Study 303. Source Identification of Bifenthrin in Placer County

September 17, 2019

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Summary

Due to frequent bifenthrin detections in urban runoff, the California Department of Pesticide Regulation (CDPR) wanted to understand the sources of bifenthrin in the urban environment. In 2016, CDPR initiated a study to address this objective by examining bifenthrin sources in Placer County near CDPR's long term monitoring sites in the Pleasant Grove Creek Watershed. Residential access to bifenthrin containing products, residential pesticide use practices, professional pesticide use including landscape practices, and label compliance and enforcement were examined. Results show that city residents have access to numerous bifenthrin (and pyrethroid) products, and pesticide applications, either by a resident or by a professional applicator, are common. Sources of professional bifenthrin use in the Pleasant Grove Creek Watershed are limited to structural applications. Since their inception in 2012, CDPR's Surface Water Regulations for pyrethroids likely influenced professional applicator behavior in the Sacramento area, which is indicated by a decrease in bifenthrin use and a concomitant decreasing trend in surface water concentrations. CDPR's 2011 Memorandum of Agreement for professional use bifenthrin products has likely contributed to the reduced bifenthrin use, as currently all professional use bifenthrin products are compliant with the agreement. During the study, the Placer County Agricultural Commissioner's office conducted numerous structural use inspections. Results from these inspections indicate that professional applicators do not always fully comply with the 2012 CDPR Surface Water Regulations nor do they always fully understand the pesticide use reporting system. For example, some professional companies erroneously and grossly over-report their pesticide use by reporting the volume of diluted product instead of concentrate (i.e., active ingredient). Continued outreach on the Surface Water Regulations, correct reporting for CDPR's Pesticide Use Reporting (PUR) database, and enhanced quality control of data entered into the PUR database are warranted. Finally, continued field and headquarter inspections of professional applicators are necessary to ensure proper pyrethroid application and reporting.

Introduction

Pyrethroids, especially bifenthrin, are common contaminants of urban waterways, which have been frequently detected at concentrations toxic to sensitive aquatic organisms (Amweg et al., 2006; Weston et al., 2005; Holmes et al., 2008). Pyrethroids dissipate slowly from hardscape applications with residual concentrations detected in runoff several months post application on concrete surfaces, making them available as a source for surface water contamination for extended periods (Jiang et. al., 2012). In addition, pyrethroids have high structural pesticide use (CDPR, 2018a). In response to pyrethroid surface water contamination, the California Department of Pesticide Regulation (CDPR) adopted Surface Water Regulations to curtail their use, with additional restrictions on bifenthrin professional products (CDPR, 2018b, 2018c). The United States Environmental Protection Agency (USEPA) swiftly followed, requesting label changes on pyrethroid products (USEPA, 2017). This combination of restrictions was expected to decrease or eliminate pyrethroid runoff from non-agricultural (urban environments) with a corresponding decrease in pyrethroid urban use. However, a recent analysis by Luo (2017) gives evidence these restrictions may not be sufficient to reduce bifenthrin runoff to concentrations below USEPA aquatic life benchmarks/benchmark equivalents or Water Board's pyrethroid concentration goals (CVRWQCB, 2015; USEPA, 2016, 2018). Monitoring by CDPR supports this. In a recent analysis, bifenthrin detections were decreasing at some CDPR Northern California's monitoring sites, but chronic USEPA aquatic life benchmarks were still exceeded (Budd, 2017).

Therefore, CDPR instituted a study to determine and identify sources of bifenthrin in urban (non-agricultural) areas and to understand any pesticide use enforcement related issues (e.g., regulatory compliance, pesticide use reporting) (Ensminger and Johnson, 2016). Enforcement Branch (ENF) and Environmental Monitoring Branch (EM) jointly initiated the study in 2016, using CDPR's monitored area in Roseville to address concerns about pyrethroids detected in the Pleasant Grove Creek Watershed. Evaluating the causes of pesticide use reporting errors for Placer County Pesticide Control Businesses (PCBs) led to a broader analysis of statewide data. A concentrated effort was made to contact companies that misreport, and requests of those companies to re-submit corrected data was successful. Effectively assessing the impacts of CDPR's Surface Water Regulations on pesticide use requires accurate reporting, as egregious errors in reporting can lead to false appearance of increasing and excessive bifenthrin use. To meet the goals of the project, the project followed the outline shown in Figure 1.

Results

1. *Product Evaluation*

a. *Retail Store Survey - Bifenthrin Products Available to Non-Professional Users*

EM recently completed a survey of pesticide products sold at seven retail stores in the Sacramento area (Budd and Peters, 2018). Pyrethroids were identified in 248 products for residential use, and bifenthrin was in 13 outdoor use products. The major products containing bifenthrin were Ortho® Bug B Gon® and Ortho® Home Defense® product lines[1], and included granular, concentrate, ready-to-spray, and ready-to-use formulations. The Home Defense® products have been common over-the-counter products since the start of CDPR's urban monitoring program whereas the Bug B Gon® products are newer (Osienski et al., 2010). Current Ortho® and Home Defense® products (excluding granular) include Z-cypermethrin with these bifenthrin products; in a previous survey only bifenthrin was listed as the active ingredient (Osienski et al., 2010). CDPR rarely detects cypermethrin (2% detection frequency in water samples in the past 3 years) in its monitoring studies in the Pleasant Grove Creek Watershed.

b. Residential Use Survey

The city of Roseville conducted a survey of city occupants' pesticide use in the PGC021 monitoring area (IPM Survey Neighborhood; Figure 2). The city of Roseville surveyed 105 residents (105 residents responded from 699 flyers left on their door; see Appendix 1 for the survey). Two-thirds of the respondents stated that they use pesticides. Most residents use a professional applicator, but self-application is also common. Monthly or quarterly applications were most common to control ants and spiders (Table 1). Ortho® Bug B Gon® was one of two products mentioned that was purchased by residents (and the only bifenthrin product); however, the percentage of residents using this product was not determined. The results of the city of Roseville's survey followed the trends observed in door-to-door surveys conducted in Folsom and Laguna Niguel (Table 1; Budd, 2015).

[1] The mention of commercial products, their sources or their use is not to be construed as either an actual or implied endorsement.

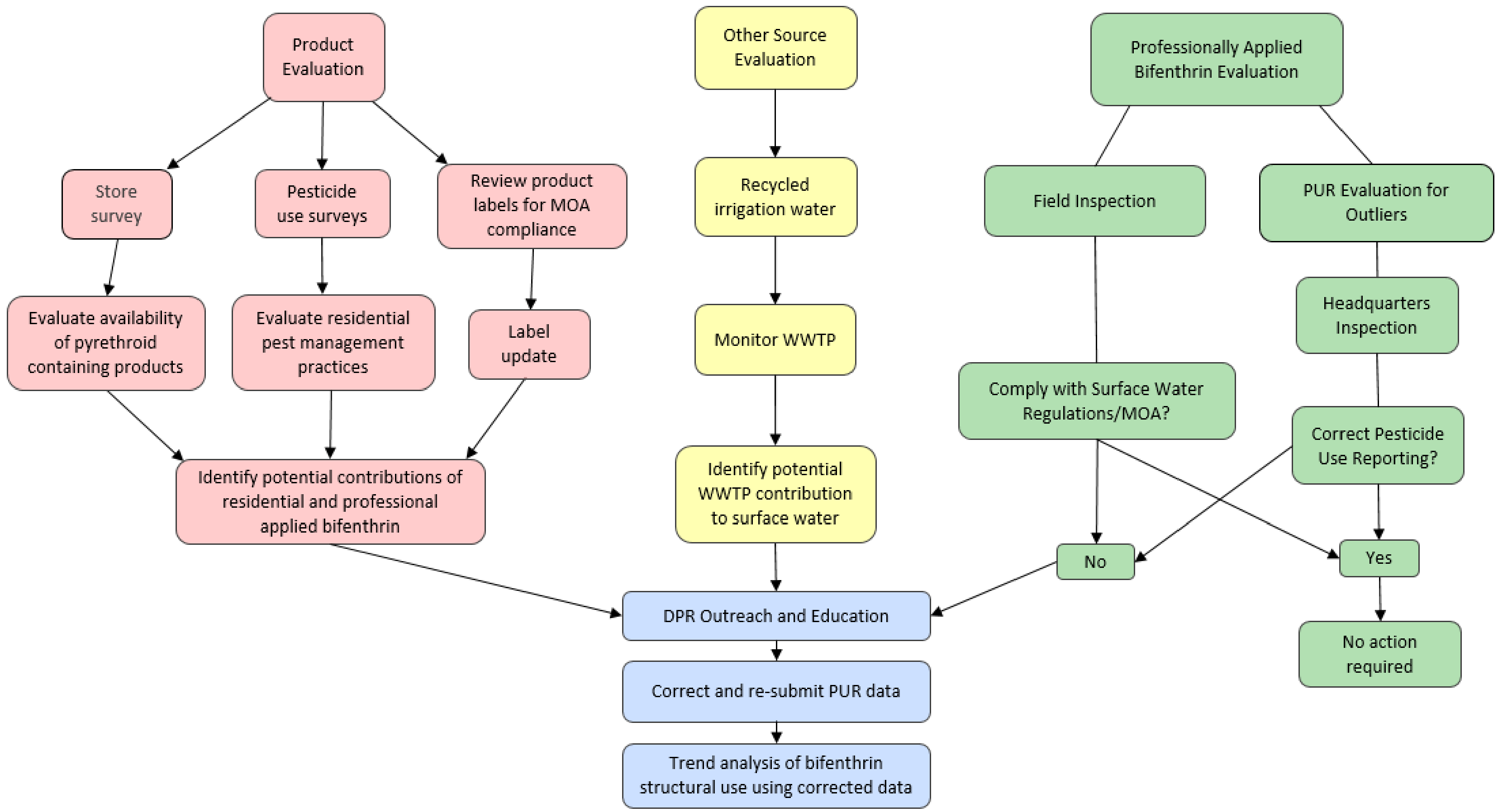

Figure 1. Schematic of project plan events. During the project period, no outreach was conducted at wastewater treatment plants (WWTP).

Figure 2. Map of Roseville monitoring areas, monitoring sites ("EM sites"), and potential sources of bifenthrin runoff. Map from City of Roseville Stormwater Management Program, used with permission (neighborhood designation assigned by City of Roseville, for use with the City's residential survey (see Results, "Residential Use Survey").

