# Carbon Sequestration in Forests: An investigation of Economic Potential and Market Design Challenges

Presented by: Francisco de la Chesnaye, USEPA
On behalf of:
Bruce A. McCarl, Texas A&M University
Heng-Chi Lee, University of Western Ontario

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# Outline of Presentation

- Project Goals
- Modeling Approach
- Thoughts on role of Land based Agricultural & Forestry activities in GHG mitigation
- Research Results
- Carbon Cost
- Future Directions and Challenges

For additional information see http://agecon.tamu.edu/faculty/mccarl/

# Project Goals

- Examine the portfolio of Agricultural & Forestry GHG mitigation strategies and identify ones for further scrutiny
- Look at market and time conditions under which strategies dominate
- Bring in a full cost and GHG accounting
- Look at market effects and co benefits/ costs

# Relevance of Ag & Forestry GHG Mitigation

- **Society is searching for low cost options.**
- **The first place they will look is in the energy sector where 80% of the emissions come from.**
- **They will only come to ag and forest if it is cheaper or otherwise attractive.**
- **Key Ag & Forestry roles in GHG emission reductions**
  - Emission reducers
  - GHG sinks
  - Substitute less emission intensive products
  - Passive sector subjected to higher input prices

# Modeling approach - FASOMGHG

**Forest & Ag Sector Optimization Model + GHG**

- Forest and agriculture sectors
- Sector linkage and land transfers
- GHG accounting
  - Forest carbon
  - Soil carbon
  - N2O
  - CH4
  - Fuel use carbon emissions
- 100 year time horizon in decade time steps
- 11 US regions

# Modeling approach - FASOMGHG

- Merger of:
  - log-level forest sector model (substantial detail on the forest inventory) and
  - multi-commodity agriculture sector model (substantial detail on cropping and livestock production options)
  - with interaction at the land base level
- Optimizing intertemporal, quasi-spatial market model
- Simulates resource management decisions, commodity production-consumption, trade and prices

# Modeling approach - FASOMGHG

| Strategy | Basic Nature | CO2 | CH4 | N2O |
|---|---|---|---|---|
| Afforestation | Sequestration | X | | |
| Existing timberland/reforestation | Sequestration | X | | |
| Deforestation | Emission | X | | |
| Biofuel Production | Offset | X | X | X |
| Crop Mix Alteration | Emiss, Seq | X | | X |
| Crop Fertilization Alteration | Emiss, Seq | X | | X |
| Crop Input Alteration | Emission | X | | X |
| Crop Tillage Alteration | Emission | X | | X |
| Grassland Conversion | Sequestration | X | | |
| Irrigated /Dry land Mix | Emission | X | | X |
| Enteric fermentation | Emission | | X | |
| Livestock Herd Size | Emission | | X | X |
| Livestock System Change | Emission | | X | X |
| Manure Management | Emission | | X | X |
| Rice Acreage | Emission | X | X | X |

# Modeling approach - FASOMGHG

- Considers saturation characteristics of both soils and forests (uses 30 years for ag soils, US Forest Service for forest soils and growth/yield characteristics of forests from forest service)
- Land exchanges in response to GHG prices, plus all the agricultural activities by decade
- Product of dissertation by Heng-Chi Lee

# Major findings

- Portfolio
- Dynamic role of strategies
- Potential measures
- Mitigation and Markets
- Dynamics and co benefits
- Policy Rules and Results

