The Role of Agriculture and Forestry
In Emerging Carbon Markets

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Global Greenhouse Gas Warming Impact

CO2- Deforestation 18%
CO2- Fossil fuels 59%
CH4 15%
N2O 8%
Cambridge Univ Press; also see: www.ipcc.ch
Natural Soil Biological Processes Exacerbated by Agriculture and Forestry

Carbon dioxide (CO2) emissions by soil microbes during the decomposition of crop residues, wood debris in forests, etc.

Nitrous oxide (N2O) emissions are a by-product of soil microbial processes associated with the nitrogen cycle:
-- Converting ammonia-nitrogen to nitrate-nitrogen
-- Under low oxygen conditions (water-logged soils), converting nitrate nitrogen to atmospheric N2 gas

Methane (CH4) emissions under low-oxygen conditions by methanogenic bacteria as they convert CO2 to CH4
(in wet soils (wetlands, rice paddies), wet manures; digestive tract of ruminant animals)
U.S. farm energy associated with fertilizer manufacture and transport exceeds gas, diesel, electricity use

**Farm Energy Use by Source**

- **Fertilizers**: 29%
- **Pesticides**: 6%
- **Natural gas and Propane**: 8%
- **Electricity**: 21%
- **Gasoline**: 9%
- **Diesel**: 27%

2008 US GHG Inventory Reports, USEPA 430-R-08-005

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**Greenhouse Gases on the Farm**

(Ontario, Canada, Ministry Ag, Food, Rural Affairs (www.gov.on.ca/OMAFRA))

<table>
<thead>
<tr>
<th>Source</th>
<th>Problem</th>
<th>CO2 1:1</th>
<th>N2O 310:1</th>
<th>CH4 21:1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field</td>
<td>Excess N fertilizer, or manure</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Poor timing and/or placement</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>No or delayed incorporation</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Excess tillage</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Animal</td>
<td>Ruminant emissions</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Decomposition of manure on pasture</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Manure</td>
<td>Decomposition during handling</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>Decomposition during storage</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Percent of total farm emissions (avg)</td>
<td>12%</td>
<td>55%</td>
<td>33%</td>
<td></td>
</tr>
</tbody>
</table>
Mitigation on the Farm

- Recycle and reduce use of disposable products
- Reduce fossil fuel use (energy efficiency)
- Renewable energy and biofuel crops
- Manure handling, storage and use
- Improve nitrogen fertilizer use efficiency
- Increase carbon sequestration
Nitrogen (N) Management and Greenhouse Gases

- Synthetic N fertilizers are energy-intensive to produce
- All N fertilizers (including manure and other organic sources) give off nitrous oxide (N₂O), a potent greenhouse gas, as they degrade in soils
- N management is often inefficient

Legume N instead of fertilizer N
A broader view of 'renewable energy'…
Re-coupling animal and crop production systems to re-cycle nitrogen, carbon, other nutrients

New approaches to N management: Linking models with weather forecasts

Cornell’s “Adapt-N” web-based nitrogen management system (http://adapt-n.eas.cornell.edu)
Excess Nitrogen in the Environment: homeowners are a big contributor

There are over 3 million acres of lawn in New York state alone!

Mitigation
(Becoming Part of the Solution)

- Recycle and reduce use of disposable products
- Reduce fossil fuel use
- Renewable energy and biofuel crops
- Improve nitrogen fertilizer use efficiency
- Increase carbon sequestration
  = building soil organic matter, which is good for soil “health” and sustainable productivity
Tillage, Soil Health, and Carbon

http://soilhealth.cals.cornell.edu

Assessing the whole soil system

- Increased tillage
- Compaction
- Poor drainage
- Reduced soil aggregation
- Declining OM (less “food” for soil)
- CO2
- Unhealthy microbial communities

The downward spiral of poor soil health

Linkages: Soil Health and GHG Mitigation

- Sustaining healthy productive soils reduces need for land clearing, deforestation, and related CO2 emissions.
- Healthy soils with good drainage are less likely to become anaerobic and thus have reduced N2O emissions (from denitrification), and reduced CH4 emissions.
- Maintaining year-round vegetation cover (winter cover cropping) increases CO2 uptake and incorporation into the soil; adding OM (composts, biochar) increases soil C stocks
- Maximizing reliance on N fixation (e.g., legume cover crops) and N mineralization for crop N needs improves NUE and reduces N2O emissions
- Using organic N sources (e.g., legume cover crops, animal manures, composts) reduces reliance on synthetic N fertilizers which are energy intensive to manufacture, transport, and apply
- Healthy soils require fewer chemical inputs, reducing carbon emissions associated with manufacture, transport, and application
- Reduced tillage frequency reduces fossil fuel emissions
- Reduced tillage increases C sequestration in upper soil profile, but impacts on lower soil profile and overall area-based C sequestration depend on soil type, cropping system, and type of tillage system used for comparison
Renewable Energy on the Farm

Source: V. Grubinger, Univ VT
www.climateandfarming.org

GH heated with waste vegetable oil
Cow Power

Manure Digester

- switchgrass
- Corn pellets
- willow
- abandoned field: goldenrod and weeds
  Low Intensity/High Diversity (LIHD)
Forestry Practices

- Protect existing tree stocks of carbon
- Afforestation projects
- Use harvest and thinning practices to optimize tree stand health, longevity, diversity, and minimize soil erosion
- Increase plantings of tree species used for furniture, housing, other long-term uses

What is the Potential for Carbon Sequestration by Agriculture and Forestry (Global)?

The soil C sink alone: Increasing soil organic C by 10% in top 1 m by 2100: 240 Pg (1 x 10^{15}) C by 2100, equivalent to reducing atm CO2 by 112 ppm.

—Rattan Lal, Ohio State Univ

McKinsey\&Co, 2009
Pathways to a Low Carbon Economy
Many ag mitigation options have low or negative cost (co-benefits)

Global GHG abatement cost curve beyond business-as-usual – 2030

Note: The curve presents an estimate of the maximum potential of all technical GHG abatement measures below 400 per tCO₂ if each year was doubled annually to 2030. It is not a forecast of what different abatement measures and technologies will be.

Source: Global GHG Abatement Cost Curve v2.0

Issues/Barriers to Agricultural Carbon Trading

- Soil C involves complex, dynamic physical, biological, and ecological processes
- Increasing C through soils and trees is a long-term enterprise
- Challenges and expense for monitoring
- “Permanence” issues: How long will the C be stored and how can this be guaranteed?
- “Leakage” issues: Carbon emissions shift to other regions as one region adopts conservation measures
- “Additionality” issues: those already practicing low-carbon management cannot receive credit
- “Equity” issues: Inequality in capacity to build soil C among soil types and cropping systems; if offset payments based on acreage, small land owners will benefit less
- Current market C prices are too low to act as an incentive
Reducing the Transaction Costs: Landscape-Level Carbon Accounting

- Detailed GIS-based soil maps
- Detailed GIS-based land use, vegetation type and cover, land management and cropping system mapping
- Climate data (temp, rainfall)
- Strategic soil carbon sampling and monitoring, other approaches such as remote sensing of land use change
- Use of simulation models of soil carbon dynamics (e.g., Century, EPIC)
- Create incentives for best management practices