Modeling Salinity Costs to Agricultural Production

Richard Howitt

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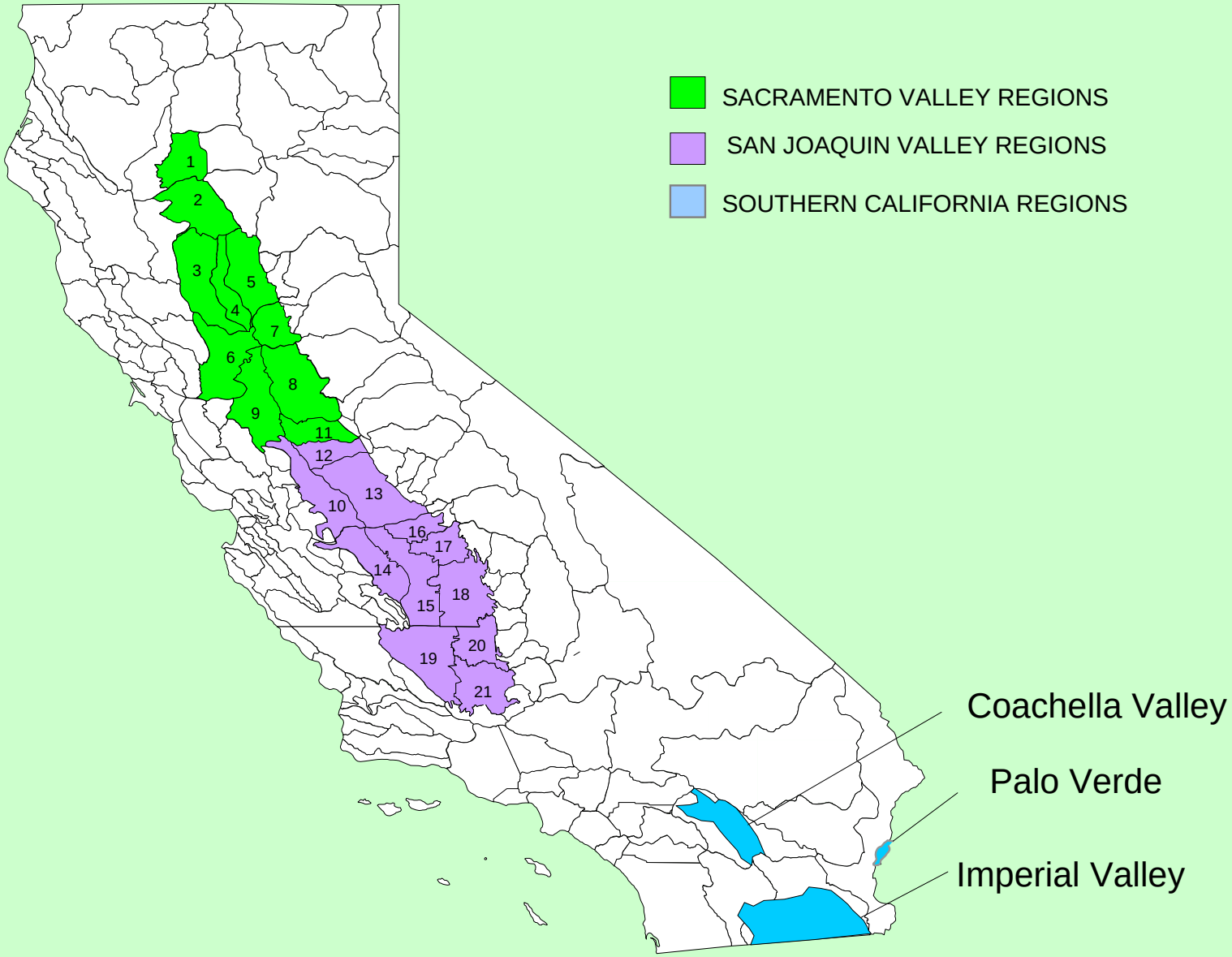
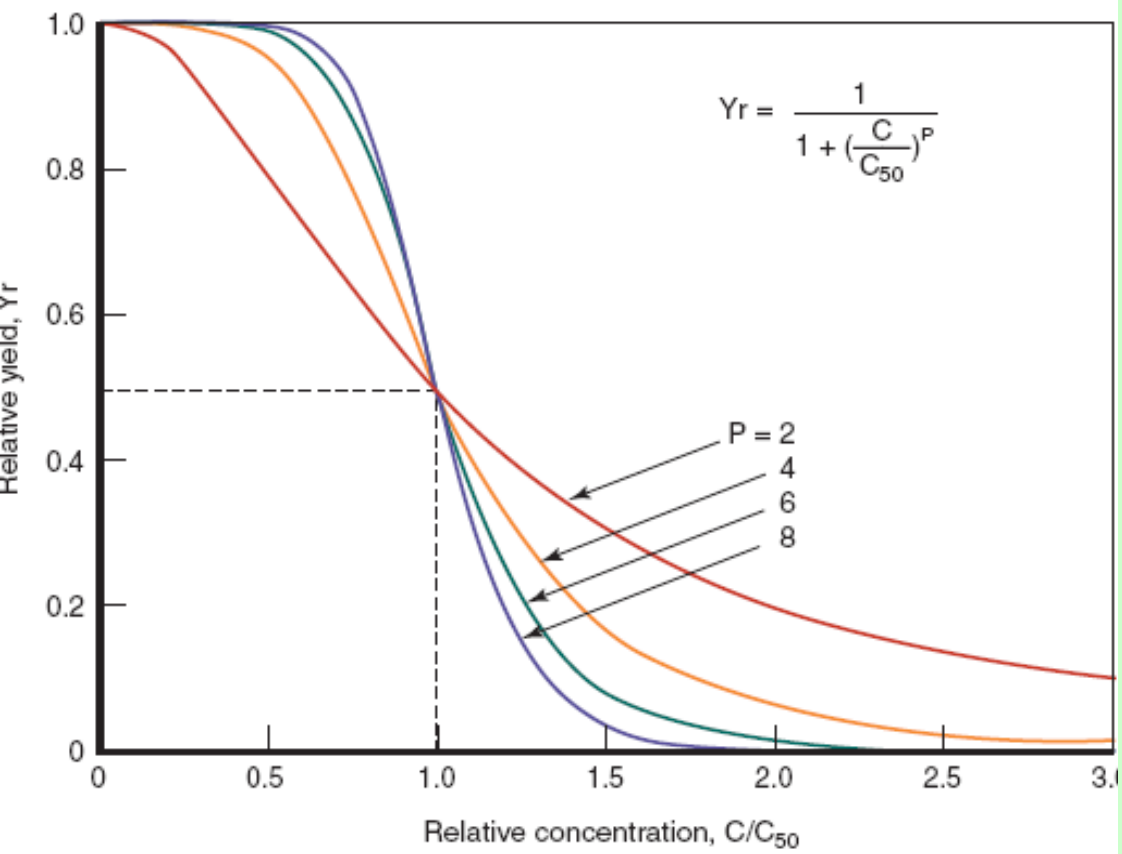
SWAP Model Regions