Table 1. Results of surveys of urban pesticide use conducted by the city of Roseville and CDPR

Parameter		Roseville [a]	Folsom [b]	Laguna Niguel [b]
Survey conducted by:		City of Roseville	DPR	
Survey type		Paper mailed to the city	Door to door verbal	
Parcels		653	346	392
Percent of all parcels participating in catchment area		15%	28%	23%
Who applies?	Self	28%	35%	31%
	Professional	40%	36%	43%
Main pest problem	ants	60%	67%	82%
	spiders	32%	45%	42%
Frequency	weekly		2%	12%
	monthly		2%	16%
	every other month	28%	--	--
	quarterly or spring, summer, & fall	20%	29%	43%
	annually		9%	4%
	as necessary		58%	24%
Product	Bayer Insect Killer (B-cyfluthrin)	Yes	Not mentioned	Not mentioned
	Ortho® Bug B Gon® (bifenthrin, Z-cypermethrin)	Yes	Not mentioned	Not mentioned
	Pyrethroid product	--	Yes – 63%	Yes – 63%
	Raid® [c]	--	17% of both areas	

[a] City of Roseville (Delyn Ellison-Lloyd, Senior Engineer, City of Roseville Stormwater Management Program, personal communication

[b] Budd (2015)

[c] Raid® may contain cypermethrin, phenothrin, allethrin, or deltamethrin

c. Sales

Prior to any use corrections to the PUR from this project work, 341,411 LB pound active ingredient (LB AI) of bifenthrin were reported by professional and agricultural applicators in 2016 (CDPR, 2018a). However, reported sales of bifenthrin totaled 602,546 LB AI (CDPR, 2018d). Theoretically unreported urban pesticide use can be estimated from the differences between the sales database and the PUR, but errors in both databases undermine the accuracy of the estimated differences (Zhang and Spurlock, 2010). Nonetheless, sales data show that Ortho® bifenthrin products are commonly reported as sold in California but without professional use, suggesting urban use (Zhang and Spurlock, 2010). This agrees with results from the retail store survey from this report (*Section 1a*) that show that Ortho® products are commonly sold in California. However, without a public reporting system for residential use or perhaps a more detailed, professional administered home occupant survey, we were not able to state specifically the amount of bifenthrin that was applied by Roseville residents.

d. Adherence of Bifenthrin Labels to CDPR's Bifenthrin Memorandum of Agreement (MOA)

CDPR's MOA is a signed agreement between CDPR and specific bifenthrin registrants to amend their professional product labels, restricting bifenthrin applications on impervious surfaces that may drain into sources of storm water. In 2016, Pesticide Registration Branch monitored registration application submissions and reviewed labels quarterly to determine compliance with CDPR's 2011 bifenthrin MOA (CDPR, 2018c). Registrant awareness and compliance with the MOA was high. In the fourth quarter 2016, there were close to 190 bifenthrin products registered in California, with 27 that fall under the MOA. Two products were out of compliance. One product is no longer registered in California. The second product was also noted as out of compliance in a previous review of pyrethroid products (Ensminger, 2015). This product accounts for more than 40% of the professional use (CDPR, 2018a) and applications prohibited in the MOA but not listed in the label of this product could have attributed to bifenthrin runoff. As of May 2017, all registered bifenthrin professional products were in compliance.

2. Other Source Evaluation

Other than residential and professional use (including vector control and landscape), the only additional potential source for bifenthrin in the Pleasant Grove Creek Watershed is from recycled water from the Pleasant Grove Wastewater Treatment plant (WWTP) which is used to irrigate parks and alongside roads in the monitoring area. Effluent from WWTP's can contain pesticides such as fipronil, imidacloprid, and pyrethroids (Sadaria et al., 2016; Weston et al., 2013). During routine monitoring in June and August 2016, two grab samples were collected at the effluent of the WWTP; bifenthrin or other pyrethroids were not detected in either sample (fipronil was detected both times).

3. Professional Bifenthrin Use Evaluation

For evaluation of professional bifenthrin use, two different types of inspections were conducted: 1) field inspections - when applicators applied pyrethroids outdoor around structures, and 2) headquarter inspections - at specific PCB offices, checking application records. Placer County CAC staff conducted field inspections; headquarter inspections were conducted jointly by Placer County CAC and CDPR Enforcement staff. Field inspections were randomly conducted, based on applicators that were encountered on any given inspection day. Oversight headquarter inspections were targeted to ensure a mixture of structural, landscape maintenance, vector control and turf management applications. Seventeen companies that perform work in the Roseville area were inspected; seven of these were selected from an outlier analysis suggesting misreporting or extremely high bifenthrin use by these PCBs (Appendix 2). Selected companies received a letter informing them of the study and asked for their cooperation; each company willingly participated (Appendix 3).

a. *Field Inspections of PCBs*

El Dorado, Placer, Sacramento and Yolo county inspection reports from July 2012–December 2016 were reviewed for Surface Water Regulation compliance. These four counties were reviewed as included in the Sacramento area because a PCB in one county frequently will apply in several of the counties in the area. In the 4½ year period, Placer County had the most active pesticide inspection program of the four counties; they conducted 60 inspections when pyrethroids were applied (Figure 3). The other three counties held between nine and 14 inspections. Compliance rate within these three counties was high. In El Dorado and Sacramento counties, all inspections were in compliance (inspectors did not always check for the Surface Water Regulations[2]). In Yolo County, seven of nine inspections complied with the regulations.

Placer County inspections are of high interest for this project, as CDPR's monitoring sites are in the county and many of the inspections were in the Pleasant Grove Creek Watershed. When pyrethroids were applied, slightly over one-fourth (26%) of all the inspections were not compliant with the Surface Water Regulations. Compliance was cyclic; initially it was low (2012–2013; 69%) as might be expected with new regulations, then compliance increased in 2014 and 2015 (88%). However, compliance dropped in 2016 to earlier levels (67%). With further review of Placer County inspections from January 2017–January 2018, non-compliance remained high (38% non-compliant).

For 2016–2018 inspections, Enforcement staff developed a supplemental form (Surface Water Regulations Supplemental Form; Appendix 4) for use with PR-ENF-108 to identify any specific violations of the Surface Water Regulations. Using this supplemental form, it was documented that applicators failed to adhere to the 1" pinstream band width on horizontal impervious surfaces, applying larger band widths (up to 1 foot) in all (10) non-compliant pyrethroid inspections. This appears to be the application change that PCBs do not follow, and it may be that applicators do not know of, or fully understand, the Surface Water Regulations. Other common issues that inspectors observe include applicators using the incorrect type or size of nozzle, nozzles not cleaned and maintained, nozzles improperly adjusted, or spray pressure not reduced on power spray rigs. Lack of knowledge was noted in some Placer County inspection reports and during a UC Davis/UC IPM outreach workshop (Sisneroz, 2017). Results from the

[2] Prior to the CalPEATS system, the DPR enforcement inspection form did not contain a field for the Surface Water Regulation requirement. The inspecting County biologist had to write this inspection line on the form.

inspections support the need for additional outreach on the regulations (especially on applications to horizontal impervious surfaces), as well as inspections to enforce the product labels and regulations.

b. Headquarter Inspections of PCBs and Interviews with Pesticide Use Reporters.

With coordination among the Placer County CAC staff and Enforcement staff, headquarter inspections were conducted on the 17 PCBs. For these inspections, a supplemental questionnaire was developed (Study 303: Headquarters Inspection Questionnaire, Appendix 5). This questionnaire gathered information on bifenthrin: where and how the company mixed and applied it; specific application methods; how its use was recorded; how and when the company learned of the 2012 Surface Water Regulations; and how it reported pesticide use. During the inspection, education and outreach was provided, including a review of PUR reporting methods and protocols, pyrethroid application practices, the link to "Pyrethroid Application Best Practices" https://www.youtube.com/watch?v=DJ5yZT0T9nI, and a review of the Surface Water Regulations. Results from the inspections are given below.

Bifenthrin Applications and Field Data Collection. Of the 17 companies chosen, 12 companies used bifenthrin products (five companies were landscape-oriented business that did not use bifenthrin). This is a small number of PCBs compared to the total number of statewide PCBs, but does shed some light on structural applications and how use data are collected:

- Most common application sites: residences, commercial buildings, and restaurants;
- Number of application sites per day by field technician: 8–10 applications (more in summer months);
- Volume (product concentrate) of bifenthrin by application type:
    - small residence (1 OZ);
    - large residence (3–20 OZ);
    - pre-construction sites (30–100+ GA);
- Most frequently used bifenthrin products:
    - Masterline® 7.9 Termiticide/Insecticide;
    - Talstar® Termiticide/Insecticide;
- Field data collected: handwritten log sheet (8); electronically on a hand-held device (4).

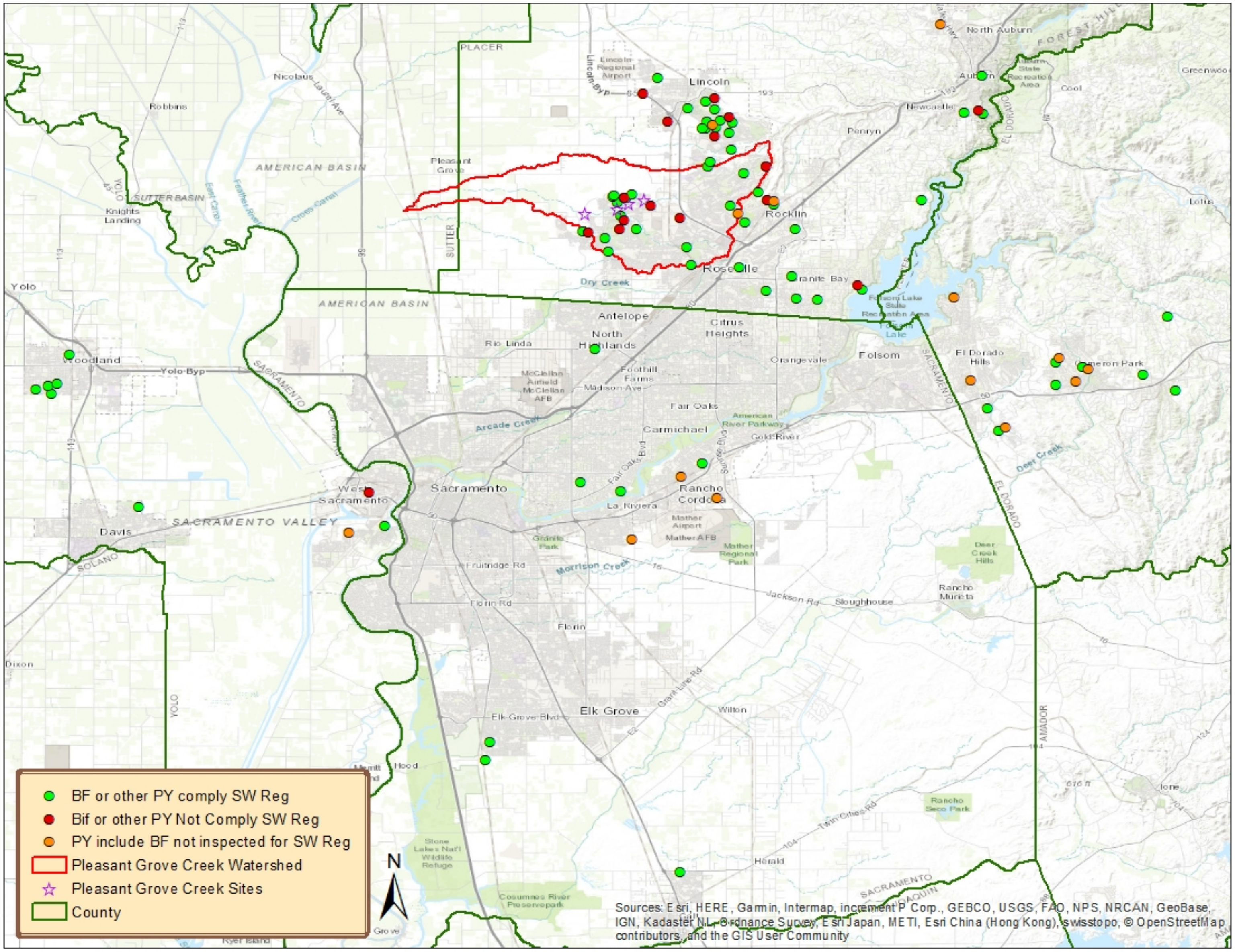

Figure 3. Surface Water Regulation inspections by County Agricultural Offices in the Sacramento area, July 2012 – December 2016 (Legend: BF, bifenthrin; PY, pyrethroid; SW Reg, Surface Water Regulations)

