2004-05) (Ruby 2005).

Recommendation 12: *Report all pesticide-related toxicity incidents and provide all pesticide-related monitoring data to U.S. EPA and DPR.* Because monitoring data provide a strong basis for pesticide regulatory agency decisions, providing all data will help U.S. EPA and DPR use their regulatory authorities to protect water quality and prevent pesticide-related noncompliance with water quality standards and NPDES permits.

Recommendation 13: *Avoid over-interpretation of non-detect chemical analytical results for pyrethroids.* Because commonly used methods (e.g., U.S. EPA method 1660) cannot detect environmentally relevant concentrations of pyrethroids, non-detect results from chemical analyses by these methods do not mean that pyrethroids are not present at concentrations sufficient to cause aquatic toxicity.

---

[13] See DPR's Internet site (http://www.cdpr.ca.gov/docs/sw/surfdata.htm) for information on data submittal.
[14] http://www.up3project.org/up3_monitoring.shtml

Recommendation 14: Obtain additional information about the linkage between pyrethroid use and surface waters in urban areas. Such information will allow toxicity reduction programs to more effectively target the causes of anticipated toxicity in surface water sediments and to determine whether voluntary measures have the capability of achieving the reductions necessary to prevent toxicity. Both monitoring and modeling will likely be needed to determine whether any one specific pyrethroid use pattern (e.g., around buildings or on lawns) is the most significant contributor to pyrethroid levels in creek sediments.

Recommendation 15: Obtain information to fill data gaps about pyrethroids. The most critical data gaps include:

- Aquatic toxicity data. Gaps include *Hyalella azteca* LC50 data for beta-cyfluthrin and tralomethrin, LC50 data for estuarine organisms (all pyrethroids), and sublethal toxicity data (EC50s) for both fresh water and estuarine organisms (all pyrethroids).
- Aquatic sediment half life values for all pyrethroids except bifenthrin and permethrin.
- LC50 values at creek temperatures, which are often lower than laboratory temperatures. Pyrethroids are generally more toxic at lower temperatures.

Recommendation 16: Assess the water quality implications of use of the insecticide fipronil in urban areas.

Recommendation 17: Encourage and support development of straightforward methods to evaluate the potential for pesticides to contribute to adverse effects on ecosystems from exposure to combinations of stressors. Pesticides, in combination with each other and other pollutants, may add to or synergize toxicity to aquatic organisms. Stress from exposure to predators, in combination with pesticide exposures, can adversely affect organisms at concentrations below documented toxicity thresholds. Development of methods to evaluate these cumulative adverse effects is critical to addressing them in pesticide regulatory processes.

Recommendation 18: Complete evaluations of methods to keep Argentine ants out of buildings. Implementation of Recommendation 2 would be facilitated by an evaluation of Argentine ant management strategies that was completed with the participation of statewide leaders from the pest control operator industry. DPR's pest management evaluation and pest management alliance program (which is currently unfunded) would be well positioned to complete such an evaluation.

Regulatory

Recommendation 19: Continue to provide U.S. EPA and DPR with information to prevent potential water quality problems associated with urban pesticide use and to encourage consistency in implementation of water quality and pesticide regulatory programs within U.S. EPA and California EPA. U.S. EPA staff have recommended that water quality agencies continue to communicate information and recommendations to U.S. EPA and expand efforts to meet in person and via teleconference directly with U.S. EPA Office of Pesticide Programs (OPP) management. Regular communication is important to ensure that U.S. EPA OPP staff (including chemical review managers) have an appreciation for water quality issues. Regular communication appears to be the most likely way to encourage U.S. EPA management to acknowledge and address the costly regulatory gaps created by uncoordinated implementation of Federal water quality and pesticide laws.

<u>Recommendation 20</u>: *Continue to strengthen the regional, statewide and nationwide network of water quality agencies working on urban pesticides issues*. Priorities include streamlining comment preparation processes and involving national organizations. There is particularly a need to determine whether coordination with urban runoff and water quality regulatory agencies elsewhere in the U.S. is possible.

