PESTICIDE USE ANNUAL REPORT

2023 Data Summary

California Department of Pesticide Regulation
P.O. Box 4015 Sacramento, CA 95812-4015

STATE OF CALIFORNIA
GAVIN NEWSOM, GOVERNOR

CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY
YANA GARCIA, SECRETARY FOR ENVIRONMENTAL PROTECTION

DEPARTMENT OF PESTICIDE REGULATION
KAREN MORRISON, DIRECTOR

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Year in Summary

Overview:

Reported pesticide use for California in 2023 totaled 176 million pounds of applied active ingredients (AIs) and 98 million acres treated. Thirteen percent of the pounds applied and 29 percent of the acres treated were adjuvants[1]. Since 2022, pounds applied of AIs decreased by six million pounds (3 percent decrease), while the acres treated increased by six million acres (6 percent increase).

Pesticide trends are reported by category based on the type of pesticide (e.g., biopesticide) or potential to cause health or environmental impacts (e.g., carcinogen). Biopesticides and petroleum/mineral oils are considered to be lower-risk to human health and the environment. Most oil pesticides used in California serve as alternatives to more toxic pesticides. Some highly refined petroleum-based oils are used by organic growers. Higher-risk categories include carcinogens, cholinesterase inhibitors, fumigants, groundwater contaminants, reproductive toxins, and toxic air contaminants.

2022 to 2023 Changes: The pounds applied and acres treated with biopesticides increased from 2022 to 2023. The pounds applied with oils decreased, while the acres treated with oils increased. Higher-risk pesticides characterized as fumigants, groundwater contaminants, and toxic air contaminants decreased in both pounds applied and acres treated. Cholinesterase inhibitors increased in pounds applied and acres treated, while carcinogens and reproductive toxins decreased in pounds applied but increased in acres treated (Table 1).

Table 1. Annual change in pounds applied and acres treated of pesticides characterized as biopesticides, oils, carcinogens, cholinesterase inhibitors, groundwater contaminants, fumigants, reproductive toxins, and toxic air contaminants from 2022 to 2023.

Category	Change in Pounds Applied	Percent Change Pounds	Change in Acres Treated	Percent Change Acres
Biopesticides	↑ 338,442	4	↑ 473,032	6
Oils	↓ -6,559,051	-19	↑ 132,346	3
Carcinogens	↓ -2,033,643	-6	↑ 396,746	6
Cholinesterase Inhibitors	↑ 132,662	5	↑ 51,639	3
Fumigants	↓ -3,278,535	-9	↓ -13,951	-7
Groundwater Contaminants	↓ -66,553	-34	↓ -62,679	-25
Reproductive Toxins	↓ -824,999	-13	↑ 7,541	0.2
Toxic Air Contaminants	↓ -3,606,968	-9	↓ -241,599	-13

[1] An adjuvant is broadly defined as any non-pesticide material used with a pesticide product or pesticide spray mixture to improve the pesticide's performance or the physical properties of the spray mixture (Examples: spreader stickers, surfactants, oils, buffering agents, etc.). California law requires registration of adjuvants, which are not considered pesticides under federal law.

Long Term Trends: Evaluating pesticide use trends spanning multiple years provides a broader overview of changes and trends in pesticide use compared to annual changes that can vary from one year to the next based on short-term conditions such as weather, water availability, changes in pricing and supply, and other factors. Since 2014, acres treated with lower-risk biopesticides and oils increased by 38 and 9 percent, respectively, while use of higher-risk categories decreased by at least 24 percent, and up to 66 percent. The pounds applied of biopesticides during this ten-year period increased by 46 percent, while pounds of oils decreased by 7 percent and higher-risk pesticide categories decreased by at least 22 percent and up to 81 percent (Table 2).

Table 2. Long-term change in pounds applied and acres treated of pesticides characterized as biopesticides, oils, carcinogens, cholinesterase inhibitors, groundwater contaminants, fumigants, reproductive toxins, and toxic air contaminants from 2014 to 2023.

Category	Change in Pounds Applied	Percent Change Pounds	Change in Acres Treated	Percent Change Acres
Biopesticides	2,762,494	46	2,204,926	38
Oils	-1,992,267	-7	418,079	9
Carcinogens	-9,480,961	-23	-2,246,969	-24
Cholinesterase Inhibitors	-1,938,648	-42	-1,913,135	-48
Fumigants	-8,955,517	-22	-137,479	-43
Groundwater Contaminants	-562,489	-81	-368,909	-66
Reproductive Toxins	-4,587,476	-45	-1,851,035	-36
Toxic Air Contaminants	-11,605,152	-25	-1,886,880	-53

The AIs with the highest total reported pounds applied in 2023 were sulfur (fungicide/insecticide), petroleum and mineral oils (fungicide/insecticide), glyphosate (herbicide), potassium N-methyldithiocarbamate ("metam-potassium," fumigant), and chloropicrin (fumigant). Fungicide/insecticide AIs have both fungicidal and insecticidal activity, although they may be used solely as a fungicide or an insecticide depending on the crop. The AIs with the highest reported acres treated in 2023 were glyphosate, petroleum and mineral oils, sulfur, lambda-cyhalothrin (insecticide), and chlorantraniliprole (insecticide). References to glyphosate, 2,4-D, *Bacillus thuringiensis,* copper, and oils throughout the report are summations of all related salts, esters, subspecies/strains, or other closely related chemical derivatives.

2023 TOP FIVE

Top 5 AIs by Pounds Applied

- Sulfur
- Oils
- Glyphosate
- Metam-potassium
- Chloropicrin

Top 5 AIs by Acres Treated

- Glyphosate
- Oils
- Sulfur
- Lambda-cyhalothrin
- Chlorantraniliprole

Pesticide Use Measures

This report focuses on two different measures of pesticide use: pounds of AI applied and acres treated. Pesticide use trends measured in pounds applied tend to be driven by pesticides with large application rates, such as sulfur, oil, or fumigants. Trends reported in acres treated focus more on widespread use weighted by the number of applications. By considering the use factors and data trends for both measures together, it is possible to get a more nuanced understanding of how pesticide use changes over time.

Pounds of AI applied: While most pesticides are applied at rates of one to two pounds per acre, some may be as low as a few ounces or as high as hundreds of pounds per acre. When comparing use among different AIs, pounds applied will emphasize pesticides used at high rates, such as sulfur, kaolin clay, oils, and fumigants.

Acres treated: The acres treated is the cumulative sum of the acres treated with an AI (applications reported in square feet are converted to acres). The acres treated measure is often greater than the total planted acreage due to multiple applications being made to the same area during a given year. For example, if a one-acre field is treated with an AI three times in a year, then the cumulative acres treated for the year is three acres, although the field itself is only one acre.

As a pesticide use measure, acres treated reflects application frequency and geographic coverage and is not influenced by high application rates that drive rankings by pounds applied. It is limited as a use measure, however, in that it is only a partial representation of the total pesticide use reported: Only applications reported with units of acres or square feet are included in the total. Applications with volume or weight units cannot be converted to acres so they are excluded. In addition, acres treated is not required for some non-agricultural (NonAg) pesticide use reports (PURs) such as structural and other types of urban uses, so these pesticide applications are not included in acres treated totals (For more information about agricultural and non-agricultural pesticide uses, see the "Agricultural (Ag) versus Nonagricultural (NonAg) Pesticide Uses" section of the Pesticide Use Annual Report Data Access, References, and Definitions Guide.

DID YOU KNOW?

Pesticide use trends may differ depending on what "pesticide use metric" is used to measure pesticide use. Pesticide use metrics include *pounds applied, acres treated, and application counts.*

Pounds applied is a use metric that tends to be driven by pesticides with high application rates, such as oil, sulfur, kaolin clay, and fumigants. These pesticides will top most lists when pesticide use is measured by pounds applied.

Acres Treated and **Application Counts** are not influenced by high application rates but are not available for all types of pesticide use. The legal requirements for certain types of NonAg PURs do not require acres treated or application counts to be reported.

Analyzing trends using multiple pesticide use metrics can offer a more nuanced, complete understanding of pesticide use.

The number of applications can also be a useful measure of pesticide use; however, its utility is limited because of inconsistencies in reporting methodologies for NonAg use and because it is not

required for structural use reporting. For Agricultural (Ag) use, each PUR represents a single application. Whereas for NonAg use, each PUR is a monthly summary of all the applications of a single product on a specific type of application site. Inconsistency in NonAg use reporting arises because there is not a standardized definition for what is to be considered as a single application, as opposed to the standard, quantified definitions that exist for a single acre or a single pound. The user-interpreted definition of a single application in NonAg use can therefore vary greatly among different pesticide applicators or businesses. For example, one business may treat an apartment building for termites and consider the building application as a whole to be a single application, while another business may treat a similar apartment building but consider each room in the building to be a single application. The differences in the user-interpreted definition of a single application result in large variation in the total number of applications for very similar pesticide applications of NonAg pesticide uses. As a result, application counts for agricultural uses are included in some of the larger tables available on the Annual Report website but are rarely used in Annual Report graphs or discussion.

The trends in use for a single AI will usually follow similar patterns of increases or decreases for both pounds applied and acres treated. However, when pounds applied and acres treated move in different directions for one AI, it is often due to fluctuations in NonAg uses of the AI which do not legally have to report acreage, or it could be from a change in use of products with higher or lower percentage concentration of the AI.

Data Summary

This report is a snapshot summary based on 2023 data submitted to DPR as of September 19, 2024. The PUR data is continually updated, so this snapshot summary may not fully correlate to later PUR data queries, including those from the California Pesticide Information Portal (CalPIP, an online query tool), that contain record corrections made after September 19, 2024.

Since 1990, the reported pounds applied of pesticides and acres treated have fluctuated from year to year. These fluctuations can be attributed to a variety of factors, including:

- New regulations,
- Changes in planted acreage,
- Types of crops planted,
- Changes in pricing and supply,
- Changes in pest management practices,
- Pest pressures, and
- Weather conditions.

An increase or decrease in use, from one year to the next or in the span of a few years, may not necessarily indicate a general use trend, but rather may represent variations related to changes in weather, pricing, supply of raw ingredients, or regulations. Regression analysis on pounds of AI since 1990 does not indicate a significant trend of either increase or decrease in total pesticide use. However, there can be significant changes in the types of

pesticides that makeup the statewide total, such as changes in the use of AIs with higher- or lower-risk to human health or the environment. See the Evaluating Risk chapter of the Pesticide Use Annual Report History and Background document for more information on the relationship between use amounts and risk.

Trends by Use Type

Pesticide use can be classified into broad use types based on the overall generalized pest categories targeted by the pesticide. Examples of use types include herbicides (for treating various weeds); insecticides, including miticides (for treating many arthropod pests); fungicides (for treating assorted fungal diseases); and many more. The PUR data does not include information on the pest targeted by any individual pesticide application, which can make it difficult to determine the intended use type. Trends were analyzed for the most common use types: insecticides, fungicides, fungicide/insecticides, herbicides, and fumigants. Given the high reported use of sulfur, oils, and other similar AIs which have both fungicidal and insecticidal activity, the fungicide/insecticide category was created. "Fumigant" is technically an application method rather than a use type, often spanning multiple target pest categories, such as a soil fumigant that treats insect, fungal disease, nematodes, and weeds.

Figures 1 and 2 measure six pesticide use types:

- Fungicides,
- Insecticides (including miticides),
- Fungicide/Insecticides (pesticides with both fungicide and insecticide/miticide properties, such as sulfur and some oils),
- Fumigants,
- Herbicides, and
- Other (all remaining pesticide types that did not have significant enough amounts used to warrant their own graph trend line).

Fumigants and fungicide/insecticides typically have high application rates, and therefore ranked high in use at the top of the graph when measured by pounds applied (Figure 1) but ranked near the bottom of the graph when measured by acres treated (Figure 2) due to less widespread use compared to other types of pesticides and a lack of acre treated values when the fumigant is a NonAg pesticide use such as structural termite control or commodity fumigations.

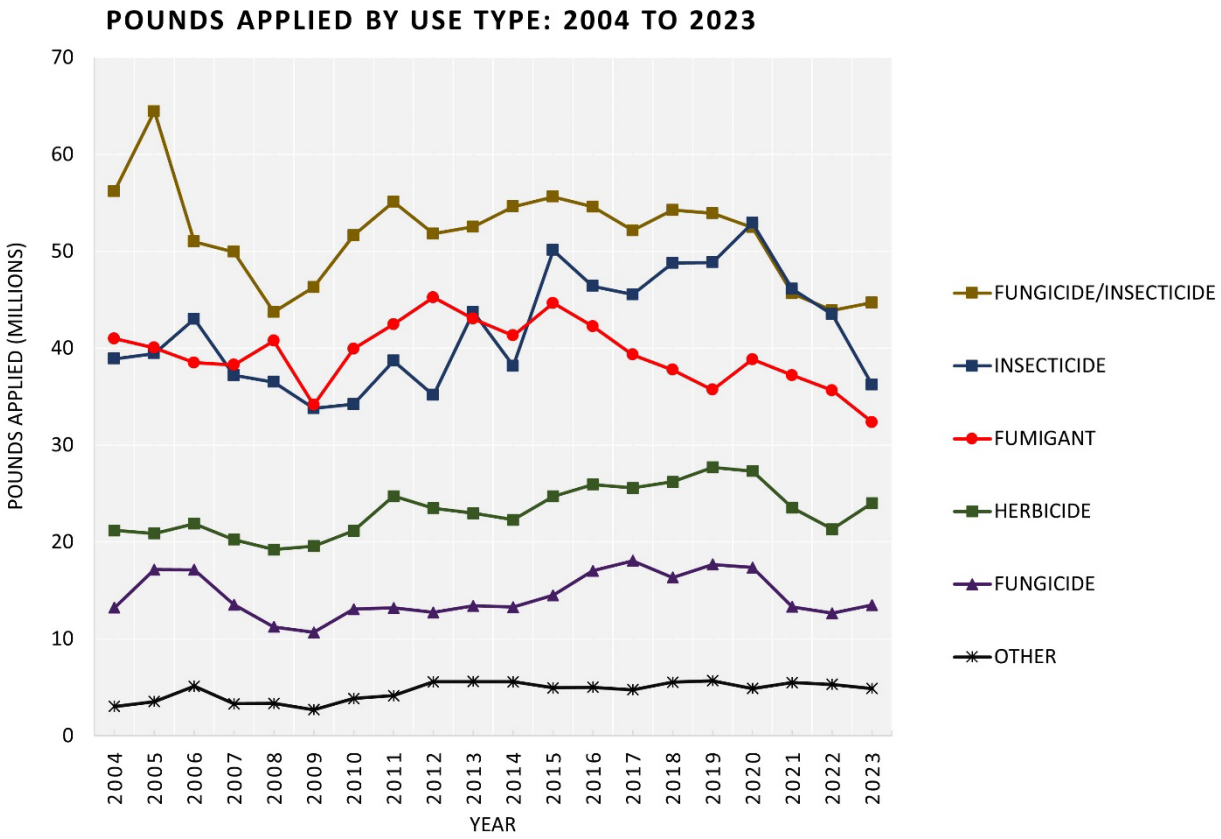


Figure 1. Pounds applied of all AIs in the major types of pesticides from 2004 to 2023, where "Other" includes pesticides such as plant growth regulators, bactericides, harvest aids, rodenticides, molluscicides, algaecides, repellents, antimicrobials, antifoulants, disinfectants, and biocides.

