The Impact of GM Corn Traits on Biofuel Production

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FAPRI

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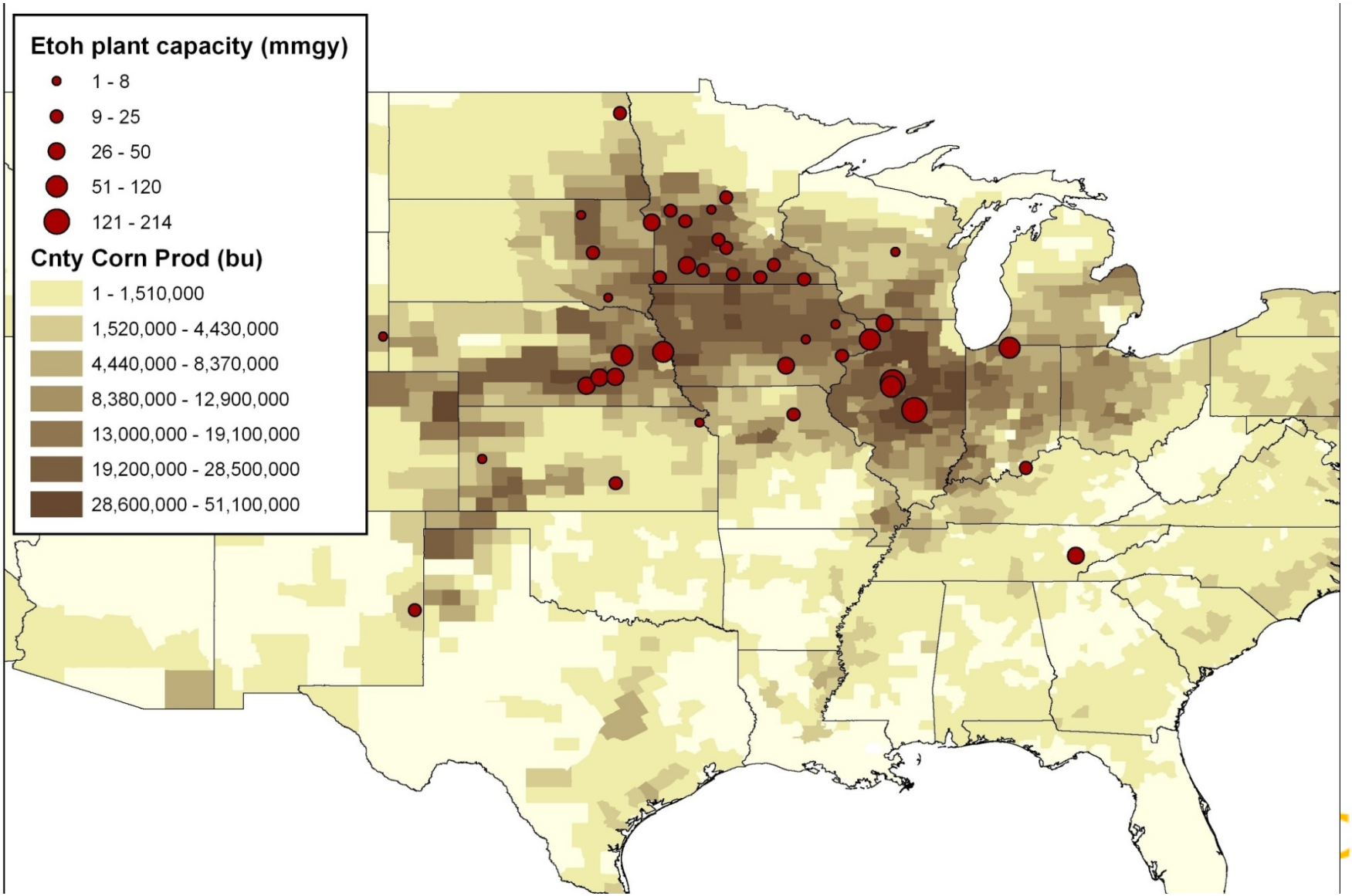
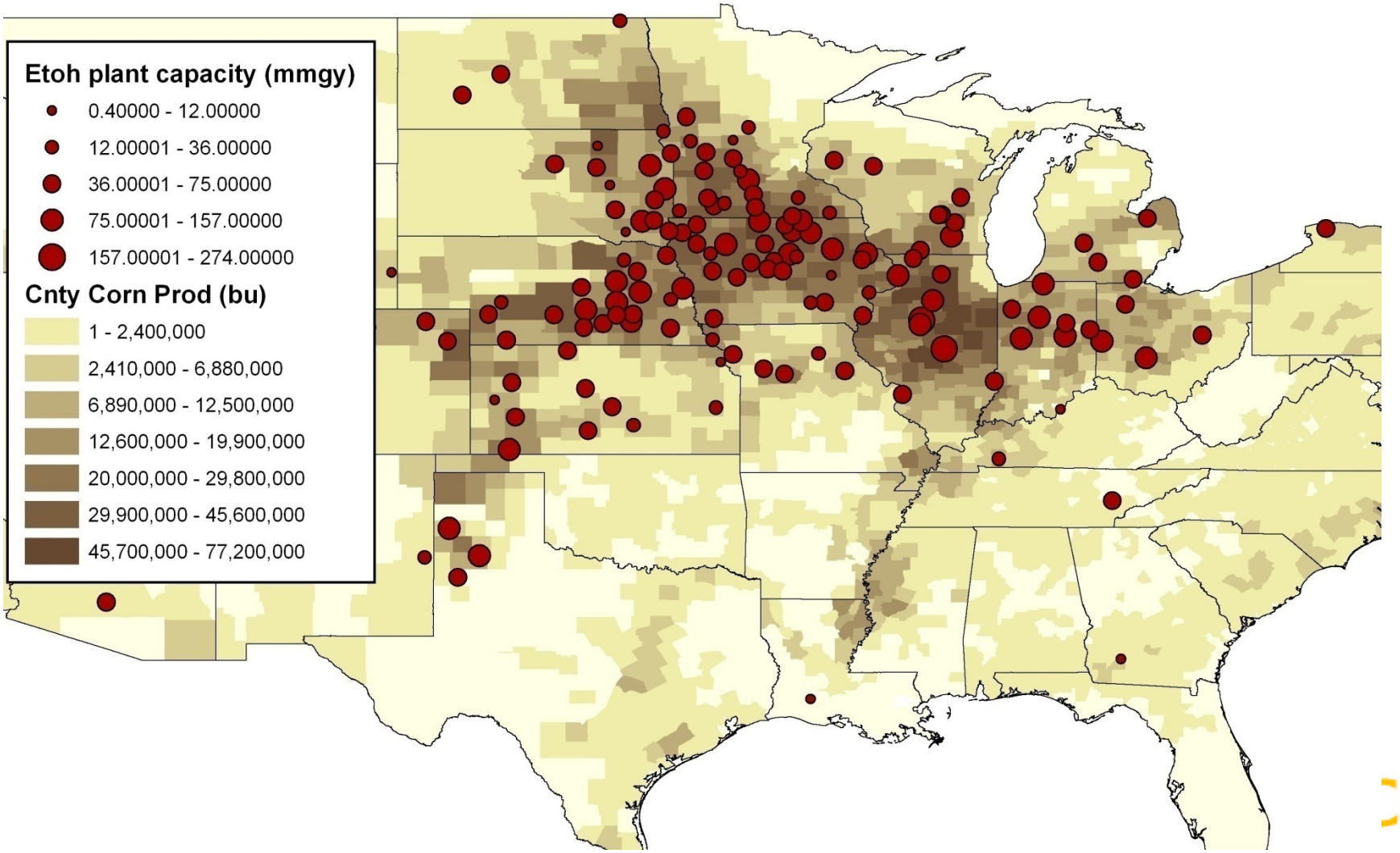
Many of the results are preliminary--
The project has been funded by the US Dept of Energy (DOE)

