Implications of corn producer participation in stover biomass markets and availability

March 2013

By:
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West Central Research and Outreach Center

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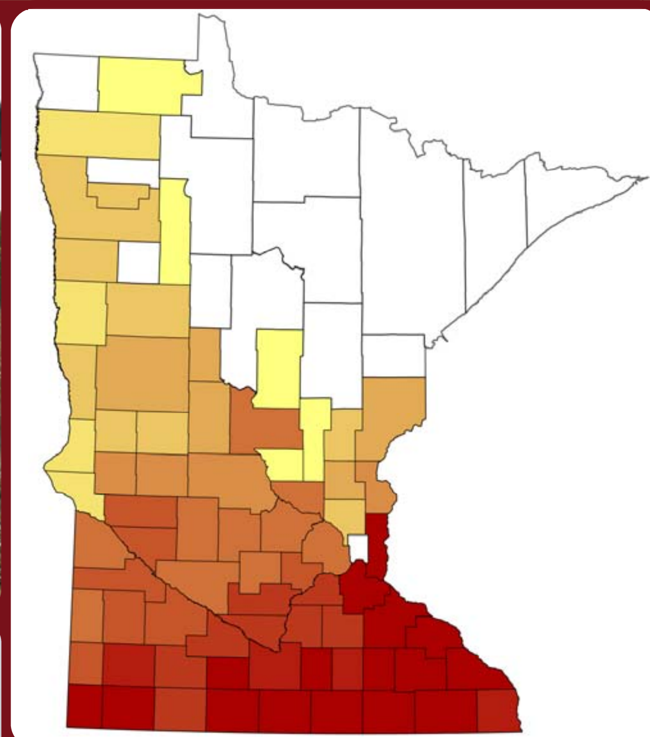
Agricultural Biomass For Energy and Bioproducts

FINAL REPORT:

Implications of corn Producer Participation in Stover Biomass Markets and Availability



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A. Report Information

Final Project Report: Implications Of Corn Producer Participation Rates On Stover Biomass Markets

Principle Investigator: Joel Tallaksen, Ph.D.

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The author wishes to recognize to efforts of several people and groups in helping with experimental design, survey development, data compilation, and reviewing findings. Dr. Aaron Rendahl from the Univ. of Minnesota, school of statistics contributed greatly to the survey design and interpretations of data. Daniel Seidenkranz and Britta Anderson were very helpful in data entry and data quality control. Michael Reese and Eric Buchanan kindly reviewed drafts of the report. Thanks also to the contributing industry stakeholders who reviewed the draft survey and provided critical feedback. A final thanks to the groups funding the study and their members; The Agricultural Utilization Research Institute, Minnesota Corn Research and Promotion Council and their member corn farmers, and the University of Minnesota- Initiative for Renewable Energy and the Environment.

Disclaimer

The opinions and findings of this document are solely those of the author and have not been reviewed by the projects sponsors; the University of Minnesota- Initiative for Renewable Energy & the Environment, the Agricultural Utilization Research Institute, or the Minnesota Corn Research and Promotion Council. Although the author has made every attempt to use the best information and data available in the development of this work, the information is still only a model of stover production and producer harvesting interest, which uses time sensitive data. While individuals interested in biomass availability for a specific facility or location can use this as a tool for understanding biomass availability, they are encouraged to perform a much more in-depth analysis for their potential supply region.

Cover illustration credits: Fall 2012 Combine Harvest Image- J. Tallaksen, Minnesota County Corn Stover Production Map- J Tallaksen (This report section 1), Stover Bales Image- USDA Photo Archive

Implications Of Corn Producer Participation Rates On Stover Biomass Markets

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Section III Supporting Information

C. Report Description

University of Minnesota, West Central Research and Outreach Center researchers organized a survey-based study to examine agricultural biomass producers' willingness to supply corn stover and develop an understanding of factors affecting producers' biomass related farm management decisions. Surveys were sent to 2500 Minnesota producers randomly selected from a list of USDA program participants. Using this data, the goal was to create a regional biomass availability model and evaluate statewide biomass availability patterns. Biomass yields and producer participation interest data were mapped using GIS software to create availability maps. The ultimate goal of WCROC's work is to develop conditions that support an economically stable, environmentally sound biomass market.

The Specific objectives of this project included:

- Determine Minnesota corn producer interest in selling corn stover biomass
- Identify producer's comfort level in their knowledge of the issues surrounding biomass harvest
- Determine which factors are most likely to influence producer opinions of biomass harvesting
- Identify information that undecided producers might want before forming their opinions
- Evaluate where facilities would be best able to find willing stover suppliers.

D. Key Words

Minnesota, biomass, corn stover, GIS, modeling, Corn Producer, Agriculture, Farmers, Survey

E. Author & Contact

The research was conducted and report authored by Dr. Joel Tallaksen of the University of Minnesota West Central Research and Outreach Center. For comments or questions regarding the work, please contact Dr. Tallaksen via e-mail at tall0007@umn.edu or by phone at 320-589-1711.

Final Report: Implications Of Corn Producer Participation Rates On Stover Biomass Markets

Section I:

Biomass Producers Survey Results

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Section I. Executive Summary

The production of next generation renewable fuels is an important component of the US government's strategy for adoption of renewable energy technologies over the next few decades (BRDTCA 2007, Biomass Board 2002). These plans rely heavily on the use of cellulosic ethanol production from agricultural biomass, especially corn stover. However, there is a question about whether biomass producers are interested in supplying biomass. Researchers at the University of Minnesota, West Central Research and Outreach Center organized a survey based study to examine agricultural biomass producer's willingness to supply corn stover and develop an understanding of factors affecting producers' farm management decisions. Surveys were sent to 2500 producers randomly selected from a list of USDA program participants.

The primary question for the survey asked producers about their interest in participating in the biomass market by supplying biomass from their lands. Producers undecided about participating were 38% of the responses. About 40% responded that they were 'interested' or 'very interested'. A little over 21% were 'not at all interested' or 'not interested' in selling biomass.

An important concern for WCROC is the level of knowledge producers have about their management options when considering removal of biomass from fields. Slightly over 45% felt they had a good level of knowledge. Just over 15% disagreed that they had a good understanding of biomass issues. A large portion (35%) were undecided about their level of knowledge.

Producers were asked which of several pre-selected factors they felt were important in making a decision on biomass removal from their lands. The results suggest that producers are most concerned about the loss of soil quality and nutrients. Concerns about added income and employment opportunities were less important.

The central economics question asked was what level of profit producers would like before they would consider selling biomass. Though there was a range of responses, it appears that it would take between $40-50 profit per acre to interest at least half of the producers in selling stover. Producers were also asked about how much profit would be needed to make them consider specialty biomass cropping; the majority indicated that a profit would have to be at least $100 per acre to get them interested. After factoring in harvest and delivery costs, these profit levels could make biomass too expensive for the facilities looking to produce cellulosic ethanol using the current ethanol prices and production technologies.

When asked what they felt the impacts of biomass harvesting would be on six preselected measures of soil health and environmental quality, producers were aware that landscape quality can decrease as harvesting increases. Decreases in soil organic matter (SOM) were the most identified quality measure impacted by harvesting biomass. A significant correlation was seen between a higher interest in selling biomass and producers' impressions that there would be less impact when harvesting material.

Producers were asked whether they would consider implementing soil conservation techniques along with biomass harvesting. With the exception of no-till, most producers indicated that they would consider implementing the other techniques. Producers interested in biomass harvesting were significantly more interested in implementing these soil conservation techniques.

Overall, the survey found a high number of producers were undecided or not interested in selling agricultural biomass at this time. Though some producers are firmly against selling biomass, many appear to be waiting for more information before considering participation in a biomass market. If a new biomass project depends on a high participation percentage in a specific region, they will likely need to be proactive in providing this data to producers in the region to make their project successful. The information that would be most important to them is the economic feasibility and soil quality impact data.

A. Introduction

The production of next generation renewable fuels is an important component of the US government's strategy for adoption of renewable energy technologies over the next few decades (BRDTCA 2007, Biomass Board 2002). These plans rely heavily on the use of cellulosic ethanol production from biomass to make transportation fuels. Though a portion of the needed biomass could come from forestry sources, the quantity required is above what can sustainably be harvested from forests in the US. In the original 'Billion Ton Study' (Perlack 2005), estimates call for just over 70% percent of the biomass feedstock to come from agriculture- the largest component being corn stover. This would require up to 256 million tons of corn stover to meet this goal by 2030. In 2011, the USDA and DOE released an updated version (US DOE 2011) of their original Billion Ton report that estimates that the US can conservatively supply roughly 125 million tons of stover annually at $50 per ton on a sustainable basis by the year 2022. The USDA and DOE studies seemed to indicate that producers will be open to supply stover at fairly modest prices. However, the studies seemed to base this on a relatively small number of producers supplying biomass to hay or straw auctions.

Beginning in 2008, the University of Minnesota biomass gasification facility located in Morris, MN began contracting with local corn producers for corn stover biomass to convert to thermal energy (heat) for the rural Minnesota campus. Based on the early government reports and their estimates, the University expected that many corn producers would be willing to supply corn stover at an average price of less than $50 per ton. However recruiting producers to supply biomass proved difficult, with lower producer interest than expected and higher prices than predicted by government studies. It became obvious that a better understanding of the agricultural producers' willingness to supply stover for renewable energy or other bio-based industries was needed.

The willingness of stover producers to supply biomass is a critical concern because many proposed biomass energy and refinery facilities would need in excess of 100,000 tons of biomass per year. Unfortunately, the issue of an unknown producer participation rate is part of a larger chicken-and-egg problem for agricultural biomass, with investors not willing to put up facilities without a verifiable stover supply and corn producers unsure about investing time, labor, and capital to harvest material for an unstable market. Lack of solid data on producer willingness to participate is a major barrier to developing stover biomass markets.

Participation in supplying biomass among agricultural producers has more recently begun to be examined for different biomass feedstock in a number of studies in the US. An early observation from these is that producers have different levels of interest in selling their biomass depending on the region of the country or state they farm in and the type of biomass that they could produce. Based on a study conducted in Iowa after the 2006 harvest (Tyndall et al, 2010), the average percentage of producers who expressed interest in supplying stover from their corn ground was only 17%, with another 37% undecided about stover harvesting. The study found that there were significant differences in participation rates within the state, with higher interest in participation in North Central Iowa. In a survey conducted in Missouri in 2007 and repeated in Illinois in 2009, 32.5% and 40.89% of producers from the respective states indicated they were willing to provide biomass under 'ideal circumstances' (Altman 2012).

As one of the organizations responsible for developing the initial biomass purchasing plan for the University Biomass Gasification Project, the University of Minnesota- West Central Research and Outreach Center (WCROC) was interested in further examining producer participation in the biomass market. This data would aid stakeholders who are interested in developing renewable energy or bio-products projects that require willing producers to supply large amounts of biomass for conversion.

WCROC organized this survey-based study to examine producers' concerns that influence their willingness to supply biomass and how regional, demographic, and producer existing knowledge influence their decisions. Based on the University's experience, it was expected that Minnesota stover producer participation rates would be similar to the Iowa study versus the early high interest assumptions of the USDA and DOE.

B. Methodology

The research used two primary methods to evaluate producer interest in stover harvesting; a focus group for general input and a mailed survey to gather specific numerical data. Held in February of 2012, the focus group brought together biomass stakeholders to discuss how they viewed biomass harvesting and their impressions of potential survey questions. The focus group felt there was a great deal of information that could be requested from producers to help answer questions about biomass availability and opinions on selling biomass. However, due to the need to respect respondent's time, the survey was kept to a minimum.

The survey (in full in Appendix A) covered five main areas related to the willingness of biomass producers in Minnesota to participate in selling biomass from their lands and what factors they used to make their decisions. The first and most important was whether biomass producers wanted to sell biomass feedstocks and which feedstocks they had available to sell. The second area was whether they felt they had the information needed to make decisions on selling or not selling biomass, plus how they received their information regarding biomass. The next subject covered was the cropping and economic factors that producers were using to make their decisions. Their opinions on the impacts of harvesting the material were also surveyed. The final area of the survey was their opinion of using alternative cropping strategies to mitigate potential impacts of over-harvesting material. As with most surveys, a demographics section was used to see if particular subgroups (i.e. younger, higher latitude, or more formally trained producers) had unique viewpoints.

The producers selected to receive the study were randomly chosen from a list provided by the USDA-Natural Resources Conservation Service that tracked individuals receiving payments for the ACRE (Average Crop Revenue Election) program. The list included all individuals receiving payments for crops grown on lands in Minnesota. The complete list (53,000 names and addresses) was trimmed to remove individuals whose mailing address was not in Minnesota. These people would likely have ownership interest in Minnesota farmland, but were not likely the primary operator or the farm decision maker. Additionally, business/individual names that included the terms 'trust' or 'estate' were removed from consideration. In the survey instructions, it asked that the survey be passed along to the person most likely to be making farm management decisions. The survey was mailed to 2500 Minnesota farm producers in April of 2012.

As surveys were returned, answers to the survey questions were entered into a database. Geographical data for analysis was generated based on the latitude and longitude of the zip code reported in the demographics section of the survey. Responses were assigned to geographical zones based on the region of the state that the survey responder indicated their production lands were in. Mapping of data was done using QGIS, an open-source GIS software package.

Two questions on the survey solicited optional written comments. Those comments are included in appendix B. Comments that did brought up interesting concerns not represented in the numerical results are highlighted in the appendix.

Statistical analysis was completed using the R statistics package. Statistics computation was performed by Dr. Aaron Rendahl of the University of Minnesota, School of Statistics. In this section of the report (section I), participation interest values were transformed so that 5 indicates high interest and 1 low interest. (note: Section II uses the surveys' original ranking of 1 being interested and 5 being uninterested.) The first step in analysis was a comparison of data from each question to the key question of producer interest in participating in the biomass market. For example, were producers who raised hogs more or less likely to be interested in supplying biomass? Then a second round of analysis examined interactions between different responses. An example of this is statistically testing whether producers in a certain region were more or less concerned about erosion when 50% of stover biomass was harvested.

In terms of statistical results, the p-value (or t-value) to determine statistical significance was 0.05 or less. This would indicate at least 95% likelihood that values were statistically different. Some of the results refer to trends in the data. A trend indicates that there is insufficient data to conclude values were statistically different, but that the observations were near statistical significance and may be shown to be statistically significant given a larger pool of data.

Due to the large amount of survey results from the study, this section does not include all output and figures from the statistical analysis. All statistical data is presented in a separate annotated appendix (Appendix C), which includes the complete data set and a limited commentary. All statistically significant findings are reported in this section.

C. Results and Discussions

Responses to the survey began to arrive within two days of sending the survey out on April 13, 2012. By the close date of August 7th, 2012, 363 valid surveys were received. This corresponds to an approximately 14.5% return rate. Figure 1 shows the zip code locations for surveys sent to producers and responses received. For statistical analysis, more responses can help identify hard to detect relationships between different variables. Although the survey response rate was lower than had been hoped for, several analyses yield statistically significant patterns in the data.

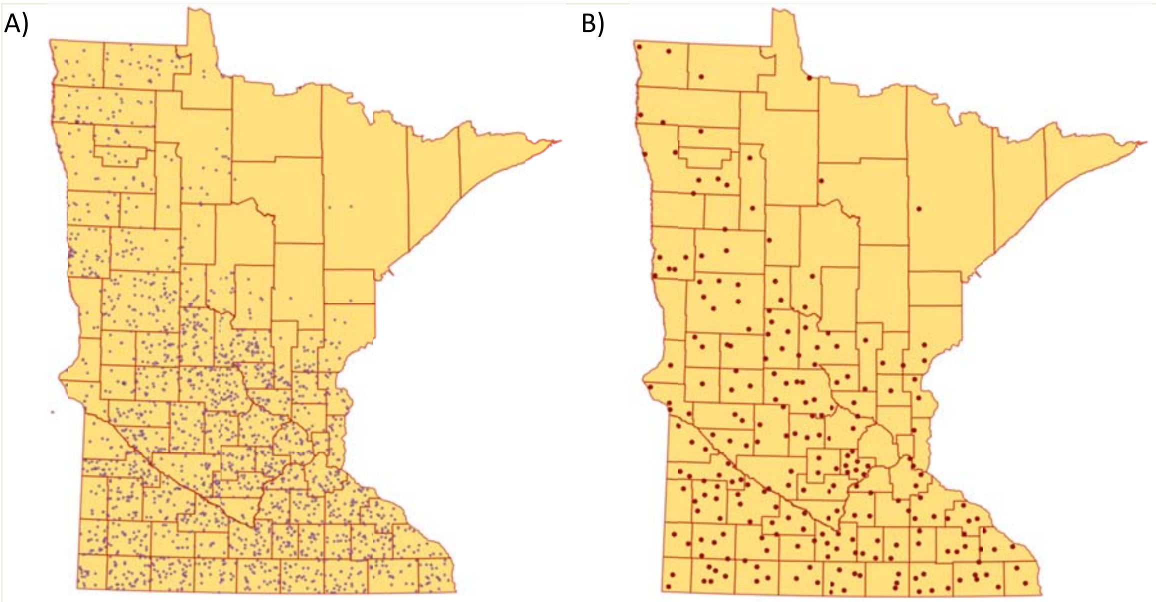

Figure 1. Location of Survey recipients and Respondents. A) Location of producers who received surveys, based on recipient's address. B) Location of respondent's production lands based on the zip code they supplied. In both maps, dots may indicate more than one respondent at the location.

1. Producer Intention of Participating in Biomass Markets

The primary question for the survey was what is the level of interest that producers had in participating in the biomass market by selling biomass from lands that they managed. Responses were received from 354 people, with a fairly wide range of participation interest levels. As shown in figure 2, the largest group of responding producers were undecided about participating (38%). Those interested or very interested in selling biomass made up about 40% of the responses. A little over 21% of the responses were not at all interested or not interested in selling biomass.

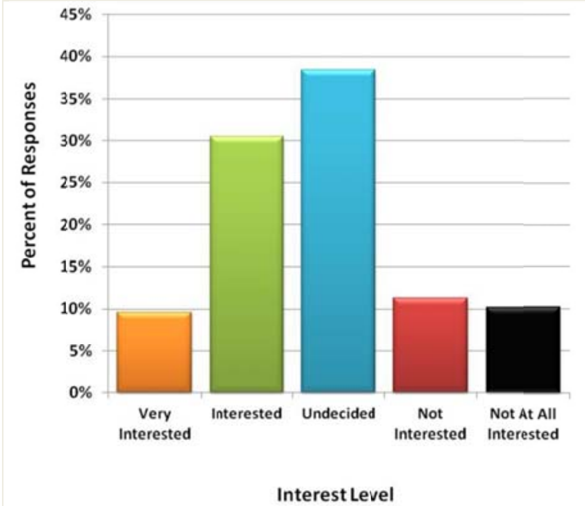

Figure 2. Interest Level of Producers in Participating In A Biomass Market. Bars represent the percentage of farm decision makers selecting the interest level when asked whether they would consider participation in biomass markets by selling biomass from lands they manage.

The next important question was "what types of biomass" the producers had to sell. Nearly 70% had corn stover available to sell (fig 3.). The finding that stover was the most available biomass for them to sell was expected as the survey went to grain producers, with corn being the largest crop in the state by acreage. There was no statistical relationship between producer's participation interest and them having a particular biomass type available. However, an interesting note was that those who said they had woody biomass were significantly more interested in selling biomass. While not totally unexpected based on the existing opportunities for woody biomass, it may indicate association between forestry biomass and agricultural biomass among producers in areas with both activities. The existing opportunities for woody feedstocks may be promoting opportunities in agriculture biomass.

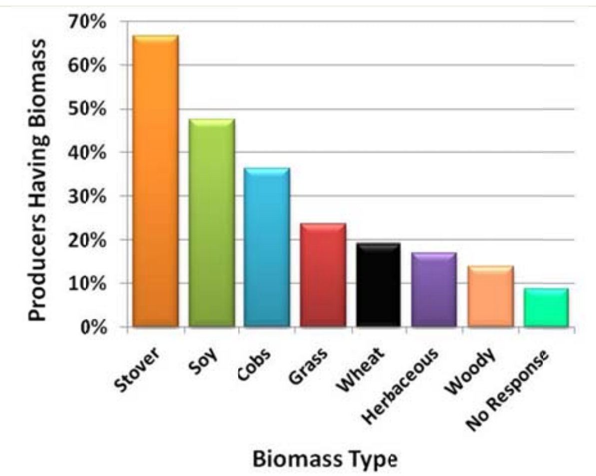

Figure 3. Percentage of Responding Producers Having Specific Biomass Types.

Producers were then asked to estimate how much of five different types of biomass they estimated they could harvest per acre. The first observation from this data (Table 1) was that although some of the estimated averages may have been relatively close actual averages for their region, most did not attempt a guess. Corn stover received the most responses with 152 estimates out of the 363 surveys received. The low number of responses to the questions suggests that most producers are not familiar with biomass yields. In terms of the estimate averages, the averages for soy, corn stover, and corn cob biomass were probably higher than can sustainably be removed on a regular basis. However, a statewide average for sustainable biomass harvest rates from these crops is difficult due to soil, climate, and farming practices variation across the state. While managed grasslands could probably provide the nearly 3 tons of biomass per acre average estimated by respondents, it is uncertain whether they would be interested in using the quality of lands and management practices that would be needed to sustainably produce that level of grass biomass.

Table 1. Producer Estimates of Crop and Grassland Biomass Productivity

	Soy	Corn Stover	Corn Cobs	Wheat Straw	Grassland
Average Est.Tons/Ac	1.62	3.47	1.64	1.78	2.97
Responses (N)	105	152	59	67	80

The fact that so few individuals ventured a guess on the biomass yield question suggests that few are familiar with yields for crop residues. This could be an indication that they need additional information in order to assess whether biomass harvesting would fit into their operations.

2. Knowledge

The level of knowledge producers have about their management options concerning removal of biomass from fields is an important concern for organizations like the University of Minnesota, Minnesota Corn Growers (MNCG), and Agricultural Utilization Research Institute (AURI). From the University's perspective, producers need up-to-date information that properly presents both the advantages and disadvantages of harvesting biomass. AURI and MNCG are also concerned that producers have information about potential new opportunities to market agricultural products, the limitation of these opportunities and how they could affect producers' farm management. For survey purposes, it was important to establish whether the respondents felt comfortable in their level of knowledge when answering survey questions. To evaluate these issues, two questions were added to determine producer knowledge and the source of knowledge.

The first question evaluated how producers assessed their knowledge of biomass harvesting by asking how strongly they agreed with the statement that they had a good level of knowledge on the topic. While it did not actually objectively test their knowledge, it provides a gauge as to whether producers feel they need more information on the subject. Slightly over 45% percent felt they had a good level on knowledge (fig. 4. Agree & strongly agree combined). Just over 15% disagreed or strongly disagreed that they had a good understanding of biomass issues. A large portion (35%) were neutral on their level of knowledge.

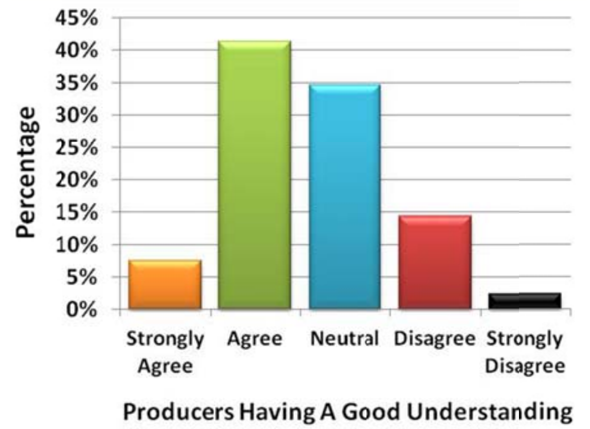

Figure 4. Producers Self-Assessed Level of Biomass Harvesting Knowledge. **Bars indicate percentage of agricultural producers agreeing to the statement that they 'had a good level of knowledge' on the biomass harvesting topic.**

These results suggest that though a good number of producers have heard about biomass harvesting, there is still a significant portion who don't feel they have all the knowledge needed to make biomass harvesting management decisions. The survey results indicate that the University and others should continue to reach out to producers and provide additional guidance and information about biomass harvesting and related issues.

The level of knowledge and producer participation interest was statistically examined to see if there was any relationship between the two variables. The analysis indicated a trend that more knowledge is linked with greater interest in selling biomass, but it was not statistically significant. It should also be noted that a causal relationship cannot be deduced from the trend. So we cannot say that providing knowledge will drive higher interest levels, nor that interested people will seek out knowledge. However, it is likely that providing more information will provide those who are undecided about supplying biomass with the information they need to decide whether or not to participate.

The next question was designed to help determine where biomass producers were getting information. It asked them to check off whether they had learned about biomass harvesting from a list of a number of possible information sources. Almost all producers indicated that agricultural magazines were one of the sources of information (Table 2). This information source received many more responses than any other source of information. An interesting observation and a concern was that many of the top cited information sources were commercial or industry related, compared with heavily research oriented groups like the USDA-ARS, University Extension, and Soil & Water Conservation Districts. While there is nothing inherently wrong with agricultural magazines and other commercial sources being leaders in presenting the information, there is more of a danger that they might present only the positive aspects or downplay conservation concerns. The data suggests that University Extension, USDA, and Soil and water conservation personnel may need to enhance efforts to hit their target audience. It might be a good strategy for them to work more closely with the top information providers to make sure the most accurate and up-to-date information is being provided by magazines and farm shows.

Table 2. Mean Participation Interest Grouped by Information Source. Average producer interest for those receiving information from each source, based on a scale of 1 (not at all interested) to 5 (very interested). Percentages are the combined percentages of those interested or very interested.

Information Source	Av. Int.	n	Percent(>=Int)
Agricultural Magazine	3.19	284	0.39
Farmers	3.17	83	0.40
Farm Shows	3.30	69	0.48
Commodity Groups	3.19	58	0.41
Univ. Extension	3.14	57	0.42
USDA (ARS and NRCS)	3.40	40	0.47
Other	3.42	38	0.50
Not Heard	3.12	28	0.43
Soil & Water Con. Dist.	3.80	15	0.60

To examine whether information source might influence the producers' interest levels, the results of the information source question were compared with the producer participation interest question. Statistically, no correlation could be detected between information source and producer's interest in participating in biomass markets. An interesting observation was the higher average interest in participation among respondents who listed the Soil & Water Conservation District as one of their information sources. Because of the low number of people listing that source, it could be an anomaly that would not have been seen with more data.

3. Factors Influencing The Biomass Harvesting Participation Decision

This section of the project examined which factors producers felt were important in making a decision on biomass removal from their lands. The question listed several factors and ask producers to indicate how important each factor was in the decision process, from 'very important' to 'not at all important'. The factors that were selected for inclusion in the question were based on discussions in the stakeholder meeting held prior to the survey. The question was designed with a mix of factors that were either positive (likely to increase interest) or negative (likely to decrease interest).

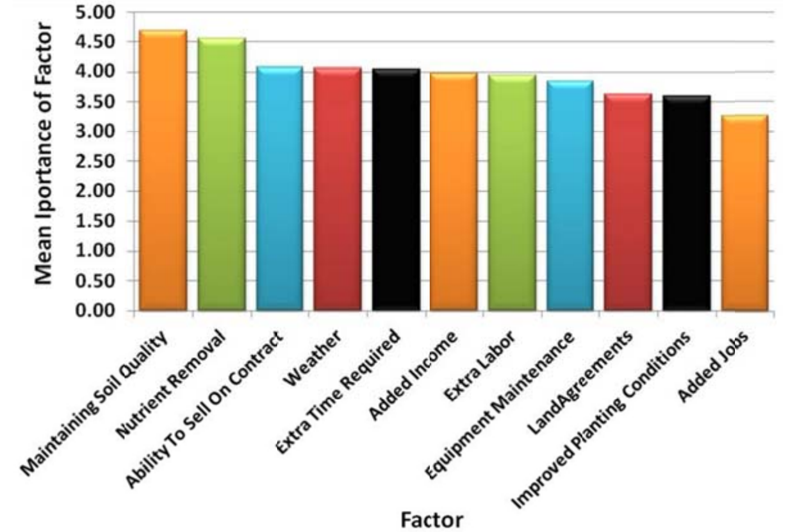

Figure 4. Mean Importance of Several Factors in Making Management Decisions Regarding Biomass Harvesting Decisions. Average producer response to importance level of factors related to biomass harvesting based on a scale of 1 (not at all important) to 5 (very important).

The results (figure 4) indicate that most producers are more concerned about the negative factors (soil quality, nutrients) when assessing whether biomass harvesting is of interest to them. The positive factors (economics) ranked lowest in mean importance. The findings from this question also highlight the divided views towards agricultural biomass production; an opportunity for added income, but a risk of lowering soil quality.

This data was then compared with the participation interest to determine if any factors were statistically correlated with increased or decreased interest in participating in the biomass market. There were several correlations, both positive and negative. Statistically significant positive correlations (indicating that a factor with a high mean importance corresponded to an increased interest) included added income, added jobs, and the ability to sell on contract. Significant negative correlations (a factor producers felt important corresponded to a decreased interest) were found with both nutrient

Table 3. Correlation Between Decision Factors and Interest Average level of interest among producers was compared with the average importance producers gave each factor. Factors and interest with significantly linkage (at $p < 0.05$) are noted by asterisk*.

	Factor	gamma	p.value
Factors Significantly Associated With Increased Interest	Added Income	0.34	<1e-04*
	Added Jobs	0.28	<1e-04*
	Ability To Sell On Contract	0.22	0.0022*
	Improved Planting	0.17	0.0127*
	Weather/timing	0.01	0.9420
	Land Rental Agreements	-0.03	0.6694
	Extra Labor	-0.09	0.1997
	Extra Time	-0.13	0.0773
	Equipment Maintenance	-0.13	0.0731
Associated with Decreased Interest	Nutrient replacement	-0.20	0.0147*
	Maintaining Soil Quality	-0.38	<1e-04*

replacement costs and maintaining soil quality. Though negative correlation trends were seen in the extra time required and equipment maintenance for biomass harvest, these were not found to be significant. An interesting note that can be taken away from the data is that the logistics factors didn't correlate strongly in the decision to market biomass. Factors such as possible weather/timing limitation, land rental agreements and extra labor also did not statistically correlate to decreased interest. These factors did not rank as critically important in the decision process and could form a second tier of considerations that producers may assess after their primary concerns have been addressed.

The next topic examined was whether the producers' access to farm equipment and machinery influenced their decision to participate in biomass harvesting. To analyze this, the survey asked producers to indicate which biomass harvest related equipment they had access to (own, lease, or could borrow) from a list of 9 possible choices that ranged from a combine (in field collection) to a flatbed truck/trailer (hauling material). The percentage of producers having access to only a portion of the equipment to collect/transport biomass was high (fig. 5). Collection of most crop residues would require a baler (square or round) and likely semi-truck with flatbed trailer for delivery. Roughly half had access to a baler, but fewer had a flatbed trailer (appendix C). An initial analysis was conducted to test for correlations between individual pieces of equipment and participation interest. There were no significant differences in correlations between these. However, a drop in participation interest (not significant) was noted in respondents who had no equipment or only a combine. To further explore the relationship between equipment and interest, the total number of pieces of equipment (fig. 6) was compared to interest levels. A significant correlation was found between the total number of equipment pieces and participation interest (fig 6). Producers with more equipment had increased interest in participating in the

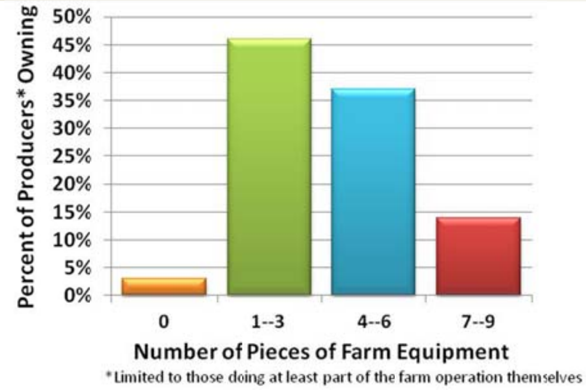

Figure 5. Producers Access to Farm Equipment. Average number of pieces of farm equipment producers had access to (own, borrow, or rent)

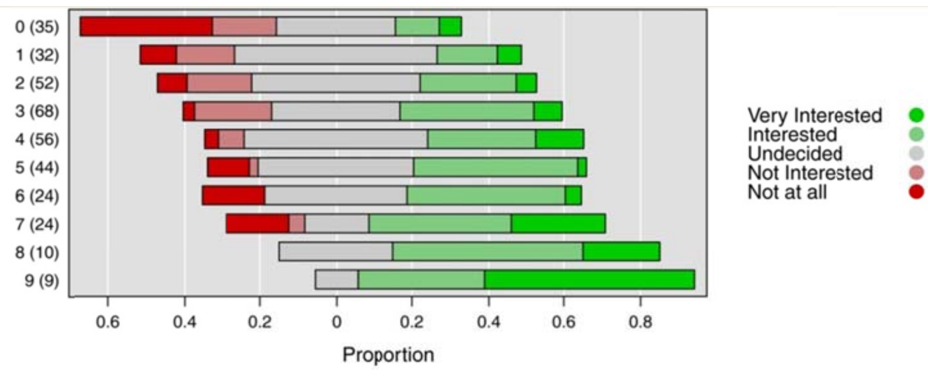

Figure 6. Sum of Equipment Ownership Versus Interest. The total number of pieces of farm equipment available to farmers from a preselected list was summed and plotted against the proportion of producers' selecting each interest level. The two measures were found to be statistically correlated at a p-value of $p < 0.0001$.

biomass market. As seen in figure 6, the proportion of producers indicating 'very interested' increased substantially among those indicating that they possessed most or all the pieces of equipment. Even those with 3-7 pieces of equipment showed a pattern of more interest than those with fewer pieces of equipment.

To examine the equipment issue more, a related question was asked on the survey about how much responsibility producers would like to take on in the biomass harvesting effort. Past biomass projects have used several types of contracts that specify who performs various rolls in the biomass supply chain. From the producer's standpoint, the least involved contract is one that pays producers for biomass as it lay on the ground. Under this type of contract, a custom contractor will come in and harvest all material, plus take care of transport off the field and storage. Contracts with the most responsibility for producers typically have them harvest the material, store it at their farm site, and deliver it to the facility when it is needed. Producers were presented with four options for their preferred level of involvement.

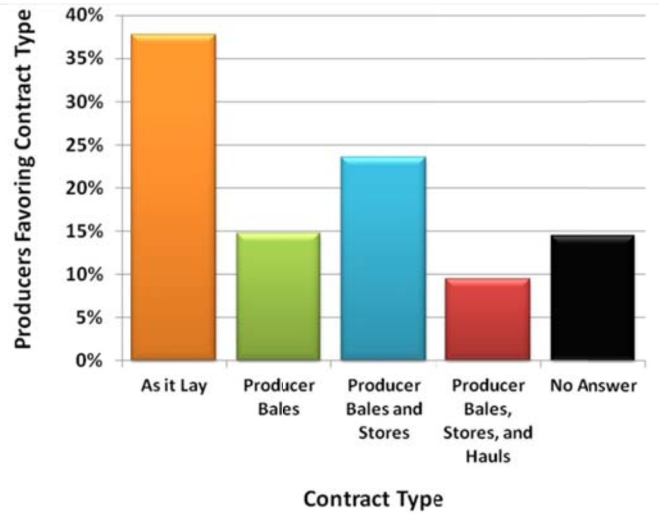

Figure 7. Proportion of Producers Choosing Different Contract Types.

Responses to the question (fig. 7) indicate that there are a diversity of opinions on the amount of responsibilities that producers would like to take on when considering collecting/transporting biomass. The most popular option among all producers was the one with the least amount of responsibilities on their part, which was selected by 37% of producers. The option requiring the most producer involvement (collecting, storing, and transporting) was chosen by roughly 15% of those surveyed.

Looking only at figure 7, it might be concluded that facilities should, perhaps, only develop contracts for biomass as it lay on the ground. However, a look at underlying statistical interactions shows that the situation is more nuanced than the figure presents. The producers

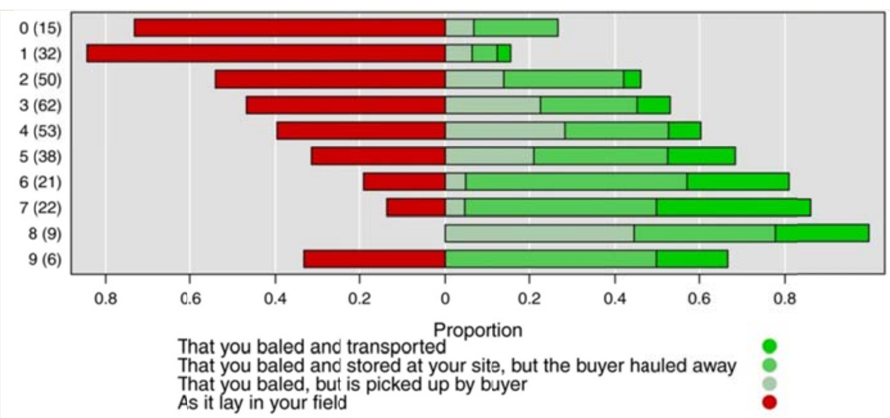

Figure 8. Correlation between Producers Equipment and Type of Contract The total number of pieces of farm equipment were summed and plotted against the proportion of producers' interested in each contract type. The two measures were found to be statistically correlated at a p-value < 0.0001.

most interested in harvesting biomass are those with more equipment (fig. 6). A correlation between those producers and contract type revealed that producers with more equipment would prefer a contract where they take on most of the responsibility (fig. 8). They would likely be paid for the additional responsibilities, thus making baled biomass a value added commodity for them. This option would be more likely to help producers pay for capital equipment such as tractors, balers, and trucks. These interactions indicate there might be reason to target the already more interested producers who have the equipment by offering contracts to pay them to fully manage their collection and delivery efforts.

4. Producers Impressions of Biomass Harvesting Economic Factors

While there are many factors that will influence producers' decisions on whether to participate in biomass harvesting or not, arguably the largest is the economics of selling biomass. Though most producers don't consciously draft a full business plan for each new activity considered, they often have done a rough estimate of added costs and income either on paper or in their head before making a management change. In both the preliminary stakeholder meeting for the project and commentary from the optional written questions on of the survey (appendix B), economic payback on the producer's time, effort and capital resources was repeatedly brought up.

The survey asked several questions to get a general sense of expectations producers had on profit levels and other factors related to biomass harvesting economics. The central economics question asked was 'what level of profit producers would like before they would consider selling biomass?' Figure 9 shows the cumulative percentage that would supply biomass as the profit level increased. It should be noted that the final $50 point was indicated as $50 or more on the survey, so some responding at that price point might expect significantly more than the $50. Roughly 15% responded that they would not sell.

Figure 9. Percentage of Producers Who Would Consider Participating As Profit per Acre Increases. Note the $50 point was "$50 or more" on the survey question.

This data suggests that to get a reasonable amount of participation, would take between $40-50 profit per acre. This price seems to be a point that would tempt undecided producers and perhaps some of the 'not interested' folks into entering the market. This data is similar to discussions we've had with individual producers interested in supplying their biomass to a market. A profit of $45 per acre would work out to $15 profit per ton of biomass at 3 tons per acre, which is removing a substantial amount of biomass. There is a discussion of what this pricing might mean for producers and facilities at the end of this section.

Examining the correlation between profit levels desired and the interest in participating showed a decrease in minimum profit desired amongst those 'interested' or 'very interested' in biomass harvesting. The average per acre profit at which those 'very interested' would consider selling biomass was $39, compared to the not interested producers who wanted an average of $47 per acre before they would consider selling. The findings were statistically significant ($p = 0.001$) and indicate that producer participation interest will very much depend on the prices paid to them by biomass facilities.

Another potential economic factor in decision making is that producers may feel they need to add additional income to their operation if crop prices are low. Currently, we have enjoyed record corn and soybean prices over the last few years. However, a drop in prices may push those 'not interested' in biomass production into the biomass market. To examine this issue, the survey asked producers at price point (per bushel of corn) they would consider selling biomass. The options ranged from $7 or less, to $3 or less, plus a 'would not sell' choice. As expected, the mean price of corn at which they would consider selling biomass to supplement income was higher ($5.04) for those who are very interested in biomass sales. Those not interested in biomass sales would consider biomass sales if the price were to drop to a mean price of $3.94 per bushel. The mean corn price per bushel for those not at all interested in biomass sales was $4.60. Although this number was higher than those 'not interested', these individuals would probably not ever sell and were likely estimating what others might consider a reasonable point. The key point where the majority of producers would begin considering biomass sales to supplement grain income was between $4-5 per bushel. This correlation between grain price and participation interest was found to be significant, both when responses included only those indicating a price levels and when individuals who indicated that they would not sell at all were added to the analysis.

Table 4. Correlation between Corn Price and Participation Interest Statistical analysis indicated price and interest were significantly associated at p=0.001

Participation Interest	Mean Corn Price
Very Interested	$5.04
Interested	$4.58
Undecided	$4.39
Not Interested	$3.94
Not at all	$4.60

Another factor that producers at the stakeholder meeting indicated may influence their decisions to participate in biomass sales was the option to set up contracts for biomass sales. A contract often locks in a specific price for the biomass being sold, thus the producer doesn't have to worry about market fluctuation or finding a buyer at the end of the season. However, the producer is then locked into supply material for a given length of time. In situations where a producer may have to buy or lease equipment, producers can use a contract to assure them of a known steady income, which may be important to help repay capital costs on equipment.. An important issue is how long producers would like to be locked into a contract. With these ideas in mind, producers were asked if they would prefer to have no contract, a 1-3 year contract, a 4-7 year contract, or a 8-12 year contract.

The results show fairly conclusively that producers are much more interested in short term contracts (58%) or no contract (20%). Interest in longer term contracts may grow if producers have had successful dealings with facilities purchasing biomass.