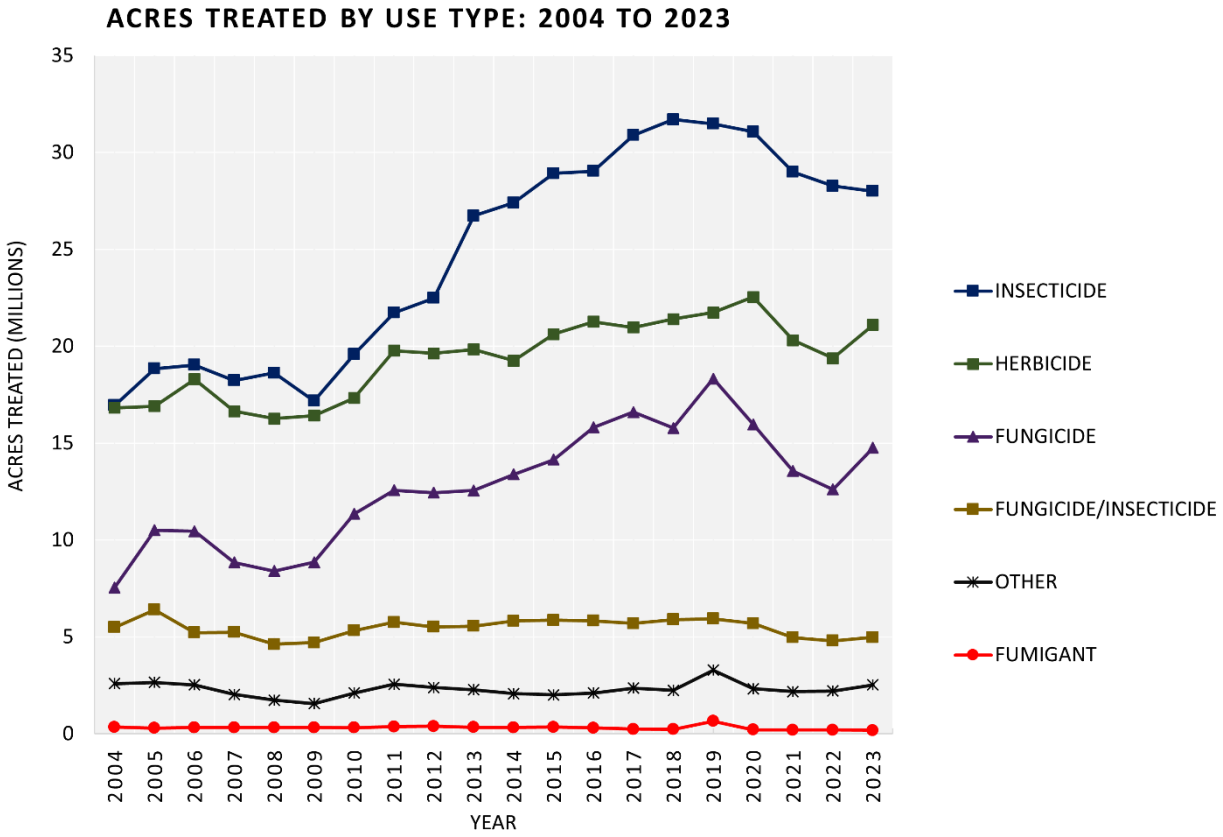


Figure 2. Acres treated by all AIs in the major types of pesticides from 2004 to 2023, where "Other" includes pesticides such as plant growth regulators, bactericides, harvest aids, rodenticides, molluscicides, algaecides, repellents, antimicrobials, antifoulants, disinfectants, and biocides.

The top five AIs for each use type by acres treated and pounds applied are detailed below.

Insecticide (including miticide)

Petroleum and mineral oils ("oil") used in insecticides ranked highest when measured by either acres treated or by pounds applied. The pyrethroid lambda-cyhalothrin, the anthranilic diamide chlorantraniliprole, the botanical miticide/insecticide abamectin, and the diacylhydrazine insect growth regulator methoxyfenozide were the remaining four of the top five insecticide AIs by acres treated. The inorganic boric acid, methoxyfenozide, the microbial *Bacillus thuringiensis*, and the inorganic diatomaceous earth made up the remainder of the top five insecticides measured by pounds applied (Figures 3a and b, Table 3, and Table 4).

Table 3. Top five insecticides in California by acres treated for 2023.

Top Five	Acres Treated
Oil	4,830,104
Lambda-Cyhalothrin	2,846,462
Chlorantraniliprole	2,216,082
Abamectin	2,065,853
Methoxyfenozide	1,972,902

Table 4. Top five insecticides in California by pounds applied for 2023.

Top Five	Pounds Applied
Oil	28,249,595
Boric Acid	744,573
Methoxyfenozide	594,707
Bacillus thuringiensis	554,968
Diatomaceous Earth	536,837

Fungicide

The inorganic fungicide copper was the most used fungicide when ranked by either acres treated or pounds applied. The strobilurin azoxystrobin, the azole difenoconazole, the strobilurin pyraclostrobin, and the pyradine fluopyram comprised the remaining four of the top five fungicides by acres treated. The inorganic potassium phosphite, the substituted benzene chlorothalonil, and the carbamates mancozeb and ziram made up the remainder of the top five fungicides by pounds applied (Figures 3a and b, Table 5, and Table 6).

Table 5. Top five fungicides in California by acres treated for 2023.

Top Five	Acres Treated
Copper	1,606,590
Azoxystrobin	1,601,606
Difenoconazole	1,012,180
Pyraclostrobin	1,009,927
Fluopyram	765,200

Table 6. Top five fungicides in California by pounds applied for 2023.

Top Five	Pounds Applied
Copper	5,639,635
Potassium Phosphite	1,305,483
Chlorothalonil	1,194,970
Mancozeb	773,398
Ziram	432,295

Fungicide/Insecticide

The category fungicide/insecticide includes a number of AIs which are used to control insects, mites, and fungal diseases. Sulfur represents most of the use in this category, with relatively minimal use of the remaining four of the top five AIs. Three inorganic AIs—sulfur, lime-sulfur, and the biopesticide kaolin clay ("kaolin")—ranked in the top five when measured by either acres treated or by pounds applied. The botanicals margosa oil and clarified hydrophobic extract of neem oil ("neem oil") made up the remaining AIs in the top five when measured by acres treated. The inorganic AIs disodium octaborate tetrahydrate and sodium tetraborate decahydrate—two AIs found in various insecticide, fungicide, or antimicrobial products—were the remaining AIs in the top five by pounds applied (Figures 3a and b, Table 7, and Table 8).

Table 7. Top five fungicide/insecticides in California by acres treated for 2023.

Top Five	Acres Treated
Sulfur	4,755,654
Lime-Sulfur	108,845
Kaolin	91,482
Margosa Oil	45,262
Neem Oil	22,585

Table 8. Top five fungicide/insecticides in California by pounds applied for 2023.

Top Five	Pounds Applied
Sulfur	39,751,726
Kaolin	3,290,868
Lime-Sulfur	1,167,299
Disodium Octaborate Tetrahydrate	234,126
Sodium Tetraborate Decahydrate	116,671

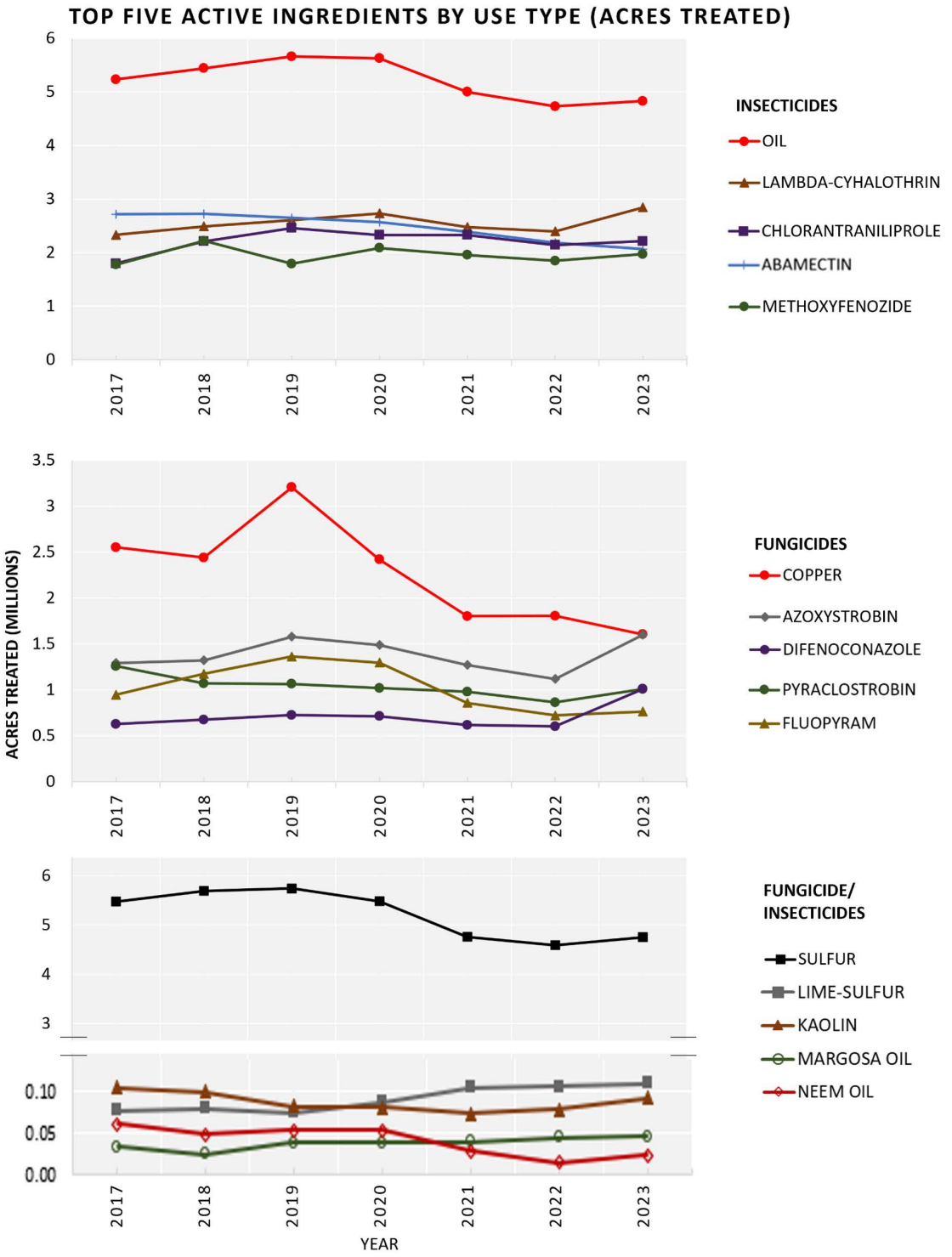


Figure 3a. Acres treated by the top five AIs in each of the major types of pesticides from 2017 to 2023. Vertical axis may be split to visually display AIs with substantially different ranges in use.

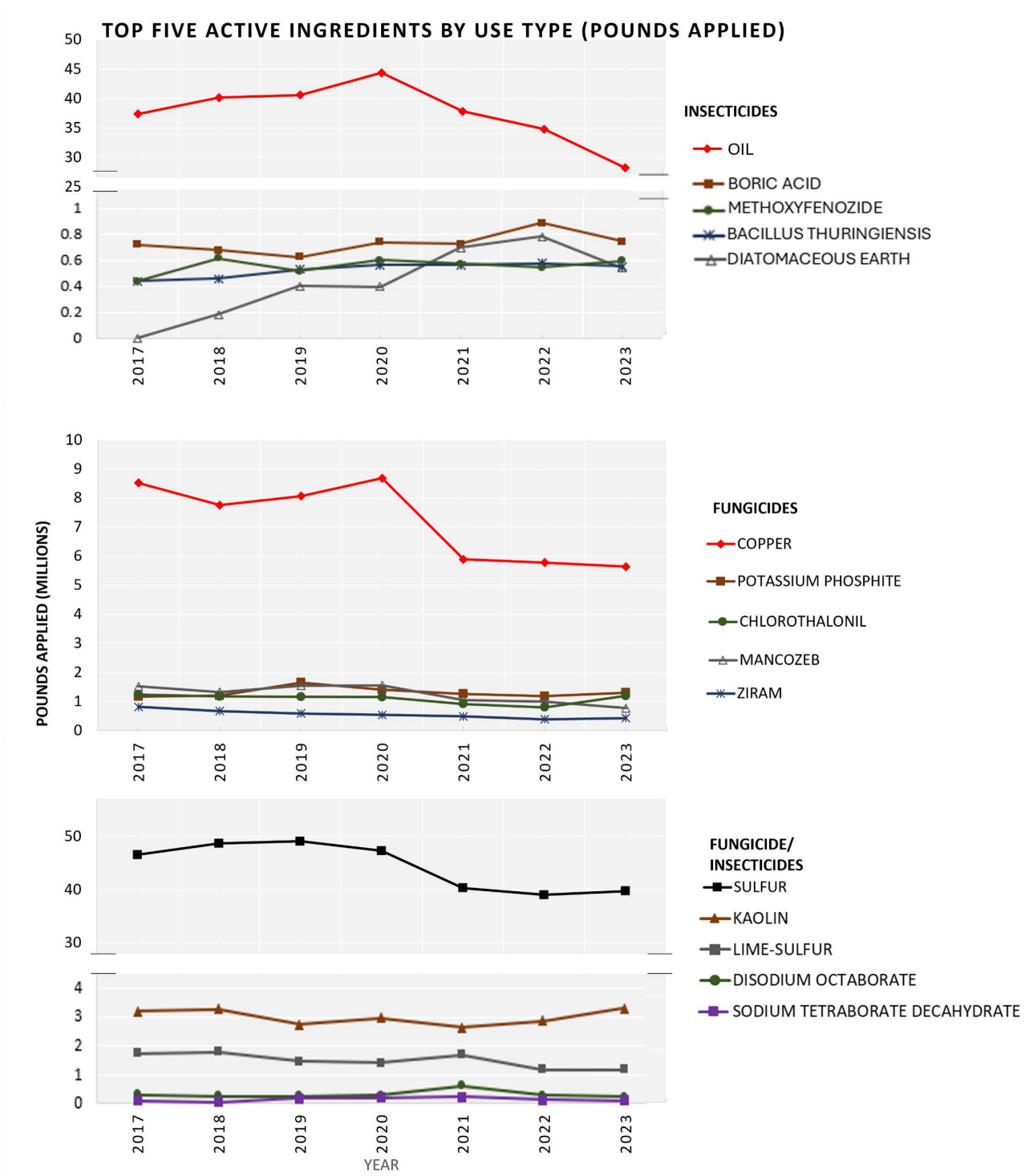


Figure 3b. Pounds applied of the top five AIs in each of the major types of pesticides from 2017 to 2023. Vertical axis may be split to visually display AIs with substantially different ranges in use.

Herbicides

The phosphonoglycine herbicides glyphosate and glufosinate-ammonium, the diphenyl ether oxyfluorfen, and the dinitroaniline pendimethalin ranked in the top five herbicide AIs when measured by both acres treated and by pounds applied. The cyclohexenone derivative clethodim made up the remainder of AIs in the top five herbicides by acres treated, while the amide propanil made up the remainder in the top five by pounds applied. (Figures 4a and b, Table 9, and Table 10).

Table 9. Top five herbicides in California by acres treated for 2023.

Top Five	Acres Treated
Glyphosate	4,840,400
Glufosinate-Ammonium	2,069,518
Oxyfluorfen	1,921,519
Clethodim	1,200,602
Pendimethalin	1,110,699

Table 10. Top five herbicides in California by pounds applied for 2023.

Top Five	Pounds Applied
Glyphosate	10,665,255
Propanil	2,489,585
Pendimethalin	2,266,480
Glufosinate-Ammonium	2,010,747
Oxyfluorfen	787,142

Fumigants

The halogenated organic 1,3-dichloropropene, the inorganic chloropicrin, and the carbamates potassium N-methyldithiocarbamate ("metam-potassium") and metam-sodium were in the top five fumigant AIs when ranked by either acres treated or pounds applied. The inorganic aluminum phosphide made up the remainder of the top five by acres treated, while the inorganic sulfuryl fluoride was the remaining top five fumigant AI by pounds applied (Figures 4a and b, Table 11, and Table 12).

Table 11. Top five fumigants in California by acres treated for 2023.

Top Five	Acres Treated
Chloropicrin	46,532
1,3-Dichloropropene	44,554
Metam-Potassium	44,045
Aluminum Phosphide	40,049
Metam-Sodium	13,237

Table 12. Top five fumigants in California by pounds applied for 2023.

Top Five	Pounds Applied
Metam-Potassium	8,633,739
Chloropicrin	8,515,832
1,3-Dichloropropene	7,023,406
Sulfuryl Fluoride	3,071,223
Metam-Sodium	2,800,317

Other

The remaining "Other" category was largely comprised of plant growth regulators, bactericides, and harvest aids/defoliants. The botanical growth regulator gibberellins and the organophosphate growth regulator ethephon ranked highest by acres treated. The inorganic hydrogen peroxide and the peroxide peroxyacetic acid, used as lower-risk bactericides/fungicides/algaecides in some crops, and the microbial *Aspergillus flavus* strain NRRL #21882 ("*Aspergillus flavus*") used to reduce aflatoxin contamination made up the remainder of the top five by acres treated. By pounds applied, post-harvest germicidal crop treatments of the inorganic sodium hypochlorite ranked highest, followed by the inorganic hydrogen peroxide, the inorganic chlorine used as a post-harvest treatment and sanitizer, the inorganic hydrogen cyanamide mostly used as a growth regulator, and the inorganic sodium percarbonate used as an algaecide (Figures 4a and b, Table 13, and Table 14).

