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Pesticides in Urban Runoff, Wastewater, and Surface Water

Annual Urban Pesticide Use Data Report 2010

Prepared for the
San Francisco Estuary Partnership

June 28, 2010

PREFACE

This is a report of research performed by TDC Environmental, LLC for the San Francisco Estuary Partnership (SFEP). This report was prepared to fulfill the annual reporting requirement in Task 7.6.1.3 of SFEP's grant agreement with the State Water Resources Control Board (Agreement Number 09-305-550-1) for Taking Action for Clean Water. Funding for this project has been provided in part by the American Recovery and Reinvestment Act of 2009 and the Clean Water State Revolving Fund, through an agreement with the State Water Resources Control Board. The contents of this document do not necessarily reflect the views and policies of the State Water Resources Control Board, nor does mention of trade names or commercial products constitute endorsement or recommendation for use. (Gov. Code, Section 7550, 40 CFR Section 31.20.)

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SUMMARY

This report is intended to assist California water quality agencies—including municipalities—by summarizing and analyzing urban pesticide use trends for the pesticides of greatest interest for urban surface water quality. This annual review is prepared by the Urban Pesticide Pollution Prevention (UP3) Project with funding from the American Recovery and Reinvestment Act of 2009 and the Clean Water State Revolving Fund, through an agreement with the State Water Resources Control Board.

This report uses existing data to examine urban use patterns for pesticides that are harming or threatening to harm surface water quality, called the "UP3 Project Priority Pesticide List." This list, identified in the UP3 Project report *Pesticides in Urban Runoff, Wastewater, and Surface Water: Annual Review of New Scientific Findings 2010*, includes the following groups of pesticides: outdoor and indoor insecticides (pyrethroids, carbaryl, fipronil, and malathion); swimming pool, spa, and fountain treatments and indoor biocides (copper and its compounds, polyhexamethylene biguanadine [PHMB], silver and its compounds, and triclosan); sewer root control chemicals (dichlobenil, diquat dibromide, and metam sodium); wood preservatives (copper and its compounds, creosote, and pentachlorophenol); and marine antifouling biocides (copper oxides, Irgarol 1051, and zinc pyrithione).

Pyrethroid insecticides are examined in greater detail than other UP3 Priority Pesticides because they have been linked to widespread toxicity in California surface waters. Pyrethroids are divided into two groups:

- The "urban high-use pyrethroids" are the pyrethroids most heavily used in urban areas: bifenthrin, cyfluthrin (including beta-cyfluthrin), cypermethrin, deltamethrin, esfenvalerate, gamma-cyhalothrin, lambda-cyhalothrin, permethrin, and tralomethrin. These photostable pyrethroids are commonly applied outdoors around buildings or on landscaping via broadcast treatments; they may also be used indoors.
- The "other urban pyrethroids" are UP3 Priority insecticides commonly used as pet flea treatments, human body treatments, impregnated in fabric, aerosol sprays, foggers, and manhole treatments: cyphenothrin, etofenprox, resmethrin, sumithrin, and tetramethrin. These pyrethroids occur primarily in low-concentration formulations like aerosols and foggers and in products designed for indoor use, probably because most (all except the relatively new ether pyrethroid, etofenprox) do not persist when exposed to sunlight.

Methodology. The urban pesticide use estimates in this report are derived primarily from pesticide sales and use data from the California Department of Pesticide Regulation (DPR). Using these data, it is possible to develop gross quantitative estimates of urban pesticide use in California. This year's analysis includes California pesticide sales and use data through calendar year 2008 (the most recent data available).

Major findings:

- Pyrethroids continue to be the most commonly applied insecticides in California urban areas. (Section 3)
- Urban usage of the pyrethroid insecticides may be on the decline. Use of the "urban high-use pyrethroids" appears to have peaked in 2006 and subsequently

declined by about 40% in terms of aquatic "toxicity equivalents".[1] Sales (pounds of pesticide "active ingredient") of "other urban pyrethroids" peaked in 2007, dropping 40% in 2008. These declines may reflect the economic slowdown since 2006 rather than a permanent change in urban insecticide use patterns. (Sections 3.1 and 3.3)

- Reported professional use remains the vast majority (nearly 90%) of all estimated urban "urban high-use pyrethroid" use, both in terms of aquatic "toxicity equivalents" and in terms of total pounds of pesticide "active ingredient". Professional applications of pyrethroids to control pests in and around structures ("structural pest control") comprise more than 95% of professional urban use of pyrethroids. Professional applicators use relatively small quantities of "other urban pyrethroids." (Sections 3.1 and 3.3)
- Nearly all cyfluthrin, beta-cyfluthrin, cypermethrin, deltamethrin, and permethrin and most (80%) bifenthrin used in California urban areas is used by professional applicators. Except for permethrin, these are the pyrethroids that have most frequently been measured in California urban creeks at levels sufficient to cause toxicity to sediment-dwelling organisms. (Section 3.1)
- Two pyrethroids—cypermethrin and bifenthrin—accounted for almost 80% of the pyrethroid-related aquatic "toxicity equivalents" estimated used in California urban areas in 2007-2008. These two pyrethroids are the two that most often appear in California urban creeks at levels sufficient to cause toxicity to sediment-dwelling organisms. (Section 3.1)
- On a quantity basis, permethrin was the most heavily used pyrethroid in California urban areas from 2003-2008. (Section 3.1)
- Since 2006, sumithrin (d-phenothrin) has been the biggest selling of the "other urban pyrethroids," with about two-thirds of total sales. (Section 3.3)
- Increasing use of fipronil suggests that it may be starting to replace pyrethroids in the urban marketplace. Fipronil use has almost doubled since 2003. (Section 3.2)
- Use of the two other potential pyrethroid alternatives on the UP3 Priority Pesticide list—carbaryl and malathion—appears to be on the decline. Reported urban use of carbaryl dropped nearly 80% between 2004 and 2008. (Section 3.2)
- Sales of the swimming pool and spa biocide PHMB (an alternative to chlorine) have increased dramatically—in 2008, sales were eight times the sales in 2003. (Section 4.2)
- Sales of the two marine antifouling biocides—Irgarol 1051 and zinc pyrithione—have seen significant increases since 2003. (Section 4.6)

[1] The use of aquatic "toxicity equivalents" allows comparison of a family of related substances that have significantly different toxicity to aquatic organisms. See Section 3.1 for details on how toxicity equivalents are calculated for pyrethroids.

1.0 INTRODUCTION

1.1 Background

This Urban Pesticide Pollution Prevention (UP3) Project report is intended to assist California urban runoff management agencies, municipal wastewater treatment plants (also known as "publicly-owned treatment works" or "POTWs"), the State Water Resources Control Board and Regional Water Quality Control Boards, California Department of Pesticide Regulation (DPR), and U.S. EPA by providing information about the use of pesticides that are harming or threatening to harm surface water quality.

Because understanding the impacts of urban pesticide use on water quality is complex and time-intensive, the UP3 Project was established in mid-2004 to help California Water Boards, municipal wastewater treatment plants, and urban runoff management agencies prevent pesticide-related water quality problems. The UP3 Project is currently funded (through 2010) by a State Water Resources Control Board grant administered by the San Francisco Estuary Partnership (SFEP). TDC Environmental provides technical support for the project.

1.2 Scope of This Report

This is the fifth analysis of urban pesticide use prepared by the UP3 Project. The UP3 Project's annual review of relevant scientific literature (TDC Environmental 2010) identified a list of pesticides that are harming or threatening to harm surface water quality, called the "UP3 Project Priority Pesticide List." Table 1 (on the next two pages) lists the UP3 Project Priority Pesticides.

For each priority pesticide, this report uses available information—primarily from California Department of Pesticide Regulation databases—to estimate total California urban use and to examine use trends. Pyrethroid insecticides are examined in greater detail than other UP3 Priority Pesticides because they have been linked to widespread toxicity in California surface waters.

This report looks exclusively at urban pesticide use. The term "pesticide" encompasses all substances used to repel, kill, or control insect or animal pests, vegetation, fungi, virus, bacteria, or any other microorganism. Pesticides include insecticides, herbicides, fungicides, wood preservatives, and biocides (which are often referred to as "antimicrobials"). For purposes of this report, "urban" was broadly defined to include essentially all non-agricultural pesticide use, including applications at residences, commercial buildings, institutions, parks, golf courses, and in rights-of-way.

This is one of three reports that have been prepared annually by the UP3 Project. The other two reports review California water quality agencies' participation in urban pesticide-related regulatory activities and update the UP3 Project Priority Pesticide List on the basis of an examination of recent scientific literature. All three reports are available online at http://www.up3project.org/up3_documents.shtml. (None of these reports was prepared in 2009 due to the suspension of the UP3 Project's grant funding.)

Table 1. UP3 Project Priority Pesticide List

Pesticide	Synonyms and Trade Names (Examples)	Priority Discharge Pathway			Potential POTW Operational Interference
		Urban Runoff	POTW	Direct*	
Pyrethroid Insecticides					
Bifenthrin	Biphenthrin, Bifenthrine, Biflex, Brigade, Capture, Onyx, Talstar	X	X		
Cyfluthrin (including Beta-Cyfluthrin)	Baythroid, Tempo, Cykick, Renounce, Tempo Ultra, Cylence	X	X		
Cypermethrin	Ammo, Cynoff, Demon, Cymbush	X	X		
Cyphenothrin	Squeeze-On for Dogs		X		
Deltamethrin	Decamethrin, Deltadust, Deltaguard, Suspend SC	X	X		
Esfenvalerate	(S)-Fenvalerate, Asana	X	X		
Etofenprox	Spot-On or Squeeze on for Cats; Zenivex		X		
Gamma-Cyhalothrin	Cobalt, Declare, Proaxis, Prolex, Standguard	X			
Lambda-Cyhalothrin	Scimitar, Demand	X			
Permethrin	Ambush, Nix, Pounce	X	X		
Resmethrin	Scourge, SBP-1382, Cardinal		X		
Sumithrin	d-Phenothrin, Anvil, Bedlam, Drops for Dogs		X		
Tetramethrin	Tetraperm		X		
Tralomethrin	Saga	X			
Other Insecticides					
Carbaryl	Sevin	X			
Fipronil	Termidor, Maxforce FC, Frontline, Chipco Choice	X	X		
Malathion	Cythion, Carbophos, Fyfanon	X	X		
Swimming Pool, Spa, and Fountain Treatments					
Copper and its compounds		X	X		

Table 1. UP3 Project Priority Pesticide List (Continued)

Pesticide	Synonyms and Trade Names (Examples)	Priority Discharge Pathway			Potential POTW Operational Interference
		Urban Runoff	POTW	Direct*	
PHMB	Baquacil, Revacil, Vantocil	X	X		
Silver and its compounds	Algaesil, Nature[2], Citrisil, Proclear, Puregreen, Silvertrine, Spa Minerals	X	X		
Indoor Biocides					
Copper	Cupron		X		
Silver and its compounds (including nanosilver)	Allclear, Duraclean, Staph Attack, Sanosil, ICX, H2OPro		X		X
Triclosan	5-Chloro-2-(2,4-Dichlorophenoxy) Phenol, Irgasan		X		
Sewer Root Control					
Copper Sulfate			X		
Dichlobenil	Root X, Root Force, Foaming Root Killer, Sanafoam Vaporooter		X		X
Diquat Dibromide	Razorooter		X		X
Metam Sodium	Sanafoam Vaporooter		X		X
Wood Preservatives					
Copper and its compounds	ACQ, ACZA, CCA, Copper Green, Cu-HDO, Copper Azole, CBA	X		X	
Creosote	Coal Tar Creosote			X	
Pentachlorophenol	PCP, Dowicide 7	X		X	
Marine Antifouling Biocides					
Copper oxides	Cuprous oxide			X	
Irgarol 1051	Cybutryne, N-Cyclopropyl-N'-(1,1-Dimethylethyl)-6-(Methylthio)-1,3,5-Triazine-2,4-Diamine			X	
Zinc Pyrithione	Zinc Omadine, Zinc-2-Pyridinethiol-1-Oxide			X	

*Immersed in surface water.
Source: TDC Environmental 2010 and DPR Product/Label database.

1.3 Report Organization

This report is organized as follows:

- *Section 1* (this section) provides the background and scope of the report and describes the methods used to estimate urban pesticide use.
- *Section 2* briefly summarizes methods used to estimate urban use of pesticides on the UP3 Project Priority Pesticide List. These methods have been described in detail in a previous UP3 Project report (TDC Environmental 2008).
- *Section 3* provides estimates of the urban use of UP3 Priority insecticides and looks at trends in their use.
- *Section 4* provides a qualitative overview of the urban use of other UP3 Priority Pesticides and identifies factors influencing the trends in use of these pesticides.
- *Section 5* summarizes this report's findings about usage, market changes, and trends in use of UP3 Project Priority Pesticides.
- *Section 6* lists the references cited in the body of the report.
- The *Appendix* provides urban pesticide sales data and use estimates in table format.

2.0 METHODOLOGY

2.1 Data Sources

This report is based on existing information available from reliable sources. The only public source of quantitative data about California pesticide use is the California Department of Pesticide Regulation (DPR). These data, which are compiled annually, are the primary information source for this report. When this report was prepared, the most recent available pesticide sales and use data were for calendar year 2008.

DPR pesticide sales and use data are described in detail elsewhere (TDC Environmental 2008). This section briefly highlights information important to interpreting the estimates in this report.

California Pesticide Sales Data

DPR makes total California sales of each pesticide active ingredient available annually. Sales data combine the sales of all products—agricultural and urban—into one reported sales total for each pesticide active ingredient. Prior to 2005, sales data were not always made public—data were provided only for active ingredients with three or more registrants. Public reports do not provide any product or sales location information. Sales data do not encompass sales of products that incorporate pesticides—but are not themselves registered pesticides—like preserved wood or pesticide-impregnated fabric.

California Pesticide Use Data

DPR compiles and releases California pesticide use reporting data on an annual basis. In general, the pesticide uses that require reporting are agricultural uses or urban applications made by professional applicators.[2] Table 2 (on the next page) provides examples of pesticide applications that require reporting—and applications that do not require reporting.

In contrast to agricultural use reporting, which includes application location and other details, urban reporting is not very detailed. Urban applications need only be reported by county. The pesticide reporting form used for urban applications provides only seven reporting categories:

- structural
- landscape maintenance
- right-of-way
- public health (only for government mosquito abatement and other public health protection programs)
- vertebrate
- commodity fumigation
- regulatory (only for government control of regulated pests)

Although applicators may write in additional categories, DPR data sets show that most use the default categories even if they do not describe the application very well.

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[2] In this report, "professional" refers to "[a]ny person engaged for hire in the business of pest control" (Title 3, California Code of Regulations, Section 6624). Professional applications can only be made by a trained person who works under the supervision of a licensed pesticide applicator or pest control operator.

