Exploring Physical and Behavioral Responses to Salinity in Agriculture: A Case Study from Kern County, California

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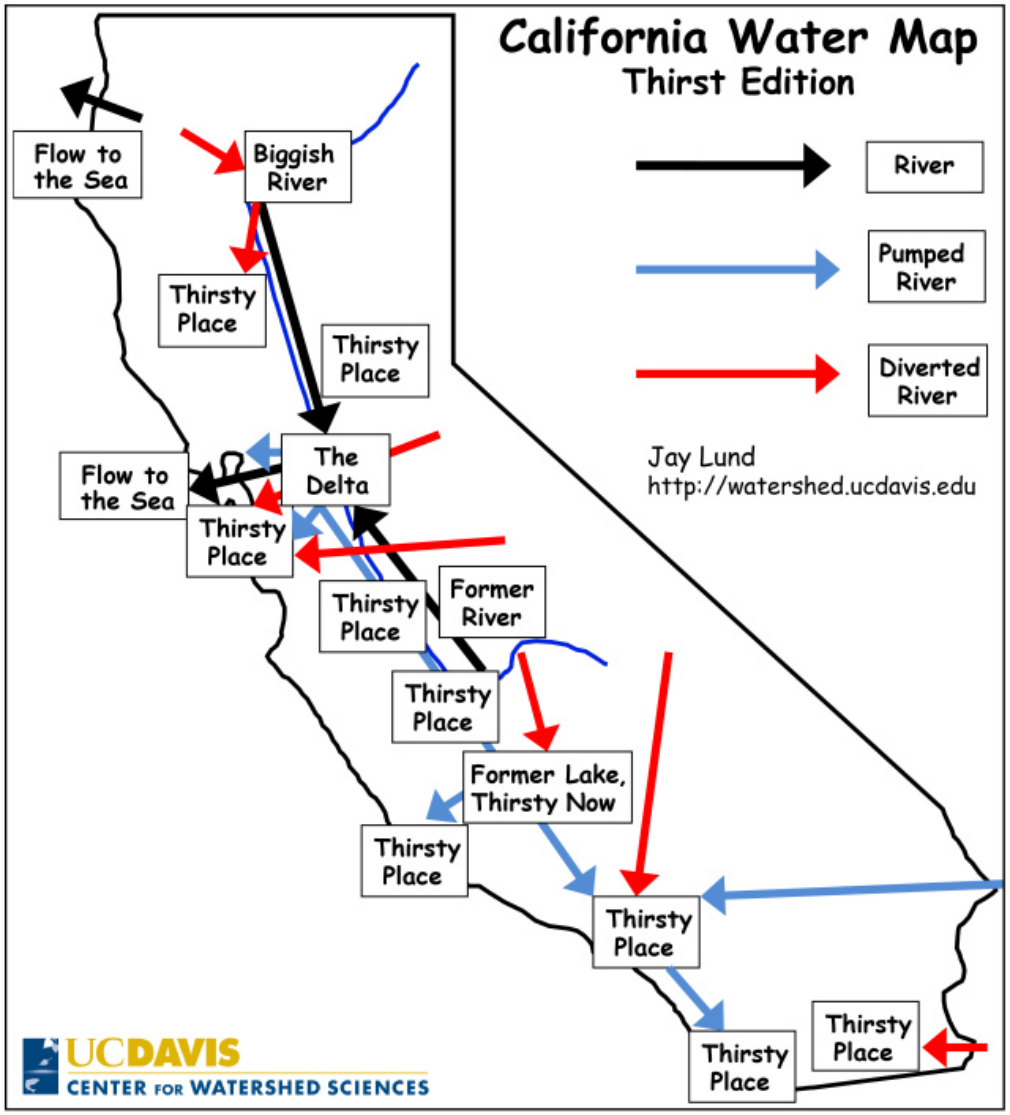
Outline

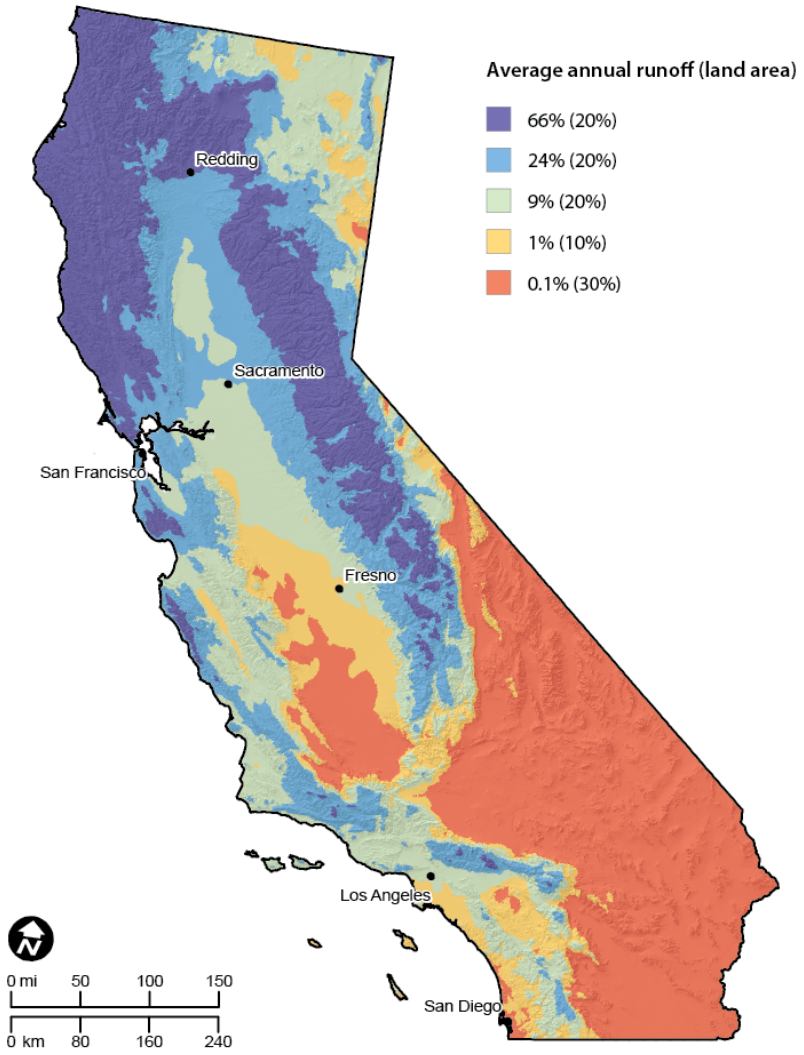
1. Water Resources in California
2. Agriculture in California
3. Behavioral and Physical Responses
4. Case Studies
   A. Central Valley Salinity Study (2009)
   B. Sacramento-San Joaquin Delta (2014)
   C. Kern County (2016)
5. Concluding Remarks

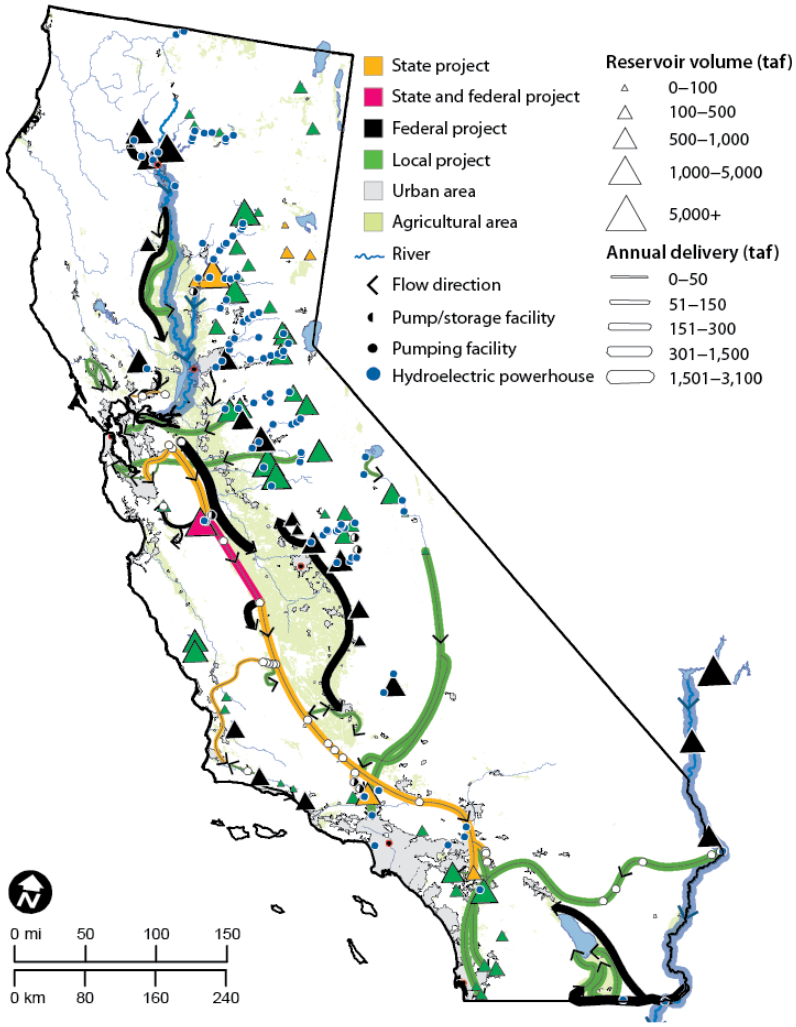
Water Resources in California Made Simple



- Mean annual runoff ~70 maf
- Water Use
  - 10% urban
  - 40% agriculture
  - 50% environment
- Irrigated area 9.3 million acres
- Many thirsty places!

