Pesticide Usage in Strawberry Farming in California and Florida

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Context

The use of pesticides in strawberry farming is extensive. USDA survey data collects the reported use of pesticides in organic strawberry farming nationwide. Although some pesticides can be washed off, many are absorbed into the plant and its fruit. This means that the strawberries we ingest may contain harmful pesticides.

This analysis focuses on California and Florida as they are the largest producers of freshmarket strawberries and strawberries for processing. This analysis seeks to find the usage of the most toxic pesticides to humans in farms in Florida and California in 2023 and compare the sales and production of strawberries between Florida and California to understand where most strawberries at the grocery store are coming from and what chemicals might be on them.

Methods

Survey and census data from 2020 to 2024 was used to conduct the analysis. Census data is a complete count of every potential strawberry operation and producer. Survey data is a subset of the population of the census data; not everyone receives a questionnaire, only a subset of the population of producers that the USDA deems representative of nationwide strawberry production receive questionnaires.

Importing Data

```
library(knitr)
library(kableExtra)
library(tidyverse)
library(stringr)
library(ggplot2)

strawberry <- read_csv("strawb_mar6.csv", col_names = TRUE, show_col_types = FALSE)


#splitting census and survey data
strawb_census <- strawberry |> filter(Program == "CENSUS")
strawb_survey <- strawberry |> filter(Program == "SURVEY")

source("Functions.R")
strawb_census <- strawb_census |> drop_one_value_col()
strawb_survey <- strawb_survey |> drop_one_value_col()
```

```
#further splitting census data to income and strawberry data
census_income <- strawb_census |> filter(Commodity == "INCOME, NET CASH FARM")
census_strawb <- strawb_census |> filter(Commodity == "STRAWBERRIES")

source("Functions.R")
census_income <- census_income |> drop_one_value_col()
census_strawb <- census_strawb |> drop_one_value_col()
```

Working with Census Data for Strawberries

```
census_strawb <- census_strawb |> separate_wider_delim( cols = "Data Item", delim = "
                                                         names = c("Fruit", "Category")
                                                         too_many = "error",
                                                         too_few = "align_start")
census_strawb <- census_strawb |> separate_wider_delim( cols = "Fruit", delim = ", ",
                                                names = c("Fruit", "Organic", "Specifica
                                                too_many = "error",
                                                too_few = "align_start")

census_strawb <- census_strawb |> drop_one_value_col()|>
                         filter(State %in% c("CALIFORNIA", "FLORIDA"))
```

```
census_income <- census_income |> separate_wider_delim(cols = "Data Item", delim = " -
                                                       names = c("Income", "Specificat
                                                       too_many = "error",
                                                       too_few = "align_start")
census_income <- census_income |> separate_wider_delim(cols = "Income", delim = ", ",
                                                  names = c("INCOME", "NET CASH FARM", "CATEG
                                                  too_few = "align_start")

census_income <- census_income |> drop_one_value_col()
census_income$CATEGORY <- str_remove(census_income$CATEGORY, "^OF ")
census_income <- census_income |> filter(State %in% c("CALIFORNIA", "FLORIDA"))
```

Working with Survey Data

```
strawb_survey <- strawb_survey |> separate_wider_delim(cols = "Data Item", delim = " -
                                                       names = c("Fruit", "Category"),
                                                       too_many = "error",
                                                       too_few = "align_start")
strawb_survey <- strawb_survey |> separate_wider_delim(cols = "Fruit", delim = ", ",
                                                  names = c("STRAWBERRIES", "Specification
                                                  too_few = "align_start",
                                                  too_many = "error")

strawb_survey <- strawb_survey |> drop_one_value_col()

#test <- strawb_survey |> filter(Category == "TREATED, MEASURED IN PCT OF AREA BEARING
```

```
# filtering strawberry data for just the chemicals
chemicals <- strawb_survey |> filter(Domain != 'TOTAL' )
chemicals <- chemicals |> drop_one_value_col()
chemicals <- chemicals |> filter(Value != "(D)" & Value != "(NA)")
chemicals <- chemicals |> drop_one_value_col()

#chemicals_yravg <- chemicals |> filter(Category == "APPLICATIONS, MEASURED IN LB / AC
#chemical_lbs <- chemicals |> filter(Category == "APLICATIONS, MEASURED IN LB")
#chemical_lbs_23 <- chemical_lbs |> filter(Year == "2023")

#cleaning chemical data
chemicals_2023 <- chemicals |> filter(Year == "2023" ) |>
  mutate(`Domain Category` = str_extract(`Domain Category`, "\\((.*?)\\)"))|>
  mutate(`Domain Category` = str_remove_all (`Domain Category`, "[()]")) |>
    separate_wider_delim(cols = "Domain Category",
                         delim = " = ",
                         names = c('Chemical_Name', 'Chemical_Code'),
                         too_few = "align_start",
                         too_many = "error")
chemicals_2023$Value <- as.numeric(as.character(chemicals_2023$Value))
chemicals_2023 <- chemicals_2023|> filter(Value != "(D)" & Value != "(NA)")
```

