

# *Regional GHG Mitigation Response and Leakage Effects:*

## *Scenario Analysis of U.S. Forestry & Agricultural Activities*

**Ben DeAngelo, Ken Andrasko**

U.S. Environmental Protection Agency

**Brian Murray, Allan Sommer**

RTI International

**Bruce McCarl, Dhazn Gillig**

Department of Agricultural Economics, Texas A&M University

3rd Annual Conference on Carbon Capture & Sequestration

May 4, 2004



# Introduction & Overview of Analysis

- Assess net GHG mitigation potential in forestry & ag
- Use FASOM-GHG model
- Assess mitigation from range of scenarios that vary:
  - price incentive (\$/tCO<sub>2</sub>)
  - eligible activities (all vs. selected)
- Compare regional participation, by mitigation option
- Evaluate effect of key issues (duration, leakage)
- Identify economic & environmental co-effects



# Modeling Framework

## Forestry and Agriculture Sector Optimization Model with Greenhouse Gases (FASOM-GHG)

Key Dimensions	Forest Sector	Ag Sector
Regions	11	63
Land Base	Private timberland, USFS FIA	All U.S. cropland, USDA NRI, Ag Census
Time Scale	Base yr = 2000, 100-yr simulations, 10-yr time steps	Same
GHG Accounting	Emissions/removals from all C pools (incl. products), FORCARB	Soil C, CENTURY CH <sub>4</sub> , N <sub>2</sub> O, IPCC Fossil Fuel CO <sub>2</sub>
Commodities	Sawlogs, pulpwood, timber from hard- & softwoods	48 primary 45 secondary

See: Adams et al. 1996; Lee 2002.





# FASOM-GHG includes full range of forestry & ag activities and net GHGs

Strategy	Basic Nature	CO2	CH4	N2O
Afforestation	Sequestration	X		
Existing rotations/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

# FASOM-GHG projects baseline against which all mitigation results are reported

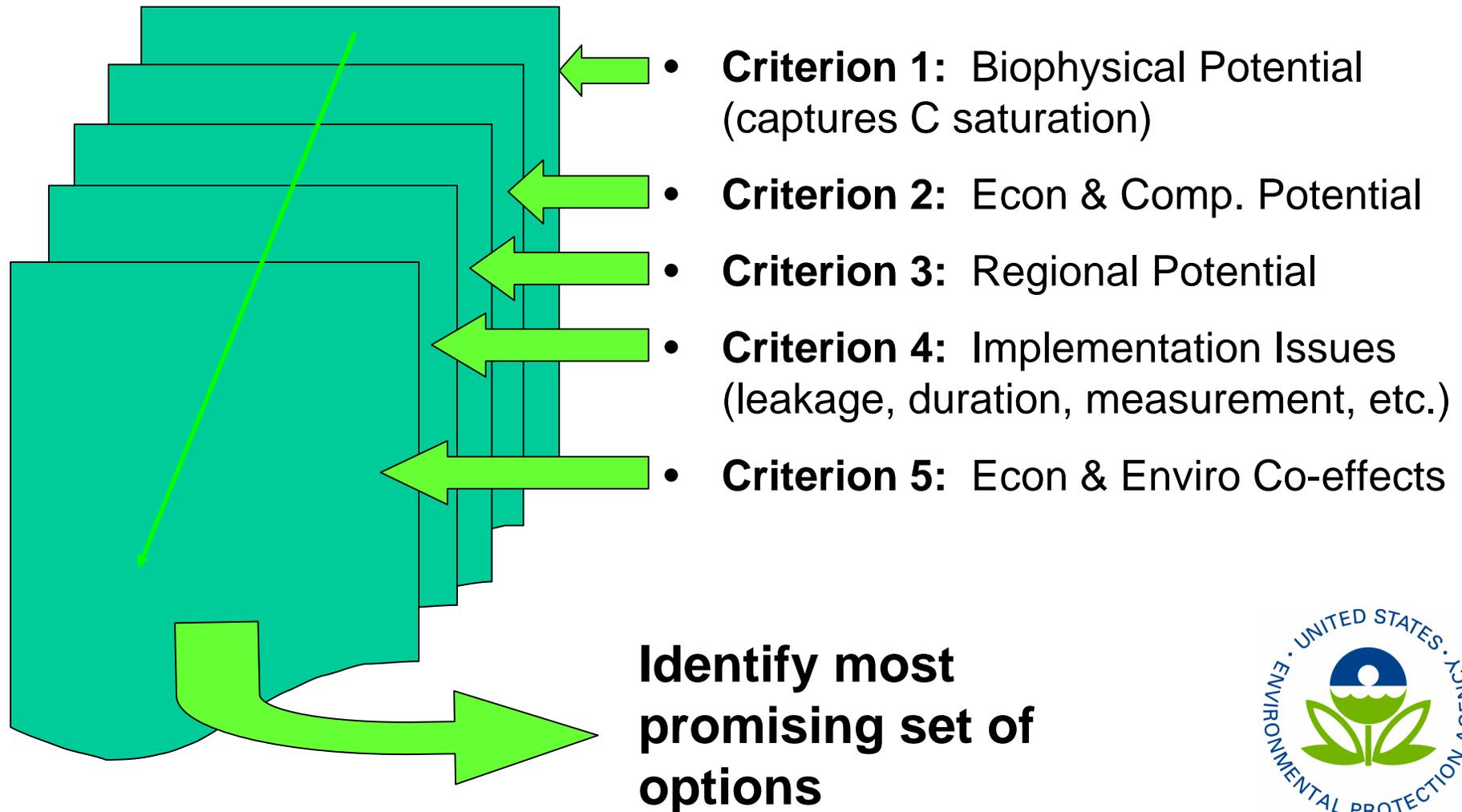
TgCO<sub>2</sub> eq./yr (+ = emissions; - = net sequestration).

