Sustainability of Food, Energy and Environment with Biofuels

Madhu Khanna

Department of Agricultural and Consumer Economics

University of Illinois

For

A New Green Revolution? Meeting Global Food and Energy Demands

March 4-6, 2009: I-Hotel and Conference Center

Champaign, Illinois

Motivations for Biofuels

- Energy Security
  - Reducing dependence on foreign oil
  - Finding renewable alternatives to oil
- Rural economic development
- Pragmatic solution for mitigating greenhouse gas emissions from transportation
- Can be easily blended with gasoline
  - with existing infrastructure and vehicle technology
- Current reliance on corn ethanol in US
  - Readily available technology; government support

Sustainability Challenges for Biofuels

Biofuels increase demand for land and water

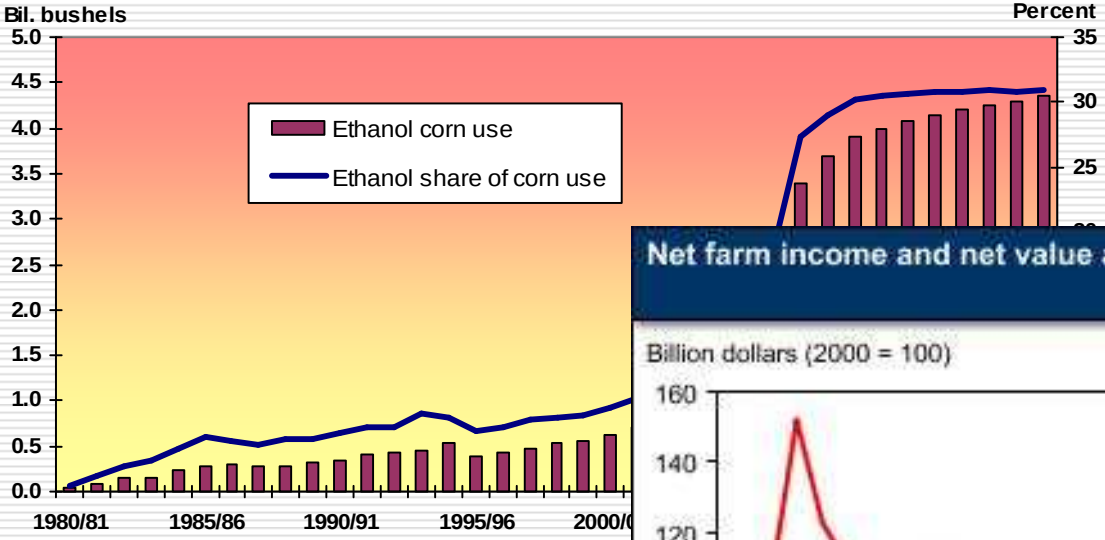
- Diversion of cropland from food and environmental preservation
- Raise food prices and hurt consumers and food importing developing countries
- Integrate agricultural and energy markets
- High oil prices lead to high food prices
- Crop price volatility leads to boom/bust in the biofuel sector

Environmental benefits of corn ethanol questionable

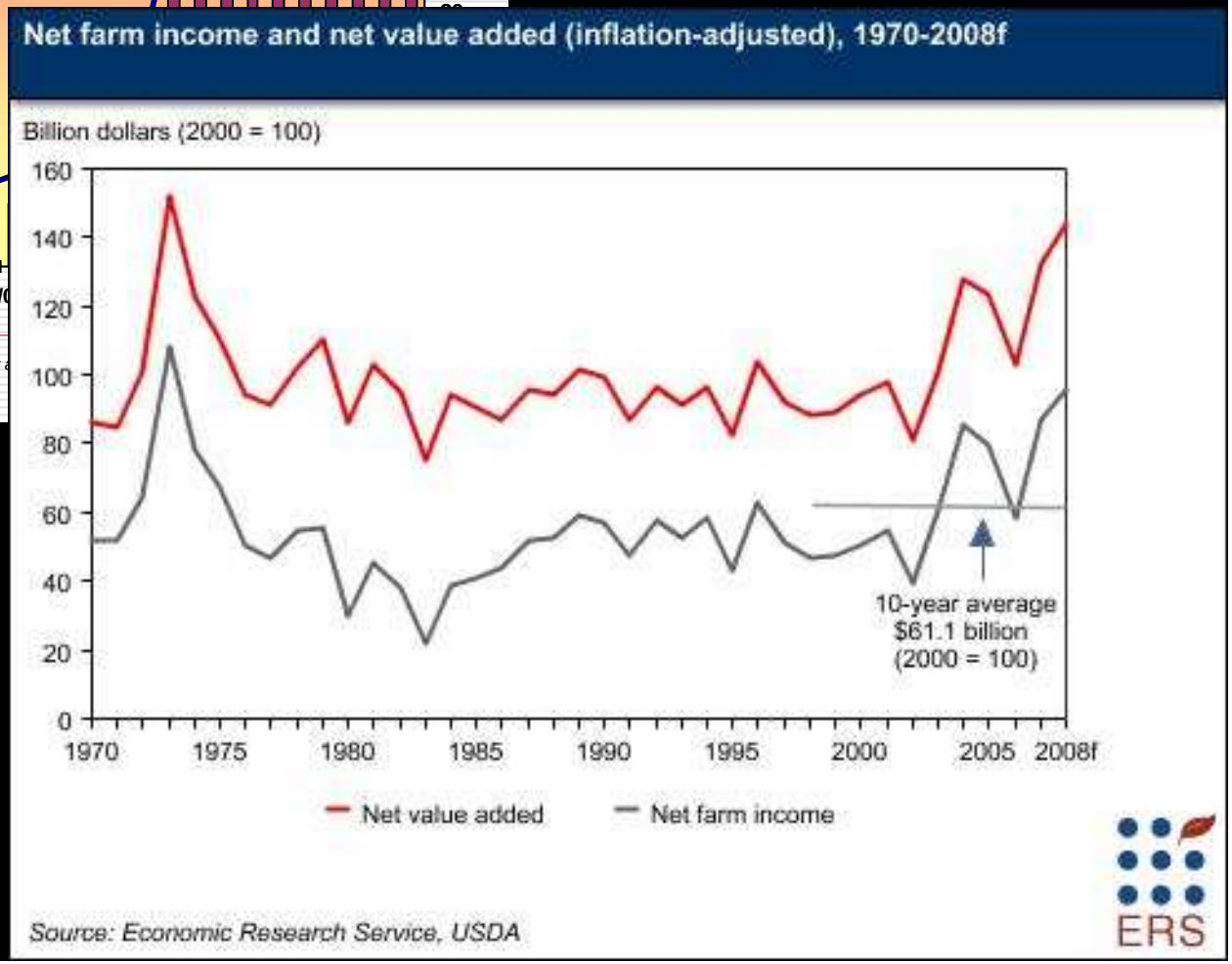
- Direct greenhouse gas reductions relatively low
- More than offset by possible indirect land use effects
- Negative water quality impacts
- Reduction in biodiversity