Water supply and Infrastructure

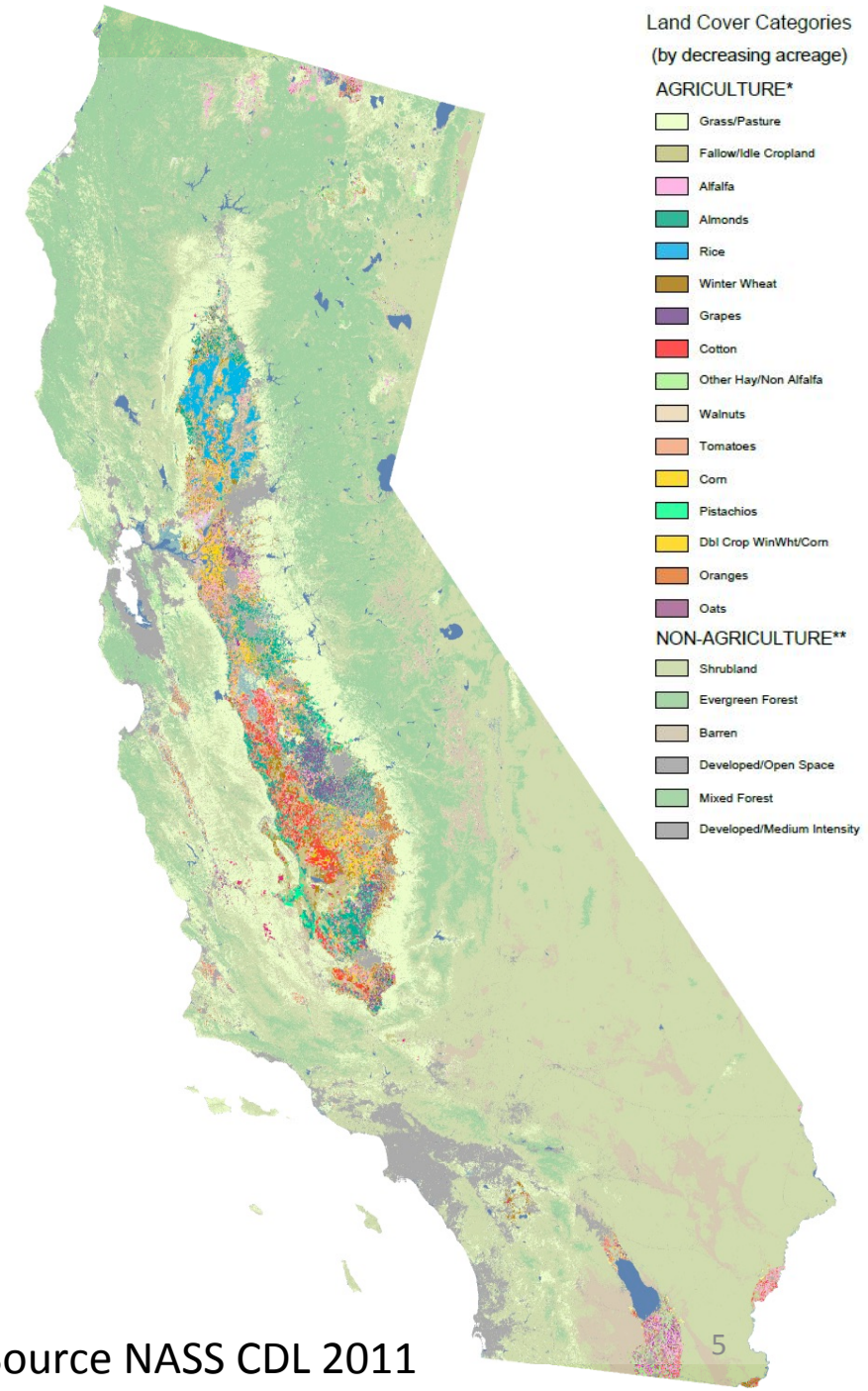




Hanak et al. (2011) Managing California's Water

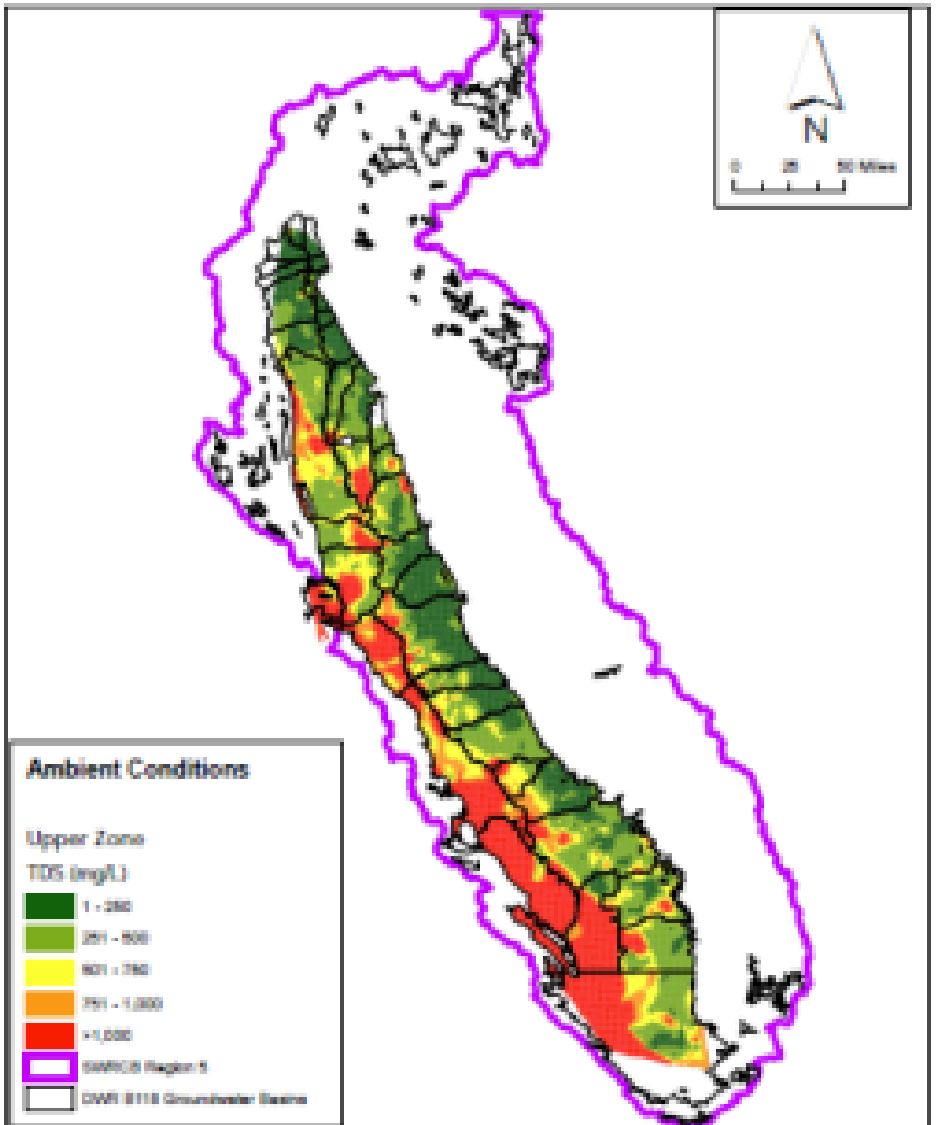
Agriculture in California

- $54 B in annual value (~$40 M in crops)
- 300+ commodities
- 9.3 M acres (7M in Central Valley)
- 400,000 Jobs
- Largest in value and size in US
- About 30 MAF/yr in applied water
- Market Driven



Source NASS CDL 2011

Salinity in water and soil affects agricultural yields ($370 million/year)



Sources:

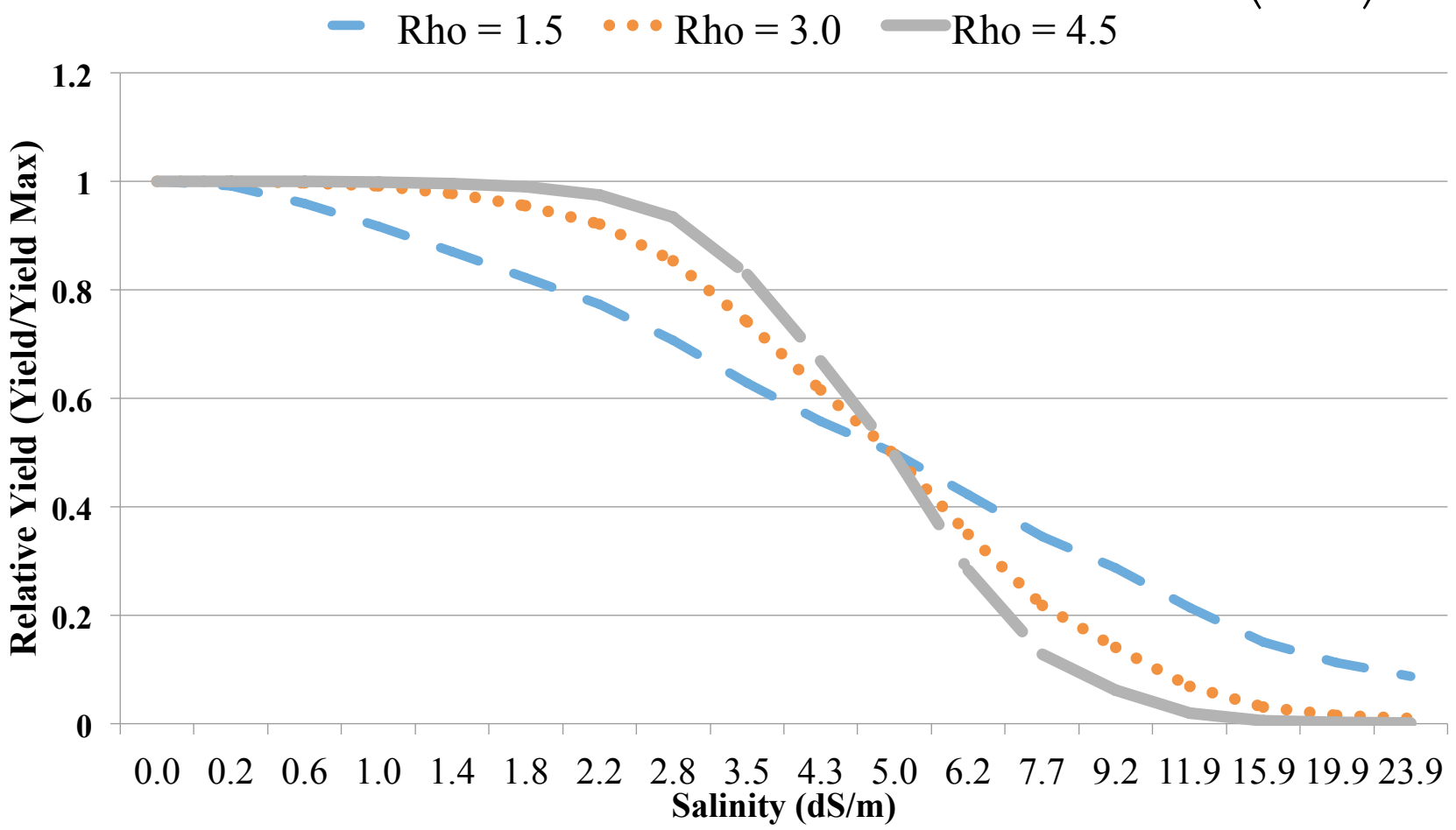
- 2 million tons/year accumulation San Joaquin Valley
- Natural occurrence GW
- Imported water
- Poor drainage
- Mobilization of naturally occurring salts in root zone
- Minerals left by crops in root zone

http://www.cvsalinity.org/index.php/committees/technical-advisory/conceptual-model-developments/171-updated-groundwater-quality-analysis-for-central-valley.html

