ELECTRIC POWER RESEARCH INSTITUTE

Biomass Supply for Power & Environmental Implications

Steven Rose
Global Climate Change Group, EPRI

With Bruce McCarl (Texas A&M University) and Greg Latta (Oregon State University)

EPRI Global Climate Change Research Seminar, Washington, DC
May 25, 2011

Key Questions

- How much biomass is available to the electric sector?

- Are there (supply-side) environmental implications?
  - For land-use?
  - For greenhouse gases?
  - For water?

- [Are there biofuel production implications?]

Public Context

- **Evaluation of fuel feedstock and generation options**

- **Complex bioenergy policy environment**
  - "Renewable" electricity
  - CAA Tailoring Rule and bioelectricity emissions
  - Climate change legislative proposals
  - Renewable fuels standard

- **Sensitive public issues**
  - Climate change concern
  - Energy security
  - Life-cycle GHG emissions
  - Forest land loss
  - Farm and forest sector income
  - Food security
  - Soils and water

How much biomass is available to the electric sector?

Approach

- Dynamic modeling of U.S. agriculture & forestry production & markets, including land-use allocation decisions
  - Simultaneous modeling of agriculture and forestry bioenergy feedstocks and end-uses – captures competition, complementarities, & co-products
- Sub-national resolution and international trade
- GHG accounting and abatement
- Policy baseline: EISA renewable fuels mandate imposed, Conservation Reserve Program (>30 mill acres)

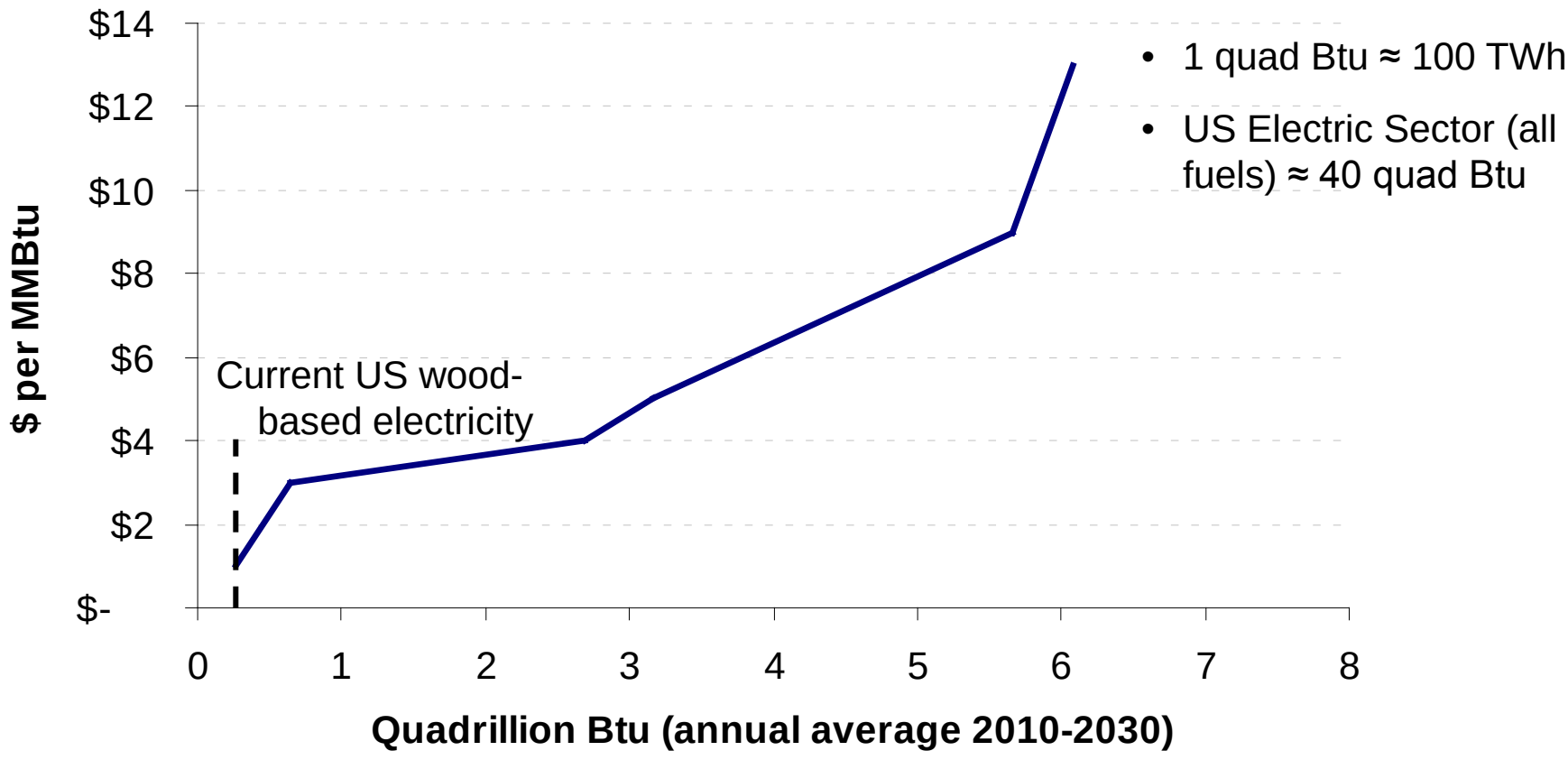
➔ **Estimating biomass supply for electricity (delivered to the power plant gate) with food, feed, and biofuel demands & production**

Biomass Feedstocks, Costs, GHG Value

~ 45 feedstocks	Ethanol	Cellulosic ethanol	Biodiesel	Bioelectricity
Starch- & Sugar-Based Crops	X			
Crop Residues		X		X
Energy Crops		X		X
Pulpwood		X		X
Logging Residues		X		X
Processing Residues		X		X
Oils & Fats			X	

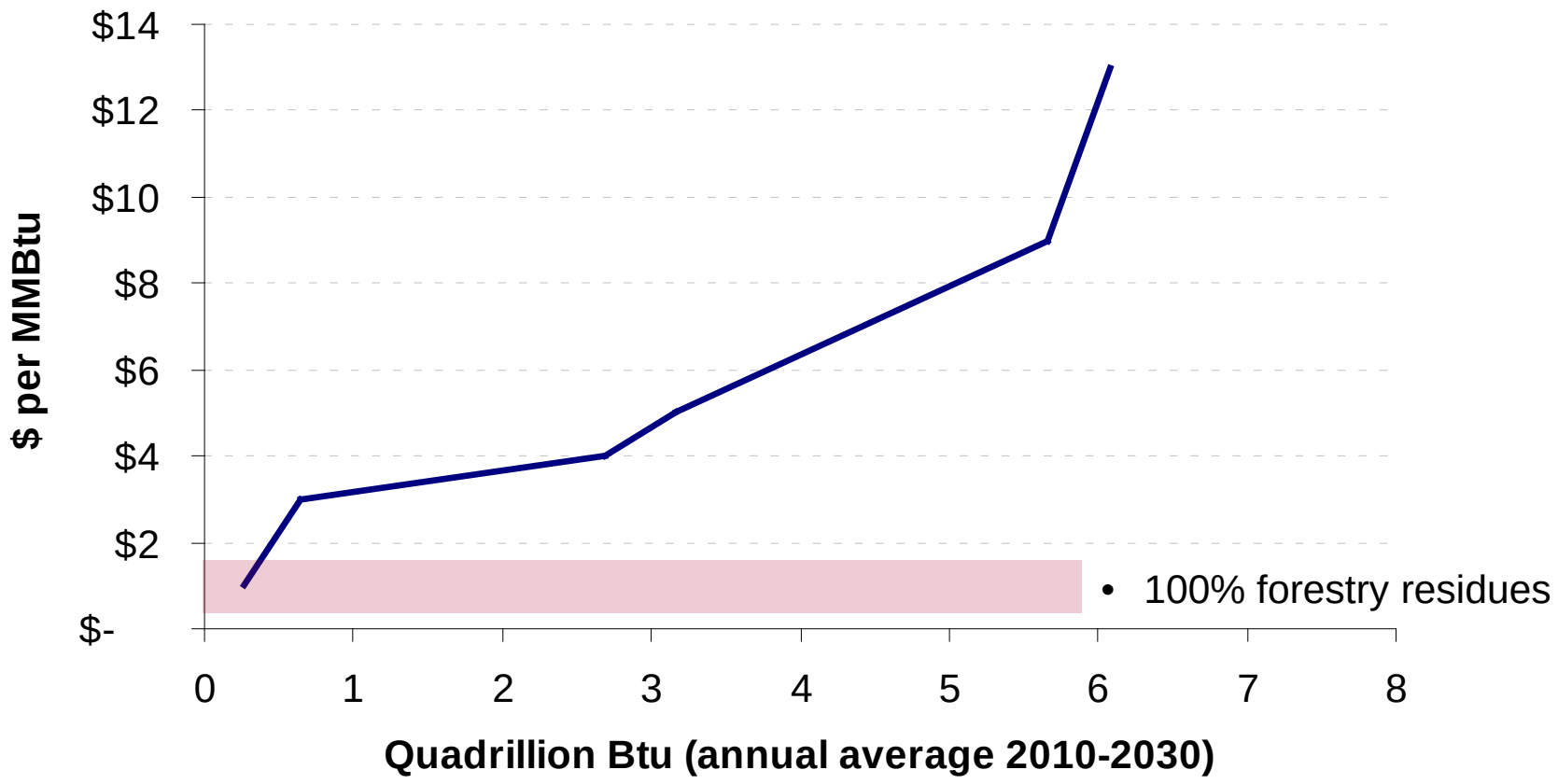
- Relative value of a feedstock a function of…
  - **Direct costs (harvesting, transportation, storage, processing)**
  - **Opportunity costs (commodity & GHG)**
  - **HHV**
  - **Moisture content**
  - **Energy prices**
  - **Co-products (e.g., oil, feed substitutes)**
  - **Direct GHG benefit if valued (e.g, ethanol vs. gasoline)**
  - **Net GHG effect if valued**

