LEGAL AGRICULTURAL USE DETERMINATION FOR IMIDACLOPRID DETECTIONS IN CALIFORNIA

Vaneet Aggarwal, Ph.D.
Environmental Scientist
Groundwater Protection Program

California Environmental Protection Agency
Department of Pesticide Regulation
Environmental Monitoring Branch
P.O. Box 4015
Sacramento, California 95812-4015

September 2021

ABSTRACT

Imidacloprid is an insecticide used on a wide variety of agricultural and non-agricultural sites to control a variety of insect pests. Imidacloprid was initially registered in 1994, and as of September 10, 2021, 253 products containing imidacloprid were registered for agricultural and non-agricultural use in California. Imidacloprid's physical and chemical properties indicate that it is persistent and mobile in the soil, and as a result, in 1999 it was placed on the California Department of Pesticide Regulation's (DPR) Groundwater Protection List (GWPL) for future groundwater monitoring.

DPR conducted focused groundwater studies in 2003 and 2009 in different areas of California, targeting sampling locations based on pounds of imidacloprid applied for agricultural use, depth to groundwater, and well availability. Sixty-seven wells were sampled from seven counties for these studies. Imidacloprid, or its degradates, were not detected in any of the collected samples. In addition to the focused studies, DPR samples approximately 60 wells annually in areas known to be vulnerable to groundwater contamination by pesticides. Recently, DPR expanded its analysis of these wells to include more pesticides, including imidacloprid; subsequently some of these wells tested positive for imidacloprid. These detections prompted additional well sampling in high-use areas throughout California to reassess current imidacloprid concentrations in groundwater. Sixty-nine wells were sampled for imidacloprid in 2017 and 2019 as part of the latest imidacloprid study. In all, DPR has analyzed more than 600 samples from 307 wells for imidacloprid: some wells were sampled multiple times, other wells were sampled once but analyzed with two different methods, and some wells were only sampled once. Imidacloprid was detected above the reporting limit of 0.05 parts per billion (ppb) in 15 wells in Fresno, Santa Barbara, and Tulare counties, with concentrations ranging from 0.051 to 5.97 ppb. The highest concentration was detected in 2017 in a well that serves a vacant home and may not be representative of concentrations in active domestic wells. The concentration in this well dropped to 0.053 ppb when follow-up sampling was conducted in 2020. Imidacloprid degradates were also analyzed for in 144 well samples, and since there were no detections, subsequent samples were not analyzed for the degradates.

Pesticide use reporting data show that all 15 wells with imidacloprid detections were located in the same or contiguous sections where it was applied for agricultural purposes. Nine of these wells were also located within the same or contiguous section of another well with imidacloprid concentrations above the reporting limit. Given the historical use of imidacloprid in California and the locations of imidacloprid detections in groundwater relative to those use patterns, this report concludes these detections are the result of the legal agricultural use of imidacloprid.

TABLE OF CONTENTS

INTRODUCTION

The purpose of this report is to determine if the detections of imidacloprid in California's groundwater are from legal agricultural use of the pesticide. Imidacloprid was recently detected above the reporting limit of 0.05 ppb in Fresno, Santa Barbara, and Tulare counties. This report will focus on these detections and associated use within the detected section[1] or the surrounding sections where the active ingredient might have been used. Maps of imidacloprid use associated with the well locations in areas of the state that were sampled, but that did not yield detections above the reporting limit, are included in Appendix 2.

LEGAL AGRICULTURAL USE DETERMINATION

DPR created the Groundwater Protection Program to fulfill the mandates of the Pesticide Contamination Prevention Act (PCPA) in the California Food and Agricultural Code (FAC §§ 13141–13152). Section 13149 of the PCPA mandates that when a laboratory-confirmed detection[2] of a pesticide active ingredient is found in groundwater and the detection is determined to have resulted from the legal agricultural use of the pesticide, then DPR is required to conduct a formal review (Detection Response Process) to determine if the use of the pesticide should continue and, if so, under what conditions.

In order to enter imidacloprid into the Detection Response Process, DPR must determine if the detections of imidacloprid resulted from legal agricultural use of the pesticide. In general, a Legal Agricultural Use determination is made when the detections of the active ingredient or its degradation product satisfy all of the following:

1. The active ingredient or its degradation product is detected in two or more wells in the same one-square-mile section of land or in adjacent sections (Goh, 1992).
2. The active ingredient is formulated in product(s) labeled for agricultural use (Oshima, 1987).
3. The active ingredient has reported agricultural use in the vicinity of the detections, or there are sites within the section where the active ingredient might be used (Oshima, 1987).

[1] As defined by the Public Lands Survey System (PLSS) (i.e., Meridian & Baseline, Township, Range, and Section. One section is 1 square mile, approximately 640 acres.

[2] A chemical detection by laboratory analysis is considered "confirmed" by either (a) an analytical chemical method approved by DPR that provides unequivocal identification of the chemical, or (b) verification, within 30 days, by a second analytical method or second analytical laboratory approved by DPR (Aggarwal, 2012).

However, situations may occur where detections are found in wells located in different, non-adjacent sections but within a region in which the active ingredient has been applied as a pesticide labeled for agricultural use. In those instances, a Legal Agricultural Use determination can still be made when the following is satisfied:

4. There is a **preponderance of evidence** presented that the detections of the active ingredient or its degradation product are the result of legal agricultural use of the active ingredient in the region in which the detections were found (Oshima, 1987).

ENVIRONMENTAL FATE PROPERTIES FOR GROUNDWATER CONTAMINATION

As part of the registration evaluation process for a new pesticide active ingredient, DPR performs an initial evaluation to assess the potential for the active ingredient or its degradation products to migrate through the soil, root zone, and deep vadose zones into groundwater. In the late 1990s, DPR scientists noted that imidacloprid had physical-chemical properties that indicated it could migrate to groundwater if its use became more widespread (Troiano, 1997). Pesticides or their degradation products are considered to have a higher potential to reach groundwater if the pesticides are incorporated into the soil, and the pesticides or their degradation products are highly mobile and persistent in the soil root zone.

DPR has established pesticide property threshold values for water solubility, soil adsorption coefficient adjusted for organic carbon (K_{oc}), hydrolysis half-life, aerobic soil metabolism half-life, and anaerobic soil metabolism half-life. These pesticide property threshold values are collectively referred to as Specific Numerical Values (SNVs) and are presented in Table 3. SNVs indicate the potential risk of groundwater contamination posed by agricultural use pesticides. When a pesticide or its degradation product exceeds an SNV for water solubility or is less than the SNV for K_{oc}, then that chemical is considered mobile in soil. Similarly, when a pesticide or its degradation product exceeds an SNV for hydrolysis half-life, aerobic soil metabolism half-life, or anaerobic soil metabolism half-life, then that chemical is considered persistent in soil. When a pesticide or its degradation product exceeds at least one mobility and one persistence SNV threshold (or in the case of soil adsorption coefficient is less than the SNV), and is applied to the soil or through chemigation, DPR adds the pesticide to the Groundwater Protection List (GWPL) (Title 3 California Code of Regulations § 6800[b]) (Dias, 2013). The GWPL is a list of pesticides identified by DPR that have the potential to pollute groundwater and DPR is required by law to monitor groundwater for these pesticides.

DPR's Pesticide Chemistry Database contains data on the physical and chemical properties of pesticide active ingredients and certain degradation products (CDPR, 2020b). Known values of the physical-chemical properties of imidacloprid are summarized in Table 3. These properties are compared against the mobility and persistence SNVs set by DPR to gauge imidacloprid's environmental fate (Table 3). Pesticides with water solubility greater than 3 ppm or K_{oc} less than 1,900 cm^3/g are considered mobile in soil. Since imidacloprid has high water solubility (514 ppm) and low adsorption coefficient (K_{oc}, 132–412 cm^3/g), it is not expected to bind to soils, and is considered mobile in soil. Pesticides with a hydrolysis half-life greater than 14 days, an aerobic soil metabolism half-life greater than 610 days, or an anaerobic soil metabolism half-life greater than 9 days are considered persistent in the soil. Since imidacloprid has a hydrolysis half-life greater than 30 days, an aerobic soil metabolism half-life of 997 days, and an anaerobic soil metabolism half-life of 27.1 days, it exceeds all the established persistence SNVs (Table 3). In addition, imidacloprid can be applied to the soil or through chemigation. As a result, DPR added imidacloprid to the GWPL in 1999, and is required to monitor for it.

REPORTED AGRICULTURAL USE

Imidacloprid is a systemic, neonicotinoid insecticide used in urban and agricultural environments worldwide to control a wide variety of sucking and piercing insect pests such as thrips, aphids, and whiteflies, as well as soil insects such as beetles, grubs, and wireworms. Products containing imidacloprid are formulated primarily as wettable powders, granules, and soluble concentrates for use on a wide variety of agricultural crops (such as field; vegetable and small fruit; tree, bush, and vine crops), non-production agricultural sites (such as animal husbandry premises, rights-of-way, and research commodities), and non-agricultural sites (such as ornamental plants, indoor and outdoor residential and commercial sites, and pet products) (Wagner, 2016; CDPR, 2018).

Since 1990, DPR has required use reports for pesticides applied to agriculture. As such, the DPR Pesticide Use Report (PUR) database contains reported agricultural use of imidacloprid (in pounds active ingredient) at the section scale (i.e., 1 square mile, approximately 640 acres) since it was first registered for use in California in 1994 (CDPR, 2020a). All use data in this report is for agricultural sites, as tabulated through the DPR PUR database. As of September 10, 2021, 253 active products containing imidacloprid were registered for agricultural and non-agricultural use in California under a wide variety of trade names (CDPR, 2021). In California, over 4.1 million pounds of imidacloprid active ingredient has been applied to treat crops on over 26 million acres from 1995 to 2018 (CDPR, 2020a). Total annual reported applications of imidacloprid (pounds active ingredient) and acres treated with imidacloprid in California during this period are shown in Figure 1. Agricultural use of imidacloprid has been steadily increasing

in California since 2000, with use rising by more than five times since 2000 (CDPR, 2020a). Since the PUR database also shows that the reported non-production agricultural use of imidacloprid is negligible (less than 42,000 pounds used statewide from 1995–2018), these use sites were not included in the analysis as a likely source of the detections. Furthermore, the PUR database shows less than 51,000 pounds of reported imidacloprid use for non-agricultural applications from 1995 to 2018 in Fresno, Santa Barbara, and Tulare counties (CDPR, 2020a), the three counties where imidacloprid was detected above the reporting limit.

Since this report is focused on agricultural use and impacts to groundwater, DPR refined the period of "recent" use to account for time between pesticide application at the ground surface and subsequent detection in shallow domestic water wells (i.e., travel time). The travel time has been estimated to be about 7 to 9 years based on vadose zone transport modeling and analysis of chlorofluorocarbon (CFC) groundwater age dating data (Spurlock et al., 2000). Using the 7- to 9-year travel time range as a basis, a period from 2006 to 2018 was conservatively chosen as a "recent" period of use to select the regions to sample where imidacloprid had moderate to high use (CDPR, 2020a).

Pesticide use data show that imidacloprid is applied to agriculture throughout California (CDPR, 2020a). The annual imidacloprid use from 2006 to 2018 is shown in Table 1 for the 20 California counties with the highest reported agricultural use. During this time period, the five counties with the highest average annual reported agricultural use (pounds per year) were: Fresno (46,323), Kern (39,442), Tulare (21,313), Santa Barbara (19,038), and Monterey (18,416) (Table 1). Imidacloprid was applied on over 174 different crops in California from 2006 to 2018, and the top 20 crops with the highest imidacloprid use are listed in Table 2. The top five crops with the total highest reported use in this period were (in descending order): wine grapes (655,235 pounds), processing tomatoes (366,025 pounds), grapes (356,644 pounds), oranges (261,624 pounds), and head lettuce (162,858 pounds) (Table 2) (CDPR, 2020a). These five crops accounted for over half of the total reported agricultural use of imidacloprid.

DPR identified seven counties for targeted imidacloprid monitoring based on the highest reported imidacloprid use and the availability of well sites (see more detailed discussion below). The total reported annual pounds of imidacloprid applied to agricultural use sites and acres treated from 2006 to 2018 in counties with targeted imidacloprid monitoring are shown in Figures 2–4 (Fresno, Santa Barbara, and Tulare) and Appendix 1 (Kern, Madera, Monterey, and San Luis Obispo). The general trend in annual use of imidacloprid from 2006 to 2018 in these seven counties is similar to the statewide trend (Figure 1). The eight crops with the highest imidacloprid use and the total reported imidacloprid use in the targeted counties for the period 2006 to 2018 are shown in Figure 5. These eight crops — wine grapes, processing

tomatoes, grapes, head lettuce, oranges, lettuce leaf, cotton, and broccoli — accounted for at least two-thirds of the total reported imidacloprid use in these counties.

Maps displaying total reported agricultural imidacloprid use from 2006 to 2018 at the section scale are shown in Figures 6–8 (central Fresno, Santa Barbara, and Tulare counties) and Appendix 2 (western Fresno, Kern, Madera, Modoc, Monterey, Riverside, San Benito, San Luis Obispo, Santa Clara, Siskiyou, and Ventura counties). The monitoring results for imidacloprid in some of these areas were from the use of the Multi-Analyte Screen in other studies. DPR uses this screen to analyze samples from all wells sampled, regardless of the study purpose. Imidacloprid was not specifically targeted in some of these studies, so samples were not necessarily collected from wells located in high imidacloprid use sections.

DETECTIONS IN GROUNDWATER

The DPR Well Inventory Database contains measured concentrations of pesticides or their degradation products in wells sampled by various local, state, and federal agencies (CDPR, 2020c). For the purposes of this report, only imidacloprid sampling conducted by DPR will be used to make a Legal Agricultural Use determination. DPR has collected and analyzed over 600 samples from 307 wells for imidacloprid since some wells have been sampled more than once (Table 4).

DPR conducted imidacloprid monitoring studies in 2003 and 2009 and sampled 67 wells from seven counties (Fresno, Monterey, San Benito, San Luis Obispo, Santa Barbara, Tulare, and Ventura). Imidacloprid or imidacloprid degradates were not detected in any of the wells tested (Weaver and Nordmark, 2004; Bergin and Nordmark, 2009). The approximate locations of wells sampled for these studies are plotted in Figures 6 through 8, and in Appendix 2.

DPR samples approximately 60 domestic wells annually (1999–present) in Fresno and Tulare counties as part of the Groundwater Protection Program's Well Network. This is a long-term groundwater monitoring study of wells located in areas known to be highly vulnerable to groundwater contamination from the legal agricultural use of pesticides. In 2014, DPR expanded its analysis of these wells to include more pesticides, including imidacloprid. That year, imidacloprid was detected above the reporting limit in a single well, then in five wells in 2015. Imidacloprid was detected in a total of nine Well Network wells between 2014 and 2020 (Table 6; Davalos, 2021). In addition, imidacloprid was detected below the reporting limit in four of the Well Network wells. Due to these detections DPR initiated additional monitoring for imidacloprid (Studies GW17 and GW17a) in moderate to high use areas with shallow

groundwater. This Legal Agricultural Use determination includes the nine Well Network wells with detections above the reporting limit.

DPR conducted targeted groundwater monitoring for imidacloprid in 2017 and 2019, while imidacloprid degradates were only analyzed in samples collected in 2017. DPR sampling protocols document the background and planning information for these imidacloprid studies (Aggarwal, 2017; 2019). Sampling locations were chosen based on the pounds of active ingredient applied (1995–2015) in a one-square-mile section area (as reported in the PUR), depth to groundwater, and well availability (Aggarwal, 2021). Sections with moderate to high reported imidacloprid use and a depth to groundwater of less than 130 feet were given high priority (2017 and 2019 had different parameters for sampling; Aggarwal, 2021). The sampled sections were located in Fresno, Kern, Madera, Monterey, San Luis Obispo, Santa Barbara, and Tulare counties. Although areas of high use were identified in other counties, these areas were not sampled due to a lack of available wells or the groundwater levels were deeper than 130 feet. Wells were chosen in the designated areas following the procedures described in Standard Operating Procedure (SOP) FSWA001.03 (Kocis, 2020). If no suitable wells were available in the target section, wells in the neighboring sections were sampled, if available. DPR sampled 69 wells for the GW17 and GW17a imidacloprid studies. Five out of the 69 wells had imidacloprid concentrations above the reporting limit, nine wells had trace concentrations, and 55 wells had no imidacloprid detections (Aggarwal, 2021). This Legal Agricultural Use determination includes the five wells from Studies GW17 and GW17a with detections above the reporting limit.

