Energy, Economics, Climate Change and Soil Security

Bruce A. McCarl
Distinguished Professor of Agricultural Economics, Texas A&M University

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Plan of Presentation

An intertwined presentation involving soil implications of

Energy related issues

Climate change energy interactions

With mixed in results from select economic inquiries
BioEnergy policy and technology developments That have potential Effects on Soil

There are soil implications from actions involving

RFS2 and corn domestically and internationally
 intensive - more intensive farming
 extensive - land use change

Cellulosic inputs to energy production
 Switching of conventional crops to energy crops
 Use of marginal lands for energy crops
 Use of residues like corn stover and logging residuals
 Possible use of cover crops

Biochar usage
 a by product from energy production via fast and slow pyrolysis.
Intensification versus Extensification

Land utilization is increasing

Three sources
  Expansion
  Greater ratio of harvested to planted
  More double cropping
Production increases (40%) have come from

- planted corn land (20%)
- yield increases (17%)
- but not total land farmed (0.3%)

Mix of intensification and acreage expansion
Global increase in harvested acres

Avg 2010-12 relative to 2004-06. Source: FAO harvested acreage data.

Source: Land Use Changes at the Intensive and Extensive Margins by Bruce Babcock, Iowa State University
Presented at the 8th annual Berkeley Bioeconomy Conference: The future of biofuels. April 1, 2015
Greater ratio of harvested to planted

Source: Land Use Changes at the Intensive and Extensive Margins by Bruce Babcock, Iowa State University
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More double cropping

Brazil data

Source: Land Use Changes at the Intensive and Extensive Margins by Bruce Babcock, Iowa State University
Presented at the 8th annual Berkeley Bioeconomy Conference: The future of biofuels. April 1, 2015
International land use change
International land use change - Leakage

Change in probability of forest

Change in Carbon

International land use change - Leakage

But this has been way smaller than expected

Source: Changes in the GTAP Modeling Framework and Data Base in its Application to Biofuels and Global Land Use Change by Wallace E. Tyner and Farzad Taheripour, Purdue University, October 2013
So intensification, extensification

More inputs
More land used
More intensive use
Less SOM??
Now some Biochar

Source

## Value Prospect
*(per ton feedstock)*

<table>
<thead>
<tr>
<th>Costs, Benefits</th>
<th>Fast</th>
<th>Slow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of feedstock</td>
<td>-$59</td>
<td>-$59</td>
</tr>
<tr>
<td>Value of energy created</td>
<td>$100</td>
<td>$25</td>
</tr>
<tr>
<td>Value of biochar</td>
<td>$2</td>
<td>$16</td>
</tr>
<tr>
<td>Biochar hauling cost</td>
<td>-$0.4</td>
<td>-$3.1</td>
</tr>
<tr>
<td>Fixed cost of facility</td>
<td>-$34</td>
<td>-$21</td>
</tr>
<tr>
<td>Operating cost of facility</td>
<td>-$56</td>
<td>-$32</td>
</tr>
<tr>
<td>GHG market ($4 CCX)</td>
<td>$3.3</td>
<td>$4.6</td>
</tr>
<tr>
<td>Net value</td>
<td>-$45</td>
<td>-$70</td>
</tr>
</tbody>
</table>
Biochar GHG items

Production
  Less sequestration, more input emissions,
  Less tillage emissions
Other use replacement
  Lost nutrient and water holding
Haul Feedstock and Biochar
  Fossil use
Processing plant
  Fossil use
Apply biochar
  Fossil use, Save inputs
Sequester
  Offset fossil energy
  Replace coal based electricity
## Biochar – Profitability points

<table>
<thead>
<tr>
<th></th>
<th>Base</th>
<th>Fast</th>
<th>Slow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity Price ($/mwh)</td>
<td>$80</td>
<td>&gt;$115</td>
<td>&gt;$304</td>
</tr>
<tr>
<td>GHG Price ($/ton co2eq)</td>
<td>$4</td>
<td>&gt;$58</td>
<td>&gt;$71</td>
</tr>
<tr>
<td>Biochar induced Yield increase.</td>
<td>5%</td>
<td>&gt;193%</td>
<td>&gt;43%</td>
</tr>
<tr>
<td>Biochar price ($ / ton)</td>
<td>$54</td>
<td>&gt;$450</td>
<td>&gt;$246</td>
</tr>
<tr>
<td>% Reduction in Cap and oper cost</td>
<td>0%</td>
<td>&lt;-49%</td>
<td>--</td>
</tr>
<tr>
<td>Feedstock cost ($ / ton maize stover)</td>
<td>$60</td>
<td>$14</td>
<td>($11)</td>
</tr>
</tbody>
</table>
Worry about biochar yield enhancements

A number of reviews have quantified the yield effects of biochar application to soil with partly contradictory findings (Biedermann & Harpole, 2013; Ippolito et al., 2012; Jeffery et al., 2011; Mukherjee & Lal, 2014).