Ethanol Industry 2000



Ethanol Industry 2008



The Biofuels Debate

- Benefits from biofuels most widely cited
  - Petroleum independence
  - Environmental gains
    - favorable energy balance,
    - lower GHG,
    - renewability
  - Farm subsidy reform
- Many of these benefits have been actively debated in both academic and policy contexts
- Recent public debate regarding impacts of biofuels on food prices has been broad, insistent, and has mobilized anti-biofuels coalitions

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The Ongoing Drive for Efficiency

- Most of future gains are expected to come from feedstocks
  - Corn yield growth has been key to efficiency gains so far

	1980	2007	Role
Ethanol yield, gal/bu	2.5	2.8	1/3
Corn yield, bu/ac	104	150	2/3
Total yield, gal/ac	260	420	

- Ethanol yield per acre -- the focus of the discussion

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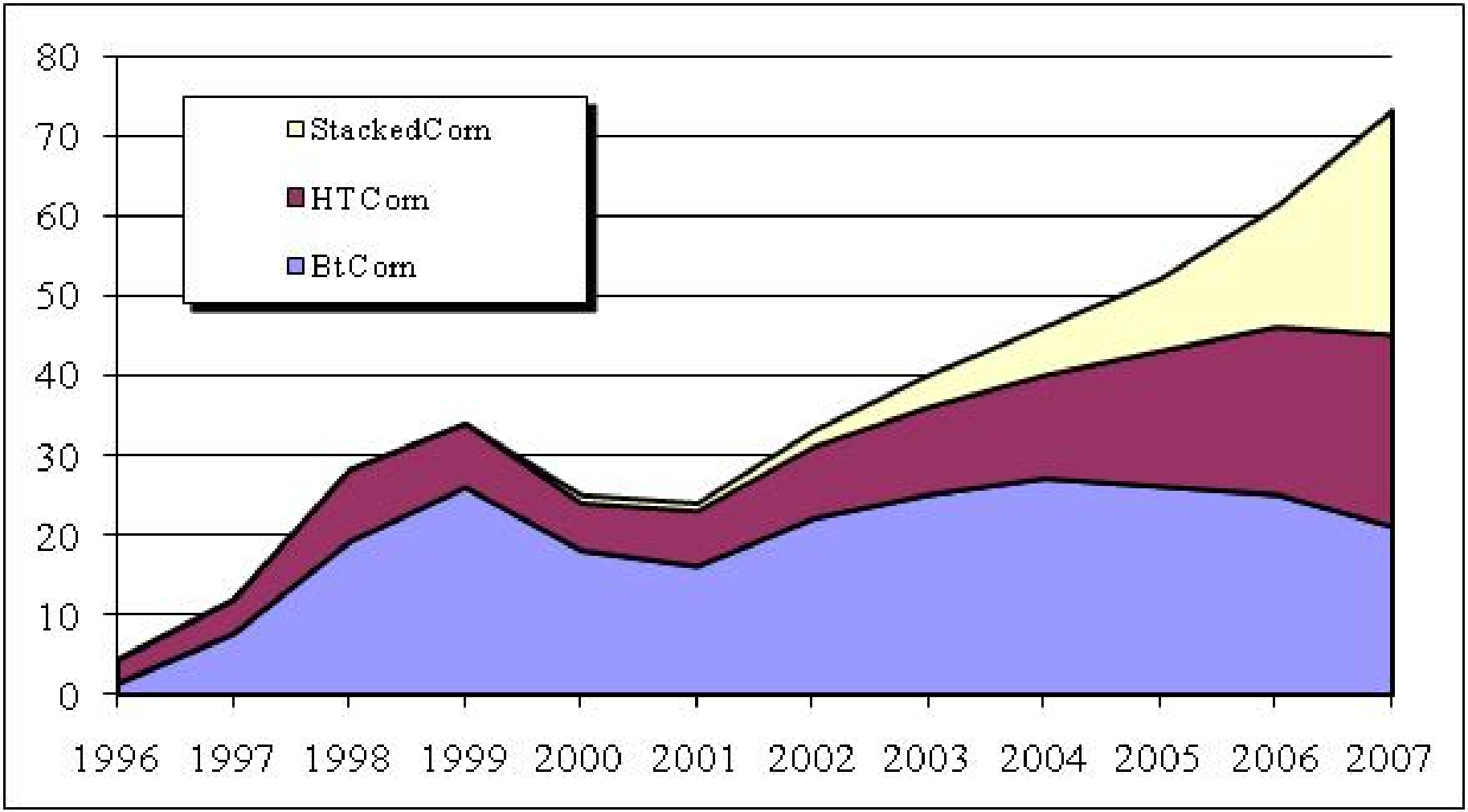
GM Adoption in Corn Production



Corn Biotech Pipeline

Short & Intermediate Corn Biotech Trait Pipeline

Syngenta	Expected Date	Monsanto	Development Phase	Dupont/Pioneer	Expected Date
VIP broad lep	2009	Drought tolerant corn	P3	Stalk rot resistant	2009
Optimum GAT	2010	Drought tolerant corn II	P2	Increased etoh 2&3	<2018
Corn rootworm II	2012	Nitrogen efficient corn	P1	Corn rootworm II & III	<2018
Corn amylase	2009	High yielding corn	P2	Corn borer II & III	<2018
Increased ethanol	2011	Yieldgard BT II	P4	Drought tolerance	2013-15
		Yieldgard Rootworm III	P1	Nitrogen efficiency	<2018
		High lysine corn	P4	Increased yield	<2018
		High oil corn	P1	Improved feed	2011-2013
		Increased etoh	current	High extractable starch	current

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How might this pipeline affect the production and use of corn ethanol?