Out of the total 307 wells sampled for imidacloprid by DPR, 15 wells had imidacloprid concentrations above the reporting limit, 14 wells had trace concentrations, and imidacloprid was not detected in 278 wells (Table 4). Imidacloprid was detected above the reporting limit in Fresno, Santa Barbara, and Tulare counties. Fresno County had 12 wells with detections, while imidacloprid was detected in one well in Santa Barbara County and two wells in Tulare County, with concentrations ranging from 0.051 to 5.97 ppb (Table 6). The highest concentration of 5.97 ppb was detected in a well that serves a vacant home. The sampled water from this well appeared murky and may not reflect the detectable residues in active domestic wells. The concentration in this well decreased to 0.053 ppb in the latest sampling event (Table 6). DPR samples this well and approximately 60 other wells annually as part of the Well Network, a 21-year ongoing groundwater monitoring study in Fresno and Tulare counties (Davalos, 2021). Imidacloprid sampling results from 2014 through 2020 for the wells from this study with either confirmed or trace detections are summarized in Table 6. Annual reported agricultural imidacloprid use data from 2006 to 2018 for the five sections with the highest imidacloprid concentrations are shown in Figure 9. A similar trend of increase in imidacloprid use from 2006

to 2018 was observed for other sections with confirmed imidacloprid detections. This increase in annual imidacloprid use from 2006 to 2018 is similar to the statewide trend.

Out of the 307 wells sampled and analyzed for imidacloprid, 144 were also analyzed for the imidacloprid degradates. The imidacloprid degradates were not detected in any of the samples tested. Additionally, the two methods were compared where at least one method (either EMON-SM-13.0 or EMON-SM-05-032) detected concentrations of imidacloprid parent above the reporting limit on replicate samples collected in 2016 and 2017 (Table 7). The average relative percent difference between the methods was found to be 26.6[3] percent. The average relative percent difference was only 7.63 percent after excluding the single well where imidacloprid was not detected by the method EMON-SM-13.0, but was detected by method EMON-SM-05-032 near the reporting limit. DPR expects an average relative percent difference of under 30 percent (SOP QAQC001.01 [Peoples, 2019]). Since imidacloprid degradates were not detected in any of the samples, the separate imidacloprid method (i.e., EMON-SM-13.0) was deemed redundant, and subsequent samples were not analyzed for imidacloprid degradates. The Multi-Analyte Screen, EMON-SM-05-032, was used exclusively from that time forward.

The California Department of Food and Agriculture's (CDFA) Center for Analytical Chemistry performed the chemical analysis. For sampling conducted in 2016 in the Well Network and in 2017 for GW17, CDFA analyzed samples for imidacloprid and imidacloprid degradates using method EMON-SM-13.0 (CDFA, 2008) and for imidacloprid using the Multi-Analyte Screen EMON-SM-05-032 (CDFA, 2013). For the other imidacloprid samples collected in the Well Network (2014–2015, 2017–2020) and in 2019 for GW17a, only the Multi-Analyte Screen EMON-SM-05-032 was used. The current version of the PCPA no longer requires confirmation of pesticide detections in at least two discrete well samples or verification of a pesticide detection by a second analytical method or analytical laboratory (FAC § 13149[d]). The PCPA allows a finding of an active ingredient or its degradates in groundwater by a single analytical laboratory using a single analytical method if the method is approved by DPR and provides unequivocal identification of those chemicals (Aggarwal, 2012). DPR determined imidacloprid is unequivocally identified in both methods via mass spectrometry (Fattah, 2008; Aggarwal, 2016). The reporting limit for imidacloprid was 0.05 ppb. The reporting limit is the smallest amount detected following the analytical method that is set at a level high enough to account for matrix effects (1 to 5 times the method detection limit). Whereas, trace concentrations are the concentrations between the method detection limit (0.01 ppb) and the reporting limit (0.05 ppb). For this document's purpose, DPR considers imidacloprid detections below the reporting limit as informative, but they are not being used to make a Legal Agricultural Use determination.

[3] Imidacloprid was not detected in one sample by method EMON-SM-13.0, and therefore a value of 0.009 (below MDL of 0.01 ppb) was used to calculate average relative percent difference.

Fourteen of the wells with imidacloprid detections above the reporting limit were located in Ground Water Protection Areas (GWPAs) (Table 8). DPR has adopted regulations to identify areas vulnerable to groundwater contamination based on either detection of specific pesticides in groundwater or on soil characteristics and depth to groundwater. These vulnerable areas are identified as either leaching GWPAs or runoff GWPAs, depending on the predicted pathway to groundwater. Imidacloprid was detected in both leaching GWPAs (Fresno County) and runoff GWPAs (Fresno and Tulare counties), providing further evidence that imidacloprid is mobile and persistent enough to move to groundwater from agricultural use. One well with a confirmed detection of imidacloprid was in a section that has not been designated as a GWPA (Santa Barbara County) (Table 8). The reported amount of imidacloprid used from 2006 to 2018 in sections with detections and the surrounding sections was also much higher in the section that has not been designated as a GWPA (Santa Barbara County) than in sections that are GWPAs (Fresno and Tulare counties) (Table 8).

There have also been reports of imidacloprid detections in groundwater by other agencies throughout the USA (Table 9). The maximum concentrations reported by other agencies ranged from 0.091 ppb in California (United States Geological Survey data in DPR's Well Inventory Database; CDPR, 2020c) to 407 ppb in New York (NYSDEC, 2014). Outside of the USA, imidacloprid detections have been reported in Pakistan, Australia, Vietnam, Canada, and Brazil (Table 9); however, use patterns, environmental conditions, and enforcement may vary.

LEGAL AGRICULTURAL USE DETERMINATION

This section documents the Legal Agricultural Use determination for imidacloprid. Imidacloprid was detected above the reporting limit (0.05 ppb) in Fresno, Santa Barbara, and Tulare counties, while trace concentrations (below the reporting limit) were detected in Fresno, Monterey, Santa Barbara, and Tulare counties. The reporting limit is set at 1 to 5 times the method detection limit in order to be high enough to account for matrix effects, and imidacloprid is unequivocally identified in the methods via mass spectrometry (Fattah, 2008; Aggarwal, 2016). For this document's purpose, a Legal Agricultural Use determination is only being made for wells with imidacloprid concentrations above the reporting limit. The process for determining legal agricultural use was described earlier in this report and is listed again below with associated details for how it is satisfied by groundwater monitoring data, reported imidacloprid use data, and other supporting information.

1. The active ingredient or its degradation product is detected in two or more wells in the same one-square-mile section of land or in adjacent sections (Goh, 1992).

   Nine imidacloprid detections in Fresno County satisfy the above (Figure 6).

   - Two wells in section 15S22E03
   - One well each in three consecutively adjacent sections: 14S23E33, 14S23E34, and 14S23E35
   - One well each in two adjacent sections: 14S22E31 and 15S22E06
   - One well each in two adjacent sections: 15S21E03 and 15S21E09

2. The active ingredient is formulated in product(s) labeled for agricultural use (Oshima, 1987).
   Imidacloprid, a systemic, neonicotinoid insecticide, is the active ingredient contained in a number of products labeled for agricultural use to control a wide variety of sucking and piercing insect pests. Since its initial registration in 1994, 687 products have been registered for use in California, and as of September 10, 2021 there were 253 active products containing imidacloprid registered for agricultural and non-agricultural use in California. Imidacloprid products are labeled for use on a wide range of crops, such as field crops (e.g., cotton, peanut, potato); vegetable and small fruit crops (e.g., cucurbit vegetables, legume vegetables, fruiting vegetables, herbs); tree, bush, and vine crops (e.g., banana and plantain, citrus, grape, stone fruit); and other crops (e.g., Christmas tree, poplar/cottonwood) to control several pests such as aphids, leafhopper, thrips, and whiteflies.

3. The active ingredient has reported agricultural use in the vicinity of the detections, or there are sites within the section where the active ingredient might be used (Oshima, 1987).
   Imidacloprid has been used in California since its initial registration in 1994. DPR has required reporting of agricultural use (i.e., individual applications) of a pesticide labeled for agricultural use since 1990. Figure 1 shows the increasing agricultural use of imidacloprid in California as reported from 1995 through 2018. Figures 6 through 8 show total reported agricultural imidacloprid use on a section basis from 2006 to 2018 in the counties where DPR has sampled for and detected imidacloprid in wells. Also included on these maps are the locations of confirmed detections of imidacloprid relative to the distribution of reported agricultural imidacloprid use. The PUR data plotted on the maps show that imidacloprid was used for agricultural purposes in each

section as well as the surrounding sections where imidacloprid was detected. The amount of imidacloprid used for agricultural purposes from 2006 to 2018 in sections with the detections and the surrounding sections is shown in Table 5.

Imidacloprid was also detected in six wells in Fresno, Santa Barbara, and Tulare counties that were located in different, non-adjacent sections. These sections, as well as the surrounding sections, had significant reported agricultural use of imidacloprid. These detections do not strictly meet the spatial designation listed above; however, a Legal Agricultural Use determination can still be made for the imidacloprid detections in these sections by satisfying the following:

4. There is a **preponderance of evidence** presented that the detections of the active ingredient or its degradation product are the result of legal agricultural use of the active ingredient in the region in which the detections were found (Oshima, 1987).

   Historically it has been difficult for DPR to gain access and collect groundwater samples from multiple wells within a single section or wells in adjacent sections. This difficulty hinders DPR from satisfying the first Legal Agricultural Use basis (i.e., detections in two or more wells in the same one-square-mile section of land or adjacent sections) for some of the imidacloprid detections despite significant reported agricultural use of imidacloprid in Fresno, Santa Barbara, and Tulare counties. Examples of this situation include the detections of imidacloprid in six wells in non-adjacent sections between 2016 and 2020:

   - Three wells in Fresno County, one well each in sections: 14S22E02, 14S22E14, and 15S24E14
   - One well in Santa Barbara County in section 10N34W17
   - Two wells in Tulare County, one well each in sections: 16S24E12 and 17S25E11

   The trend in imidacloprid's reported agricultural annual use in Fresno, Santa Barbara, and Tulare counties from 2006 to 2018 (Figures 2, 3, and 4, respectively) clearly shows that a significant amount of imidacloprid has been applied in these counties for insect control on a variety of crops (e.g., wine grapes, processing tomatoes, orange, and cotton; Figure 5). Agricultural imidacloprid use around these detections from 2006 to 2018 on a section basis and the approximate locations of the wells in which imidacloprid was recently detected (2016–2020) are shown on Figures 6, 7, and 8, respectively. All six wells with imidacloprid detections were located in sections where imidacloprid was used for agricultural purposes between 2006 and 2018 (Table 5). Therefore, the detections in these three counties and the associated significant agricultural use over

many years in the sections provide a preponderance of evidence that these detections originated as a result of the legal agricultural use of imidacloprid.

CONCLUSIONS

DPR evaluated recent groundwater monitoring data collected in areas where imidacloprid has reported agricultural use. The data strongly supports that agricultural use of imidacloprid has resulted in the pesticide migrating to groundwater in California. Imidacloprid detections in wells in Fresno, Santa Barbara, and Tulare counties between 2014 and 2020 meet all of DPR's Legal Agricultural Use determination requirements:

1. Detections in two or more wells in the same one-square-mile section of land or in an adjacent section of land,
2. Reported use of imidacloprid in the vicinity of detections, and
3. The active ingredient is formulated in product(s) labeled for agricultural use; or
4. The preponderance of evidence.

Therefore, this report concludes that imidacloprid has migrated to groundwater due to legal agricultural use.

REFERENCES

Contact GWPP@cdpr.ca.gov for references not currently available on the web.

Aggarwal, V. 2012. Memorandum to Lisa Ross. Evaluating Analytical Methods for Compliance with the Pesticide Contamination Prevention Act requirements. Available at: https://www.cdpr.ca.gov/docs/emon/grndwtr/polprocd/pcpa_requirements_analytical_methods_compliance.pdf (verified July 22, 2020). California Department of Pesticide Regulation, Sacramento, California.

Aggarwal, V. 2016. Memorandum to Joy Dias. The Qualification of Method EMON-SM-05-032 as Unequivocal According to Criteria in the Pesticide Contamination Prevention Act. Available at: https://www.cdpr.ca.gov/docs/emon/pubs/anl_methds/emon-sm-05-032_memo.pdf (verified July 22, 2020). California Department of Pesticide Regulation, Sacramento, California.

Aggarwal, V. 2017. Protocol for Ground Water Protection List Monitoring for imidacloprid. Available at: https://www.cdpr.ca.gov/docs/emon/pubs/protocol/studygw17protocol.pdf (verified December 03, 2020). California Department of Pesticide Regulation, Sacramento, California.

Aggarwal, V. 2019. Protocol for Additional Groundwater Protection List Monitoring for Imidacloprid. Available at: https://www.cdpr.ca.gov/docs/emon/pubs/protocol/study_gw17a_imdacloprid.pdf (verified July 02, 2020). California Department of Pesticide Regulation, Sacramento, California.

Aggarwal, V. 2021. Study GW17/GW17a: Groundwater Protection List Monitoring for Imidacloprid. Available at: https://www.cdpr.ca.gov/docs/emon/pubs/ehapreps/study_gw17.pdf (verified March 30, 2021). California Department of Pesticide Regulation, Sacramento, California.

Baig, S.A., N.A. Akhter, M. Ashfaq, M.R. Asi, and U. Ashfaq. 2012. Imidacloprid Residues in Vegetables, Soil and Water in the Southern Punjab, Pakistan. Journal of Agricultural Technology 8(3): 903-916. Available at: http://www.ijat-aatsea.com/pdf/v8_n3_12_may/10%20IJAT_2012_Sajjad%20Ahmad%20...vironmental%20Technology.pdf (verified July 22, 2020).

Bergin, R. and C. Nordmark. 2009. GW 09: Ground Water Monitoring for Imidacloprid and Four Degradates in High Use Areas in California. California Department of Pesticide Regulation, Sacramento, California.

Bortoluzzi, E.C., D.S. Rheinheimer, C.S. Gonçalves, J.B.R. Pellegrini, A.M. Maroneze, M.H.S. Kurz, N.M. Bacar, and R. Zanella. 2007. Investigation of the Occurrence of Pesticide Residues in Rural Wells and Surface Water Following Application to Tobacco. Quimica Nova 30(8): 1872-1876. Available at: https://www.researchgate.net/profile/Renato_Zanella/publication/228685153_Investigation_of_the_occurrence_of_pesticide_residues_in_rural_wells_and_surface_water_following_application_to_tobacco/links/0fcfd51236065583de000000/Investigation-of-the-occurrence-of-pesticide-residues-in-rural-wells-and-surface-water-following-application-to-tobacco.pdf (verified July 22, 2020).

Bradford, B.Z., A.S. Huseth, and R.L. Groves. 2018. Widespread Detections of Neonicotinoid Contaminants in Central Wisconsin Groundwater. PLoS ONE 13(10): e0201753. Available at: https://doi.org/10.1371/journal.pone.0201753 (verified July 22, 2020).

California Department of Food and Agriculture (CDFA). 2008. Determination of Imidacloprid and the Olefinic Imidacloprid, Guanidine, Olefinic Guanidine, Urea Metabolites in Well Water by High Performance Liquid Chromatography Tandem Mass Spectrometry. California Department of Food and Agriculture, Sacramento, California.

CDFA. 2013. Determination of 44 Pesticides on Well Water by Liquid Chromatography Coupled to Linear Ion Trap Quadrupole and Gas Chromatography Coupled to Triple Quadrupole Mass Spectrometer. California Department of Food and Agriculture, Sacramento, California.