What can we do with SWAP?

- Evaluate changes at the extensive and intensive margins:
  - **EXTENSIVE**
    - Changes in the total area of irrigated crops
    - Adjustments in the regional cropping mix.
  - **INTENSIVE**
    - A change in crop input use per acre
    - Changes in water application efficiency due to technology and management.

Yield Reduction by Salinity



Crop	C_{50} (mS/cm)
Alfalfa	6.85
Field corn	6.85
Grain	13.04
Orchard	4.13
Pasture	8.85
Rice	18.00
Sugar beet	13.04
Tomato	6.85
Truck crop	6.50
Wine grape	8.85

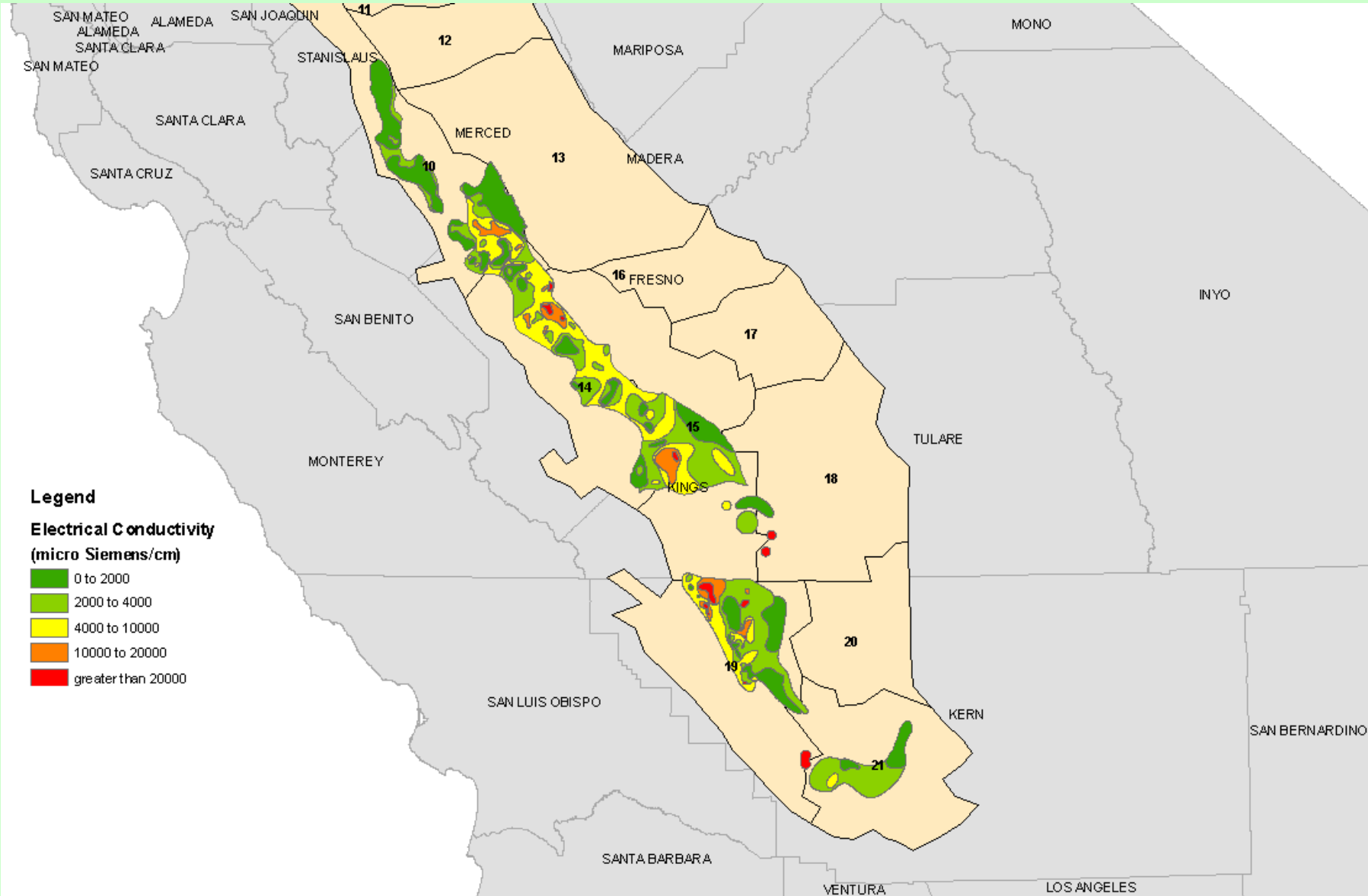
Here we used P=2.5 based on the crop mix empirical average.