Efficiency Gains – Measurement Issues

- Dimensions of Impact
  - Economic,
  - Environmental,
  - Energy
- Ethanol an energy product - efficiency gains must be measured on energy balance basis.
- Life-cycle analysis is transparent, inclusive, and can be applied across all technologies/traits
  - LCA is well understood and reported

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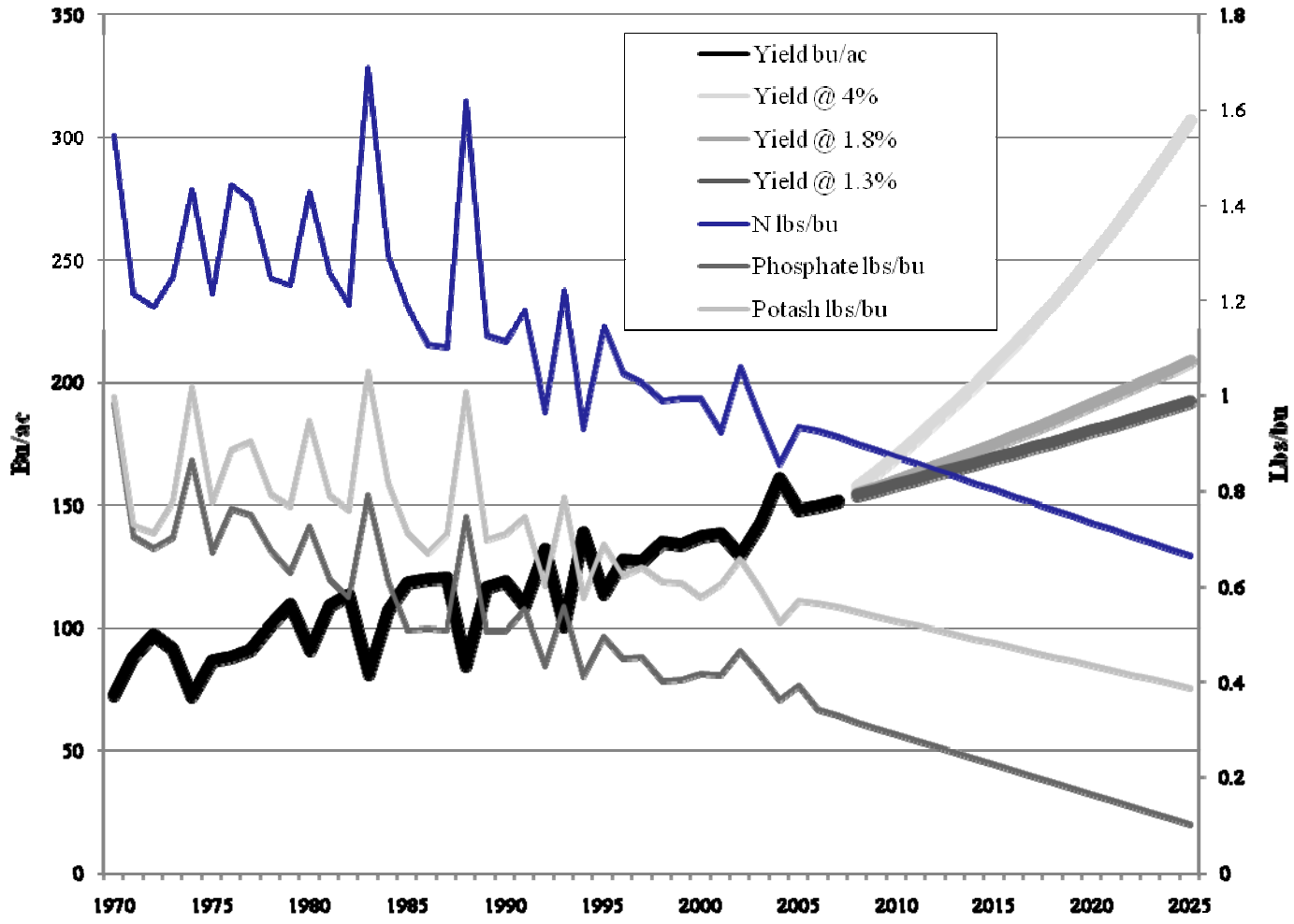
Key Assumptions In Our Analysis