U.S. Biomass Supply for Electricity

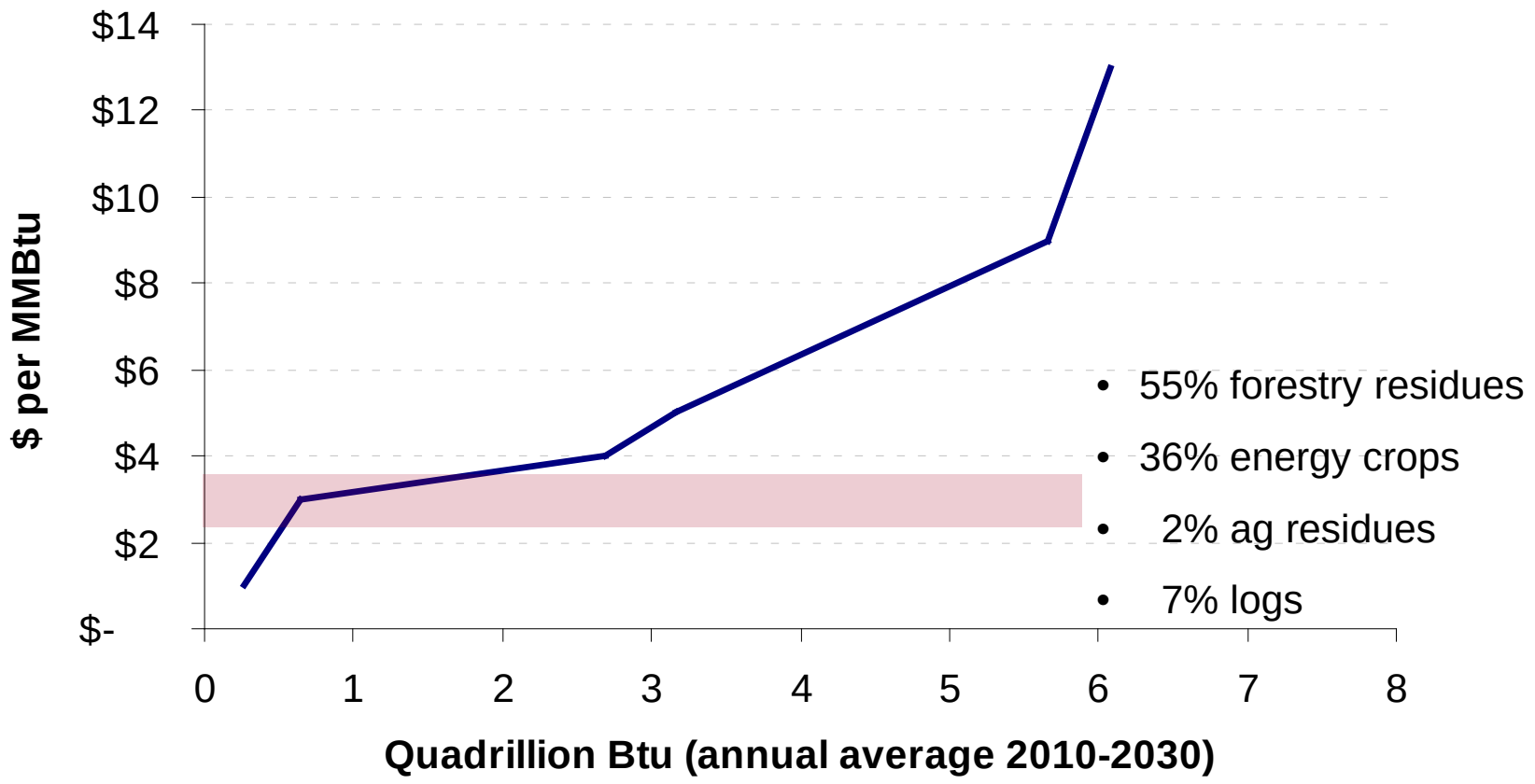


- 1 quad Btu ≈ 100 TWh
- US Electric Sector (all fuels) ≈ 40 quad Btu

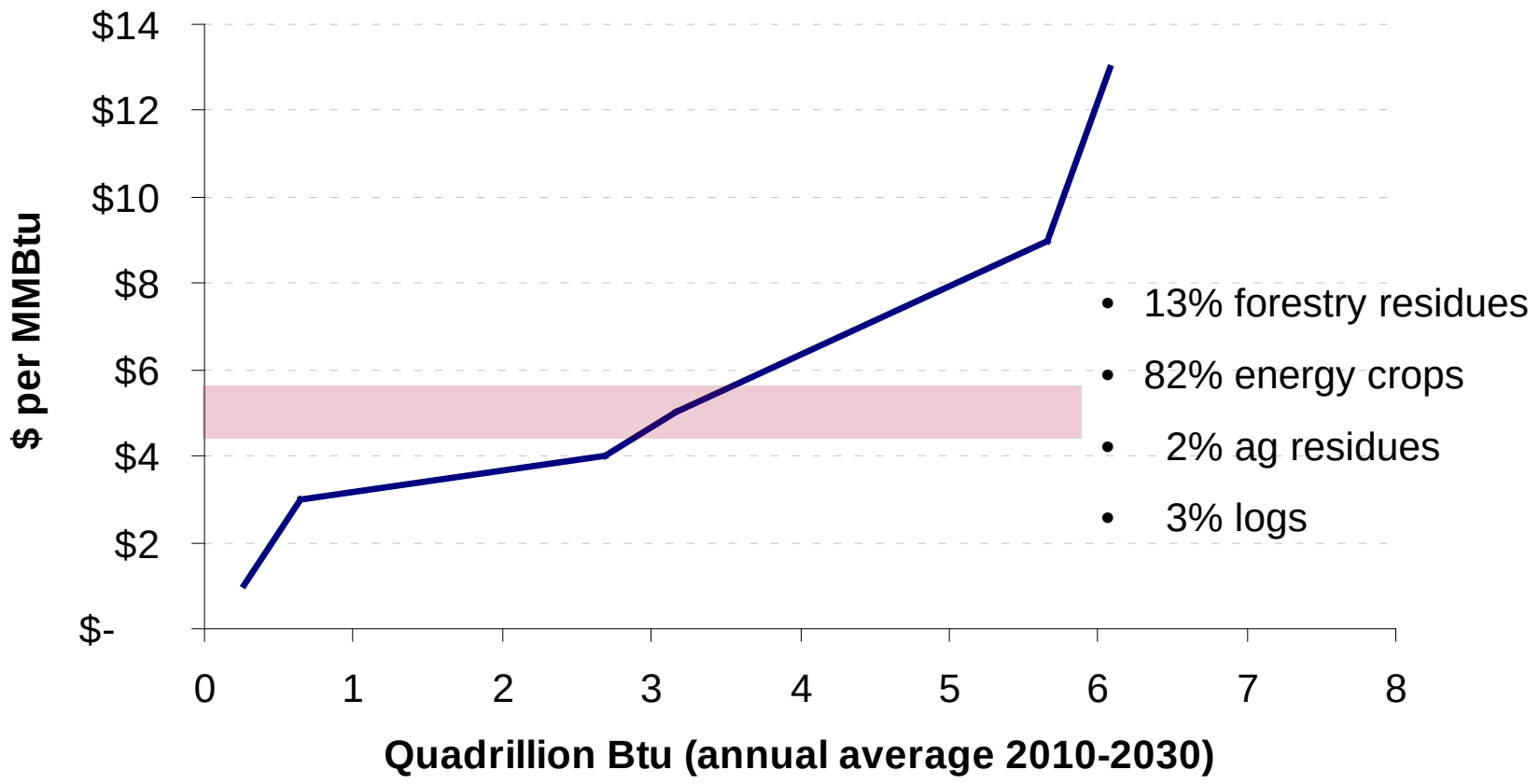