Central Valley Salinity Study

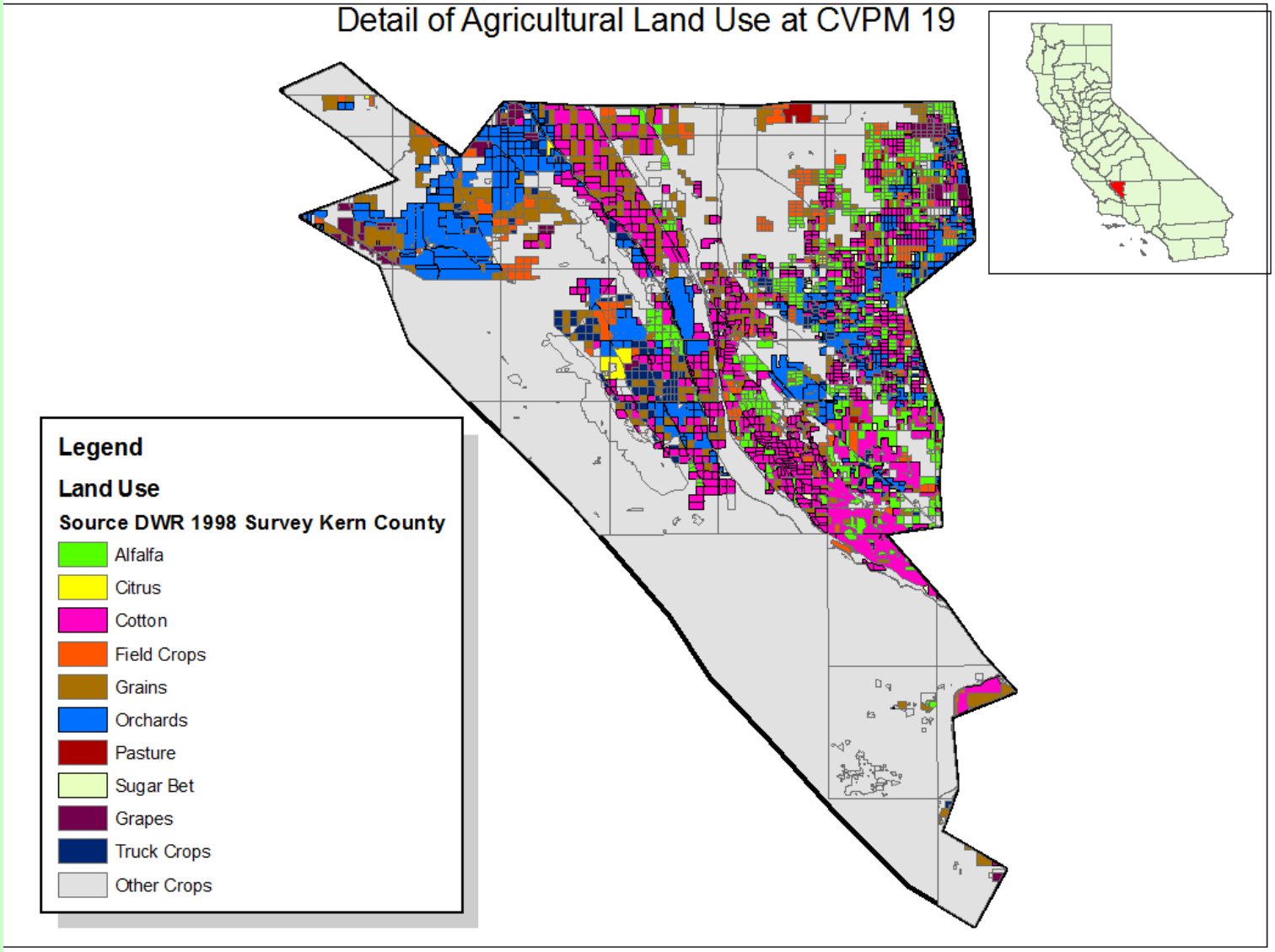
- Estimate the effects of no action
- SWAP is used as an input for another model called REMI, to estimate regional effects
- Two Approachs
  - Analytical optimization model
  - Inductive econometric model
  - Salt accumulation estimations year 2030

