Salinity and Crop Choice in the Sacramento-San Joaquin Delta

Anita M. Chaudhry, Professor, Department of Economics, California State University, Chico
Janine M. Stone, Assistant Professor, Department of Economics, California State University, Chico
Spencer Carroll, GIS Assistant III, Geographical Information Center, California State University, Chico
Dean H. K. Fairbanks, Professor, Department of Geography and Planning, California State University, Chico
Jeffrey Michael, Director of the Center for Business and Policy Research, University of the Pacific

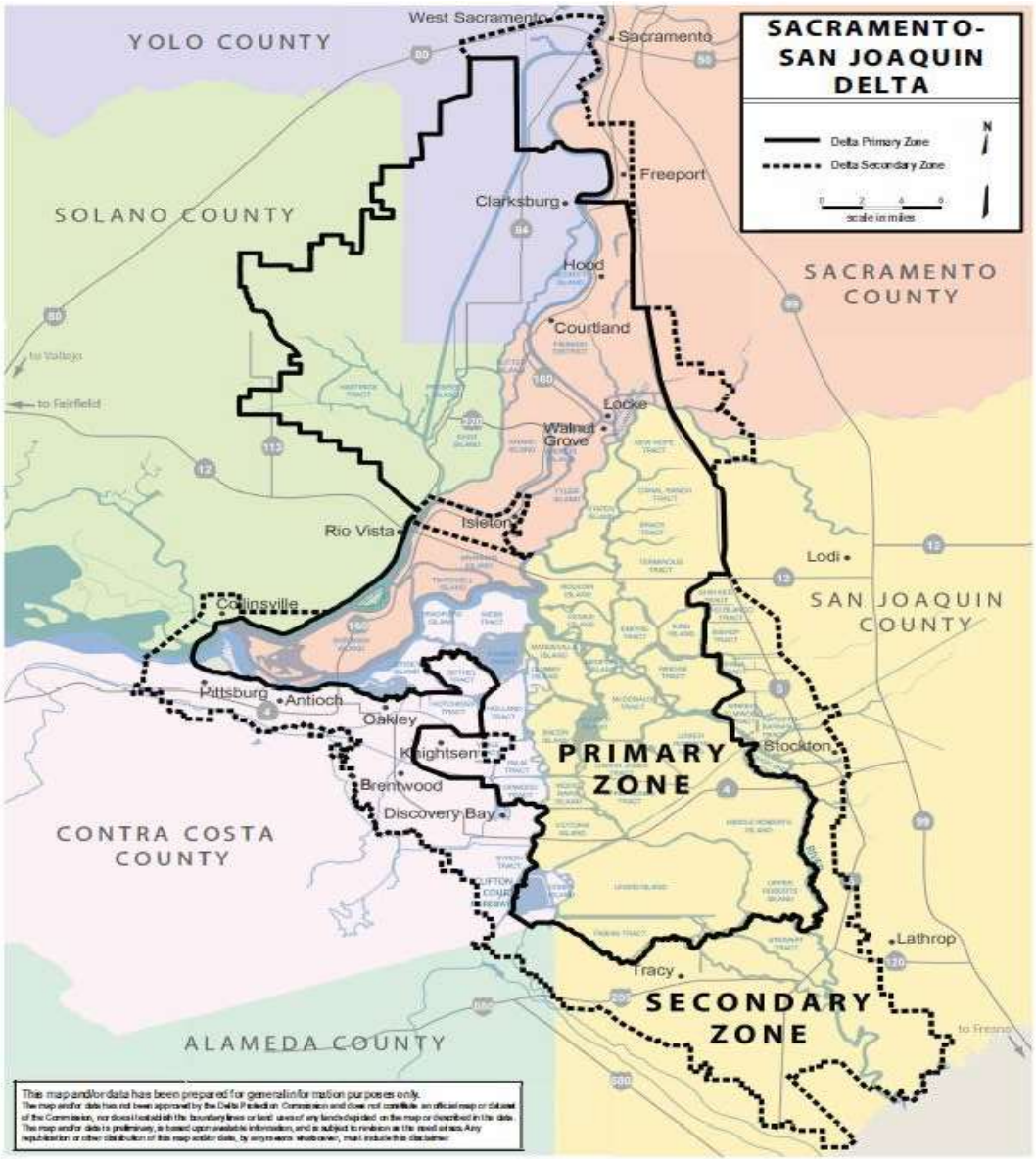
UNIVERSITY OF THE PACIFIC
Center for Business & Policy Research

