Economics of VOC Reductions Preliminary Results

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VOC Emissions from Pesticides:
Current Research and Research Needs

Project Objective

- Evaluate the effect of proposed regulations on California agricultural producers and consumers

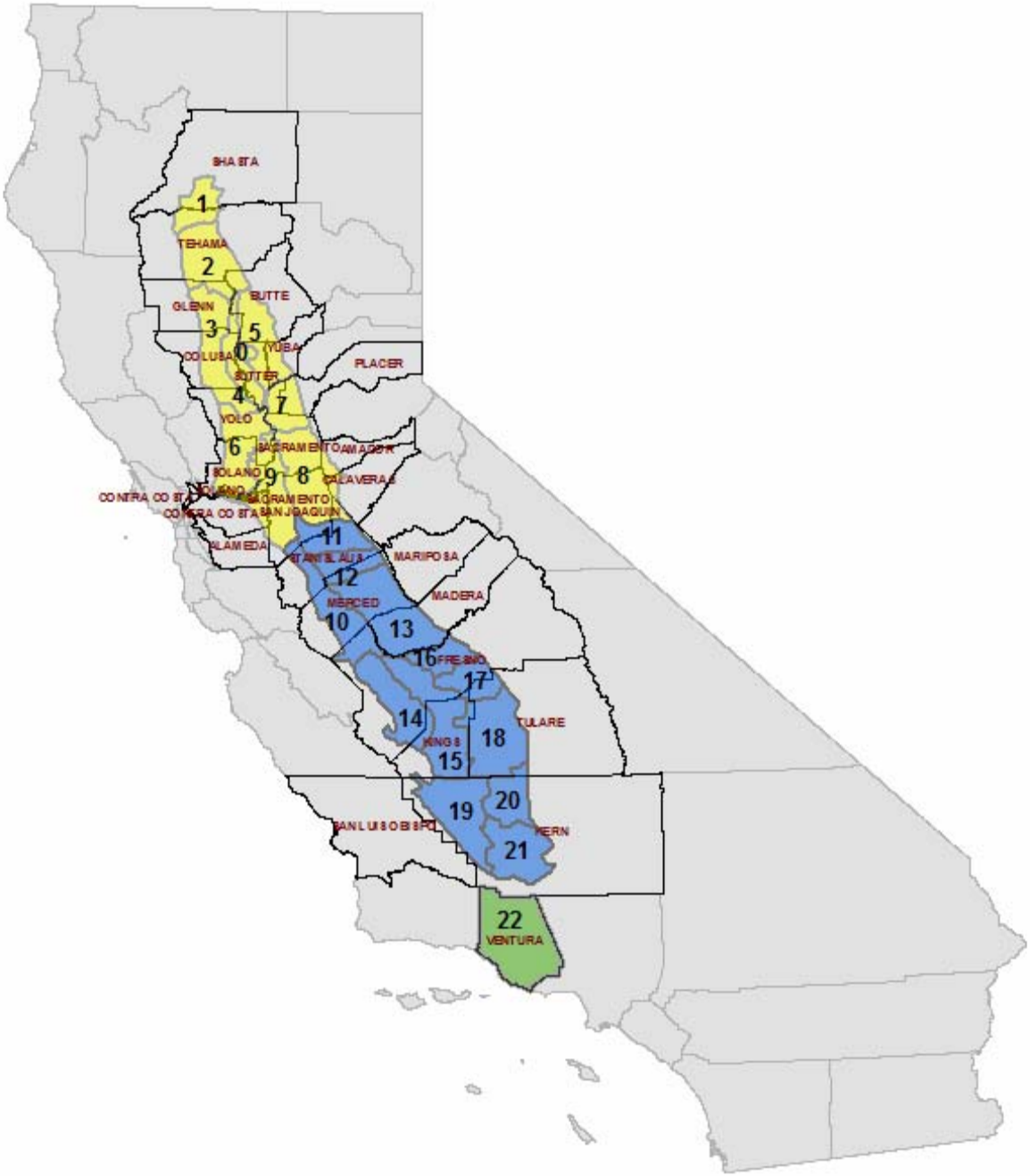
- Current focus: fumigant application methods

Approach

- California agriculture
  - Market-driven
  - Complex system
  - Interdependent decisions
- Utilize a multi-crop, multi-region model
  - Complexity of CA agriculture requires some simplifying assumptions in order to represent its market-driven nature
  - Positive mathematical programming

Positive Mathematical Programming Model

- 22 production regions in the Sacramento Valley, San Joaquin Valley, and Ventura County (approximately 67% of total value of California's crop production)
- 19 crops
  - alfalfa, almonds, carrots, citrus, cotton, field crops, grain, lemons, nuts, pasture, processing tomatoes, raisins, rice, stone fruit, strawberries, sugar beets, table grapes, truck crops, winegrapes
- Three steps
  - Calibration: actual production average over four years
  - Cost functions estimation
  - Acreage allocation model
    - Each production region chooses crops to maximize profits
    - Production decisions interact through
      - Output prices
      - Resource constraints
    - Effects of regulations on acreage, yields, etc. evaluated
      - Yield distributions, random shocks


SHASTA
1
TEHAMA
2
GLENN
BUTTE
3
5
COLUSA
10
YUBA
PLACER
SUTTER
4
7
YOLO
6
SACRAMENTO
AMADOR
SOLANO
9
8
CALAVERAS
CONTRA COSTA
SACRAMENTO
CONTRA COSTA
SAN JOAQUIN
11
ALAMEDA
STANISLAUS
MARIPOSA
12
MERCED
MADERA
10
13
16
FRESNO
17
14
TULARE
KINGS
18
15
19
20
SAN LUIS OBISPO
KERN
21
22
VENTURA