U.S. Biomass Supply for Electricity



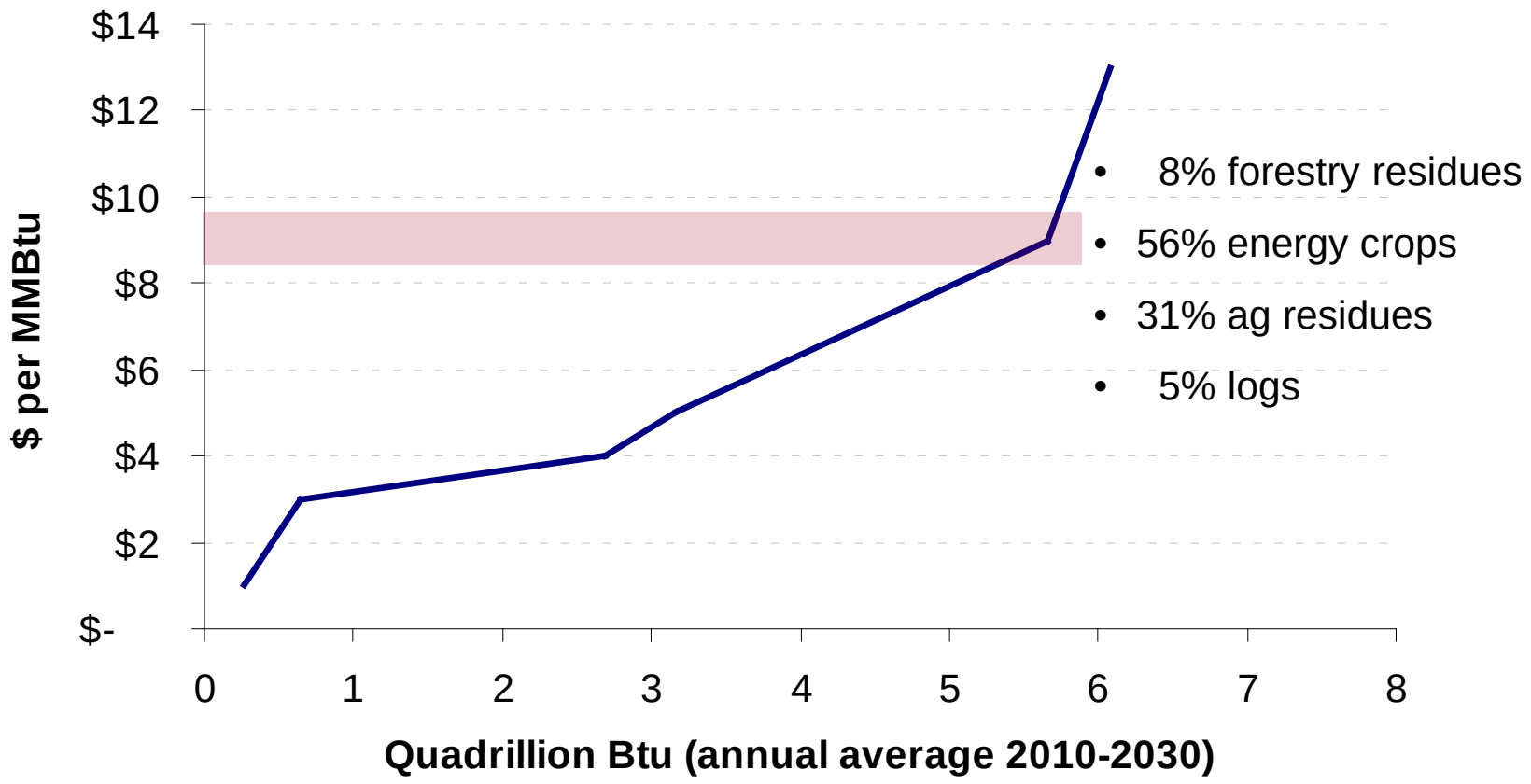
U.S. Biomass Supply for Electricity



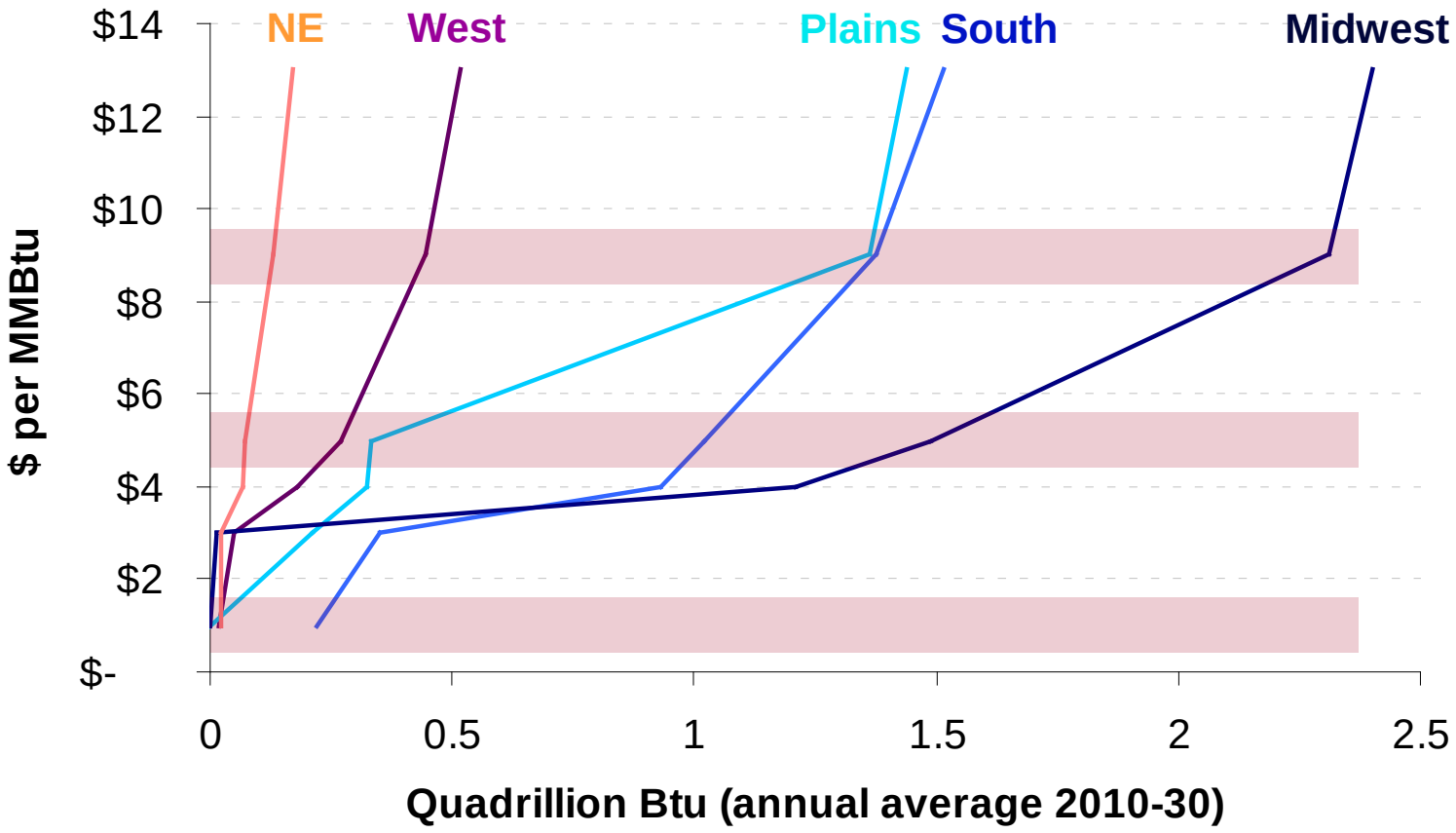
U.S. Biomass Supply for Electricity