# Major findings – Portfolio Results

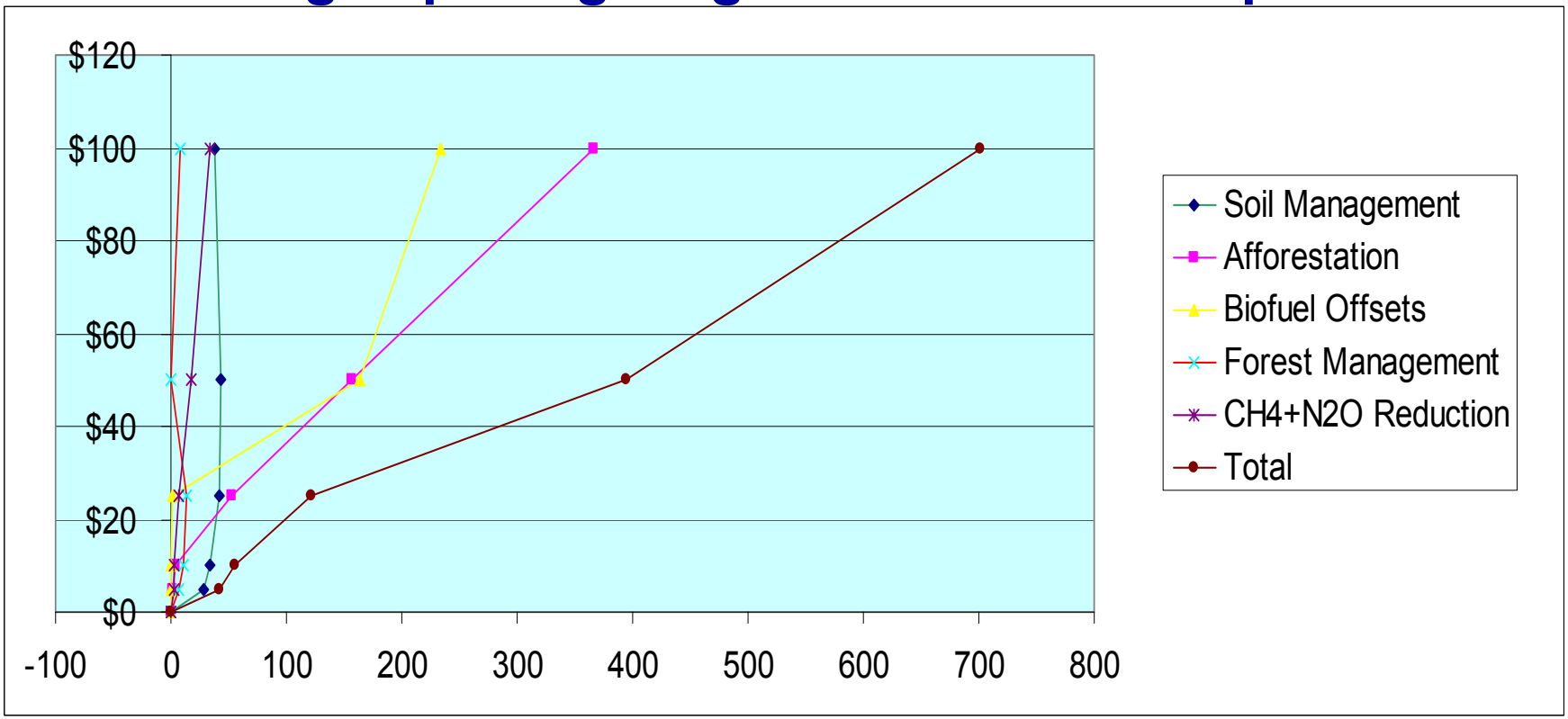
## Millions of metric tons CE by source at alternative prices

| | GHG Price ($/ton C) | | | | | |
|---|---|---|---|---|---|---|
| Activity | $5 | $10 | $25 | $50 | $100 | $200 |
| Soil Management | 28.7 | 33.7 | 41.5 | 43.0 | 37.8 | 27.0 |
| Afforestation | 1.0 | 3.8 | 53.0 | 156.3 | 366.2 | 358.2 |
| Forest Management | 7.0 | 11.2 | 12.9 | -0.6 | 7.8 | 62.0 |
| Biofuel Offsets | 0.0 | 0.0 | 1.5 | 162.9 | 233.7 | 375.1 |
| CH4+N2O Reduction | 2.1 | 2.9 | 6.1 | 17.1 | 34.4 | 43.0 |
| Other Activities | 1.7 | 2.1 | 3.9 | 13.8 | 18.6 | 22.4 |
| Total | 42.4 | 55.5 | 121.7 | 394.9 | 700.8 | 890.7 |

