AAEA Extension Section Webinar

Inflated Expectations, Unfulfilled Mandates, and Cost-Efficient Feedstock Systems for Cellulosic Biofuels – What's a Farmer to do?

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A project of the ***Western Extension Committee and*** many others.

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Today's Speakers

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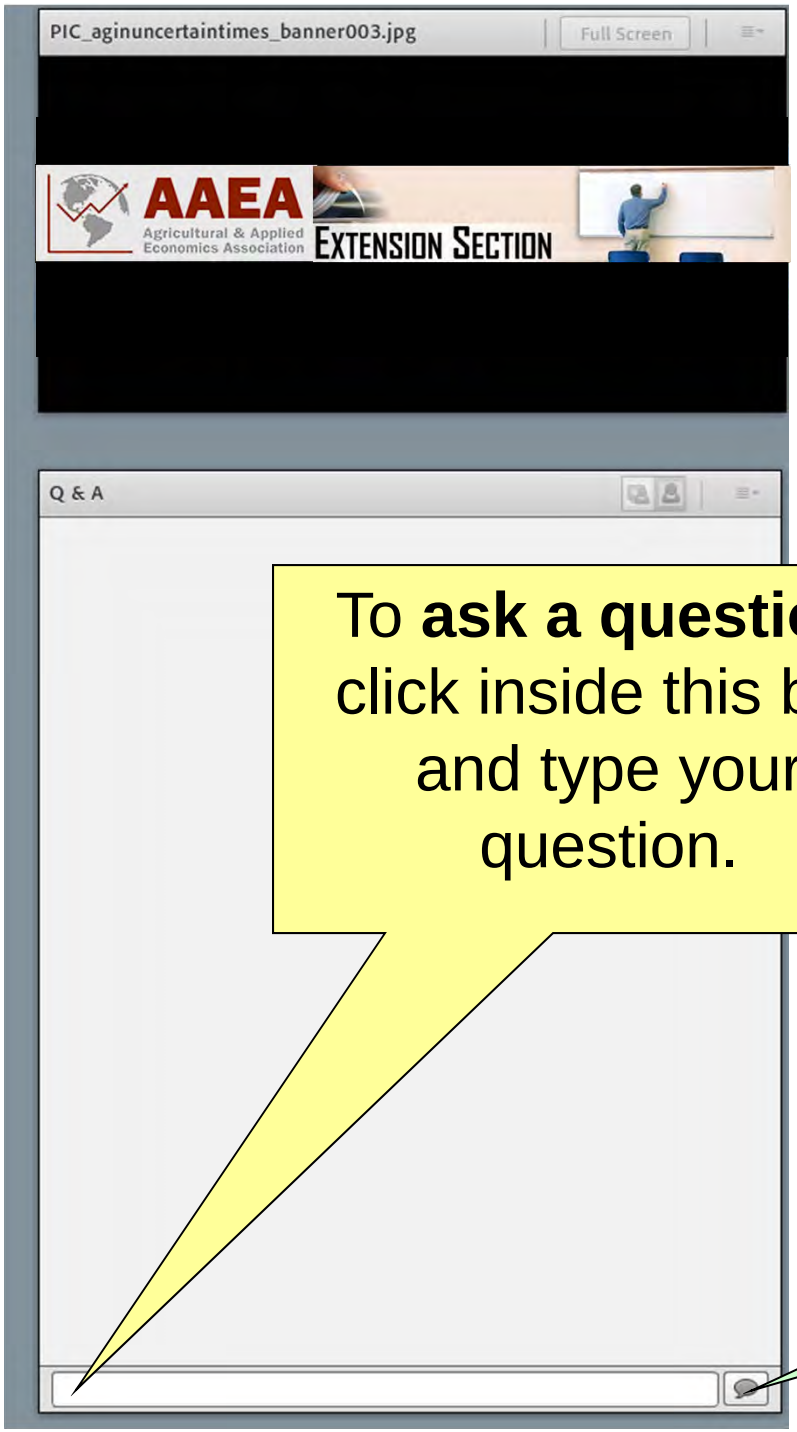
Using the Question and Answer (Q & A) Window



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Inflated Expectations, Unfulfilled Mandates, and Cost-Efficient Feedstock Systems for Cellulosic Biofuels

Francis Epplin
Department of Agricultural Economics
Oklahoma State University

AAEA Extension Section Webinar
11 am Central
April 20, 2011

Issues

- Energy
- Corn Ethanol
- Cellulosic Ethanol
- Drop-In Fuels
- What is a farmer to do?

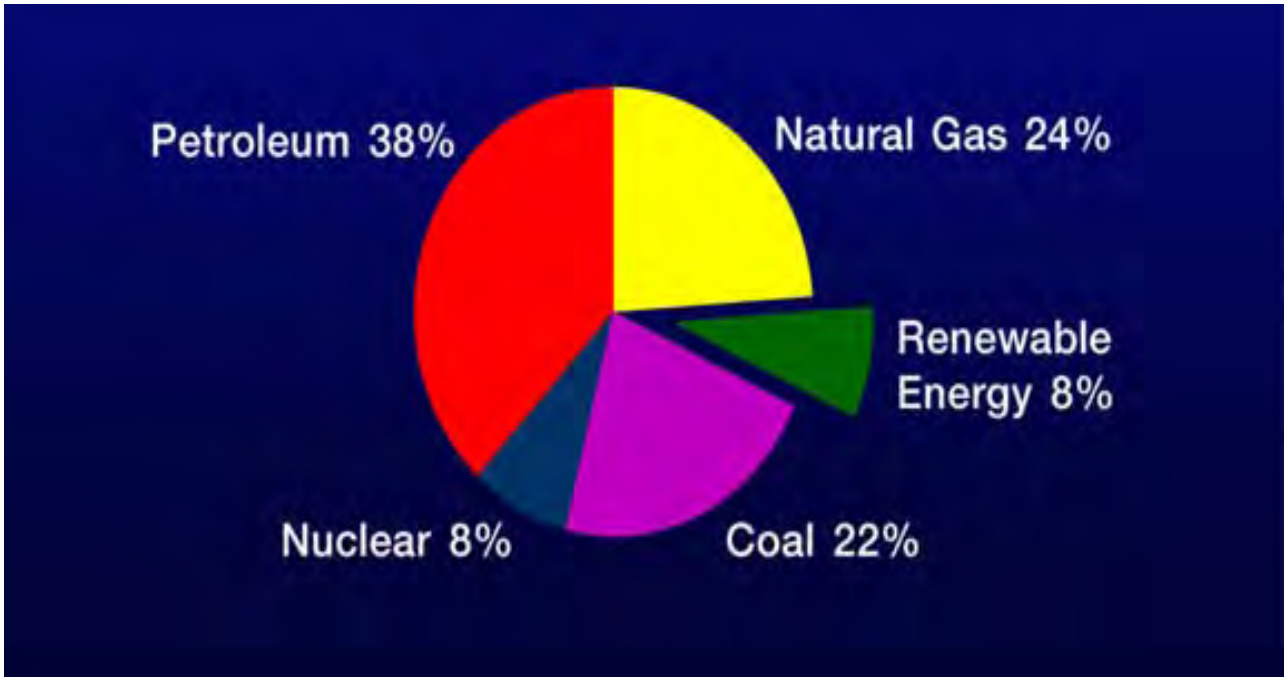
Energy

- U.S. Crude Oil Use
- 19.1 million barrels per day in 2010

How Much is 19.1 Million Barrels of Crude Oil ?

