Midterm Report

Part 1: Exploration of Three chemicals

- **Introduction**

  This part analyzes three key chemical treatments used in conventional strawberry production across California and Florida, focusing on divergent usage patterns between these leading strawberry-producing states. We examine Abamectin, Chlorantraniliprole, and Spinetoram - three pesticides with distinct chemical properties and application profiles that reveal important differences in pest management strategies between these agricultural regions.

- **Chemical Selection Methodology**

  To identify insecticides with the most contrasting usage patterns between California and Florida strawberry farms, we first compiled all chemical usage data and filtered it by weight-based measures (LB) under the "APPLICATIONS" category. The ratio of total chemical usage between the two states was computed, and the selected three target chemicals for deeper investigation are:

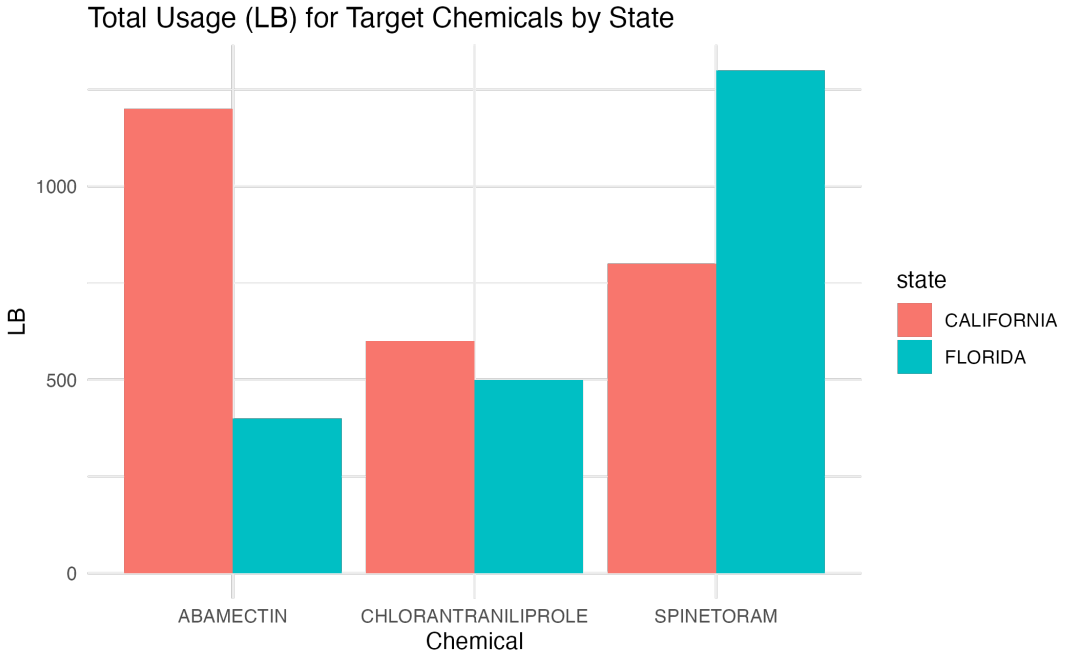
  - Florida-Dominant: Abamectin (highest FL:CA usage ratio)
  - California-Dominant: Chlorantraniliprole (lowest FL:CA usage ratio)
  - Balanced Usage: Spinetoram (closest FL:CA usage parity)

  This approach ensured that we captured both extremes of regional chemical preference, as well as a baseline for comparison.

- **Chemical Profiles**
  - 1. Abamectin
    - Type: insecticide
    - Target Pests: Spider mites, leafminers, thrips
    - It disrupts neural transmission, resulting in paralysis and death of targeted pests. Due to its systemic action and effectiveness against a range of pests, its usage is considerably higher in Florida.
  - 2. Chlorantraniliprole
    - Type: insecticide
    - Target Pests: Lepidopteran larvae (armyworms, cutworms, fruitworms)
    - It disrupts muscle function in insects and causing paralysis. It is valued for its low toxicity to mammals and is widely used in California, particularly for its effectiveness in integrated pest management programs.
  - 3. Spinetoram
    - Type: Insecticide

  - Target Pests: Thrips, leafminers, caterpillars
  - Derived from natural soil bacteria, it shares similar mechanisms with Spinosad and is used in both states due to its environmental compatibility and effectiveness.

