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U.S. Biomass Supply for Power & Environmental Implications (Draft Results)

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United States Energy Association, Washington, DC

June 23, 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)

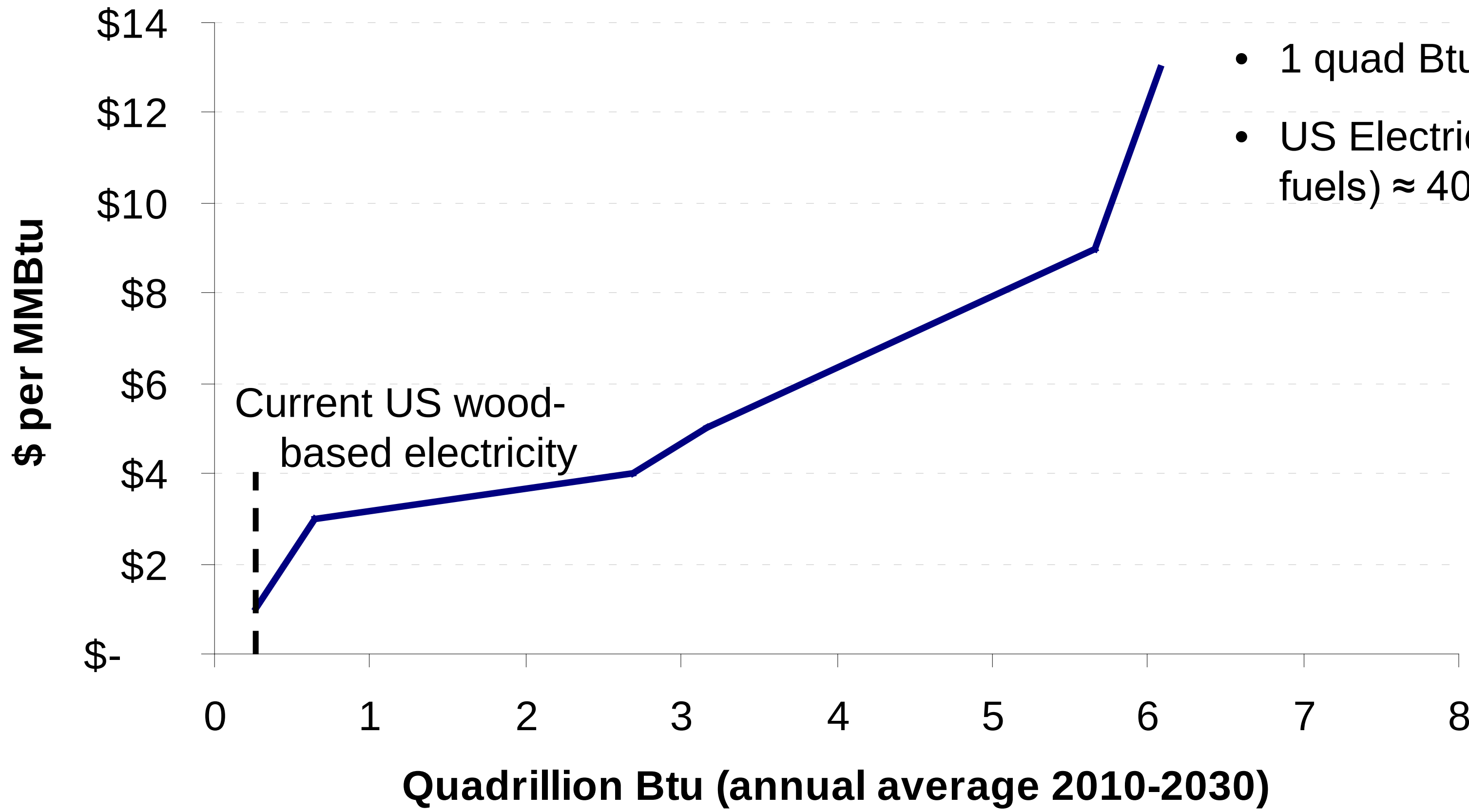
➔ **Estimating biomass supply for electricity (delivered to power plant gates) accounting for food, feed, and biofuel demands & production**

Biomass Feedstocks, Costs, GHG Value in the Modeling

~ 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	

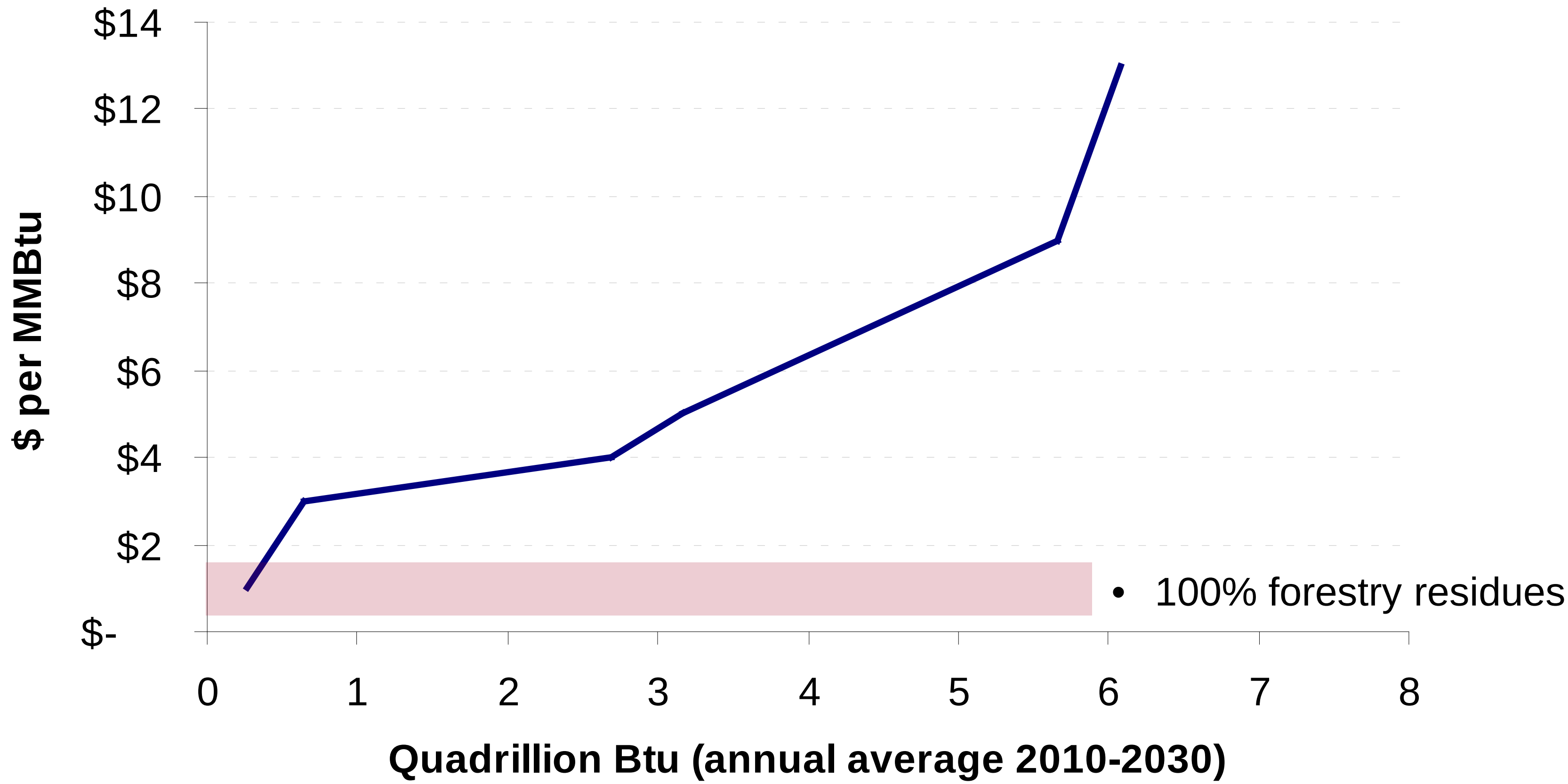
- Relative value of a feedstock a function of…
  - **Direct costs (harvesting, transportation, storage, processing)**
  - **Opportunity costs (commodity & GHG)**
  - **HHV**
  - **Moisture content**
  - **Energy prices**
  - **Co-products (e.g., oil, feed substitutes)**
  - **Direct GHG benefit if valued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

