Agricultural and Economic Impacts of Moving to a Biobased Economy

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Background

- A number of studies exist. Examples include
  - Farm Income and Prices: Urbanchuk (ethanol from corn), USDA (ethanol from corn); de la Torre Ugarte (energy crops)
  - Environmental: Life Cycle Assessments such as Sheehan (corn stover to ethanol) and Wang (corn and switchgrass to ethanol)
  - Economic Development and Jobs: English (co-firing biomass; ethanol from corn stover); Repowering the Midwest (electricity)

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Limitations of Existing Studies

- Ceteris parabis analyses
  - They examine the implications of a single feedstock-technology-product in isolation (i.e., the impacts of producing ethanol from corn grain or of producing biodiesel from soybeans but not both).
- Biobased industry vision
  - Simultaneous production of hundreds of products using multiple technologies all relying on the same set of biomass feedstocks
- Competition for feedstocks
  - For new bioproducts as well as traditional food, feed, industrial, and export demands

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Analytical Needs

- Develop a rigorous framework to evaluate the implications of competition as the biobased industry grows
  - Implications of different technologies
  - Implications of different management practices
  - Implications of different policies (agricultural, environmental, energy, etc.)

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Analytical Needs

- With respect to the agricultural sector, a need to understand implications of resource competition, changes in land use, and changes in crop management practices on
  - Crop prices and supplies
  - Commodity payments
  - Farm income
  - Rural development potential
  - Environmental impacts--soil, water quality, wildlife habitat in addition to emissions
- Analysis needed for national, regional, and local geographic units

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University of Tennessee Study to Develop the Framework

- Initial effort, not a final product and results are preliminary
- Not a prediction/projection of how a biobased industry will expand—a way to rigorously evaluate the dynamic interactions that might occur under a number of conditions and to assess some of their implications
- Modify a dynamic model of the U.S. agricultural sector (POLYSYS) to accommodate an expanding biobased industry
  - Five biomass feedstocks (soybean oil, corn grain, corn stover, wheat straw, and switchgrass)
  - Multiple bioenergy and bioproducts (ethanol from corn grain and cellulose; biodiesel from soybeans; electricity from cellulose; and levulinic acid, succinic acid, lactic acid, and 1,3-propanediol from grain and/or cellulose)

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The Polysys Model

- Dynamic model of the US agricultural sector
- Includes major crops including hay and alfalfa
- Includes livestock
- Includes all major cropland land types (cropped, in pasture, idle, in CRP)
- Includes food, feed, industrial, and export demands and carryover stocks
- Includes 305 geographic regions
- Anchored to USDA baseline projections
- Allocates land based on relative profitability

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Baseline Polysys Modifications

- Ag crop residues (corn stover, wheat straw)
  - control for erosion, continuous crop rotation, current mix of tillage practices, harvested as large round bales
- Switchgrass (production beginning in 2007)
  - best estimate of yields and production costs, harvested as large round bales
- Account for co-products such as DDGs
- Includes only acres currently in crop production
- Current and projected near term conversion costs and efficiencies for bioenergy/bioproducts
- USDA baseline food, feed, and export needs (2005 baseline)

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Bioenergy/Bioproduct Demand-- Baseline

- Bioenergy/bioproduct demand is based on DOE Vision)(net of current production)

	Ethanol	Biodiesel	Electricity	Total Bioproducts
2005	2.3 b gal	0.14 b gal	88 b kwh	616 m lbs
2014	16.7 b gal	0.55 b gal	160 b kwh	2269 m lbs

Note: Analyses requires demand level met regardless of cost

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Results of Baseline Analysis

- Insufficient feedstocks to meet demand even with switchgrass production beginning in 2007
- Options
  - Additional feedstocks (forestry, urban residues, other crop residues, other crops such as oilseeds, livestock wastes)
  - Improved conversion efficiencies
  - Improve crop yields
  - Increase the land base (CRP, pasture acres)
  - Change crop management practices (tillage practices)
  - Decrease demand

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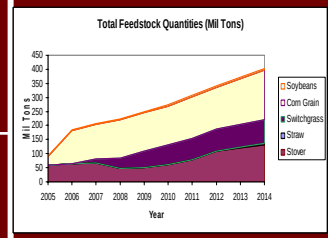
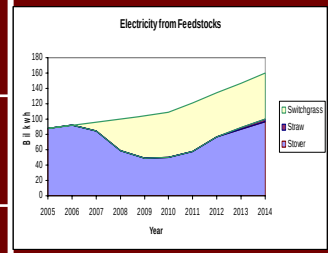
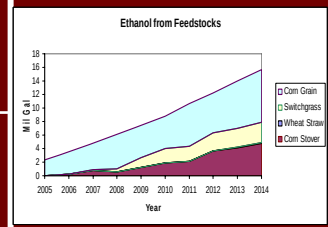
Changing the Landbase (Feedstock Mix—Year 2014)