Table 13. Top five "Other" in California by acres treated for 2023.

Top Five	Acres Treated
Gibberellins	425,563
Ethephon	394,844
Hydrogen Peroxide	360,727
Peroxyacetic Acid	357,156
Aspergillus flavus	264,726

Table 14. Top five "Other" in California by pounds applied for 2023.

Top Five	Pounds Applied
Sodium Hypochlorite	796,318
Hydrogen Peroxide	659,087
Chlorine	522,963
Hydrogen Cyanamide	388,268
Sodium Percarbonate	367,206

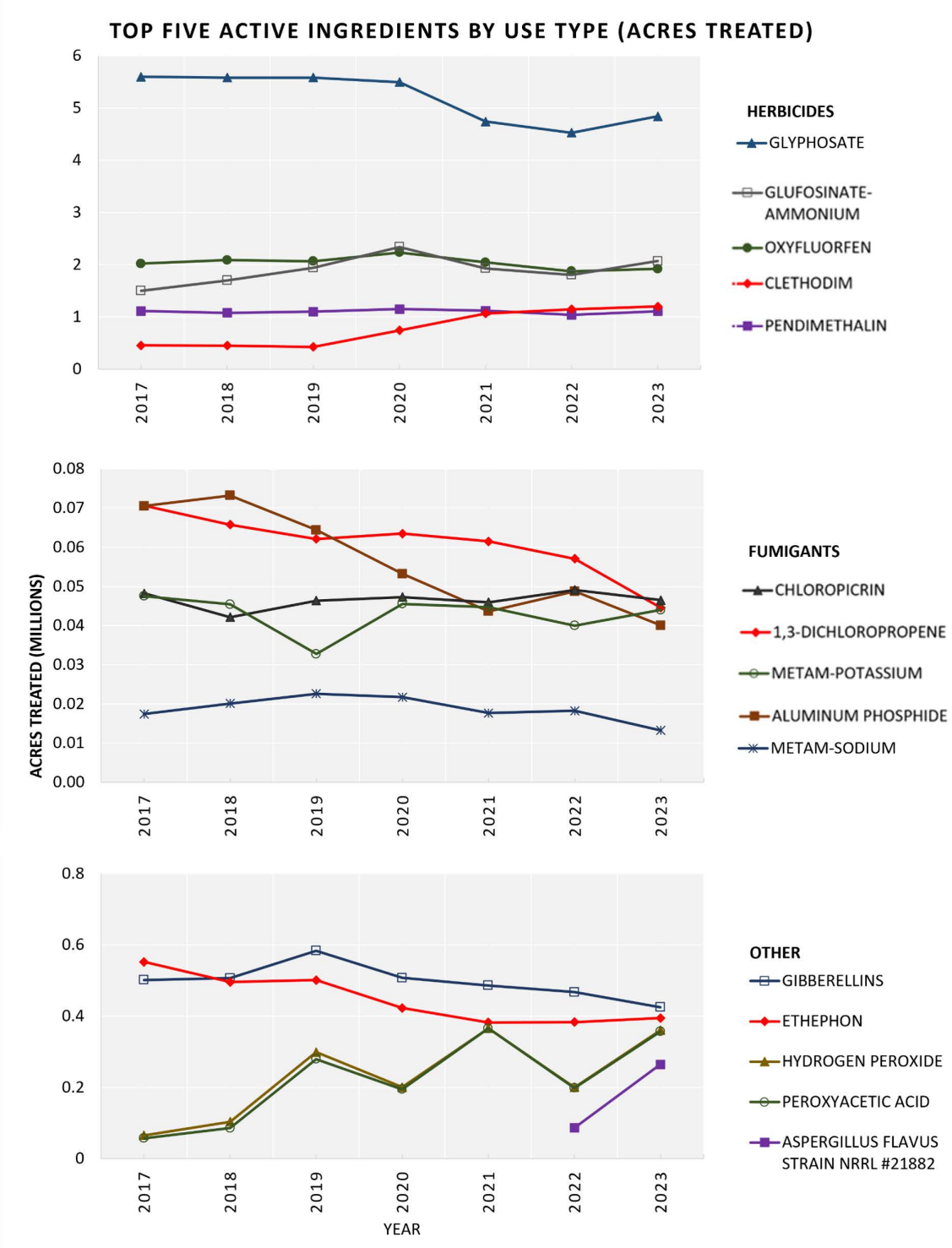


Figure 4a. Acres treated by the top five AIs in each of the major types of pesticides from 2017 to 2023: herbicides, fumigants, and "other" ("Other" includes pesticides such as plant growth regulators, bactericides, harvest aids, rodenticides, molluscicides, algaecides, repellents, antimicrobials, antifoulants, disinfectants, and biocides).

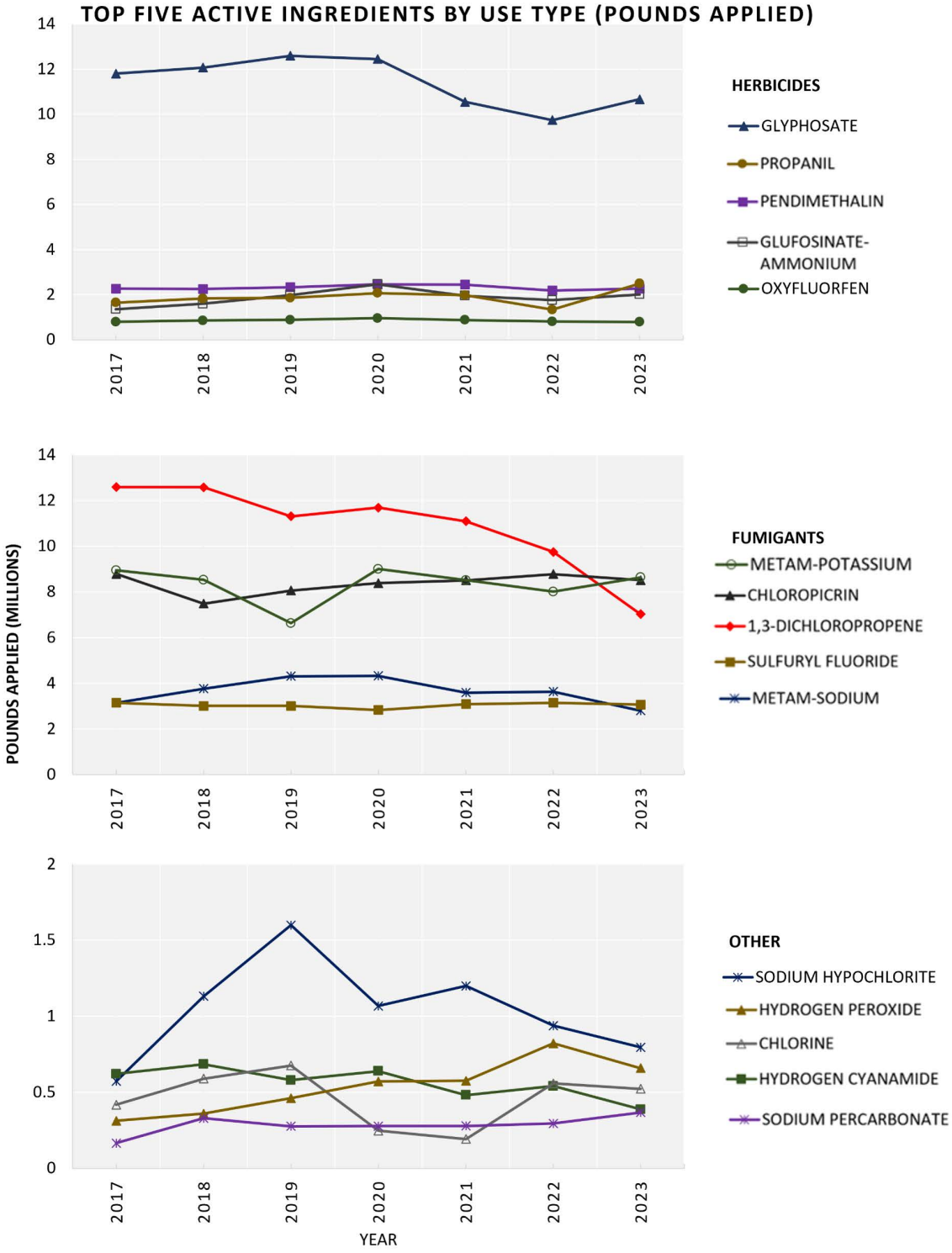


Figure 4b. Pounds applied of the top five AIs in each of the major types of pesticides from 2017 to 2023: herbicides, fumigants, and "other" ("Other" includes pesticides such as plant growth regulators, bactericides, harvest aids, rodenticides, molluscicides, algaecides, repellents, antimicrobials, antifoulants, disinfectants, and biocides).

Pesticide Use by County

In 2023, as in previous years, the region of highest pesticide use was California's San Joaquin Valley. The top five counties with the highest use were Fresno, Kern, Tulare, San Joaquin, and Monterey accounting for 50 percent of the total pounds applied in California (Table 15). These counties were also among the leading producers of agricultural commodities.

Table 15. Total pounds applied of AIs by county, rank, and the percent change from 2022 and 2023, ordered by 2023 rank, descending. Shaded rows show the counties where pounds applied decreased from 2022 to 2023. N/A stands for Not Applicable. Statewide totals may not exactly equal the sum of the columns due to rounding.

County	2022 Lbs Applied	2022 Rank	2023 Lbs Applied	2023 Rank	Percent Change
Fresno	26,559,818	1	26,288,224	1	-1%
Kern	25,944,244	2	24,295,677	2	-6%
Tulare	17,633,288	3	16,798,434	3	-5%
San Joaquin	11,951,581	4	11,040,931	4	-8%
Monterey	9,998,594	5	9,155,256	5	-8%
Merced	8,029,146	7	7,096,296	6	-12%
Madera	8,319,297	6	6,668,849	7	-20%
Kings	6,661,031	8	6,256,523	8	-6%
Ventura	6,255,123	10	6,087,653	9	-3%
Santa Barbara	6,018,310	11	5,886,604	10	-2%
Stanislaus	6,422,187	9	5,532,385	11	-14%
Sacramento	4,496,804	12	4,847,854	12	8%
Imperial	4,441,580	13	4,367,021	13	-2%
Yolo	3,729,984	14	3,782,762	14	1%
Butte	2,910,000	15	2,892,138	15	-1%
Riverside	2,562,026	17	2,814,749	16	10%
Sutter	2,460,747	18	2,658,624	17	8%
San Luis Obispo	2,691,058	16	2,637,034	18	-2%
Los Angeles	2,370,247	19	2,497,443	19	5%
Colusa	1,344,514	26	2,483,361	20	85%
Sonoma	2,312,392	20	2,449,036	21	6%
Glenn	1,511,239	23	2,208,872	22	46%
Mendocino	1,783,322	21	1,800,289	23	1%
Solano	1,191,919	27	1,479,617	24	24%
Siskiyou	1,475,377	24	1,452,026	25	-2%
San Diego	1,559,626	22	1,426,356	26	-9%
Santa Cruz	1,351,975	25	1,331,742	27	-1%
Napa	1,147,536	28	1,321,838	28	15%
Tehama	1,042,148	30	1,035,340	29	-1%
Yuba	1,079,573	29	916,102	30	-15%
Orange	802,624	31	837,426	31	4%
Santa Clara	679,262	33	748,292	32	10%
San Benito	775,759	32	634,101	33	-18%
Contra Costa	472,952	36	574,852	34	22%
Lake	582,921	34	562,423	35	-4%

County	2022 Lbs Applied	2022 Rank	2023 Lbs Applied	2023 Rank	Percent Change
Placer	478,251	35	381,379	36	-20%
Alameda	258,935	39	328,981	37	27%
San Bernardino	434,009	37	317,631	38	-27%
Shasta	259,455	38	262,027	39	1%
El Dorado	250,549	40	240,745	40	-4%
Lassen	178,764	42	221,144	41	24%
San Mateo	193,701	41	199,821	42	3%
Modoc	134,632	44	188,563	43	40%
Del Norte	134,854	43	140,518	44	4%
Plumas	97,284	46	115,217	45	18%
Amador	119,239	45	109,996	46	-8%
Marin	85,974	47	85,901	47	-0.1%
Nevada	72,113	49	55,975	48	-22%
Calaveras	82,495	48	53,168	49	-36%
Tuolumne	44,338	50	42,997	50	-3%
Humboldt	32,069	52	30,039	51	-6%
San Francisco	28,759	53	27,770	52	-3%
Trinity	33,033	51	27,729	53	-16%
Inyo	15,327	54	7,021	54	-54%
Mariposa	5,278	55	5,703	55	8%
Mono	3,439	56	3,281	56	-5%
Sierra	3,345	57	2,437	57	-27%
Alpine	305	58	310	58	2%
Total	181,514,349	N/A	175,714,481	N/A	-3%

Production Ag and Largest NonAg Uses

Production agricultural pesticide use (Ag PURs) has always made up the majority of total reported pounds applied in California.[1] In 2023, Ag PURs made up 91 percent of the total pounds applied. Structural pest control and rights of way made up the largest segments of non-production-agricultural pesticide uses (NonAg PURs), contributing 2.0 and 1.9 percent of total pesticide use, respectively. Post-harvest treatments, landscape maintenance, treated lumber, and industrial water were the next highest uses, representing 1.0, 0.9, 0.6, and 1.0 percent of all use in 2023, respectively. Post-harvest treatments are predominantly commodity fumigations but can also include pesticide treatments to irrigation ditches and other parts of fields not planted in crops.

The remaining assortment of NonAg types of pesticide applications each made up less than 0.5 percent of all pesticide use and therefore were not considered high enough in volume on their own to warrant their own individual group heading. These uses were lumped together under an "All Other" group, including applications such as pesticide use for research purposes, vector control, and pest control through fumigation of non-food and non-feed materials. Together, the "All Other" category represented 1.7 percent of total pounds applied.

[1] For more information about what pesticide uses are reported, see the Types of Pesticide Use Reported section in the Pesticide Use Annual Report Data Access, References, and Definitions Guide

From 2022 to 2023, production agriculture decreased in pounds applied by 3.4 percent, post-harvest treatments increased by 3.9 percent, structural pest control use decreased by 2.1 percent, landscape maintenance increased by 13.7 percent, rights of way decreased by 3.4 percent, treated lumber decreased by 2.3 percent, industrial water decreased by 8.7 percent, and all other uses ("All Others") increased by 0.03 percent (Table 16).

Table 16. Pounds applied of pesticide AIs, from 2004 to 2023, by general use categories. Values in the Total Pounds Applied column may not exactly equal the sum of the columns due to rounding.

Year	Production Agriculture	Post-Harvest Treatment	Structural Pest Control	Landscape Maintenance	Rights of Way	Treated Lumber	Industrial Water	All Others	Total Pounds Applied
2004	165,927,707	1,869,498	5,115,771	1,614,358	4,342,525	472,612	146,086	2,094,899	181,583,456
2005	178,478,409	2,260,855	5,620,705	1,779,356	3,937,208	123,374	230,243	4,261,400	196,691,551
2006	168,777,239	2,209,812	5,270,325	2,290,223	3,699,576	282,831	120,259	6,196,550	188,846,816
2007	157,544,197	2,271,908	3,967,255	1,677,544	3,394,199	1,261,168	202,453	2,524,799	172,843,523
2008	151,601,483	2,534,748	3,203,656	1,596,775	3,564,094	217,054	383,507	3,122,569	166,223,887
2009	147,128,549	1,474,075	2,911,006	1,351,549	3,167,436	125,031	641,635	2,160,742	158,960,022
2010	160,585,552	2,156,825	3,698,774	1,739,415	3,436,330	840,484	940,512	2,875,216	176,273,109
2011	178,069,121	1,541,491	3,148,477	1,728,172	4,477,966	80,383	1,226,815	3,117,040	193,389,464
2012	172,165,319	1,217,529	3,463,476	1,551,224	3,267,277	111,538	2,308,847	3,660,257	187,745,467
2013	179,370,643	1,466,229	3,803,222	1,466,085	3,271,143	781,337	2,577,748	3,362,697	196,099,105
2014	174,883,419	1,281,171	3,713,623	1,619,243	2,979,261	231,257	2,849,840	2,896,435	190,454,249
2015	195,266,116	1,450,925	4,216,121	1,689,364	3,554,008	446,665	1,976,586	3,389,880	211,989,665
2016	192,127,966	1,764,745	3,932,741	1,736,139	3,713,183	1,468,828	1,933,616	3,257,663	209,934,881
2017	188,817,772	1,635,327	3,643,811	1,581,020	3,699,445	1,511,081	1,499,130	3,605,436	205,993,022
2018	191,874,126	1,477,191	3,453,324	1,520,280	4,099,879	1,292,218	1,722,068	4,388,169	209,827,255
2019	190,950,089	1,571,103	3,368,792	2,291,408	5,117,840	1,282,319	2,062,345	4,056,045	210,699,942
2020	197,276,672	1,948,682	3,303,128	2,095,861	5,129,877	1,521,186	1,177,337	3,231,616	215,684,359
2021	173,793,478	1,638,583	4,051,388	1,565,045	3,689,905	1,157,285	2,165,888	3,015,142	191,076,715
2022	165,619,646	1,634,313	3,659,765	1,367,786	3,361,409	1,075,904	1,878,829	2,916,697	181,514,349
2023	159,945,931	1,698,220	3,583,212	1,554,893	3,248,149	1,051,554	1,714,859	2,917,663	175,714,481

Trends in Use for Select Pesticide Categories

Pesticide use is summarized for the following eight categories that are based on either the type of pesticide (e.g., biopesticides) or a pesticide's potential to cause health or environmental impacts (e.g., carcinogens):

- Biopesticides,
- Oils,
- Carcinogens,
- Cholinesterase inhibitors,
- Fumigants,
- Groundwater contaminants,
- Reproductive toxins, and
- Toxic air contaminants.