U.S. Biomass Supply for Electricity

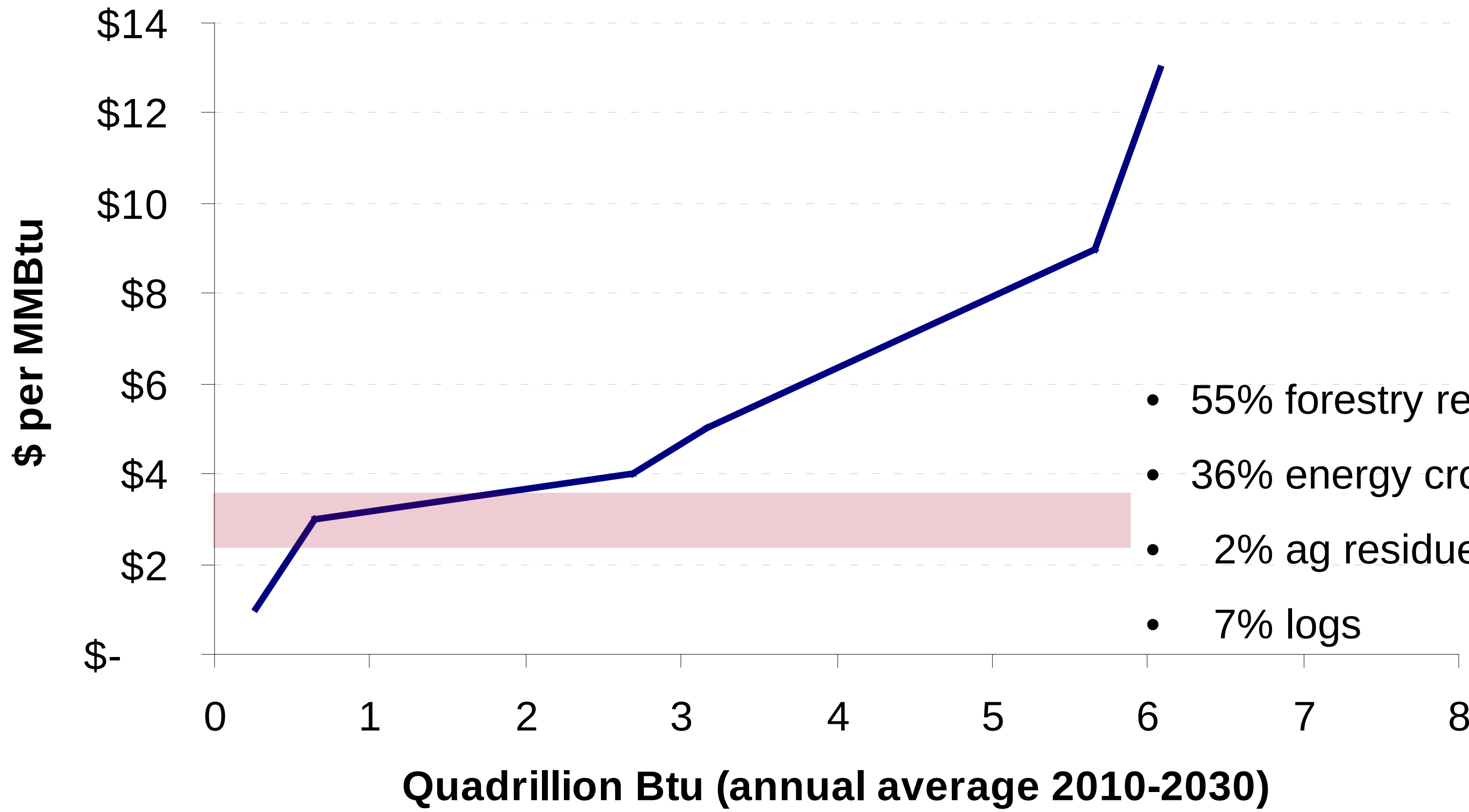


- 1 quad Btu ≈ 100 TWh
- US Electric Sector (all fuels) ≈ 40 quad Btu

U.S. Biomass Supply for Electricity