Central Valley Salinity

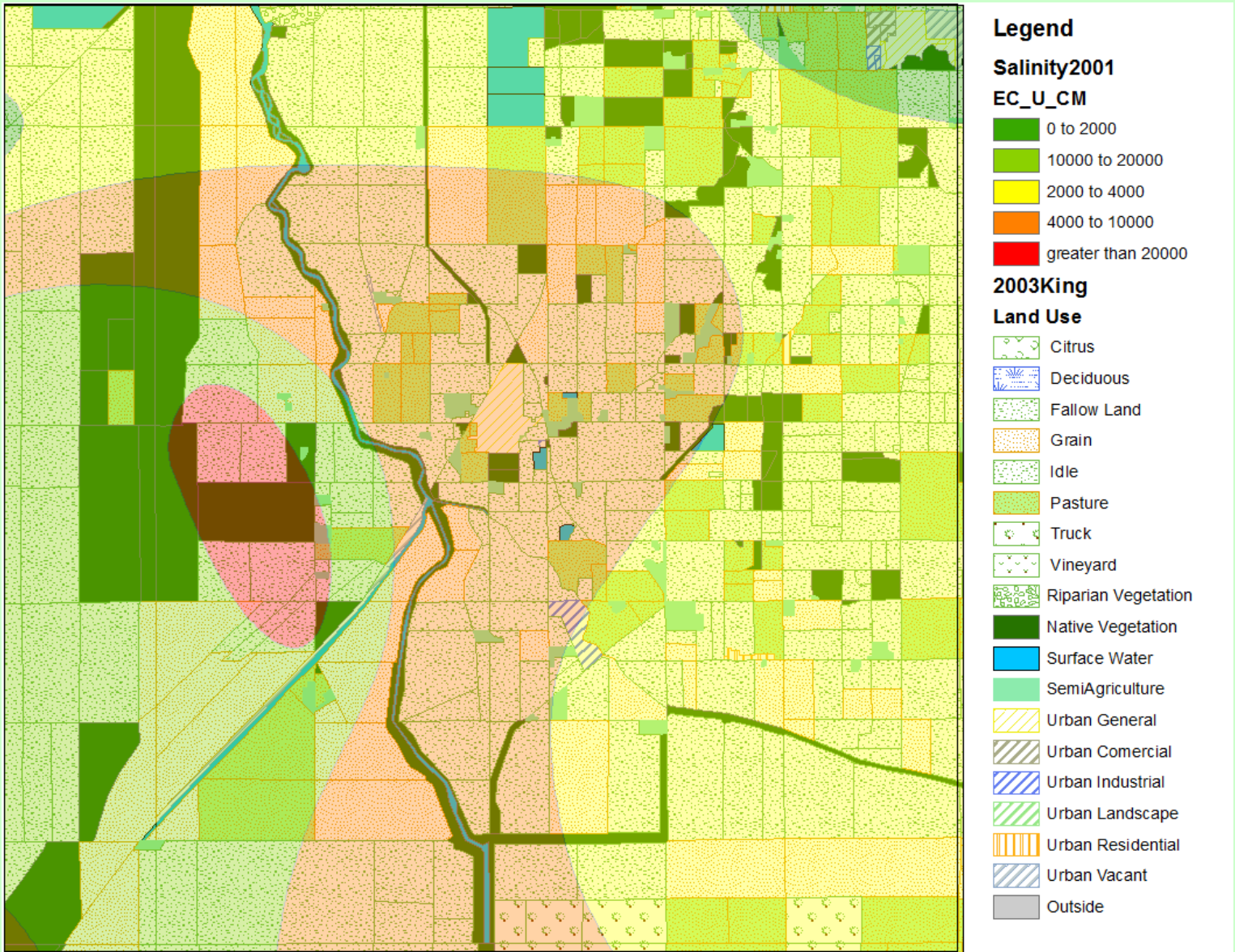
(Bureau of Reclamation)