Knowledge of Surface Water Regulations. The companies that used bifenthrin products reported familiarity with Surface Water Regulations and training was common (Figure 4). Most companies learned of the regulations from a manufacturer supplier, Pesticide Control Operators of California (PCOC), or through continuing education workshops. For on-going training, most received training in-house; second-most common was from a manufacturer supplier. Training from a suppler was either a presentation or educational video. Most received training once, or a couple of times a year. Monthly training was not as common. Individual companies (5 of 10) had incentive programs for "clean" field inspections, and 9 of 10 had a disciplinary program in place for misuse of pesticides (two companies did not supply an answer).

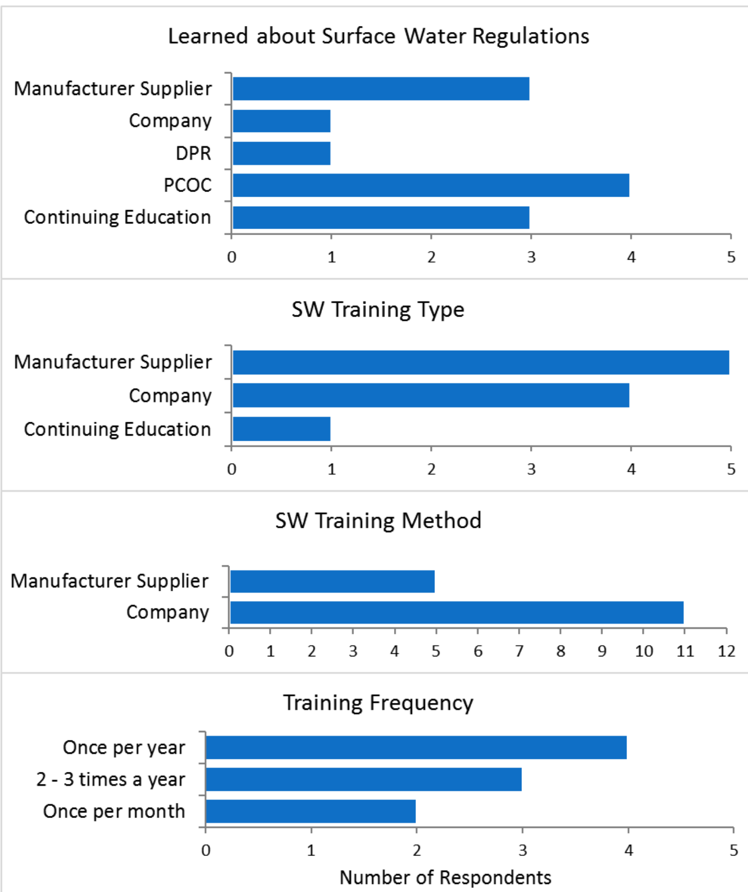

Figure 4. Surface Water Regulation knowledge and training. Manufacturer supplier training consisted of presentations or educational video.

PUR Reporting. Error-free PUR data are crucial for scientific use of the data, so information on the supplemental questionnaire was asked to better understand the PUR data process at the company level. Of the 12 companies interviewed, most staff responsible for the data were self-trained, frequently with guidance from the owner or president of the company (Figure 5). Some learned at a previous job or others in the industry. Data submitted to CAC are usually via a PUR manager or owner/president of the company; less common is via administrative staff. Paper copies of the data are frequently sent to CAC but submitting through CalAg Permits is also common.

Companies that submit paper copies may enter the data manually or through PUR software designed for managing the data. All three methods can lead to data errors, as most companies had been notified by CAC about previous errors in their data (Figure 5). The types of errors included duplicate entries for a month, missing number of applications (no longer a requirement), wrong units, and incorrect USEPA registration number. Two companies were found to erroneously report in diluted product, but 11 companies reported correctly in volume of concentrate, most often with the unit ounce.

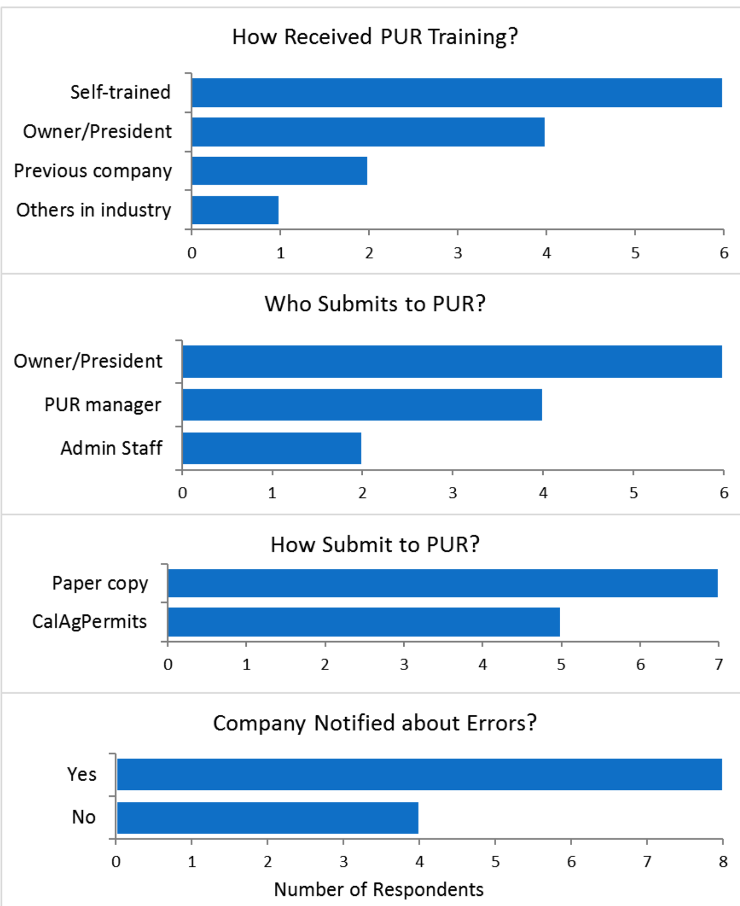

Figure 5. PUR training and data submittal information.

4. *Correcting the Data*

Working with Placer CAC and PCB personnel, the sources of PUR data entry errors were identified. Data misreporting could be under- or over-reporting and could occur in several ways. Only one incident of under-reporting was found during the project period, which was the result of CAC staff not entering the submitted data for one month (on the order of 30–40 LB AI, one-time error). Over-reporting was more common (Figure 6). The greatest amount of over-reporting occurs when a company systematically, over time, reports the volume of diluted product applied instead of the volume of product concentrate (on the order of 100 to 1000s LB AI reported per month, a systematic error over months or years). Of a similar magnitude but not as frequent, the wrong unit was entered, for instance gallons instead of ounces. This could result from human or software error. The third type of over-reporting was random single-time typographical error during data entry by PCB or CAC staff. Dropping the decimal point produced the most egregious over-reporting errors (on the order of 10s of 1000s LB AI, random one-time errors); for example, in one report, an intended entry of 52.12 ounces was entered as 5212 ounces. The magnitude of all over-reporting overshadows potential subtle temporal trends in the actual amount of active ingredient used over time.

With improved understanding of error types and magnitudes, multi-year analyses of the use reports of bifenthrin, beta-cyfluthrin, cyfluthrin, cypermethrin, and permethrin, and the phenylpyrazole insecticide, fipronil, were performed. Individual companies were contacted by telephone to confirm identified misreporting. During this process, companies were informed about how to report correctly and 2015–2016 amended use reports were submitted by the company back to the county.

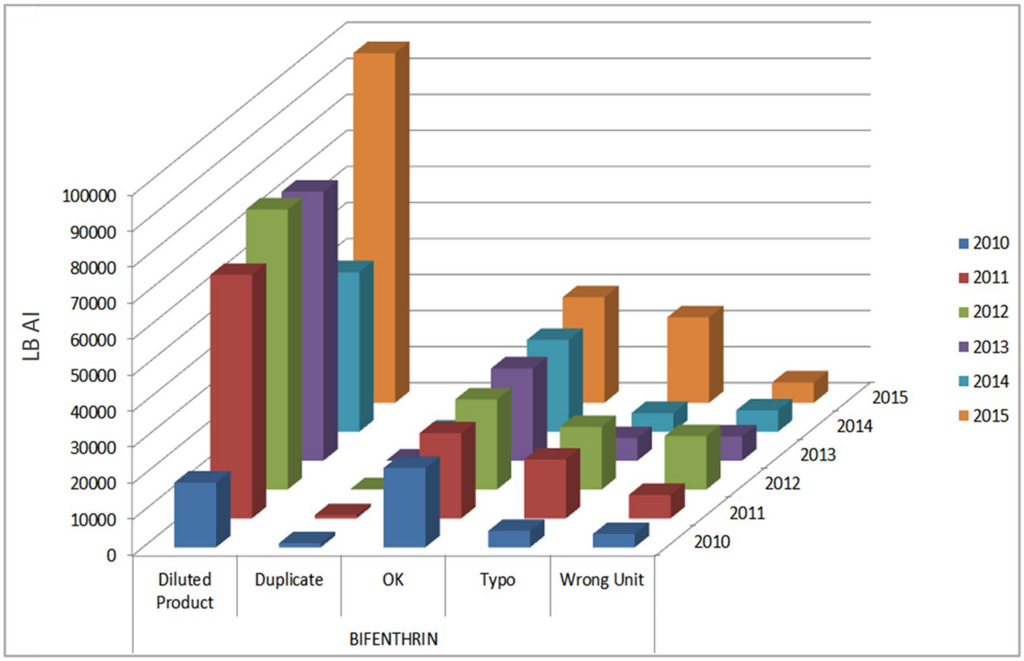

Figure 6. Types and amounts of misreporting for bifenthrin use by professional applicators statewide, 2010–2015.