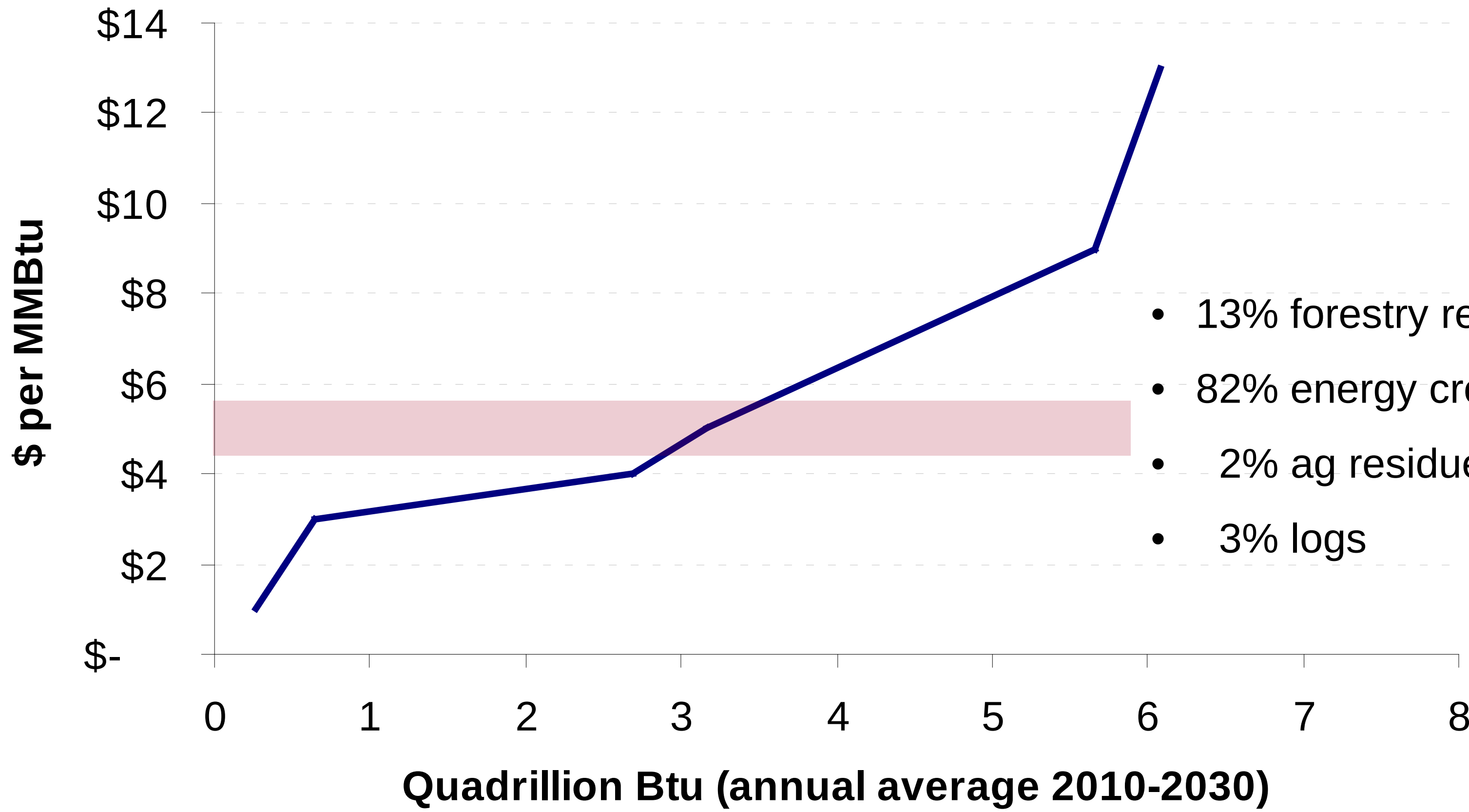


U.S. Biomass Supply for Electricity



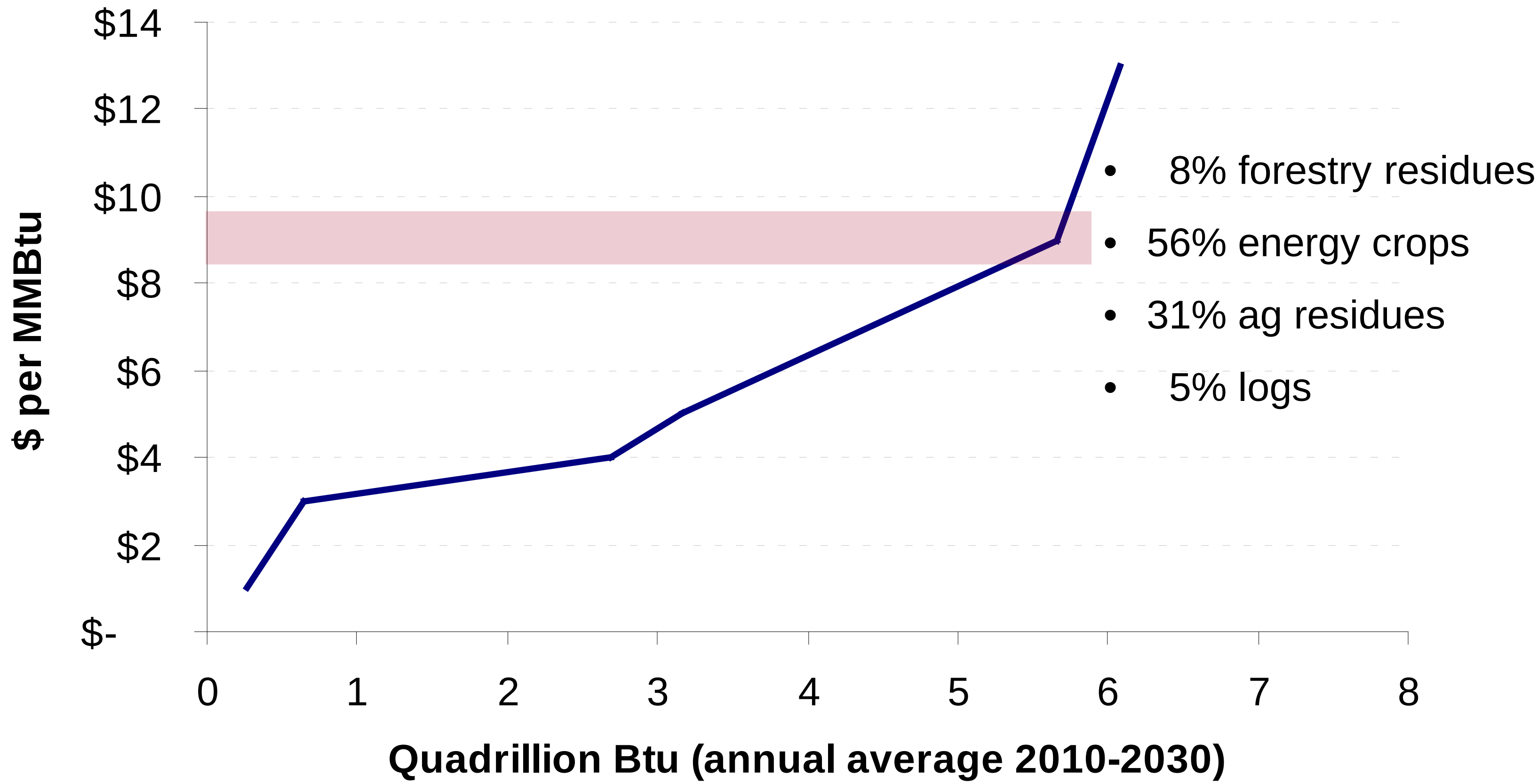
- 55% forestry residues
- 36% energy crops
- 2% ag residues
- 7% logs