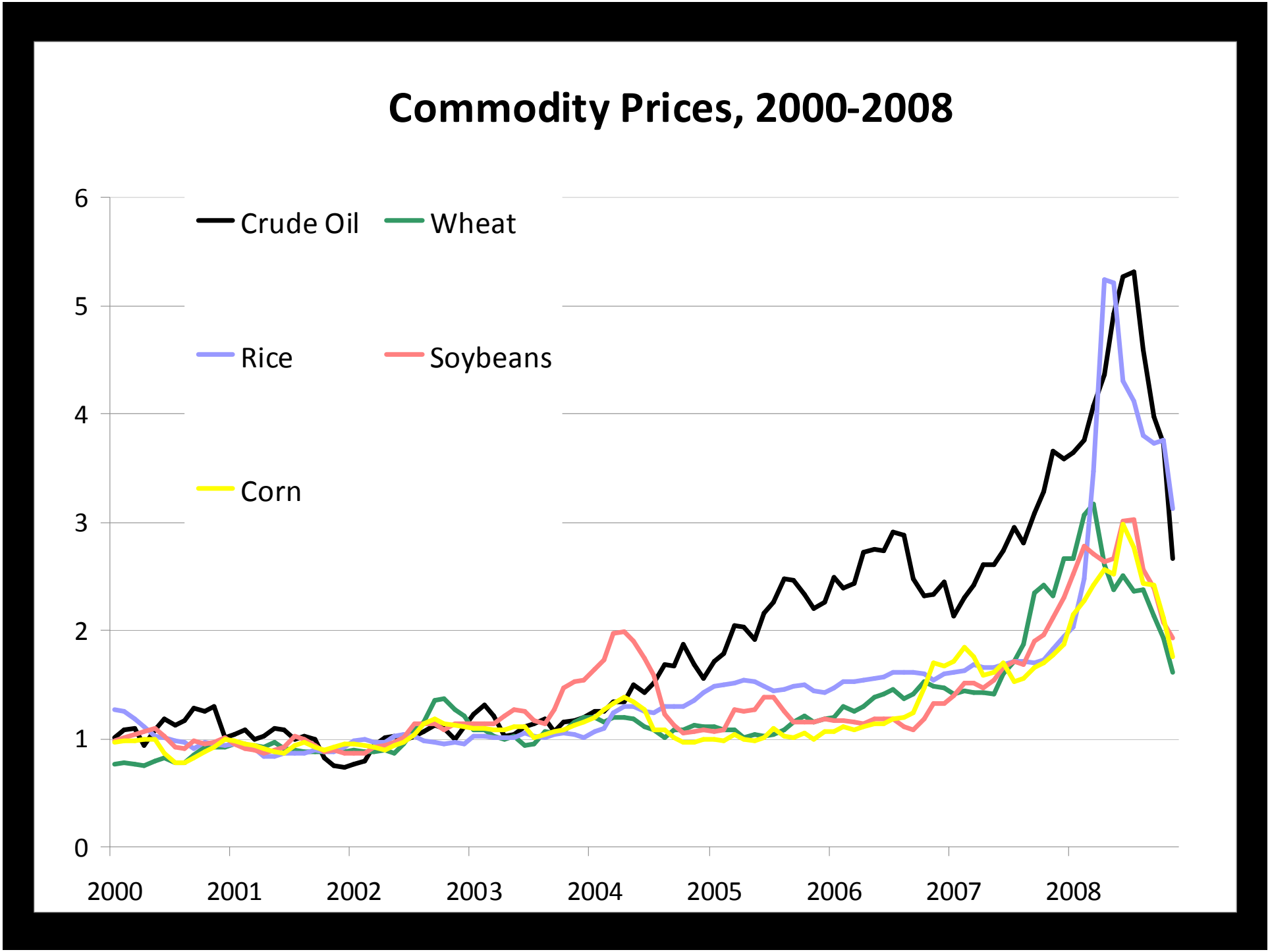
U.S. Corn Used in Ethanol Production

1995/96 through 2007/08F

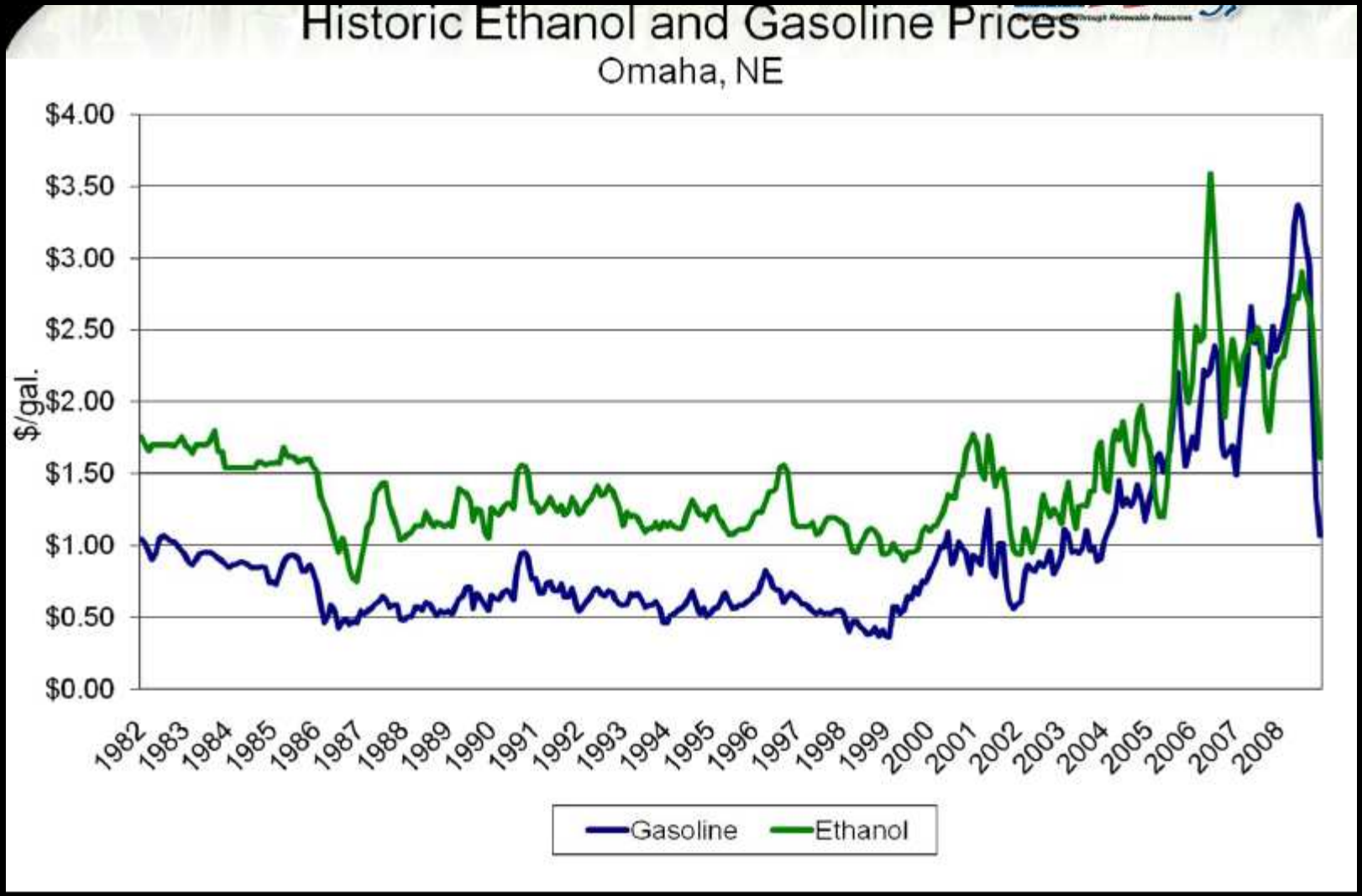


Note: 2006/07 through 2015/16 are projected based on the *World Agricultural Supply a*
Agricultural Projections to 2016, February 2007 .

