Economics of Cover Crops

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Wisconsin Cover Crops Conference
March 14, 2014
Goal Today

- Provide a meta-view of cover crop economics
- Main point: Cover crop economics is very idiosyncratic
  - Depends on the specifics of the farmer, the farm, and the field
  - Cover crop species, crop species, soil, weather, management, pest pressure, …
  - Farmer preferences, attitudes, beliefs, capabilities, values
- Very difficult to generalize about net benefit of cover crops
Benefits of Cover Crops: Environmental

- **Erosion Reduction**
  - Covering the soil reduces soil erosion, enhances soil quality by not having as much loss

- **Reduced Nitrogen Losses**
  - Cover crop scavenges the nitrogen and converts it to plant tissue for later release (mineralization)

- Commercial vegetable growers use cover crops after short season crops for wind erosion control and to scavenge N

- Cover crops after corn silage or winter wheat

- Cover crops in 2013 for prevented plant acres
What’s the Value of a Ton of Soil?

- Lit review, multiple impacts, by county for policy analysis
- Irrigation ditches & canals, Recreational fishing, Freshwater & marine fisheries, Flood damages, Road drainage ditches, Municipal & industrial water use, Municipal water treatment, Steam power plants, Soil productivity, Dust cleaning, Water-based recreation, Navigation, Reservoir services
- Lower bound on value of eroded/saved soil
• Benefit ranges $8.81 to $6.57/ton in WI
• Most values are constant across WI counties
• Soil Productivity is $1.21/ton

• Variation is water-based recreation and reservoirs
• High is Door County
• Low is Iowa County
Soil Erosion

- Most of the costs/benefits are off site: public or others pay the costs/get the benefits
- Farmer’s direct cost is Soil Productivity: $1.21/ton in 1990 dollars, convert to 2014 dollars using CPI:
  \[ $1.21 \times 1.79 = $2.17/A/yr \]
- Wisconsin state average loss is 4.6 tons/A in 2007
  \[ $2.17 \times 4.6 = $9.98/A/yr \]
- Main Point: Soil erosion costs WI farmers on average about $10/A in lost productivity each year

[Provided URL]
http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/nra/nri/?cid=stelprdb1041887
Soil Erosion: Main Point

- Can come up with about $10/A per year as the average value of lost productivity per typical acre
- Reality: this will vary depending on the amount of soil erosion on the specific area, the soil’s specific productivity, crop prices, …
- Soil erosion tends to be episodic: Means most of the time soil erosion is low, with a few high losses a few times
- Cover crops can reduce this loss some, but many times it will be small, but how do they perform under high loss events?
What’s the Value of Scavenged N?

- Cover crops scavenge or fix N for follow crops
- How much? It Depends!
- Wide ranges listed that vary based on the type of soil, weather, cover crop species, management, etc.
- Cereals can immobilize 50 lbs N/A, or “cereal rye often showed negative NFRVs [nitrogen fertilizer replacement value], most likely due to N immobilization resulting from decomposition of the high C:N cover crop residues”
- Legumes can immobilize 100 lbs N/A or “Half the studies on hairy vetch indicated a NFRV >70 lbs N/acre while 80% of the studies found NFRVs >50 lbs N/acre”
Cover Crops and Nitrogen

- Gabriel et al. (2013), 5-year study in Spain, cover crops before corn, estimated probability functions
- Very skewed, with lots of low values, some high values

\[ \chi^2 = 12.0 \]
\[ \chi^2 = 14.4 \]

**Vetch**
- Mean = 82 kg/ha
- Median = 35 kg/ha
- 12 kg/ha

**Barley**
- Mean = 64 kg/ha
- Median = 39 kg/ha
- 22 kg/ha
Cover Crops and Nitrogen

- Just because a cover crop immobilizes N does not mean the follow crop gets it
- Crop residues must be mineralized (decompose) and then taken up by the follow crop
- Depends on how terminate cover crop (herbicide versus tillage), soil temperature and moisture, timing relative to the major uptake period of follow crop, cover crop species, …
- Gabriel et al. (2013): average uptake rate by corn: 90% for barley, 81% for vetch, 65% for rapeseed
- Some cover crops can even consume soil N!
- Ruark and Stute: “Cover Crop Considerations for 2012”

http://ipcm.wisc.edu/blog/2012/08/considerations-for-cover-crops-in-2012/
Cover Crops and Nitrogen

- UW Extension, Ruark and Stute: N credits as vary by cover crop species, size, planting date
- Can credit about 40 lbs N/A, and sometimes a lot more
- What happens if the follow crop does not take up the N?

