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Biomass Supply for Power & Environmental Implications

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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)

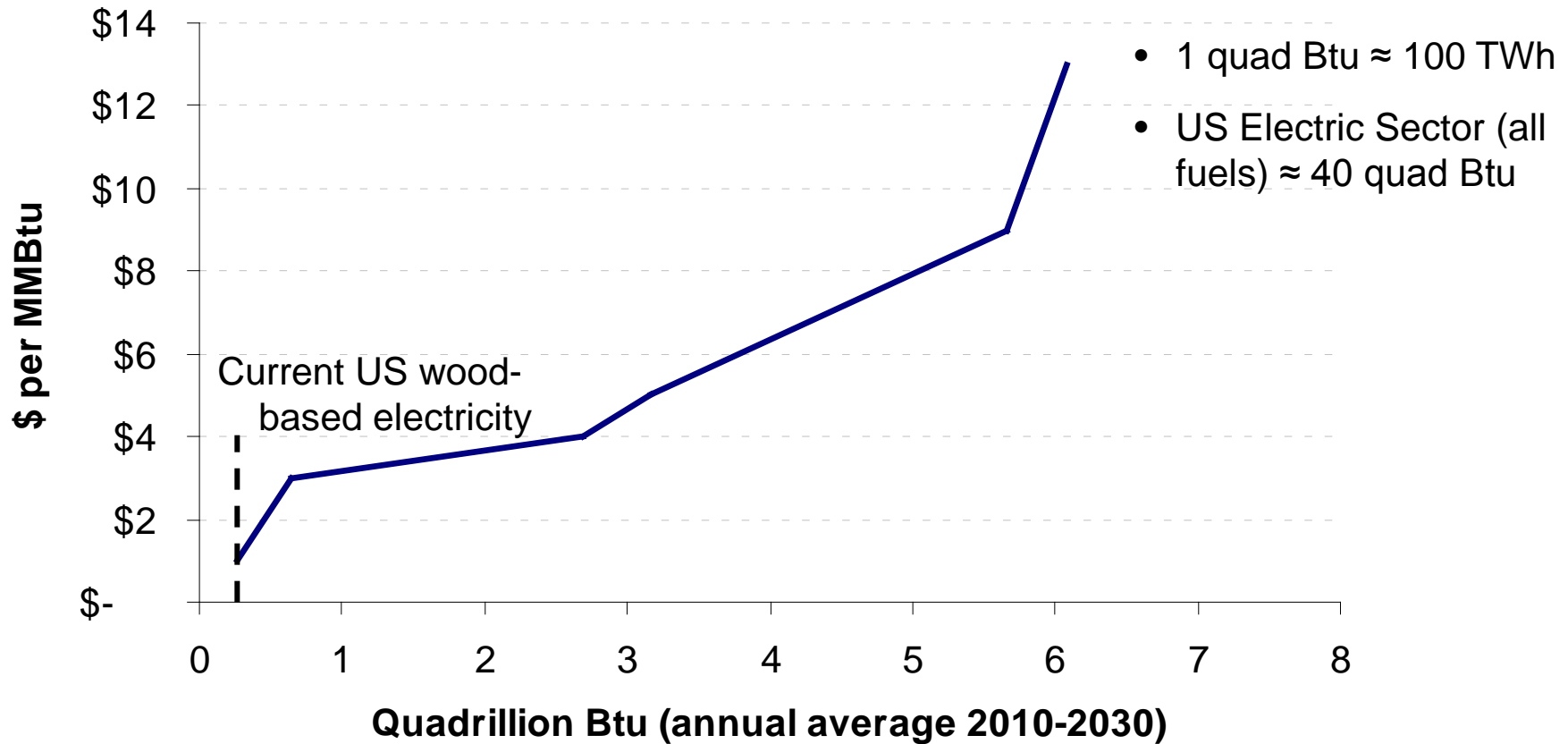
→ Estimating biomass supply for electricity (delivered to the power plant gate) with food, feed, and biofuel demands & production

Biomass Feedstocks, Costs, GHG Value

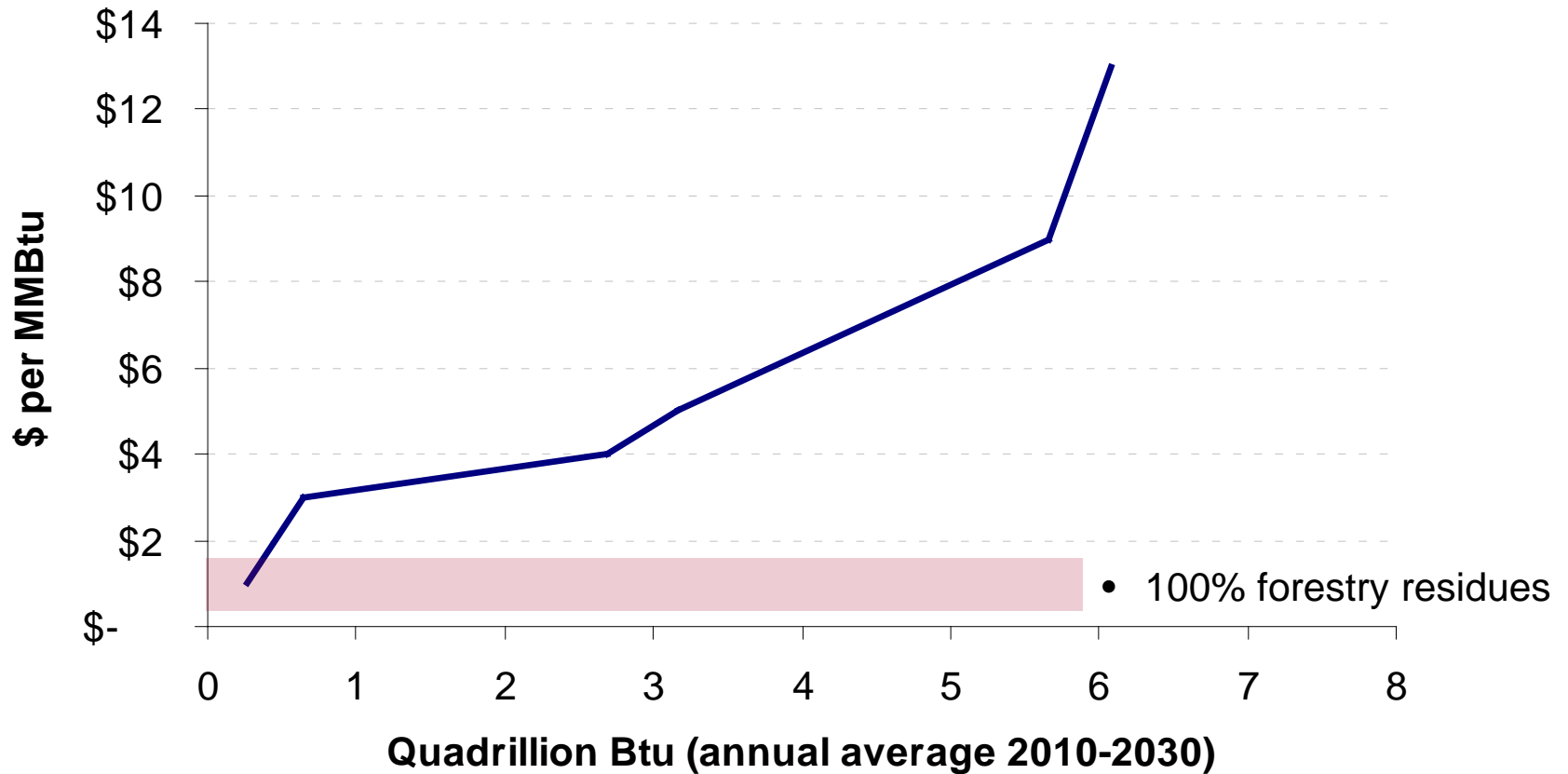
<i>~ 45 feedstocks</i>	Ethanol	Cellulosic ethanol	Biodiesel	Bioelectricity
Starch- & Sugar-Based Crops	X			
Crop Residues		X		X
Energy Crops		X		X
Pulpwood		X		X
Logging Residues		X		X
Processing Residues		X		X
Oils & Fats			X	