Although there are an extensive number of pesticides, fungicides, and other chemicals used in strawberry production, 5 in total were chosen as they were the most toxic to humans and the surrounding ecosystem. The five chemicals chosen are: bifenthrin, captan, chloropicrin, malathion, and thiram.

Bifenthrin is classified as a restricted-use insecticide by the US EPA as it is a possible carcinogen and is highly toxic to aquatic life. Captan is a fungicide that has low toxicity levels when ingested but can cause skin and eye irritation. Captan, like bifenthrin, is very toxic to aquatic life. Chloropicrin was historically used by riot police and by the US military as a tear gas but is now used as a pesticide. Malathion is an insecticide and it's moderately toxic to humans. Ingestion or inhalation of malathion will affect the nervous system, resulting in muscle weakness, twitching, and slurred speech, as it is a neurotoxin. Lastly, thiram is a fungicide that has low to moderate toxicity to humans upon ingestion. Thiram is a nuerotoxin; when tested on mice, the mice had symptoms of lethargy and reduced motor activity. Additionally, mice born tomothers exposed to thiram had extreme fetal malformations.

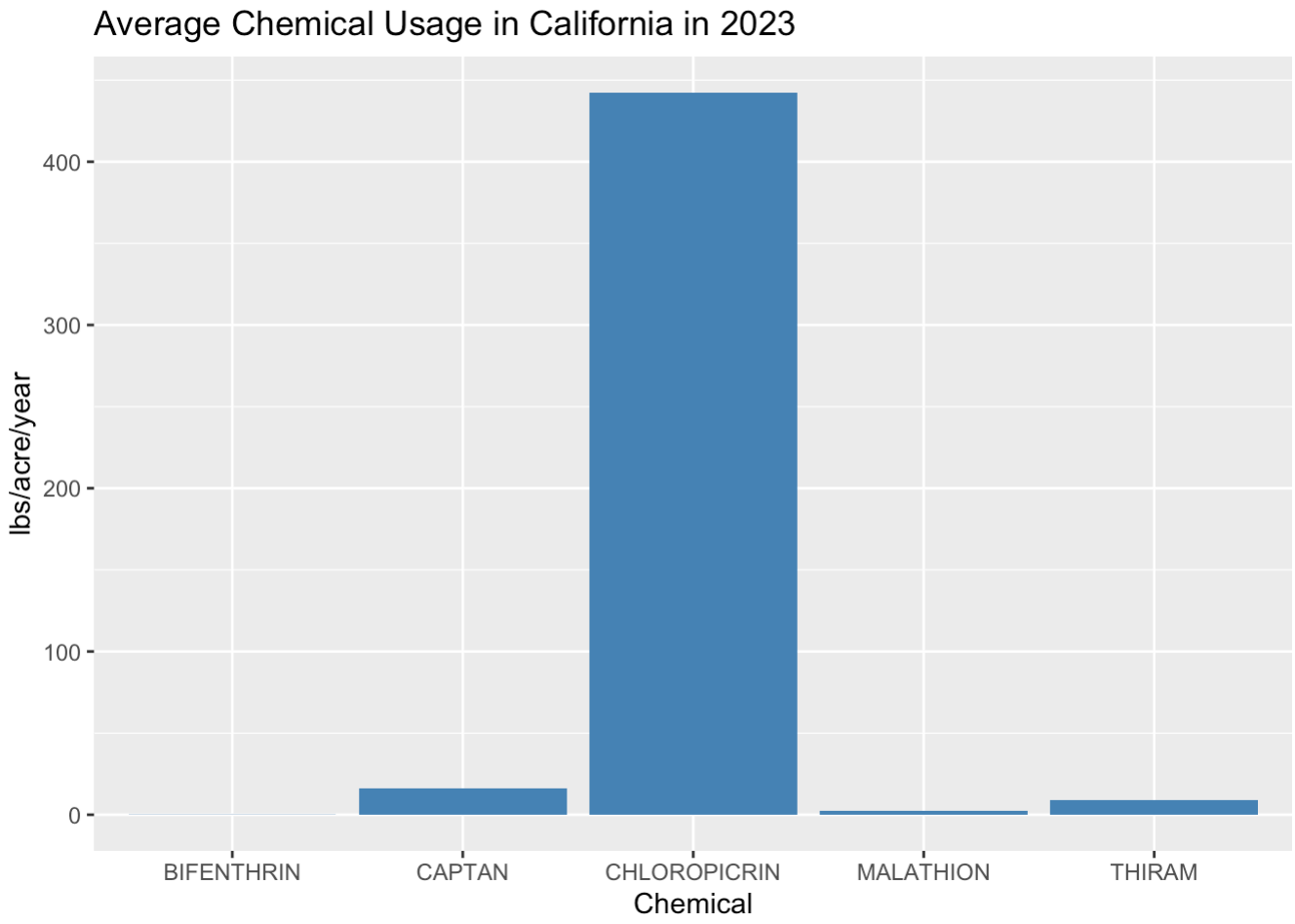
Extracting Chemical Data for each state

```
flo_chem <- chemicals_2023 |> filter(State == "FLORIDA")
cali_chem <- chemicals_2023 |> filter(State == "CALIFORNIA")

flo_chem <- flo_chem |> filter(Chemical_Name != "TOTAL") |>
  filter(Chemical_Name %in% c("BIFENTHRIN","THIRAM", "CAPTAN"))
cali_chem <- cali_chem |> filter(Chemical_Name != "TOTAL")|> filter(Chemical_Name %in%

cali_chem <- cali_chem |>
  select(Chemical_Name, Chemical_Code, Domain, Category, Value) |>
  pivot_wider(
    names_from = Category,
```

