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

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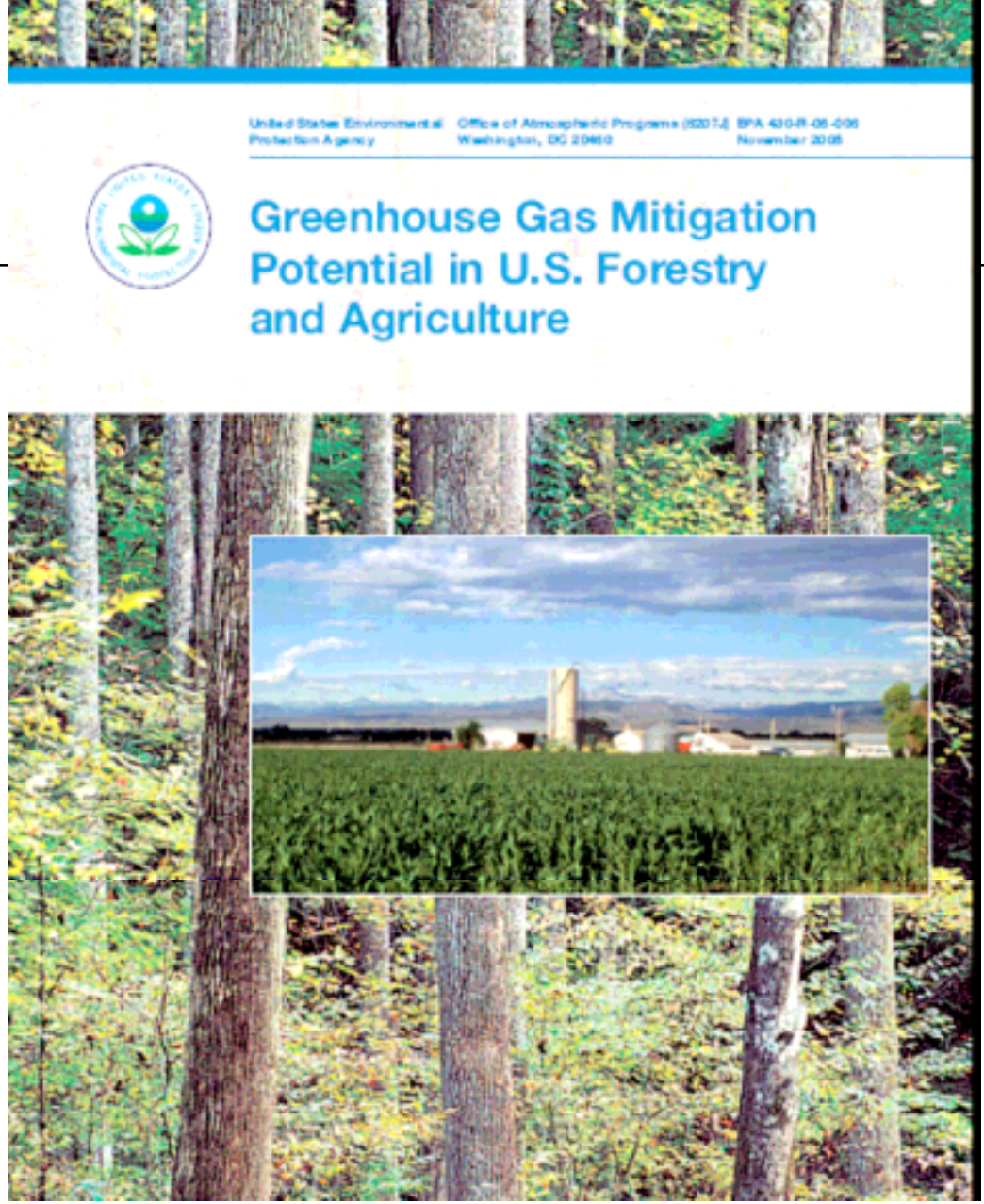
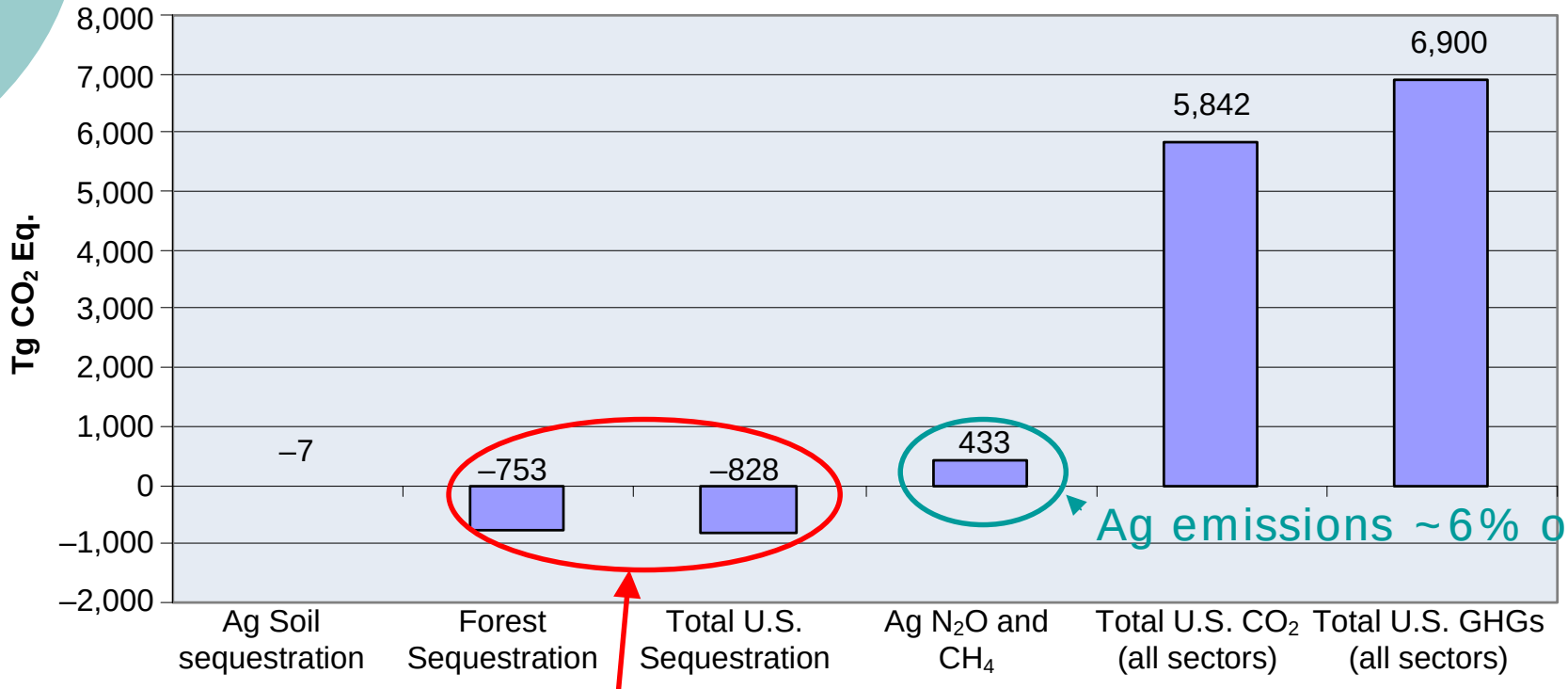