California Department of Pesticide Regulation (CDPR). 2018. California Neonicotinoid Risk Determination. Available at: https://www.cdpr.ca.gov/docs/registration/reevaluation/chemicals/neonicotinoid_risk_determination.pdf (verified December 09, 2020). California Department of Pesticide Regulation, Sacramento, California.

CDPR. 2020a. Pesticide Use Reports. Available at: http://www.cdpr.ca.gov/docs/pur/purmain.htm (verified July 22, 2020). California Department of Pesticide Regulation, Sacramento, California.

CDPR. 2020b. Pesticide Chemistry Database. California Department of Pesticide Regulation, Sacramento, California.

CDPR. 2020c. Well Inventory Database. Available at: https://www.cdpr.ca.gov/docs/emon/grndwtr/well_inventory_databse/index.htm (verified July 22, 2020). California Department of Pesticide Regulation, Sacramento, California.

CDPR. 2021. Pesticide Chemical Information Query. California Department of Pesticide Regulation, Sacramento, California.

Davalos, J. 2021. Study 228: Monitoring the Concentrations of Detected Pesticides in Wells Located in Highly Sensitive Areas (Well Network Sampling). Annual Update 2020. Available at: https://www.cdpr.ca.gov/docs/emon/pubs/ehapreps/study_228_2020.pdf (verified March 28, 2021). California Department of Pesticide Regulation, Sacramento, California.

Dias, J. 2013. Memorandum to David Duncan. Guidelines for Identifying Pesticides to be Added to and Removed from the Groundwater Protection List: Title 3, California Code of Regulations Section 6800(b). Available at: https://www.cdpr.ca.gov/docs/emon/grndwtr/polprocd/gwp_cacode_6800b.pdf (verified October 01, 2020). California Department of Pesticide Regulation, Sacramento, California.

Fattah, W. 2008. Memorandum to Randy Segawa. Determination if the California Department of Food and Agriculture, Center for Analytical Chemistry's High Performance Liquid Chromatography-Tandem Mass Spectrometry Method (EMON-SM-13.0) for Imidacloprid, Imidacloprid Olefin, Imidacloprid Urea, Imidacloprid Guanidine, and Imidacloprid Guanidine Olefin Meets the "Unequivocal Detection" Criteria. California Department of Pesticide Regulation, Sacramento, California.

Giroux, I., and B. Sarrasin. 2011. Pesticides et nitrates dans l'eau souterraine près de cultures de pommes de terre - Échantillonnage dans quelques régions du Québec en 2008 et 2009, ministère du Développement durable, de l'Environnement et des Parcs, Direction du suivi de l'état de l'environnement, Centre d'expertise en analyse environnementale du Québec, ISBN 978-2-550-61396-1, 31 p. et 5 annexes. Available at: http://www.environnement.gouv.qc.ca/pesticides/pomme_terre/pesti-nitrates2008-2009.pdf (verified July 22, 2020).

Goh, K.S. 1992. Memorandum to John S. Sanders, Ph.D. Identification of Pesticide Management Zones. California Department of Pesticide Regulation, Sacramento, California.

Kocis, T. 2020. SOP FSWA001.03. Obtaining and Preserving Well Water Samples. Available at: https://www.cdpr.ca.gov/docs/emon/pubs/sops/fswa00103.pdf (verified July 22, 2020). California Department of Pesticide Regulation, Sacramento, California.

Lamers, M., M. Anyusheva, N. La, V.V. Nguyen, and T. Streck. 2011. Pesticide Pollution in Surface- and Groundwater by Paddy Rice Cultivation: A Case Study from Northern

Vietnam. CLEAN - Soil, Air, Water, 39(4), 356–361. Available at: https://farmlandbirds.net/sites/default/files/lamers_2011.pdf (verified July 22, 2020).

Masters, B., C. Mortimore, J. Armour, and D.M. Silburn. 2014. Pesticides in Groundwater of the Tully-Murray and Johnstone Catchments: 2012/2013 Report, Wet Tropics Region. Queensland Department of Natural Resources and Mines. Available at: https:// www.qld.gov.au/ data/assets/pdf_file/0025/69082/rp54c-pesticidesgroundwater -wet-tropics-report-2012-13.pdf (verified July 22, 2020).

Minnesota Department of Agriculture. 2019. 2018 Water Quality Monitoring Report. Available at: https://wrl.mnpals.net/islandora/object/WRLrepository%3A3399/datastream/ PDF/download/WRLrepository_3399.pdf (verified July 22, 2020).

New York State Department of Environmental Conservation (NYSDEC). 2014. Water Quality Monitoring Data for Pesticides on Long Island, NY. Referenced in the NYSDEC Long Island Pesticide Pollution Prevention Strategy. Available at: http://134.179.112.44/docs/ materials_minerals_pdf/suffolkdata.pdf (verified July 22, 2020).

Oshima, R. 1987. Memorandum to EM and PM employees. Legal Agricultural Use Criteria. Available at: http://www.cdpr.ca.gov/docs/emon/grndwtr/polprocd/policy26.pdf (verified July 22, 2020). California Department of Pesticide Regulation, Sacramento, California.

Peoples, S. 2019. SOP QAQC001.01. Chemistry Laboratory Quality Control. Available at: https://www.cdpr.ca.gov/docs/emon/pubs/sops/qaqc00101.pdf (verified November 24, 2020).California Department of Pesticide Regulation, Sacramento, California.

Spurlock, F., K. Burow, and N. Dubrovsky. 2000. Chlorofluorocarbon Dating of Herbicide Containing Well Waters in Fresno and Tulare Counties, California. Journal of Environmental Quality, 29, 474–483.

Troiano, J. 1997. Memorandum to Jeanne Martin. Response to Imidacloprid. California Department of Pesticide Regulation, Sacramento, California.

Wagner, S. 2016. Environmental Fate of Imidacloprid. California Department of Pesticide Regulation, Sacramento, California.

Weaver, D.J. and C. Nordmark. 2004. Summary of Results for Fiscal year 2003/04 Ground Water Protection List Monitoring for Imidacloprid and Three of its Degradates. California Department of Pesticide Regulation, Sacramento, California.

FIGURES

Figure 1. Annual reported agricultural imidacloprid use and acres treated in California statewide from 1995 to 2018 (CDPR, 2020a).

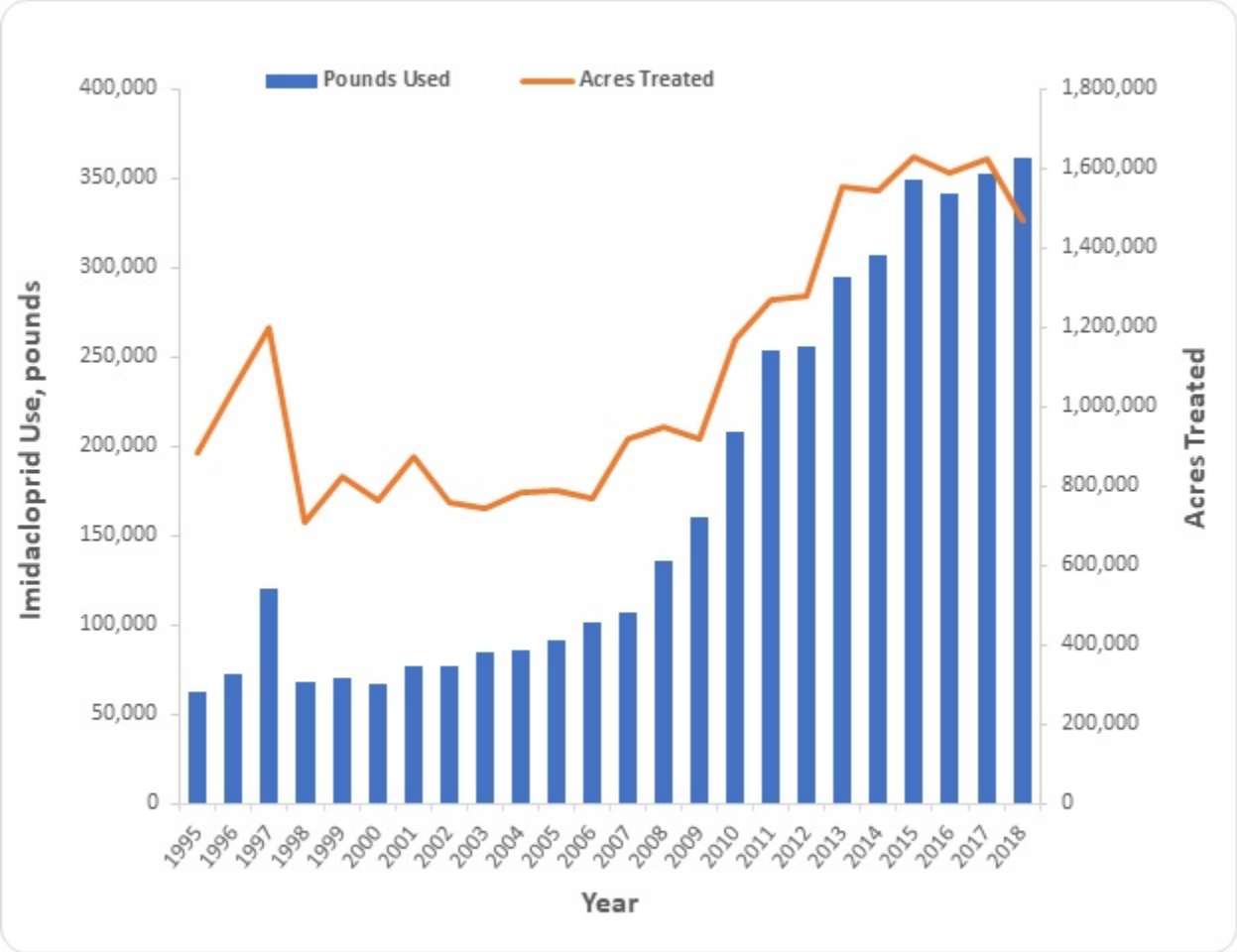


Figure 2. Annual reported agricultural imidacloprid use and acres treated in Fresno County from 2006 to 2018 (CDPR, 2020a).

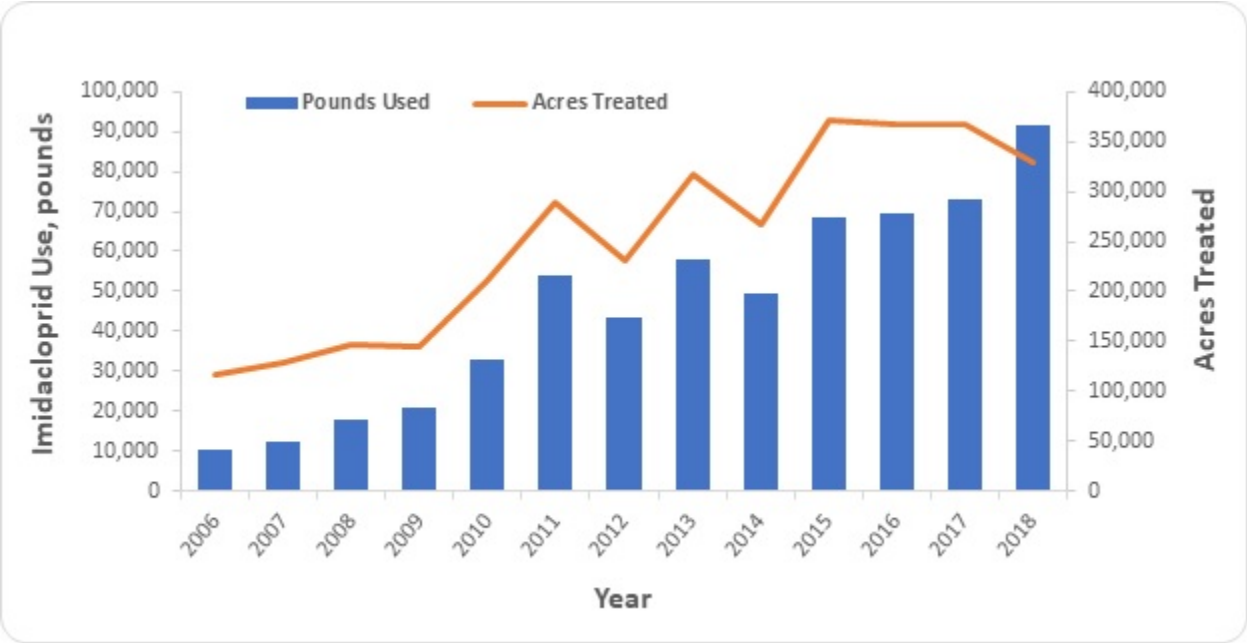


Figure 3. Annual reported agricultural imidacloprid use and acres treated in Santa Barbara County from 2006 to 2018 (CDPR, 2020a).

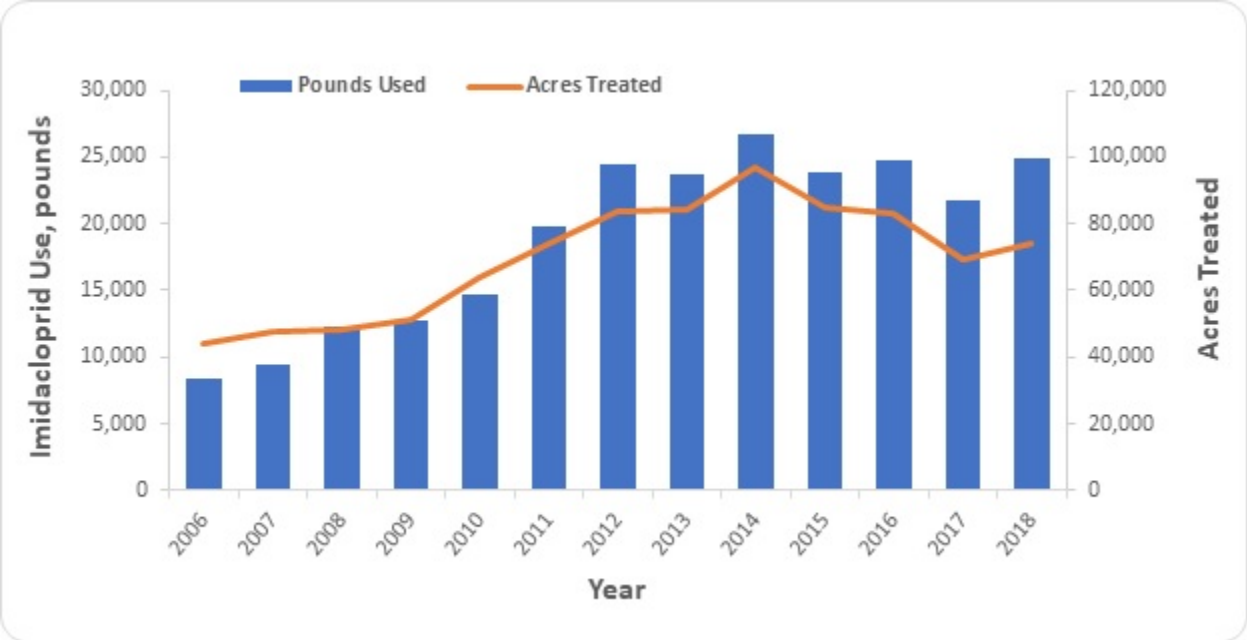


Figure 4. Annual reported agricultural imidacloprid use and acres treated in Tulare County from 2006 to 2018 (CDPR, 2020a).

