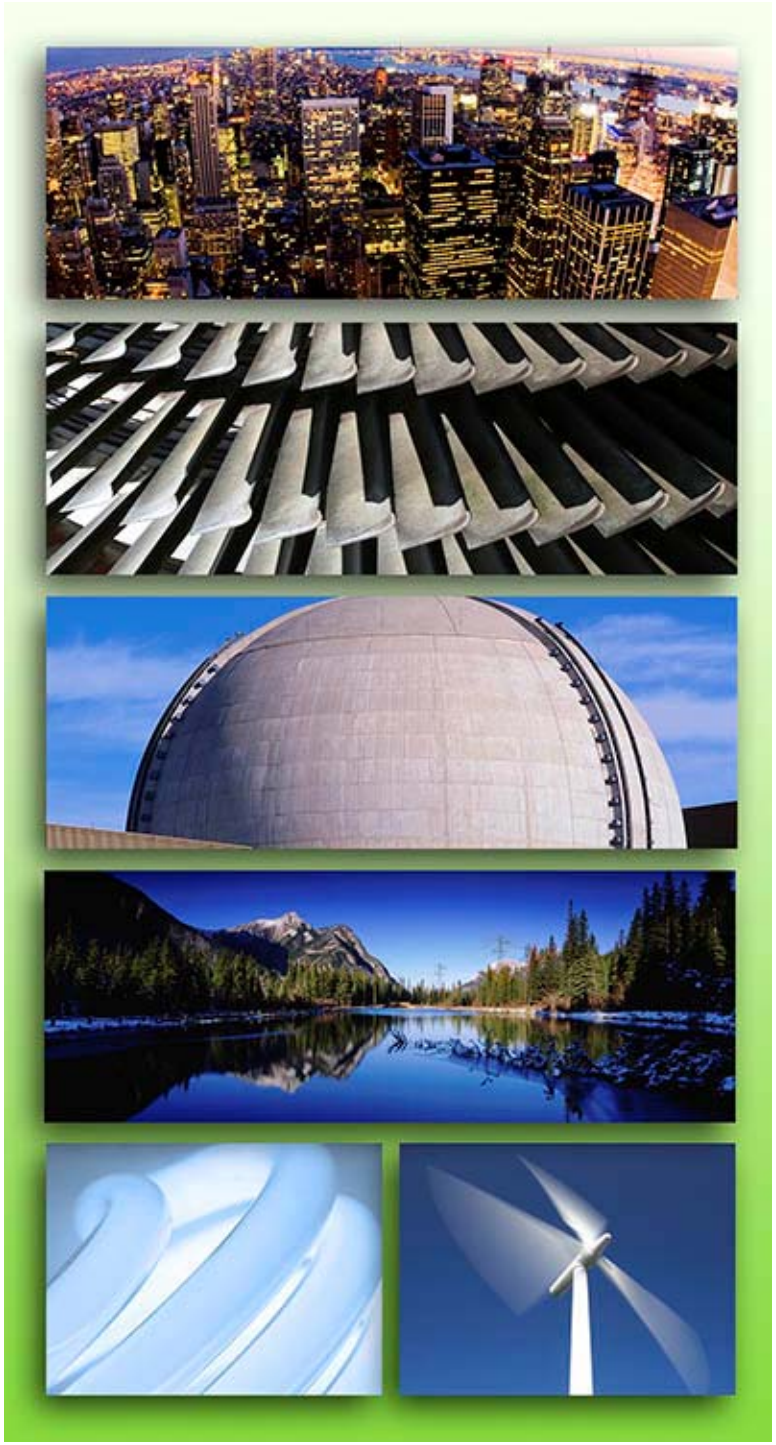

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Potential for Agricultural and Forest GHG Mitigation in the U.S.