http://www.epa.gov/sequestration/greenhouse_gas.html

US Forestry and Agriculture National GHG Balance

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

[a] 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.
Source: EPA (2005).



Sector is a net sink, nationally (offsets ~12% of emissions)

Mitigation Options in Forestry and Agriculture: Sequestration, Emissions Reduction and Biofuels

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Strategy	Mitigation Activities	Target GHG
Afforestation	Convert agricultural lands to forest	CO_2
Forest management	Lengthen timber harvest rotation Increase forest management intensity Forest preservation Avoid deforestation	CO_2
Agricultural soil carbon sequestration	Crop tillage change Crop mix change Crop fertilization change Grassland conversion	CO_2
Fossil fuel mitigation from crop production	Crop tillage change Crop mix change Crop input change Irrigated/dry land mix change	CO_2
Agricultural CH4 and N2O mitigation	Crop tillage change Crop mix change Crop input change Irrigated/dry land mix change Enteric fermentation control Livestock herd size change Livestock system change Manure management Rice acreage change	CH_4 N_2O

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

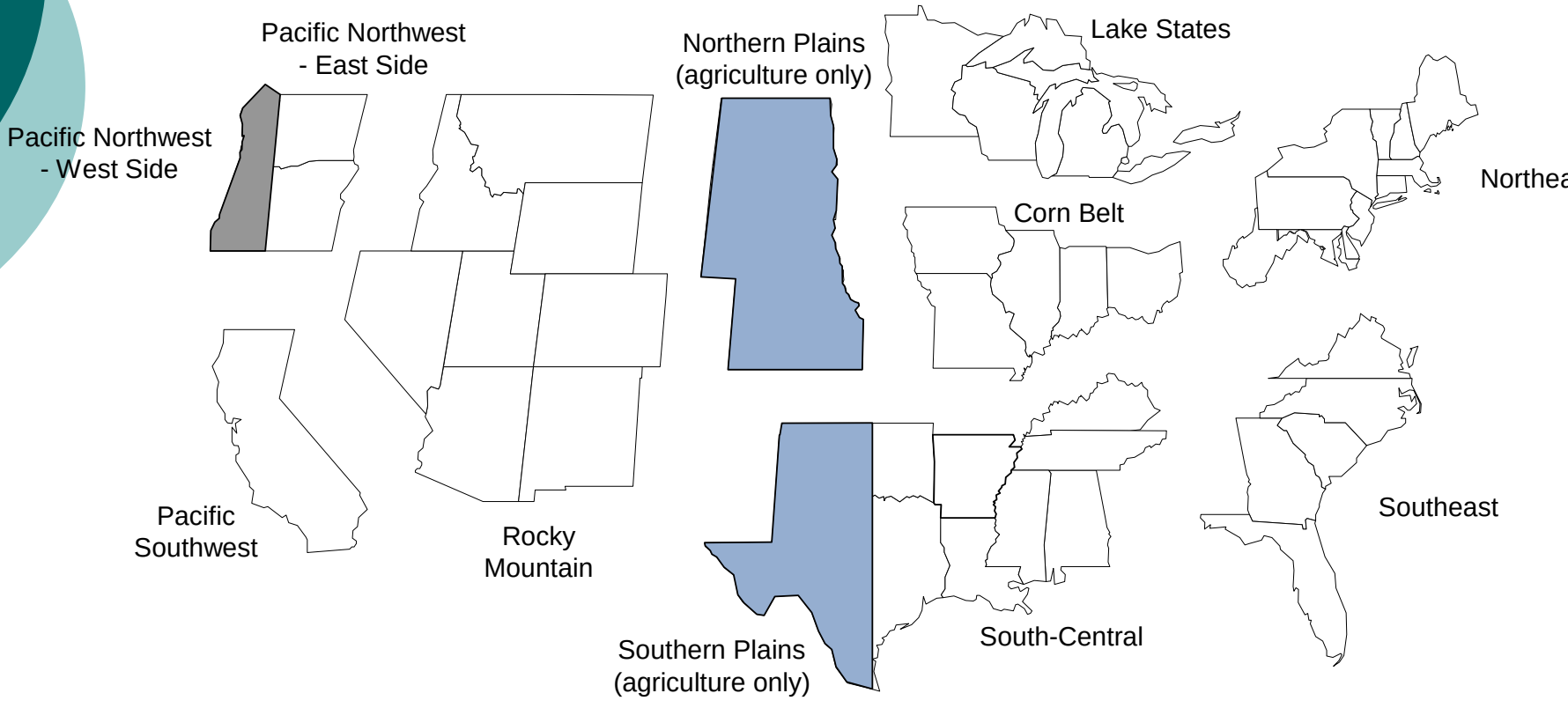
Prices Paid for GHG Mitigation
($1-50 per t CO_2)