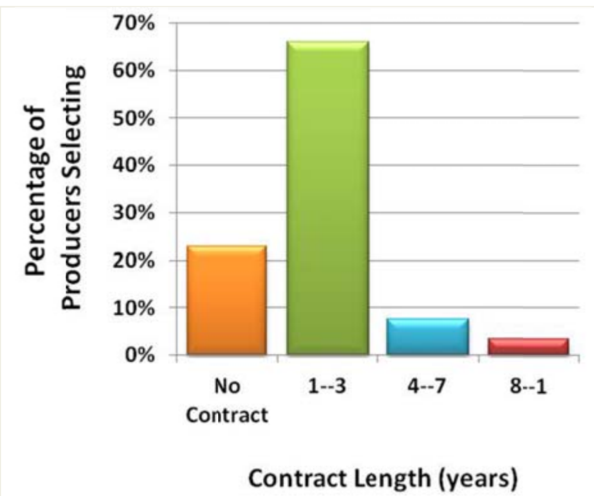

Figure 10. Producer Opinion On Contract Length Percentage of producers expressing a preference for each type of contract.

Although most of this report focuses on biomass from standard agricultural crops, corn stover in particular, there has been interest in production of alternative crops grow specifically for biomass. Grown on marginal lands, alternative crops potentially could provide income on land that might not normally be productive and perhaps provide other benefits such as wildlife habitat or erosion control. As with any potential conversion of land to a new use, producers will need to see that they can make a profit harvesting biomass from specialty crops. Producers were asked at what level of profit they would considered planting marginal lands with biomass crops.

Responses indicate that there may be some interest in biomass cropping on the part of producers. However, the majority indicated that a profit would have to be at least $100 per acre to get them interested. In a system averaging 4 tons per acre/yr, this would equate to a profit of at least $25 per ton. As indicated in table 5, there was a significant interaction between the mean profit producers identified and the interest in participating in the biomass market. Those who were interested were satisfied with a lower profit per acre.

Table 5. Specialty Biomass Cropping Profit and Participation Interest.
Statistically associated using the gamma statistic. (p=0.00012.)

Participation Interest	Mean profit
Very Interested	$74.55
Interested	$81.24
Undecided	$84.91
Not Interested	$95.65
Not at all	$82.00

For both corn stover collection and specialty biomass cropping, the cost of harvesting, storage, and delivery of the biomass is going to be an important factor. An estimate by Lazarus (2008) put the cost of harvesting stover biomass (with fertilizer replacement) and delivery to a facility at $50 per ton. The Revised Billion Ton Report (US DOE 2011) uses the figures- $15 for harvesting, $6.90 for nutrient replacement, and $3.00 per ton for delivery of corn stover for a rough total of $25 per ton. In a test harvest of prairie grassland biomass conducted for the WCROC (Tallaksen, 2007), we found that harvesting using a custom contractor at two sites larger than 50 acres cost roughly $39 per ton for harvest and delivery of biomass. Lazarus found that managed grassland biomass would likely costs $77 per ton to establish, harvest, and deliver. As can be seen from these numbers, there is not yet a consensus as to the final cost of harvesting and transporting material. However, without efficiencies of scale and improved equipment, it is likely to be towards the higher end of the estimates found in the literature cited above.

Should the harvest and delivery costs be near the $50 per ton mark, adding another $15 or $25 per ton profit could make the biomass too expensive for use in renewable energy production at this time. The economics will likely change should conventional fossil fuels become scarce and their prices rise. Bio-product facilities may be able to pay more for feedstocks due to the higher end value of their products. In personal communications with different individuals in the energy industry, they appear interested in keeping their biomass feedstocks under $50 per ton delivered. This leaves little room for the stover producer to make $15 profit per ton ($45 per acre @ 3 tons per acre) for stover. Producers will need more economics information that specifically shows a realistic profit before they invest a significant effort in biomass collection.

5. Producer Assessments of Harvest Impacts and Mitigation Strategies

As was noted above in the section on general factors affecting producers decision to participate, many producers recognize that harvesting material from agricultural fields has the potential, if material is overharvested, to decrease soil and landscape qualities. To further examine this issue, the survey had a set of questions that asked about producer's impressions of how biomass harvesting might impact the landscape and what techniques they would consider to reduce or fully mitigate potential problems with overharvesting. The goal was to narrow down which environmental concerns producers felt were most likely to occur, and also to see how significantly they felt harvesting could impact areas of concern.

A multi-part question asked how producers felt three different harvest rates (30% removed, 50% removed, and 70% removed) would affect six measures of soil health and environmental quality. An additional part asked how producers thought grain yields would respond to the 30% harvest rate. For each quality measure and each harvest rate, respondents were given options that indicated the quality measure (increased, decreased, or stayed the same), or a choice to indicate that they were not certain (not sure). For statistical analysis, answers were converted to 'yes' (quality will decrease), 'no' (quality will increase), or 'same'.

The results (fig. 11) indicate that producers are, in general, fairly aware that landscape quality can decrease as harvesting increases. Decreases in soil organic matter (SOM) were the most

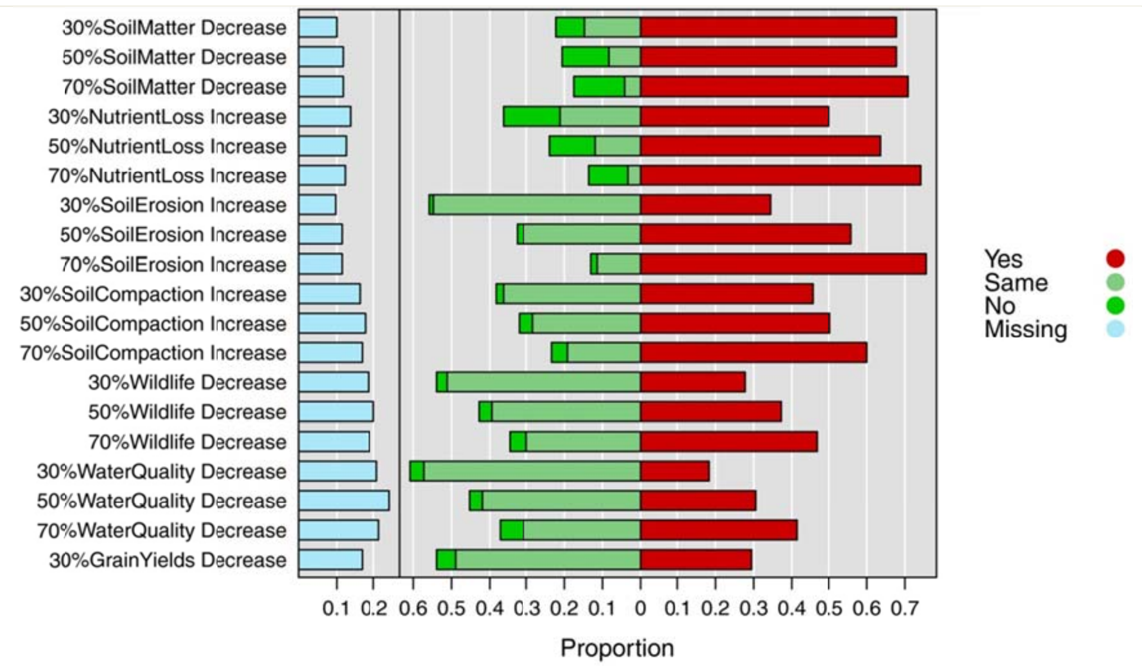

Figure 11. Producer Assessments of Environmental Impacts at Different Harvest Rates. Plot data indicates the proportion of producers feeling that the factor on the left would get worse (yes), get better (no), or stay the same at 30, 50, and 70% harvest rates. Missing includes 'not sure'

identified quality measure impacted by harvesting biomass, with almost 70% saying that all levels of biomass harvest would reduce SOM. Very little difference was noted in responses between the three different harvest rates, with 65, 65, and 70% saying there would be an SOM decrease at the 30, 50, and 70 percent harvests, respectively.

Increased nutrient loss, erosion, and soil compaction were identified as the next most impacted quality measures as a result of biomass harvesting. Unlike the results from the SOM question, for these measures there were fewer producers who felt the lower levels of removal impacted the quality measure. However, the perceived impacts increase substantially as the harvest rate increased. For example, nutrient loss increases were identified by 40% of the respondents at the lowest harvest rate versus 75% at the highest harvest rate.

A topic where producers were less sure of the biomass harvesting impacts on the landscape were the effects on wildlife and the quality of water. This uncertainty is seen in the greater number of responses in the 'not sure' ('missing' on fig. 11) category.

While not an environmental or landscape effect, the survey added the question about perceived grain yield impacts to determine whether producers might believe there is an impact of biomass removal on grain yield. Most felt that there would not be a decrease ('same') or there would be an increase in grain yield, roughly 30% thought yields would decrease with the lowest level of biomass harvesting. Unfortunately, only the 30% harvest rate question was included due to an editing error.

One item that can't be judged based on the responses to the different parts of this question was the magnitude of the increase or decrease that the producers expected. In other words, respondents identified the increase or decrease in the quality measure and recognized that more material removed will impact the measure more, but were not asked specifically how much it would change. It is also the case that the most important measure of soil or landscape quality in the producers' decision to harvest biomass cannot be determined by the data from this question. However, based on the data from table 3 and this section, it is safe to say that maintaining soil quality is very important to producers and that soil erosion, nutrients, and organic matter are all top producer concerns.

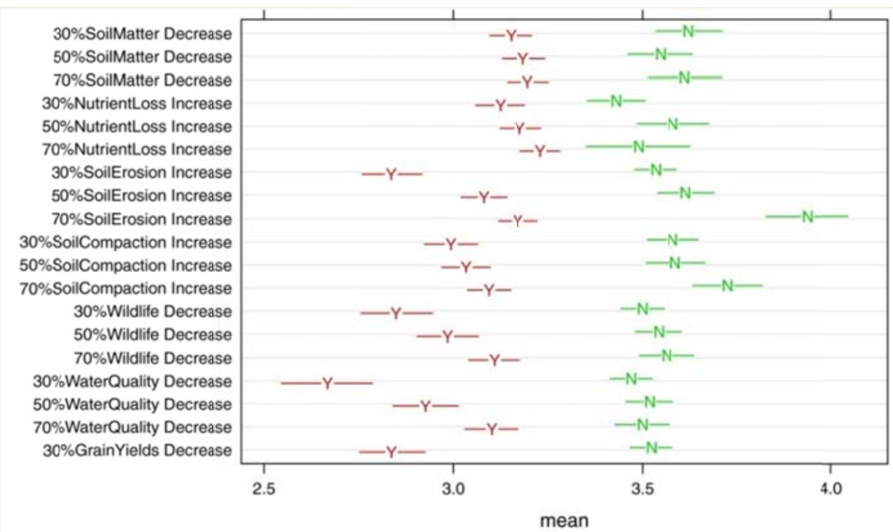

Figure 12. Mean Participation Interest Compared to Perceived Impacts. Plot data indicates the proportion of producers feeling that the factor on the left would get worse (yes), get better (no), or stay the same at 30, 50, and 70% harvest rates. Missing includes 'not sure'

In terms of the producers' ability to accurately judge impacts, the answers to most of the questions are field specific and producer accuracy cannot explicitly be determined. On low yielding sandy soils, 30% biomass removal will impact soil organic matter, while it probably would not affect a good loam soil with higher yields. Similarly, erosion on soils with heavy slopes or in arid regions will likely be impacted at even the lowest levels of harvesting (30%); whereas, flat land with adequate moisture and decent yields should not be significantly impacted. This question was designed to examine the perceived impacts versus the likely impacts as determined by soil science models and other predictors.

This question was further examined (fig. 12) to determine whether there was a statistical correlation between producers who said they were interested in participating in supplying biomass and their assessed impacts of harvesting on the soil and environmental quality measure. In almost every case, a significant correlation was seen between a higher interest in selling biomass and their impression that there would be less impacts when harvesting material. In the few remaining measures, there was a clear trend towards higher interest being associated with less perceived impacts. Based on this data, it can't be said that people who aren't interested in selling biomass are overly cautious when it comes to landscape quality measures or, conversely, that people interested in selling biomass are not sufficiently concerned about the landscape. However, it is a very clear indicator of the differences of opinions about harvesting and selling biomass, plus the factors that are influencing decisions.

A final examination of this topic looked at whether location was a factor in producers' impressions of impacts on the soil quality measures (SOM, erosion, compaction). Agricultural production and associated biomass residue production varies dramatically throughout the state, chiefly along gradients of soils, rainfall, and temperature (see section II for more information). The important question was whether producers had different impressions of biomass harvesting impacts based on the region they farm in. To conduct an analysis for statistical differences between regions and perceived soil impacts, the state was divided into four zones (fig. 13) and producers placed into groups representing their region based on their zip code.

The analysis found that there were statistical differences in the perceived negative impacts of several soil quality measures between zones, with noticeable trends in others quality measures (table 6). The overall pattern indicated that producers in the northernmost region felt that there would be fewer negative impacts on soil quality measures from harvesting biomass than in the more southern zones. Zone 3, running west to east through south central Minnesota, had the highest number of people responding that they felt there would be soil and landscape impacts from harvesting.

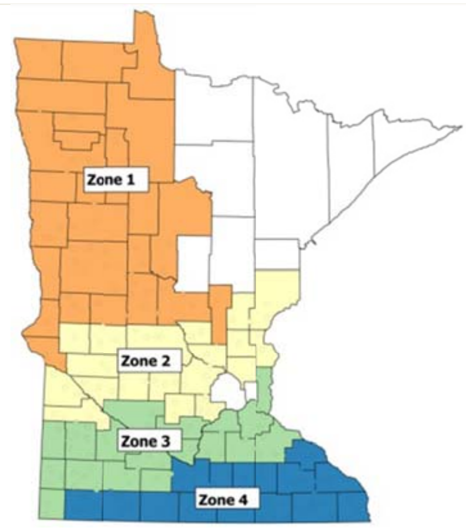

Figure 13 Four Zones Used to Group Producers Responses. Producers' locations were mapped by zip code and zones with equal number of producers were created based on corn production and landscape.

These results are interesting because the latest research on soil organic matter and biomass removal suggests that the more northern (lower grain yielding) areas would be most likely to lose organic matter under even fairly low biomass harvesting regimes. The other soil quality measures examined (erosion and compaction) are much more field and situationaly dependent. A good follow-up to this question would be to examine where producers in the different regions are getting their information and how appropriate the information is for the given region.

Table 6. Relationship Between Zone and Perceived Change in Impact. Table shows the percent of responding producers who indicate the factor would be worse with biomass removal. Analysis examined whether response was statistically different between zones for each factor listed using a chi-squared test. (p-values with '*' are significant at $p<0.05$)

	Zone 1	Zone 2	Zone 3	Zone 4	p.value
30% Soil Matter Decrease	75.4%	67.6%	84.8%	75.9%	0.099
50% Soil Matter Decrease	70.4%	71.8%	90.7%	71.1%	0.008*
70% Soil Matter Decrease	76.7%	71.8%	93.5%	76.3%	0.005*
30% Soil Erosion Increase	33.3%	27.0%	46.2%	43.2%	0.055
50% Soil Erosion Increase	58.0%	54.8%	73.7%	69.5%	0.047*
70% Soil Erosion Increase	83.3%	83.8%	87.0%	87.3%	0.849
30% Soil Compaction Increase	49.3%	49.3%	63.5%	58.7%	0.224
50% Soil Compaction Increase	52.3%	55.1%	71.8%	71.1%	0.026*
70% Soil Compaction Increase	62.1%	73.2%	80.8%	76.0%	0.086

The next set of questions dealt with producers' level of interest in implementing measures that would help mitigate potential impacts to their land from harvesting biomass. Several cropping techniques have been shown to help maintain soil quality under biomass harvesting regimes. There are two main mechanisms by which these techniques mitigate possible biomass harvesting impacts; adding another soil biomass source, or reducing the typical loss of biomass due to heavy tillage. By planting cover crops, producers can add more biomass to the soil (both above and below ground) and possibly have a second crop that adds commercial value to the field. Rotating crops can also help build soil by planting species that may allow the soil to rebuild itself with more root and shoot biomass than is seen in a conventional corn and soybean rotation. Tilling the soil hastens the breakdown of SOM(tiny pieces of decaying plant material). This SOM is important for maintaining soil moisture, nutrients, and air exchange. Traditional tillage, such as with moldboard plowing, is very disruptive to soil structure and causes much more rapid decomposition of organic material. New techniques, such as no or reduced tillage, slow the breakdown of SOM and can help build up the soil. Unfortunately, producers have expressed reservation about implementing some of these techniques for several important reasons.

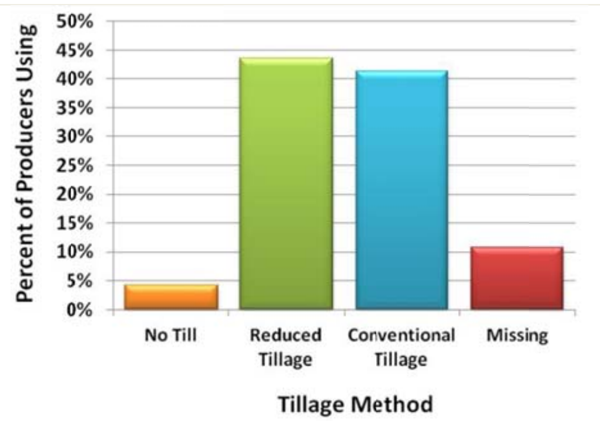

Figure 13. Percentage of Responding Producers Currently Using Each Tillage Practice.

To better understand producers' willingness to adopt new techniques, the survey first asked respondents about their current tillage methods (fig. 13). Rather than give specific definitions for each type of tillage, the producer could choose where they thought their tillage method would fall on a scale from no-till to conventional tillage. Slightly more than half were currently using some form of conservation tillage, which can help reduce the loss of SOM. There did not appear to be any correlation between those interested in participation in the biomass market and current tillage techniques.

The next step was to determine whether producers would consider implementing different techniques to mitigate possible soil quality impacts from biomass removal. The techniques selected for this question were reduced tillage, new crop rotations, cover crops, and no-till. Producers were asked whether they would consider implementing these techniques, would not consider implementing them, or already had. With the exception of no-till, most producers indicated that they would consider implementing the other techniques (fig. 14). Further analysis indicated that with the exception of reduced tillage, which is already widely used, producers interested in biomass harvesting were significantly more interested in implementing these tillage techniques (table 7). The results may indicate a realization on the part of producers that tillage and soil conservation practices may have to change if they want to harvest biomass. However, they may also indicate that individuals interested in biomass harvesting are, in general, the early adaptors, who already see these techniques as practices that could be good for their operation. One somewhat unexpected finding was the high number of producers who would not consider no-till, but would consider new crop rotations and cover cropping. Though no-till is not currently particularly popular, in many ways it would likely be less of a change to many producers systems than a new crop rotation or cover crop.

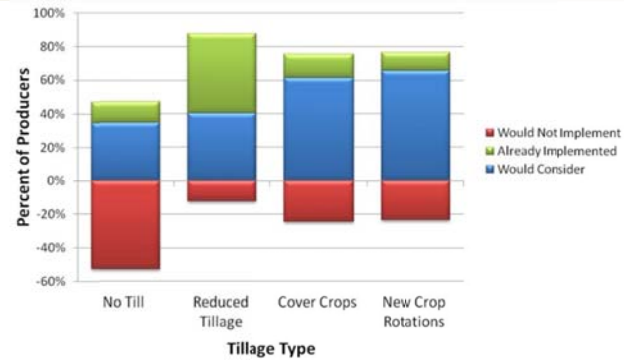

Figure 14. Producers' Willingness To Implement Cropping Techniques.

Table 7. Correlation of Willingness to Change Techniques and Participation Interest. Correlations determined using the gamma statistic. (*Significance at $p < .05$.)

Technique	gamma	p-value
No Till	0.19	0.015*
Reduced Tillage	0.09	0.253
Cover Crops	0.27	0.001*
New Crop Rotations	0.32	< 1e-04*

The willingness of producers to implement these new practices was also compared with the producers' education levels and number of years farming to see if maybe their experience or training influenced their willingness to adopt the techniques. There did not appear to be any statistically significant correlations between these factors. However, a couple of trends were noted. The first was that respondents who had farmed longer indicated that they were more likely to have already implemented reduced tillage. This may indicate that those with more years farming are using less tillage than they have in the past or possibly that producers with less years of farming have a more specific definition of reduced tillage and don't feel their current techniques qualify as reduced tillage. The second observation was the trend that producers with higher levels of education were less opposed ('would consider' or 'had already implemented') to no-till techniques.

Combined, the producers' understanding of agricultural biomass harvest impacts and willingness to consider alternative techniques are an important component of developing sustainable plans to harvest agricultural biomass. The impression from this data is that more needs to be done to provide all producers with accurate information so everyone understands the direct link between the ability to remove higher amounts of biomass and soil conservation techniques. On many soils, biomass removal may only be sustainable when reduced on no-till farming is implemented.

6. Demographics

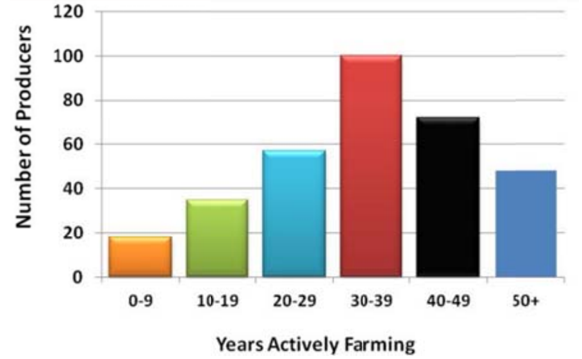

Figure 15. Years of Farming Experience

The last section of the survey was the demographics section. Producers were asked several different questions to see if specific factors in their background or aspects of their current operation might have a role in their decision to participate in a biomass market. The first question asked how many years they had actively been farming. Results indicated that most producers had multiple decades of experience. For statistical purposes, survey responses were grouped into ten year increments (fig. 15). Analysis of the time spend farming and participation interest in harvesting biomass found that there was a statistical correlation between the number of years spent farming and the interest in biomass harvesting. In this case, there appeared to be more interest in participation in the biomass market among individuals who had farmed less than 30 years. Based only on this information, it is hard to determine what reasoning was seen for this difference. Possible explanations may be that producers with less years of farming felt they needed added income or that farmers who have been actively farming for 30 or more years didn't care to add additional activities to their operations. The potential for added physical activity needed to harvest biomass may also discourage those with more years of farming from addition biomass harvesting to their operations.

Table 8. Mean Participation Interest Grouped by Years Farming. Participation Interest had a negative (gamma = .16) correlation with years farming at a significance of p=0.006.

Time farming (yr)	Mean Interest	n
0-9	3.39	18
10-19	3.43	35
20-29	3.40	57
30-39	3.27	100
40-49	3.03	72
50+	3.04	48

The producer's level of education was the next demographic topic covered. The number of producers who indicated the highest level of education they completed is shown in figure 16. Statistical analysis did not find any correlation between education and interest in participating in biomass markets.

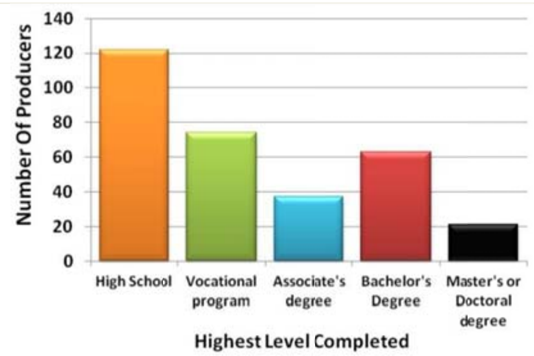

Figure 16. Producer's Highest Education Level

To analyze possible affects that the location of the land being farmed may have on participation interest, a GIS based analysis was done of producer interest levels versus location. The zip code that each producer reported as the location of the largest part of their farming operation was converted to a longitude and latitude, which was mapped using GIS software (see Section II for more information on this work). Two tests were performed on the data, one grouping responses into three statewide zones and another using four zones (fig. 17, table 9). For each, the state was divided into regional zones with roughly equal numbers of respondents. The divisions were somewhat based upon yields, but also upon rough topology. Statistical analysis looked for correlations between the location and participation level. The analysis did not find a statistically significant correlation between the two in either the three or four zone tests (p-values of 0.12 and 0.07 respectively). However, the data has a strong trend towards more participation interest in the northern zones. The high variability in participation interest levels likely limited the ability to detect statistical significance.

As reported above, there were statistically significant interactions between the four zone grouping and potential impacts to soil quality measures. Further examination of location data might yield other variables with correlations to regions and would be a good next step if this data is further analyzed.

Table 9 Mean Interest Among Producers Group in Three or Four Zones Within Minnesota. (percent interested includes very interested and interested)

Three Zones			Four Zones		
	Mean Interest	Percent Interested		Mean Interest	Percent Interested
Zone 1	3.31	0.46	Zone 1	3.41	0.50
Zone 2	3.32	0.44	Zone 2	3.35	0.44
Zone 3	3.06	0.34	Zone 3	3.14	0.39
			Zone 4	3.03	0.33

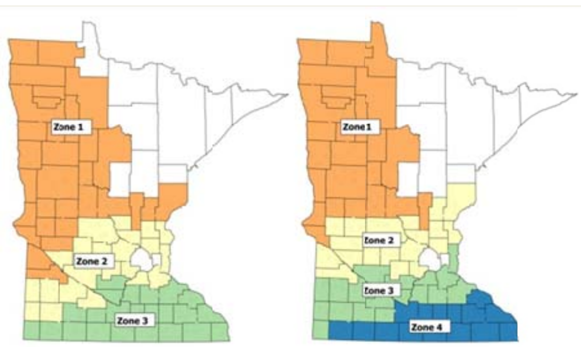

Figure 17 Maps of Three and Four Zone Producer Grouping.

The next set of data covered the producer's farming operation. Farm sizes, crops, and livestock were all examined to see if there was a relationship between these and participation

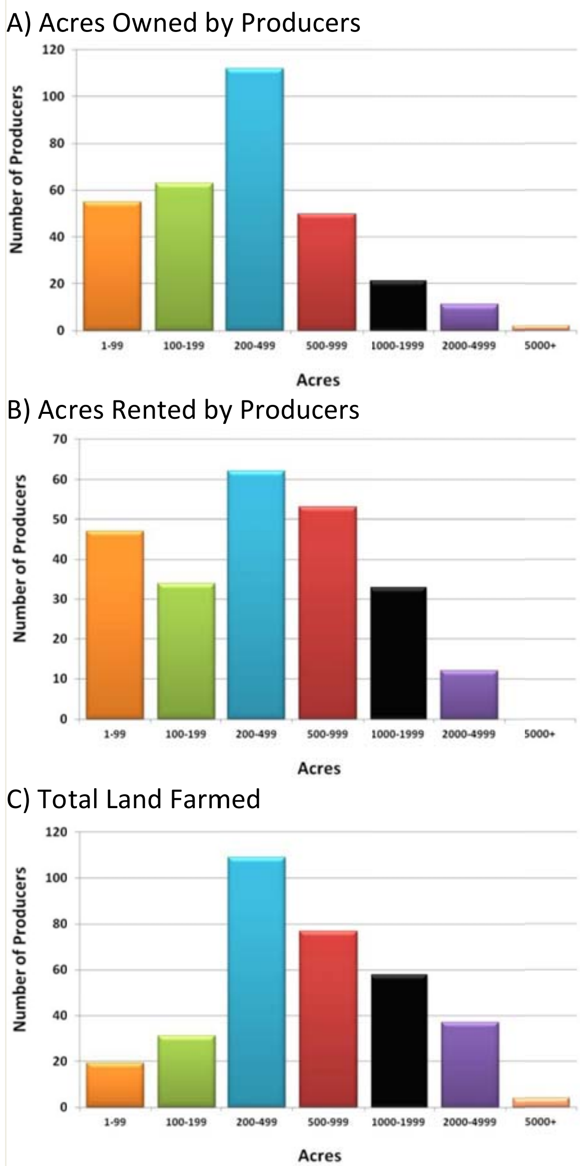

Figure 18 Land Farmed by Producers. Amount of land farmed by producers, the total number of producers for each was 314, 241, and 335 for owned, rented, and farmed respectively.

interest. In terms of acreage, there appeared to be little correlation between farm size (fig 18) and participation interest. As expected, corn was the most common crop grown (fig 19) among producers responding to the survey, with soybeans being a close second. There was a fairly high amount of mean acreage reported for both corn and soybeans. Producers also reported wheat, pasture land, and other crops as being part of their operations. However, there was much less acreage in these crops.

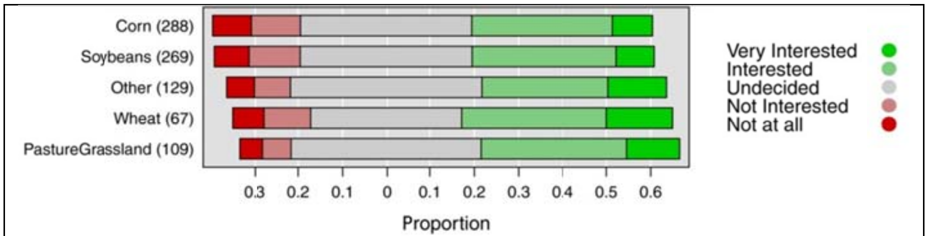

Figure 19 Biomass Market Participation Interest Among Producer Growing Various Crops. Produces with the selected crop plotted against the proportion of producers' selecting each interest level

For statistical comparison, the interest in participation in biomass markets was compared separately for each crop. The comparison was whether interest levels were the same among those who grew the particular crop and those who did not. Only those with pastures or grassland were statistically associated with having an increased interest in biomass market participation (table 10). There was a trend that people who responded that they had 'other' crops had an increased participation interest as well. While this data doesn't fully explain these results, it is likely that individuals with pasture or grassland acreage don't use biomass from these lands for livestock feed or bedding and are looking for other ways they can use the land for income.

Table 10 Correlation Between individual Crops Grown and Participation Interest Correlations determined using ANOVA . (*significant at Pr(t) <.05)

Crop	Significance
Corn	0.360
Soybeans	0.752
Wheat	0.212
Pasture	0.040*
Other	0.063

The same statistical comparisons were used to test whether there was a relationship between raising livestock and participation interest. Producers were asked how many of five common animals they raised on their farms and allowed to indicate they raised other animals. The responses (fig. 20) indicated that the number of producers raising beef- 41%, dairy- 15%, hogs- 12%,

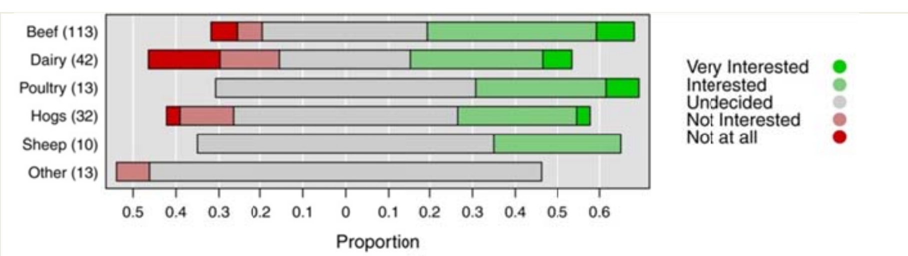

Figure 20 Biomass Market Participation Interest Among Producer Raising Various Livestock. Produces with the selected type of livestock plotted against the proportion of producers' selecting each interest level

poultry- 5%,sheep- 4%, other- 5%. The relatively small number of producers having poultry, sheep, and other livestock meant that statistics could not be calculated for those animals. For those raising hogs, there did not appear to be any significant difference in participation interest (table 11). There was however a significant difference in interest among producers who raised dairy cattle. Dairy producers had significantly less interest in participating in biomass markets. This is likely due to their need for the different agricultural residues (stover, cobs, straw, and hay) for bedding and food for their cattle and their existing workload. Whereas, those raising beef cows had a trend towards being more interested in being part of a biomass market, though it was not statistically significant. This could also be because their cattle are more likely to be a smaller part of their operation and daily work load. The beef cattle producer may have enough time and land to both collect biomass and raise beef cows. Depending on region of the state, beef producers also tend to have traditionally harvested more stover biomass for bedding and other uses as part of the operation. Therefore, they would have added experience and equipment that a dairy producer might not have.

Table 11. Correlation Between Livestock Raised and Participation Interest.
Correlations determined using ANOVA. (*significant at Pr(t) <.05)

Crop	Significance
Beef	0.108
Dairy	0.048*
Hogs	0.514

D. Conclusions

With a producer participation interest rate of 40%, the findings suggest that Minnesota producers as a whole are not currently that interested in supplying biomass to a biomass market. The assumption by early government studies that massive amounts of biomass would be fairly easily available at reasonable prices does not appear to be accurate for Minnesota at this time. However, interest was higher than reported in Iowa (17%) during the 2006 study (Tyndal, 2010). The results were somewhat similar to the 2007/2009 survey of Missouri (32.5%) and Illinois producers (40.89%) (Sanders, 2012), but cannot be directly compared due to differences in the questions asked of producers.

When looking at the producers who are not interested or not sure about marketing their biomass, there appear to be two somewhat distinct groups; those who are undecided because of lack of knowledge or a negative impression, and those who are firmly against it. Those who are firmly against being part of a biomass market tend to be very concerned with the soil quality and landscape impacts of harvesting biomass. The significant number of producers responding that they were undecided (38%) about participation suggests that either they are waiting for others to try biomass harvesting first or have not gotten the information they need to make a more concrete decision about participation.

The responses to the questions of self-identified knowledge level and the impacts of harvesting also indicate that many producers need more information before firmly deciding whether biomass harvesting would be a good fit for their operation. Based on their assessment of factors influencing their decisions, they are most interested in information concerning soil conservation and crop management practices to protect their land. However, producers will also need solid economic data that demonstrates a reasonable profit for biomass harvesting before they agree to participate.

Renewable energy or bio-product projects that are being considered would benefit from taking time to talk with producers in the intended supply region to determine the level of participation interest in the area and be ready to provide local producers with the most up-to-date information. Facilities may also, at least initially, have to pay more for biomass to increase interest and assure a steady biomass supply. Should the use of biomass prove successful over the long term, a stable biomass market will likely form as more producers become familiar with biomass harvesting.

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Final Report: Implications Of Corn Producer Participation Rates On Stover Biomass Markets

Section II:

Minnesota Corn Stover Biomass Availability Modeling

Prepared for:

By

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West Central Research and Outreach Center
University of Minnesota

March 2013

Section II. Biomass Availability Models

Table of Contents

Acknowledgments:

The author wishes to recognize to efforts of several people and groups in helping with experimental design, survey development, data compilation, and reviewing findings. Dr. Aaron Rendahl from the Univ. of Minnesota, school of statistics contributed greatly to the survey design and interpretations of data. Daniel Seidenkranz and Britta Anderson were very helpful in data entry and data quality control. Michael Reese and Eric Buchanan kindly reviewed drafts of the report. Thanks also to the contributing industry stakeholders who reviewed the draft survey and provided critical feedback. A final thanks to the groups funding the study and their members; The Agricultural Utilization Research Institute, Minnesota Corn Research and Promotion Council and their member corn farmers, and the University of Minnesota- Initiative for Renewable Energy and the Environment.

Disclaimer

The opinions and findings of this document are solely those of the author and have not been reviewed by the projects sponsors; the University of Minnesota- Initiative for Renewable Energy & the Environment, the Agricultural Utilization Research Institute, or the Minnesota Corn Research and Promotion Council. Although the author has made every attempt to use the best information and data available in the development of this work, the information is still only a model of stover production and producer harvesting interest, which uses time sensitive data. While individuals interested in biomass availability for a specific facility or location can use this as a tool for understanding biomass availability, they are encouraged to perform a much more in-depth analysis for their potential supply region.

Executive summary:

In the future, biomass energy and bio-products derived from agricultural biomass will likely be important renewable resources for the nation as well as a valuable new market for agriculture. Unfortunately, an accurate understanding of the extent and locations of viable agricultural biomass supplies is a barrier to implementing the technologies to convert biomass to other products. The large volumes of biomass needed and the cost of transporting feedstocks necessitates locating biomass processing facilities near adequate biomass supplies. This portion of the research modeled Minnesota's corn stover biomass supply using county level corn production data and producer interest levels (from section I of this report) to predict locations that would best support biomass facilities. A part of this goal was to develop models that could be updated with new information over time. To create a biomass availability model and evaluate statewide patterns, biomass yields and producer participation interest data were mapped using GIS software to create production maps with county level resolution. Eight statewide biomass supply regions were selected and evaluated to see how corn stover production and availability varied in areas throughout Minnesota.

Projected total corn stover biomass production statewide was over 33 million tons, based on 2011 county corn production data. The highest production levels were found in southern Minnesota, where more land was dedicated to corn production and yields were higher. Conversely, average interest in participating in biomass markets (selling biomass) was highest in north western Minnesota. After factoring both production and interest levels into available biomass calculation for the 8 regions analyzed, it was clear that the higher supplies in southern Minnesota more than made up for the decrease in interest. In southern supply regions (based on a 70 mile radius), over 10 million tons of production was estimated to be 'purchasable', versus less than 1 million tons in the northwestern corn production areas.

One piece of data that must always be incorporated into the model is soil conservation. Determining how much biomass can be removed without impacting soil on a state or regional level is difficult because of variations in soil, climate, and erosion potentials for individual fields. As a simpler method, collecting biomass every other corn crop would likely leave sufficient biomass and provide marketable biomass in southern and central parts of Minnesota. However, stover harvesting in northern, low yielding regions or any field statewide that has steep slopes is not recommended.

After factoring in conservation, there appears to be a fairly homogeneous area of southern Minnesota that would be able to supply a larger 500,000+ ton facility. However, central locations may not support a facility much larger than 100,000 tons. Based on production estimates and conservation considerations, a map with likely locations for facilities is presented.

It is important to keep in mind that this model uses a snapshot of conditions to model corn stover biomass availability. Both the producer participation interest and corn yields vary considerably. The 2011 harvest was lower than both 2010 and the estimate for 2012, meaning the model numbers may be lower than will be seen in the future. Interest will also change depending on the price offered for stover biomass. However after looking at all factors, biomass facilities that are willing to pay producers fairly should not have a problem finding a sufficient supply.

A. Introduction

In the future, biomass energy and bio-products derived from agricultural biomass will likely be important renewable resources for the nation as well as a valuable new market for agriculture. Unfortunately, an accurate understanding of the extent and locations of viable agricultural biomass supplies is one barrier to implementing the technologies to convert biomass to other products. The large volumes of biomass needed and the cost of transporting feedstocks necessitates locating biomass processing facilities near adequate biomass supplies. This portion of the project modeled Minnesota's corn stover biomass supply using county level corn production data and producer interest levels (from section I of this report) to predict locations that would best support biomass facilities.

In order to develop agricultural biomass projects for energy or other industrial uses, it is important to look beyond the simple question of whether or not biomass being grown in a particular area. Many of the early projections of biomass availability by the USDA and others failed to account for the factors that will limit 'purchasable' biomass for use in industry. While there are several factors that could influence biomass availability, two important ones are the actual willingness of producers to supply biomass and the amount of biomass that should remain on fields to maintain soil quality.

Section one of this report had questions to assess statewide and regional differences in producers' willingness to supply corn stover biomass for energy and other uses. This section used the surveyed regional interest level data in combination with initial recommendations on maintaining soil quality to identify the potential amount of biomass available for purchase at specific locations throughout the state. The research used a set of diverse locations where biomass facilities could be located in Minnesota to gauge factors that influence the stover supply in those regions. This information will assist stakeholders considering investing in biomass facilities by providing a more complete model of 'purchasable' biomass in the state. In addition to survey data, production and conservation information was integrated from sources such as the USDA- National Agricultural Statistic Service, USDA- Agricultural Research Service, and the Minnesota Department of Natural Resources.

Another important goal of the modeling work was to develop a framework to allow future calculation of biomass availability. The spreadsheet and GIS modeling used to calculate biomass availability is designed to be easily updated as new data becomes available. Similarly, additional geographical areas can be mapped quickly and information entered into the database. It is expected that increases in yields and new information on harvests will change this model significantly as time progresses.

B. Methodology

This work was done in three phases, the first being the calculations of total stover biomass production. Minnesota counties and adjacent counties in bordering states were each analyzed for production levels and then the data was used to select a number of possible biomass supply regions and calculate stover produced in those regions. The next phase examined how producer interest in each of these regions affected the amount of biomass that might be put into a larger stover biomass marketplace. The final work examined soil conservation concerns and the amount of biomass needing to remain on the field to maintain soil quality.

Total County Stover Production

Total biomass production in each county was calculated by multiplying the total acres of harvested corn (for grain) by the total tons per acre of stover (NASS, 2011). Since the total tons of stover per acre is very close to the same weight as the total weight of grain per acre, we can calculate stover yields by using grain yields. Equation 1 below shows the formula for the calculations. The grain weight in bushels is multiplied by the weight of a standardized bushel of grain (56 lbs. at 15.5% moisture) and divided by 2000 (lbs. per ton) to get the total tons per acre of biomass. This yield per acre is at 15.5% moisture as opposed to the 0% moisture (bone dry) typically used for biomass financial transactions and energy calculations. Calculation of total tons per county uses equation 2, which multiplies the tons per acre by the total amount of harvest corn acreage.

<u>County Total Stover Estimation Equations:</u>

$$(1) Tons\ of\ stover\ per\ acre = \frac{(grain\ yield\ (bu)*56\ (lbs/bu)}{2000}$$

$$(2) Total\ Tons\ of\ Stover\ Biomass = (Acres\ of\ Harvest\ Corn)*(Tons\ of\ Stover\ Per\ Acre)$$

Regional Production and Availability Estimation

Geographical Information System (GIS) software was used to map the location of each survey response received from corn producers. The software ties data with map locations, so that each survey response is mapped to its zip code with a data record that contained the producer's level of interest in biomass, plus other factors such as the amount of corn the producer planted. GIS maps were also created that included every Minnesota county (base map supplied by US. Census Bureau), which linked to a database containing the average percentage of a county planted with corn stover, the average 2011 yield of corn grain (USDA-NASS) and the total county stover production from above (appendix D). This data was also obtained for counties in states bordering Minnesota which might be in the supply radius of one of the chosen locations.

Calculation of corn stover biomass produced in each region was based on county level data from the counties that made up the supply region. The GIS software is able to identify the acreage of each county that is within the 50 or 70 mile radius (regional biomass supply zone) from the selected facility location (Figure 3). With this acreage and the percentage of county land in corn production (NASS), the total acres of corn stover production was calculated (Eq. 3). Tons per acre of corn stover is almost exactly equal to the weight of the grain remove from each acre.