- 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

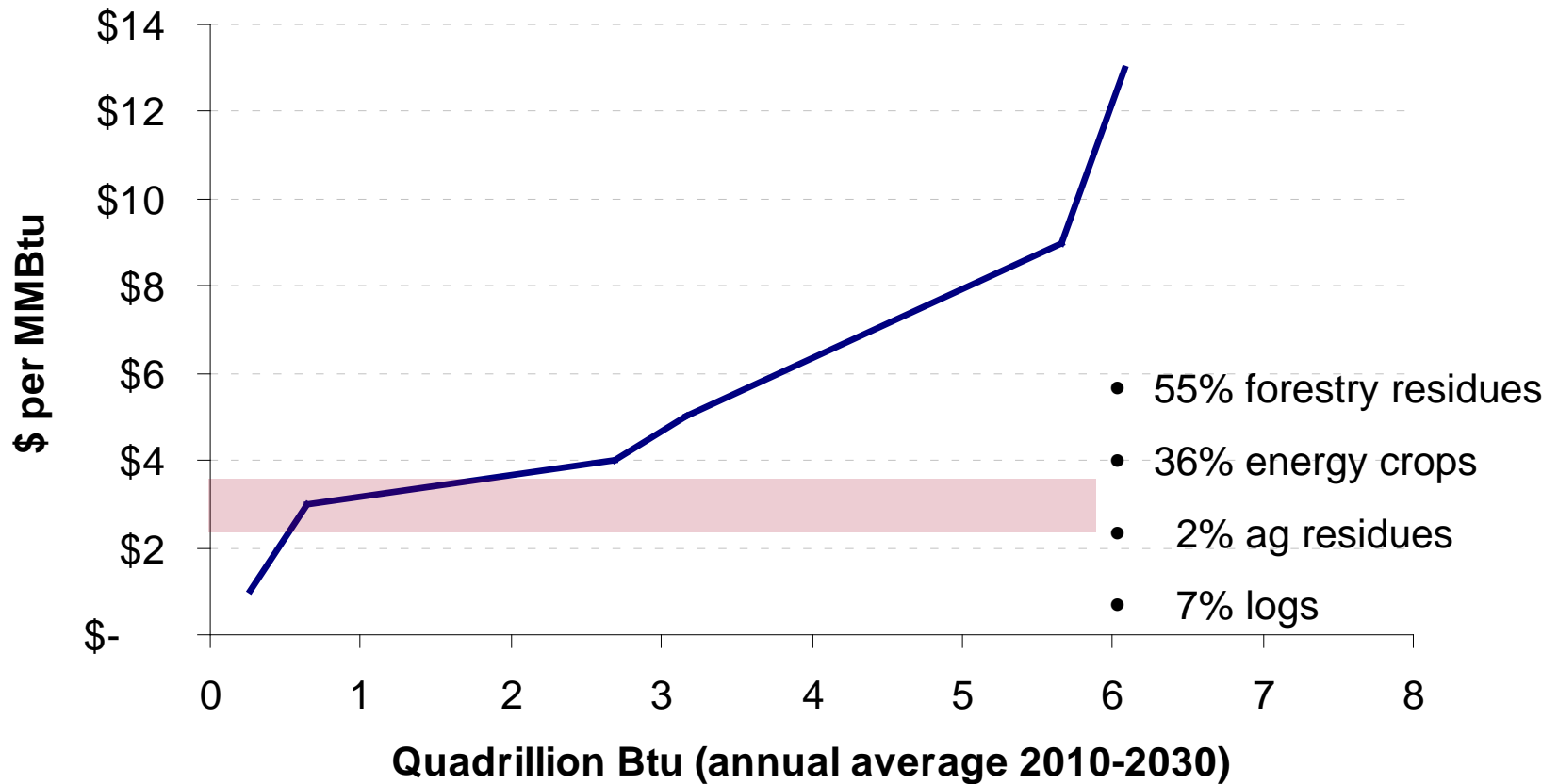
U.S. Biomass Supply for Electricity



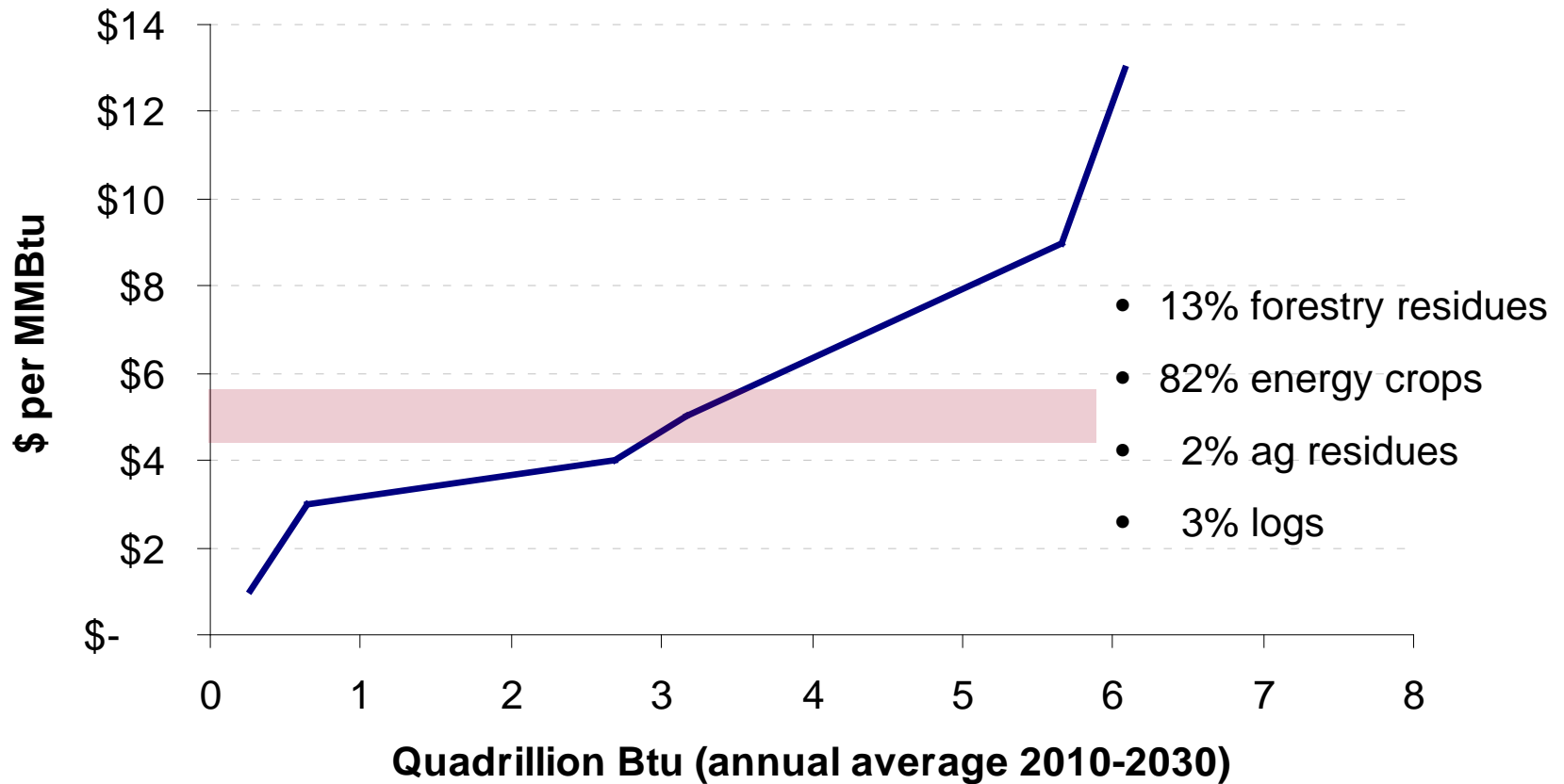