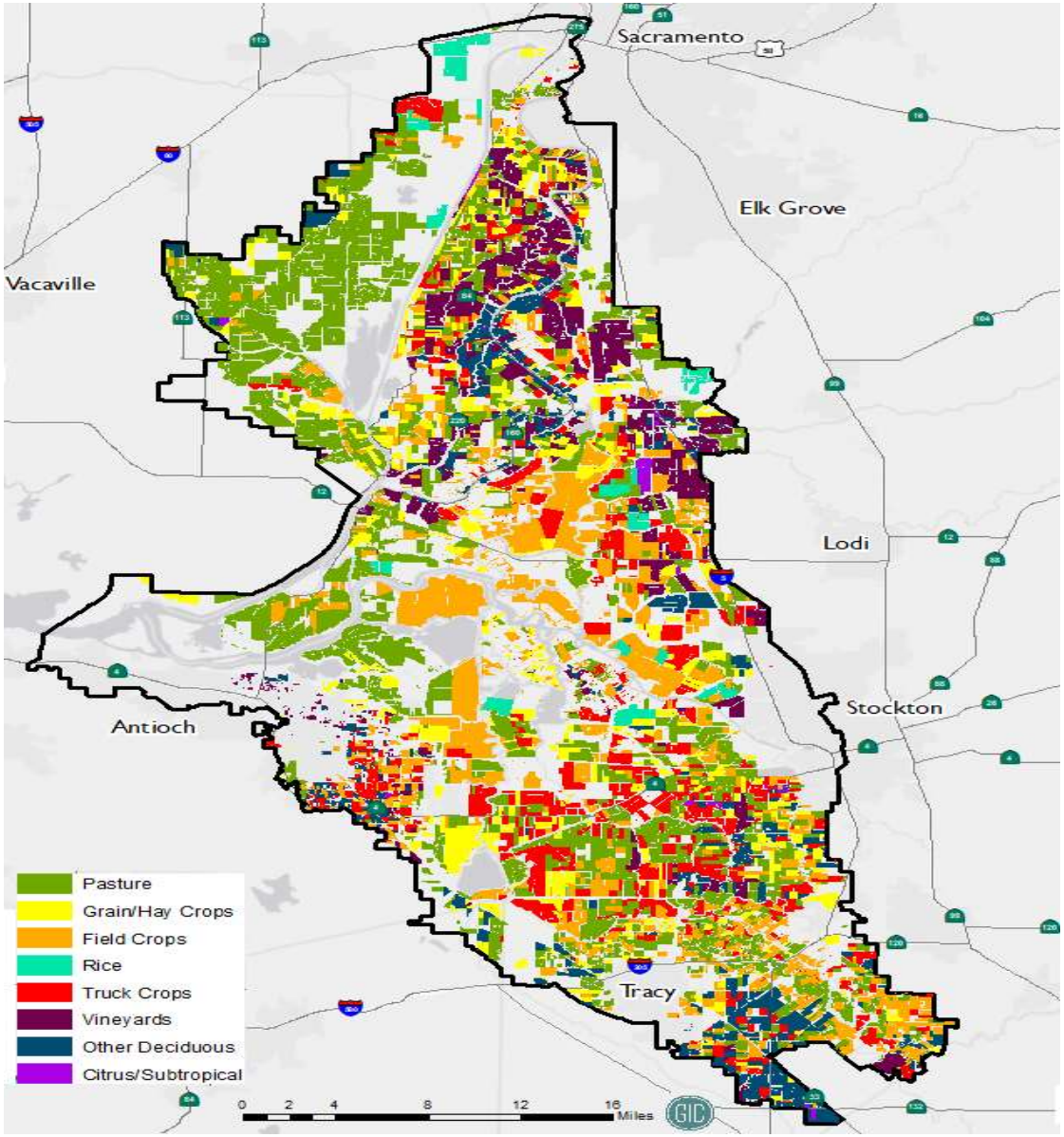
Outline

- Introduction
  - Salinity impacts on crop growth and growers' planting decisions
  - Existing literature
- Methods
  - Parcel-level crop choice and salinity data
  - Multinomial logit models of crop choice
- Results and Conclusions
  - Short and long-run responses to salinity levels in the Delta

