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US Corn Ethanol: Emerging Technologies at the Biorefinery and Field Level

Briefing

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- The Production Technologies of First and Second Generation Biofuels are Rapidly Advancing
  - At the Plant Level
  - During Feedstock Production
- Main Drivers Are:
  - RFS2, Innovation Cycles, Access to Capital
- Technologies also Ensure Long-Term Sustainability

2013 Corn Ethanol: New Technologies

Ethanol Plant Level as well as Corn Production

- Front End Oil Recovery - BOS (Brix Oil Separation)
- Protein Recovery - MSC - Maximum Stillage Co-Products
- Fiber Bypassing/Separation - Pre and Post-Fermentation - to be used in conjunction with SGT/Front End Oil and MSC
- Fiber Bypassing/Separation
- Process - Pre Fermentation
- CHP - Combined Heat and Power - 200 psig steam
- CHP - Combined Heat and Power - 400-600 psig steam
- Super Heated Steam Dryers
- Additional Energy and Yield Projects
- Liquefaction Mash Exchanger Plate Expansion
- Fermentation Exchanger Plate Expansion
- CO2 Scrubber Ethanol Reclaim
- 200 Proof Denaturing
- VFD Drive Addition
- DDGS Cooling
- Central Vent Condensing

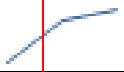
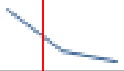
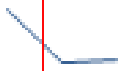
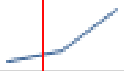
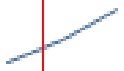
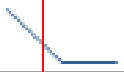
- Corn Replacement Feed
- Nitrogen Stabilizers
- Control Release Nitrogen
- Soil Testing
- Remote Sensing
- Farm Machinery Technologies Using GPS Tracking Technology
- Modern Hybrids and GEO Traits
- Enzymes Contained in Corn Endosperm