- Daily U.S. use (2010)

- Accounts for about 38% of U.S. Energy Use



BP Deepwater Horizon Macondo

- Spilled crude oil for 87 days
- April 20 – July 15, 2010
- Estimated 4.9 million barrels spilled
- How much was leaked relative to U.S. use?

- Equivalent to **6 hours** of U.S. use

Issues

- Energy
  - 19.1 Million Barrels / day
  - 6 hours (2010 Gulf Oil Spill)

- **Corn Ethanol**

- Cellulosic Ethanol
- Drop-In Fuels
- What is a farmer to do?

Why corn ethanol ?

Historical context ---

- To address the “excess capacity” problem in U.S. agriculture

Corn Ethanol

- 2010
  - 13.2 billion gallons of ethanol from grain
  - Contained **gross** energy equivalent to **9 days** of U.S. crude oil use
    - Diesel tractors, combines, and trucks don’t use ethanol blends

Corn Ethanol

- 2010 corn crop
  - 12.66 billion bu
  - If every bu had been converted to ethanol it would contain **gross** energy equivalent to

    24 days (6.6%)

    of U.S. crude oil use

Issues

- Energy
  - 19.1 Million Barrels / day
  - 6 hours (2010 Gulf Oil Spill)
- Corn Ethanol
  - 9 days (2010)

- **Cellulosic Ethanol**

- Drop-In Fuels
- What is a farmer to do?

Cellulosic Ethanol

- 1910 Standard Alcohol Company built a cellulosic ethanol plant in South Carolina to process waste wood from a lumber mill, sold to DuPont who operated it until after WW I. (Source: Sherrard, E.C. and F. W. Kressman. 1945. "Review of Processes in the United States Prior to Wold War II." Industrial & Engineering Chemistry 37:5-8.)

- 1940s During WW II a cellulosic ethanol plant was funded by the Government as an insurance plant, in case of grain shortage.

- Economics was a secondary consideration during wartime

The Promise of Cellulosic Ethanol

- Convert “waste” to fuel
- Some early proponents projected feedstock cost to be close to zero.
- Some projected a “tipping” fee; expected that owners of “waste” would be willing to pay for someone to use it.

The Promise of Cellulosic Ethanol

(one example)

Science

Lynd et al. (1991)

hypothesized that by the year **2000**,

technology would be developed enabling the production of **cellulosic ethanol** for a wholesale selling price of **$0.60 per gallon** (1985 $)

(**$1.22** in 2010 dollars).

U.S. Energy Independence and Security Act of 2007 (EISA)

Renewable Fuel Standards 2

RFS2

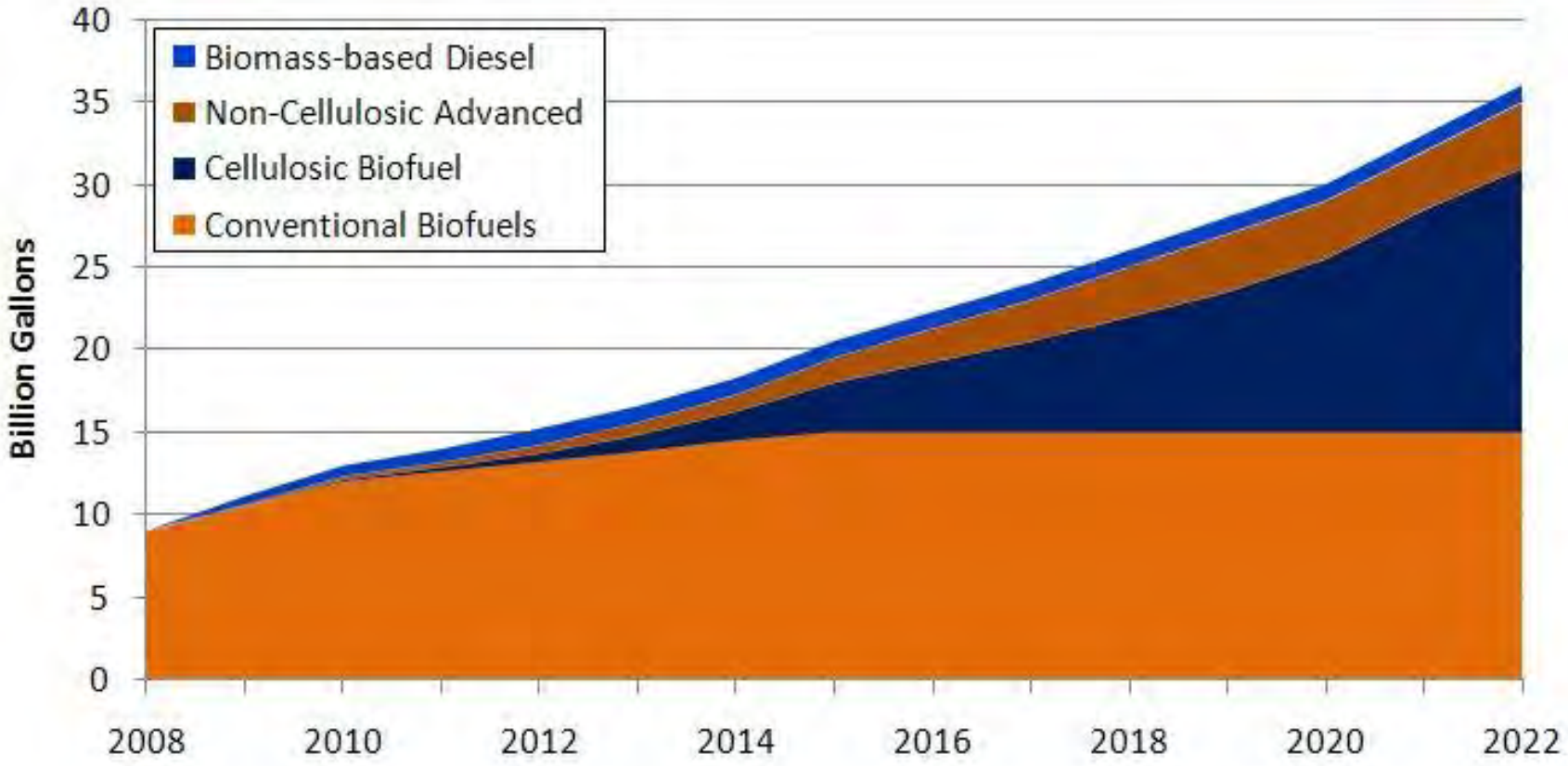
- Mandated use of biofuels
  - these mandates are conditional on production or production capacity

U.S. Energy Independence and Security Act of 2007 (EISA)

Why mandates?