Introduction

- **Delta Region**
  - ~500,000 acres of farmland in San Joaquin, Sacramento, Yolo, Solano and Contra Costa Counties
  - ~$965,000,000 in revenues in 2016 (Delta Protection Commission)
  - Increasing acreage planted in grapes, almonds, and walnuts (high value crops)
  - Crops vulnerable to salinity levels in at planting and growth stages of development
    - Crops have been classified based on tolerance for salinity at the root zone (Hoffman, 2010)


SACRAMENTO-
SAN JOAQUIN
DELTA
Delta Primary Zone
Delta Secondary Zone
N
scale in miles
YOLO COUNTY
SOLANO COUNTY
SACRAMENTO
COUNTY
SAN JOAQUIN
COUNTY
CONTRA COSTA
COUNTY
ALAMEDA COUNTY
PRIMARY
ZONE
SECONDARY
ZONE
West Sacramento
Sacramento
Freeport
Clarksburg
Hood
Courtland
Locke
Walnut
Grove
Rio Vista
Isleton
Lodi
Collinsville
Pittsburg
Antioch
Oakley
Knightsen
Brentwood
Discovery Bay
Stockton
Lathrop
Tracy
to Vallejo
to Fairfield
to Fresno
This map and/or data has been prepared for generalinformation purposes only.


Sacramento
Elk Grove
Vacaville
Lodi
Stockton
Antioch
Tracy
Pasture
Grain/Hay Crops
Field Crops
Rice
Truck Crops
Vineyards
Other Deciduous
Citrus/Subtropical
0 2 4 8 12 16
Miles

Existing Literature: Salinity and Crop Choice

2007-2012 Delta Protection Commission Economic Sustainability Plan

- Cross-sectional model predicting crop choice as a function of salinity
  - Decreased planting of orchard, truck crops; increased pasture, forage

Mendellin-Azuara et al., (2014)

- Assume no impacts of salinity on crop choice/growth with salinity levels under 1000 us/cm
- Find saline areas have already transitioned to salt-tolerant crops; predict negligible impacts of increasing salinity on Delta revenues

Our Approach

- Update 2012 ESP for years up to 2016—group crops by their salinity tolerance
- Use parcel-level crop choice and salinity data to predict crop choice as a function of changes in year-to-year growing season salinity levels, holding characteristics of parcel constant
- *All else equal, we predicted increasing salinity decreases odds of planting more salt-tolerant crops*

Methods: Data

Crop-choice data

- California Agricultural Commissioners and Sellers Association (CASACA) data, 2007-2016
  - Self-reported crop and pesticide use for fields
- Field data were placed within recorded land ownership (tax parcel) and irrigation district boundaries in ArcGIS
- Over 22,000 observations for ~3,000 parcels