Two main lessons/benefits arose from the corrected PUR datasets:

1. A small fraction of reporting companies (around 6%) has a large impact on misreporting. For example, in bifenthrin PURs (2010–2015), roughly 100 of about 1,500 Structural Pest Control Board registered reporting companies contributed as much as 100,000 LB AI error in a year for bifenthrin. Over the course of the study, some generalities were observed of typical correct amounts of AI per report (month) based on company type and size:
   - Large companies (> 200 employees) with thousands of applications per month or pre-construction companies correctly report on the order of 100s LB AI;
   - Intermediate-sized companies (26–200 employees) correctly report about 30 LB AI;
   - Smaller companies (< 26 employees, most PCBs) correctly report 0.5–10 LB AI;
   - Any single monthly report over 100 LB AI is an error >90% of the time.

2. Statistical analysis of correct/incorrect report data for each active ingredient further refined generalized estimates for each active ingredient. Each active ingredient has a unique amount reported in a month because of industry standards for their use. For example, permethrin is regularly used in higher amounts compared to other pyrethroids for large-scale termite abatement in structures.

A critical outcome of this study is the development of thresholds, above which triggers an error flag in CalAg Permits. The error flag would be triggered at the point of data entry, eliminating the need to identify and correct errors later (as in after data are formally released for public download). Table 3 shows conservative (more error flags which would be false positives) initial thresholds ranging from 25 to 250 LB AI per record for the six active ingredients. Details of the derivations of the bifenthrin threshold are found in Appendix 6. Variation in thresholds reflects different use patterns.

Table 3. Threshold alerts for pyrethroids and fipronil

Insecticide	Threshold Alert
Bifenthrin	100 LB AI/record
Beta-cyfluthrin	25 LB AI/record
Cyfluthrin	40 LB AI/record
Cypermethrin	125 LB AI/record
Permethrin	250 LB AI/record
Fipronil	50 LB AI/record

Future reporting errors should be vastly reduced for those companies educated about the correct method to report pesticide use. In addition, the most common error of reporting diluted product in lieu of concentrate should be reduced in the future by all companies reporting in CalAg Permits. The other errors introduced by typographical errors and unit errors will be corrected before getting into the system with the use of the error flag in CalAg Permits.

Because of this project, the CalAg Permits program was recently modified to clarify the definition of **Total Product Used**, adding the warning statement: **Liquids: Report concentrate, not diluted mix used** when in this field of the program (Figure 7).

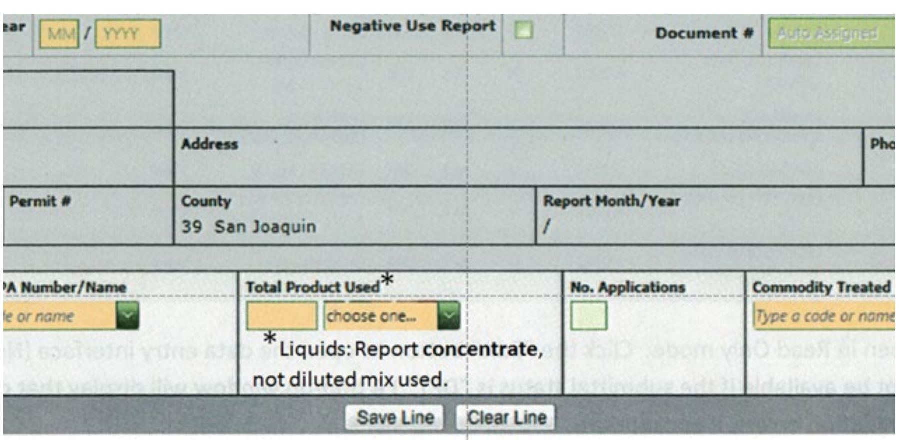

Figure 7. Modification of CalAgPermits to clarify the definition of total product used.

5. Outreach beyond Headquarter Inspection Education

Through EM contract 15-C0056 (http://cdpr.ca.gov/docs/emon/surfwtr/contracts.htm), UC Davis developed outreach workshops to train Sacramento area professional applicators on the pyrethroid regulations. In 2017 and 2018, three workshops were held in West Sacramento, Roseville, and Folsom (Sisneroz, 2017). In addition to the outreach workshops, EM's Surface Water Protection Program (SWPP) has been involved in five different outreach events in Roseville targeting city residents. Outreach events were organized by the city of Roseville and occurred in May and August 2016, April and August 2017, and February 2018. EM presented material on their monitoring efforts in Pleasant Grove Creek. For the February 2018 event, SWPP prepared and distributed a brochure on water quality (Appendix 7).

6. Trends in Bifenthrin Use and Monitoring Data

Headquarter inspections show that the main source of bifenthrin by professional applicators in Pleasant Grove Creek Watershed was from structural applications. Surveyed companies performing vector control or general pest control in the study area (i.e., in parks, schools, streetscapes, and greenbelts) are not contributing to bifenthrin runoff in the watershed. PUR use data confirm low use for the county for non-structural applications (Figure 8). None of these previously uninvestigated potential sources were found to contribute to the bifenthrin load to surface waters within the Pleasant Grove Creek Watershed. The five landscape companies inspected did not report using bifenthrin, and most of the structural companies interviewed were discontinuing or decreasing their use of bifenthrin.

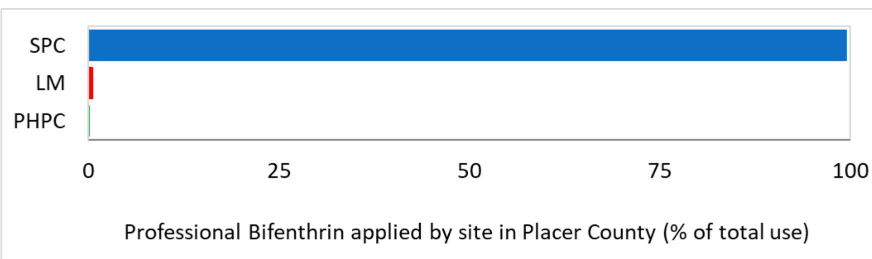

Figure 8. Professional bifenthrin applications in Placer County by site. Landscape maintenance (LM) and public health pest control (PHPC) had less than 1% off all professional bifenthrin applications in Placer County (SPC, structural pest control).

EM conducted trend analysis for structural applications of bifenthrin use with PUR data before corrections from this study, and corrected PUR data from 2015 and 2016. Because a major finding of this study is that structural pest control use data have egregious errors, and these errors obscure trends, we expanded the data correction portion of the study to the entire state. Thus, statewide and Sacramento area bifenthrin 2012–2016 structural use was reviewed (only 2015 and 2016 data were corrected). The analysis was limited to all 7.9% formulated bifenthrin products for structural pest control applications (see Appendix 2).

Uncorrected use reports show a fluctuation in the amount of bifenthrin that was used between 2012–2016, with 2015 having the highest use during this period (Figure 9; blue bars). Egregious errors identified during this project were corrected for 2014, 2015 and 2016 which resulted in a significant decrease in reported bifenthrin use for those years in the Sacramento region and statewide. There are likely associated errors with use reports for 2012–2014; however, they were not corrected within the PUR during this project (not all 2014 data were corrected). Although it is not possible to predict corrected use trends without taking 2012–2014 data into account, it is unlikely the associated errors for these years would indicate an upward trend of bifenthrin used by PCBs if they could accurately be corrected.

A potential decrease in bifenthrin use within the Sacramento region is reflected in the water monitoring data. EM has monitored runoff in the Pleasant Grove Creek Watershed since 2008. Monitoring efforts have centered on sources (at neighborhood storm drain outfalls) and at the watershed level (at a downstream receiving water site). Source data help CDPR evaluate the effectiveness of the Surface Water Regulations due to high detection frequencies at these sites. The outfall areas represent runoff from approximately 900 homes and 200 acres in Roseville (Figure 2). The outfalls drain into tributary streams feeding into the main stem of Pleasant Grove Creek. Four conclusions can be drawn from the source (storm drain outfall) monitoring data, which are specific to Pleasant Grove Creek:

1. Detection frequency of bifenthrin has remained constant since monitoring began in 2009 (detection frequency at the three storm drain outfalls is 98%);
2. Concentrations of bifenthrin in storm drain water have significantly decreased since 2008 (Figure 10; p=0.0007 [Akritas–Theil– Sen line with associated Kendalls tau correlation coefficient]);
3. Detected bifenthrin concentrations are above water quality criteria, but exceedance frequencies have decreased since regulations went into effect (Figure 11); and
4. Sediment bifenthrin concentrations or potential sediment toxicity (normalized to organic carbon and converted to toxicity units based on LC_{50} values) have not significantly changed since 2008 (Figure 12).

In the Sacramento area, as bifenthrin use for structural pest control appeared to have decreased since the regulations, we observed a concurrent decrease in bifenthrin water concentrations in runoff (Figures 10, 11). This suggests that the Surface Water Regulations may have been effective in reducing bifenthrin in urban runoff on a regional scale (i.e., in the Sacramento area). However, it remains to be seen if the response to the regulations will result in concentrations decreasing below aquatic toxicity thresholds (Luo, 2017) (Figure 11). The lack of reduction in sediments (Figure 12) is likely due to bifenthrin's long persistence once sorbed to organic material. Bifenthrin-contaminated sediments may be a source of bifenthrin in the water phase (Gan et al., 2005).