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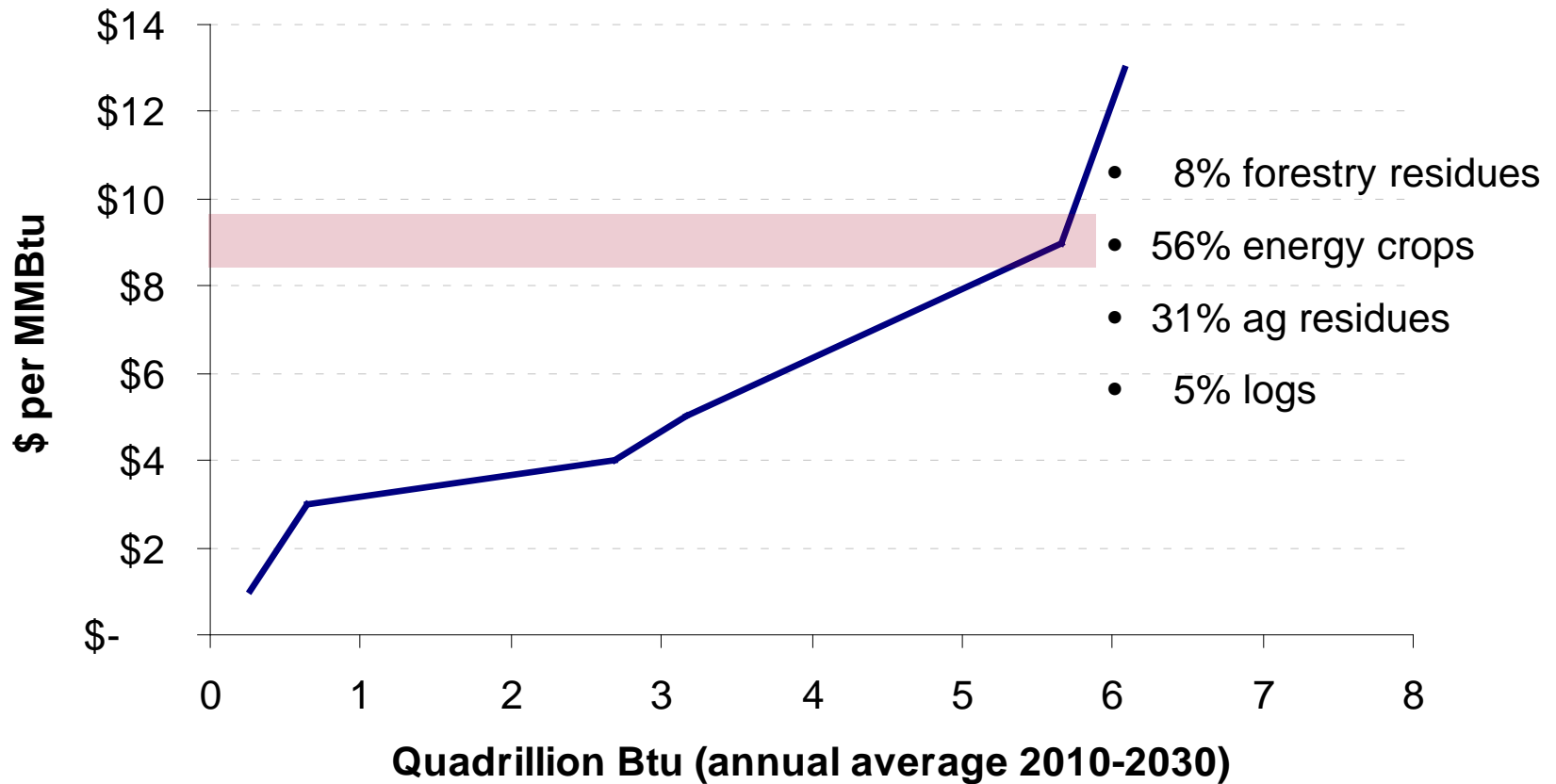
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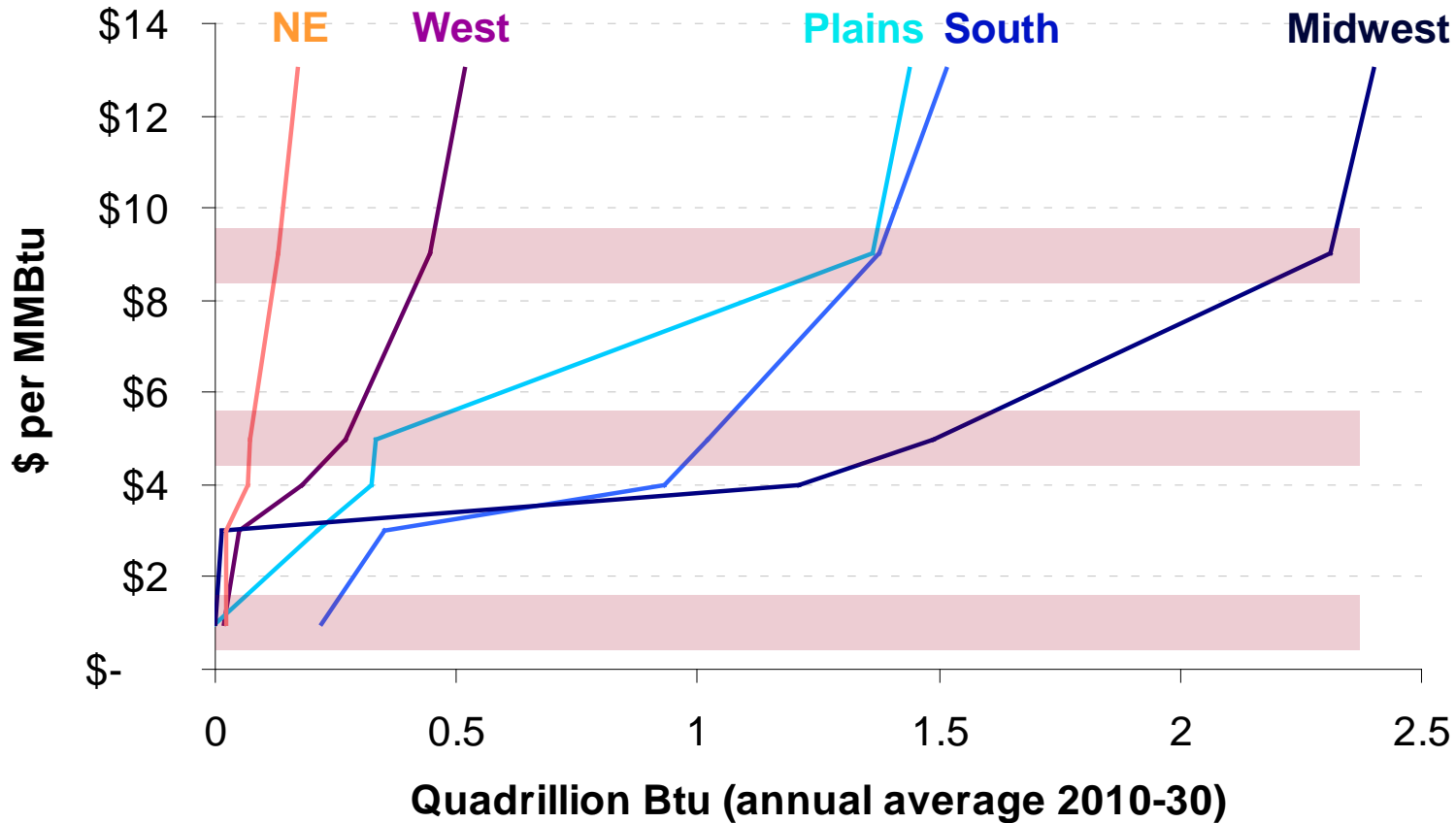
U.S. Biomass Supply for Electricity