U.S. Biomass Supply for Electricity

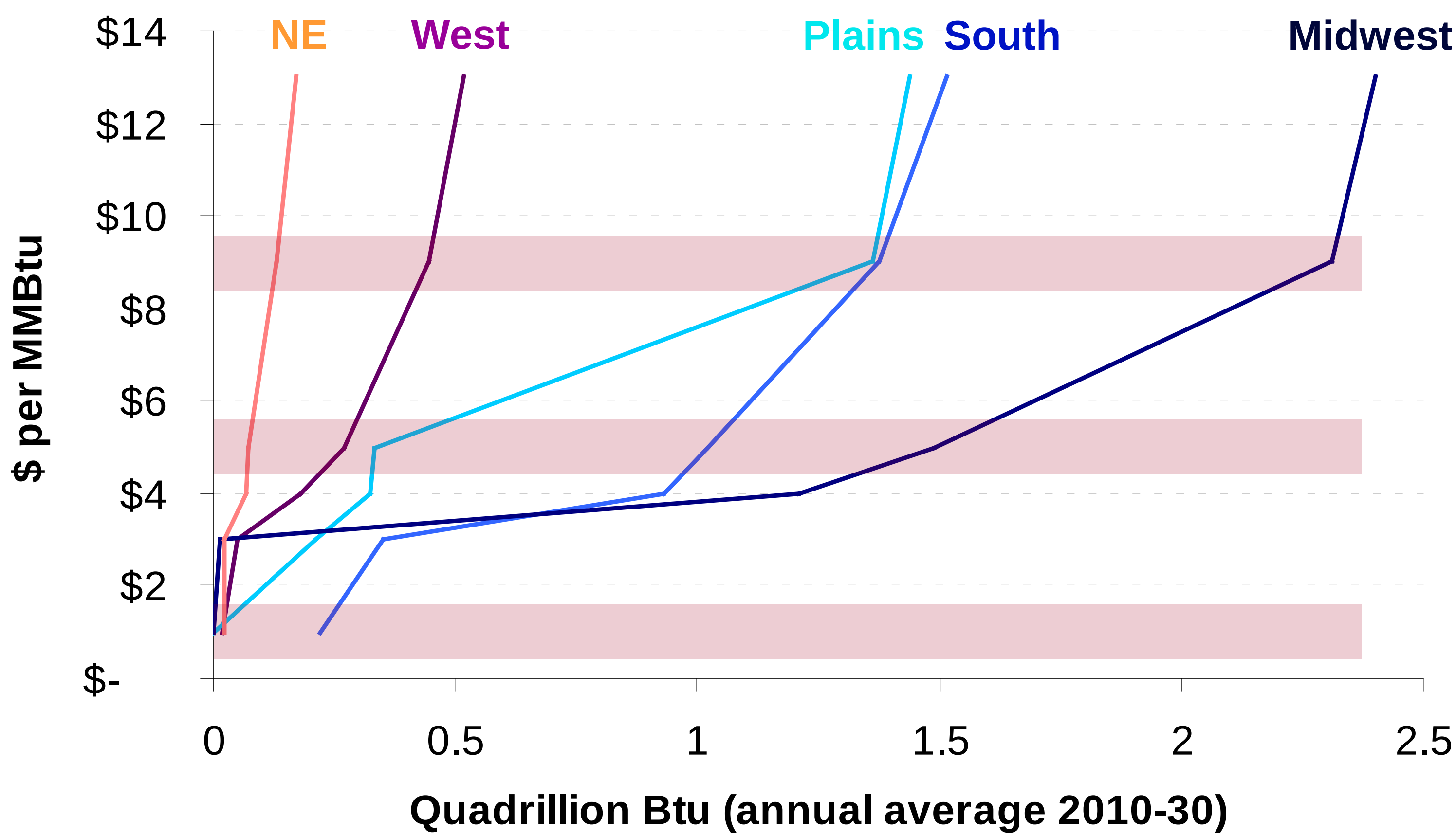


- 13% forestry residues
- 82% energy crops
- 2% ag residues
- 3% logs

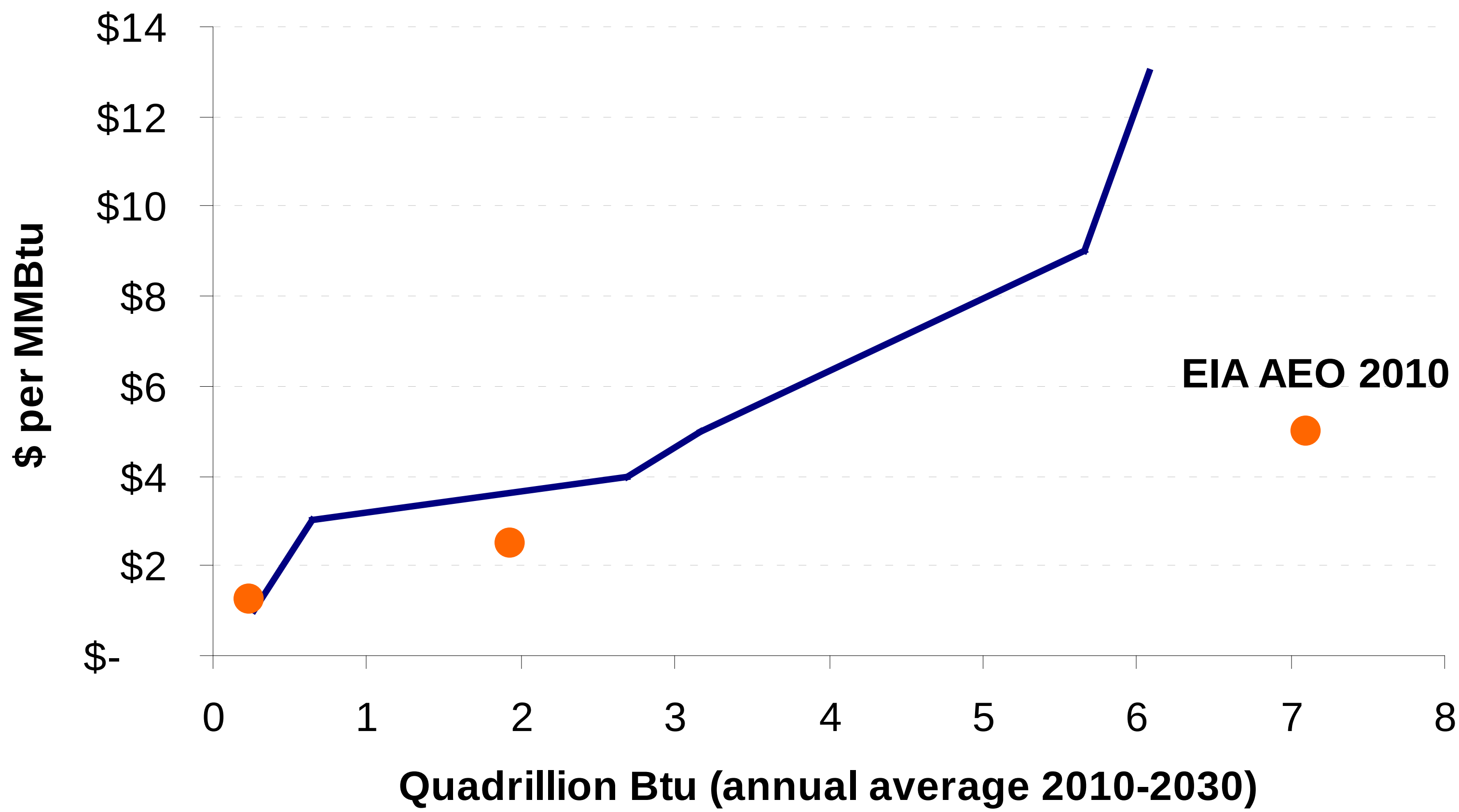
U.S. Biomass Supply for Electricity



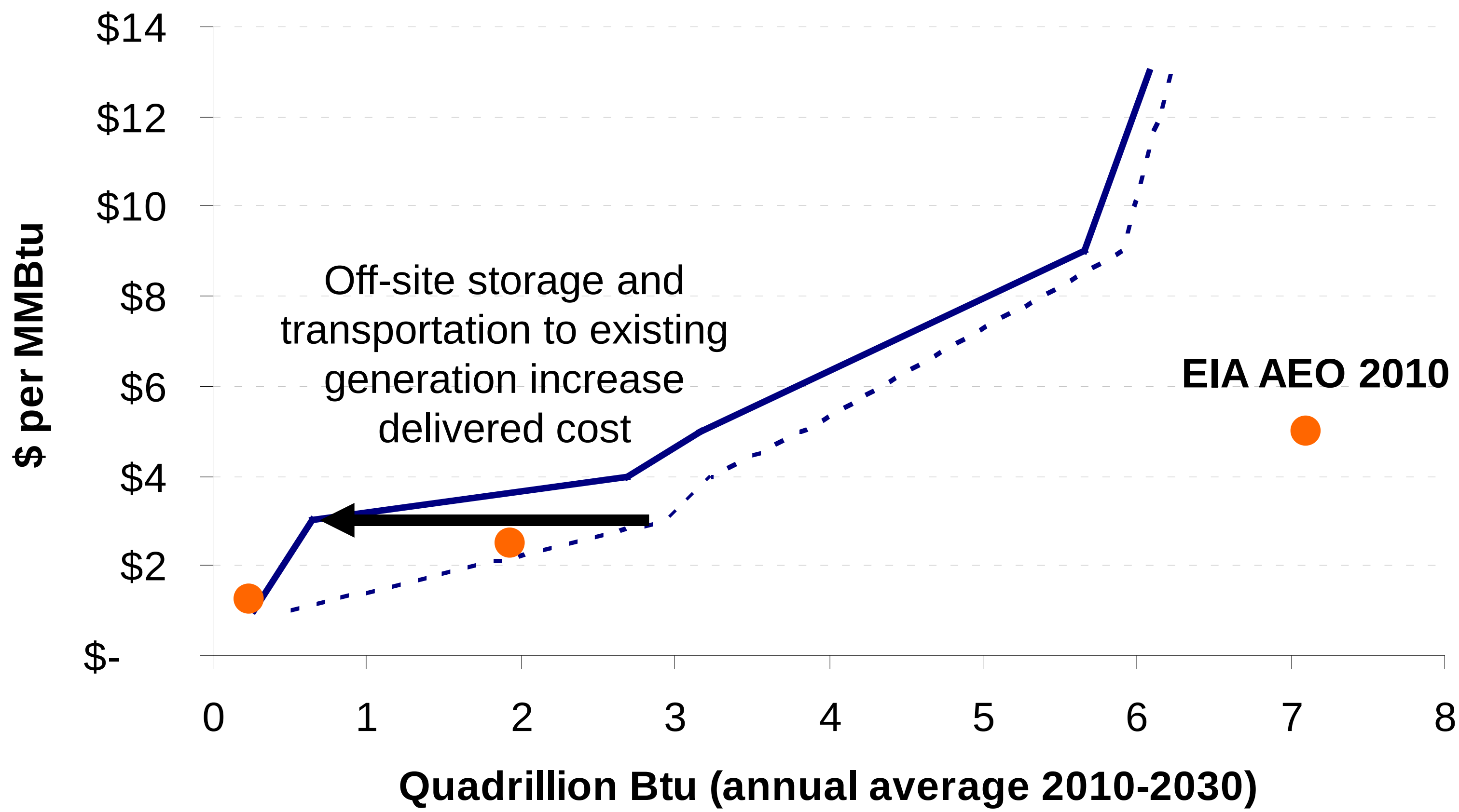
Largest Supplies in Midwest, South, Plains