- Experts proclaimed it was doable
- Means to ensure a market by requiring existing system to use biofuels if produced
- Guaranteed market was expected to facilitate investment in biorefineries

EISA – 2007 - RFS2 Mandates



Source: http://www.pewclimate.org/federal/executive/renewable-fuel-standard

U.S. Energy Independence and Security Act of 2007 (EISA)

Cellulosic ethanol mandates

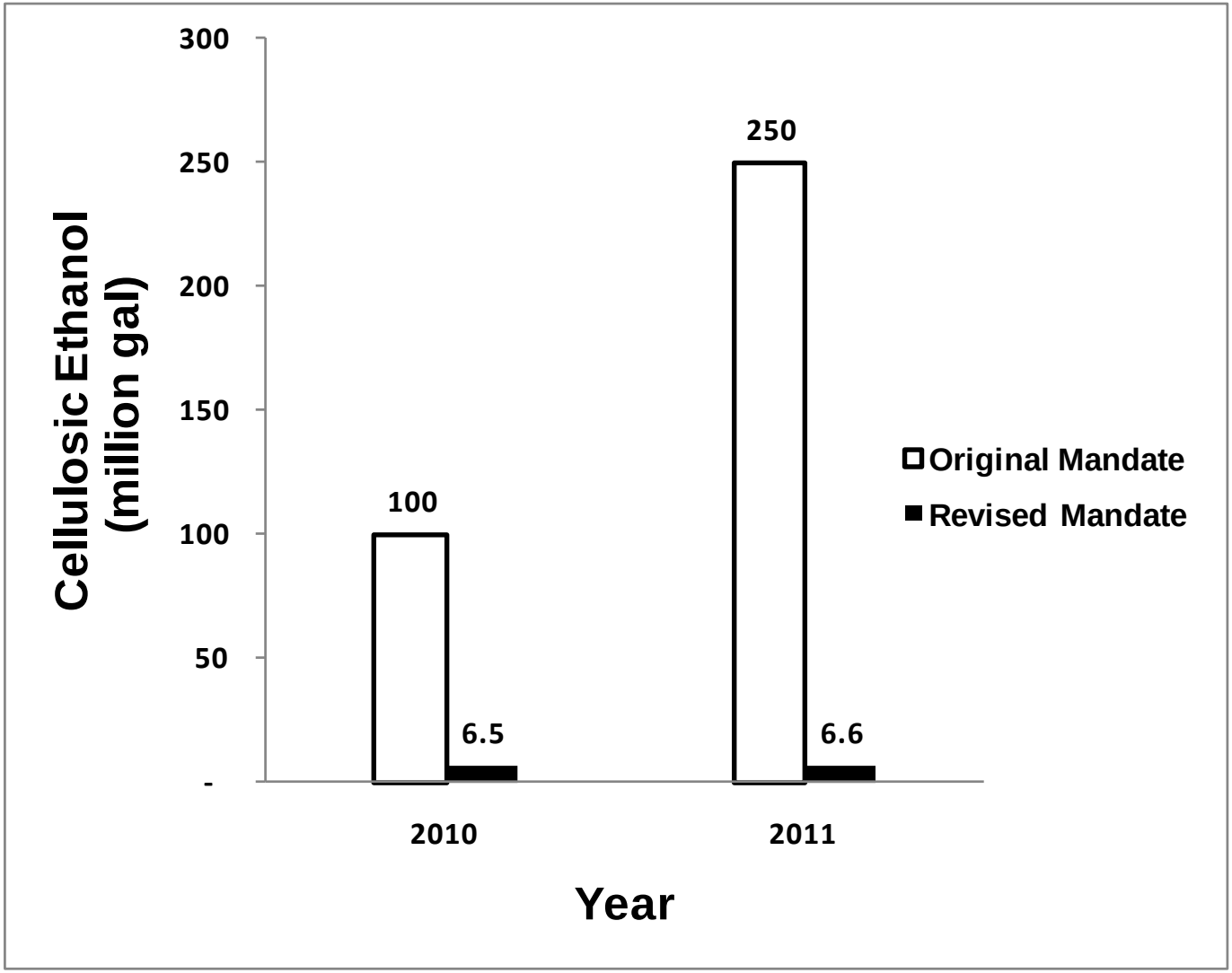
- 2010 100,000,000 gallons
- 2011 250,000,000 gallons

Unfulfilled Mandate

Cellulosic Ethanol

- 2010 mandate 100,000,000 gallons
  - EPA reduced to 6,500,000 gallons
- 2011 mandate 250,000,000 gallons
  - EPA reduced to 6,600,000 gallons

RFS2 Mandates for Cellulosic Ethanol



Failure to Meet Cellulosic Ethanol Mandate

Why?

- Conversion cost targets were not achieved

- Best of several competing technologies for conversion remains to be determined

Cost

Kazi et al. (2010) Evaluated Eight Alternatives for Producing Cellulosic Ethanol

- Lowest Cost Production System
  - Estimated Cost - $5.13 / gallon gasoline equivalent

  - Kazi, Fortman, Anex (Iowa State); Hsu, Aden, Dutta (NREL); Kothandaraman (ConocoPhillips) (Fuel 89 2010)

Failure to Meet Cellulosic Ethanol Mandate

Why?

- More costly to produce than anticipated

- Blend wall

Blend Wall

2010

- U.S. used 138.5 billion gallons of gasoline and blends that contained 13.2 billion gallons of ethanol

- When blends were limited to 10%, mandated levels of corn ethanol approached limit
  - flex fuel and 2001 and newer vehicles may use E15 if a source can be located

Reasons to Move Beyond Ethanol

- Ethanol is not an ideal liquid fuel substitute in a country with infrastructure and vehicles designed to use gasoline, diesel, and jet fuel.
- Less energy dense
- Mixes with water
- Can’t be moved practically through U.S. pipeline system
- Requires splash blending or blender pumps
- Has higher vapor pressure
- Cost?