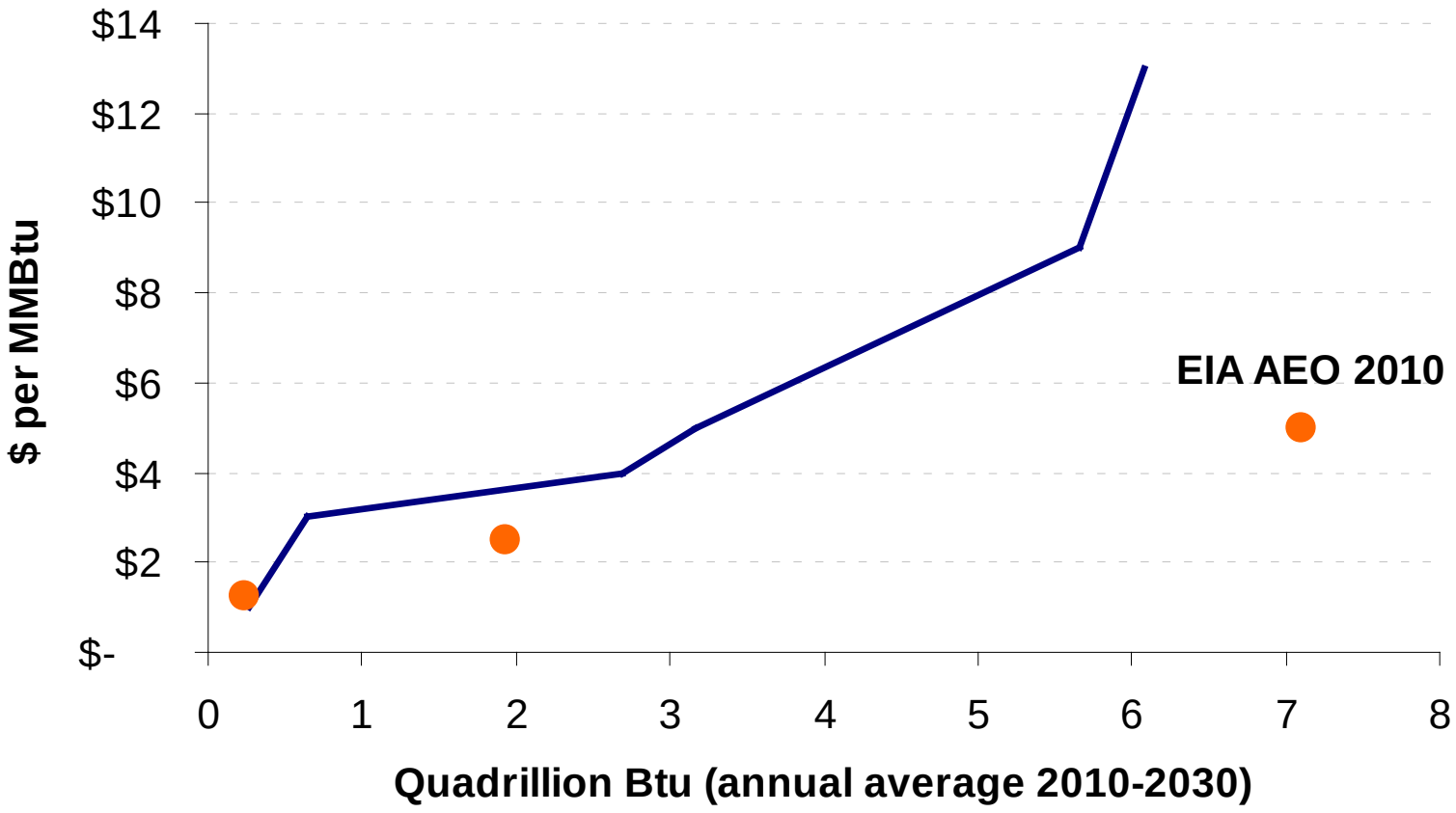
U.S. Biomass Supply for Electricity



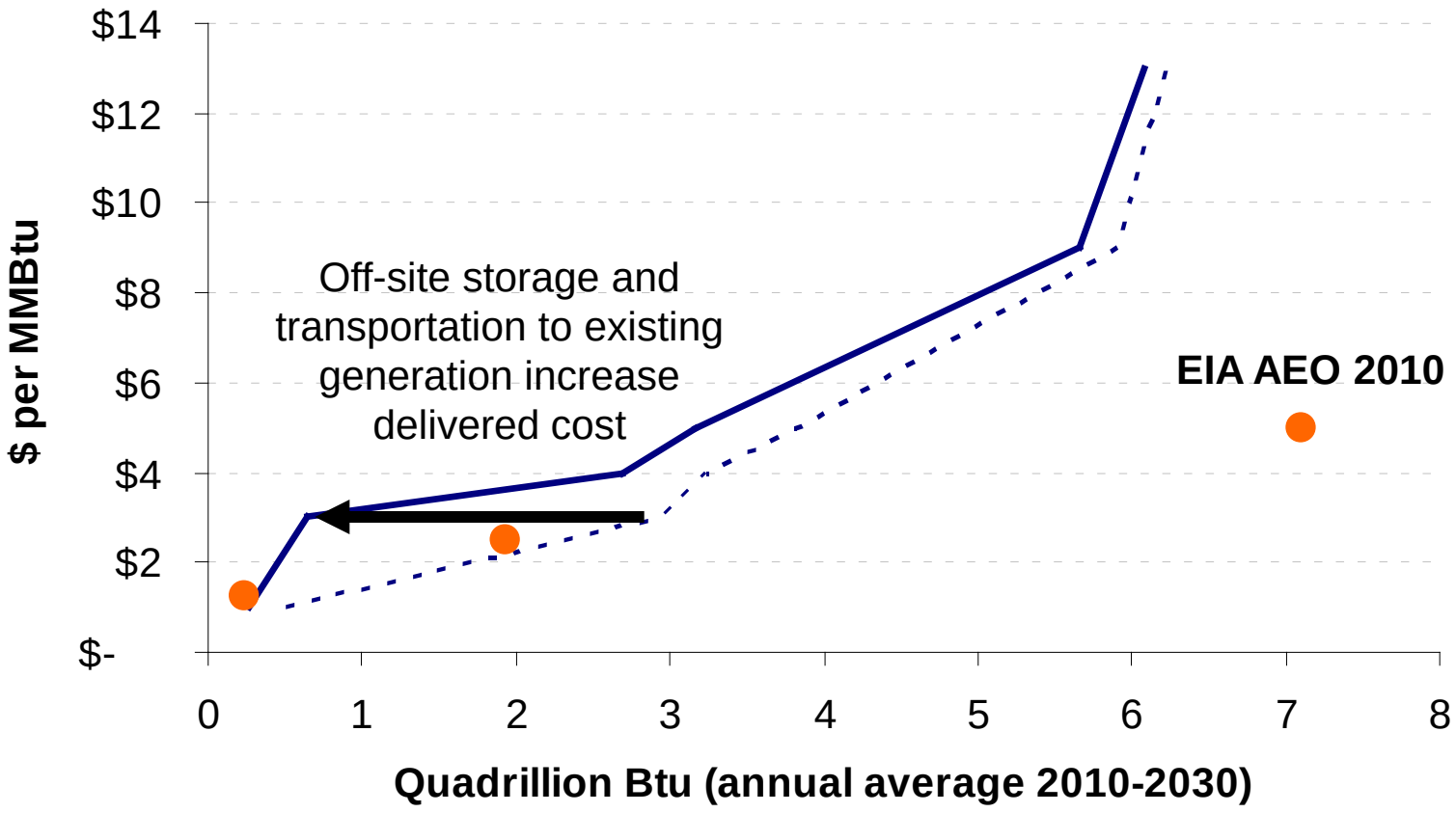
Largest Supplies in Midwest, South, Plains