Sectors can make a difference

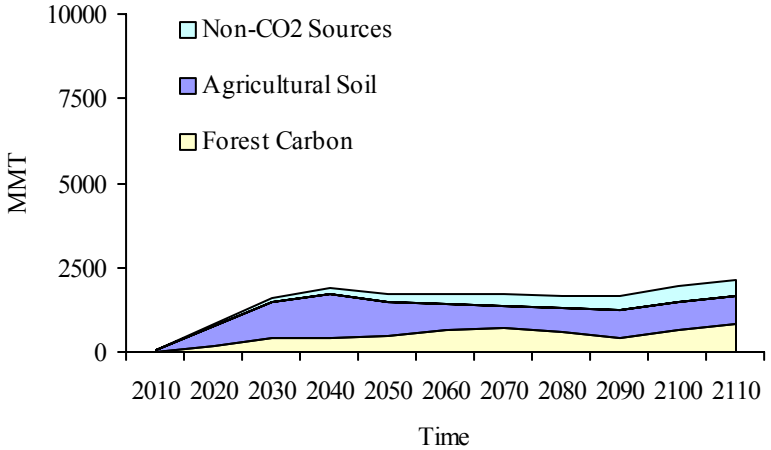
# Major findings – Portfolio Results

## MMT arising at price giving $/tonne carbon equiv

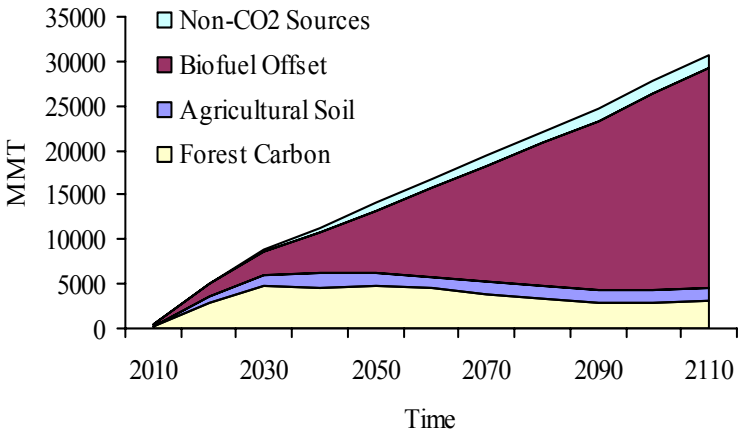



- Small importance of CH4 and N2O
- Different strategies dominate at different price levels

# Major findings – Dynamic role of strategies




> 30 years & <$50/TCE

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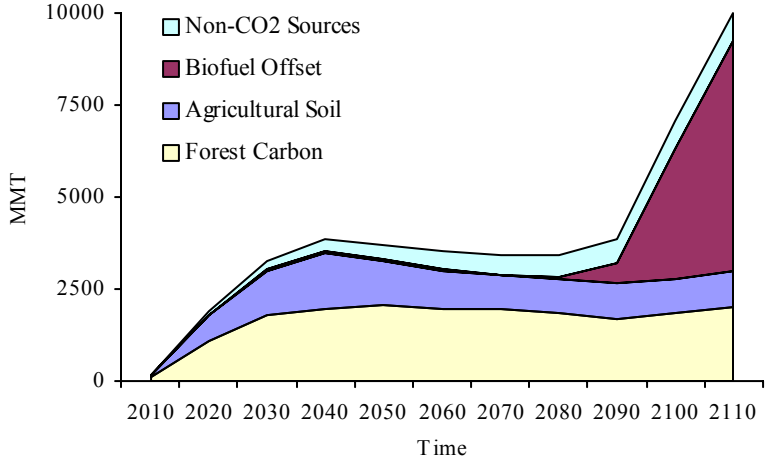
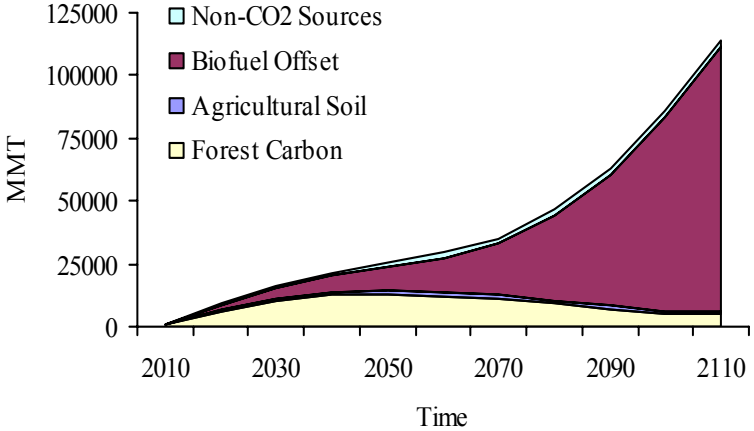



