Data Needs and Empirical Difficulties for Economic Analysis

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Research Questions

• Under which conditions do cover crops provide the greatest benefits?
  – Crop rotations
  – Soil class
  – Tillage
  – Residue removal

• How much corn residue can be sustainably removed with and without cover crops?
What We Don’t Know

• There are many claimed benefits for improved soil health and cover crops:
  – Reduced soil erosion
  – Increased soil organic carbon
  – Reduced nitrate leaching
  – Increased water retention capacity
  – And many others

• We have a pretty good idea of the technical soil impacts for many of these cases.

• We do not know what they are worth.
How Do We Get to Economic Values?

- There are projects in place that are using strip trials to try to estimate physical and economic impacts of different cultivation practices and cover crops.
- We need to continue these and move them closer to estimating economic impacts (e.g., SHP).
- However, we also need to get better economic estimates of the different categories of benefits such as soil erosion.
- We also need data and analysis on farmer fields and measures of economic impacts (e.g., yields and costs) that matter to farmers.
- We can also use models to help estimate economic values.
### Impact Area Economic Values

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Indicator</th>
<th>Site</th>
<th>Value</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>USDA</td>
<td>2014</td>
<td>Soil Erosion</td>
<td>On-Site</td>
<td>10.17</td>
<td>$/ton</td>
</tr>
<tr>
<td>USDA</td>
<td>2014</td>
<td>Soil Erosion</td>
<td>Off-Site</td>
<td>17.99</td>
<td>$/ton</td>
</tr>
<tr>
<td>Hansen &amp; Ribaudo</td>
<td>2008</td>
<td>Soil Erosion</td>
<td>On-Site</td>
<td>1.01</td>
<td>$/ton</td>
</tr>
<tr>
<td>Hansen &amp; Ribaudo</td>
<td>2008</td>
<td>Soil Erosion</td>
<td>Off-Site</td>
<td>2.77</td>
<td>$/ton</td>
</tr>
<tr>
<td>Lal</td>
<td>2014</td>
<td>Soil Organic Carbon</td>
<td>On-Site</td>
<td>0.06</td>
<td>$/lb.</td>
</tr>
<tr>
<td>Christianson et al.</td>
<td>2013</td>
<td>Denitrification</td>
<td>On-Site</td>
<td>0.95</td>
<td>$/lb.</td>
</tr>
<tr>
<td>Methanol Institute</td>
<td>2011</td>
<td>Denitrification</td>
<td>Off-Site</td>
<td>0.6</td>
<td>$/lb.</td>
</tr>
<tr>
<td>US EPA</td>
<td>2008</td>
<td>Denitrification</td>
<td>Off-Site</td>
<td>1.5</td>
<td>$/lb.</td>
</tr>
</tbody>
</table>

Value of soil erosion ranges between $3.78/ton and $28.16/ton just from these sources. Value of denitrification ranges between $0.60/lb. and $1.50/lb.
Landscape Environmental Assessment Framework (LEAF)

- Developed by Muth & Bryden (2011)
  - Revised Universal Soil Loss Equation, Version 2 (RUSLE 2)
  - Wind Erosion Prediction System (WEPS)
  - Soil Condition Index (SCI)
  - DeNitrification – DeComposition (DNDC)

- Simulates environmental outcomes from different management practices
LEAF

• Geographic region for this study: Indiana
• Management practices: two cover crop options, four residue removal rates, two crop rotations, two tillage practices.
• Each permutation of management practices is run on soil types in SSURGO database.
  – Only soil types with greater than 1000 acres were used
Cover Crops Improve Environmental Outcomes

Soil erosion with and without cover crops for corn soybean rotation and reduced till.
Nitrate leaching with and without cover crops for continuous corn rotation and reduced till.
Benefits vary by group

- Reduced till benefits more from cover crops than no till.
- Continuous corn rotations benefit more from cover crops than corn soybean rotations.
- Soils with higher LCC rating benefit the most from cover crops.
- Cover crops are usually needed to maintain positive SOC for medium residue harvest and high residue harvest.
SOC Change for continuous corn no till.
• Considering only the private benefits of reduced soil erosion, reduced nitrate leaching and increased SOC rarely justifies the costs of cover crops. To convince farmers to adopt, we will need better information on economic benefits.

• For high residue harvest, the social benefits of cover crops always exceed the costs.

• Corn silage is a highly erosive crop without cover crops.
Private and social benefits of cover crops.
Continuous corn and no till.
Private and social benefits of cover crop.
Continuous corn and reduced till.