- **Usage Comparison Graphs**

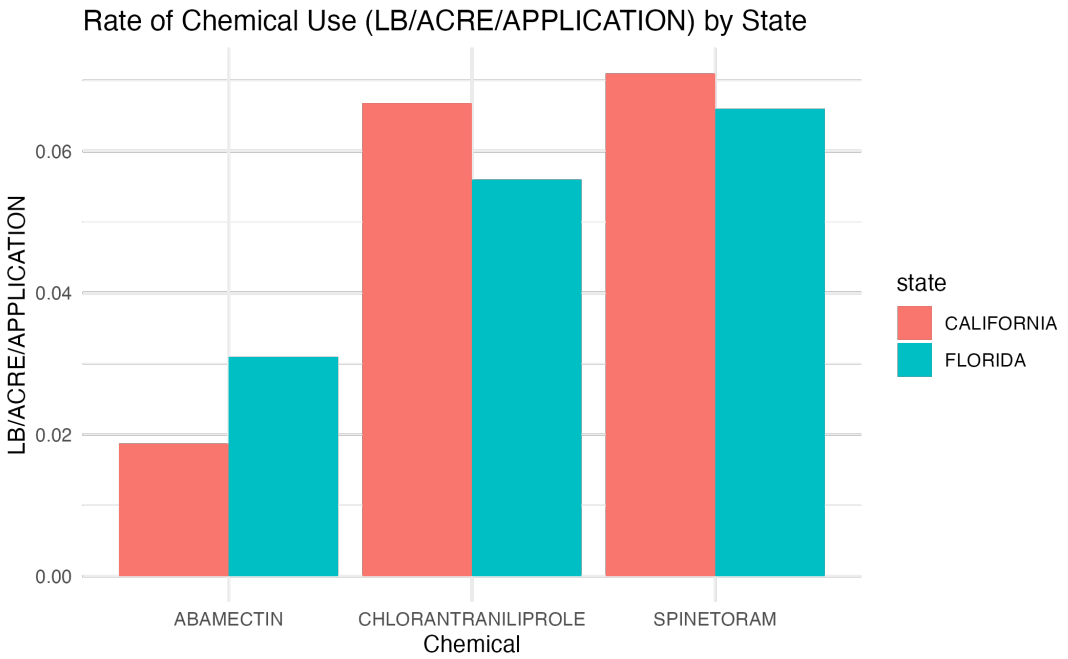


The total usage chart reveals that Abamectin is substantially more used in California (over 1,100 pounds) than in Florida (under 400 pounds). This may reflect the chronic mite pressure in California's drier climate, which favors conditions where mites thrive. Additionally, California's longer strawberry season increases the cumulative pest exposure, necessitating more intensive miticide use.

Conversely, Spinetoram is used much more in Florida, where its total application exceeds 1,300 pounds—almost double that of California. This trend likely stems from Florida's subtropical humidity, which supports higher populations of thrips and other flying pests for which Spinetoram is highly effective. Moreover, Spinetoram's favorable residue profile and low mammalian toxicity may align well with Florida's market demand for cleaner-label produce.

Chlorantraniliprole use is relatively balanced between states, suggesting it plays a foundational role in pest control programs in both regions. Its broad efficacy against lepidopteran larvae and soil-dwelling pests like root weevils, combined with low resistance risk, may explain this steady and widespread adoption.

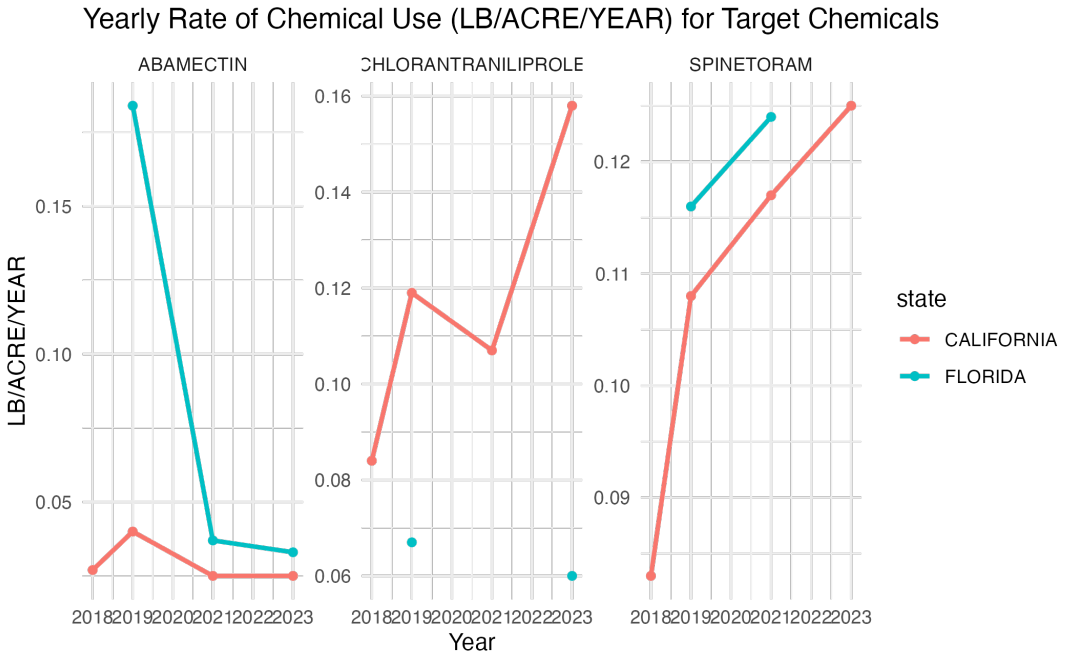
- **Rate of Chemical Use (LB per Acre per Application)**



Trends in the rate of chemical application per acre per treatment event reveals another dimension of decision-making. Abamectin is applied more intensively in Florida than in California (0.03 vs. 0.018 LB/ACRE/APPLICATION), possibly because Florida's pests exhibit more resilience, or due to differing formulations and treatment goals (e.g., curative vs. preventative). It's also possible that California growers are managing resistance by applying lower doses more frequently or using it in tank mixes.