Decade	Agricultural Soil Carbon Sequestration	Biofuel Offset	Forest Carbon Sequestration	Crop Management Fossil Fuels	Agricultural CH <sub>4</sub> and N <sub>2</sub> O Emissions	Total Net GHG Emissions
2010	32	-11	-436	197	489	270
2020	10	-11	-222	200	503	479
2030	-83	-11	-145	213	560	535
2040	-148	-11	-225	229	597	442
2050	-167	-11	-170	242	626	520

- Declining rate of forest seq. over time; consistent with other projections.
- Forest sink smaller than reported in EPA inventory; no public lands here.
- Ag CH<sub>4</sub> & N<sub>2</sub>O calibrated with EPA inventory and projections.
- Biofuels include ethanol and energy crops (Oak Ridge, EIA).
- Ag soil carbon from CENTURY model



# Important to Evaluate Options Using Multiple Criteria, from biophysical potential to implementation issues, to co-effects



# Mitigation Scenarios with FASOM-GHG including ALL Activities & GHGs

Constant & Rising Price Scenarios, price signal begins in 2010

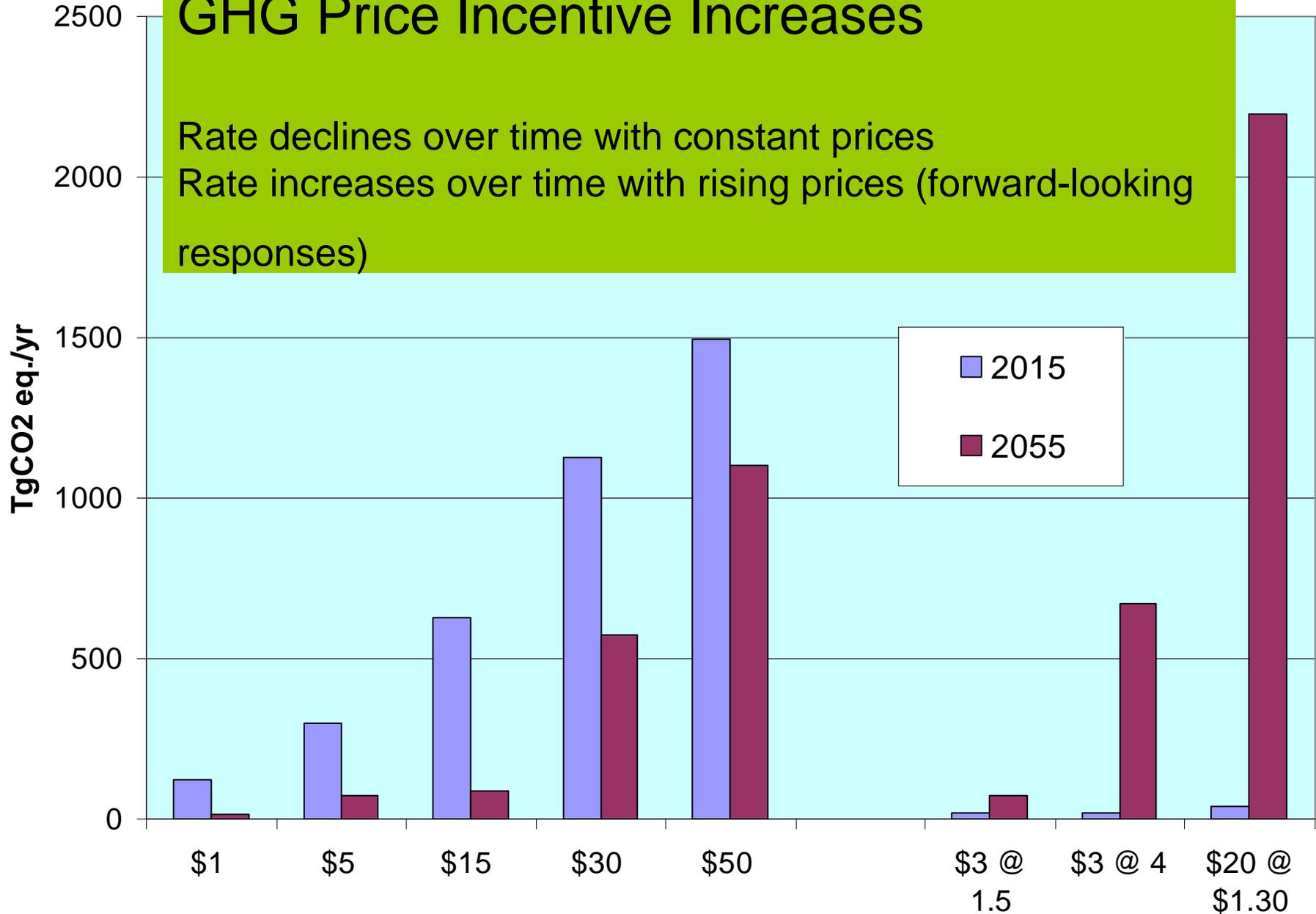
	<b>\$/tonne CO<sub>2</sub> eq.</b>	<b>\$/tonne C eq.</b>	<b>Rising by...</b>	<b>Capped at...</b>
Constant	1	3.6		
	5	18		
	15	55		
	30	110		
	50	183		
Rising	3	11	1.5% / yr	
	3	11	4% / yr	\$30/tCO <sub>2</sub>
	20	73	\$1.30/tCO <sub>2</sub> /yr	\$75/tCO <sub>2</sub>

Note: Rising price paths and caps are similar to those chosen by Stanford Energy Modeling Forum-21



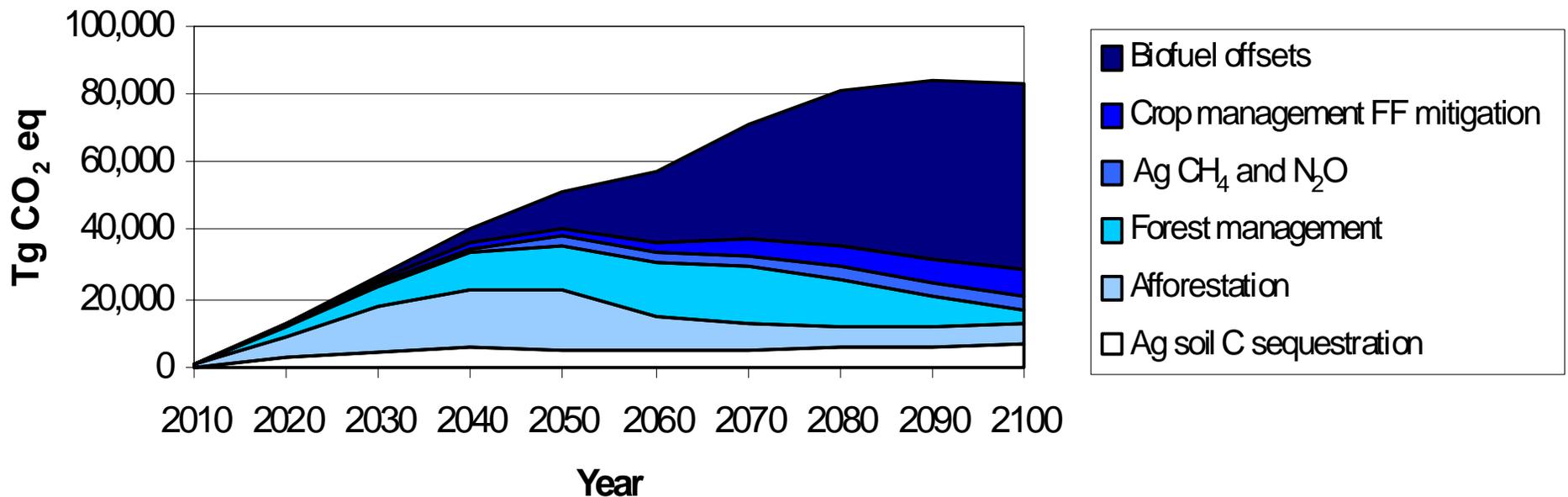
# Average Annual Mitigation Increases as GHG Price Incentive Increases