The summaries and the data are not intended to serve as indicators of actual pesticide impacts to the public or the environment as they do not account for label restrictions, mitigation methods, and other practices that may significantly reduce offsite movement of pesticides and potential for exposure. Rather, the data supports DPR regulatory functions to enhance public safety and environmental protection by increasing the understanding of the change in use of lower- and higher-risk AIs over time. Note that the pounds of AI applied include both Ag and NonAg PURs, while the reported acres treated include primarily Ag PURs since most NonAg uses do not require reporting of acres treated.

The following section discusses changes in use from the previous year as well as graphs showing long-term use for each of the eight categories. Note that some AIs belong to more than one higher-risk category. For example, many fumigants are also toxic air contaminants, so the total use of those AIs is included under both the fumigant and toxic air contaminant category totals. Tables of the amount of the individual chemicals used in each category over the last ten years can be downloaded under the Pesticide Category Lists section on the 2023 Summary Data website.

Table 17. The total pounds applied for eight different pesticide categories with the change and percent change from 2022 to 2023. Values in the Change column may not exactly equal the difference of the two Acres Treated columns due to rounding.

Category	2022 Lbs Applied	2023 Lbs Applied	Change	% Change
Biopesticides	8,484,749	8,823,191	338,442	4
Oils	34,829,380	28,270,329	-6,559,051	-19
Carcinogens	34,505,252	32,471,609	-2,033,643	-6
Cholinesterase inhibitors	2,575,671	2,708,333	132,662	5
Fumigants	35,638,985	32,360,449	-3,278,535	-9
Ground water contaminants	196,633	130,080	-66,553	-34
Reproductive toxins	6,422,478	5,597,479	-824,999	-13
Toxic air contaminants	38,102,766	34,495,798	-3,606,968	-9

Table 18. The total acres treated for eight different pesticide categories with the change and percent change from 2022 to 2023. Values in the Change column may not exactly equal the difference of the two Acres Treated columns due to rounding.

Category	2022 Acres Treated	2023 Acres Treated	Change	% Change
Biopesticides	7,597,632	8,070,665	473,032	6
Oils	4,839,348	4,971,693	132,346	3
Carcinogens	6,674,724	7,071,470	396,746	6
Cholinesterase inhibitors	2,030,155	2,081,795	51,639	3
Fumigants	197,807	183,856	-13,951	-7
Ground water contaminants	249,926	187,248	-62,679	-25
Reproductive toxins	3,279,201	3,286,742	7,541	0.2
Toxic air contaminants	1,932,322	1,690,723	-241,599	-13

Biopesticides

Biopesticides include naturally occurring substances that control pests (biochemical pesticides) and microorganisms that control pests (microbial pesticides). The definition may also include new technologies that do not easily fit into one of those two categories.
Use of biopesticides increased by 338 thousand pounds applied (4 percent increase) and by 473 thousand acres treated (6 percent increase) between 2022 and 2023. Most of the increase in pounds applied since last year was due to greater use of the fungicide/insecticide kaolin clay and the fungicide potassium phosphite, which increased by 428 thousand pounds applied (15 percent increase) and 125 thousand pounds applied (11 percent increase), respectively. The increase in acres treated was largely due to 160 thousand more acres treated (80 percent increase) with the microbiocide hydrogen peroxide, 78 thousand more acres treated (3 percent increase) with the adjuvant citric acid, and 66 thousand more acres treated (16 percent increase) with the fungicide potassium phosphite. Over the last ten years, biopesticide pounds applied have increased by 46 percent and acres treated have increased by 38 percent (Figure 5).

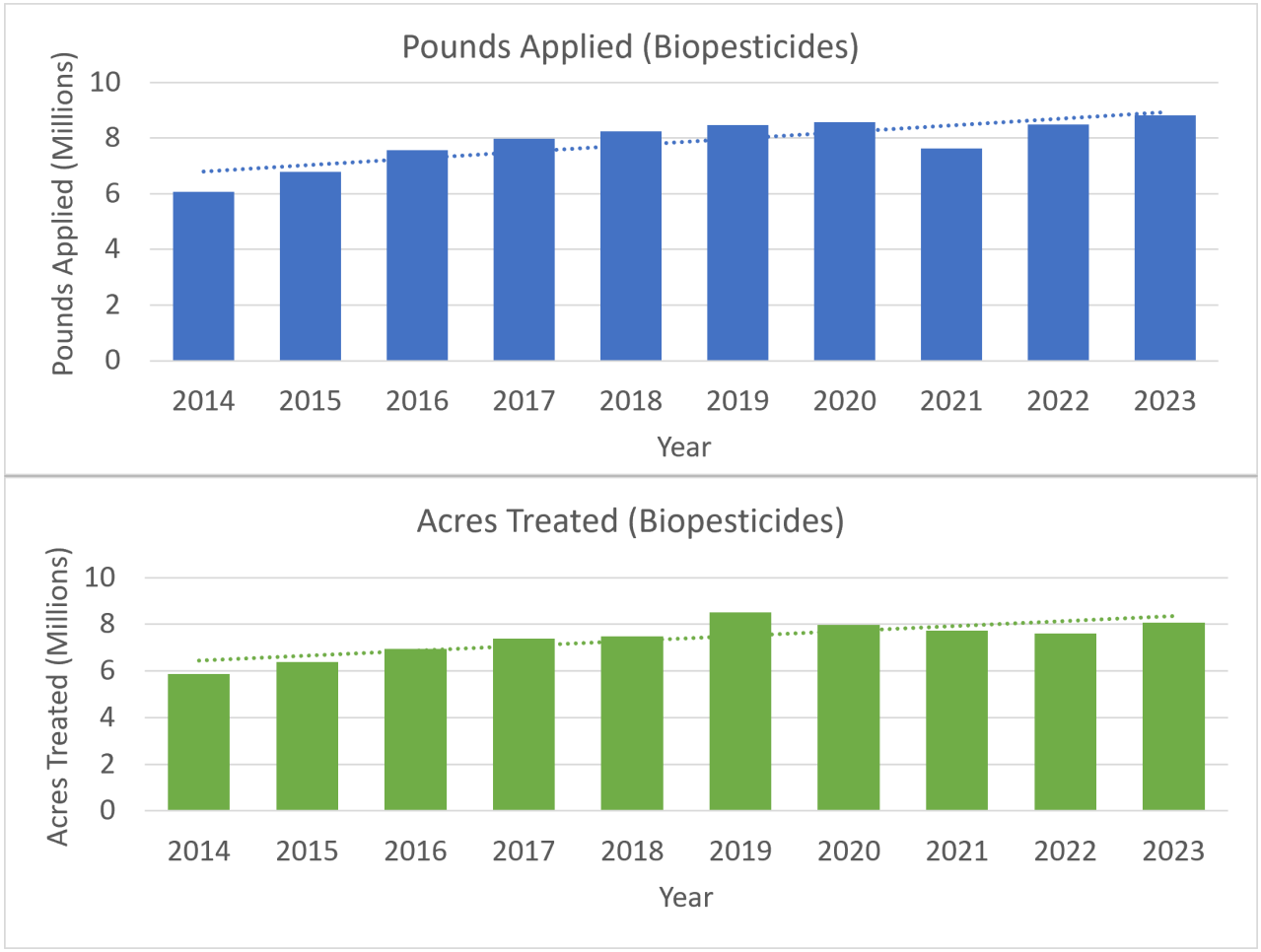


Figure 5. Use trends of pesticides that are biopesticides from 2014 to 2023.

Oils

The oils category includes pesticides with a petroleum-based oil AI (botanical oils are not included in these totals). Petroleum-based oils are often used as broad spectrum insecticides or fungicides. As an insecticide, the oil kills insects by either physically blocking their ability to breathe or affecting how they eat. As a fungicide, the oil smothers the fungus pathogens and limits spore germination. Some refined petroleum-based oils are relatively lower risk than conventional pesticides and may be used in organic farming. Use of oil pesticides decreased in amount by 6.6 million pounds applied (19 percent decrease) but increased in acres treated by 132 thousand acres treated (3 percent increase) between 2022 and 2023. Only oil AIs derived from petroleum distillation are included in these totals. Over the last ten years, pounds applied of oils have decreased by 7 percent and acres treated have increased by 9 percent (Figure 6).

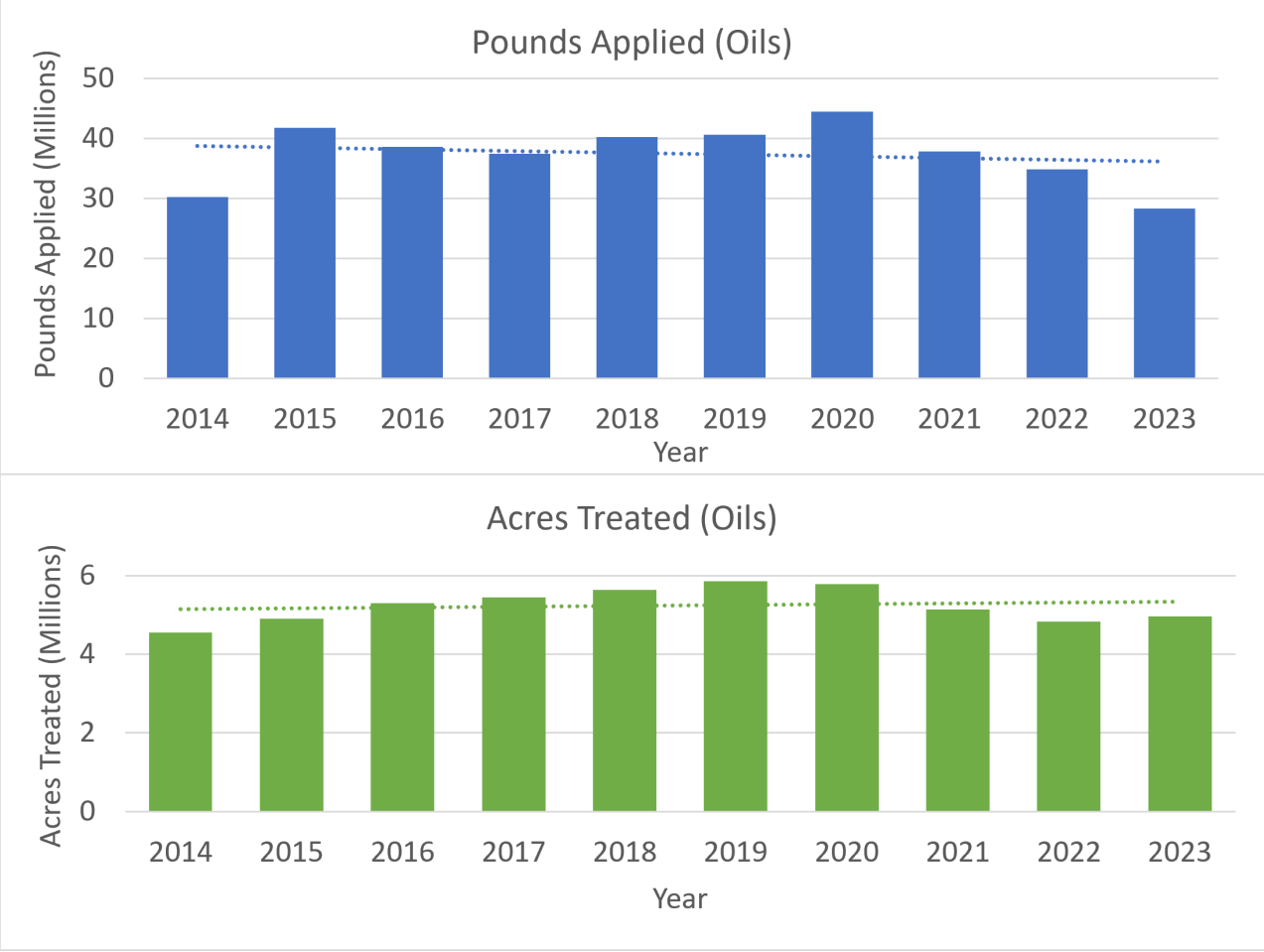


Figure 6. Use trends of pesticides that are oils from 2014 to 2023.

Carcinogens

The carcinogens category included all AIs listed on the State's Proposition 65 list of chemicals known to cause cancer as well as the AIs receiving a "carcinogen," "probable carcinogen," or "possible carcinogen" rating from the U.S. EPA's Chronic Dose-Response Assessment Table (Dose-Response Assessment for Assessing Health Risks Associated with Exposure to Hazardous Air Pollutants). The amount used of pesticides classified as carcinogens decreased by 2 million pounds applied from 2022 to 2023 (6 percent decrease). The acres treated with carcinogens increased by 397 thousand acres treated (6 percent increase).

The decrease in pounds applied was largely due to less use of the fumigant 1,3-dichloropropene, which decreased by 2.7 million pounds applied (28 percent decrease) and the fumigant metam-sodium, which decreased by 836 thousand pounds (23 percent decrease). The increase in acres treated was mostly due to more acres treated with the herbicide glyphosate, potassium salt, which increased by 286 thousand acres treated (13 percent increase) and the fungicide chlorothalonil which increased by 249 thousand acres treated (70 percent decrease). Over the last ten years, pounds applied of pesticides that are carcinogens have decreased by 23 percent and acres treated have decreased by 24 percent (Figure 7).