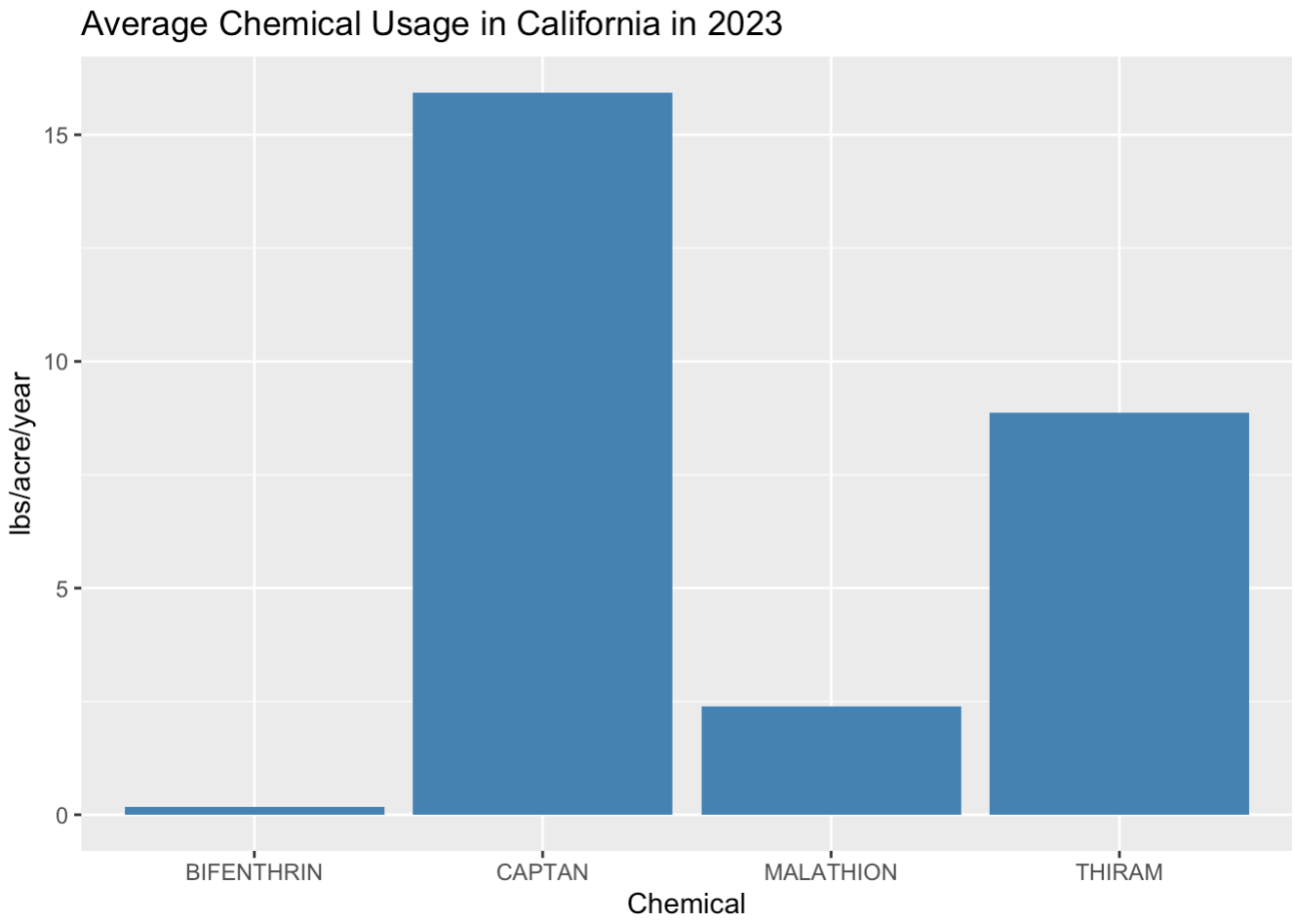
```
    values_from = Value
  )

flo_chem <- flo_chem |> select(Chemical_Name, Chemical_Code, Domain, Category, Value)
                        pivot_wider(names_from = Category, values_from = Value)
```