Table 2. Overview of Pesticide Use Reporting in California

Examples of Pesticide Applications that Do Require Reporting	Examples of Pesticide Applications that Do Not Require Reporting
All applications by professional applicators *All applications to agricultural crops* Structural pest control (other than by a residential pesticide user), such as: • Termite, ant, and cockroach treatments • Building fumigation Landscape maintenance (other than by a residential pesticide user), such as: • Lawns • Gardens • Golf courses • Parks • Cemeteries Road, rail, and utility rights of way, for purposes such as: • Weed control • Algae control Mosquito control applications by mosquito abatement agencies Food product fumigation	*All applications by non-professionals* (assuming application by non-professionals is legal) Incorporation of pesticides into consumer products, such as: • Wood preservatives • Biocides in soaps, cleaning products, or impregnated into solid materials (e.g., cutting boards, toys, clothing) • Biocides incorporated in products to prevent the product's degradation (e.g., in sponges and liquid products) • Insecticide-treated clothing • Biocides in paints • Biocide-generating equipment (e.g., clothes washing machines that generate silver ions) Swimming pool, spa, and fountain treatments, such as: • Algaecides • Biocides (e.g., chlorine) Cooling water system treatment with biocides Use of biocides, such as: • Bleach use • Hospital and medical facility and equipment disinfection • Drinking water and wastewater disinfection Pet flea treatments Marine antifouling paint application

Source: TDC Environmental, based on review of California pesticide use reporting data, California pesticide products, and pesticide use reporting requirements in California law.

Most reported applications of UP3 Priority Pesticides fall into two categories: structural pest control and landscape maintenance. While landscape maintenance applications can usually be assumed to occur outdoors, the four types of structural pest control insecticide applications differ in their implications for water quality:

- Outdoors, above ground – treatments around buildings, such as those used to control ants.
- Pre-construction termiticide applications – treatment of the ground below a structure. Such applications are only briefly exposed, in the time period between treatment and when the building foundation is poured.
- Indoors – indoor sprays and foggers, often for ant, flea, and cockroach control.
- Underground injection – pesticide injection into soil under (or around) structures to control termites.

It may be possible to use product label information and/or applicator license information to distinguish between termite control and outdoor applications; however, such analysis was beyond the scope of this report.

Survey data suggests that the quantity of insecticide active ingredient applied indoors by professional applicators is relatively small (Flint 2003; Wilen 2001; Wilen 2002). Although indoor insecticide use quantities are small relative to outdoor use quantities, they may be sufficient to cause or contribute to toxicity in municipal wastewater treatment plant effluent. Available survey data do not provide sufficient information to make quantitative estimates of indoor use of insecticides that are used both outdoors and indoors.

2.2 Estimating Urban Pesticide Use

It is possible to develop gross estimates of California pesticide use based on DPR data. The estimation method has previously been described in detail (see TDC Environmental 2008). The following two equations briefly summarize the estimation method:

Urban Use	≈	Reported Urban Use	+	Statewide Over-the-Counter (OTC) Sales
Statewide OTC Sales	≈	Statewide Sales	–	Statewide Reported Use

The values for "Reported Urban Use," "Statewide Reported Use," and "Statewide Sales" are obtained from DPR's annual compilation of pesticide use report data (DPR 2005, 2006a, 2006b, 2007d, 2008c, 2009) and DPR's annual pesticide sales reports (DPR 2007a, 2007b, 2007c, 2008a, 2008b, 2010). "Statewide Over-the-Counter Sales" and "Urban Use" are calculated using the equations above.

This method tends to overestimate non-professional pesticide use because it assumes that all pesticides sold are used, i.e., that statewide over-the-counter sales are equal to statewide pesticide use. While this is likely a good assumption for professional applicators, consumers are known to store and eventually dispose of potentially significant quantities of pesticides. In reality, non-professional urban pesticide use is somewhat less than over-the-counter pesticide sales. Because the fraction of unused pesticides is unknown, the method does not include a correction for the overestimate.

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." In this report the phrase "reported urban" indicates pesticide applications by professional applicators and "unreported urban" indicates estimated non-professional urban pesticide use.

In light of the uncertainties in DPR data, which are detailed in previous reports (see TDC Environmental 2008), this analysis focuses on general trends and conclusions that can be supported by the available data. Without further pesticide-specific analysis that is beyond the scope of this report, conclusions are best limited to qualitative statements (i.e., "relatively large fraction" and "relatively small fraction").

To reflect the uncertainties in quantitative estimates, this report utilizes significant figures when presenting estimates. Pesticide sales and use data from DPR and calculated urban use estimates are rounded to provide the appropriate number of significant figures.

3.0 URBAN USE OF UP3 PROJECT PRIORITY INSECTICIDES

This section provides estimated urban use of the insecticides on the UP3 Priority Pesticides list and looks at trends in the use of these insecticides. Insecticides—particularly pyrethroid insecticides—are examined in greater detail than other UP3 Priority Pesticides because they have been linked to widespread toxicity in California surface waters. Regulatory responses to pyrethroid-related toxicity are underway both at DPR (the pyrethroid "reevaluation") and the Water Boards (designations of surface waters as "impaired" under section 303(d) of the Clean Water Act).

The insecticide analysis is divided into three subsections—two for urban high-use insecticides and one covering other urban insecticides. The "urban high-use insecticides" are UP3 Priority insecticides most heavily used in urban areas. These insecticides are commonly applied outdoors around buildings or on landscaping via broadcast treatments; most may also be used indoors. Urban high-use insecticides are divided into two groups: (1) pyrethroids and (2) other high-use insecticides.

The "other urban insecticides" are UP3 Priority insecticides commonly used as pet flea treatments, human body treatments, impregnated in fabric, aerosol sprays, foggers, and manhole treatments. These insecticides occur primarily in low-concentration formulations like aerosols and foggers and in products designed for indoor use, probably because most (all except the relatively new ether pyrethroid, etofenprox) do not persist when exposed to sunlight.

The outdoor use patterns for the "urban high-use insecticides" create the potential for these insecticides to be washed into urban runoff. Some urban high-use insecticides also have use patterns associated with discharges to municipal wastewater treatment plants (see Table 1); however, these use patterns are believed to entail a relatively small fraction of total sales. Although indoor use of these insecticides may be small relative to outdoor use, indoor use quantities may be sufficient to cause or contribute to toxicity in municipal wastewater treatment plant effluent. The "other urban insecticides" are used primarily indoors; they are rarely used in significant quantities outdoors, except when applied by mosquito abatement districts.

3.1 Urban High-Use Pyrethroids

All of the pyrethroids commonly applied outdoors around buildings or on landscaping via broadcast treatments are "second-generation" pyrethroids. These pyrethroids were designed to be less photosensitive than the original "first generation" pyrethroids. This property allows these pyrethroids to provide insect control for a longer time period after outdoor application. Priority urban high-use pyrethroids are: bifenthrin, cyfluthrin (including beta-cyfluthrin), cypermethrin, deltamethrin, esfenvalerate, gamma-cyhalothrin, lambda-cyhalothrin, permethrin, and tralomethrin. While these pyrethroids are primarily applied outdoors, all may also be used indoors.

Urban High-Use Pyrethroid Toxic Equivalents Scheme ("Permethrin Equivalents")

The pyrethroids are a family of pesticides with similar mechanisms of toxicity. 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.

Pyrethroids' toxicity is explained best in terms of the sum of the "toxic units" of the pyrethroids present (Weston et al. 2004; Weston et al. 2005; Trimble et al. 2009). For pyrethroids, a convenient way of expressing "toxic units" is "*permethrin equivalents*."[3] *Permethrin equivalents* are calculated based on the toxicity of each pyrethroid to the standard test organism *Hyalella azteca*, as explained below. Among standard aquatic toxicity test organisms, *Hyalella azteca* is the most sensitive to pyrethroids.

Table 3 summarizes the average concentration of each pyrethroid that is lethal to 50% of *Hyalella azteca* test organisms placed in sediment for a 10-day test period (10-day LC50). 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 calculated by multiplying the quantity of a pyrethroid by the "Ratio to Permethrin LC50" listed in Table 3.

Table 3. Toxicity of Pyrethroids in Sediment 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][a]	[10][a]
Cypermethrin	0.38	29
Deltamethrin	0.79	14
Esfenvalerate	1.54	7.03
Gamma-Cyhalothrin	--[b]	[46] [b]
Lambda-Cyhalothrin	0.45	24
Permethrin	10.83	1.00
Tralomethrin	[0.79][c]	[14][c]

Source: Maund et al. 2002 (cypermethrin); Amweg et al. 2005 (all others).
[a] No data available. Because it is a subset of cyfluthrin isomers, beta-cyfluthrin was assumed to have the same toxicity as cyfluthrin. Similarly, since gamma-cyhalothrin is a subset of lambda-cyhalothrin isomers and toxicity to some species is similar (He et al. 2008; Giddings et al. 2009), it was assumed to have the same toxicity as lambda-cyhalothrin. Since toxicity may be related to stereochemistry (He et al. 2008; Giddings et al. 2009), this assumption should be reexamined when more data become available.
[b] Value based on isomer-specific water column toxicity data for *H. azteca*. Gamma-cyhalothrin toxicity is about 1.9 times that of lambda-cyhalothrin (Smith and Lizotte 2007).
[c] No data available. Because tralomethrin quickly degrades into deltamethrin in the environment (DPR 2000), tralomethrin was assumed to have the same toxicity as deltamethrin.

Urban High-Use Pyrethroids Sales

Figures 1 and 2 (on the next page) summarize California pyrethroids sales from 2000-2008. Permethrin comprised about half of the total sales quantity of these pyrethroids. When viewed in terms of aquatic toxicity, the picture changes—bifenthrin and cypermethrin comprise the majority of the *permethrin equivalents* sold.

The figures suggest that sales peaked in 2006 and are beginning to trend downward. Since factors like weather, pest pressures, and economic conditions affect pesticide sales, the apparent downward trend might not reflect a long-term change in pesticide use patterns.

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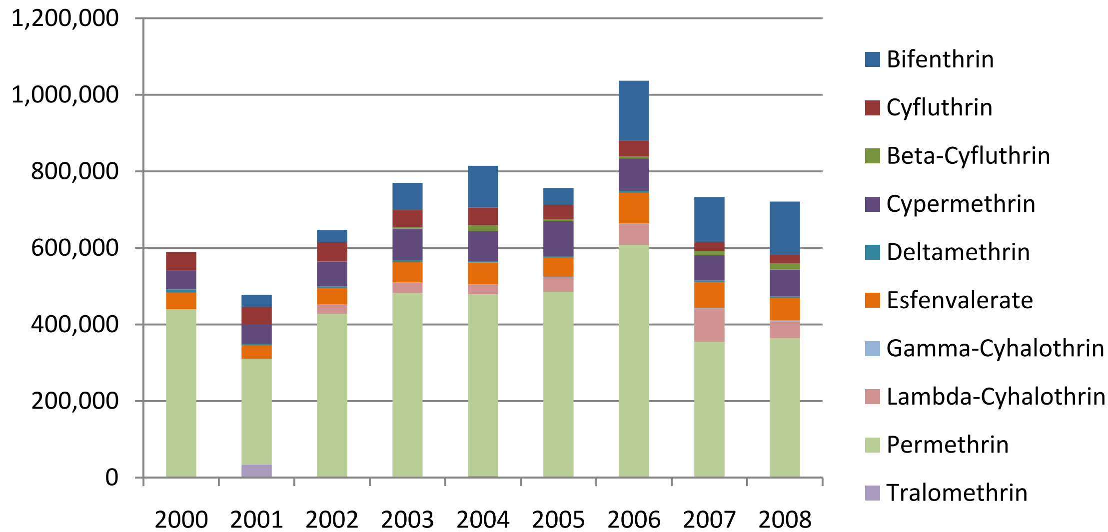
[3] To ensure that the reader recognizes where this convention—rather than pounds of active ingredient—is used, the phrase "*permethrin equivalents*" is italicized throughout this report.

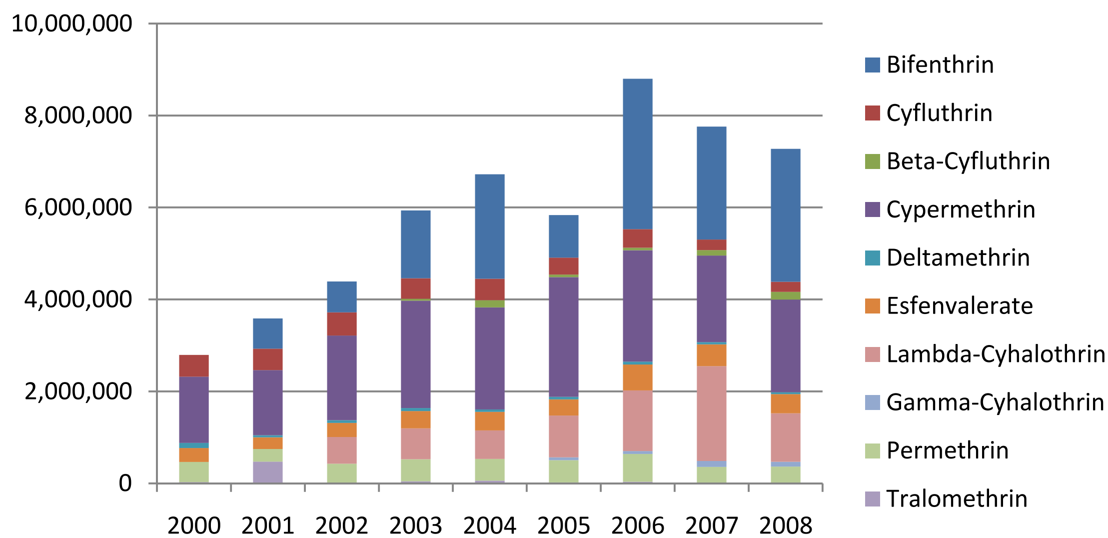
These data reflect both urban and agricultural sales trends. On average, reported agricultural use equals about one-third of the total sales quantity of these pyrethroids each year.

Figure 1. California Urban High-Use Pyrethroids Sales 2000-2008 (Pounds of Pesticide Active Ingredient)



Source: DPR pesticide sales data (DPR 2002a, 2002b, 2003, 2007a, 2007b, 2007c, 2008a, 2008b, 2010). DPR's data include both agricultural and urban product sales.

Figure 2. California Urban High-Use Pyrethroids Sales 2000-2008 (Expressed in Terms of Toxicity Using *Permethrin Equivalents*)

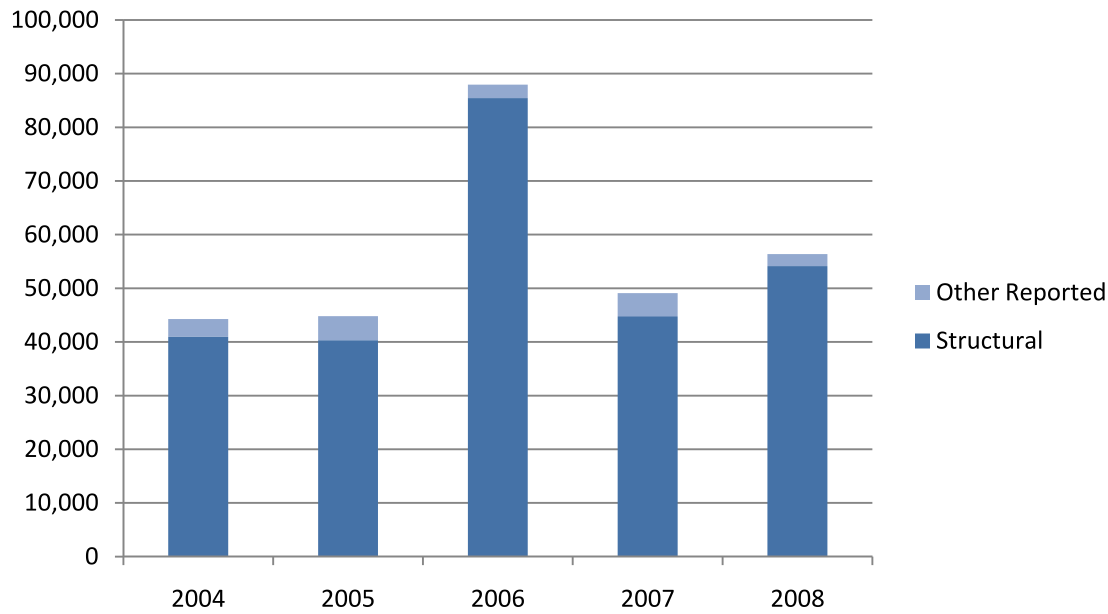


Source: DPR pesticide sales data (DPR 2002a, 2002b, 2003, 2007a, 2007b, 2007c, 2008a, 2008b, 2010). Conversion to *permethrin equivalents* based on values in Table 3. DPR's data include both agricultural and urban product sales.