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



Part of the Difference – Storage & Transportation to Existing Generation



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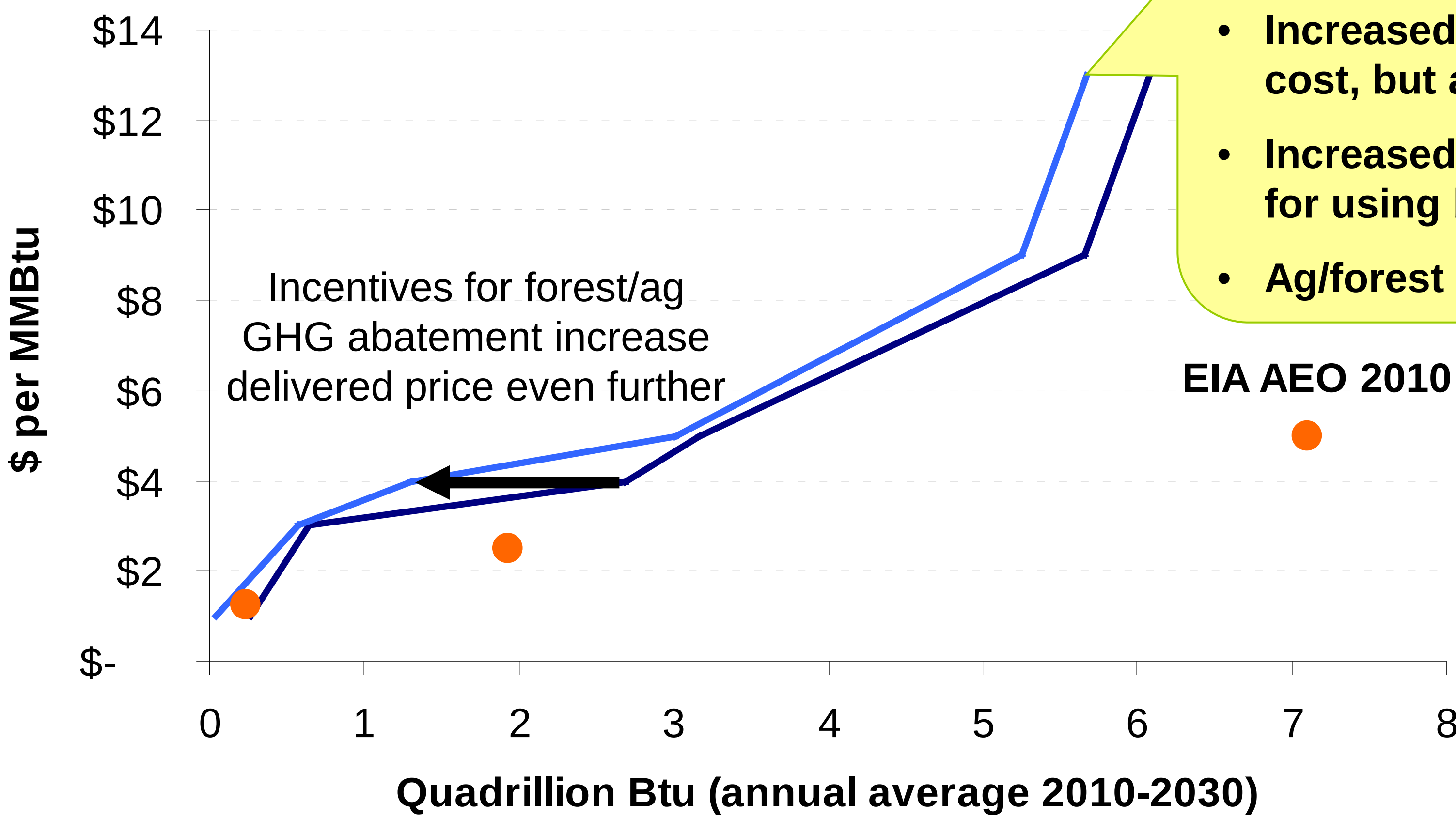
Another issue – GHG Incentives Can Increase Delivered Cost (e.g., $30/tCO_2e + 5% per year)

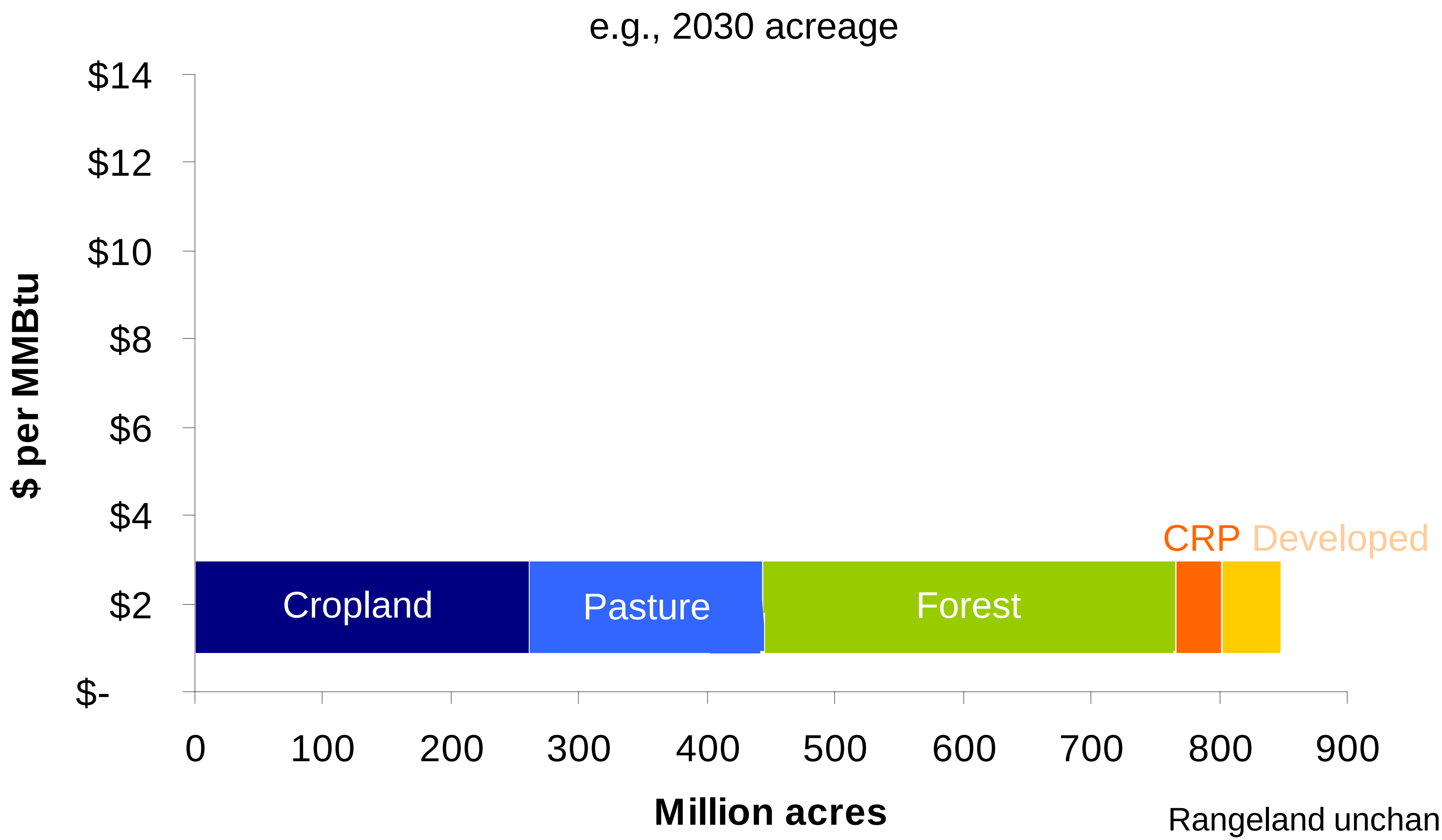


With GHG price…

- **Increased delivered cost, but also**
- **Increased incentive for using biomass**
- **Ag/forest offsets**

Are there (supply-side) environmental implications?