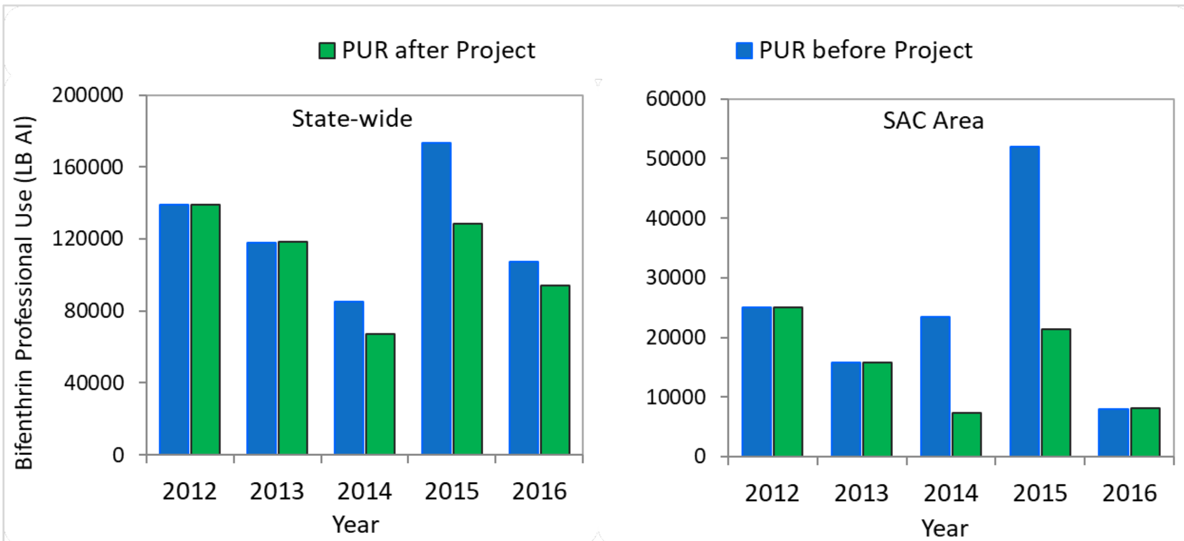

Figure 9. Bifenthrin structural use (7.9% formulation for structural pest control applications) since the Surface Water Regulations were enacted. Blue bars, PUR before Project 303 was initiated; green bars, 2014–2016 data corrected after Project 303.

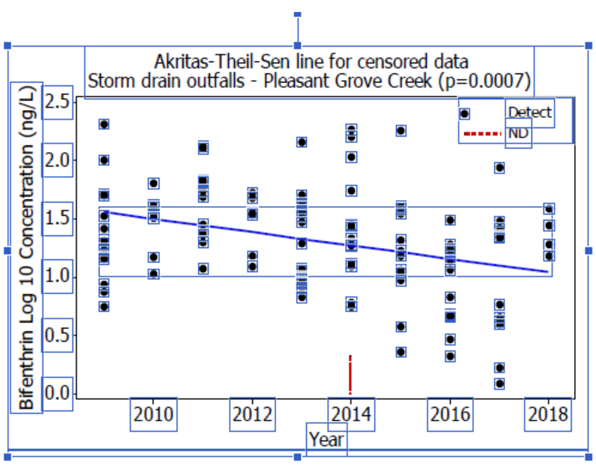

Figure 10. Northern California, Sacramento area, bifenthrin water concentrations (dots) and trend (blue line) at storm drain outfalls in the Pleasant Grove Creek Watershed (ND, non-detection).

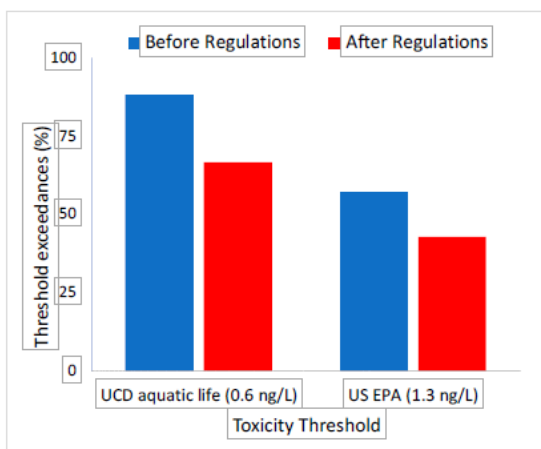

Figure 11. Northern California, Sacramento area, bifenthrin exceedances (based on estimated bioavailable concentrations) at storm drain outfalls compared to water quality criteria.

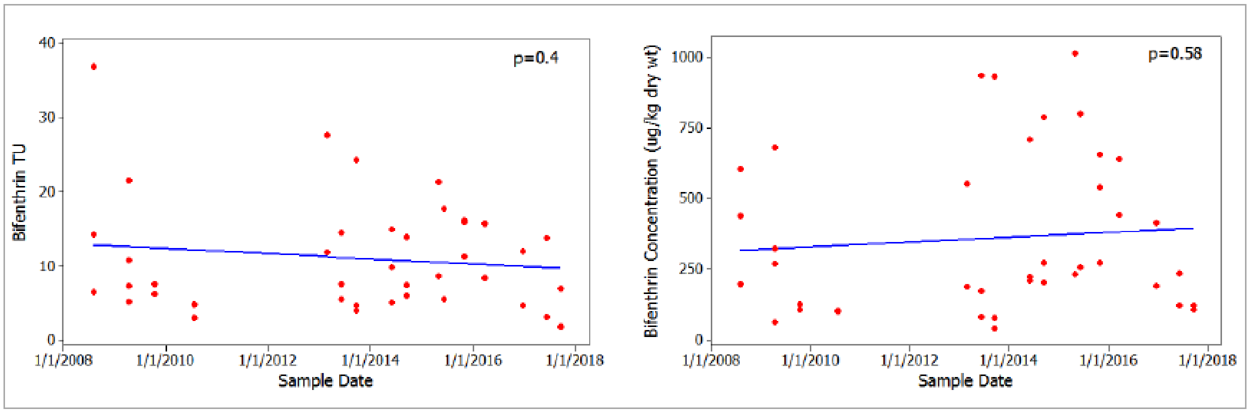

Figure 12. Northern California, Sacramento area, bifenthrin sediment toxicity unit and concentration trends at storm drain outfalls in the Pleasant Grove Creek Watershed. TUs are based on bifenthrin concentration, sediment organic carbon, and the LC_{50} for bifenthrin to *Hyalella azteca* from laboratory studies. Trends in bifenthrin concentration or TUs were not significant in either direction.

Conclusions

This report investigates the urban sources of bifenthrin runoff in CDPR's monitoring area in Roseville in the Pleasant Grove Creek Watershed as well as enforcement issues pertaining to bifenthrin use. Work from this study led to four significant findings:

I. Sources of bifenthrin are from two distinct groups: 1) Roseville residents; and 2) professional applicators for hire in structural pest control work. No other sources were identified for bifenthrin, e.g., vector control, landscape applications, or recycled water from WWTPs. Although use by residents is not recorded, over a quarter of the residents within the study area apply pesticides to their property for pest management purposes. The prevalence of pyrethroids in products available to the public in stores surrounding the Pleasant Grove Creek Watershed suggests that applications made by residents likely contribute to the bifenthrin loading to the system.

II. Regionally, bifenthrin structural pest control use appears to be decreasing, as indicated by the corrected PUR data for the Sacramento area. The Surface Water Regulations likely contributed to this decline in use by limiting the amount of bifenthrin applied to impervious surfaces and reduced off-site movement to the creeks.

III. Bifenthrin concentrations decreased in waters of the Pleasant Grove Creek watershed. However, sediments continue to contain pyrethroids likely due to bifenthrin's long persistence once sorbed to sediment.

IV. Applicators do not always make bifenthrin applications that are compliant with the Surface Water Regulations. The most frequent violation is exceeding the 1” pinstream application.
V. A small percentage of PCBs do not know how to report their pesticide use correctly, consistently reporting diluted product rather than product concentrate. This leads to egregious errors in the use reporting for structural applications making it impossible to accurately quantify the true amount of pesticide applied, or to investigate trends of pesticide use over time. Other common errors include reporting the wrong unit or misplacing decimal points, as there are no quality control checks at this point in the data entry. These errors are common with small companies (e.g., less than 10 employees) as well as large companies (e.g., 1000s of employees). As a result of this study, CalAg Permits has instituted a reminder to report product concentrate, not diluted product for liquid applications. CalAg Permits is in the process of adding pop-up flags when reported amounts are exceeded for certain active ingredients. These two changes should drastically reduce errors in the PUR database, such that the data used by the public and scientific communities will be more accurate.

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Appendixes

Appendix 1. City of Roseville Survey

Pesticide Use At Your Home

1. Are pesticides applied outside of your home to control insects? (including professional applications)
   - ❑ Yes ❑ No (Skip to question #14)

2. Which insects are being treated with pesticides outside of your home in your landscape or hard surfaces. (Select up to 5)
   - ❑ Ants ❑ Aphids ❑ Fleas
   - ❑ Lawn pests (grubs)
   - ❑ Mosquitos ❑ Roaches
   - ❑ Snails ❑ Spiders ❑ Termites
   - ❑ Wasps / Yellow jackets ❑ Don't know
   - ❑ Other ____________

3. Who applies pesticides outside of your home? (Select all that apply)
   - ❑ Myself or other resident
   - ❑ Professional Pesticide Company
   - ❑ Landscaping Company or Gardener
   - ❑ Landlord or Property Management
   - ❑ Homeowners Association
   - ❑ Mosquito Abatement District
   - ❑ Not sure

4. Which professional company or landscaper applies pesticides outside at your home? (for education and outreach)
   - Name: ____________
   - ❑ I do not use a professional company.

5. How often are pesticides applied outside of your home?
   - ❑ Daily ❑ Weekly
   - ❑ Monthly ❑ Every other month
   - ❑ Quarterly ❑ Every 6 months
   - ❑ Once a year ❑ Don't know

6. What season(s) are pesticides most likely to be applied outside your home? (Select all that apply)
   - ❑ Spring (March-May)
   - ❑ Summer (June-August)
   - ❑ Fall (September-November)
   - ❑ Winter (December-February)

7. Do you know which pesticide products are applied outside of your home?
   - ❑ Yes ❑ No (Skip to question #9)

8. What are the names of the products apply outside of your home? (Select all that apply)
   - ❑ Amdro, Quick Kill
   - ❑ Bayer, Insect Killer
   - ❑ Bonide, Eight Insect Control
   - ❑ Cutter, Bug Free Backyard – liquid
   - ❑ Ortho, Bug B Gone – granular
   - ❑ Ortho, Bug B Gone – liquid
   - ❑ Ortho, Home Defense Insect Killer – liquid
   - ❑ Spectracide, Insect Killer – granular
   - ❑ Spectracide, Triazicide Insect Killer – liquid
   - ❑ Other: ____________

9. When you apply pesticides outside of your home, how thoroughly do you read the label prior to the application?
   - ❑ Someone other than myself applies the pesticide (Skip to question #14)
   - ❑ I do not read the label (Skip to question #11)
   - ❑ I skim the label to get an idea of how to apply the product
   - ❑ I thoroughly read the label to understand how to apply and safely use the product

10. Do you follow all the directions on the label when applying pesticides outside of your home?
    - ❑ Yes ❑ Most often ❑ No

11. Where do you you typically apply pesticides?
    - ❑ Only in limited areas where pests are known to be located (spot treatment)
    - ❑ Broadly beyond the area where the pests are visible (broadcast treatment)
    - ❑ Selected areas where pests may be located (no visible insects at treatment time)

12. How do you dispose of excess pesticides?
    - ❑ Put all on the landscape or hard surfaces
    - ❑ Take to the regional household hazardous waste facility (Fiddyment & Athens Road)
    - ❑ Pour down the sink
    - ❑ Pour in the gutter
    - ❑ Store at my home