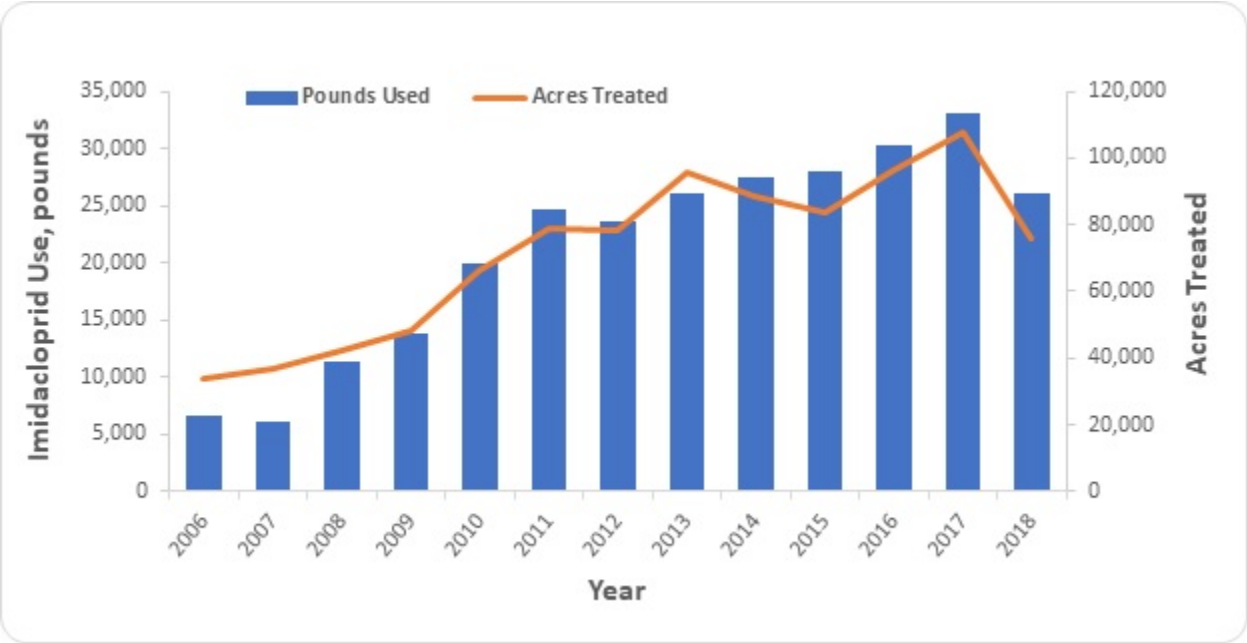
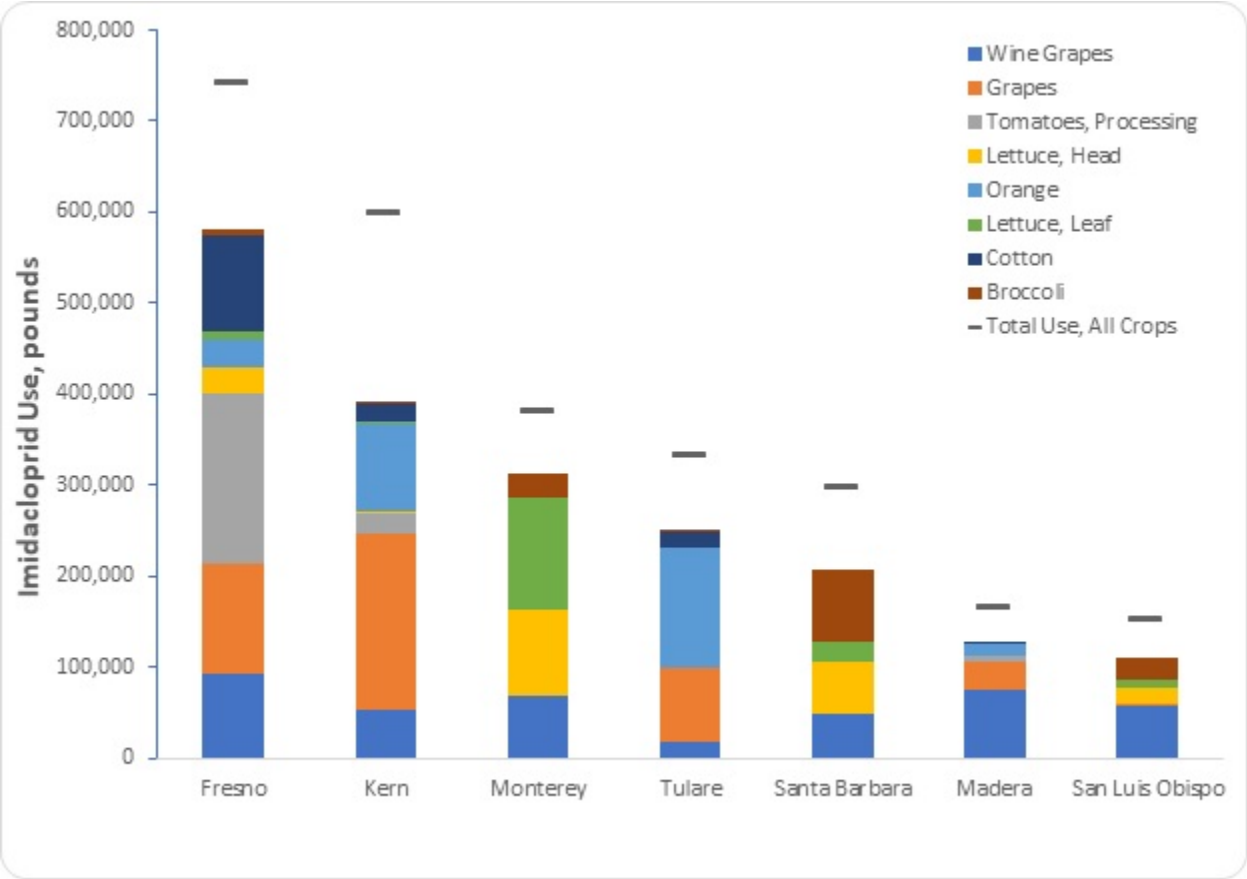


Figure 5. Reported imidacloprid use by top eight crops in targeted counties from 1995 to 2018 (CDPR, 2020a).



Reported agricultural imidacloprid use (pounds) by top eight crops in targeted counties from 1995 to 2018 (CDPR, 2020a).

Crop	**Fresno**	**Kern**	**Monterey**	**Tulare**	**Santa Barbara**	**Madera**	**San Luis Obispo**
Wine Grapes	94,156	52,778	69,454	17,617	48,139	76,225	58,852
Grapes	119,306	193,698	230	81,228	9	30,961	1,326
Processing Tomatoes	187,533	22,523	5	346	5	6,448	0
Head Lettuce	28,443	1,514	93,379	92	57,486	9	17,188
Orange	30,693	98,387	0	131,453	0	11,496	4
Leaf Lettuce	9,001	341	123,311	22	23,310	0	8,622
Cotton	104,712	21,725	0	18,921	0	3,434	0
Broccoli	6,444	49	27,028	1,384	79,080	0	25,414
Total Use, All Crops	741,064	598,278	381,020	332,521	295,566	164,631	150,803

Figure 6. Total reported agricultural imidacloprid use (pounds per section) from 2006 to 2018 and DPR sampled wells in central Fresno County (CDPR, 2020a).

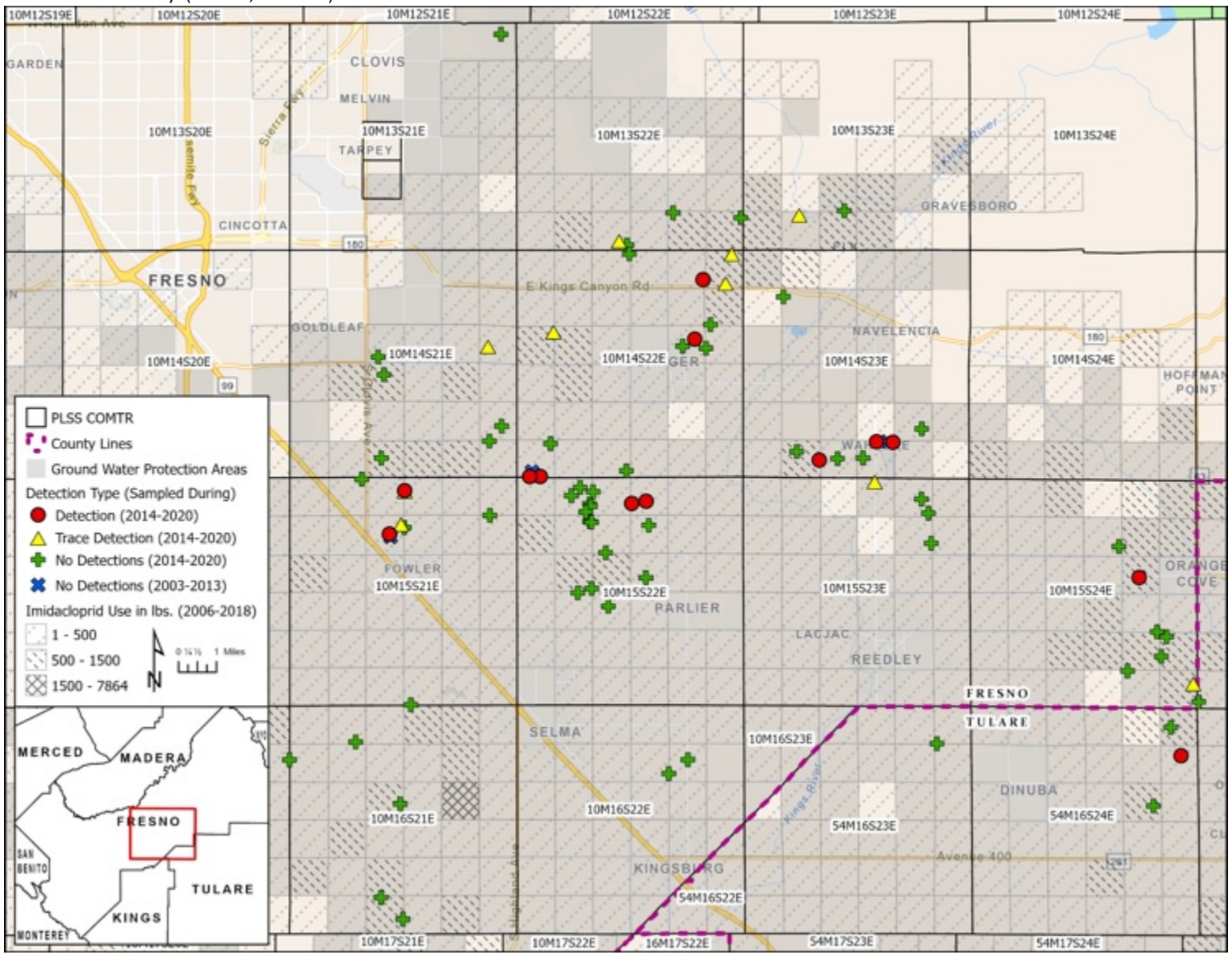


Figure 7. Total reported agricultural imidacloprid use (pounds per section) from 2006 to 2018 and DPR sampled wells in Santa Barbara County (CDPR, 2020a).

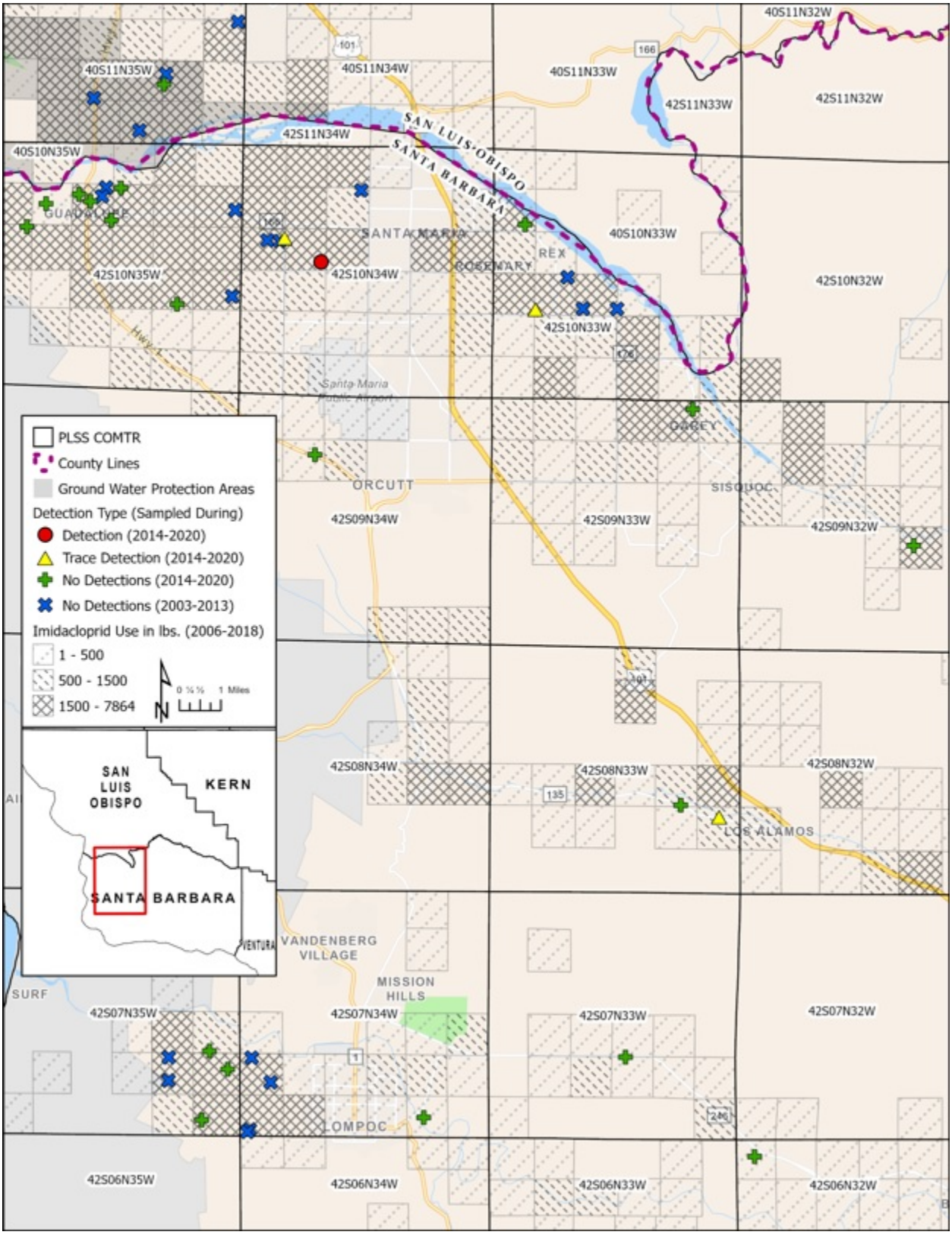


Figure 8. Total reported agricultural imidacloprid use (pounds per section) from 2006 to 2018 and DPR sampled wells in Tulare County (CDPR, 2020a).

