THE ECONOMIC EFFECTS ON AGRICULTURE OF WATER EXPORT SALINITY SOUTH OF THE DELTA

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Outline

- Introduction
- Model and Methods
- Results
- Limitations
- Conclusions
Introduction

- Soil salinization a long standing issue
  - Mesopotamia
  - Nile Delta
  - The Sacramento-San Joaquin Delta
- Delta salinity model (in Lund et al. 2007)
- California problems with salinity and drainage (Howitt et al. 2008)
Model and Methods

- Extension of Howitt et al. 2008 considering...
  - Agricultural yields are reduced, salinity root zone
  - Salinity in shallow groundwater is correlated to that in the root zone
  - Saline soil areas are likely to increase with saline water exports

- Regional income effects
  - Employment
  - Income
  - Total output
Model and Methods

- GIS-based data
  - DWR land use surveys
  - USBR EC in shallow groundwater
- Saline zones distributed within each CVPM
Howitt *et al.* (2008)

- Analyze socioeconomic impact of inaction with respect to salinity problems in the Central Valley by 2030.
  - Crops and animal feeding operations
  - Residential, food processing and industrial uses
  - System-wide effects income, employment and total output
  - Non-market costs and benefits
Howitt et al. (2008)

- Howitt took the Van Genuchten and Hoffman (1984) model on yield reductions due to salinized soils for a crop mix in the Central Valley
- GIS referenced information on salinity
- Land use surveys from DWR and agricultural commissioners reports
- Revenue losses were calculated for year 2030
Van Genuchten and Hoffman (1984), yield reduction and salinity

$$Y_r = \frac{1}{1 + \left(\frac{C}{C_{50}}\right)^P}$$

<table>
<thead>
<tr>
<th>Crop</th>
<th>$C_{50}$ (mS/cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>6.85</td>
</tr>
<tr>
<td>Field corn</td>
<td>6.85</td>
</tr>
<tr>
<td>Grain</td>
<td>13.04</td>
</tr>
<tr>
<td>Orchard</td>
<td>4.13</td>
</tr>
<tr>
<td>Pasture</td>
<td>8.85</td>
</tr>
<tr>
<td>Rice</td>
<td>18.00</td>
</tr>
<tr>
<td>Sugar beet</td>
<td>13.04</td>
</tr>
<tr>
<td>Tomato</td>
<td>6.85</td>
</tr>
<tr>
<td>Truck crop</td>
<td>6.50</td>
</tr>
<tr>
<td>Wine grape</td>
<td>8.85</td>
</tr>
</tbody>
</table>

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

Assumed salinity in shallow groundwater lowers yields half as much as salinity in root zone.
Model and Methods

- More saline areas grow over time

<table>
<thead>
<tr>
<th>Zone</th>
<th>Salinity level (EC in shallow groundwater (µS/cm))</th>
<th>Share of non-saline acres transferred to the saline zone (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0-2000</td>
<td>50</td>
</tr>
<tr>
<td>B</td>
<td>2000-4000</td>
<td>30</td>
</tr>
<tr>
<td>C</td>
<td>4000-10000</td>
<td>10</td>
</tr>
<tr>
<td>D</td>
<td>10000-20000</td>
<td>10</td>
</tr>
<tr>
<td>E</td>
<td>above 20000</td>
<td>0</td>
</tr>
</tbody>
</table>

![Map showing zones and percentages]
Continued salt exports expand saline soil areas

- From Shoups (2004)...

Following historic trends, area of saline groundwater is likely to increase by roughly 13 percent
Annual salt accumulation close to half a million tons

From Shoups et al. (2005)
Orlob (1991) found similar net salt accumulation rates.

**Chart:**
- **Title:** Total net accumulation = 18,621,000 tons
- **Mean rate:** 446,000 tons/year (1950 - 1989)
- **Net accumulation:** 0 (1930 - 1949)
- **Yearly data points:**
  - 1920 - 1930
  - 1930 - 1940
  - 1940 - 1950
  - 1950 - 1960
  - 1960 - 1970
  - 1970 - 1980
  - 1980 - 1990
Model and Methods

- GIS along with cost and price data used to calibrate a profit maximization model
- 2030 land conversion from urban to agriculture, shifts in crop demand and endogenous prices are considered.
Model and Methods

- Each saline area within a CVPM represents a production region.
- Area of production region was changed to mimic assumed soil salinization trends.
- A similar model followed for Confined Animal Operations (CAFO).
- Six levels of increase in saline area were assumed from 3 to 15 percent.
Crops and Confined Animal Operations Results

The graph shows the relationship between percent increase in saline land and crop revenue losses ($ million/year). The revenue losses increase significantly as the percent increase in saline land increases.
Revenue losses with and without export salinity reductions

Water quality improvements from 300 mg/l to 150 mg/l would decrease losses by $241 million per year by 2030
Revenue losses over time with and without export salinity reductions

With water quality improvements from 300 to 200 mg/l, total losses of $392 million could be postponed from 2030 to 2043, thirteen years.
Daily Exports for different PC sizes

<table>
<thead>
<tr>
<th>Peripheral Canal Size (cfs)</th>
<th>Salt Exported (Tons/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-Delta</td>
<td>5400</td>
</tr>
<tr>
<td>2K</td>
<td>4400</td>
</tr>
<tr>
<td>7.5K</td>
<td>3700</td>
</tr>
<tr>
<td>15K</td>
<td>3500</td>
</tr>
</tbody>
</table>
Regional income losses from export salinity

![Graph showing cost reduction vs. peripheral canal capacity](graph.png)
Jobs lost from export salinity

<table>
<thead>
<tr>
<th>Peripheral Canal Capacity (thousands cfs)</th>
<th>Jobs saved (thousands)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>13</td>
</tr>
<tr>
<td>7.5</td>
<td>22</td>
</tr>
<tr>
<td>15</td>
<td>24</td>
</tr>
</tbody>
</table>
Limitations

- More geohydrology studies needed for salt loads and relationship between groundwater and soil salinization
- Departure from historic operation conditions could change levels of salinity, with or without a peripheral canal
- Better water quality may attract higher value crops to increase benefits from a peripheral canal.
Conclusions

- Substantial long term economic costs from Delta salt exports to agriculture in Central Valley
- Revenue losses may range between $341 and $440 million per year for crops and CAFO (2030)
- Even a small (2000 cfs) peripheral facility can reduce exported salts by nearly 20 percent
- The smaller the canal, the larger the share of economic benefits for urban uses