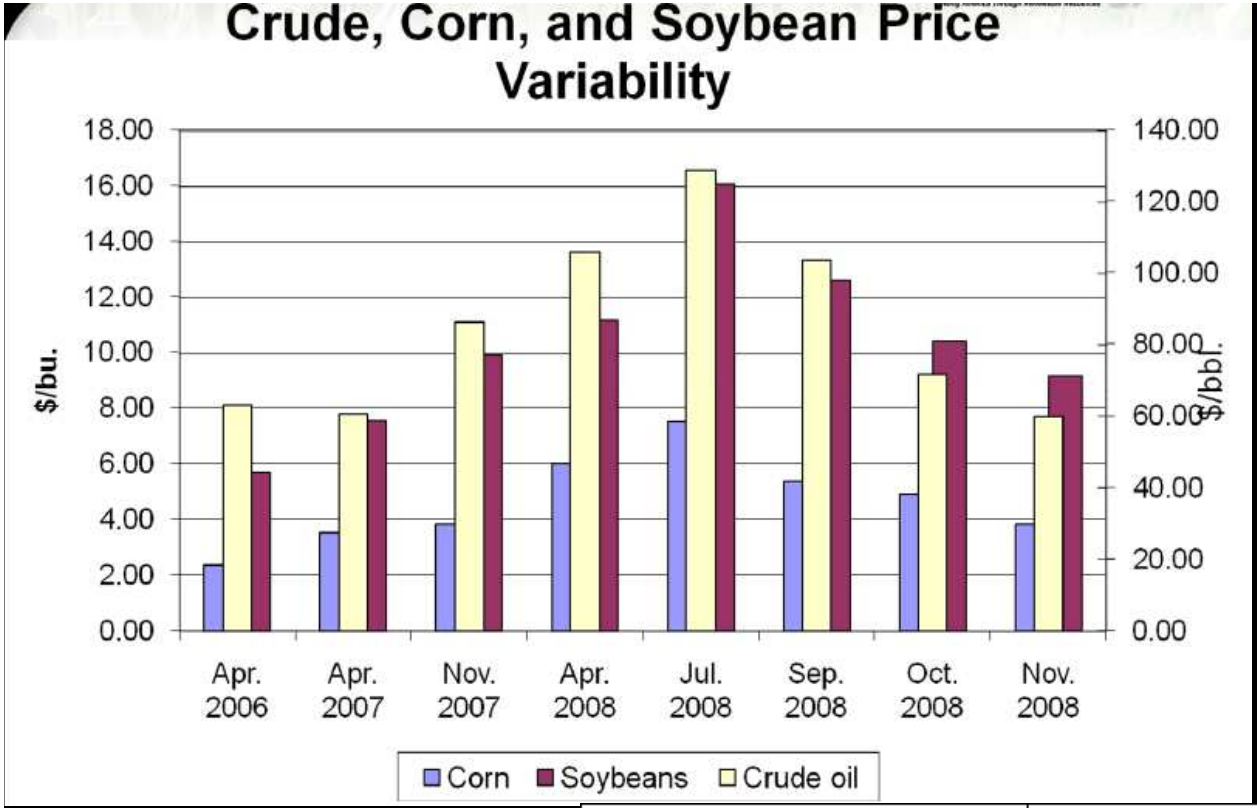



Commodity Prices, 2000-2008
Crude Oil
Wheat
Rice
Soybeans
Corn
6
5
4
3
2
1
0
2000
2001
2002
2003
2004
2005
2006
2007
2008

Relationship between Gasoline with Ethanol



Tyner, 2009



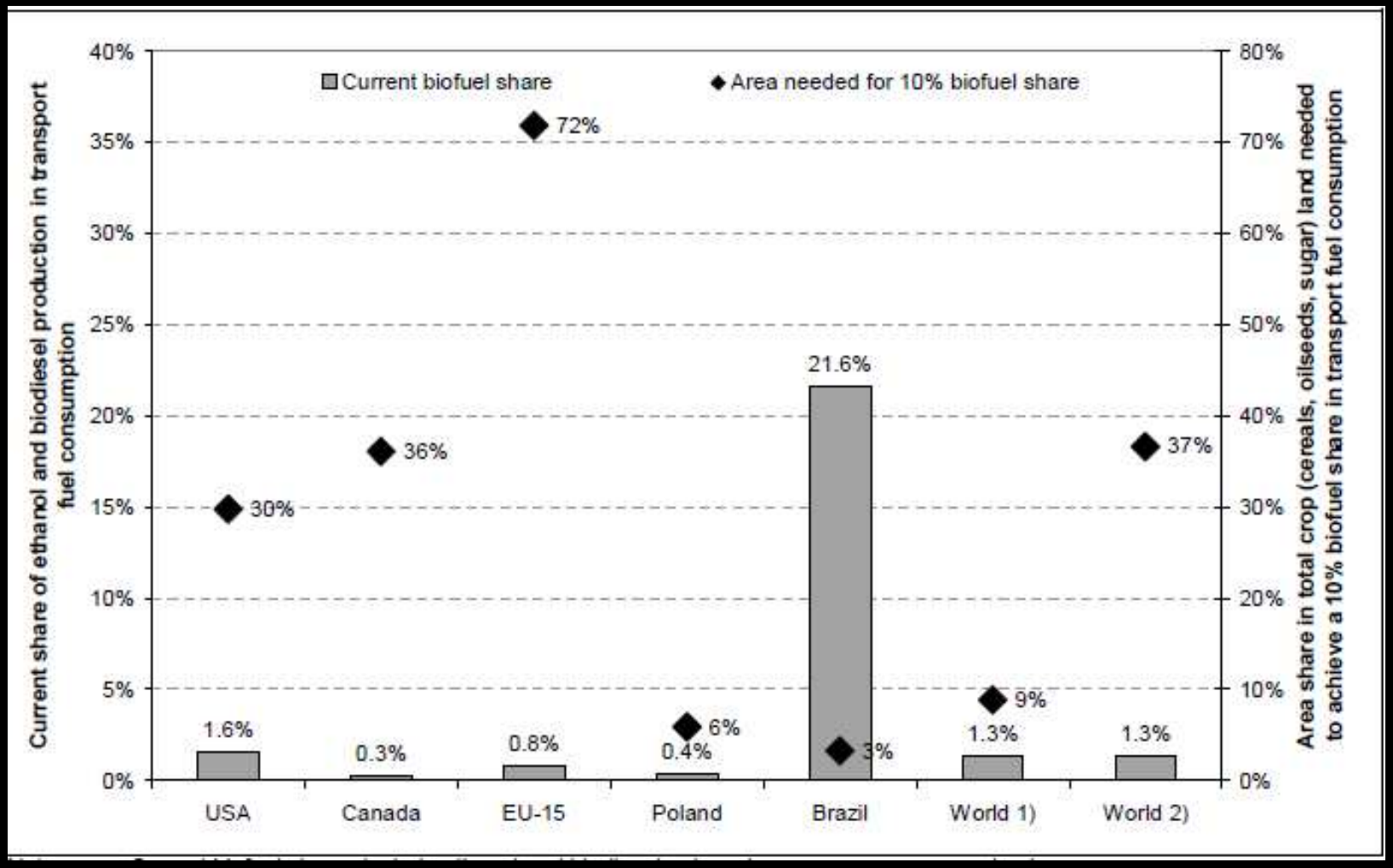
Integration of Agricultural and Energy Sectors

Agricultural and Energy Price Correlations

Tyner, 2009

Period	Correlation type	Correlation
1988-2005	Crude - gasoline	0.95
	Crude – corn	-0.26
	Gasoline - corn	-0.25
2006-2008	Crude - gasoline	0.92
	Crude – corn	0.80
	Gasoline - corn	0.67

Biofuel Share in Transport Fuel Consumption and Land Requirements for 10% Biofuel Share



All areas requirements are calculated on the basis of average crop area and yield data for 2000-2004 and transport fuel consumption in 2004

OECD, 2006

Global Potential for Ethanol from Principal Grain and Sugar Crops

Crop	Global acreage (million hectares)[a]	Global average yield (tons/hectare)[a]	Global production (million tonnes)	Conversion efficiency (litres/tonne)[b]	Land intensity (litres/hectare)	Maximum ethanol (billion litres)	Gasoline equivalent (billion litres)	Supply as % of 2003 global gasoline use[c] (%)
Wheat	215	2.8	602	340	952	205	137	12
Rice	150	4.2	630	430	1806	271	182	16
Corn	145	4.9	711	400	1960	284	190	17
Sorghum	45	1.3	59	380	494	22	15	1
Sugarcane	20	65	1300	70	4550	91	61	6
Cassava	19	12	219	180	2070	39	26	2
Sugarbeet	5.4	46	248	110	5060	27	18	2
Total	599					940	630	57

[a] Data from FAO online statistical database.