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Impact of Yield Enhancement

	Baseline	Historical Yield Trend		Conservative Yield Growth Scenario		Aggressive Yield Growth Scenario	
Yield Path (annual % growth)	1.3	1.3	1.3	1.8	1.8	4	4
Year	2007	2017	2025	2017	2025	2017	2025
Yield bu/ac	151	172	191.6	180.6	208.5	224	306.84
N g/bu	413.7	351.1	301.1	351.1	301.1	351.1	301.1
P g/bu	148.2	91.0	45.2	91.0	45.2	91.0	45.2
K g/bu	251.9	209.2	175.0	209.2	175.0	209.2	175.0
Reductions in Corn Production							
Total energy		-14%	-25%	-16%	-27%	-22%	-36%
Petroleum		-10%	-19%	-14%	-22%	-24%	-37%
NOx		-14%	-26%	-17%	-29%	-24%	-40%
CO2		-11%	-21%	-13%	-22%	-18%	-30%
Reductions in Ethanol Production							
Total energy		-2%	-3%	-2%	-3%	-2%	-4%
Petroleum		-10%	-17%	-12%	-21%	-22%	-34%
NOx		-9%	-17%	-11%	-19%	-16%	-26%
CO2		-4%	-7%	-4%	-7%	-6%	-9%

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Total Impact of Technology

Impact of reductions in processing energy

- At an assumed .5% and 1% annual rate of reduction.
  - A 5% reduction in direct energy input =
    - A 2% reduction in gross energy needed to produce a gallon of ethanol and a 4% reduction in CO2
  - A 20% reduction in direct energy inputs =
    - 7% decrease in gross energy use and 14% reduction in CO2

Total Impact of Technology

Year	2017	2025	2017	2025		
Corn Yield Path	1.8	1.8	4	4	Herbaceous	Corn
Conversion Energy Path	-1%	-1%	-1%	-1%	Biomass	Stover
Total energy	-5%	-9%	-6%	-10%	-14%	-23%
Petroleum	-13%	-22%	-23%	-36%	-23%	-19%
NOx	-14%	-25%	-19%	-32%	19%	16%

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Implications

- New biotech pipeline will drastically lower the energy cost of production –especially on the farm.
- Most of gains are associated with corn yield improvements, especially if coupled with continued declines in per bu fertilizer requirements
- Still, much of corn ethanol's energy requirements are associated with the conversion process –especially natural gas
  - Indirect energy requirements are large.
  - Combined Heat and Power (CHP) and shift towards wet DDGS could meaningfully reduce energy requirement
- Corn ethanol will improve, but perhaps fall short of cellulosic ethanol's ability to:
  - Convert as much biomass to energy on a given acre
  - Operate a conversion facility with less energy.