Rate declines over time with constant prices  
Rate increases over time with rising prices (forward-looking responses)



# Cumulative Mitigation Results Over Time Show...

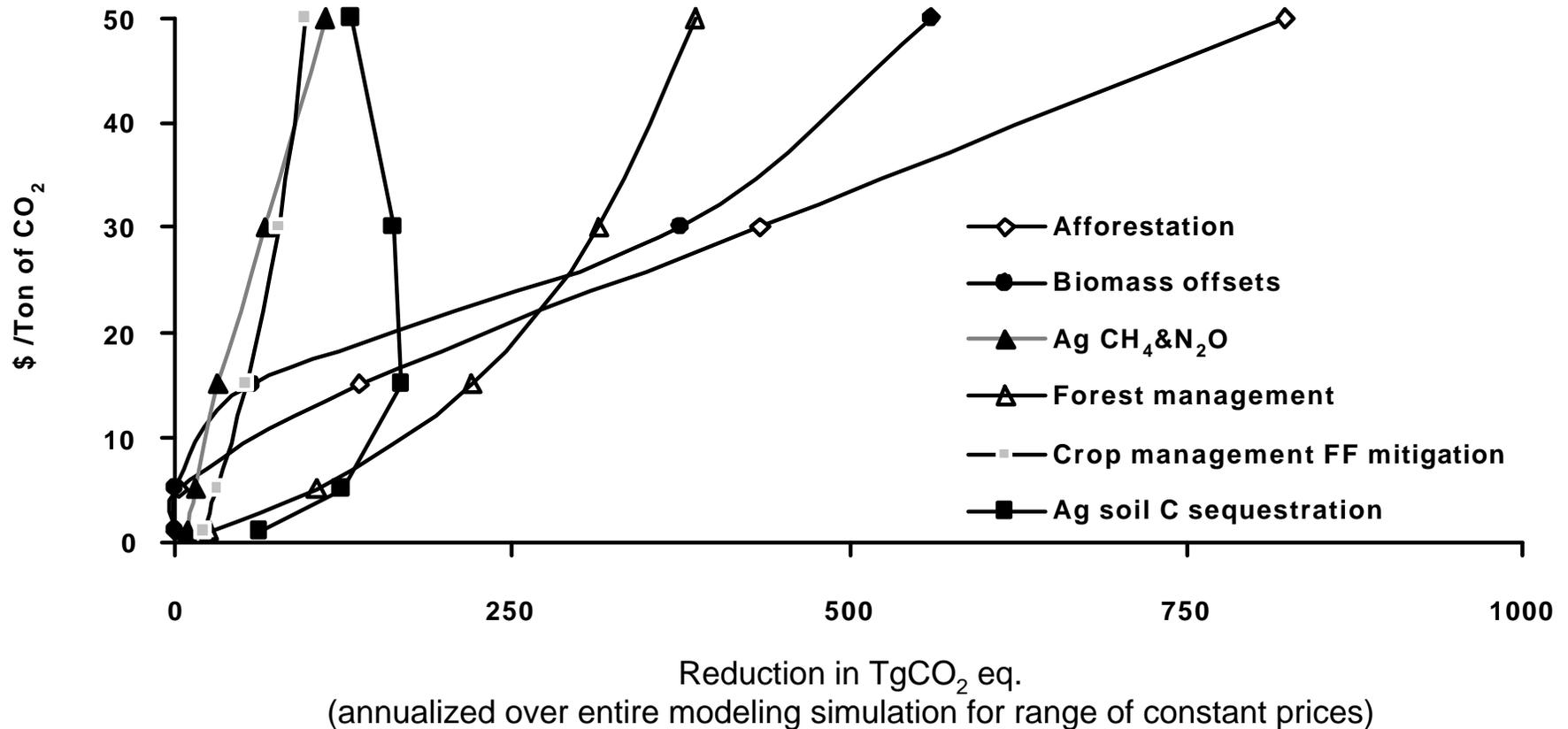
\$30/tCO<sub>2</sub> constant scenario



- Cumulative mitigation continues to increase, even if annual mitigation rates decline.
- As C-seq. options saturate, permanent emission reduction options (biofuels, ag non-CO<sub>2</sub>) contribute more to portfolio.