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



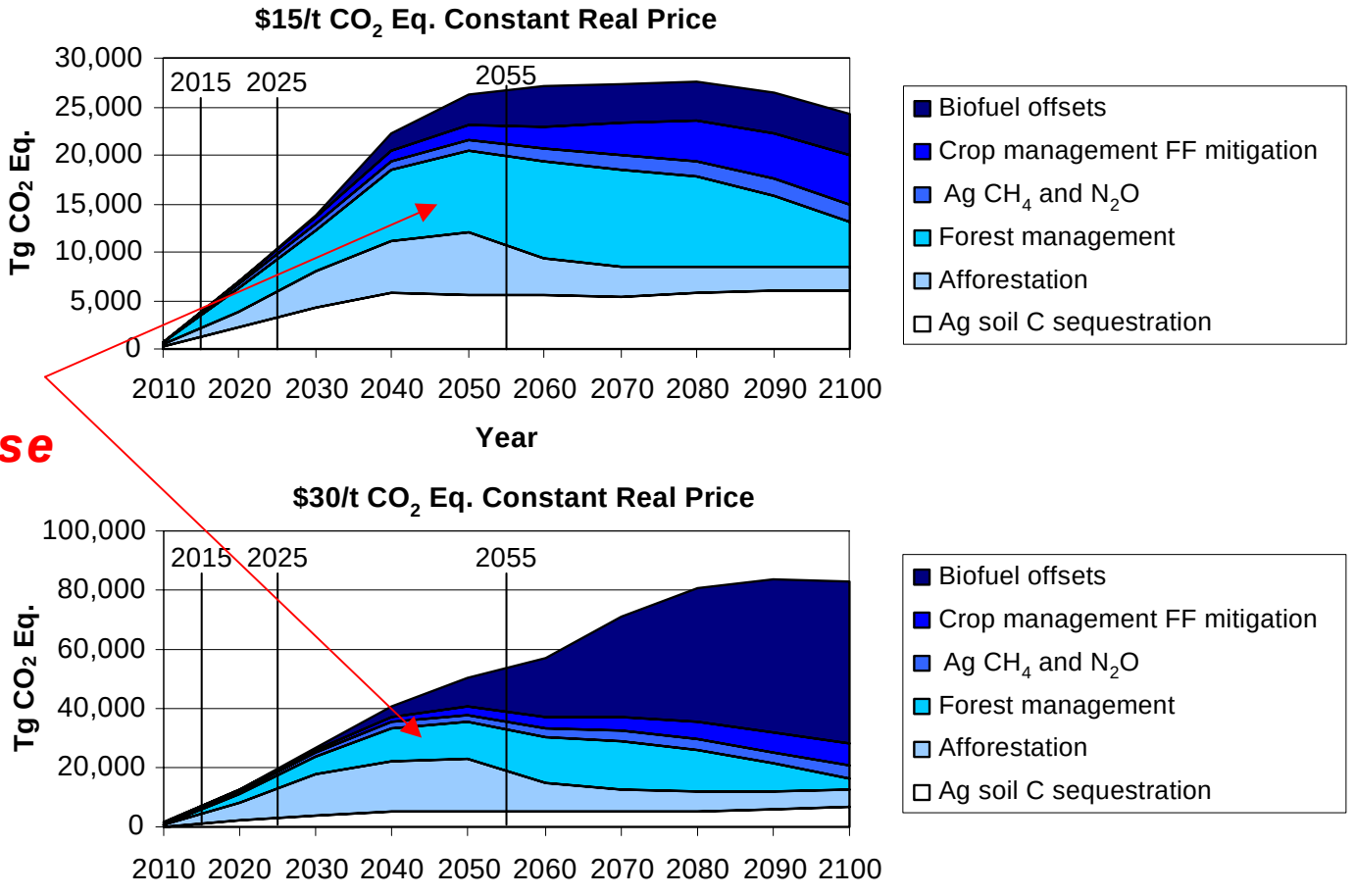
National GHG Mitigation Totals by Key Activity:

Annualized Averages, 2010–2110

	GHG Price ($/ ton CO_2)				
Activity	**$1**	**$5**	**$15**	**$30**	**$50**
Afforestation	0.0	2.3	137.3	434.8	823.2
Forest management	24.8	105.1	219.1	314.2	384.8
Agricultural soil carbon sequestration	62.0	122.7	168.0	162.4	130.6
Fossil fuel mitigation from crop production	20.5	31.9	53.1	77.6	95.7
Agricultural CH_4 and N_2O mitigation	9.4	15.2	32.0	66.8	110.2
Biofuel offsets	0.0	0.1	57.2	374.6	560.9
All Activities	116.8	277.3	666.7	1,430.4	2,105.4

Cumulative mitigation peaks, reverses (sequestration dynamics)