Equation 4 converts the yield in bushels of corn grain into a yield in tons per acre of stover which is use in further calculations. The total tons of stover produced in a county were calculated by multiplying the county land in corn production by tons per acre for that particular county (Equation 3). The total stover produced in the region of the supply radius was calculated by adding the biomass from each of the counties, both Minnesota and other states, that made up the supply radius (Eq. 5).

<u>County Contribution to Stover Production in Radius:</u>

$$(3)\ Acres\ of\ Corn\ Stover = \binom{Acres\ of\ County}{in\ Radius} * \binom{Percent\ of\ County}{Land\ in\ Corn\ Production}$$

$$(4) Tons\ of\ stover\ per\ acre = \frac{(grain\ yield\ (bu) * 56\ (lbs/bu)}{2000}$$

$$(5) Total\ Tons\ of\ Stover\ Biomass = (Acres\ of\ Stover) * (Tons\ of\ Stover\ Per\ Acre)$$

<u>Regional Stover Estimation Equations:</u>

$$(5)\ Total\ Tons\ of\ Stover\ produced = \sum \binom{Tons\ in\ each}{Minnestota\ County} + \sum \binom{Tons\ in\ each}{border\ count}$$

Availability of Biomass for Purchase

Calculations for the 'purchasablity' of biomass were designed to estimate the amount of biomass that can be purchased from producers in the region. It is based on the interest in participating in the biomass market by selling stover produced during corn grain production. The calculation uses the level of interest producers indicated they had in biomass sales in the survey conducted in spring of 2012 as the first part of this project (Section I). The question asked of producers was "If a regional market for biomass existed, would you be interested in participating by selling biomass from lands you manage?" and allowed the respondent to answer on a 1-5 scale from "Very Interested" (1) to "Not at all interested" (5). For each of the regions, the average interest was calculated from the surveys received in the given radius as identified with the GIS software. It should be noted that several regions contain 1 or more county(ies) in a border state. These residents were not surveyed; therefore, average interest data for the region is solely that of the Minnesota residents.

Determining which producers would sell their stover biomass based on the level of interest indicated on the survey was difficult and would vary considerably depending on factors that the individuals considered important to their farm operations. To establish some loose numbers for making availability estimates, a low and a high participation estimate was chosen based on the number of survey responses from very interested, interested, and undecided producers. Charts for each region with the numbers of responses in each interest category are in appendix D. The equations to determine the high (5) and low (6) biomass sales participation are below.

$$(5) Low\ Participation = \frac{Very\ Interested + Interested}{Total\ Responses}$$

$$(6) High\ Participation = \frac{Very\ Interested + Interested + ((1/2)\ Undecided)}{Total\ Responses}$$

C. Results

State and County Stover Biomass Production

The initial assessment of total statewide biomass production began with an analysis of the biomass produced in each county (Table 1.) In looking at the results, counties with both high total corn acreage and a high yield produced the largest amount of biomass. While some counties had fairly high corn yield, they had far fewer acres planted to corn. For example, Wabasha County had good average yield (181 bu/ac), but relatively few acres planted to corn (87,000 ac). Total Stover production for Minnesota was estimated around 33,400,000 tons for 2011. This includes all aboveground non-grain biomass at 15.5% moisture (leaves, stalks, and cobs).

Table 1. Minnesota County† Level Biomass Production Estimates Based on 2011 Yields

County	Harvested Corn Acres	2011 Yield	Tons per Acre	Total Tons*	County	Harvested Corn Acres	2011 Yield	Tons per Acre	Total Tons*
Anoka	6,700	119	3.34	22,399	**Morrison**	70,200	144	4.02	282,260
Becker	42,400	122	3.40	144,245	**Mower**	205,000	178	4.99	1,022,294
Benton	39,000	109	3.05	119,137	**Murray**	175,200	169	4.72	826,594
Big Stone	91,500	111	3.10	283,870	**Nicollet**	119,400	162	4.52	540,261
Blue Earth	194,600	172	4.82	937,738	**Nobles**	203,500	176	4.93	1,002,848
Brown	157,300	164	4.60	723,202	**Norman**	73,800	118	3.30	243,422
Carver	55,900	155	4.33	242,293	**Olmsted**	116,500	183	5.12	596,946
Chippewa	144,700	155	4.34	628,403	**Otter Tail**	145,400	133	3.72	540,655
Chisago	26,700	135	3.77	100,552	**Pine**	13,000	134	3.75	48,703
Clay	113,500	114	3.18	361,339	**Pipestone**	99,500	154	4.32	429,601
Clearwater	2,400	104	2.92	7,002	**Polk**	60,300	125	3.49	210,375
Cottonwood	175,100	166	4.64	812,394	**Pope**	113,200	136	3.82	432,016
Crow Wing	8,000	109	3.05	24,438	**Red Lake**	14,000	121	3.38	47,314
Dakota	85,000	176	4.92	417,928	**Redwood**	237,000	151	4.23	1,002,036
Dodge	121,400	183	5.13	622,733	**Renville**	254,500	146	4.09	1,041,109
Douglas	58,300	124	3.46	201,601	**Rice**	88,700	160	4.47	396,879
Faribault	217,000	175	4.90	1,063,908	**Rock**	133,200	181	5.06	673,566
Fillmore	182,200	179	5.02	914,717	**Roseau**	7,900	106	2.96	23,359
Freeborn	201,500	180	5.05	1,016,688	**Scott**	38,500	163	4.56	175,498
Goodhue	155,300	179	5.00	776,189	**Sherburne**	29,500	145	4.06	119,687
Grant	102,300	124	3.46	353,753	**Sibley**	153,500	159	4.45	683,812
Hennepin	12,200	145	4.07	49,669	**Stearns**	177,900	138	3.86	686,907
Houston	53,900	172	4.82	259,582	**Steele**	115,000	171	4.77	549,010
Isanti	31,200	127	3.55	110,860	**Stevens**	123,400	140	3.91	482,346
Jackson	194,300	165	4.61	895,490	**Swift**	176,400	154	4.31	761,131
Kanabec	12,300	125	3.51	43,119	**Todd**	59,700	132	3.69	220,150
Kandiyohi	150,500	150	4.20	632,100	**Traverse**	134,000	112	3.13	419,098
Lac Qui Parle	174,000	144	4.04	703,030	**Wabasha**	87,700	181	5.08	445,200
Le Sueur	92,400	159	4.46	411,882	**Wadena**	19,900	126	3.53	70,151
Lincoln	111,800	148	4.14	463,299	**Waseca**	121,000	178	4.97	601,370
Lyon	176,400	151	4.22	743,844	**Washington**	21,000	178	5.00	104,899
Marshall	12,200	115	3.21	39,113	**Watonwan**	135,600	179	5.00	677,729
Martin	224,500	176	4.93	1,105,707	**Wilkin**	89,800	121	3.39	303,991
McLeod	111,000	147	4.10	455,633	**Winona**	75,000	179	5.01	376,110
Meeker	114,000	145	4.05	461,563	**Wright**	72,900	146	4.08	297,199
Mille Lacs	17,100	101	2.83	48,455	**Yellow Medicine**	196,000	156	4.36	853,933

†Counties without corn or with limited data not included *Biomass tonnage at 15.5% Moisture

County level Biomass production

Total stover production at the county level was mapped using GIS and the county level corn grain production data (Figure 1). As expected, counties in the southern portion of the state had considerably more production than in the northern areas, which lie at the northern edge of the Corn Belt. A second map (Figure 2) was produced that examined the production density of stover. The production density is actually a more useful measure of the productivity of a region. Visually assessing total county production by county, may lead to the impression that a large county is very productive, when in fact it is the counties size that resulted in the high tonnage of biomass produced.

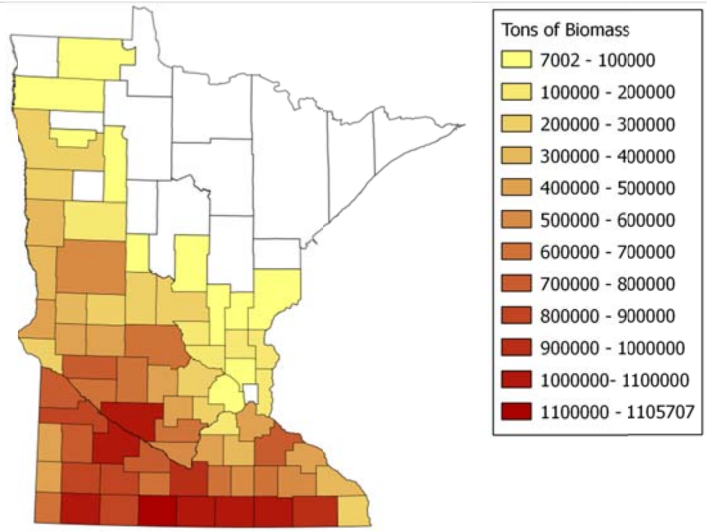


Figure 1. Total County Production of Corn Stover Biomass. Total tonnage of biomass produced in each county as calculated by acreage in corn grain and yields. Biomass is calculated at 15.5% moisture. Counties with no or extremely limited corn production colored in white.

Site Selection for Supply Regions

Selection of stover supply zone for analysis was based upon a visual assessment of the production density map along with other considerations. Regions were selected that would potentially show different amounts of biomass based on their location in the state, corn yields, amount of land planted in corn, average interest level of producers, and the authors assessment of regional interest in locating biomass plants in particular regions. The hub cities (Figure 3A) of each supply region were all county seats, often the most populated town in the region, plus were linked to both rail and state highways. The physical size, farm population, general population, and landscape were different between supply zones. The goal was to identify what might be regional 'hotspots' that had the infrastructure, labor, and community interest to support large (100,000 or more tons per year) or small (less than 100,000 tons) biomass facilities.

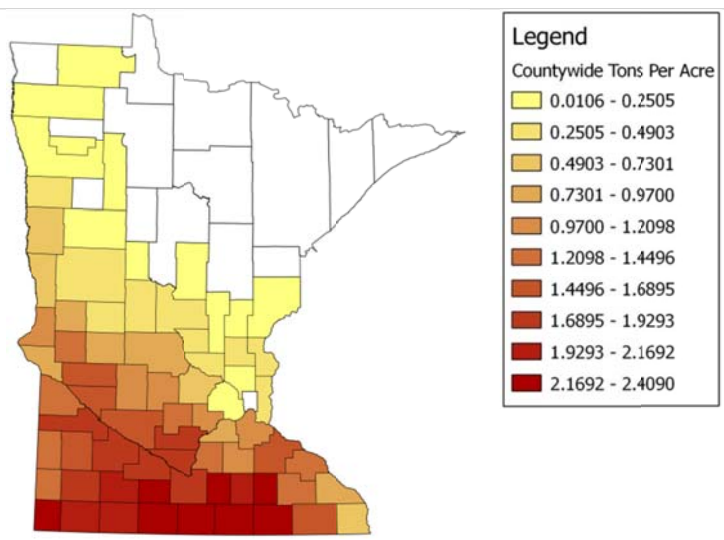
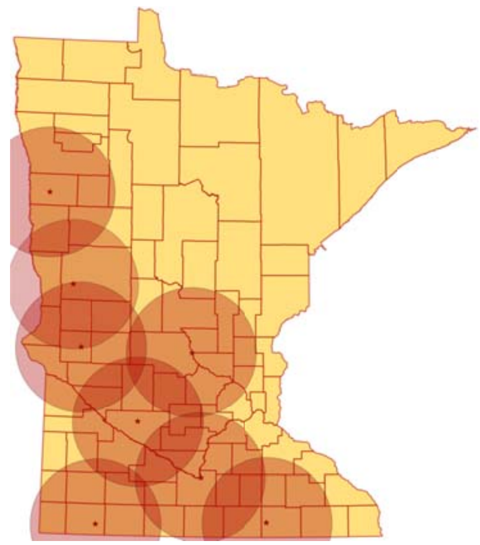


Figure 2. County Corn Stover Production Density. Density of biomass production in each county calculated by taking total county production and dividing by the size in acres of the entire county. Counties with no or extremely limited corn production colored in white.

Another factor in site selection was the distance between the center of each supply radius and overlap of supply zones. Two different radii were selected for testing in each region; 50 miles and 70 miles. Many in the industry have generally indicated to a maximum of between 50 and 75 miles for transporting biomass before transportation costs become prohibitive. The overlap between supply zones was limited to less than 40% between any two supply radii if possible, based on visual analysis (figure3B). However, significant overlap was seen when all 70 Mile supply radii were mapped simultaneously.

A. Cities Selected as Biomass Hubs

B. 70 Mile Supply Radii from Hubs



C. Border Counties Used in Analysis

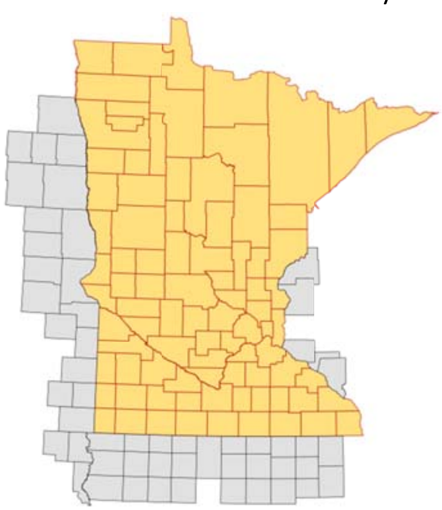


Figure 3. Geographical Information System Mapping of the Selected Corn Stover Biomass Supply Regions. A) Map showing the locations chosen as the hub of each supply region. B) The 70 mile zone around each Hub city from which biomass would be collected. C) Map Showing the extent that the 70 mile supply zones would reach into adjacent states and the counties making up the zones. Full details on regions and the specific counties included in each is in appendix D.

Regional Analysis Results

The next portion of the report is the individual stover production and participation interest data for each of the 8 regions. The text gives a brief overview of the landscape of the region and summary data compiled from the complete data set (appendix D). The percent of land planted in corn listed in the text is a simple average of counties that have a portion of their land in the region; it is not based on the proportion of each county in the region. It was calculated based on the acres of corn (for grain) harvested in each county for the 2011 production season (NASS 2011). Participation interest levels were determined by averaging the reported interest from survey responses in the region. Important note: A lower producer interest value indicates more interest (i.e. 1- 'very interested' to 5-'not at all interested').

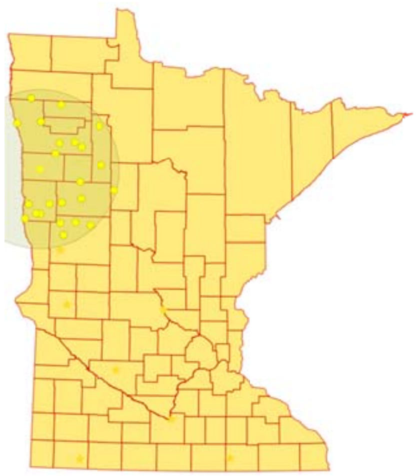
Each section contains a figure with four panels. In the first panel is a map showing the location of the region within Minnesota. The 70 mile radius is indicated by shaded circular region. Survey responses for that region are indicated by yellow dots. The next panel shows a closer view of the region. The counties that making up the region are roughly labeled, but labels are somewhat haphazardly placed due to limitations of the software. The inner more darkly shaded circle in this panel is the 50 mile radius, while the lighter larger circle is the 70 mile radius.

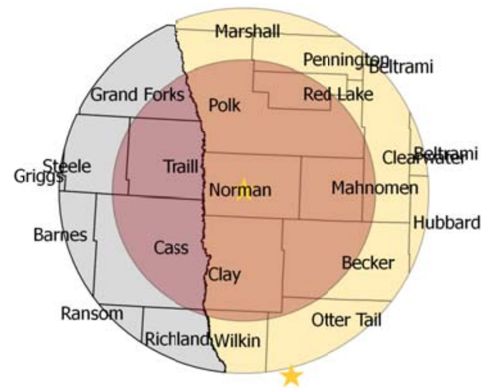
The next two panels are tables with the 50 and 70 mile county production estimates based on acres of corn harvested in the portion of each county in the radius and the yield of corn. Due to space limitations, some counties with no corn production were not included in the panel. The complete data tables are in Appendix D.

While reviewing this data, it is important to realize that it is total production data. It does not account for material that cannot be collected because of equipment limitations or that should be left on the surface for soil conservation purposes.

1. Raw Stover Production in Ada (Norman County) Region

Ada is located at the northern edge of corn production in Northwest Minnesota. The region is at the historic prairie-forest transition zone. Acreage dedicated to corn production is significantly lower in the region than the statewide average (average of 11% of land planted to corn in counties making up the 70 mile radius). The soil and climate differences are evident in fairly low average corn yields in the region (113.24 bu/ac) . The number of surveys with valid interest responses were 16 and 27 in the 50 and 70 mile radii, respectively. Interest levels corresponded to 2.94 and 2.44 in the 50 and 70 mile radii.





Stover in Portions of the Counties Within 50 Mile Radius

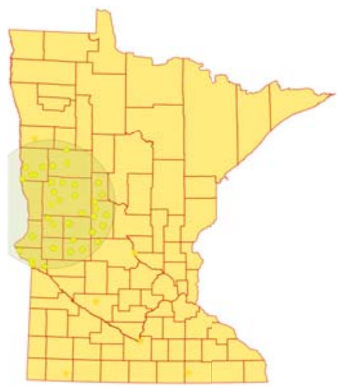
Minnesota County	Area in Radius	Harvested Corn Acres	Corn Yield bu/acre	Total Stover Produced
Becker	510,303	23,389	121.5	79,569
Clay	674,328	113,500	113.7	361,339
Clearwater	72,969	266	104.2	776
Mahnomen	373,431			
Norman	561,639	73,800	117.8	243,422
Otter Tail	42,661	4,356	132.8	16,198
Pennington	28,964			
Polk	983,086	46,326	124.6	161,623
Red Lake	220,199	11,127	120.7	37,605
Wilkin	50,938	9,506	120.9	32,179
	3,518,518	**282,270**		**932,710**
Cass_ND	732,348	133,101	101.6	378,646
Grand Forks	159,460	13,440	101.5	38,196
Richland	4,846	1,365	96.4	3,685
Steele_ND	64,712	9,517	110.9	29,553
Trail_ND	550,458	91,393	108.1	276,628
	1,511,824	**266,222**		**726,709**
Grand Total	**5,030,342**	**548,492**		**1,659,420**

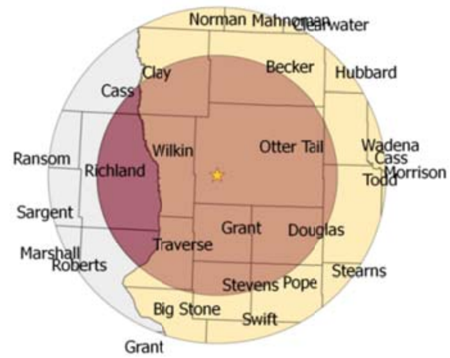
Stover in Portions of the Counties Within 70 Mile Radius

Minnesota County	Area in Radius	Harvested Corn Acres	Corn Yield bu/acre	Total Stover Produced
Becker	905,542	41,504	121.5	141,197
Beltrami	76,000			
Clay	674,328	113,500	113.7	361,339
Clearwater	615,309	2,241	104.2	6,540
Hubbard	124,345			
Mahnomen	373,431			
Marshall	275,213	2,892	114.5	9,272
Norman	561,639	73,800	117.8	243,422
Otter Tail	546,948	55,850	132.8	207,672
Pennington	382,362			
Polk	1,279,618	60,300	124.6	210,375
Red Lake	277,055	14,000	120.7	47,314
Wilkin	303,389	56,617	120.9	191,659
	6,395,179	420,704		1,418,789
Border States				
Barnes	239,659	24,598	110.6	76,176
Cass_ND	1,131,434	205,634	101.6	584,986
Grand Forks	654,900	55,198	101.5	156,872
Griggs	11,896	595	108.7	1,811
Ransom	81,544	10,258	116.6	33,489
Richland	343,111	96,662	96.4	260,911
Steele_ND	444,110	65,316	110.9	202,818
Trail_ND	552,909	91,800	108.1	277,860
	3,459,564	669,507		1,594,923
Grand Total	**9,854,743**	**970,764**		**3,013,712**

2. Raw Stover Production in Fergus Falls (Ottertail County) Region

Fergus Falls is located in Western Minnesota. Although some of the counties within the 70 mile radius are predominantly agricultural, many have significant portions of forested land and produce only a small amount of grain. Roughly 18% of the land in counties within the 70 mile radius was used for corn production in 2011. Average yield was 121 bu/ac. Within a 50 mile radius of Fergus Falls, 30 surveys were received, with an average producer interest of 2.56. Expanding to a 70 mile radius increases the responses to 60, with an average of 2.72.





Stover in Portions of the Counties Within 50 Mile Radius

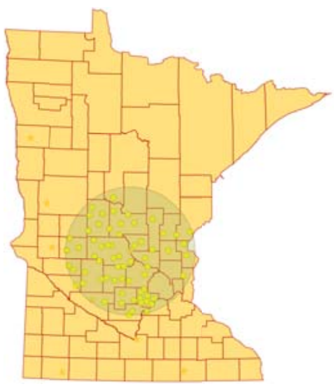
Minnesota County	Area in Radius (Acres)	Harvested Corn Acres	Corn Yield bu/acre	Total Stover Produced
Becker	410,489	18,814	121.5	64,005
Big Stone	2,487	673	110.8	2,087
Clay	390,075	65,656	113.7	209,022
Douglas	420,617	53,195	123.5	183,949
Grant	368,477	102,300	123.5	353,753
Otter Tail	1,417,148	144,708	132.8	538,082
Pope	84,521	20,848	136.3	79,565
Stevens	203,866	68,279	139.6	266,890
Todd	76,346	7,272	131.7	26,815
Traverse	309,741	110,531	111.7	345,698
Wadena	37,761	2,162	125.9	7,620
Wilkin	481,206	89,800	120.9	303,991
	4,202,735	**684,238**		**2,381,478**
Border States				
Cass_ND	43,604	7,925	101.6	22,545
Richland	652,973	183,957	96.4	496,537
Roberts	128,768	24,462	122.8	84,110
	825,346	**216,344**		**603,192**
Grand Total	**5,028,081**	**900,582**		**2,984,669**

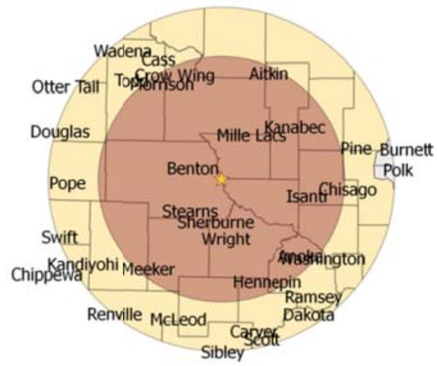
Stover in Portions of the Counties Within 70 Mile Radius

Minnesota County	Area in Radius	Harvested Corn Acres	Corn Yield bu/acre	Total Stover Produced
Becker	912,593	41,827	121.5	142,296
Big Stone	300,627	81,306	110.8	252,245
Clay	674,288	113,493	113.7	361,318
Clearwater	18,059	66	104.2	192
Douglas	460,981	58,300	123.5	201,601
Grant	368,477	102,300	123.5	353,753
Morrison	15,077	1,435	143.6	5,769
Norman	151,771	19,943	117.8	65,780
Otter Tail	1,423,927	145,400	132.8	540,655
Pope	439,931	108,515	136.3	414,135
Stearns	104,818	20,968	137.9	80,963
Stevens	368,444	123,400	139.6	482,346
Swift	168,205	61,635	154.1	265,941
Todd	582,879			
Traverse	375,506	134,000	111.7	419,098
Wadena	345,913	19,801	125.9	69,803
Wilkin	481,206	89,800	120.9	303,991
	7,511,955	1,122,189		3,959,887
Border States				
Cass_ND	453,879	82,491	101.6	234,670
Grant	1,908	530	123.5	1,832
Marshall	75,055	789	114.5	2,528
Ransom	170,141	21,403	116.6	69,875
Richland	926,444	261,000	96.4	704,491
Roberts	523,114	99,375	122.8	341,692
Sargent	190,009	35,157	90.2	88,794
	2,340,551	500,744		1,443,882
Grand Total	**9,852,506**	**1,622,934**		**5,403,768**

3. Raw Stover Production in St. Cloud (Stearns County) Region

St. Cloud lies at the northern edge of the Corn Belt in Central Minnesota. The region around St. Cloud has both forested (northern) and agricultural (south and west) lands, in addition to being close to the Twin Cities metro area (southeast). The average amount of land planted to corn in the 70 mile radius was 15.11%, with zero percent in some counties and up to 40% in others. The average yield for the region was 130.1 bushels in 2011. Fifty one survey responses were received from the 50 mile radius surrounding St. Cloud, with an average interest level of 2.53. A 70 Mile radius resulted in 92 responses with an interest level averaging 2.71.





Produced in Portions of the Counties Within 50 Mile Radius

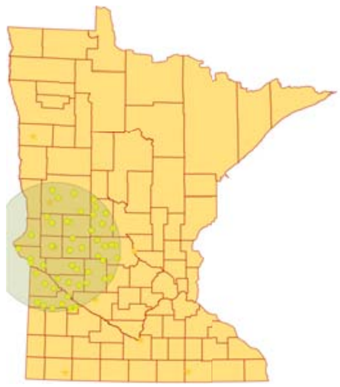
Minnesota County	Area in Radius	Harvested Corn Acres	Corn Yield bu/acre	Total Stover Produced Tons
Anoka	147,462	3,465	119.4	11,584
Benton	264,244	39,000	109.1	119,137
Carver	61,795	14,362	154.8	62,251
Chisago	1,587	150	134.5	564
Crow Wing	133,531	1,444	109.1	4,411
Douglas	456	58	123.5	199
Hennepin	188,130	5,914	145.4	24,078
Isanti	251,368	27,155	126.9	96,488
Kanabec	162,179	5,846	125.2	20,492
Kandiyohi	255,411	69,659	150	292,569
McLeod	144,046	49,449	146.6	202,980
Meeker	398,625	110,189	144.6	446,133
Mille Lacs	370,374	14,535	101.2	41,186
Morrison	684,943	65,179	143.6	262,070
Pope	35,944	8,866	136.3	33,837
Renville	1,596	643	146.1	2,630
Sherburne	288,362	29,500	144.9	119,687
Stearns	889,301	177,900	137.9	686,907
Todd	284,103	27,060	131.7	99,787
Wright	457,019	72,900	145.6	297,199
Grand Total	**5,020,477**	**723,273**		**2,824,189**

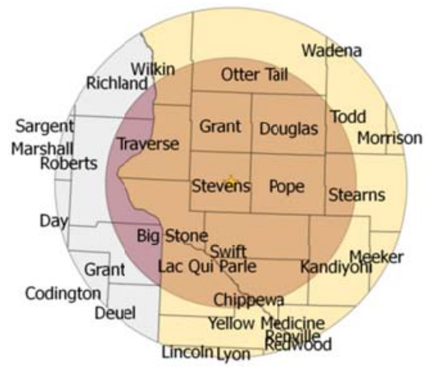
Stover in Portions of the Counties Within 70 Mile Radius

Minnesota County	Area in Radius	Harvested Corn Acres	Corn Yield bu/acre	Total Stover Produced
Aitkin	332,489	--	--	--
Anoka	285,143	6,700	119.4	22,399
Benton	264,244	39,000	109.1	119,137
Carver	240,517	55,900	154.8	242,293
Chippewa	76,507	29,422	155.1	127,776
Chisago	258,474	24,382	134.5	91,824
Crow Wing	453,235	4,901	109.1	14,973
Dakota	30,426	6,897	175.6	33,910
Douglas	260,731	32,975	123.5	114,026
Hennepin	388,078	12,200	145.4	49,669
Isanti	288,811	31,200	126.9	110,860
Kanabec	341,248	12,300	125.2	43,119
Kandiyohi	551,819	150,500	150	632,100
McLeod	323,344	111,000	146.6	455,633
Meeker	412,412	114,000	144.6	461,563
Mille Lacs	435,736	17,100	101.2	48,455
Morrison	737,712	70,200	143.6	282,260
Otter Tail	49,530	5,058	132.8	18,806
Pine	236,029	3,344	133.8	12,530
Pope	344,908	85,076	136.3	324,684
Renville	286,373	115,383	146.1	472,009
Scott	117,999	19,296	162.8	87,960
Sherburne	288,362	29,500	144.9	119,687
Sibley	224,042	89,506	159.1	398,731
Stearns	889,301	177,900	137.9	686,907
Swift	166,232	60,912	154.1	262,821
Todd	616,368	58,707	131.7	216,490
Wadena	30,289	1,734	125.9	6,112
Washington	101,508	7,874	178.4	39,331
Wright	457,019	72,900	145.6	297,199
Burnett	32,908	737	118	2,434
Polk	29,551	1,393	124.6	4,858
Grand Total	**9,839,050**	**1,447,996**		**5,800,553**

4. Raw Stover Production in Morris (Stevens County) Region

Morris is located in West Central Minnesota, with most adjacent counties being heavily agricultural and corn production being a very important economic driver. Counties within a 50 mile radius of Morris had 25.9% of their land planted with corn that average 132 bushels per acre. In the 70 Mile radius, counties had 24.6% of land planted to corn with an average of 134.1 bushels per acre. Producer interest in the 50 mile radius was 2.57, which is the average of 43 surveys. Seventy-five producers responded in the 70 mile radius with an average interest of 2.46.





Stover in Portions of the Counties Within 50 Mile Radii

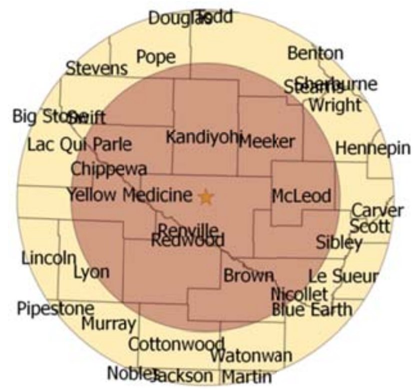
Minnesota County	Area in Radius	Harvested Corn Acres	Corn Yield bu/acre	Total Stover Produced
Big Stone	338,317	91,500	110.8	283,870
Chippewa	305,096	117,331	155.1	509,543
Douglas	458,747	58,017	123.5	200,624
Grant	368,477	102,300	123.5	353,753
Kandiyohi	173,465	47,310	150	198,702
Lac Qui Parle	384,318	134,183	144.3	542,153
Otter Tail	343,837	35,110	132.8	130,552
Pope	458,926	113,200	136.3	432,016
Stearns	188,772	37,763	137.9	145,810
Stevens	368,444	123,400	139.6	482,346
Swift	481,408	176,400	154.1	761,131
Todd	82,920	7,898	131.7	29,124
Traverse	375,506	134,000	111.7	419,098
Wilkin	121,003	22,581	120.9	76,441
Yellow Medicine	11,192	4,488	155.6	19,554
	4,460,429	**1,205,481**		**4,584,719**
Border States				
Deuel	163	33	148.8	136
Grant	199,944	55,510	123.5	191,955
Richland	63,319	17,838	96.4	48,149
Roberts	302,733	57,510	122.8	197,741
	566,159	**130,891**		**437,981**
Grand Total	**5,026,588**	**1,336,372**		**5,022,700**

Stover in Portions of the Counties Within 70 Mile Radii

Minnesota County	Area in Radius	Harvested Corn Acres	Corn Yield bu/acre	Total Stover Produced
Big Stone	338,317	91,500	110.8	283,870
Chippewa	376,265	144,700	155.1	628,403
Douglas	460,981	58,300	123.5	201,601
Grant	368,477	102,300	123.5	353,753
Kandiyohi	542,881	148,062	150	621,861
Lac Qui Parle	498,359	174,000	144.3	703,030
Lincoln	19,420	6,180	148	25,611
Lyon	55,397	21,147	150.6	89,171
Meeker	106,691	29,492	144.6	119,406
Morrison	55,688	5,299	143.6	21,307
Otter Tail	1,072,574	109,523	132.8	407,249
Pope	458,926	113,200	136.3	432,016
Redwood	4,101	1,722	151	7,282
Renville	190,182	76,627	146.1	313,464
Stearns	559,685	111,962	137.9	432,307
Stevens	368,444	123,400	139.6	482,346
Swift	481,408	176,400	154.1	761,131
Todd	534,192	50,880	131.7	187,626
Traverse	375,506	134,000	111.7	419,098
Wadena	13,066	748	125.9	2,637
Wilkin	353,899	66,043	120.9	223,567
Yellow Medicine	446,393	179,010	155.6	779,911
	7,680,852	1,924,494		7,496,649
Codington	130,364	22,509	143	90,127
Day	73,627	9,992	145.8	40,793
Deuel	232,510	46,504	148.8	193,755
Grant	440,511	122,299	123.5	422,909
Marshall	84,453	887	114.5	2,845
Richland	476,683	134,292	96.4	362,482
Roberts	728,016	138,300	122.8	475,531
Sargent	3,178	588	90.2	1,485
	2,169,343	475,372		1,589,926
Grand Total	**9,850,195**	**2,399,867**		**9,086,575**

5. Raw Stover Production in Olivia (Renville County) Region

Olivia is in the southern portion of West Central Minnesota, which is highly agricultural. 34.8 % of county lands are in corn production within the 50 mile radius of Olivia and yields are 154.4 bu/ac. The average interest in biomass production was 2.61, based on 61 surveys returned. In the 70 mile radius, 31.1% of land grew corn that yielded 151.1 bu/a on average. Interest in selling stover biomass averaged 2.75 on the 124 surveys received from within the 70 mile radius.



Stover in Portions of the Counties Within 50 Mile Radii

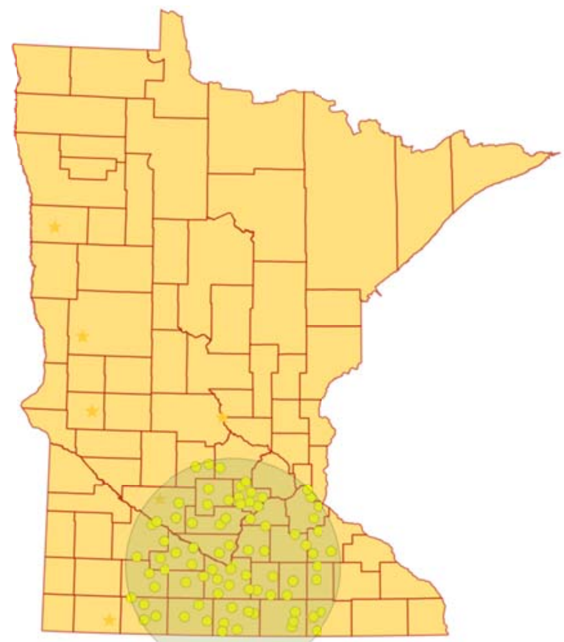
Minnesota County	Area in Radius	Harvested Corn Acres	Corn Yield bu/acre	Total Stover Produced
Blue Earth	5,080	2,018	172.1	9,726
Brown	374,994	149,105	164.2	685,523
Carver	16,101	3,742	154.8	16,220
Chippewa	357,612	137,527	155.1	597,251
Cottonwood	115,297	48,644	165.7	225,688
Kandiyohi	551,819	150,500	150	632,100
Lac Qui Parle	82,415	28,775	144.3	116,261
Lyon	237,543	90,676	150.6	382,363
McLeod	323,343	110,999	146.6	455,630
Meeker	412,379	113,991	144.6	461,526
Murray	9,652	3,671	168.5	17,319
Nicollet	167,999	67,231	161.6	304,209
Pope	33,434	8,247	136.3	31,474
Redwood	564,324	237,000	151	1,002,036
Renville	631,653	254,500	146.1	1,041,109
Sibley	303,519	121,258	159.1	540,178
Stearns	156,320	31,271	137.9	120,744
Swift	249,978	91,598	154.1	395,229
Watonwan	17,512	8,441	178.5	42,188
Wright	92,668	14,782	145.6	60,262
Yellow Medicine	317,971	127,511	155.6	555,540
Grand Total	**5,021,613**	**1,801,486**		**7,692,575**

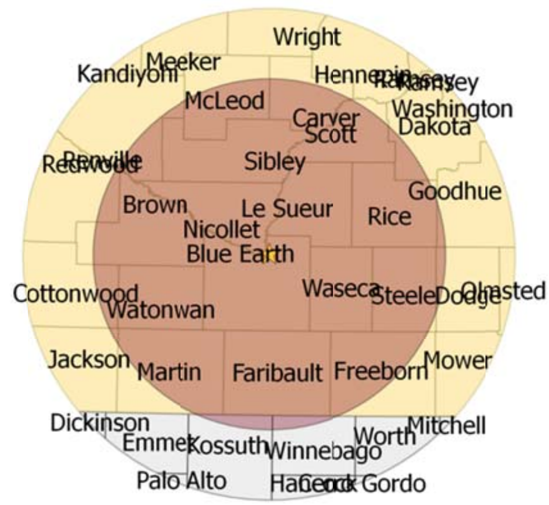
Stover in Portions of the Counties Within 70 Mile Radii

Minnesota County	Area in Radius	Harvested Corn Acres	Corn Yield bu/acre	Total Stover Produced
Benton	4,052	598	109.1	1,827
Big Stone	36,733	9,935	110.8	30,821
Blue Earth	261,780	104,016	172.1	501,235
Brown	395,605	157,300	164.2	723,202
Carver	231,160	53,725	154.8	232,867
Chippewa	376,265	144,700	155.1	628,403
Cottonwood	415,027	175,100	165.7	812,394
Douglas	4,614	583	123.5	2,018
Hennepin	79,257	2,492	145.4	10,144
Jackson	93,255	39,367	164.6	181,435
Kandiyohi	551,819	150,500	150	632,100
Lac Qui Parle	404,738	141,313	144.3	570,959
Le Sueur	178,574	54,424	159.2	242,599
Lincoln	213,653	67,994	148	281,765
Lyon	462,113	176,400	150.6	743,844
Martin	47,447	22,828	175.9	112,430
McLeod	323,344	111,000	146.6	455,633
Meeker	412,412	114,000	144.6	461,563
Murray	338,206	128,632	168.5	606,885
Nicollet	298,359	119,400	161.6	540,261
Nobles	3,770	1,658	176	8,172
Pipestone	9,403	3,134	154.2	13,533
Pope	405,688	100,068	136.3	381,900
Redwood	564,324	237,000	151	1,002,036
Renville	631,653	254,500	146.1	1,041,109
Scott	86,013	14,066	162.8	64,117
Sherburne	58,340	5,968	144.9	24,215
Sibley	384,225	153,500	159.1	683,812
Stearns	820,627	164,162	137.9	633,862
Stevens	89,729	30,052	139.6	117,467
Swift	480,978	176,243	154.1	760,452
Todd	6,955	662	131.7	2,443
Watonwan	280,500	135,199	178.5	675,725
Wright	417,400	66,580	145.6	271,435
Yellow Medicine	473,128	189,731	155.6	826,621
Grand Total	9,841,148	3,306,830		14,279,284

6. Raw Stover Production in Mankato (Blue Earth County) Region

Mankato is located in central southern Minnesota, in mostly heavily agricultural lands. Within the 50 mile radius, counties averaged 38.7 % of their land in corn production, with yields averaging 167.4 bushels. The 70 Mile radius includes regions in the metro area, likely resulting in the reduction of land in corn production to 36.4%, with yields of 162.9 bu/ac. The number of responses to the survey from each the 50 and 70 mile radius was 71 and 111, respectively, corresponding to average interests of 2.86 and 2.88.