# Mitigation Contributions by Options show...

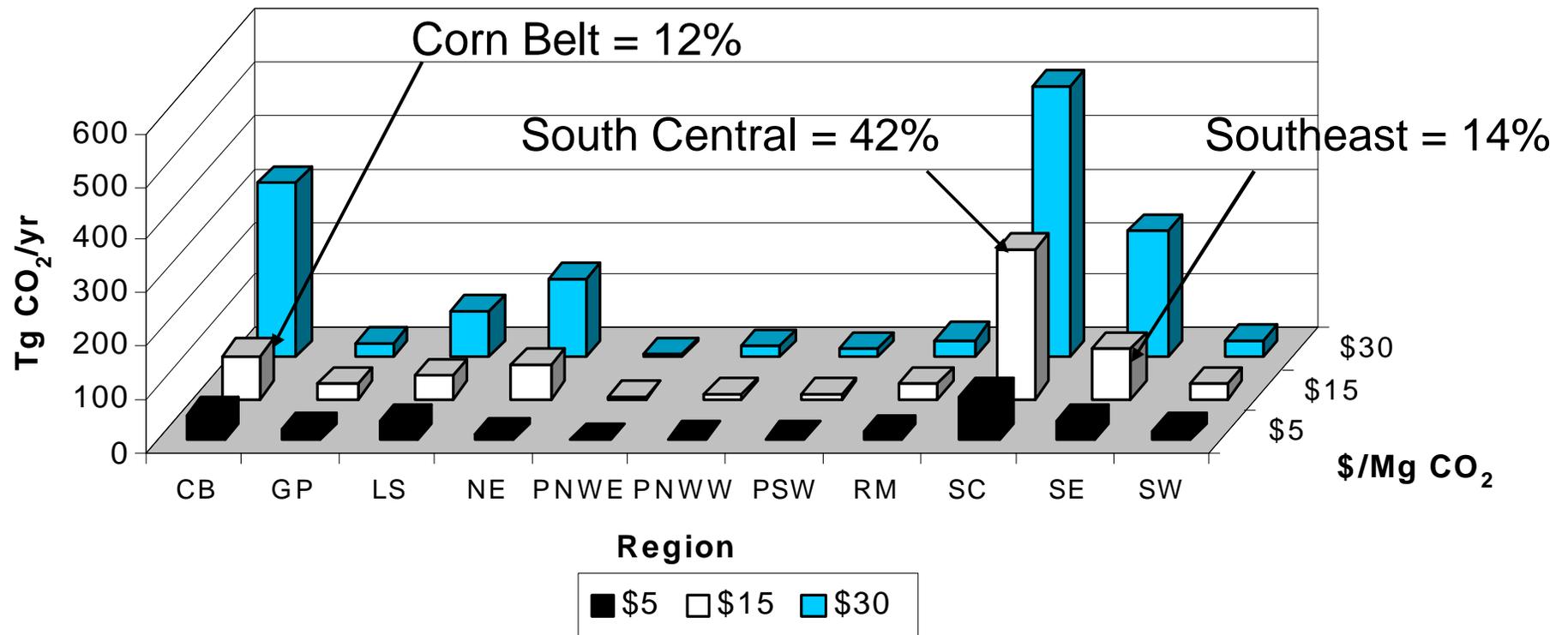


- Forest management & ag soil C dominate at low prices
- As prices rise, ag soil C out-competed by Aff & Biofuels
- Aff & Biofuels dominate at highest prices
- Ag non-CO<sub>2</sub> and Ag ff CO<sub>2</sub> remain small but steadily increase



# Regional Mitigation Potential Varies Across U.S.

Results in TgCO<sub>2</sub> eq./year, annualized over 2010 - 2100.