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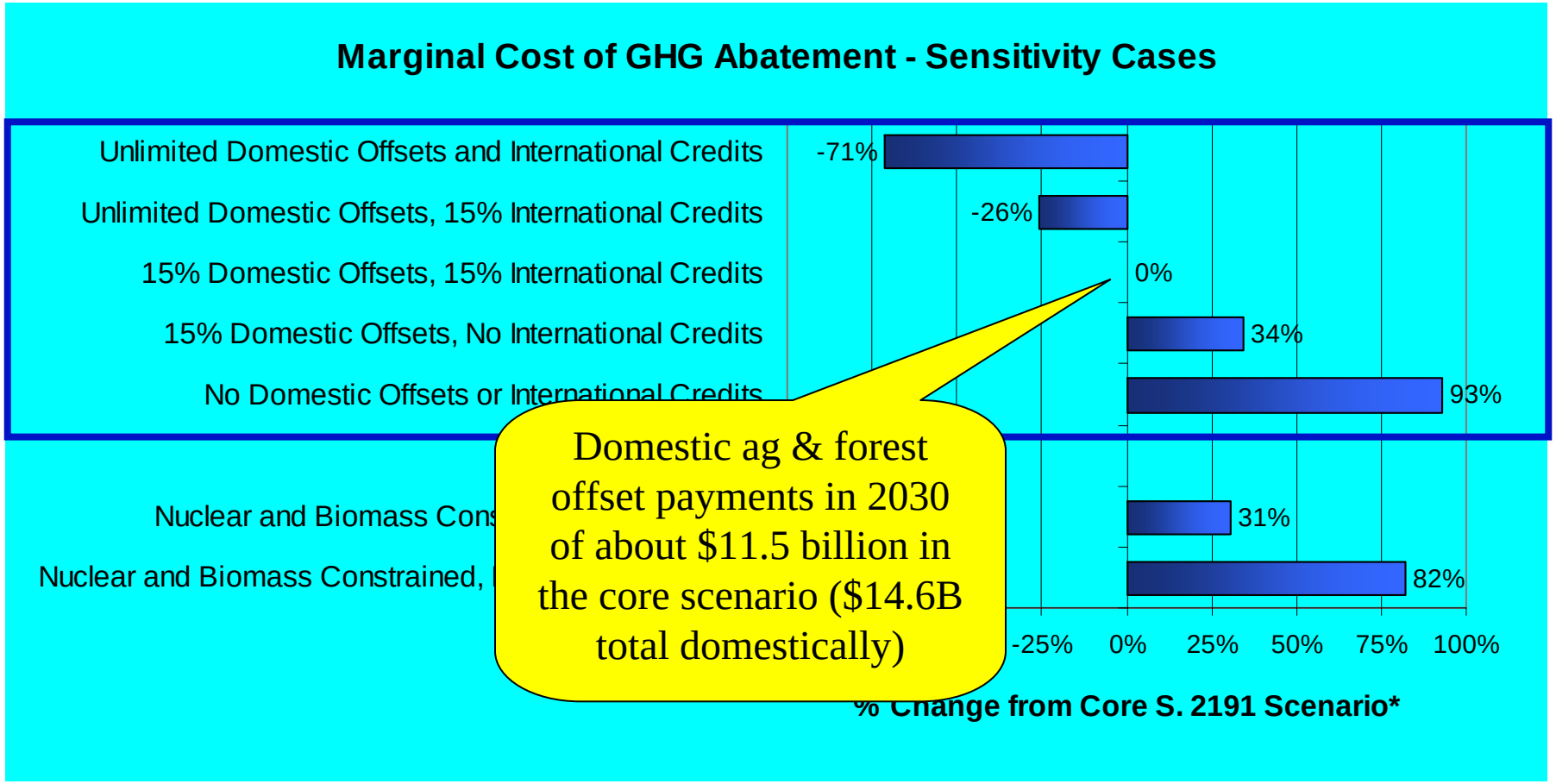
Key points

- U.S. forest, agriculture, and bioenergy offer significant GHG mitigation potential, e.g., ~50 $GtCO_2eq$ cumulative to 2050 (EPA, 2008)
- However, there is greater uncertainty in reductions vs. capped sectors
- **Preliminary** new estimates suggest lower forest & ag baseline emissions
  - Lower overall emissions in the US – reduces compliance burden for capped sectors (and potential international commitments)
  - However, potentially lower agriculture & forestry offset potential for some options (results not yet available)
- A number of important methodological and policy design considerations for assessing and exploiting mitigation potential

Offsets in recent domestic climate policy analysis e.g., EPA's S.2191 results



Source: EPA's analysis of the Lieberman-Warner Climate Security Act of 2008 (S. 2191), http://www.epa.gov/climatechange/economics/economicanalyses.html

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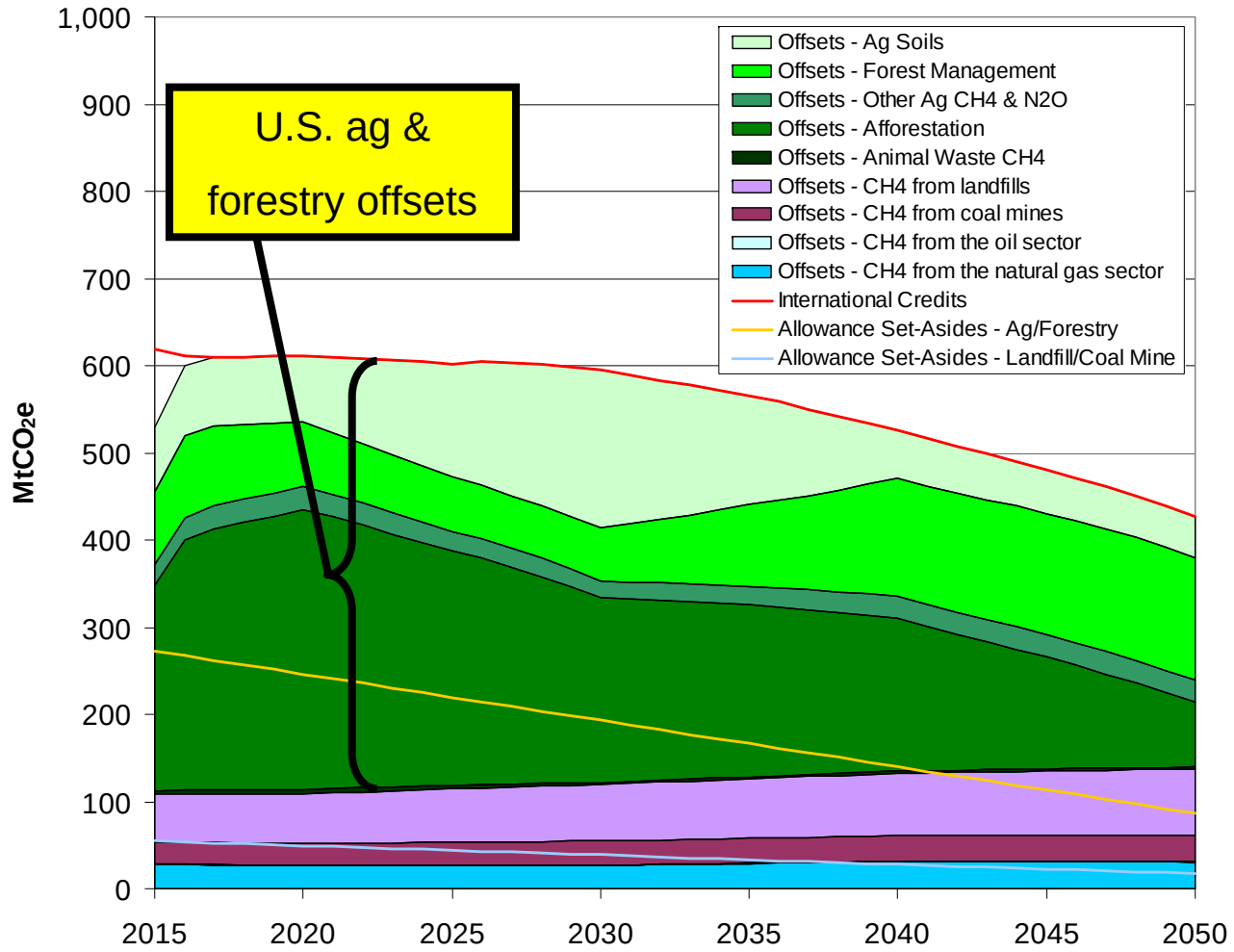
EPA S. 2191 Scenario – Source of offsets