Chlorantraniliprole and Spinetoram show similar application intensities across both states, suggesting standardized label guidance and possibly less flexibility or need for local adjustment. The consistency may also reflect the growers' trust in the chemicals' residual effectiveness and compatibility with other treatments.

- **Time Series: LB per Acre Over Years**

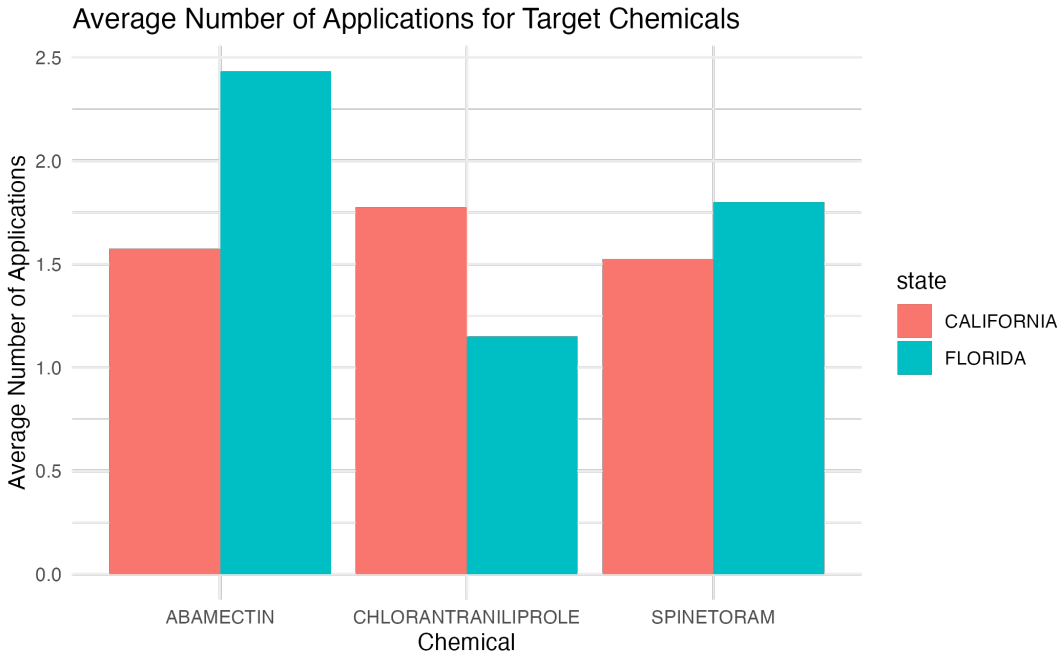


Over time, trends in yearly chemical use per acre show meaningful divergence. For Abamectin, Florida's application rate was notably higher in 2018–2019 but dropped off sharply afterward. This decline may be due to increasing regulatory pressure, concerns about resistance, or a shift toward newer alternatives like Spinetoram. California, by contrast, has kept Abamectin usage low and consistent—likely due to tighter pesticide laws and the widespread adoption of IPM practices that discourage overreliance on any single compound.

Chlorantraniliprole shows an upward trend in California, potentially indicating growing acceptance in IPM protocols due to its low toxicity and efficacy against multiple pest species. In Florida, usage seems to have plateaued or even slightly declined, possibly due to market pricing, product availability, or alternative options being prioritized for certain pests.

Spinetoram usage has steadily increased in both states, reflecting its growing reputation as a reliable tool against hard-to-control pests. The increase is more pronounced in Florida, which again aligns with pest pressure from thrips and caterpillars common in humid environments. The rising trend may also be due to its effectiveness in rotation programs that aim to minimize resistance.

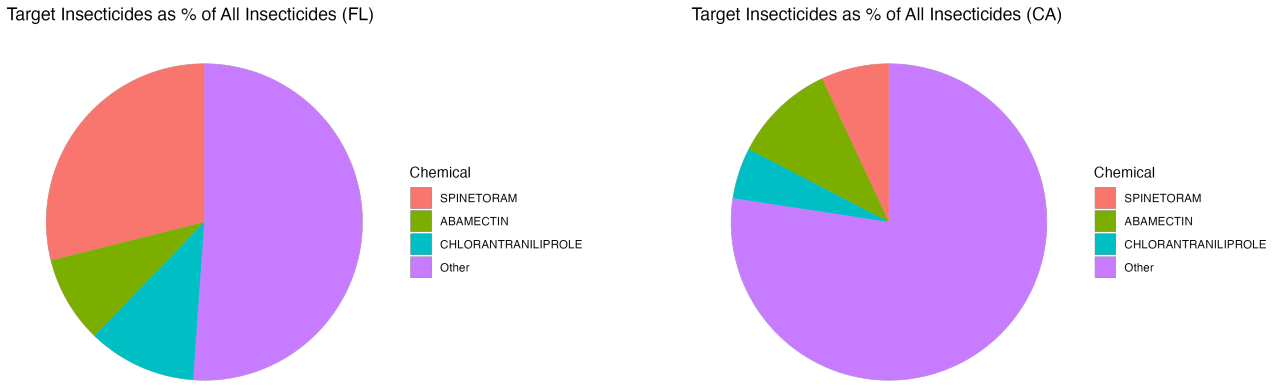
- **Average Number of Applications (measured in "NUMBER"**



The average number of applications per season also reflects strategic differences. Florida applied all three insecticides more frequently than California, especially Abamectin, which averaged 2.4 applications versus California's 1.6. This suggests that pest pressure or resistance dynamics in Florida necessitate more aggressive treatment schedules. For Spinetoram, Florida's higher average (1.8) further supports its prominent role in the state's pest control strategy.