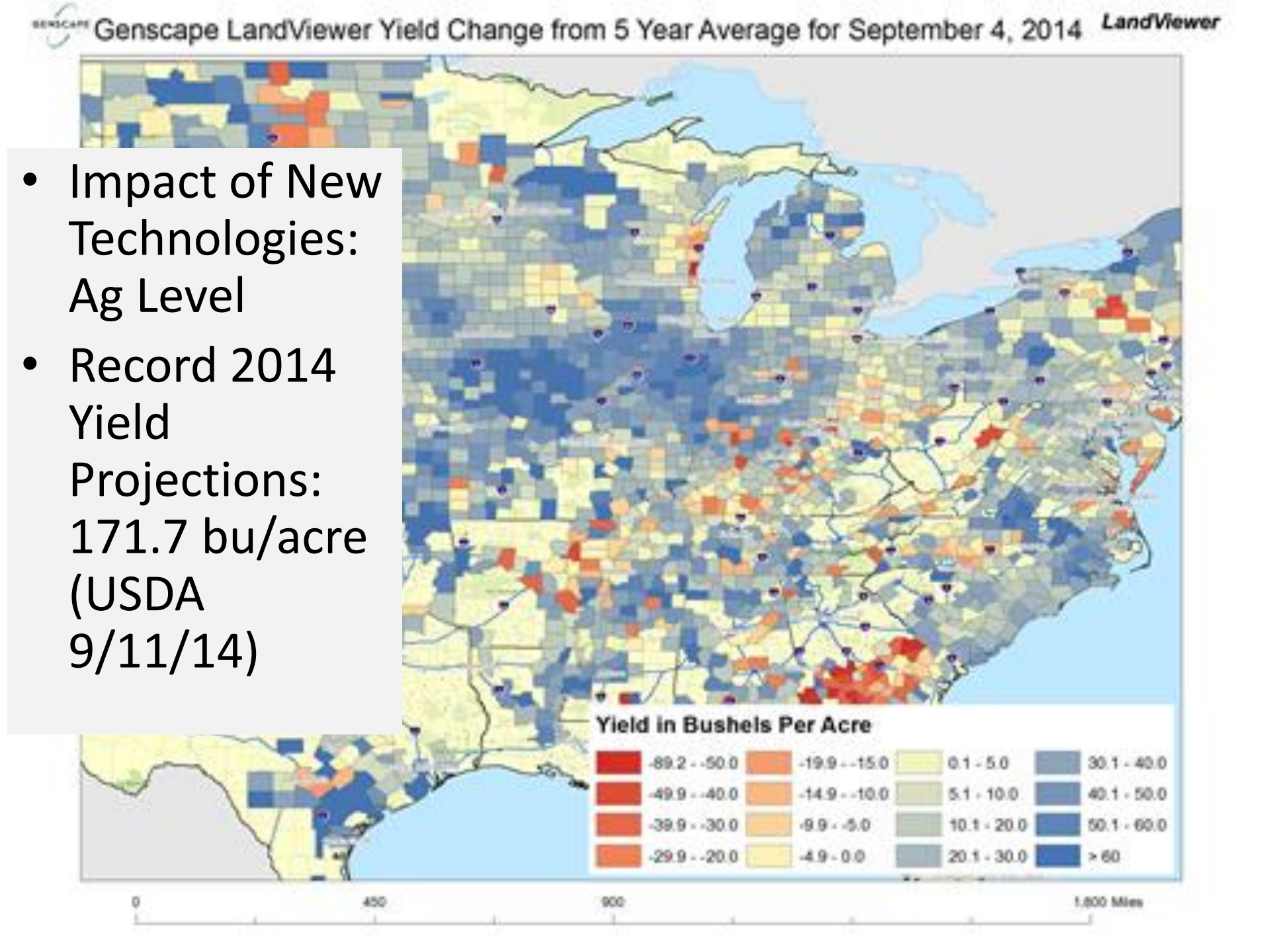
Impact of New Technologies: Plant Level

From 2001 to 2013:

- 34% reduction in thermal energy use and
- a 31% reduction in electricity while
- increasing yield by 7%
- but RFS2 uses 2007 data

RFS2 Data

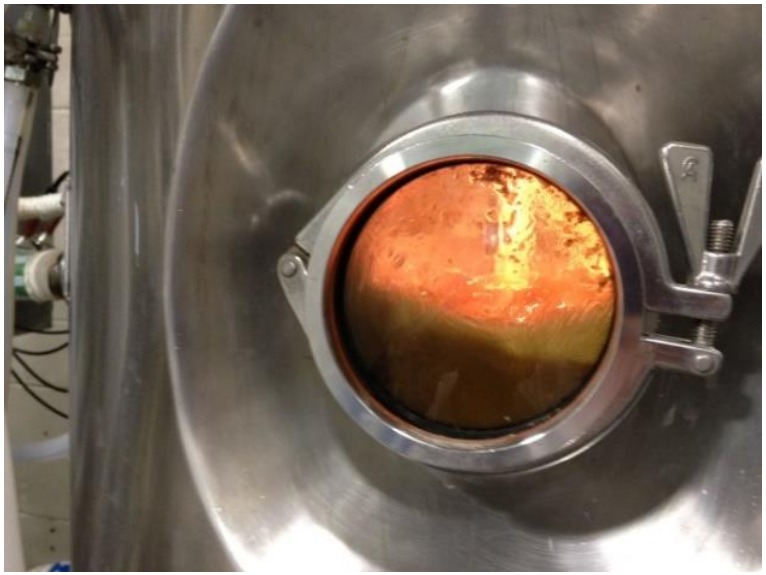
	2001	2008	2012	Trend
Yield (undenatured, gallon/bushel)	2.64	2.78	2.82	
Thermal Energy (Btu/gallon, LHV)	36,000	26,206	23,862	
Electricity Use (kWh/gallon)	1.09	0.73	0.75	
DDG Yield (dry) incl. corn oil (lbs/bu)		15.81	15.73	
Corn Oil Separated (lbs/bushel)	0	0.11	0.53	
Corn Oil Separated (% of Plants)	0%	33%	74%	
Water Use (gallon/gallon)	5	2.72	2.7	



- Impact of New Technologies: Ag Level
- Record 2014 Yield Projections: 171.7 bu/acre (USDA 9/11/14)

Example 1: Corn Kernel Fiber to Ethanol

- Fiber in corn kernel is processed into cellulosic ethanol at existing starch ethanol plants
- Potential to produce 1 billion plus gallons of cellulosic ethanol out of existing dry grind plants
- Quad County Corn Processors just started commercial operation
- Rapid adoption expected mirroring the rate of corn oil separation technologies



Example 2: Corn Replacement Feed

- Higher corn yields have also increased the amount of plant residue (stover etc.) produced by modern hybrids
  - Stover is becoming a management issue
- Growers have started to remove corn stover for use as animal feed in nearby feedlot operations
- Stover, pretreated with ~5% lime substitutes for corn and other feed