Cost Functions

- Quadratic and exponential cost functions

$$TC_{gj} = \alpha_{gj} \cdot x_{gj,land} - \frac{1}{2}\gamma_{gj} \cdot x_{gj,land}^{2}$$

$$TC_{gj} = \delta_{gj} e^{\beta_{gj} x_{gj,land}}$$

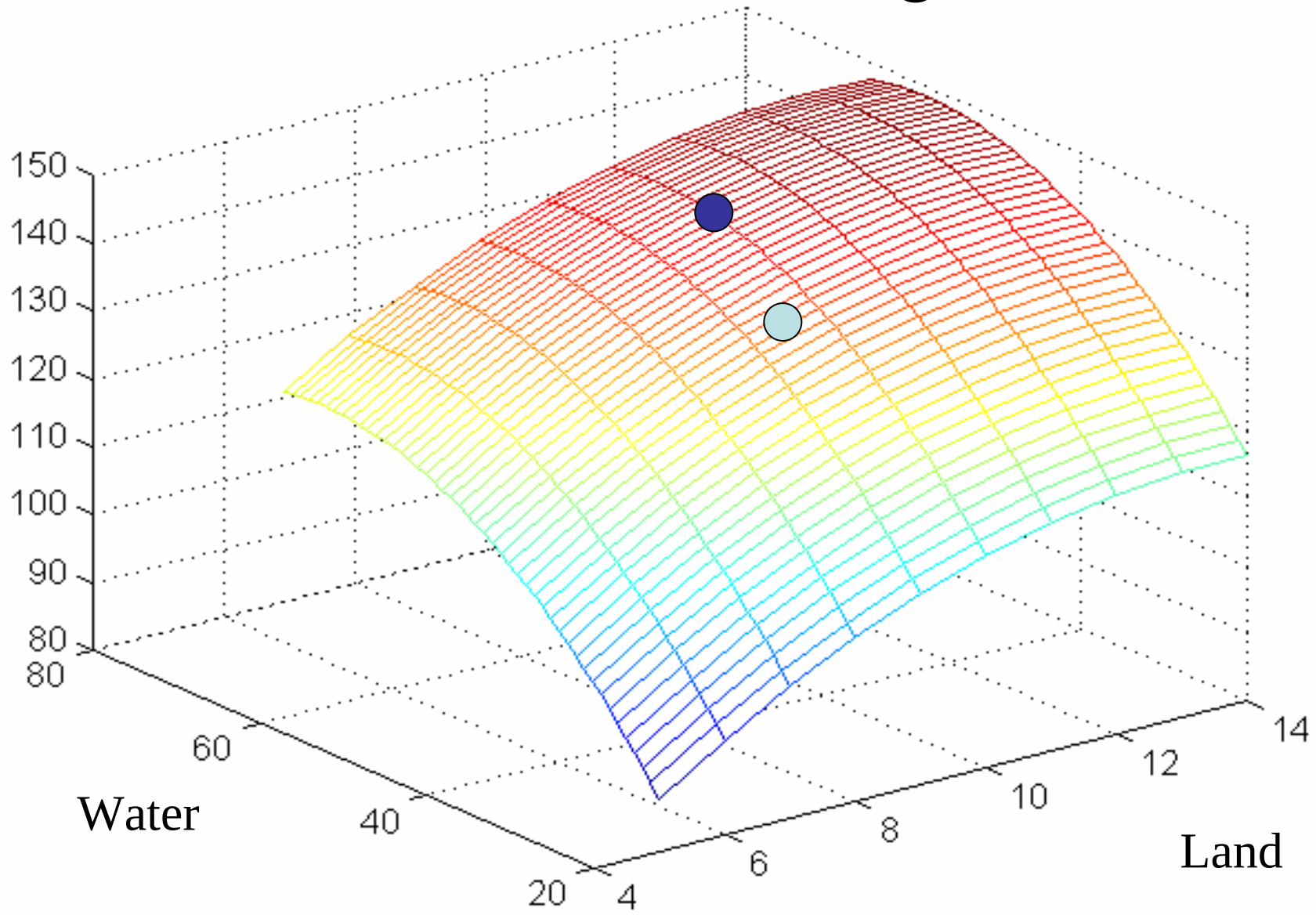
- Exponential cost seems to work best

j: Crop index

g: Region index

i: Input index

Cost Function: Processing Tomatoes



Profit Maximization

Revenue

Cost

$$\text{Maximize Total Profit} = \sum_i \sum_g p_{ig} Y_{ig} Yr_{ig} - \sum_i \sum_g \delta_{ig} Exp(\gamma_{ig} X_{ig,land}) - \sum_{j \neq land} \sum_i \sum_g c_{ijg} X_{ijg}$$

$$\text{s.t. } AX \leq B \qquad \text{Resource constraints.}$$

$$Y_{ig} = \tau_{ig} \left[\sum_j \beta_{ijg} X_{ijg}^{\sigma/\sigma-1} \right]^{\sigma-1/\sigma} \qquad \text{Production Function}$$