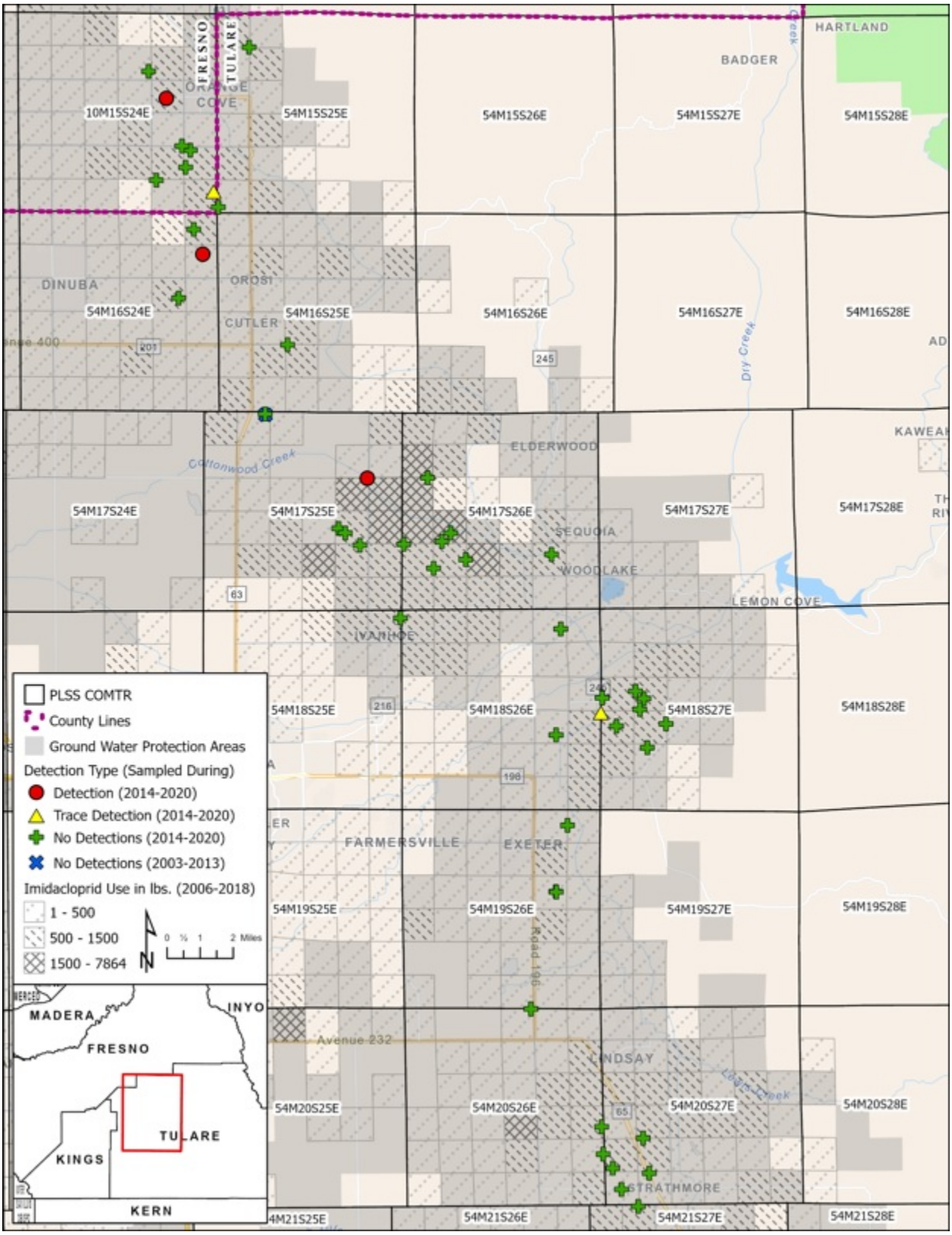
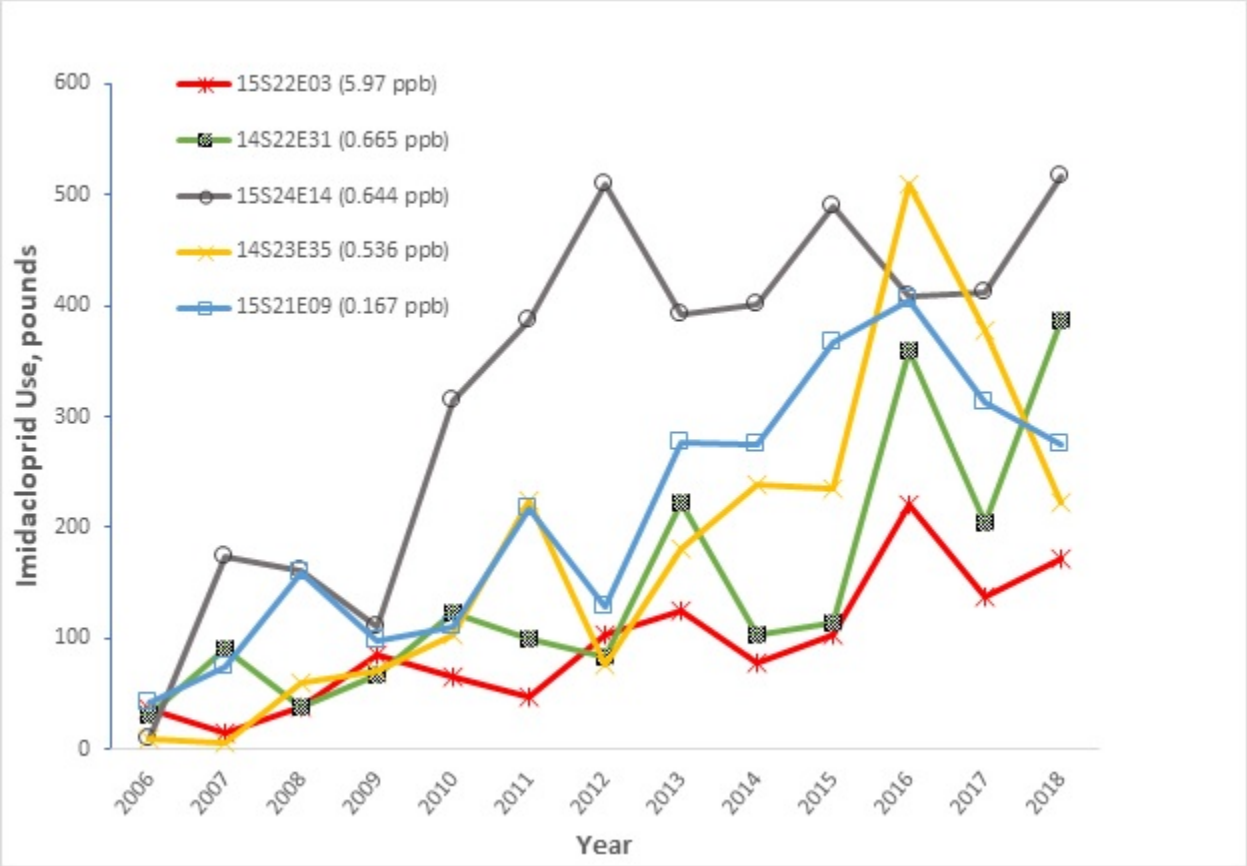


Figure 9. Annual reported agricultural imidacloprid use (pounds, 2006-2018) in the detected section and the surrounding eight sections for five wells in the Well Network with the highest detected imidacloprid concentrations (CDPR, 2020a).



Annual reported agricultural imidacloprid use (pounds, 2006-2018) in the detected section and the surrounding eight sections for five wells in the Well Network with the highest detected imidacloprid concentrations (CDPR, 2020a).

Well location (Highest Imidacloprid Conc, ppb)	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
15S22E03 (5.97)	36	15	39	84	65	48	104	124	79	104	221	138	172
14S22E31 (0.665)	31	91	39	68	123	99	83	223	104	115	359	204	387
15S24E14 (0.644)	10	174	162	111	315	387	510	392	402	491	409	413	516
14S23E35 (0.536)	9	5	60	70	103	224	76	182	238	235	510	377	222
15S21E09 (0.167)	43	75	159	98	110	217	128	277	275	366	405	312	274

TABLES

Table 1. Annual reported agricultural imidacloprid use (pounds) by top 20 California counties from 2006 to 2018 (CDPR, 2020a).

County	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total	Average
Fresno	10,193	12,583	17,777	21,018	32,937	53,933	43,392	58,181	49,628	68,363	69,764	72,839	91,598	602,204	46,323
Kern	13,640	14,765	26,249	33,041	39,462	43,421	44,934	46,505	45,938	47,278	49,350	52,507	55,660	512,749	39,442
Tulare	6,694	6,094	11,334	13,768	19,938	24,623	23,680	26,124	27,433	28,047	30,251	33,051	26,028	277,066	21,313
Santa Barbara	8,304	9,358	12,319	12,773	14,744	19,859	24,443	23,699	26,730	23,931	24,718	21,720	24,893	247,490	19,038
Monterey	12,010	14,439	15,343	15,534	18,411	20,082	21,909	20,352	23,332	23,844	19,426	18,689	16,042	239,414	18,416
Imperial	14,686	13,611	10,793	9,907	13,561	15,197	16,842	15,659	19,266	16,507	17,669	21,011	15,929	200,636	15,434
San Joaquin	2,645	3,339	3,857	8,054	9,799	11,638	10,532	13,018	18,758	27,487	18,323	26,688	25,634	179,771	13,829
Madera	2,772	4,173	7,067	7,718	10,074	10,942	10,368	13,735	14,244	19,605	17,360	16,321	13,826	148,206	11,400
Kings	3,672	6,092	5,499	7,136	8,228	7,904	8,414	12,912	12,010	14,197	14,894	16,822	13,119	130,898	10,069
San Luis Obispo	4,426	3,762	4,743	4,447	6,566	10,549	9,233	11,168	11,144	14,680	12,700	12,838	13,884	120,141	9,242
Riverside	5,597	4,002	3,521	4,202	5,380	4,387	8,373	11,348	9,861	11,654	9,888	8,949	10,551	97,712	7,516
Merced	1,445	1,627	3,826	3,743	5,895	6,347	4,474	7,975	10,566	13,297	11,866	11,538	12,474	95,073	7,313
Ventura	8,438	4,179	4,297	4,888	5,796	5,992	5,599	6,169	6,955	6,201	6,757	5,225	4,932	75,428	5,802
Stanislaus	684	1,388	1,184	2,344	2,396	3,827	2,841	6,512	5,069	5,478	5,903	6,226	6,922	50,774	3,906
Sacramento	222	866	1,556	3,689	3,855	3,125	4,697	3,245	4,391	3,807	10,105	3,788	4,416	47,762	3,674
Sonoma	656	731	1,224	1,584	2,364	2,047	1,859	1,763	2,944	2,645	2,722	3,463	4,069	28,070	2,159
Yolo	433	383	365	582	1,309	1,476	1,641	1,957	2,511	3,946	3,122	2,949	3,584	24,258	1,866
San Benito	1,126	1,296	1,242	1,273	1,299	1,561	1,498	1,764	2,066	1,877	1,636	2,206	2,020	20,864	1,605
San Diego	218	318	135	740	674	578	1,495	2,023	2,299	2,131	1,623	2,051	1,330	15,615	1,201
Napa	393	403	798	655	804	1,079	1,226	1,172	1,508	1,536	1,310	1,214	1,850	13,948	1,073

Table 2. Total reported imidacloprid use (pounds) by top 20 crops from 2006 to 2018 (CDPR, 2020a).

Crop	Imidacloprid Use (pounds)	Percent of Total Use (%)
GRAPES, WINE	655,235	20
TOMATOES, FOR PROCESSING/CANNING	366,025	11
GRAPES	356,644	11
ORANGE (ALL OR UNSPEC)	261,624	8
LETTUCE, HEAD (ALL OR UNSPEC)	162,858	5
LETTUCE, LEAF (ALL OR UNSPEC)	154,537	5
BROCCOLI	149,372	5
TANGERINE (MANDARIN, SATSUMA, MURCOTT, ETC.)	142,396	4
COTTON, GENERAL	106,803	3
PISTACHIO (PISTACHE NUT)	96,166	3
LEMON	66,531	2
CAULIFLOWER	61,315	2
POMEGRANATE (MISCELLANEOUS FRUIT)	56,947	2
STRAWBERRY (ALL OR UNSPEC)	53,111	2
WALNUT (ENGLISH WALNUT, PERSIAN WALNUT)	46,849	1
PEPPERS (FRUITING VEGETABLE), (BELL, CHILI, ETC.)	46,569	1
TOMATO	43,174	1
CANTALOUPE	39,122	1
POTATO (WHITE, IRISH, RED, RUSSET)	34,690	1
SUGARBEET, GENERAL	22,559	0.7

Table 3. Physical and chemical properties of imidacloprid and Specific Numerical Values.

	Mobility Properties		Persistence Properties			
	Water Solubility (mg/L)	Soil Adsorption Coefficient, Koc (cm^3/g)	Hydrolysis Half-life (days)	Aerobic Soil Metabolism Half-life (days)	Anaerobic Soil Metabolism Half-life (days)	Field Studies Half-life (days)
Specific Numerical Values (SNVs)	> 3	< 1,900	> 14	> 610	> 9	-
Imidacloprid[a]	514	132 - 412	> 30	997	27.1	26.5 - 146

a. Pesticide Chemistry Database (CDPR, 2020b).

Table 4. Summary of the 307 well samples for imidacloprid by DPR (CDPR, 2020c).

County	Sampling Date Range	Well Samples	No Detection	Trace* Detection	Quantifiable Detection	Imidacloprid Concentration (ppb)
Fresno	10/21/2003 - 6/1/2020	94	73	9	12	0.051 - 5.97
Kern	11/19/2019	3	3	0	0	-
Madera	6/5/2017 - 6/6/2017	3	3	0	0	-
Modoc	10/27/2015 - 10/6/2016	7	7	0	0	-
Monterey	10/21/2003 - 11/5/2019	72	71	1	0	-
Riverside	3/20/2018 - 3/22/2018	7	7	0	0	-
San Benito	2/23/2009 - 8/23/2019	20	20	0	0	-
San Luis Obispo	11/11/2003 - 11/28/2017	14	14	0	0	-
Santa Barbara	11/4/2003 - 11/15/2019	37	33	3	1	0.103
Santa Clara	8/23/2019	1	1	0	0	-
Siskiyou	10/28/2015	2	2	0	0	-
Tulare	11/4/2003 - 6/28/2017	41	38	1	2	0.074 - 0.124
Ventura	10/22/2003 - 4/4/2018	6	6	0	0	-
Grand Total		**307**	**278**	**14**	**15**	**0.051 - 5.97**

* Trace concentrations = between the method detection limit (0.01 ppb) and the reporting limit (0.05 ppb).

Table 5. Details of imidacloprid detections by DPR and reported agricultural imidacloprid use information for the sections with detections.

County	Location (Meridian-Township/Range-Section)[a]	Number of Wells Sampled	Wells with Positive Imidacloprid Detections[b]					Imidacloprid Use (lbs) 2006-2018	
			Number of Positive Wells	Year Highest Conc Was Detected	Highest Detected Conc (ppb)	Latest Year Detected Section Was Sampled	Detected Conc (ppb) - Latest year	In Section[c]	9-Section[d]
Detections Greater Than Limit of Quantitation (Above Reporting Limit)									
Fresno	15S22E03	2	2	2017	5.97[e]	2020	0.055	75	1,230
Fresno	14S22E31	2	1	2015	0.665[f]	2015	0.665	294	1,926
Fresno	15S24E14	1	1	2016	0.644	2019	ND[g]	702	4,290
Fresno	14S23E35	1	1	2018	0.536	2019	0.47	338	2,311
Fresno	15S21E09	2	1	2017	0.167	2019	ND	420	2,739
Fresno	14S23E34	2	1	2015	0.12	2019	Trace	204	1,721
Fresno	15S21E03	1	1	2020	0.112	2020	0.112	384	4,752
Fresno	14S22E14	2	1	2020	0.106	2020	0.106	138	1,619
Fresno	15S22E06	1	1	2017	0.072	2017	0.072	416	2,704
Fresno	14S23E33	2	1	2015	0.065	2019	ND	34	1,780
Fresno	14S22E02	1	1	2017	0.054	2017	0.054	390	4,796
Santa Barbara	10N34W17	1	1	2017	0.103	2017	0.103	2,559	19,628
Tulare	16S24E12	1	1	2017	0.124	2017	0.124	427	3,542
Tulare	17S25E11	1	1	2017	0.074	2017	0.074	270	4,598
Detections Between Limit of Detection and Limit of Quantitation (Below Reporting Limit)									
Fresno	13S22E33	1	1	2018	Trace[h]	2019	Trace	235	2,195
Fresno	13S23E32	1	1	2017	Trace	2019	ND	346	4,902
Fresno	14S21E13	1	1	2017	Trace	2019	Trace	230	3,281
Fresno	14S22E01	2	2	2017	Trace	2017	Trace	1,187	5,592
Fresno	14S22E18	1	1	2017	Trace	2017	Trace	851	3,956

County	Location (Meridian-Township/Range-Section)[a]	Number of Wells Sampled	Wells with Positive Imidacloprid Detections[b]					Imidacloprid Use (lbs) 2006-2018	
			Number of Positive Wells	Year Highest Conc Was Detected	Highest Detected Conc (ppb)	Latest Year Detected Section Was Sampled	Detected Conc (ppb) - Latest year	In Section[c]	9-Section[d]
Fresno	15S21E09	2	1	2017	Trace	2017	Trace	420	2,739
Fresno	15S23E03	1	1	2017	Trace	2017	Trace	435	2,062
Fresno	15S24E36	1	1	2016	Trace	2017	Trace	730	2,430
Monterey	15S03E09	2	1	2019	Trace	2019	Trace	217	4,945
Santa Barbara	08N33W25	1	1	2019	Trace	2019	Trace	1,271	8,948
Santa Barbara	10N33W20	1	1	2019	Trace	2019	Trace	5,705	13,329
Santa Barbara	10N34W14	1	1	2017	Trace	2017	Trace	1,534	6,008
Tulare	18S26E24	1	1	2017	Trace	2017	Trace	679	5,471

a. Meridian, township, range, and section of the well(s). A section is approximately one square mile.

b. Data in these columns apply only to the wells that have had at least one sample with imidacloprid concentration above the detection limit.

c. Reported agricultural imidacloprid use (pounds, 2006-2018) in the section where the positive well is located.

d. Reported agricultural imidacloprid use (pounds, 2006-2018) in the section where the positive well is located and the surrounding 8 sections.

e. Sampled water appeared murky, and may not reflect the detectable residues in active domestic wells.

f. Well went dry and is no longer sampled.

g. ND = non-detect = below the method detection limit (0.01 ppb).

h. Trace concentrations = between the method detection limit (0.01 ppb) and the reporting limit (0.05 ppb).