- 4 regions dominate: South Central, Corn Belt, Southeast, Northeast
- Note: % above represent % national mitigation at \$15/tCO<sub>2</sub>



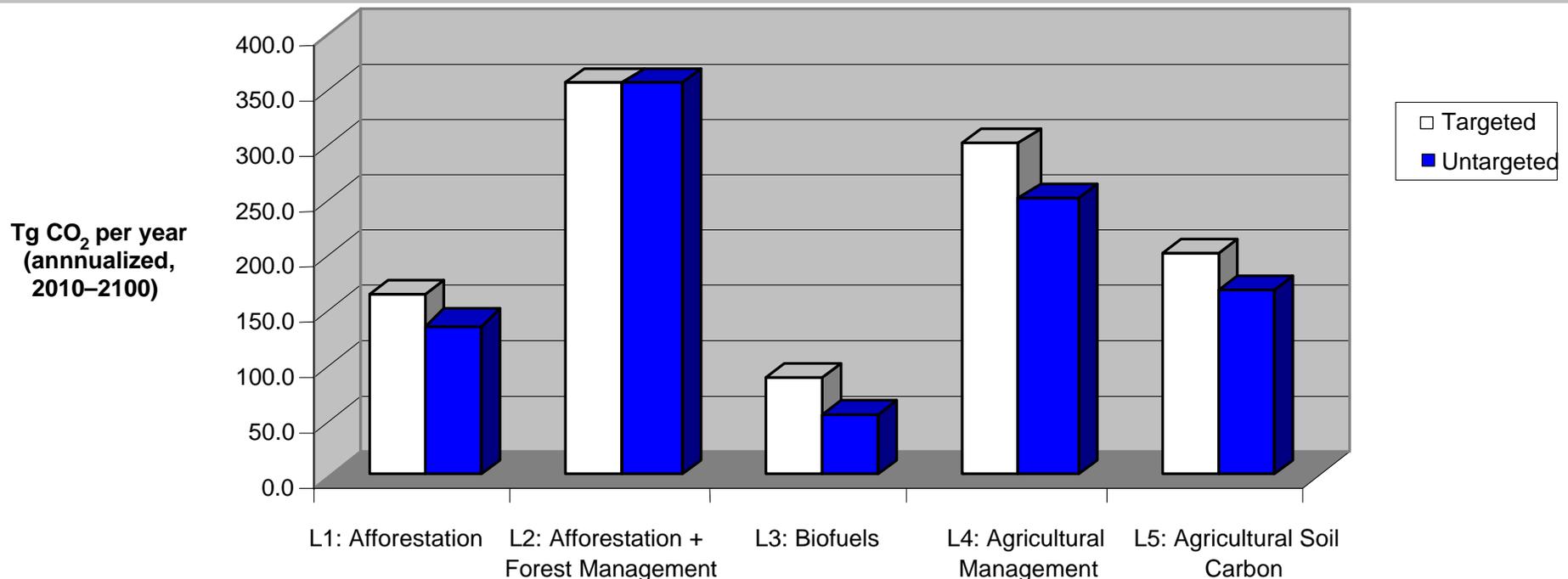
# Mitigation Scenarios with Selected Activities Only

- Scenarios: Pay only for...
  - Afforestation
  - Afforestation & Forest Management
  - Biofuels
  - Ag soil carbon
  - Agricultural Management (includes soil carbon, CH<sub>4</sub>, N<sub>2</sub>O, and fossil fuels)



# Mitigation Potential of *Selected* Activities vs. All-Activity Scenarios

GHG Mitigation by Activity: Targeted Payments vs. Untargeted Payments (\$15/t CO<sub>2</sub>)



- When only selected activity is paid for, mitigation potential is higher.
- Selected activity is not competing with other activities.
- Aff & For Mgmt compete for mitigation, so this combo shows no difference.