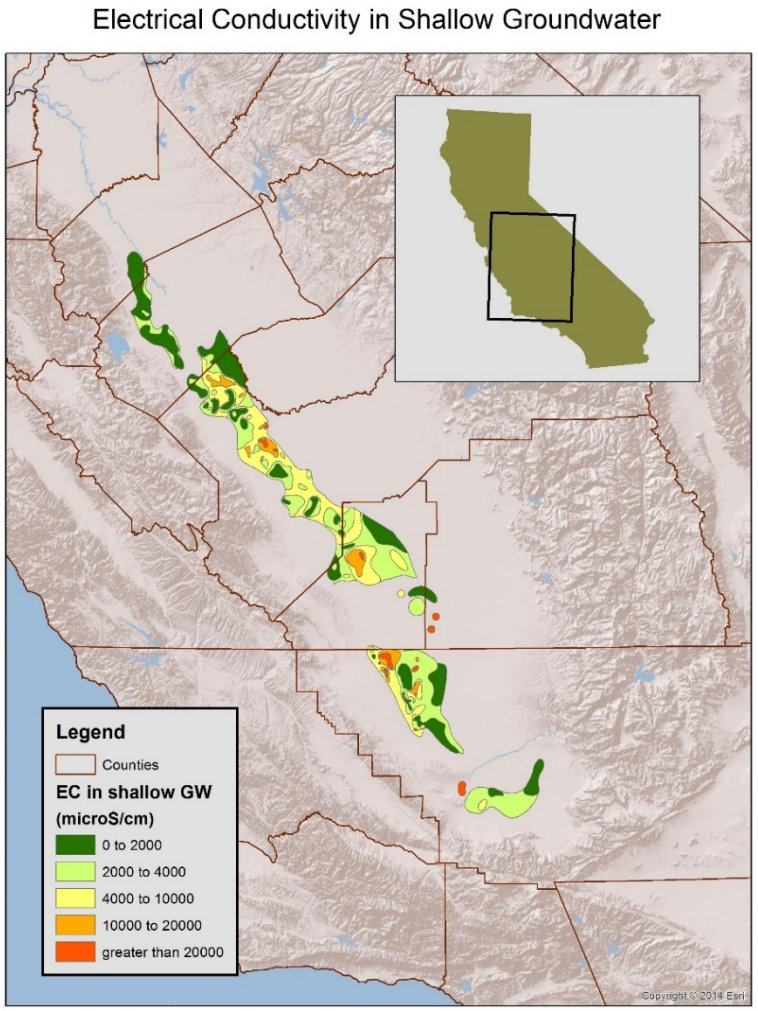
Salinity Response

$$Y = \frac{Y_{max}}{1 + \left(\frac{c}{c_{50}} \right)^{\rho}},$$

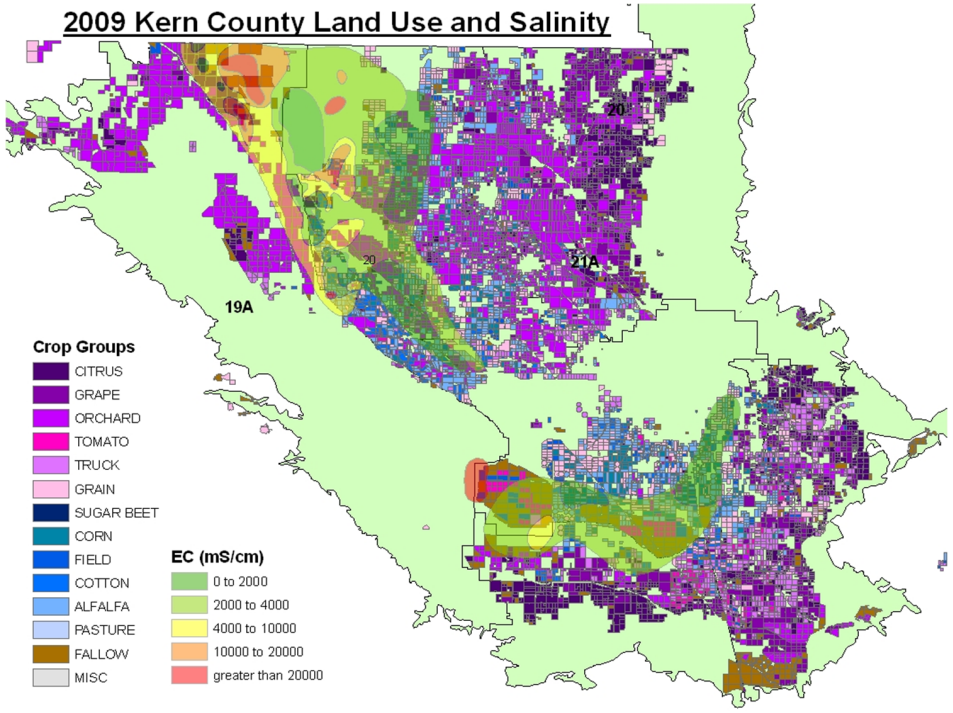
Van Genuchten and Hoffman (1994)



A) Central Valley Salinity Study



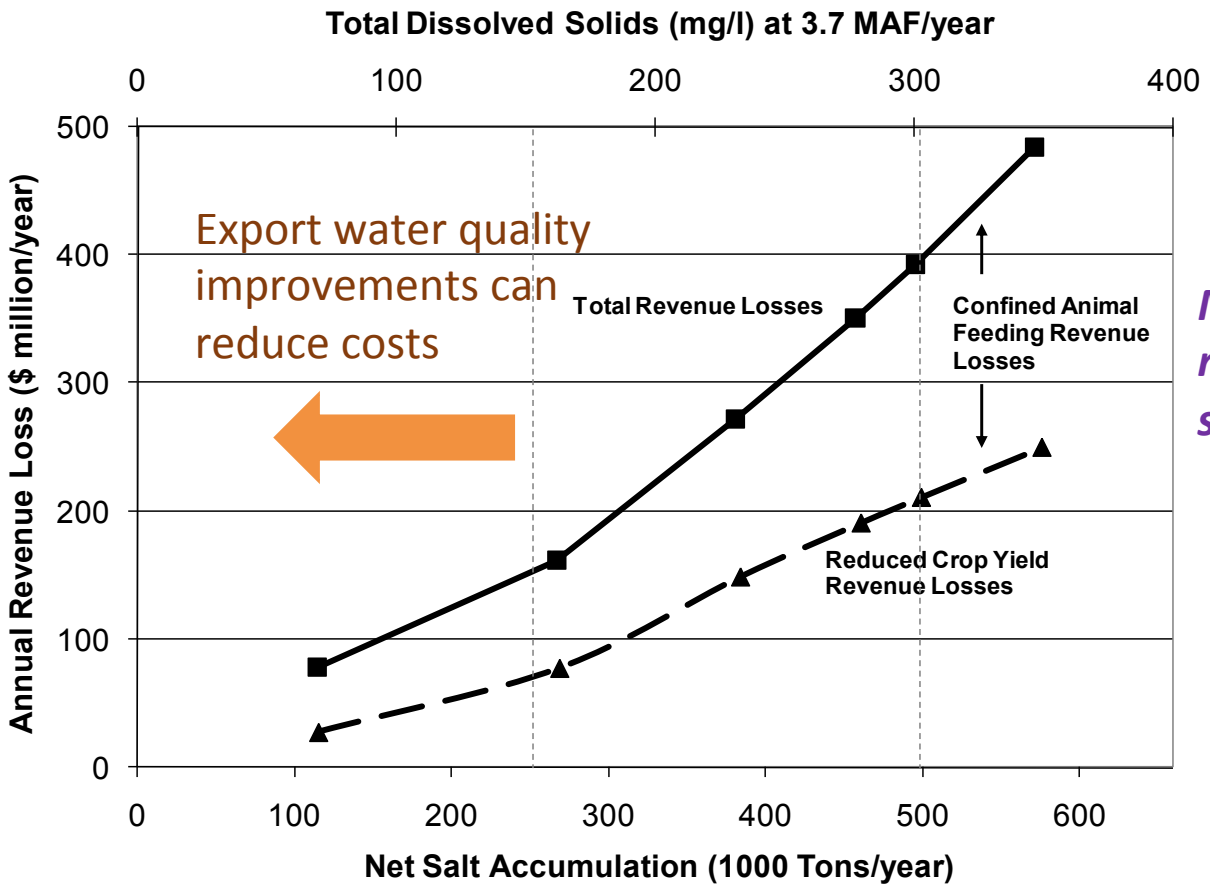
Adapted from Medellin-Azuara et al. (2008). The Economic Effects on Agriculture of Water Export Salinity South of the Delta



MacEwan, Howitt, Medellin-Azuara (2016)

Central Valley Salinity Study
Howitt et al . (2009)