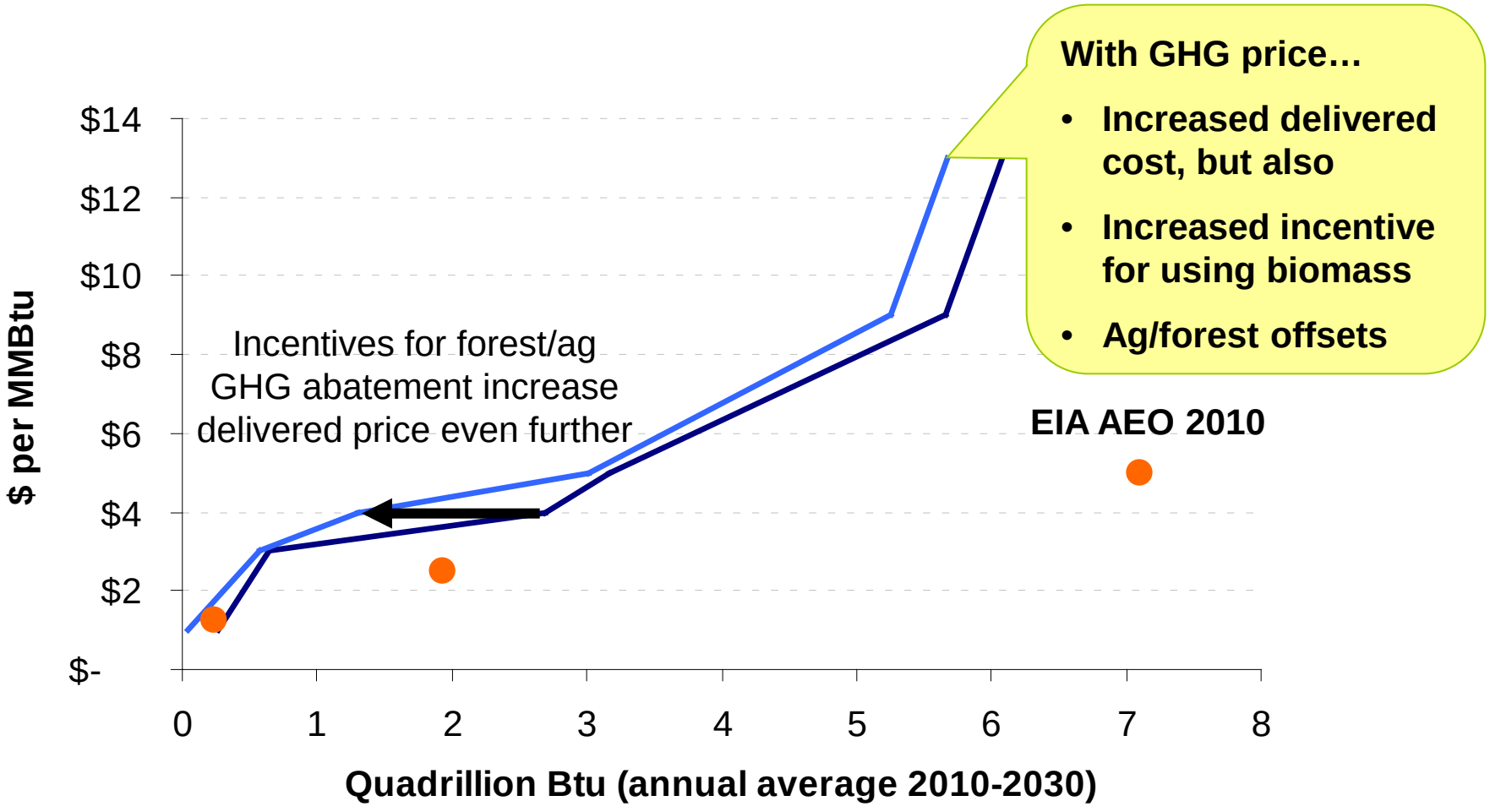
Our U.S. Estimate Over 50% Less EIA's



Part of the Difference – Storage & Transportation to Existing Generation

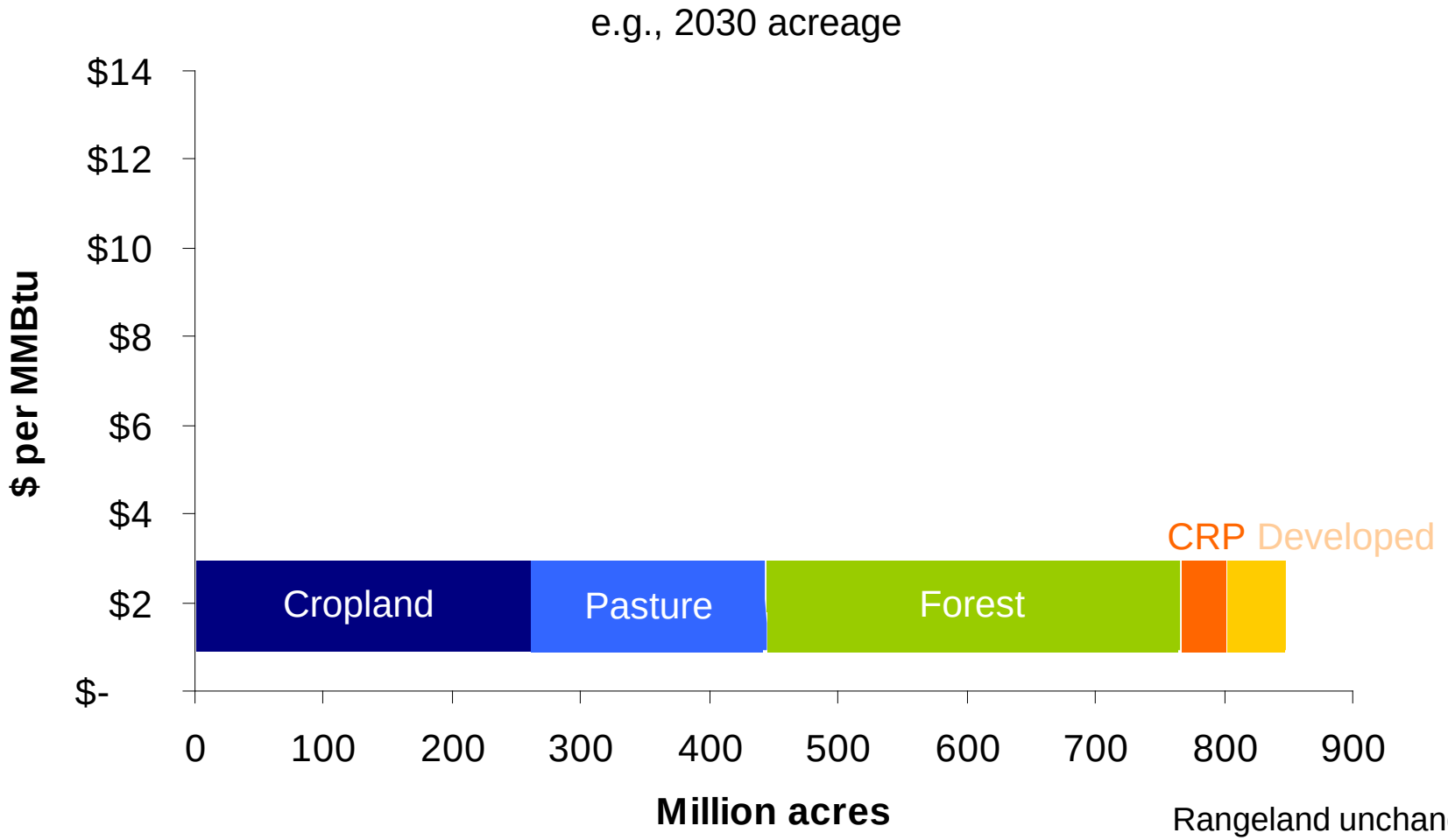


Another issue – GHG Incentives Can Increase Delivered Cost (e.g., $30/tCO$_2$e + 5% per year)