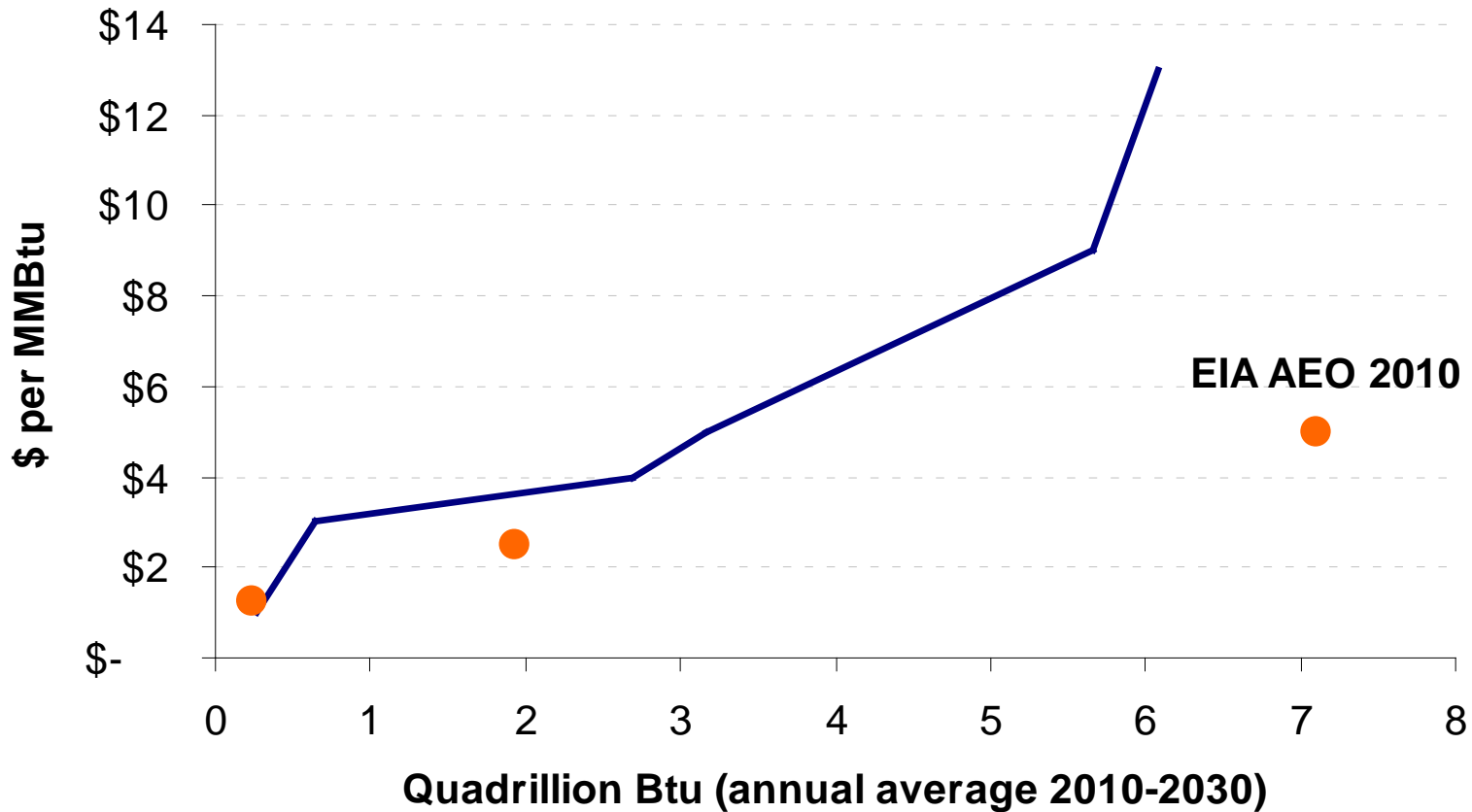
U.S. Biomass Supply for Electricity



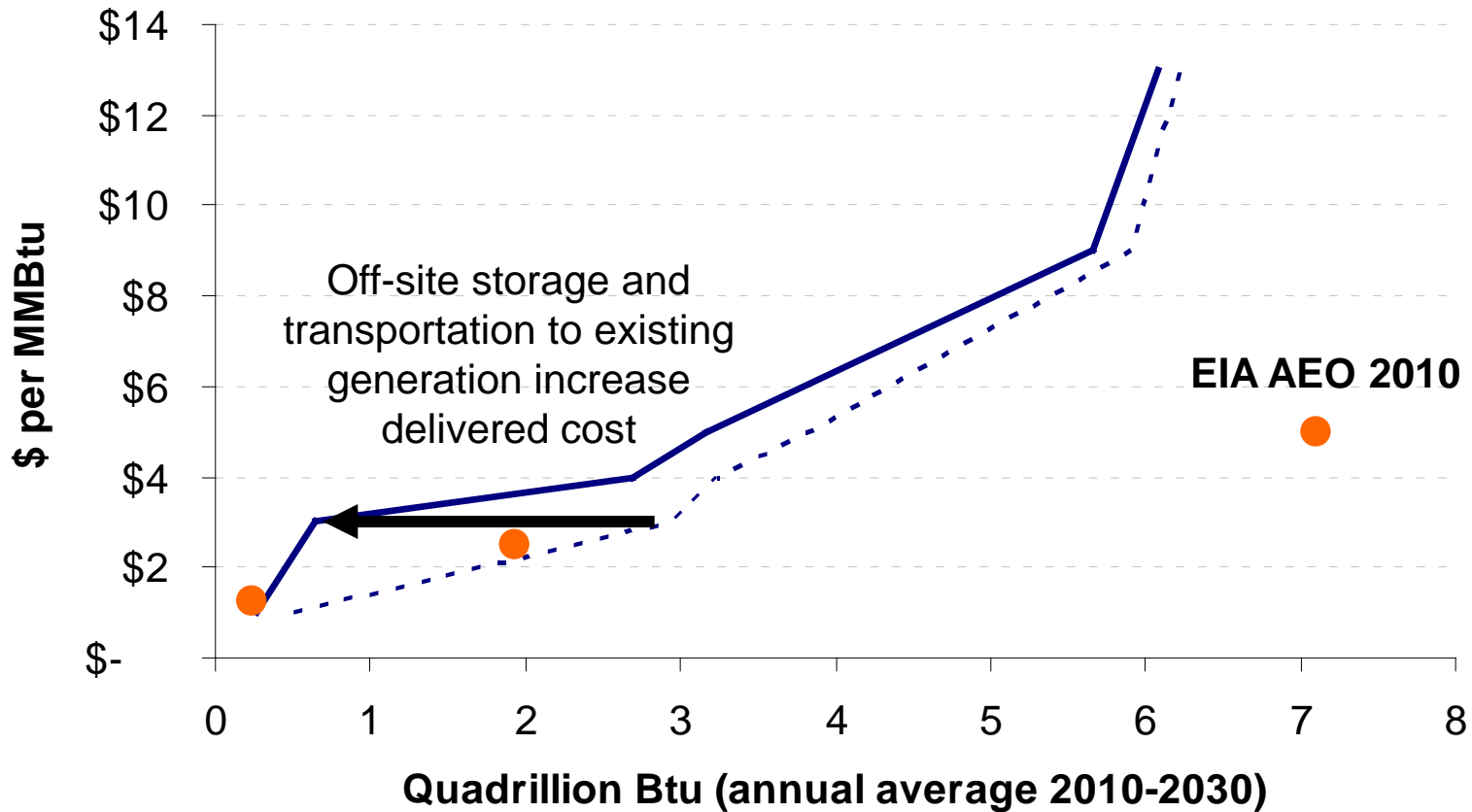
Largest Supplies in Midwest, South, Plains