Urban High-Use Pyrethroid Reported Use

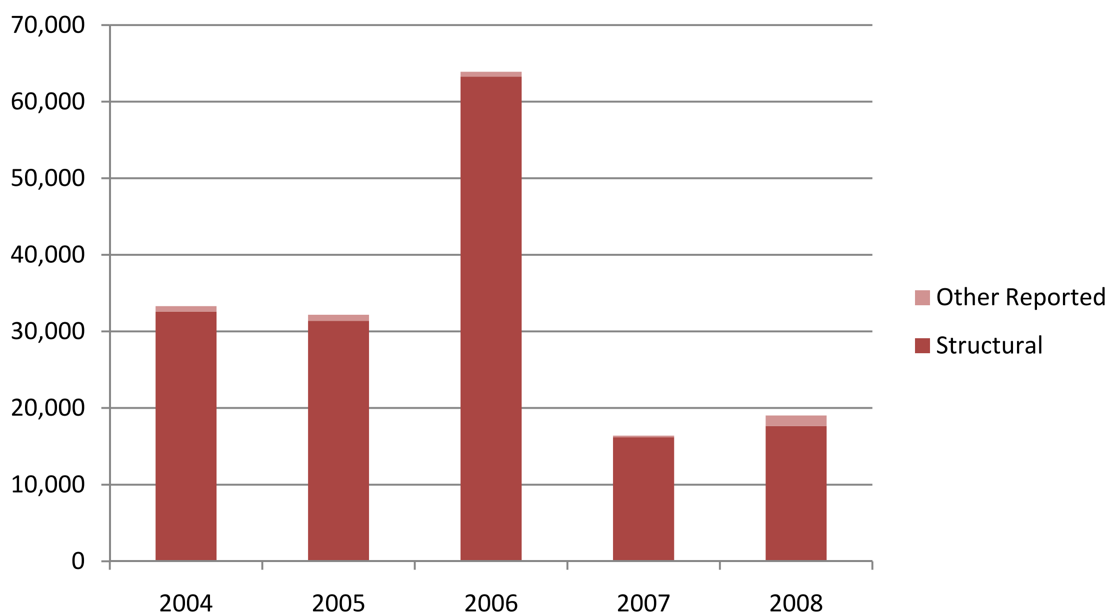
Figures 3 through 9 show California reported urban use for the urban high-use pyrethroids commonly used by professional applicators. Graphs are not provided for esfenvalerate, gamma-cyhalothrin, and tralomethrin due to their small reported urban use (<300 pounds each). While the percentage differs slightly among the individual pyrethroids, in total more than 95% of reported urban use of the urban high-use pyrethroids is for structural pest control.

Figure 3. California Bifenthrin Reported (Professional) Urban Use, 2004-2008 (Pounds of Active Ingredient)



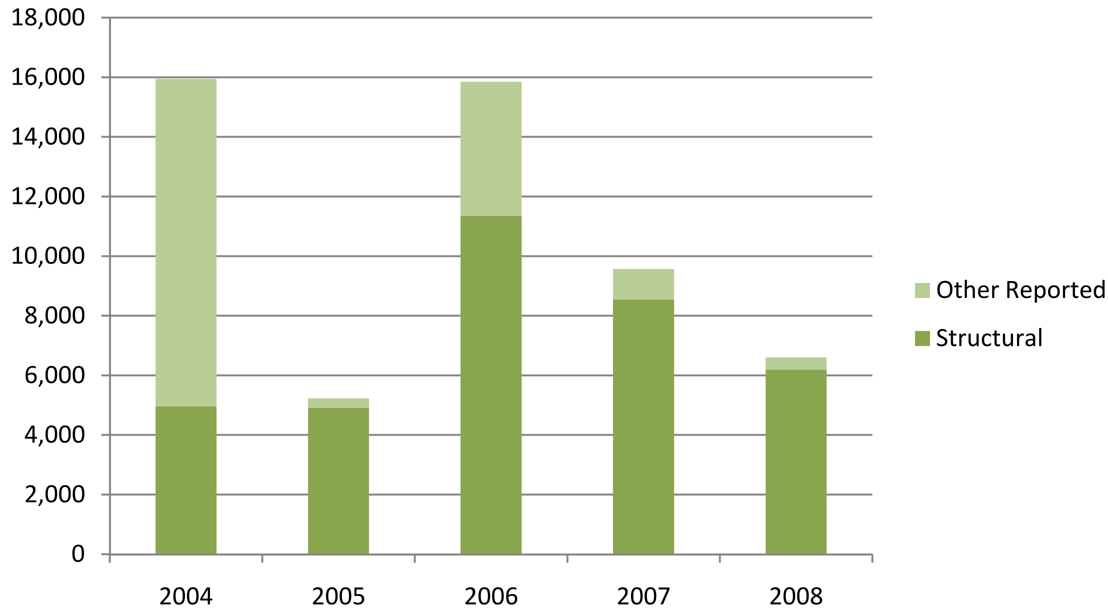
Source: DPR pesticide use reports (DPR 2006a, 2006b, 2007d, 2008c, 2009).

Figure 4. California Cyfluthrin Reported (Professional) Urban Use, 2004-2008 (Pounds of Active Ingredient)



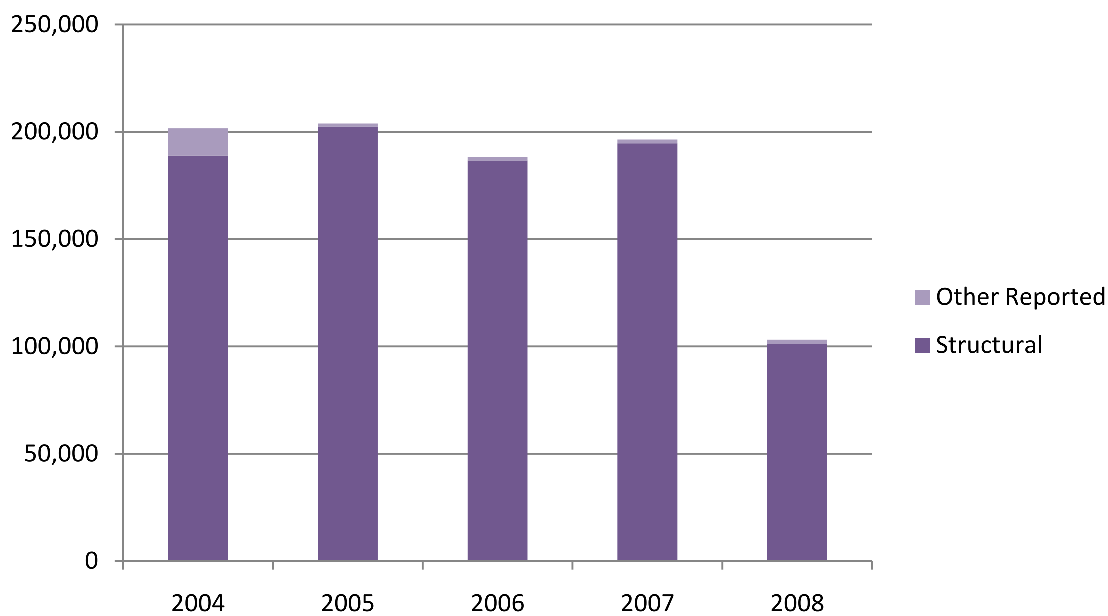
Source: DPR pesticide use reports (DPR 2006a, 2006b, 2007d, 2008c, 2009).

Figure 5. California Beta-Cyfluthrin Reported (Professional) Urban Use, 2004-2008 (Pounds of Active Ingredient)



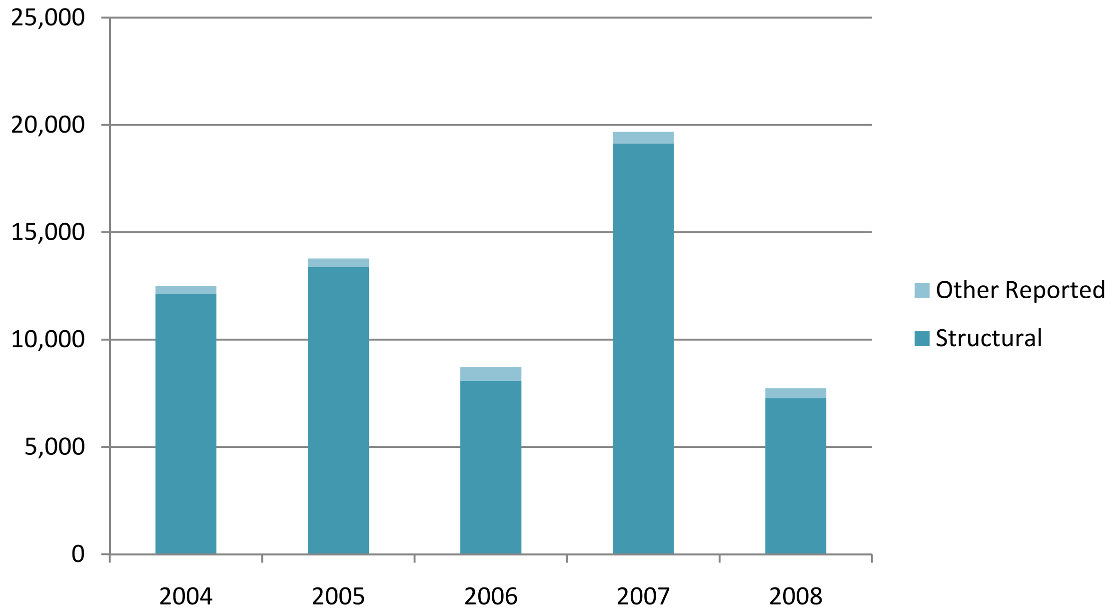
Source: DPR pesticide use reports (DPR 2006a, 2006b, 2007d, 2008c, 2009).

Figure 6. California Cypermethrin Reported (Professional) Urban Use, 2004-2008 (Pounds of Active Ingredient)



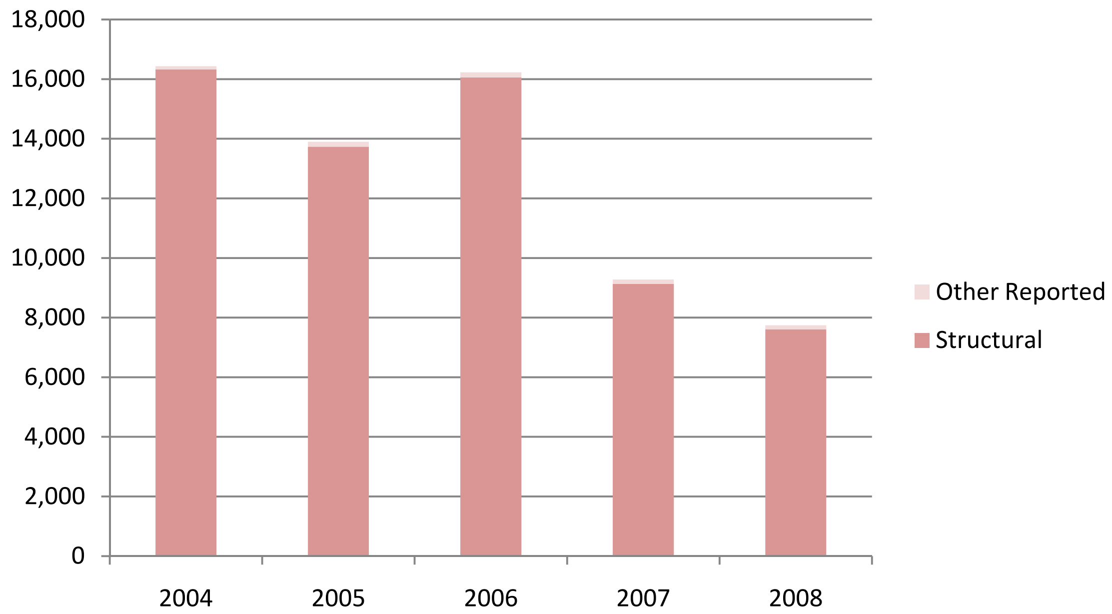
Source: DPR pesticide use reports (DPR 2006a, 2006b, 2007d, 2008c, 2009).

Figure 7. California Deltamethrin Reported (Professional) Urban Use, 2004-2008 (Pounds of Active Ingredient)



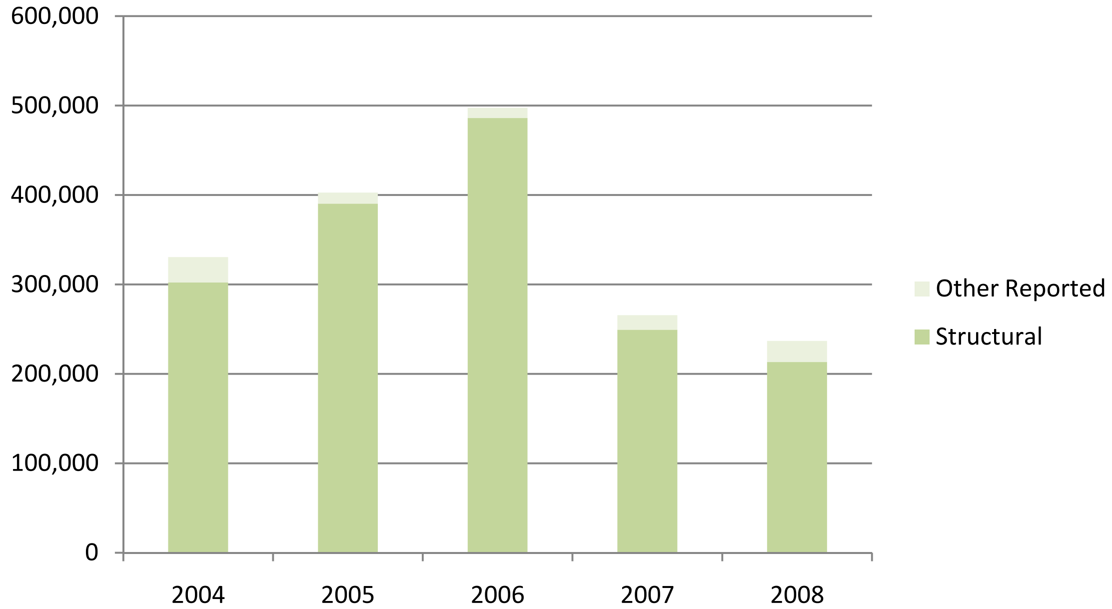
Source: DPR pesticide use reports (DPR 2006a, 2006b, 2007d, 2008c, 2009).

Figure 8. California Lambda-Cyhalothrin Reported (Professional) Urban Use, 2004-2008 (Pounds of Active Ingredient)



Source: DPR pesticide use reports (DPR 2006a, 2006b, 2007d, 2008c, 2009).