- Abatement from domestic offsets limited to 15% each year.
- Abatement from international credits limited to 15% each year.
- Allowance set-asides prescribed as 4% of allowances in each year for Ag/Forestry abatement projects, and 1% are set aside for landfill and coal mine CH_4 abatement projects.
- IGEM model results in figure

Source: EPA's analysis of the Lieberman-Warner Climate Security Act of 2008 (S. 2191), http://www.epa.gov/climatechange/economics/economicanalyses.html

Mitigation options

Non-capped emissions, i.e., potential offset activities

Capped emissions, i.e., potential capped sector reductions

Crops
- Crop tillage change
- Crop mix change
- Grassland conversion
- Reduced use of crop fertilizers
- Using nitrification inhibitors
- Reduced legiminous cropping
- Rice acreage change

Livestock
- Anaerobic digestors
- Manure management system change
- Livestock dietary change
- Improved pasture and range management
- Bovine somatotropin
- Reduction in herd size

Forestry
- Afforestation
- Forest management: Reforestation
- Forest management: Intensiv
- Avoided deforestation

Biofuels*
- Ethanol and ethanol-gasoline
- Biomass electricity

Fossil fuel use
- Stationary, mobile, and upstream chemical manufacturing

Large potential (but new scientific uncertainty), MMV possible given emerging tools & methods, environmental co-benefits, permanence an issue

MMV elusive (farm records?), baseline overuse, low GHG reduction potential, GHGs highly weather-dependent

MMV, baseline and additionality are straightforward

iteria

- Feasibility of monitoring, ification
- tial – s
- s
- ditionality
- Reversibility (permanence)
- Leakage potential
- ation
- mental co-benefits

** FASOMGHG2 includes additional bioenergy options*

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Modeling approach – sector modeling informs economy-wide modeling

Economy-wide modeling

(i.e., Computable General Equilibrium, CGE, model)

- Estimate the cost-effective economy-wide portfolio of mitigation technologies
- Market interactions and feedbacks, and budget reallocations that will occur given the scale of the policies
- Macro effects

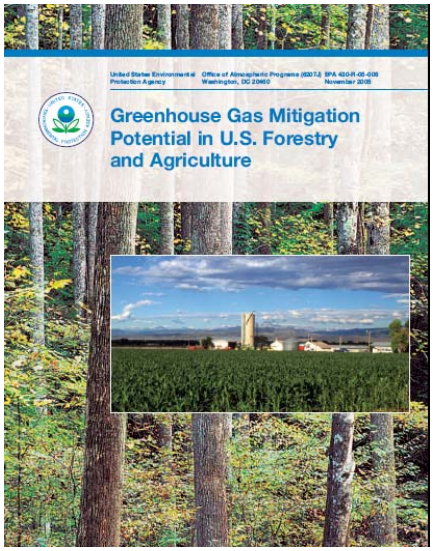
Agriculture and forestry sector modeling

Agriculture, forestry, and bioenergy mitigation supplies

(as well as liquid and solid energy supplies from biomass)

- Detailed representation of emissions, [illegible] technologies
- [illegible]ferences
- [illegible]on (i.e., opportunity [illegible] between mitigation options
- Land related investment decisions

Principal source of analysis



- Most (if not all) domestic economy-wide analyses with ag and forestry mitigation use the EPA 2005 report (FASOMGHG)