	Ethanol	Biodiesel	Electricity	Bio-products
Corn Grain (m bu)	2880			125.3
Soybeans (m bu)		394		
Corn Stover (m dt)	69.2		64.5	0.31
Wheat Straw (m dt)	3		2.8	0.01
Switchgrass (m dt)	41.8		38.9	0.18







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Economic Impacts (million $)

	Change in Net Returns--2014	Change in Commodity Payments--2007	Change in Commodity Payments--2010	Change in Commodity Payments--2014
Corn Grain	21,534	- 844	0	0
Corn Stover	2,612			
Wheat Grain	961	- 457	0	0
Wheat Straw	71.5			
Soybeans	3,896	- 1,310	0	0
Switchgrass	7,109			
Total Other Grain Crops	1,260	- 164	- 25	- 226
Total	37,443.5	- 2,775	- 25	- 226

*2014 Contract Payments = $5,215 million

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Cost of Producing Bioenergy/Bioproducts

	Change in Cost Between 2005 and 2014
Ethanol	+ $0.65/gal
Biodiesel	+ $ 1.40/gal
Electricity	+ $0.042/kwh
Levulinic Acid	- $0.24/lb
Succinic Acid	+ $0.05/lb
Lactic Acid	+ $0.07/lb
1,3-PDO	+ $0.36/lb

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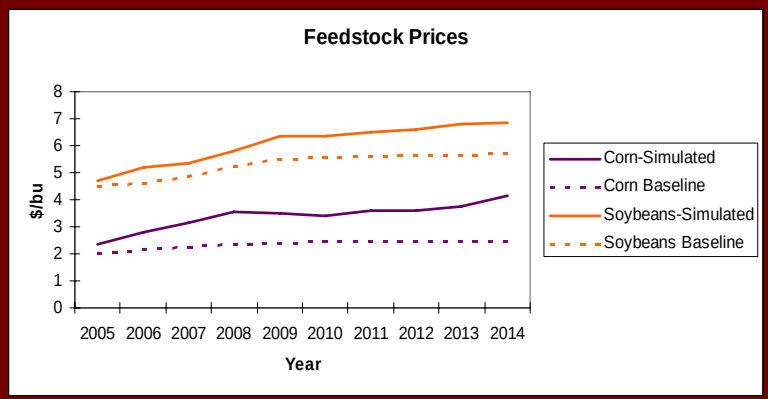
Select Changes in Crop Prices

	USDA Baseline 2014	Estimated Price 2014	Change from Baseline
Cellulose	0	$49.34/dt	+ $49.34/dt
Corn	$2.45/bu	$4.16/bu	+ $1.71/bu
Soybeans Oil	$5.70/bu $0.24/lb	$6.84/bu $0.355/lb	+ $1.14/bu + $0.115/lb
Wheat	$3.60/bu	$4.04/bu	+ $0.46/bu