p_{jg}: Selling price of crop j in region g

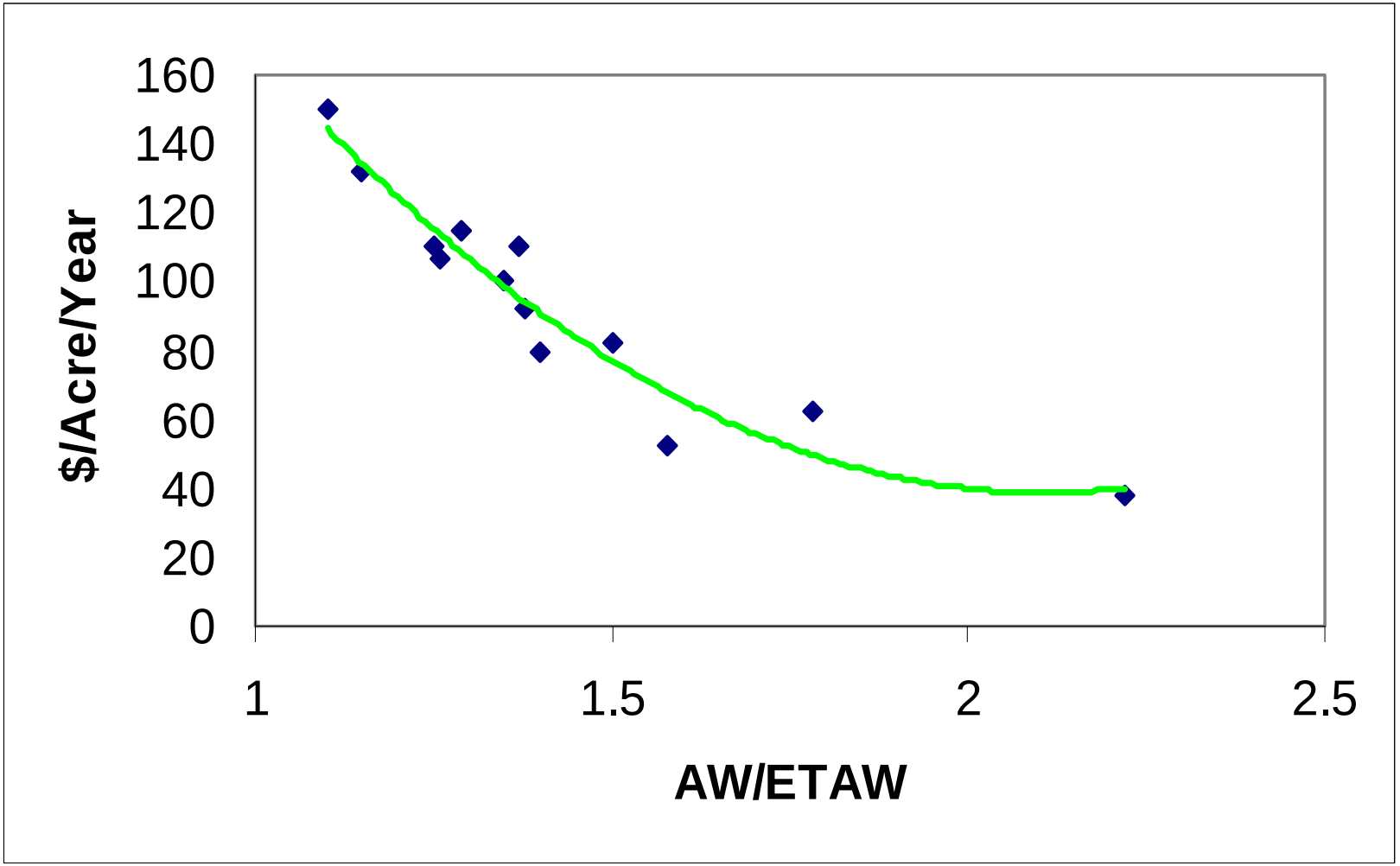
α_{ijg}, γ_{ijg}: Cost function parameters

j: Crop index

g: Region index

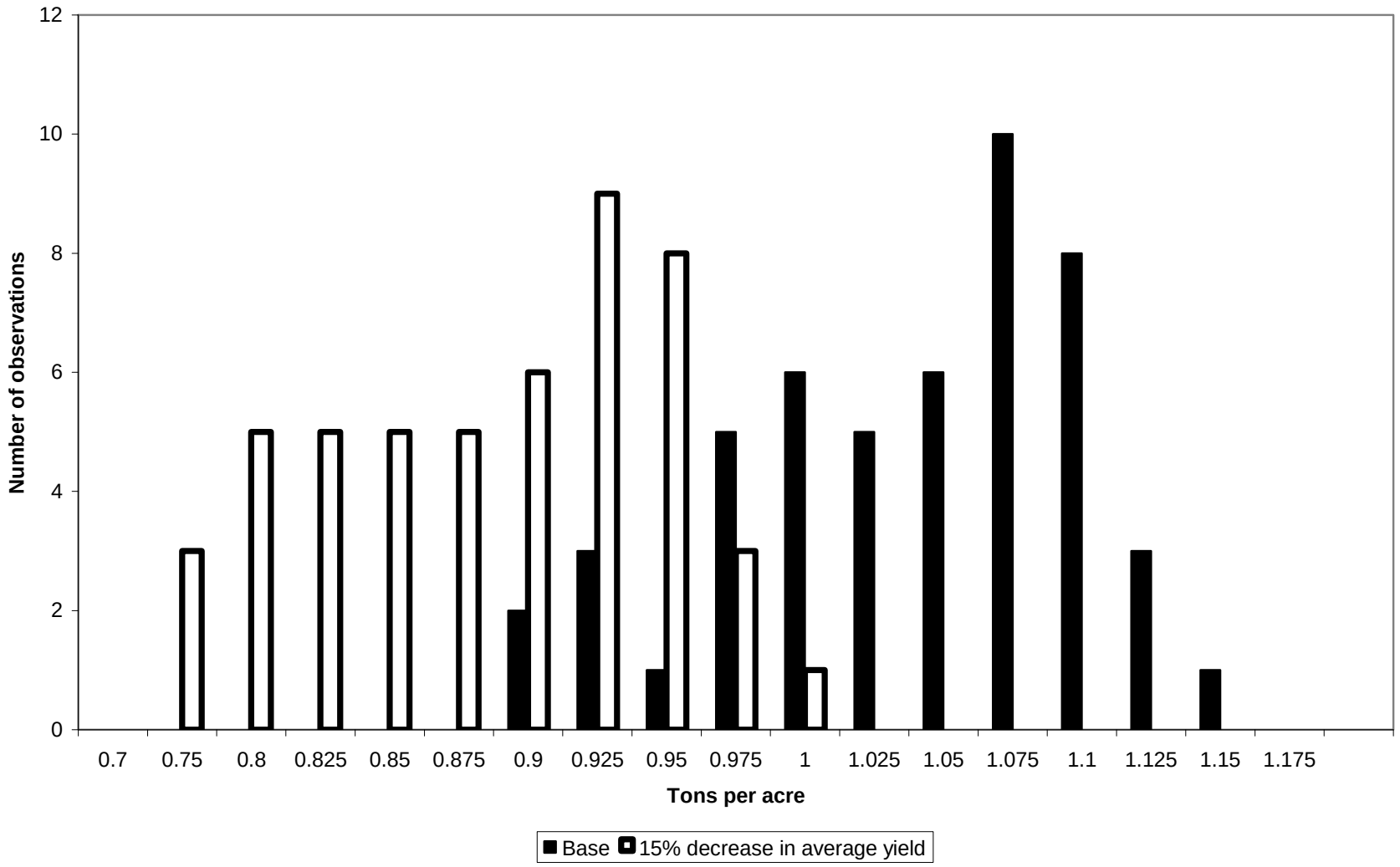
i: Input index

Water Efficiency-Cost Trade-offs: Orchards



Effects of Fumigant Use Regulations

- Cost effects
  - Alternative treatment costs, including water costs, and weeding costs
  - Focusing on fumigation, so treatment costs are certain
    - Simplify by assuming weeding costs also certain
- Average yield effects
- Yield variance effects
  - Uneven pest control