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Markets and Policy

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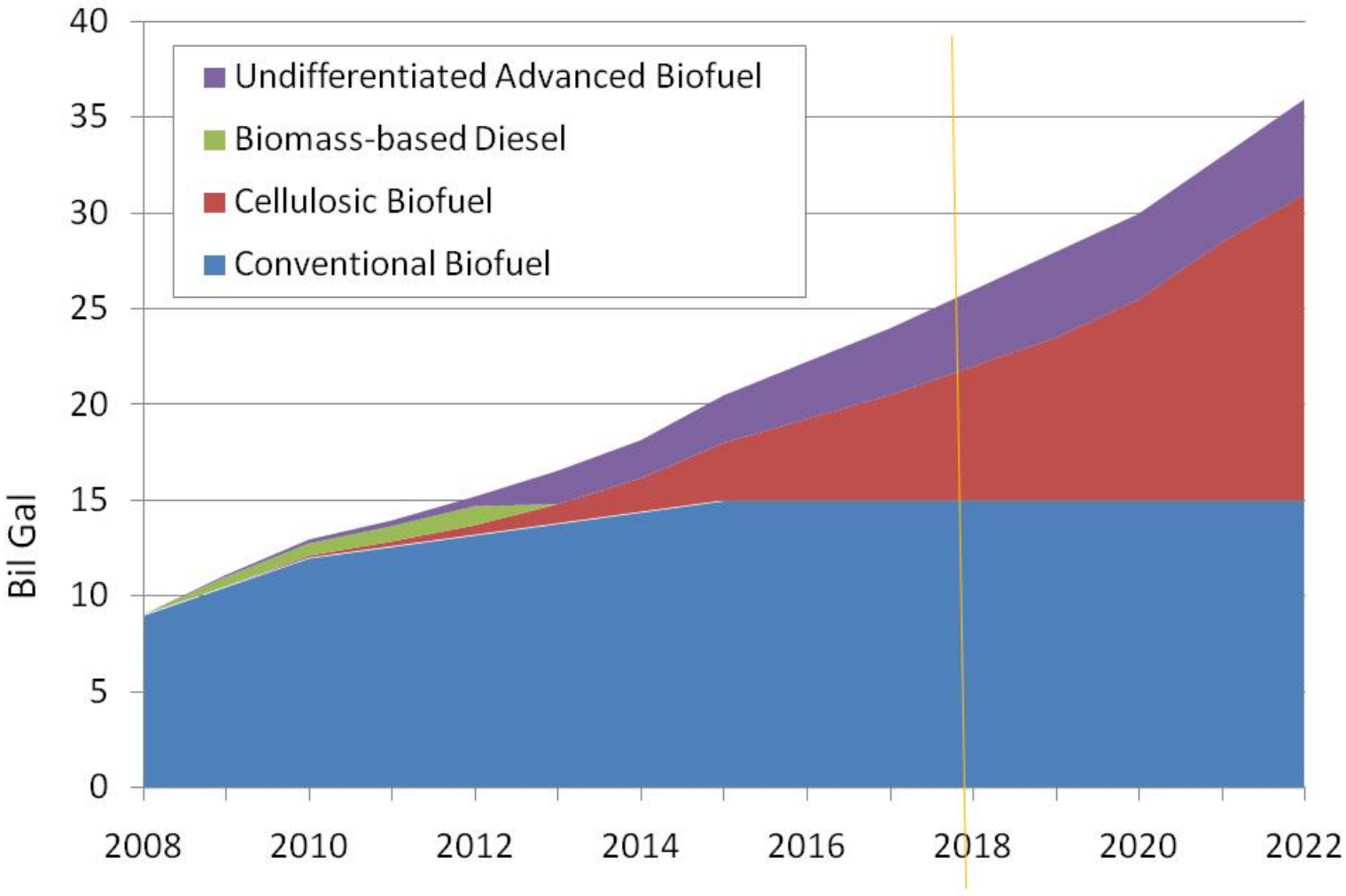
The Energy Independence & Security Act of 2007