0 - 30 years & <$50/TCE




0 - 30 years & >$50/TCE

Source: Lee, Heng-Chi, **An Economic Investigation of the Dynamic Role for Greenhouse Gas Emission Mitigation by the U.S. Agricultural and Forest Sectors ,** PhD Dissertation, Texas A&M University,December 2002

# Major findings – Dynamic role of strategies

| Time from now | <$50/metric ton | >$50/metric ton |
|---|---|---|
| >30 years | Limited forest and afforest<br>Non co2 | Bio fuels<br>Non co2 |
| O to30 years | Ag soils<br>Limited forest and afforest<br>Non co2 | Limited Ag soils<br>Forest and afforest<br>Biofuels<br>Non co2 |

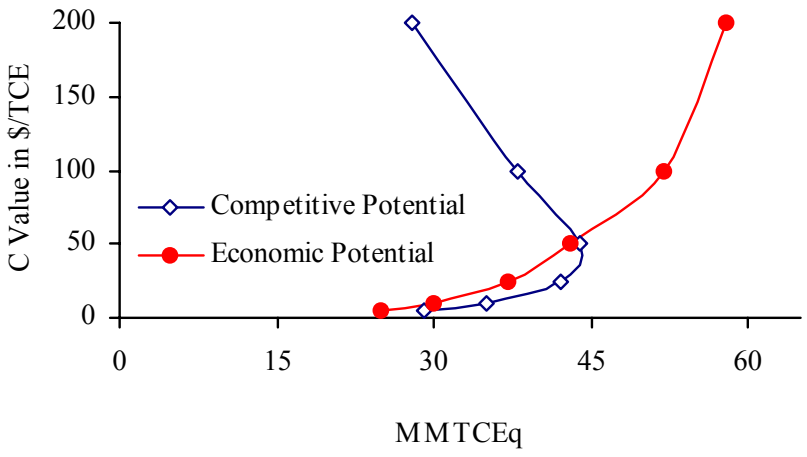
**Level of Price**

# Major findings – Potential measures

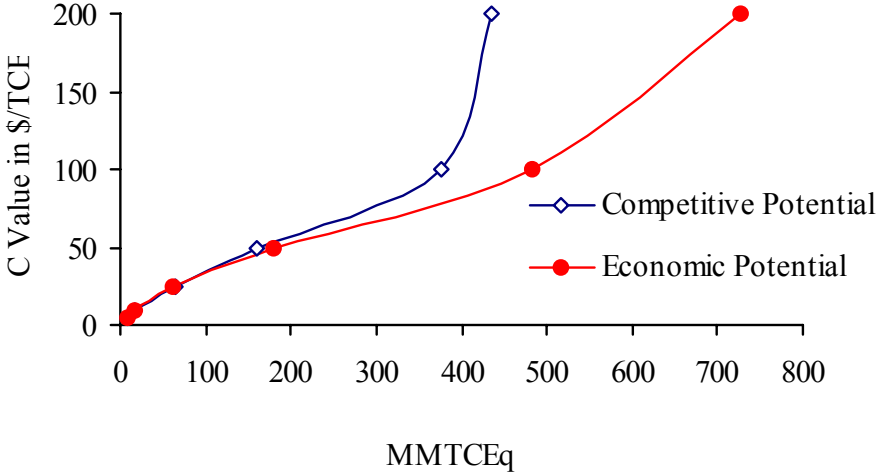
- Many estimates of potential have been generated, most are technical practice based without economic concern
- But practice adoption costs money and foregoes income
- Also strategies may be competitive