<u>Recommendation 21</u>: *Increase efforts to raise urban pesticide surface water quality issues at the national level*. It is unlikely that California's experience with pesticide-related surface water quality problems in urban areas is unique. Water quality agency staff should increase efforts to participate in public forums (such as national advisory committees and national conferences) to enhance nationwide understanding of managing urban pesticides to prevent surface water quality problems. While budgets may limit travel, opportunities may exist for scholarships, U.S. EPA-funded travel, attending meetings in California, or participation by teleconference.

<u>Recommendation 22</u>: *Continue efforts to determine possible approaches and next steps toward developing practical methods for U.S. EPA and DPR to address the environmental effects of all ingredients in individual pesticide products when those products are registered or re-registered*. Continuing to facilitate the process of finding ways to fill these methodology gaps needs to be a priority for California water quality agencies. Conceptual models of pesticide fate and transport in urban environments may be useful tools to facilitate dialogue between water quality and pesticide regulators.

<u>Recommendation 23</u>: *Actively seek to strengthen communication between California water quality agencies and California and U.S. EPA pesticide regulators*. Enhanced communication will increase pesticide regulator appreciation for and consideration of the scientific and regulatory issues around pesticides and water quality. Water quality agencies can facilitate communication by being responsive to requests for dialogue and by trying to provide information and background using terminology that is accessible.

<u>Recommendation 24</u>: *When implementing pesticide regulatory controls, consider the environmental properties of the pesticides likely to replace any pesticides proposed for phase out (or great reduction of) urban uses and design a program to avoid environmental impacts.* Past experience suggests that leaving these changes solely to the free market may not ensure protection of human health and the environment.

<u>Recommendation 25</u>: *Modify California pesticide use reporting forms to differentiate between outdoor pesticide applications around structures and underground or indoor pesticide applications to control pests in structures.* To estimate the amount of pesticides subject to runoff in urban areas, it is necessary to separate above ground and underground/indoor pesticide applications.

<u>Recommendation 26</u>: *Field verify California pesticide use reporting data.* While DPR's pesticide use reporting system can provide valuable information for managing pesticide related water quality problems, available information suggests that the error rate for reported data could be much greater than 10% for individual pesticide active ingredients. An audit that included field verification of reporting would be able to determine the level of error in the data. Auditing urban uses would be particularly helpful, given that this analysis identifies structural pest control applications a significant urban use of pyrethroids, which have been linked to adverse effects in aquatic ecosystems.

<u>Funding</u>

<u>Recommendation 27</u>. *California and Federal environmental agencies need to obtain the funding necessary to implement the above recommendations.* Many of the above

recommendations have not been implemented due to lack of funds, rather than lack of interest among agencies capable of implementing them.

Recommendation 28*: Identify a stable funding source for pesticide-related urban surface water quality surveillance monitoring.*

Recommendation 29: *Develop a stable funding mechanism to continue scientific and regulatory support for California water quality agency participation in U.S. EPA and DPR regulatory activities affecting water quality*. Funding is also needed for interagency coordination and communication functions, such as those provided by the Urban Pesticides Committee and the UP3 Project web site. Funding for the UP3 Project ends in March 2007.

5.0 REFERENCES

Amweg, E. L., D. P. Weston and N. M. Ureda (2005). "Use and Toxicity of Pyrethroid Pesticides in the Central Valley, California, USA." *Environmental Toxicology and Chemistry* **24**(4): 966-972. Corrected per erratum published in *Environmental Toxicology and Chemistry* **24**(5).

Amweg, E. L., D. P. Weston, et al. (2006). "Pyrethroid Insecticides and Sediment Toxicity in Urban Creeks from California and Tennessee." *Environmental Science & Technology* **40**(5): 1700-1706.