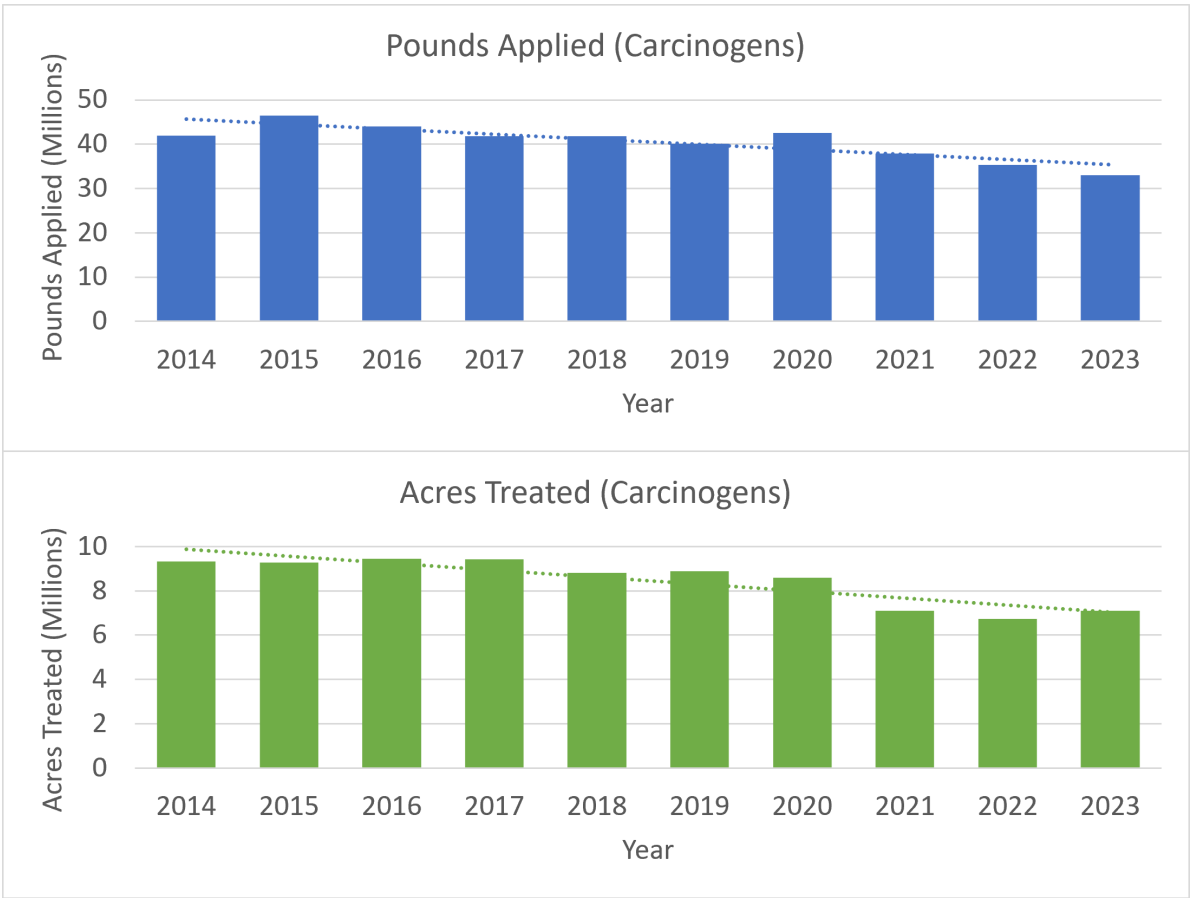


Figure 7. Use trends of pesticides identified as potentially carcinogenic by the U.S. EPA or the State's Proposition 65 list from 2014 to 2023.

Cholinesterase Inhibitors

Cholinesterase (ChE) inhibiting pesticides block the enzyme cholinesterase that breaks down acetylcholine, which can result in overstimulation of the nervous symptom. Organophosphates and carbamates are the two primary chemical classes of ChE-inhibiting pesticides, although not all pesticides in these two classes exhibit Ch-E inhibition. Use of organophosphorus and carbamate cholinesterase-inhibiting pesticides in 2023 increased from the previous year by 133 thousand pounds applied (5 percent increase) and increased by 52 thousand acres treated (3 percent increase). The increase in pounds applied and acres treated since last year was largely due to greater use of the herbicide thiobencarb predominantly on rice, which increased by 236 thousand pounds applied (103 percent increase) and 70 thousand acres treated (100 percent increase). Over the last ten years, pounds applied of pesticides that are cholinesterase inhibitors have decreased by 42 percent and acres treated have decreased by 48 percent (Figure 8).

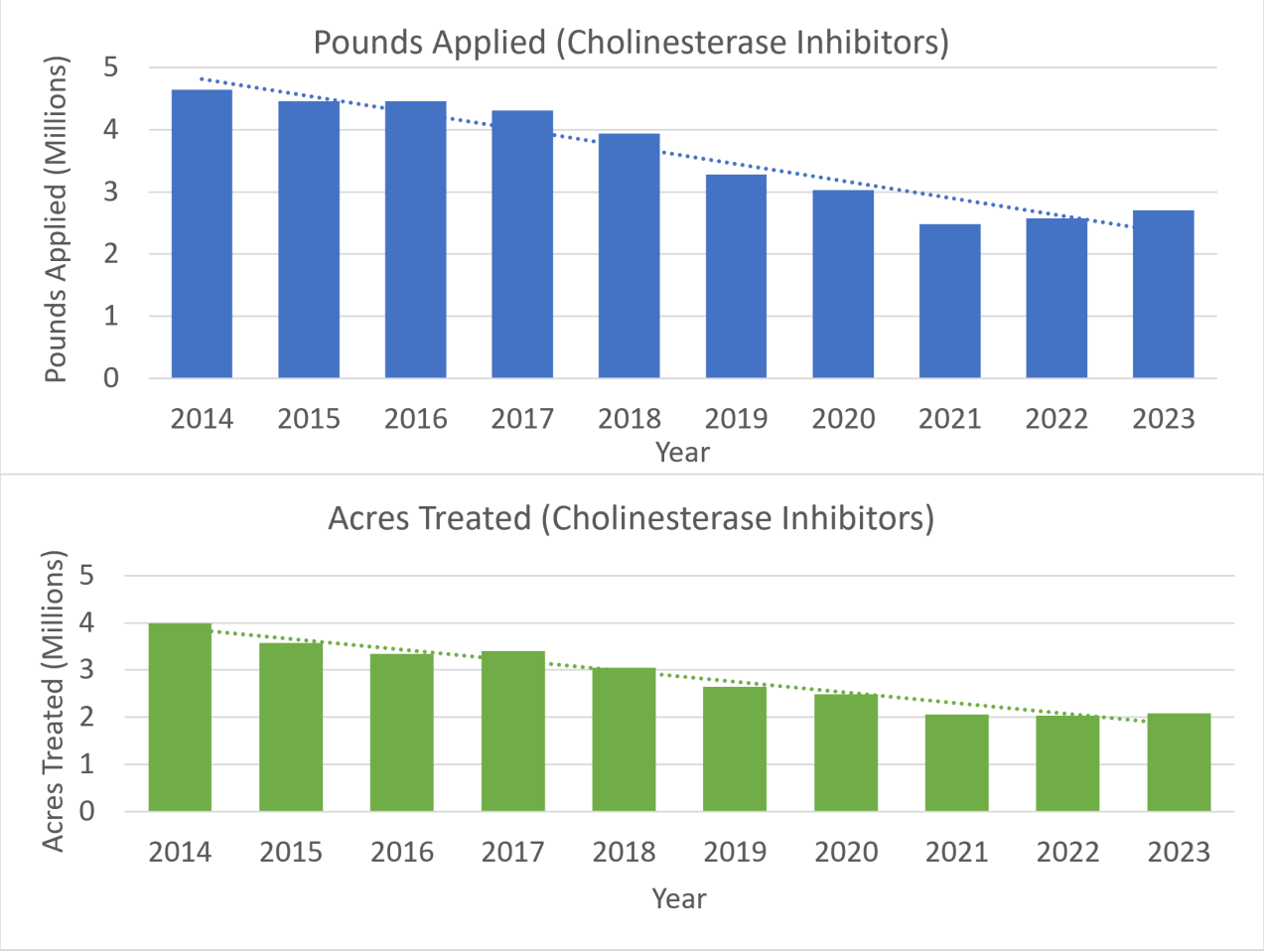


Figure 8. Use trends of pesticides that are organophosphorus or carbamate cholinesterase-inhibiting pesticides from 2014 to 2023.

Fumigants

The fumigant category includes all higher-risk AIs applied as fumigants. Fumigants are volatile gas pesticides that can penetrate into soil, stored products (such as food, seeds, fibers), structures, and other sites to kill pests. The use of higher-risk fumigant AIs declined by 3.3 million pounds applied (9 percent decrease) and by 14 thousand acres treated (7 percent decrease) between 2022 and 2023. The decrease in pounds applied since the last year was largely due to less use of the fumigants 1,3-dichloropropene and metam-sodium, which decreased by 2.7 million pounds applied (28 percent decrease) and 836 thousand pounds applied (23 percent decrease), respectively. The decrease in acres treated was predominantly due to 12.5 thousand less acres treated with 1,3-dichloropropene (22 percent decrease) and 8.7 thousand less acres treated with aluminum phosphide (18 percent decrease). Over the last ten years, pounds applied of pesticides that are fumigants have decreased by 22 percent and acres treated have decreased by 43 percent (Figure 9).

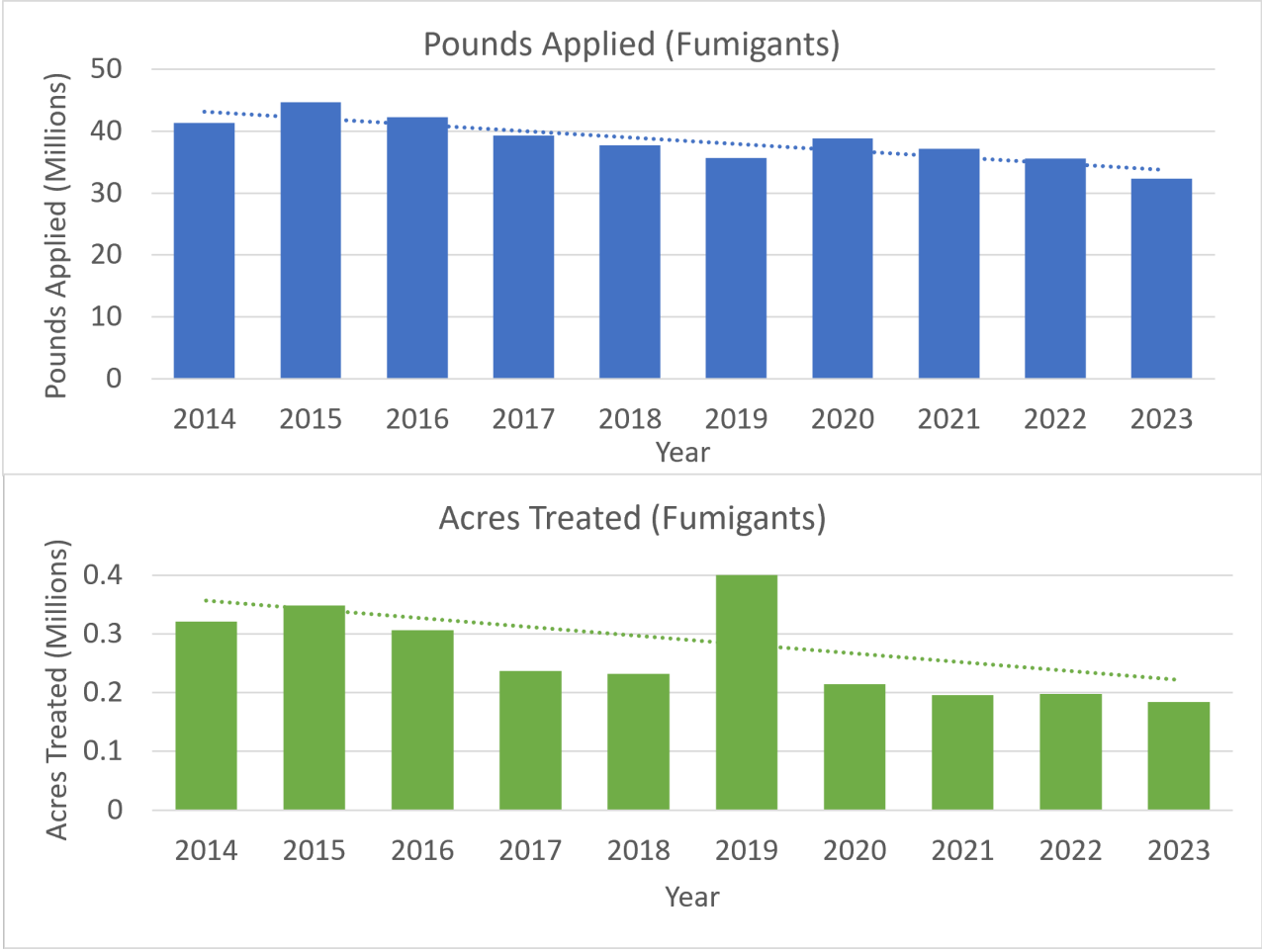


Figure 9. Use trends of pesticides that are fumigants from 2014 to 2023.

Groundwater Contaminants

Groundwater contaminants are defined as pesticides that have the potential to pollute groundwater based on their chemical properties and labeled use. The groundwater contaminant category included all AIs listed in the California Code of Regulations, Title 3, Division 6, Chapter 4, Subchapter 1, Article 1, Section 6800(a). Groundwater contaminants decreased by 67 thousand pounds applied (34 percent decrease) and decreased by 63 thousand acres treated (25 percent decrease) between 2022 and 2023. The reduction in pounds applied since the last year was mostly due to less use of the herbicides diuron, which decreased by 33 thousand pounds applied (36 percent decrease) and simazine, which decreased by 22 thousand pounds applied (35 percent decrease). Diuron and simazine were also largely responsible for the decrease in acres treated, with 48 thousand less acres treated with diruon (25 percent decrease) and 15 thousand less acres treated with simazine (38 percent decrease) since 2022. Over the last ten years, pounds applied of pesticides that are groundwater contaminants have decreased by 81 percent and acres treated have decreased by 66 percent (Figure 10).

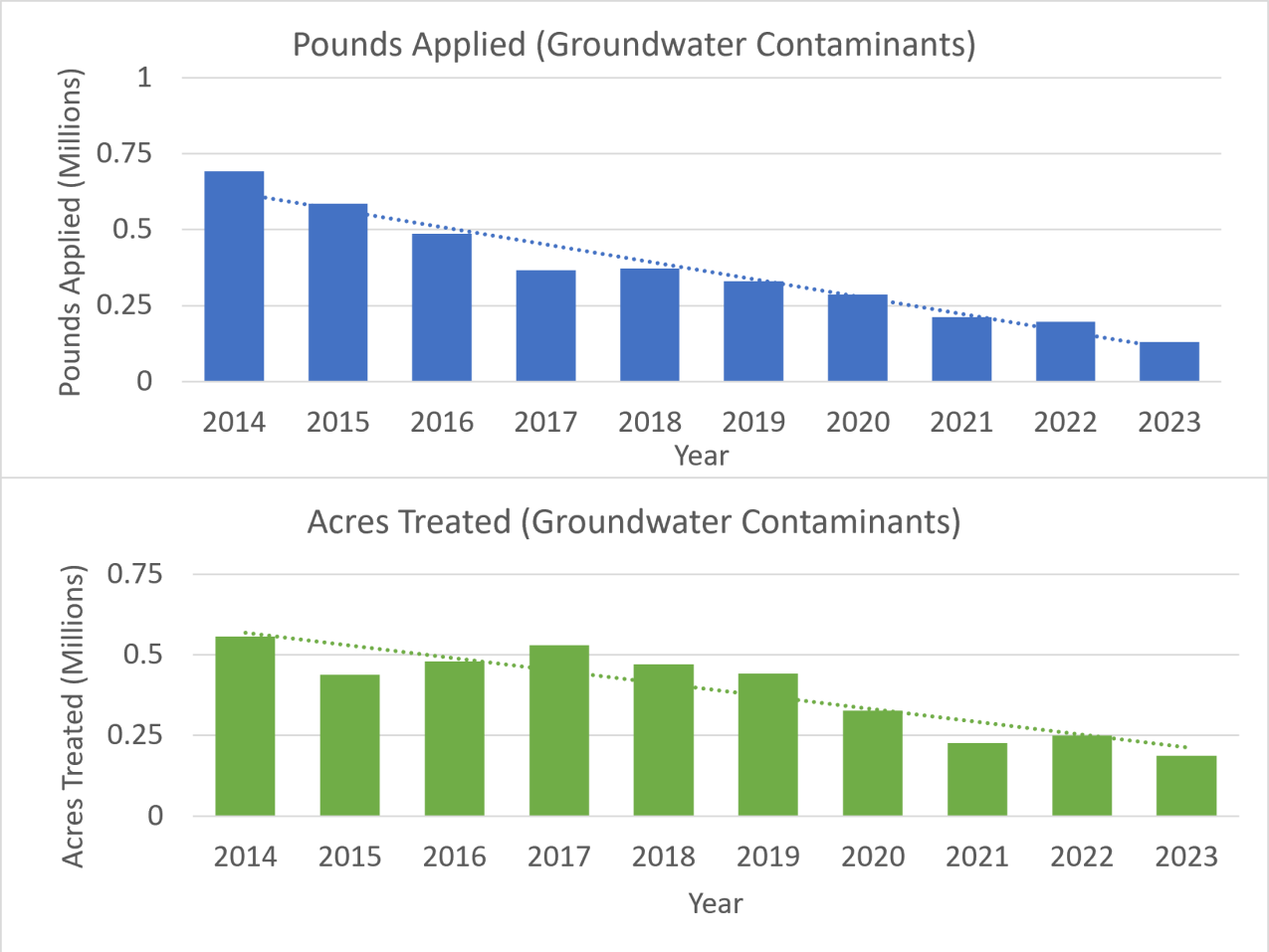


Figure 10. Use trends of pesticides that are groundwater contaminants from 2014 to 2023.