Field Characteristics

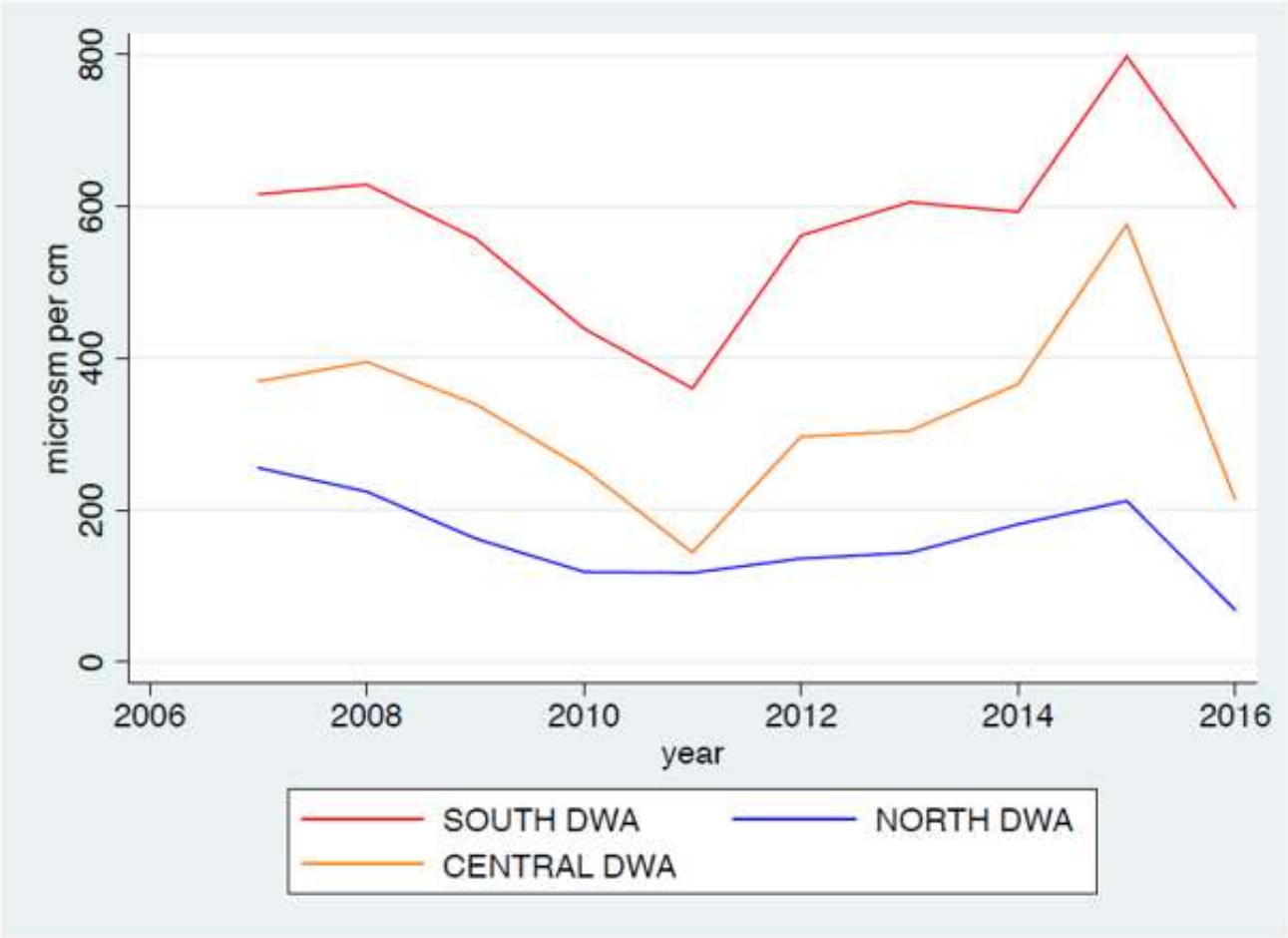
- Soil type, slope/elevation, shallow groundwater depth
  - USDA Soil Survey Geographic Database