Figure 9. California Permethrin Reported (Professional) Urban Use, 2004-2008 (Pounds of Active Ingredient)

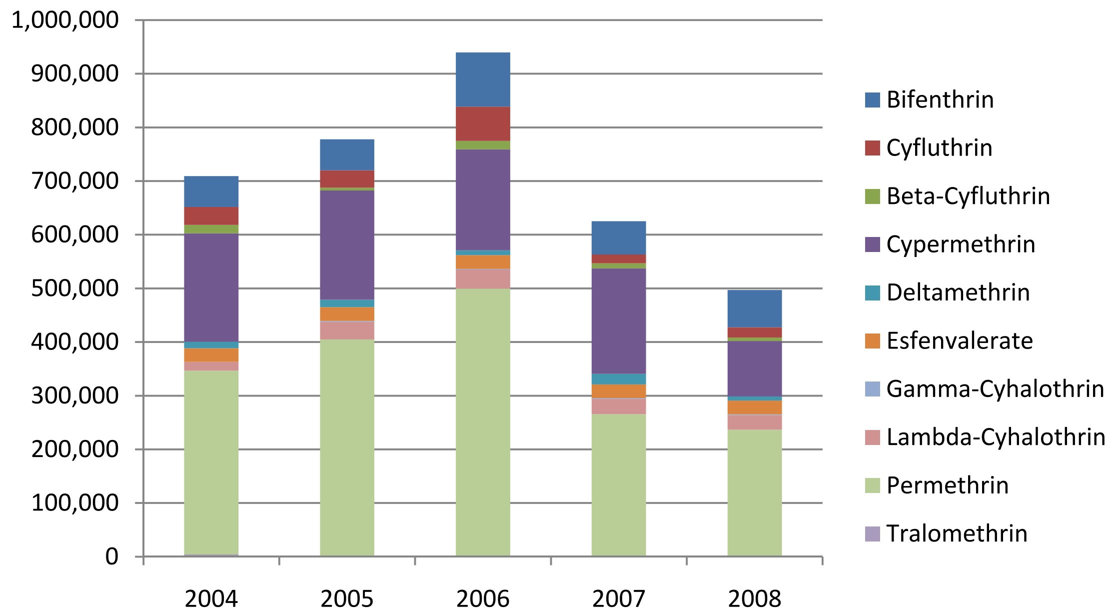


Source: DPR pesticide use reports (DPR 2006a, 2006b, 2007d, 2008c, 2009).

Total Urban High-Use Pyrethroid Use

Total urban use of the urban high-use pyrethroids was estimated on the basis of sales and reported use data using the method described in Section 2. Figures 10 and 11 summarize estimated urban use of the urban high-use pyrethroids. Figure 10 is based on the total pyrethroid quantity.

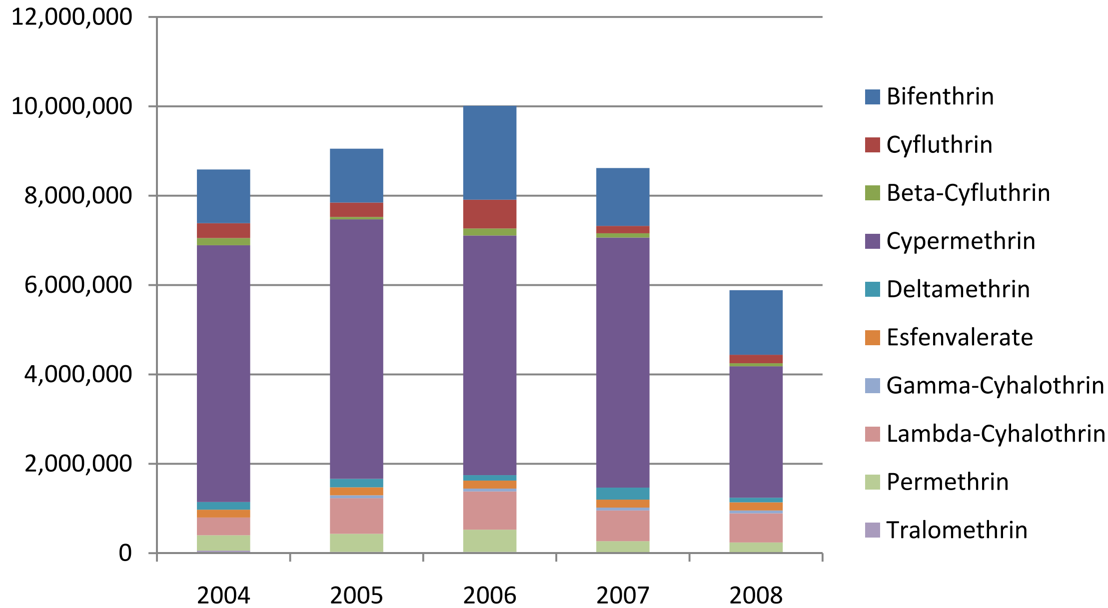
Figure 10. California Urban High-Use Pyrethroids Estimated Urban Use 2004-2008 (Pounds of Pesticide Active Ingredient)



Source: DPR pesticide sales data (DPR 2007b, 2007c, 2008a, 2008b, 2010), DPR pesticide use reports (DPR 2006a, 2006b, 2007d, 2008c, 2009), and mathematical calculations (see Section 2).

Figure 11 expresses usage in *permethrin equivalents* to account for the toxicity of the individual pyrethroids.

Figure 11. California Urban High-Use Pyrethroids Estimated Urban Use 2004-2008 (Expressed in Terms of Toxicity Using *Permethrin Equivalents*)

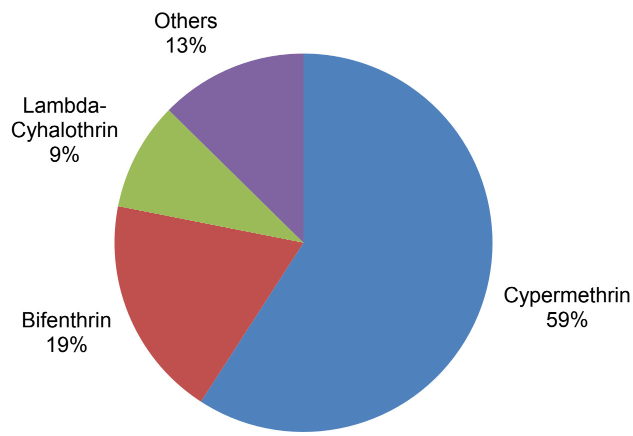


Source: DPR pesticide sales data (DPR 2007b, 2007c, 2008a, 2008b, 2010), DPR pesticide use reports (DPR 2006a, 2006b, 2007d, 2008c, 2009), and mathematical calculations (see Section 2). Conversion to *permethrin equivalents* based on values in Table 3.

Like the sales figures above, these figures suggest that urban pyrethroid usage peaked in 2006 and has subsequently declined by about half (in pounds), or 40% in *permethrin equivalents*. This may reflect the economic slowdown since 2006 rather than a permanent change in urban insecticide use patterns.

While permethrin comprises the largest fraction of total quantity of estimated urban use of the urban high-use pyrethroids, considering toxicity reveals that cypermethrin and bifenthrin comprise the majority of aquatic toxicity equivalents (*permethrin equivalents)* estimated used. Figure 12 (on the next page) shows the breakdown of urban high-use pyrethroid contributions to total estimated *permethrin equivalents* used in California urban areas in 2007 and 2008. Estimated use of cypermethrin and cyfluthrin (including beta-cyfluthrin) began declining sooner and declined at a faster rate than use of the other pyrethroids that are more toxic than permethrin. This decline has caused lambda-cyhalothrin to replace cyfluthrin as the third largest contributor to total *permethrin equivalents* used.

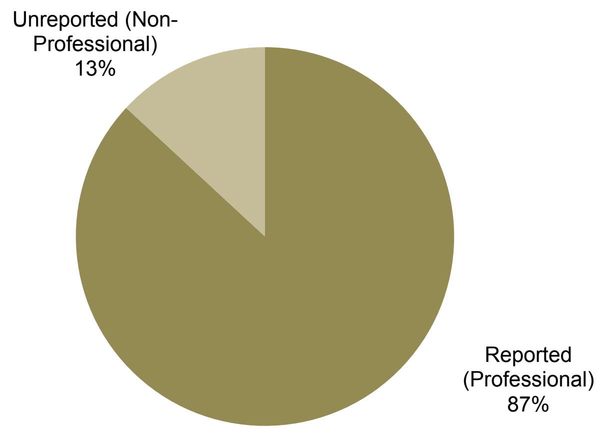
Figure 12. California Urban High-Use Pyrethroids Estimated Urban Use 2007-2008 2-Year Average (*Permethrin Equivalents*)



Source: DPR pesticide sales data (DPR 2008b, 2010), DPR pesticide use reports (DPR 2008c, 2009), and mathematical calculations (see Section 2). Conversion to *permethrin equivalents* based on values in Table 3.

Figure 13 compares estimated professional use of urban high-use pyrethroids to estimated use by non-professionals. (In this and subsequent figures, “reported urban” indicates pyrethroid applications by professional applicators and “unreported urban” indicates estimated non-professional urban use.) Although overall use has declined, professional use remains most of the total estimated urban high-use pyrethroid use, both in terms of pyrethroid aquatic toxicity equivalents (shown) and in terms of quantity (graph not shown).

Figure 13. California Urban High-Use Pyrethroids Estimated Urban Use 2007-2008 2-Year Average (*Permethrin Equivalents*)



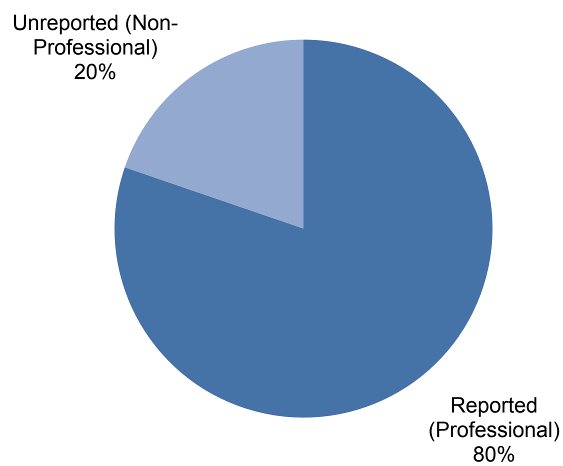
Source: DPR pesticide sales data (DPR 2008b, 2010), DPR pesticide use reports (DPR 2008c, 2009), and mathematical calculations (see Section 2). Conversion to *permethrin equivalents* based on values in Table 3.

Pyrethroids Urban Use

A comparison of sales to reported use shows that nearly all cyfluthrin, beta-cyfluthrin, cypermethrin, deltamethrin, and permethrin applied in California urban areas is used by professional applicators. While all of these pyrethroids are sold over the counter, the quantity of over-the-counter sales is small compared to professional use quantities. In contrast, nearly all esfenvalerate estimated used in urban areas is associated with over-the-counter sales. While over-the-counter sales comprised the majority of gamma-cyhalothrin and tralomethrin estimated use, total urban use of these two pyrethroids in 2007-2008 was relatively small (<2,000 pounds).

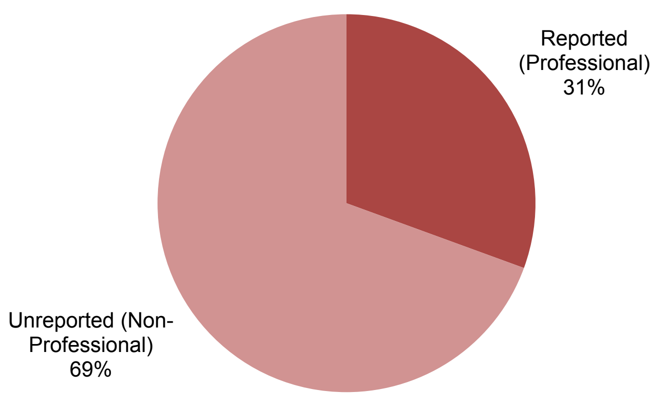
For bifenthrin and lambda cyhalothrin, both professional and non-professional applications comprise meaningful fractions of total estimated urban use. Figures 14 and 15 show the fraction of bifenthrin and lambda-cyhalothrin estimated used by professionals (reported) and non-professionals (unreported). Most bifenthrin used in urban areas is applied by professional applicators. Most lambda-cyhalothrin use is by non-professionals.

Figure 14. California Bifenthrin Estimated Urban Use, 2007-2008 2-Year Average (Pounds of Active Ingredient)



Source: DPR pesticide sales data (DPR 2008b, 2010), DPR pesticide use reports (DPR 2008c, 2009), and mathematical calculations (see Section 2).

Figure 15. California Lambda-Cyhalothrin Estimated Urban Use 2007-2008 2-Year Average (Pounds of Active Ingredient)



Source: DPR pesticide sales data (DPR 2008b, 2010), DPR pesticide use reports (DPR 2008c, 2009), and mathematical calculations (see Section 2).

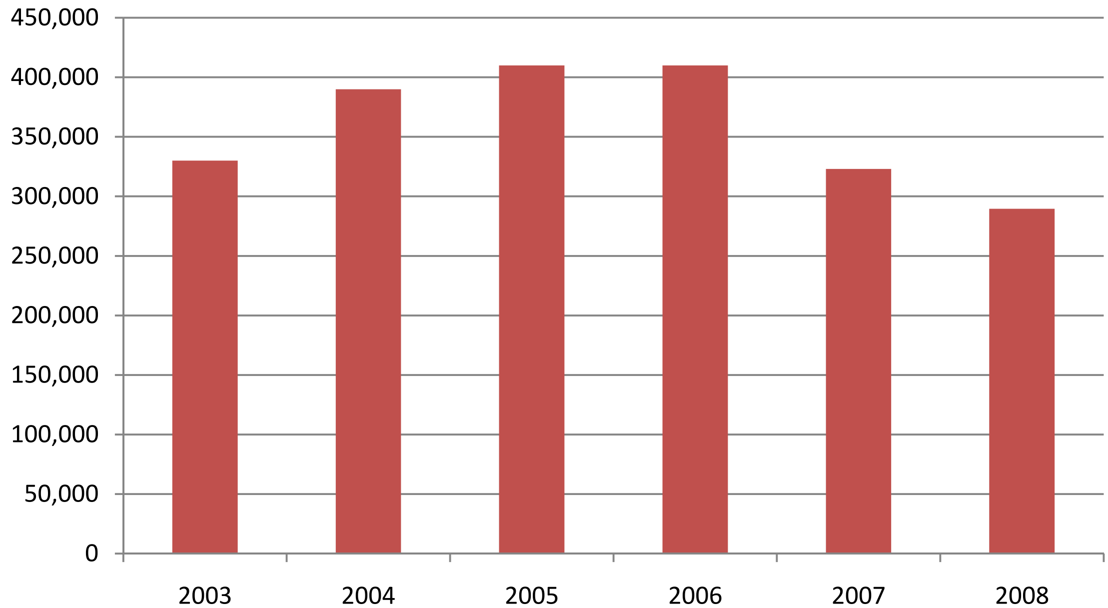
3.2 Other Urban High-Use Insecticides

Three non-pyrethroid insecticides that are commonly applied outdoors around buildings or on landscaping via broadcast treatments are on the UP3 Priority Pesticide List: carbaryl, fipronil, and malathion. Both fipronil and malathion may be used indoors; both have indoor use patterns associated with discharges to municipal wastewater treatment plants (see Table 1).