Yield Observations from Monte Carlo Simulations: Almonds, V15, 50 draws
Number of observations
0
2
4
6
8
10
12
0.7
0.75
0.8
0.825
0.85
0.875
0.9
0.925
0.95
0.975
1
1.025
1.05
1.075
1.1
1.125
1.15
1.175
Tons per acre
Base
15% decrease in average yield

Caveats

- Model of **California** agriculture
  - Doesn't allow for trade to increase
    - May overstate effects on consumers, understate effects on producers
- Annual model
  - Broad approximations of effects on perennial crops
    - Cost effects (failed replant)
    - Yield effects (long-term effects on plant vigor)
    - Currently assuming identical percentage effects across perennial crops

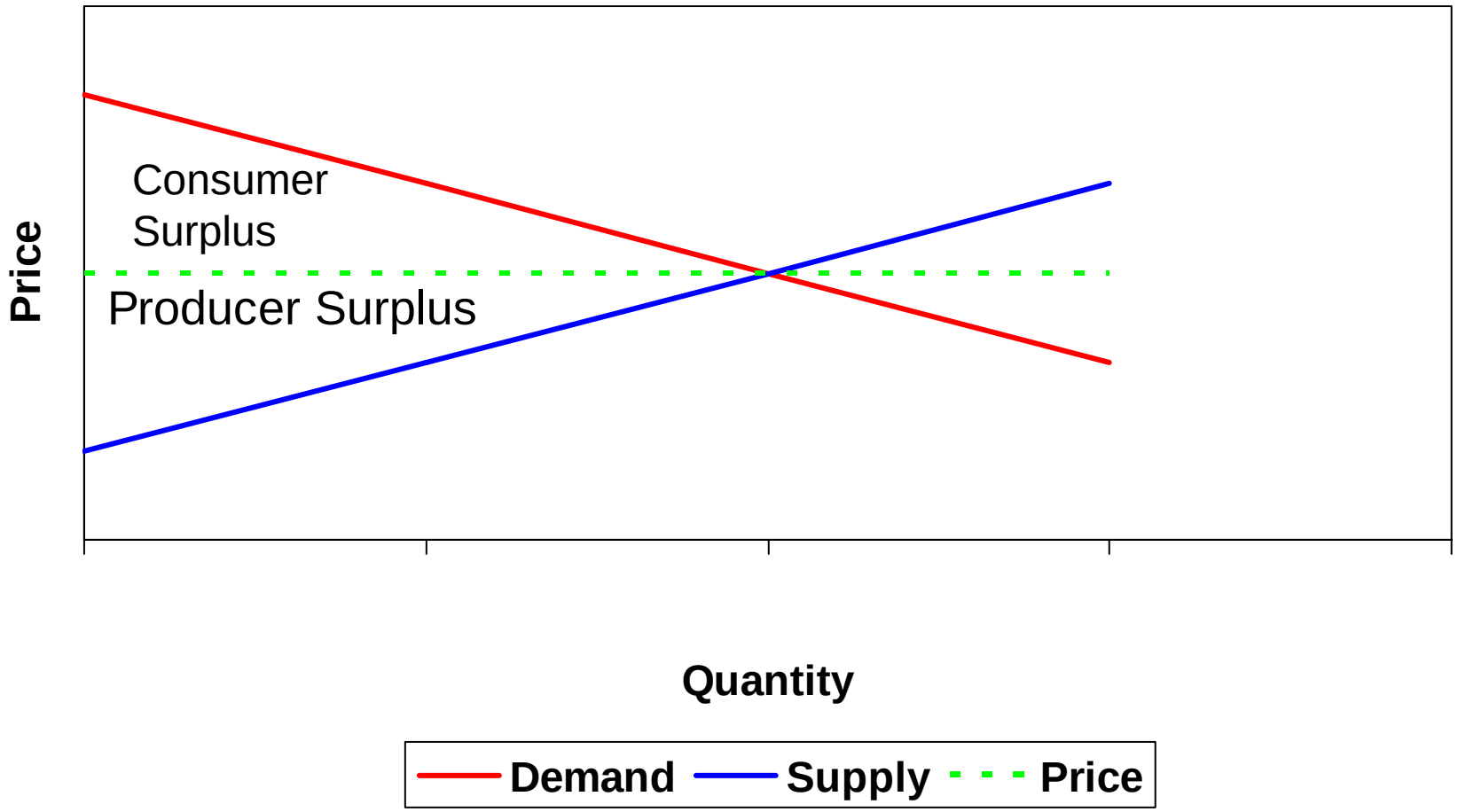
Scenarios

- Scenario 1: Thought experiment
  - Reduce application rates enough to meet emission reduction requirements (approximately 50%)
- Scenario 2: Move to low emission methods identified by CDPR
  - Based on NAA-active ingredient assumptions by CDPR
  - Also evaluate jointly with a rate reduction for Ventura NAA
- Sensitivity analysis

Evaluated Impacts

- Acreage, yields
  - by crop, region
- Consumer surplus: Consumers' willingness to pay minus actual payments
  - by crop
- Producer surplus: Revenues minus variable costs
  - by crop, region
- VOC emissions
  - Based on CDPR estimates by AI and region, PUR data on AI and crop

Consumer and Producer Surplus



Scenario 1 Results

- Relatively small changes in acreage
- Emissions reduced by required percentage
- Very small reductions in total consumer, producer surplus
  - Larger reductions in consumer surplus than in producer surplus
    - Assumes buyers don't move to purchasing from other areas
  - Outcomes vary across crops, regions
    - Sacramento Valley slightly better off
    - San Joaquin Valley, Ventura County slightly worse off

Scenario 1: Large Effects Case

- Substantial yield losses (12.5-20%)
  - More than most likely scenario
- Yield variances tripled
- Increase in weeding cost, reduction in fumigant material costs

Change in total consumer surplus	Change in total producer surplus
-$566 million	-$101 million
-5.5%	-1.0%

Scenario 1

Why do large changes in average yields and yield variances have small effects on overall surplus?