Disaggregated Farm Level Data

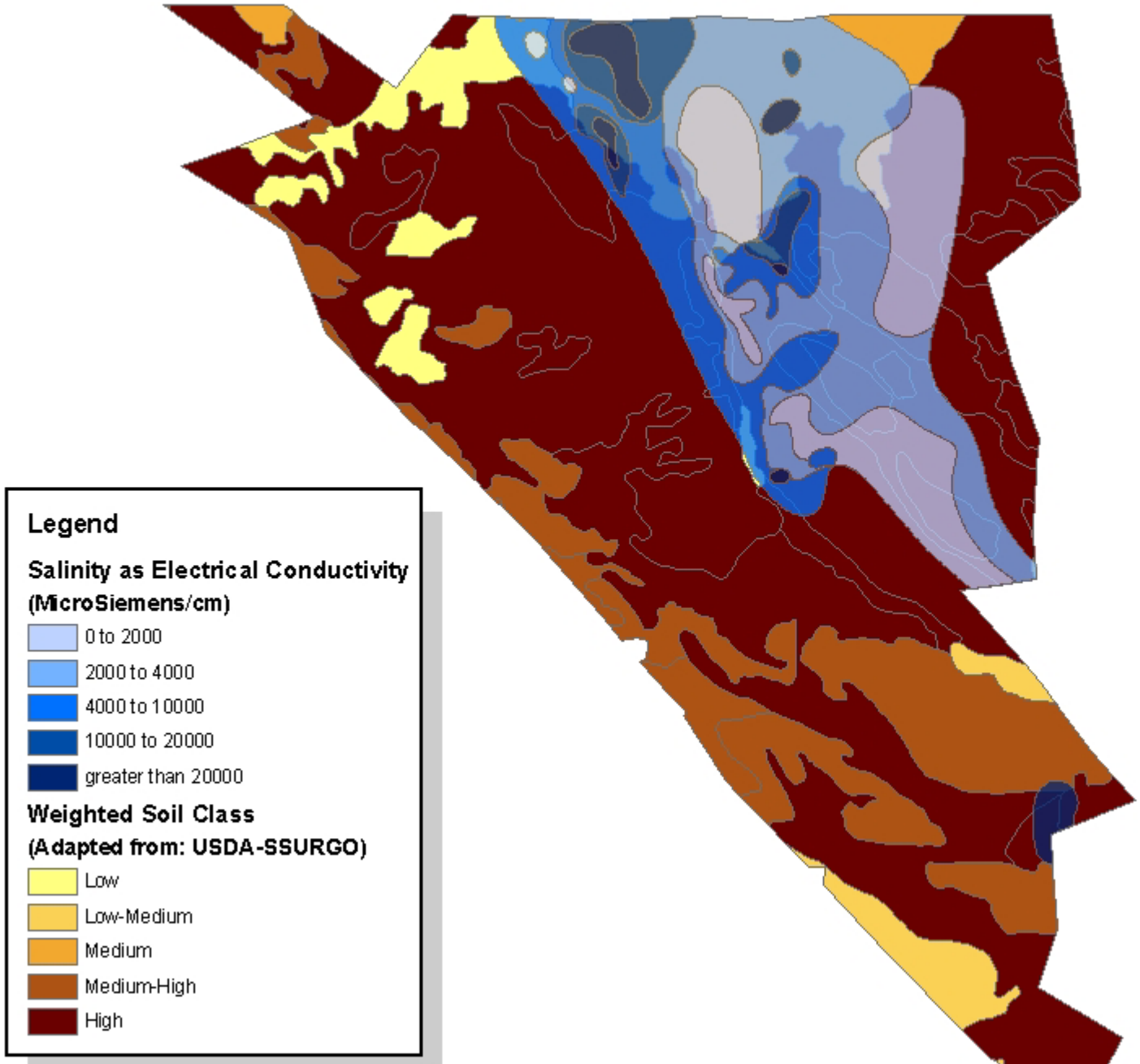


Kings County Salinity-Land Use



Deductive versus Inductive Approach

- Validate/compare effects of salinity on the economics of agricultural production in California's Central Valley
- Same initial conditions.
- Inductive approach, Multinomial logit.
  - Dependent variable, probability of observing a crop
  - Explanatory variables, soil type, salinity, field size.