13. How do you dispose of water used to rinse application equipment & mixing containers?
    - ❑ Toss it in the gutter
    - ❑ Pour it down the sink
    - ❑ Spread over the landscape
    - ❑ Put it on hard surfaces

14. Where does runoff from rainstorms and over-irrigation flow after it enters the storm drain?
    - ❑ Local waterways such as creeks
    - ❑ Soaks in the ground
    - ❑ Wastewater treatment plant
    - ❑ Don't know

15. Runoff from residential neighborhoods is treated and filtered to remove pollutants before it is discharged into the environment.
    - ❑ True ❑ False

Demographic Information

16. Do you own or rent your home?
    - ❑ Owner ❑ Renter
    - ❑ Live with others

17. What type of residence do you live in?
    - ❑ Single family home
    - ❑ Apartment/townhouse/condo
    - ❑ Other: ____________

18. Gender of survey respondent:
    - ❑ Male ❑ Female

19. Number of people in the household
    - ❑ 1-2 ❑ 3-4
    - ❑ 5-6 ❑ More than 6

20. Are there children in the home?
    - ❑ Yes ❑ No
    - Ages: ____________

21. Are there pets in the home?
    - ❑ Yes ❑ No

22. Age bracket (years) of the respondent
    - ❑ 18-24 ❑ 25-34
    - ❑ 35-44 ❑ 45-54
    - ❑ 55-64 ❑ 65 +
    - ❑ Refuse to disclose but over 18

23. Household income bracket:
    - ❑ < $15k ❑ $15k - $30k
    - ❑ $30k - $50k ❑ $50k - $70k
    - ❑ $70k - $90k ❑ $90k - $100k
    - ❑ $100k + ❑ Refuse to disclose

Thank you for your participation in this survey!

Stormwater Management Program
www.roseville.ca.us/stormwater
(916) 774-5751

City of Roseville California

Partner with Roseville

The City would like to know how and when you use pesticides outside of your home. Often times, pesticides applied in landscapes and hard surfaces are transported by rain and irrigation runoff to local waterways. Pleasant Grove Creek has been impacted by pesticide contamination.

The City in conjunction with the State Department of Pesticide Regulation and the Pyrethroid Working Group, an association of pesticide manufacturers, is attempting to determine the relationship between residential pesticide applications and the water quality in Pleasant Grove Creek.

You can help with this effort by completing this survey and participating in future City outreach events and programs. Thank you for your support.

for Cleaner Creeks

Appendix 2. Outlier Analysis

To target PCBs who potentially misreport their use data for headquarter inspections, we reviewed statewide 2011–2015 Pesticide Use Report (PUR) bifenthrin structural data for potential outliers. For this analysis, we only reviewed the 7.9% active SC bifenthrin formulation (29 products) for structural pest control applications. The 7.9% formulation is used for perimeter sprays on impervious surfaces (high runoff potential), accounts for most (98%) of all bifenthrin reported structural use (in total LB AI [pound active ingredient]), and the use is distinctly different than other formulations (e.g., bait stations). Limiting the analysis to the five-year span allowed for finding the more recent outliers (2016 data was not available at the time of this analysis). “Outlier” refers to an “unusually extreme value” (Wilhoit, 2018). An outlier may be a true value and not necessarily an error in the data, but it is of such a high value that it is outside the range of normal distribution. For this analysis, we used the trimmed mean method at 5 standard deviations to determine outliers (Wilhoit, 2018). Records were reviewed as LB AI/application. Although application count is not a required data entry field in PUR for structural reporting, it was uniform in the 5-year period (81–98% of the PUR records had application count, by year). Where no application count was given, it was assumed to be one (Wilhoit, 2018). This method identified 1.8% of the statewide bifenthrin structural records as outliers; narrowing to the Sacramento area (defined as El Dorado, Placer, Sacramento, and Yolo counties for this study) limited it to 0.3% of the records. Twelve companies with the most or highest outliers in their reporting were selected as most probable companies that misreported their data (Table 3-1). Seven were selected for headquarter inspections.

Table 2-1. Bifenthrin Outliers, 2011–2015 (Sacramento area*)

Pest Control Business	Number of outlier records	Most Recent Year	High outlier (LB AI/application)	Chosen for HQ inspect
SAC PCB 1	11	2015	15	NO
SAC PCB 2	19	2015	51	YES
SAC PCB 3	10	2015	14	NO
SAC PCB 4	13	2015	50	YES
SAC PCB 5	2	2011	287	YES
SAC PCB 6	28	2012	2206	YES
SAC PCB 7	10	2015	10	NO
SAC PCB 8	25	2015	698	YES
SAC PCB 9	85	2013	334	YES
SAC PCB 10	9	2015	458	NO
SAC PCB 11	44	2015	102	YES
SAC PCB 12	10	2015	5	NO

*Sacramento area = El Dorado, Placer, Sacramento, and Yolo counties

Appendix 3. CDPR Letter to Pesticide Control Businesses

dpr

Department of Pesticide Regulation

Date

Contact Name
Company Name
Street Address
City, California Zip

Dear:

The Department of Pesticide Regulation (DPR) is interested in protecting surface water from the effects of pesticides, particularly pyrethroids. In January, 2016, the DPR released "Study 303, Work Plan for Determining the Effectiveness of California Department of Pesticide Regulation's Urban-Based Pyrethroid Regulations." An important component of this study is reviewing pyrethroid use and reporting with you and your company.

In the coming weeks, you will be contacted by the Placer County Agricultural Commissioner (Placer CAC) to arrange a routine headquarters inspection. In addition, as part of the study, a questionnaire interview will be conducted to evaluate bifenthrin use practices and reporting. Staff from DPR will be overseeing the inspection and conducting the interview.

For the interview, it is crucial that the person in your business who submits Pesticide Use Reports to the Placer CAC be available, and that use reports for bifenthrin and fipronil applications are available. The interview is not an enforcement response, nor an investigation, but is an important part of this informational study. Please have the appropriate staff available.

Thank you for participating in this important study. If you would like to review the study work plan, it is available on DPR's website at http://www.cdpr.ca.gov/docs/emon/pubs/protocol/study303_pyrethroids.pdf. You may contact Mara Johnson, Senior Environmental Scientist at 916-376-8952, Mara.Johnson@cdpr.ca.gov if you have any questions.

Sincerely,

Donna Marciano
Chief, Enforcement Branch
916-324-4100

cc: Placer CAC
EBL, DPR Enforcement Branch

1001 I Street • P.O. Box 4015 • Sacramento, California 95812-4015 • www.cdpr.ca.gov

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Appendix 4. Field Inspection Supplemental Form

STATE OF CALIFORNIA
DEPARTMENT OF PESTICIDE REGULATION

SURFACE WATER REGULATIONS Supplemental Form

(TEMP. 7/15) Page 1 of 1

Form #:

Form # - Inspection Serial Number

Conditions:

Pest control for hire (including maintenance gardeners).
Outdoor application.
Structural, residential, industrial, and institutional sites:
Pyrethroid AI:
bifenthrin bioallethrin S-bioallethrin
cyfluthrin beta-cyfluthrin gamma-cyhalothrin
lambda-cyhalothrin cypermethrin deltamethrin
esfenvalerate fenpropathrin tau-fluvalinate permethrin
phenothrin prallethrin resmethrin tetramethrin

Surface Water Regulation Section 6970

A. APPLICATION					B. MIX/LOAD		
COMPLIANCE			REQUIREMENTS	Section	COMPLIANCE		
Yes	No	N/A			Yes	No	N/A
			Method of Application-Landsp	6970(a)			
			Method of Application-Imperv.	6970(b)			
			Vertical Surfaces-Method, 2' up	6970(c)			
			Granules Swept from Imperv.	6970(d)			
			No Contact w/Precip, Stormwat	6970(e)			
			No Standing Water	6970(f)			
			Wellhead Protection				

INSTRUCTIONS:

The Surface Water Regulations Supplemental Form will help the inspector document pyrethroid inspection requirements. Follow the directions provided below:

1. Record the PR-ENF-108 inspection form serial number in the space provided above. Enter Requirement 27: Surface Water on the inspection form.

2. When performing inspections, check YES, NO, or N/A in the compliance column of the appropriate new requirements listed on this page under the inspection title that corresponds with the inspection you are performing.

3. When a non-compliance is noted for any of the requirements listed on the Interim Checklist, document the non-compliance and the circumstances related to that non-compliance in the **Remarks** section of the inspection form and/or on the Inspection Report Supplement (PR-ENF-111). Include the code section in your description.

4. Provide the party inspected with a copy of the inspection form and the Inspection Report Supplement, if applicable, in accordance with DPR guidance and CAC policy. **It is not necessary** to provide a copy of the Interim Checklist to the party inspected.

5. On county file copies of the inspection report and the inspection report sent to DPR, attach the Interim Checklist as page two. When an Inspection Report Supplement is included in the package, the Interim Checklist would be page three of the inspection report package.

Page ____ of ____

Appendix 5. Study 303 Headquarters Inspection Questionnaire

STATE OF CALIFORNIA

STUDY 303: Headquarters Inspection Questionnaire

(REV. 01/16) Page 1 of 1

DEPARTMENT OF PESTICIDE REGULATION
ENFORCEMENT BRANCH

Inspection Type:

☐ PEST CONTROL HEADQUARTER INSPECTIONS REPORT (PR-ENF-109)

☐ PEST CONTROL BUSINESS HEADQUARTER INSPECTIONS REPORT (PR-ENF-110)

109 or 110 Form Inspection Number

Inspecting County

FIRM INSPECTED	BUSINESS TYPE (Circle One or Write-In) Structural/Golf Course/School/Park Maintenance/Streetscape Maintenance	License # for PUR
TELEPHONE NUMBER		
FIRM MAILING ADDRESS	FIRM LOCATION	
PERSON(S) INTERVIEWED	POSITION(S)	

YES	NO	BIFENTHRIN APPLICATION SITES
		1. Residential (Please Circle) Hardscape Ornamental Landscape Lawns Subterranean
		2. Streetscape
		3. Commercial (Please Circle) Hardscape Ornamental Landscape Lawns Subterranean
		4. Nursery Stock
		5. School
		6. Park
		7. Restaurant
		8. Golf Course
		9. Right of Way
		10. Other (Please List)