Reasons to Move Beyond Ethanol

- Other potential “drop-in” biofuels produced from cellulosic feedstock may be more economical

Issues

- Energy
  - 19.1 Million Barrels / day
  - 6 hours (2010 Gulf Oil Spill)
- Corn Ethanol
  - 9 days (2010)
- Cellulosic Ethanol
  - Unfulfilled expectations
- **Drop-In Fuels**

- What is a farmer to do?

Drop-In Biofuels

The ideal drop-in

- invisible to the operator
- meet fuel performance requirements of existing engines
- require no change to the current stock of engines
- could be mixed or alternated with petroleum fuels (wouldn’t encounter a blend wall)
- require no change to the infrastructure
- be economically competitive

Example Drop-In Biofuel

- fast pyrolysis of **cellulosic biomass** to bio-oil
- upgrading of the bio-oil to naphtha and diesel range fuels.
- Wright et al. (2010) estimate production cost of $2.11 per gallon of gasoline equivalent for the nth plant
  - (Of course this estimate may be as overly optimistic as the 1991 estimate of cellulosic ethanol production cost of $1.22.)

Potential Feedstocks for Drop-In Biofuels

- Implications for agriculture if technology bypasses cellulosic ethanol?

- Crop residues and perennial grasses are also potential feedstocks for “drop-in” biofuels

Potential Feedstocks

- Municipal solid waste
- Forest residue
- Sugarcane bagasse
- Crop residue (corn stover, wheat straw)
- Dedicated energy crops
  - Perennial grasses (switchgrass, miscanthus)
  - Energy sorghum
  - Energy cane

Potential Feedstocks

- If the technology can use any of the feedstocks, expect entrepreneurs to locate plants near what they consider to be an inexpensive source of feedstock
  - The least-cost source will be used first

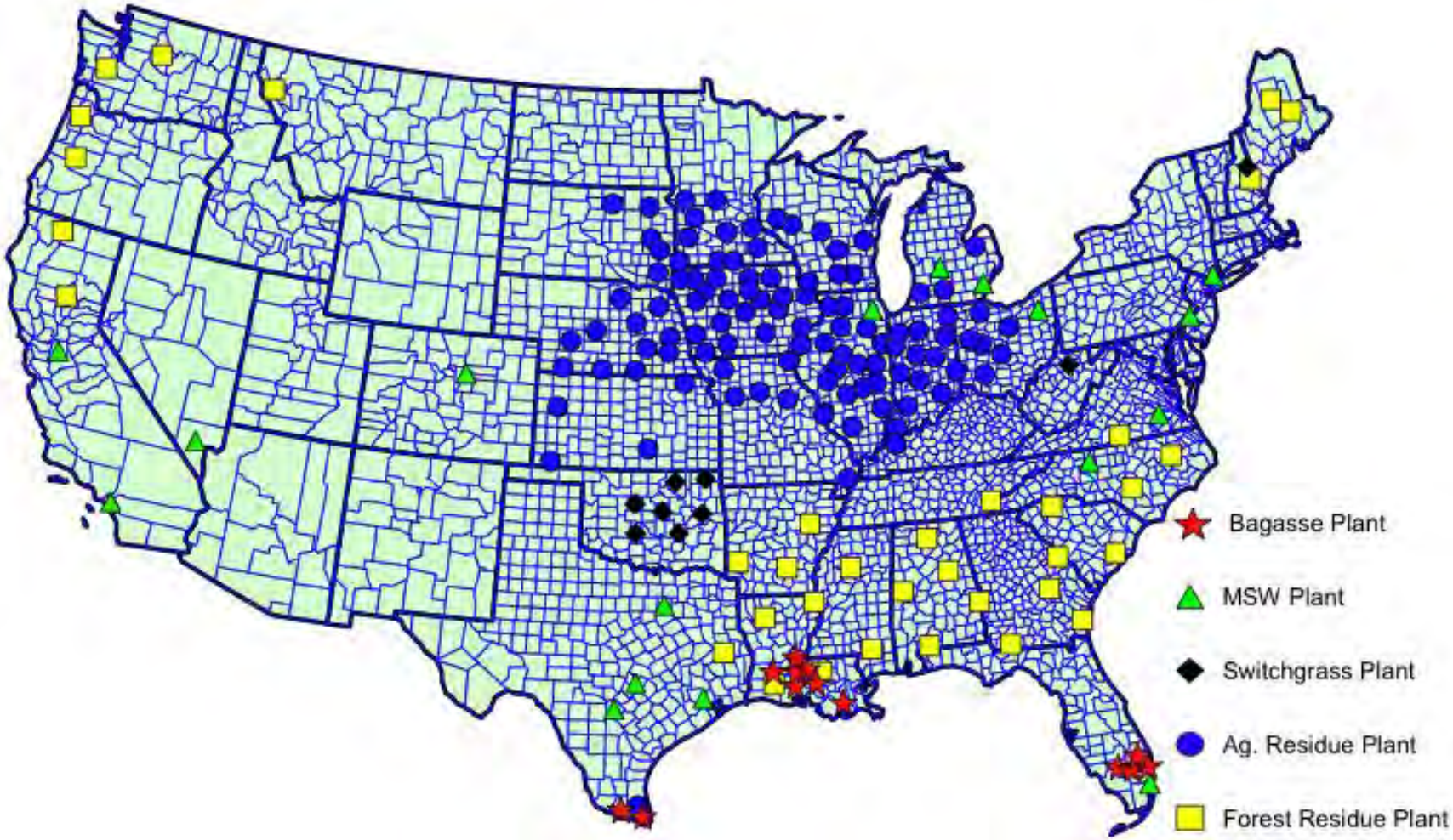
Quantity of Feedstock Required for a 2,000 tons per day Biorefinery

- 350 days of operation per year
- 700,000 tons of biomass per year
- 17 dry tons per truck
- 118 trucks per day
- 24 hours per day
- 4.9 trucks per hour

Biorefineries

- For 16 billion gallons per year
- 300 2000 tons/day plants
  5 trucks / hour each
- 150 4000 tons/day plants
  10 trucks / hour each

EPA Projections of Cellulosic Biorefineries to Fulfill RFS2 Mandates



One projection

Challenge for Biorefineries

- Highly coordinated harvest system
- Efficient system to provide a flow of biomass throughout the year from thousands of acres

Feedstock Flow Management

5-10 trucks/hour/plant

- Harvest
- Storage
- Transportation

- Most efficient system may differ depending on feedstock
  - Crop residue
  - Perennial grass

Contracts for Feedstock

- Most efficient contracting system may differ depending on feedstock
  - Crop residue
  - Perennial grass

Issues

- Energy
  - 19.1 Million Barrels / day
  - 6 hours
- Corn Ethanol
  - 9 days
- Cellulosic Ethanol
  - Unfulfilled expectations
- Drop-In Fuels
  - Hope
- **What is a farmer to do?**

What is a farmer to do?