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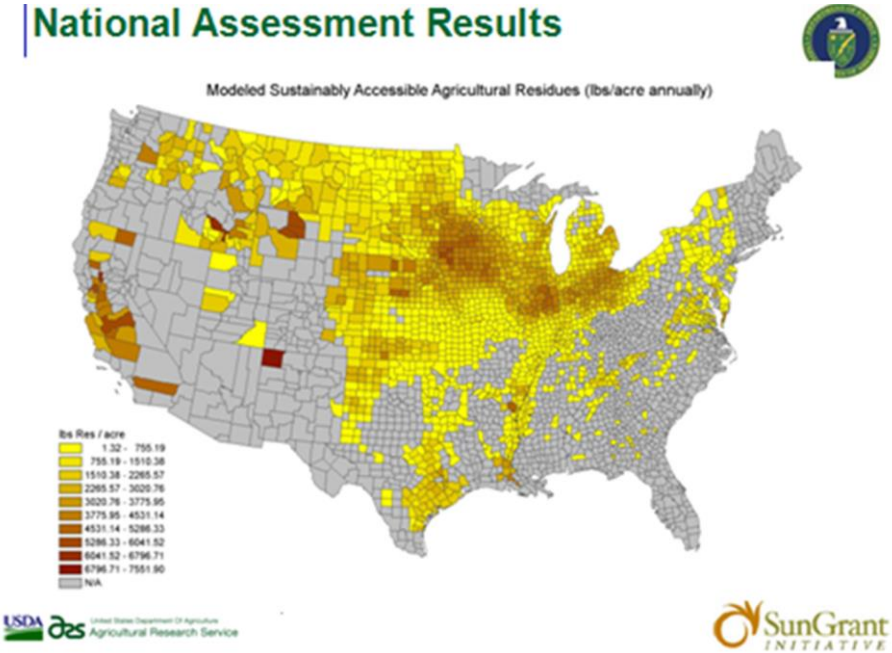
Land Use Impact: CRF

- A simplified insight into the co-product impact of stover:
- A corn field with a yield of 170 bu/acre produces 4.75 tons of corn and approximately an equivalent amount of corn stover
- If 30% or 1.43 tons of that stover can be sustainably removed for CRF (a reasonable removal rate for many areas) this is equivalent to producing an extra 50+ bushel of corn on that acre (assuming 1:1 substitution in animal diets)
- In this case this would constitute a 30% land credit form this field



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Land Use Impact: DDG

RESEARCH Open Access

Land usage attributed to corn ethanol production in the United States: sensitivity to technological advances in corn grain yield, ethanol conversion, and co-product utilization

Rita H Mumm[1*], Peter D Goldsmith[2], Kent D Rausch[3] and Hans H Stein[4]

Abstract

Background: Although the system for producing yellow corn grain is well established in the US, its role among other biofeedstock alternatives to petroleum-based energy sources has to be balanced with its predominant purpose for food and feed as well as economics, land use, and environmental stewardship. We model land usage attributed to corn ethanol production in the US to evaluate the effects of anticipated technological change in corn grain production, ethanol processing, and livestock feeding through a multi-disciplinary approach. Seven scenarios are evaluated: four considering the impact of technological advances on corn grain production, two focused on improved efficiencies in ethanol processing, and one reflecting greater use of ethanol co-products (that is, distillers dried grains with solubles) in diets for dairy cattle, pigs, and poultry. For each scenario, land area attributed to corn ethanol production is estimated for three time horizons: 2011 (current), the time period at which the 15 billion gallon cap for corn ethanol as per the Renewable Fuel Standard is achieved, and 2026 (15 years out).

Results: Although 40.5% of corn grain was channeled to ethanol processing in 2011, only 25% of US corn acreage was attributable to ethanol when accounting for feed co-product utilization. By 2026, land area attributed to corn ethanol

Mumm et al: "Although 40.5% of corn grain was channeled to ethanol processing in 2011, only 25% of U.S. corn acreage was attributable to ethanol when accounting for feed co-product utilization."

Chicago Tribune: 5/9/2014: "The government diverts nearly 40 percent of the U.S corn crop for ethanol….."

SCOTT OLSON/GETTY

The government diverts nearly 40 percent of the U.S. corn crop for ethanol, and that drives up beef cost

Hamburger price helper

Federal ethanol policy reaches your barbecue grills

Checked the price of ham

weight. Under pressure from high feed costs over the years, cattle producers who must compete for grain with ethanol makers have cut back their herds. With live-

Nevertheless, the government RFS mandate has been schedu to keep going up, transferring wealth from American consum ers to politically

Technologies that Ensure Sustainability

- Verification of Biorefinery Process Integrity
  - Sophisticated process monitoring and quality assurance programs (QAP) including third party verifiers (for example Genscape Inc.)
  - Emerging under RFS2 for starch and cellulosic ethanol
- Agricultural sustainability such as third party verifiers (for example International Sustainability and Carbon Certification) or benchmarking (for example Field to Market)

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