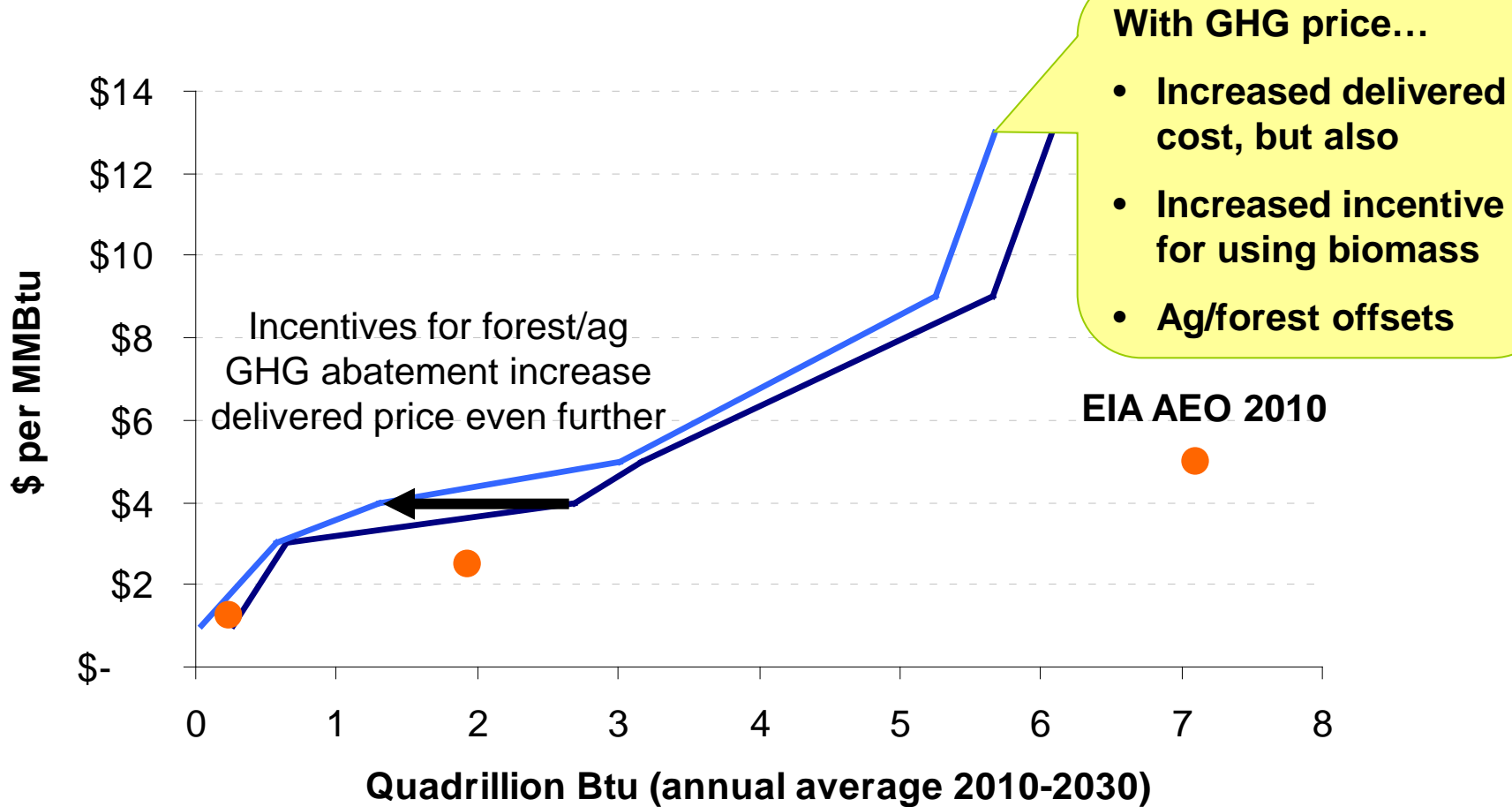
Our U.S. Estimate Over 50% Less EIA's



Part of the Difference – Storage & Transportation to Existing Generation



Another issue – GHG Incentives Can Increase Delivered Cost (e.g., \$30/tCO₂e + 5% per year)

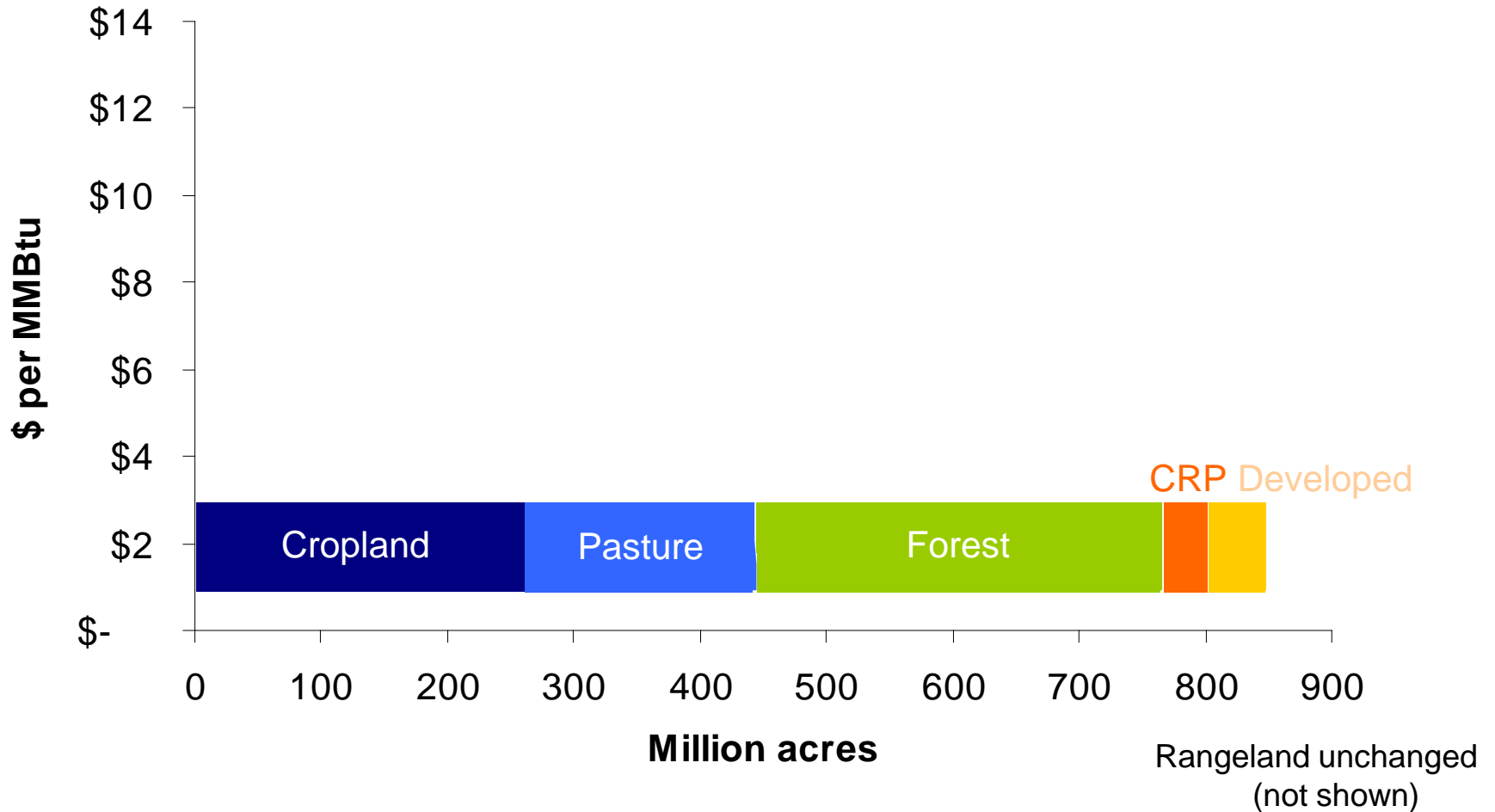


Are there (supply-side) environmental implications?