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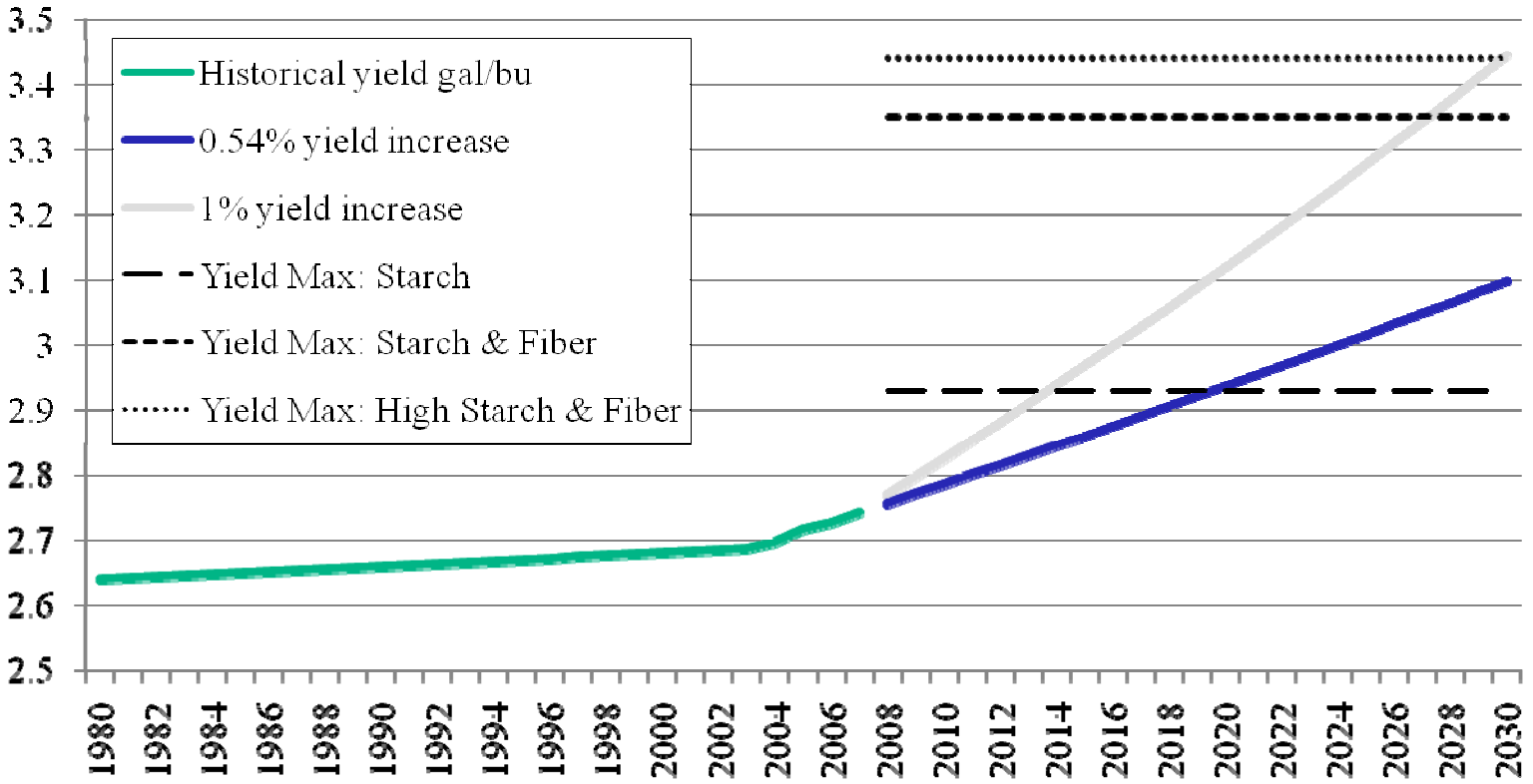
Technology Scenarios



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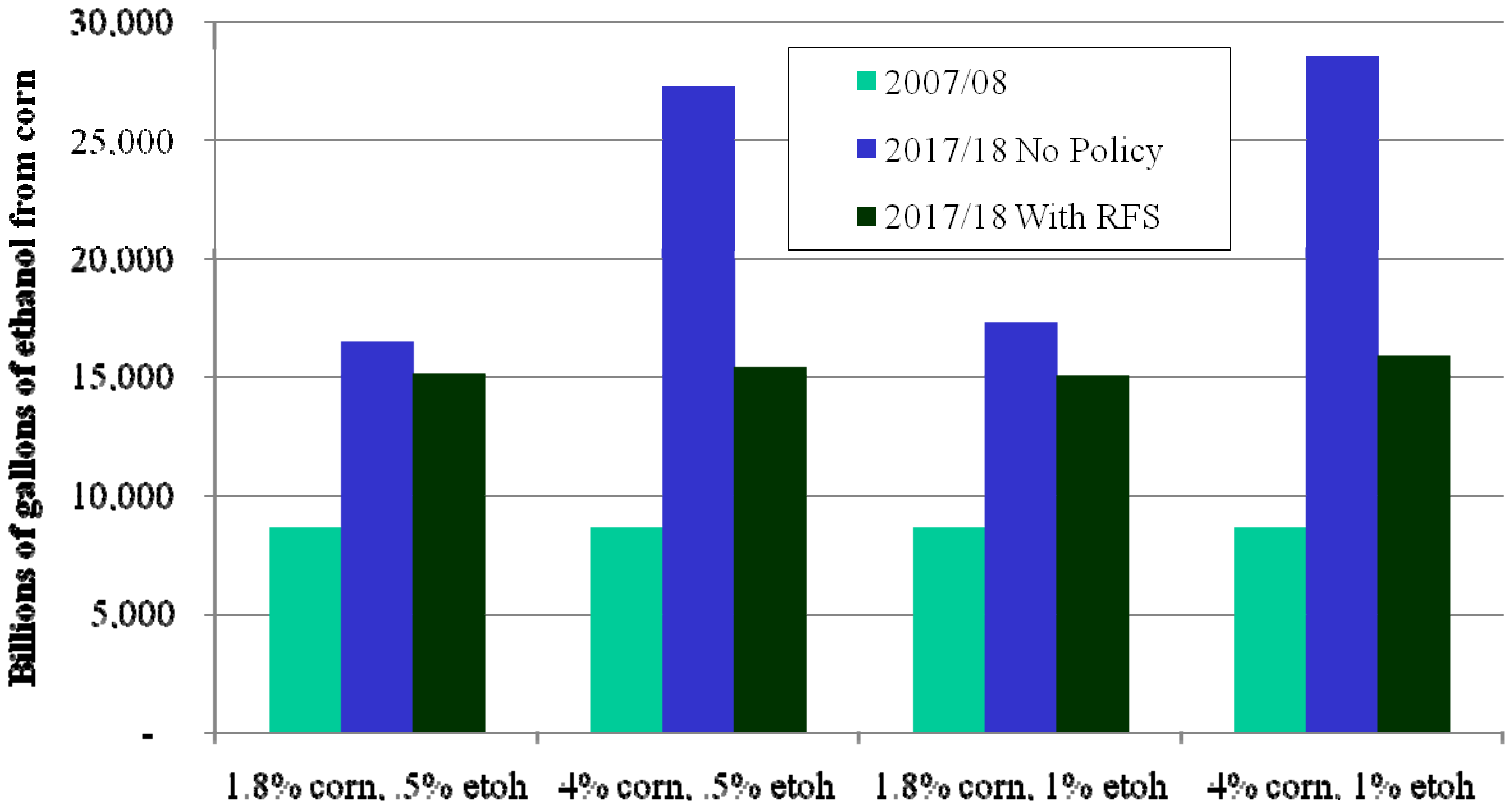
Corn and Ethanol Yields With and Without Markets or Policies