Brank, G., Assistant Director, California Department of Pesticide Regulation (2005). Telephone conversation about estimated error rate in DPR pesticide sales data. April 7.

Brank, G. Assistant Director, California Department of Pesticide Regulation (2006). Telephone conversations and e-mails about estimated error rates in DPR data. June 19-23.

California Department of Finance (DOF) (2006). California Statistical Abstract. Table B-3 –Total Population, California & Counties. Sacramento, California, January.

California Department of Pesticide Regulation (DPR) (2000a). "State of California Pesticides Sold in California for Year: 1999, Combined Disclosed Active Ingredients by Chemical Name."

California Department of Pesticide Regulation (DPR) (2000b). *Summary of Pesticide Use Report Data 1999, Indexed by Chemical, Preliminary Data*, September.

California Department of Pesticide Regulation (DPR) (2001a). "State of California Pesticides Sold in California for Year: 2000, Combined Disclosed Active Ingredients by Chemical Name."

California Department of Pesticide Regulation (DPR) (2001b). *Summary of Pesticide Use Report Data 2000, Indexed by Chemical, Preliminary Data*, October.

California Department of Pesticide Regulation (DPR) (2002a). "State of California Pesticides Sold in California for Year: 2001, Combined Disclosed Active Ingredients by Chemical Name."

California Department of Pesticide Regulation (DPR) (2002b) *Summary of Pesticide Use Report Data 2001, Indexed by Chemical,* October.

California Department of Pesticide Regulation (DPR) (2003a). "State of California Pesticides Sold in California for Year: 2002, Combined Disclosed Active Ingredients by Chemical Name."

California Department of Pesticide Regulation (DPR) (2003b) *Summary of Pesticide Use Report Data 2002, Indexed by Chemical,* October.

California Department of Pesticide Regulation (DPR) (2004). "DPR reports mill compliance results." Press release.

California Department of Pesticide Regulation (DPR) (2005a). "State of California Pesticides Sold in California for Year: 2003, Combined Disclosed Active Ingredients by Chemical Name."

California Department of Pesticide Regulation (DPR) (2005b). *Summary of Pesticide Use Report Data 2003, Indexed by Chemical,* January.

California Department of Pesticide Regulation (DPR) (2006a). Pesticide use report data. Obtained from the California Pesticide Information Portal (Cal-PIP). June.

California Department of Pesticide Regulation (DPR) (2006b). "State of California Pesticides Sold in California for Year: 2004, Combined Disclosed Active Ingredients by Chemical Name." February 24.

California Department of Pesticide Regulation (DPR) (2006c). *Summary of Pesticide Use Report Data 2004, Indexed by Chemical,* January.

Flint, M. L. (2003). *Residential Pesticide Use in California: A Report of Surveys Taken in the Sacramento (Arcade Creek), Stockton (Five-Mile Slough) and San Francisco Bay Areas with Comparisons to the San Diego Creek Watershed of Orange County, California.* Prepared by the University of California Statewide IPM Project for the California Department of Pesticide Regulation, March 15.

Johnson, B. (2005). *Diazinon and Pesticide-Related Toxicity in Bay Area Urban Creeks. Water Quality Attainment Strategy and Total Maximum Daily Load (TMDL)*. Final Staff Report. Prepared by the California Regional Water Quality Control Board, San Francisco Bay Region. November 9.

Maund, S. J., M. J. Hamer, M. C. Lane; E. Farrelly; J. H. Rapley; U. M. Goggin; W. E.Gentle (2002). "Partitioning, bioavailability, and toxicity of the pyrethroid insecticide cypermethrin in sediments." *Environmental Toxicology and Chemistry* **21**(1): 9-15.

Moran, K. (2005). "Bay Area Pesticide Use: Urban/Agricultural Use Comparison, 2003." Memorandum to B. Johnson, San Francisco Bay Water Board. May 11.