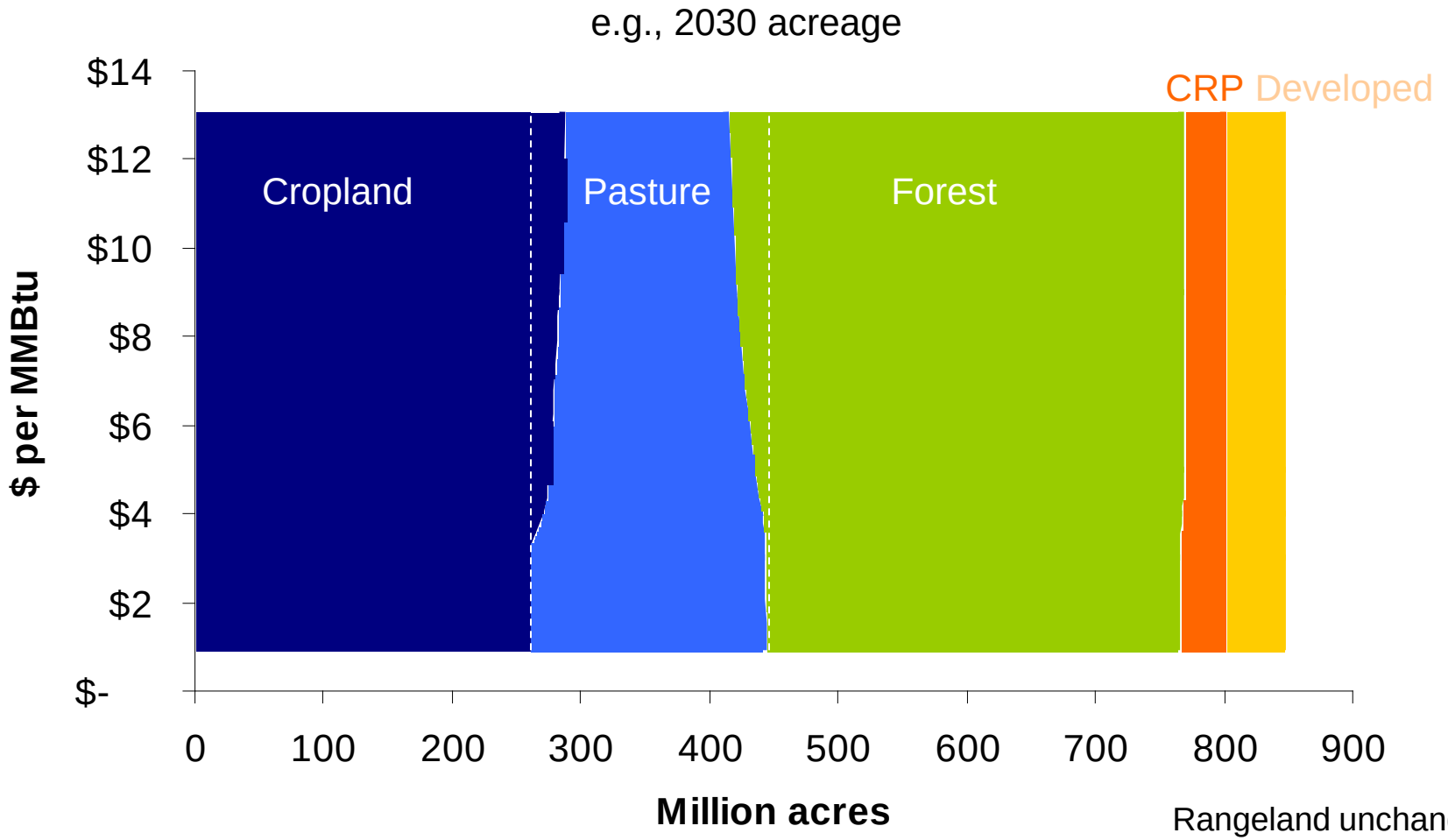
Are there (supply-side) environmental implications?

Nationally, Forest & Cropland Expand with Pasture Conversion as Bioelectricity Increases



Rangeland unchanged (not shown)

Nationally, Forest & Cropland Expand with Pasture Conversion as Bioelectricity Increases



Rangeland unchanged (not shown)

Direct GHG Offset of Fossil Fuels – GHG Beneficial but Not Neutral

Percent of fossil emissions offset per unit energy (e.g., Southeast)

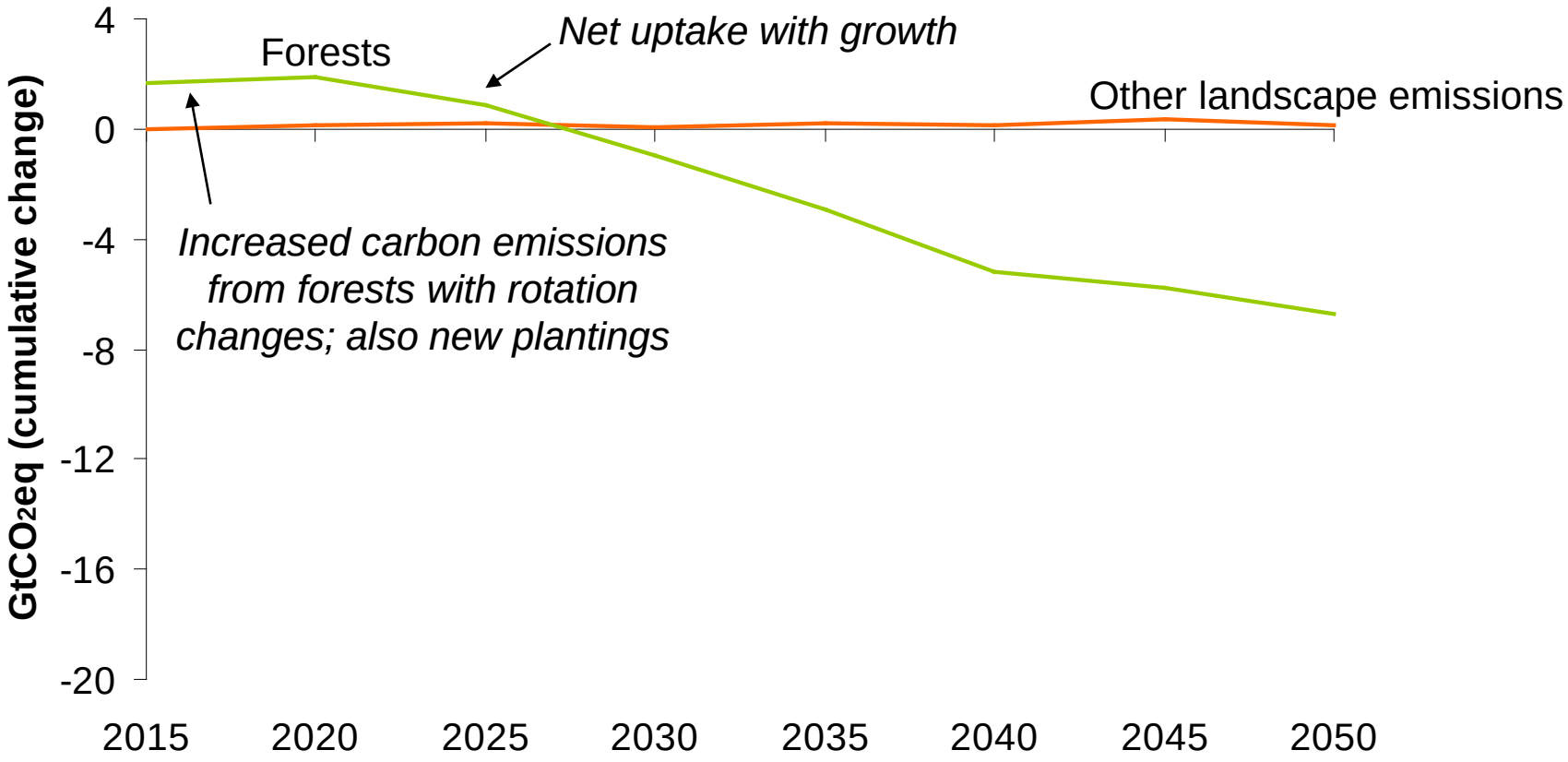
	100% bioelectricity
Corn	
Corn residue	97%
Softwood pulp	98%
Softwood harvest residue	98%
Softwood mill residue	99%
Switchgrass	92%

Included: production, hauling, processing fertilizer manufacture, feedstock conversion, and byproduct credit GHG emissions and carbon sequestration

