Where Dirt and Policy Meet: The Economics of Soil Carbon

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Objectives

• Introduce the Notion of Carbon Markets
• Identify Key Economic Issues
• Briefly Discuss Tools
• Present Preliminary Results
• Hear from You About Contracts for Soil Carbon Sequestration
Why A Carbon Market?

• **Emissions Reductions**
  – Reduce CO2 and other GHG

• **Efficient Allocation of Emissions**
  – Distribute the emissions efficiently across regions, countries, sectors, industries within sectors, and firms within industries

• **Kyoto Protocol**
  – Took effect on February 16, 2005
What Is Traded?

• Allowance-Based Transactions
  – Trading of government-issued allowances to emit GHG

• Project-Based Transactions
  – Trading emissions credits generated by projects that reduce GHG emissions
Carbon Market Volume

State and Trends of Carbon Market 2005

FIGURE 1: ANNUAL VOLUMES (million tCO₂e) OF PROJECT-BASED EMISSION REDUCTIONS TRADED (up to 2012 vintages)
Who’s Buying?


Jan. 2004 – April 2005
Who Is Selling?


Jan. 2004 – April 2005
FIGURE 6: TOTAL MARKET VALUE (ESTIMATE) PER YEAR in million U.S. dollars (nominal)
Prices Paid for Carbon

FIGURE 5: PRICES FOR NON-RETAIL PROJECT-BASED ERs January 2004 to April 2005 (in U.S.$ per tCO$_2$e)

ER = Emission Reductions (projects); VER = Verified Emissions Reductions; CER = Certified Emissions Reductions; ERU = Emission Reduction Units
Key Economic Issues

• Private Costs and Benefits
  – Level of profitability
  – Cash flow
  – Changes in production costs
  – Change in farmers’ time requirements

• Social Costs and Benefits
  – Types of costs; timing
  – Types of benefits; timing; beneficiaries
One Tool -- LUS Analysis

• Focus on Land Use Systems (LUS)
  - Multi-year duration
  - Different intermediate and end uses

• Estimate Economic Effects
  - Discounted streams of input costs and product revenues
  - Calculate economic returns to key factors of production
    - Land, labor

• Estimate the Environmental Effects

• Estimate the Sociocultural Effects

• Highlight Institutional Impediments to LUS Adoption
The Field 74 Carbon Sequestration Project

• **Focus:** Identify the impacts in a maize-wheat system of reduced till vs. standard till on CO$_2$ and N$_2$O flux, crop yield, water quality and balance, and system profitability
CO₂ and N₂O flux

**CO₂ flux from portable chambers, Jan-Dec 2004**

- Minimum Till
- Standard Till

**N₂O flux from portable chambers, April-Dec 2004**

- Standard Till
- Minimum Till
Yield and Profitability

• Results to date
  – Yields declined sharply in year one
    • RT yield ➞ 3.64 tons/acre
    • ST yield ➞ 5.32 tons/acre
  – Despite reduced operational costs in RT system profits fell sharply
    • RT NPV/acre (7 years) ➞ $1022
    • ST NPV/acre (7 years) ➞ $1597
Costs of Additional Soil Carbon in Field 74

- **Annual Yield Increase** (per Adoption Incentive)
- **Net C Gain** (lbs SOC/yr/ac)
- **Cost of SOC** ($/ton)

Bar chart showing the relationship between annual yield increase and net carbon gain at different cost levels. The chart includes data points for 0%, 3%, 5%, and 8% adoption incentives.
C Sequestration in LTRAS Organic vs. Conventional Maize-Tomato Systems

**Focus:** Identify the effects of organic (vs. conventional) management of a maize-tomato rotation over 9 years on soil organic carbon, crop yields and system profitability.