- When production declines, prices increase
- When the returns to one crop declines, producers allocate less acreage to it when maximizing profits, provided returns to other crops are unchanged
- Here, in contrast, multiple crops are affected, so the acreage response is dampened

Scenario 2 Results

- Larger changes in acreage allocations than Scenario 1, but still a minor share of the whole
- Emissions reduced by approximately the necessary percentage in the San Joaquin Valley
- Emissions not reduced sufficiently in Ventura County by shift in application methods alone
- Changes in total consumer, producer surplus still small
  - Differences by crops larger
  - Sacramento Valley producers benefit
  - San Joaquin Valley and Ventura County producers slightly hurt

Scenario 2:
Focus on Large Effects Case

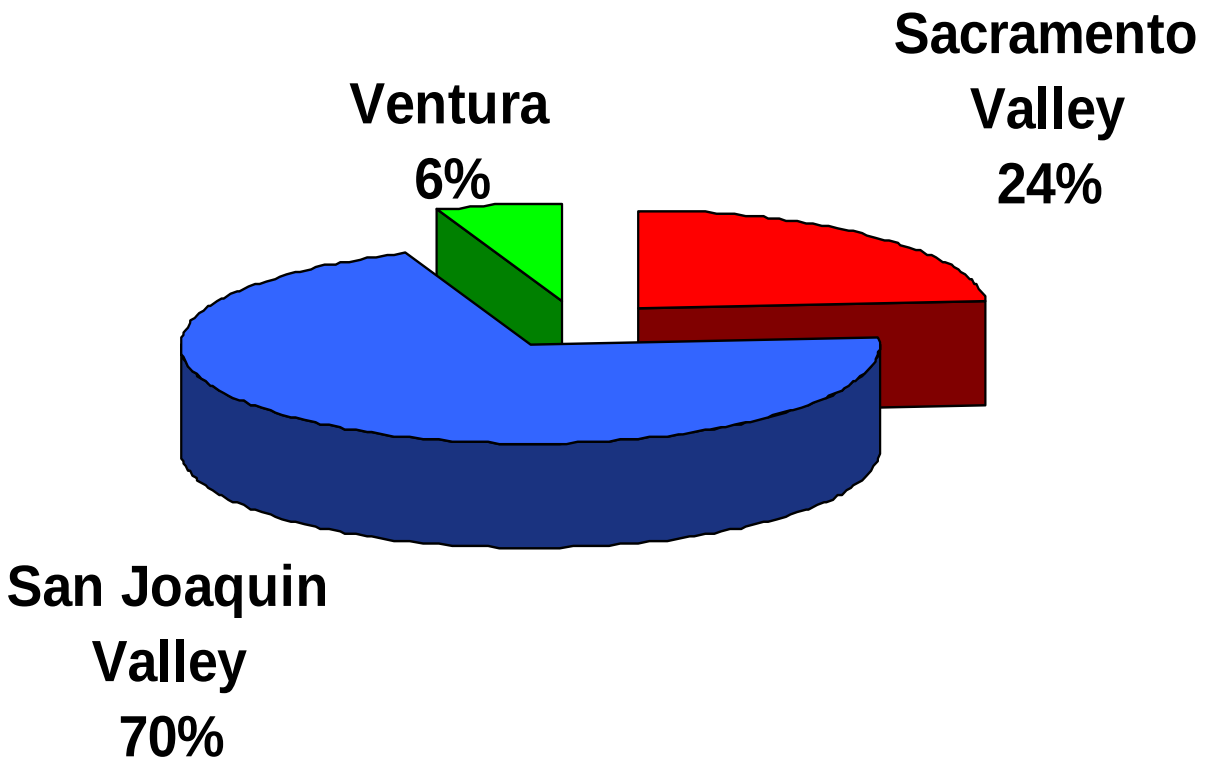
- Substantial yield losses (12.5-20%)
  - More than most likely scenario
- Yield variances tripled
- Increase in weeding cost, reduction in fumigant material costs, no allowance for cost of failed plantings
- Not reporting results from all simulations in sensitivity analysis- this one has relatively large effects

Change in total consumer surplus	Change in total producer surplus
-$583 million	-$101 million
-5.6%	-1.0%