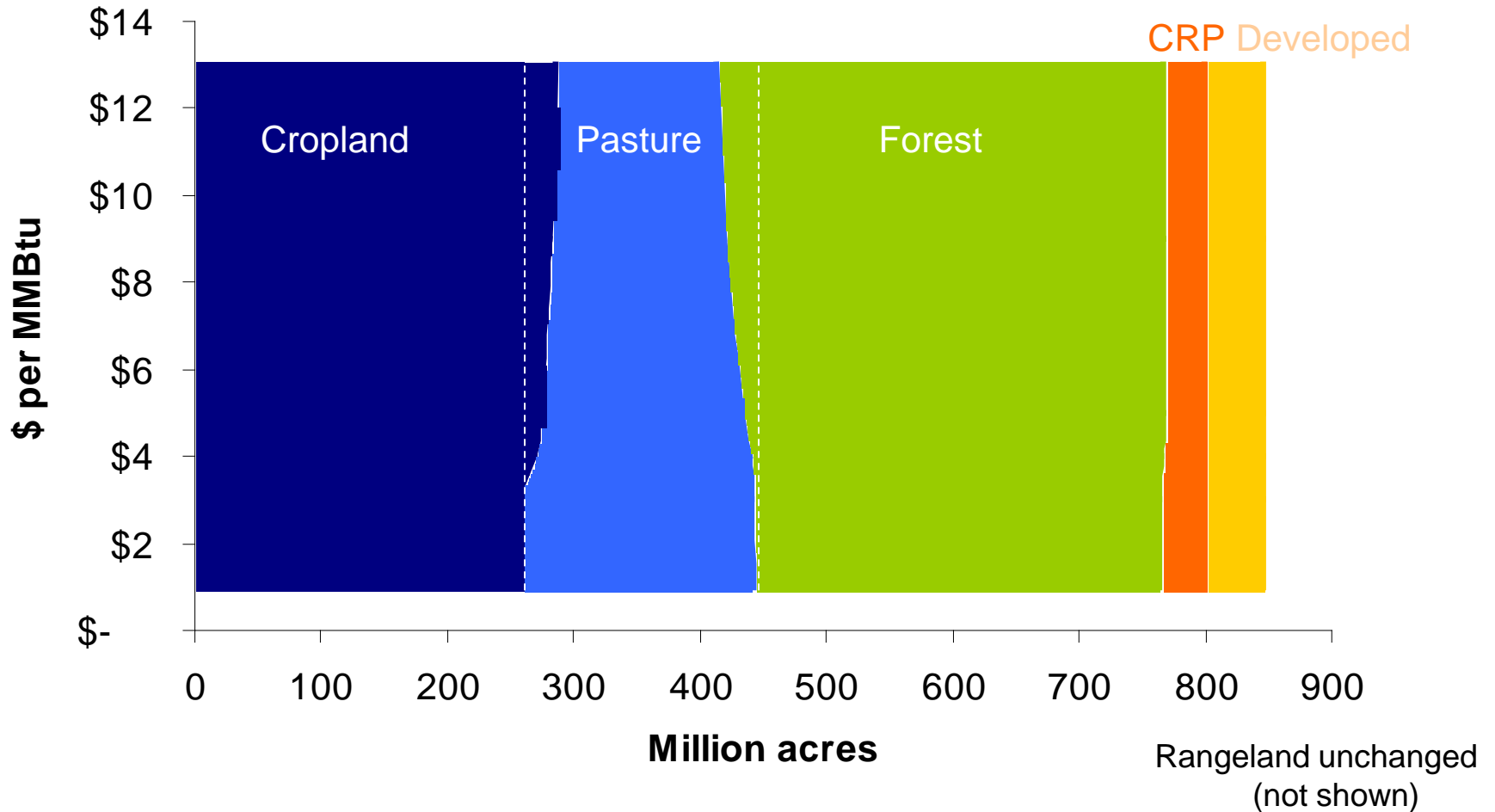
Nationally, Forest & Cropland Expand with Pasture Conversion as Bioelectricity Increases

e.g., 2030 acreage



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

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

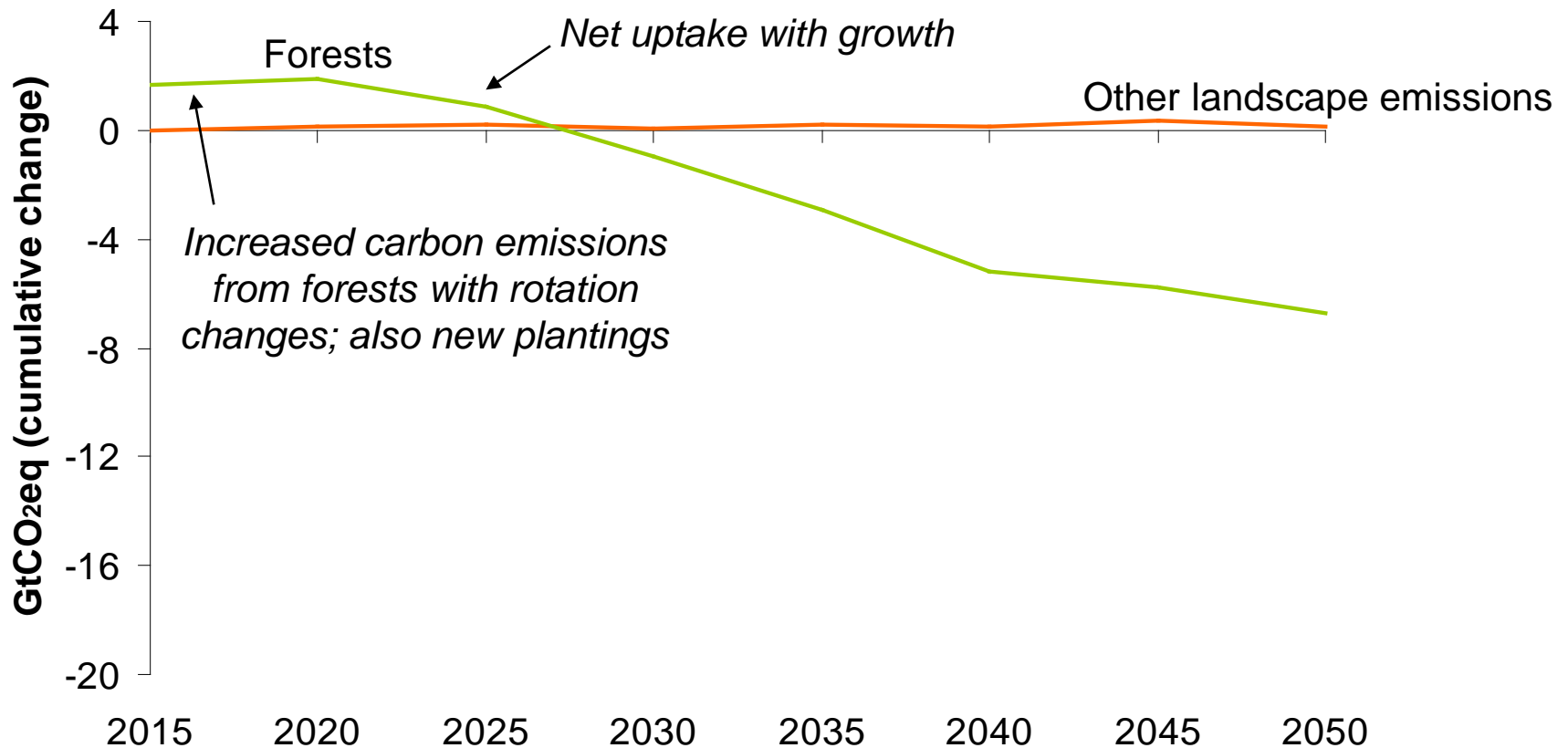
	100% bioelectricity
Corn	
Corn residue	97%
Softwood pulp	98%
Softwood harvest residue	98%
Softwood mill residue	99%
Switchgrass	92%