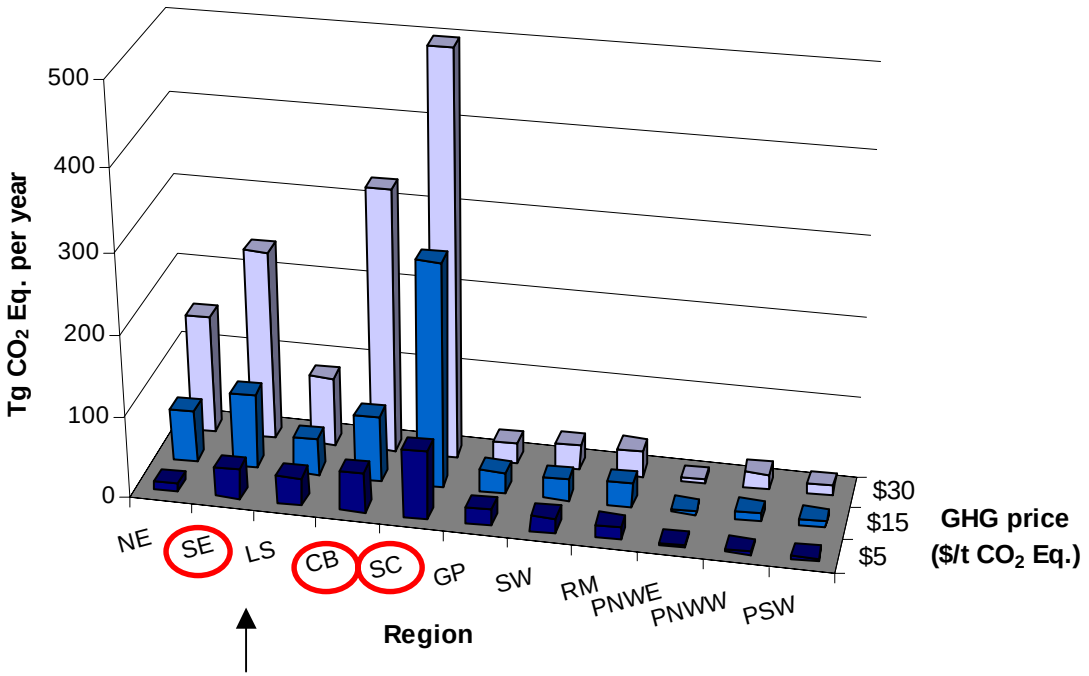
Cumulative GHG Mitigation over Time
Quantities are Tg CO_2 Eq. cumulative net emissions reduction below baseline.



reversal through harvesting and land use eversion

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

	Low price	*High Price*
Short-run	**Agricultural Soil C Sequestation** **Forest management**	**Afforestation**
Long-run	**Forest management**	**Afforestation** **Biofuels**

Issue: Forest management can be difficult to measure, monitor, and compare to baseline

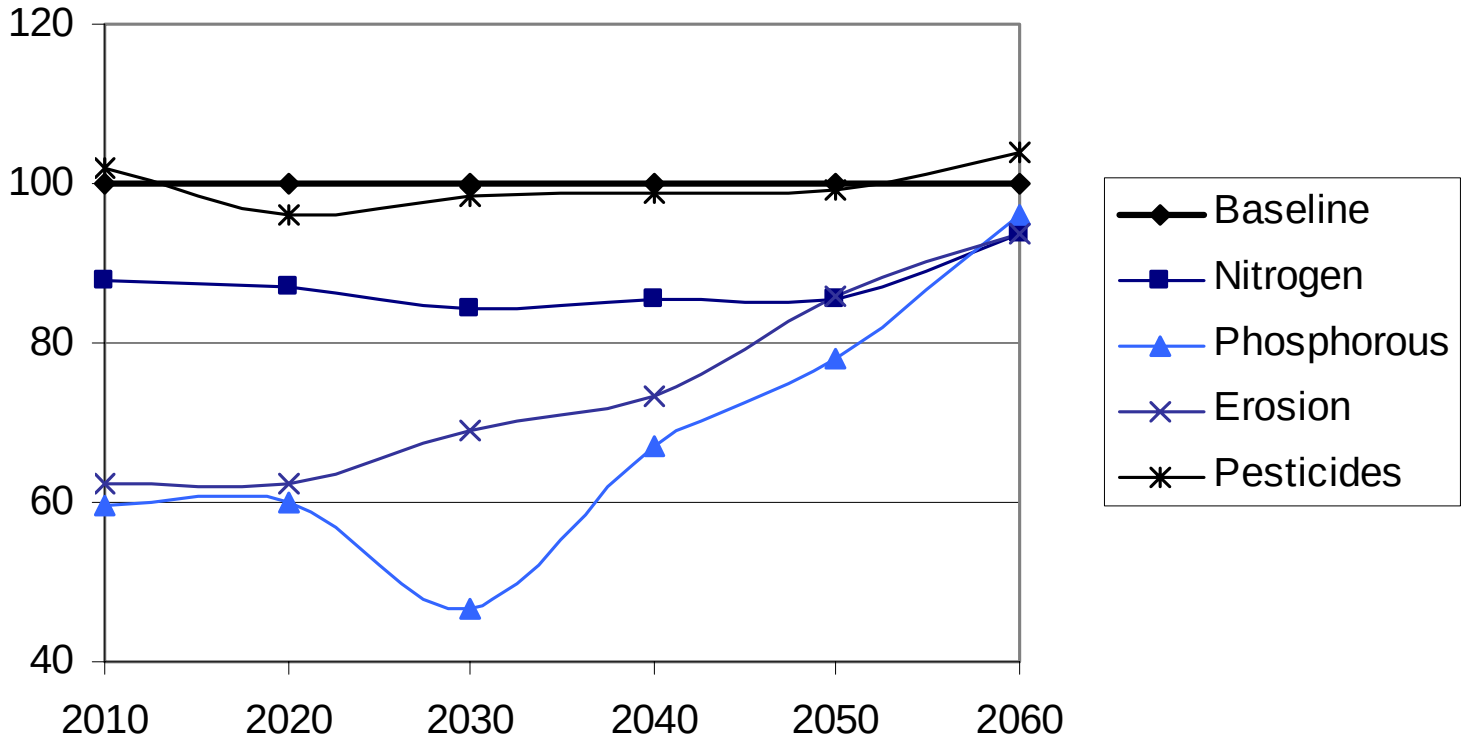
Environmental Co-effects of Mitigation Strategies