### Table 9.5. Green manure nitrogen credits.

<table>
<thead>
<tr>
<th>Crop</th>
<th>&lt; 6” growth</th>
<th>&gt; 6” growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alfalfa</td>
<td>40</td>
<td>60–100 (^a)</td>
</tr>
<tr>
<td>Clover, red</td>
<td>40</td>
<td>50–80 (^a)</td>
</tr>
<tr>
<td>Clover, sweet</td>
<td>40</td>
<td>80–120 (^a)</td>
</tr>
<tr>
<td>Vetch</td>
<td>40</td>
<td>40–90 (^a,b)</td>
</tr>
</tbody>
</table>

\(^a\) Use the upper end of the range for spring seeded green manures that are plowed under the following spring. Use the lower end of the range for fall seedings.

\(^b\) If top growth is more than 12 inches before tillage credit 110–160 lb N/A.
What’s the Value of Scavenged or Fixed N?

- Multiply 40 lbs/A by N price
- This year about $0.44/lb, or $17.60/A, but with some upside potential for more N

<table>
<thead>
<tr>
<th>N Price</th>
<th>N Value at 40 lbs/A</th>
<th>N Value at 60 lbs/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>$0.35/lb</td>
<td>$14</td>
<td>$21</td>
</tr>
<tr>
<td>$0.40/lb</td>
<td>$16</td>
<td>$24</td>
</tr>
<tr>
<td>$0.45/lb</td>
<td>$18</td>
<td>$27</td>
</tr>
<tr>
<td>$0.50/lb</td>
<td>$20</td>
<td>$30</td>
</tr>
<tr>
<td>$0.55/lb</td>
<td>$22</td>
<td>$33</td>
</tr>
<tr>
<td>$0.60/lb</td>
<td>$24</td>
<td>$36</td>
</tr>
<tr>
<td>$0.65/lb</td>
<td>$26</td>
<td>$39</td>
</tr>
<tr>
<td>$0.70/lb</td>
<td>$28</td>
<td>$42</td>
</tr>
</tbody>
</table>
Benefits of Cover Crops: Agronomic

• After soil productivity and N, it gets much harder to estimate $ values for the benefits
• Weed Suppression
• Insect/Pathogen Suppression
• Soil “Health”
• Yield Effects
Cover Crops and Weed/Pest Control

- Cover crops can suppress weeds, break up pest cycles, serve as biofumigants, …
- Many of these effects have been documented, showing statistically significant effects
- 1) Statistical significance ≠ management
- 2) Effective pest control with cover crops usually requires careful management and agro-ecological knowledge to be effective:
  - Cover crop × pest × crop × environment × management effects
- Most farmers usually want better and simpler control than cover crops provide
Weed Suppression using Cover Crops

- Cover crops can suppress weeds: Show a statistically significant reduction in weed population density or biomass
- Statistically significant weed suppression ≠ management
- Weed management often needs one or both of the two big hammers farmers have: herbicide and/or tillage
- Effective weed suppression with cover crops usually requires careful management: good establishment, proper timing of establishment and termination
- Roller-crimper and rye cover crop can provide effective weed control in some cases, but perennial weeds harder to suppress, need herbicide
Weed suppression by rolling-crimping rye cover crop

Weed suppression related to density of cover crop

Pigweed growth is suppressed by cover crop residue, the more the better. Green bars represent rye biomass (left axis); orange dots represent pigweed density (right axis). PD1, PD2, and PD3 correspond to cereal rye planting dates 1, 2, and 3 (4 weeks prior, 2 weeks prior, and on the average first frost date). WF is winter fallow; CT is conventional tillage (multiple disking).

Source: http://www.mccc.msu.edu/events/2012/2012Monsanto/16-Soteres.pdf
Cover Crop alone may not provide needed weed control.....