- Wait until a contract is offered
- Evaluate alternatives
- Request assistance from local and state Cooperative Extension Service
- Prior to signing a contract, prior to investing in specialized equipment, and prior to establishing a perennial grass, consider the potential for biorefinery bankruptcy

Issues

- Energy
  - 19.1 Million Barrels / day
  - 6 hours
- Corn Ethanol
  - 9 days
- Cellulosic Ethanol
  - Unfulfilled expectations
- Drop-In Fuels
  - Hope
- **What is a farmer to do?**
  - **Relax and farm**

Challenges

- Economically viable conversion system
- Profitable business model
- Energy is a commodity
  - The least-cost source will be used first
  - In the absence of policy incentives (subsidies, carbon taxes, mandates) extremely difficult to compete with fossil fuels on cost

Summary

- Energy
  - 19.1 Million Barrels / day
  - 6 hours
- Corn Ethanol
  - 9 days
- Cellulosic Ethanol
  - Unfulfilled expectations
- Drop-In Fuels
  - Hope
- What is a farmer to do?
  - Relax and farm

Acknowledgements

- Oklahoma Agricultural Experiment Station
- USDA/NIFA
- Oklahoma Bioenergy Center
- Sun Grant Initiative
- Biobased Products and Energy Center at Oklahoma State University

OKLAHOMA STATE UNIVERSITY
AGRICULTURE

Economics of Wheat/Corn Stover Collection, Dakota Spirit AgEnergy

AAEA Extension Section Webinar

Dr. Cole Gustafson
Dr. Thein Maung
Mr. David Saxowsky
Ms. Tanja Miljkovic
Dr. John Nowatzki

April 20, 2011

Dakota Spirit Ag Energy

- Wheat straw biorefinery
- Complement 99mw CHP
- Is wheat straw collection feasible?

- www.dakotaspiritagenergy.com

Inbicon Biomass Refinery:
Straw Storage

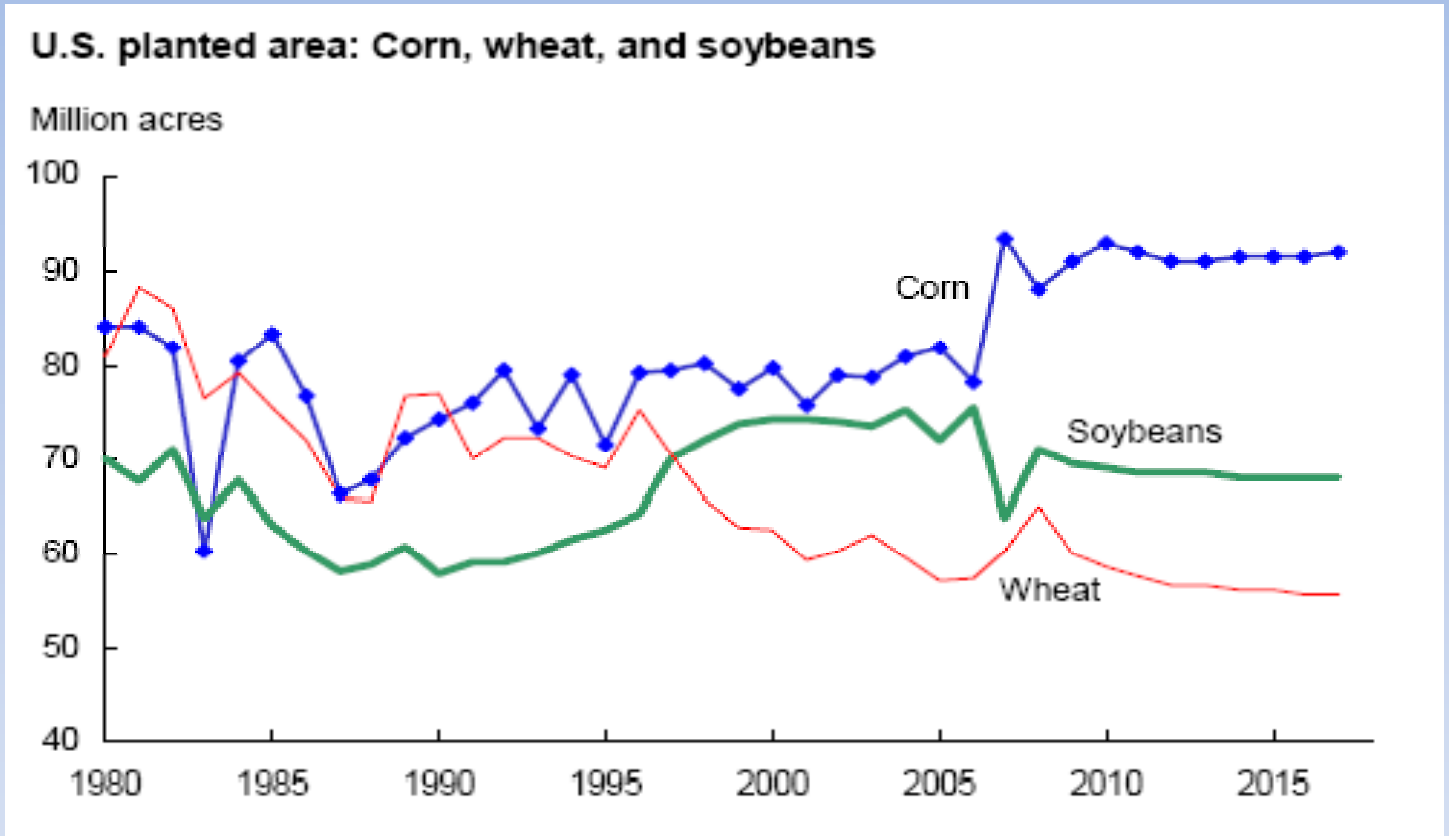
Inbicon Biomass Refinery:
Kalundborg – Design

Demonstration Plant, 4t/hr of straw		Tonnes/ year	Tonnes DM/year	GJ/year
Input	Straw	30,000	25,000	432,000
Output	Ethanol	4,300	4,200	114,800
	Bio pellets	13,000	12,300	181,100
	Animal feed	11,100	7,210	112,500