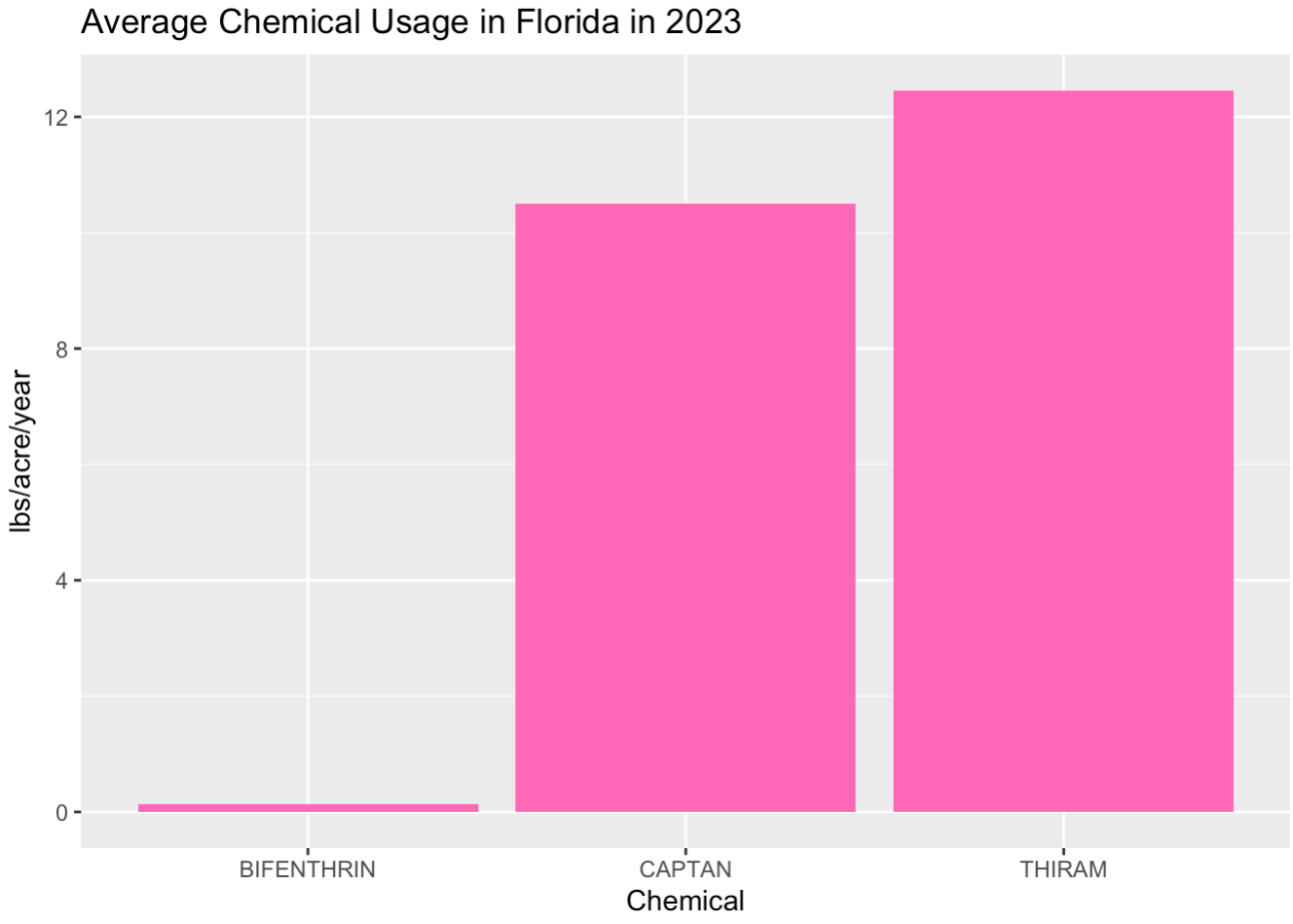
Plotting Chemical Data from California and Florida

```
#plotting cali data
ggplot(cali_chem, aes(x = Chemical_Name, y = `APPLICATIONS, MEASURED IN LB / ACRE / YE
  labs(title = "Average Chemical Usage in California in 2023", x = "Chemical", y = "lb
```




```
# plotting cali chemicals without chloropicrin

cali_zoom <- cali_chem |> filter(Chemical_Name != "CHLOROPICRIN")

ggplot(cali_zoom, aes(x = Chemical_Name, y = `APPLICATIONS, MEASURED IN LB / ACRE / YE
  labs(title = "Average Chemical Usage in California in 2023", x = "Chemical", y = "lb
```


Average Chemical Usage in California in 2023
lbs/acre/year
15
10
5
0
BIFENTHRIN
CAPTAN
MALATHION
THIRAM
Chemical


Average Chemical Usage in Florida in 2023
lbs/acre/year
12
8
4
0
BIFENTHRIN
CAPTAN
THIRAM
Chemical

Tables for Cali and Florida

```
cali_chem |>   select(-c("Chemical_Code", "Domain")) |>
  kable(caption = "Chemical Usage in California in 2023",
        col.names = c("Chemical Name", "Lb/Acre/Application", "Lb/Acre/Year", "Number
  kable_styling(full_width = FALSE, bootstrap_options = c("striped", "hover", "condens
   row_spec(0, bold = TRUE, color = "white", background = "#481F01")
```

Chemical Usage in California in 2023

Chemical Name	Lb/Acre/Application	Lb/Acre/Year	Number of Applications	Percent Crop Treated
CAPTAN	1.693	15.932	9.4	88
THIRAM	2.201	8.873	4.0	70
BIFENTHRIN	0.116	0.178	1.5	60
MALATHION	1.807	2.398	1.3	19
CHLOROPICRIN	188.284	442.413	2.3	59

```
flo_chem |>   select(-c("Chemical_Code", "Domain")) |>
  kable(caption = "Chemical Usage in Florida in 2023",
        col.names = c("Chemical Name","Lb/Application", "Lb/Acre/Application", "Lb/Acr
  kable_styling(full_width = FALSE, bootstrap_options = c("striped", "hover", "condens
   row_spec(0, bold = TRUE, color = "white", background = "#036c5f")
```