Costs of Salinity Accumulation

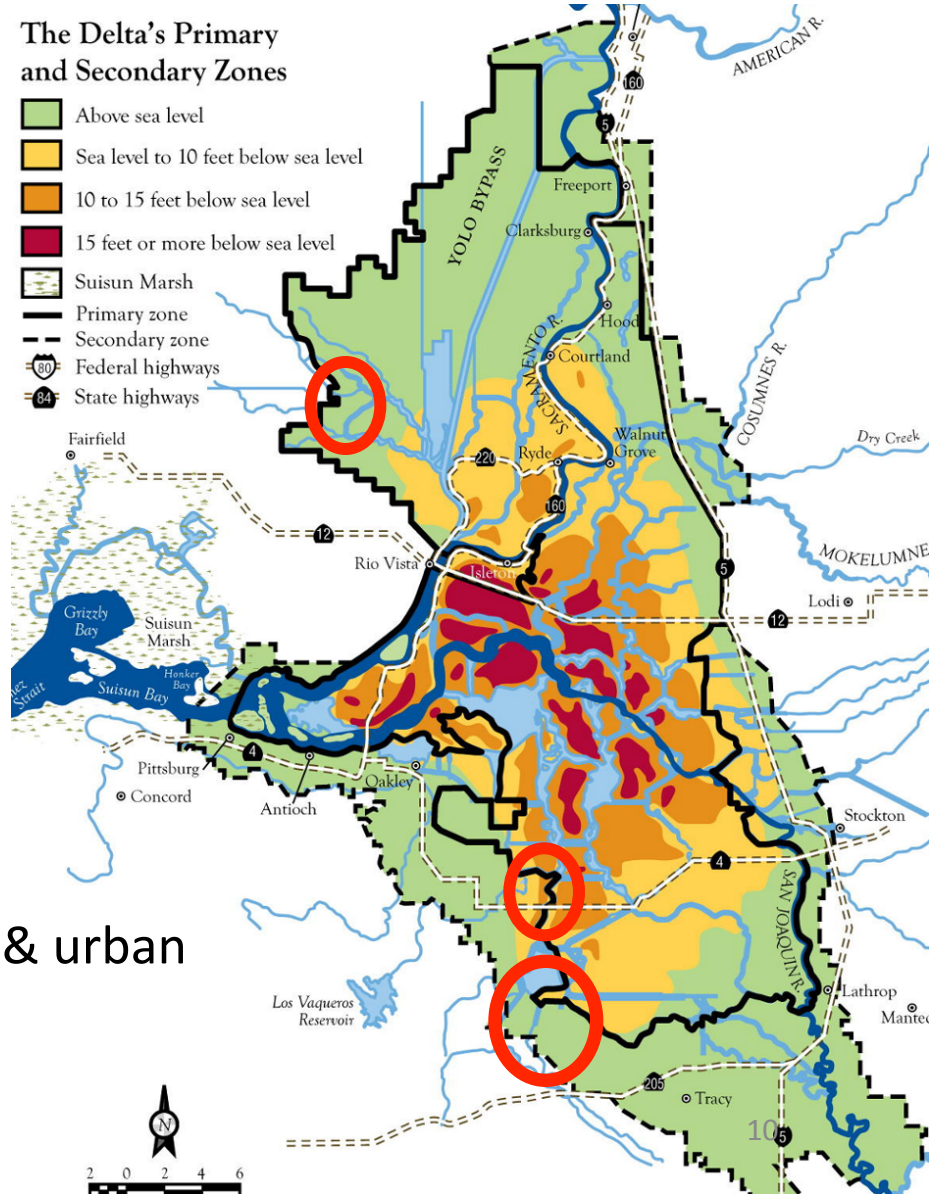


More research is needed on soil salinization

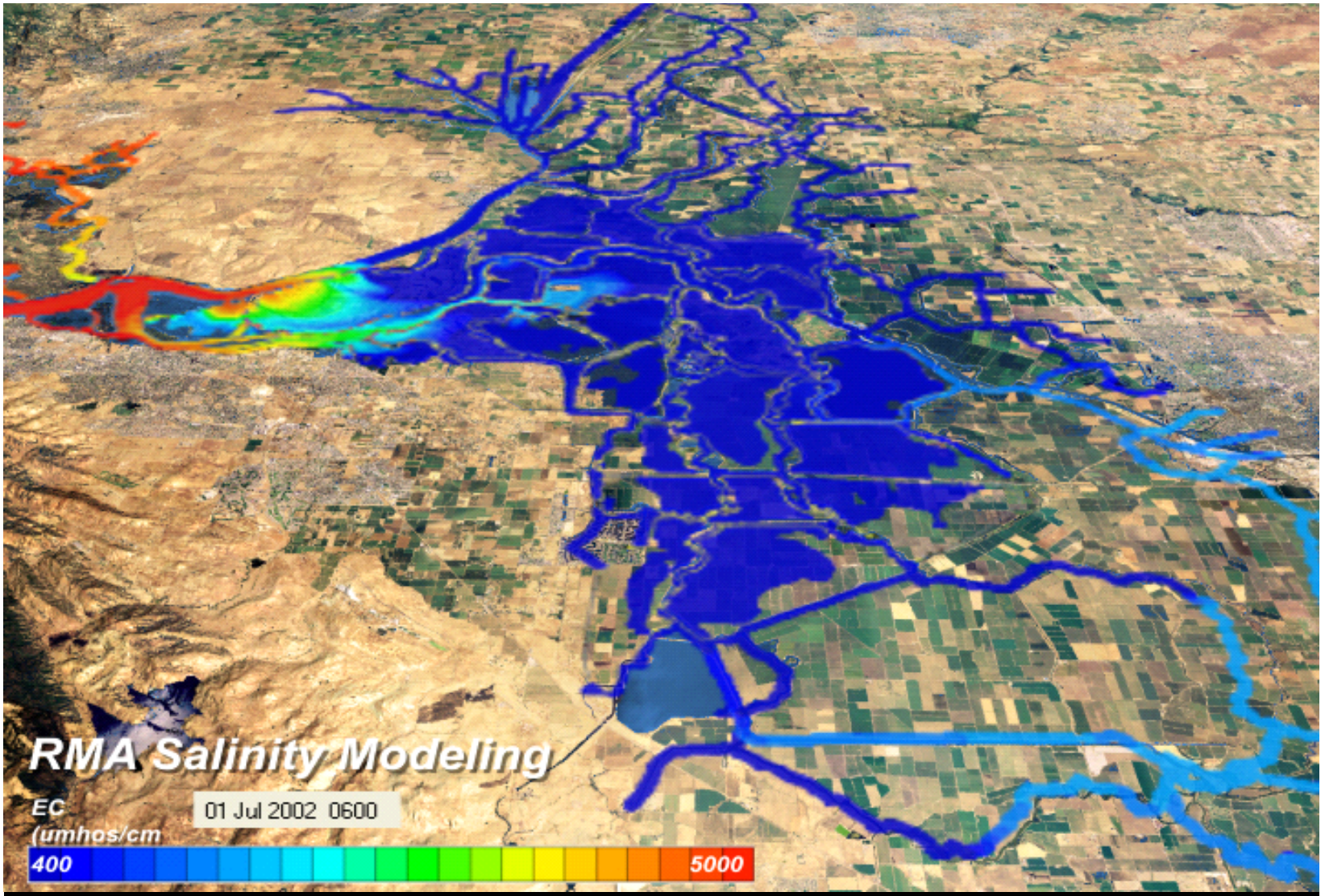
Medellin-Azuara et al. (2008). The Economic Effects on Agriculture of Water Export Salinity South of the Delta

B) Case Study Sacramento-San Joaquin Delta

- Physical instability
  - Land subsidence
  - Sea level rise
  - Floods
  - Earthquakes
- Ecosystem instability
  - Habitat alteration
  - Invasive species
- Economic instability
  - High costs to repair islands
  - Worsening water quality for agric. & urban users