Legend
Salinity as Electrical Conductivity
(MicroSiemens/cm)
0 to 2000
2000 to 4000
4000 to 10000
10000 to 20000
greater than 20000
Weighted Soil Class
(Adapted from: USDA-SSURGO)
Low
Low-Medium
Medium
Medium-High
High

Multinomial Logit model specification

$$\Pr(Crop = k) = \frac{e^{\mathbf{x}_i^{'}\beta_k}}{\sum_{l=1}^{12} e^{\mathbf{x}_i^{'}\beta_l}}$$

- Citrus and Pasture were both dropped from the Multinomial logit model as they are less than 1% of acres in all but one CVPM
- Zone – Integer 0-4 with increasing salinity
- Soil – Integer 0-5 with decreasing soil quality
- Acres – Continuous measure of parcel area

Marginal Effects of Salinity

Evaluated Separately at Average and by Respective Salinity Zone

Marginal Effects						
Crop	Salt Tolerance dS/m*	CVPM 10	CVPM 14	CVPM 15	CVPM 19	CVPM 21
Table Grapes	1	-0.20%**	-1.06%**	-8.67%**	-0.94%	-13.02%
Orchard	1.4	-12.29%**	-4.69%**	-17.40%**	-5.68%**	-6.22%
Truck	1.5	-2.95%*	-1.56%*	0.22%*	-0.76%*	-11.78%
Tomato	1.7	.	-2.07%*	0.75%*	-0.07%**	.
Grain	4.5	0.60%	1.55%*	3.83%*	2.82%**	6.74%
Field	5	2.21%**	-0.45%**	0.69%	-0.96%*	6.40%
Cotton	5.1	6.30%*	4.57%*	9.30%*	5.80%**	7.80%
Alfalfa	8	5.79%*	2.71%*	4.52%*	-0.40%**	6.87%

•Obtained from http://www.agric.nsw.gov.au/reader/wm-plants-waterquality
•*Denotes significance at 5%
•**Denotes significance at 1%