# Major findings – Potential measures

- **Economic vs competitive potential**



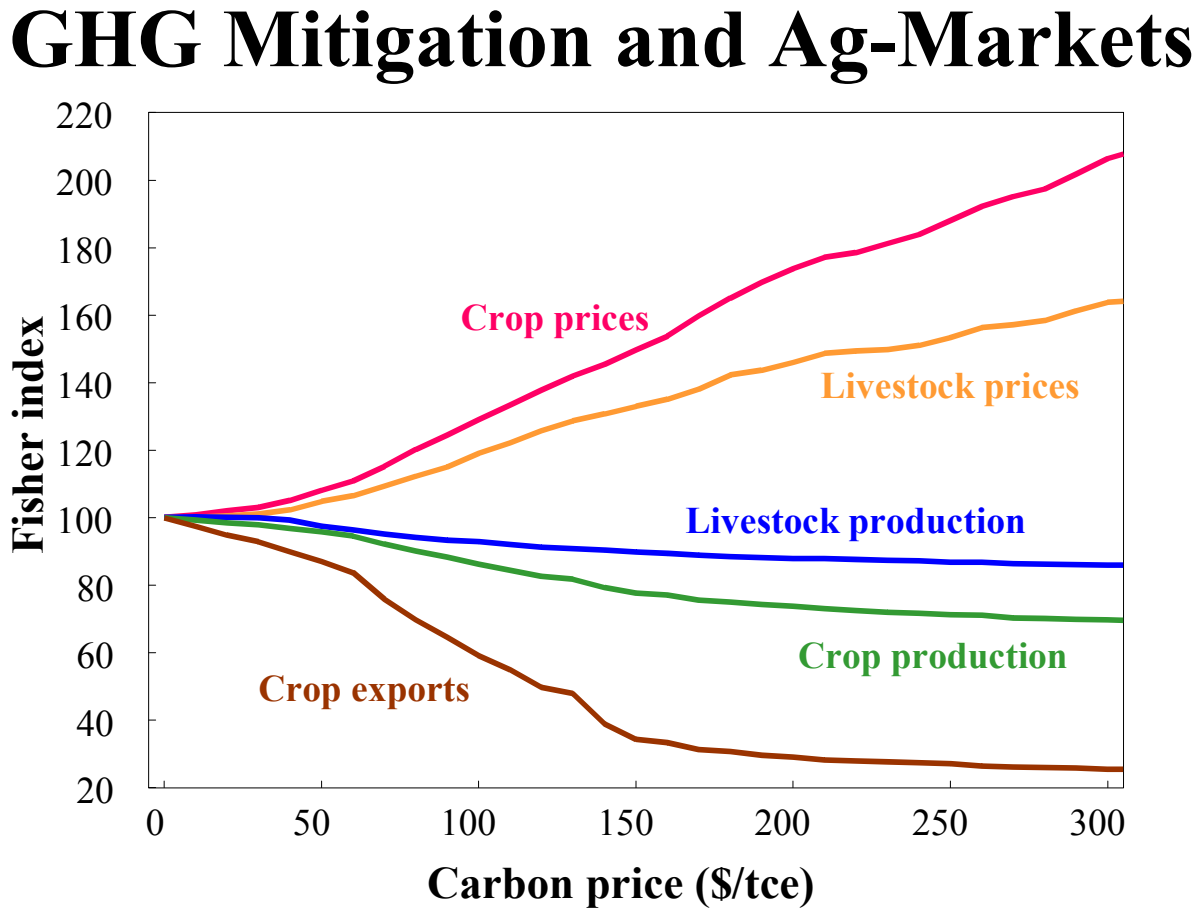

Annual Soil Carbon Sequestration on Crop Land




Annual Carbon Sequestration in Forest Sector

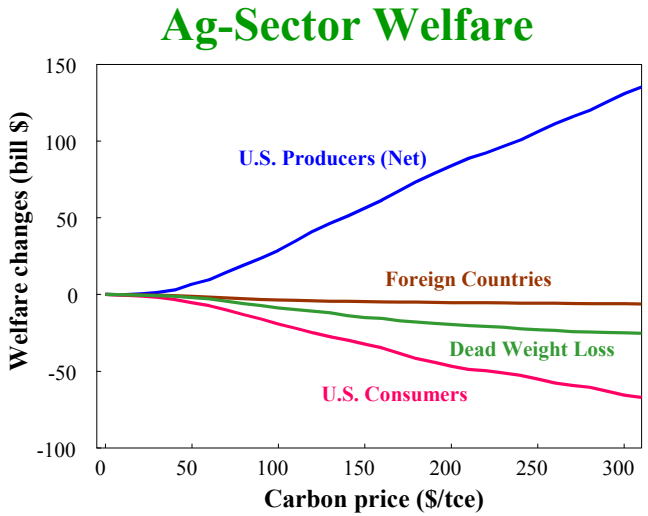
- **Economic potential is how much one would get if this was the only strategy employed**