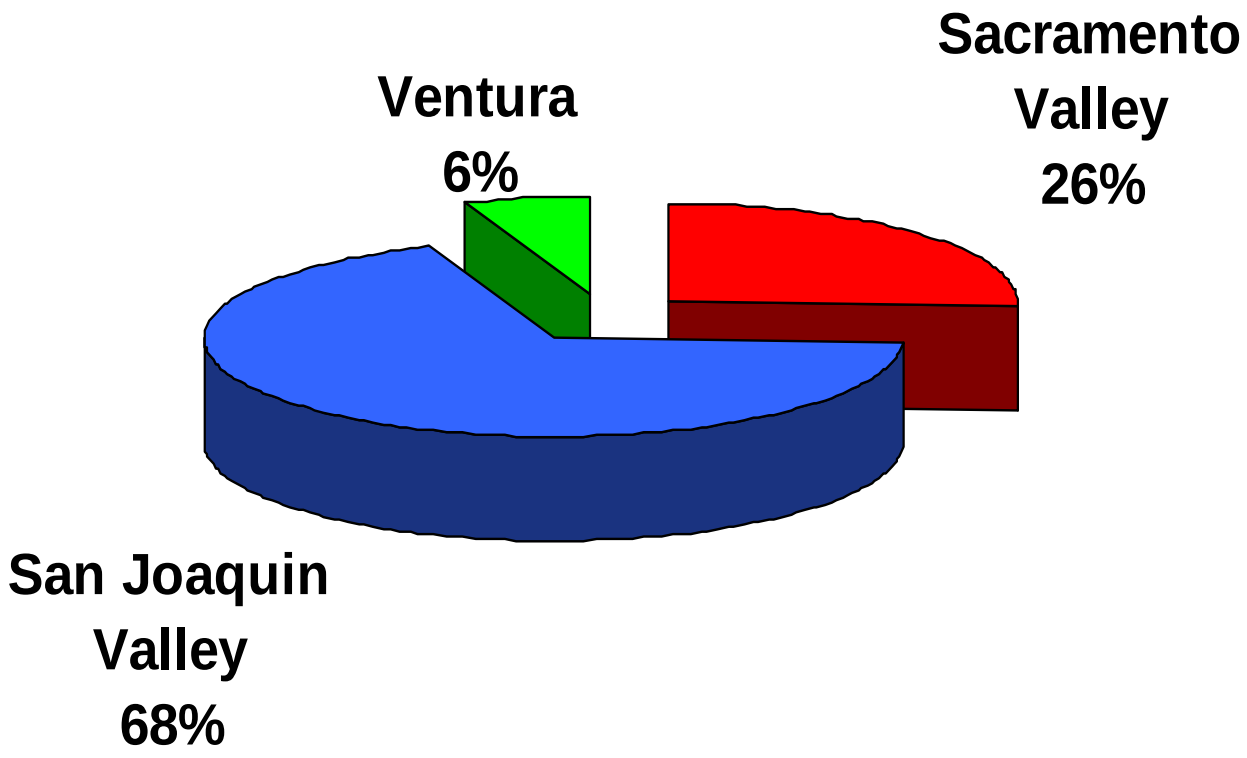
Scenario 2: Large Effects Case

Region	Change in Producer Surplus
Sacramento Valley	+$172 million +7.4%
San Joaquin Valley	-$252 million -3.7%
Ventura County	-$21 million -3.6%

Regional Shares of Base Producer Surplus



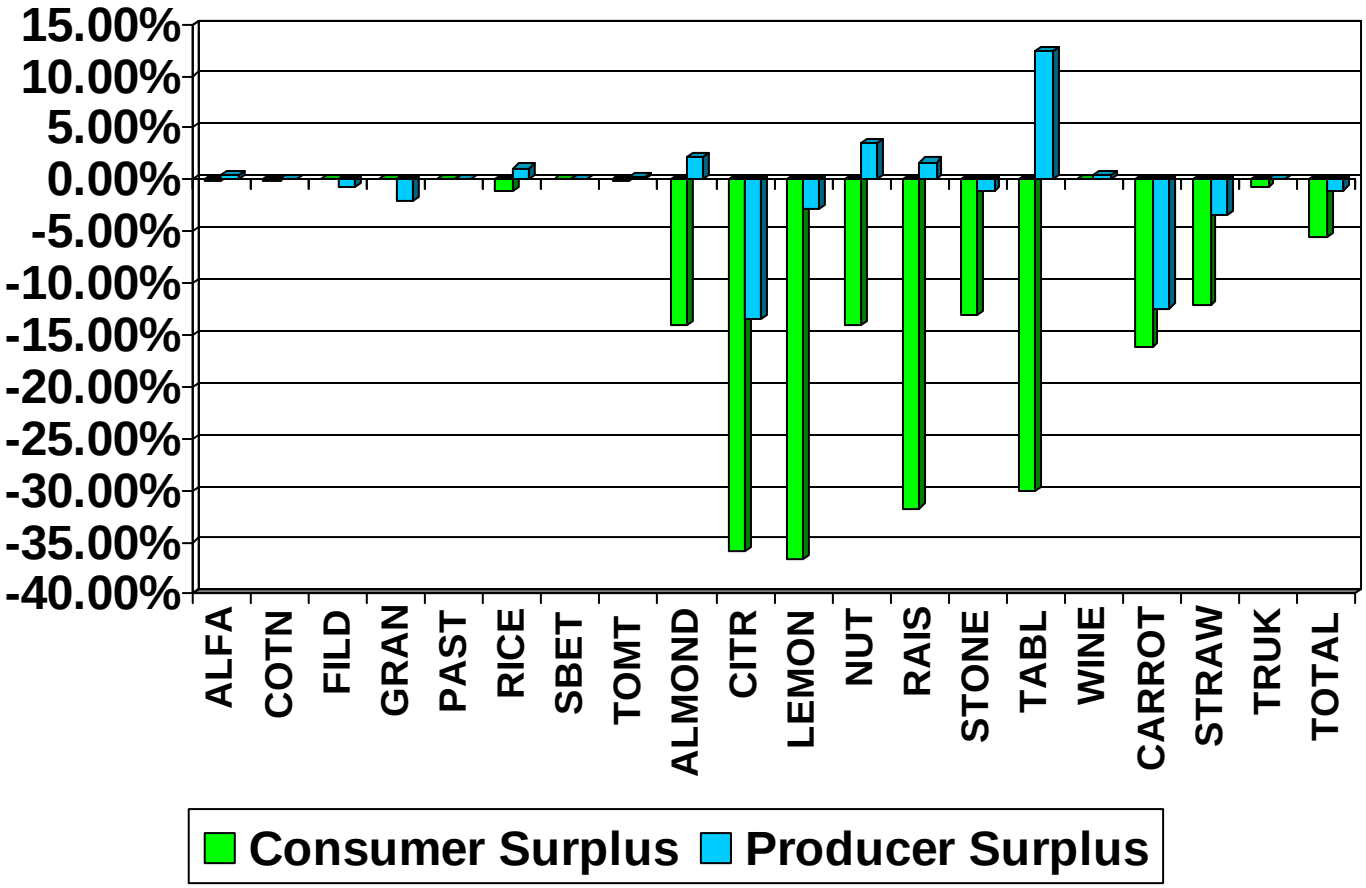
Regional Shares of Policy Producer Surplus