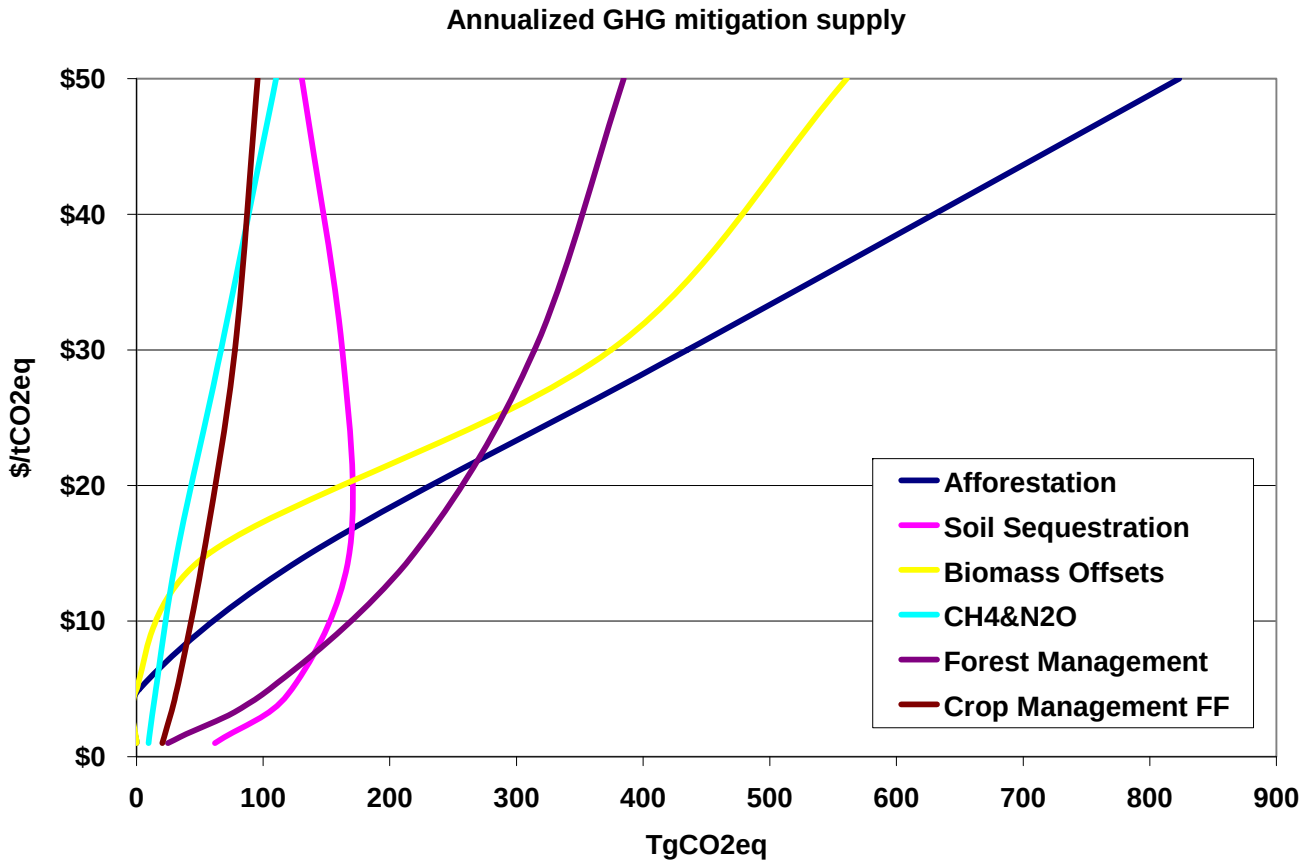
- New estimates under development with updated model – FASOMGHG2 (EPRI collaboration with Duke University's Nicholas Institute, and Texas A&M University)

Modeling competitive mitigation potential – FASOMGHG2

- FASOMGHG2 – U.S. **F**orest and **A**gricultural **S**ector **O**ptimization **M**odel with **GHG**s
  - Simultaneously examines land-based GHG strategies in the U.S.
    - Land is allocated between activities (and combined with other inputs) based on relative rents (including GHG payments) and suitability to maximize intertemporal welfare
  - Sectors
    - Forest — approximately 80 log and wood products markets
    - Agriculture – crops and animal products
      - over 70 primary and about 60 processed commodities, 20 processed feeds
  - 63 US regions (11 previously) and international trade with 28 major trading partners
  - Bioenergy options
    - Forestry & agricultural dedicated and residue feedstocks
    - Multiple liquid and solid conversion technologies, including 1st and 2nd generation biofuels
  - 3 GHG markets — CO_2, N_2O, CH_4