Oros, D. R. and I. Werner (2005). *Pyrethroid Insecticides: An Analysis of Use Patterns, Distributions, Potential Toxicity and Fate in the Sacramento-San Joaquin Delta and Central Valley*. White Paper for the Interagency Ecological Program. San Francisco Estuary Institute Contribution 415. Oakland, CA.

Owen, L. Mill Assessment Program Branch, California Department of Pesticide Regulation (2006). Telephone conversation about quality assurance review of DPR pesticide sales data. July 6.

Pesticide Action Network (PAN) (2004). "Analysis of Reported Pesticide Sales Versus Reported Pesticide Use." October 17.

Ruby, A. (2005). Technical Memorandum: Analysis of Bay Area Urban Creeks Monitoring, 2004-05. Prepared for the Clean Estuary Partnership (San Francisco Bay). December.

Ruby, A., (2006). CEP Urban Creeks Monitoring Plan 2005-06. Prepared for the Clean Estuary Partnership (San Francisco Bay) in cooperation with the Diazinon/Toxicity Work Group. February.

TDC Environmental (2001). *Diazinon & Chlorpyrifos Products: Screening for Water Quality Implications*. Prepared for the San Francisco Estuary Project. May 15.

TDC Environmental (2003). *Insecticide Market Trends and Potential Water Quality Implications*. Prepared for the San Francisco Estuary Project. April.

TDC Environmental (2004). *San Francisco Bay Area Pesticide Retail Store Survey*. Funded by the City of San José. June.

TDC Environmental (2005a). *Improving Urban Pesticide Regulatory Activities to Protect Water Quality: Annual Update 2005*. Prepared for the San Francisco Estuary Project. December.

TDC Environmental (2005b). *San Francisco Bay Area Pesticide Retail Store Survey*. Prepared for the San Francisco Estuary Project. September.

TDC Environmental (2005c). *Urban Pesticides Use Trends Annual Report 2005*. Prepared for the San Francisco Estuary Project. March.

TDC Environmental (2005d). *Pesticides in Urban Surface Water: Annual Research and Monitoring Update 2005*. Prepared for the San Francisco Estuary Project, February.

TDC Environmental (2006). *Pesticides in Urban Surface Water: Annual Research and Monitoring Update 2006*. Prepared for the San Francisco Estuary Project, February.

Weston, D. P., J. You and M. J. Lydy (2004). "Distribution and Toxicity of Sediment-Associated Pesticides in Agriculture-Dominated Water Bodies of California's Central Valley." *Environmental Science & Technology* **38**(10): 2752-2759.

Weston, D. P., R. W. Holmes, et al. (2005). "Aquatic Toxicity Due to Residential Use of Pyrethroid Insecticides." *Environmental Science & Technology* **39**(24): 9778-9784.

Wilen, C. (2001). *Survey of Residential Pesticide Use and Sales in the San Diego Creek Watershed of Orange County*, California. Prepared by the University of California Statewide IPM Project for the California Department of Pesticide Regulation. October 16.

Wilen, C. (2002). *Survey of Residential Pesticide Use in the Chollas Creek Area of San Diego County and Delhi Channel of Orange County, California*. Prepared by the University of California Statewide IPM Project for the California Department of Pesticide Regulation. September 2.

Wilen, C. A., N. I. Kreidich, M. L. Flint, and M. Zhang (2005). *Tracking Non-Residential Pesticide Use in Urban Areas of California*. Prepared by the University of California for the California Department of Pesticide Regulation. June 10.

Wilhoit, L., M. Zhang, and L. Ross (2001). *Data Quality of California's Pesticide Use Report*. Final report to the California Department of Food and Agriculture for Contract Agreement No. 98-0241. August.

Wilhoit, L. (2002). *Pesticide Use Report Loading and Error-Handling Processes*. California Department of Pesticide Regulation report PM 02.01. January.

Wilhoit, L., California Department of Pesticide Regulation, Pest Management and Licensing Branch (2005). Telephone conversation about estimated error rate in Pesticide Use Reporting data. April 7.