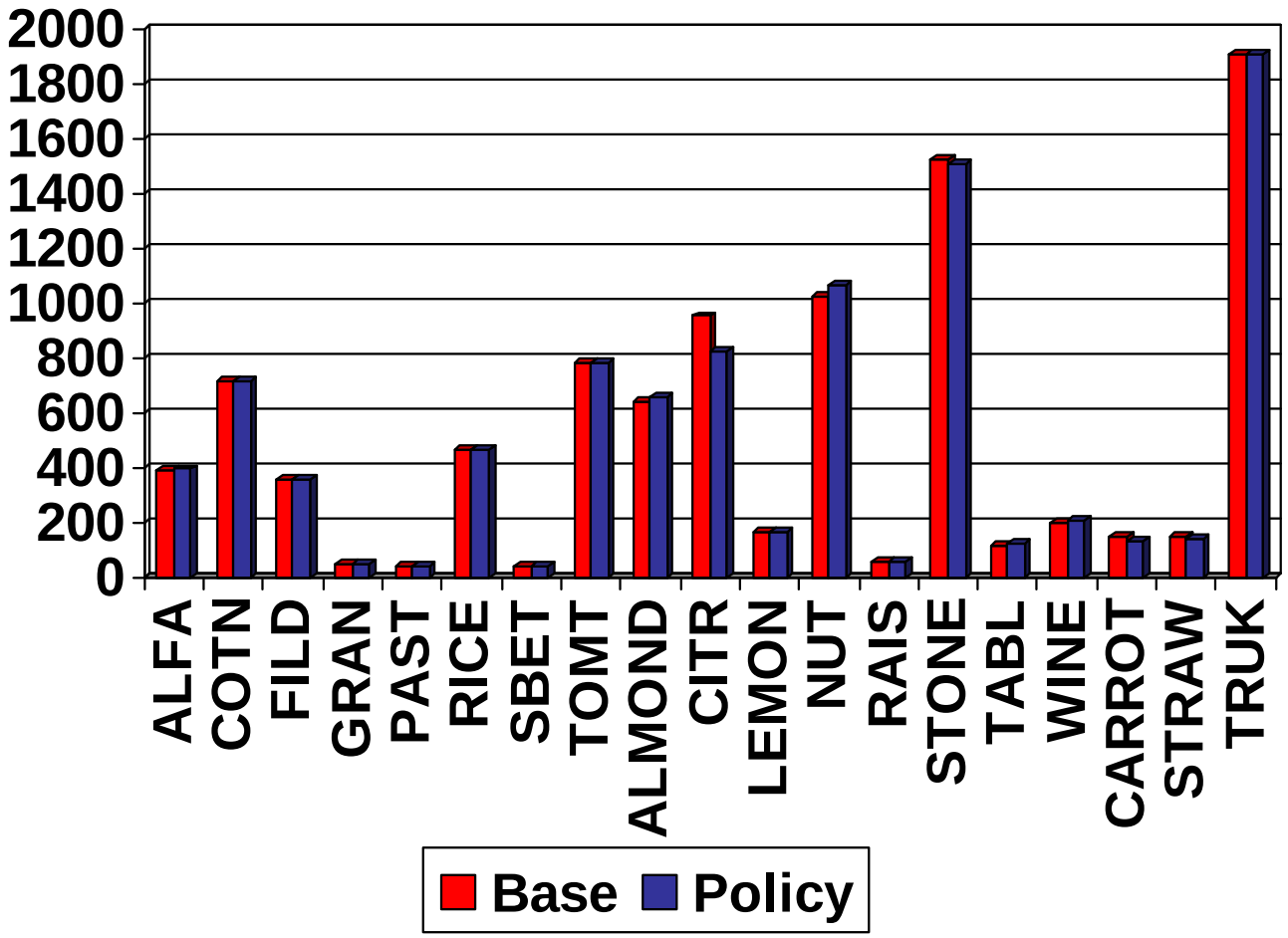
Scenario 2: Large Effect Case

Crop	Change in Consumer Surplus	Change in Producer Surplus
Fumigated perennials	-$531 million -15.5%	-$83 million -1.8%
Fumigated annuals	-$27 million -2.3%	-$23 million -1.0%
Other	-$7 million -0.3%	+$5 million +0.2%

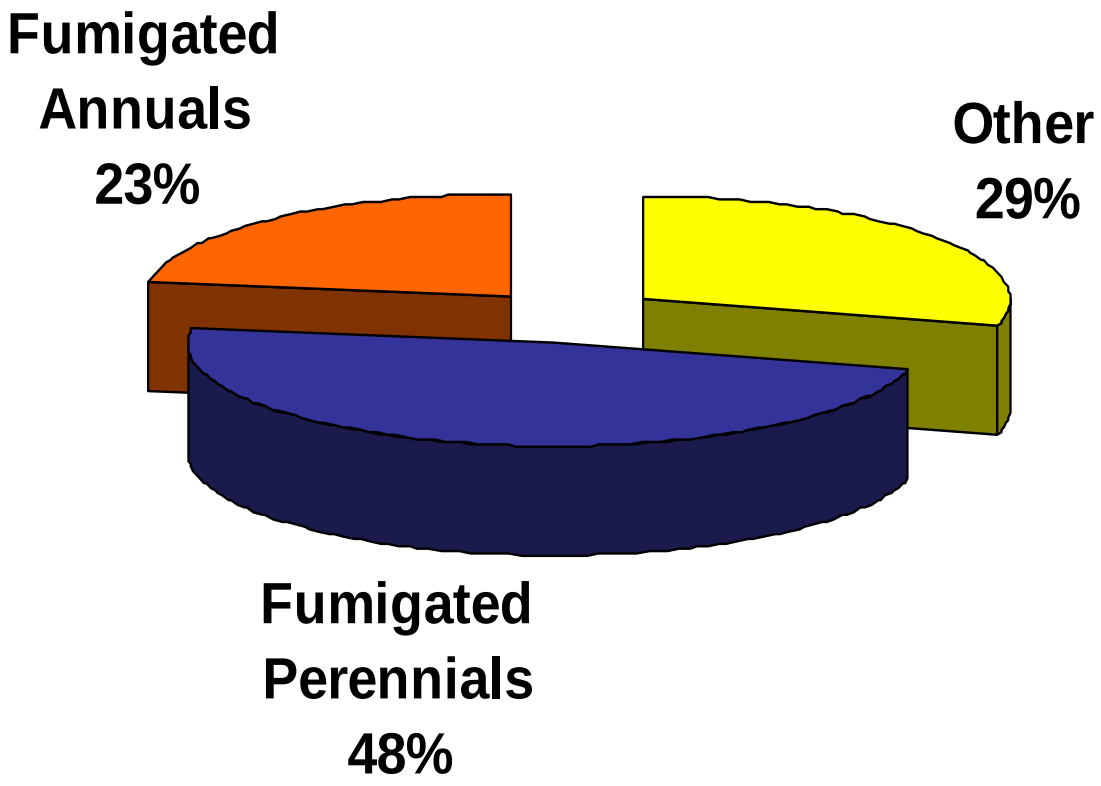
Percent Change in Consumer and Producer Surplus by Crop