BIFENTHRIN PRODUCT MIXING, APPLYING, RECORDKEEPING, TRAINING, AND REPORTING

Mixing, Applying, and Recordkeeping	
1. Are bifenthrin concentrates mixed in the office or field, or both?	
2. Who records the amount of bifenthrin concentrate used for mixing?	Where?
3. How do applicators log bifenthrin applications in the **field**?	
4. Where and how are containers rinsed?	
5. Where do applicators log bifenthrin use in the **office**?	Daily Weekly Monthly (Circle one)
6. How does the office compile bifenthrin use reports from multiple applicators?	
7. How many gallons of a diluted bifenthrin product are applied at a **large** residence?	**Small** residence?
8. Approx. how many applications does a **single applicator** complete in one **summer** month?	**Winter** month?
9. Approx. how many applications does your **office** complete in one **summer** month?	**Winter** month?
10. How do you define "one application"?	
11. Which bifenthrin product do you most often apply?	
12. Approx. how many gallons of **concentrate/month** do you go through in **summer**?	In **winter**?
13. Do you apply **granular** bifenthrin lawn care products?	Which one(s)?
Training	
1. Date company learned of CA Surface Water Regulations for pyrethroids:	How?
2. How are employees trained on CA Surface Water Regulations?	
3. How often are employees trained on CA Surface Water Regulations?	
4. Please describe your training materials.	
5. Does your company have an incentive program for "clean inspections" or a disciplinary action program for "pesticide misuse"? (Circle)	
Reporting	
1. How is the person who compiles/submits Pesticide Use Reports (PURs) trained and how often?	
2. Who submits PURs and how often?	
3. Are PURs submitted electronically, by paper, or by another method?	
4. Do you sometimes get PURs "kicked back"?	Why?
5. Do you report amount of concentrate used, or finished product used?	Units: Gallons or Ounces (Circle)

Interviewer (*Print Name*)	*Signature*	TIME AND DATE INTERVIEWED

BIFENTHRIN PURs Scanned (circle) 2015 2014 2013 2012

FIPRONIL PURs Scanned (circle) 2015 2014 2013 2012

Appendix 6. Select Alert Threshold for Urban PUR at Point of Entry

As part of this study (Project 303), bifenthrin PUR statewide records were investigated for potential data errors. Bifenthrin 2010–2015 statewide PUR records were used in this analysis (total of 153,948 records). Due to the wide range of the reported use amount in each record, the reported use amount was logarithmically transformed and binned by every 0.2 unit in log10 scale, e.g., the bin with label value of -7.0 in the figures enclose records whose use amount are in the range of [-7.0, -6.8) in log10 scale. Missing values were substituted by -7 at log10 scale.

Counts of erroneous records were first identified (Figure 6-1). Even though the total number of erroneous records was small, they accounted for a significant amount of reported use (Figure 6-2). After the misreported data was verified and corrected, the total amount of use was greatly reduced (Figure 6-3). There is much fluctuation in percent error in the reported use of each individual bin but a much smoother trend cumulatively (Figure 6-4). Considering that the trigger will alert records with reported use amount higher than or equal to the threshold, all accumulative calculations are downward accumulative, namely counting the records that would trigger the alert. Depending on alert threshold selected, the error that can be corrected differs (Figure 6-5). There is a diminished return when the threshold value changes from high to low (Figure 6-6).

Candidate threshold values are listed in Table 6-1. The eventual selection of the final threshold is a tradeoff between the use amount corrected and the number of records that would trigger the alert.

Table 6-1. Bifenthrin Alert Threshold Candidates

Bin label	Threshold, lbs	# Counts trigger alert	% Counts trigger alert	# Error counts trigger alert	Correct alerting: ratio of error counts vs. total counts	% Cumulative correction
0.8	6.3	8396	5.5%	2953	35.2%	99.3%
1.0	10.0	5636	3.7%	2510	44.5%	98.6%
1.2	15.8	3502	2.3%	2060	58.8%	97.4%
1.4	25.1	2329	1.5%	1601	68.7%	95.6%
1.6	39.8	1574	1.0%	1248	79.3%	93.4%
1.8	63.1	1136	0.7%	995	87.6%	90.8%
2.0	100.0	768	0.5%	720	93.8%	86.4%
2.2	158.5	493	0.3%	486	98.6%	80.6%
2.4	251.2	336	0.2%	334	99.4%	74.5%

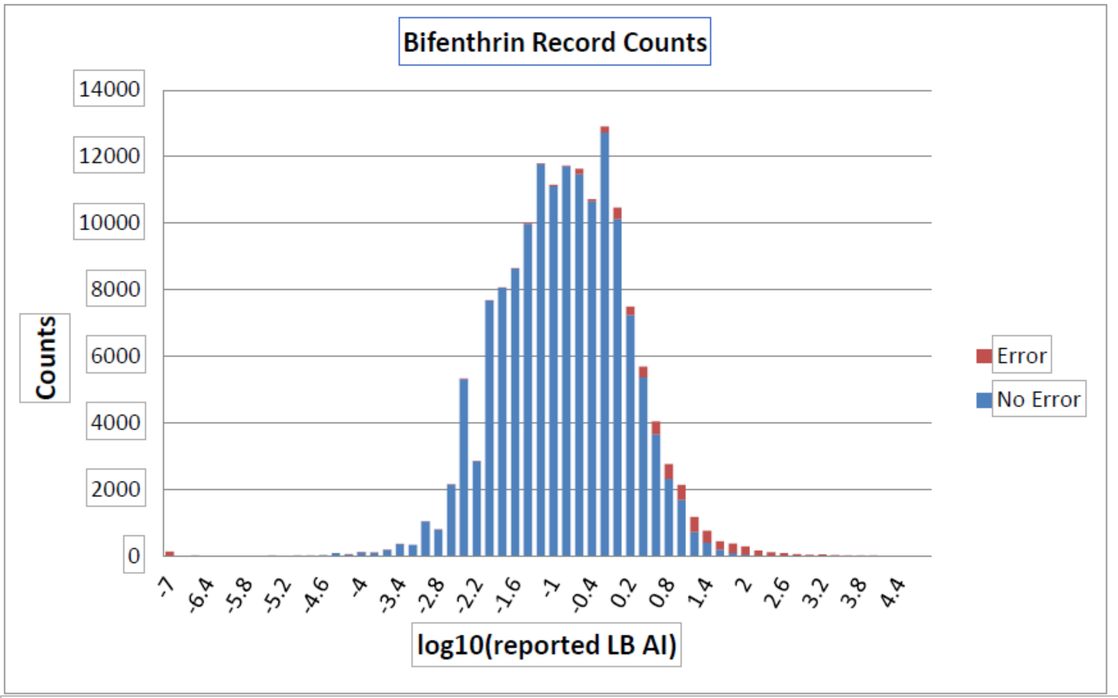

Figure 6-1. Bifenthrin counts of records. This is a histogram of the records and the bins were organized with the logarithmically transformed reported use amount for each record.

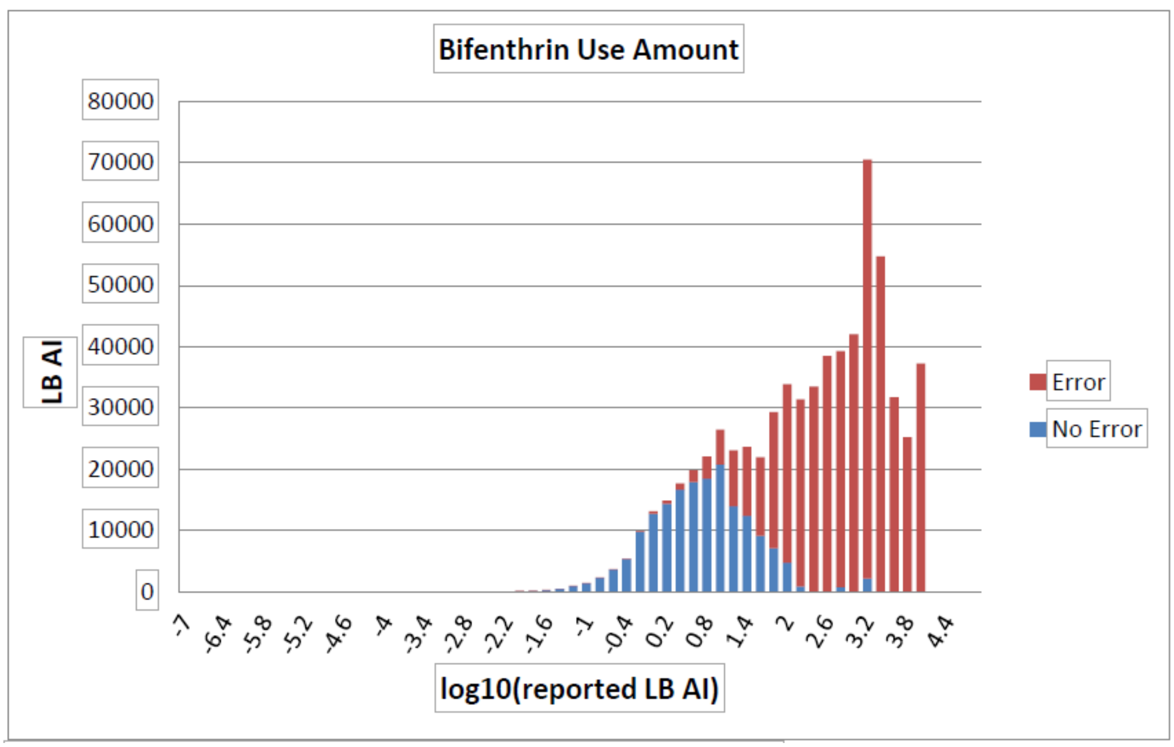

Figure 6-2. Bifenthrin use amount as reported for each bin.

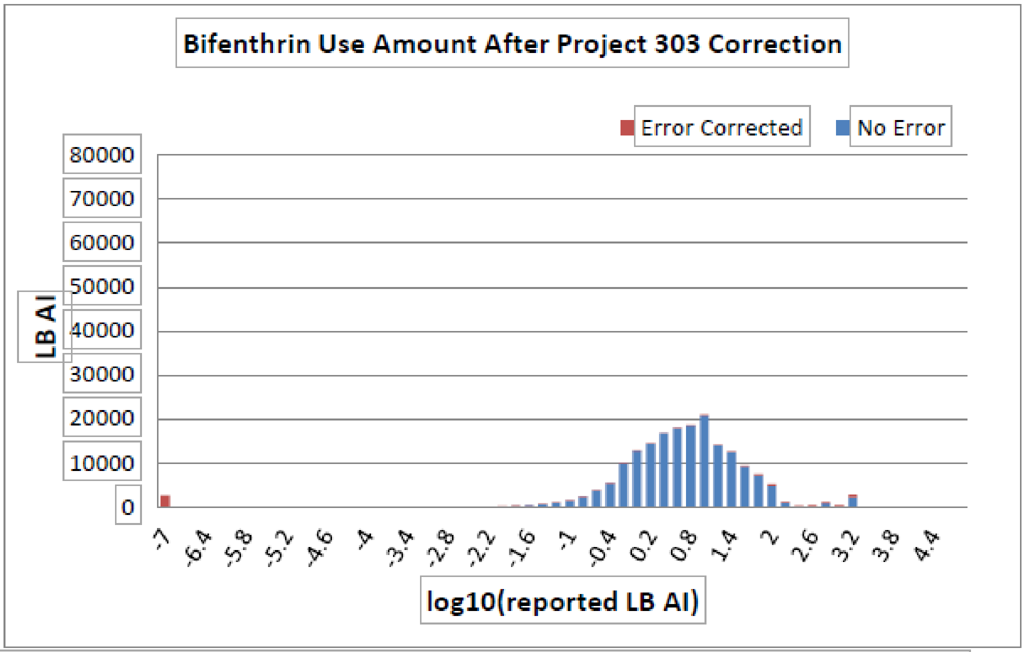

Figure 6-3. Bifenthrin use amount after Project 303 correction for each bin.