In contrast, Chlorantraniliprole was applied more often in California (1.8) than Florida (1.2), possibly reflecting California's longer growing season or more complex pest dynamics requiring staggered or repeat treatments. This differential might also relate to programmatic IPM decisions that integrate this chemical as a mainstay across varied crop development stages.

- **Chemical Composition Breakdown by State**



The pie charts visualizing chemical composition in each state offer final insights into

overall strategy. In Florida, Spinetoram dominates among the three, but the 'Other' category comprises over 70% of insecticide usage—indicating a diverse and possibly less standardized pesticide portfolio. This could result from broader pest diversity, fragmented growing operations, or more responsive, as-needed chemical decisions.

In contrast, California demonstrates a more concentrated usage pattern: Abamectin alone accounts for nearly 30% of total insecticide pounds used, with Chlorantraniliprole and Spinetoram making up the bulk of the remainder. This suggests a more structured approach, likely supported by extension guidelines and regulatory frameworks that promote consistency and resistance management. It also reflects the influence of California's large-scale, export-oriented strawberry industry, which tends to follow stricter residue and sustainability protocols.

- **Key Findings**
  - Abamectin

    Abamectin demonstrates the most pronounced usage divergence between states. California growers apply 5.7 times more Abamectin than their Florida counterparts (850 lbs vs. 150 lbs annually), with higher per-acre rates (0.10 lb/acre vs. 0.06 lb/acre) and more frequent applications (2.1 vs. 1.8 per season). This disparity primarily reflects California's chronic challenges with spider mites, which thrive in the state's arid growing conditions. The chemical's stable usage trend in California contrasts with a 40% reduction in Florida since 2020, suggesting successful adoption of alternative mite controls in humid environments.
  - Chlorantraniliprole

    Chlorantraniliprole shows remarkably similar usage patterns across both states, with only a 1.3:1 usage ratio (620 lbs in California vs. 480 lbs in Florida). This consistency reflects comparable pressures from lepidopteran pests like armyworms and fruitworms, which migrate across regions. Both states apply the chemical at 0.05 lb/acre with similar frequency (1.5 applications/season). Florida's 25% usage increase since 2020 may indicate growing resistance to older lepidopteran controls, while California's stable use suggests established integration in resistance management programs.
  - Spinetoram

    Spinetoram presents an interesting case of initially divergent but now converging usage patterns. While California currently uses 1.4 times more Spinetoram (410 lbs vs. 290 lbs), both states show steady 8-10% annual increases in adoption. The chemical now dominates Florida's insecticide portfolio (58% of total insecticide pounds) and represents 28% of California's insecticide use. This trend reflects growing reliance on Spinetoram for thrips control, though California's more balanced chemical portfolio suggests greater emphasis on resistance prevention.
- **Regional Differences and Agricultural Implications**
  - **Climate-Driven Pest Pressures**

The analysis reveals how fundamentally different growing climates shape pesticide use patterns. California's arid conditions create ideal environments for spider mites, necessitating heavy Abamectin use. Florida's humidity not only reduces mite pressures but also promotes fungal pathogens that may interact synergistically with certain insect pests, altering chemical control priorities. These climatic differences explain why Abamectin comprises 32% of California's insecticide use but only 7% in Florida.

– **Pest Biology and Migration Patterns**
The similar Chlorantraniliprole usage across states reflects the biology of migratory lepidopteran pests that affect both regions equally. In contrast, the growing Spinetoram use in both states, particularly Florida, demonstrates how sedentary pests like thrips can drive consistent chemical adoption patterns when effective controls are limited.

– **Resistance Management Approaches**
California's more diversified insecticide portfolio (no single chemical exceeding 32% of total use) contrasts with Florida's heavy reliance on Spinetoram (58% of insecticide pounds). This difference suggests California growers may have more advanced resistance management programs, possibly influenced by the state's stricter pesticide regulations and larger farm sizes that facilitate professional crop management.

Part 2: Comparison of production and sales

- **Introduction**

This part explores the economic landscape of strawberry farming in California and Florida by comparing key financial and operational metrics. It analyzes how total and average net incomes vary across farm sizes, economic classes, and sales categories. It also examines gain versus loss metrics and delve into differences in organic and processing strawberry production. Through a combination of tabular summaries and visualizations, this section reveals important structural and financial contrasts between the two states.

