Economics of Climate Change Mitigation in Forestry, Agriculture, and Land Use Change: a National Assessment for the USA

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US Forestry and Agriculture National GHG Balance

Forestry and Agriculture Net Contribution to GHG Emissions in the United States, 2003

- Total agriculture and forestry sequestration also includes urban trees and landfilled yard trimmings and food scraps. Negative values represent a sink, positive values a source.


Ag emissions ~6% of total

Sector is a net sink, nationally (offsets ~12% of emissions)
## Mitigation Options in Forestry and Agriculture: Sequestration, Emissions Reduction and Biofuels

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Mitigation Activities</th>
<th>Target GHG</th>
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</thead>
<tbody>
<tr>
<td>Afforestation</td>
<td>Convert agricultural lands to forest</td>
<td>CO₂</td>
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<tr>
<td>Forest management</td>
<td>Lengthen timber harvest rotation</td>
<td>CO₂</td>
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<tr>
<td></td>
<td>Increase forest management intensity</td>
<td></td>
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<td></td>
<td>Forest preservation</td>
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<td></td>
<td>Avoid deforestation</td>
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<tr>
<td>Agricultural soil carbon sequestration</td>
<td>Crop tillage change</td>
<td>CO₂</td>
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<td></td>
<td>Crop mix change</td>
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<td>Crop fertilization change</td>
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<td></td>
<td>Grassland conversion</td>
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<td>Fossil fuel mitigation from crop production</td>
<td>Crop tillage change</td>
<td>CO₂</td>
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<td></td>
<td>Crop mix change</td>
<td></td>
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<td></td>
<td>Crop input change</td>
<td></td>
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<tr>
<td></td>
<td>Irrigated/dry land mix change</td>
<td></td>
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<tr>
<td>Agricultural CH4 and N2O mitigation</td>
<td>Crop tillage change</td>
<td>CH₄, N₂O</td>
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<td></td>
<td>Crop mix change</td>
<td></td>
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<td></td>
<td>Crop input change</td>
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<td></td>
<td>Irrigated/dry land mix change</td>
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<td></td>
<td>Enteric fermentation control</td>
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<td></td>
<td>Livestock herd size change</td>
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<td></td>
<td>Livestock system change</td>
<td></td>
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<td></td>
<td>Manure management</td>
<td></td>
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<td></td>
<td>Rice acreage change</td>
<td></td>
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<tr>
<td>Biofuel offsets</td>
<td>Produce crops for biofuel use</td>
<td>CO₂</td>
</tr>
</tbody>
</table>
Central Questions

- What is the total GHG mitigation potential in the US from the full suite of forestry and agricultural activities over time and at different costs?

- How does the portfolio of forestry and agricultural activities change over time and at different levels of GHG reduction incentives (or “GHG prices”)?

- What is the regional distribution of GHG mitigation opportunities within the United States?

- What are the implications of carbon saturation and reversibility (or duration)?

- What are some of the non-GHG environmental co-effects of GHG mitigation activities?
Simulating Effects of a GHG Price for Forest and Agricultural Practices

Prices Paid for GHG Mitigation ($1-50 per t CO₂)

FASOMGHG Economic Model of US Forest and Agriculture Sector

GHG Mitigation by
- Sector
- Activity
- Region
- Time Period

Non-GHG Co-effects
- Erosion
- Nutrients
- Pesticides
FASOMGHG Regions

- Northeast
- Southeast
- Lake States
- Corn Belt
- Northern Plains
  (agriculture only)
- Pacific Northwest
  - West Side
- Pacific Northwest
  - East Side
- Rocky Mountain
- Southern Plains
  (agriculture only)
- South-Central
- Northern Plains
  (agriculture only)
# National GHG Mitigation Totals by Key Activity:
Annualized Averages, 2010–2110

<table>
<thead>
<tr>
<th>Activity</th>
<th>GHG Price ($/ ton CO₂)</th>
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<tbody>
<tr>
<td></td>
<td>$1</td>
</tr>
<tr>
<td>Afforestation</td>
<td>0.0</td>
</tr>
<tr>
<td>Forest management</td>
<td>24.8</td>
</tr>
<tr>
<td>Agricultural soil carbon sequestration</td>
<td>62.0</td>
</tr>
<tr>
<td>Fossil fuel mitigation from crop production</td>
<td>20.5</td>
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<tr>
<td>Agricultural CH₄ and N₂O mitigation</td>
<td>9.4</td>
</tr>
<tr>
<td>Biofuel offsets</td>
<td>0.0</td>
</tr>
<tr>
<td>All Activities</td>
<td>116.8</td>
</tr>
</tbody>
</table>
Cumulative mitigation peaks, reverses (sequestration dynamics)

Cumulative GHG Mitigation over Time
Quantities are Tg CO$_2$ Eq. cumulative net emissions reduction below baseline.

C reversal through harvesting and land use reversion
Potential is not uniform across regions

Total Forest and Agriculture GHG Mitigation by Region
Quantities are Tg CO2 Eq. per year net emissions reduction below baseline, annualized over the time period 2010–2110.

Opportunities primarily in the eastern US
Opportunity Matrix

<table>
<thead>
<tr>
<th></th>
<th>Low price</th>
<th>High Price</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Short-run</strong></td>
<td>Agricultural Soil C Sequestration</td>
<td>Afforestation</td>
</tr>
<tr>
<td></td>
<td>Forest management</td>
<td></td>
</tr>
<tr>
<td><strong>Long-run</strong></td>
<td>Forest management</td>
<td>Afforestation Biofuels</td>
</tr>
</tbody>
</table>

*Issue: Forest management can be difficult to measure, monitor, and compare to baseline*
Environmental Co-effects of Mitigation Strategies

- Forest Structure/Habitat
- Water quality
- Water quantity
GHG mitigation can reduced agricultural runoff into waterways

Pollutant Loading Effects Over Time of a $15/t CO_2 Eq. GHG Price

Note: All values indexed to a baseline value of 100.
Changes in Water Quality Index (WQI):
$50/\text{Tonne C} \ (\sim$15/tonne CO$_2$)

- Linked national FASOMGHG model with RTI national water quality model (NWPCAM) to simulate water quality effects of GHG mitigation in Ag/land use
  - Found overall improvements in water quality nationally and in most regions
  - Pattanayak et al, 2005 Climatic Change
Do Recent Findings Undermine the Value of Forest Carbon Sequestration?

**Water stresses from plantations**

**Methane emissions from plants/trees**

Conclusion: Both studies, while important, do not substantially undermine sequestration as a mitigation strategy.

Summary

- **Forests and agriculture** have tremendous biophysical potential to offset GHG emissions.
- **Cost per ton is less than many alternatives** for emission reduction.
- The mitigation portfolio changes with the GHG price:
  - Lower Prices: Ag and Forest C management
  - Higher Prices: Afforestation and Biofuels
- Most **mitigation opportunities concentrated** in the South and Midwest.
- **Policy design** matters:
  - Per ton vs per acre
  - Targeted programs can cause leakage which undermines net benefits.
- Opportunity for **water quality co-benefits**:
  - But other mitigation options in the energy sector have co-benefits too.
- Recent scientific findings about some (-) plantation co-effects do not substantially undermine value of forest C sinks as a mitigation strategy.
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