Chemical Usage in Florida in 2023

Chemical Name	Lb/Application	Lb/Acre/Application	Lb/Acre/Year	Number of Applications	Percent Crop Treated
BIFENTHRIN	100	0.117	0.136	1.2	6
CAPTAN	NA	2.012	10.509	5.2	96
THIRAM	NA	2.156	12.456	5.8	63

From the table and the bar chart depicting chemical usage in California, it is clear that chloropicrin is used almost more than any of the other 4 chemicals in units of pounds per acre per year. Chloropicrin is used almost 40 times more than any other chemical. Below is an additional bar chart without chloropicrin to show properly the scale at which the other chemicals are used in California farms.

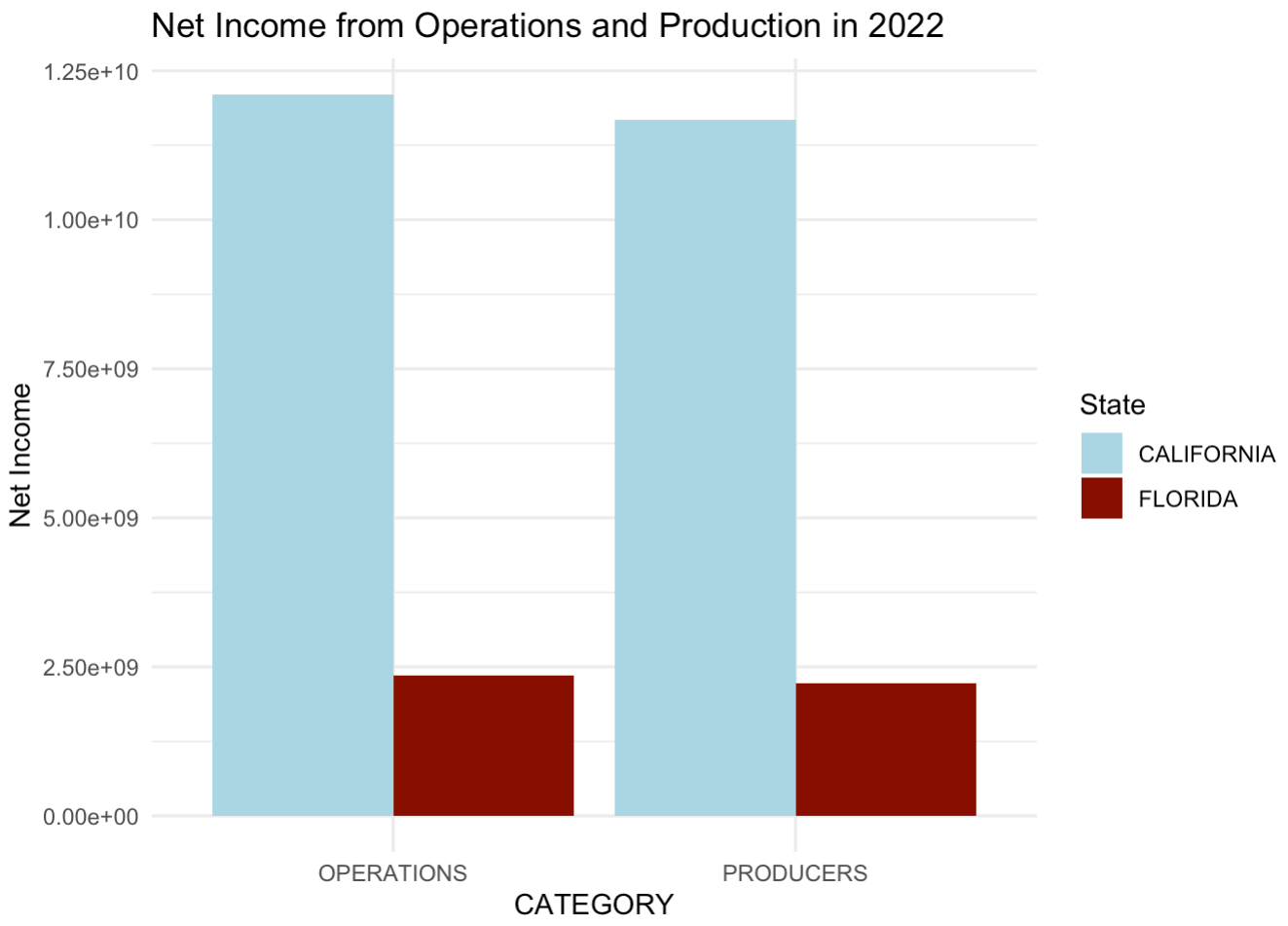
Chloropicrin and malathion are not used in Florida, however, 2 of these chemicals used in Florida are highly toxic to aquatic life. Seeing as Florida contains a lot of marshland and is a peninsula, the usage of these insect and fungicides are very harmful to the environment.