Inbicon

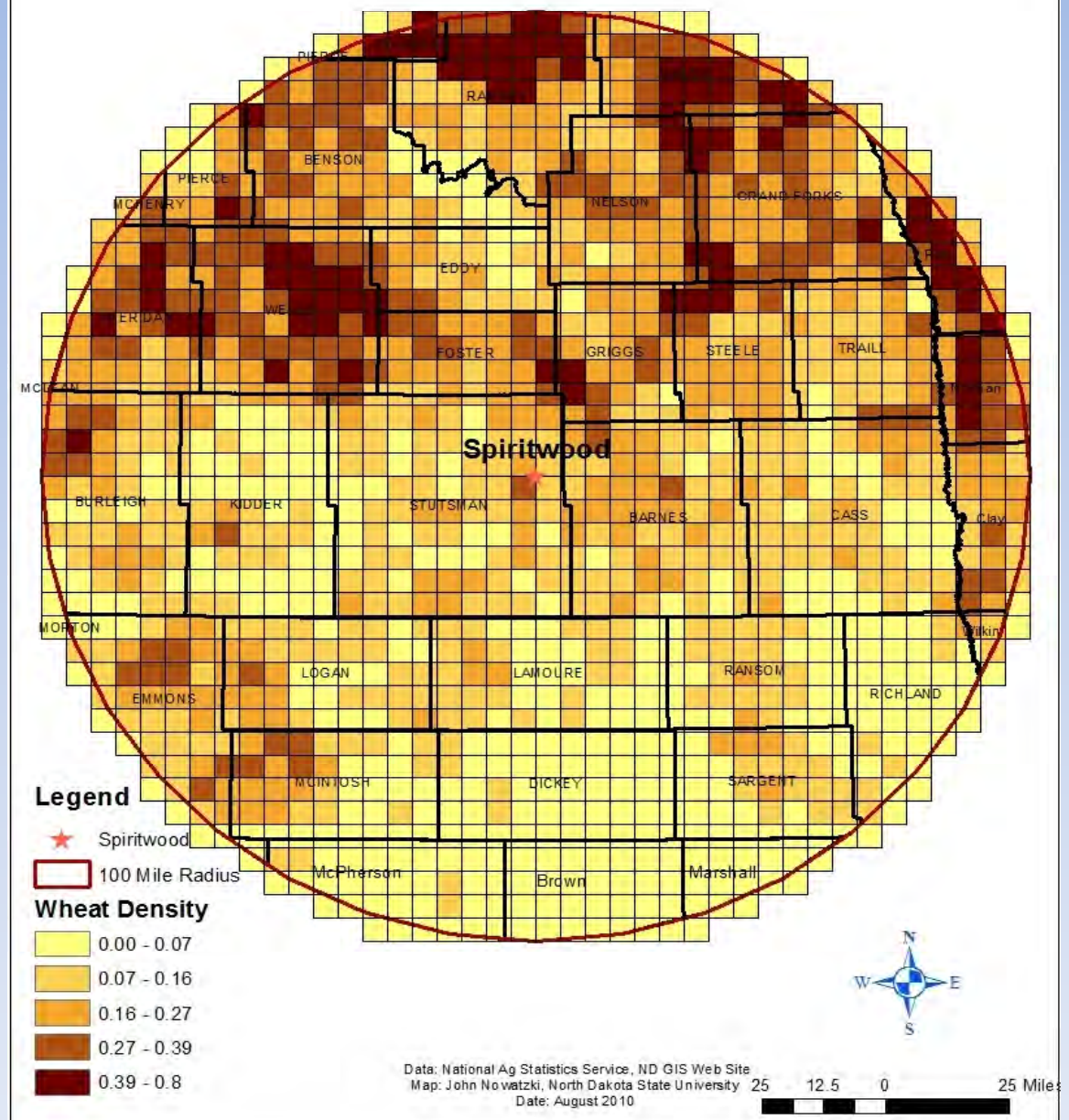
Core Questions

- How much wheat stover is available
- Are farmers willing to provide
- What are logistics?