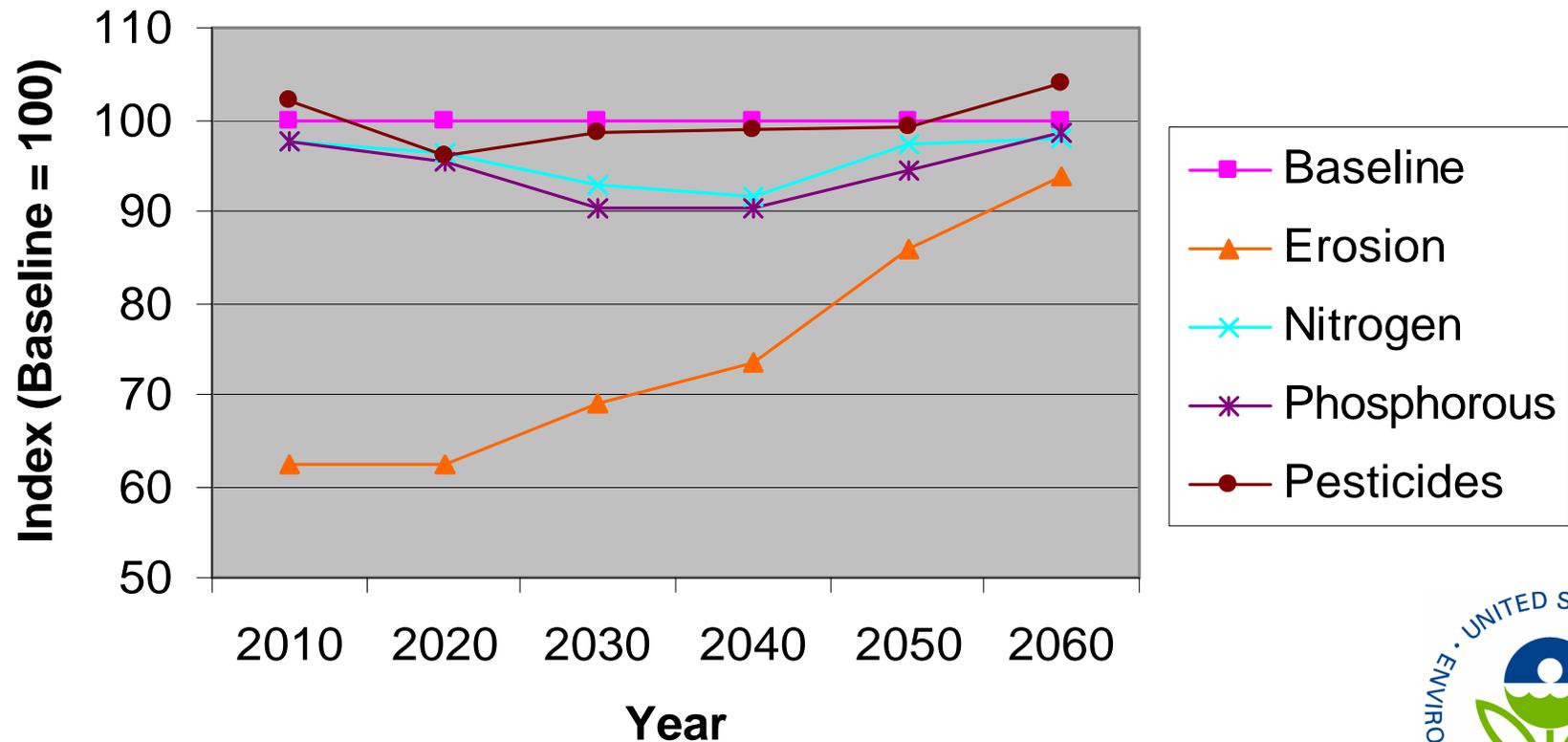
# Leakage Estimates for Selected Activity Scenarios

Scenario at \$15/tCO <sub>2</sub>	Leakage Rate (%)
Afforestation only	28
Afforestation + For Mgmt	-5
Biofuels only	4
Agricultural Soil Carbon	1
Agricultural Management	~ 0

Leakage =  $(A - B)/A * 100$ : A = GHG effects of selected activity; B = GHG effects of all activities  
Underlying GHG effects are annualized over entire FASOM-GHG simulation.