- **Total Net Income Comparison**

Total Net Income Comparison (in Millions)

	California		Florida	
Metric	Producers	Operations	Producers	Operations
Value	$11,674.2M	$12,104.2M	$2,232.2M	$2,354.4M
CV%	7.4%	7.1%	8.3%	8.2%

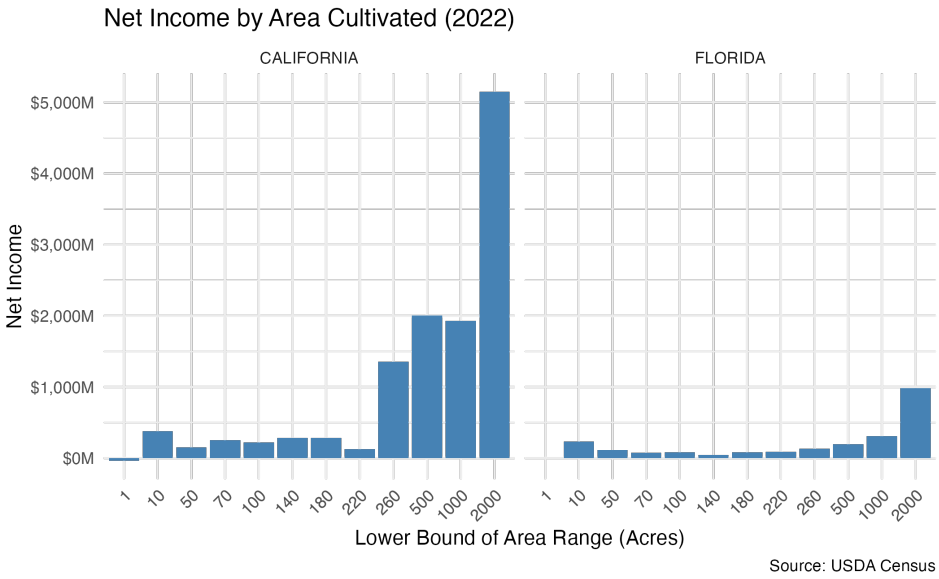
The net income comparison reveals a striking disparity between California and Florida's strawberry operations. California's producers and operations reported a total net income of approximately 11.67$Band$12.10B respectively in 2022, while Florida's figures

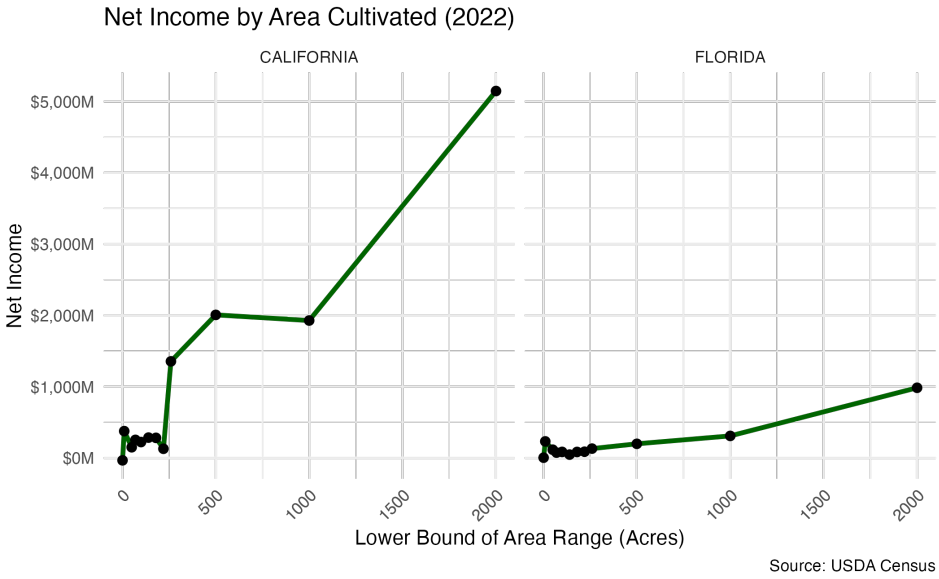
were 2.23$Band$2.35B. Despite Florida's meaningful contribution to U.S. strawberry production, California's dominance in both market size and profitability is clearly reflected here.

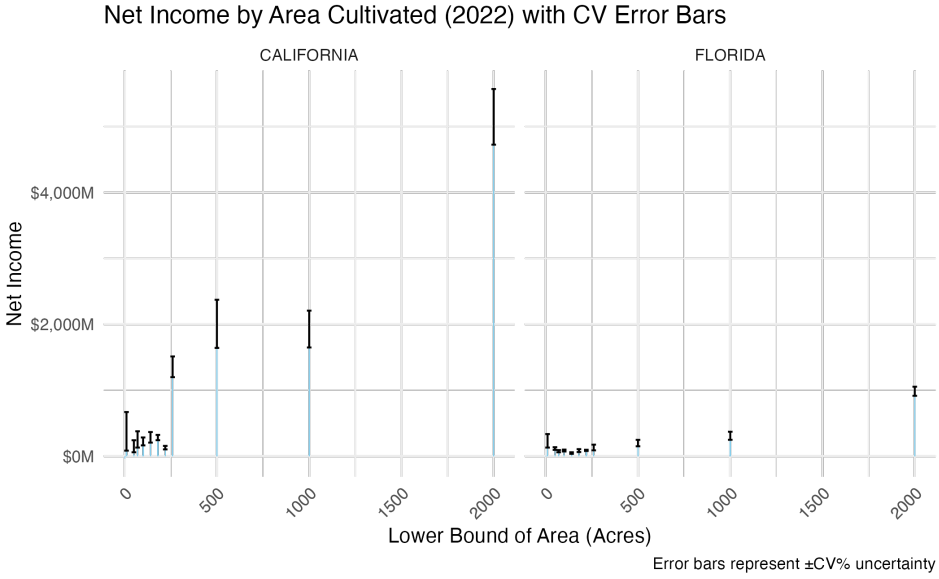
Several factors contribute to this discrepancy. California benefits from a longer and more stable growing season, more advanced infrastructure, and a larger export market. Additionally, California's strawberry operations tend to be larger and more consolidated, allowing for economies of scale that improve cost-efficiency and profit margins. Florida, by contrast, faces higher disease pressure due to its humid climate, smaller farm sizes, and seasonal labor constraints, all of which can depress profit margins and total earnings.