Stover in Portions of the Counties Within 50 Mile Radii

Minnesota County	Area in Radius	Harvested Corn Acres	Corn Yield bu/acre	Total Stover Produced
Blue Earth	489,753	194,600	172.1	937,738
Brown	356,768	141,858	164.2	652,204
Carver	157,994	36,720	154.8	159,160
Cottonwood	61,802	26,074	165.7	120,975
Dakota	49,776	11,283	175.6	55,476
Dodge	22,610	9,763	183.2	50,079
Faribault	461,735	217,000	175.1	1,063,908
Freeborn	281,616	122,837	180.2	619,788
Goodhue	12,188	3,792	178.5	18,952
Jackson	4,059	1,714	164.6	7,898
Le Sueur	303,182	92,400	159.2	411,882
Martin	356,033	171,293	175.9	843,651
McLeod	189,563	65,074	146.6	267,118
Nicollet	298,359	119,400	161.6	540,261
Redwood	40,160	16,866	151	71,310
Renville	103,873	41,852	146.1	171,207
Rice	325,408	87,474	159.8	391,395
Scott	215,240	35,198	162.8	160,445
Sibley	384,225	153,500	159.1	683,812
Steele	272,539	113,384	170.5	541,296
Waseca	276,915	121,000	177.5	601,370
Watonwan	281,331	135,600	178.5	677,729

Stover in Portions of the Counties Within 70 Mile Radii

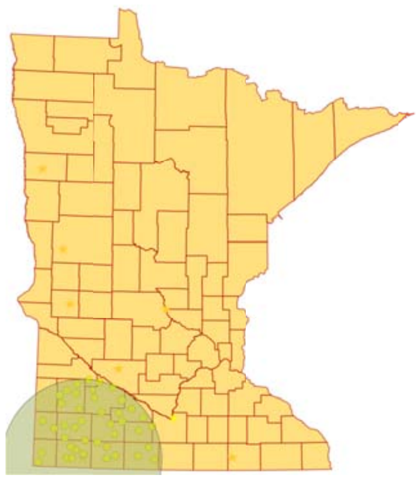
Minnesota County	Area in Radius	Harvested Corn Acres	Corn Yield bu/acre	Total Stover Produced
Blue Earth	489,753	194,600	172.1	937,738
Brown	395,605	157,300	164.2	723,202
Carver	240,517	55,900	154.8	242,293
Cottonwood	358,391	151,205	165.7	701,532
Dakota	360,930	81,812	175.6	402,255
Dodge	281,161	121,400	183.2	622,733
Faribault	461,735	217,000	175.1	1,063,908
Freeborn	461,958	201,500	180.2	1,016,688
Goodhue	320,121	99,598	178.5	497,793
Hennepin	301,030	9,463	145.4	38,528
Jackson	283,960	119,872	164.6	552,465
Kandiyohi	30,619	8,351	150	35,073
Le Sueur	303,182	92,400	159.2	411,882
Martin	466,624	224,500	175.9	1,105,707
McLeod	323,344	111,000	146.6	455,633
Meeker	177,995	49,202	144.6	199,208
Mower	211,352	95,222	178.1	474,855
Nicollet	298,359	119,400	161.6	540,261
Olmsted	53,162	14,790	183	75,786
Ramsey	15,651	0	0	0
Redwood	368,214	154,639	151	653,815
Renville	468,802	188,886	146.1	772,693
Rice	329,968	88,700	159.8	396,879
Scott	235,434	38,500	162.8	175,498

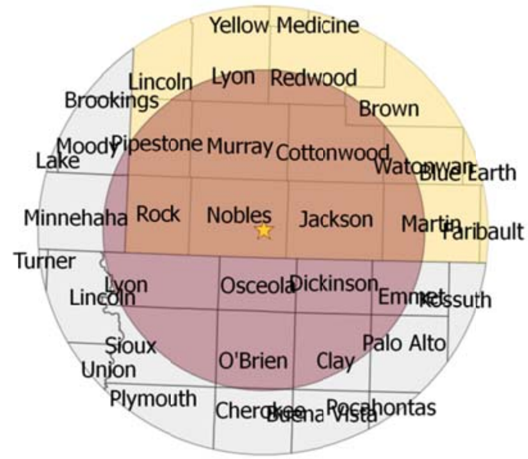
	4,945,129	**1,918,682**		**9,047,653**
Border States				
Kossuth	38,962	20,099	179	100,737
Winnebago	31,118	15,600	176	76,879
	70,079	**35,700**		**177,616**
Grant Total	**5,015,208**	**1,954,381**		**9,225,270**

Sibley	384,225	153,500	159.1	683,812
Steele	276,423	115,000	170.5	549,010
Waseca	276,915	121,000	177.5	601,370
Washington	17,465	1,355	178.4	6,767
Watonwan	281,331	135,600	178.5	677,729
Wright	209,022	33,341	145.6	135,927
	8,683,245	3,155,038		14,751,041
Border States				
Cerro Gordo	5,128	2,564	169	12,134
Hancock	84,549	46,256	179	231,837
Dickinson	18,749	7,057	169	33,392
Palo Alto	10,831	5,366	174	26,143
Worth	194,583	91,826	173	444,804
Kossuth	349,057	180,069	179	902,505
Mitchell	6,828	3,524	180	17,763
Emmet	216,331	99,208	169	469,452
Winnebago	256,912	128,800	176	634,726
	1,142,968	564,670		2,772,756
Grant Total	**9,826,213**	**3,719,708**		**17,523,797**

7. Raw Stover Production in Worthington (Nobles County) Region

Worthington is located in southwest Minnesota, near both the South Dakota and Iowa borders in very productive agricultural lands. Within the 50 mile radius of Worthington, 41.9% of land is in corn production and yields in 2011 were 169.7 bu/ac. The 37 survey responses received in the 50 mile radius indicate an average interest of 3.16. The 70 Mile radius had 41.6% of its land planted with corn, which yielded an average of 168.4 bu/ac. Sixty-one surveys were received with an average interest of 2.95.





Stover in Portions of the Counties Within 50 Mile Radii

Minnesota County	Area in Radius	Harvested Corn Acres	Corn Yield bu/acre	Total Stover Produced
Brown	42,858	17,041	164.2	78,349
Redwood	126,263	53,027	151	224,197
Murray	460,646	175,200	168.5	826,594
Pipestone	248,000	82,669	154.2	356,931
Lyon_MN	126,322	48,220	150.6	203,335
Lincoln_MN	7,823	2,490	148	10,317
Rock	309,222	133,200	180.6	673,566
Nobles	462,651	203,500	176	1,002,848
Martin	188,624	90,750	175.9	446,962
Jackson	460,270	194,300	164.6	895,490
Watonwan	71,089	34,265	178.5	171,255
Cottonwood	415,027	175,100	165.7	812,394
	2,918,796	**1,209,762**		**5,702,238**
Border States				
Cherokee	4,413	1,801	176	8,877
Clay_IA	285,548	118,833	185	615,557
Dickinson	258,522	97,300	169	460,424
Emmet	137,715	63,155	169	298,849
Lincoln_SD	775	302	143.2	1,211
Lyon_IA	359,846	172,414	185	893,107
Minnehaha	98,545	30,773	163.1	140,535
Moody	15,825	6,344	185.4	32,932
O'Brien	364,711	164,875	185	854,055
Osceola	255,696	114,900	184	591,965
Palo Alto	34,694	17,189	174	83,745
Sioux	280,127	143,595	177	711,658

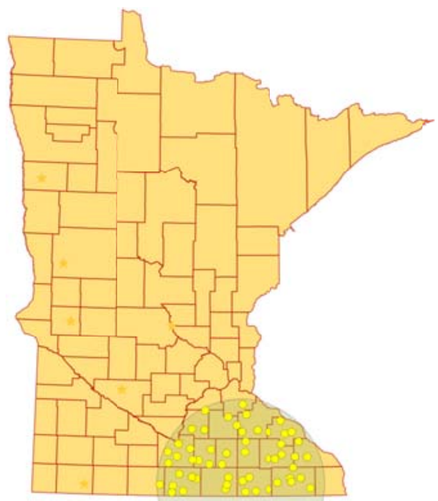
Stover in Portions of the Counties Within 70 Mile Radii

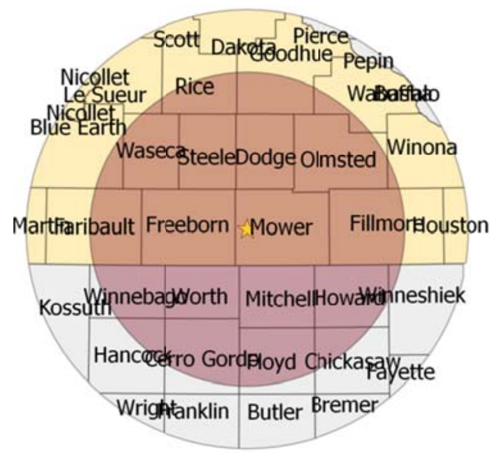
Minnesota County	Area in Radius	Harvested Corn Acres	Corn Yield bu/acre	Total Stover Produced Tons
Yellow Med.	46,291	18,563	155.6	80,876
Brown	331,073	131,641	164.2	605,232
Redwood	530,212	222,674	151	941,465
Murray	460,646	175,200	168.5	826,594
Pipestone	298,492	99,500	154.2	429,601
Lyon_MN	440,682	168,219	150.6	709,348
Lincoln_MN	250,212	79,628	148	329,979
Rock	309,222	133,200	180.6	673,566
Nobles	462,651	203,500	176	1,002,848
Martin	466,624	224,500	175.9	1,105,707
Jackson	460,270	194,300	164.6	895,490
Watonwan	281,328	135,598	178.5	677,720
Cottonwood	415,027	175,100	165.7	812,394
Blue Earth	44,176	17,553	172.1	84,584
Faribault	31,914	14,998	175.1	73,534
	4,828,819	1,994,175		9,248,937
Border States				
Brookings	80,884	19,770	159.1	88,073
Buena Vista	255,297	118,184	180	595,648
Cherokee	310,632	126,792	176	624,831
Clay_IA	366,447	152,500	185	789,950
Dickinson	258,522	97,300	169	460,424
Emmet	257,527	118,100	169	558,849
Kossuth	145,589	75,105	179	376,428
Lake_SD	13,118	4,030	157.7	17,794
Lincoln_SD	336,969	131,311	143.2	526,506
Lyon_IA	376,513	180,400	185	934,472

	2,096,418	**931,483**		**4,692,915**	Minnehaha	409,284	127,809	163.1	583,679
					Moody	306,747	122,971	185.4	638,368
Grand Total	**5,015,214**	**2,141,245**		**10,395,153**	O'Brien	366,977	165,900	185	859,362
					Osceola	255,696	114,900	184	591,965
					Palo Alto	339,809	168,356	174	820,232
					Plymouth	281,334	120,254	164	552,205
					Pocahontas	64,075	31,794	181	161,131
					Sioux	492,580	252,500	177	1,251,390
					Turner	13,845	5,225	149.4	21,858
					Union	73,749	29,733	148.2	123,380
						5,005,593	2,162,936		10,576,546
					Grand Total	**9,834,412**	**4,157,110**		**19,825,483**

8. Raw Stover Production in Austin (Mower County) Region

Austin is located in South Eastern Minnesota. The region is fairly agricultural, but also contains some lands that are hilly and difficult to plant with row crops. Significant portions of both the 50 and 70 mile radii are in Iowa and a tiny portion of the 70 mile radius is in Wisconsin. Within the 50 mile radius, 39.92% of the land is in corn production, with average yields of 177.1 bu/ac. Forty one producers in the 50 mile radius responded to the survey and their interest in selling stover averaged 2.90. In the 70 mile radius, 37.9% of land was planted in corn, with average yields of 176.5 bu/ac. The average interest from producers was 2.88, based on 73 survey responses.





Stover in Portions of the Counties Within 50 Mile Radii

Minnesota County	Area in Radius	Harvested Corn Acres	Corn Yield bu/acre	Total Stover Produced
Goodhue	184,258	57,328	178.5	286,524
Wabasha	54,435	13,585	181.3	68,962
Blue Earth	56,692	22,526	172.1	108,549
Winona	11,941	2,183	179.1	10,945
Steele	276,423	115,000	170.5	549,010
Dodge	281,161	121,400	183.2	622,733
Olmsted	405,636	112,855	183	578,268
Faribault	242,791	114,103	175.1	559,427
Fillmore	356,193	117,691	179.3	590,857
Freeborn	461,958	201,500	180.2	1,016,688
Mower	455,011	205,000	178.1	1,022,294
Le Sueur	10,416	3,175	159.2	14,151
Rice	156,186	41,985	159.8	187,857
Waseca	265,743	116,118	177.5	577,108
	3,218,843	**1,244,449**		**6,193,375**

Border States

Cerro Gordo	288,966	144,485	169	683,701
Hancock	77,509	42,405	179	212,531
Howard	287,231	121,383	185	628,762
Chickasaw	93,169	43,186	188	227,332
Floyd	261,150	120,220	181	609,273
Worth	257,039	121,300	173	587,577
Mitchell	300,282	155,000	180	781,200

Stover in Portions of the Counties Within 70 Mile Radii

Minnesota County	Area in Radius	Harvested Corn Acres	Corn Yield bu/acre	Total Stover Produced
Dakota	185,611	42,073	175.6	206,863
Goodhue	493,588	153,569	178.5	767,535
Nicollet	42,881	17,161	161.6	77,649
Wabasha	351,414	87,700	181.3	445,200
Blue Earth	403,049	160,149	172.1	771,724
Winona	302,353	55,267	179.1	277,152
Steele	276,423	115,000	170.5	549,010
Dodge	281,161	121,400	183.2	622,733
Olmsted	418,738	116,500	183	596,946
Martin	90,752	43,662	175.9	215,046
Houston	113,018	16,738	172	80,611
Faribault	461,735	217,000	175.1	1,063,908
Fillmore	551,430	182,200	179.3	914,717
Freeborn	461,958	201,500	180.2	1,016,688
Mower	455,011	205,000	178.1	1,022,294
Scott	51,019	8,343	162.8	38,031
Le Sueur	270,536	82,451	159.2	367,533
Rice	329,968	88,700	159.8	396,879
Waseca	276,915	121,000	177.5	601,370
	5,817,559	2,035,412		10,031,890

Border States

Bremer	133,963	60,495	196	331,994

Winnebago	209,720	105,141	176	518,134
Winneshiek	15,049	5,028	186	26,188
	1,790,116	**858,147**		**4,274,700**
Grand Total	**5,008,959**	**2,102,596**		**10,468,075**

Buffalo	28,346	3,916	160	17,542
Butler	252,191	120,593	186	628,048
Cerro Gordo	367,796	183,900	169	870,215
Chickasaw	323,391	149,900	188	789,074
Fayette	58,618	24,800	186	129,157
Floyd	320,628	147,600	181	748,037
Franklin	239,795	134,209	189	710,236
Hancock	362,625	198,390	179	994,329
Howard	302,890	128,000	185	663,040
Kossuth	291,172	150,208	179	752,840
Mitchell	300,282	155,000	180	781,200
Pepin	30,445	5,589	158	24,726
Pierce	24,399	4,641	166	21,572
Winnebago	256,912	128,800	176	634,726
Winneshiek	364,007	121,630	186	633,451
Worth	257,039	121,300	173	587,577
Wright_IA	91,248	44,991	189	238,094
	4,005,747	1,853,525		9,555,857
Grand Total	**9,823,306**	**3,888,937**		**19,587,747**

9. Estimates of Biomass Production and 'Purchasable' Biomass

Although it was expected that stover production in the northern regions would be somewhat less than that found in the southern regions, the clear difference in regional production was striking. Roughly 5 times more stover biomass was being produced in the Worthington and Austin regions compared to the Ada region (Table 2). The two factors that most contributed to the lower production in northern areas were the relatively low percentages of land planted in corn (Ada- 11% vs. Worthington-41.6%) and the significantly lower yields (Ada- 113 bu/ac Worthington-168 bu/ac). Even central Minnesota regions that were heavily agricultural had considerably less stover production than in southern Minnesota. Again, corn yields and land dedicated to corn production were lower in central regions. One likely reason that corn production acreage was lower in more central regions was that fewer producers plant corn on corn. In fact, some of the bordering counties in Iowa had more than 50% of their county in corn production, indicating a high percentage of continuous corn planting.

Table 2 Total Annual Regional Biomass Produced And Market Participation Interest In Each Region Total aboveground biomass produced in each region (no allowance for conservation), organized from northern regions (Ada) to southern regions (Austin)

	50 Mile Radius				
	Participation		All Above Ground Biomass (tons)		
Region	Low	High	Minnesota	Border	Total
Ada	43.75%	56.25%	932,710	825,683	1,758,393
Fergus Falls	56.67%	68.33%	2,381,478	603,192	2,984,669
St. Cloud	47.06%	69.61%	2,824,189	-	2,824,189
Morris	48.84%	67.44%	4,584,719	437,981	5,022,700
Olivia	50.00%	67.42%	7,692,575	-	7,692,575
Mankato	38.03%	57.04%	9,047,653	177,616	9,225,270
Worthington	27.03%	51.35%	5,702,238	4,692,915	10,395,153
Austin	36.59%	58.54%	6,193,375	4,274,700	10,468,075
	70 Mile Radius				
	Participation		All Above Ground Biomass (tons)		
Region	Low	High	Minnesota	Border	Total
Ada	59.26%	70.37%	1,418,789	2,274,164	3,692,953
Fergus Falls	43.33%	60.83%	3,959,887	1,443,882	5,403,768
St. Cloud	42.39%	63.04%	5,793,262	7,292	5,800,553
Morris	49.33%	68.67%	7,496,649	1,589,926	9,086,575
Olivia	42.74%	62.50%	14,279,284	-	14,279,284
Mankato	41.44%	58.11%	14,751,041	2,772,756	17,523,797
Worthington	36.07%	55.74%	9,248,937	10,576,546	19,825,483
Austin	34.25%	55.48%	10,031,890	9,555,857	19,587,747

While there was higher biomass production in southern Minnesota, the producers in northern Minnesota regions appeared to be more interested in selling their biomass than their southern counterparts. The estimated biomass market participation percentages were roughly 15% higher in Northern Minnesota regions than in the southern regions. Due to high variability in the survey data, statistical differences in interest levels could not be determined. In terms of biomass likely to be available for purchase, the increase in producer market participation interest (willingness to sell) in the northern regions did not make up for the sheer volume of biomass being produced in southern Minnesota. As indicated on Table 3, there was still several times more purchasable biomass in the southern regions of Austin and Worthington compared to Ada and Fergus Falls in the northern regions.

Table 3. 'Purchasable' Biomass Based on Production and Interest*

Amount of biomass that might be purchasable based on produce interest in the biomass market and biomass produced in each region.

A. Biomass Availability Low Participation

Region	Purchasable Biomass	
	50 miles	70 Miles
Ada	725,996	1,785,903
Fergus Falls	1,691,313	2,341,633
St. Cloud	1,329,030	2,458,930
Morris	2,452,947	4,482,710
Olivia	3,846,287	6,103,242
Mankato	3,508,201	7,262,114
Worthington	2,809,501	7,150,174
Austin	3,830,269	6,708,803

B. Biomass Availability High Participation

Region	Purchasable Biomass	
	50 miles	70 Miles
Ada	933,424	2,120,760
Fergus Falls	2,039,524	3,287,292
St. Cloud	1,965,857	3,656,871
Morris	3,387,403	6,239,448
Olivia	5,186,660	8,924,552
Mankato	5,262,302	10,182,747
Worthington	5,338,051	11,050,269
Austin	6,128,011	10,867,282

*Important Note: this table does not include biomass that should remain on fields to maintain soil quality and prevent erosion (see section 10).

10. Factoring Soil Conservation into the Availability Modeling

A key goal of this work was to assess how producer interest in participation would affect the ability to purchase biomass and potential facility locations based on that information. However, accurate modeling of biomass availability should include other significant factors that would influence the amount of biomass available for sale. Though there are several minor practical limitations (weather, equipment, labor) that can make biomass harvesting difficult and reduce interest in biomass markets, soil conservation is a key long term factor that needs to be adequately addressed. The survey results in section one of this report clearly indicate that producers are sensitive to soil conservation needs and will not participate until they feel confident harvest will not impact their lands.

Overharvesting of biomass is a serious concern for both the overall health of our agricultural soils and the image of biofuels and bio-products industries. Therefore, modeling biomass availability needs to include some measure to account for biomass that must remain in the field to renew the soil. The estimated hundreds of thousands or millions of tons available in each region in table 3 above do not consider soil conservation. Removal of biomass affects soil in three major ways; reduces nutrient levels, increases potential for erosion (both wind and water), and reduces soil carbon. With fertilizers available to add nutrients back to soil, nutrient loss is not necessarily a soil health issue, but an economic issue. However, erosion and soil carbon loss are very important because neither can be quickly or cheaply corrected.

Soil erosion by both wind and water is reduced by the protective covering that biomass provides on the soil surface and they ability of pieces of biomass within the soil to hold soil clumps together. Minnesota soils typically experience more water erosion concerns than wind concerns. In uneven or hilly fields, biomass is invaluable in protecting the soil from water erosion. Failure to maintain proper soil cover can lead to devastating losses of soil, especially from heavy rainfalls. Because of its value in these situations, significantly more biomass should be left on fields that have slopes in them. Several soil models can predict the amount of biomass needed to prevent erosion on individual fields. However, in terms of statewide modeling, it is difficult to estimate where additional biomass may be needed to help prevent erosion and, thus, would be unavailable to the biomass market. Figure 4 points out one area (southeast Driftless region) in the state where producers should be more concerned about removing biomass to limit erosion. However, erosion is very field specific and should be assessed on an individual farm or field basis.

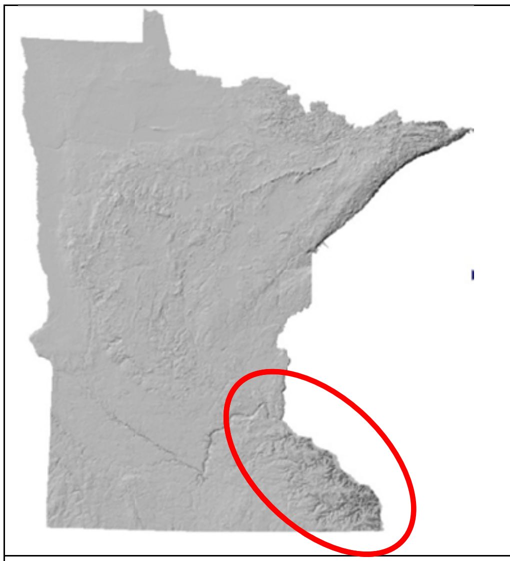


Figure 4. Contour map of Minnesota Dark areas on the contour map indicated land with more differences in elevation (slope), which are prone to erosion. The area circled in red indicates an area with steep slopes where added caution should be used when considering biomass removal.

Soil carbon (and soil organic matter) are both formed from the decomposition of crop residues. These often microscopic particles help the soil by holding nutrients and water, as well as forming a healthy soil structure. Good loamy agricultural soils in Minnesota have abundant organic matter that formed as a result of prairie biomass prior to settlement. Research has indicated that overharvesting of biomass on fields not prone to erosion will often begin causing soil carbon losses before any erosion problems occur (Wilhelm et al 2004, 2007). Soil carbon reductions, and the resulting soil productivity problems, occur much more gradually than erosion and are usually not visible for decades. Therefore, plans for biomass harvesting should include leaving sufficient material on the soil surface to preserve soil carbon regardless of whether symptoms of reduced soil carbon are seen.

At this time, there are few agreed upon standards for the amount of corn stover that can be safely removed from fields while maintaining soil carbon. As soil carbon changes occur slowly and farming practices affect soils differently, current research efforts may not provide soil data to set biomass harvesting guidelines for several years.

A very preliminary estimate of the amount of stover biomass that can be harvested was proposed by W. Whilhem and his collogues at the USDA-ARS (Whilhelm *et al* 2007, Johnson *et al* 2010, Karlen *et al* 2011). The estimate actually looks at how much material should be left on a field versus how much can be removed. It is very conservative and suggests that only a fraction of the material on many fields can be removed. By visually assessing a graph of their preliminary finds, I was able to use their estimates on two of the regions analyzed above. The findings suggest that producers should use reduced or no-till farming in combination with cover crops, rotating fields subject to biomass harvests to maintain the most biomass available for harvesting. However, even with best practices, low corn grain yields and corresponding biomass tonnage in northern regions were not sufficient to maintain soil carbon, let alone allow for harvest for energy or other uses. In southern regions, there would be harvestable biomass after accounting for that needing to be left for soil quality management. However, the Whilhelm *et al* calculations suggests that none of the regions produced enough biomass to maintain soil carbon when heavy tillage, such as moldboard plowing, was extensively used.

Table 4. Estimated Annual Biomass Available With Both Minimum Conservation and Producers Participation Interest Considered *Data indicates potential biomass availability in each region, using total production in the region with interest and an every other corn crop harvest of stover.

A. Biomass Availability Low Participation

	Purchasable Biomass	
Region	50 miles	70 Miles
Ada	362,998	892,952
Fergus Falls	845,656	1,170,816
St. Cloud	1,226,473	2,241,355
Morris	664,515	1,229,465
Olivia	1,923,144	3,051,621
Mankato	1,754,101	3,631,057
Worthington	1,404,750	3,575,087
Austin	1,915,134	3,354,402

B. High Participation Biomass Availability

	Purchasable Biomass	
Region	50 miles	70 Miles
Ada	466,712	1,060,380
Fergus Falls	1,019,762	1,643,646
St. Cloud	1,693,701	3,119,724
Morris	982,929	1,828,435
Olivia	2,593,330	4,462,276
Mankato	2,631,151	5,091,374
Worthington	2,669,026	5,525,134
Austin	3,064,006	5,433,641

The variation in soils, slopes, and tillage methods makes regional or statewide modeling of the biomass needing to remain in fields very difficult. In the absence of solid guidelines, it is recommend that soils prone to erosion should not have any biomass removed (Whilhelm et al. 2007). On soils that don't have high potential for erosion, producers should consider harvesting biomass from corn stover every other corn crop. Combined with good cropping techniques, harvesting alternating corn crops should maintain soil health and produce a marketable amount of biomass. In terms of the modeling work presented in this study, this recommendation would mean that roughly half of the regional biomass production would be available. After figuring in both producer interest in marketing biomass and minimum soil conservation, there is still a significant amount of biomass available in most regions (Table 4). However, yields in some northern regions were simply too low to for the alternate harvesting strategy to maintain soil quality and would not be good candidates for a facility.

11. Locating Biomass Facilities Based on Availability Modeling

When considering where a biomass facility should be located, an important question is 'what is the size of the facility and how much biomass will it need to operate?' As the technology is perfected, a typical cellulosic ethanol facility is expected to produce between 80 and 100 gallons of ethanol per ton of biomass feedstock. Using the high yield rate of 100 gallons per ton to simplify the math, a 10 million gallon per year (MGY) facility would require 100,000 tons of biomass.

In terms of specific locations for facilities; agriculturally, Southern Minnesota and southern portions of West Central Minnesota are fairly homogenous and would yield a significant biomass supply. Therefore, other factors are likely to decide specific locations for biomass facilities. Transportation infrastructure would be critical as would water, electricity, and natural gas resources. Access to capital may be another factor in facility location; this is one area where local producer interest may play a role by helping to drive a community project located in their region. Early ethanol cooperatives used this model, with producers putting their own capital into projects that benefited their hometowns.

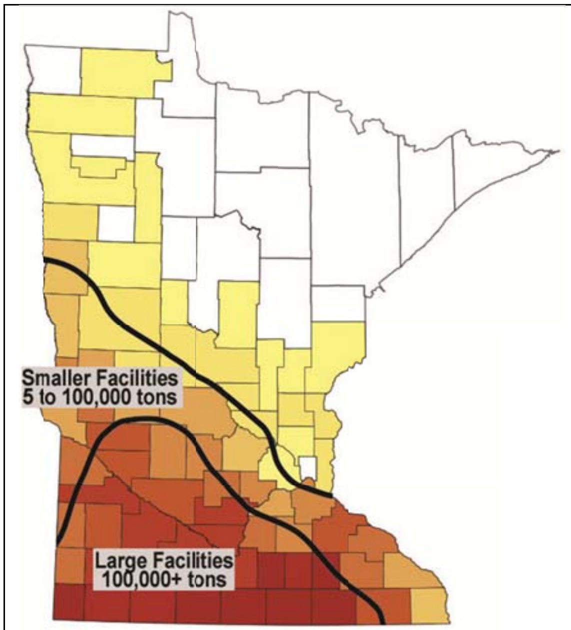


Figure 5 Statewide Range of Locations for Corn Stover Biomass Facilities.
Boundary lines indicates approximate ranges for locating larger (100,000+ ton per year) and smaller (below 100,000 tons per year) facilities. Due to soil conservation issues, a facility in the northern counties is not recommended. Counties with no or extremely limited corn production colored in white

Another method to assess possible locations is to identify where facilities should not be located. The top tier of counties in the state produce barely enough stover to maintain soil quality and should not be harvested for biomass. This also limits some counties on the Western edge of the state as the adjacent North and South Dakota counties have fairly low yields. Another limitation in terms of conservation is the southeast corner of the state. Though yields can be fairly high in this region, the landscape is hilly and erosion prone and has soils that are more sensitive to erosion. In terms of practical limitations, a major facility would likely be located well out of the metro area. This would avoid a dead zone of supply and biomass transportation near or though the heavily populated area. Figure 5 uses biomass production and these limitations to suggest a potential range of Southern Minnesota that might be best suited to hosting a biomass facility.

As a whole, all the data clearly indicates that southern Minnesota would be the best location for a large biomass to energy facility or bio-products plant that relies on corn stover biomass. Supplying 500,000 tons of stover in a 70 mile radius could be accomplished while maintaining soil quality and preventing erosion as long as best soil management practices were used. A smaller facility 10-20 MGY (200,000 tons), could be possible in more northern regions, but more attention may be needed to assure on-farm soil management techniques were adequate to protect the soil.

Though participation interest was lower in southern Minnesota, producer interest levels are determined by their knowledge of economic, soil conservation, and practical issue about biomass harvesting. The number of producers undecided about participation in biomass markets (from section I) suggests that they are waiting for more information to make a determination about participation. A good information and outreach campaign targeting producers would provide undecided producers with the facts that they need and a portion of them would likely be interested in selling biomass.

12. Model Limits and Areas for Improving Models.

Though this model is more precise than earlier estimates, there are several factors that could impact its results. One important consideration is how interest on the survey is interpreted and how different factors affect that interest. Producers responding one way or another about their level of interest had a specific set of conditions in mind when they responded. For example, they may be interested in selling biomass if the price was over a certain value or they could get a long term contract. Converting their generic level of interest into a more concrete participation level was difficult without a much more in-depth survey or face to face interview. The method for calculating the high and low participation levels based on this generic interest was somewhat arbitrary, meaning that the ultimate predictions of total 'purchasable' biomass has a wide margin for error. However, the patterns of more interest in different regions would likely remain.

It is also important to remember that this survey was a snapshot of how producers think they will act in the future. It is based on their current understanding and needs. As they become more familiar with biomass related issues, they would likely change their level of interest one way or the other. Future changes in their situation would also likely change their interest as they consider whether their operations need added income and if their time is better spent pursuing other opportunities. As an example, improved biomass harvesting equipment and techniques or the increased availability of custom harvesters who could complete biomass collection would likely change participation interest. Another factor that would quickly change producers' participation interest levels is whether other producers are having success in marketing biomass.

Economics and biomass payments on the facilities' part are another important driver or hindrance of producer interest. Early predications that producers would accept $30 per ton (before harvesting costs) for biomass do not appear to be all that accurate. Most Producers surveyed in this study felt that a profit of at least $30 per acre after all harvesting costs was necessary. It is unlikely that facilities could find enough interested suppliers if they paid less than $60 per ton. The high value of corn grain has decreased the need for many producers to supplement their income with other products. In addition, some are reluctant to remove biomass from top quality, high value farmland because of concerns of lowering soil quality.

One area often incorporated into biomass availability studies by the USDA and DOE is a forecast of future yields based on advances in crop genetics, cropping techniques, and nutrient management. As predicted in those studies, increases in grain yields would raise the amount of stover entering the market. While it is likely that increases in yields will occur, it is difficult to predict the magnitude of those changes. Future yield increases may not continue on the rapid trajectory that they have been. For this study it was decided not to use a future forecast, but to look at present values.

The major work for this study began after corn harvest data was available from the 2011 cropping season. Therefore, that data was used as a basis for the estimates in this model. In terms of recent seasons, 2011 yields were significantly lower than the previous seasons (2008-2010) and are likely to be lower than 2012- based on early predictions. Therefore, stover production estimates presented here would probably be lower than a current five-year average.

In terms of the model as a whole, it was hoped that the number of survey responses would have been sufficient to allow more analysis of how interest affected stover supply at the county level. Unfortunately, most counties had too few responses to accurately assess participation interest in the county. The larger number of responses in the 50 and 70 mile radii led us to conduct the analysis on a regional scale. A much larger scale survey effort would be needed to increase the number of respondents to the point where county level analysis could be done. In a case where stakeholders were interested in building a facility, it would be beneficial for them to conduct a fairly in-depth regional modeling effort that included a high response rate survey.

The model would also benefit from more formal guidelines on biomass harvesting and soil conservation. The rotational harvesting strategy suggested above is only an interim solution for factoring conservation into biomass availability. In addition, a large part of estimating the allowable stover harvest rate is producer's willingness to adopt no, low, or conservation tillage techniques. At this point, it is hard to determine whether most producers would be willing to consider changing tillage methods in order to allow biomass to be harvested on their lands.

While this model does have limitations, it gives a more nuanced picture of current corn stover biomass yields in Minnesota than previous USDA or DOE estimates. Hopefully, as new data becomes available, the models can be updated and some of these limitations can be overcome.

D. Conclusions

The findings of this study are that there is a tremendous amount of corn stover production in Minnesota, a portion of which can be used in bioenergy or bioproduct production. Overall, there appear to be enough interested producers to supply bioenergy or bioproduct facilities. In terms of biomass available from producers, the slightly higher interest in selling biomass by northern producers was no match for the much higher production in southern Minnesota. There is a fairly large homogenous region in southern Minnesota with both high yields and a high percentage of land in corn production. This southern region would be the best location for multiple large-scale biomass facilities, though central regions would likely support smaller biomass facilities. Northern Minnesota biomass facilities would need to rely on biomass sources other than corn stover at this time.

The data from this project supports the idea that a larger biomass facility could be located in Minnesota. However, after formal plans for any facility have been proposed and a location scouted, a great deal more work is needed to further develop and evaluate the facilities' stover supply chain plan. The supply chain plan is a very crucial step that should be completed before any construction efforts for any larger biomass plant project. It will have to include interfacing with local producers to more solidly establish their willingness to supply biomass (participation interest). Working with area agronomists to determine the ability of the specific region to support biomass harvesting will also be an important component in developing the supply chain. This may also involve working with producers to implement best management practices in their operations. The other major factor that will influence plans for feedstock supply chains is improved guidance on soil conservation measures and revised data on enhanced cropping systems and improved corn varieties. Both sets of information are likely to impact estimates of available biomass and should be included in any formal feedstock supply chain planning effort.

E. References

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Biomass Harvesting Survey

Survey Instructions:
Please write responses as clearly as possible. While accurate numbers are always helpful, feel free to use estimates if you don't have the exact numbers available. When you have completed the survey, use the pre-addressed postage-paid envelope to send it back to us.

Background Information:

Over the last decade, there have been limited supplies of some fossil fuels and significant increases in energy prices. As a result, there has been a great deal of research looking at other sources of energy. One possible source is the conversion of biomass into energy. Biomass is material that was living and now has energy stored in the components that made up the living cells. Wood is a very familiar example of biomass. During growth, trees use energy from the sun to make wood and bark. We can convert wood biomass into heat energy using a stove or fireplace. Wood can also be used in larger facilities to generate electricity and steam.

In the Midwest, researchers are studying how we could use biomass from agriculture to make energy and other products that are now made from crude oil. The largest source of biomass in agriculture is crop residues; such as straws and corn stover (stalks). New perennial energy crops and native grasses are also being examined as a potential source of biomass that would be grown exclusively for energy. Fast growing perennial hybrid tree species are another option being studied for land that does not have high crop yields.

Before developing an industry to make energy from agricultural biomass, we need to find out whether farmers are willing to grow and supply biomass. This survey is an effort to ask farm decision makers if they would like to be involved in a biomass market and also find out why they may or may not want to supply biomass.

Since one of the goals of the survey is to determine the current level of knowledge about biomass harvesting, we ask that you try to answer the questions with the knowledge you have right now. On the included yellow quarter sheet, you have the option to provide us with your e-mail address so that we can supply you with more information about biomass harvesting. The information will also be available online at the Minnesota Corn Growers website (www.mncorn.org).

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1.) Would you agree that you have a good understanding of issues related to collecting agricultural biomass for use in energy or bioproducts manufacturing? Please check one.

☐ Strongly Agree	☐ Agree	☐ Neutral	☐ Disagree	☐ Strongly Disagree

2.) Where you have previously learned about biomass harvesting? Check all that apply.

☐ Have not heard about biomass harvesting
☐ USDA-NRCS or USDA-ARS
☐ Agricultural magazines
☐ University Extension
☐ Farm Commodity Groups
☐ Farm Trade Shows
☐ Other Farmers
☐ SWCD
☐ Other Please List
– ___________________
– ___________________

3.) If a regional market for biomass existed, would you be interested in participating by selling biomass from lands you manage? Please check one.

☐ Very Interested	☐ Interested	☐ Undecided	☐ Not Interested	☐ Not at all Interested

4.) Say you were to choose to sell biomass, what types of biomass would you have available to sell? Check all that apply.

☐ soybean straw/stubble
☐ corn stover
☐ corn cobs
☐ Wheat/oat straw
☐ Grassland or Pasture
☐ woody perennials (hybrid popular, willows)
☐ herbaceous bioenergy crops
(prairie grass, switchgrass, big bluestem, elephant grass)

5.) Based on your current knowledge, how much yield do you estimate you could get on your land from the following crops?

Soybean straw/stubble ______ tons/acre

Corn stover ______ tons/acre

Corn cobs ______ tons/acre

Wheat/oat straw ______ tons/acre

Grassland/pasture ______ tons/acre

6.) How important would the following factors be for making management decisions about biomass harvesting in your operation? Check one per factor.

Land Rental Agreements	☐ Very important	☐ Important	☐ Moderately important	☐ Little importance	☐ Not at all important
Improved Planting or Seedbed Conditions	☐ Very important	☐ Important	☐ Moderately important	☐ Little importance	☐ Not at all important
Nutrient Replacement Costs	☐ Very important	☐ Important	☐ Moderately important	☐ Little importance	☐ Not at all important
Weather/Timing	☐ Very important	☐ Important	☐ Moderately important	☐ Little importance	☐ Not at all important
Added Income	☐ Very important	☐ Important	☐ Moderately important	☐ Little importance	☐ Not at all important
Extra Labor Required	☐ Very important	☐ Important	☐ Moderately important	☐ Little importance	☐ Not at all important
Equipment Maintenance	☐ Very important	☐ Important	☐ Moderately important	☐ Little importance	☐ Not at all important
Extra Time Required	☐ Very important	☐ Important	☐ Moderately important	☐ Little importance	☐ Not at all important
Ability to Sell Biomass on Contract	☐ Very important	☐ Important	☐ Moderately important	☐ Little importance	☐ Not at all important
Maintaining Soil Quality	☐ Very important	☐ Important	☐ Moderately important	☐ Little importance	☐ Not at all important
Added Jobs	☐ Very important	☐ Important	☐ Moderately important	☐ Little importance	☐ Not at all important

Please list any other factor(s) and how important they would be in your farm's decision whether or not to participation in biomass markets.

____

____

7.) After paying all costs, at what profit level would you consider selling biomass from your croplands (assuming current grain prices)? Check the box of the lowest profit per acre that would be acceptable.

Biomass Profit Per Acre

☐ $10 or more	☐ $20 or more	☐ $30 or more	☐ $40 or more	☐ $50 or more	☐ Would Not Sell

8.) How low would the price of corn need to be before you would consider selling biomass to supplement the corn grain income? Check the box of the highest price at which you would consider selling biomass.

Corn Price per Bushel

☐ $7 or less	☐ $6.00 or less	☐$5.00 or less	☐$4.00 or less	☐ $3.00 or less	☐ Would Not Sell

9.) Say you were to sell biomass and had the option to sell it under a biomass supply contract for a specified price, what length of contract would you prefer? Please check one.

☐ No contract, spot market pricing	☐ 1-3 years	☐ 4-7 years	☐ 8-12 years

10.) Say you were to sell biomass from your land, which of the following options for selling the biomass would most interest you? Please check one.

☐ Sell the biomass as it lay in your field, the buyer would come in and remove it.

☐ Sell biomass you have baled, but is picked up by the buyer in your field.

☐ Sell biomass you baled and stored at your site, but is hauled away by the buyer.

☐ Sell biomass that you have baled and transported to a buyer's storage site.

11.) Which of the following pieces of equipment does your operation have access to (own, lease, or can borrow)? Check all that apply.

☐ Combine

☐ Stalk chopping head

☐ Wind rower

☐ Square baler (Large)

☐ Live-bottom, conveyor, or walking floor trailer

☐ Semi-tractor

☐ Flatbed trailer

☐ Seed drill

☐ Round baler

12.) What percentage of your operation is done by custom operators (combining, baling, and trucking for example)? ______%

13.) The next set of questions are meant to gauge how you feel different biomass harvest rates will affect cropland and other environmental factors related to farming.

If 30% of biomass is removed do you feel the factor listed on the left will increase, stay the same or decrease? Check one response per factor.

	Increase	Stay the Same	Decrease	Not sure
Soil erosion	☐	☐	☐	☐
Grain yields	☐	☐	☐	☐
Nutrient loss	☐	☐	☐	☐
Soil organic matter	☐	☐	☐	☐
Water quality	☐	☐	☐	☐
Wildlife habitat	☐	☐	☐	☐
Soil compaction	☐	☐	☐	☐

If 50% of biomass is removed do you feel the factor listed on the left will increase, stay the same or decrease? Check one response per factor.

	Increase	Stay the Same	Decrease	Not sure
Soil erosion	☐	☐	☐	☐
Nutrient loss	☐	☐	☐	☐
Soil organic matter	☐	☐	☐	☐
Water quality	☐	☐	☐	☐
Wildlife habitat	☐	☐	☐	☐
Soil compaction	☐	☐	☐	☐

If 70% of biomass is removed do you feel the factor listed on the left will increase, stay the same or decrease? Check one response per factor.

	Increase	Stay the Same	Decrease	Not sure
Soil erosion	☐	☐	☐	☐
Nutrient loss	☐	☐	☐	☐
Soil organic matter	☐	☐	☐	☐
Water quality	☐	☐	☐	☐
Wildlife habitat	☐	☐	☐	☐
Soil compaction	☐	☐	☐	☐

14.) Which of the following tillage methods most closely describes tillage on your croplands? Please check one.

☐ No till (no tillage and planting with a no-till planter)

☐ Reduced or conservation tillage

☐ Conventional tillage

15.) Which of the following farming practices would you consider implementing if you were to begin harvesting biomass on your land? Check one response per farming practice.

	Already Implemented	Would Consider	Would not Implement
No till	☐	☐	☐
Reduced or conservation tillage	☐	☐	☐
Cover crops	☐	☐	☐
New crop rotations	☐	☐	☐

16.) How many acres do you have in a conservation program (CRP, WRP, RIM for example) that are planted to?

Grasses/prairie_____ Acres

Trees _____ Acres

Other _____Acres

16b.) If you have CRP, in what year will most of your CRP land expire?_________

17.) Say you had lands in conservation programs, would you consider some harvesting of biomass if it were allowed without penalty?

☐ Yes ☐ No

18.) Would you be more likely to consider enrolling in conservation programs if you were allowed to harvest biomass for selling to the bioenergy market?

☐ Yes ☐ No

19.) After paying all costs, at what level of profit level might make you consider growing specially planted biomass crops such as switchgrass on low productivity or marginal lands? Please check the box of the lowest profit per acre that would be acceptable.

Profit Per Acre

☐$20 or more	☐$40 or more	☐$60 or more	☐$80 or more	☐$100 or more	☐ Would Not Sell

20.) How many years have you been actively involved in farming? ______

21.) What is the highest level of formal education/training that you have completed?

- ☐ High school
- ☐ Vocation program
- ☐ Associates degree
- ☐ Bachelor's degree
- ☐ Master's or Doctoral degree.

22.) In what zip code is the largest part of your farm operation located? __________

23.) How many total acres do you manage (own and rent)?_____ Acres

24.) How many cropland acres do you own? _____ Acres

25.) How many cropland acres do you rent? _____ Acres

26.) On average, how many acres do you plant of the following crops/plantings?