Carbaryl

Figure 16 summarizes California carbaryl sales from 2003-2008. These data reflect both urban and agricultural sales trends. On average, reported agricultural use equals about half of the total sales quantity of carbaryl each year.

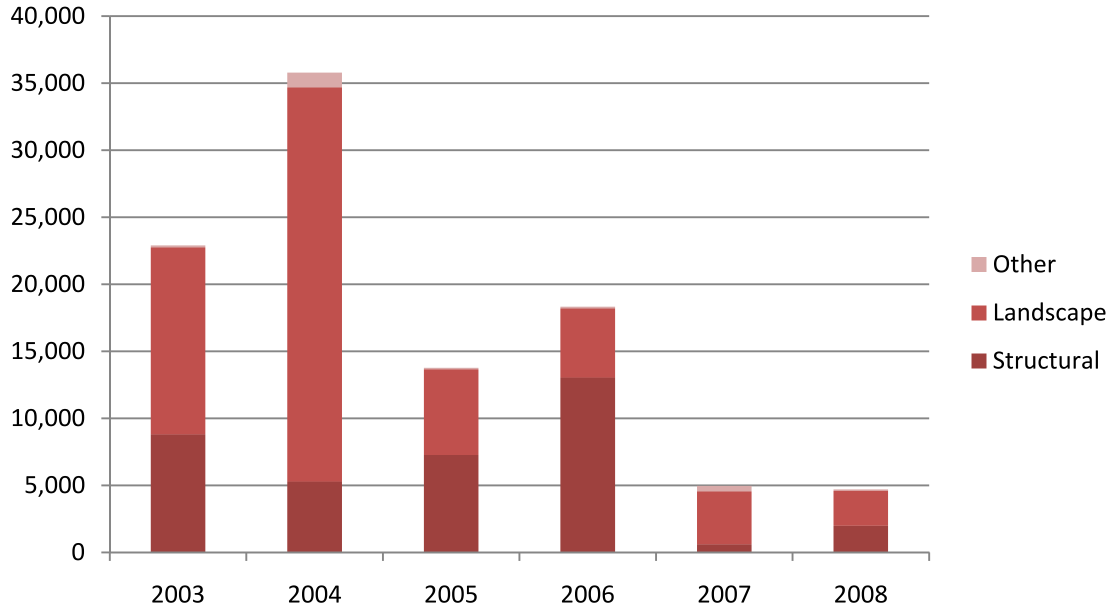
Figure 16. California Carbaryl Sales 2003-2008
(Pounds of Pesticide Active Ingredient)



Source: DPR pesticide sales data (DPR 2007a, 2007b, 2007c, 2008a, 2008b, 2010). DPR's data include both agricultural and urban product sales.

Figure 17 (on the next page) shows California reported urban carbaryl use. Most reported carbaryl urban use is for structural pest control and landscape maintenance. The dramatic (about 80%) drop in carbaryl reported urban use between 2004 and 2008 matches an 80% reduction in the number of U.S. EPA-registered carbaryl products during the same time period, likely in response to requirements stemming from U.S. EPA's 2003 Interim Reregistration Eligibility Decision (U.S. EPA 2008a).

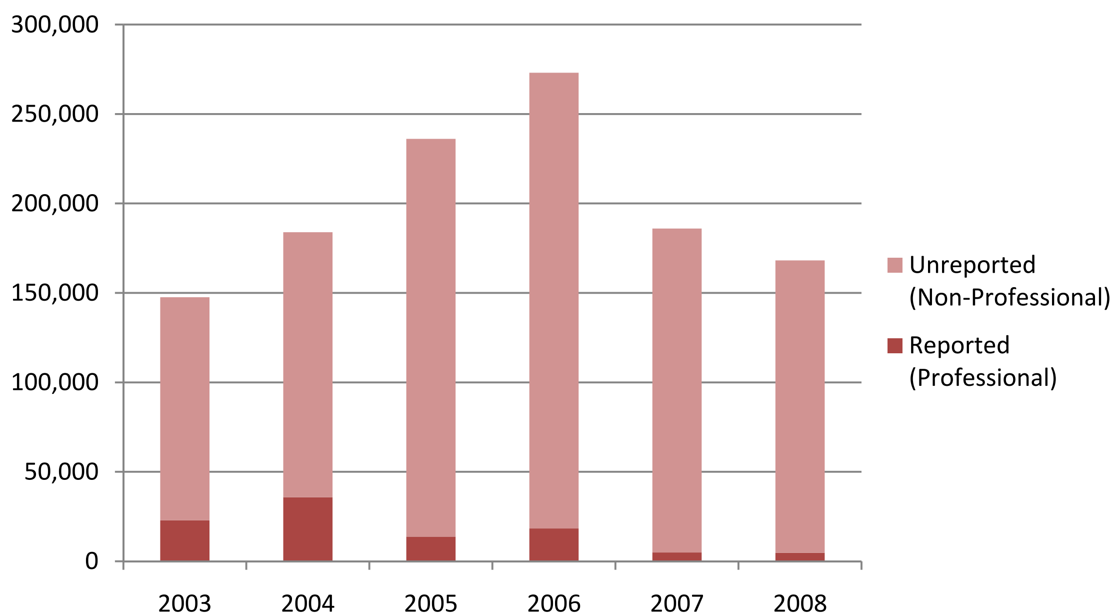
Figure 17. California Reported (Professional) Urban Carbaryl Use 2003-2008 (Pounds of Pesticide Active Ingredient)



Source: DPR pesticide use reports (DPR 2005, 2006a, 2006b, 2007d, 2008c, 2009).

Total urban carbaryl use was estimated on the basis of sales and reported use data using the method described in Section 2. Figure 18 summarizes estimated carbaryl urban use. Most estimated urban carbaryl use is unreported.

Figure 18. California Estimated Carbaryl Urban Use 2003-2008 (Pounds of Pesticide Active Ingredient)



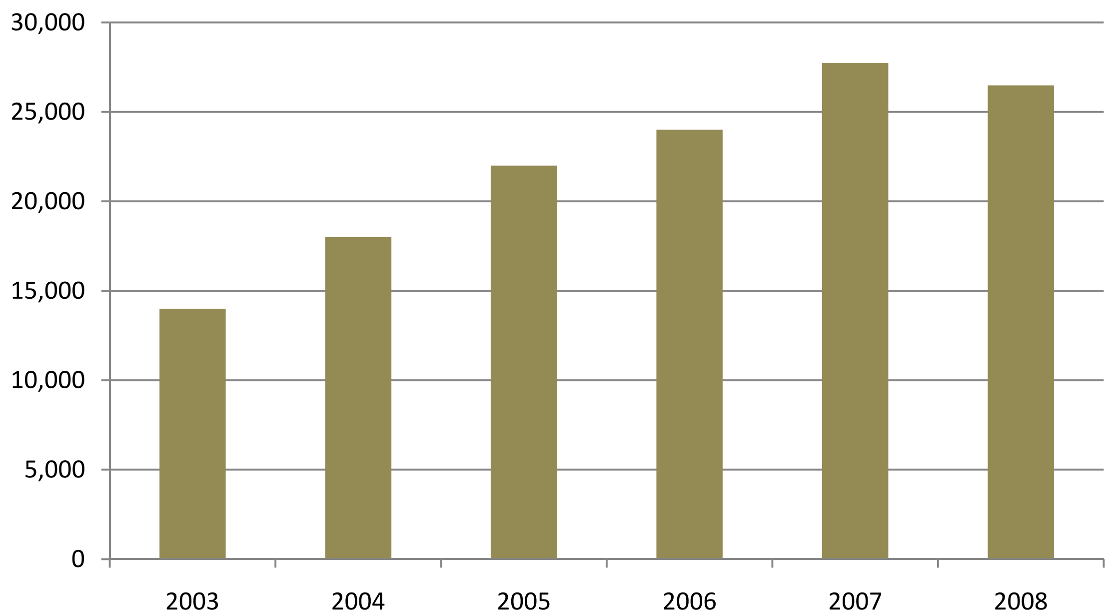
Source: DPR pesticide sales data (DPR 2007a, 2007b, 2007c, 2008a, 2008b, 2010), DPR pesticide use reports (DPR 2005, 2006a, 2006b, 2007d, 2008c, 2009), and mathematical calculations (see Section 2).

Both total sales and estimated urban use data suggest that carbaryl use peaked in 2005-2006 and is beginning to trend downward. The downward trend probably reflects a long-term reduction in carbaryl product availability in response to U.S. EPA regulatory requirements (U.S. EPA 2008a). When U.S. EPA completes the regulatory process necessary for full implementation of the new restrictions on carbaryl use identified in its Registration Eligibility Decisions (U.S. EPA 2007), carbaryl use—particularly urban use—is likely to continue to decline.

Fipronil

Figure 19 summarizes California fipronil sales from 2003-2008. Since all California registered fipronil products are for urban use, this chart reflects total estimated urban fipronil use. In California, registered fipronil products fall into two primary categories: products for professional applicators and drops for pet flea and tick control. Due to significant reporting errors for fipronil use (Moran 2007), estimating non-professional fipronil use (i.e., use that may be associated with sewer discharges rather than urban runoff) is impossible. Since applications of the non-professional products involve relatively small quantities of fipronil and there are several alternatives, it is reasonable to assume that most fipronil is used by professionals for structural pest control.

Figure 19. California Fipronil Sales 2003-2008
(Pounds of Pesticide Active Ingredient)



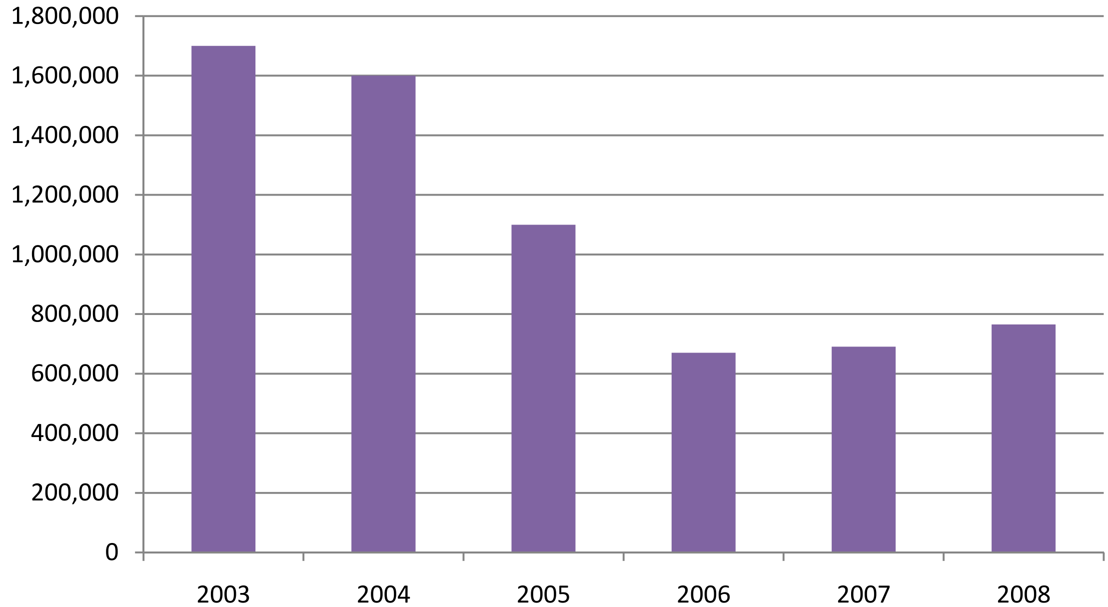
Source: DPR pesticide sales data (DPR 2007a, 2007b, 2007c, 2008a, 2008b, 2010).

The data in Figure 19 suggest that fipronil use has almost doubled since 2003. Its growth may be spurred by its use as an alternative to the pyrethroids. In 2010, fipronil will lose some patent protection, making it likely that new fipronil products will enter the market, which could stimulate additional increases in fipronil use.

Malathion

Figure 20 (on the next page) summarizes California malathion sales from 2003-2008. These data reflect both urban and agricultural products. On average, reported agricultural use equals about half of the total malathion sales quantity each year.

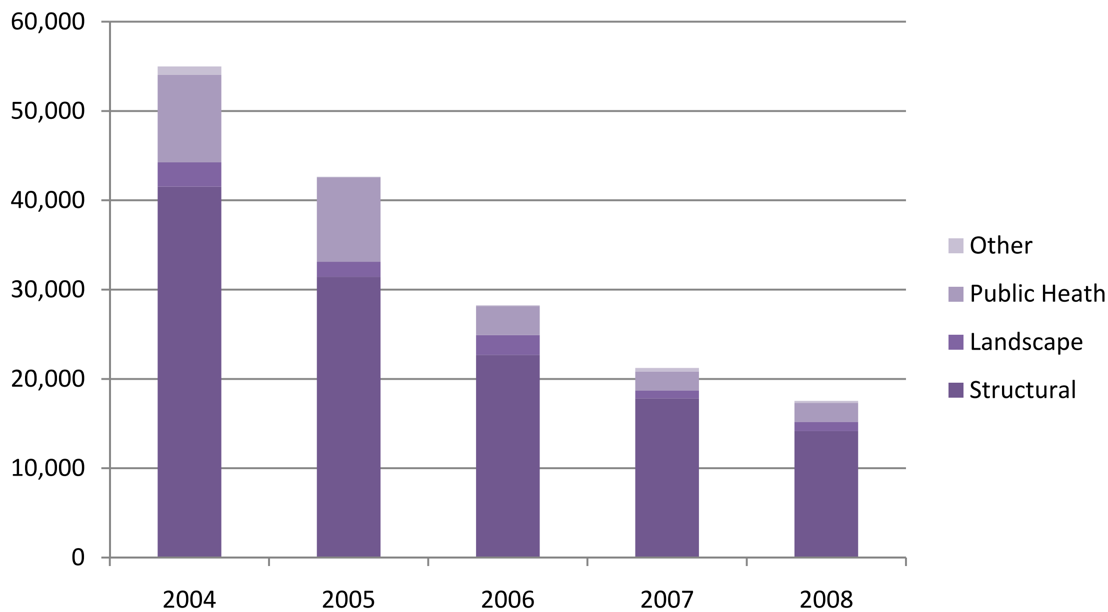
Figure 20. California Malathion Sales 2003-2008 (Pounds of Pesticide Active Ingredient)



Source: DPR pesticide sales data (DPR 2007a, 2007b, 2007c, 2008a, 2008b, 2010). DPR's data include both agricultural and urban product sales.

Figure 21 shows California reported urban malathion use. Most reported malathion urban use is for structural pest control. The decline in malathion reported urban use (nearly 70% drop since 2004) likely reflects response to changes in allowable malathion use associated with U.S. EPA's reregistration process (see U.S. EPA 2009).