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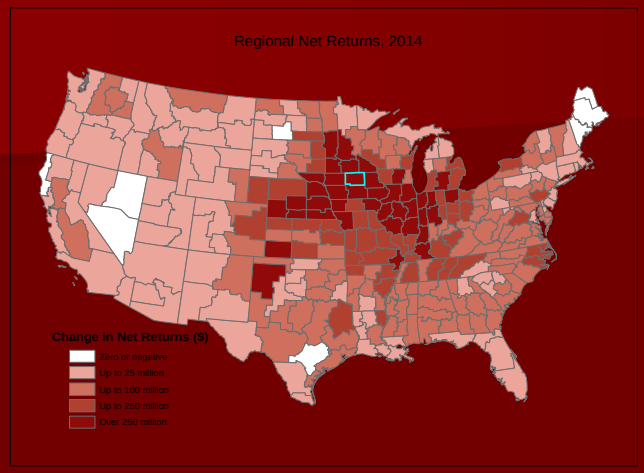
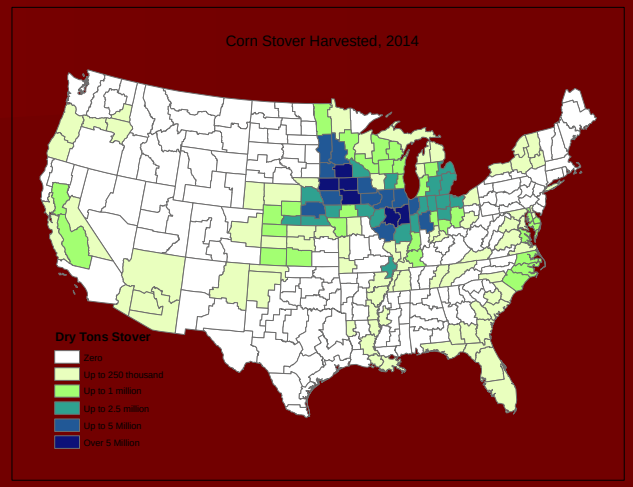
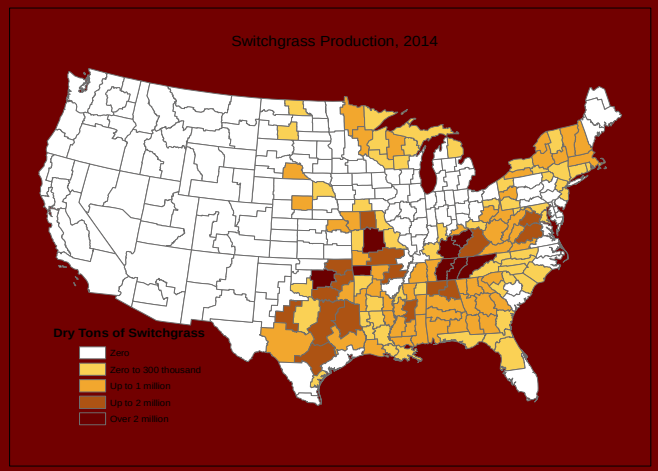
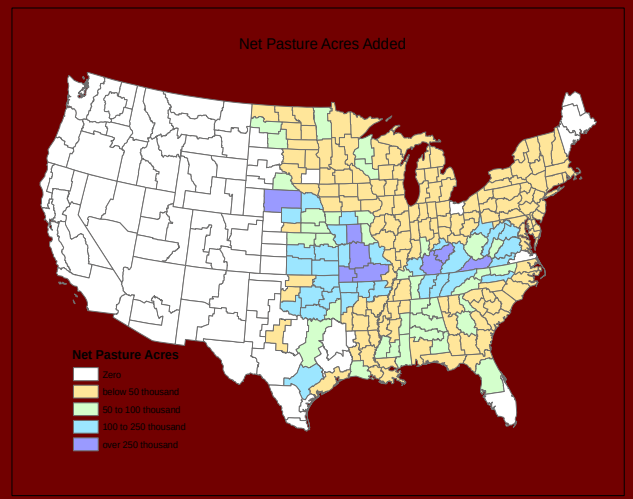
Regional Distribution









Land Use Changes (million acres)

	Estimated Change in Acres--2014
Switchgrass	+17.96
Corn	+ 0.8
Wheat	- 0.8
Soybeans	+ 1.4
Other 5 Grain Crops	-0.02
Hay	+16.43
CRP	(7.2)
Pasture	-35.1

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Environmental Considerations

- Increased Use of Crop Residues
  - Quantities available based on maintaining erosion <= T, which will increase erosion over current levels for any given tillage practice and crop rotation—Implications of shifting tillage and rotations?
  - Soil organic matter (carbon)—rigorous assessment in Iowa indicated that if sufficient quantities are left to control for erosion, soil organic matter will ***not*** be drawn down in most cases, but there are exceptions.
  - Crop yields—in some studies, removal of residues result in lower crop yields relative to non-removal. Role of soil organic matter, soil moisture, soil temperature?

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Environmental Considerations

- Switchgrass
  - Data is limited
    - Follow recommended management practices (i.e., no-till planting through existing residues; no fertilizer in establishment and limited levels thereafter), switching acres from traditional crops to SG production is expected to lead to improvements in erosion, soil organic matter, chemical and nutrient runoff (nutrient implications in soybeans needs to be looked at in more detail)
    - Caveat—soils prone to forming gullies may/may not be appropriate and may/may not require cover crops at establishment
    - Pasture—Depends on the existing management situation, but if already in perennial grass with low intensity management, converting to SG production may not significant improvements, and may have adverse impacts depending on how the site is prepared for SG planting
  - Management of establishment year is key

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Environmental Considerations

- Conservation Reserve Program
  - If properly planted to switchgrass, can maintain erosion and soil carbon benefits
  - Wildlife habitat
    - How often can you harvest (current policy is every 3 years)
    - What's the best method of harvest (solid, strips?)
    - Interim management needs

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Final Thoughts

- The question/issue is not whether we can develop a biobased industry but rather how do we want to see the industry develop
  - Must decide what our vision of biomass is-- (i.e., just a source of primary energy; a means to address agricultural and rural economic issues; other)
  - Understand the implications of different R&D strategies and whether or not they support or undermine the vision
  - What tradeoffs are we willing to make

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