- **Competitive potential is how much one gets when other strategies are possible**
- **Technical potential often overstates what can be achieved (above TP of ag soils is at 140 MMT)**

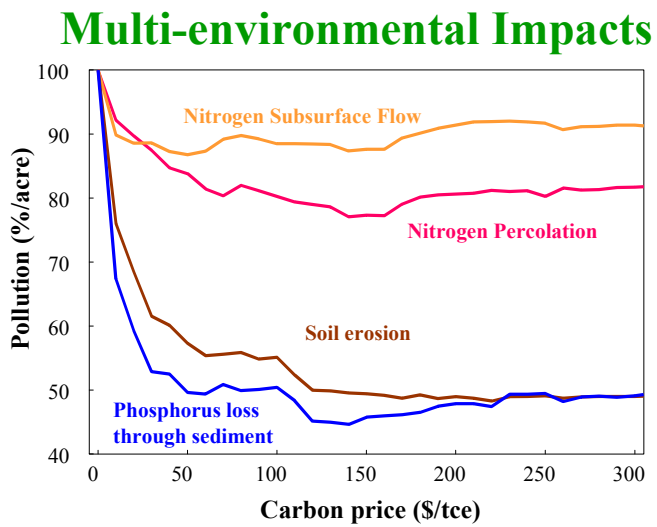
# Results – Mitigation and Market Effects




Tradeoff between carbon and traditional production –
ag prices rise, forest products fall