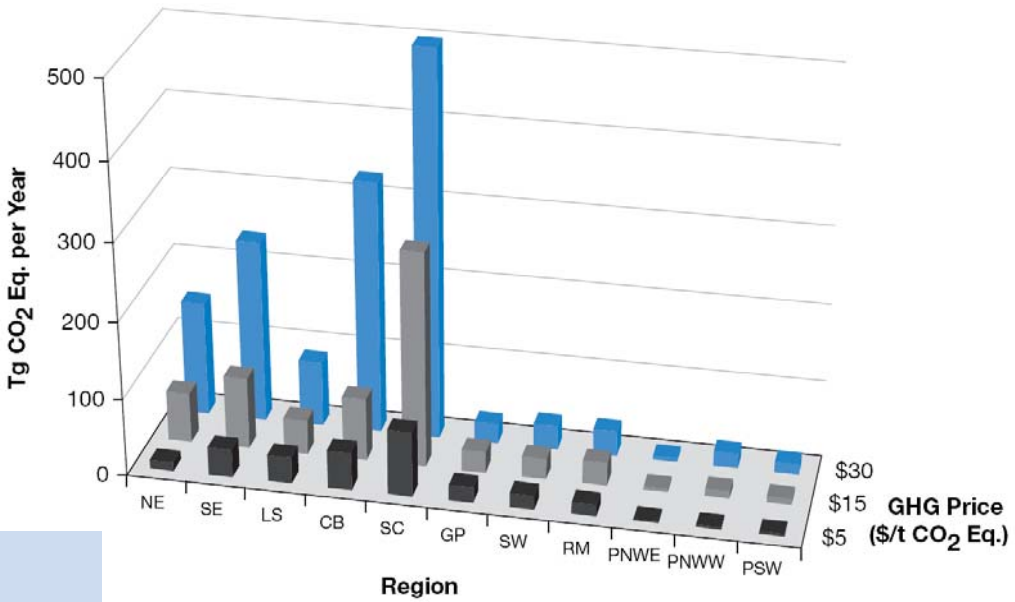
- The model has a long, robust history
  - Ag sector model development begun in 1974
  - Forest sector model development begun in 1995
  - Dozens of peer reviewed papers generated

Competitive mitigation potential –
Technologies interact (via input and commodity markets)



Source: EPA 2005 report

Regionally unique mitigation opportunities –
not uniformly distributed across the country



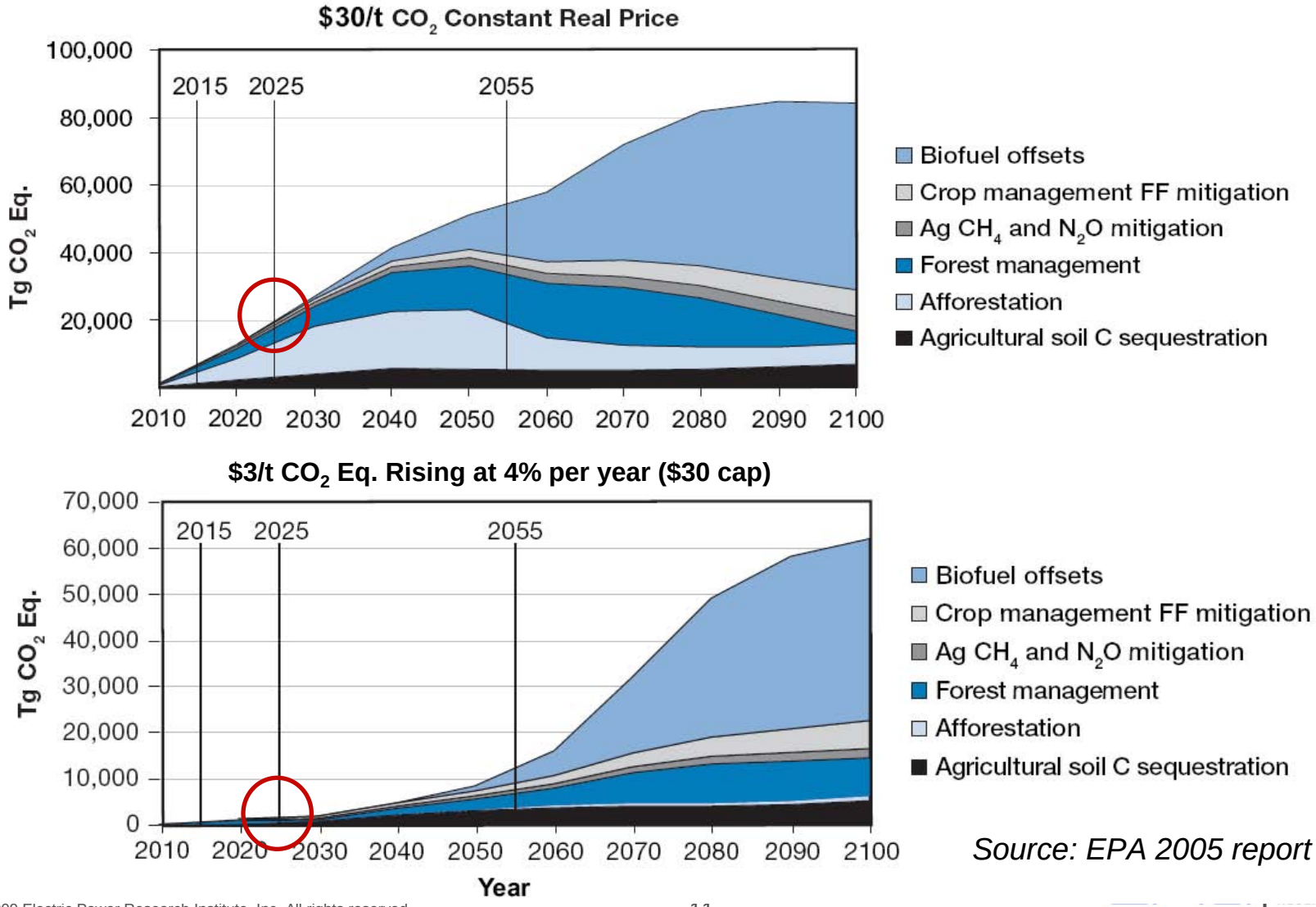
CB	Corn Belt
NP	Northern Plains
LS	Lake States
NE	Northeast
PNWE	Pacific Northwest-east side
PNWW	Pacific Northwest-west side
PSW	Pacific Southwest
RM	Rocky Mountains
SC	South-Central
SE	Southeast
SW	Southwest