SWAP and Econometrics Comparison

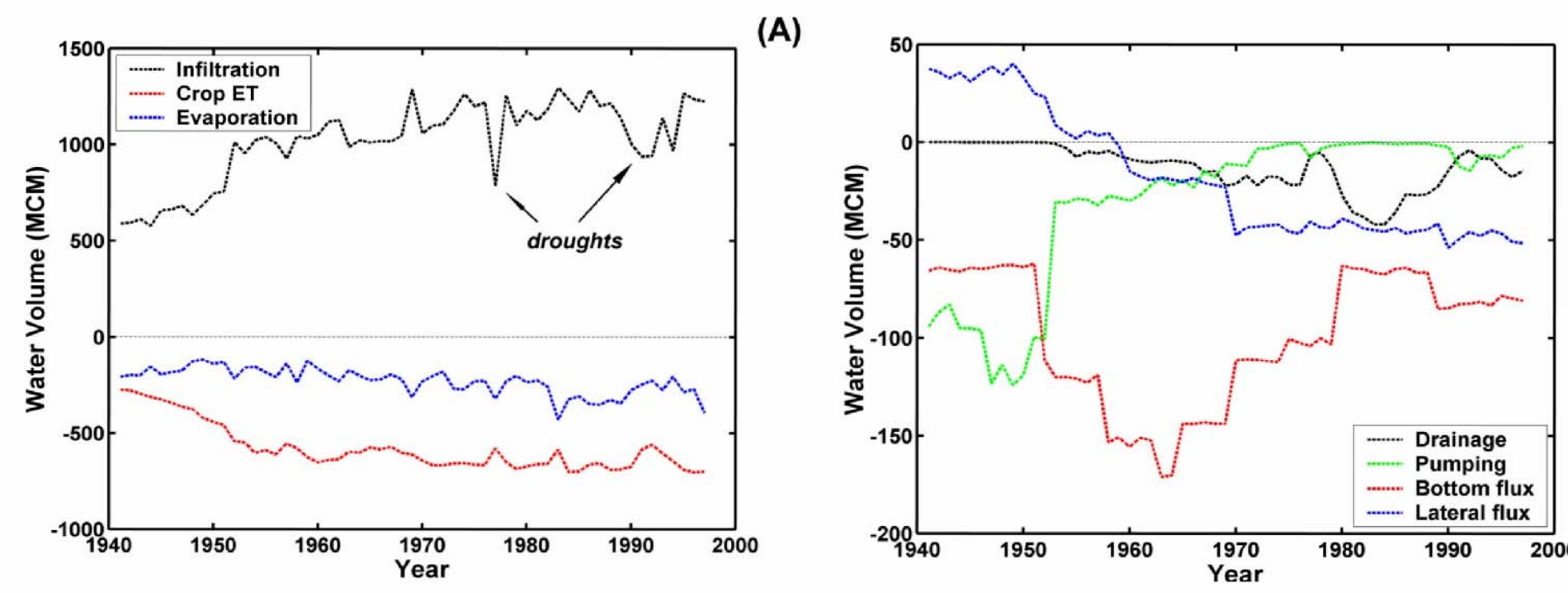
	CVPM 10	CVPM 14	CVPM 15	CVPM 19
	Ratio of Abs. Acre	**Ratio of Abs. Acre**	**Ratio of Abs. Acre**	**Ratio of Abs. Acre**
Crop	SWAP/MNL	SWAP/MNL	SWAP/MNL	SWAP/MNL
Alfalfa	0.59	0.82	0.74	0.43
Citrus	0.97	0.88	0.43	0.17
Cotton	0.61	0.83	0.90	0.90
Field	0.63	0.96	0.92	0.80
Grains	0.52	0.87	0.89	0.73
Orchards	2.23	3.75	2.61	1.22
Pasture	0.82	1.10	1.00	0.37
S. Beet	0.63	0.62	0.66	0.60
Grapes	13.33	7.93	17.48	.
Truck	0.79	1.19	1.15	0.97
Total	**1.97**	**1.38**	**1.08**	**0.80**

Annual Crop Revenue Loss due to Salinity Change 2030 ($1000)

			Regions			
Crop	10	14	15	19	21	Total Revenue
Alfalfa	-979	-3439	-13109	-1229	175	-18582
Citrus	-15	0	-8	-8	-65	-96
Cotton	-25733	-35869	-35782	-1372	-3959	-102714
Field crops	17599	-4727	3671	-2562	-311	13670
Grain	-3061	-15918	4494	-15542	-6896	-36922
Orchard	-1010	-9717	-2481	-1027	-90	-14324
Pasture	-744	55	-406	-314	2	-1407
Sugar Beet	28	-1318	-180	-63	0	-1533
Table	-35	-2408	-1149	-343	-105	-4041
Truck	-618	-17616	-180	-215	-136	-18765
Regional revenue	-14569	-90956	-45128	-22676	-11385	-184714

Hydrology dynamics from 1940-1998

Hopmans, Schoups, & Maurer



Conclusions

- In the future, water quality effects may be a bigger restriction on California crop production than water quantity.
- The costs of salinity on California crops is through yield reduction.
- The effect of salinity & drainage on California crop production can be estimated using spatial econometric methods.
- Water quantity and quality policies are closely linked
- Water prices and restrictions influence drainage quantity.