Corn	__________	Wheat	__________
Soybeans	__________	Pasture/Grassland	__________
Other	__________		

27.) How many head of the following livestock does your operation have?

Cattle (Beef)	__________	Hogs	__________
Cattle (Dairy)	__________	Sheep	__________
Poultry	__________	Other	__________

28.) Are their other issues or comments you have regarding agricultural biomass harvesting that you feel should be addressed?____

____

____

Statistical Results For Corn Producer Participation Survey

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This appendix is an annotated version of the underling statistical output from the project. It is not meant as a readable, standalone document. However, it may be of interest for those wanting to see and understand the statistical analysis for the project.

The survey covered five main areas related to the willingness of biomass producers in Minnesota to participate in selling biomass and what factors they used to make their decisions. The first and most important was whether biomass producers wanted to sell biomass feedstocks and the materials they had available to sell. The second topic was whether they felt they had the information they needed to make decisions on selling or not selling biomass, plus where they got their information. The next area covered was the cropping and economic factors that producers were using to make their decisions. Their opinions on the impacts of harvesting the material were also surveyed. The final area of the survey was their opinion of using alternative cropping strategies to mitigate potential impacts of harvesting material. As with most surveys, a demographics section was used to see if particular subgroups (i.e. younger, higher latitude, or more formally trained producers) had unique viewpoints.

During the development of the survey, it was pointed out by a test audience that there is a great deal more information that could be requested from producers. However, due to the need to respect respondents' time, the survey was kept to a minimum. The question on the final survey most directly addressed the farmers' opinion on biomass supply and impacts.

The survey was sent to 2500 Minnesota farm producers in April of 2012. The producers selected to receive the study were randomly chosen for a list provided by the USDA NRCS that tracked individuals receiving payments for the ACRE program. This included individuals receiving payments for crops grown on lands in Minnesota. The complete list (53,000) was trimmed to remove individuals whose address was not in Minnesota. These people would likely have ownership interest in farmland, but were not likely the primary operator or farm decision maker. Additionally, business/individual names that included the terms 'trust' or 'estate' were also removed from consideration. In the survey instructions, it ask that the survey be passed along to the person most likely to be making farm management decisions.

Over the next three months, roughly 363 responses were received from across the state. Data was entered and the survey window for numerical data was closed in August, 2012. Surveys received after that were reviewed for written comments only. Information was typed into a large Excel spreadsheet. Geographical data for analysis was generated based on the latitude and longitude of the zip code reported in the demographics section of the survey. Mapping of data was done using QGIS. Statistical analysis was completed using the R statistical package.

Terminology/abbreviations

Upr- **The highest value of an individual data point in a group of data**

Lwr- **The lowest value of an individual data point in a group of data**

Se- **Standard error of the mean. A statistical measure that looks at how well the values of a sample are centered on the mean.**

n or N- **Number of data points in a sample.**

Gamma- **Statistical measure to determine whether two variables have linkage in some way. A gamma of 1 or -1 indicates a strong positive or negative (respectively) association between to variables.**

Sigma- **Standard error of the gamma statistic**

Table of Contents

A. Interest in Participation in Biomass Market

1. Interest in Selling Biomass

This question is the heart of the survey, 'would you be interested in participating in selling biomass if a market were available?' Most of the other questions in the survey were compared to this question to see which factors influenced the interest level of producers. The question was asked after questions about what respondents knew about agricultural biomass to reduce any chance of biasing the respondent's answers to the knowledge questions.

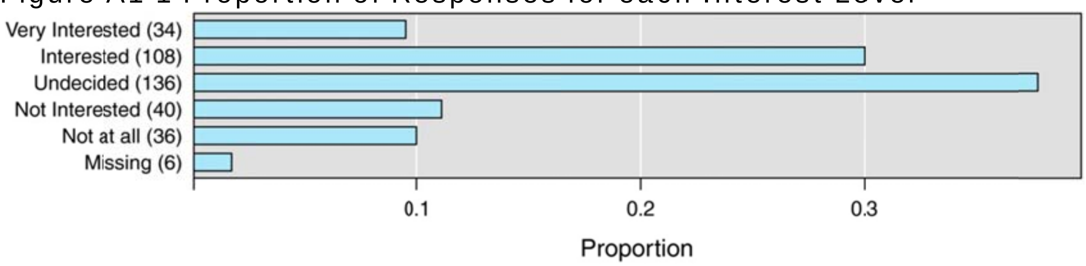
Question:

3.) If a regional market for biomass existed, would you be interested in participating by selling biomass from lands you manage? Please check one.

☐ Very Interested	☐ Interested	☐ Undecided	☐ Not Interested	☐ Not at all Interested

Results:

Figure A1-1 Proportion of Responses for each Interest Level



Of the 354 who responded to the question, 142 (40.1%) were interested or very interested, 136 (38.4%) were undecided, and 76 (21.5%) were not interested or not at all interested.

Evaluation:

This data is in line with other surveys that show producers have a wide variety of opinions on the harvesting of biomass.

2. Types of Biomass Available to Sell

In addition to the willingness to sell biomass, it is important to ask which specific types of biomass producers may have available to sell. The question was developed to determine their available biomass sources. It focused both on traditional agricultural crops as well as potential biomass cropping and grassland maintenance feedstocks.

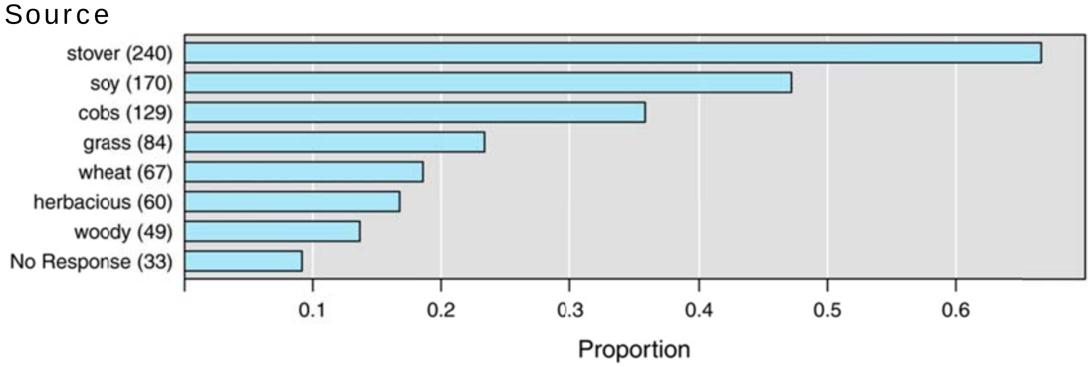
Question:

4.) Say you were to choose to sell biomass, what types of biomass would you have available to sell?
Check all that apply.

- ☐ soybean straw/stubble
- ☐ corn stover
- ☐ corn cobs
- ☐ Wheat/oat straw
- ☐ Grassland or Pasture
- ☐woody perennials (hybrid popular, willows)
- ☐herbaceous bioenergy crops (prairie grass, switchgrass, big bluestem, elephant grass)

Results:

Figure A2-1 Proportion of Respondents Receiving Information by Source



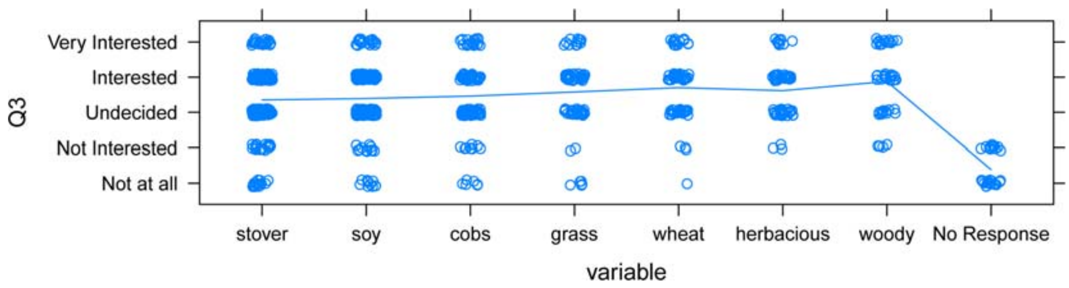
The most common biomass that farmers had available was stover (67%); the least common kind was woody material (13.6%). There were 33 (9.2%) who did not specify any kind of biomass; they either have no biomass available or skipped the question.

Comparing the kind of available biomass with the interest (table A2-1), we see only small difference, except for those who did not specify a kind of biomass; the mean interest (using a 1–5 scale) ranges from 3.35 for stover to 3.88 for woody. An anova (excluding those who did not specify a kind) has a p-value of 0.0032; however, pairwise comparisons using Tukey's correction for multiple comparisons only allow us to conclude (at the 0.05 level) that there is more interest for woody than soy and stover.

Table A2-1 Correlation of Interest in Selling Biomass To Biomass Types Available

Biomass Type	Int. (mean)	se	lwr	upr	n	Percent(>=Int)
stover	3.35	0.06	3.30	3.40	236	0.46
soy	3.39	0.08	3.33	3.46	168	0.48
cobs	3.46	0.09	3.39	3.53	128	0.48
grass	3.58	0.11	3.49	3.67	83	0.58
wheat	3.70	0.11	3.61	3.79	67	0.58
herbaceous	3.62	0.10	3.53	3.70	60	0.52
woody	3.88	0.14	3.76	3.99	49	0.65
No Response	1.39	0.09	1.31	1.46	31	0.00

Figure A2-2 Bucket Diagram of Biomass Available by Interest Level



Interpretation:

The finding that respondents said stover was the most available biomass for them to sell was expected as the survey went to grain producers, who on a statewide basis produce more corn than any other grain. However, an interesting note was that those who said they had woody biomass were significantly more interested in selling biomass. While not totally unexpected based on the existing opportunities for woody biomass, the level of significant indicates association between interest and woody material among people who were sent the survey based on their receiving assistance for participation in farm programs based on row crops

3. Biomass Productivity

A question about the level of productivity of particular crops was included to see whether producers had a sense of the harvestable amount of biomass on their lands and how that fit actual field data.

Question:

5.) Based on your current knowledge, how much yield do you estimate you could get on your land from the following crops?

Soybean straw/stubble ______ tons/acre

Corn stover ______ tons/acre

Corn cobs ______ tons/acre

Wheat/oat straw ______ tons/acre

Grassland/pasture ______ tons/acre

Results:

Table A3-1 Producer Estimates of Biomass Yields

	Soy	Corn Stover	Corn Cobs	Wheat Straw	Grassland
Average Tons/Ac	1.62	3.47	1.64	1.78	2.97
Responses (N)	105	152	59	67	80

Interpretation:

The first observation from this data was that although some of the estimate averages may have been relatively close, most did not attempt a guess. It suggests that most producers are not familiar with biomass yields. In terms of the estimate averages, the averages for soy, corn stover and corn cob biomass were higher than can probably be removed on a regular basis. While managed grasslands could probably provide 3 tons of biomass per acre, it is unlikely the using the types of land and or management practices that could generate that much biomass would interest producers.

B. Knowledge of Biomass Issues

1. Background Knowledge

This question asked whether producers felt they had a good understanding agricultural biomass and issues related to collecting biomass. The intent was to see what links their perceived level of knowledge had to the interest in selling biomass.

Question:

1.) Would you agree that you have a good understanding of issues related to collecting agricultural biomass for use in energy or bioproducts manufacturing? Please check one.

☐ Strongly Agree	☐ Agree	☐ Neutral	☐ Disagree	☐ Strongly Disagree

Results:

Question 1 was about their knowledge of the practice; 49.3% agreed or strongly agreed that they had a good knowledge. There was not a statistically significant relationship with interest in selling; the gamma value was 0.10 with a p-value of 0.16. However, it may be of interest that the group with the most knowledge were more interested (n = 26, average 3.46; 54% interested or very interested) than the others and the group with the least knowledge were less interested (n = 8, average 2.12; 12% interested or very interested).

Figure B1-1 Producers Self-Reported Level of Biomass Knowledge

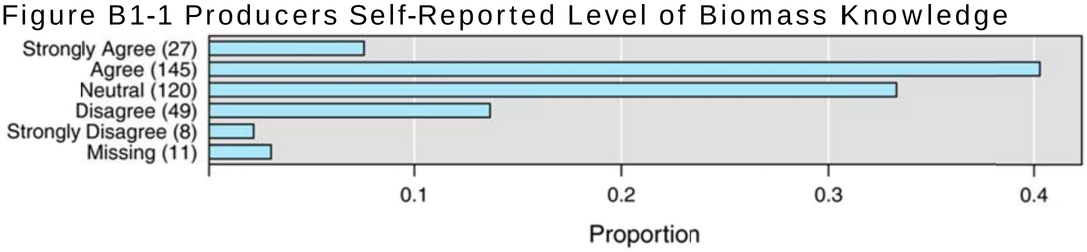


Table B1-1 Correlation Between Knowledge and Interest

	gamma	sigma	lwr	upr	p.value
Q1:Knowledge	0.10	0.07	0.04	0.24	0.16

Table B2-2 Mean Participation Interest Among Knowledge Groupings

	mean	se	lwr	upr	n	Percent(>=Int)
Strongly Agree	3.46	0.29	3.22	3.70	26	0.54
Agree	3.20	0.09	3.13	3.28	142	0.43
Neutral	3.18	0.08	3.11	3.25	119	0.36
Disagree	3.27	0.16	3.13	3.40	49	0.41
Strongly Disagree	2.12	0.40	1.80	2.45	8	0.12

Interpretation:

The data shows a trend that more knowledge is linked with greater interest in selling biomass, but it was not statistically significant. It should also be noted that a causal relationship cannot be deduced from the trend. So we cannot say that providing knowledge will drive interest, nor that interested people will seek out knowledge.

Also important to remember that this is self-reported knowledge. It indicates how thorough producers felt their knowledge was, and not how accurate their knowledge actually is.

2. Information Sources for Producers

This question was designed to assess where producers are getting their information on biomass harvesting. It is useful in targeting research and outreach to inform stakeholders using the latest information in biomass news and research. It is can also indicate whether producers are getting information from sources with that could promote particular viewpoints on biomass collection and use.

Question:

2.) Where you have previously learned about biomass harvesting? Check all that apply.

- ☐ Have not heard about biomass harvesting
- ☐ USDA-NRCS or USDA-ARS
- ☐ Agricultural magazines
- ☐ University Extension
- ☐ Farm Commodity Groups
- ☐ Farm Trade Shows
- ☐ Other Farmers
- ☐ SWCD
- ☐Other Please List __________________________

Results:

Figure B2-1 Producers Sources of Biomass Information

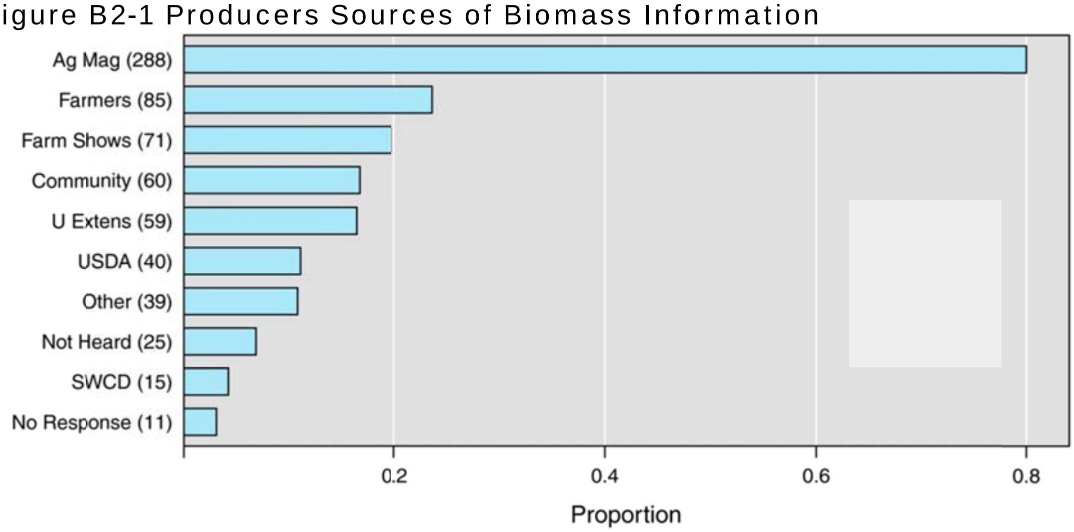


Table B2-1 Mean Interest Among Producers By Information Source

	mean	Se	lwr	upr	n	Percent(>=Int)
Ag Mag	3.19	0.06	3.14	3.24	284	0.39
Farmers	3.17	0.11	3.07	3.26	83	0.40
Farm Shows	3.30	0.12	3.20	3.41	69	0.48
Commodity Groups	3.19	0.14	3.07	3.31	58	0.41
U Extens	3.14	0.15	3.01	3.27	57	0.42
USDA	3.40	0.20	3.24	3.56	40	0.47
Other	3.42	0.20	3.26	3.59	38	0.50
Not Heard	3.12	0.21	3.04	3.39	28	0.43
SWCD	3.80	0.20	3.63	3.97	15	0.60

Figure B2-2 Number of Sources of Information versus Interest Level

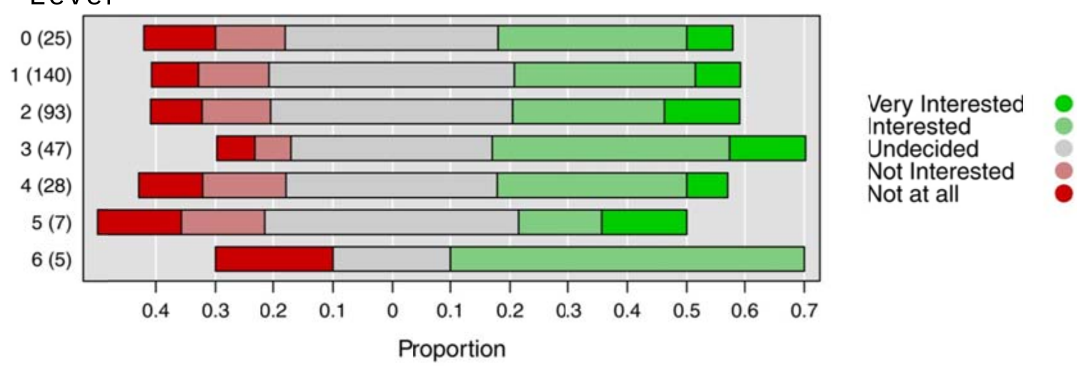


Table B2-2 Mean Interest Versus Number of Sources

# of Sources	mean	se	lwr	upr	n	Percent(>=Int)
0	3.12	0.23	2.93	3.31	25	0.40
1	3.19	0.09	3.11	3.26	140	0.39
2	3.23	0.11	3.13	3.32	93	0.39
3	3.47	0.15	3.34	3.59	47	0.53
4	3.11	0.21	2.93	3.28	28	0.39
5	3.00	0.49	2.60	3.40	7	0.29
6	3.20	0.58	2.73	3.67	5	0.60

Table B2-3 Gamma For Number of Sources Vs. Interest

	gamma	sigma	lwr	upr	p.value
Q2sum.Q3	-0.05	0.06	-0.17	0.07	0.41

Interpretation:

It appears that getting information out will depend on using agricultural media and farm shows. This also suggests that University Extension, USDA, and Soil and water conservation folks may need to enhance efforts to hit their target audience.

C. Factors in Decision Making Process

1. Important Factors in Decision

This question was designed to determine which factors farmers thought were most important in considering harvesting biomass. Though the individual results can not rank overall importance, the question was set up to allow the composite data to indicate which factors the group felt were most important in their decisions.

Question:

6.) How important would the following factors be for making management decisions about biomass harvesting in your operation? Check one per factor.

Land Rental Agreements	☐ Very important	☐ Important	☐ Moderately important	☐ Little importance	☐ Not at all important
Improved Planting or Seedbed Conditions	☐ Very important	☐ Important	☐ Moderately important	☐ Little importance	☐ Not at all important
Nutrient Replacement Costs	☐ Very important	☐ Important	☐ Moderately important	☐ Little importance	☐ Not at all important
Weather/Timing	☐ Very important	☐ Important	☐ Moderately important	☐ Little importance	☐ Not at all important
Added Income	☐ Very important	☐ Important	☐ Moderately important	☐ Little importance	☐ Not at all important
Extra Labor Required	☐ Very important	☐ Important	☐ Moderately important	☐ Little importance	☐ Not at all important
Equipment Maintenance	☐ Very important	☐ Important	☐ Moderately important	☐ Little importance	☐ Not at all important
Extra Time Required	☐ Very important	☐ Important	☐ Moderately important	☐ Little importance	☐ Not at all important
Ability to Sell Biomass on Contract	☐ Very important	☐ Important	☐ Moderately important	☐ Little importance	☐ Not at all important
Maintaining Soil Quality	☐ Very important	☐ Important	☐ Moderately important	☐ Little importance	☐ Not at all important
Added Jobs	☐ Very important	☐ Important	☐ Moderately important	☐ Little importance	☐ Not at all important

Please list any other factor(s) and how important they would be in your farm's decision whether or not to participation in biomass markets.

____

Results:

Maintaining soil quality was the most important factor in influencing producers decisions, while adding jobs was least important (important or very important for 95% and 45%, respectively). I use a stacked bar chart, centered around the "moderately important" response to show these variables, as well as a table with the mean response (using a 1–5 scale) and the percent for whom the factor was important or very important. Factors are sorted by the mean response.

Figure C1-1 Importance of Each Factor In Participation Decision

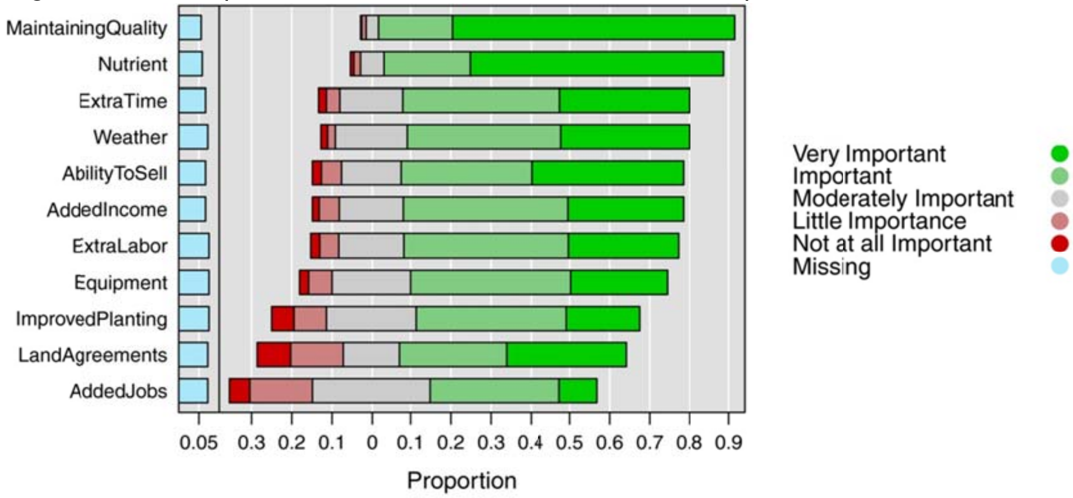


Table C1-1 Average Importance for Decision Factors

	mean	se	lwr	upr	n	Percent(>=Important)
MaintainingQuality	4.69	0.03	4.66	4.72	340	0.95
Nutrient	4.55	0.04	4.52	4.59	339	0.91
AbilityToSell	4.07	0.05	4.02	4.11	336	0.76
Weather	4.05	0.05	4.01	4.09	334	0.76
ExtraTime	4.04	0.05	4.00	4.08	336	0.77
AddedIncome	3.97	0.05	3.93	4.02	336	0.75
ExtraLabor	3.94	0.05	3.90	3.99	333	0.74
Equipment	3.85	0.05	3.80	3.89	333	0.70
LandAgreements	3.62	0.07	3.56	3.68	334	0.61
ImprovedPlanting	3.60	0.06	3.55	3.65	333	0.61
AddedJobs	3.27	0.06	3.22	3.31	334	0.45

The Goodman-Kruskal gamma statistic was used to assess the relationship between the importance of each factor and their interest in harvesting biomass. It show that Added Income, Added Jobs, Ability to Sell, and Improved Planting were all significantly positively associated with more interest, and Nutrient and Maintaining Quality were negatively associated with more interest.

Table C1-2 Relationship (gamma) between Interest and Decision Factors

	gamma	sigma	lwr	upr	p.value
AddedIncome	0.34	0.07	0.21	0.47	<1e-04
AddedJobs	0.28	0.07	0.15	0.41	<1e-04
AbilityToSell	0.22	0.07	0.08	0.35	0.0022
ImprovedPlanting	0.17	0.07	0.04	0.31	0.0127
Weather	0.01	0.07	-0.14	0.15	0.9420
LandAgreements	-0.03	0.07	-0.16	0.10	0.6694
ExtraLabor	-0.09	0.07	-0.24	0.05	0.1997
ExtraTime	-0.13	0.07	-0.26	0.01	0.0773
Equipment	-0.13	0.07	-0.27	0.01	0.0731
Nutrient	-0.20	0.08	-0.37	-0.04	0.0147
MaintainingQuality	-0.38	0.08	-0.54	-0.21	<1e-04

Plots of the interest for each factor are shown (figure C1-2), with the mean interest added, and tables of the mean interest for each level of each factor. These are valuable because they allow one to assess how much a difference is actually present. Specifically, since a difference can be statistical significant even if it is small, we can assess if the difference is one that we think is practically important. They also allow us to see how the pattern of interest changes as the rating of importance changes for each factor. To mention two in particular, we note that for the Added Income factor, the differences between not at all, little, moderately, and important all seem practically important, but that there is little difference between important and very important. For added jobs, however, the differences are smaller and perhaps more driven simply by the not at all important group.

Figure C1-2 Bucket Diagram Factors Vs. Interest

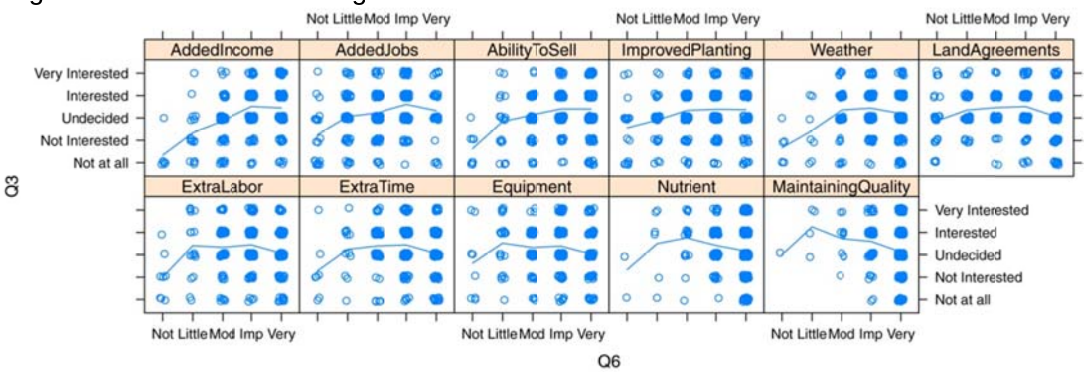


Table C1-3 Correlations between mean interest and importance of each factor:

AddedIncome

	Mean	se	lwr	upr	n	Percent(>=Int)
Very Important	3.45	0.10	3.36	3.53	103	0.50
Important	3.51	0.07	3.45	3.57	147	0.51
Moderately Important	2.86	0.13	2.75	2.97	58	0.22
Little Importance	2.33	0.26	2.12	2.55	18	0.11
Not at all Important	1.33	0.33	1.06	1.60	6	0.00

AddedJobs

	mean	se	lwr	upr	n	Percent(>=Int)
Very Important	3.32	0.20	3.16	3.49	34	0.44
Important	3.60	0.08	3.54	3.67	116	0.55
Moderately Important	3.23	0.09	3.15	3.30	106	0.37
Little Importance	3.06	0.16	2.93	3.18	54	0.37
Not at all Important	2.25	0.28	2.02	2.48	20	0.15

AbilityToSell

	mean	se	lwr	upr	n	Percent(>=Int)
Very Important	3.40	0.09	3.32	3.47	136	0.47
Important	3.40	0.08	3.34	3.46	115	0.44
Moderately Important	3.13	0.13	3.02	3.24	55	0.38
Little Importance	2.83	0.29	2.59	3.08	18	0.28
Not at all Important	1.62	0.26	1.41	1.84	8	0.00

ImprovedPlanting

	mean	se	lwr	upr	n	Percent(>=Int)
Very Important	3.37	0.15	3.25	3.49	65	0.49
Important	3.39	0.07	3.33	3.45	134	0.45
Moderately Important	3.33	0.11	3.24	3.43	81	0.48
Little Importance	2.90	0.19	2.73	3.06	29	0.24
Not at all Important	2.55	0.29	2.31	2.79	20	0.15

Weather

	mean	se	lwr	upr	n	Percent(>=Int)
Very Important	3.19	0.10	3.11	3.27	114	0.41
Important	3.43	0.08	3.37	3.50	138	0.44
Moderately Important	3.35	0.13	3.24	3.47	65	0.48
Little Importance	2.43	0.48	2.04	2.82	7	0.29
Not at all Important	1.67	0.33	1.40	1.94	6	0.00

LandAgreements

	mean	se	lwr	upr	n	Percent(>=Int)
Very Important	3.07	0.11	2.97	3.16	107	0.36
Important	3.51	0.09	3.43	3.58	95	0.53
Moderately Important	3.46	0.12	3.36	3.56	52	0.52
Little Importance	3.35	0.12	3.25	3.45	46	0.39
Not at all Important	2.87	0.22	2.68	3.05	30	0.23

ExtraLabor

	mean	se	lwr	upr	n	Percent(>=Int)
Very Important	3.07	0.10	2.99	3.16	97	0.31
Important	3.45	0.07	3.39	3.51	148	0.48
Moderately Important	3.34	0.14	3.22	3.46	59	0.51
Little Importance	3.41	0.33	3.14	3.69	17	0.47
Not at all Important	2.00	0.38	1.69	2.31	8	0.12

ExtraTime

	mean	se	lwr	upr	n	Percent(>=Int)
Very Important	3.06	0.10	2.98	3.14	114	0.33
Important	3.44	0.08	3.38	3.51	142	0.48
Moderately Important	3.40	0.13	3.30	3.51	57	0.49
Little Importance	3.25	0.33	2.98	3.52	12	0.50
Not at all Important	2.29	0.52	1.86	2.71	7	0.14

Equipment

	mean	se	lwr	upr	n	Percent(>=Int)
Very Important	3.04	0.12	2.94	3.14	85	0.29
Important	3.39	0.08	3.33	3.46	145	0.46
Moderately Important	3.33	0.11	3.24	3.42	70	0.50
Little Importance	3.52	0.26	3.30	3.74	21	0.57
Not at all Important	2.62	0.60	2.14	3.11	8	0.25

Nutrient

	mean	se	lwr	upr	n	Percent(>=Int)
Very Important	3.17	0.07	3.11	3.23	227	0.38
Important	3.42	0.10	3.34	3.50	78	0.46
Moderately Important	3.76	0.23	3.57	3.95	21	0.67
Little Importance	3.50	0.67	2.95	4.05	6	0.67
Not at all Important	2.33	0.67	1.81	2.86	3	0.00

Maintaining Quality

	mean	se	lwr	upr	n	Percent(>=Int)
Very Important	3.13	0.07	3.08	3.19	252	0.36
Important	3.60	0.11	3.51	3.69	68	0.59
Moderately Important	3.73	0.27	3.50	3.95	11	0.64
Little Importance	4.25	0.48	3.87	4.63	4	0.75
Not at all Important	3.00				1	0.00

Interpretation:

The question was designed with factors that were either positive (likely to increase interest) or negative (likely to decrease interest). The results suggest that producers are more interested in the negative factors (soil quality, nutrients, time) when assessing whether biomass harvesting is of interest to them. The positive factors (economics) ranked lowest in importance.

The results from this question also highlight the divided views agricultural biomass production; an opportunity for added income, but a risk of lowering the soil health.

An interesting note that can be taken away from the data is that the logistics factors did not seem very important when respondents were analyzing their choices. Things like weather, timing, and equipment were not as important. It could be that these factors are more of a second tier factor in the decision process or that producers don’t think they are much of an issue.

2. Biomass Harvesting Equipment Available to farmers

This question was designed to look at the type of equipment farmers have available that might be used in biomass collection. It was meant to answer the question 'Does the access to capital equipment influence the decision to participate in a biomass market?'

Question:

11.) Which of the following pieces of equipment does your operation have access to (own, lease, or can borrow)? Check all that apply.

- ☐Combine
- ☐Stalk chopping head
- ☐Wind rower
- ☐Square baler (Large)
- ☐ Live-bottom, conveyor, or walking floor trailer
- ☐Semi-tractor
- ☐Flatbed trailer
- ☐Seed drill
- ☐Round baler

Results:

Figure C2-1 Proportion of Each Type of Equipment Owned

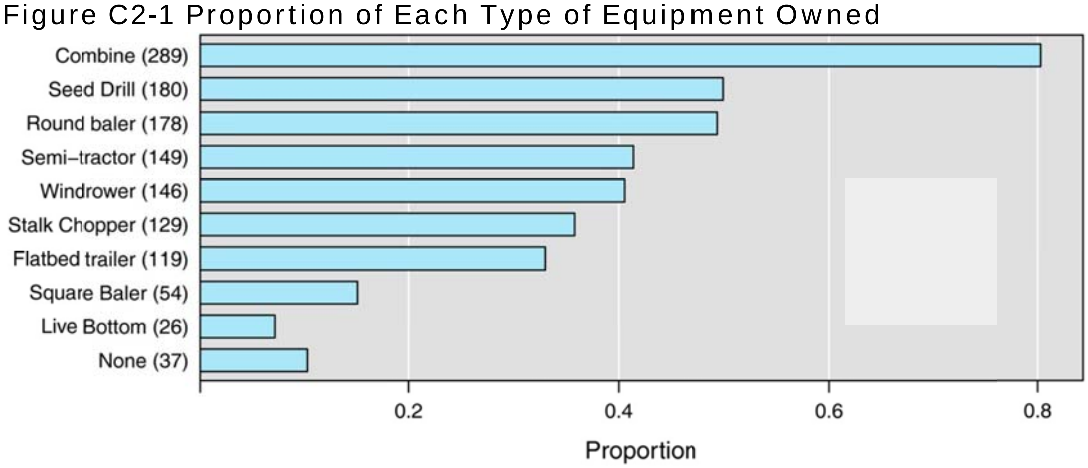
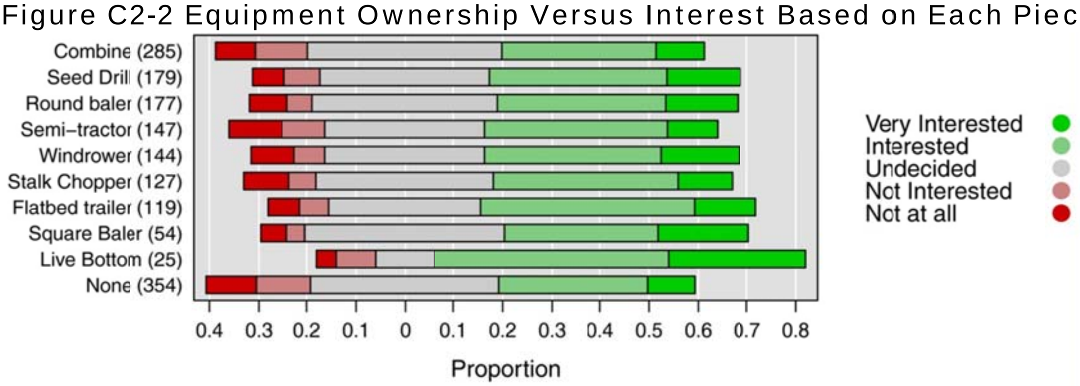


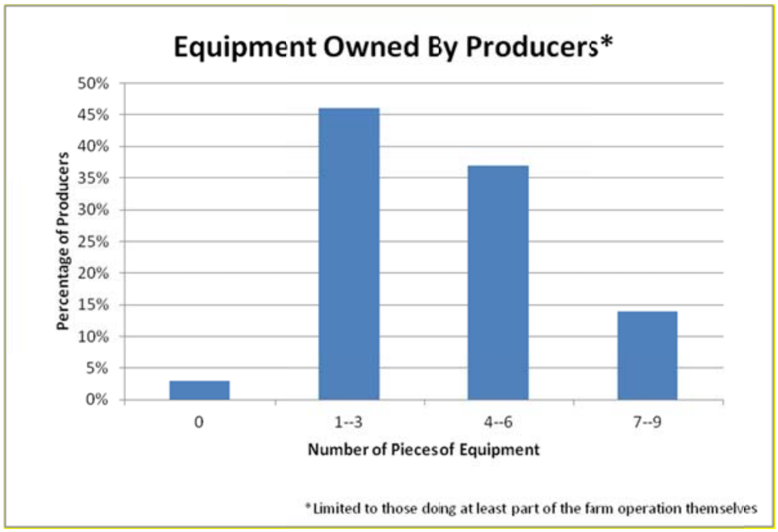
Figure C2-2 Equipment Ownership Versus Interest Based on Each Piece



Interpretation:

No significance between any one piece of equipment and interest. However, observation that none and combine were lower led to a further analysis of interaction of number of pieces of equipment and interest. See section C5

Figure C2-3 Percent of Producers Owning a Certain Levels of Equipment



Interpretation:

The percentage of producers not having access to equipment to collect/transport biomass is significant. Collection of most crop residues would require a baler (square or round) and likely semi-truck with flatbed trailer. Roughly half had access to a baler, but fewer had a flatbed trailer. This is a likely reason that many producers were amenable to the biomass being sold as it lay on the field type contract.

3. Producer Participation in Contracted Sales

Biomass energy facilities have proposed a number of methods of purchasing biomass from producers. These options span from the producer bringing material to the facility to the facility sending contractors to the producer's land to get the material. This question asked which of four options the producers would prefer.

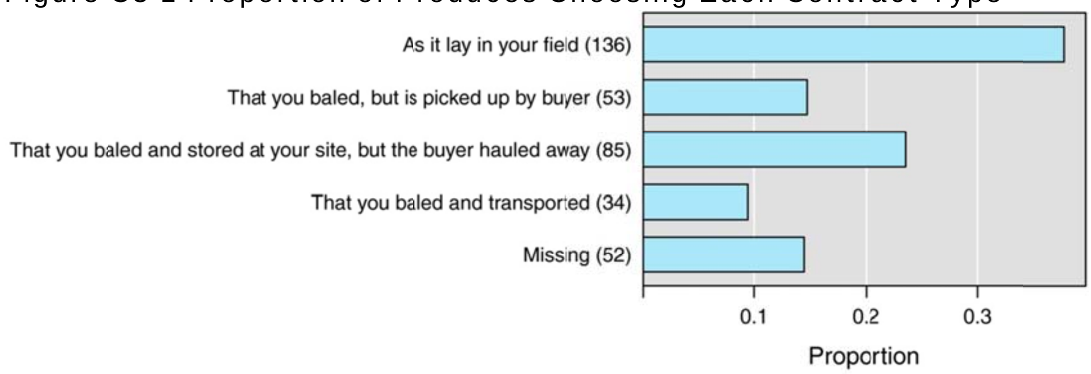
Question:

10.) Say you were to sell biomass from your land, which of the following options for selling the biomass would most interest you? Please check one.

☐ Sell the biomass as it lay in your field, the buyer would come in and remove it.
☐ Sell biomass you have baled, but is picked up by the buyer in your field.
☐ Sell biomass you baled and stored at your site, but is hauled away by the buyer.
☐ Sell biomass that you have baled and transported to a buyer's storage site.

Results:

Figure C3-1 Proportion of Produces Choosing Each Contract Type



Interpretation:

Responses from this question indicate that there is a diversity of opinions on the amount of responsibilities that producers would like to take on when considering collecting/transporting biomass from their lands. The least involved option would take all responsibilities from the producer, with custom contractors coming on to the land and removing the materials. This was the most popular option with 37% of farmers saying they would be most interested in this option. The option the producer would be most involved in would be collecting and transporting the materials from their lands (roughly 15% interest). This option would be more likely to help producers pay for existing capital equipment such as tractors, balers, and trucks.

See section C-5 for interactions between this question and others, which yielded some interesting results.

4. Custom Operators in Farming

Farmers who use a significant amount of custom operators in their crop management may have different a different perspective on whether the possibility of harvesting and selling biomass works for their organization. This question directly asked about the level of custom operators in their operation.

Question:

12.) What percentage of your operation is done by custom operators (combining, baling, and trucking for example)? ______%

Results:

Figure C4-1 Percentage of Custom Operators Used In Farming

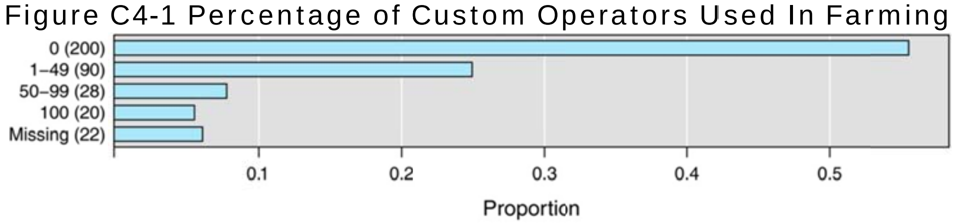


Figure C4-2 Percent Custom Operators Versus Interest

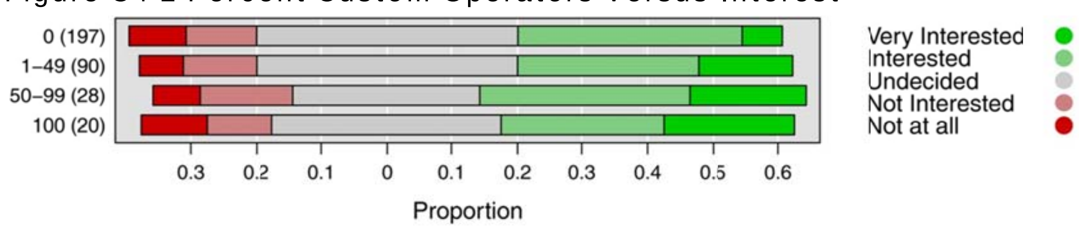


Table C4-1 Correlation of Percent Custom Versus Interest

	gamma	sigma	lwr	upr	p.value
Custom Operators vs Interest	-0.07	0.07	-0.21	0.06	0.2703

Interpretation:

The results indicate that most producers are completing their operations without the aid of custom operators or minimal hiring of custom services. There was no statistical association between producer interest and the use of custom operators.