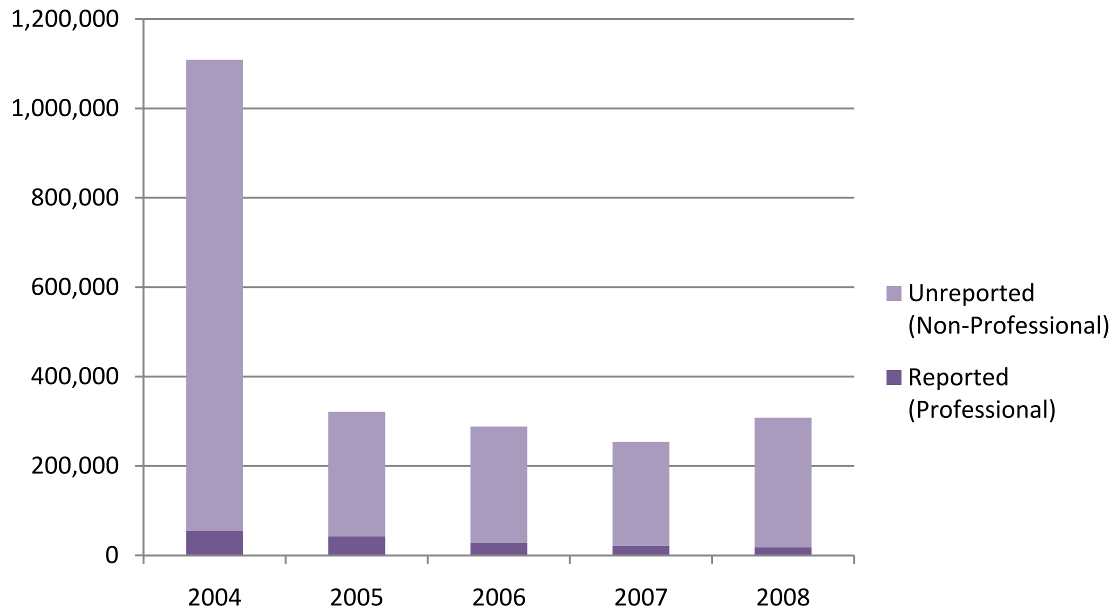
Figure 21. California Reported (Professional) Urban Malathion Use 2004-2008 (Pounds of Pesticide Active Ingredient)



Source: DPR pesticide use reports (DPR 2006a, 2006b, 2007d, 2008c, 2009). Due to an apparent reporting error, 2003 data are not included.

Total urban malathion use was estimated on the basis of sales and reported use data using the method described in Section 2. Figure 22 summarizes estimated malathion urban use. Most estimated urban malathion use is unreported. Estimated urban use has decreased by about 70% since 2004. Since the decrease is probably associated with U.S. EPA's reregistration process, malathion urban use is unlikely to return to past levels.

Figure 22. California Estimated Malathion Urban Use 2004-2008 (Pounds of Pesticide Active Ingredient)



Source: DPR pesticide sales data (DPR 2007b, 2007c, 2008a, 2008b, 2010), DPR pesticide use reports (DPR 2006a, 2006b, 2007d, 2008c, 2009), and mathematical calculations (see Section 2).

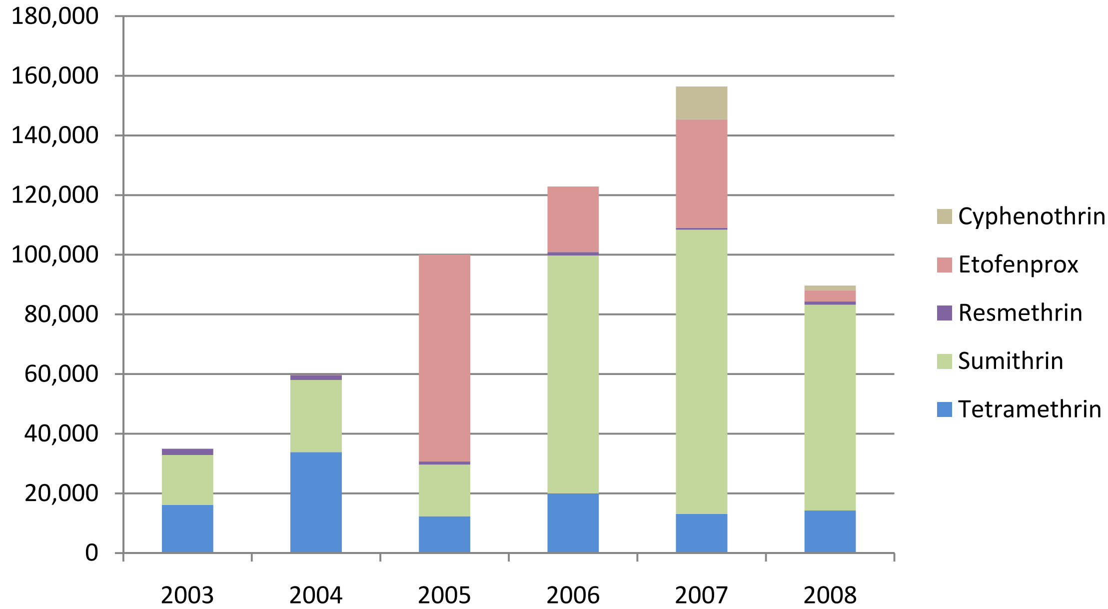
3.3 Other Urban Pyrethroids

With the exception of the relatively new ether pyrethroid etofenprox, all of the other urban pyrethroids are "first generation" pyrethroids, which are more photosensitive than newer pyrethroids. These older pyrethroids are used primarily indoors, where photosensitivity has less impact on their insect control performance. Priority other urban pyrethroids are: cyphenothrin, etofenprox, resmethrin, sumithrin, and tetramethrin.

Because aquatic toxicity data suitable for calculation of *permethrin equivalents* is not available for any of these pyrethroids, this section does not include any adjustments for differences in relative toxicity among the other urban pyrethroids.

Figure 23 summarizes 2003-2008 California sales of other urban pyrethroids. Since 2006, sumithrin (d-phenothrin) has comprised about two-thirds of total sales quantity of these pyrethroids. Etofenprox entered the market in 2004; cyphenothrin entered the market in 2007. Other urban pyrethroids sales quantities are small compared to urban high-use pyrethroid sales quantities.

Figure 23. California Other Urban Pyrethroids Sales 2003-2008 (Pounds of Pesticide Active Ingredient)



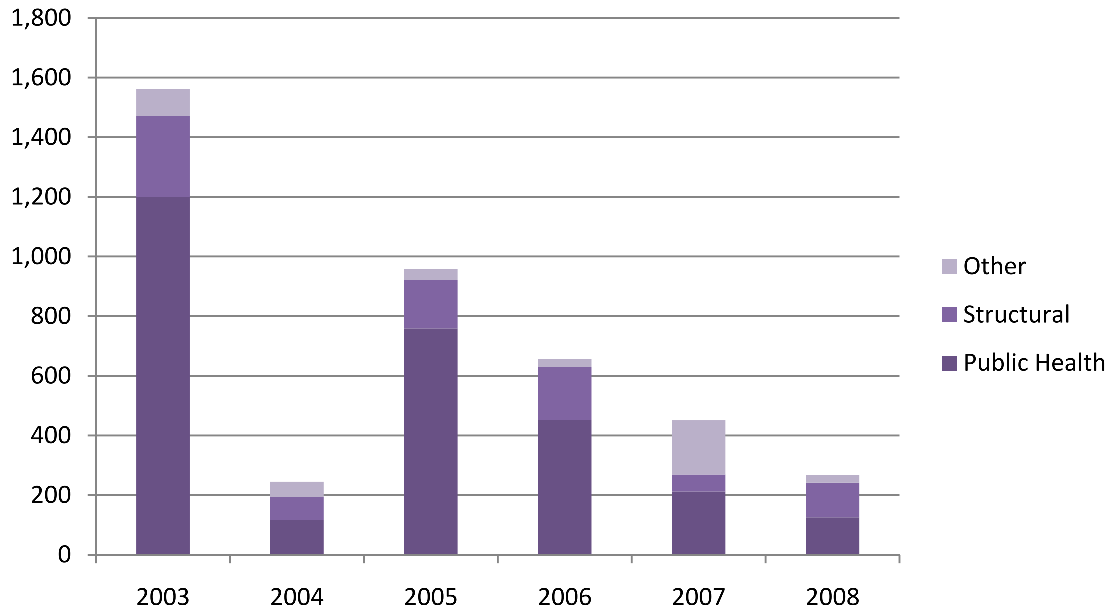
Source: DPR pesticide sales data (DPR 2007a, 2007b, 2007c, 2008a, 2008b, 2010). DPR's data include both agricultural and urban product sales.

Since none of these pyrethroids had meaningful agricultural reported use, sales data provide reasonable estimates of their urban use. Figure 23 suggests that sales peaked in 2007 and might have started to trend downward (2008 sales were 40% below 2007). Since factors like weather, pest pressures, and economic conditions affect pesticide sales, reduced sales in 2008 might not reflect a permanent change in use levels. In the future, use of pyrethroids and other insecticides indoors could increase in response to a recent resurgence in bed bugs (U.S. EPA 2010).

Only sumithrin and resmethrin had reported use greater than 10 pounds a year. For both pyrethroids, the primary reported use was for public health pest control, probably mosquito abatement. Reported use comprised less than 5% of the total sales of sumithrin. Figure 24 shows resmethrin reported use, which varied from 15% (2004) to almost 90% (2005) of resmethrin sales. Changes in public health pest control applications were the dominant factor in the changes in resmethrin reported use.

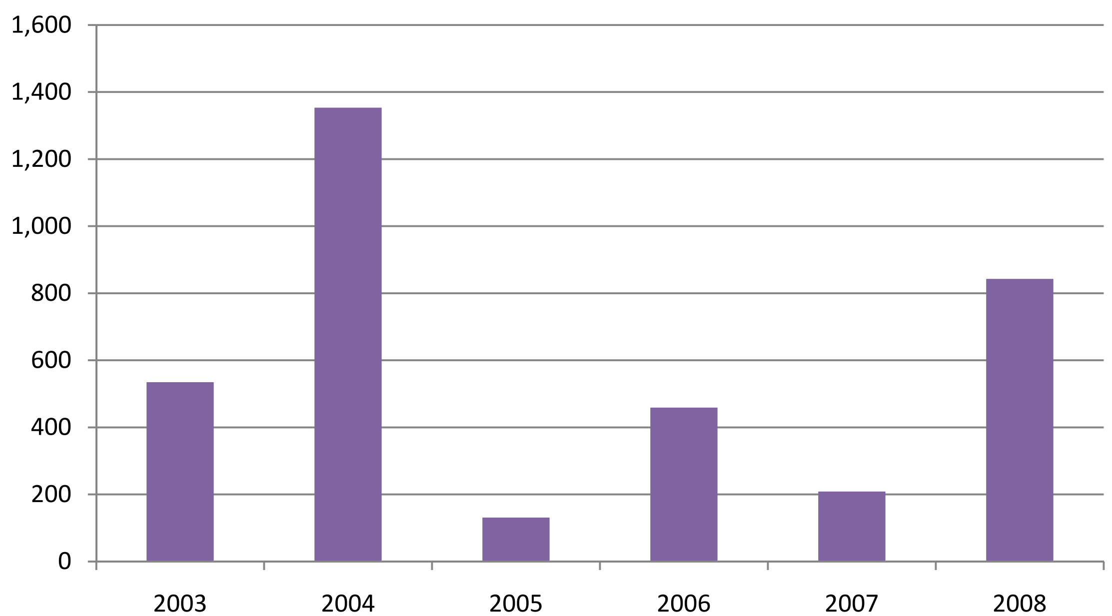
Except for resmethrin, total sales of these pyrethroids should correlate with use patterns associated with discharges to municipal wastewater treatment plants (e.g., indoor applications and pet treatments). For resmethrin, sales overestimate non-professional (likely indoor) use due to its public health use. Estimated resmethrin non-professional use is shown in Figure 25. Although estimated use varies from year to year, average total resmethrin use comprises only a small portion of total other urban pyrethroid use.

Figure 24. California Reported (Professional) Urban Resmethrin Use 2003-2008 (Pounds of Active Ingredient)



Source: DPR pesticide use reports (DPR 2005, 2006a, 2006b, 2007d, 2008c, 2009).

Figure 25. California Estimated Unreported (Non-Professional) Resmethrin Urban Use 2003-2008 (Pounds of Active Ingredient)



Source: DPR pesticide sales data (DPR 2007a, 2007b, 2007c, 2008a, 2008b, 2010), DPR pesticide use reports (DPR 2005, 2006a, 2006b, 2007d, 2008c, 2009), and mathematical calculations (see Section 2).

4.0 URBAN USE OF OTHER UP3 PROJECT PRIORITY PESTICIDES

This section provides a qualitative overview of the urban use of non-insecticide UP3 Priority Pesticides and identifies factors influencing the trends in use of these pesticides. The analysis is grouped by use pattern, using the same groupings as in Table 1:

- Swimming pool, spa, and fountain treatments
- Indoor biocides
- Sewer root control products
- Wood preservatives
- Marine antifouling biocides

Nearly all UP3 Priority Pesticides within these five use patterns have many other urban and agricultural uses. Since pesticide active ingredients with copper and silver fall into multiple priority use categories, this section starts with a subsection looking at copper and silver pesticides.

4.1 Overview of Copper and Silver Pesticides

Copper

Copper-containing pesticides are widely used to control fungi, mildew, algae, bacteria, and roots. Table 4 (on the next page) summarizes registered uses of the 20 copper-containing pesticides in the California pesticide market. The table highlights those copper-containing pesticides registered for the five use patterns that are the focus of this section. Nearly all of the highlighted copper compounds are registered for multiple use patterns. Due to the overlapping use patterns, neither sales nor reported use data provide much insight into the amount of copper used in each of the five pesticide use patterns reviewed in this section.

Silver

Like copper, silver appears in multiple chemical forms in the California pesticide market. Table 5 (on the next page) shows the five silver-containing registered pesticides, which are all registered for at least one priority use pattern. Most metallic silver products and all silver chloride and silver iodide products are for use in pools, spas, and fountains. Ionic silver products are all indoor cleaning/biocides.

Use of silver biocides in California appears to be growing. Sales of silver metal-containing pesticides have more than doubled since the year 2000 (DPR 2002a, 2002b, 2003, 2007a, 2007b, 2007c, 2008a, 2008b, 2010). The first reported sales of silver chloride, silver iodide, and ionic silver as pesticides were in 2008. In contrast to other silver pesticides, silver nitrate sales are declining (DPR 2002a, 2002b, 2003, 2007a, 2007b, 2007c, 2008a, 2008b, 2010).

Table 4. Registered Uses of Copper-Containing Pesticide Active Ingredients

Copper Active Ingredient	Pool/Spa/ Fountain	Indoor Biocide	Root Control	Wood Preservative	Marine Antifouling	Other Ag or Urban Uses
Copper	X			X		X
Copper 8-quinolinoleate		X		X		
Copper Ammonia Complex						X
Copper Ammonium Carbonate				X		
Copper Carbonate	X			X		X
Copper Citrate Chelate						X
Copper Ethanolamine Complexes, Mixed	X			X		X
Copper Ethylenediamine Complex	X					X
Copper Gluconate Chelate						X
Copper Hydroxide	X	X		X	X	X
Copper Naphthenate		X		X		
Copper Oxide (Cuprous)					X	X
Cupric Oxide				X		
Copper Oxychloride						X
Copper Resinate						X
Copper Soap (Copper Octanoate)						X
Copper Sulfate (Basic)	X		X			X
Copper Sulfate (Pentahydrate)	X		X	X		X
Copper Thiocyanate					X	
Copper Triethanolamine Complex	X					

Source: California Department of Pesticide Regulations Product/Label Database, 2010.

Table 5. Registered Uses of Silver-Containing Pesticide Active Ingredients

Silver Active Ingredient	Pool/Spa/ Fountain	Indoor Biocide	Other Ag or Urban Uses
Silver	X	X	X
Silver, Ionic (Ag+)		X	
Silver Chloride	X		
Silver Iodide (Colloidal)	X		
Silver Nitrate		X	X

Source: California Department of Pesticide Regulations Product/Label Database, 2010.