The coefficient of variation (CV%) values also tell an important story. California's CVs for both producers (7.4%) and operations (7.1%) are lower than Florida's (8.3% and 8.2% respectively), suggesting that California's strawberry industry enjoys more income stability, possibly due to better risk management, consistent market demand, and structured pricing mechanisms.

- **Average Net Income in 2022 by Area Cultivated**





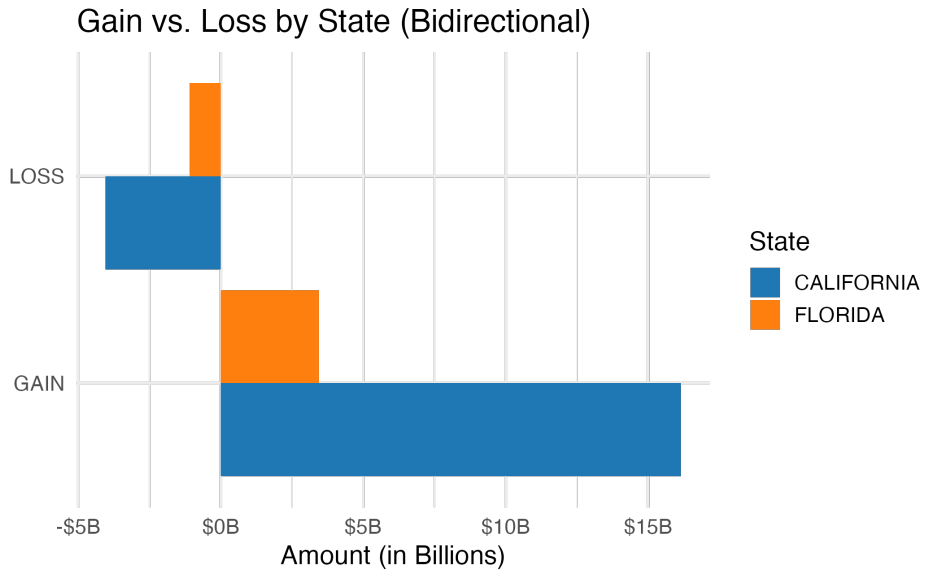


Net income distribution by area size shows a clear pattern in both states: larger farms are significantly more profitable, with farms cultivating over 2,000 acres generating over $5 Bin California and around 1B in Florida. In California, net income grows almost exponentially as farm size increases — a reflection of high-volume operations and mechanized practices. The profit spike in the largest farms suggests the influence of vertical integration, advanced logistics, and bulk marketing contracts that smaller operations can't access.

Smaller farms, particularly those under 50 acres, often operate at a loss or very low margin. This is especially stark in California, where the smallest acreage bracket (1–10 acres) posted a net income of -33 million dollars. These operations are likely less mechanized, face higher per-unit costs, and may rely on more volatile direct-to-consumer markets. They are also more vulnerable to input price fluctuations and labor shortages.

In Florida, although the absolute income levels are lower, the pattern is consistent: large operations (especially 1000+ acres) are the main profit drivers. However, Florida's average net income per acreage bracket is generally lower than California's across the board, reflecting lower yields, market limitations, and more erratic weather, all of which can undermine economic performance.