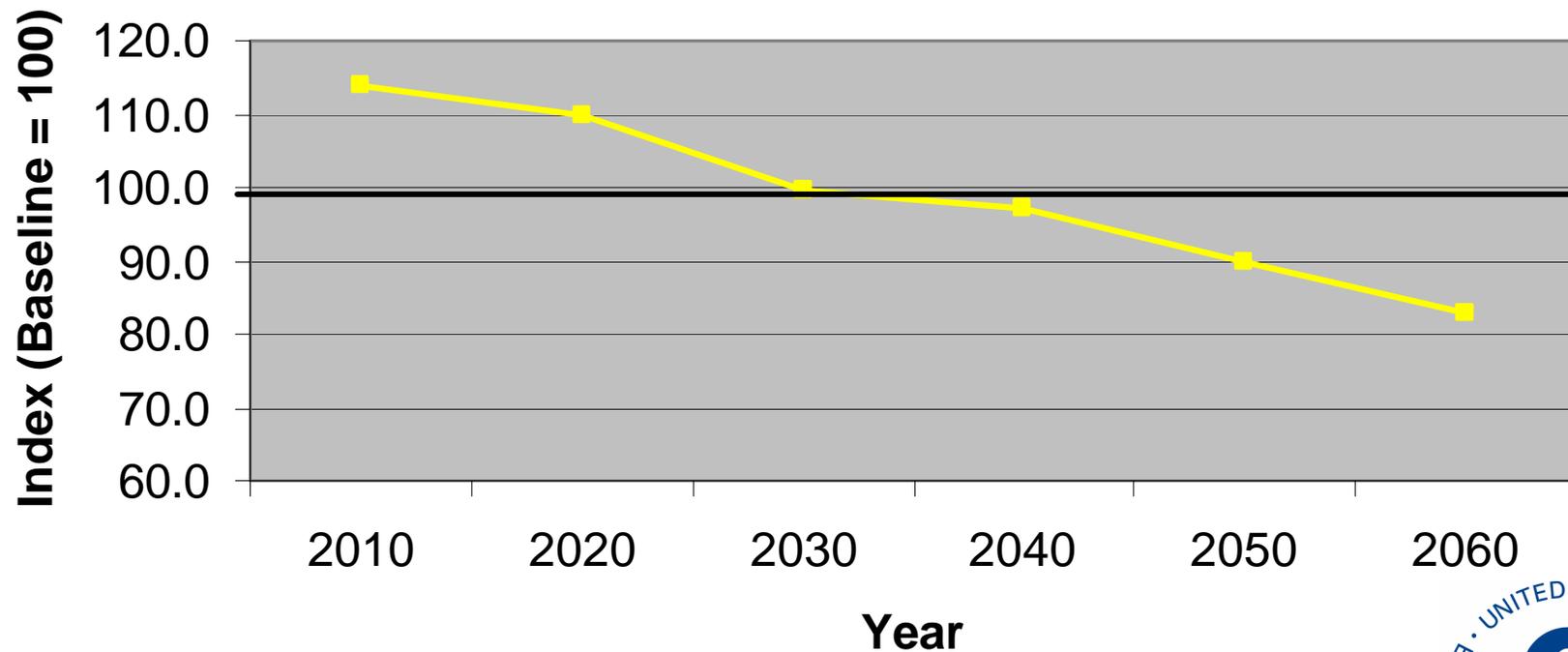
# Mitigation Actions Have Environmental Co-effects

## Change in Environmental Parameters due to GHG Mitigation at Constant \$15/tCO<sub>2</sub> Scenario



# Mitigation Actions Have Economic Co-effects

## Timber Price Index Over Time Under Constant \$15/tCO<sub>2</sub> Scenario



- Initial harvests delayed (prices rise); by 2030, afforestation increases timber supply (prices decline)

# Summary and Key Findings to Date

- GHG mitigation potential estimated to be very significant.
- Level and time path of price incentive influences mitigation estimate.
- Carbon saturation causes decline in annual mitigation rate, though *cumulative* mitigation steadily increases.
- As C-seq. options saturate, permanent emission reduction options (biofuels, ag non-CO<sub>2</sub>) contribute more to portfolio.
- Ag soil C & For Mgmt dominate at low GHG prices; Aff & Biofuels dominate at higher prices.
- South-Central, Corn Belt, Southeast, & Northeast offer largest mitigation potential.
- Leakage estimated by limiting eligible activities. Affor.-only scenario shows highest leakage; ag soil carbon leakage is minimal.
- Economic & environ. co-effects can be significant.
- Many implementation issues (e.g., measurement, verification) not accounted for in modeling, and could impact estimated mitigation.