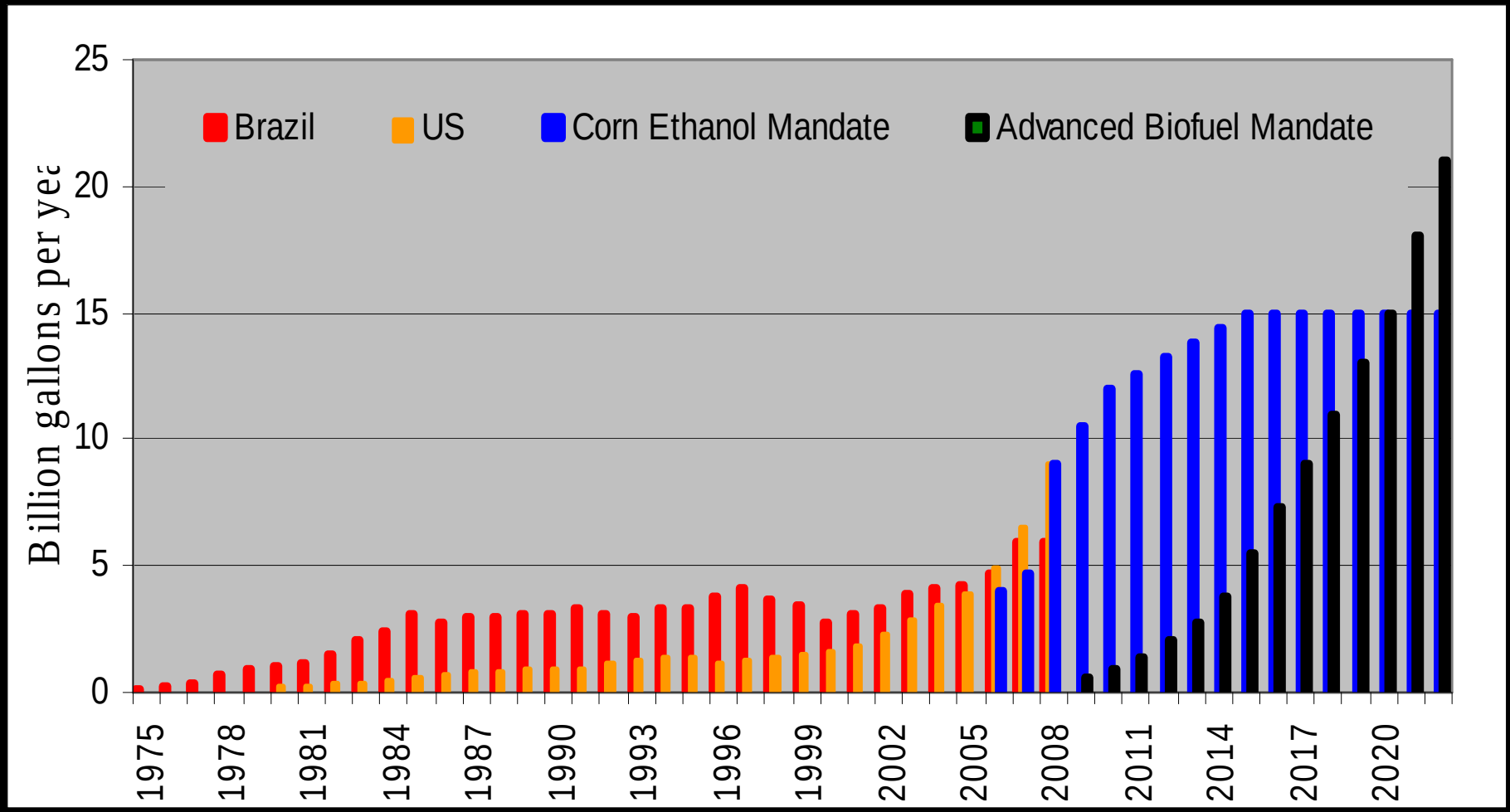
[b] Data from various sources.

[c] Global gasoline use in 2003 = 1100 billion litres (Kim and Dale 2004).

- 7 crops account for 42% of global cropland
  - Entire production of these would offset 57% of 2003 gasoline consumption
- Using 25% of these would offset 15% of 2003 gasoline consumption

Rajagopal et al., 2007

Ethanol Production and US Mandates



Mitigating the Competition for Land

Technological Innovations

- Increase in crop productivity
- Second-generation biofuels
  - Crop residues
    - corn stover, wheat straw
  - Dedicated energy crops
    - Miscanthus, switchgrass and woody biomass

Bringing marginal land into production

35 million acres under the Conservation Reserve Program in the US

Trends and Variability in U.S. Corn Yields Over the Twentieth Century

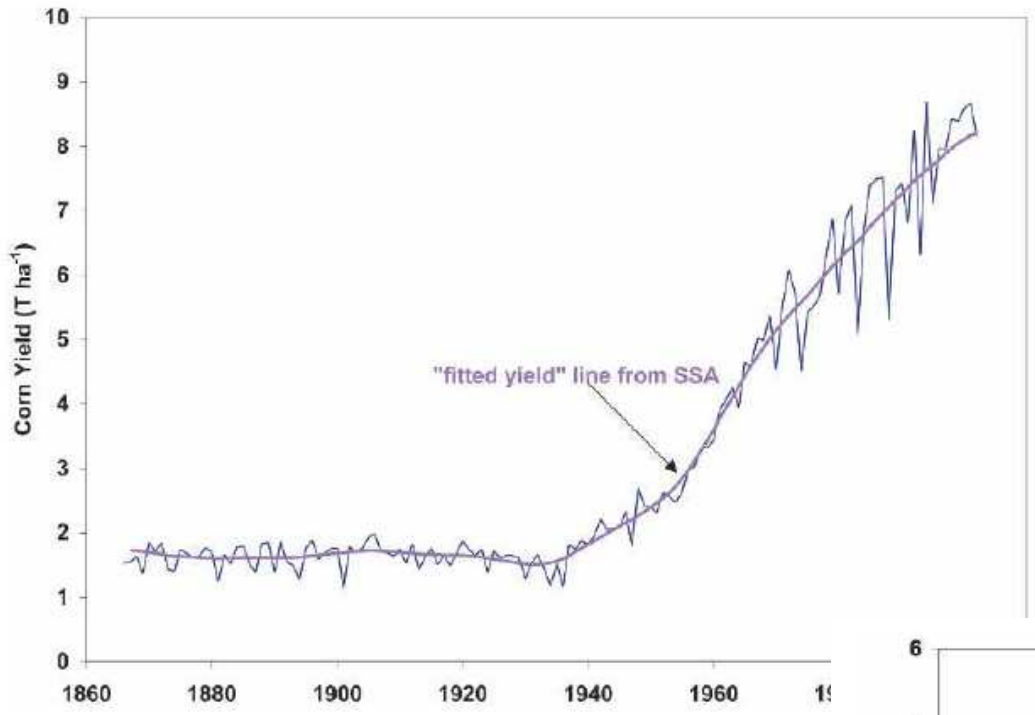


Figure 1. The U.S. national corn yield average data from the USDA "fitted yield" line (pink line) using SSA.