Not included: land conversion and land management change GHGs (next slide)

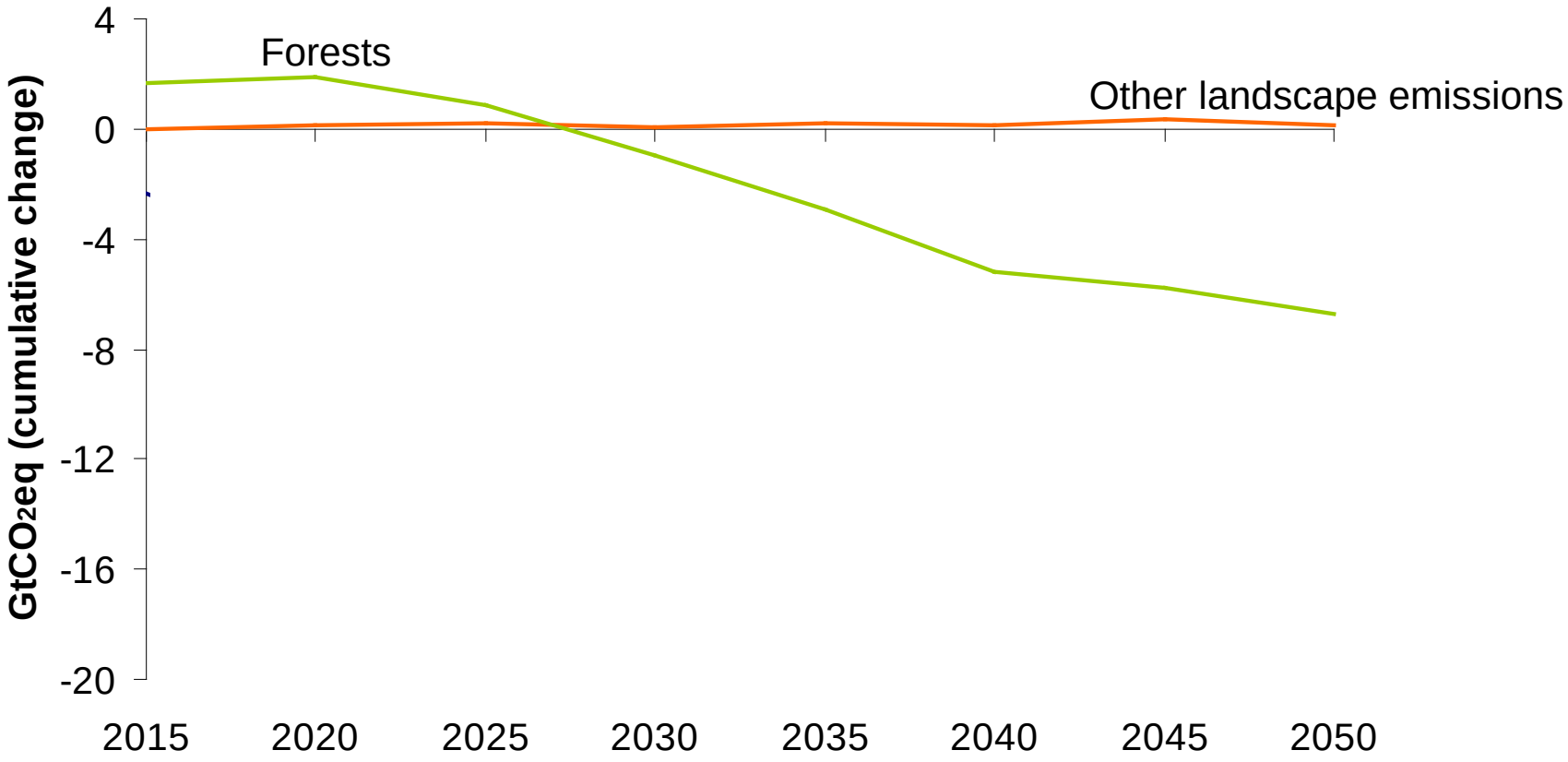
Indirect US Landscape GHG Changes – Driven by Forest Adjustments

Change in cumulative emissions w/ $9 vs. $1/MMBtu demand



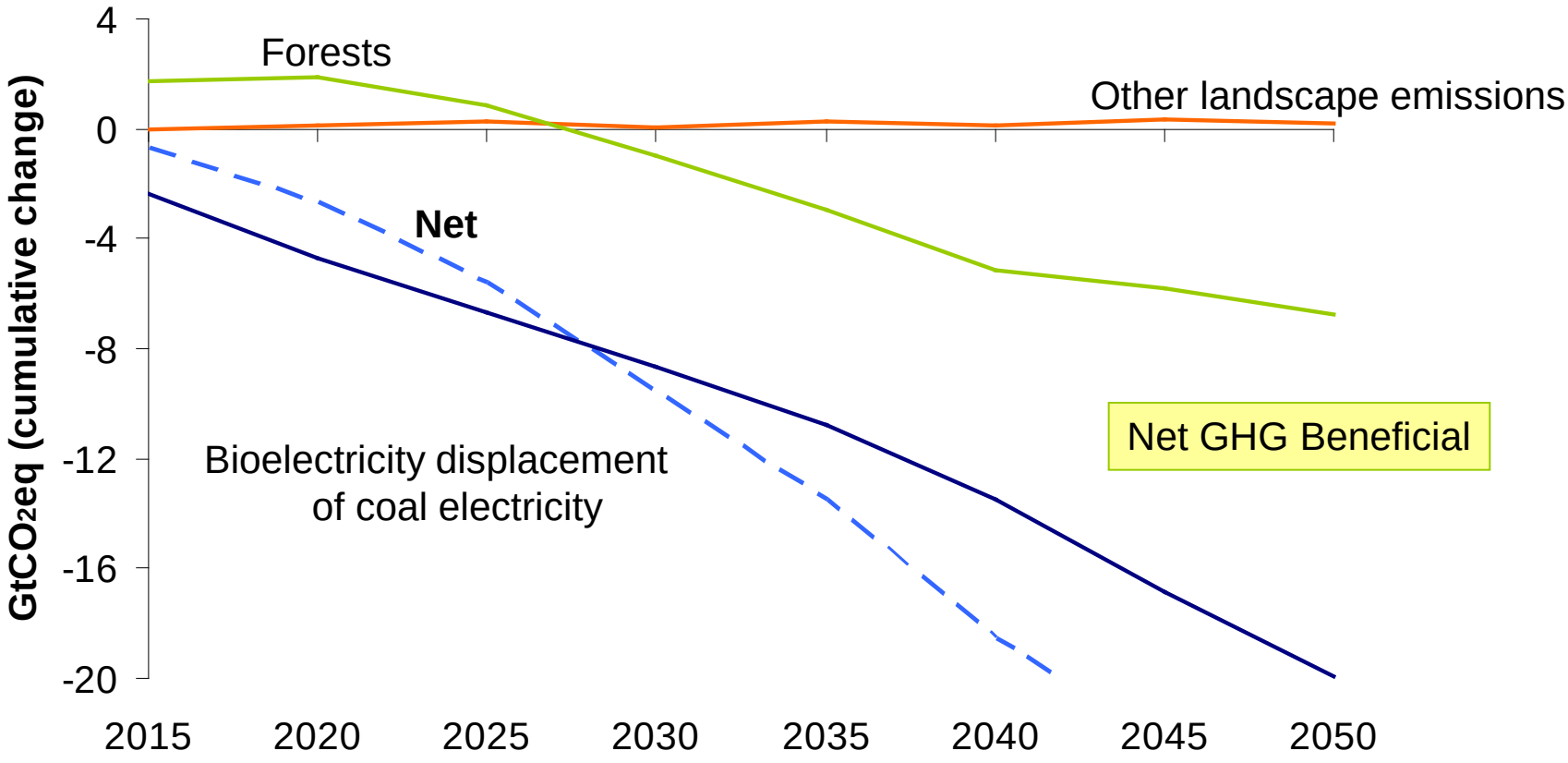
Net GHG Implications (US Direct + Indirect)

