AAEA Extension Section Webinar

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

Brought to you by the AAEA Extension Section and the Western Extension Committee. Technology hosted by Montana State University.
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John Nelson & Jon Newkirk

A project of the Western Extension Committee and many others.
Our emcee for today is:

**John Hewlett**
Farm/ranch Management Specialist
University of Wyoming
Today’s Speakers
Dr. Francis Epplin
Dept. of Agricultural Economics
Oklahoma State University

Dr. Cole Gustafson
Dept. of Agribusiness and Applied Economics
North Dakota State University
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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 \textcolor{red}{\textit{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


• 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).

Renewable Fuel Standards 2
RFS2

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

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


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

<table>
<thead>
<tr>
<th>Year</th>
<th>Original Mandate</th>
<th>Revised Mandate</th>
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<tbody>
<tr>
<td>2010</td>
<td>100</td>
<td>6.5</td>
</tr>
<tr>
<td>2011</td>
<td>250</td>
<td>6.6</td>
</tr>
</tbody>
</table>
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 n\textsuperscript{th} 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
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

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

- How much wheat stover is available
- Are farmers willing to provide
- What are logistics?
U.S. planted area: Corn, wheat, and soybeans

USDA Baseline Forecast, 2010
Corn Density

Legend
- Spiritwood
- 5 Mile Grid
- 100 Mile Radius

Corn Density_ND Density
- 0.00 - 0.00
- 0.06 - 0.16
- 0.16 - 0.27
- 0.27 - 0.39
- 0.39 - 0.89

Data: National Ag Statistics Service, ND GIS Web Site
Map: John Novacki, North Dakota State University
Date: August 2018
Top three counties with highest production of wheat

- Starred counties

Top three counties with highest production of corn

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

Percent of Fields Tilled

Weeks After Harvest

- Weeks After Harvest:
  - 1
  - 2
  - 3
  - 4

- Percent of Fields Tilled:
  - 0
  - 0.1
  - 0.2
  - 0.3
  - 0.4
  - 0.5
  - 0.6
  - 0.7
  - 0.8
<table>
<thead>
<tr>
<th>Reason</th>
<th>Percent Response</th>
<th>Number of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Too distant to haul</td>
<td>0.00%</td>
<td>0</td>
</tr>
<tr>
<td>No market</td>
<td>38.89%</td>
<td>7</td>
</tr>
<tr>
<td>Environmental concern</td>
<td>11.11%</td>
<td>2</td>
</tr>
<tr>
<td>Fertility loss</td>
<td>50.00%</td>
<td>9</td>
</tr>
<tr>
<td>Loss of wildlife habitat</td>
<td>0.00%</td>
<td>0</td>
</tr>
<tr>
<td>No time</td>
<td>0.00%</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>100.00%</td>
<td>18</td>
</tr>
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</table>
### Table 2.11. Most Important Factor in Decision to Sell Straw

<table>
<thead>
<tr>
<th>Contract Factor</th>
<th>Percent Response</th>
<th>Number of Participants</th>
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<tbody>
<tr>
<td>Price</td>
<td>93.33%</td>
<td>14</td>
</tr>
<tr>
<td>Quality discounts</td>
<td>0.00%</td>
<td>0</td>
</tr>
<tr>
<td>Delivery time</td>
<td>0.00%</td>
<td>0</td>
</tr>
<tr>
<td>Distance to haul</td>
<td>0.00%</td>
<td>0</td>
</tr>
<tr>
<td>Storage payment</td>
<td>0.00%</td>
<td>0</td>
</tr>
<tr>
<td>Other factor</td>
<td>6.67%</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100.00%</strong></td>
<td><strong>15</strong></td>
</tr>
</tbody>
</table>
# Farm Focus Group

**Table 2.12. Price of Wheat Straw Participants Willing to Accept**

<table>
<thead>
<tr>
<th>Participant Number</th>
<th>Wheat Straw ($/ton)</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>35.00</td>
</tr>
<tr>
<td>3</td>
<td>40.00</td>
</tr>
<tr>
<td>4</td>
<td>30.00</td>
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<tr>
<td>5</td>
<td>25.00</td>
</tr>
<tr>
<td>6</td>
<td>20.00</td>
</tr>
<tr>
<td>7</td>
<td>25.00</td>
</tr>
<tr>
<td>8</td>
<td>50.00</td>
</tr>
<tr>
<td>9</td>
<td>40.00</td>
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<td>10</td>
<td>50.00</td>
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<td>11</td>
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<td>15.00</td>
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<tr>
<td>15</td>
<td>15.00</td>
</tr>
<tr>
<td>16</td>
<td>50.00</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>30.67</strong></td>
</tr>
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</table>
Table 2.13. Preference for Handling Straw

<table>
<thead>
<tr>
<th>Preference</th>
<th>Percent Response</th>
<th>Number of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Just bale and leave in field</td>
<td>0.00%</td>
<td>0</td>
</tr>
<tr>
<td>Bale and stack at road</td>
<td>0.00%</td>
<td>0</td>
</tr>
<tr>
<td>Bale, stack, and store</td>
<td>0.00%</td>
<td>0</td>
</tr>
<tr>
<td>Bale, haul part way to Spiritwood</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Just sell straw</td>
<td>81.25%</td>
<td>13</td>
</tr>
<tr>
<td>Not interested at all</td>
<td>6.25%</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>100.00%</td>
<td>16</td>
</tr>
</tbody>
</table>
Potential Constraints

1) Rotary Combines
2) Tenant vs. Land Owner
3) USDA/NRCS
<table>
<thead>
<tr>
<th>Bu/ac</th>
<th>t/ac</th>
<th>t/ac</th>
<th>t/ac</th>
<th>t/ac</th>
<th>t/ac</th>
</tr>
</thead>
<tbody>
<tr>
<td>103</td>
<td>2.2</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>156</td>
<td>3.3</td>
<td>0.0</td>
<td>1.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>200</td>
<td>4.5</td>
<td>1.1</td>
<td>2.1</td>
<td>0.0</td>
<td>0.9</td>
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<tr>
<td>259</td>
<td>5.6</td>
<td>2.2</td>
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Stover Harvest to Maintain Carbon

- Continuous Corn
- Corn Soybean Rotation

Source: PRX 2010, Johnson 2006
Questions?

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Today’s Speakers

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