Reproductive Toxins

The reproductive toxins category included all AIs listed on the State's Proposition 65 list of chemicals known to cause reproductive toxicity in the form of birth defects or reproductive harm. Use of reproductive toxins decreased by 825 thousand pounds applied (13 percent decrease) and increased by 7.5 thousand acres treated (0.2 percent increase) between 2022 and 2023. The decrease in pounds applied since the last year was mostly due to less use of the fumigant metam sodium by 836 thousand pounds (23 percent decrease). The increase in acres treated was largely due to 82 thousand more acres treated with the adjuvant ethylene glycol (72 percent increase) and 82 thousand more acres treated with the fungicide thiophanate-methyl (74 percent increase). Over the last ten years, pounds applied of pesticides that are reproductive toxins have decreased by 45 percent and acres treated have decreased by 36 percent (Figure 11).

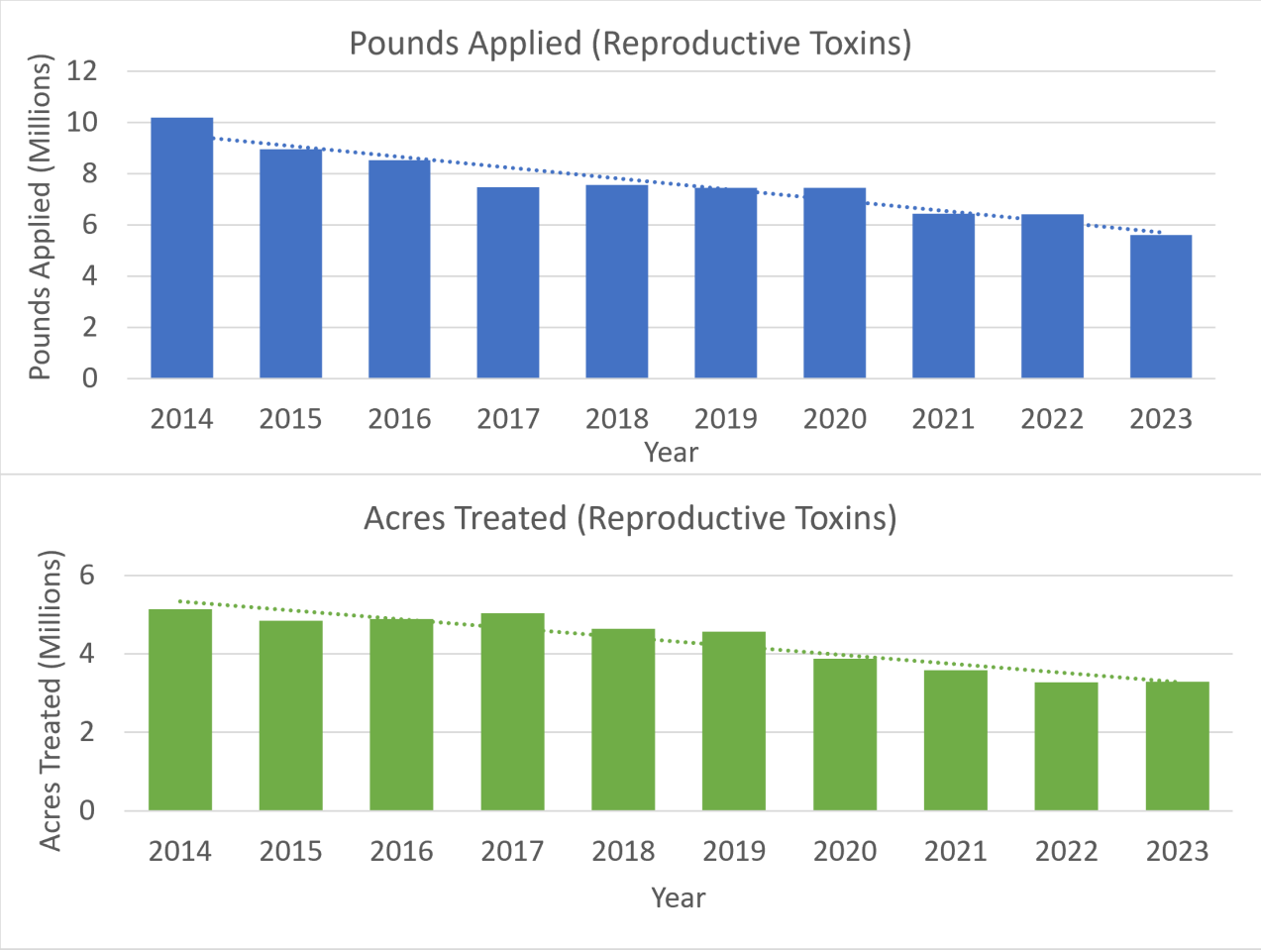


Figure 11. Use trends of pesticides that are on the State's Proposition 65 list of chemicals that are "known to cause reproductive toxicity" from 2014 to 2023.

Toxic Air Contaminants

Toxic air contaminants (TACs) are defined as air pollutants that may cause or contribute to increases in serious illness or death, that may pose a present or potential hazard to human health, or pesticides identified as hazardous air pollutants per Section 7412 of Title 42 of the United States Code and pesticides determined to be TACs in consultation with the Office of Environmental Health Hazard Assessment. The toxic air contaminants category included all AIs listed in the California Code of Regulations, Title 3, Division 6, Chapter 4, Subchapter 2, Article 1, Section 6860. Toxic air contaminants decreased by 3.6 million pounds applied (9 percent decrease) and decreased by 242 thousand acres treated (13 percent decrease) between 2022 and 2023. Most of the change in pounds applied since the last year was due to decreased use of the fumigants 1,3-dichloropropene and metam-sodium, which declined by 2.7 million pounds applied (28 percent decrease) and 836 thousand pounds applied (23 percent decrease), respectively. The decrease in acres treated was largely due to less acreage treated with the fungicide mancozeb and the herbicide 2,4-D, dimethylamine salt, which decreased by 119 thousand acres treated (21 percent decrease) and 43 thousand acres treated (15 percent decrease), respectively. Over the last ten years, pounds applied of pesticides that are toxic air contaminants have decreased by 25 percent and acres treated have decreased by 53 percent (Figure 12).

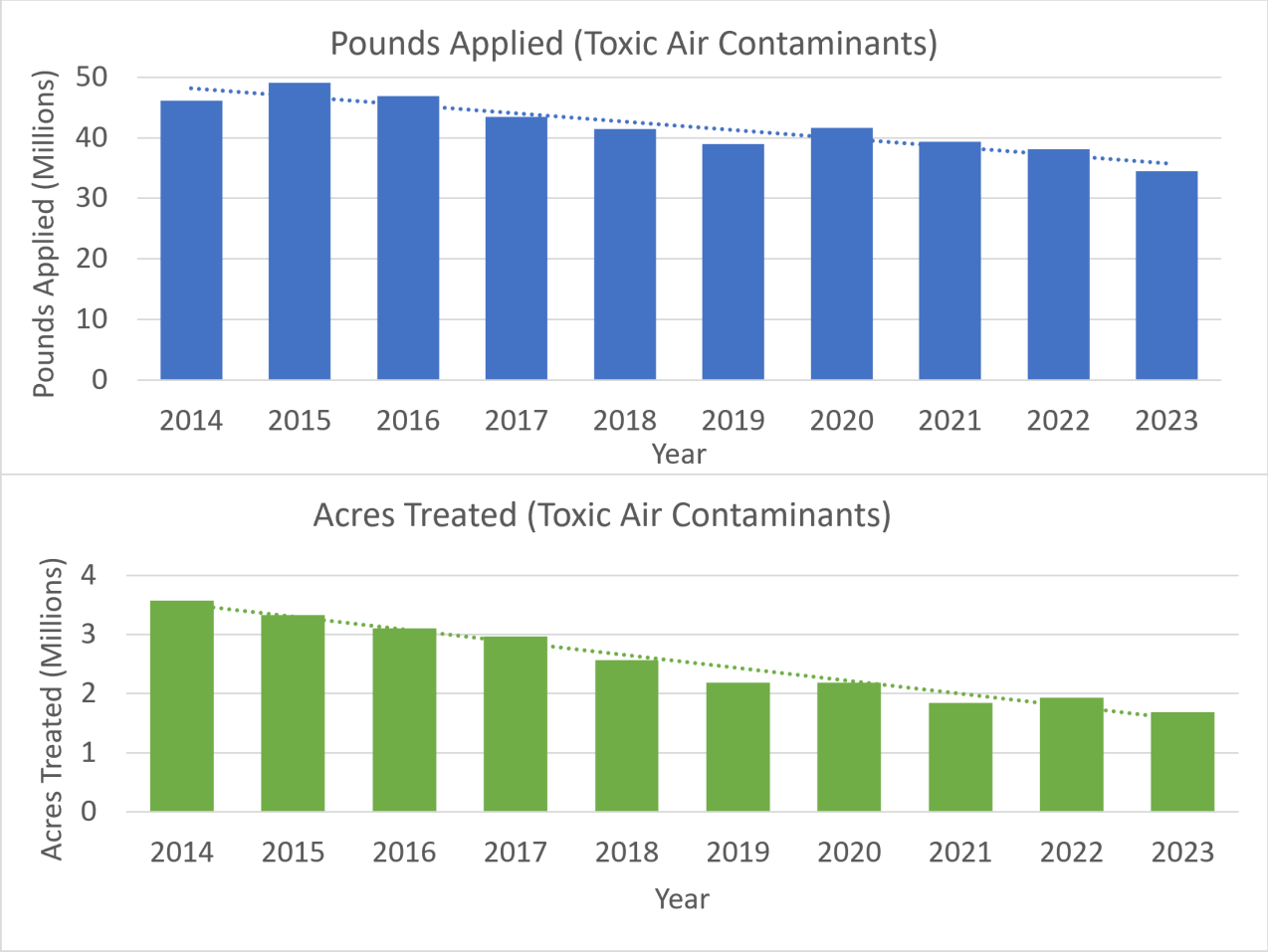


Figure 12. Use trends of pesticides that are toxic air contaminants from 2014 to 2023.

Trends in Pesticide Use for Select Commodities

A grower's or applicator's decision to apply pesticides may depend on several factors, such as:

- Potential pesticide risk to the environment, farm workers, or general public,
- The presence of biological control agents (e.g., predatory insects and other natural enemies),
- Other available management practices,
- Pest pressure,
- Cost of pesticides and labor,
- Value of the crop, and
- Pesticide resistance and effectiveness.

Pest population and the resulting pest pressure are determined by complex ecological interactions. Weather is a critically important factor and affects different pest species in different ways. However, sometimes the causes of pest outbreaks are unknown.

Crops treated with the highest total pounds applied of pesticides in 2023 were:

1. Wine grape,
2. Almond,
3. Strawberry,
4. Table and raisin grape, and
5. Processing tomato

Besides total pounds applied, the magnitudes of changes in use can be of interest in understanding pesticide use trends. Table 19 shows the change in pounds applied for ten crops (or sites): Table 19a shows the crops or sites with the greatest *increases* in pounds applied, and 19b shows the crops or sites with the greatest *decreases* in pounds applied, over the last year. Sometimes changes in use can be due to different pesticide practices, but other times the increase or decrease in use may simply occur because the total crop acreage increased or decreased. Therefore, in addition to the change in pounds applied of pesticide since last year, the table also includes the change in acres planted, bearing, or harvested, as measured by the Quick Stats Database of US Department of Agriculture, National Agricultural Statistics Service (USDA NASS).

Table 19. The change in pounds of AI applied and acres planted, bearing, or harvested, and the percent change from 2022 to 2023 for the crops or sites with the greatest increase (a) and decrease (b) in pounds applied. N/A means not available. Acre values sourced from the USDA NASS Quick Stats database.

a. Crops or Sites with Greatest Increase	Change in pounds applied	Change in acres planted, bearing, or harvested	Percent Change in pounds applied	Percent Change in acres treated
Rice	2,683,190	261,000	81	103
Pistachio	1,349,184	34,000	21	8
Wine Grape	812,877	-5,000	3	-1
Processing Tomato	744,279	38,000	8	16
Uncultivated Ag	189,293	N/A	14	N/A

b. Crops or Sites with Greatest Decrease	Change in pounds applied	Change in acres planted, bearing, or harvested	Percent Change in pounds applied	Percent Change in acres treated
Almond	-6,912,494	30,000	-22	2
Walnut	-1,613,574	-15,000	-32	-4
Carrot	-1,312,471	-7,000	-27	-11
Cannabis	-694,392	N/A	-78	N/A
Sweet Potato	-283,857	-3,000	-22	-14

Crops or sites with the greatest *increase* in the amount applied from 2022 to 2023 included rice, pistachio, wine grape, processing tomato, and uncultivated agricultural areas ("Uncultivated Ag"). The increase in pounds applied to rice, pistachio, and processing tomato may be due in part to the increase in planted (rice and processing tomato) or bearing (pistachio) acreage. Pounds applied to wine grapes increased despite a decrease in planted acres (Table 19a).

Crops or sites with the greatest *decrease* in the amount applied from 2022 to 2023 included almond, walnut, carrot, cannabis, and sweet potato. The decrease in pounds applied to walnut, carrot, and sweet potato may be due in part to less planted (carrot and sweet potato) or bearing (walnut) acreage. The pounds applied to almonds decreased despite an increase in bearing acres (Table 19b).

Top Agricultural Commodities by Pesticide Use:

Top commodities by pesticide use were defined as the commodities that were treated with more than four million pounds of AIs applied or had more than three million acres treated in 2023. Twelve commodities were chosen based on these criteria, listed here in descending order by pounds applied:

1. Wine grape
2. Almond

3. Strawberry
4. Table and raisin grape[1]
5. Processing tomato
6. Orange
7. Pistachio
8. Rice
9. Tangerine
10. Walnut
11. Alfalfa
12. Cotton

Collectively, the pesticides used on these commodities represent 69 percent of the total amount used (pounds applied) and 73 percent of the acres treated in 2023 (Table 20).

Table 20. Pounds applied and acres treated of the top 12 crops, sorted by descending pounds applied, for 2023.

Crop	Pounds Applied	Acres Treated
Wine Grape	26,341,481	9,905,000
Almond	23,908,413	23,211,809
Strawberry	13,075,406	2,705,540
Table and Raisin Grape	11,730,354	4,596,988
Processing Tomato	10,421,111	3,790,433
Orange	9,550,802	2,741,577
Pistachio	7,719,338	8,652,840
Rice	5,995,283	3,840,919
Tangerine	4,605,809	1,389,244
Walnut	3,469,405	3,129,675
Alfalfa	2,256,327	4,422,636
Cotton	1,796,887	3,637,498

Pesticide use may increase or decrease due to new acreage put into production or acreage taken out of production. Using total acreage[2] values from the Quick Stats Database of US Department of Agriculture, National Agricultural Statistics Service (USDA NASS), Figure 13 shows that the decrease in pounds of AIs applied for strawberry, walnut, and orange is likely due, at least in part, to decreases in total acreage from 2022 to 2023. Similarly, the increase in pounds applied for table and raisin grapes, processing tomato, pistachio, and rice may be due in part to increased total acreage in production in 2023 compared to 2022. The pounds applied to almond and tangerine decreased despite an increase in total acreage, while the pounds applied to cotton, alfalfa, and wine grape increased despite a decrease or no change in total acreage (Figure 13).