5. Interactions: Contract Type, Custom Harvest, And Equipment Ownership

Examination of the data for this section hinted at potential statistically significant patterns influencing producer' interest that were not detected with a simple looking only at producer interest and a single variable. These potential interactions were further analyzed.

Sum of Equipment versus Interest

To examine whether the total number of pieces of equipment had an association with interest, total number or pieces was grouped into four categories (0, 1-3, 4-6, 7-9) and compared to interest.

Figure C5-1 Sum of Equipment Ownership Versus Interest

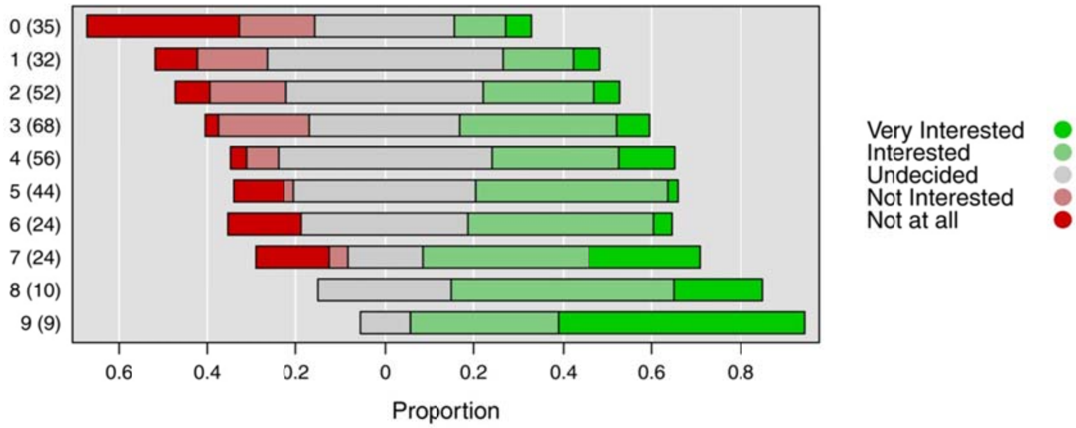


Table C5-1 Correlation Between Sum of Equipment and Interest

	gamma	sigma	lwr	upr	p.value
Number equipment vs Interest	0.30	0.05	0.20	0.41	<1e-04

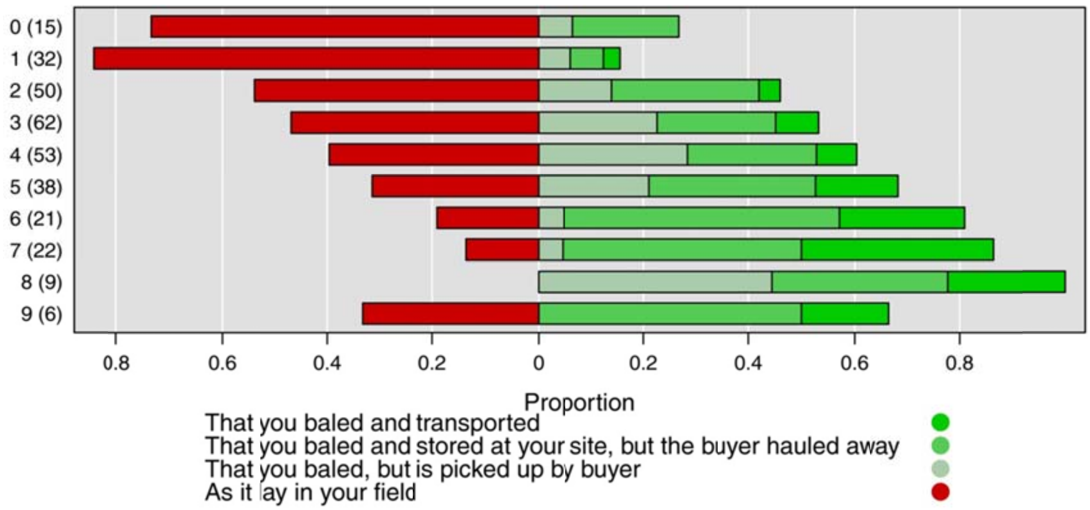
Interpretation:

The interest level was very significantly tied to the number of pieces of equipment a producer had.

Sum of Equipment and Contract Type

To examine whether the total number of pieces of equipment had an association with interest, total number or pieces was grouped into four categories (0, 1-3, 4-6, 7-9) and grouping the percent custom into <100% and 100%; after investigation, this seemed to capture the association in a straightforward way.

Figure C5-2 Equipment Ownership (Sum) Versus Contract Type



Interpretation:

As would be expected, people who had more equipment were more interested in contracts where they had added responsibility to harvest and deliver the material.

Use of Custom Operators Association with Contract Type and Pieces of Equipment

Figure C5-3 Percent of Custom Operators Versus Contract Type

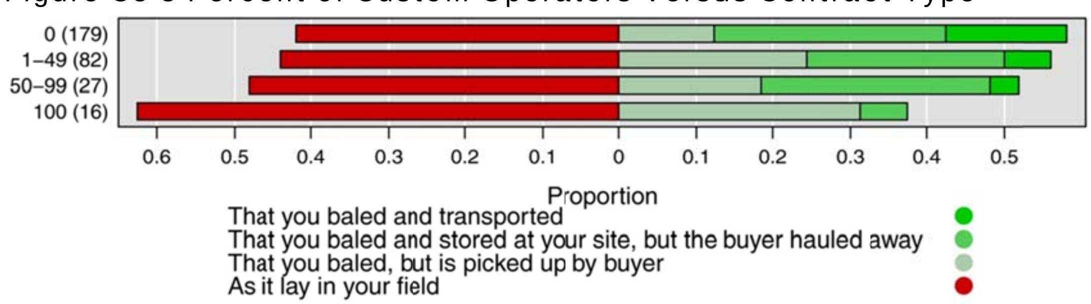


Table C5-2 Correlation Between Custom Harvest and Other Variables

	gamma	sigma	lwr	upr	p.value
Custom Operators vs Contract Type	-0.20	0.07	-0.33	-0.06	0.0042
Custom Operators vs Equipment Owned	-0.13	0.06	-0.25	-0.01	0.03

Interpretation:

As expected, people who contract more of their work to custom operators were more likely to be interested in a contract that sold biomass as it lay on the ground. Similarly, people who used custom operators tended to have less equipment (chart not shown).

D. Impacts Of Harvesting & Methods of Mitigating Impacts

1. Impacts of Harvesting

Although some producers and soil scientists have noted that they feel there could be negative consequences for harvesting biomass, it is difficult to tell how widespread these feelings are. This question asked producers their impression of the level of impacts at different biomass harvest rates.

Question:

13.) The next set of questions are meant to gauge how you feel different biomass harvest rates will affect cropland and other environmental factors related to farming.

If 30% of biomass is removed do you feel the factor listed on the left will increase, stay the same or decrease? Check one response per factor.

	Increase	Stay the Same	Decrease	Not sure
Soil erosion	☐	☐	☐	☐
Grain yields	☐	☐	☐	☐
Nutrient loss	☐	☐	☐	☐
Soil organic matter	☐	☐	☐	☐
Water quality	☐	☐	☐	☐
Wildlife habitat	☐	☐	☐	☐
Soil compaction	☐	☐	☐	☐

If 50% of biomass is removed do you feel the factor listed on the left will increase, stay the same or decrease? Check one response per factor.

	Increase	Stay the Same	Decrease	Not sure
Soil erosion	☐	☐	☐	☐
Nutrient loss	☐	☐	☐	☐
Soil organic matter	☐	☐	☐	☐
Water quality	☐	☐	☐	☐
Wildlife habitat	☐	☐	☐	☐
Soil compaction	☐	☐	☐	☐

If 70% of biomass is removed do you feel the factor listed on the left will increase, stay the same or decrease? Check one response per factor.

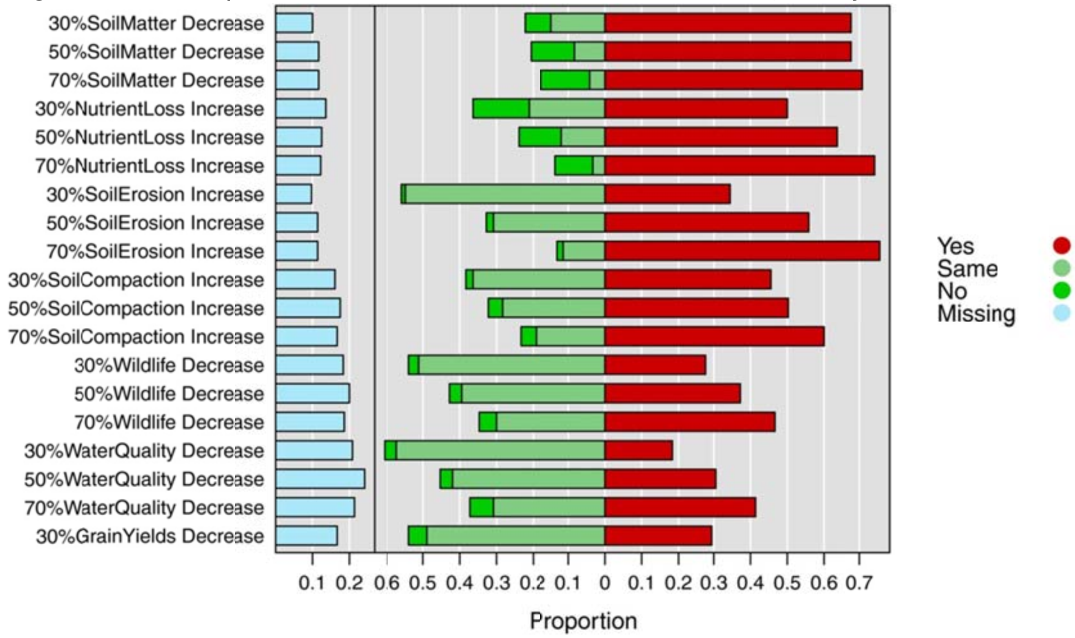
	Increase	Stay the Same	Decrease	Not sure
Soil erosion	☐	☐	☐	☐
Nutrient loss	☐	☐	☐	☐
Soil organic matter	☐	☐	☐	☐
Water quality	☐	☐	☐	☐
Wildlife habitat	☐	☐	☐	☐
Soil compaction	☐	☐	☐	☐

Results:

For consistency in plotting and analysis, the "worse" direction was considered, rather than increase or decrease. The responses were plotted using a stacked bar plot, shifted this time to have to the center between "worse"

Analysis of how their response changes with percent and how this is related to their interest in selling follows:

Figure D1-1 Impacts of Three Removal Levels On Quality Measures



The first item compared how their response changed as the percent increased, using McNemar's test. For this test, the number of responses that felt the factor would get worse was counted as the percent increased, and compared it to the percent that felt the factor would get better. This comparison was done for 30% vs. 50%, 50% vs. 70%, and an overall effect, where any change over the three levels was considered. There were statistically significant differences for all factors at all levels except for soil organic matter.

Table D1-1 Comparing 30% and 50%

	better	same	worse	no.answer	p.value
SoilMatter	34	250	29	47	0.61429
NutrientLoss	21	216	62	61	<1e-04
SoilErosion	7	226	82	45	<1e-04
SoilCompaction	12	251	26	71	0.03496
Wildlife	9	235	35	81	0.00016
WaterQuality	9	209	42	100	<1e-04

Comparing 50% and 70%

	better	same	worse	no.answer	p.value
SoilMatter	16	277	20	47	0.61708
NutrientLoss	9	261	41	49	< 1e-04
SoilErosion	1	241	71	47	< 1e-04
SoilCompaction	3	254	33	70	< 1e-04
Wildlife	9	239	34	78	0.00025
WaterQuality	12	222	32	94	0.00418

Over all three: 30%, 50%, 70%

	better	same	worse	conflict	no.answer	p.value
SoilMatter	34	235	35	13	43	1
NutrientLoss	15	198	86	15	46	<1e-04
SoilErosion	5	161	150	3	41	<1e-04
SoilCompaction	12	225	56	3	64	<1e-04
Wildlife	18	200	69	0	73	<1e-04
WaterQuality	17	180	69	4	90	<1e-04

To compare their view on each factor with their interest in selling, the gamma statistic was again computed. Except for Nutrient Loss, all are statistically significant with a negative association.

Table D1-2

	-gamma	Sigma	Lwr	Upr	p.value
30%SoilMatter Decrease	-0.30	0.09	-0.47	-0.13	0.00071
50%SoilMatter Decrease	-0.24	0.09	-0.41	-0.06	0.00898
70%SoilMatter Decrease	-0.26	0.10	-0.45	-0.07	0.00817
30%NutrientLoss Increase	-0.09	0.08	-0.24	0.06	0.23844
50%NutrientLoss Increase	-0.24	0.09	-0.42	-0.06	0.00760
70%NutrientLoss Increase	-0.16	0.12	-0.40	0.07	0.17633
30%SoilErosion Increase	-0.47	0.07	-0.61	-0.33	< 1e-04
50%SoilErosion Increase	-0.38	0.08	-0.53	-0.23	< 1e-04
70%SoilErosion Increase	-0.53	0.09	-0.71	-0.35	< 1e-04
30%SoilCompaction Increase	-0.39	0.08	-0.54	-0.23	< 1e-04
50%SoilCompaction Increase	-0.37	0.08	-0.53	-0.21	< 1e-04
70%SoilCompaction Increase	-0.42	0.09	-0.59	-0.25	< 1e-04
30%Wildlife Decrease	-0.40	0.08	-0.56	-0.24	< 1e-04
50%Wildlife Decrease	-0.33	0.08	-0.49	-0.17	< 1e-04
70%Wildlife Decrease	-0.25	0.08	-0.41	-0.10	0.00154
30%WaterQuality Decrease	-0.42	0.09	-0.60	-0.25	< 1e-04
50%WaterQuality Decrease	-0.36	0.08	-0.51	-0.20	< 1e-04
70%WaterQuality Decrease	-0.21	0.08	-0.37	-0.06	0.00775
30%GrainYields Decrease	-0.44	0.08	-0.59	-0.29	< 1e-04

The mean interest was also compared for those who thought the factor would get worse and those who thought it would stay the same or improve; this is shown below both graphically and in a table. The plot shows

Figure D1-2 Mean Interest among Those Thinking Measure Would Be Worse With Removal.

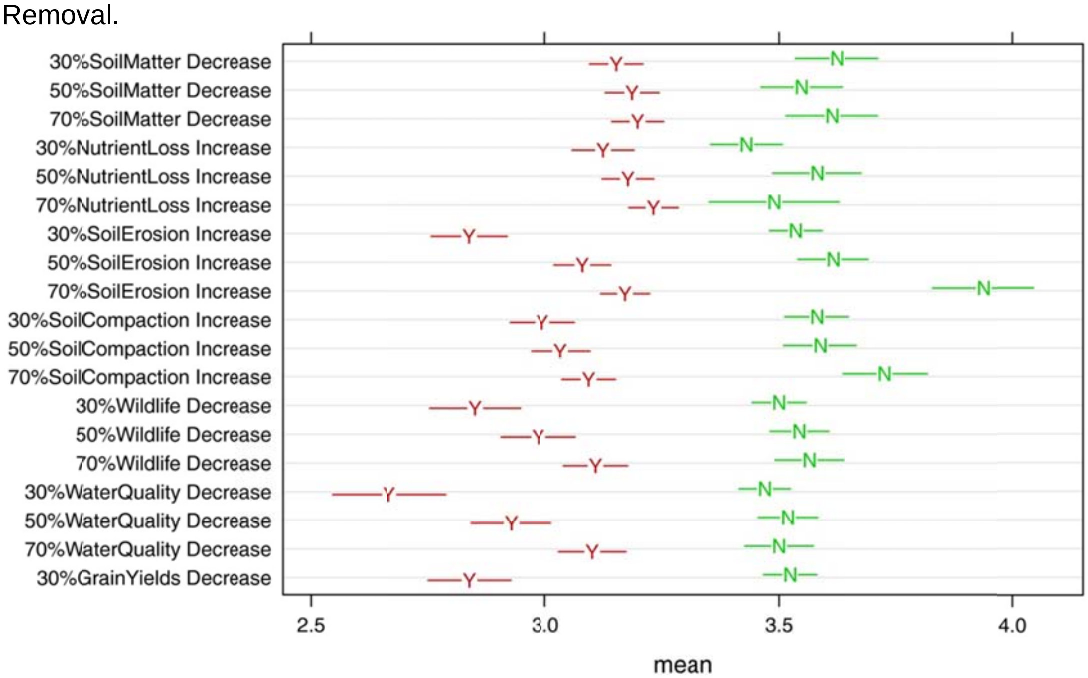


Table D3-2

	Y.mean	Y.se	Y.n	N.mean	N.se	N.n
30%SoilMatter Decrease	3.15	0.07	243	3.62	0.11	77
50%SoilMatter Decrease	3.19	0.07	242	3.55	0.10	73
70%SoilMatter Decrease	3.20	0.07	253	3.61	0.12	62
30%NutrientLoss Increase	3.12	0.08	177	3.43	0.09	130
50%NutrientLoss Increase	3.18	0.07	226	3.58	0.11	86
70%NutrientLoss Increase	3.23	0.06	264	3.49	0.17	49
30%SoilErosion Increase	2.84	0.10	123	3.54	0.07	198
50%SoilErosion Increase	3.08	0.07	199	3.62	0.09	117
70%SoilErosion Increase	3.17	0.06	269	3.94	0.13	47
30%SoilCompaction Increase	2.99	0.08	162	3.58	0.08	136
50%SoilCompaction Increase	3.03	0.08	180	3.59	0.09	114
70%SoilCompaction Increase	3.09	0.07	213	3.73	0.11	84
30%Wildlife Decrease	2.85	0.11	100	3.50	0.07	190
50%Wildlife Decrease	2.99	0.10	134	3.54	0.07	151
70%Wildlife Decrease	3.11	0.08	166	3.56	0.09	124
30%WaterQuality Decrease	2.67	0.15	66	3.47	0.07	215
50%WaterQuality Decrease	2.93	0.10	110	3.52	0.08	160
70%WaterQuality Decrease	3.10	0.09	148	3.50	0.09	132
30%GrainYields Decrease	2.84	0.10	105	3.52	0.07	191

Interpretations:

Soil organic matter (SOM):

Most producers (roughly 70%) though SOM decrease was likely at all harvest rates. There was no statistical difference between harvest rates. This was probably because so many thought it was very important and there could be an impact at any harvest rate.

Soil nutrient levels, erosion, and compaction:

These factors were all fairly important impacts in most producers' responses. Results showed a fairly significant increase in perceived impact as more material was removed. The impact on nutrients tended to be higher at lower removal rates, whereas erosion appeared to have more perceived impact at higher removal rates. to have response to the amount removed.

Wildlife and water quality:

These factors tended to be perceived as not being impacted as significantly in general. However, there was a definite increase in perceived impact as harvest rates increased.

Grain yields:

Due to an error in final editing of the survey, only the 30% harvest rate perceived impacts were assessed. While most felt that there would not be a decrease in grain yield, roughly 30% though it would decrease.

NOTE: a statistically significant pattern was noticed in perceived impacts and region of the state. This is in section E of this appendix.

2. Tillage Practices Being Used

Research has demonstrated that alternative tillage practices can mitigate some negative impacts of harvesting biomass, but have their own drawbacks. There are reservations on the part of some producers to change their current agronomic practices to include these practices. As a baseline, producers were surveyed to find out what practices they were already using on their lands

Question:

14.) Which of the following tillage methods most closely describes tillage on your croplands? Please check one.

☐No till (no tillage and planting with a no-till planter)

☐Reduced or conservation tillage

☐Conventional tillage

Results:

There was no significant difference between interest levels for the three type of tillage. Both a Kruskal-Wallis test to test for an overall difference between the three groups (p =0.70) and a Wilcoxon test between just reduced/conservation and conventional (p =0.88) were used.

Figure D2-1 Proportion of Respondents Using Alternate Tillage Types

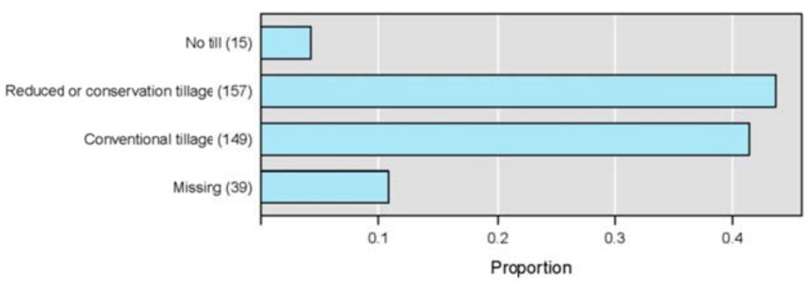


Table D2-1 Mean Participation Interest Versus Tillage Being Used

	mean	se	lwr	upr	N	Percent(>=Int)
No till	3.20	0.20	3.03	3.37	15	0.13
Reduced or conservation tillage	3.24	0.09	3.16	3.31	157	0.43
Conventional tillage	3.28	0.09	3.20	3.35	145	0.44

Interpretation:

Slightly more than half were currently using some form of conservation tillage. There was no apparent relationship between interest and tillage currently practiced.

3. Openness to Alternative Tillage:

Following the base question of whether they currently used alternative tillage techniques, a second question asked whether they would be open alternative tillage or cropping techniques.

Question:

15.) Which of the following farming practices would you consider implementing if you were to begin harvesting biomass on your land? Check one response per farming practice.

	Already Implemented	Would Consider	Would not Implement
No till	☐	☐	☐
Reduced or conservation tillage	☐	☐	☐
Cover crops	☐	☐	☐
New crop rotations	☐	☐	☐

Results:

A stacked bar chart and table present the responses. To compare with interest, the gamma statistic was used for each tillage type; Also below are plots of this relationship and tables of the average interest for each category.

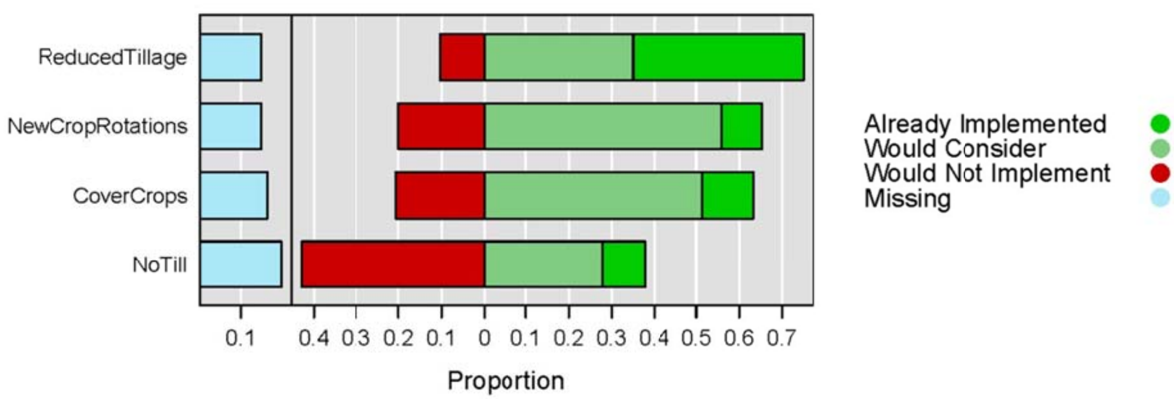


Table D3-1

	No Till	Reduced Tillage	Cover Crops	NewCrop Rotations
Already Implemented	36	144	43	34
Would Consider	100	126	185	201
Would Not Implement	154	37	74	72
Missing	70	53	58	53

Table D3-2 Gamma for Q15

	gamma	Sigma	lwr	Upr	p.value
NoTill	0.19	0.08	0.04	0.34	0.01496
ReducedTillage	0.09	0.08	-0.06	0.25	0.25268
CoverCrops	0.27	0.08	0.11	0.43	0.00094
NewCropRotations	0.32	0.08	0.16	0.48	< 1e-04

Figure D3- Bucket Diagram Openness of Producers to Alternative Practices Versus Participation Interest

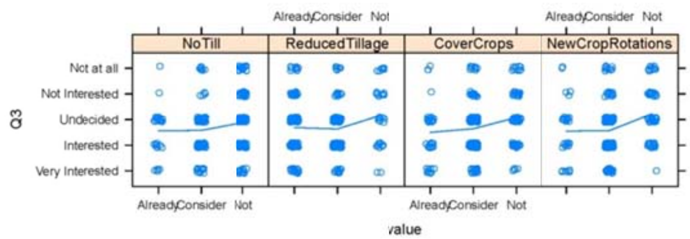


Table D3-3 Openness of Producers to Alternative Practices Versus Participation Interest

NoTill

	mean	se	lwr	upr	n	Percent(>=Int)
Already Implemented	3.44	0.15	3.32	3.57	36	0.39
Would Consider	3.42	0.10	3.34	3.51	99	0.47
Would Not Implement	3.11	0.09	3.03	3.18	151	0.38

ReducedTillage

	mean	se	lwr	upr	n	Percent(>=Int)
Already Implemented	3.31	0.09	3.24	3.38	144	0.44
Would Consider	3.37	0.09	3.29	3.44	122	0.45
Would Not Implement	2.84	0.20	2.68	3.00	37	0.35

CoverCrops

	mean	se	lwr	upr	n	Percent(>=Int)
Already Implemented	3.50	0.18	3.35	3.65	42	0.50
Would Consider	3.36	0.07	3.30	3.42	183	0.45
Would Not Implement	2.92	0.13	2.81	3.02	73	0.30

NewCropRotations

	mean	se	lwr	upr	n	Percent(>=Int)
Already Implemented	3.45	0.20	3.29	3.62	33	0.45
Would Consider	3.43	0.07	3.38	3.49	199	0.47
Would Not Implement	2.77	0.13	2.67	2.88	71	0.28

i. Openness to Tillage Changes and Years Farming

The stacked bar charts below compared openness to changing tillage with the number of years farming (section F.). The gamma test was used to examine potential associations;

Figure D3-2

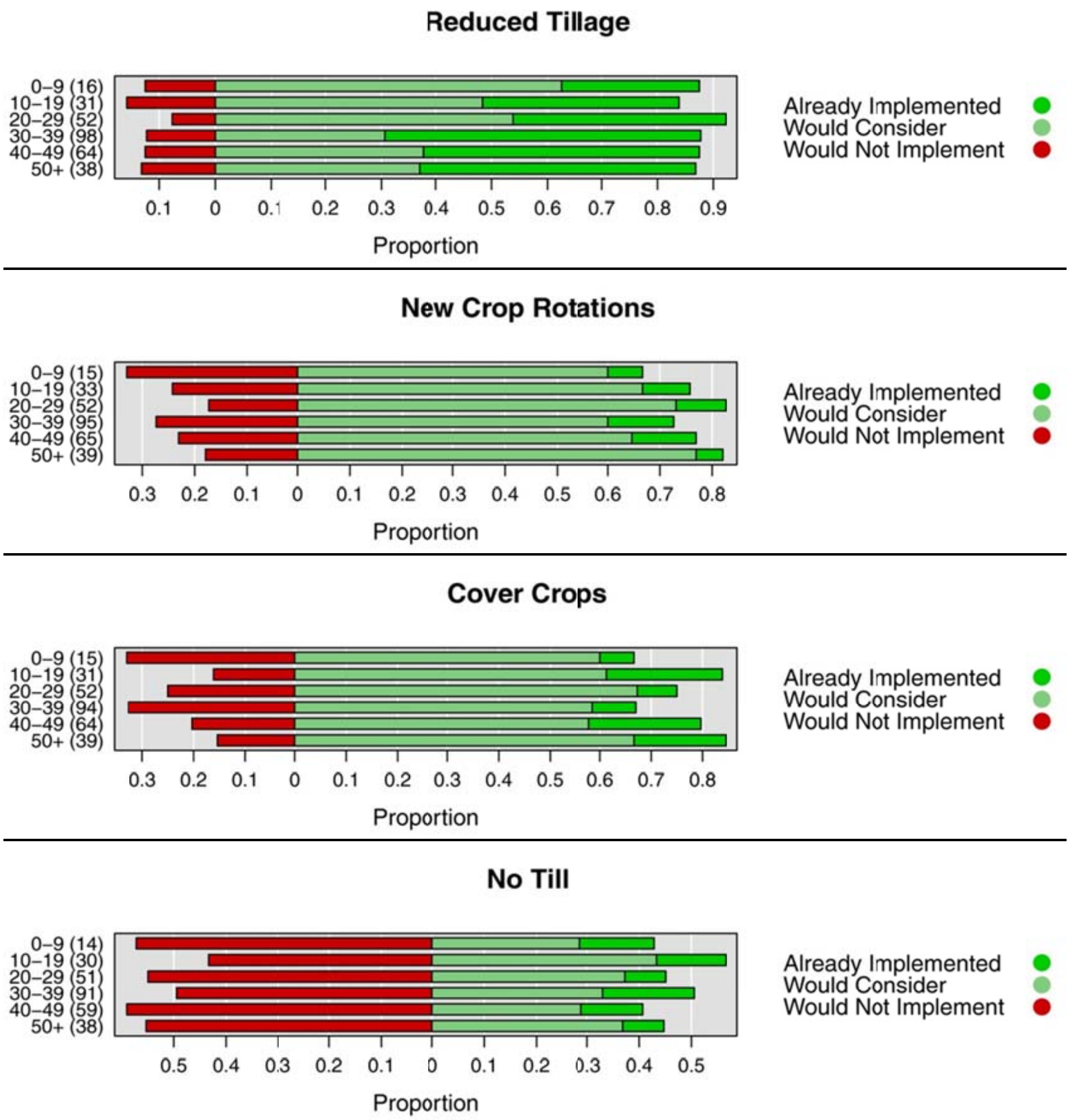
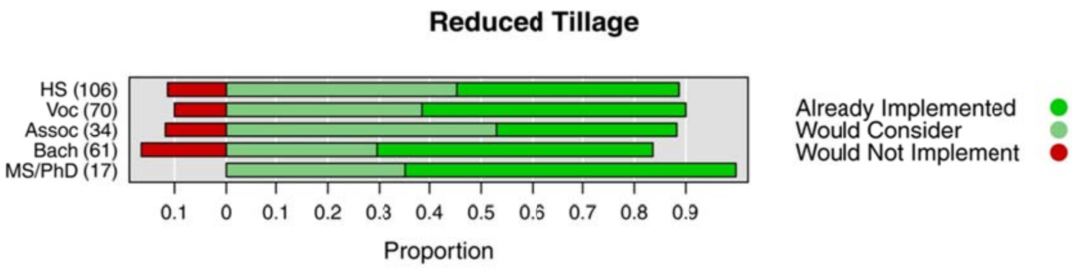


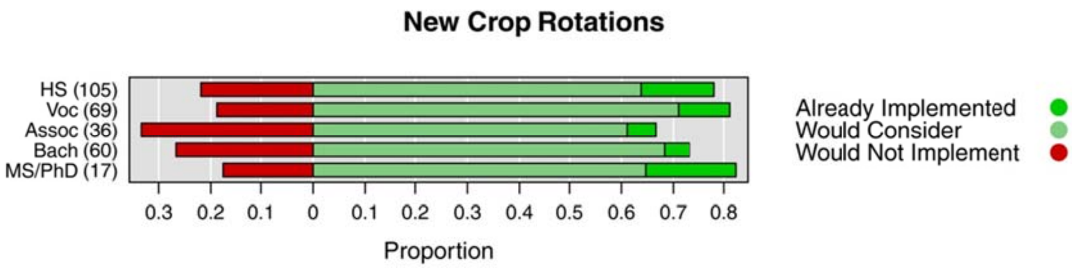
Table D3-2

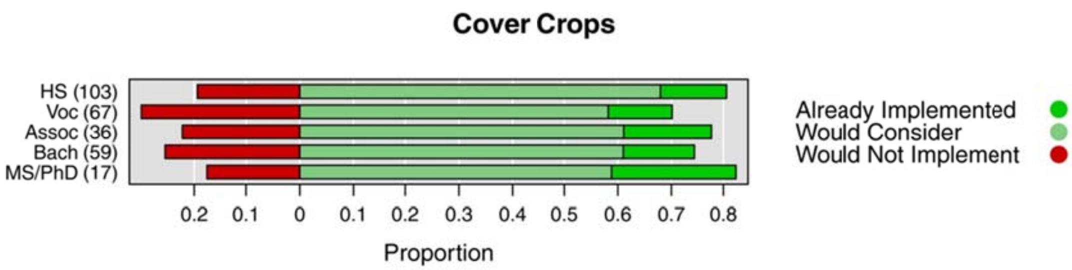
	gamma	sigma	lwr	upr	p.value
ReducedTillage	-0.110	0.061	-0.229	0.010	0.071
NewCropRotations	-0.020	0.064	-0.145	0.106	0.76
CoverCrops	-0.083	0.065	-0.209	0.044	0.2
NoTill	0.061	0.063	-0.062	0.184	0.328

ii. Openness to Tillage Changes and Education

Openness to tillage changes was compared highest level of education (Q21). Stacked bar charts below show the results. The Gamma test was also used.







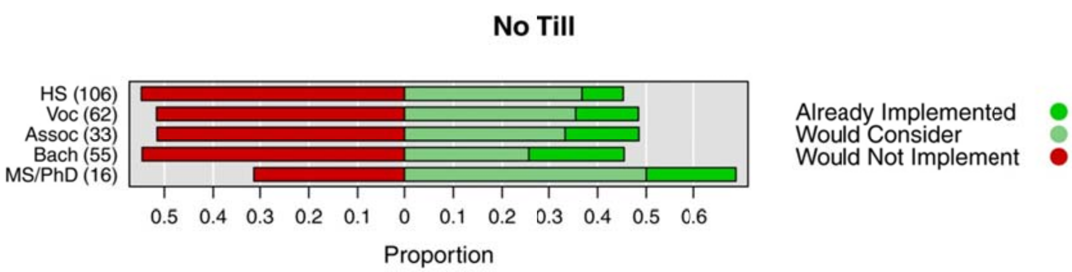


Table D3-2 Tillage by Education

	gamma	sigma	lwr	upr	p.value
ReducedTillage	-0.09	0.08	-0.24	0.06	0.25
NewCropRotations	0.11	0.09	-0.06	0.28	0.22
CoverCrops	0.00	0.08	-0.16	0.16	0.99
NoTill	-0.11	0.08	-0.26	0.04	0.16

Interpretation:

There was a significant correlation between those who are interested in biomass harvesting and willing to consider alternative tillage. It might be that these individuals are potential early adaptors in both practices or that there is a realization that tillage/conservation practices may have to change to sustainably harvest biomass.

Responses to no till indicate that it is not particularly popular, a small percentage of producers have implemented it (roughly 10%), and few would consider it (27%). Over 45% indicated they would not consider it.

Reduced tillage already has roughly 30% adoption, with another 35% willing to consider it.

New crop rotations and cover crops both had few current practitioners, but each had over 50% or the respondents indicating they would consider implementing. Only around 20% indicated that they would not be interested.

Thought there were a few trends in the comparisons of openness to change tillage practices when compared to education level or compared to years farming, these were not significant.

4. Conservation Program Participation

Many producers participate in the programs to preserve conservation lands for wildlife and other benefits. One strategy for successfully managing vegetation on these lands is through periodic removal of biomass. The ability to harvest and sell this biomass has been suggested as an opportunity to promote conservation efforts and provide added income to the producer. A series of questions was designed to assess how farmers felt about CRP program land as a source of sellable biomass.

Question:

16.) How many acres do you have in a conservation program (CRP, WRP, RIM for example) that are planted to?

Grasses/prairie _____ Acres
Trees _____ Acres
Other _____Acres

16b.) If you have CRP, in what year will most of your CRP land expire?_________

17.) Say you had lands in conservation programs, would you consider some harvesting of biomass if it were allowed without penalty?

☐ Yes ☐ No

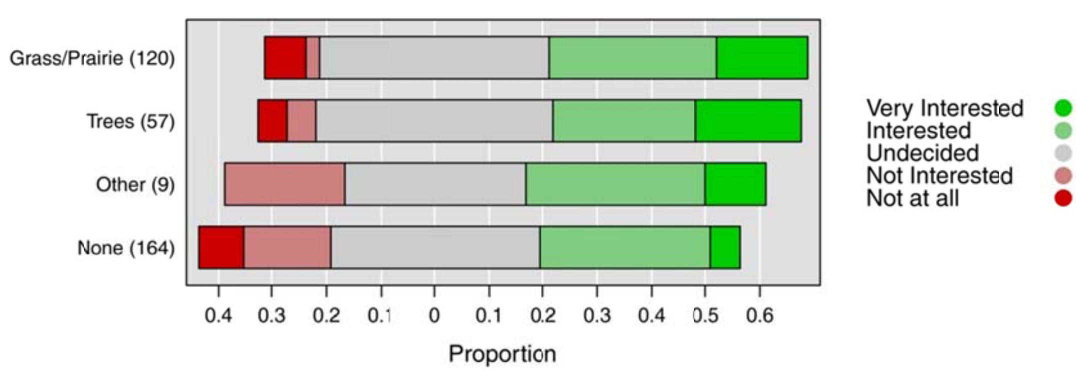
18.) Would you be more likely to consider enrolling in conservation programs if you were allowed to harvest biomass for selling to the bioenergy market?

☐ Yes ☐ No

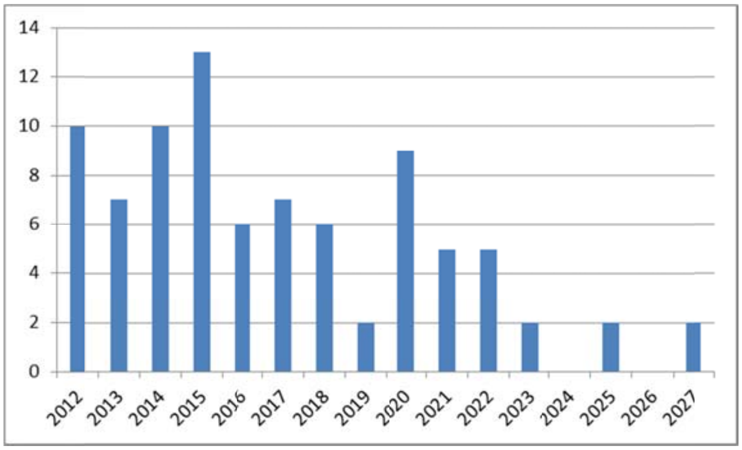
Results:

Table D3-2Land in CRP by type

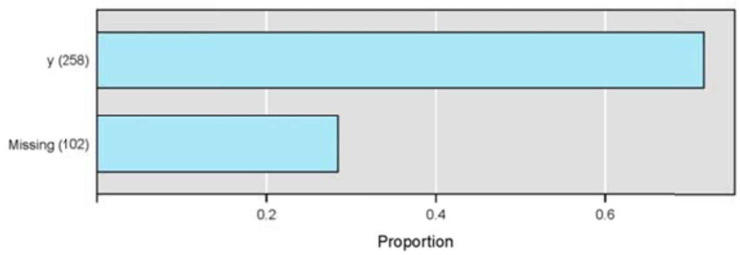
	Grasses	Trees	Other
Average Acres	67.6	46.4	106.1
Count	120	57	9



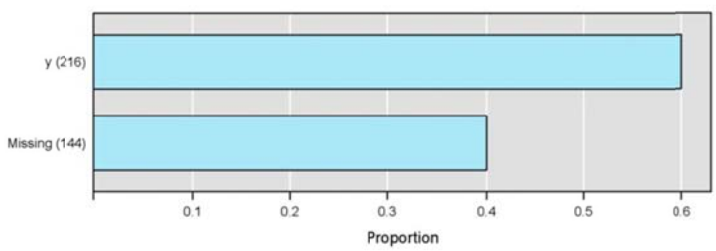
Date of Expiration of CRP Lands



Consider Harvesting CRP if Allowed without Penalty



More Likely To Enroll In CRP If Biomass Harvesting Allowed



Interpretation:

These question were not statistically analyzed, however most producers indicate that they would consider permitted biomass harvesting as positive feature of conservation programs.

E. Economics of Biomass Harvesting

1. Profit Needed to Interest Farmers

One of the most important factors that would encourage a producer to enter the biomass market is economics. The first question asked how much financial incentive (profit) a producer would want to interest them in supplying material to the agricultural biomass market.

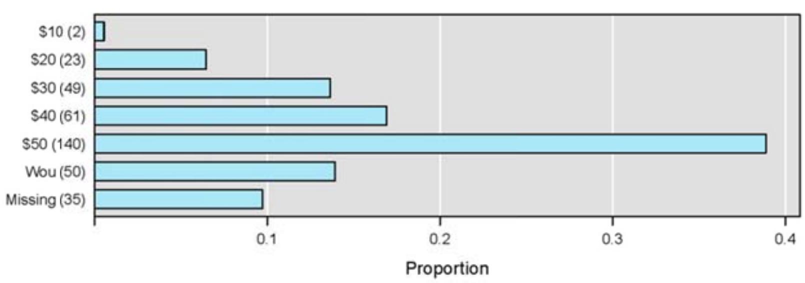
Question:

7.) After paying all costs, at what profit level would you consider selling biomass from your croplands (assuming current grain prices)? Check the box of the lowest profit per acre that would be acceptable.

Biomass Profit Per Acre

☐$10 or more	☐$20 or more	☐$30 or more	☐$40 or more	☐$50 or more	☐ Would Not Sell

Results:



Desired profit was examined both with and without those who indicated that they would not sell; This was done because perhaps only their willingness to sell was associated with interest, not the price. However, both were statistically significantly associated. In the plot below, the average price among those who would sell is shown; the table gives both the percent who would sell and the mean price for them.

