Water Quality, Quantity and Mediterranean Crop Production

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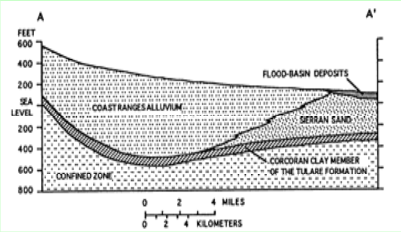
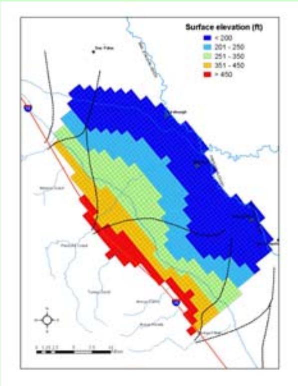
Irrigation Water Quality & Quantity

- Mediterranean crops are usually irrigated
- Mediterranean climate does not naturally flush salts and residuals from the root zone
- Without explicit management salinity and residuals accumulate.
- Salinity problems are evident in Spain, Egypt, and California.
- Water quality problems are often linked with high water use.

Groundwater Flows- Western San Joaquin Valley (Belitz et al., 1993)



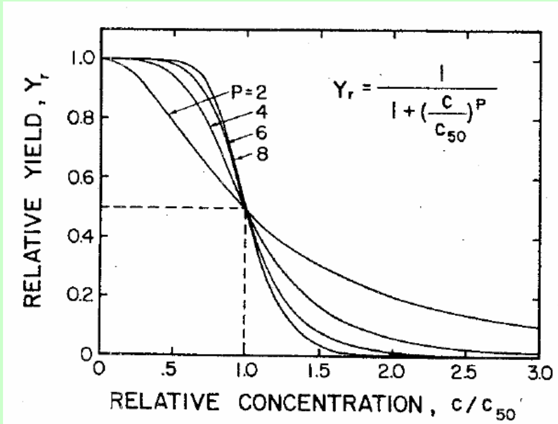


Yield Effects

- Mediterranean crop yields are reduced by saline water conditions.
- High value orchard and vegetable crops have a lower salinity tolerance threshold than field crops.
- Reducing soil profile salinity requires:
  - Additional leaching water and a drainage outlet.
  - Or more efficient water management and technology

Yield Reduction by Salinity

VanGenucten & Maas



$Y = Y_m/[1+(c/c_{50})^P]$

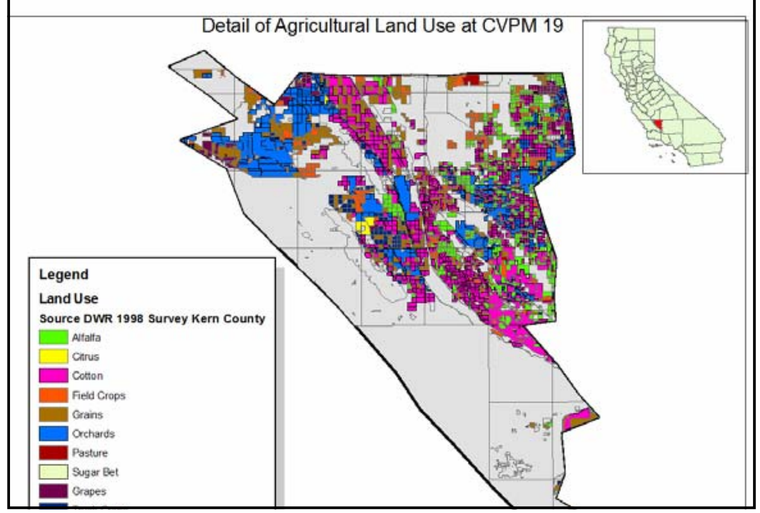
(Salinity indirectly measured as Electrical Conductivity, EC)

Consumption Quality Effects

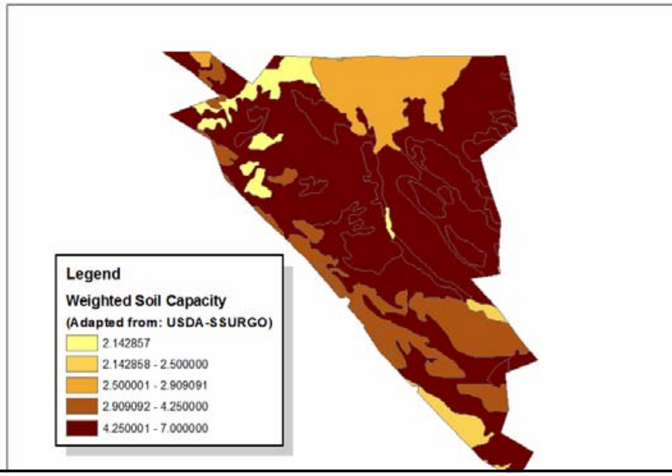
- Mediterranean crops are directly consumed, thus there is a direct linkage between water and crop quality
- Salinity levels are usually indicators of drainage volume.
- Agricultural drainage may contain:
  - Natural contaminants,---- Hg, Se, As
  - Production contaminants– Pesticides, Heavy metals, Nitrogen, etc