[1] Table and raisin grapes are grouped together due to similar pesticide use.
[2] Total acreage may be acres planted, harvested, or bearing depending on the unit reported for the commodity in NASS

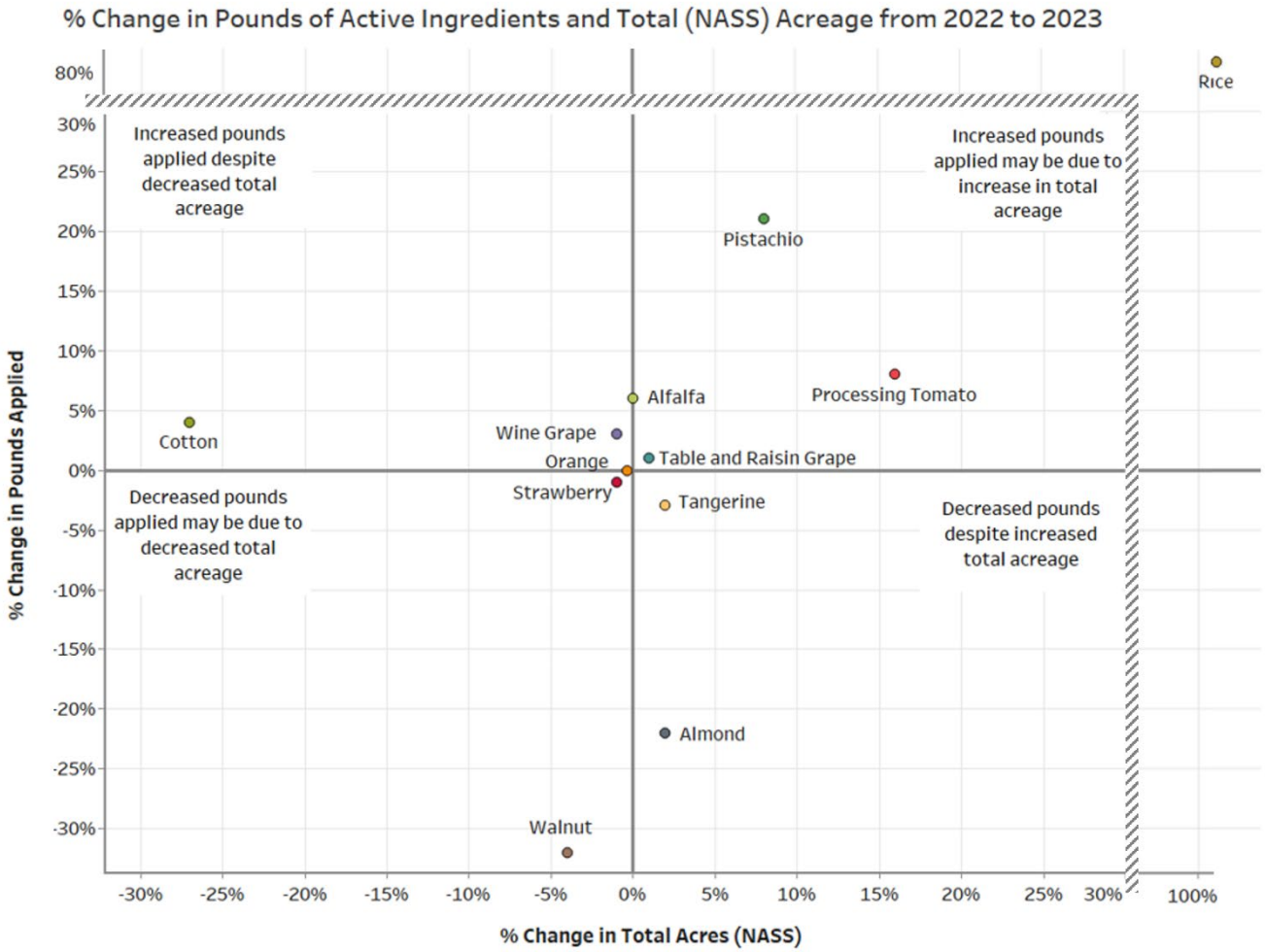


Figure 13. Graph showing percentage change in pounds of AIs applied from 2022 to 2023 against the change in the total acreage of the crop. Pounds applied is determined from the PUR data while the total acreage comes from the Quick Stats database, USDA National Agricultural Statistics Service (NASS). Total acreage may be acres planted, harvested, or bearing depending on the unit reported for the commodity in NASS. (Scale breaks of 50 to 70 percent were inserted into each axis of the graph as gray hashmarks to preserve optimal visualization of data points while accommodating the much larger percent increase in rice).

The following sections summarize the changes in pesticide use and top five pesticides by pounds applied and acres treated for the 12 top crops. A general use type (insecticide, fungicide, herbicide, etc.) is included for each AI. Note that use types may vary depending on the product that contains the AI, and there may be more than one use type for each AI. The tables contain the use type most often associated with the AI. Oil is listed as "many types" due to the many different types of pesticides that contain oil as an AI. The majority are insecticides, fungicides, and adjuvants. Most oil pesticides used in California serve as alternatives to more toxic pesticides. For the top five tables for each of the 12 crops, the following AIs are summations of all related salts, esters, subspecies/strains, or other closely related chemical derivatives: glyphosate, 2,4-D, *Bacillus thuringiensis,* copper, and oil.

Alfalfa

Harvested alfalfa acreage[1] did not change from 2022 to 2023, remaining at 480 thousand acres (Figure 13). In 2023, there were 2.3 million pounds of AI applied to alfalfa compared to 2.1 million pounds applied in 2022 (6 percent increase). Similarly, the acres treated also increased, going from 4.2 million acres treated in 2022 to 4.4 million in 2023 (5 percent increase).

The top five AIs used in alfalfa were mostly herbicides. Glyphosate and pendimethalin were in the top five when ranked by pounds applied and by acres treated. The insecticides lambda-cyhalothrin and indoxacarb, and the herbicide clethodim made up the remainder of the top five by acres treated, while the herbicides trifluralin and 2,4-DB, dimethylamine salt, and the fungicide/insecticide sulfur, comprised the remaining top five when measured by pounds applied (Tables 21, 22).

Table 21. The 2023 top five AIs by acres treated on alfalfa.

Top Five	Type	Acres Treated
Lambda-cyhalothrin	Insecticide	308,576
Pendimethalin	Herbicide	261,312
Clethodim	Herbicide	258,440
Glyphosate	Herbicide	220,503
Indoxacarb	Insecticide	191,077

Table 22. The 2023 top five AIs by pounds applied to alfalfa. Fung/Insect = Fungicide/Insecticide

Top Five	Type	Pounds Applied
Pendimethalin	Herbicide	526,260
Glyphosate	Herbicide	359,204
Sulfur	Fung/Insect	151,618
Trifluralin	Herbicide	101,455
2,4-DB, Dimethylamine Salt	Herbicide	68,551

ALFALFA

Alfalfa stem nematode damage (*Ditylenchus dipsaci*). Photo by Howard F. Schwartz, Colorado State University, Bugwood.org

Alfalfa leaf spot (*Pseudopeziza medicaginis*), a disease on alfalfa. Photo by Craig Grau, Bugwood.org

Alfalfa caterpillar (*Colias eurytheme*), a pest on alfalfa. Photo by John Capinera, University of Florida, Bugwood.org

[1] Quick Stats Database of US Department of Agriculture, National Agricultural Statistics Service

Almond

Statewide bearing almond acreage[1] increased from 1.35 million acres in 2022 to 1.38 million acres in 2023 (2 percent increase) (Figure 13). Despite the increased bearing acreage, the pounds of AI applied to almonds decreased from 31 million pounds in 2022 to 24 million pounds in 2023 (22 percent decrease). Almond acres treated with AIs increased from 22 million acres treated to 23 million acres treated (4 percent increase).

Glyphosate made the top five AIs when ranked by both pounds applied and acres treated. The remaining top four AIs by acres treated included the insecticides abamectin, chlorantraniliprole, and methoxyfenozide, and the herbicide oxyfluorfen. The remaining top five AIs by pounds applied included oil AIs, the fumigant 1,3-dichloropropene, the fungicide-insecticide sulfur, and the herbicide glufosinate-ammonium. (Tables 23, 24).

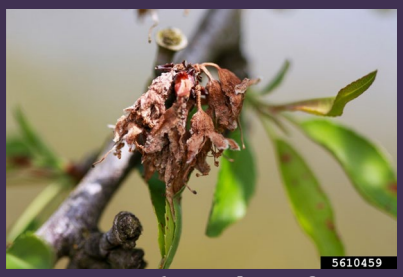
Table 23. The 2023 top five AIs by acres treated on almond.

Top Five	Type	Acres Treated
Glyphosate	Herbicide	1,553,900
Abamectin	Insecticide	1,009,154
Chlorantraniliprole	Insecticide	999,609
Methoxyfenozide	Insecticide	973,343
Oxyfluorfen	Herbicide	884,120

Table 24. The 2023 top five AIs by pounds applied to almond. Fung/Insect = Fungicide/Insecticide.

Top Five	Type	Pounds Applied
Oil	Many	8,251,628
Glyphosate	Herbicide	3,042,023
1,3-Dichloropropene	Fumigant	925,203
Sulfur	Fung/Insect	840,664
Glufosinate-Ammonium	Herbicide	760,842

ALMOND



Brown rot (*Monilinia fructicola*), a disease on almond. Photo by Gerald Holmes, Strawberry Center, Cal Poly San Luis Obispo, Bugwood.org

Rust (*Tranzschelia discolor*), a disease on almond. Photo by Gerald Holmes, Strawberry Center, Cal Poly San Luis Obispo, Bugwood.org

Anthracnose (*Polystigma fulvum*), a disease on almond. Photo by Diego Olmo, Laboratori Sanitat Vegetal-Illes Balears, Bugwood.org

[1] Quick Stats Database of US Department of Agriculture, National Agricultural Statistics Service

Cotton

The total acres planted[1] of cotton decreased from 134 thousand acres in 2022 to 98 thousand acres in 2023 (27 percent decrease) (Figure 13). Despite the decrease in planted acres, the pounds of AI applied increased from 1.7 million pounds applied in 2022 to 1.8 million pounds applied in 2023 (4 percent increase). In contrast, the acres treated decreased from 3.7 million acres treated in 2022 to 3.6 million acres treated applied in 2023 (1 percent decrease).

The herbicide glyphosate and the plant growth regulator ethephon made the top five lists by both acres treated and pounds applied. The insecticide flonicamid, the plant growth regulator mepiquat chloride, and the defoliant thidiazuron made up the remaining top five AIs by acres treated, while the herbicide/defoliant urea dihydrogen sulfate and the insecticides oxamyl and naled were the remaining three top five AIs by pounds applied (Tables 25, 26).

Table 25. The 2023 top five AIs by acres treated on cotton. PGR = Plant Growth Regulator. Herb/Def = Herbicide/Defoliant

Top Five	Type	Acres Treated
Glyphosate	Herbicide	200,127
Flonicamid	Insecticide	161,955
Mepiquat Chloride	PGR	144,597
Ethephon	PGR	136,464
Thidiazuron	Defoliant	131,491

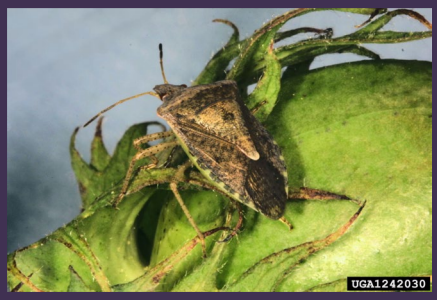
Table 26. The 2023 top five AIs by pounds applied to cotton.

Top Five	Type	Pounds Applied
Glyphosate	Herbicide	313,541
Urea Dihydrogen Sulfate	Herb/Def	143,624
Ethephon	PGR	143,421
Oxamyl	Insecticide	68,822
Naled	Insecticide	60,446

COTTON

Discoloration caused by cotton aphid (*Aphis gossypii*). Photo by Phillip Roberts, University of Georgia, Bugwood.org

Cotton bollworm (*Helicoverpa zea*), a pest on cotton. Photo by Russ Ottens, University of Georgia, Bugwood.org



Brown stink bug (*Euschistus servus*), a pest on cotton. Russ Ottens, University of Georgia, Bugwood.org

[1] Quick Stats Database of US Department of Agriculture, National Agricultural Statistics Service

Orange

Total statewide bearing acreage[1] for orange decreased from 137 thousand acres in 2022 to 136.5 thousand acres in 2023 (0.4 percent decrease) (Figure 13). Pounds of AI applied decreased from 9.56 million pounds applied in 2022 to 9.55 million pounds applied in 2023 (0.1 percent decrease). In contrast, the acres treated increased from 2.5 million acres in 2022 to 2.7 million acres treated in 2023 (9 percent increase).

Oil was by far the most used AI by both pounds applied and acres treated. The fungicide copper and the herbicide glyphosate were also ranked in the top five AIs when measured by either pounds applied or acres treated. The insecticide/miticide abamectin and the insecticide cyantraniliprole rounded out the top five AIs by acres treated, while the biopesticide fungicide-insecticide kaolin clay ("kaolin") and the fumigant 1,3-dichloropropene completed the top five list by pounds applied (Tables 27, 28).

Table 27. The 2023 top five AIs by acres treated on orange.

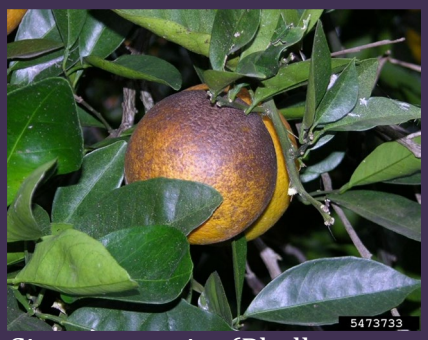
Top Five	Type	Acres Treated
Oil	Many	301,991
Abamectin	Insecticide	145,468
Copper	Fungicide	134,808
Cyantraniliprole	Insecticide	117,376
Glyphosate	Herbicide	110,795

Table 28. The 2023 top five AIs by pounds applied to orange. Fung/Insect = Fungicide/Insecticide.

Top Five	Type	Pounds Applied
Oil	Many	4,493,054
Copper	Fungicide	552,377
Kaolin	Fung/Insect	236,930
Glyphosate	Herbicide	137,078
1,3-Dichloropropene	Fumigant	59,390

ORANGE

Orange tortrix (Argyrotaenia franciscana), a pest on citrus. Photo by Mark Dreiling, Bugwood.org



Citrus rust mite (Phyllocoptruta Olivera), a pest on citrus. Photo by Don Ferrin, Louisiana State University Agricultural Center, Bugwood.org

Mottling of leaves from citrus greening (*Candidatus Liberibacter asiaticus*), a disease on citrus caused by Asian citrus psyllid (*Diaphorina citri*). Photo by Natalie Hummel, Louisiana State University AgCenter, Bugwood.org

[1] Quick Stats Database of US Department of Agriculture, National Agricultural Statistics Service

Pistachio

The total bearing acreage[1] of pistachio increased from 428 thousand acres in 2022 to 462 thousand acres in 2023 (8 percent increase) (Figure 13). Similarly, pesticide use also increased: Pounds of AI applied to pistachio increased from 6 million pounds applied in 2022 to 8 million pounds applied in 2023 (21 percent increase). Acres treated increased from 7 million acres treated in 2022 to 9 million acres treated in 2023 (17 percent increase).

The herbicide glyphosate made the top five AIs when ranked by both pounds applied and by acres treated. The four insecticides lambda-cyhalothrin, bifenthrin, methoxyfenozide, and chlorantraniliprole completed the top five when measured by acres treated, while the fungicide/insecticide sulfur, oil AIs, and the herbicides glufosinate-ammonium and pendimethalin made up the rest of the top five when measured by pounds applied (Tables 29, 30).

Table 29. The 2023 top five AIs by acres treated on pistachio.

Top Five	Type	Acres Treated
Lambda-Cyhalothrin	Insecticide	647,519
Glyphosate	Herbicide	556,944
Bifenthrin	Insecticide	419,128
Methoxyfenozide	Insecticide	344,954
Chlorantraniliprole	Insecticide	329,521

Table 30. The 2023 top five AIs by pounds applied to pistachio. Fung/Insect = Fungicide/Insecticide

Top Five	Type	Pounds Applied
Sulfur	Fung/Insect	1,252,270
Oil	Many	1,188,447
Glyphosate	Herbicide	1,074,341
Glufosinate-Ammonium	Herbicide	316,324
Pendimethalin	Herbicide	227,054

PISTACHIO

Darkling beetle (*Blapstinus histricus*), a pest on pistachio. Photo by Lindsey Seastone, USDA APHIS PPQ, Bugwood.org

False chinch bug (*Nysius raphanus*), a pest on pistachio. Photo by Chuck Bargeron, University of Georgia, Bugwood.org

European fruit lecanium (*Parthenolecanium corni*), a pest on pistachio. Photo by Raymond Gill, CDFA, Bugwood.org

[1] Quick Stats Database of US Department of Agriculture, National Agricultural Statistics Service

Processing Tomato

The statewide planted acreage[1] of processing tomatoes increased from 231 thousand acres in 2022 to 269 thousand acres in 2023 (16 percent increase) (Figure 13). Pounds of AI applied increased from 9.7 million pounds applied in 2022 to 10.4 million pounds applied in 2023 (8 percent increase). The acres treated increased from 3 million acres treated in 2022 to 4 million acres treated in 2023 (30 percent increase).