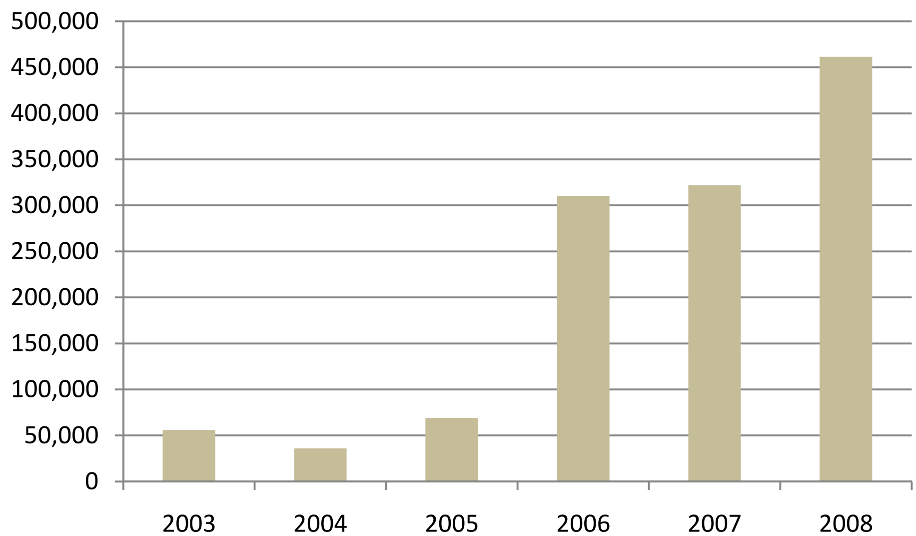
4.2 Swimming Pool, Spa, and Fountain Treatments

Swimming pools, spas and fountains are treated with two types of pesticides—biocides and algaecides. Three categories of swimming pool, spa, and fountain treatments are on the UP3 Priority Pesticide List: copper-containing pesticides, silver-containing pesticides, and polyhexamethylene biguanadine (PHMB).

Swimming pool, spa, and fountain treatments do not fall within California's pesticide use reporting system. Due to the overlapping uses of copper and silver active ingredients, their use cannot be estimated with sales data. Because PHMB has more limited use patterns, sales data provide insight into PHMB usage.

PHMB is registered for use as a swimming pool biocide, a materials preservative, and as a biocide in general cleaning products. Although one agricultural product was registered in 2008, there was no meaningful reported use of PHMB, which indicates that sales provide a good basis for estimating total PHMB urban use. Because sales data are aggregated for all products, it is not possible to separate swimming pool products (which may be discharged to sewers or storm drains) from indoor use products (which may be discharged to sewers). Figure 26 shows that PHMB sales have increased dramatically since 2003-2008 sales were eight times 2003 sales.

Figure 26. California PHMB Sales 2003-2008
(Pounds of Pesticide Active Ingredient)



Source: DPR pesticide sales data (DPR 2007a, 2007b, 2007c, 2008a, 2008b, 2010, Owen 2008). DPR's data include both agricultural and urban product sales.

4.3 Indoor Biocides

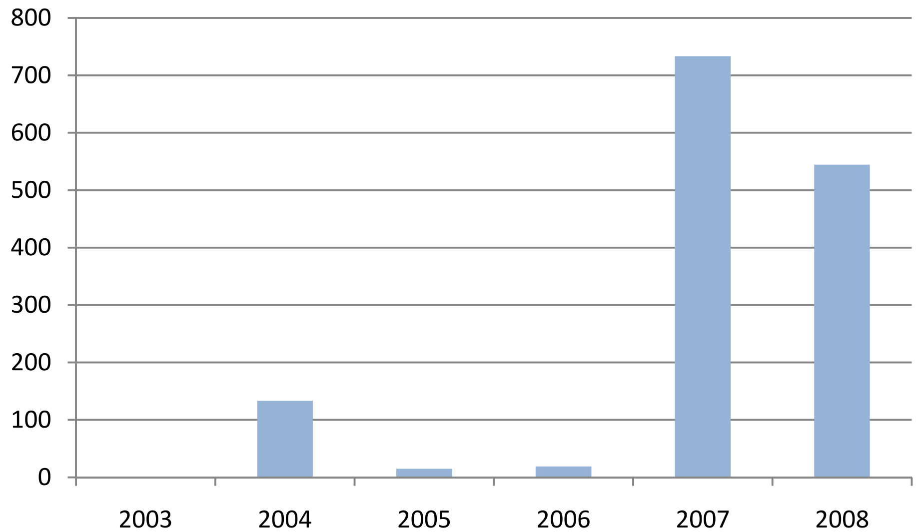
Many biocides can be used indoors in manners that entail discharges to municipal wastewater treatment plants. The UP3 Project Priority List includes three types of indoor biocides: copper-containing biocides, silver-containing biocides, and triclosan.

Applicators do not need to report biocide applications. DPR's database reflects a few rare reports that are too limited to provide meaningful information about use patterns. Due to the overlapping uses of copper and silver active ingredients, their use as indoor biocides cannot be estimated with sales data.

Triclosan appears in a variety of household products. Most triclosan-containing products (e.g., biocidal soaps)—likely representing the majority of triclosan use—are regulated by the Food and Drug Administration (FDA). Pesticide regulators excuse FDA-regulated products from pesticide registration.

In California, only three products containing triclosan are registered for use only as pesticides—a cooling water treatment and two fabric treatment products. Figure 27 shows 2003-2008 triclosan sales in these pesticide products. These spotty data are unlikely to reflect overall trends in the triclosan market.

Figure 27. California Triclosan Pesticide Sales 2003-2008 (Pounds of Pesticide Active Ingredient)



Source: DPR pesticide sales data (DPR 2007a, 2007b, 2007c, 2008a, 2008b, 2010).

4.4 Sewer Root Control Products

All four pesticide active ingredients that are used to control root intrusion into sewer lines are on the UP3 Priority Pesticide List: copper sulfate, dichlobenil, diquat dibromide, and metam sodium.

While applicators must report sewer root control applications, the urban pesticide reporting form does not provide an obvious reporting category. Applicators could logically elect to report sewer root control in the "landscape maintenance" or "rights-of-way" categories, rather than write in sewers as the application site. The same ingredients used for root control pesticide occur in other products that can be applied for landscape maintenance and/or rights-of-way. Due to the reporting system, pesticide use reporting data do not provide insight about sewer root control applications.

Due to the overlapping uses of copper sulfate, its usage for root control cannot be estimated with sales data. In the San Francisco Bay area, use is probably negligible because of a DPR prohibition on use of copper sulfate use for sewer root control in the nine San Francisco Bay Area counties.

Sales data for the other three root control pesticides (dichlobenil, diquat dibromide, and metam sodium) do not provide the basis for use estimates because all three are also registered for multiple uses. Dichlobenil and diquat dibromide are used in landscaping herbicide products. The main use of metam sodium is for agricultural soil fumigation.

Root control pesticide use is likely to increase in coming years in response to new water quality protection requirements for sanitary sewer systems. In the next few years, U.S. EPA will implement new health protection requirements for metam sodium stemming from its 2008 reregistration decision (U.S. EPA 2008b). The new safety measures will increase cost of metam sodium applications, potentially shifting the market toward alternative pesticides and non-chemical alternatives (like mechanical removal).

4.5 Wood Preservatives

The UP3 Priority Pesticide List includes three types of wood preservatives: copper compounds, creosote, and pentachlorophenol. As shown in Table 4, several copper compounds may be used to treat wood in California. Neither creosote (used primarily to treat pilings and railroad ties) nor pentachlorophenol (used primarily to treat utility poles and crossarms) is registered for use in California. However, according to Western Wood Preservers Institute (WWPI) data, creosote and pentachlorophenol-treated wood manufactured outside of California is sold and used in California (Smith 2003).

DPR's pesticide use reporting database does not provide a ready data source for evaluating wood preservative use. Requirements for reporting wood preservative applications vary by product and application location. Since reporting forms do not provide a clear category for wood preservative treatments, reporting can fall into multiple categories that overlap with other uses of the same pesticide active ingredients. Of the many copper-containing wood preservative ingredients, two compounds are used only as wood preservatives. These two (copper ammonium carbonate and cupric oxide) were reported under four categories: fumigation, other," "lumber, treated," "landscape maintenance," and "structural pest control." Except for one copper-copper containing wood preservative (copper naphthenate, which is sold at retail to non-professionals for on-site wood treatment), essentially all applications of the three preservatives on the UP3 Priority Pesticide List should occur at wood treatment facilities serving the California market. DPR sales data only reflects copper wood preservatives sold to California wood treaters. The WWPI estimates that California wood treatment facilities supply about 80% of the treated wood sold in California (Smith 2003). DPR's sales data do not include treated wood shipped from out of state, since "treated product" sales are not reported.

Copper wood preservatives have multiple pesticidal uses. Using publicly available data from DPR, separating wood preservative sales from sales of other products with the same active ingredient is impossible. Further confounding the data sets, common names for wood preservatives are not linked directly to their pesticide active ingredients. For example, "ammoniacal copper quat" (ACQ) wood products may have been treated with either copper ammonium carbonate or copper ethanolamine complexes.

Using wood preservative industry market data, it might be possible to estimate wood preservative use in California; however, such estimates are beyond the scope of this report.

With the phase out of residential uses of chromate copper arsenate (CCA), other wood preservatives have grown in market share. Two commonly available alternatives are copper-containing: ACQ and copper naphthenate.

4.6 Marine Antifouling Biocides

Three marine antifouling biocides appear on the UP3 Priority Pesticide List: copper compounds, Irgarol 1051, and zinc pyrithione.

Applicators do not need to report marine antifouling biocide applications. DPR's database reflects a few rare reports that are too limited to provide meaningful information about use patterns.

The primary application method for marine antifouling biocides is as boat bottom paint. The paints themselves are registered pesticides included in DPR's sales data reporting system. Sales data may provide a useful means of estimating antifouling biocide use; however, sales do not exactly equal use for the following reasons:

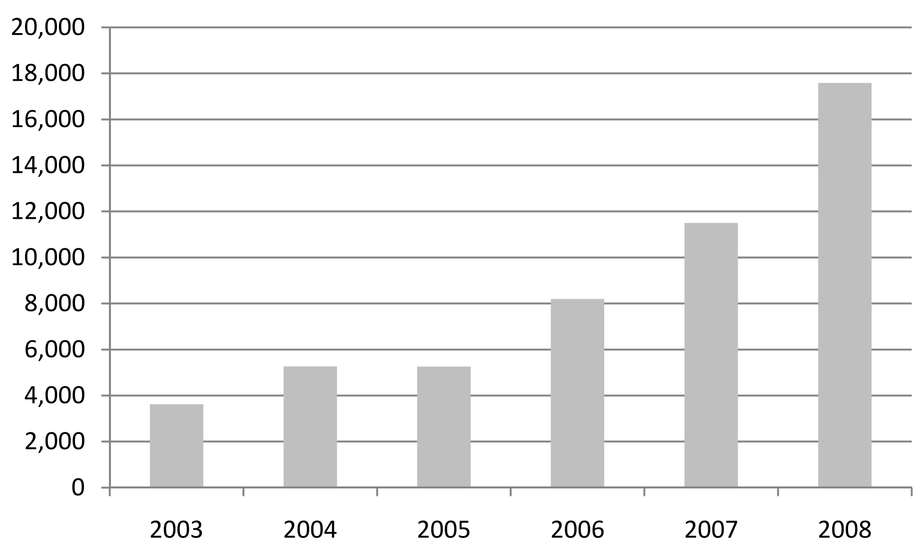
- Some marine antifouling paint may not be completely used up by purchasers.
- New boats may receive their first antifouling coating in another state. (A boat coated with marine antifouling paint is a “treated product” that is not included in pesticide sales data.)
- Boats that are ordinarily harbored in California may occasionally be serviced outside of California (and vice versa).

None of these activities is likely to comprise a significant fraction of total boat bottom paint sales.

Due to the many overlapping uses of copper pesticides, copper use in marine antifouling biocides cannot be estimated with sales data. Recent DPR regulatory attention to water pollution from copper-containing marine antifouling coatings (DPR 2010) may be encouraging voluntary market shifts to alternatives.

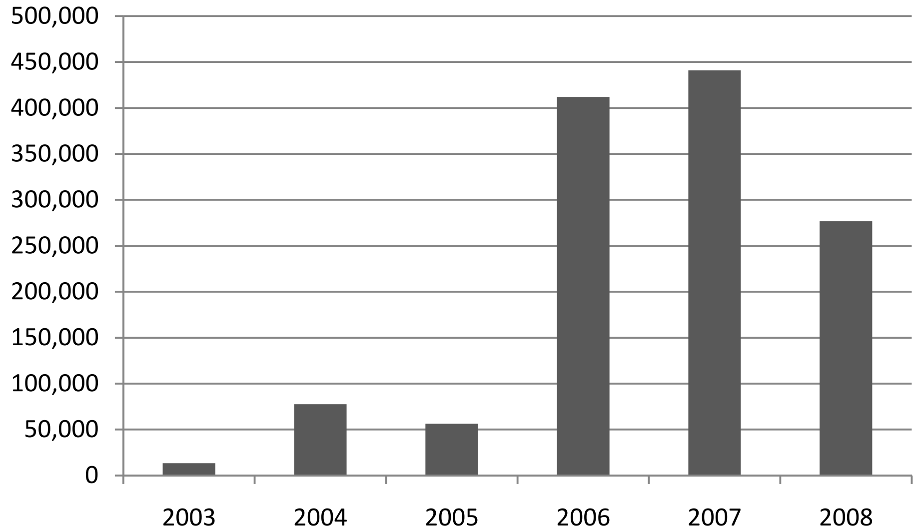
Both Irgarol 1051 and zinc pyrithione are registered for use both in marine antifouling coatings and as industrial preservatives. Sales data for both pesticides, shown in Figures 28 and 29, reflect only urban use; however, it is not possible to separate preservative sales from antifoulant sales. Nonetheless, the trend toward increased sales of both biocides—particularly the increase in zinc pyrithione sales since 2005—and the increased number of registered antifouling products containing these two biocides suggest that these two biocides are likely comprising a growing share of the marine antifoulant market.

Figure 28. California Irgarol 1051 Sales 2003-2008
(Pounds of Pesticide Active Ingredient)



Source: DPR pesticide sales data (DPR 2007a, 2007b, 2007c, 2008a, 2008b, 2010).

Figure 29. California Zinc Pyrithione Pesticide Sales 2003-2008 (Pounds of Pesticide Active Ingredient)



Source: DPR pesticide sales data (DPR 2007a, 2007b, 2007c, 2008a, 2008b, 2010).

5.0 CONCLUSIONS

Pyrethroids

Pyrethroids continue to be the most commonly applied insecticides in California urban areas. Total pyrethroid estimated urban use exceeds the total estimated urban use of all other UP3 Priority Pesticide List insecticides combined.

Pyrethroids are more heavily used in urban areas than in agricultural areas. On average, agricultural applications comprise only about one-third of the total annual use of the urban high-use pyrethroids.

Urban usage of pyrethroids may be on the decline. Use of "urban high-use pyrethroids" appears to have peaked in 2006 and subsequently declined by about 40% (in terms of aquatic "toxicity equivalents", 50% in pounds of "active ingredient"). Sales (pounds of pesticide active ingredient) of "other urban pyrethroids" peaked in 2007; dropping 40% in 2008. These declines may reflect the economic slowdown rather than a permanent change in urban insecticide use patterns.