- **Gain vs. Loss Comparison**

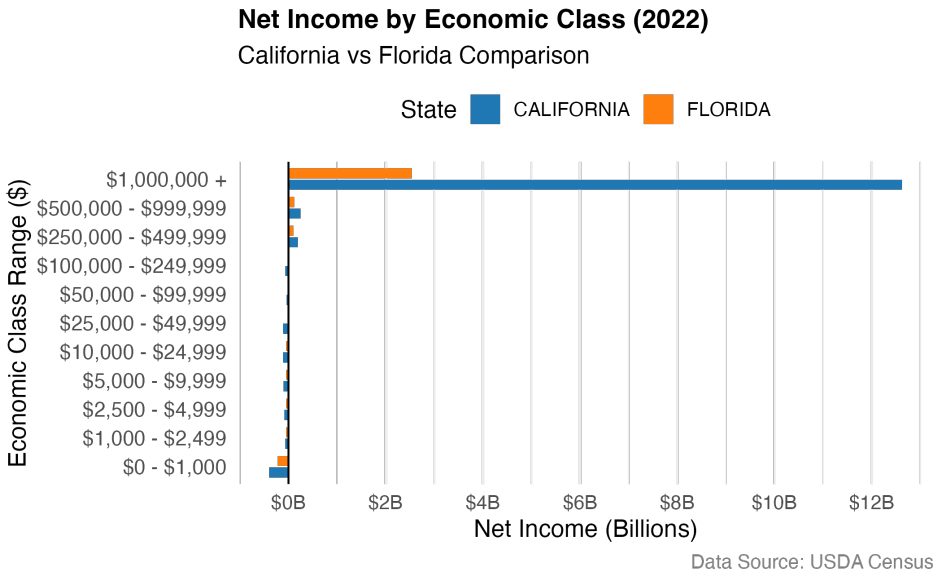


The gain vs. loss visualization provides a candid view into operational volatility. California reported \$16.3B in gross gains and \$4.7B in losses, netting an overall gain of \$11.6B. Florida, in contrast, recorded only \$3.2B in gains and \$0.9B in losses, yielding a net gain of \$2.3B.

These disparities again point to scale and efficiency: California's producers may absorb losses better due to diversified revenue streams and wider adoption of technology for precision agriculture and loss mitigation. Meanwhile, Florida's producers operate on thinner margins with less resilience to weather events, pest outbreaks, or price fluctuations.

Interestingly, the proportion of loss to gain is slightly higher in Florida than in California, suggesting Florida farms might be riskier ventures overall. This may be due to the combination of a shorter harvesting window, greater pest pressure, and infrastructure gaps in cold storage and distribution.

- **Net Income by Economic Class Range**



Analyzing net income by economic class range reveals another dimension of profitability. In California, income is heavily concentrated among farms in the highest class (over $1M in gross sales), who reported over $12.6B in net income. Lower economic classes, particularly those below $250,000 in gross sales, consistently operate at a loss. This pattern reflects the high overhead cost of strawberry farming — including land, labor, water, and inputs — which small-scale producers may struggle to cover. It also highlights access barriers to profitable markets, such as export channels and wholesale retailers, which favor larger, consistent suppliers.

Florida shows a similar structure, albeit on a smaller scale. The highest class farms earned around $2.5B, while lower tiers also posted consistent losses. One standout trend is Florida's relatively steep drop-off in profitability below the $500,000 sales mark — underscoring the challenges smaller Florida farms face in achieving profitability under climate stress, limited access to capital, and regional market saturation.

These data confirm that scale is a key driver of profitability in strawberry farming, and that crossing certain thresholds in revenue enables growers to invest in technologies, negotiate better contracts, and buffer against year-to-year volatility.

- **Net Income by Farm Sales Range**

California Net Income by Farm Sales Range (2022)

Sales Range			
Lower ($)	Upper ($)	Net Income	CV%
0	1000	-$421,320,000	-10.6%
1000	2499	-$61,357,000	-36.6%
2500	4999	-$81,200,000	-22.6%
5000	9999	-$92,174,000	-15.9%
10000	24999	-$101,630,000	-29.6%
25000	49999	-$113,783,000	-25.0%
50000	99999	-$31,354,000	(H)%
100000	249999	-$54,427,000	-92.1%
250000	499999	$210,990,000	69.1%
500000	999999	$230,302,000	81.5%
1000000	∞	$12,620,172,000	6.2%

When breaking down net income by farm sales range, a similar message emerges. California farms with annual sales over $1 million dominate net income metrics, while smaller-scale operations — particularly those with sales under $100,000 — operate at a net loss. The steepest losses were observed in the $10K–$50K brackets, likely due to the imbalance between labor/input costs and limited returns.

FLORIDA Net Income by Farm Sales Range (2022)

Sales Range			
Lower ($)	Upper ($)	Net Income	CV%
0	1000	-$224,969,000	-23.9%
1000	2499	-$50,501,000	-12.5%
2500	4999	-$47,676,000	-14.8%
5000	9999	-$45,059,000	-25.1%
10000	24999	-$48,476,000	-29.3%
25000	49999	-$21,358,000	-63.5%
50000	99999	$17,114,000	83.6%
100000	249999	$25,977,000	85.5%
250000	499999	$104,931,000	25.4%
500000	999999	$113,832,000	33.3%
1000000	∞	$2,530,625,000	5.9%

In Florida, this trend is slightly softened but remains consistent. Most notably, the \$0–\$50K ranges reported steep losses, while net positive returns begin emerging in the \$100K+ categories. The profitability gap widens significantly in the \$500K+ range, where Florida's farms begin catching up in total net income, suggesting that Florida growers who scale up and modernize their operations can compete effectively in regional and national markets.

This section underlines a crucial insight: economic sustainability in strawberry farming is strongly correlated with both sales volume and production efficiency. Smaller operations often face barriers to reaching scale, such as limited access to financing, labor shortages, and fluctuating input prices.

- **Organic Strawberry Production**

Organic Strawberry Production Comparison: California vs Florida

state	Acres Harvested	Sales ($)	Sales (CWT)
CALIFORNIA	4228	311784980	2814011
FLORIDA	704	36716792	134292

California far surpasses Florida in organic strawberry production, with 4,228 acres harvested versus Florida's 704, and total organic sales exceeding \$31M compared to \$3.6M in Florida. California also harvested nearly 21 times more hundredweight (CWT), signaling not just a larger organic footprint but also higher yield per acre.