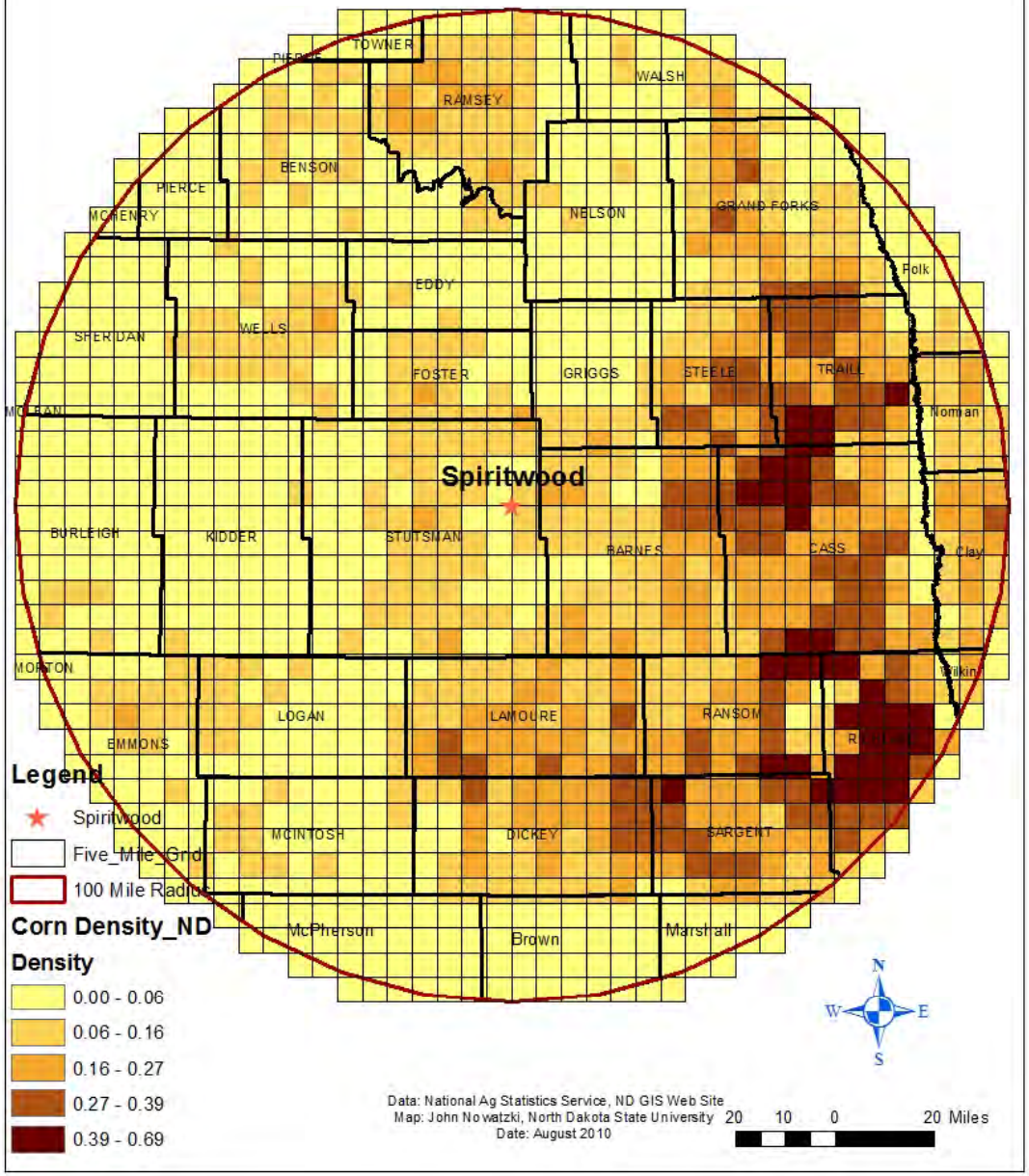


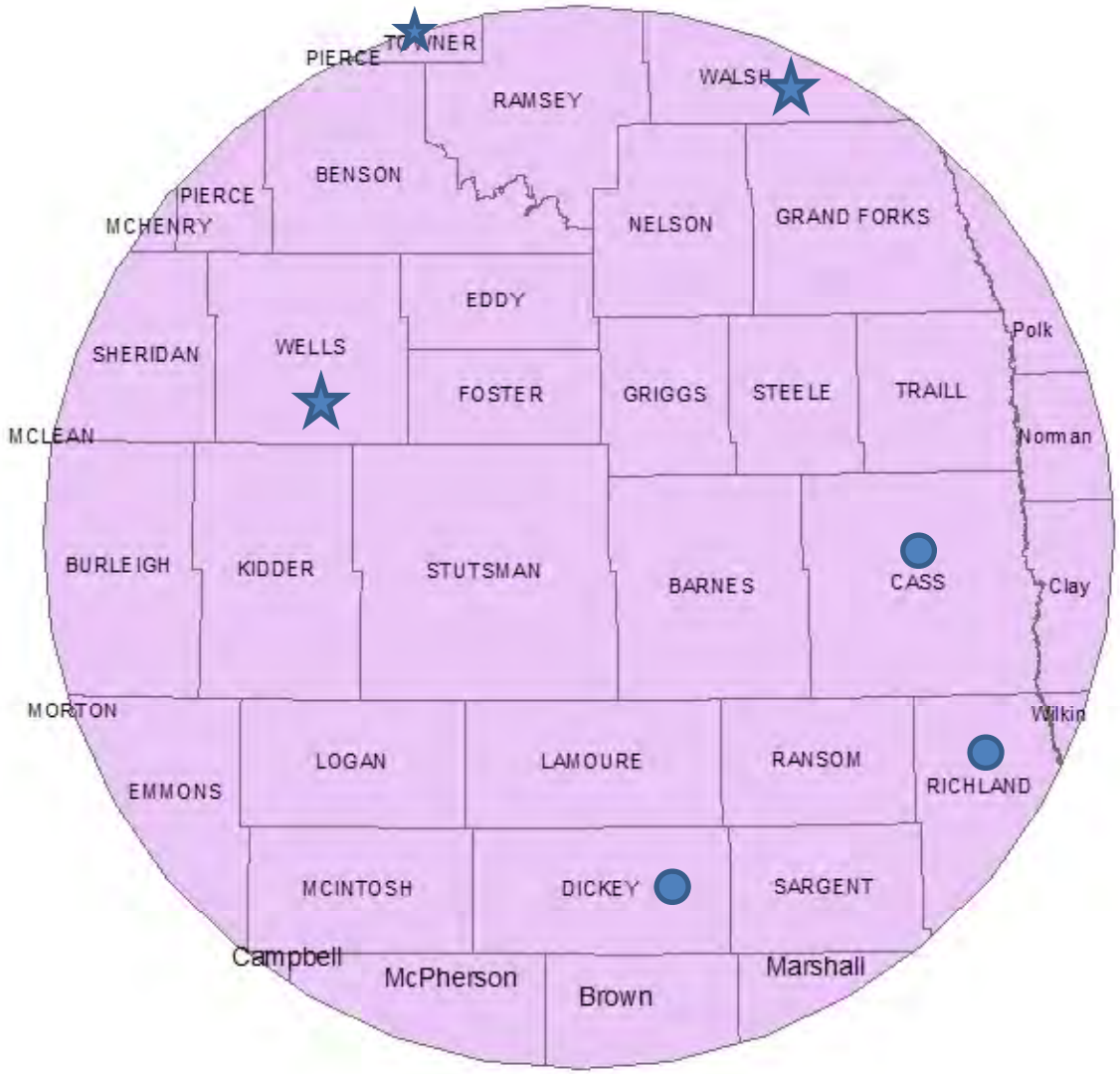
USDA Baseline Forecast, 2010

Wheat Density



Corn Density





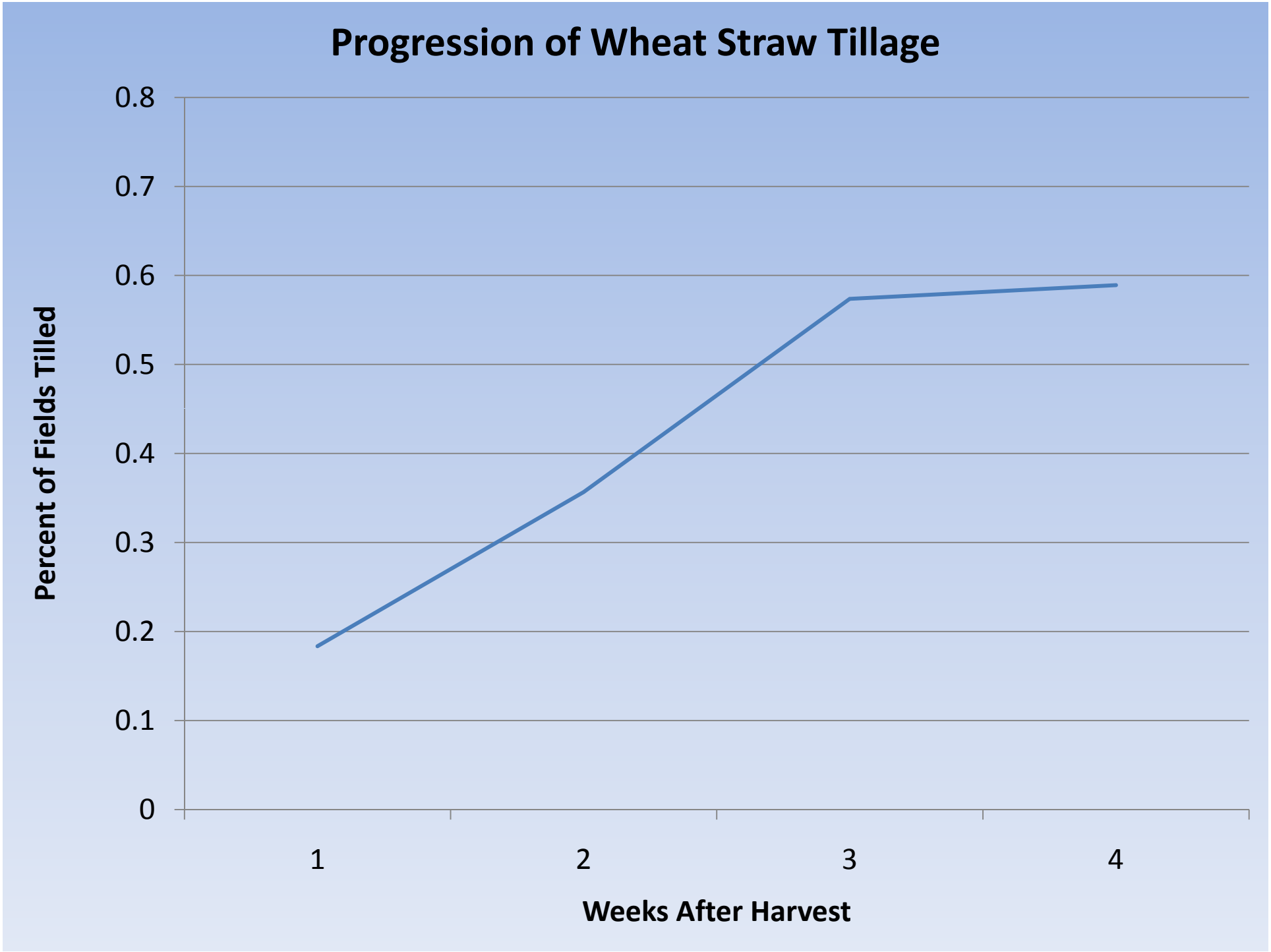
★ Top three counties with highest production of wheat