The bar graph depicting chemical usage in Florida shows the average usage of bifenthrin, captan, and thiram in Florida in units of pounds per acre per year. Thiram is the most used chemical in Florida, but it is not used nearly to the scale of chloropicrin in California.

Working with Income Data

Income from strawberry farms is further divided into income from operations, which refers to marketing, processing, and the other businesses involved in strawberry production. Producers refer to the farmers that grow the strawberries. The following bar graph compares income in dollars between Florida and California's producers and operations sectors.

```
#working with income data from census

census_income_totals <- census_income |> filter(Domain == "TOTAL")
census_income_totals <- census_income_totals |> drop_one_value_col()

#plotting income measured in $
total_netincome <- census_income_totals |> filter(Specification == "NET INCOME, MEASUR
                                                                  Value = as.numeric(Val

ggplot(total_netincome, aes( x = CATEGORY, y = Value, fill = State)) +
  geom_bar(stat = "identity", position = "dodge") +
   labs(title = "Net Income from Operations and Production in 2022",
      x = "CATEGORY", y = "Net Income") +
  scale_fill_manual(values = c("CALIFORNIA" = "lightblue", "FLORIDA" = "darkred")) +
  theme_minimal()
```



The following table compares the acres of strawberries harvested in California and Florida and their associated total sales measured in total and in cost per hundredweight or one hundred pounds.

```
strawberry_table <- census_strawb |> filter(is.na(Specification))
#splitting income into income from operations and producers
strawberry_table <- strawberry_table |>
```