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How Markets and Policies Matter?

Greater supply

- Lower price
- Increase in all uses
  - feed, exports
- Decrease in competing sources
  - ethanol imports

Policy

- Mandates as a minimum of use

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Market Impacts

		Yield 1.8% Eth. 0.5%	Yield 4.0% Eth. 0.5%	Yield 1.8% Eth. 1.0%	**Yield 4.0% Eth. 1.0%**
Corn	Planted Area	0%	-3%	-1%	**-3%**
	Production	2%	13%	2%	**13%**
	Domestic Use	1%	8%	0%	**7%**
	Exports	5%	33%	7%	**33%**
	Price ($/bu.)	-3%	-21%	-4%	**-21%**
Soybean	Planted Area	0%	2%	1%	**3%**
	Soybeans ($/bu.)	0%	-2%	0%	**-2%**
Sorghum	Planted Area	-2%	-9%	-2%	**-9%**
	Sorghum ($/bu.)	-2%	-13%	-2%	**-13%**
Ethanol	Production	0%	1%	0%	**3%**
	Corn Dry Milled	0%	2%	-2%	**1%**
	Corn Cost of Ethanol	-3%	-21%	-7%	**-23%**
	Ethanol ($/gallon)	-2%	-12%	-4%	**-13%**
	Distillers Grains ($/ton)	-3%	-20%	-2%	**-19%**
	Net Operating Return	1%	-8%	-3%	**-5%**
	Net Imports (Ethyl Alcohol)	-4%	-13%	-8%	**-13%**

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Market Impact: No RFS

		Yield 1.8% Eth. 0.5%	Yield 4.0% Eth. 0.5%	Yield 1.8% Eth. 1.0%	**Yield 4.0% Eth. 1.0%**
Corn	Planted Area	0%	-1%	0%	**-1%**
	Production	2%	15%	2%	**15%**
	Domestic Use	2%	11%	2%	**11%**
	Exports	4%	27%	4%	**28%**
	Price ($/bu.)	-3%	-19%	-3%	**-19%**
Soybean	Planted Area	0%	1%	0%	**2%**
	Soybeans ($/bu.)	0%	2%	0%	**2%**
Sorghum	Planted Area	-2%	-8%	-2%	**-8%**
	Sorghum ($/bu.)	-2%	-11%	-2%	**-12%**
Ethanol	Production	2%	13%	5%	**15%**
	Corn Dry Milled	2%	14%	2%	**14%**
	Corn Cost of Ethanol	-3%	-18%	-6%	**-21%**
	Ethanol ($/gallon)	0%	-3%	-1%	**-4%**
	Distillers Grains ($/ton)	-4%	-23%	-7%	**-25%**
	Net Operating Return	6%	41%	11%	**47%**
	Net Imports (Ethyl Alcohol)	2%	10%	4%	**11%**

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