One recent paper I reviewed had authors looking at 298 cases finding 176 positive (yield increase), 114 negative (yield decrease), and 7 results without change, but only 82 (corresponding to 27.5%) of the yield differences were significant.


RFS2 and Cellulosic

Switching of conventional crops to energy crops
Enforcing mandates does this

Use of marginal lands for energy crops

Use of residues like corn stover and logging residues
Corn residues are important and this allows no till but is low density

Possible use of cover crops
Allows more residue recovery

Cover Crop Economics Research and CTIC/SARE Cover Crop Survey Wallace E. Tyner December 16, 2014
Use of marginal lands for energy crops

In modeling We find that using marginal land for producing cellulosic biofuel

- Increases fertilizer use, erosion and runoff (contrary to NAS study)
- Increases GHG net emissions
- Increases profits to agricultural producers
- Takes some pressure off of conventional land use to satisfy the RFS mandate.
- Reduces several agricultural product prices although this is not true for all agricultural products.
- Does not affect prices under a carbon market as that causes use of switchgrass for electricity.

Layla Shiva, Economic Analysis on Voluntary Carbon Offset Market and Bioenergy Policy, Ph.D. Dissertation, Texas A&M University, December, 2014
Climate change /Energy Interaction Effects

Soil implications of

Climate change and adaptation

Land loss

Higher energy prices due to carbon taxes in terms of
tillage intensity (reduction to conserve energy)
Biofuel feedstocks (increase)


Carbon emission constrained firms in markets like the ETF, California CARB or the Renewable Portfolio Standard.

Low role for soils at high emissions prices

Climate change
What is projected? -- a drying region

Precipitation varies with northern gains, subtropic drying

Source IPCC 2013, WGI
Given the emission growth – Action Eras, and Inevitability

Era 1 – In this time period (now until 2040-2050) there is not much contribution from limiting emissions with an inevitable amount of climate change. Needs adaptation plus mitigation

Era 2 – In this time period (2050-2100) mitigation has effects and the climate is warming the question is how much

Effects of climate change are already here
Agriculture is adapting and will continue

Location of median corn and wheat acres in US over time
Corn 147 miles north and west, wheat 173 miles

From USDA Data

# Land Use

- Farm adaptations are mainly irrigation, crop mix, land use and to a lesser extent irrigation methods.
- We have seen crop land to grassland and lowered stocking rates.


### Table 5 Changes of Land Use Allocation and Cattle Stocking Rate

<table>
<thead>
<tr>
<th>Land Use Allocation and Cattle Stocking Rate</th>
<th>2010-2039</th>
<th>2040-2069</th>
<th>2070-2099</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Crop</strong></td>
<td>-0.22</td>
<td>-0.28</td>
<td>-0.33</td>
</tr>
<tr>
<td><strong>Pasture</strong></td>
<td>0.28</td>
<td>0.35</td>
<td>0.41</td>
</tr>
<tr>
<td><strong>Other land use</strong></td>
<td>-0.06</td>
<td>-0.07</td>
<td>-0.08</td>
</tr>
<tr>
<td><strong>Cattle stocking rate</strong> (animal/acre)</td>
<td>-35.48</td>
<td>-41.86</td>
<td>-48.87</td>
</tr>
</tbody>
</table>

Note: For land use allocation, this table shows the changes of predicted probabilities that are calculated from the FMNL model with pooled sample and sub-regional dummies.

For cattle stocking rate, this table shows the predicted changes of cattle stocking rate that are derived from the OLS model with pooled sample.
If small glaciers and polar ice caps on the margins of Greenland and the Antarctic Peninsula melt, the projected rise in sea level will be around 0.5 m.

Melting of the Greenland ice sheet would produce 7.2 m of sea-level rise

Melting of the Antarctic ice sheet would produce 61.1 m of sea level rise.
Technology and demand

People are observing that yield growth is falling off. Corn illustrates 3.7% before 1973, 1.7% since.

Soil need implications of the population and income based energy, and food demand growth coupled with technological progress.
Soil value

I had a PhD student and an MS student study soil value

PhD student looked at value of retaining soils and found little – why? Deep soils and little marginal loss in yield


MS student found value because of ditch clearing, water treatment, dredging etc.


I also think we could do a cross sectional hedonic and look at places where soil loss effects productivity
Challenges to Soil Security

Greater **demands** on land base – population, energy and climate effects-adaptation

Land use drifting toward poles

Marinal and expansion

Need marginal value studies
The future of energy and climate change are uncertain.

We will be squeezed.