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)

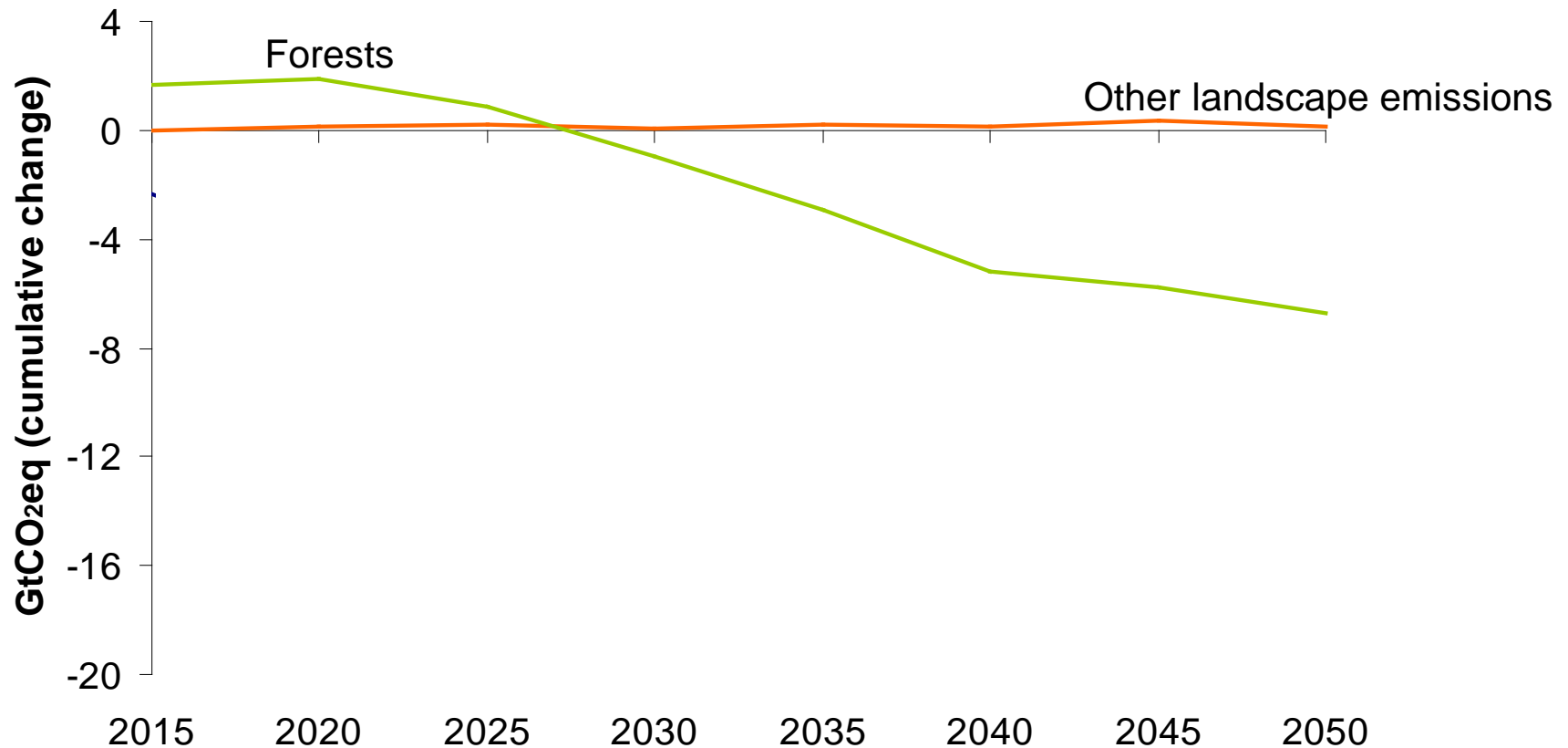
Indirect US Landscape GHG Changes – Driven by Forest Adjustments

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



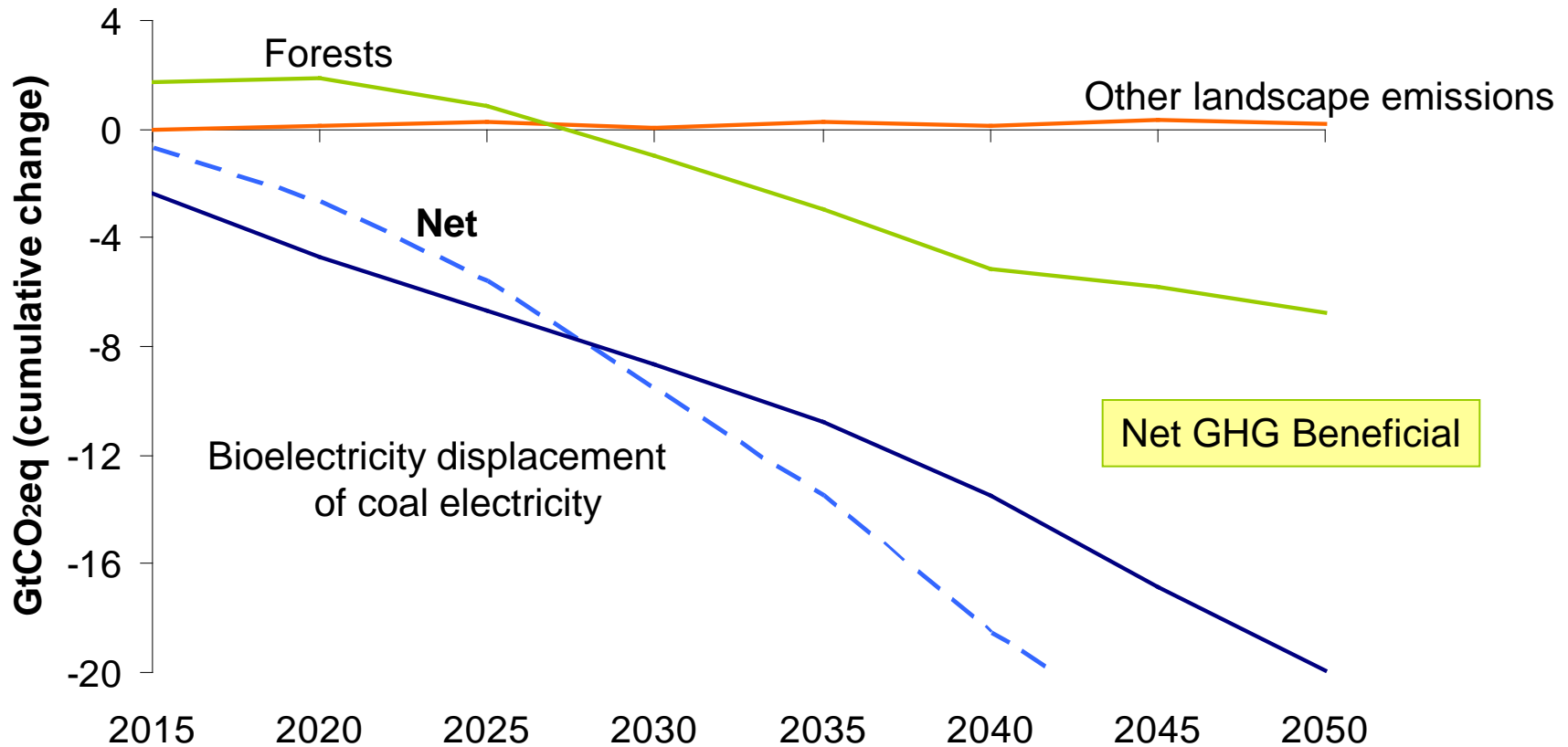
Net GHG Implications (US Direct + Indirect)