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



Rangeland unchanged (not shown)

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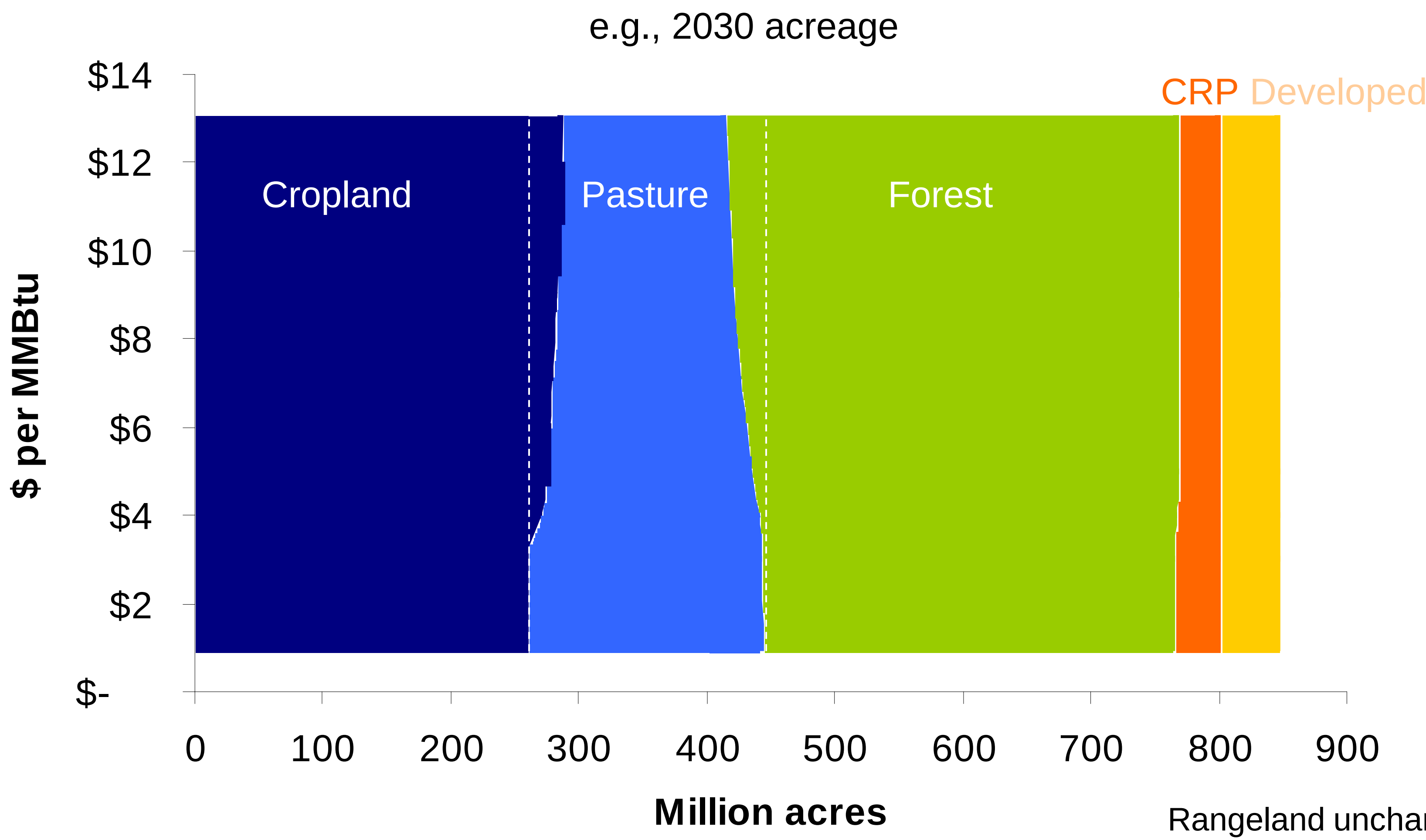


Rangeland unchanged (not shown)

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

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

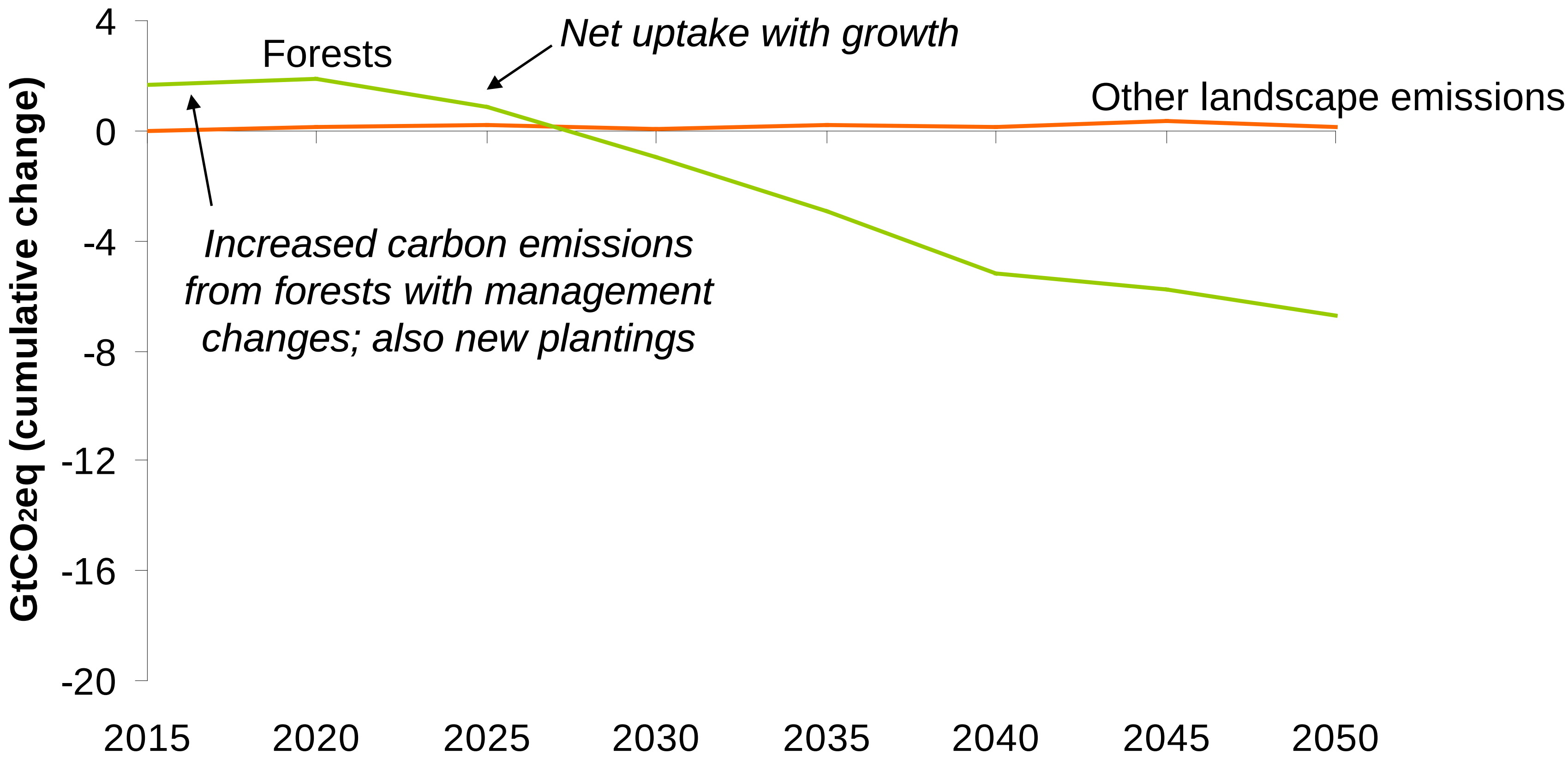
	Ethanol	Cellulosic ethanol	100% bioelectricity
Corn	32-35%		
Corn residue		69%	97%
Softwood pulp		77%	98%
Softwood harvest residue		77%	98%
Softwood mill residue		82%	99%
Switchgrass		74%	92%