Annual-average U.S. corn yield has steadily increased since the 1950s

Percentage gain in yield over each previous year has steadily declined since the 1960s to less than 1.5% growth p.a. in 2001

Kucharik and Ramankutty, 2005

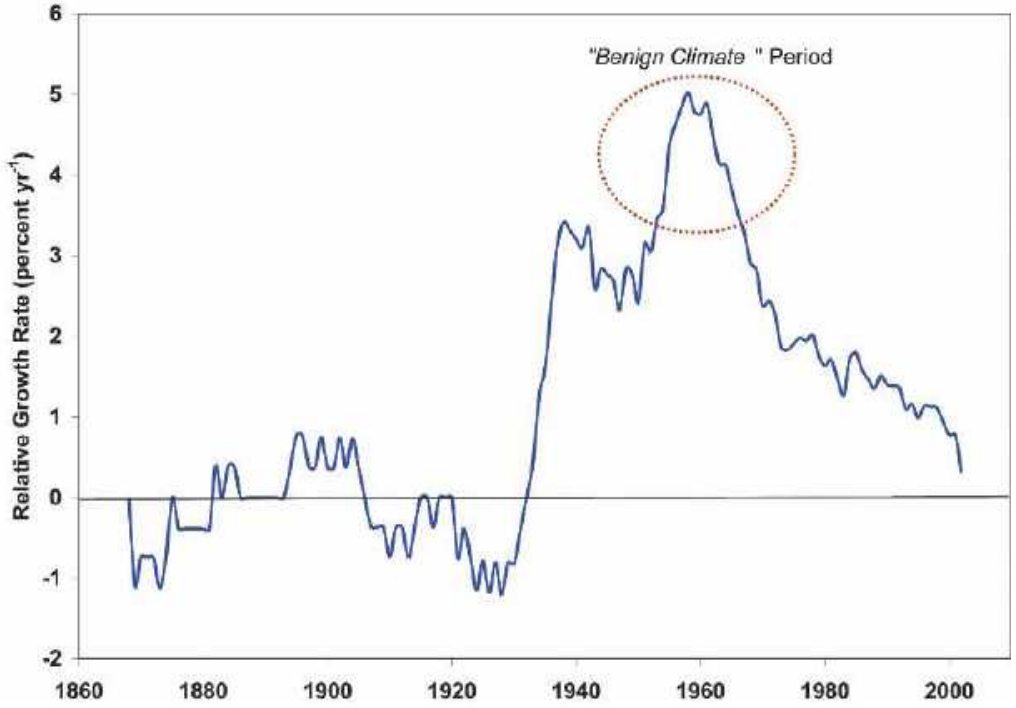
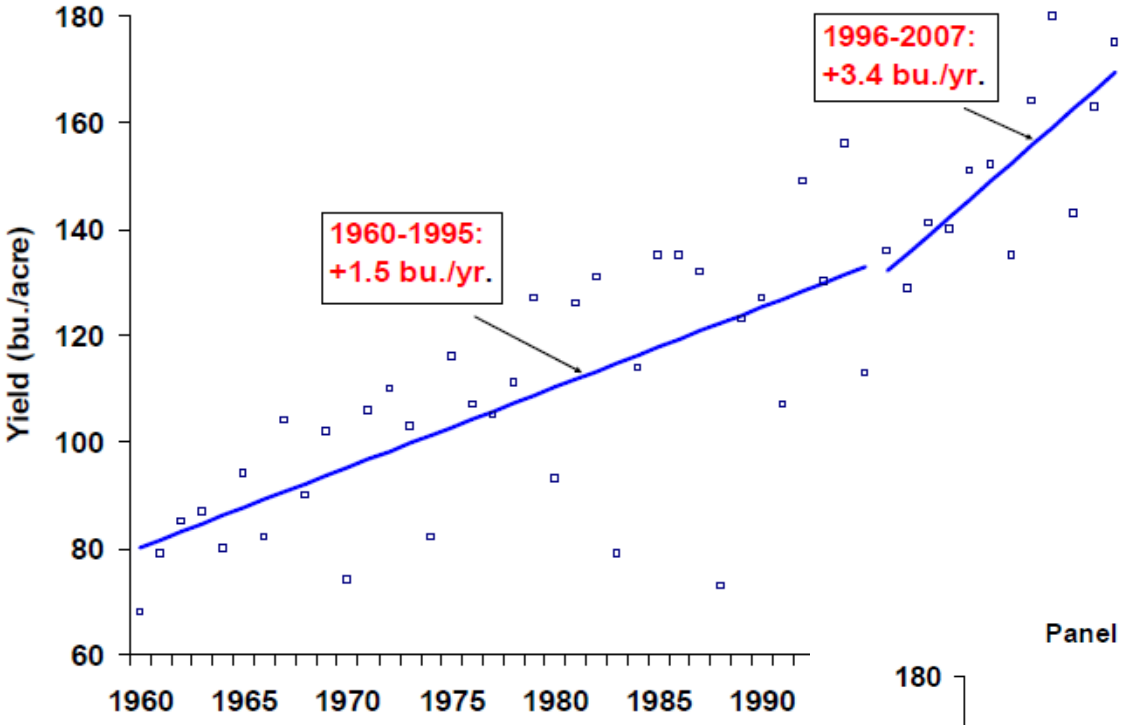


Figure 2. Annual corn yield growth rate (% yr^{-1}) calculated from the fitted yield line in Figure 1.



Illinois Corn Yields 1960-2007

Tannura, Irwin, and Good, 2008

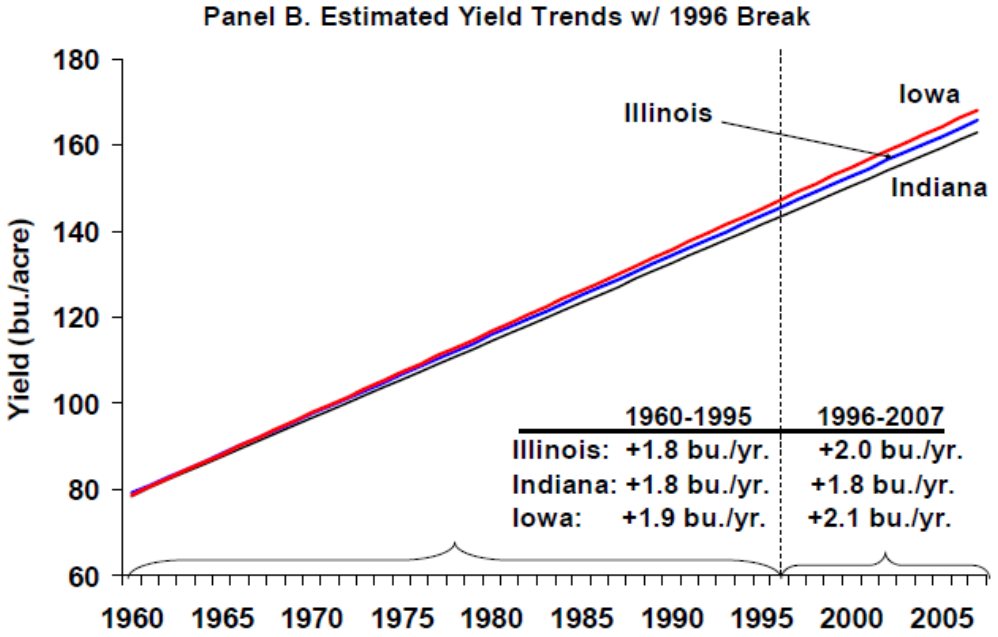


Figure 2. Estimated Trends in Illinois, Indiana, and Iowa Corn Yields after Adjusting for the Effect of Weather, 1960-2007

Potential for Quantum Leap in Corn Yields with Biotechnology?