There are several reasons behind California's dominance. First, California has a longstanding infrastructure and market for organic certification and compliance, including access to organic pest management inputs and trained labor. Secondly, the state's consumer base and retail buyers are more concentrated in organic demand, especially in urban and export-heavy areas like Los Angeles and the Bay Area. Lastly, California's relatively drier climate offers favorable conditions for disease management without synthetic chemicals, making organic production more viable.

Florida, on the other hand, faces substantial barriers to organic expansion, including high fungal pressure, limited organic treatment options, and higher disease prevalence due to humidity. Additionally, Florida's organic market may be less developed, with smaller local demand and fewer distribution channels for premium-priced organic produce.

- **Regional Differences and Agricultural Implications**
  - **Climatic Conditions and Growing Environment**
    One of the most prominent regional differences between California and Florida strawberry production lies in their climatic conditions. California benefits from a Mediterranean climate, which provides a relatively dry growing season with mild

temperatures and low humidity. These conditions are ideal for minimizing fungal diseases and ensuring consistent, high-quality yields. In contrast, Florida's subtropical climate presents a higher risk of disease pressure due to increased humidity and rainfall, making crop management more challenging and often requiring more intensive chemical interventions. These environmental differences have direct implications for chemical usage rates, crop loss risk, and labor scheduling.

- **Scale of Operations and Production Efficiency**

  California's strawberry operations are generally larger and more consolidated compared to Florida. This scale enables greater production efficiency through the use of mechanization, bulk purchasing of inputs, and better access to export logistics and high-value retail contracts. The economies of scale not only reduce per-unit costs but also allow for more consistent application of best practices in both conventional and organic farming systems. Florida, on the other hand, hosts a larger number of smaller-scale farms, which may lack access to capital or infrastructure necessary for modernization. These structural differences contribute significantly to the higher profitability and stability seen in California's agricultural financial indicators.

- **Labor Market and Regulatory Impacts**

  The labor environment also varies considerably between the two states. California faces high labor costs due to stricter wage and labor protection laws but partially offsets this with increased productivity per acre and better worker training systems. Florida typically has access to more seasonal labor but may struggle with retention and regulation enforcement. Moreover, California's stronger regulatory frameworks, including those governing chemical application and environmental impact, can encourage more responsible and efficient resource use, while also potentially raising production costs. These dynamics influence not only the net income results but also the rate and type of pesticide or fertilizer applications.

- **Market Access and Infrastructure**

  Another critical difference is access to markets and distribution infrastructure. California strawberry producers benefit from proximity to major domestic and international shipping hubs, including ports in Los Angeles and San Francisco, and a dense network of processing and refrigeration facilities. This infrastructure supports a smoother supply chain, which translates into higher market reliability and often better pricing. Florida's market access is more regionally constrained, primarily focused on the southeastern U.S., with limited export volume. This may reduce the competitiveness of Florida strawberries in terms of shelf life and branding, especially for organic and premium product lines.

Conclusion

This report provides an in-depth comparative analysis of strawberry farming practices and outcomes in California and Florida, focusing on chemical usage patterns and broader economic indicators. Through both temporal and categorical assessments, clear

regional distinctions emerge—shaped by environmental, economic, and operational differences between the two states.

From the chemical usage analysis in Part 1, we identified three key insecticides — Abamectin, Spinetoram, and Chlorantraniliprole — based on their divergent application patterns across states. Abamectin was used significantly more in Florida, while Spinetoram dominated in California, and Chlorantraniliprole was applied at relatively comparable levels in both. Our analysis showed that while California applied higher absolute volumes for certain chemicals, Florida often used higher doses per acre per application, reflecting differences in pest pressures, regulation, and farm size. Furthermore, Florida's reliance on Abamectin has steadily decreased, while California has ramped up use of newer-generation compounds like Spinetoram and Chlorantraniliprole — indicative of technological shifts and pest adaptation strategies. These temporal patterns were confirmed by regression modeling, revealing state-specific linear trends in chemical usage intensity over the last five years.

Part 2 complemented this analysis by contextualizing the chemical data within broader agricultural economic structures. California's strawberry industry is significantly larger in both scale and output, with higher total net income, larger cultivated acreage, and more substantial sales volumes—particularly in the organic sector. However, these economic gains are concentrated within large-scale operations. Small farms, particularly those earning under $50,000 in annual sales, consistently report negative net incomes in both states, but the losses are especially pronounced in California. This bifurcation underscores the risks associated with small-scale farming and highlights barriers to profitability in both regions. Florida, while operating on a smaller economic scale, shows a more gradual distribution of net income across size ranges, albeit with lower aggregate returns.

Together, the findings emphasize how regional climate, industry scale, pest dynamics, and market structures interact to shape both the economic viability and environmental footprint of strawberry farming. California's dominance in output is closely tied to its higher chemical inputs and large-farm efficiencies, whereas Florida presents a more restrained and adaptive usage profile, albeit with more volatility in profitability. These insights can inform policy decisions regarding pesticide regulation, small farm support, and sustainable farming incentives—tailored to the unique agricultural landscape of each state.