<table>
<thead>
<tr>
<th>LUS</th>
<th>Even Years</th>
<th>Odd Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional maize-tomato (CMT)</td>
<td>fertilized irrigated corn</td>
<td>fertilized irrigated tomato</td>
</tr>
<tr>
<td>Organic maize-tomato (OMT)</td>
<td>winter legume / irrigated corn compost / no pesticides</td>
<td>winter legume / irrigated tomato compost / no pesticides</td>
</tr>
</tbody>
</table>
## Crop Yields
*(tons/acre)*

<table>
<thead>
<tr>
<th></th>
<th>Year</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>Avg</th>
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</thead>
<tbody>
<tr>
<td><strong>Conventional</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>maize</td>
<td></td>
<td>5.84</td>
<td>4.64</td>
<td>4.64</td>
<td>5.66</td>
<td>5.63</td>
<td>5.28</td>
<td></td>
<td></td>
<td></td>
<td>5.28</td>
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<tr>
<td>tomato</td>
<td></td>
<td>12.97</td>
<td>25.15</td>
<td>10.46</td>
<td>27.54</td>
<td>19.03</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Organic</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>maize</td>
<td></td>
<td>3.98</td>
<td>3.02</td>
<td>3.87</td>
<td>3.29</td>
<td>2.39</td>
<td>3.31</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>tomato</td>
<td></td>
<td>31.16</td>
<td>26.31</td>
<td>30.73</td>
<td>32.40</td>
<td>30.15</td>
<td></td>
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</tbody>
</table>
## Profitability

<table>
<thead>
<tr>
<th>System</th>
<th>Net Present Value ($)</th>
<th>Returns to Land ($/ac/year)</th>
<th>Profitability as % of Conventional System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional</td>
<td>8278</td>
<td>307</td>
<td>--</td>
</tr>
<tr>
<td>Organic, No Premium</td>
<td>1981</td>
<td>73</td>
<td>24%</td>
</tr>
<tr>
<td>Organic, Declining Premium</td>
<td>4315</td>
<td>160</td>
<td>52%</td>
</tr>
<tr>
<td>Organic, Premium</td>
<td>5607</td>
<td>623</td>
<td>203%</td>
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</table>
Soil Carbon Accumulation
(over 9 years)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Soil Carbon Content (tons/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic Maize-Tomato</td>
<td>2.44</td>
</tr>
<tr>
<td>Conventional Maize-Tomato</td>
<td>0.16</td>
</tr>
</tbody>
</table>
Profitability & Increased Soil C

![Graph showing the relationship between soil carbon content (tons C/acre/yr) and returns to land ($/acre/yr). The graph includes data points for various LTRAS yields and organic premiums.](image)

- **LTRAS Yields, Organic, Premium**
- **LTRAS Yields, Conventional**
- **LTRAS Yields, Organic, No Premium**
- **LTRAS Yields, Organic, Declining Premium**
- **Average Local Yields, Organic, Premium**
- **Average Local Yields, Organic, No Premium**
- **Average Local Yields, Organic, Declining Premium**
- **Average Local Yields, Conventional**
Case Study Conclusions (Preliminary)

- Stocks of Soil Carbon Can Be Increased in California, but the Amounts Will Depend on:
  - climatic conditions
  - management strategy
  - product mix
  - soil type

- Changes in Product Mix and Crop Management Strategies Can Increase Soil Carbon
  - Such Changes Can Be Costly to Farmers, and Yields and Profits May Decline

- Soil Carbon-Profitability Trade-Offs
  - Field 74 Study Exhibited Trade-Offs

- Soil Carbon-Profitability Synergies
  - LTRAS Tomato/Maize Study Exhibited Synergies
    - These depended greatly on price the premiums
Policy Implications

- Paying Farmers to Sequester Carbon Could Be Expensive
- Payment schemes would have to address local heterogeneity in soil and climate conditions
- Soil Carbon Pools Have Maxima and Sequestered Carbon Can Be Quickly Lost
  - Payment schemes need to take account of this
- Not All Increases in Soil Carbon Are ‘Sequestered’
  - Out-of-system inputs can matter greatly
  - Perhaps these ‘imports’ should also be paid for under incentive schemes
Implications for Research

• We Need to Know Much More About Carbon Dynamics in California Soils
  – Product mixes
  – Soil management practices
  – Soil types
  – Limits to and stability of carbon pools

• We Need to Know More About the Effects of Different Tillage and Residue Management Strategies on:
  – Yields
  – Production costs
  – Risk
  – Profits
Contracts for Soil Carbon Sequestration

- Standard Contracts
- Modifying Contracts to Meet the Needs of California Farmers
  - Duration
  - Up-Front costs
  - Escrow accounts
  - Monitoring
  - Within-contract changes in
    - Product mix
    - Production technology
• THANKS!

• WHAT ARE YOUR VIEWS?