Source: EPA 2005 report

Annualized $TgCO_2eq$

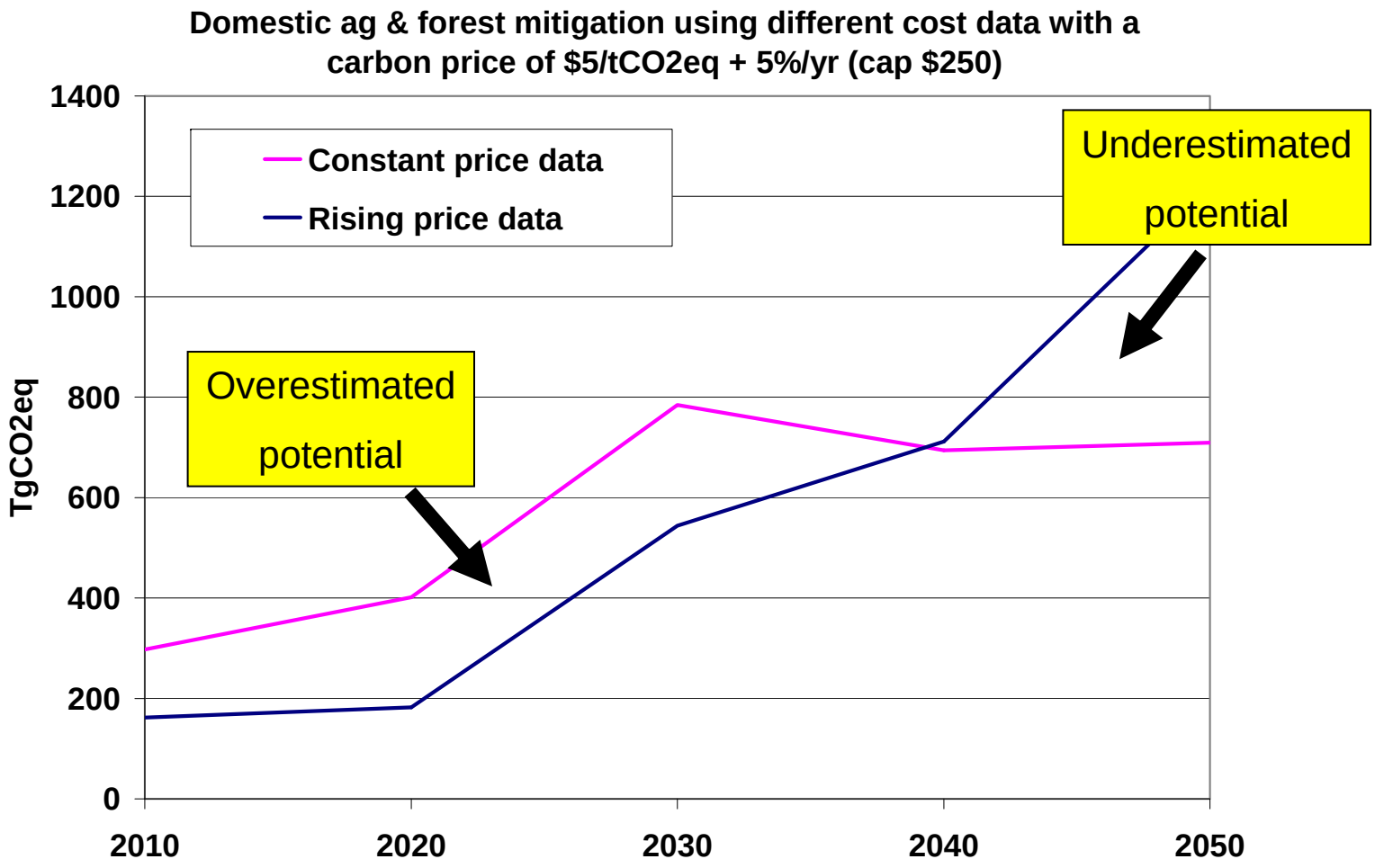
	$30
Afforestation	
CB	162.5
LS	14.9
PNWE	2.3
PSW	2.4
RM	11.8
SC	228.6
SE	12.4
US	434.8
Biofuel Offsets	
CB	51.1
GP	1.1
LS	19.3
NE	125.1
PNWE	0.1
PSW	0.0
RM	0.2
SC	69.9
SE	107.5
SW	0.3
US	374.6

Expectations matter
e.g., cumulative mitigation with constant & rising GHG prices