# Results – Co Benefits, Economic, and Environment

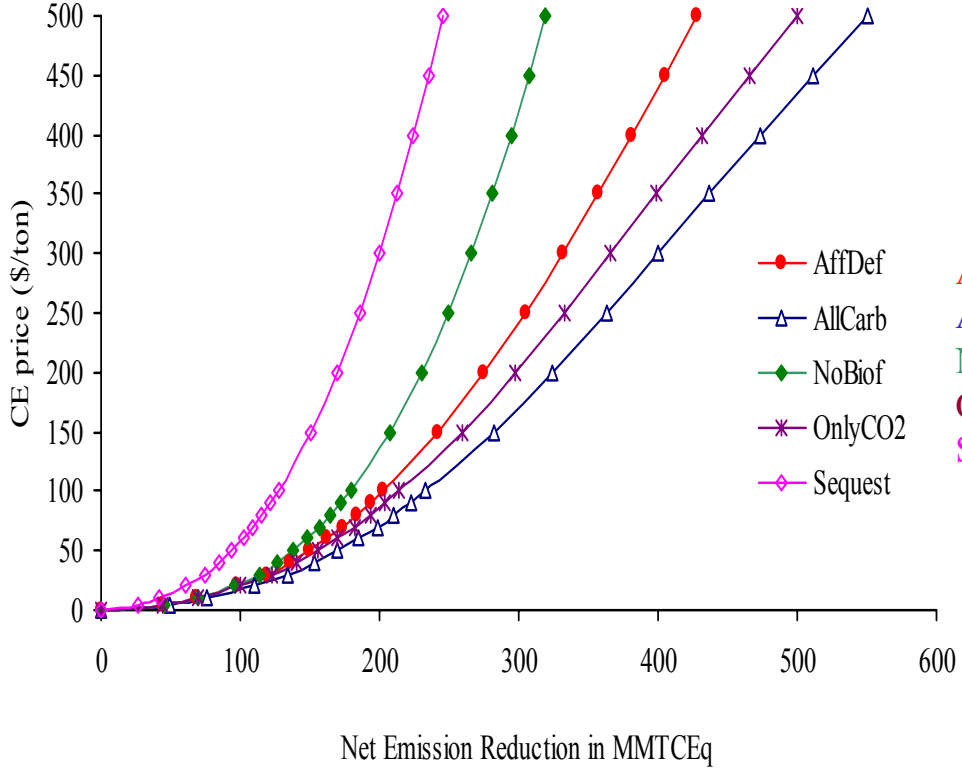



- Producers gain & Consumers lose
- Exports reduced
- Environmental gains
- High prices erode co-benefits due to intensification
- Some co-benefits do not saturate over time but continue to be accrued (erosion, runoff, farm income).
- Ecosystem gains in habitat may saturate

# Results – Policy Rules and Results

Implementation policy and response (from ASM summary)




Affdef -- afforestation and deforestation only
Allcarb -- all forestry and ag
Nobiof -- no biofuels
OnlyC02 -- no non co2 gasses
Sequest -- ag soils only

Rules make a difference

# **Omitted Factors –** Full Cost of Carbon

Carbon will cost money to produce, sell, and measure, govt may help

Not all carbon may be saleable

$$\text{Private cost per ton} = \frac{(\text{PDC} + \text{PAIC} + \text{MTC} - \text{GC})}{\text{QGHGO} * \text{DISC}}$$

where DISC = (1-ADD)*(1-LEAK)*(1-UNCER)*(1-PERM)

# Omitted Factors – Full Cost of Carbon

$$\text{Private cost per ton} = \frac{(\text{PDC} + \text{PAIC} + \text{MTC} - \text{GC})}{\text{QGHGO} * \text{DISC}}$$

PDC – Cost producer incurs to switch from current practices

PAIC - Cost to get producer to adopt above PDC in terms of incentive to get trained bear extra risk etc.

MTC- Transactions cost to assemble, measure, monitor, certify, sell, carbon

GC- Government cost share

Red terms omitted above

# Omitted Factors – Full Cost of Carbon

$$\text{Private cost per ton} = \frac{(\text{PDC} + \text{PAIC} + \text{MTC} - \text{GC})}{\text{QGHGO} * \text{DISC}}$$

| | |
|---|---|
| QGHGO | Nominal quantity of offsets |
| ADD | Discount for what would have been done in baseline. |
| LEAK | Leakage discount |
| UNCER | Uncertainty discount |
| PERM | Permanence discount |

where DISC = (1-ADD)*(1-LEAK)*(1-UNCER)*(1-PERM)

Red terms omitted above

# Directions & Challenges

- Other costs of strategies (assembly, brokerage, measurement, etc.)
- Discounts for leakage, saturation, uncertainty additionality
- Dynamic response functions from FASOMGHG
- Better ag carbon – Century, EPIC
- Better forest carbon
- Better non-CO2
- Improved animal emission accounting & management
- Updated forest inventory and growth
- CGE

# For More

- http://agecon.tamu.edu/faculty/mccarl/model.html
- http://agecon.tamu.edu/faculty/mccarl/mitigate.html
- http://agecon.tamu.edu/faculty/mccarl/climchg.html