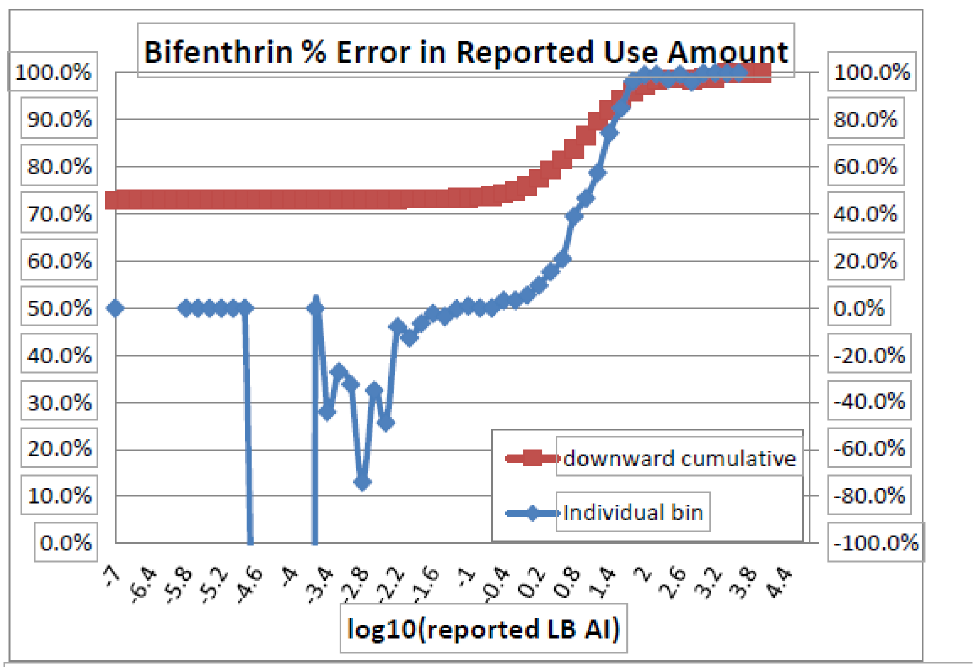

Figure 6-4. Bifenthrin percentage of error in reported use amount. Calculated by [(use amount reported – use amount after correction)/ use amount reported] for individual%, or [(downward cumulative use amount reported – downward cumulative use amount after correction)/ downward cumulative use amount reported] for the cumulative%. Visually the curve for individual bin shows the difference in the values of Figure 6-2 and Figure 6-3 normalized by values in Figure 6-2.

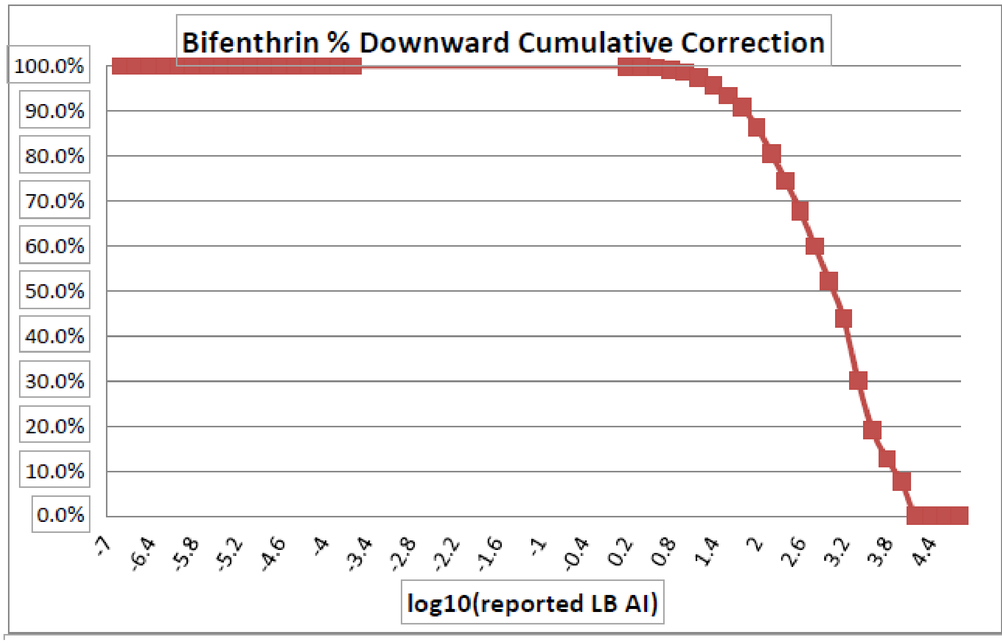

Figure 6-5. Bifenthrin cumulative percentage of correction. Calculated by [(downward cumulative use amount reported – downward cumulative use amount after correction) / total errors corrected at each threshold value on the horizontal axis].

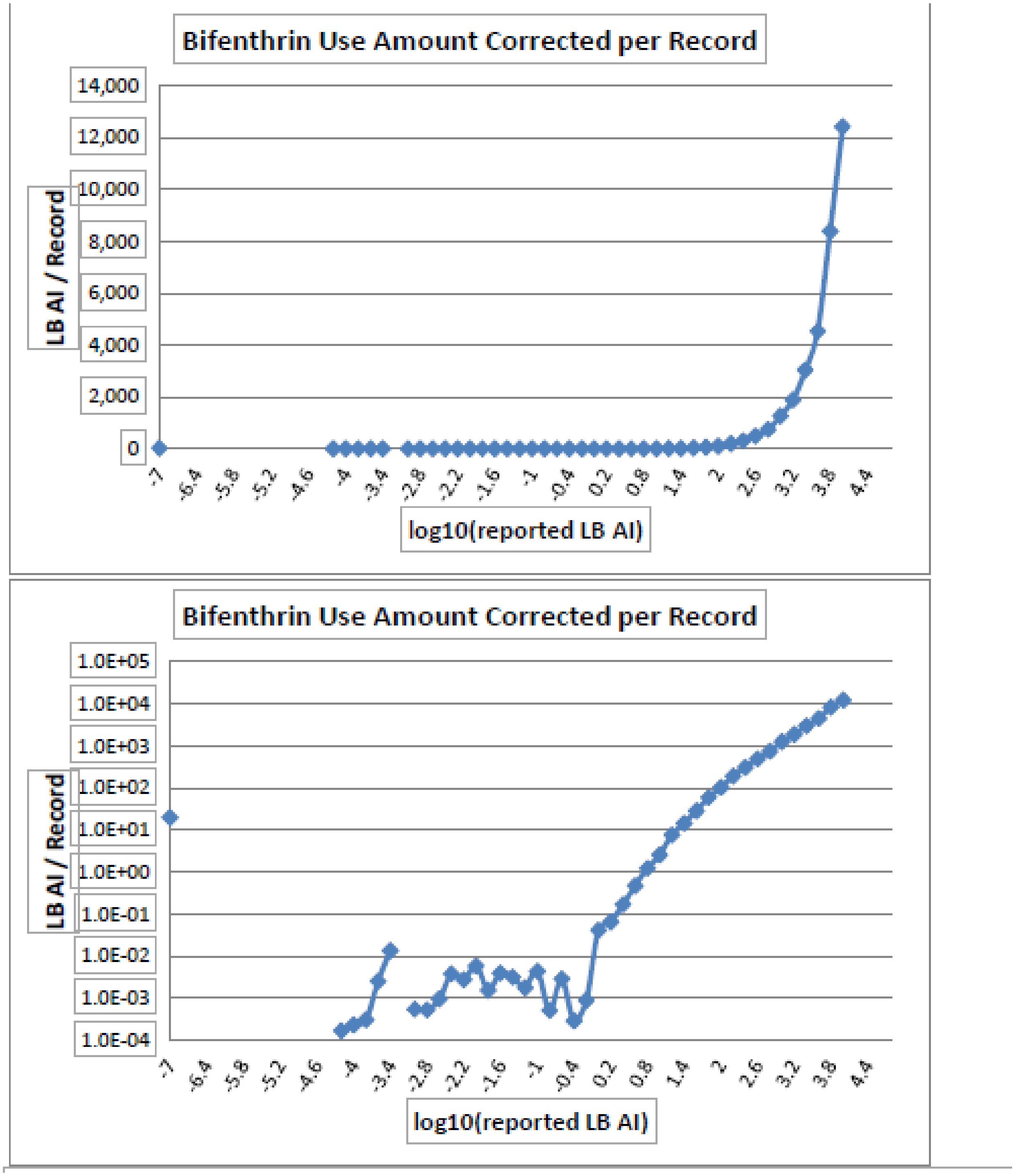

Figure 6-6. Bifenthrin diminished return as use amount corrected per record, calculated by [(use amount reported – use amount after correction)/ # of records in each bin at each threshold value on the horizontal axis]. Linear vertical axis in upper panel and logarithmic vertical axis in lower panel.

Appendix 7. SWPP Outreach Brochure

KEEP OUR WATERS CLEAN

Many substances used around the home can end up in local creeks and rivers. Storm drains in the street provide a direct route for chemicals such as pesticides and fertilizers to end up in the water, especially if they are applied to areas like driveways and sidewalks. These chemicals can be toxic to fish and other critters that live in the water, disrupting nature's delicate balance.

Be a good environmental steward and help keep chemicals and other contaminants out of our urban creeks and waterways.

- Keep pesticides and fertilizers off hard surfaces like driveways and sidewalks
- Use pesticides that are less toxic to aquatic life like oils, soaps, botanicals, and microbials
- Maintain an efficient irrigation system that produces little or no runoff. Reduce your landscape's need for water
- Control ants by using containerized baits and eliminating food sources

Storm drains provide a route for pesticides into our creeks!

"Minimize the use of pesticides that pollute our waterways. Use nonchemical alternatives or less toxic pesticide products whenever possible. Read product labels carefully and follow instructions on proper use, storage, and disposal".

– UC IPM (ipm.ucanr.edu)

California Department of Pesticide Regulation

For more information, see DPR Pest Management http://www.cdpr.ca.gov/docs/pestmgt/ipminov/ipmmenu.htm