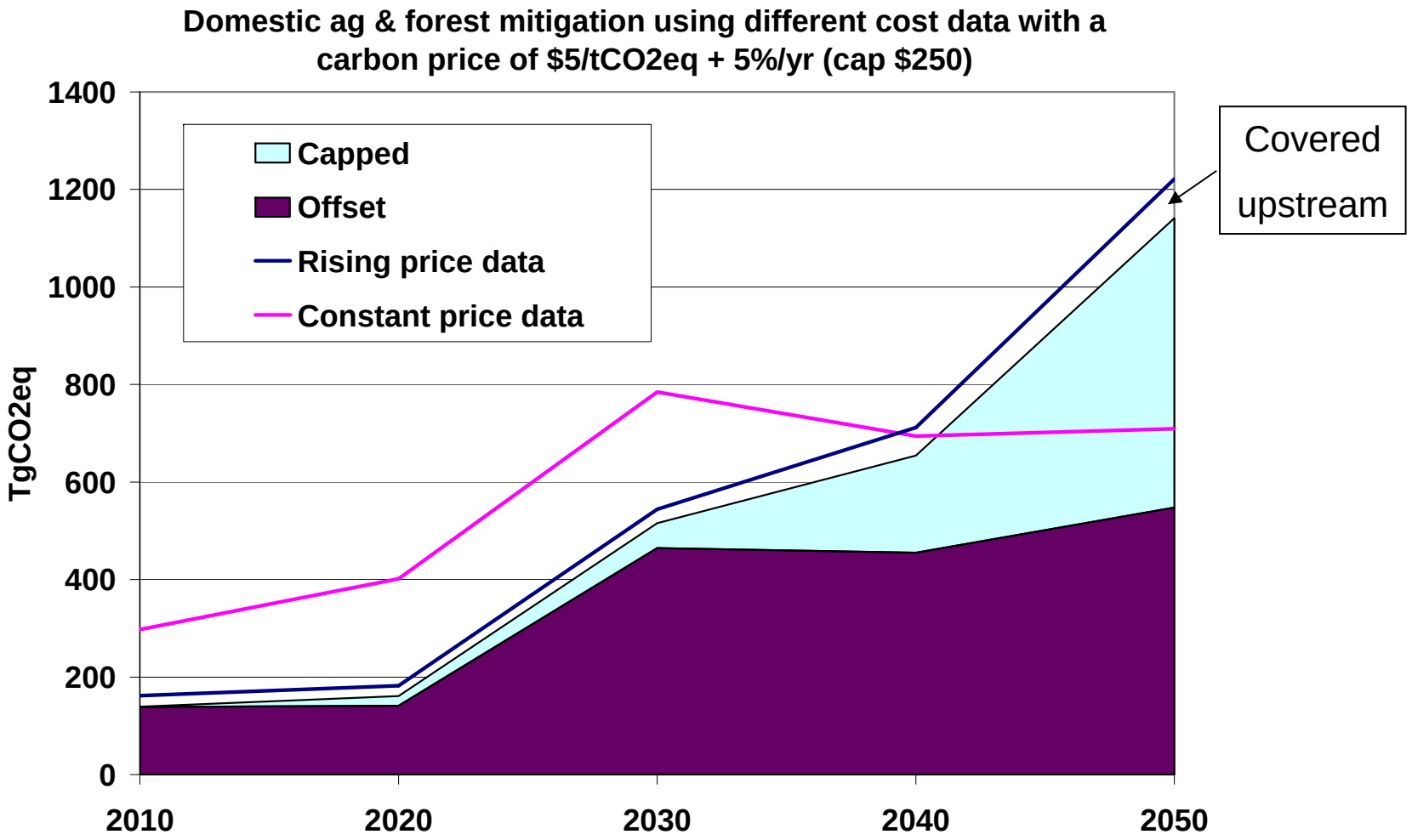
Source: EPA 2005 report

Ignoring price expectations is problematic



Source: S. Rose

Ignoring price expectations is problematic



Source: S. Rose

A new preliminary baseline – suggests more cropland

- Changing economic and policy environment and expectations
  - Higher energy prices due to global economic growth (AEO 2008)
  - Energy Independence and Security Act of 2007 (EISA) / Renewable Fuels Standard (RFS2)
  - Reduction of Conservation Reserve Program (CRP) land to 32 million acres – constrained by 2008 Farm Bill
  - Shift towards reduced tillage
  - Changes in agricultural product demand (increased) and mix (towards meat) – especially internationally
  - Lower autonomous crop productivity growth projections
  - Increase in Canadian timber harvests (due to pest outbreaks)
  - Other input updates (e.g., USDA ag prices/quantities/acreage, FIA forest inventory and RPA projections)

- New model structure – increased geographic, temporal, economic, and bioenergy resolution

- Implications (relative to 2005 report projections)
  - By 2050, more cropland, less pasture/range land, less private timberland
  - Decline in net US ag, forest, and bioenergy baseline emissions

Mitigation implications not yet know

- New results forthcoming – scenarios will evaluate overall cost containment potential of US ag & forestry offsets, limited eligible offset activities, offset supply constraints over time, energy and climate policy interactions, and regional land-use and market implications

- Net effect for legislation costs?
  - Potentially a reduced compliance burden – baseline US forest & ag emissions reduction
  - US forest & ag offset payments?
    - Some mitigation options may be more expensive – supplemental activity (beyond baseline) confronted with higher land prices and some reductions in the baseline
    - However, substantial potential there originally
  - Bioenergy supplies and fossil fuel use (on farm, upstream) affected as well
  - Overall offset supply if use constrained?