Total Private Benefits ($/acre-year)
Total Social Benefits ($/acre-year)
Cover Crop Price
SOUTHEAST ELKHART COUNTY, CORN SILAGE-SOYBEANS AND NO-TILL SOIL EROSION

No Cover Crop

Positive Average SOC
Positive SCI
Erosion < T-Factor

Winter Rye Cover Crop

Positive Average SOC
Positive SCI
Erosion < T-Factor
Elkhart County, Indiana

- Average Soil Erosion: 36.12 Tons/Acre/year
- Average Change in Soil Organic Carbon: -44.03 Lbs./Acre/Year
- 0% of Acreage has erosion levels less than their T-Factor, the maximum level of sustainable erosion
- 0% of acreage has positive Soil Conditioning Index (SCI), a qualitative predictor of a management practice’s impact on organic matter
Elkhart County, Indiana

- Average Soil Erosion: 1.71 Tons/Acre/year
- Average Change in Soil Organic Carbon: 78.92 Lbs./Acre/Year Increase
- 100% of Acreage has erosion levels less than their T-Factor, the maximum level of sustainable erosion
- 100% of acreage has positive Soil Conditioning Index (SCI), a qualitative predictor of a management practice’s impact on organic matter
Dairy Private and Social Costs

Dairy Feeding Trial Two
Continuous Corn Rotation, Low Residue Harvest, No Cover Crop

- Private Feed Economic
- Social Erosion (Low) Value
- Net Social Impact

Total $/Year

- 300,000
- 250,000
- 200,000
- 150,000
- 100,000
- 50,000
- 0

- 50,000
Conclusions

• Cover crops improve environmental outcomes.
• Reduced till benefits more from cover crops than no till.
• Continuous corn rotations benefit more from cover crops than corn soybean rotations.
• Soils with higher LCC rating benefit the most from cover crops.
• Cover crops are usually needed to maintain positive SOC for medium residue harvest and high residue harvest.
• Considering only the private benefits of reduced soil erosion, reduced nitrate leaching and increased SOC rarely justify the cost of cover crops.
• For high residue harvest, the social benefits of cover crops always exceed the costs.
• Cover crops provide huge environmental benefits for corn silage.
Limitations of Modeling Research

- LEAF
  - Not experimental data.
- Estimates of environmental values
  - Hard to measure.
- Only some of the benefits included in the study.
  - Other benefits excluded.
Getting Farmer Field Data

• Need much larger number of participating farmers to get reliable data sets.
• Need to limit crop rotations to the main rotations used in an area (e.g., C-C or C-S in Indiana).
• Need to focus initially in an area with relatively homogenous soil classes and slopes.
• Need to have enough farmers doing cover crops or whatever is being studied to do valid comparisons.
<table>
<thead>
<tr>
<th>County</th>
<th>Share of cover crops land in the total farm land (%)</th>
<th>Dominant soil region (number)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIAMI</td>
<td>6.56%</td>
<td>7</td>
</tr>
<tr>
<td>WABASH</td>
<td>3.89%</td>
<td>7</td>
</tr>
<tr>
<td>NOBLE</td>
<td>3.87%</td>
<td>7</td>
</tr>
<tr>
<td>CLINTON</td>
<td>3.07%</td>
<td>8</td>
</tr>
<tr>
<td>BENTON</td>
<td>3.00%</td>
<td>8</td>
</tr>
<tr>
<td>WHITLEY</td>
<td>2.97%</td>
<td>7</td>
</tr>
<tr>
<td>DECATUR</td>
<td>2.62%</td>
<td>9</td>
</tr>
<tr>
<td>TIPPECANOE</td>
<td>2.36%</td>
<td>9</td>
</tr>
<tr>
<td>DEKALB</td>
<td>1.47%</td>
<td>7</td>
</tr>
<tr>
<td>HAMILTON</td>
<td>1.41%</td>
<td>8</td>
</tr>
<tr>
<td>TIPTON</td>
<td>1.19%</td>
<td>8</td>
</tr>
<tr>
<td>CARROLL</td>
<td>1.14%</td>
<td>9</td>
</tr>
<tr>
<td>MONTGOMERY</td>
<td>1.13%</td>
<td>9</td>
</tr>
<tr>
<td>JAY</td>
<td>1.09%</td>
<td>7</td>
</tr>
<tr>
<td>WELLS</td>
<td>1.09%</td>
<td>7</td>
</tr>
<tr>
<td>FAYETTE</td>
<td>1.03%</td>
<td>9</td>
</tr>
</tbody>
</table>
Selection of Participants