- ✓Forest Structure/Habitat
- ✓Water quality
- ✓Water quantity

GHG mitigation can reduced agricultural runoff into waterways

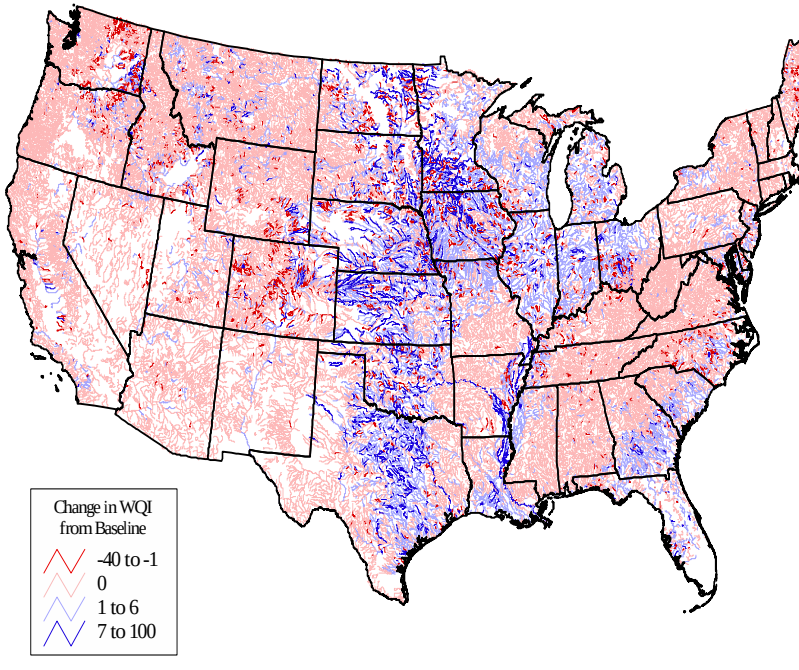
Pollutant Loading Effects Over Time of a $15 / t CO_2 Eq. GHG Price

Note: All values indexed to a baseline value of 100.



Changes in Water Quality Index (WQI):
$50/Tonne C (~$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
R.B. Jackson, E.G. Jobbagy, R. Avissar, S.B. Ray, D.J. Barrett, C.W.Cook, K.A. Farley, D.C. le Maitre, B.A. McCarl, and B.C. Murray.Dec 2005. Trading water for carbon with biological carbon sequestration. Science. 310:1944-1947.

Methane emissions from plants/trees
Keppler, J.T.G. Hamilton, M.Bras, and T. Rockmann. Jan 2006.Methane emissions from terrestrial plants under aerobic conditions. Nature. 439:187-191.

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

http://www.env.duke.edu/institute/methanewater.p

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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