A Spatial Cross Section Estimation of Salinity Effects

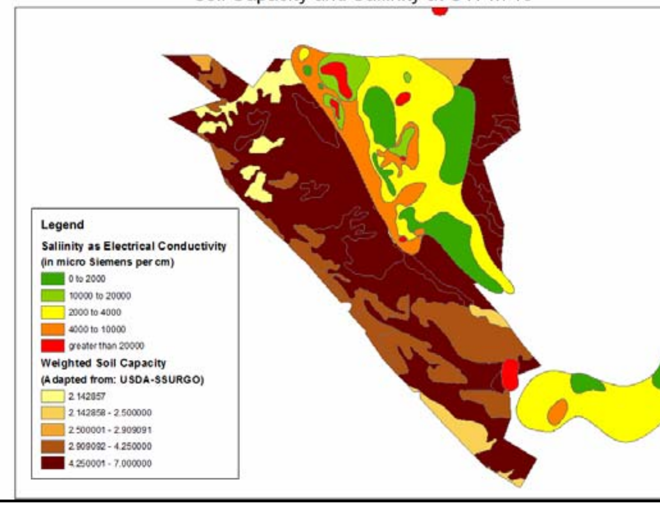
- Three cross section field level GIS overlays of crop, soil class, salinity depth and concentration.
- Region 19 (West Kern Co) Sample 4705 fields, Total acreage 637,188
- Estimate the observed marginal crop adjustment to salinity.
- Fit a multinomial logit model to estimate the probability of observing a given crop on a field
- Calculate the marginal probability as a function of five salinity levels.



Soil Capacity at CVPM 19



Soil Capacity and Sailinity at CVPM 19



Data Summary by Crop Type

Crop	% of Total	Avg Acres	Avg Zone	Avg Soil
Alfalfa	19.51%	82.2	1.03	6.55
Citrus	0.79%	65.92	1.59	6.77
Cotton	31.67%	143.13	1.37	6.37
Corn	4.78%	95.37	0.85	6.06
Grain	14.22%	143.93	1.53	5.67
Orchard	13.71%	246.27	0.58	5.99
Pasture	0.51%	197.03	0.46	6.64
S. Beet	1.55%	56.69	0.73	6.81
Grapes	2.83%	131.59	0.03	5.85
Truck	4.21%	79.42	0.72	6.92
Fallow	5.10%	96.42	1.28	5.95
Tomato	1.13%	78.69	0.94	6.72

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
- Zone – Integer 0-4 with increasing salinity
- Soil – Integer 0-5 with decreasing soil quality
- Acres – Continuous measure of parcel area

Estimation Results

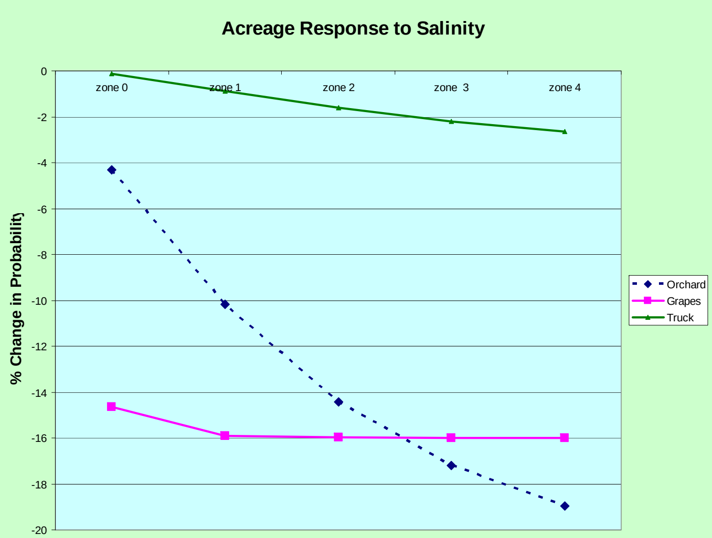
Crop	Approximate Salt Tolerance (ds/m)	Acres	Zone	Soil	Constant	Base Probability
Grapes	1	.0031**	**-2.5914****	-.2126**	-0.2005	0.36%
Orchard	1.4	.0041**	**-.3995****	-.1675**	.5713*	13.53%
Truck	1.5	.00005*	**-.2152****	.3889**	-3.9945**	3.21%
Tomato	1.7	-.0004	**-0.0495**	0.1018	-3.4469**	1.04%
Grain	4.5	.0034**	**.2064****	-.1989**	0.2942	15.16%
S. Beet	4.7	-.0081**	**-.2202***	0.1426	-2.7495**	0.78%
Corn	5	0.0013	**-0.1719****	-.1744**	-0.2608	5.01%
Cotton	5.1	.0036**	**.1851****	-0.0030	-0.0899	35.20%
Alfalfa	8	base	**base**	base	base	19.37%
				-		