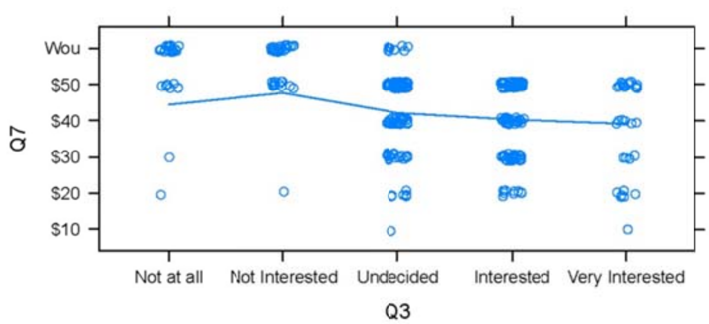


Table E1-1 Willingness to sell versus interest

	N	N.not	p.not	N.would	mean.would
Very Interested	33	0	0.00	33	39.09
Interested	105	0	0.00	105	40.29

Undecided	122	10	0.08	112	42.14
Not Interested	34	21	0.62	13	47.69
Not at all	27	18	0.67	9	44.44

Table E1-2

	Gamma	sigma	lwr	upr	p.value
Q7.all	-0.51	0.06	-0.62	-0.39	<1e-04
Q7.priceonly	-0.27	0.08	-0.43	-0.11	0.001

Table E1-2 Number interested in selling vs Per Acre Profit

Profit	$10	$20	$30	$40	$50	NO Sale
N	2	23	49	61	140	50
Cumulative N	2	25	74	135	275	50
Cumulative %	0.62%	7.69%	22.77%	41.54%	84.62%	15.38%

Interpretation:

Both among all producers, and those interested in biomass markets, there was a strong correlation between price and willingness to sell. This demonstrates that economics will likely convince more to enter the market. Table E1-2 shows the cumulative percentage of sellers as profit goes up. Data suggests that to get a reasonable amount of participation, would take between $40-50 profit per acre. This price seems to be a point that would convince fence sitters and some not interested folks into the market. Unfortunately, this would work out to $20.45 profit per ton of biomass ($45 per ac at 2.2 tons), which may be more than the market can bare at this time. This data is similar to discussions we've had with individual producers interested in biomass.

2. Influence of Corn Grain Price on Interest

With high grain prices, farmers may not feel inclined to supplement their income with the sale of biomass. This question asked how low grain prices would have to be before they would consider selling biomass.

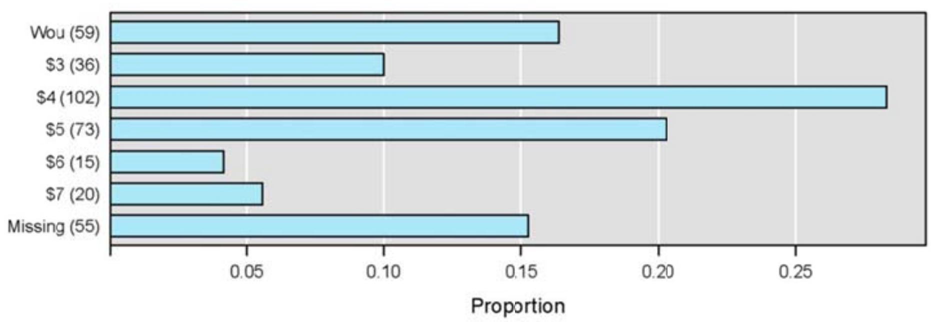
Question:

8.) How low would the price of corn need to be before you would consider selling biomass to supplement the corn grain income? Check the box of the highest price at which you would consider selling biomass.

Corn Price per Bushel

$7 or less	$6.00 or less	$5.00 or less	$4.00 or less	$3.00 or less	Would Not Sell

Results:



The Grain Price variable was examined both with and without those who would not sell; as before, this was done because perhaps only their willingness to sell was associated with interest, not the price. However, both were statistically significantly associated. In the plot below, the average price among those who would sell is shown; the table gives both the percent who would sell and the mean price for them.

Table E2-1 Corn Price Influence Counts Vs. Interest

	N	N.not	p.not	N.would	mean
Very Interested	31	3	0.10	28	$5.04
Interested	91	2	0.02	89	$4.58
Undecided	119	14	0.12	105	$4.39
Not Interested	34	18	0.53	16	$3.94
Not at all	26	21	0.81	5	$4.60

Table E2-2 Gamma for Q8 Versus Interest

	gamma	sigma	lwr	upr	p.value
Q8.all	-0.51	0.06	-0.62	-0.39	<1e-04
Q8.priceonly	-0.27	0.08	-0.43	-0.11	0.001

Table E2-3 Number Interested In Selling Vs. Price

Price per bu	$7	$6	$5	$4	$3	NO Sale
N	20	15	73	104	36	50
Cumulative N	20	35	108	212	248	50
Cumulative %	6.7%	11.7%	36.2%	71.1%	83.2%	12.1%

Interpretation:

Responses to this question indicate that producer's decisions are sensitive to economic considerations and that grain prices would influence their decision about entering the biomass market. Table E2-3 shows the cumulative percentage of sellers as grain price goes down. The key point where the majority of producers would begin considering biomass sales to supplement grain income was between $4-5 per bushel.

3. Economic Point at Which Biomass Cropping Might Interest Producers

This question examined whether producers would be interested in growing specialty biomass crops at different levels of profit.

Question:

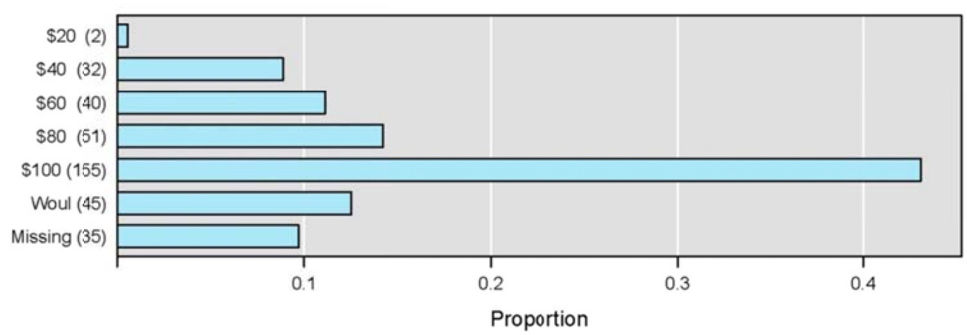
19.) After paying all costs, at what level of profit level might make you consider growing specially planted biomass crops such as switchgrass on low productivity or marginal lands? Please check the box of the lowest profit per acre that would be acceptable.

Profit Per Acre

☐$20 or more	☐$40 or more	☐$60 or more	☐$80 or more	☐$100 or more	☐ Would Not Sell

Results:

The profit variable was examined both with and without those who would not sell; this was done because perhaps only their willingness to sell was associated with interest, not the price. However, both were statistically significantly associated. In the plot below, the average price among those who would sell is shown; the table gives both the percent who would sell and the mean price for them.



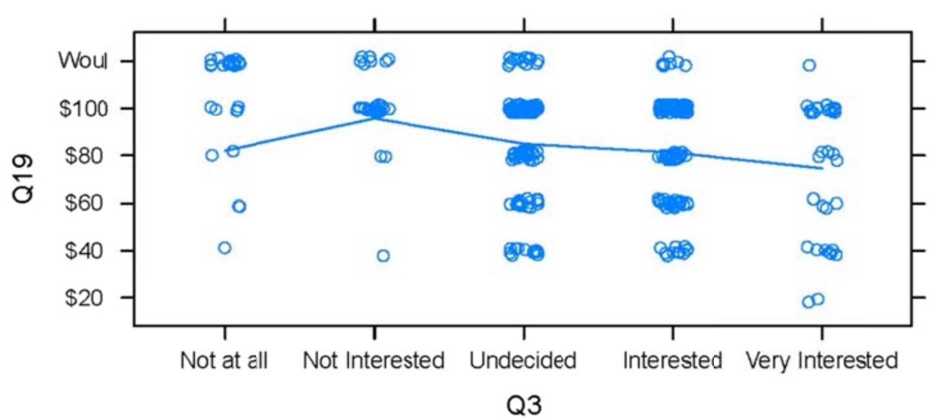


Table E3-1

	Gamma	sigma	lwr	upr	p.value
Q19.all	0.39	0.06	0.27	0.52	<12-04
Q19.priceonly	0.25	0.08	0.09	0.40	0.0017

Table E3-2

N	N	N.not	p.not	N.would	mean.would
Very Interested	34	1	0.03	33	74.55
Interested	104	7	0.07	97	81.24
Undecided	126	12	0.10	114	84.91
Not Interested	30	7	0.23	23	95.65
Not at all	27	17	0.63	10	82.00

Interpretation

Responses indicate that there may be some interest in biomass cropping on the part of producers. However, the majority indicated that a profit would have to be at least $100 per acre to get them interested. In a system averaging 4 tons per acre/yr, this would equate to a profit of at least $25 per ton. That would mean the biomass would likely cost more than $75 per ton after factoring in all costs. Obviously, there is a chance that higher yielding crops and reduced cost harvesting could bring the final biomass costs down. But $75 per ton would be too expensive for most facilities at this time.

4. Length of Biomass Purchase Contract

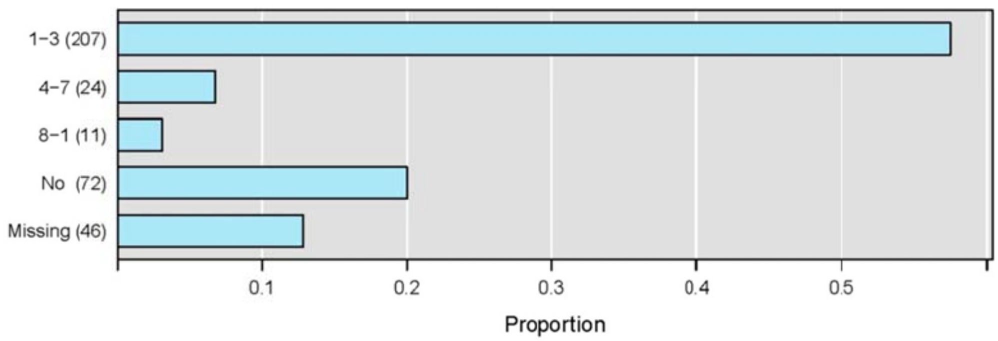
Collecting and using biomass for energy or other applications would likely involve a substantial outlay of capital for equipment and facilities. Therefore, both on the consumer and supplier side there has been discussion of long term contracts to ensure a dependable supply and market to provide long term stable funding. This question asked producers what length of contract they would prefer to enter into.

Question:

9.) Say you were to sell biomass and had the option to sell it under a biomass supply contract for a specified price, what length of contract would you prefer? Please check one.

☐No contract, spot market pricing	☐1-3 years	☐4-7 years	☐8-12 years

Results:



Interpretation:

The results show fairly conclusively that producers are much more interested in short term contracts (58%) or no contract (20%). This may be because on the farm side, the producers have equipment paid off or are not prepared to commit for more than a short trial period. This may change if they had successful dealings with facilities purchasing biomass.

F. Demographics

Demographic for the survey were relatively standard. Rather than age, the survey asked for the years spent farming. It also examined education, farm operation and scale, and location.

i. Overall Demographics Interpretation:

Though some patterns are discussed more detail on the following pages, the summary on this page has the key points.

The was a significant pattern of farmers with few years farming being more interested in biomass harvesting. Possible factors related to this pattern could be the less 'seasoned' producers need for additional income, higher levels of resilience and energy, and less resistance to change.

There was not any statistical correlation between education level and interest in biomass harvesting.

There were no significant differences in interest between the location of the farming operation. However, there was a noticeable trend that the northern zones had more interest in participation than the southern zones. Section F3 describes some statistical associates between location and perceived impacts.

The amount of land farmed (both total and owned) was not statistically associated with interest levels.

The presence of certain livestock did appear to be significantly associated with interest levels. Dairy producers were significantly less interested in biomass, while beef producers showed a trend towards increased interest. Hog production did not seem to be associated with interest in biomass harvesting.

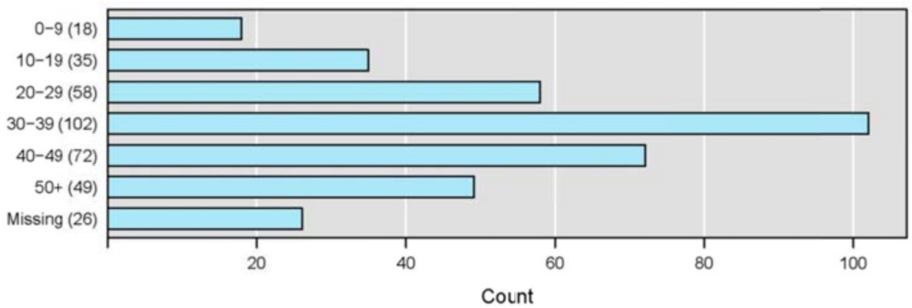
Grain production of common grains, corn, beans, wheat, was not associated with interest in biomass production. However, those having pastures were significantly more interested in biomass harvesting.

1. Years Involved In Farming

Question:

20.) How many years have you been actively involved in farming? ______

Results:



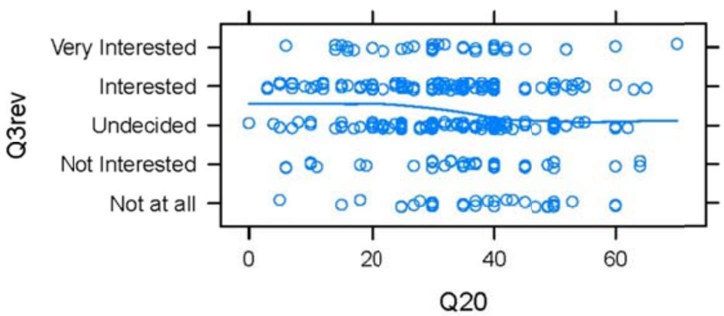


Table F1-1 **gamma for Interest and Time Farming**

	gamma	sigma	lwr	upr	p.value
Time Farming	0.16	0.06	0.05	0.27	0.0056

Table F1-2 **Interest averages for time farming categories**

Time farming (yr)	mean	se	lwr	upr	n	Percent(>=Int)
0-9	3.39	0.23	3.20	3.58	18	0.56
10-19	3.43	0.19	3.27	3.59	35	0.51
20-29	3.40	0.12	3.30	3.51	57	0.47
30-39	3.27	0.11	3.18	3.36	100	0.44
40-49	3.03	0.13	2.92	3.13	72	0.29
50+	3.04	0.16	2.91	3.17	48	0.35

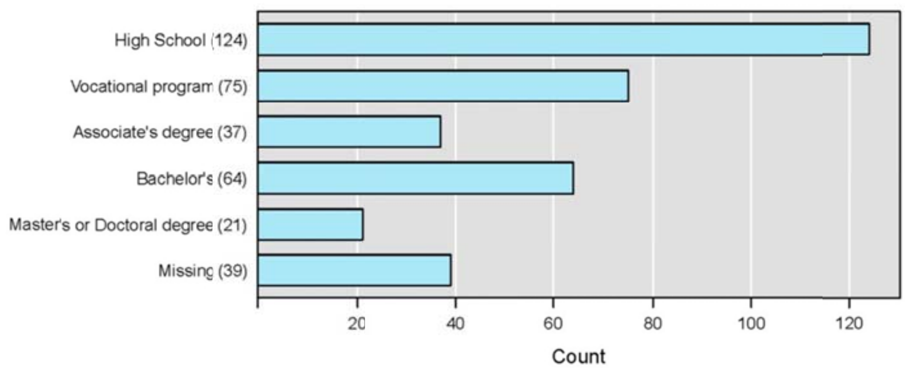
2. Educational Background

Question:

21.) What is the highest level of formal education/training that you have completed?

☐High school
☐Vocation program
☐Associates degree
☐Bachelor's degree
☐Master's or Doctoral degree.

Results:



Education was not statistically significantly associated with interest level.

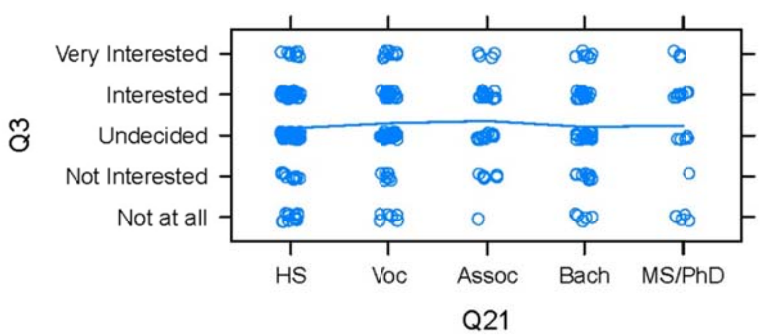


Table F2-1 **Gamma for Interest and Education**

	gamma	sigma	lwr	upr	p.value
Q21	-0.03	0.06	-0.16	0.09	0.59

Table F2-2 **Average Interest by Education Level**

	mean	se	lwr	upr	n	Percent(>=Int)
High School	3.17	0.09	3.09	3.25	122	0.39
Vocational program	3.30	0.13	3.19	3.40	74	0.43
Associate's degree	3.35	0.16	3.22	3.49	37	0.46
Bachelor's	3.21	0.14	3.09	3.32	63	0.40
Master's or Doctoral degree	3.24	0.29	3.00	3.48	21	0.52

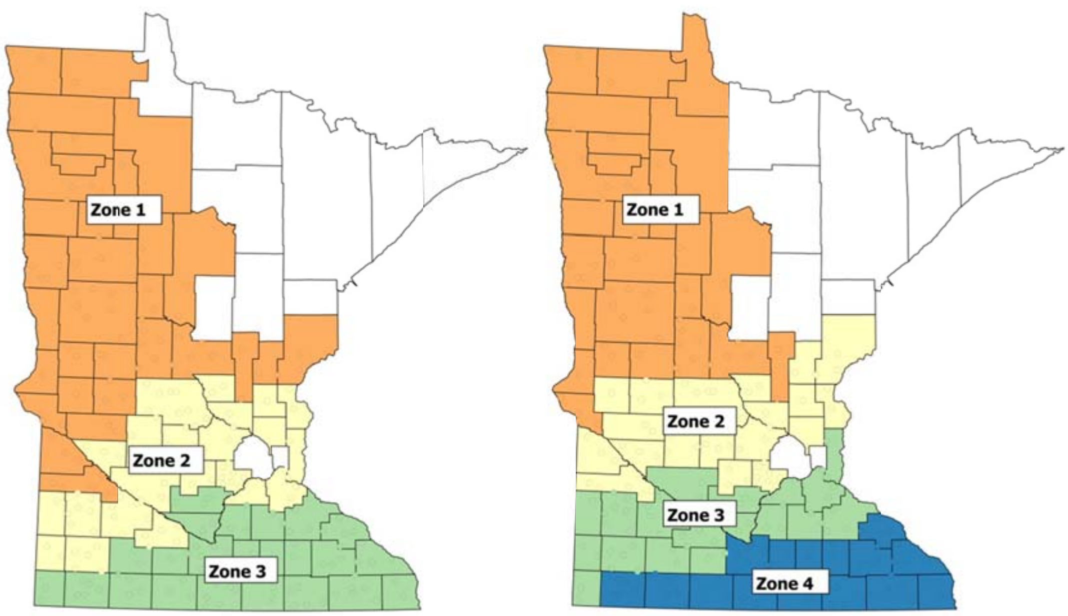
3. Location of Operation

Question:

22.) In what zip code is the largest part of your farm operation located? ___________

Results:

Zone Maps For Minnesota Based on Three and Four Zones.



Three Zone: Number of participates

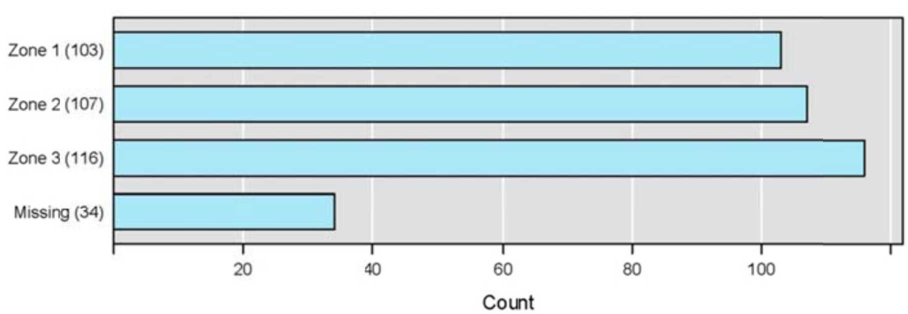


Table F3-1 **Average Interest by Zone (3 zone layout)**

	mean	se	Lwr	upr	n	Percent(>=Int)
Zone 1	3.31	0.11	3.22	3.40	100	0.46
Zone 2	3.32	0.09	3.25	3.40	105	0.44
Zone 3	3.06	0.10	2.98	3.14	116	0.34

Four Zone: Number of Participants

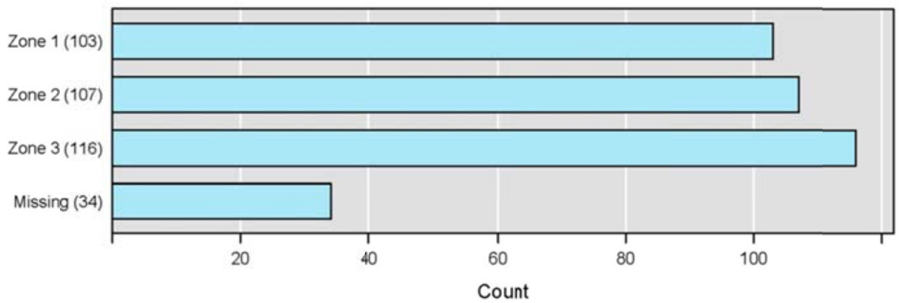


Table F3-2 **Average Interest by Zone (4 zone layout)**

	mean	se	Lwr	upr	n	Percent(>=Int)
Zone 1	3.41	0.13	3.30	3.52	74	0.50
Zone 2	3.35	0.10	3.26	3.44	80	0.44
Zone 3	3.14	0.11	3.04	3.23	80	0.39
Zone 4	3.03	0.12	2.94	3.13	87	0.33

The relationship between zones and their concern about increased soil erosion, increased soil compaction, and decreased soil matter (from Question 13) was examined in more detail. The proportion from each zone who thought each factor would get worse was calculated and compared to those who thought it would stay the same or get better. The differences in these proportions were tested using a chi-squared test. The plot and table below show these proportions; the table also has p-values from the chi-squared test.

We see that there is a statistically significant difference between zones for soil matter concerns at 50% and 70% removal, with Zone 3 showing more concern than the other zones. We also see statistically significant differences at the 50% removal level for soil erosion and soil compaction; for these Zone 3 again show more concern, with Zone 4 also having high concern. As “statistical significance" is not all-or-nothing and our cutoff of 0.05 is traditional but arbitrary, we look at the other variables as well. They show similar patterns, which is suggestive of differences at those removal values as well, and supports a conclusion of differences between the zones.

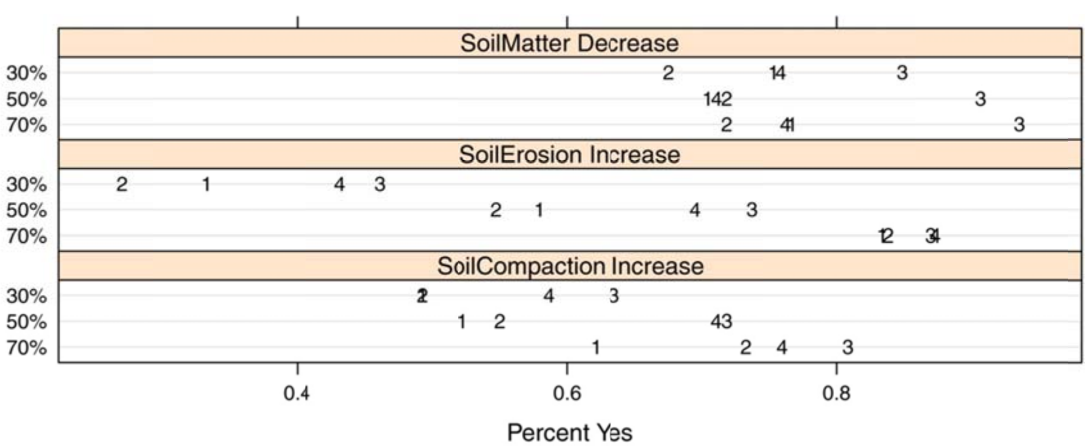


Table F3-3 Predicted Impacts by Zone (4 zone layout)

	Zone 1	Zone 2	Zone 3	Zone 4	p.value
30% SoilMatter Decrease	75.4%	67.6%	84.8%	75.9%	0.099
50% SoilMatter Decrease	70.4%	71.8%	90.7%	71.1%	0.008
70% SoilMatter Decrease	76.7%	71.8%	93.5%	76.3%	0.0051
30% SoilErosion Increase	33.3%	27.0%	46.2%	43.2%	0.0552
50% SoilErosion Increase	58.0%	54.8%	73.7%	69.5%	0.0467
70% SoilErosion Increase	83.3%	83.8%	87.0%	87.3%	0.8489
30% SoilCompaction Increase	49.3%	49.3%	63.5%	58.7%	0.2244
50% SoilCompaction Increase	52.3%	55.1%	71.8%	71.1%	0.0229
70% SoilCompaction Increase	62.1%	73.2%	80.8%	76.0%	0.0855

4. Farm Size and Scale

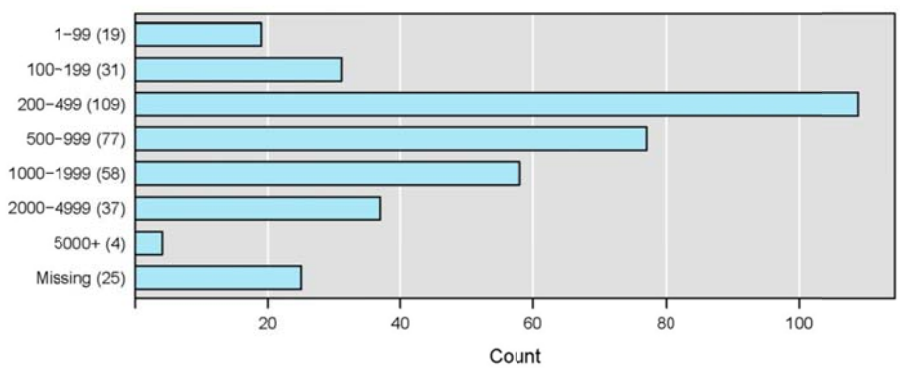
Questions:

23.) How many total acres do you manage (own and rent)?_____ Acres

24.) How many cropland acres do you own? _____ Acres

25.) How many cropland acres do you rent? _____ Acres

Results:



Total acres were not statistically significantly associated with interest level.

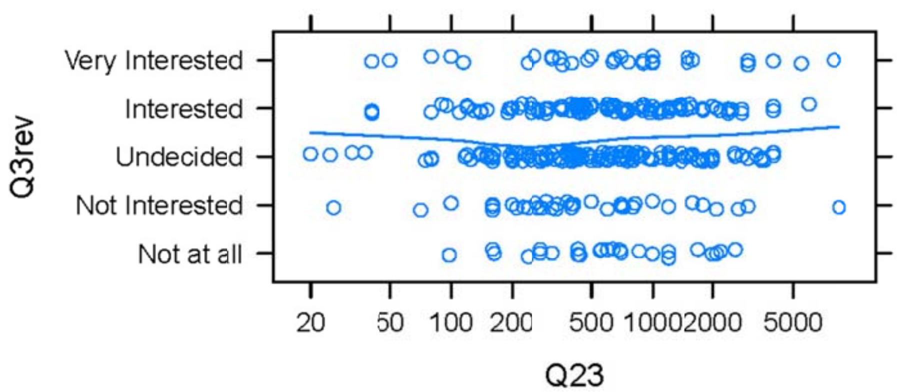


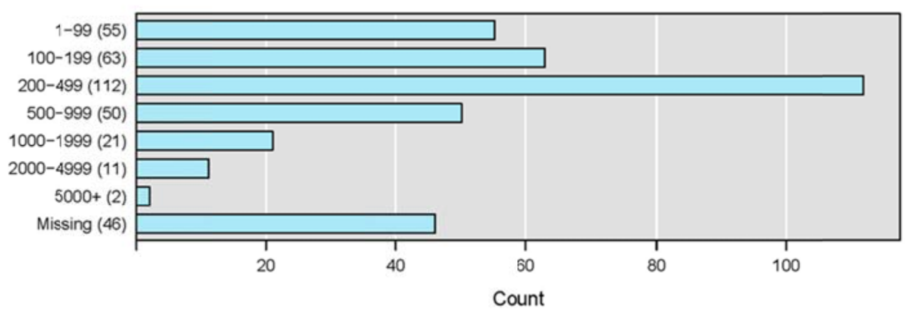
Table F4-1 **gamma for Farm Size**

	gamma	sigma	Lwr	upr	p.value
Q23	-0.06	0.06	-0.18	0.06	0.36

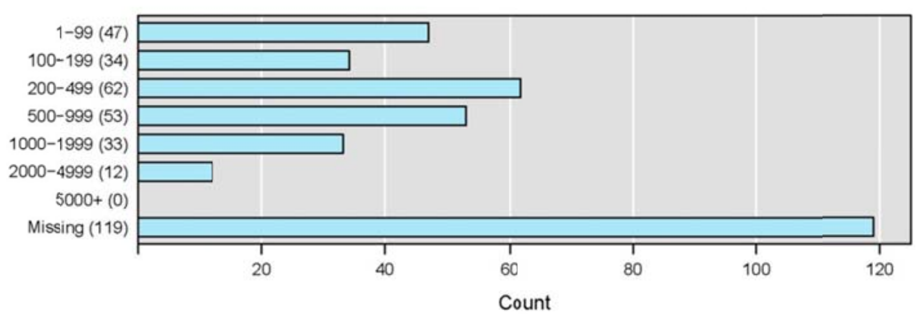
Table F4-2 **average interest for Q23**

	mean	se	lwr	upr	n	Percent(>=Int)
1-99	3.42	0.25	3.22	3.62	19	0.47
100-199	3.16	0.17	3.02	3.31	31	0.35
200-499	3.19	0.10	3.11	3.26	108	0.38
500-999	3.24	0.12	3.14	3.34	76	0.42
1000-1999	3.36	0.15	3.24	3.48	56	0.48
2000-4999	3.22	0.19	3.07	3.38	36	0.42
5000+	4.00	0.71	3.43	4.57	4	0.75

Acres Owned



Acres Rented

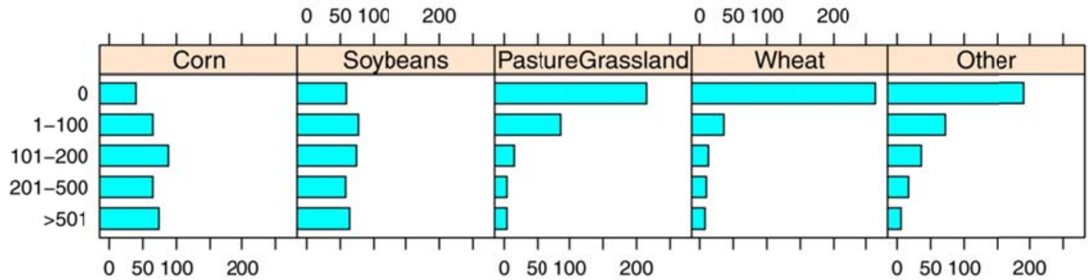


5. Crops Grown

Questions:

26.) On average, how many acres do you plant of the following crops/plantings?

Corn	___________	Wheat	___________
Soybeans	___________	Pasture/Grassland	___________
Other	___________		



The above plot shows how much of each crop the respondents had; to summarize, The percent (excluding those who did not respond) that had each crop was noted: Corn, 88%; Soybeans, 82%; PastureGrassland, 34%; Wheat, 20%; Other, 41%. Further analyses were done only using whether or not a respondent had a given crop, the number of acres was not used.

The relationship with interest for each of the five crops is shown. Note that individuals with more than one kind of crop are counted multiple times.

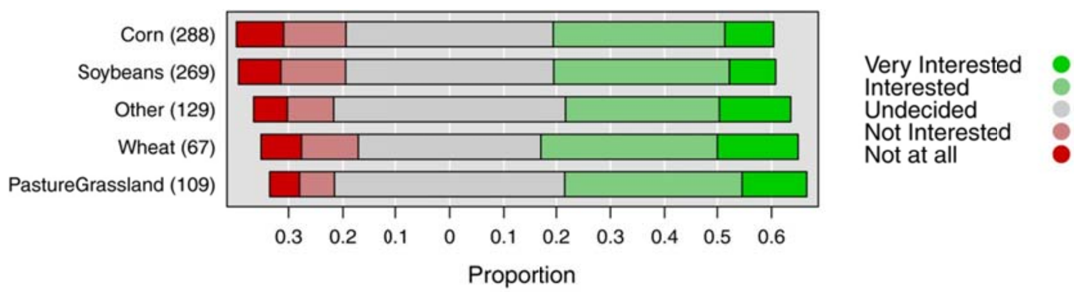


Table F5-1 Interest by Crop Grown

	mean	se	lwr	upr	n	Percent(>=Int)
Corn	3.21	0.06	3.16	3.26	288	0.41
Soybeans	3.22	0.06	3.17	3.28	269	0.41
Other	3.34	0.09	3.27	3.42	129	0.42
Wheat	3.37	0.13	3.26	3.49	67	0.48
Pasture Grassland	3.39	0.09	3.32	3.47	109	0.45

The possibility of multiple responses makes the analysis difficult; a separate analyses for each crop was the best option, comparing those that did have the crop with those who didn't. The table below shows the mean difference. That is, those with corn had an average interest of 0.16 less than those who did not. The difference with pasture is the only one that is statistically significant at the 0.05 level.

Table F5-2 Interest difference by Crop

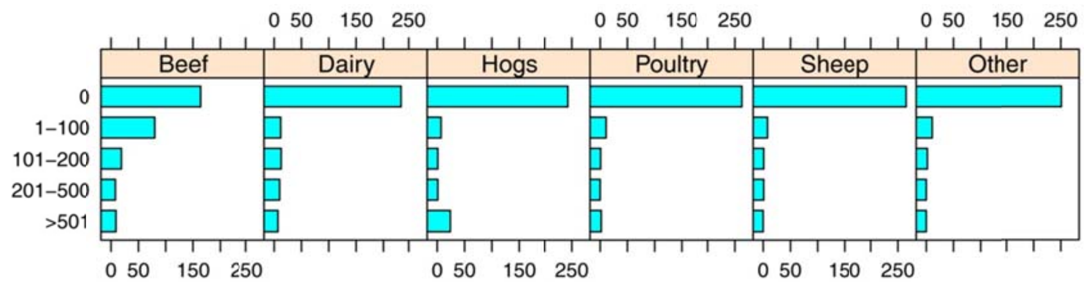
	Estimate	Std. Error	t value	Pr(>|t|)
Corn	-0.16	0.18	-0.92	0.3604
Soybeans	-0.05	0.15	-0.32	0.7516
Wheat	0.18	0.14	1.25	0.2120
Pasture	0.26	0.12	2.07	0.0396
Other	0.22	0.12	1.87	0.0627

6. Livestock

Questions:

27.) How many head of the following livestock does your operation have?

Cattle (Beef)	___________	Hogs	___________
Cattle (Dairy)	___________	Sheep	___________
Poultry	___________	Other	___________



The above plot shows how much of each animal the respondents had; to summarize, the percent (excluding those who did not respond) that had each animal was noted: Beef, 41%; Dairy, 15%; Hogs, 12%; Poultry, 5%; Sheep, 4%; Other, 5%. Further analyses were done only using whether or not a respondent had a given animal, the number was not used. First, the relationship with interest was shown for each of the six animals. Note that individuals with more than one kind of animal are counted multiple times.

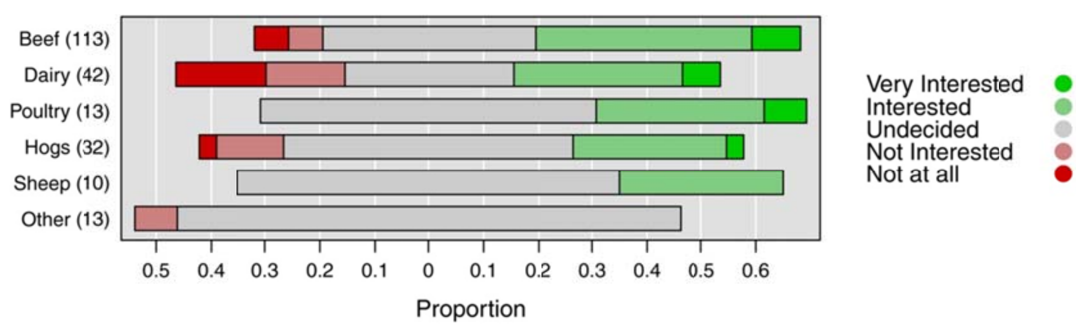


Table D6-1 Interest by Livestock Type

	mean	se	lwr	upr	n	Percent(>=Int)
Beef	3.39	0.09	3.31	3.46	113	0.487
Dairy	2.98	0.19	2.82	3.13	42	0.381
Poultry	3.46	0.18	3.31	3.61	13	0.385
Hogs	3.16	0.14	3.04	3.27	32	0.313
Sheep	3.30	0.15	3.17	3.43	10	0.300
Other	2.92	0.08	2.86	2.99	13	0.000

Again, the possibility of multiple responses makes the analysis difficult; as in the crop question, separate analyses were done for each crop, comparing those that did have that animal with those who did not. The table below shows the mean difference. (Only those with > 15 are shown.) That is, those with dairy animals had an average interest of 0.34 less than those who did not.

Table D6-2 Interest Difference by Livestock Type

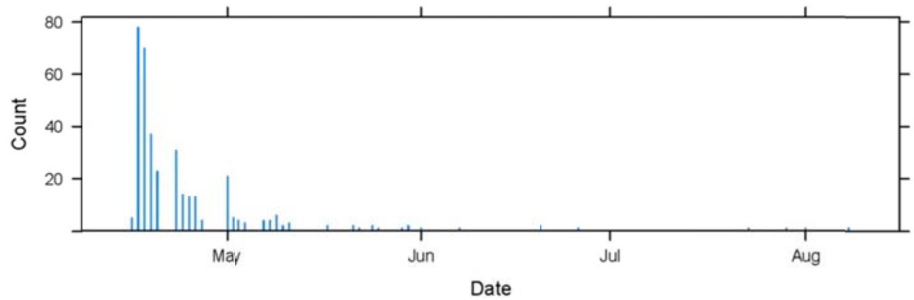
	Estimate	Std. Error	t value	Pr(>|t|)
Beef	0.20	0.13	1.61	0.108
Dairy	-0.34	0.17	-1.99	0.048
Hogs	-0.13	0.20	-0.65	0.514

7. Date Survey Response Received

One indirect method of examining statistical bias is analyzing factors such as when the survey was received.

Results:

Most of the surveys were received in the first few weeks, but a few trickled in over the next couple months.



To test for difference in early vs. late responders, the responders were divided into those who responded in the first two weeks (received by Monday of the third week, May 1) and those who responded later (received May 2 or later). There were 51 late responders, 14.%. The analysis examined difference in interest (Q3), knowledge (Q1), years farming (Q20), education (Q21), zone (Q22), and acres (Q23–Q25), and none had a statistically significant relationship with response time.

Table D7-1 **Response time and knowledge**

	Not.Late	Late
Strongly Agree	27	0
Agree	122	23
Neutral	102	18
Disagree	40	9
Strongly Disagree	7	1

Interpretation:

Though not statistically significant, it is interesting to note that all the individuals who strongly agreed that they had a good understanding of biomass issues (in Q1) were early responders.

Comment Recorded From Survey Questions 6 & 28

Two questions on the survey asked for feedback from the respondents. The feedback received on the questions is below. A few responses brought up issues that had not been discussed in section I or II of this report and are highlighted in yellow.

6.) Please list any other factors and how important they would be in your farm's decision whether or not to participate.

*I would consider leasing non-crop land for biomass production if it didn't degrade the environment and improved wildlife habitat. A commercial enterprise who managed the processes is the bester answer to me.

*Return on time and investment- not willing to do for nothing, previous markets (UMM) and cvec have not been sufficient

*A Biomass market needs to be around long term. Direct competition with fossil fuels is a mistake. You can never compete with natural gas. You have to market a "better" product to justify the price.

*Additional Machinery Cost

*Long Term commitment

*organic matter loss to soil

*More information needed

*I don't have any harvesting at all. I put in wildlife blend several years ago its great.

*Soils need crop residue to maintain organic matter

*organic matter is more important to me than $50 an acre

*Cost, labor, soil management

*I can contract a profit on my corn and beans right now with existing equipment. Needs to be profitable. Also -> major issue is how to transport biomass and store it. Distance to processor.

*We have cattle and use corn stalks ourselves. I have no interest in removing additional organic matter from my fields.

*"important-currently using corn/soybean stover for livestock

*very important- exposure to erosion and effects on soil structures"

*bailing, storing, hauling bales. Equipment costs. Weather is rarely cooperative for this in the fall.

*ease of managing multiple field sites that are small and not capable of other agromic crops

*Dairy operation-currently use most of stover from crops

*"increase labor and equipment changes

*timely baling and removal"

*"better use of highly erodible land

*diversification of income"

*I think it is a terrible idea, we need to conserve our soil

*We seem to have trouble with biofuels

*sale of product

*trucking of product

*I would like to buy state woods next door (flat) for hybrid trees or prairie grass for a Bio Baler if possible.

*organic matter loss and soil erosion caused by lack of soil cover may be worth more than $50.00/ ac.

*We already use most of the corn stover for bedding for our livestock operation.

*If they would work into a rotation with our other crops

*We use all of our corn acres for the dairy operation but have a lot of rough acres for grass or wood

*So far I haven't seen any numbers on transporting and storage of biomass, that are sustainable anyway.

*probably not every year on every field because it would adversely affect organic matter

*The loss of organic material from the soil.

*Will not work

*Don't need more work

*Who would transport material?

*Location- how far to haul

*what's equipment need and cost of it.

*Cost of extra equipment

*The reduction of organic matter lost of harvested to maintain soil tilth, nutrients, etc.