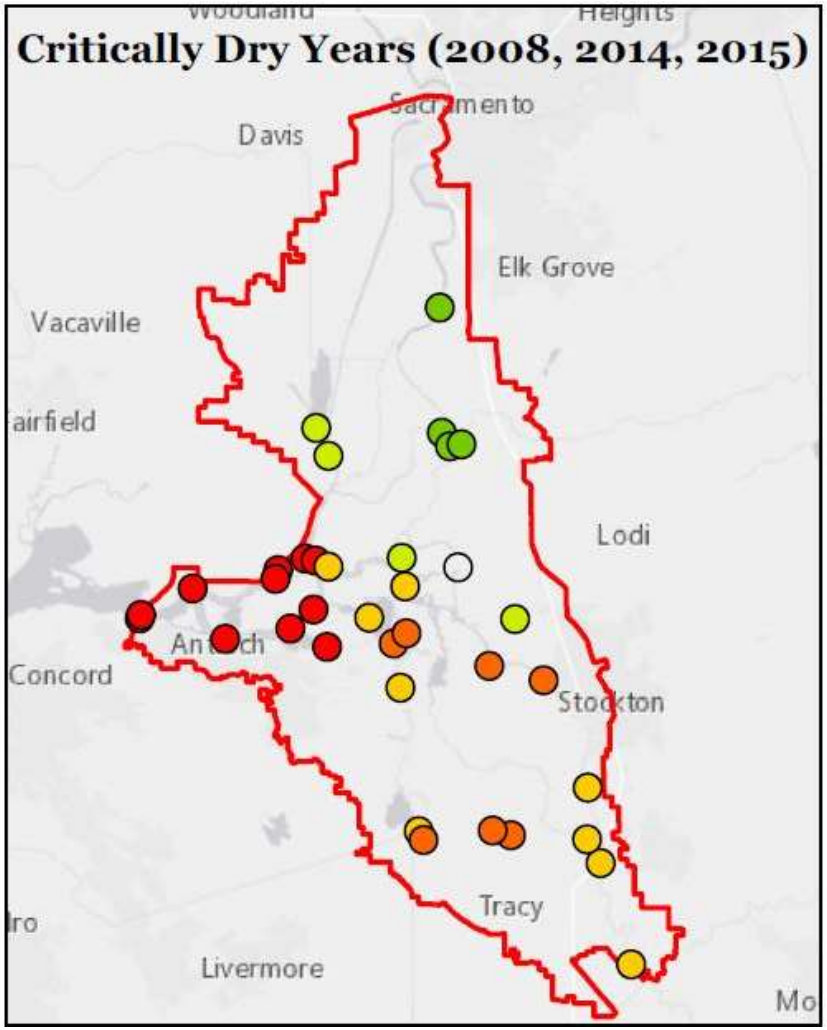
Methods: Data

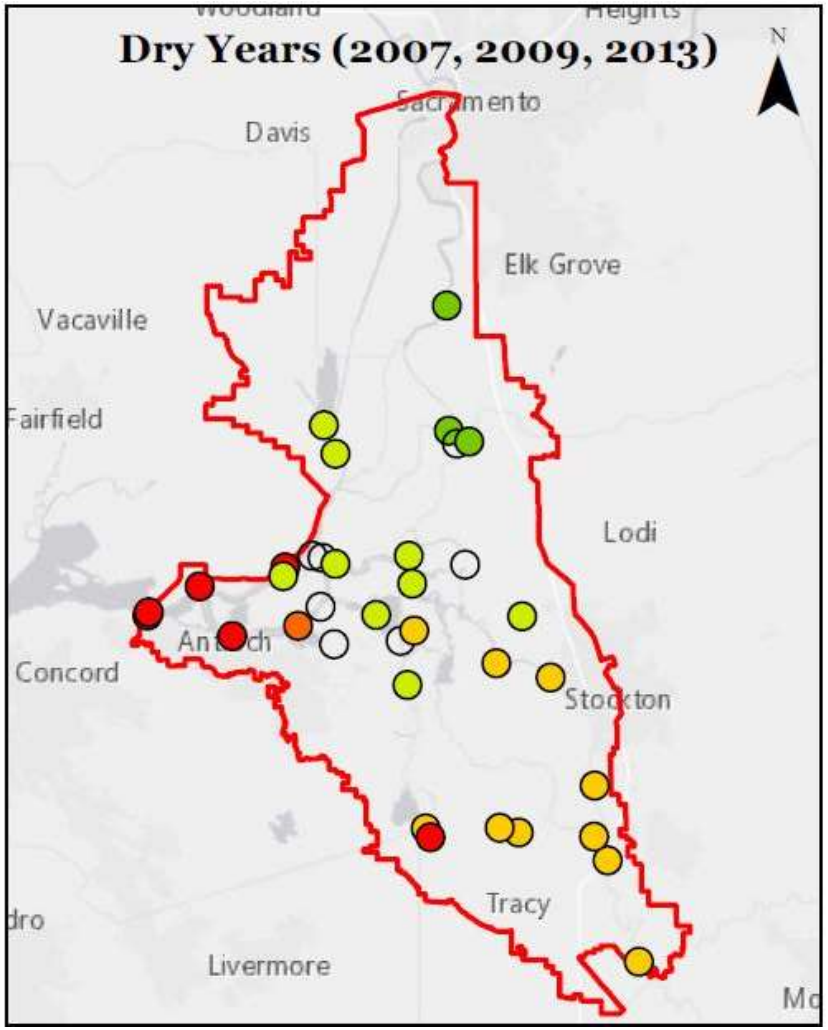
Salinity Data

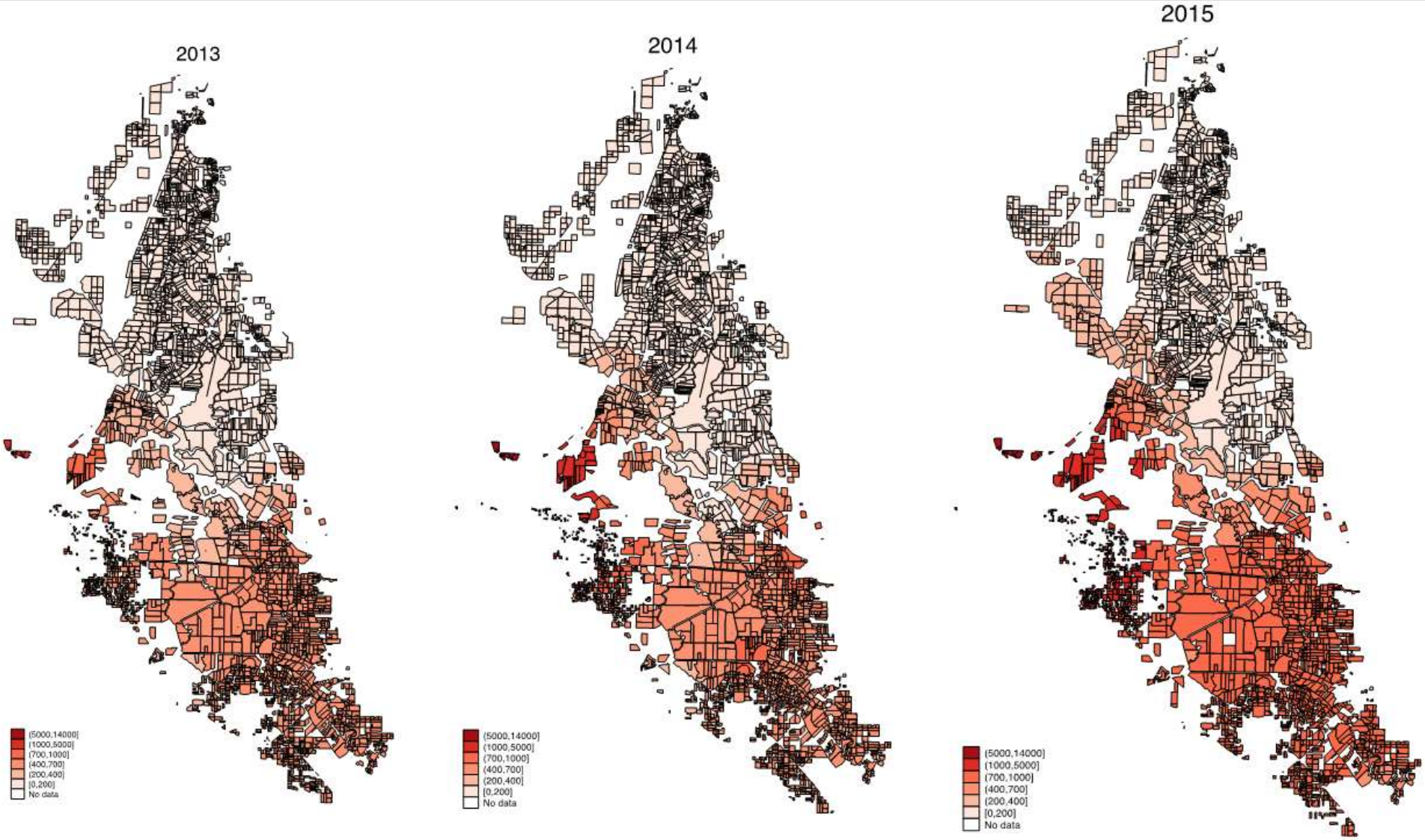
- USGS and CDEC monitoring stations for surface water salinity
- Monthly average for salinity calculated for growing season (April-August)
- Spline interpolation used to assign monthly salinity levels to parcels

Growing Season (April-August) Salinity Levels




Critically Dry Years (2008, 2014, 2015)
Davis
Elk Grove
Vacaville
Lodi
Concord
Stockton
Tracy
Livermore