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



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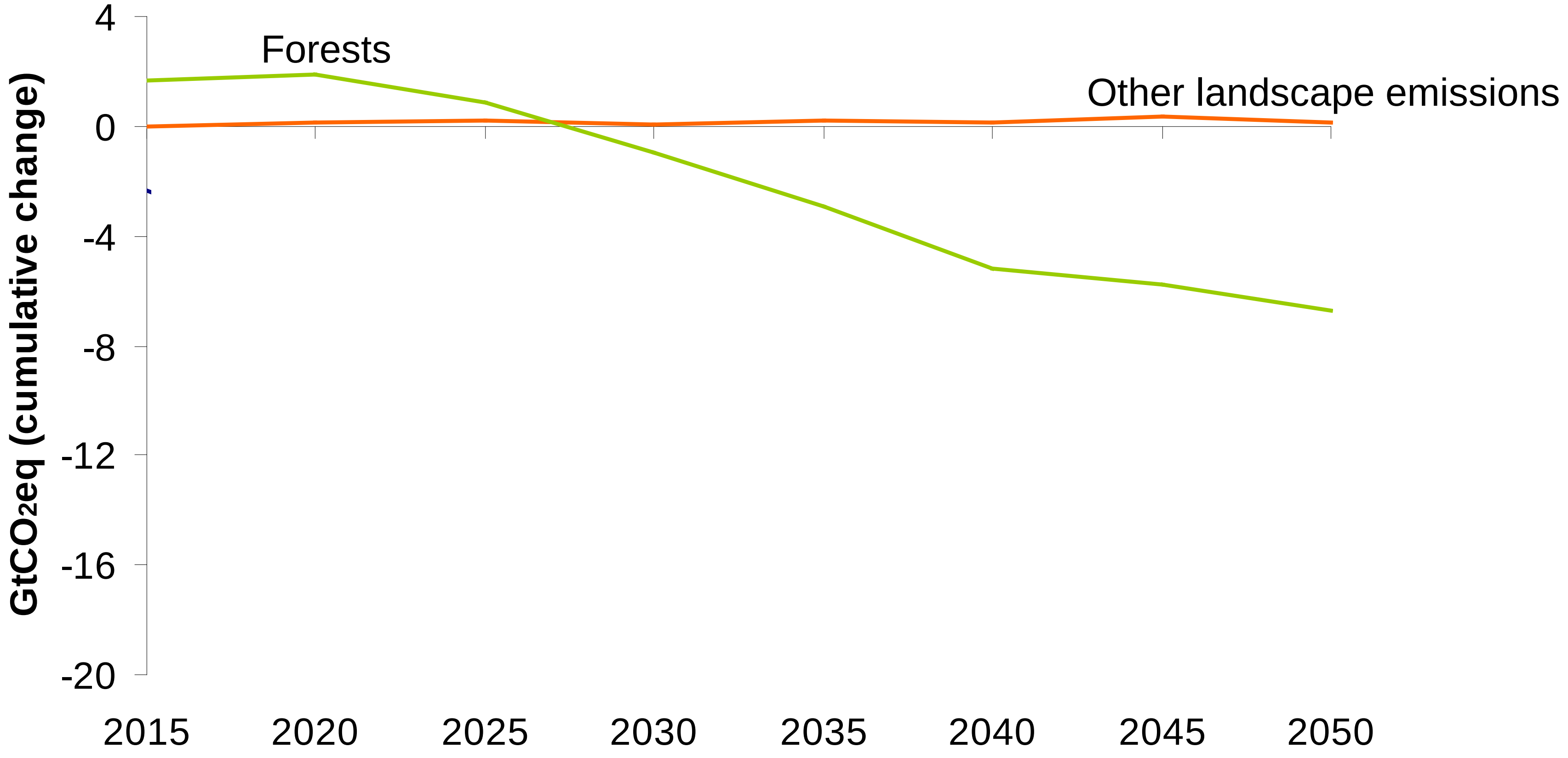
Net GHG Implications (US Direct + Indirect)

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



Net GHG Implications (US Direct + Indirect)