Table 6. Summary of wells in the Well Network with imidacloprid detections between 2014 through 2020 (Davalos, 2021).

County	Location (Meridian-Township/Range-Section)[a]	Imidacloprid Concentration[b], ppb							Reported Agricultural Imidacloprid Use (lbs) 2006-2018	
		2014	2015	2016	2017	2018	2019	2020	In Section[c]	9-Section[d]
Fresno	15S22E03	ND[e]	T[f]	ND	5.97[g]	0.095	T	0.053	75	1,230
Fresno	14S22E31	0.059	0.665	Dry	NLS[h]	NLS	NLS	NLS	294	1,926
Fresno	15S24E14	NS[i]	ND	0.644	ND	ND	ND	NS	702	4,290
Fresno	14S23E35	NS	0.218	0.209	0.534	0.536	0.47	0.073	338	2,311
Fresno	15S21E09	T	0.051	0.072	0.167	0.053	ND	NS	420	2,739
Fresno	14S23E34	NS	0.12	0.08	0.09	T	T	NS	204	1,721
Fresno	15S21E03	ND	ND	ND	T	T	T	0.112	384	4,752
Fresno	14S22E14	ND	ND	ND	0.066	0.091	0.085	0.106	138	1,619
Fresno	14S23E33	NS	0.065	ND	ND	ND	ND	NS	34	1,780
Fresno	13S22E33	ND	ND	ND	ND	T	T	ND	235	2,195
Fresno	13S23E32	ND	ND	ND	T	ND	ND	NS	346	4,902
Fresno	14S21E13	ND	ND	ND	T	T	T	ND	230	3,281
Fresno	15S24E36	NS	ND	T	T	NLS	NLS	NS	730	2,430

a. Meridian, township, range, and section of the well(s). A section is approximately one square mile.

b. Data in these columns apply only to the wells that have had at least one sample with imidacloprid concentration above the detection limit using method EMON-SM-05-032.

c. Reported agricultural imidacloprid use (pounds, 2006-2018) in the section where the positive well is located.

d. Reported agricultural imidacloprid use (pounds, 2006-2018) in the section where the positive well is located and the surrounding 8 sections.

e. ND = non-detect = below the method detection limit (0.01 ppb).

f. T = trace concentrations = between the method detection limit (0.01 ppb) and the reporting limit (0.05 ppb).

g. Sampled water appeared murky, and may not reflect the detectable residues in active domestic wells.

h. NLS = no longer sampled as well went dry.

i. NS = Well not sampled.

Table 7. Comparison of imidacloprid concentrations (ppb) on replicate samples using two analytical methods (EMON-SM-13.0 and EMON-SM-05-032).

County	Location (Meridian-Township/Range-Section)[a]	Imidacloprid Concentration (ppb)[b]	
		EMON-SM-13.0	EMON-SM-05-032
Detections Greater Than Limit of Quantitation (Above Reporting Limit)			
Fresno	14S22E02	0.054	0.054
Fresno	14S23E34	ND[c]	0.080
Fresno	14S23E35	0.238	0.209
Fresno	15S21E09	0.066	0.072
Fresno	15S22E06	0.067	0.072
Santa Barbara	10N34W17	0.103	0.104
Tulare	16S24E12	0.124	0.105
Tulare	17S25E11	0.069	0.074
Detections Between Limit of Detection and Limit of Quantitation (Below Reporting Limit)			
Fresno	14S22E01	Trace[d]	Trace
Fresno	14S22E01	Trace	Trace
Fresno	14S22E18	Trace	ND
Fresno	15S21E09	Trace	Trace
Fresno	15S22E03	Trace	ND
Fresno	15S23E03	Trace	ND
Tulare	18S26E24	Trace	ND

a. Meridian, township, range, and section of the well(s). A section is approximately one square mile.

b. Imidacloprid was not detected in forty-four other wells analyzed using both methods.

c. ND = non-detect = below the method detection limit (0.01 ppb).

d. Trace concentrations = between the method detection limit (0.01 ppb) and the reporting limit (0.05 ppb).

Table 8. Imidacloprid detections, Ground Water Protection Area details, and reported agricultural imidacloprid use information for the sections with detections.

County	Location (Meridian-Township/Range-Section)[a]	Wells with Positive Imidacloprid Detections[b]				Reported Agricultural Imidacloprid Use (lbs) (2006 - 2018)	
		Highest Detected Conc (ppb)	GWPA	GWPA Pathway	Soil Condition	In Section[c]	9-Section[d]
Detections Greater Than Limit of Quantitation (Above Reporting Limit)							
Fresno	15S22E03	5.97[e]	Yes	Leaching	Coarse-Textured	75	1,230
Fresno	14S22E31	0.665[f]	Yes	Leaching	Coarse-Textured	294	1,926
Fresno	15S24E14	0.644	Yes	Runoff	Medium-Coarse-Textured + Hardpan	702	4,290
Fresno	14S23E35	0.536	Yes	Runoff	Not Classified	338	2,311
Fresno	15S21E09	0.167	Yes	Leaching	Coarse-Textured	420	2,739
Fresno	14S23E34	0.12	Yes	Leaching	Coarse-Textured	204	1,721
Fresno	15S21E03	0.112	Yes	Leaching	Coarse-Textured	384	4,752
Fresno	14S22E14	0.106	Yes	Runoff	Medium-Coarse-Textured + Hardpan	138	1,619
Fresno	15S22E06	0.072	Yes	Leaching	Coarse-Textured	416	2,704
Fresno	14S23E33	0.065	Yes	Leaching	Coarse-Textured	34	1,780
Fresno	14S22E02	0.054	Yes	Runoff	Medium-Textured + Hardpan	390	4,796
Santa Barbara	10N34W17	0.103	No	NA	No Soil or DGW Data	2,559	19,628
Tulare	16S24E12	0.124	Yes	Runoff	Medium-Textured + Hardpan	427	3,542
Tulare	17S25E11	0.074	Yes	Runoff	Medium-Fine-Textured + Hardpan	270	4,598
Detections Between Limit of Detection and Limit of Quantitation (Below Reporting Limit)							
Fresno	13S22E33	Trace[g]	Yes	Leaching	Coarse-Textured	235	2,195
Fresno	13S23E32	Trace	Yes	Runoff	Medium-Fine-Textured + Hardpan	346	4,902

County	Location (Meridian-Township/Range-Section)[a]	Wells with Positive Imidacloprid Detections[b]				Reported Agricultural Imidacloprid Use (lbs) (2006 - 2018)	
		Highest Detected Conc (ppb)	GWPA	GWPA Pathway	Soil Condition	In Section[c]	9-Section[d]
Fresno	14S21E13	Trace	Yes	Runoff	Medium-Textured + Hardpan	230	3,281
Fresno	14S22E01	Trace	Yes	Runoff	Medium-Coarse-Textured + Hardpan	1,187	5,592
Fresno	14S22E18	Trace	Yes	Runoff	Medium-Textured + Hardpan	851	3,956
Fresno	15S21E09	Trace	Yes	Leaching	Coarse-Textured	420	2,739
Fresno	15S23E03	Trace	Yes	Runoff	Medium-Coarse-Textured + Hardpan	435	2,062
Fresno	15S24E36	Trace	Yes	Runoff	Medium-Textured + Hardpan	730	2,430
Monterey	15S03E09	Trace	No	NA	Fine-Textured	217	4,945
Santa Barbara	08N33W25	Trace	No	NA	No Soil or DGW Data	1,271	8,948
Santa Barbara	10N33W20	Trace	No	NA	No Soil or DGW Data	5,705	13,329
Santa Barbara	10N34W14	Trace	No	NA	No Soil or DGW Data	1,534	6,008
Tulare	18S26E24	Trace	Yes	Runoff	Medium-Coarse-Textured + Hardpan	679	5,471

a. Meridian, township, range, and section of the well(s). A section is approximately one square mile.

b. Data in these columns apply only to the wells that have had at least one sample with imidacloprid concentration above the detection limit.

c. Reported agricultural imidacloprid use (pounds, 2006-2018) in the section where the positive well is located.

d. Reported agricultural imidacloprid use (pounds, 2006-2018) in the section where the positive well is located and the surrounding 8 sections.

e. Sampled water appeared murky, and may not reflect the detectable residues in active domestic wells.

f. Well went dry and is no longer sampled.

g. Trace concentrations = between the method detection limit (0.01 ppb) and the reporting limit (0.05 ppb).

Table 9. Groundwater monitoring for imidacloprid by other agencies in California or in other locations.

Place	Number of Wells Sampled	Number of Positive Wells	Range or Maximum Concentration (ppb)
In USA			
California[a]	303	4	0.005 - 0.091
Wisconsin[b]	1840	202	4.54
Minnesota[c]	2164	168	2.26
New York[d]	174	174	407
Outside USA			
Canada[e]	77	44	6.10
Brazil[f]	12	8	6.22
Australia[g]	7	2	1.50
Pakistan[h]	72	3	0.83
Vietnam[i]	8	5	1.53

a. Detections reported to DPR. CDPR, 2020c.

b. Bradford et al., 2018.

c. Minnesota Department of Agriculture, 2019.

d. New York State Department of Environmental Conservation, 2014.

e. Giroux and Sarrasin, 2011.

f. Bortoluzzi et al., 2007.

g. Masters et al., 2014.

h. Baig et al., 2012.

i. Lamers et al., 2011.

APPENDIX 1

Figure A1-1. Annual reported agricultural imidacloprid use and acres treated in Kern County from 2006 to 2018 (CDPR, 2020a).

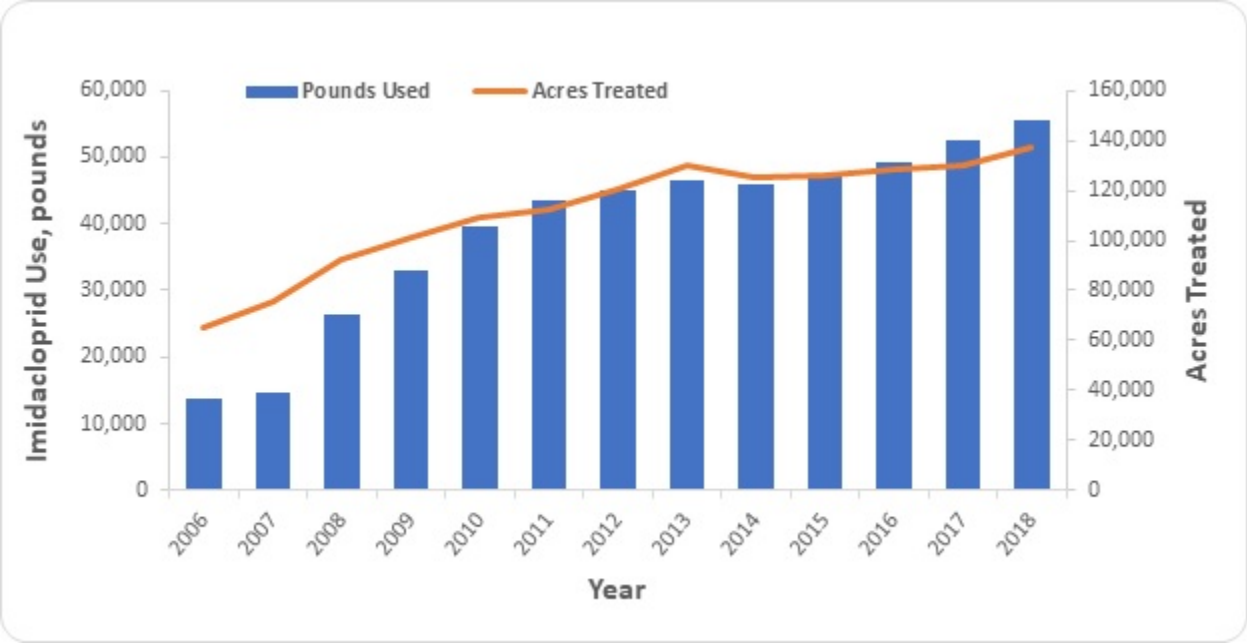


Figure A1-2. Annual reported agricultural imidacloprid use and acres treated in Madera County from 2006 to 2018 (CDPR, 2020a).

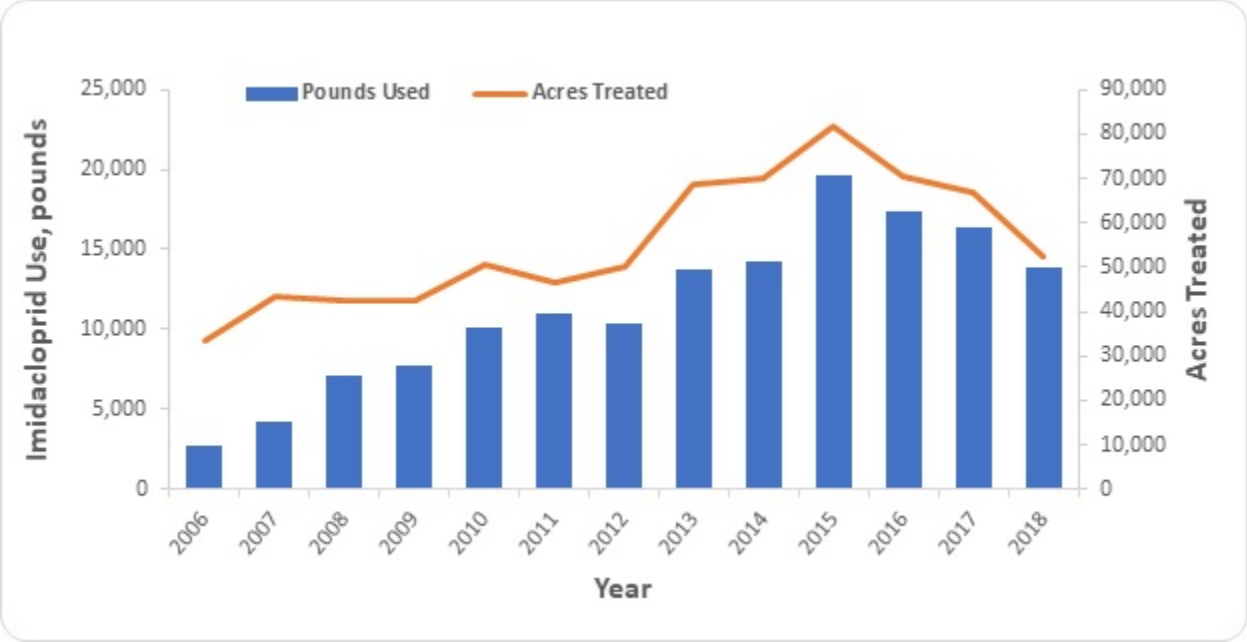


Figure A1-3. Annual reported agricultural imidacloprid use and acres treated in Monterey County from 2006 to 2018 (CDPR, 2020a).