Dry Years (2007, 2009, 2013)
N
Davis
Elk Grove
Vacaville
Fairfield
Lodi
Concord
Stockton
Tracy
Livermore


2013
2014
2015
(5000,14000]
(1000,5000]
(700,1000]
(400,700]
(200,400]
[0,200]
No data

Methods: Crop Grouping

- Grouped crops based on salinity tolerance
  - Initially grouped by crop type, e.g., grasses, grains, orchards, vegetable, berry crops
  - Sub-grouped by salt tolerance : Tolerant, Moderately Tolerant, Moderately Sensitive, and Sensitive
  - 17 total crop groups

Methods: Multinomial Logit Models

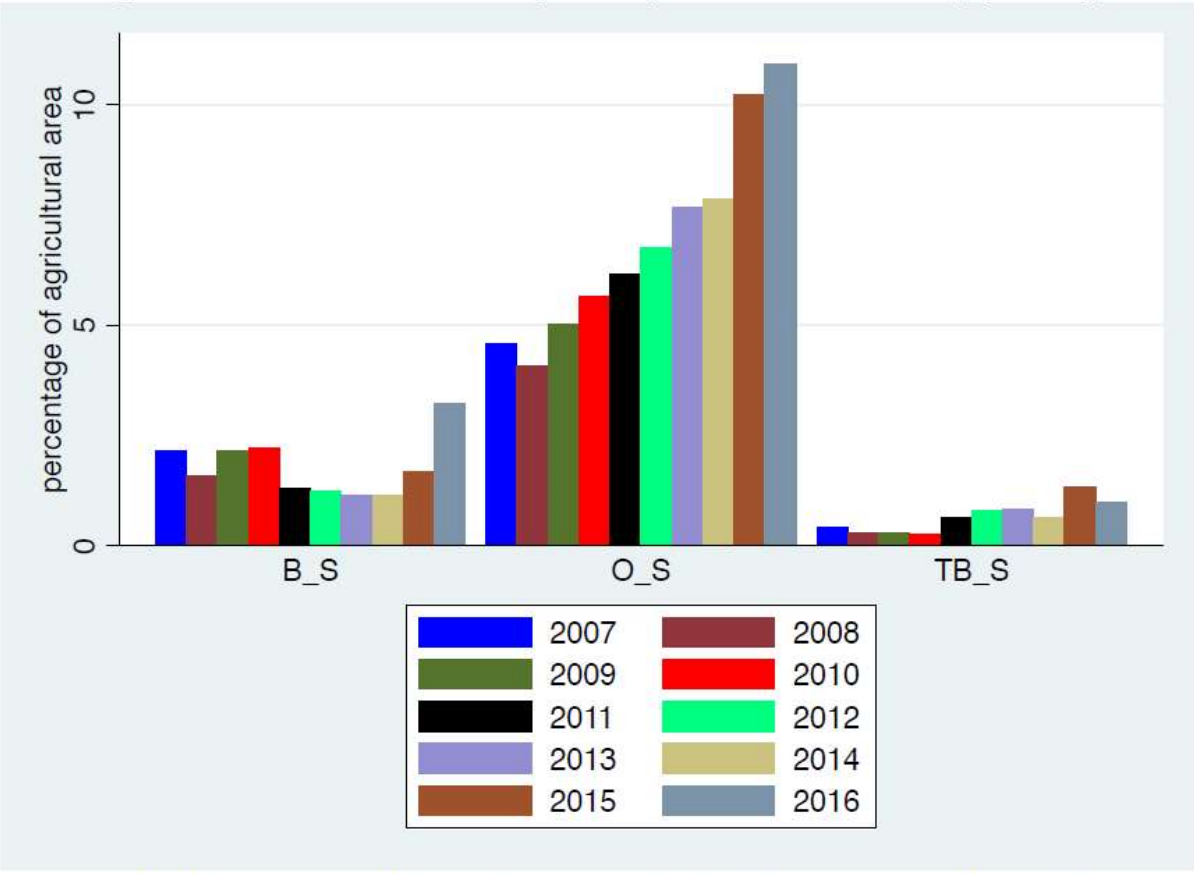
- Salinity=f(irrigation season salinity levels, parcel acreage, soil irrigation capacity class, elevation, slope, soil water storage capacity, annual dummy variables)