When aquatic toxicity is considered, the relative importance of the "urban high-use pyrethroids" is very different than it is when viewed in terms of quantity (pounds of pesticide active ingredient) alone.

- Two pyrethroids—cypermethrin and bifenthrin—accounted for almost 80% of the pyrethroid-related aquatic "toxicity equivalents" estimated used in California urban areas in 2007-2008. These two pyrethroids are the two that most often appear in California urban creeks at levels sufficient to cause toxicity to sediment-dwelling organisms (Trimble 2009).
- Lambda-cyhalothrin has replaced cyfluthrin as the third most used pyrethroid in terms of "toxicity equivalents."
- On a quantity (pounds of pesticide active ingredient) basis, permethrin was the most heavily used pyrethroid in California urban areas from 2003-2008. Permethrin alone represented almost half of the total estimated urban use of urban high-use pyrethroids.

Since 2006, sumithrin (d-phenothrin) has been the biggest selling of the "other urban pyrethroids," with about two-thirds of total sales.

Professionals are the primary users of "urban high-use pyrethroids". "Other urban pyrethroids" are little used by professional applicators.

- Reported professional use remains the vast majority (nearly 90%) of all estimated urban high-use pyrethroid use, both in terms of aquatic "toxicity equivalents" and in terms of pounds of pesticide active ingredient.
- Professional applications of pyrethroids to control pests in and around structures ("structural pest control") comprise more than 95% of professional urban use of pyrethroids.
- Nearly all cyfluthrin, beta-cyfluthrin, cypermethrin, deltamethrin, and permethrin and most (80%) bifenthrin used in California urban areas is used by professional applicators. Except for permethrin, these are the pyrethroids that have most frequently been measured in California urban creeks at levels sufficient to cause toxicity to sediment-dwelling organisms (Trimble 2009).

- Nearly all esfenvalerate and most lambda-cyhalothrin, gamma-cyhalothrin, and tralomethrin use is by non-professionals.

Other Urban High-Use Insecticides

Carbaryl use peaked in 2005-2006 and is beginning to trend downward. Professional urban use dropped by about 80% between 2004 and 2008. The downward trend probably reflects a long-term change in pesticide use patterns; it appears to be a response to regulatory requirements stemming from U.S. EPA's recent reregistration process.

Increasing use of fipronil suggests that it may be starting to replace pyrethroids in the urban marketplace. Fipronil use has almost doubled since 2003.

Estimated malathion urban use has decreased significantly (by about 70%) since 2004. Since the decrease is probably associated with restrictions coming out of U.S. EPA's reregistration process, use is unlikely to return to past levels.

Other UP3 Priority Pesticides

Due to the many overlapping uses of most of the pesticides used for other priority use patterns (swimming pool, spa, and fountain treatments, indoor biocides, sewer root control products, wood preservatives, marine antifouling biocides), quantitative use estimates cannot be made. A few trends can be discerned from available data; these are summarized below.

Sales of the swimming pool and spa biocide PHMB (an alternative to chlorine) have increased dramatically. In 2008, sales were eight times the sales in 2003.

Sales of the two marine antifouling biocides—Irgarol 1051 and zinc pyrithione—have seen significant increases since 2003. Irgarol 1051 sales in 2008 were almost five times 2003 sales. Zinc pyrithione 2008 sales were about 20 times its 2003 sales.

While discerning use rates for the four root control chemicals (all of which are UP3 Priority Pesticides) is impossible, the use of some or all of these four chemicals is likely to increase in coming years in response to new water quality protection requirements for sanitary sewer systems.

6.0 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).

California Department of Pesticide Regulation (DPR) (2000). *Deltamethrin Risk Characterization Document*. DPR Health Assessment Section, Medical Toxicology Branch. June 13.

California Department of Pesticide Regulation (DPR) (2002a). "State of California Pesticides Sold in California for Year: 2000, Combined Disclosed Active Ingredients by Chemical Name." November 1.

California Department of Pesticide Regulation (DPR) (2002b). "State of California Pesticides Sold in California for Year: 2001, Combined Disclosed Active Ingredients by Chemical Name." November 19.

California Department of Pesticide Regulation (DPR) (2003). "State of California Pesticides Sold in California for Year: 2002, Combined Disclosed Active Ingredients by Chemical Name." October 8.

California Department of Pesticide Regulation (DPR) (2007a). "State of California Pesticides Sold in California for Year: 2003, Combined Disclosed Active Ingredients by Chemical Name." March 6.

California Department of Pesticide Regulation (DPR) (2007b). "State of California Pesticides Sold in California for Year: 2004, Combined Disclosed Active Ingredients by Chemical Name." March 6.

California Department of Pesticide Regulation (DPR) (2007c). "State of California Pesticides Sold in California for Year: 2005, Combined Disclosed Active Ingredients by Chemical Name." June 13.

California Department of Pesticide Regulation (DPR) (2008a). "State of California Pesticides Sold in California for Year: 2006, Combined Disclosed Active Ingredients by Chemical Name." January 23.

California Department of Pesticide Regulation (DPR) (2008b). "State of California Pesticides Sold in California for Year: 2007, Combined Disclosed Active Ingredients by Chemical Name." November 7.

California Department of Pesticide Regulation (DPR) (2010). "State of California Pesticides Sold in California for Year: 2008, Combined Disclosed Active Ingredients by Chemical Name." March 2.

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

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

California Department of Pesticide Regulation (DPR) (2006b). *Summary of Pesticide Use Report Data 2005, Indexed by Chemical,* November.

California Department of Pesticide Regulation (DPR) (2007d). *Summary of Pesticide Use Report Data 2006, Indexed by Chemical,* November.

California Department of Pesticide Regulation (DPR) (2008c). *Summary of Pesticide Use Report Data 2007, Indexed by Chemical,* November.

California Department of Pesticide Regulation (DPR) (2009). *Summary of Pesticide Use Report Data 2008, Indexed by Chemical,* November.

California Department of Pesticide Regulation (DPR) (2010). Notice of Decision to Initiate Reevaluation of Copper Based Waterway Antifouling Paint Pesticides. June 1.

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.

Giddings, J. M., I. Barber, et al. (2009). "Comparative aquatic toxicity of the pyrethroid insecticide lambda-cyhalothrin and its resolved isomer gamma-cyhalothrin." *Ecotoxicology* **18**(2): 239-49.

He, L. M., J. Troiano, et al. (2008). "Environmental chemistry, ecotoxicity, and fate of lambda-cyhalothrin." *Reviews of Environmental Contamination and Toxicology* **195**: 71-91.

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. D. (2007). "Urban Use of the Insecticide Fipronil—Water Quality Implications." Memorandum prepared for the UP3 Project. June 18.

Owen, L. Product Compliance Branch Chief, California Department of Pesticide Regulation (2008). Email with correction for PHMB sales data. December 11.

Smith, S. T. (2003). Economic Evaluation of Alternate Materials to Treated Wood in California. Prepared by AquAeTer, Inc. for the Western Wood Preservers Institute. May.

Smith, S. and R. E. Lizotte, Jr. (2007). Influence of Selected Water Quality Characteristics on the Toxicity of λ-Cyhalothrin and γ-Cyhalothrin to *Hyalella azteca*. *Bulletin of Environmental Contamination and Toxicology* **79**: 548-551.

TDC Environmental (2008). *Pesticides of Interest for Urban Surface Water Quality: Urban Pesticides Use Trends Annual Report 2008*. Prepared for the San Francisco Estuary Project. July 30.

TDC Environmental (2010). *Pesticides in Urban Runoff, Wastewater, and Surface Water: Annual Review of New Scientific Findings 2010*. Prepared for the San Francisco Estuary Project, March.

Trimble, A. J., D. P. Weston, et al. (2009). "Identification and Evaluation of Pyrethroid Insecticide Mixtures in Urban Sediments." *Environmental Toxicology and Chemistry* **28**(8): 1687-1695.

U.S. EPA (2007). Reregistration Eligibility Decision (RED) for Carbaryl. EPA-738-R-07-018. September.

U.S. EPA (2008a). Amended Reregistration Eligibility Decision (RED) for Carbaryl. EPA-738-R-08-010. August.

U.S. EPA (2008b). Reregistration Eligibility Decision (RED) for the Methyldithiocarbamate Salts (Metam-sodium, Metam-potassium) and Methyl Isothiocyanate (MITC). EPA-738-R-08-006. July.

U.S. EPA (2009). Reregistration Eligibility Decision (RED) for Malathion. EPA-738-R-06-030. May.

U.S. EPA (2010). Pesticide News Story: New Bed Bug Web Page Available. May 14.

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.

APPENDIX

Urban pesticide sales data and use estimates are provided in the tables below. Values in tables are rounded to reflect the appropriate number of significant figures (two for sales data, one for urban use estimates).

Table A-1. California Urban High-Use Pyrethroids Sales 2000-2008 (Pounds of Pesticide Active Ingredient)

Pyrethroid	2000	2001	2002	2003	2004	2005	2006	2007	2008
Bifenthrin	NR*	32,000	32,000	71,000	110,000	44,000	160,000	120,000	140,000
Cyfluthrin	47,000	47,000	51,000	45,000	46,000	37,000	41,000	23,000	22,000
Beta-Cyfluthrin	NR	NR	NR	4,300	16,000	5,500	5,400	12,000	17,000
Cypermethrin	50,000	50,000	65,000	82,000	78,000	91,000	85,000	66,000	71,000
Deltamethrin	8,300	3,200	4,400	4,900	3,900	4,000	4,700	3,500	3,100
Esfenvalerate	43,000	36,000	43,000	54,000	57,000	50,000	80,000	68,000	59,000
Gamma-Cyhalothrin	NR	NR	NR	NR	NR	1,400	1,400	2,800	2,300
Lambda-Cyhalothrin	NR	NR	24,000	28,000	26,000	38,000	55,000	86,000	44,000
Permethrin	440,000	280,000	430,000	480,000	470,000	480,000	610,000	350,000	360,000
Tralomethrin	1,900	34,000	NR	3,300	4,200	1,500	2,500	89	21

Source: DPR pesticide sales data (DPR 2002a, 2002b, 2003, 2007a, 2007b, 2007c, 2008a, 2008b, 2010).
*Prior to 2005, sales data were not always made public—data were provided only for active ingredients with three or more registrants. The tables in this section indicated "NR" when sales data were not reported for a pesticide prior to 2005.

Table A-2. California Urban High-Use Pyrethroids Estimated Urban Use 2004-2008 (Pounds of Pesticide Active Ingredient)

Pyrethroid	2004	2005	2006	2007	2008
Bifenthrin	60,000	60,000	100,000	60,000	70,000
Cyfluthrin	30,000	30,000	60,000	20,000	20,000
Beta-Cyfluthrin	20,000	5,000	20,000	10,000	7,000
Cypermethrin	200,000	200,000	200,000	200,000	100,000
Deltamethrin	10,000	10,000	10,000	20,000	10,000
Esfenvalerate	30,000	30,000	30,000	30,000	30,000
Gamma-Cyhalothrin	0	1,000	1,000	1,000	1,000
Lambda-Cyhalothrin	20,000	30,000	40,000	30,000	30,000
Permethrin	300,000	400,000	500,000	300,000	200,000
Tralomethrin	4,000	2,000	2,000	60	50

Source: DPR pesticide sales data (DPR 2007b, 2007c, 2008a, 2008b, 2010), DPR pesticide use reports (DPR 2006a, 2006b, 2007d, 2008c, 2009), and mathematical calculations (see Section 2).

Table A-3. California Sales of Other Urban High-Use Insecticides 2003-2008 (Pounds of Pesticide Active Ingredient)

Insecticide	2003	2004	2005	2006	2007	2008
Carbaryl	330,000	390,000	410,000	410,000	320,000	290,000
Malathion	1,700,000	1,600,000	700,000	670,000	690,000	770,000
Fipronil	14,000	18,000	22,000	24,000	28,000	26,000

Source: DPR pesticide sales data (DPR 2007a, 2007b, 2007c, 2008a, 2008b, 2010).

Table A-4. California Estimated Urban Use of Other Urban High-Use Insecticides 2003-2008 (Pounds of Pesticide Active Ingredient)

Insecticide	2003	2004	2005	2006	2007	2008
Carbaryl	100,000	200,000	200,000	300,000	200,000	200,000
Malathion	Not Estimated*	1,000,000	300,000	300,000	300,000	300,000

Source: DPR pesticide sales data (DPR 2007a, 2007b, 2007c, 2008a, 2008b, 2010), DPR pesticide use reports (DPR 2005, 2006a, 2006b, 2007d, 2008c, 2009), and mathematical calculations (see Section 2).
*Urban use reports contained data inconsistent with other years.

Table A-5. California Other Urban Pyrethroids Sales 2000-2008 (Pounds of Pesticide Active Ingredient)

Pyrethroid	2000	2001	2002	2003	2004	2005	2006	2007	2008
Cyphenothrin	NR	NR	NR	NR	NR	0	0	11,000	1,500
Etofenprox	NR	NR	NR	NR	18	69,000	22,000	36,000	3,800
Sumithrin	28,000	47,000	16,000	17,000	24,000	17,000	80,000	95,000	69,000
Resmethrin	2,400	2,400	4,900	2,100	1,600	1,100	1,100	660	1,10
Tetramethrin	8,200	7,200	18,000	16,000	34,000	12,000	20,000	13,000	14,000

Source: DPR pesticide sales data (DPR 2002a, 2002b, 2003, 2007a, 2007b, 2007c, 2008a, 2008b, 2010).

Table A-6. California Other Urban Pyrethroids Estimated Urban Use 2003-2008 (Pounds of Pesticide Active Ingredient)

Pyrethroid	2003	2004	2005	2006	2007	2008
Cyphenothrin	0	0	0	0	10,000	2,000
Etofenprox	0	20	70,000	20,000	40,000	4,000
Sumithrin	20,000	20,000	20,000	80,000	100,000	70,000
Resmethrin	2,000	2,000	1,000	1,000	400	1,000
Tetramethrin	20,000	30,000	10,000	20,000	10,000	10,000

Source: DPR pesticide sales data (DPR 2007a, 2007b, 2007c, 2008a, 2008b, 2010), DPR pesticide use reports (DPR 2005, 2006a, 2006b, 2007d, 2008c, 2009), and mathematical calculations (see Section 2).

Table A-7. California Sales of Other Priority Pesticides 2000-2008 (Pounds of Pesticide Active Ingredient)

Pesticide	2000	2001	2002	2003	2004	2005	2006	2007	2008
Irgarol 1051	NR	16,000	2,800	3,600	5,300	5,300	8,200	12,000	18,000
PHMB	27,000	NR	NR	56,000	36,000	69,000	310,000	320,000	460,000
Metallic Silver	560	410	400	520	680	960	730	760	1,300
Silver Chloride	NR	NR	NR	NR	NR	0	0	0	100
Silver Iodide, Collodial	NR	NR	NR	NR	NR	0	0	0	35
Silver Nitrate	NR	NR	NR	160	370	140	82	75	36
Silver, Ionic	NR	NR	NR	NR	NR	0	0	0	200
Triclosan	NR	NR	NR	NR	130	15	19	730	540
Zinc Pyrithione	NR	NR	NR	13,000	78,000	56,000	412,000	440,000	280,000

Source: DPR pesticide sales data (DPR 2002a, 2002b, 2003, 2007a, 2007b, 2007c, 2008a, 2008b, 2010).