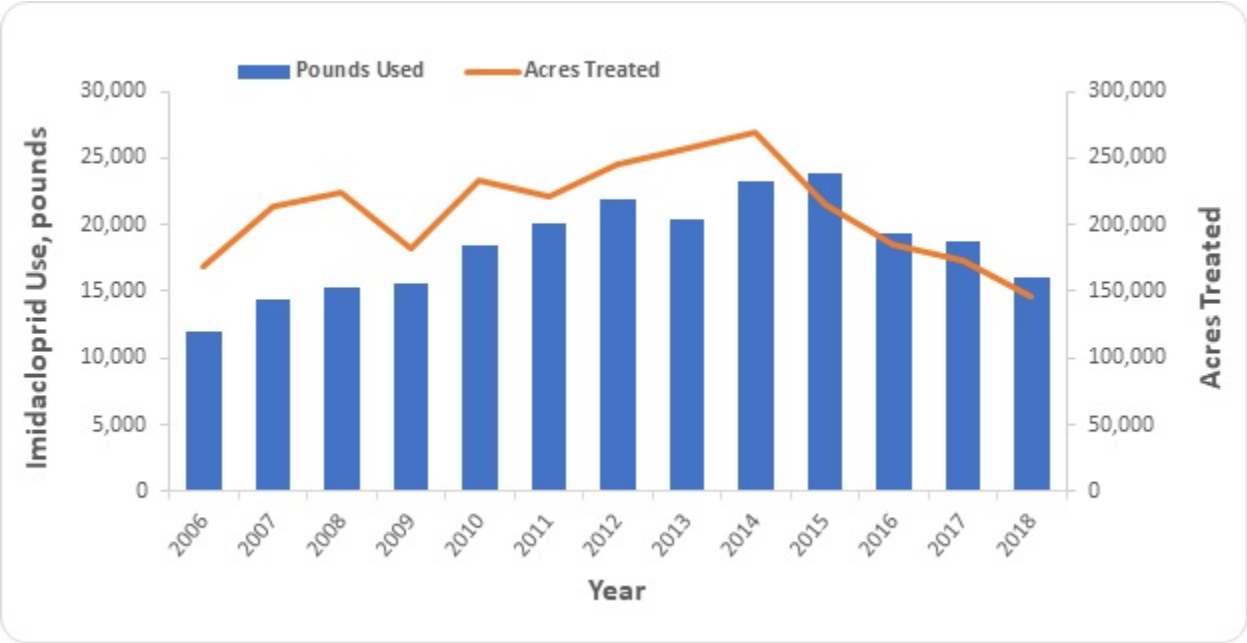
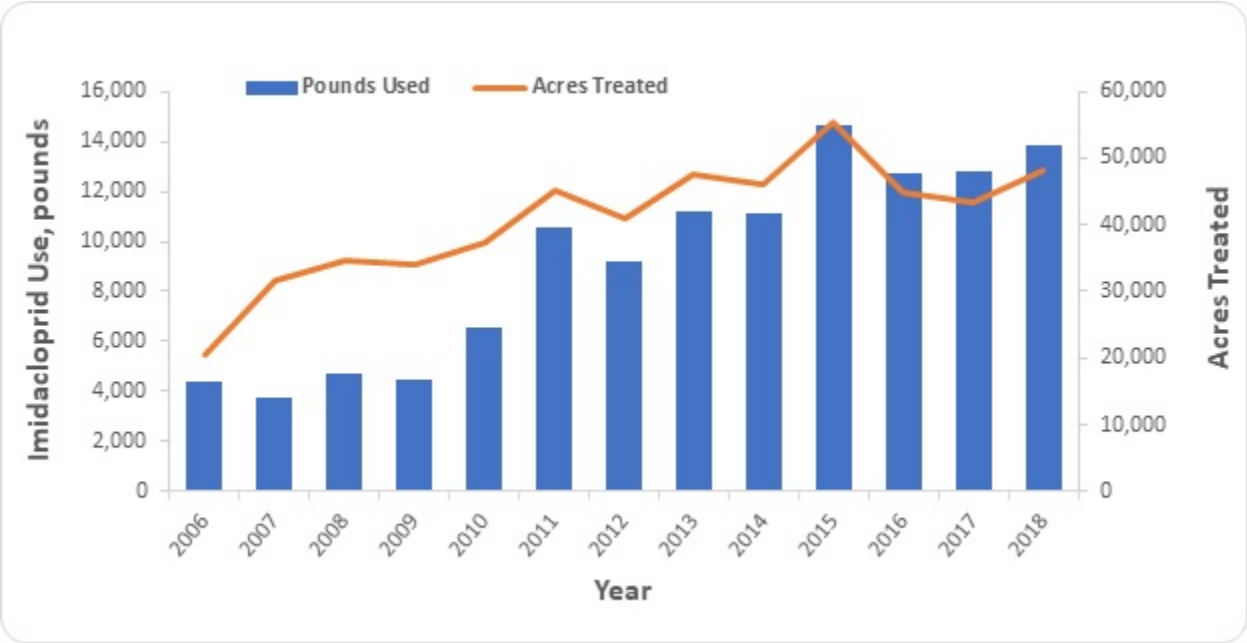


Figure A1-4. Annual reported agricultural imidacloprid use and acres treated in San Luis Obispo County from 2006 to 2018 (CDPR, 2020a).



APPENDIX 2

Figure A2-1. Total reported agricultural imidacloprid use (pounds per section) from 2006 to 2018 and DPR sampled wells in western Fresno and Madera counties (CDPR, 2020a).

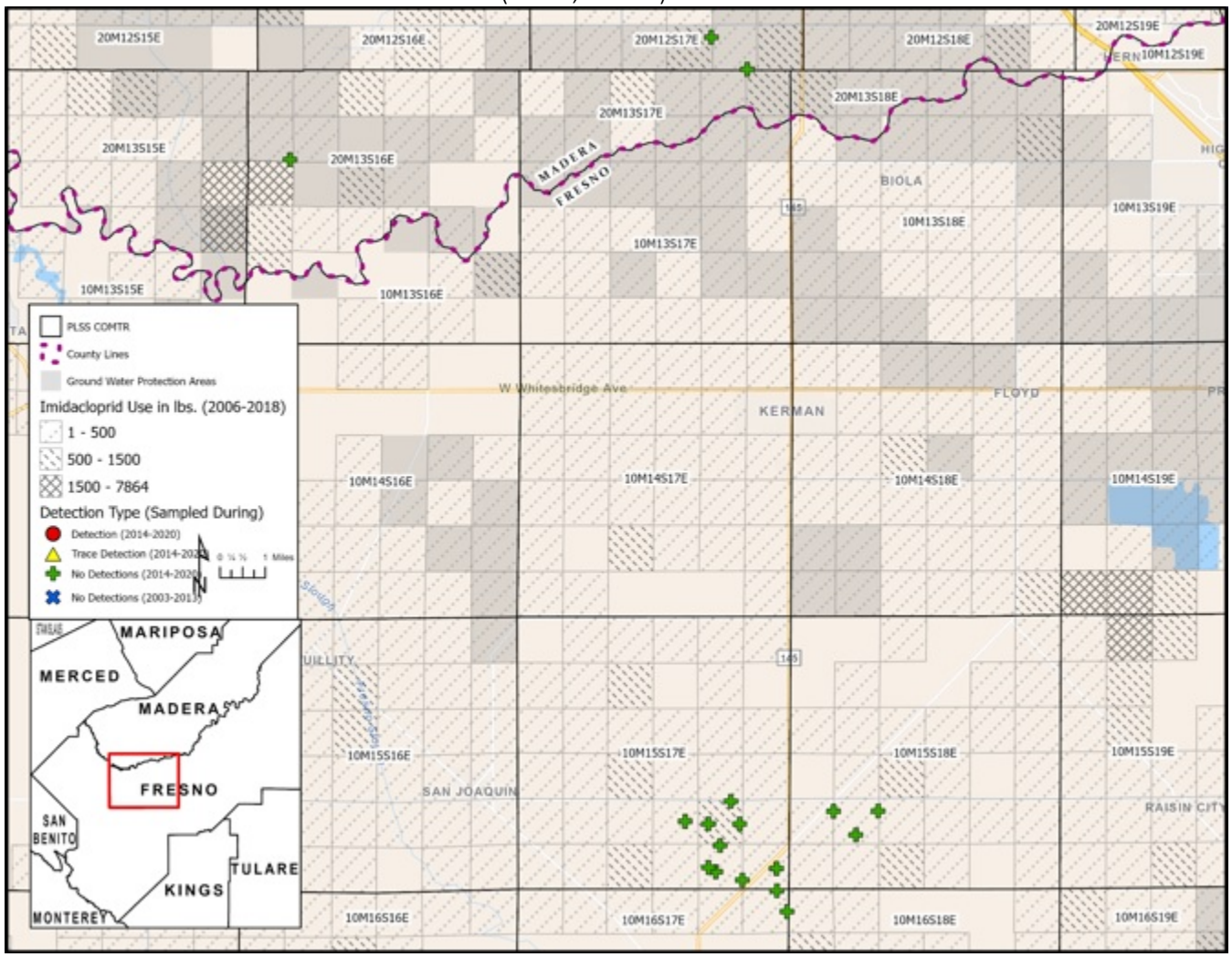


Figure A2-2. Total reported agricultural imidacloprid use (pounds per section) from 2006 to 2018 and DPR sampled wells in Kern County (CDPR, 2020a).

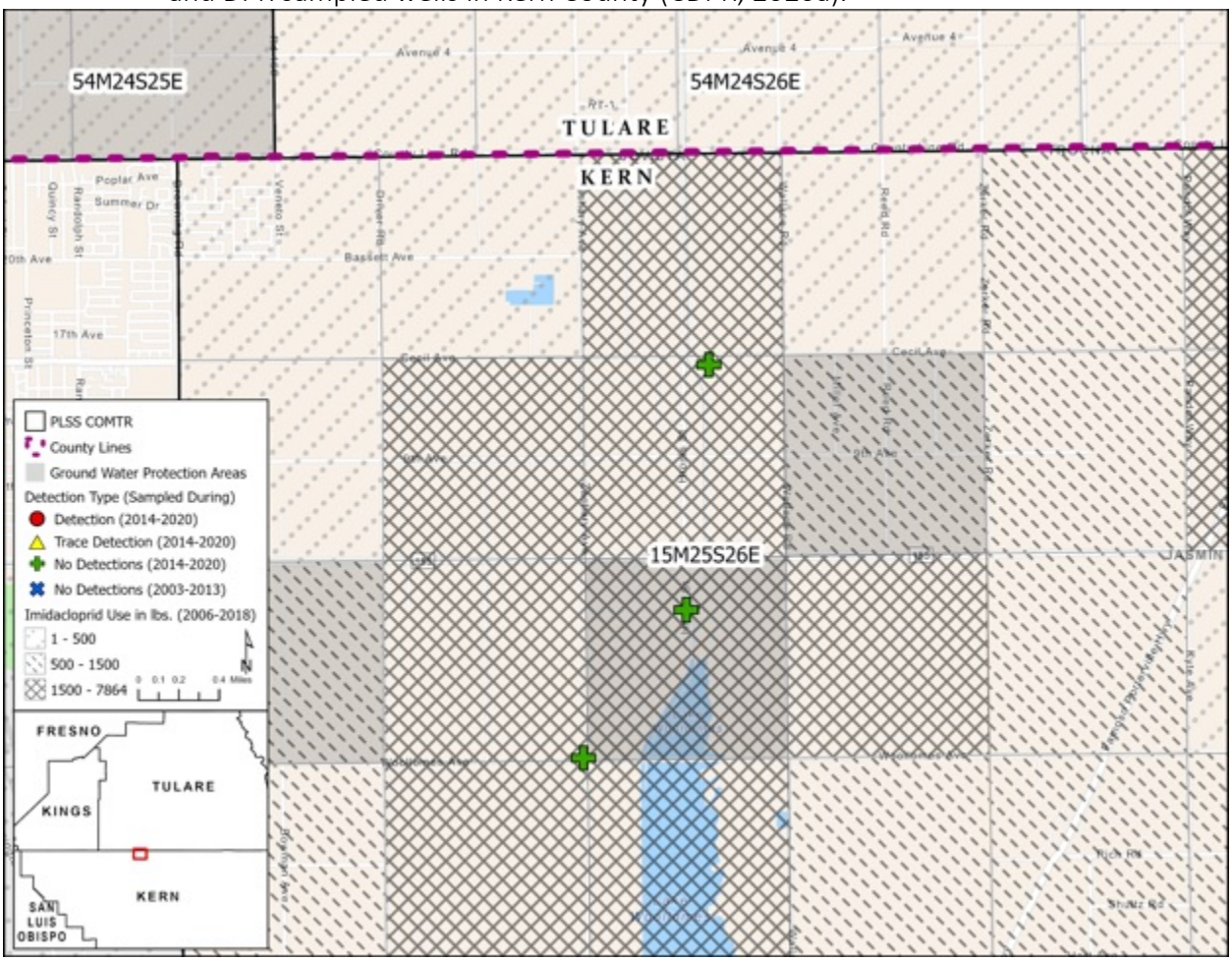


Figure A2-3. Total reported agricultural imidacloprid use (pounds per section) from 2006 to 2018 and DPR sampled wells in Modoc and Siskiyou counties (CDPR, 2020a).

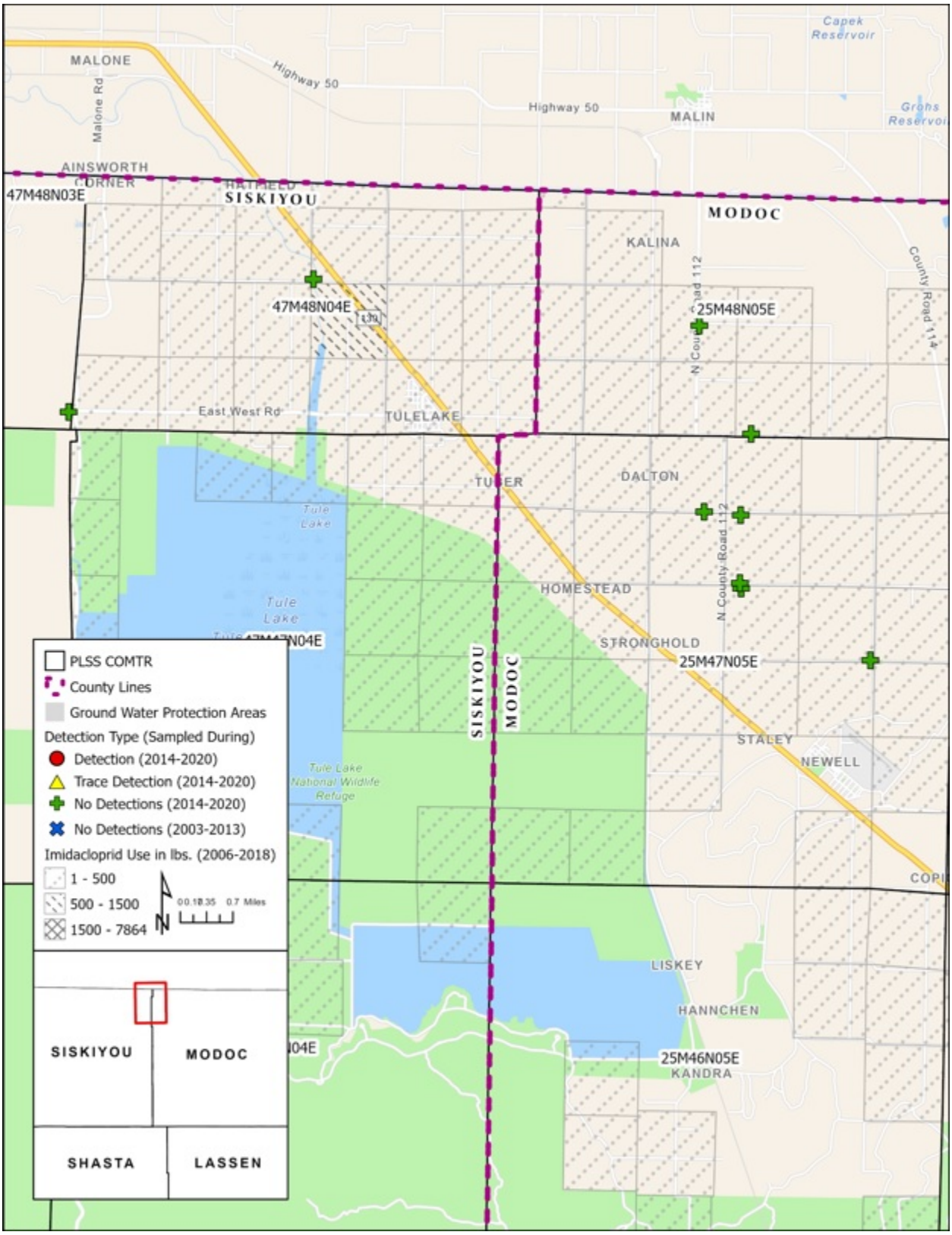


Figure A2-4. Total reported agricultural imidacloprid use (pounds per section) from 2006 to 2018 and DPR sampled wells in northern Monterey, San Benito, and Santa Clara counties (CDPR, 2020a).