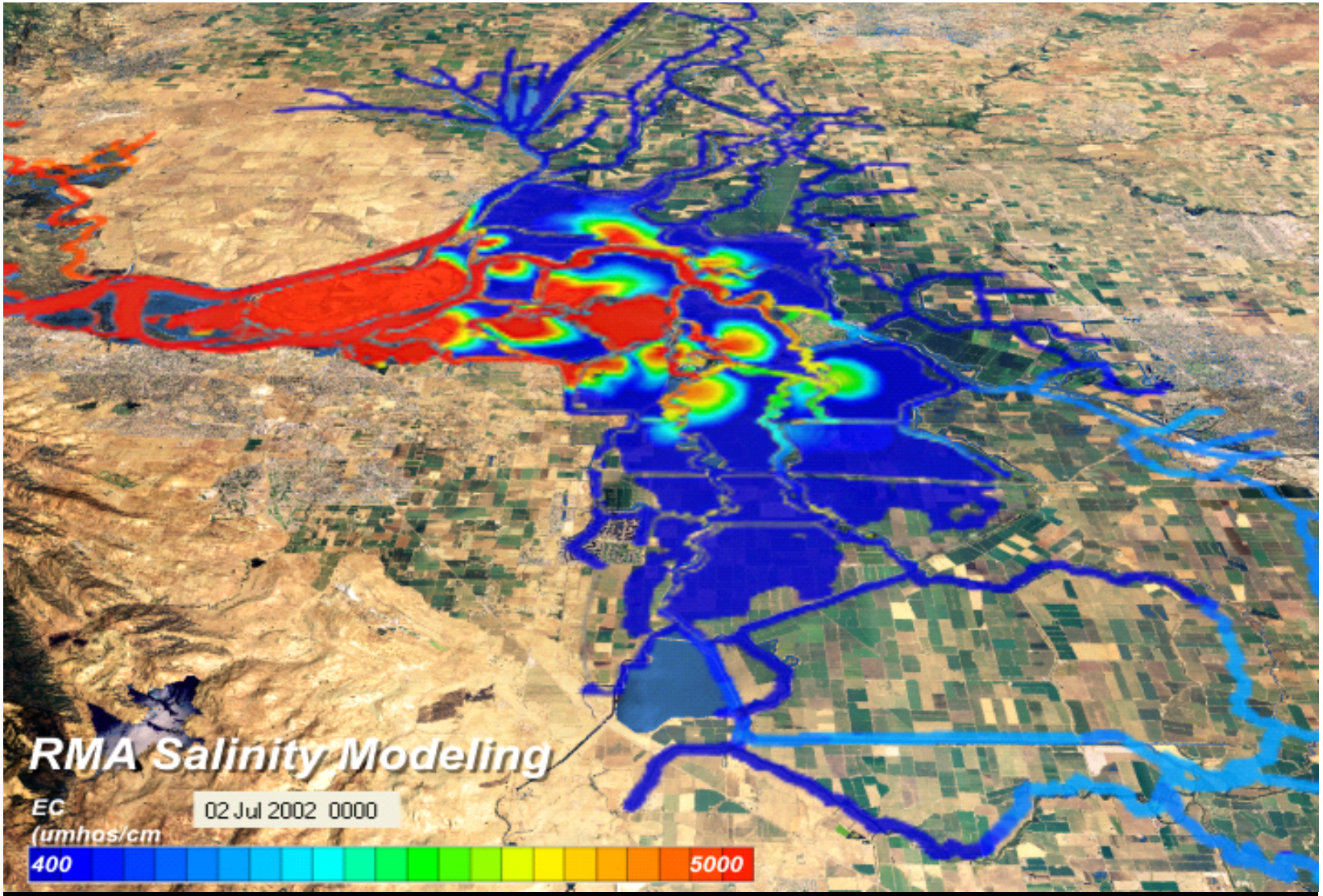


The “Big Gulp”: 6.5 Magnitude Earthquake
causing 20-Island Failure



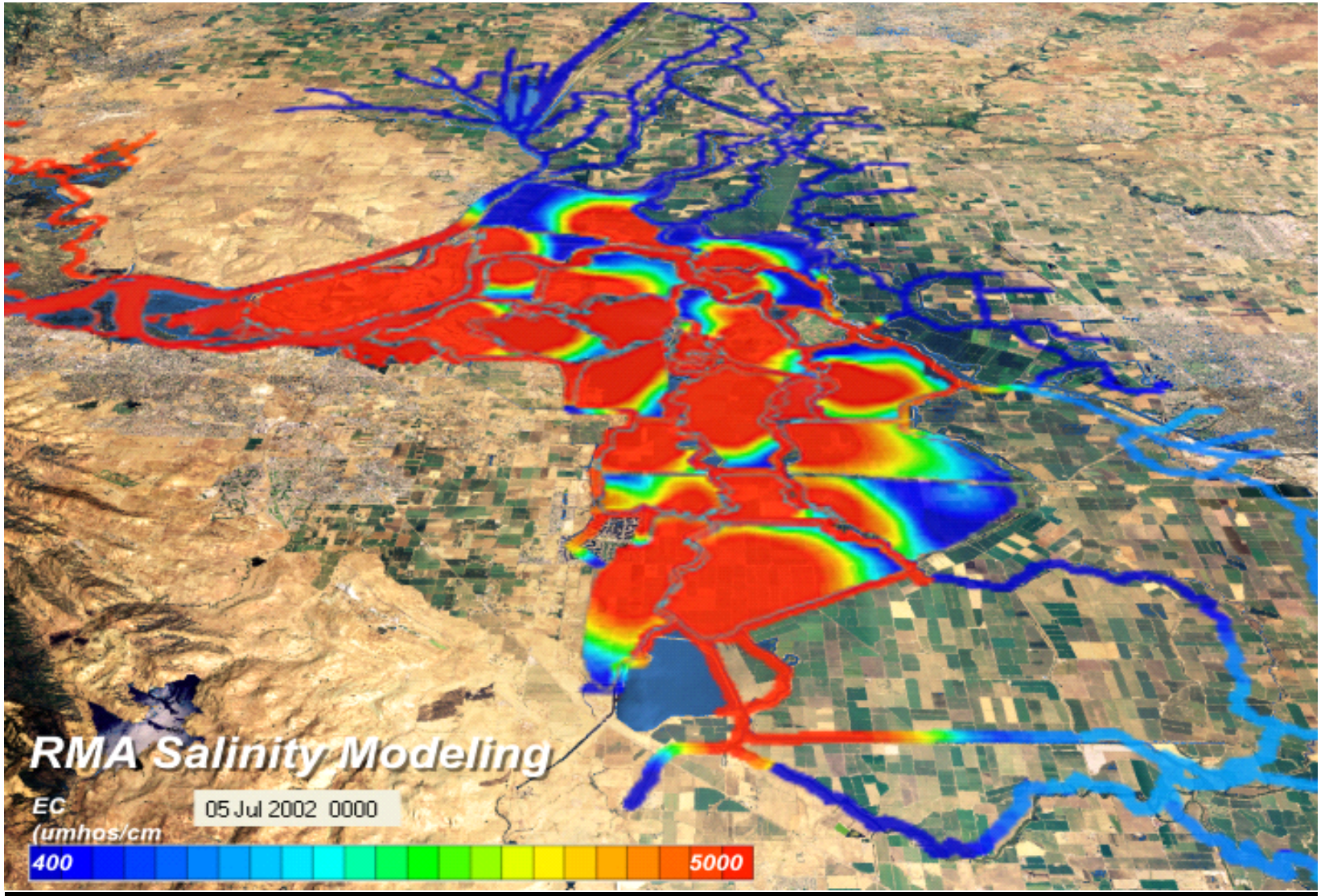
0 – 6 hours: Islands flood with fresh water

6.5 Magnitude Earthquake causing 20-Island failure



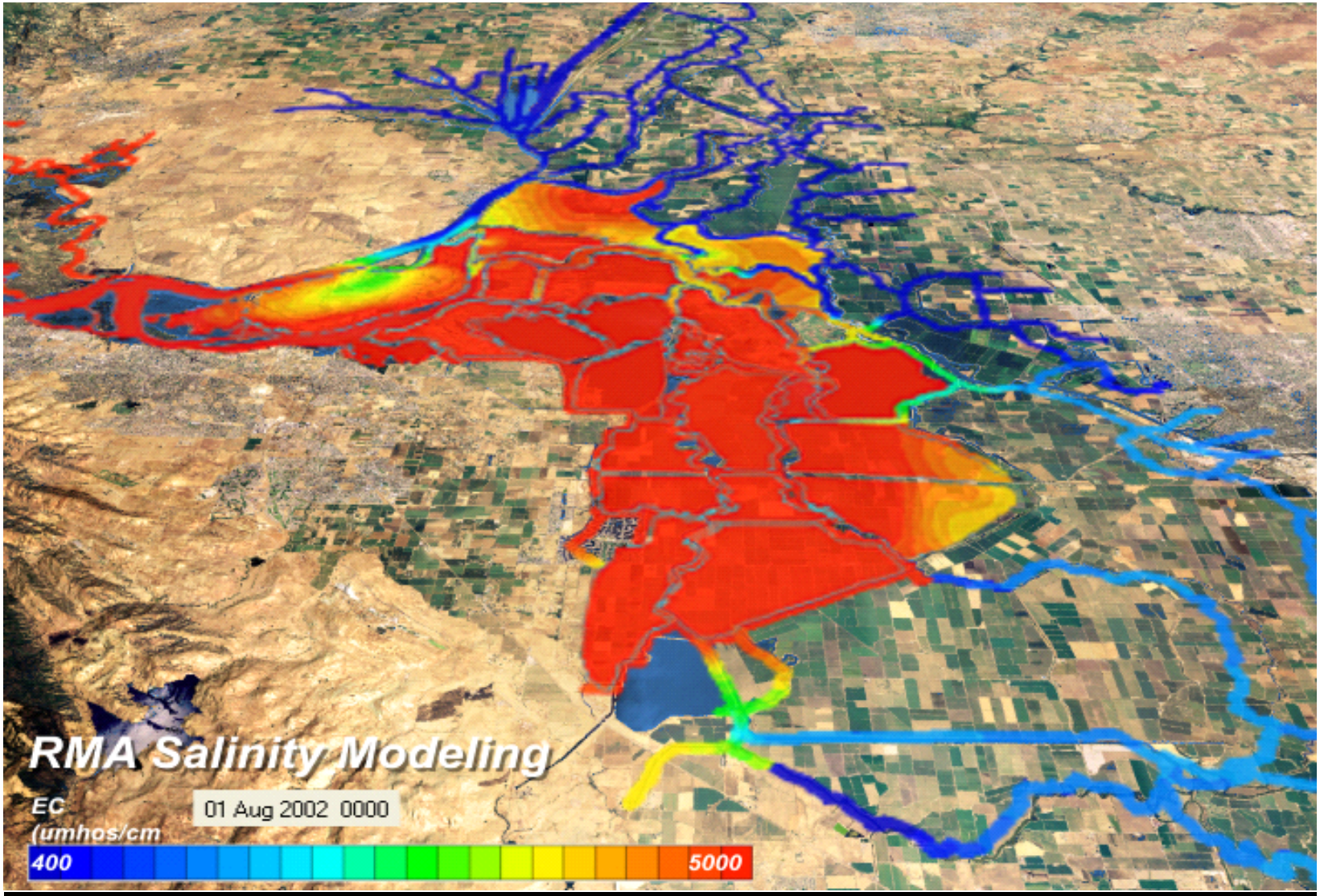
12 – 24 hours: Salt water intruding into Delta