- Cross Sectional Model—captures impact of salinity on crop choice across parcels, with control variables
- Fixed Effects: impact of year-to-year changes in salinity levels on crop choice for a given parcel, holding all other variables constant

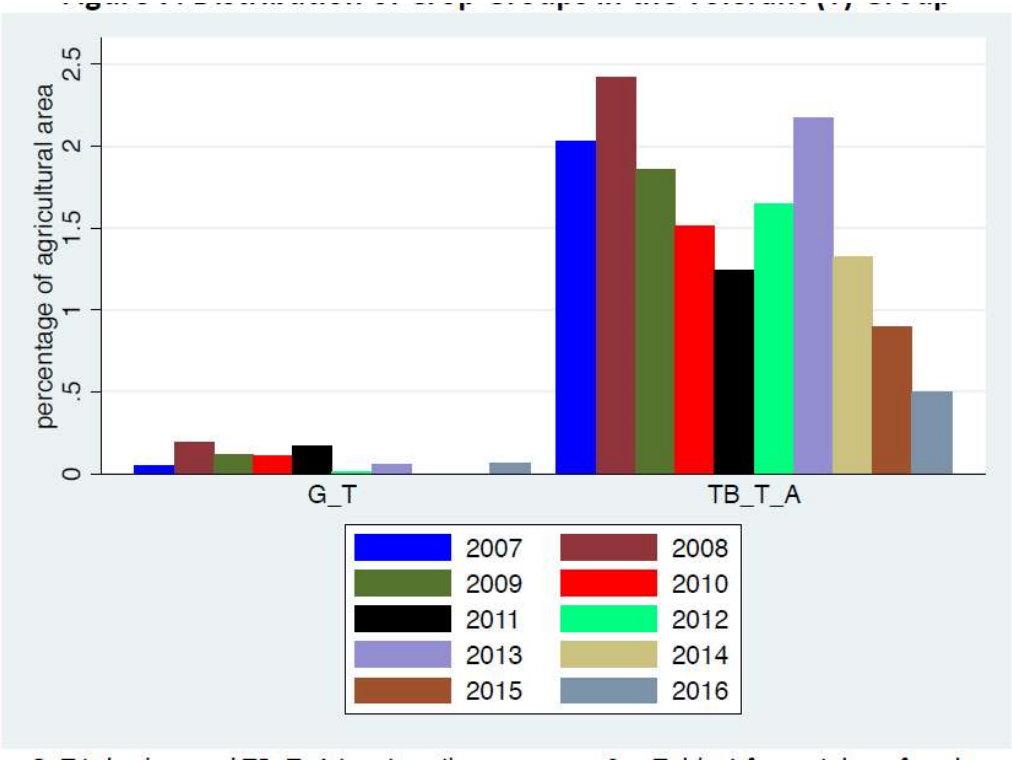
Results: Cross-Sectional Model

- Regions with historically higher irrigation water salinity levels have fewer acres in salt-sensitive, high revenue crops (e.g., grapes and orchards)

Share of Acreage in Sensitive Crops



Share of Acreage in Tolerant Crops



Results: Fixed-Effects Model

- Holding characteristics of soils constant, we see that salinity levels also affect short-term crop choice
  - Plant fewer acres in salt-sensitive vegetables (e.g., cucumber, potatoes, pumpkin)
  - Increased acres in forage, pasture, safflower, rye, and hay crops
  - Increases probability of planting moderately-tolerant orchard crops (e.g., pistachio, olive)
  - Salinity has no impact on annual changes in high-value, permanent crops (e.g., orchards)

  Contrary to our hypothesis:
  - Increasing salinity decreases probability of growing tolerant field crops

Discussion

- Spatial differences in historical salinity levels and soil conditions drive regional crop choice
- Farmers **do respond to annual changes in salinity levels by switching to more drought-tolerant annual crops**
- Year-to-year salinity changes have little impact on planting of permanent crops

- Other factors have a large impact on short-term response to salinity
  - Farmers' ability to mitigate salinity, crop revenues, historical cropping practices

- Next steps: evaluate different time horizons
  - E.g., after how many years of increasing salinity levels do farmers shift away from high value, sensitive crops?