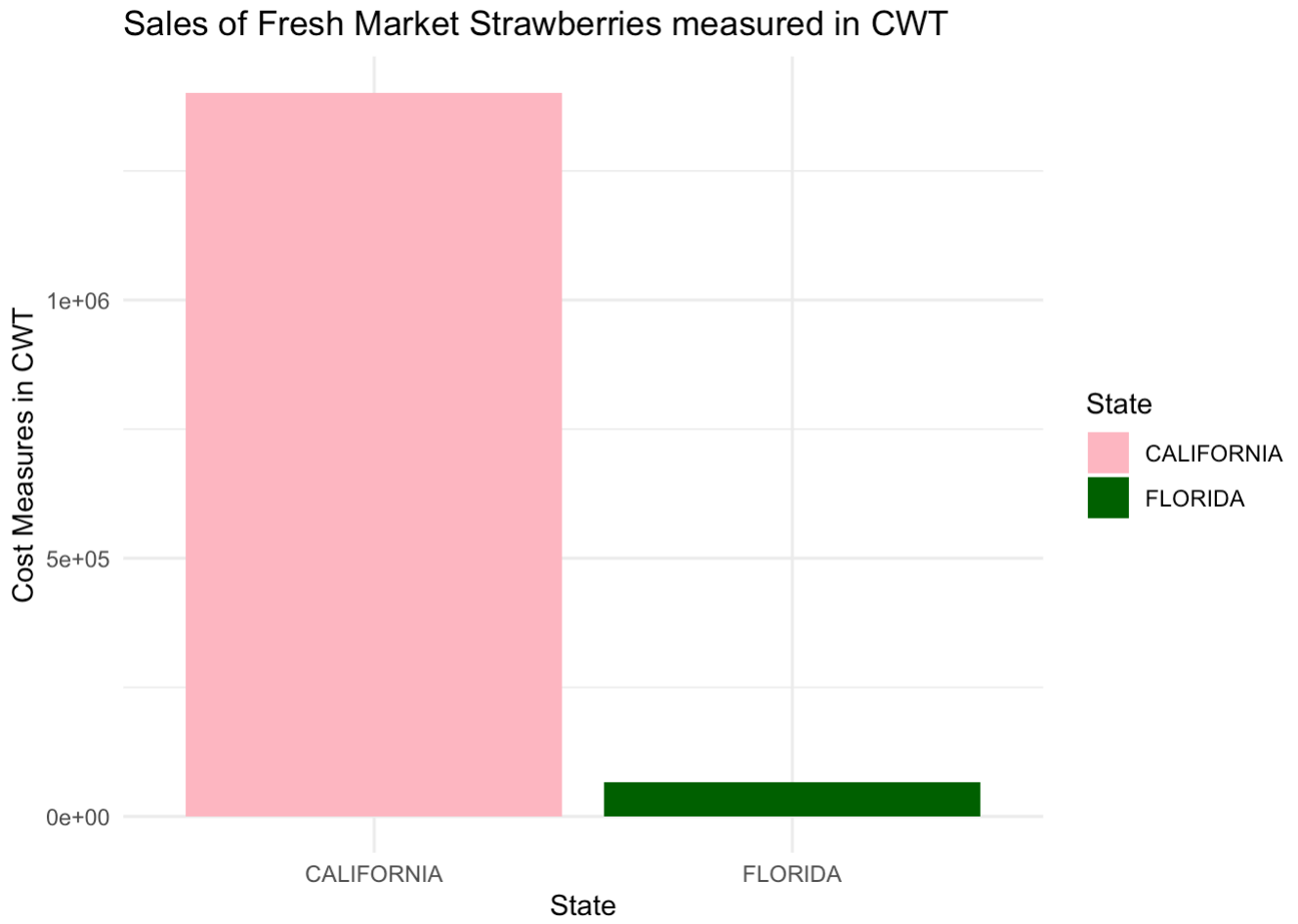
```
  select(State, Category, Value) |>
  pivot_wider( names_from = State, values_from = Value )

strawberry_table |> kable(caption = "Harvest and Sales Stats in Florida and California
      col.names = c("", "California", "Florida")) |>
  kable_styling(full_width = FALSE, bootstrap_options = c("striped", "hover", "condens
                row_spec(0, bold = TRUE, color = "white", background = "#4E98a1")
```

Harvest and Sales Stats in Florida and California

	California	Florida
ACRES HARVESTED	4,228	704
SALES, MEASURED IN $	311,784,980	18,358,396
SALES, MEASURED IN CWT	1,412,627	67,146

It's clear from the graph and the table that strawberry farming and processing is operating at a significantly larger scale in California than in Florida. Below is another graph comparing strawberry sales in California and Florida in units of cost per hundred pounds.

```
fresh_market <- census_strawb |> filter(Specification == "FRESH MARKET") |>
                         filter(Category == "SALES, MEASURED IN CWT") |>
                        mutate(Value = gsub("[^0-9.-]", "", Value),
                                                        Value = as.numeric(Val


ggplot(fresh_market, aes( x = State, y = Value, fill = State)) +
  geom_bar(stat = "identity", position = "dodge") +
   labs(title = "Sales of Fresh Market Strawberries measured in CWT",
      x = "State", y = "Cost Measures in CWT") +
  scale_fill_manual(values = c("CALIFORNIA" = "lightpink", "FLORIDA" = "darkgreen")) +
  theme_minimal()
```



Discussion

California is the largest producer of strawberries in the nation, however, more than half of their crop is treated with chloropicrin– a highly toxic chemical– at very high doses in comparison to the usage of other chemicals (442.4 lbs per acre per year). Driscoll's, the world's largest berry company, sources majority of their strawberries from California farms. Even Smuckers, a company known for their peanut butter and jams, gets their strawberries from California.

Eating strawberries should not be a hazardous activity. Although no washing method is 100% effective, washing produce can remove some pesticides. However, it can be useful to be aware of where strawberries are being grown and under what conditions. It may be beneficial to buy produce from local farmers rather than large-scale farms with habits of using toxic pesticides.

Works Cited

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