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



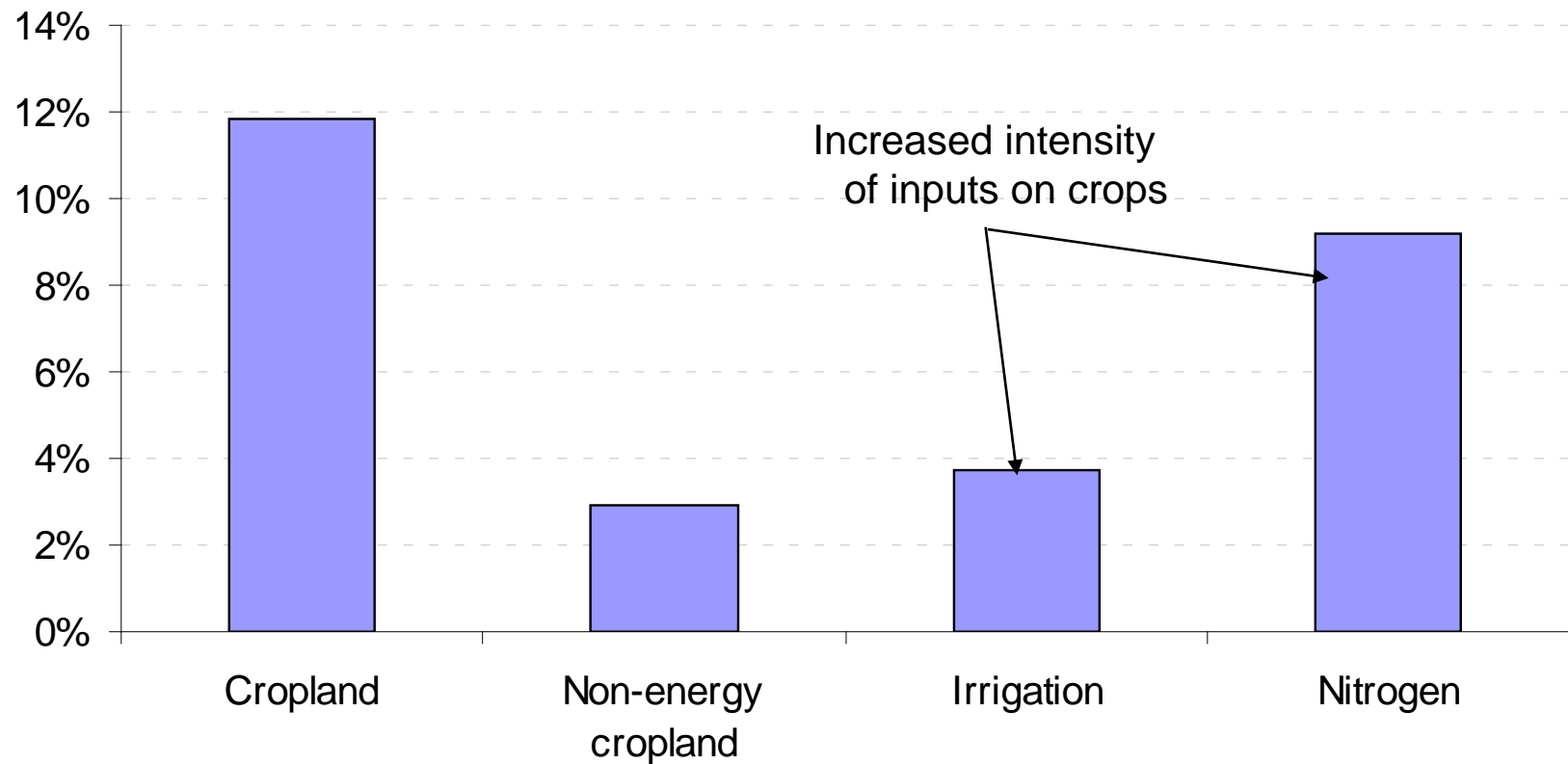
Net GHG Implications (US Direct + Indirect)

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



National Water and Nitrogen Implications with Increased Biomass Demand

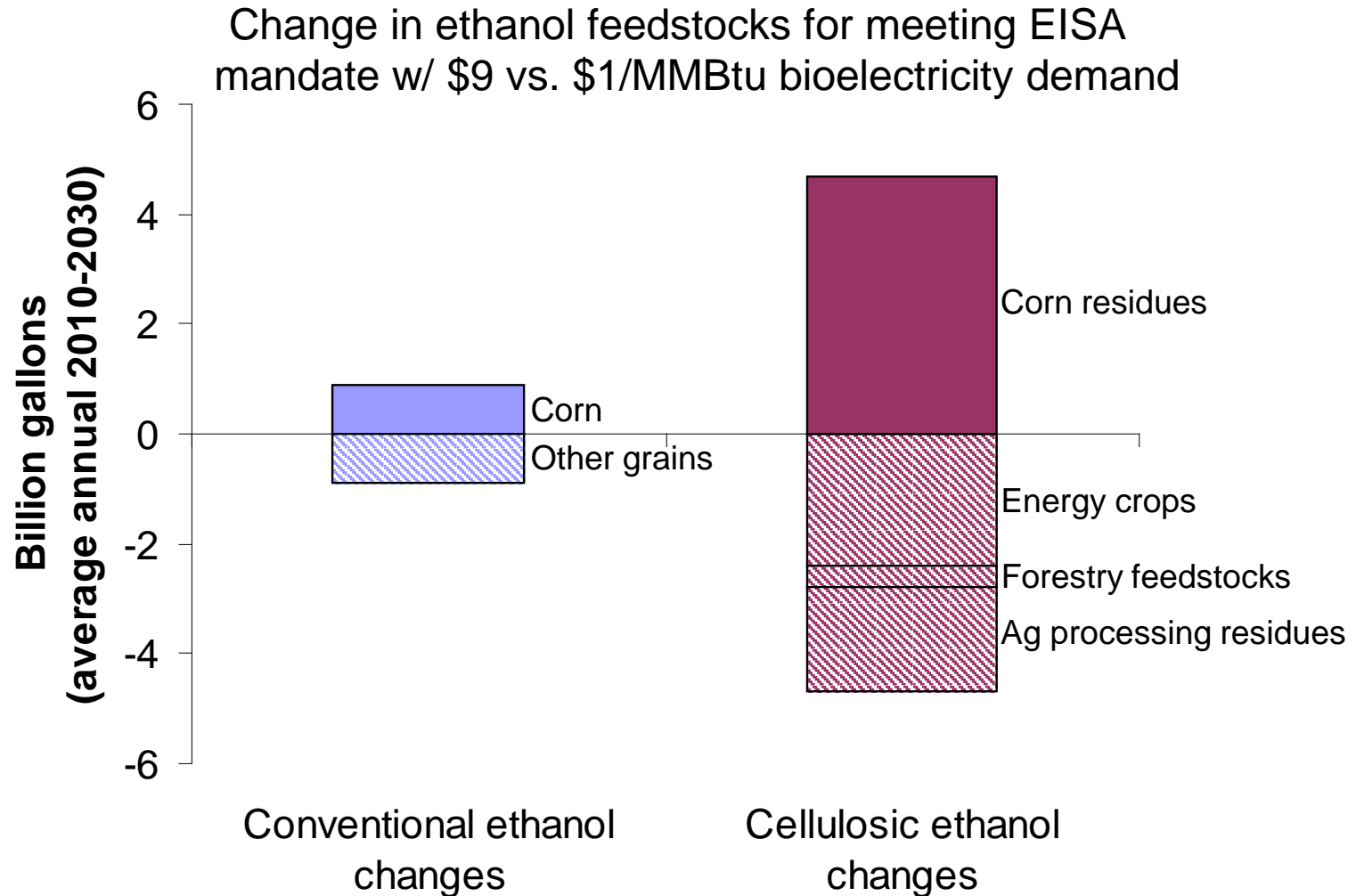
Changes by 2030 with \$9 vs \$1/MMBtu demand



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