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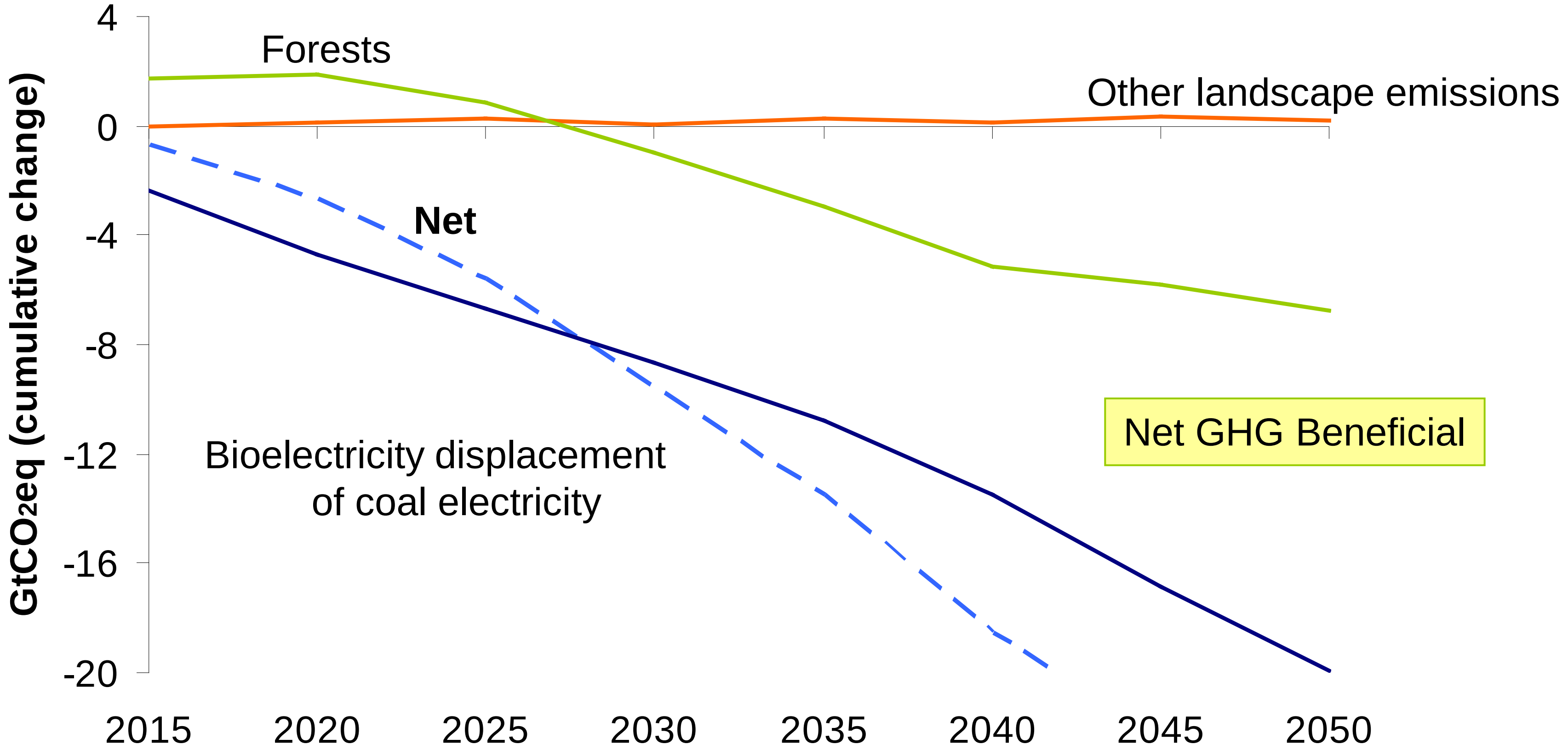
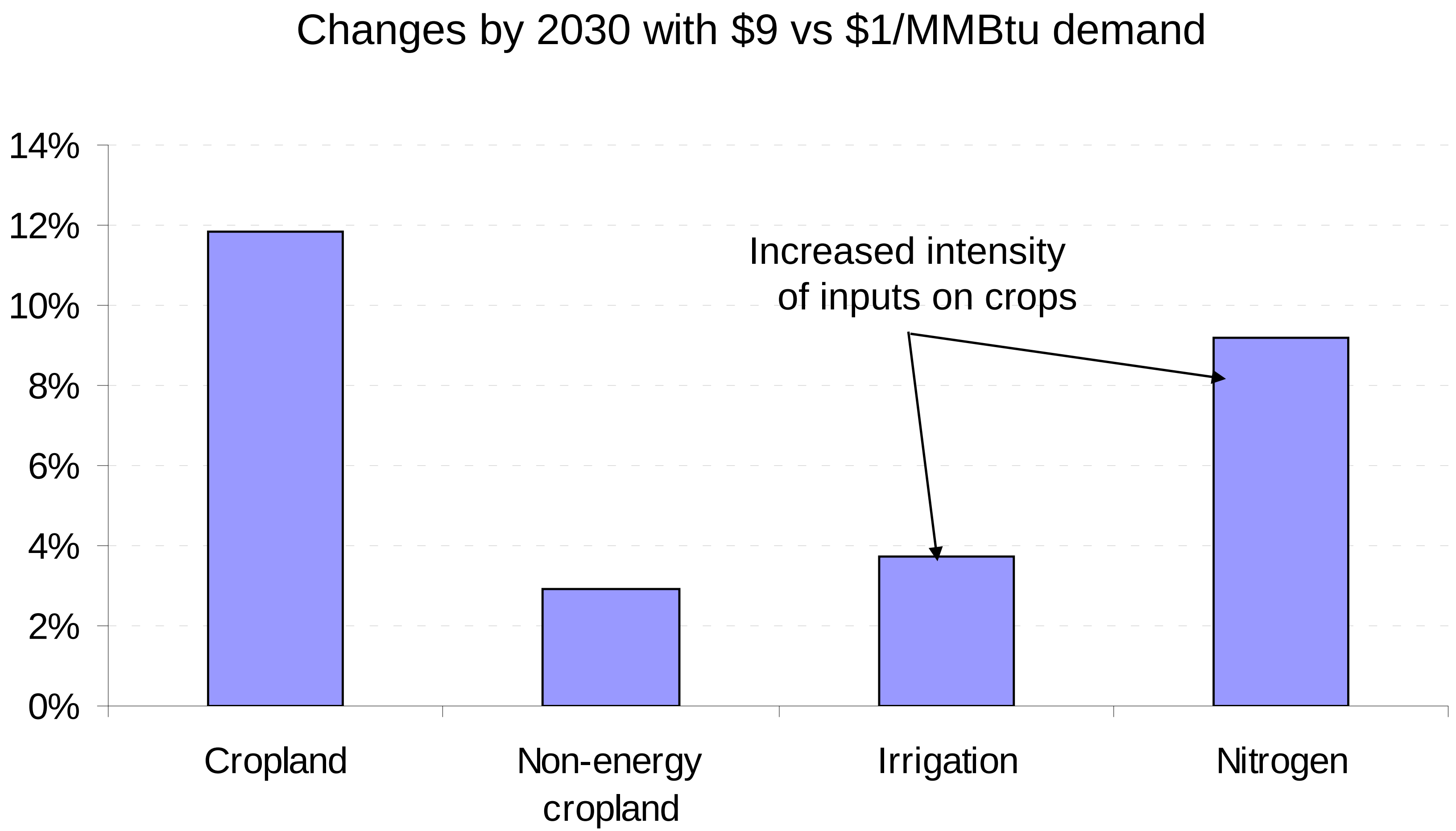
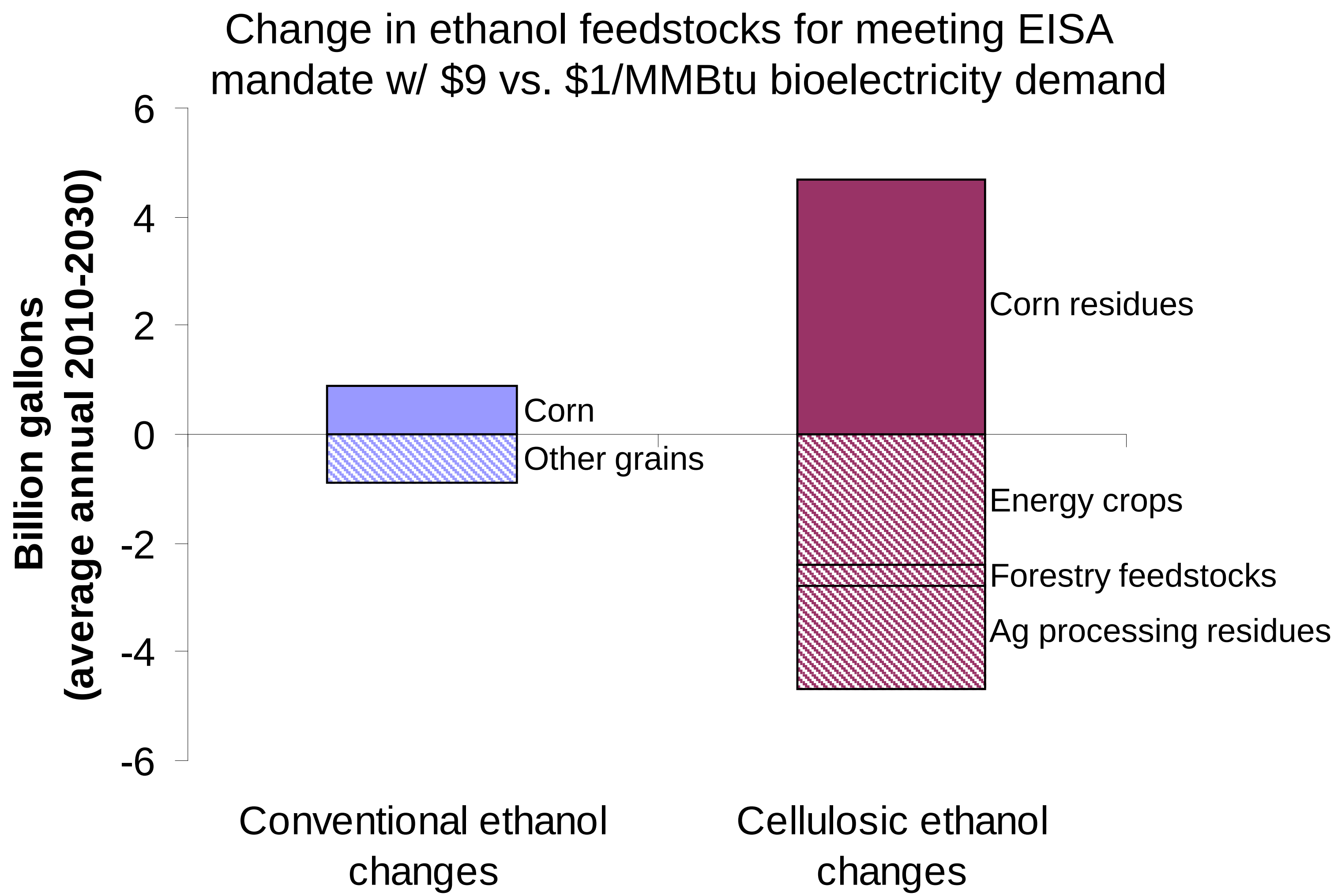


National Water and Nitrogen Implications with Increased Biomass Demand



Are there biofuel production implications?

Ethanol Implications



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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 more expensive than previously estimated
- Variation in feedstocks & regional supply will be important
- Bioelectricity can…
  - Yield net gains in forest acreage
  - 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

Thank you!

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