Marginal Effects of Salinity

Evaluated Separately at Average and by Respective Salinity Zone

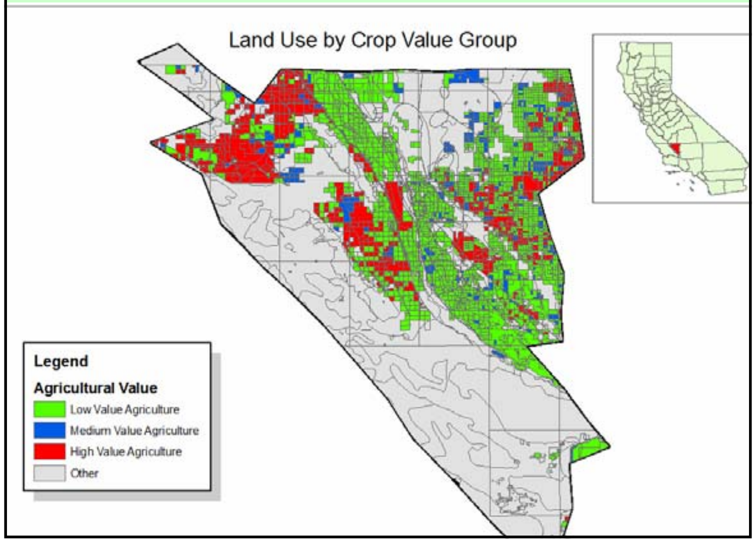
Crop	Average	Zone 0	Zone 1	Zone 2	Zone 3	Zone 4
Grapes	-0.94%**	-14.63%**	-1.26%**	-0.09%	-0.01%	0.00%
Orchard	-5.68%**	-4.33%**	-5.84%**	-4.24%**	-2.79%**	-1.76%**
Truck	-0.76%**	-0.13%	-0.75%**	-0.72%**	-0.59%**	-0.46%**
Tomato	-0.07%	0.14%	-0.06%	-0.11%	-0.12%	-0.12%**
Grain	2.82%**	4.43%**	2.88%**	2.47%**	2.15%**	1.84%**
S. Beet	-0.19%*	-0.04%	-0.19%*	-0.18%**	-0.14%**	-0.11%**
Corn	-0.96%**	0.06%	-0.94%**	-0.98%**	-0.86%**	-0.71%**
Cotton	5.79%**	9.96%**	5.97%**	4.77%**	3.85%**	3.01%**
Alfalfa	-0.40%	3.34%**	-0.24%	-1.22%**	-1.68%**	-1.87%**
Fallow	0.46%*	1.30%	0.50%	0.23%	0.05%	-0.09%

** Denotes Significance at the 1% level
* Denotes Significance at the 5% level
+ Reported as percentage change in probability of observing crop from a one unit (discrete) change in salinity zone



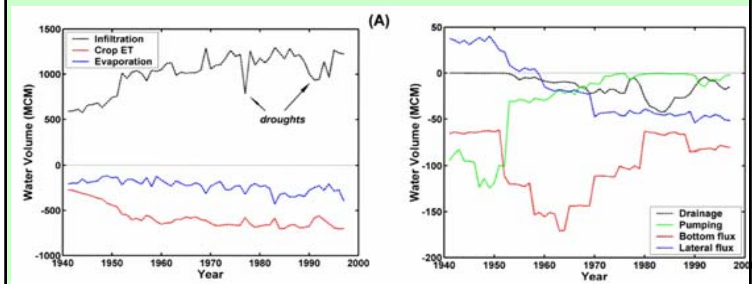
Conclusions from Estimations

- Changes in marginal crop probability mirror theoretical agronomic salinity predictions
- Both intensive and extensive margin effects are reflected in the marginal probabilities
- Grouping fields by farm unit and calculating rotational changes may be preferable
- Spatial specifications seemed driven by salinity and soil type and did not improve the model explanatory power.



Hydrology dynamics from 1940-1998

Hopmans, Schoups, & Maurer



Salinity Control Policies

- Increased water price or supply constraints strongly reduce infiltration. 1991 California drought water prices were \$0.26/ M^3. Current prices are \$0.20/ M^3 or higher.
- Efforts to encourage "best management practices" are generally ineffective.
- Salinity management charges based on technology and applied water can be currently implemented They do not fully internalize management incentives
- Cap and trade the regional salinity assimilation capacity. Theoretically optimal. Currently- estimation of field/farm evapotranspiration (ET) is not reliable enough for use in setting salinity charges.

Conclusions

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