Additional considerations

- **Policy design**
  - **Energy-climate policy interaction**
    - Land-use complementarities/conflicts between RFS, RPS, and climate policy?
  - **"Regionality"**
    - Different offset opportunities and bioenergy supplies (feedstocks, conversion facilities, grid integration)
  - **International competition**
    - Cost of US ag/forest mitigation affected by international ag & forest GHG policies – could increase US ag & afforestation mitigation costs (Hertel et al., 2008)
  - **Annual vs. cumulative offset constraints (over the policy horizon)**
    - Annual constraints limit the fungibility of offsets and create a separate market
    - Cumulative constraints increase fungibility, allowing for offset banking/borrowing and lowering compliance costs
  - **RFS2 after the policy horizon?** – Does it end? Currently modeling as a post-2022 floor

- **Additional comments**
  - Transactions costs – Not modeled. Estimates lacking. Will vary by activity.
  - Scientific question of soil carbon benefits of tillage changes – are we overestimating carbon benefits for shifts to reduced tillage practices?

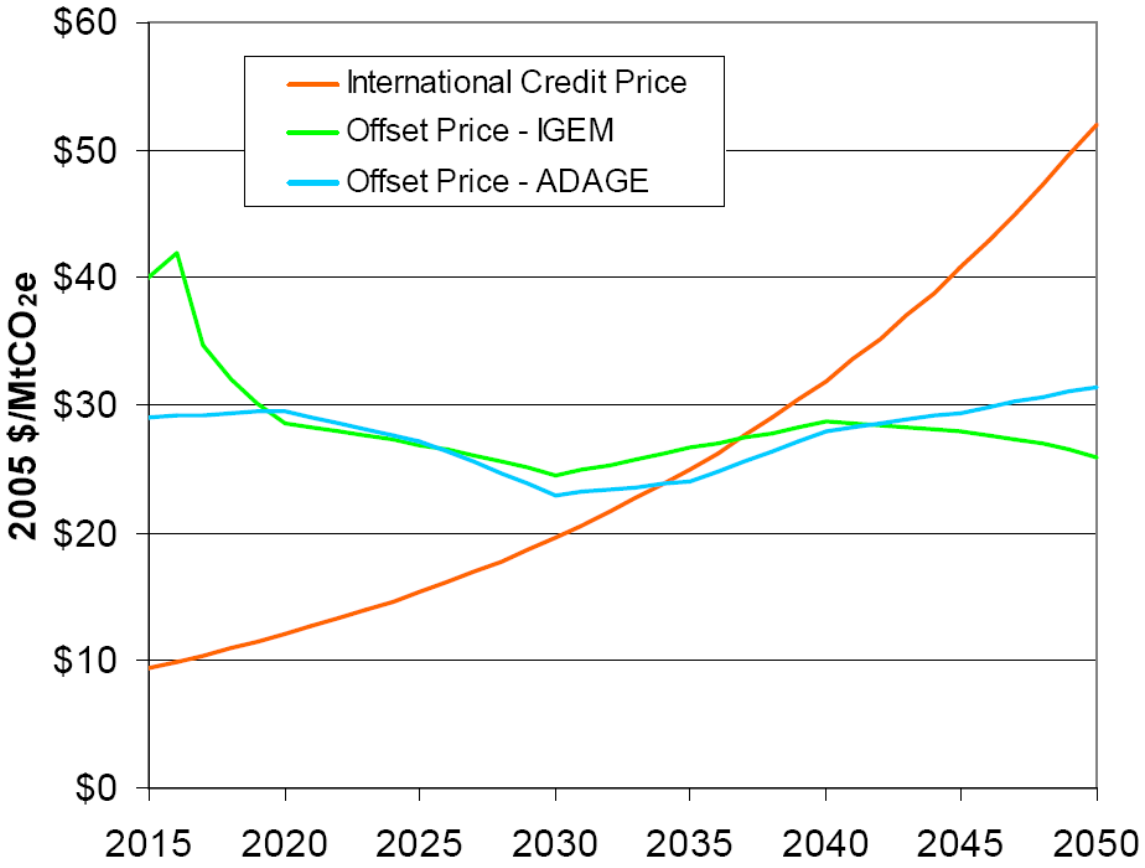
Summary remarks

- Significant interaction between technologies
- Prices expectations will influence land management decisions
- Energy policies will likely redefine mitigation potential
- Potentially significant GHG mitigation potential
- Preliminary revised baseline suggests lower national ag & forest emissions. Revised mitigation potential estimates in development. Potentially lower offset potential for some options and overall

- This kind of modeling informs policy design thinking about…
  - Relative potential of options
  - Evaluation of alternative policy designs (e.g., limited eligibility)
  - Leakage (e.g., 24% for afforestation only, EPA, 2005)
  - Regional and national baselines/additionality
  - Regional and national production, market, and welfare implications
  - Interactions between policies

Extra slides

Annual offset constraints create two GHG markets – allowance and offset



Allowance prices ($/MtCO$_2$eq)

2015: $29 - $40

2030: $61 - $83

2050: $159 - $220

Source: EPA's analysis of the Lieberman-Warner Climate Security Act of 2008 (S. 2191), http://www.epa.gov/climatechange/economics/economicanalyses.html