Source: http://www.mccc.msu.edu/events/2012/2012Monsanto/16-Soteres.pdf
Cover Crops and Weeds

- Cover crops can augment herbicides
  - Potentially useful when have herbicide resistant weeds
- Termination important to keep cover crops from becoming weeds
  - Buckwheat, annual rye grass
- Some cover crops are invasive
- Herbicide restrictions if feed some cover corps

Source: [http://www.mccc.msu.edu/events/2012/2012Monsanto/16-Soteres.pdf](http://www.mccc.msu.edu/events/2012/2012Monsanto/16-Soteres.pdf)
Cover Crops and Insects/Pathogens

- Cover crops can provide habitat for beneficial insects and increase insect biodiversity, provide insect suppression
- Break up disease cycles, serve as biofumigants
- Statistically significant suppression ≠ management
- Cover crops can also harbor crop pests and/or pathogens, supporting them at times when they don’t have habitat, then they move to crops
- Effective use of cover crops for pest control requires careful management and agro-ecological knowledge
- Cover crop × pest × crop × environment × management effects
- Pesticides are effective, easier to use, and often cheap
Cover Crops and Pests

- Main Point: Cover crop benefits are a harder sell for pest control (weeds, insects, pathogens)
- Cover crop $\times$ pest $\times$ crop $\times$ environment $\times$ management effects
- Many interactions mean that pest control with cover corps is managerially complex and inconsistent benefits observed
- Sometimes have great pest control using cover crops, but many times just suppression, sometimes even extra losses

![Probability vs Pest Control Benefit](image-url)
Cover Crops and Soil Moisture

- Cover crop × crop × environment × management interactions matter
- Cover crops use soil moisture, which is good in wet years and heavy soils, bad in dry years and lighter soils
- 2012 drought year versus 2013 wet spring: cover crop effects = ???

- June 29, 2012, Columbia County, WI
- Rye cover crop harvested May 10th, corn planted in both areas on same day
- Cover crop used soil moisture in a year that it mattered
- Same effect if had used cover crops for 20 years???
Cover Crops and Soil

• Cover crops can improve soil health, soil structure, soil organic matter, soil water holding capacity, …
• Most of these are slow processes and hard to observe in a short time period: they take a while to be measurable
• Would you notice the productivity impact of soil erosion?
• Improved soil “health” correlates with improved outcomes for agriculture (higher yields, lower costs, etc.)
• Correlation means it’s not a perfect one-to-one link, but inconsistent and sometimes not there
  • Sometimes cover crops can make you worse off
Cover Crops and Soil

- Main Point: improving soil has benefits
- Much of the time they are small, even losses if managed wrong (2012 drought), but sometimes quite large
- The benefits will be slow and hard to see and vary year to year, depending on the weather
- Have to pay costs now for future soil benefits that may or may not be noticeable for several years: A hard sell
Benefits of Cover Crops: Yield

- Yield is the Integrator: Yield takes a lot of these benefits and adds them up for the net impact that matters.
- Because the benefits are many and variable, the yield effects are variable too: have a probability distribution.
- Means sometimes there are benefits, sometimes there are not, which is a definition of Risk.
- Cover crops are not sure bet, but are they a good bet?
- Depends on your willingness and capacity to bear risk.
Fig. 4. Probability distributions of the cover crop effect on maize yield.

Source: Gabriel et al. (2013)
Benefits of Cover Crops: Yield

- Bergtold et al. (2012) survey of 300 Alabama farmers
- 67% had used cover crop in last three years
- 37% of the adopters perceived a yield benefit (63% did not)
- Of those perceiving a benefit, average was 12.8% across crops

Average of the negative benefits was ???

Average over all outcomes = ???

Average of the positive benefits was 12.8%
Cover Crops and Costs

- **Direct Costs**: most are clear and easy for farmers to calculate: seed, establishment, termination or harvest
- **Managerial Costs**: Value of the extra time and effort to manage properly and to acquire the needed knowledge and experience
  - Harder to quantify, varies greatly among farmers
- **Indirect Costs**: when problems arise: deplete soil moisture, slower soil warming, delayed N release, less flexibility, …
  - Hard to quantify individually, appear as Yield Risk: increased probability of lower yields
Economics of Cover Crops

- Net Benefit: Price \times \text{Extra Yield} – \text{Extra Costs}
- Is the yield increase on average enough to justify the cover crop cost? To justify the risk?
- Is the nitrogen cost savings enough to justify the yield risk?
- Depends on your costs and your willingness and capacity to bear risk, how much you discount the future, and the value you get from the non-monetary benefits of cover crops
- What’s the base case for comparison? Extra yield and Extra cost relative to what?
Costs, Benefits, and the Human Condition

- A common issue underlying many human problems
- Pay high costs now and wait a long time before the benefits become apparent and eventually exceed the costs
- Switch costs and benefits labels: Benefits are large now and high costs are not paid until the far off future
- Once add the uncertainty/variability, even more unclear: Good or bad outcomes due to good or bad luck
Summary