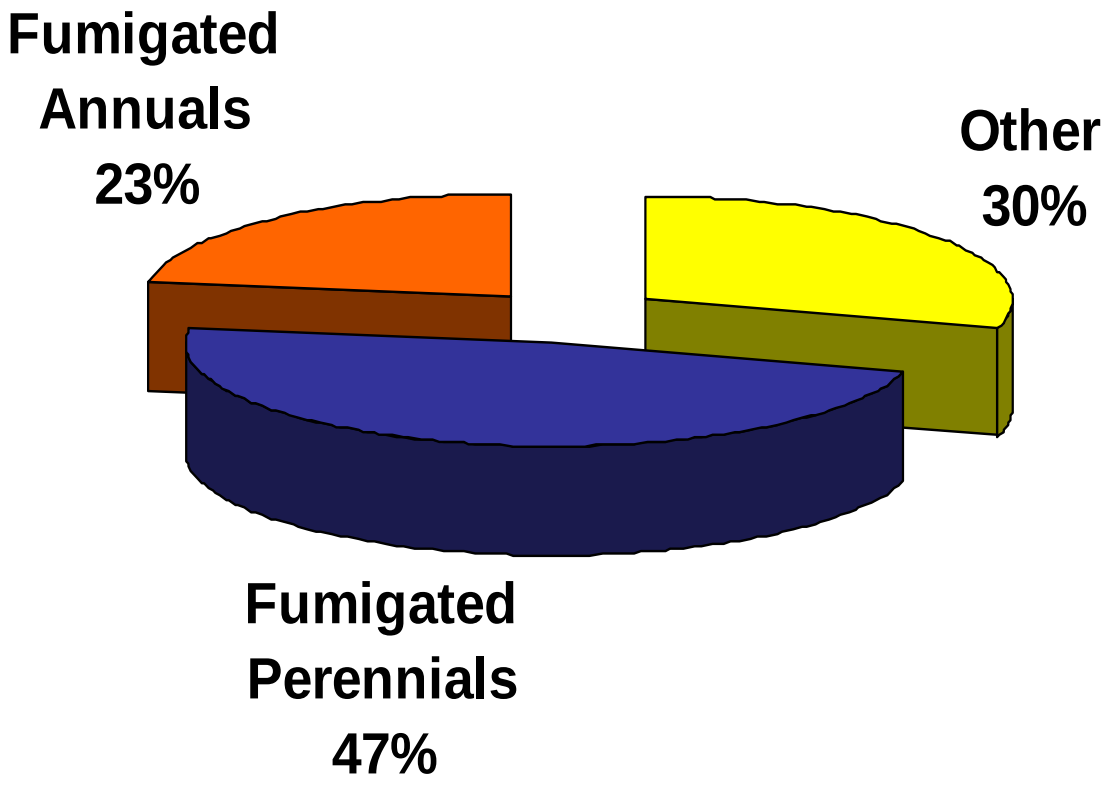
Producer Surplus by Crop
($ Millions)



Crop Group Shares of Base Producer Surplus



Crop Group Shares of Policy Producer Surplus



Scenario 2: Large Effects Case

- Emission reduction calculations
  - Base uses current application method emission percentages
  - Policy uses low emission application method emission percentages
    - Rate reduction imposed for Ventura County
  - PUR 2004 application acres and pounds by crop

Region	Emission Reduction
San Joaquin Valley	51.6%
Ventura County (43% rate reduction)	66.6%

Scenario 2: Large Effects Case

- No rate reduction imposed for Ventura County, but assume average yields still reduced, yield variance increased
- Moving to low emission methods alone will not reduce emissions sufficiently

Region	Emission Reduction
San Joaquin Valley	51.6%
Ventura County (no rate reduction)	22.4%

Scenario 2: Large Effects Case

Strawberries, Ventura County	Percent Change
Acres	-1.6%
Yield	-13%
Price	+9.1%
Producer Surplus	-7% -$5 million

Scenario 2: Large Effects Case

Carrots San Joaquin Valley	Percent Change
Acres	-4.8%
Yield	-23%
Price	+10.6%
Producer Surplus	-12.2% -$19 million

More Caveats

- Aggregated categories, like truck crops, don’t represent movement across crops *within* the category
- Relatively little is known about the effects of changing application methods on yield variance
  - Water seals likely to lead to more uneven control, which is likely to affect variability

Ongoing Work

- Continuing to refine analysis
  - Crop-specific effects of low emission methods
  - Changes in application costs
- Incorporating S.E. Desert NAA
  - Addition of new crops
    - Estimation of demand, supply elasticities
- Evaluating other policy measures