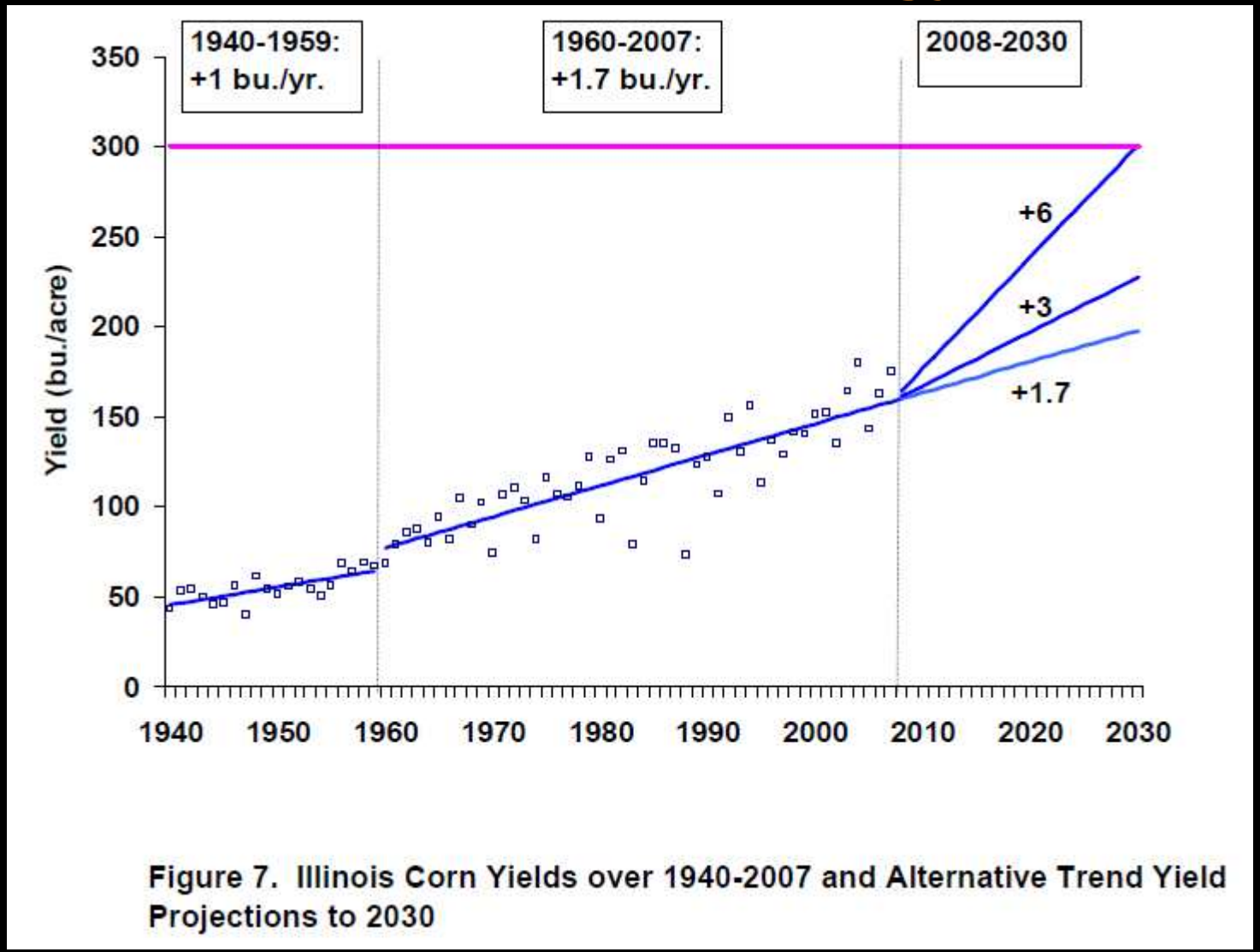


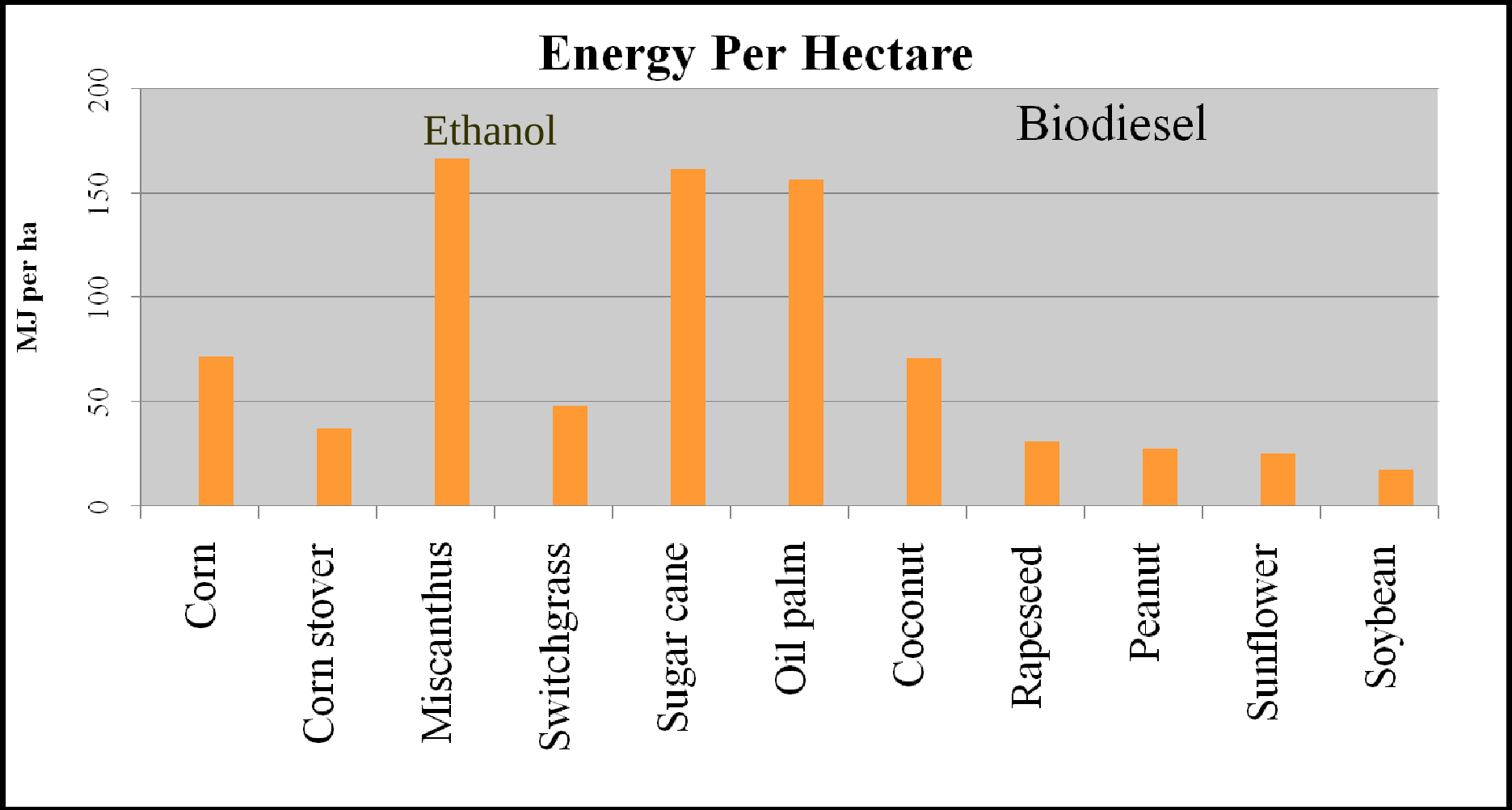
Figure 7. Illinois Corn Yields over 1940-2007 and Alternative Trend Yield Projections to 2030