- Cover crops are diverse, managerially complicated, with several smaller, difficult to measure and uncertain benefits and costs, so that benefits may or may not justify the costs.
- “Typical” shape of the probability function for the net benefit of cover crops in terms of $/A for the farmer.
- Each situation moves this net benefit curve around: cover crop, crop, soil, weather, management, pest pressure, etc.
- Very hard to generalize about net benefit of cover crops.
Ways to Increase Cover Crop Use

- **Reduce the costs**
  - Cost share for direct inputs/costs
  - Reduce complexity and risk: develop locally relevant and practical practices and clearly and effectively communicate them

- **Increase the benefits**
  - Honest assessment of the benefits and risks to manage farmer expectations and to maintain legitimacy/credibility
  - Establish long-term trials, find long-term users to demonstrate the future benefits and inspire long-term investment

- **Institutional impediments**
  - Crop insurance rules
  - Rental arrangements: Create and distribute example leases that require and reward appropriate cover crop use

- Farmers are preeminently practical – if it works, they will use it
Cover crops are not a sure bet, but are they a good bet? Depends on your risk preferences, your risk bearing capacity, your discount of the future relative to the present, your valuation of the non-monetary benefits of cover crops, ... What one person considers an unacceptable risk or a waste of time another person will take on and passionately pursue. Personal values and specific situation matter when it comes to cover crop adoption and use. UW Hatch Grant: The ABC’s of BMP Adoption: The Role of Attitudes, Beliefs and Characteristics in Cover Crop Adoption.
ABC’s of BMP Adoption

- Traditional economic models tend to focus on farmer and farm Characteristics to understand what drives adoption
  - Age, education, farm size, crops grown, livestock, debt to asset ratio, average yields, off-farm income, ethnicity, …
- Attitudes and Beliefs play an important role in adoption of some practices on farms, it’s not just Dollars and Data
- Can we better understand the adoption process and how to increase adoption if we model the role of attitudes and beliefs
- What can we learn from other behavioral sciences?
Theory of Planned Behavior (Ajzen 1991)

Adapted from: http://people.umass.edu/aizen/tpb.diag.html
Theory of Planned Behavior (Ajzen 1991)

- Beliefs influence Attitudes that influence Intentions and then Behaviors
- **Behavioral beliefs**: Probability assessments about the consequences of specific behaviors
  - **Attitudes toward a behavior**: Measures the degree that performing the behavior is positively or negatively valued
- **Normative beliefs**: Perception about specific behavior as influenced by significant others
  - **Subjective norms**: Perception of pressures about whether or not a behavior should be performed
- **Control beliefs**: Beliefs about what helps and hinders performing a specific behavior
  - **Perceived behavioral control**: Perceived ease or difficulty for person to perform a specific behavior
- Way to think about how people see the world and what they value
Traditional Economic Models: Adoption as Function of Characteristics
Survey in Progress

- Mail survey this winter of smaller organic and conventional vegetable growers, focused on cover crop use
- Ask about their cover cropping practices: species and issues, plus about their cover cropping Attitudes and Beliefs
- Goal: Compare standard economic model versus the Theory of Planned Behavior model of cover crop adoption
- Which a better predictor of behavior
- Gain insights regarding role of attitudes and beliefs in order to increase appropriate cover crop use among farmers
- Expect results by winter 2014/15
Cover Cropping Attitudes and Beliefs

- Cover cropping improves farm profitability
- Cover cropping improves soil health
- Cover cropping improves fertility
- Cover cropping decreases weed/pest problems
- Cover cropping increases biodiversity/habitat
- Cover crop benefits are more long-term & only become apparent over time
- Most of the vegetable farmers I know use cover crops
- I don’t know much about cover cropping
- Using cover crops is complicated
Cover Cropping Attitudes and Beliefs

- My farm’s financial situation limits my use of cover cropping
- I experiment with new varieties and approaches to cover cropping
- I try new cover crops and cover crop practices when I see others use them successfully
- I feel pressured to use cover crops by experts & advocates at various events & meetings
- Farmers and experts that I respect use cover crops and encourage others to do so
- I use cover crops because I am supposed to
- I would use less cover crops if I could
Cover Cropping Attitudes and Beliefs

- Cover crops require special equipment
- Cover crops require extra time to manage
- Useful information about cover crops is difficult to find
- Cover crop seed is expensive
- Cover crop residues are difficult to manage
- Cover crops are difficult to establish
- Cover crops increase pest pressure
- Cover crops become weeds
- Planting cover crops instead of a cash crop decreases income
- Cover crops have a short planting window
Thanks for Your Attention! 
Questions?

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