Change in cumulative emissions w/ $9 vs. $1/MMBtu demand

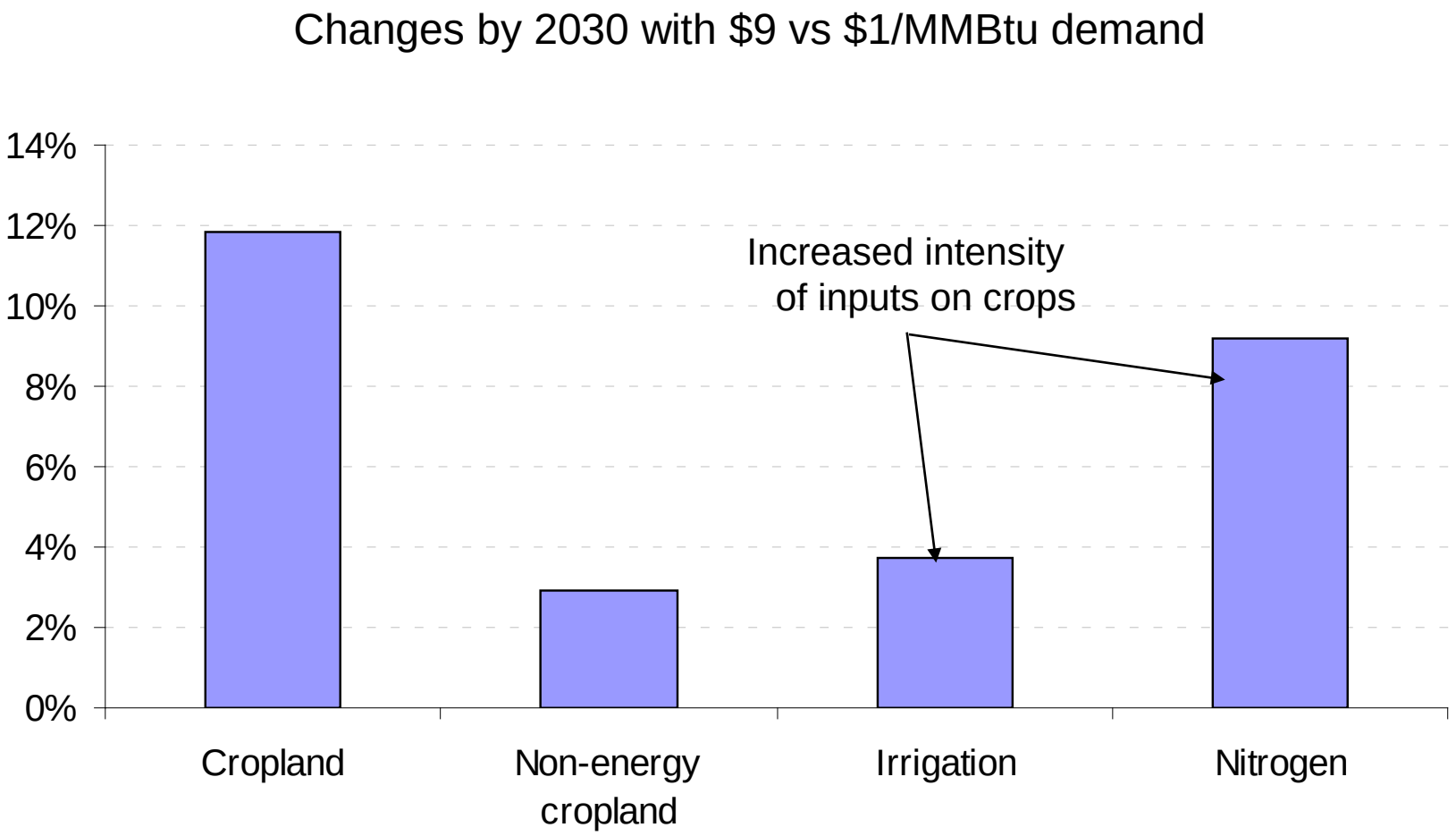


Net GHG Implications (US Direct + Indirect)

Change in cumulative emissions w/ $9 vs. $1/MMBtu demand

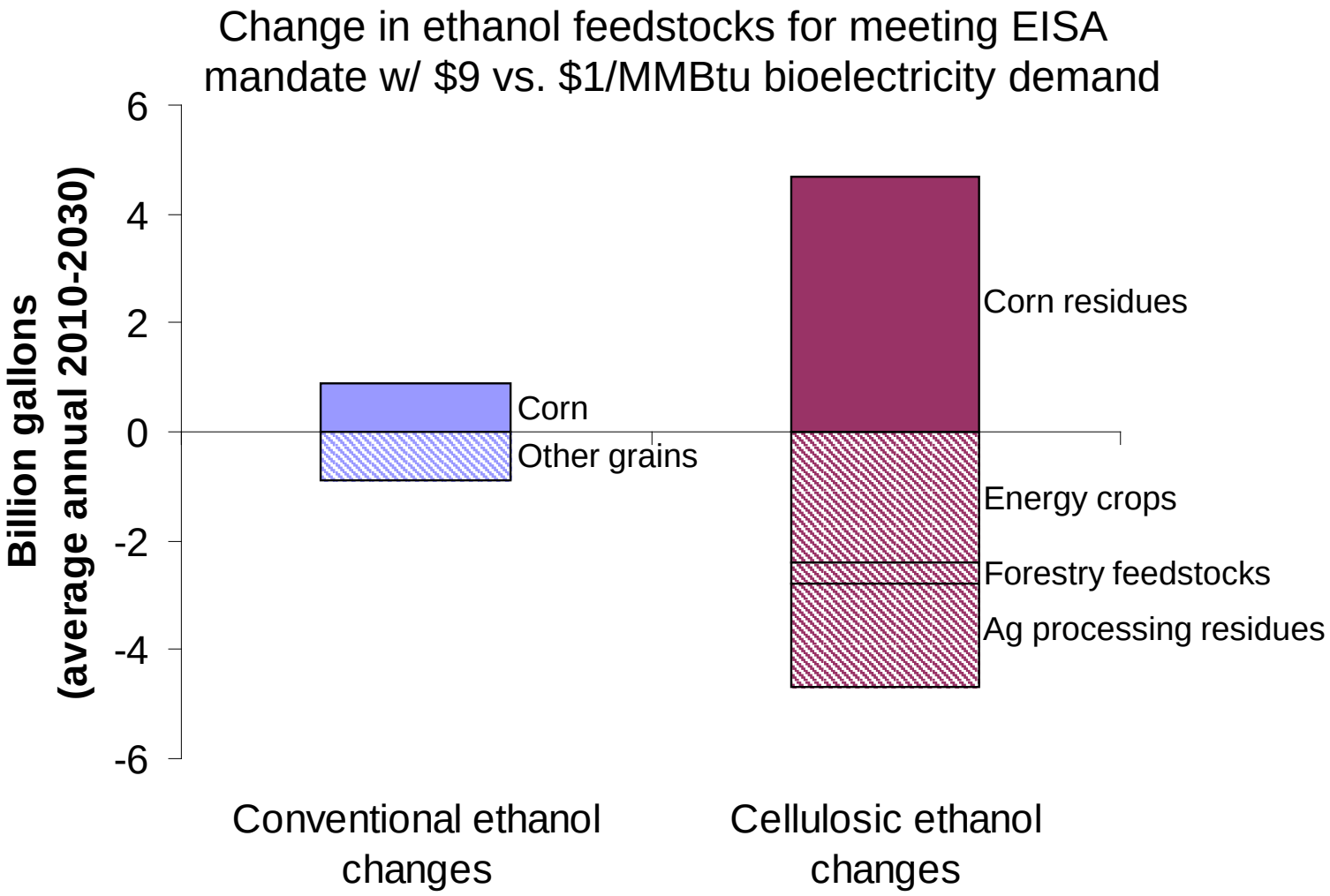


National Water and Nitrogen Implications with Increased Biomass Demand



Are there biofuel production implications?

Ethanol implications



Summary and Concluding Remarks

- Detailed economic modeling of U.S. agriculture & forestry markets, including multiple bioenergy feedstocks and land-use

Insights

- Cost of biomass feedstocks for generation far from straightforward and likely more expensive than previously estimated
- Variation in feedstocks & regional supply will be important
- Bioelectricity can…
  - Yield net gains in forests
  - Out-compete biofuels on a GHG basis (per unit energy)
  - Be net GHG beneficial in the U.S.
- Biofuels market likely affected
- Biomass end-use allocation and electricity penetration will depend on performance, cost, technology options, and policy

Together…Shaping the Future of Electricity