● Top three counties with highest production of corn

Potential Wheat Straw Supply

- 1.16 million tons (bone dry)
- 10% moisture
- Plant height 34.6”
- Combine height 7.6”
- Producers are willing to supply
- Adequate time to harvest

Wheat @ 25%	25 Mile Radius		50 Mile Radius		75 Mile Radius		100 Mile Radius	
State/ County	Total (ton)	Ton per Acre	Total (ton)	Ton per Acre	Total (ton)	Ton per Acre	Total (ton)	Ton per Acre
ND								
Barnes	22,278	0.42	62,277	0.42	62,619	0.42	62,619	0.42
Benson					22,235	0.36	53,106	0.36
Burleigh					2,215	0.36	26,373	0.36
Cass			9,754	0.43	56,933	0.43	76,923	0.43
Dickey					13,430	0.38	16,916	0.38
Eddy			12,250	0.40	19,884	0.40	19,884	0.40
Emmons					885	0.31	27,693	0.31
Foster	6,240	0.43	32,309	0.43	32,309	0.43	32,309	0.43
Grand Forks					28,800	0.45	90,227	0.45
Griggs	6,401	0.42	30,636	0.42	30,636	0.42	30,636	0.42
Kidder			4,175	0.34	20,203	0.34	20,283	0.34
La Moure			20,655	0.41	28,667	0.41	28,667	0.41
Logan			3,390	0.29	20,383	0.29	22,061	0.29
McHenry							1,611	0.31
McIntosh					10,013	0.34	29,672	0.34
Nelson			6,558	0.38	40,886	0.38	46,909	0.38
Pierce							14,463	0.34
Ramsey					11,790	0.38	47,129	0.38
Ransom			2,727	0.47	24,699	0.47	26,652	0.47
Richland					1,055	0.40	38,686	0.67
Sargent					5,384	0.44	22,609	0.44
Sheridan					1,263	0.32	27,646	0.32
Steele			19,528	0.45	37,035	0.45	37,035	0.45
Stutsman	29,067	0.38	57,961	0.38	57,988	0.38	57,988	0.38
Towner							9,475	0.38
Traill					25,967	0.46	44,029	0.46
Walsh							48,751	0.42
Wells			11,716	0.40	70,831	0.40	80,858	0.40
ND Total	63,987	0.40	273,934	0.41	626,111	0.40	1,041,210	0.40


Progression of Wheat Straw Tillage
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Percent of Fields Tilled
1
2
3
4
Weeks After Harvest

Farm Focus Group

Table 2.7. Reasons Why Participants Do Not Collect More Straw

Reason	Percent Response	Number of Participants
Too distant to haul	0.00%	0
No market	38.89%	7
Environmental concern	11.11%	2
Fertility loss	50.00%	9
Loss of wildlife habitat	0.00%	0
No time	0.00%	0
Total	100.00%	18

Farm Focus Group

Table 2.11. Most Important Factor in Decision to Sell Straw

Contract Factor	Percent Response	Number of Participants
Price	93.33%	14
Quality discounts	0.00%	0
Delivery time	0.00%	0
Distance to haul	0.00%	0
Storage payment	0.00%	0
Other factor	6.67%	1
Total	100.00%	15

Farm Focus Group

Table 2.12. Price of Wheat Straw Participants Willing to Accept

Participant Number	Wheat Straw ($/ton)
1	-
2	35.00
3	40.00
4	30.00
5	25.00
6	20.00
7	25.00
8	50.00
9	40.00
10	50.00
11	20.00
12	30.00
13	15.00
14	15.00
15	15.00
16	50.00
Average	**30.67**

Farm Focus Group

Table 2.13. Preference for Handling Straw

Preference	Percent Response	Number of Participants
Just bale and leave in field	0.00%	0
Bale and stack at road	0.00%	0
Bale, stack, and store	0.00%	0
Bale, haul part way to Spiritwood	12.50%	2
Bale, haul to Spiritwood	0.00%	0
Just sell straw	81.25%	13
Not interested at all	6.25%	1
Total	100.00%	16

Potential Constraints

1) Rotary Combines
2) Tenant vs. Land Owner
3) USDA/NRCS

		Stover Harvest to Maintain Carbon			
		Continuous Corn		Corn Soybean Rotation	
Grain Yield	Stover	Plow	Chisel/ No Till	Plow	Chisel/ No Till
Bu/ac	t/ac	t/ac	t/ac	t/ac	t/ac
103	2.2	0.0	0.0	0.0	0.0
156	3.3	0.0	1.0	0.0	0.0
200	4.5	1.1	2.1	0.0	0.9
259	5.6	2.2	3.2	0.0	2.1
312	6.7	3.3	4.3	0.9	3.2
363	7.8	4.4	5.4	2.1	4.3
415	8.9	5.5	6.6	3.2	5.4

Source: PRX 2010, Johnson 2006

Questions?

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Today's Speakers

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