The fungicide/insecticide sulfur and the fungicide chlorothalonil made the top five list by both pounds applied and acres treated. The insecticides lambda-cyhalothrin, imidacloprid, and chlorantraniliprole made up the remaining three of the top five AIs by acres treated. The fumigant potassium N-methyldithiocarbamate ("metam-potassium"), the biopesticide kaolin clay ("kaolin"), and the herbicide glyphosate ranked in the top five by pounds applied (Tables 31, 32).

Table 31. The 2023 top five AIs by acres treated on processing tomato. Fung/Insect = Fungicide/Insecticide

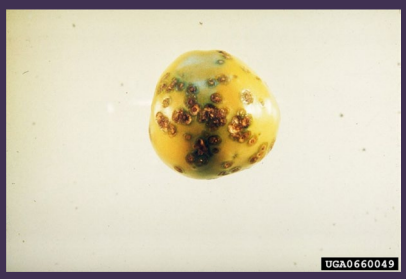
Top Five	Type	Acres Treated
Sulfur	Fung/Insect	281,324
Chlorothalonil	Fungicide	225,278
Lambda-Cyhalothrin	Insecticide	181,030
Imidacloprid	Insecticide	163,419
Chlorantraniliprole	Insecticide	162,466

Table 32. The 2023 top five AIs by pounds applied to processing tomato. Fung/Insect = Fungicide/Insecticide

Top Five	Type	Pounds Applied
Sulfur	Fung/Insect	5,953,362
Metam-potassium	Fumigant	2,166,614
Kaolin	Fung/Insect	495,622
Chlorothalonil	Fungicide	438,588
Glyphosate	Herbicide	186,122

PROCESSING TOMATO

Potato/tomato psyllid (*Bactericera cockerelli*), a pest on tomato. Photo by Whitney Cranshaw, Colorado State University, Bugwood.org



Bacterial spot (*Xanthomonas vesicatoria*), a disease on tomato. Volcani Center, Agricultural Research Organization, Bugwood.org

Bacterial speck (*Pseudomonas syringae*), a disease on tomato Photo by Gerald Holmes, Strawberry Center, Cal Poly San Luis Obispo, Bugwood.org

[1] Quick Stats Database of US Department of Agriculture, National Agricultural Statistics Service

Rice

The statewide planted acreage[1] of rice more than doubled from 254 thousand acres in 2022 to 515 thousand acres in 2023 (103 percent increase) (Figure 13). This increase likely explains much of the increase in the pounds of AI applied to rice in 2023, going from 3 million pounds applied in 2022 to 6.0 million pounds applied in 2023 (81 percent increase). The acres treated with AIs increased from 2 million acres treated in 2022 to 4 million acres treated in 2023 (93 percent increase).

The herbicide propanil ranked in the top five AIs by both acres treated and pounds applied. The fungicide azoxystrobin and the herbicides triclopyr (triethylamine salt), halosulfuron-methyl, and benzobicyclon made up the remaining four of the top five AIs by acres treated, while the fungicide copper, the herbicide thiobencarb, the algaecide sodium percarbonate, and the herbicide/defoliant sodium chlorate ranked in the top five by pounds applied (Tables 33, 34).

Table 33. The 2023 top five AIs by acres treated in rice.

Top Five	Type	Acres Treated
Propanil	Herbicide	546,837
Triclopyr, Triethylamine Salt	Herbicide	340,709
Azoxystrobin	Fungicide	318,997
Halosulfuron-Methyl	Herbicide	249,483
Benzobicyclon	Herbicide	232,857

Table 34. The 2023 top five AIs by pounds applied to rice. Herb/Def = Herbicide/Defoliant

Top Five	Type	Pounds Applied
Propanil	Herbicide	2,488,310
Copper	Fungicide	1,047,321
Thiobencarb	Herbicide	464,633
Sodium Percarbonate	Algaecide	228,388
Sodium Chlorate	Herb/Def	97,556

RICE

Chloratic rice seedling with Bakanae (*Fusarium fujikuroi*) disease. Photo by O.P. Sharma, Bugwood.org

Sheath spot (*Rhizoctonia oryzae*), a disease on rice. Photo by Donald Groth, Louisiana State University AgCenter, Bugwood.org

Stem rot (*Sclerotium oryzae*), a disease on rice. Photo by Donald Groth, Louisiana State University AgCenter, Bugwood.org

[1] Quick Stats Database of US Department of Agriculture, National Agricultural Statistics Service

Strawberry

The total planted acreage[1] of strawberry in California decreased from 43.6 thousand acres in 2022 to 43.1 thousand acres in 2023 (1 percent decrease) (Figure 13). The pounds applied decreased from 13.2 million pounds applied in 2022 to 13.1 million pounds applied in 2023 (1 percent decrease). The acres treated decreased from 2.9 million acres treated in 2022 to 2.7 million acres treated in 2023 (8 percent decrease).

Sulfur, a fungicide/insecticide, ranked in the top five by both pounds applied and acres treated. The fungicides captan, "captan, other related," and fludioxonil, followed by the insecticide *Bacillus thuringiensis,* rounded off the top five by acres treated (AIs with "other related" following their name are the naturally occurring impurities or impurities formed during the synthesis of the chemical compound). The fumigants chloropicrin, 1,3-dichloropropene, potassium N-methyldithiocarbamate ("metam-potassium"), and metam sodium made up the remaining four of the top five AIs by pounds applied (Tables 35, 36).

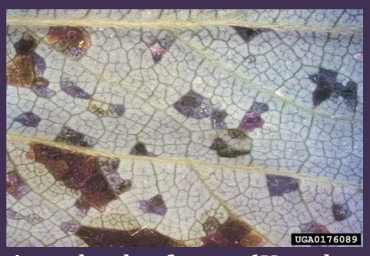
Table 35. The 2023 top five AIs by acres treated on strawberry. Fung/Insect = Fungicide/Insecticide.

Top Five	Type	Acres Treated
Captan	Fungicide	195,385
Sulfur	Fung/Insect	135,466
Captan, Other Related	Fungicide	107,493
Fludioxonil	Fungicide	74,636
Bacillus thuringiensis	Insecticide	71,560

Table 36. The 2023 top five AIs by pounds applied to strawberry. Fung/Insect = Fungicide/Insecticide.

Top Five	Type	Pounds Applied
Chloropicrin	Fumigant	6,885,311
1,3-Dichloropropene	Fumigant	1,727,978
Metam-Potassium	Fumigant	1,674,597
Sulfur	Fung/Insect	543,175
Metam-Sodium	Fumigant	492,032

STRAWBERRY



Angular leaf spot (*Xanthomonas fragariae*), a disease on strawberry. Photo by U. Mazzucchi, Università di Bologna, Bugwood.org

Anthracnose (*Colletotrichum acutatum*), a disease on strawberry. Photo by Gerald Holmes, Strawberry Center, Cal Poly SLO, Bugwood.org

Stunted roots caused by red stele root rot (Phytophthora fragariae var. fragariae), a disease on strawberry. Photo by SCRI-Dundee , Scottish Crop Research Institute, Bugwood.org

[1] Quick Stats Database of US Department of Agriculture, National Agricultural Statistics Service

Table and Raisin Grape

Total bearing acreage[1] of table and raisin grape increased from 250 thousand acres in 2022 to 253 thousand acres in 2023 (1 percent increase) (Figure 13). The pounds of AI applied increased from 11.6 million pounds applied in 2022 to 11.7 million pounds applied in 2023 (1 percent increase). The acres treated declined from 5 million acres treated in 2022 to 4.6 million acres treated in 2023 (7 percent decrease).

The fungicide/insecticide sulfur and the fungicide copper made the top five AIs by acres treated and pounds applied. The plant growth regulator gibberellins, the fungicide tebuconazole, and the insecticide imidacloprid comprised the remaining three top five AIs by acres treated, while the fungicide/insecticide lime-sulfur, the fumigant 1,3-dichloropropene, and oil AIs completed the top five AIs by pounds applied (Tables 37, 38).

Table 37. The 2023 top five AIs by acres treated on table and raisin grape. Fung/Insect = Fungicide/Insecticide. PGR = Plant Growth Regulator.

Top Five	Type	Acres Treated
Sulfur	Fung/Insect	1,323,253
Copper	Fungicide	283,101
Gibberellins	PGR	248,532
Tebuconazole	Fungicide	96,111
Imidacloprid	Insecticide	93,158

Table 38. The 2023 top five AIs by pounds applied to table and raisin grape. Fung/Insect = Fungicide/Insecticide.

Top Five	Type	Pounds Applied
Sulfur	Fung/Insect	8,441,398
Lime-Sulfur	Fung/Insect	565,403
Copper	Fungicide	353,765
1,3-Dichloropropene	Fumigant	243,523
Oil	Many	211,507

TABLE AND RAISIN GRAPE

Phomopsis cane and leaf spot (*Phomopsis viticola*), a disease on grape. Photo by Plant Pathology , University of Georgia, Bugwood.org

Grape leaffolder (*Desmia funeralis*), a pest on grape. Photo by Ansel Oommen, Bugwood.org

Grape mealybug (Pseudococcus maritimus), a pest on grape. Photo by Whitney Cranshaw, Colorado State University, Bugwood.org

[1] Quick Stats Database of US Department of Agriculture, National Agricultural Statistics Service

Tangerine

Total statewide bearing acreage[1] for tangerine increased from 66 thousand acres in 2022 to 67 thousand acres in 2023 (2 percent increase) (Figure 13). Pounds of AI applied decreased from 4.8 million pounds applied in 2022 to 4.6 million in 2023 (3 percent decrease). In contrast, the acres treated increased from 1.3 million acres treated in 2022 to 1.4 million acres treated in 2023 (9 percent increase).

Oil was the most used AI by both pounds applied and acres treated. The fungicide copper and the herbicide glyphosate were also ranked in the top five AIs when measured by either pounds applied or acres treated. The insecticide/miticide abamectin and the plant growth regulator gibberellins rounded out the top five AIs by acres treated, while the biopesticide kaolin clay ("kaolin") and the fumigant 1,3-dichloropropene completed the top five list by pounds applied (Tables 39, 40).

Table 39. The 2023 top five AIs by acres treated on tangerine. PGR = Plant Growth Regulator.

Top Five	Type	Acres Treated
Oil	Many	134,863
Glyphosate	Herbicide	73,906
Abamectin	Insecticide	61,412
Copper	Fungicide	52,236
Gibberellins	PGR	43,366

Table 40. The 2023 top five AIs by pounds applied to tangerine. Fung/Insect = Fungicide/Insecticide.

Top Five	Type	Pounds Applied
Oil	Many	2,094,690
Kaolin	Fung/Insect	904,472
Copper	Fungicide	192,377
Glyphosate	Herbicide	134,796
1,3-Dichloropropene	Fumigant	44,178

TANGERINE

Citricola scale (*Coccus pseudomagnoliarum*), a pest on citrus. US National Collection of Scale Insects Photographs , USDA ARS, Bugwood.org

California red scale (*Aonidiella aurantia*), a pest on citrus. Photo by Dennis Navea, ControlBest, Bugwood.org


Anthracnose (*Colletotrichum spp.*), a disease on citrus. Photo by Cesar Calderon, USDA APHIS PPQ,

[1] Quick Stats Database of US Department of Agriculture, National Agricultural Statistics Service

Walnut

Total bearing acreage[1] of walnuts decreased from 400 thousand acres in 2022 to 385 thousand acres in 2023 (4 percent decrease) (Figure 13). The pounds applied decreased from 5 million pounds applied in 2022 to 4 million pounds applied in 2023 (32 percent decrease). Acres treated decreased from 5 million in 2022 to 3 million acres treated in 2023 (31 percent decrease).

The top five AIs used in walnut included the fungicides copper and mancozeb and the herbicide glyphosate for both pounds applied and acres treated. The remaining two AIs by acres treated were the plant growth regulator ethephon and the herbicide oxyfluorfen, while the biopesticide kaolin clay ("kaolin") and the fumigant 1,3-dichloropropene made up the remaining two top five AIs when measured by pounds applied (Tables 41, 42).

Table 41. The 2023 top five AIs by acres treated on walnut. PGR = Plant Growth Regulator.

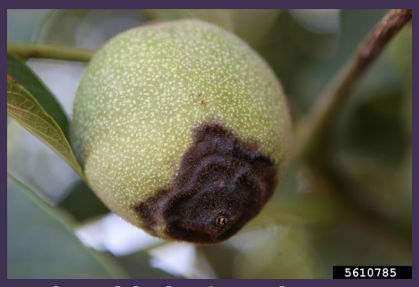
Top Five	Type	Acres Treated
Glyphosate	Herbicide	285,590
Ethephon	PGR	163,156
Oxyfluorfen	Herbicide	156,260
Copper	Fungicide	151,768
Mancozeb	Fungicide	133,738

Table 42. The 2023 top five AIs by pounds applied to walnut. Fung/Insect = Fungicide/Insecticide

Top Five	Type	Pounds Applied
Glyphosate	Herbicide	526,004
Copper	Fungicide	515,636
Kaolin	Fung/Insect	404,993
Mancozeb	Fungicide	238,910
1,3-Dichloropropene	Fumigant	202,440

WALNUT

Red-humped caterpillar (*Schizura concinna*), a pest on walnut. Photo by Howard Ensign Evans, Colorado State University, Bugwood.org



Walnut blight (*Xanthomonas arboricola pv. juglandis*), a disease on walnut. Photo by Gerald Holmes, Strawberry Center, Cal Poly San Luis Obispo, Bugwood.org

San Jose scale (*Comstockaspis perniciosa*), a pest on walnut. Photo by John .A. Davidson, Univ. Md, College Pk, Bugwood.org

[1] Quick Stats Database of US Department of Agriculture, National Agricultural Statistics Service

Wine Grape

The bearing acreage[1] of wine grapes in California decreased from 575 thousand acres in 2022 to 570 thousand acres in 2023 (1 percent decrease) (Figure 13). Pounds of AI applied increased from 25.5 million pounds applied in 2022 to 26.3 million pounds applied in 2023 (3 percent increase). The acres treated increased from 9.5 million acres treated in 2022 to 9.9 million acres treated in 2023 (4 percent increase).

The fungicide/insecticide sulfur, oil, and the herbicides glufosinate-ammonium and glyphosate made up the top five AIs when ranked by either acres treated or pounds applied. The fungicide copper rounded out the top five AIs by acres treated, while the fumigant 1,3-dichloropropene was the remaining AI of the top five by pounds applied (Tables 43, 44).

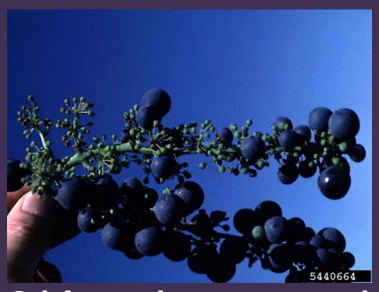
Table 43. The 2023 top five AIs by acres treated on wine grape. Fung/Insect = Fungicide/Insecticide.

Top Five	Type	Acres Treated
Sulfur	Fung/Insect	2,328,124
Oil	Many	343,934
Glufosinate-Ammonium	Herbicide	325,503
Copper	Fungicide	309,632
Glyphosate	Herbicide	255,810

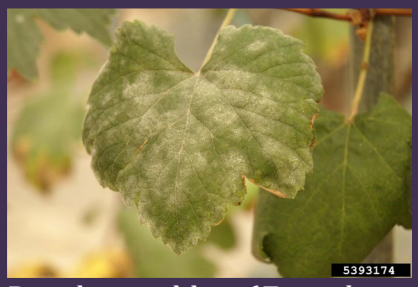
Table 44. The 2023 top five AIs by pounds applied to wine grape. Fung/Insect = Fungicide/Insecticide.

Top Five	Type	Pounds Applied
Sulfur	Fung/Insect	19,752,343
Oil	Many	2,402,491
Glyphosate	Herbicide	492,856
1,3-Dichloropropene	Fumigant	299,496
Glufosinate-Ammonium	Herbicide	291,142

WINE GRAPE



California dagger nematode (*Xiphinema index*), a pest on grape. Photo by Jonathan D. Eisenback, Virginia Polytechnic Institute and State University, Bugwood.org



Powdery mildew (*Erysiphe necator*), a disease on grape. Photo by Yuan-Min Shen, National Taiwan University, Bugwood.org

Western grape leafhopper nymphs (*Erythroneura elegantula*), a pest on grape. Photo by Eugene E. Nelson, Bugwood.org

[1] Quick Stats Database of US Department of Agriculture, National Agricultural Statistics Service

Pesticide Use Annual Report
2023 Data Summary

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