Tannura, Irwin, and Good, 2008

The Promise of Second Generation Biofuels

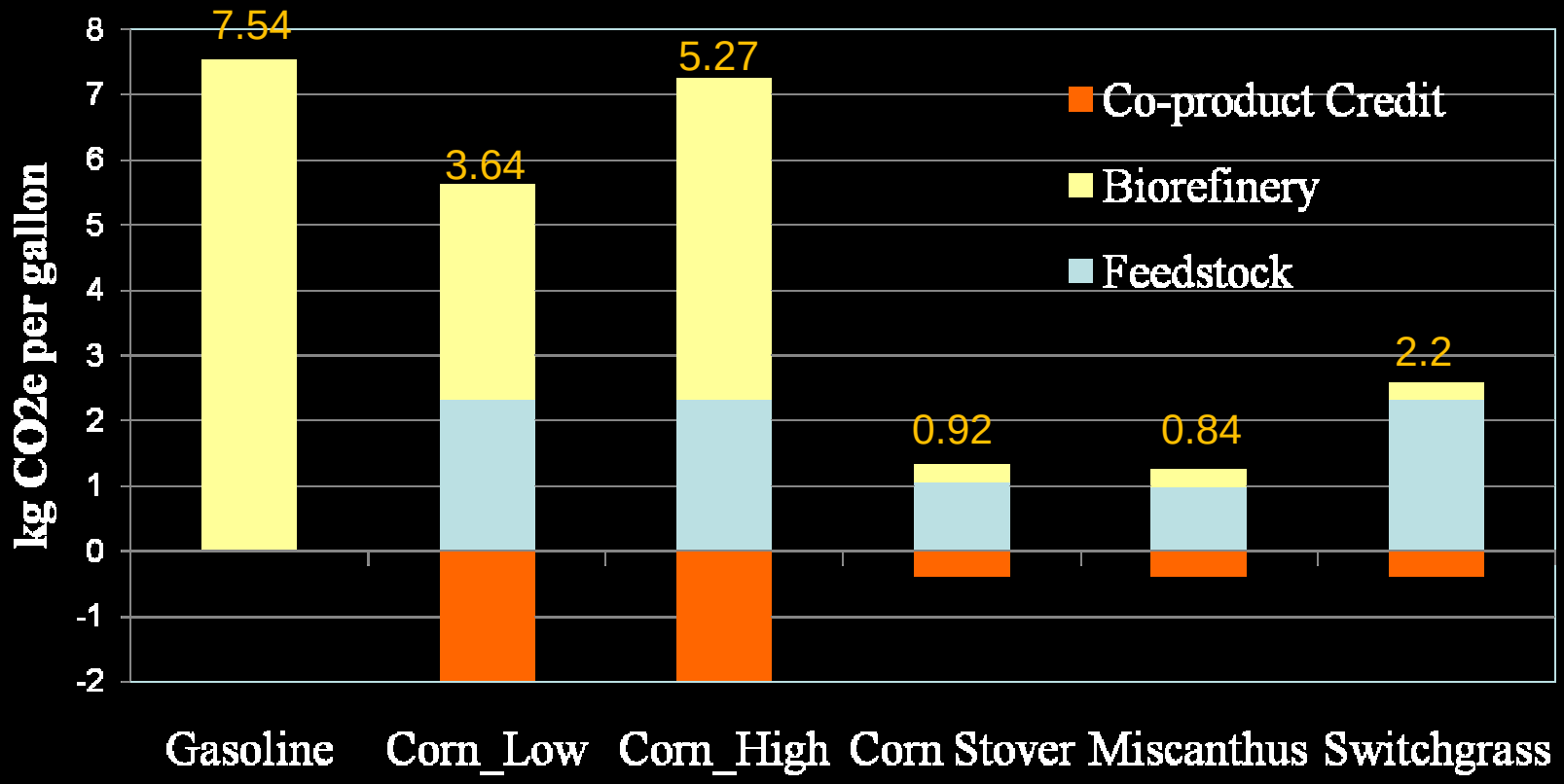
- High yielding ; potential to grow productively even on marginal, abandoned lands
- Large direct greenhouse gas mitigation
  - Through soil carbon sequestration
  - Low life cycle emissions
- Minimal negative impacts on water quality, biodiversity
- Need for innovation
  - Cost-effective technologies for harvesting, storage, transport of biomass and conversion to fuel

Efficiency of Land in Producing Energy



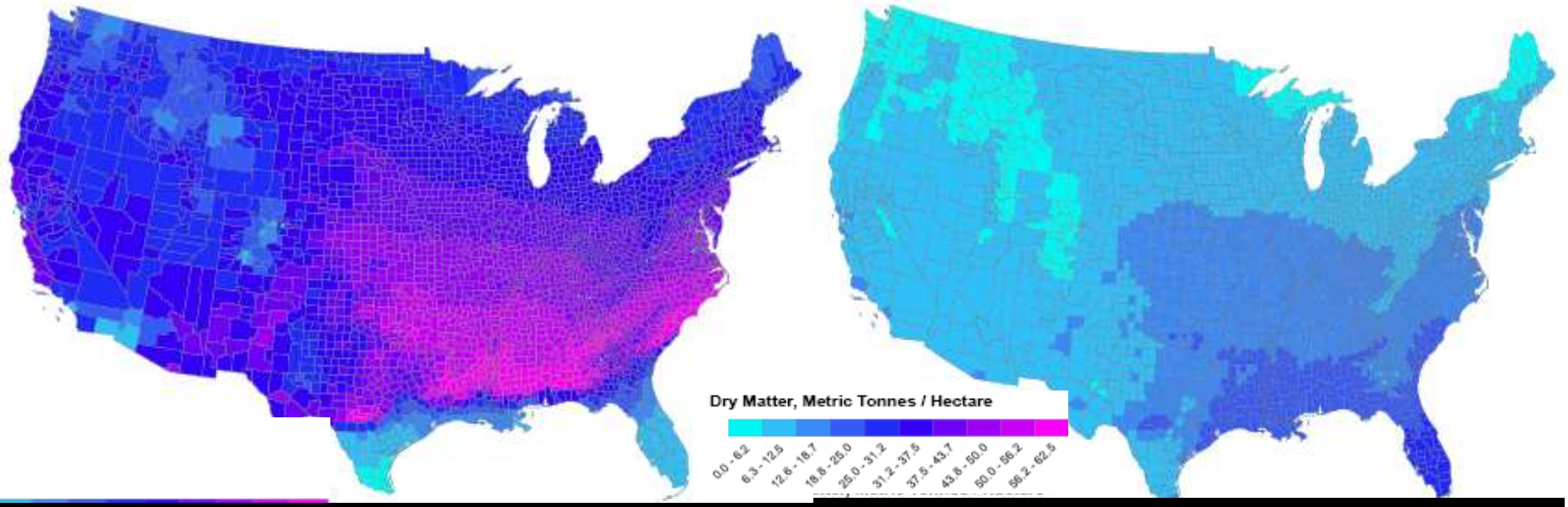
Nelson (forthcoming)