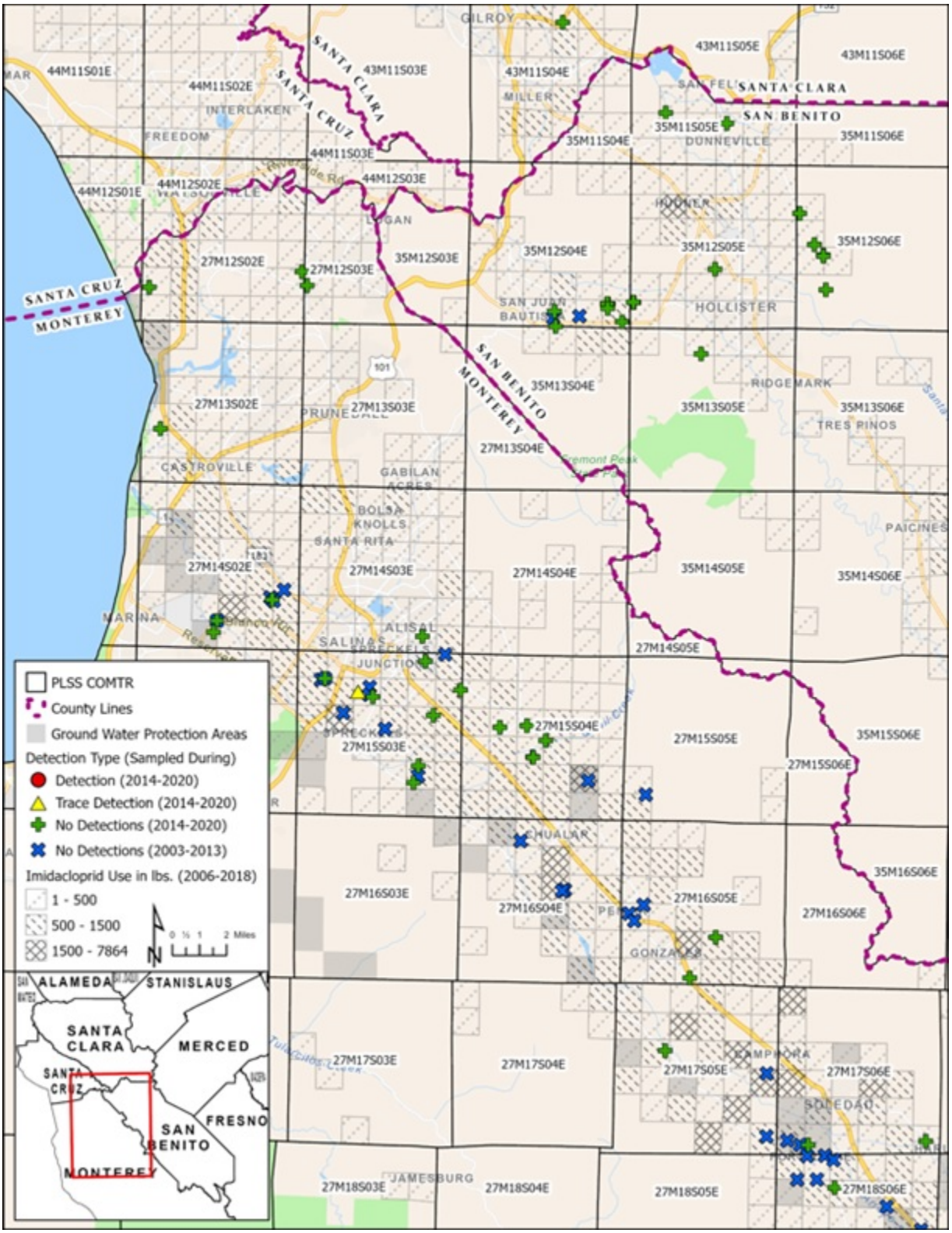


Figure A2-5. Total reported agricultural imidacloprid use (pounds per section) from 2006 to 2018 and DPR sampled wells in southern Monterey County (CDPR, 2020a).

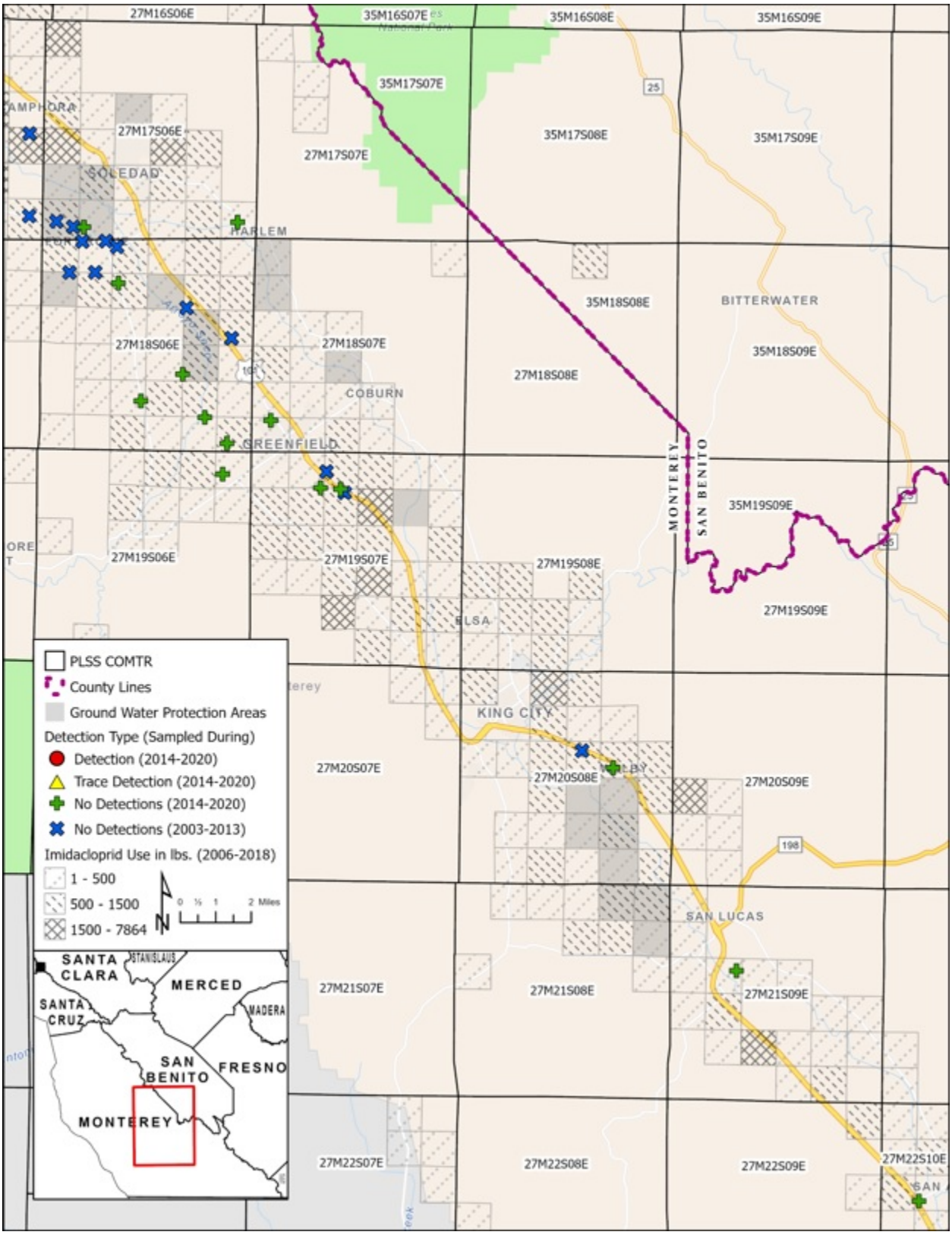


Figure A2-6. Total reported agricultural imidacloprid use (pounds per section) from 2006 to 2018 and DPR sampled wells in Riverside County (CDPR, 2020a).

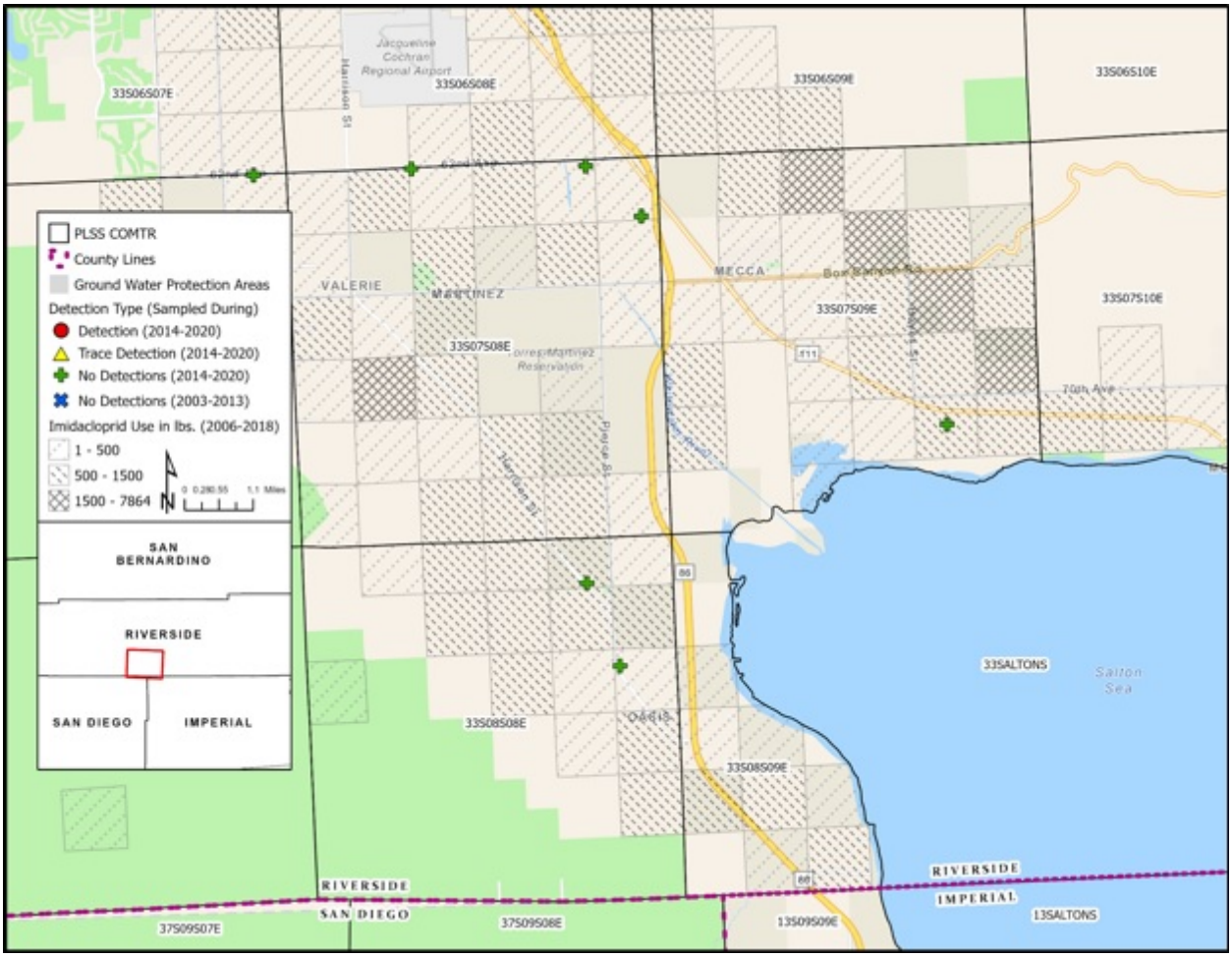


Figure A2-7. Total reported agricultural imidacloprid use (pounds per section) from 2006 to 2018 and DPR sampled wells in San Luis Obispo County (CDPR, 2020a).

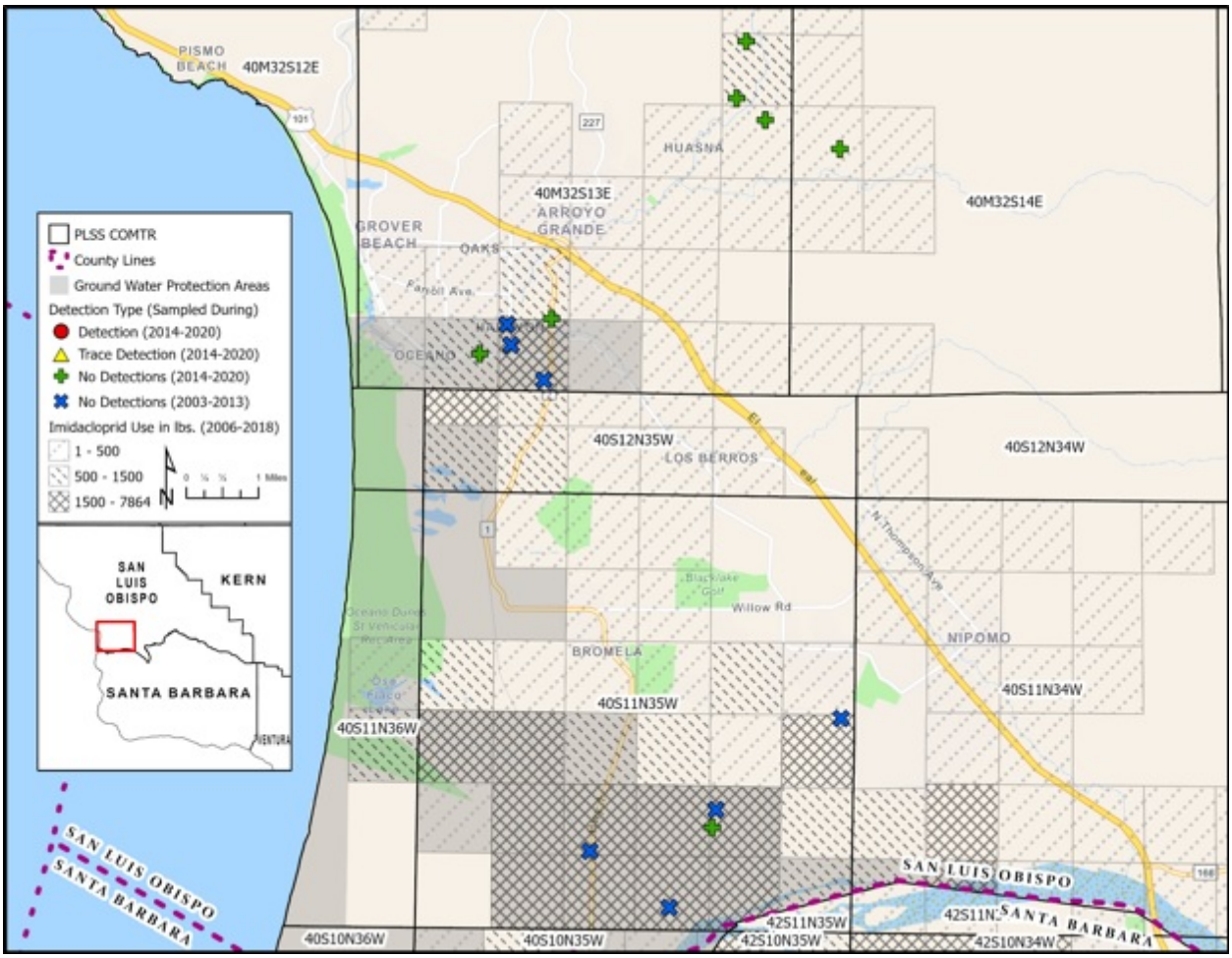


Figure A2-8. Total reported agricultural imidacloprid use (pounds per section) from 2006 to 2018 and DPR sampled wells in Ventura County (CDPR, 2020a).