6.5 Magnitude Earthquake causing 20-Island failure



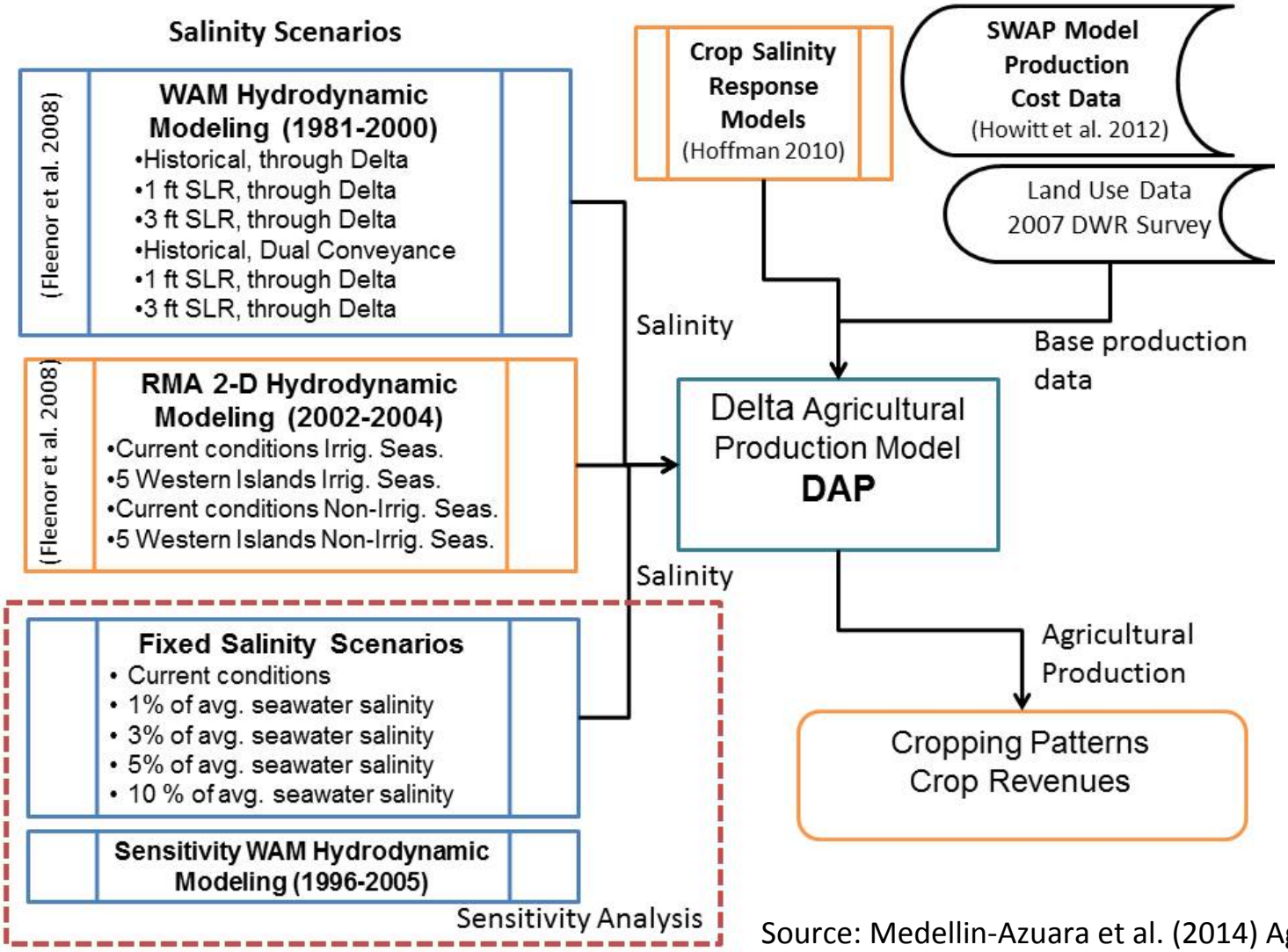
1 – 7 days: Salt water throughout Delta

6.5 Magnitude Earthquake causing 20-Island failure



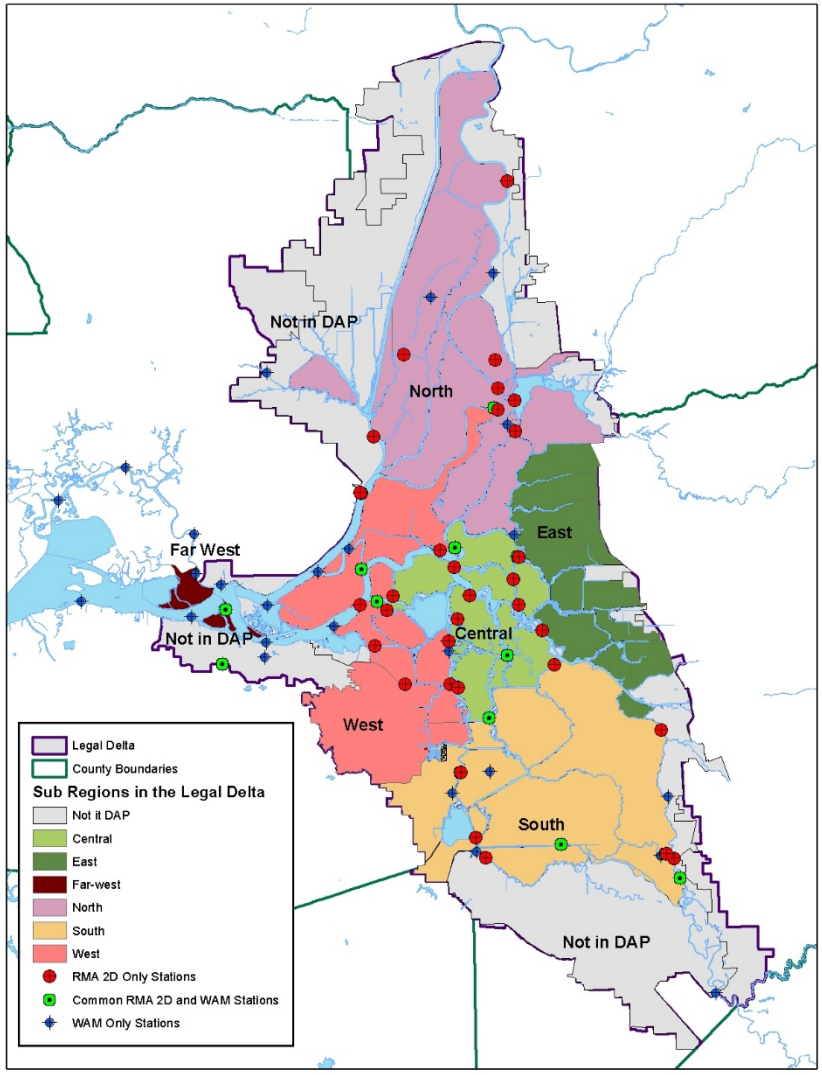
30 days: A saline estuary

A Suite of Models



Source: Medellin-Azuara et al. (2014) Ag. Losses from Salinity

Delta Agricultural Production Model (DAP)

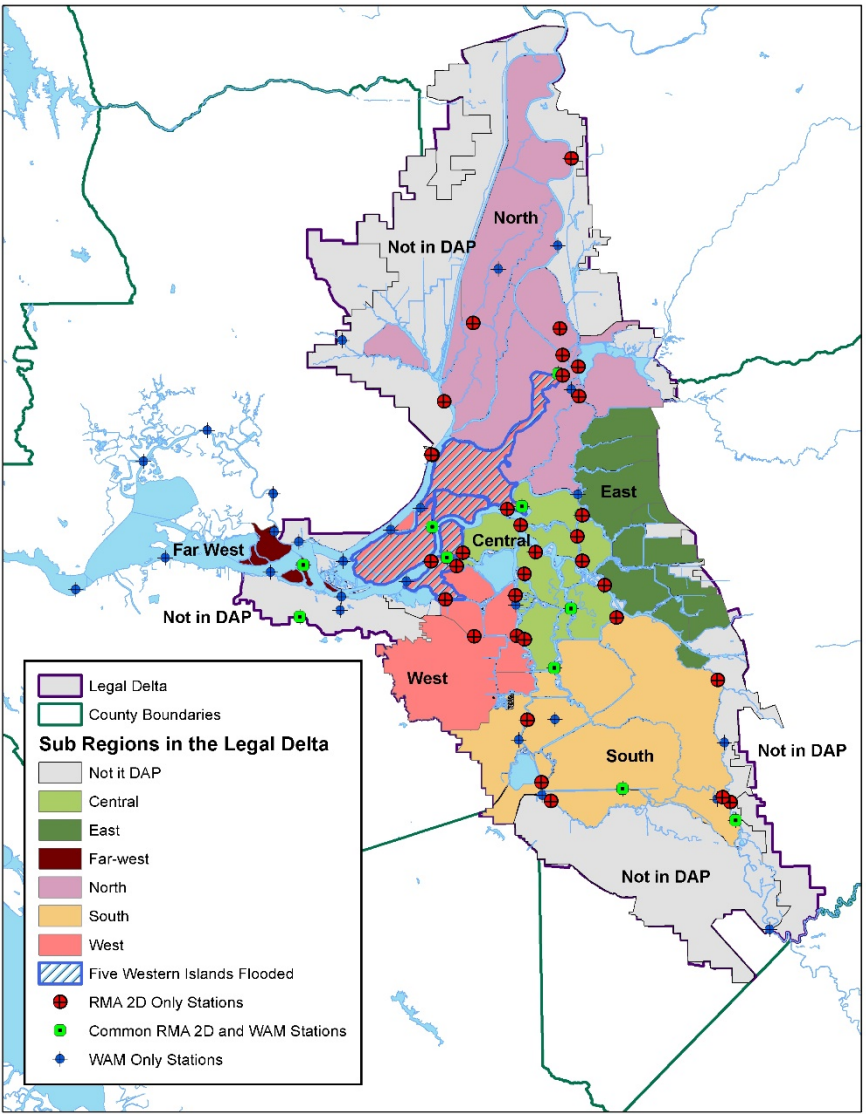


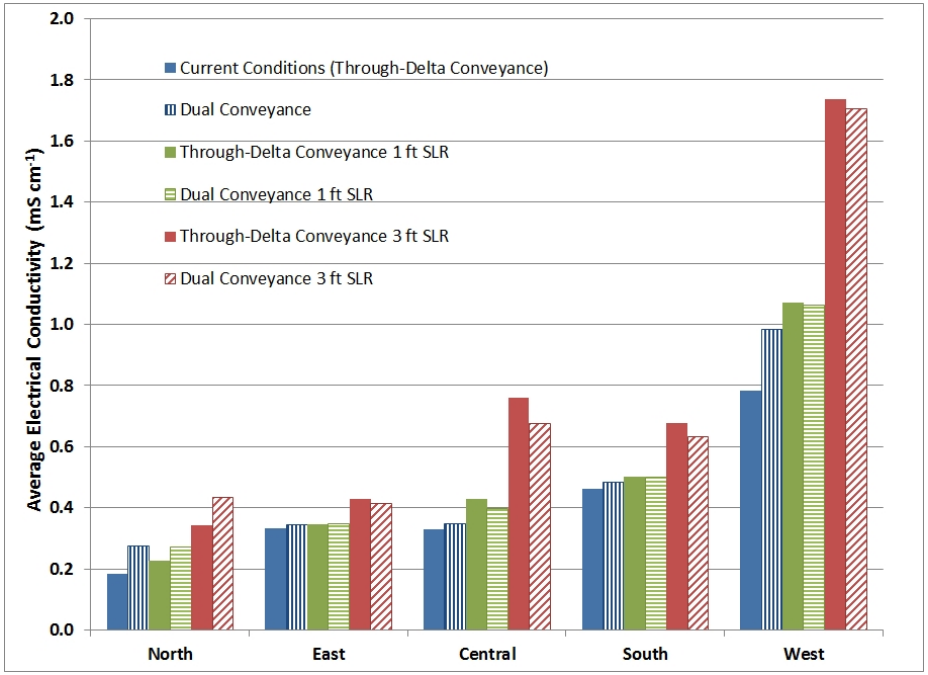
Source: Medellin-Azuara et al. (2014) Ag. Losses from Salinity