1. Is your farm located in one of the counties listed below?
   - Miami
   - Wabash
   - Noble
   - Clinton
   - Benton
   - Whitley
   - Decatur
   - Tippecanoe
   - Dekalb
   - Hamilton
   - Tipton
   - Carroll
   - Montgomery
   - Jay
   - Wells
   - Fayette

2. In all or some of your fields, do you have a rotation only consisting of corn and/or soybeans?
3. Do you plant genetically modified corn and/or soybeans?
4. Do you have at least 5 years of historical data at the field level?
Selection of Participants

5. Do you grow cover crops between cash crop seasons?
   - if NO ➤ Non-cover crop farmer selected

6. Have you been growing cover crops on some fields for at least 5 years?
   - if YES ➤ Cover crop farmer selected
   - if NO ➤ Use the non cover crop fields, if any
### Data collection for CC and NCC fields

<table>
<thead>
<tr>
<th>Data</th>
<th>Motivation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of acres for the field</td>
<td>Description purposes</td>
</tr>
<tr>
<td>Slope class of the field</td>
<td>Variable in the regression model</td>
</tr>
<tr>
<td>Corn or soybeans yield (bu./ac)</td>
<td>Dependent variable in the regression model</td>
</tr>
<tr>
<td>Tillage system</td>
<td>Variable in the regression model</td>
</tr>
<tr>
<td>Total amount of N (lbs./ac) only for corn years</td>
<td>Variable in the regression model</td>
</tr>
<tr>
<td>If field poorly drained:</td>
<td>Variable in the regression model</td>
</tr>
<tr>
<td>Drainage system of the field</td>
<td></td>
</tr>
</tbody>
</table>

### Data collection for CC fields

<table>
<thead>
<tr>
<th>Data</th>
<th>Motivation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cover crop and seeding rate (in lbs./ac)</td>
<td>Quantify the establishment cost</td>
</tr>
<tr>
<td>Seeding method</td>
<td>Quantify the establishment cost</td>
</tr>
<tr>
<td>Herbicide product used to terminate the cover crop and application rate</td>
<td>Quantify the termination cost</td>
</tr>
<tr>
<td>If participant received cost share assistance : name of the program</td>
<td>Quantify private benefits of cover crops or social costs of cover crops</td>
</tr>
</tbody>
</table>
# Data collection from the Literature

<table>
<thead>
<tr>
<th>Data</th>
<th>Motivation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average growing season temperature (May-Sept)</td>
<td>Variable for the regression model</td>
</tr>
<tr>
<td>Average growing season precipitation (May-Sept)</td>
<td>Variable for the regression model</td>
</tr>
<tr>
<td>Corn and soybean prices</td>
<td>Quantify private benefits</td>
</tr>
<tr>
<td>Cash crop production costs (seed, fertilizers, herbicides, machinery repairs and others)</td>
<td>Quantify private costs</td>
</tr>
<tr>
<td>Cover crop seed cost</td>
<td>Quantify the establishment cost for cover crops</td>
</tr>
<tr>
<td>Cover crop seeding method cost</td>
<td>Quantify the establishment cost for cover crops</td>
</tr>
<tr>
<td>Herbicide cost for herbicides used in terminating the cover crops and cost of spraying</td>
<td>Quantify the termination cost for cover crops</td>
</tr>
</tbody>
</table>
Methodology Overview

1. Dataset conception for corn and soybeans observations
   - Field number, year dummies, cash crop yield, cover crop regime, soil type, soil slope, tillage regime, average temperature, and average precipitation
   - For corn dataset: nitrogen application

2. Multiple regression analysis: evaluate the difference in yields between CC and NCC fields
   - Estimated 350 fields of data need to be collected for the analysis
   - If 5 fields per farmer, 70 farmers need to be recruited

3. Benefit-Cost analysis: “with” cover crops and “without” cover crops
Summary

- The farmer’s selection process will enable the researchers to have less heterogeneity in soil type, soil slope, and crop rotation.
- The data required by farmers is not complicated and represents the minimum needed to get reliable results.
- **Limitation**: results will only be valid for the particular area where this research is implemented, but it can be replicated elsewhere.
- The process can be repeated by selecting other areas with different soil types, soil slopes, and crop rotations.
Thanks!