Life Cycle Greenhouse Gas Emissions



Miscanthus Yields

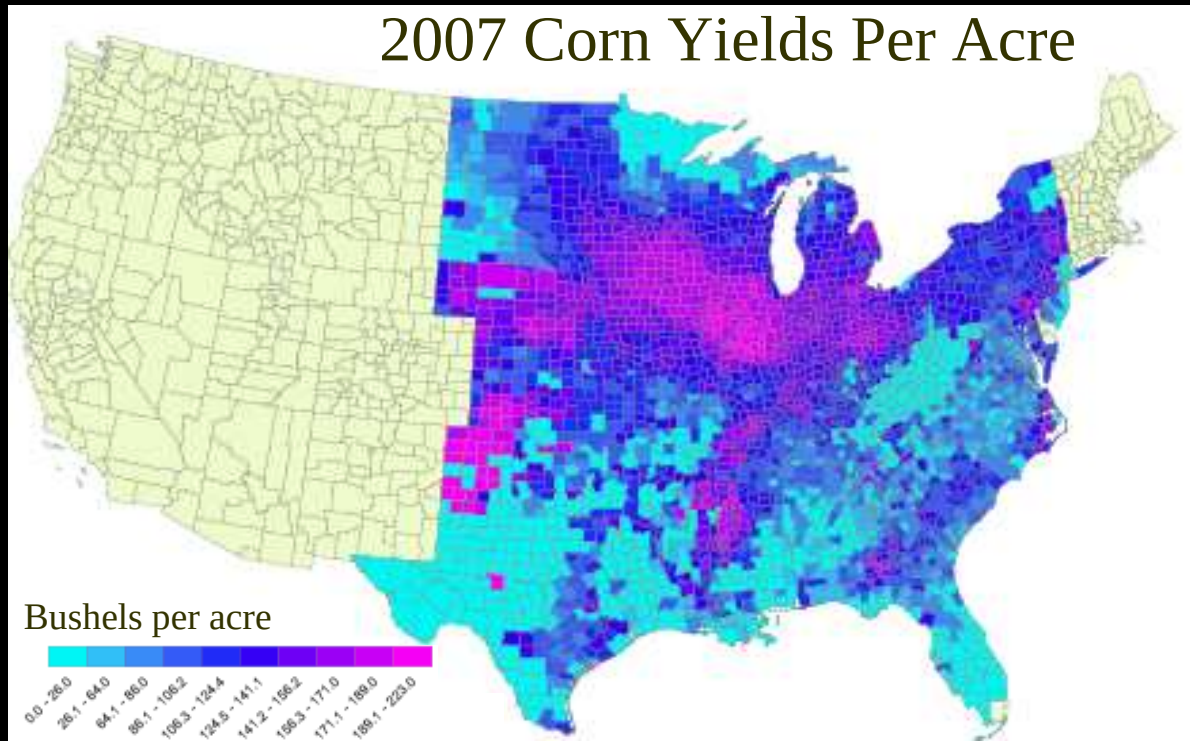
Switchgrass Yields



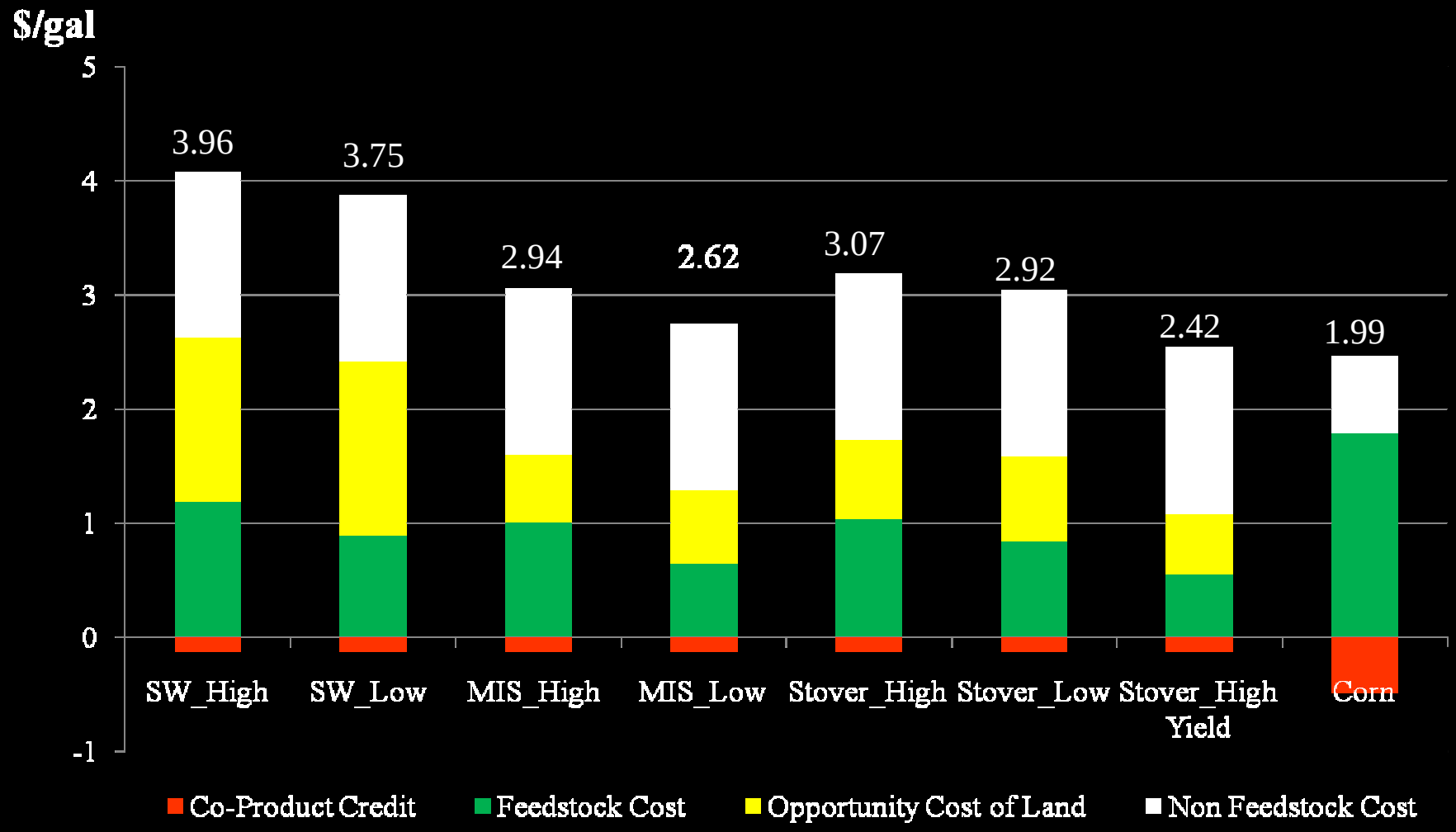
Potential for Co-Existence of Food and Fuel Crops

Preliminary Estimates: Jain and Erickson, 2008

2007 Corn Yields Per Acre



Costs of Biofuel Production



Policy Interventions for Sustainable Biofuels

- Reward biofuels based on environmental performance
  - Greenhouse gas mitigation
  - Water quality
  - Biodiversity preservation
- Mandates sensitive to food security concerns
- Incentives to use Conservation Reserve Program land for dedicated energy crops while preserving environmental benefits