- Self-calibrated model
- Production terminated for flood and habitat
- Salinity effects, WAM, RMA. Closest station

Van Genuchten and Hoffman (1994)

No Significant Changes in Salinity Expected with Sea Level Rise, or Dual Conveyance





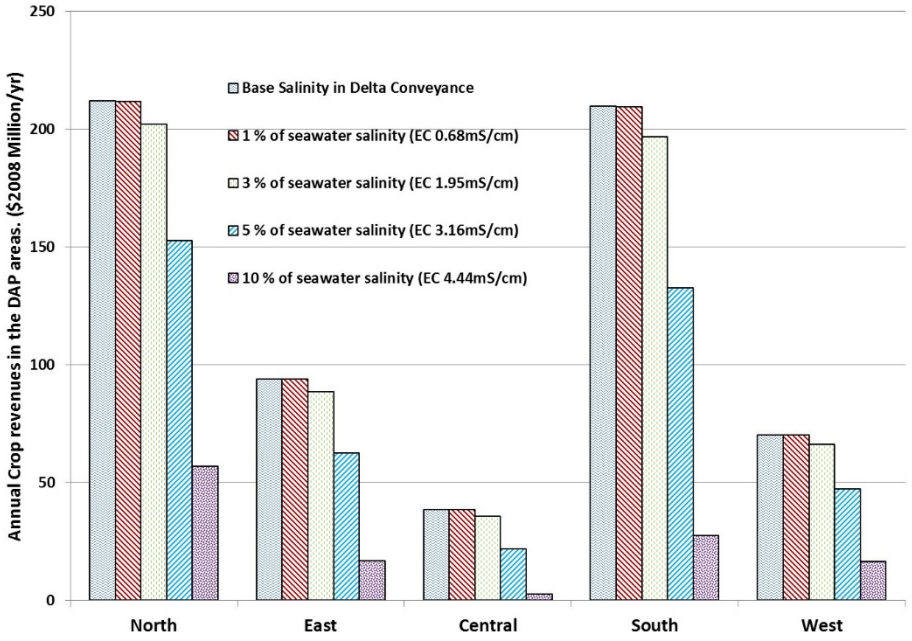
- WAM Historical hydrology, operations and exports, 4.9 MAF/yr of exports and 20 year time period (1980-2000)

Source: Medellin-Azuara et al. (2014) Ag. Losses from Salinity

Hydrodynamic models show little change in salinity and farm revenues

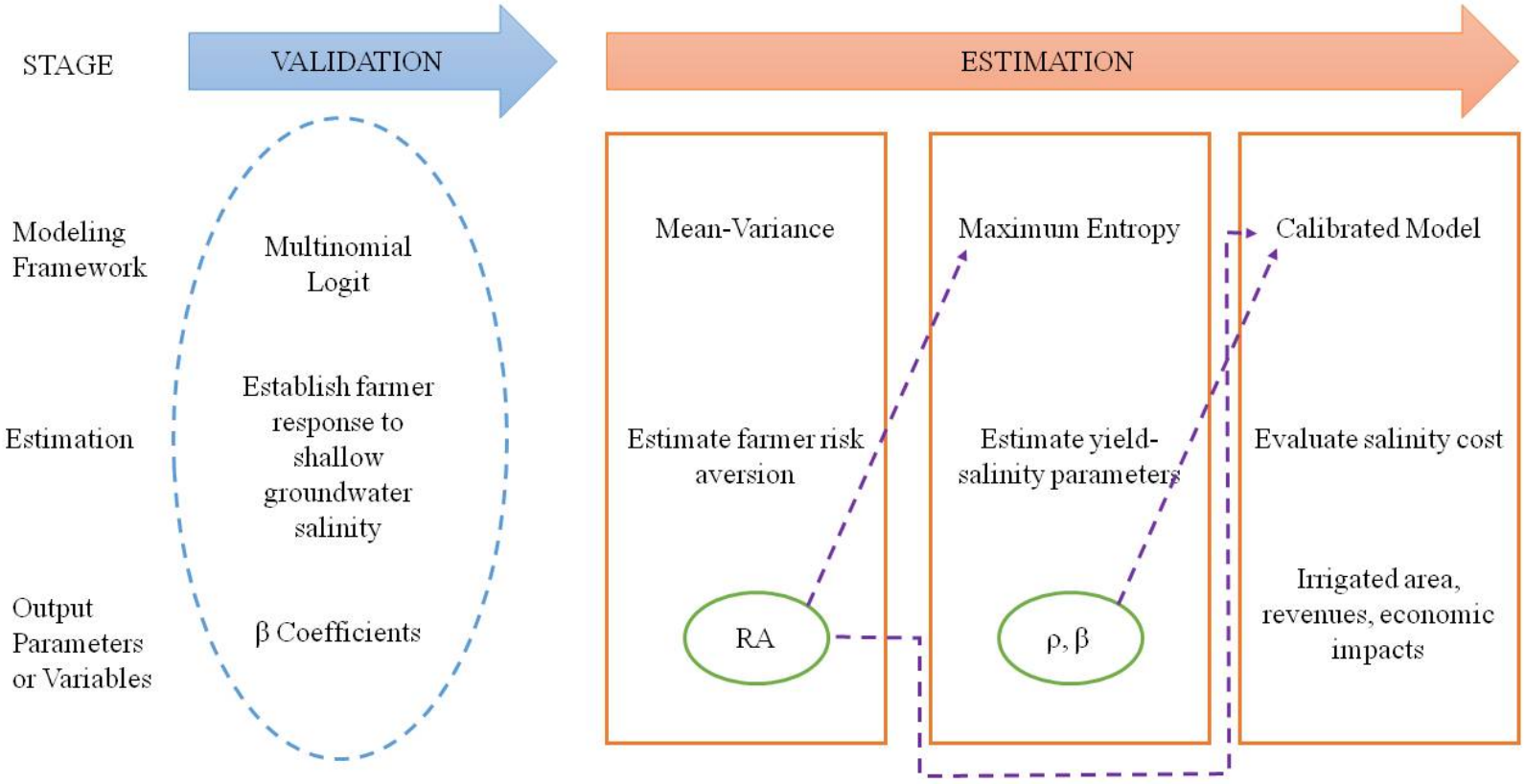
Hydrodynamic modeling

Fixed Salinity Scenarios

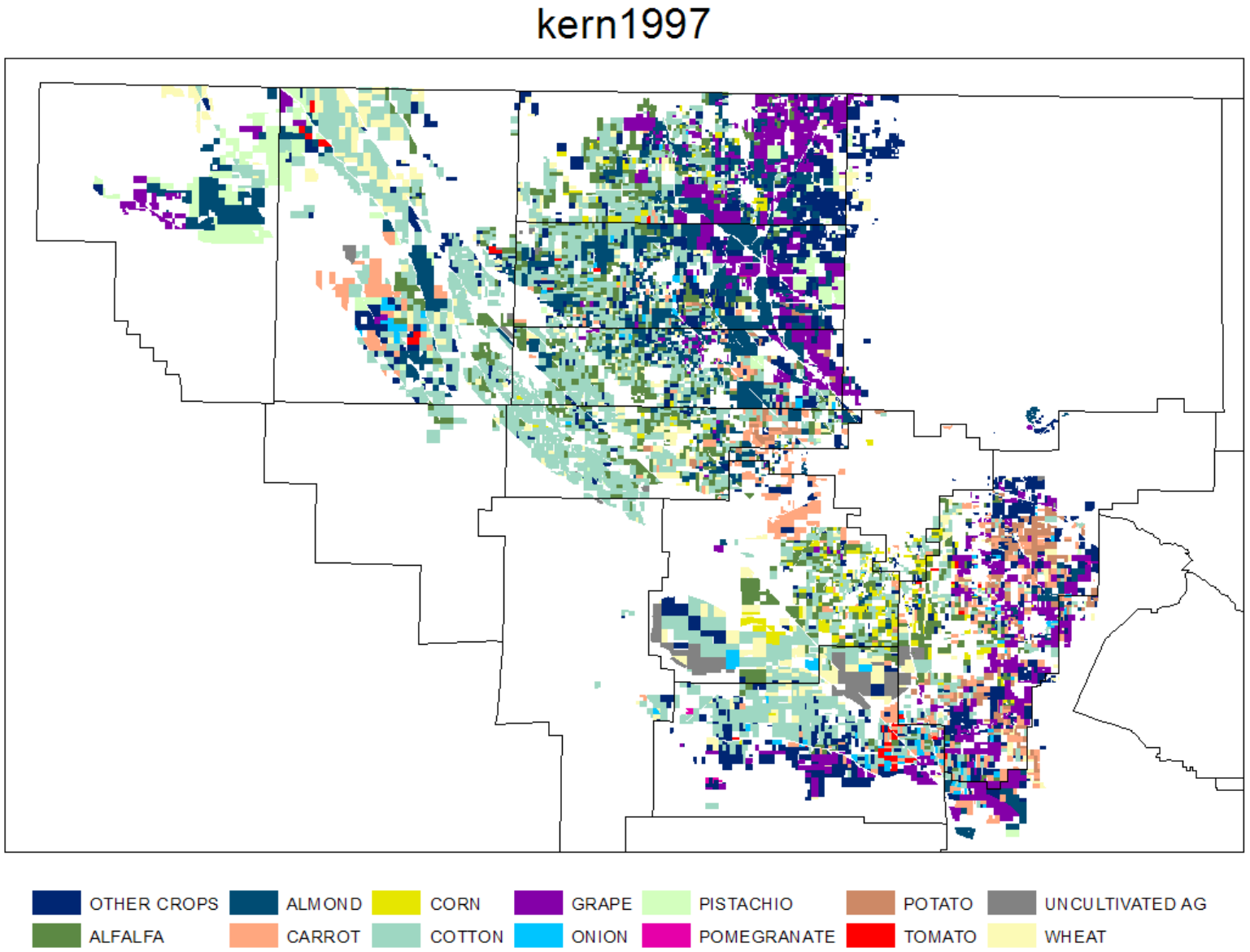


Source: Medellin-Azuara et al. (2014) Ag. Losses from Salinity

C) Behavioral versus physical response: Kern County



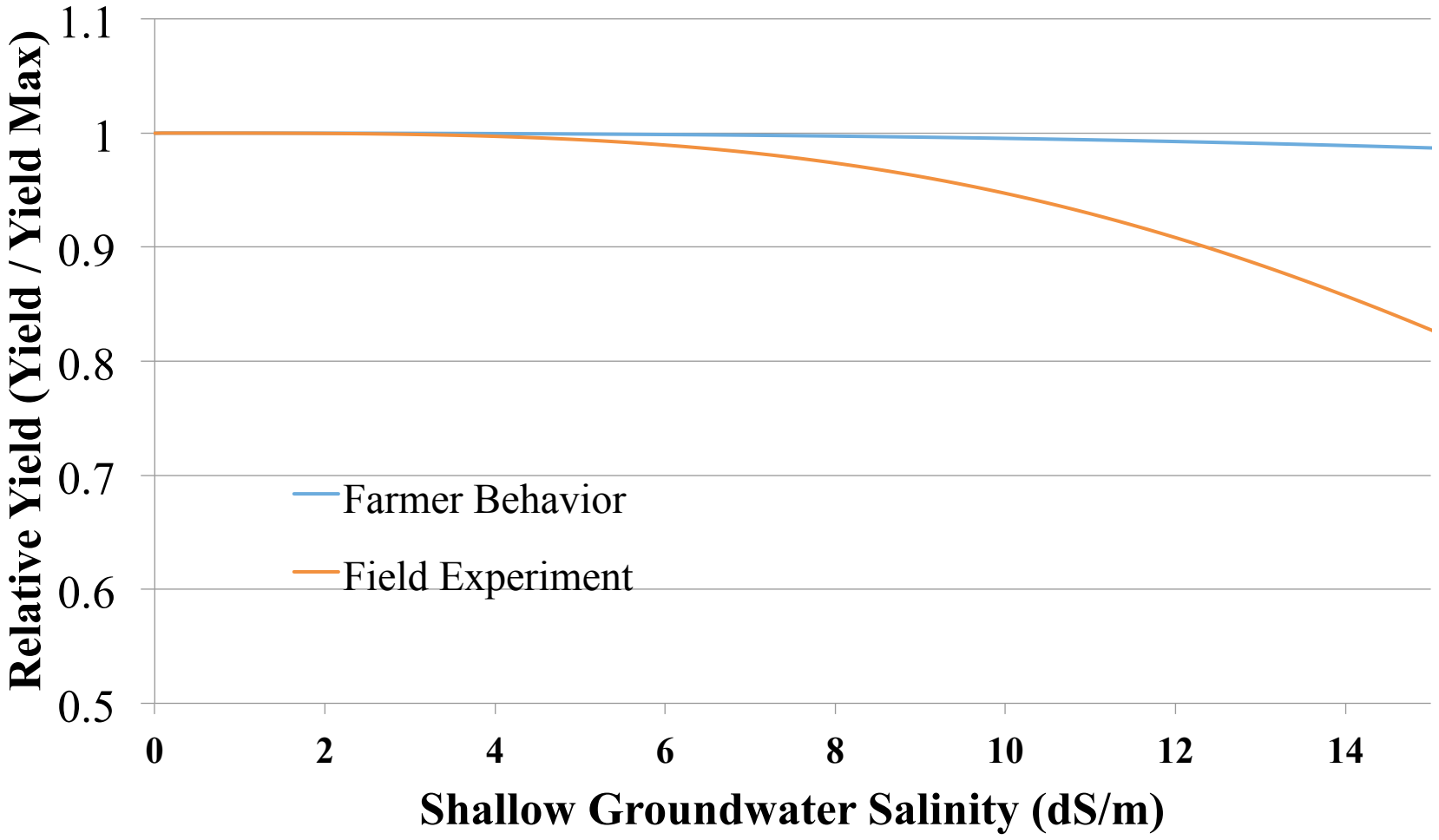
Parcel level information to calibrate behavioral model



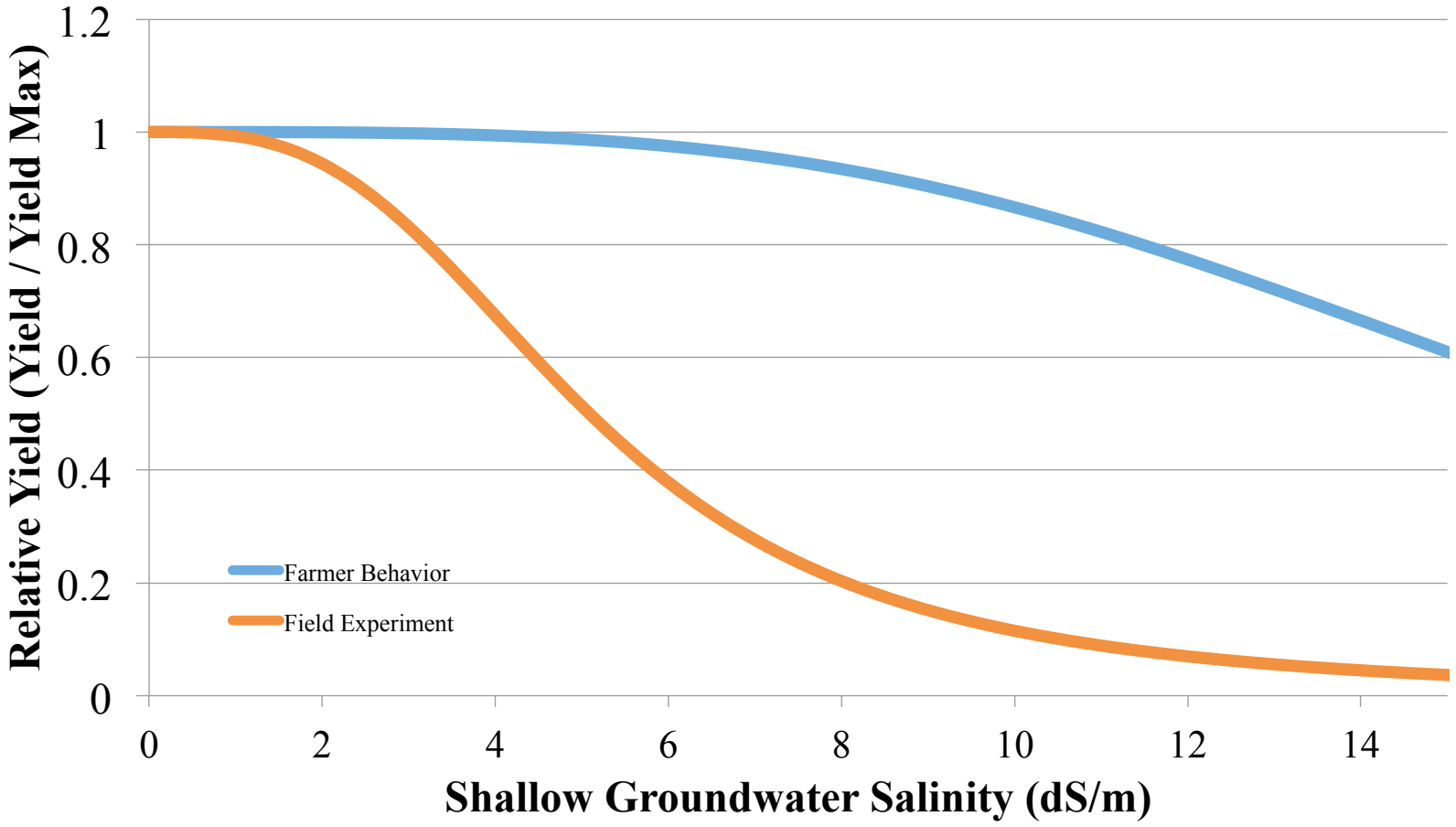
Marginal effects of salinity by threshold salt tolerance

Crop Group	Threshold dS/m	Marginal Effect
Vegetable	1.4	-0.0184***
Fruit/Nuts	1.4	-0.0482***
Potato	1.7	-0.0202***
Vine	1.7	-0.0655***
Tomato	1.9	0.00315***
Alfalfa	2.2	0.0379***
Cucurbit	2.4	-0.000447
Corn	3.7	0.000601
Dry Beans	4.9	0.00352***
Cotton	5.1	0.0526***
Grain/Field	6.7	0.0302***
Fallow	n/a	0.0248***

Behavioral versus physical: grain



Behavioral versus physical: almonds and pistachios



Looking Forward

- CV-SALTS (Central Valley Salinity Alternatives for Long-Term Sustainability)
  - Safe Drinking Water
  - Achieve Balanced Salt and Nitrate Loading
  - Implement Managed Aquifer Restoration
- Management practices can help reduce 15% of the annual salt load
- Brine pipeline, biofuels, other projects

Conclusions

- Salinity in soil and irrigation water has a detrimental effect on crops ($370 million/year by some estimates)
- Long term cost of inaction in managing salinity in the California's Central Valley will be high ($1.5 billion)
- Agricultural impacts of salinity the Sacramento-San Joaquin Delta are small compared to other stressors
- Behavioral responses to salinity may help improve understanding of salinity impacts to irrigated agriculture


Thank you!
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http://watershed.ucdavis.edu/Medellin