*Returning organic matter back to the soil

*How long are contracts

*probably not interested want to keep stover on field

*How would affect soil organic matter and soil structure and soil erosion.

*the price would have to justify the work/harvest and trucking to get it to the nearest plant.

*If biomass sold could make up for loss of blow down is one factor to consider.

*Transportation of biomass and proximity of processing

*organic matter taken away

*After selling off the crop residue year after year, I would not want to remove the organic matter from my soil.

*profitability-very important

*Timely removal of the biomass to insure fall tillage

*price of biomass…

*soil erosion- very important

*crop rotation or continuous corn?

*With dairy we need all biomass for feed or bedding.

*If good economics for area, creating jobs

*If done on CRP

*need if to maintain soil tilth

*having a processing plant close to my farm for ease of sale and delivery of products.

*longevity of biomass fuels- investment in equipment and time to repay

*most of are fields are pastured after harvest.

*Because I just have 15.8 acres of field I rent to a dairy farmer on 2/3-1/3 share agreement. He needs straw for his dairy here. I have him my share of straw, just to keep him as a willing renter. It would be next to impossible to get another renter due to small acerage

*how would it affect organic matter in the soil?

*Major factor would be additional equipment needed to harvest biomass

*I might retire soon so my answers may not be relevant

*profitable per acre

*salvage crop or is it main crop
*Would like to see about biomass. Have a meeting my place face to face about this.
*With no manure to apply on fields, removal of the stover is a huge factor to me.
*1) Determine an accurate value of nutrients lost in harvested biomass.
*2)Equipment costs to harvest biomass
*Have soil testing done to determine type of biomass grown.
*Soil and water conservation wants trash. Fertilizer loss
*added equipment needed
*Loss of organic matter
*Ability to still get fall tillage done. Cost to replace organic matter and nutrients
*We rent what tillable acres there are
*At this time biomass is important for fertilizer also
*would like to understand things better
*Net Income
*How far to market
*How far is it to a market place?
*Doesn't address energy issues, shifts to production of fertilizer and trasportation of biomass exceed value of energy gained
*We have livestock and most of these potential crops are used for them
*My ground is very sandy. I need to return biomass to soil to keep organic matter
*Simplicity and freedom to market myself
*Ground I farm is not as high producing (sandy) as heavy ground
*We care highly about soil quality. We do not want to hurt future yields by harvesting biomass.
*delivery location and methods
*It could not interfere with producing enough forage etc for my beef operation

28.) Are their other issues or comments you have regarding agricultural biomass harvesting that you feel should be addressed?

*Cob collection needs to be delinked to harvesting

*completed contract with Minn. Power in Hybrid Tree production. Not very favorable. Would consider production again but would need partnership with power plant or other to make it work. Sale of timber was not profitable.

*- Look at "lessons learned" from past projects such as jerusalem (SP) artichokes etc."

*"Counter Party Risk (who you contract with, quality, viability of the intended use preferably without govt. subsidy.

*I don't think many people realize how hard it is to bale cornstalk in the fall. Some years you only have a few hours to do it, in the dry years its easier. It is hard if you want to put up dry cornstalks. Many years that is the biggest problem. Not sure if you want wet stalks, but then they will heat. I would say 1/2 the years are very hard to make good cornstalk bedding. Also it is very hard on equipment. A lot of dirt comes with baling cornstalks which is hard on balers and biq square balers have many more moving parts and are expensive. They are easier to haul. Hauling cornstalks and storing them is a very big job. I doubt if any grain farmers would take this on.

*Need to discuss best biomass product that could be grown in clay soil of North Itasca county

*Are you considering livestock manure as a replacement for the biomass harvested off fields.

*How far or close would these plants be. What's the after waste to this. Is it ash or manure?

*Added road traffic and heavy loads on roads.

*If I were to plant a crop for biomass harvesting, I would like to be able to insure it.

* We looked into it w/ UMM and CVEC, but the juice wasn't worth the squeeze. We can't spend a bunch of time and money w/ no significant return. Some people can afford to sacrifice to "get in on the ground" floor or do charity work but we can't.

*If farmers see long term profit potential, we will invest all necessary resources to capture that, especially regarding corn stover or cobs, as the grain we raise is already highly profitable and a mature, liquid market exists, which is not the case with switchgrass for example.

*If it is profitable, there will be growers.

*I feel the stover from corn and soybeans should be baled as the crop is being harvested. Combine should pull baler.

*I don't believe in mining the soil

*It's a great idea. I don't farm my land, and when I put the wildlife blend in it was great. Now my weeds are controlled and the deer and birds really like it.

*Local communities could contribute yard waste, branches, lawn clippings, etc.

*I don't like seeing everything getting taken off our fields unless it is getting replaced.

*long term effects on the soil

*Is there a nutrient imbalance in a system that removes 50 to 70% of crop residue to be used for production of energy and other bioproducts vs the "old" system of returning those residues to the soil. If there is net loss how long can our current replacement of these nutrients via commercial fertilizer last? I have a neighbor who has been removing close to 100% residue every year and claims his organic matter levels haven't dropped. What about his soil structure/erosion potential, microbes and bacterial health? I think these issues also need to be addressed.

*Crop sharing with intended livestock feed excess production sold as biomass

*Tile lines plugged with grass roots this will not work with tiled land. Any tiler knows this, why not you guys?

*To be profitable a biomass program should not be tied to government subsidies and DNR interests. I was involved in a start up biomass program and immediately they completely to DNR proposed switchgrass type model completely ignoring crop residue models that would be profitable without government money. I never went back to any meetings after that.

*If I sell it, they better bale it and take it within 3 days of harvest or I won't wait to spread fert and do tillage. I would only sign a contract if I was released of the contract if they did not come and take it. Time is of the essence in the fall.

*- Variability in fossil fuel costs (Sub $2 nat. gas may slow development.

*- storage, handling, infrastructure costs for biomass appear to be underappreciated.

*It is a bad idea. Put the organic matter back in the soil, unless your harvesting grass land as grass hay.

*No CRP acres should be allowed for biomass production

*Is this really cost effective?

*It would manage CRP and other lands better. (i.e. less brush rodents-gophers, thistle)

*We are not interested because we use all of our biomass for cattle bedding and for feed. Great idea except for loss of ground cover (erosion problems)

*My hybrid poplar were planted for fiber production but now paper mills and chic board manufacturers are only looking for biomass. I would rather be producing for fiber use.

*concentrate on all the state land that is mis managed for hunting & income potential logging that is not being done. I see millions of dollars going to waste all the tops and cull logs could be used for biomass and all the boxelder and junk trees around farms could be used.

*How are you going to store? Fire Hazard?

*I harvest chopped and baled stalkage now for bedding because sawdust is high priced and scarce. I wish I could buy state woods recently clear-cut a few years ago for Bio-Baler situation

*I feel that nutrients and organic matter removed might affect soil quality over a period of time. The price of the biomass harvested would have to cover the cost of replacing these nutrients plus cover machinery and baler costs and still have a decent profit.

*Time to get biomass harvested, stored, shipped, and marketed on top of grains, vegetables, and hay.

*There must be a market and it must be competitive with current markets.

*Biomass is a big joke. Farmland for Food

*Don't need another thing subsidized by the government

*The host of straw and stover plow down would concern me. This material is important for microbe activity, aeration, compaction and the maintenance of healthy living soil. To be able to rotate 6-8 years of switchgrass into the kow crop acres would be good for the soil, disease control and weed resistance, and wildlife habitat.

*I don't know much about it, so I really can't say

*I feel the negative effects of biomass harvesting far outweigh any advantages. If biomass harvesting was profitable, fertilizer prices would increase, operational costs to maintain equipment would increase, soil quality would be eroded due to the removal of soil nutrients(impossible to replace commercially), and most importantly, wildlife habitat would be greatly impacted.

*Geterdone

*cost/sales market

*labor supply

*Nutrient replacement is a big issue

*I think the overall cost would be too high.

*We use our stover as primarily bedding and some feed in our beef operation. Harvest 80+ acres at 50 to 75% removal. It does affect soil tilth and structure, less O.M. means less micro-organisms working in soil I think. Fertilizer can't replace that.

*price per acre

*Haven't put much thought towards it.

*cost and fuel requirements for all operations related to harvest and disposal of spent biomass.

*Northern MN has a large number of acres coming out of CRP, best use for some of this land would be producing biomass while having a cover on the land that is not disturbed by tillage. Some is marginal, highly erodible but can produce good levels of biomass. Grass, willow reeds, cattails etc. I have mowed some as a tall as the tractor cab at times. Need a return per acre exceeding CRP or plus CRP pmt as some of this will not get back in CRP program. Need an incentive.

*Cost of moving biomass to processing plant.

*We were in the commercial hay business for 15 years, raising up to 650 acres of alfalfa. Transportation and storage quality

*We are having a real hard time acquiring animal manures as fertilizer for the demand in Biomass operation. So, instead of utilizing locally produced fertilizer we are forced to purchase foreign produced petroleum based products for fertilizer. This is a REAL large problem in central MN.

*I won't do biomass

*The difficulties in harvesting and transporting large quantities of quality biomass

*Probably, I really need to study more the long term effects on our biomass.

*I have been a no-till, strip till operation for 10 yrs and have seen my organic content triple. The benefits from that are immeasurable. I believe most farmers and the public has no idea how valuable organic matter is too a healthy soil, or more would do things differently!

*Cost of fertilizer varying will determine how much stover can be removed.

*Using CRP for growing biomass rather than non CRP

*would deplete the soil, add to the erosion

*biomass should not be harvested in large quantities.

*I agree with the concept but for my operation it is not a practical alternative because of my small acreage.

*I feel that biomass is a great fuel source and should be used to the maximum that it is available. I feel it would be a great addition to fuel for our country.

*Time management in the fall during harvest and stored and transportation.

*We are retiring and not at all interested

*CRP should be used to an advantage for farmers to give a % back and harvest utilize to an advantage.

*If biomass harvesting can be completed in a timely manner to allow tillage in fall and profitbale, would be willing to participate.

*Corn stalk take a lot out of the ground.

*I think in our area of the state most years it would be hard to get corn stover dry enough to bale without molding.

*Don't know how much about it yet. Need to learn a lot more about it. Not sure if I should have even answered this survey!

*Water. I have good land which should be in corn, soybean, alfalfa production but needs tile which I've been doing to raise food. What I don't understand is why we the U.S. lets it run down the river. We need to tile to farm our good land but why we let it all run down the river and flood towns makes no sense. We need to address this now before it's too late. Then biomass trees and grass are okay but takin trash off corn and soybean fields is counter productive. I wish people would shut their lights off our cities are light up I've driven by football and baseball fields and blinded. No shit.

*No, Not at this time. Would have a good outlet for extra corn stover what is hard to deal with the fatter years.

*Ability to complete work based on weather.

*transportation and storage

*Soy is not a wise choice because of its energetic properties. Industrial hemp is the best self-renewable source, Sunflowers area good chance if managed properly.

*Left over or rained on hay

*cost of transportation

*HEL government won't let you take off residue on the slopes of southeastern MN. Would increase erosion. Not good for the land and Mississippi River which is 6 miles away.

*Guaranteeing future sales. Don't want to invest in change that is not worth it due to short profit potential

*Farming is high input and high risk, It would have to be profitable and plants would seem to have to be small and numerous to reduce freight which would be very expensive.

*Custom harvesting opportunities

*when you burn manure or other organic matter it is gone

*Biomass being used for energy will increase our costs for feeding and bedding our livestock. We have already experienced this on our farm.

*We use our stalks as bedding and roughage

*Storage requirements

*The quantity of energy produced has to be greater than the product taken from the land

*You have covered a lot of bases. Generally we are not interested in removing corn stover from our fields because we remove so much with corn silage.

*need to have a reliable market and stable price

*We probably would not sell corn stalks/ bean stover/ barley straw. We use it for our livestock bedding. If we had extra, the price of biomass would have to be higher than we could get by selling to local livestock farms for hay or bedding. Would maybe consider harvest of fast growing trees on some very marginal land, but it would only be probably 5 acres. Would also maybe consider biomass harvest on a double-crop planted after combining barely/bailing the straw for our use. Has sorghum been looked into for this kind of purpose?

County Biomass Supply Supplemental Modeling Data

Compilation and Interpretation:

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56267

Table of Contents

Introduction:

This appendix has the primary modeling results and data used for the work in Section 2. The methodology and formulas to obtain these results are listed in Section 2. The results show the 'raw' data used to calculate total county and regional biomass amounts. As with appendix B, this is not meant as a stand-alone document, but to provide additional information for those interested in methodology used for Section 2.

Interest Levels

Low	43.75%	Interested & very interested
High	56.25%	Interested, very interested, and half of undecided

The high and low producer interest calculations are determined by the count of different interest levels in the given radius. The formulas for this were:

$$(5) Low\ Participation = \frac{Very\ Interested + Interested}{Total\ Responses}$$

$$(6) High\ Participation = \frac{Very\ Interested + Interested + ((½)\ Undecided)}{Total\ Responses}$$

County Biomass Models

Minnesota		Percent of					
County	AREA (sq m)	Area in Radius (Acres)	County in Harvested Corn	Harvested Corn Acres	Corn Yield bu/acre	Tons Per Acre	Total Stover Produced Tons

These data tables model the amount of biomass in each county and portion of the county making up the radius of interest (50 or 70 miles) in the supply zone. The GIS software supplies the area of each county making up the given radius, then the spreadsheet calculates the total biomass. USDA data is used for percent of county in corn and yield, for this work, the data from the 2011 harvest was used.

Some of the information used in the table:

- <u>County-</u> County Name (border states with the same county name had a state code added)
- <u>Area-</u> Area of the county inside the radius in sq. M
- <u>Area in Radius-</u> Area of the county inside the radius in Acres
- <u>Percent of County in Harvested Corn-</u> percent of corn grain harvested for entire county
- <u>Total Acres of Corn Harvested</u> (in Radius)- Acres of county in radius that grain corn is produced on
- <u>Tons per Acre-</u> tons of stover per acre as determined by county grain yields from USDA data

GIS Area Calculation

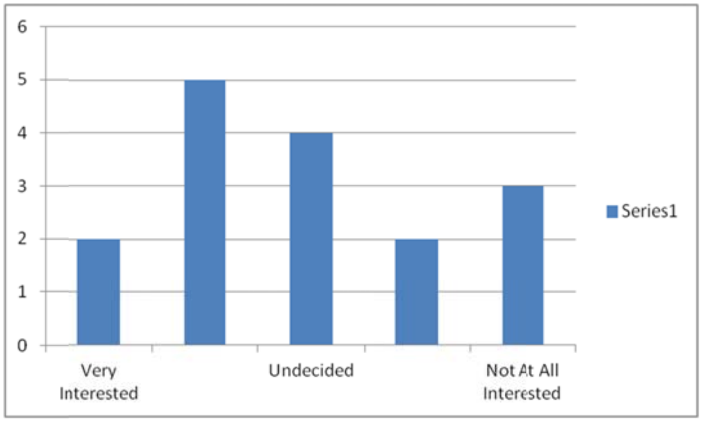
GIS County Area Calculation Accuracy	
Radius	70
Total from GIS	9,850,195
Total in Radius (pi * R^2 *640)	9,852,035
Percent Error in Coverage	-0.02%

As an extra step to verify results, this check adds up the calculated acres from each county that are included in the radius. This number is compared to the total number of acres as determined by the mathematical formula for area in a circle with a given radius. There is a chance that the GIS software or data entered may have put an error in the total acres for each county. Examining the difference between the two is a way to make sure that no errors were introduced during the complex calculation of area that the GIS software performs.

1. Ada Supply Region Data

A. 50 Mile Radius

Number of surveys received from within radius that had a valid response for interest level was 16



Estimate	Percentage Interested	Groups included
Low	43.75%	Interested & very interested
High	56.25%	Interested, very interested, and half of undecided

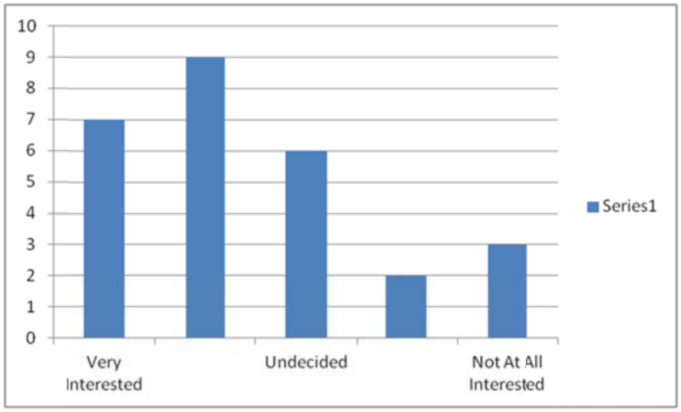
Contribution of Individual Counties to Corn Stover Biomass Available in Supply Radius							
Minnesota							
County	**AREA (sq m)**	**Area in Radius (Acres)**	**Percent of County in Harvested Corn**	**Harvested Corn Acres**	**Corn Yield bu/acre**	**Tons Per Acre**	**Total Stover Produced Tons**
Becker	2065125770	510,303	4.583%	23,389	121.5	3.402	79,569
Clay	2728911067	674,328	16.832%	113,500	113.7	3.1836	361,339
Clearwater	295295698.3	72,969	0.364%	266	104.2	2.9176	776
Mahnomen	1511225644	373,431					
Norman	2272876629	561,639	13.140%	73,800	117.8	3.2984	243,422
Otter Tail	172644090.6	42,661	10.211%	4,356	132.8	3.7184	16,198
Pennington	117213883.7	28,964					
Polk	3978413335	983,086	4.712%	46,326	124.6	3.4888	161,623
Red Lake	891114520.3	220,199	5.053%	11,127	120.7	3.3796	37,605
Wilkin	206137640	50,938	18.661%	9,506	120.9	3.3852	32,179
	Total	**3,518,518**		**282,270**			**932,710**
Border States							
Cass_ND	2963710570	732,348	18.175%	133,101	101.6	2.8448	378,646
Grand Forks	645311493.5	159,460	8.428%	13,440	101.5	2.842	38,196
Richland	19612514.27	4,846	28.172%	1,365	96.4	2.6992	3,685
Steele_ND	261881757.9	64,712	14.707%	9,517	110.9	3.1052	29,553
Trail	2227627434	550,458	16.603%	91,393	108.1	3.0268	276,628
	Total	**1,511,824**		**248,817**			**726,709**
	Grand Total	**5,030,342**	**Acres Corn-->**	**531,817**		**Total Tons -->**	**1,659,420**

GIS County Area Calculation Accuracy	
Radius	50
Total from GIS	5,030,342
Total in Radius (pi * R^2 *640)	5,026,548
Percent Error in Coverage	0.08%

B. 70 Mile Radius

Number of surveys received from within radius that had a valid response for interest level was 27

Estimate	Percentage Interested	Groups included
Low	59.26%	Interested & very interested
High	70.37%	Interested, very interested, and half of undecided



Contribution of Individual Counties to Corn Stover Biomass Available in Supply Radius

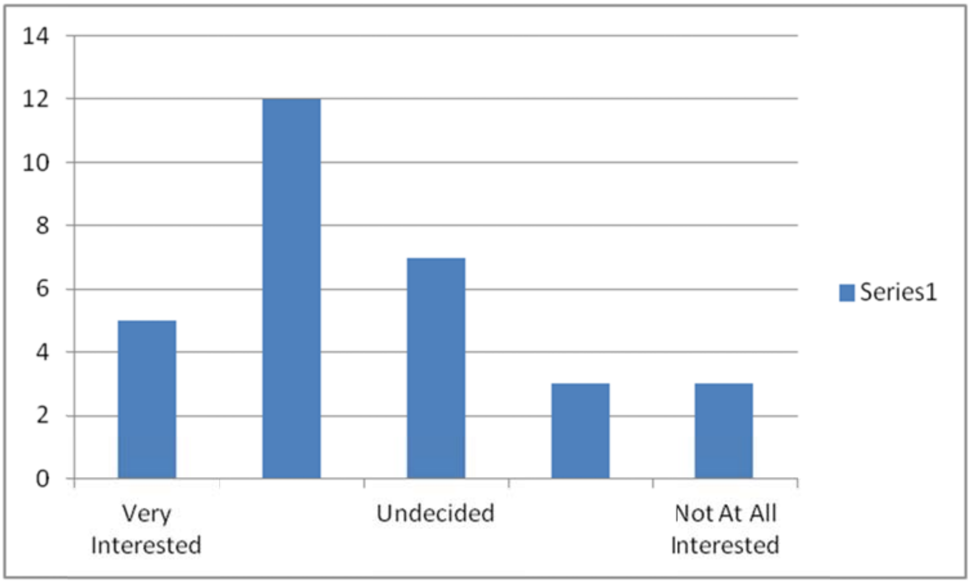
Minnesota County	AREA (sq m)	Area in Radius (Acres)	Percent of County in Harvested Corn	Harvested Corn Acres	Corn Yield bu/acre	Tons Per Acre	Total Stover Produced Tons
Becker	3664605532	905,542	4.583%	41,504	121.5	3.402	141,197
Beltrami	307561367.5	76,000					
Clay	2728911067	674,328	16.832%	113,500	113.7	3.1836	361,339
Clearwater	2490071391	615,309	0.364%	2,241	104.2	2.9176	6,540
Hubbard	503205729.7	124,345					
Mahnomen	1511225644	373,431					
Marshall	1113748138	275,213	1.051%	2,892	114.5	3.206	9,272
Norman	2272876629	561,639	13.140%	73,800	117.8	3.2984	243,422
Otter Tail	2213423542	546,948	10.211%	55,850	132.8	3.7184	207,672
Pennington	1547365153	382,362					
Polk	5178440192	1,279,618	4.712%	60,300	124.6	3.4888	210,375
Red Lake	1121201994	277,055	5.053%	14,000	120.7	3.3796	47,314
Wilkin	1227775364	303,389	18.661%	56,617	120.9	3.3852	191,659
	Sub-total	**6,395,179**		**420,704**			**1,418,789**
Border States							
Barnes	969867328.5	239,659	10.264%	24,598	110.6	3.0968	76,176
Cass_ND	4578759938	1,131,434	18.175%	205,634	101.6	2.8448	584,986
Grand Forks	2650288605	654,900	8.428%	55,198	101.5	2.842	156,872
Griggs	48142532.42	11,896	5.001%	595	108.7	3.0436	1,811
Ransom	329996009.1	81,544	12.579%	10,258	116.6	3.2648	33,489
Richland	1388524609	343,111	28.172%	96,662	96.4	2.6992	260,911
Steele_ND	1797253864	444,110	14.707%	65,316	110.9	3.1052	202,818
Trail_ND	2237547168	552,909	16.603%	91,800	108.1	3.0268	277,860
	Sub total	**3,459,564**		**550,060**			**1,594,923**
	Grand Total	**9,854,743**	**Acres Corn-->**	**970,764**		**Total Tons -->**	**3,013,712**

GIS County Area Calculation Accuracy	
Radius	70
Total from GIS	9,854,743
Total in Radius (pi * R^2 *640)	9,852,035
Percent Error in Coverage	0.03%

2. Fergus Falls Supply Region Data

A. 50 Mile Radius

Number of surveys received from within radius that had a valid response for interest level was



Estimate	Percentage Interested	Groups included
Low	56.67%	Interested & very interested
High	68.33%	Interested, very interested, and half of undecided

Contribution of Individual Counties to Corn Stover Biomass Available in Supply Radius

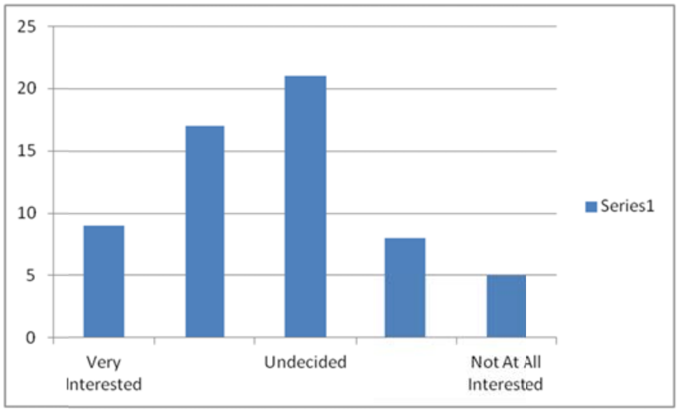
Minnesota County	AREA (sq m)	Area in Radius (Acres)	Percent of County in Harvested Corn	Harvested Corn Acres	Corn Yield bu/acre	Tons Per Acre	Total Stover Produced Tons
Becker	1661192133	410,489	4.583%	18,814	121.5	3.402	64,005
Big Stone	10066265.01	2,487	27.046%	673	110.8	3.1024	2,087
Clay	1578581381	390,075	16.832%	65,656	113.7	3.1836	209,022
Douglas	1702180209	420,617	12.647%	53,195	123.5	3.458	183,949
Grant	1491176569	368,477	27.763%	102,300	123.5	3.458	353,753
Otter Tail	5735003649	1,417,148	10.211%	144,708	132.8	3.7184	538,082
Pope	342044200.3	84,521	24.666%	20,848	136.3	3.8164	79,565
Stevens	825018900.3	203,866	33.492%	68,279	139.6	3.9088	266,890
Todd	308959895.7	76,346	9.525%	7,272	131.7	3.6876	26,815
Traverse	1253477523	309,741	35.685%	110,531	111.7	3.1276	345,698
Wadena	152815238.7	37,761	5.724%	2,162	125.9	3.5252	7,620
Wilkin	1947376319	481,206	18.661%	89,800	120.9	3.3852	303,991
	Total	**4,202,735**		**684,238**			**2,381,478**
Border States							
Cass_ND	176460665.7	43,604	18.175%	7,925	101.6	2.8448	22,545
Richland	2642493430	652,973	28.172%	183,957	96.4	2.6992	496,537
Roberts	521106249.5	128,768	18.997%	24,462	122.8	3.4384	84,110
	Total	**825,346**		**216,344**			**603,192**
	Grand Total	**5,028,081**	**Acres Corn-->**	**900,582**		**Total Tons -->**	**2,984,669**

GIS County Area Calculation Accuracy	
Radius	50
Total from GIS	5,028,081
Total in Radius (pi * R^2 *640)	5,026,548
Percent Error in Coverage	0.03%

B. 70 Mile Radius

Number of surveys received from within radius that had a valid response for interest level was 60

Estimate	Percentage Interested	Groups included
Low	43.33%	Interested & very interested
High	60.83%	Interested, very interested, and half of undecided



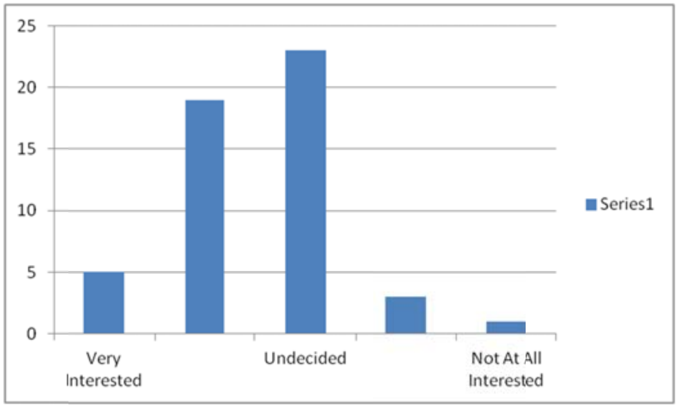
Contribution of Individual Counties to Corn Stover Biomass Available in Supply Radius							
Minnesota							
County	**AREA (sq m)**	**Area in Radius (Acres)**	**Percent of County in Harvested Corn**	**Harvested Corn Acres**	**Corn Yield bu/acre**	**Tons Per Acre**	**Total Stover Produced Tons**
Becker	3693138831	912,593	4.583%	41,827	121.5	3.402	142,296
Big Stone	1216594861	300,627	27.046%	81,306	110.8	3.1024	252,245
Cass_MN	344095304.3	85,028					
Clay	2728752218	674,288	16.832%	113,493	113.7	3.1836	361,318
Clearwater	73084227.68	18,059	0.364%	66	104.2	2.9176	192
Douglas	1865527010	460,981	12.647%	58,300	123.5	3.458	201,601
Grant	1491176569	368,477	27.763%	102,300	123.5	3.458	353,753
Hubbard	430796215.3	106,452					
Mahnomen	517071689.8	127,771					
Morrison	61016401.05	15,077	9.516%	1,435	143.6	4.0208	5,769
Norman	614196992.7	151,771	13.140%	19,943	117.8	3.2984	65,780
Otter Tail	5762435832	1,423,927	10.211%	145,400	132.8	3.7184	540,655
Pope	1780340342	439,931	24.666%	108,515	136.3	3.8164	414,135
Stearns	424184108.2	104,818	20.004%	20,968	137.9	3.8612	80,963
Stevens	1491043304	368,444	33.492%	123,400	139.6	3.9088	482,346
Swift	680703092.3	168,205	36.643%	61,635	154.1	4.3148	265,941
Todd	2358831605	582,879					
Traverse	1519622377	375,506	35.685%	134,000	111.7	3.1276	419,098
Wadena	1399863792	345,913	5.724%	19,801	125.9	3.5252	69,803
Wilkin	1947376319	481,206	18.661%	89,800	120.9	3.3852	303,991
	Sub-total	**7,511,955**		**1,122,189**			**3,959,887**
Border States							

Cass_ND	1836786855	453,879	18.175%	82,491	101.6	2.8448	234,670
Grant	7723250.897	1,908	27.763%	530	123.5	3.458	1,832
Marshall	303737348.8	75,055	1.051%	789	114.5	3.206	2,528
Ransom	688538159.4	170,141	12.579%	21,403	116.6	3.2648	69,875
Richland	3749191153	926,444	28.172%	261,000	96.4	2.6992	704,491
Roberts	2116972353	523,114	18.997%	99,375	122.8	3.4384	341,692
Sargent	768939907.4	190,009	18.503%	35,157	90.2	2.5256	88,794
	Sub total	**2,340,551**		**500,744**			**1,443,882**
	Grand Total	**9,852,506**	**Acres Corn-->**	**1,622,934**		**Total Tons -->**	**5,403,768**

3. St. Cloud Supply Region Data

A. 50 Mile Radius

Number of surveys received from within radius that had a valid response for interest level was 51



Estimate	Percentage Interested	Groups included
Low	47.06%	Interested & very interested
High	69.61%	Interested, very interested, and half of undecided

Contribution of Individual Counties to Corn Stover Biomass Available in Supply Radius

Minnesota County	AREA (sq m)	Area in Radius (Acres)	Percent of County in Harvested Corn	Harvested Corn Acres	Corn Yield bu/acre	Tons Per Acre	Total Stover Produced Tons
Anoka	596757894.1	147,462	2.350%	3,465	119.4	3.3432	11,584
Benton	1069360155	264,244	14.759%	39,000	109.1	3.0548	119,137
Carver	250076355.8	61,795	23.242%	14,362	154.8	4.3344	62,251
Chisago	6422232.164	1,587	9.433%	150	134.5	3.766	564
Crow Wing	540379721.2	133,531	1.081%	1,444	109.1	3.0548	4,411
Douglas	1845692.631	456	12.647%	58	123.5	3.458	199
Hennepin	761336595.2	188,130	3.144%	5,914	145.4	4.0712	24,078
Isanti	1017252369	251,368	10.803%	27,155	126.9	3.5532	96,488
Kanabec	656314131.7	162,179	3.604%	5,846	125.2	3.5056	20,492
Kandiyohi	1033612050	255,411	27.273%	69,659	150	4.2	292,569
McLeod	582936220.4	144,046	34.329%	49,449	146.6	4.1048	202,980
Meeker	1613181271	398,625	27.642%	110,189	144.6	4.0488	446,133
Mille Lacs	1498853453	370,374	3.924%	14,535	101.2	2.8336	41,186
Morrison	2771870191	684,943	9.516%	65,179	143.6	4.0208	262,070
Pope	145462356.8	35,944	24.666%	8,866	136.3	3.8164	33,837
Renville	6456975.838	1,596	40.291%	643	146.1	4.0908	2,630
Sherburne	1166963245	288,362	10.230%	29,500	144.9	4.0572	119,687
Stearns	3598880861	889,301	20.004%	177,900	137.9	3.8612	686,907
Todd	1149727397	284,103	9.525%	27,060	131.7	3.6876	99,787
Wright	1849493512	457,019	15.951%	72,900	145.6	4.0768	297,199
	Total	**5,020,477**		**723,273**			**2,824,189**
Border States							
No Area In Border States							
	Total	**0**		**0**			**0**

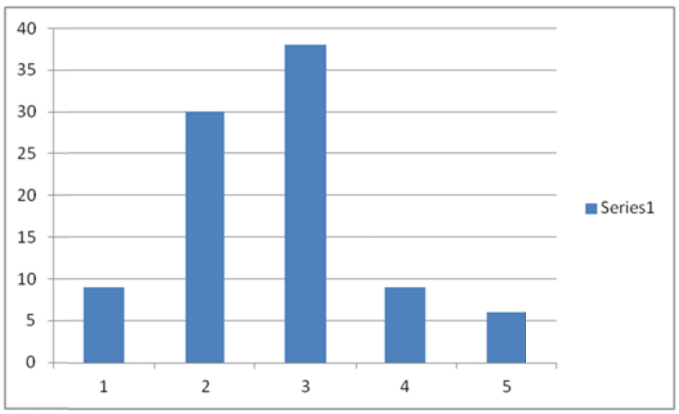
Grand Total	**5,020,477**	**Acres Corn-->**	**723,273**	**Tons Stover -->**	**2,824,189**

GIS County Area Calculation Accuracy	
Radius	50
Total from GIS	5,020,477
Total in Radius (pi * R^2 *640)	5,026,548
Percent Error in Coverage	-0.12%

B. 70 Mile Radius

Number of surveys received from within radius that had a valid response for interest level was 92

Estimate	Percentage Interested	Groups included
Low	42.39%	Interested & very interested
High	63.04%	Interested, very interested, and half of undecided



Contribution of Individual Counties to Corn Stover Biomass Available in Supply Radius

Minnesota County	AREA (sq m)	Area in Radius (Acres)	Percent of County in Harvested Corn	Harvested Corn Acres	Corn Yield bu/acre	Tons Per Acre	Total Stover Produced Tons
Aitkin	1345536477	332,489	--	--	--	--	--
Anoka	1153932761	285,143	2.350%	6,700	119.4	3.3432	22,399
Benton	1069360155	264,244	14.759%	39,000	109.1	3.0548	119,137
Carver	973339343.3	240,517	23.242%	55,900	154.8	4.3344	242,293
Cass_MN	750096610.4	185,353	0.000%	0	0	0	0
Chippewa	309614782.5	76,507	38.457%	29,422	155.1	4.3428	127,776
Chisago	1046010616	258,474	9.433%	24,382	134.5	3.766	91,824
Crow Wing	1834179917	453,235	1.081%	4,901	109.1	3.0548	14,973
Dakota	123129877.3	30,426	22.667%	6,897	175.6	4.9168	33,910
Douglas	1055143861	260,731	12.647%	32,975	123.5	3.458	114,026
Hennepin	1570499285	388,078	3.144%	12,200	145.4	4.0712	49,669
Isanti	1168776986	288,811	10.803%	31,200	126.9	3.5532	110,860
Kanabec	1380984505	341,248	3.604%	12,300	125.2	3.5056	43,119
Kandiyohi	2233137027	551,819	27.273%	150,500	150	4.2	632,100
McLeod	1308529982	323,344	34.329%	111,000	146.6	4.1048	455,633
Meeker	1668975804	412,412	27.642%	114,000	144.6	4.0488	461,563
Mille Lacs	1763364204	435,736	3.924%	17,100	101.2	2.8336	48,455

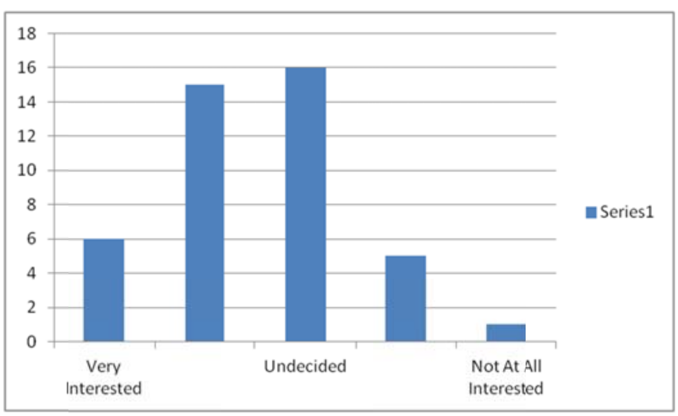
Morrison	2985421108	737,712	9.516%	70,200	143.6	4.0208	282,260
Otter Tail	200439809.3	49,530	10.211%	5,058	132.8	3.7184	18,806
Pine	955178418.8	236,029	1.417%	3,344	133.8	3.7464	12,530
Pope	1395796995	344,908	24.666%	85,076	136.3	3.8164	324,684
Ramsey	414186402.5	102,348	0.000%	0	0	0	0
Renville	1158912243	286,373	40.291%	115,383	146.1	4.0908	472,009
Scott	477527302.4	117,999	16.353%	19,296	162.8	4.5584	87,960
Sherburne	1166963245	288,362	10.230%	29,500	144.9	4.0572	119,687
Sibley	906666813.4	224,042	39.951%	89,506	159.1	4.4548	398,731
Stearns	3598880861	889,301	20.004%	177,900	137.9	3.8612	686,907
Swift	672718222.2	166,232	36.643%	60,912	154.1	4.3148	262,821
Todd	2494358568	616,368	9.525%	58,707	131.7	3.6876	216,490
Wadena	122574392.6	30,289	5.724%	1,734	125.9	3.5252	6,112
Washington	410790624.8	101,508	7.757%	7,874	178.4	4.9952	39,331
Wright	1849493512	457,019	15.951%	72,900	145.6	4.0768	297,199
	Sub-total	**9,776,591**		**1,445,867**			**5,793,262**
Border States							
Burnett	133174873.1	32,908	2.238%	737	118	3.304	2,434
Polk	119588578	29,551	4.712%	1,393	124.6	3.4888	4,858
	Sub total	62,459		2,129			7,292
	Grand Total	**9,839,050**	**Acres Corn-->**	**1,447,996**		**Tons Stover -->**	**5,800,553**

GIS County Area Calculation Accuracy	
Radius	70
Total from GIS	9,839,050
Total in Radius (pi * R^2 *640)	9,852,035
Percent Error in Coverage	-0.13%

4. Morris

A. 50 Mile Radius

Number of surveys received from within radius that had a valid response for interest level was 43



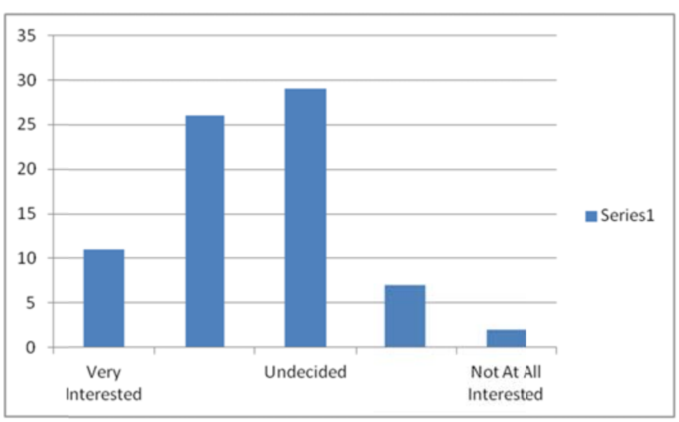
Estimate	Percentage Interested	Groups included
Low	48.84%	Interested & very interested
High	67.44%	Interested, very interested, and half of undecided

Contribution of Individual Counties to Corn Stover Biomass Available in Supply Radius							
Minnesota County	AREA (sq m)	Area in Radius (Acres)	Percent of County in Harvested Corn	Harvested Corn Acres	Corn Yield bu/acre	Tons Per Acre	Total Stover Produced Tons
Big Stone	1369122251	338,317	27.046%	91,500	110.8	3.1024	283,870
Chippewa	1234680738	305,096	38.457%	117,331	155.1	4.3428	509,543
Douglas	1856485474	458,747	12.647%	58,017	123.5	3.458	200,624
Grant	1491176569	368,477	27.763%	102,300	123.5	3.458	353,753
Kandiyohi	701990625.4	173,465	27.273%	47,310	150	4.2	198,702
Lac Qui Parle	1555280550	384,318	34.915%	134,183	144.3	4.0404	542,153
Otter Tail	1391459318	343,837	10.211%	35,110	132.8	3.7184	130,552
Pope	1857211829	458,926	24.666%	113,200	136.3	3.8164	432,016
Stearns	763936091.7	188,772	20.004%	37,763	137.9	3.8612	145,810
Stevens	1491043304	368,444	33.492%	123,400	139.6	3.9088	482,346
Swift	1948191311	481,408	36.643%	176,400	154.1	4.3148	761,131
Todd	335565582	82,920	9.525%	7,898	131.7	3.6876	29,124
Traverse	1519622377	375,506	35.685%	134,000	111.7	3.1276	419,098
Wilkin	489683902.8	121,003	18.661%	22,581	120.9	3.3852	76,441
Yellow Medicine	45293634.8	11,192	40.101%	4,488	155.6	4.3568	19,554
	Total	**4,460,429**		**1,205,481**			**4,584,719**
Border States							
Deuel	660156.2247	163	20.001%	33	148.8	4.1664	136
Grant	809147402.5	199,944	27.763%	55,510	123.5	3.458	191,955
Richland	256243761.7	63,319	28.172%	17,838	96.4	2.6992	48,149
Roberts	1225117810	302,733	18.997%	57,510	122.8	3.4384	197,741
	Total	**566,159**		**130,891**			**437,981**
	Grand Total	**5,026,588**	**Acres Corn-->**	**1,336,372**		**Total Tons -->**	**5,022,700**

GIS County Area Calculation Accuracy	
Radius	50
Total from GIS	5,026,588
Total in Radius (pi * R^2 *640)	5,026,548
Percent Error in Coverage	0.00%

B. 70 Mile Radius

Number of surveys received from within radius that had a valid response for interest level was 75



Estimate	Percentage Interested	Groups included
Low	49.33%	Interested & very interested
High	68.67%	Interested, very interested, and half of undecided

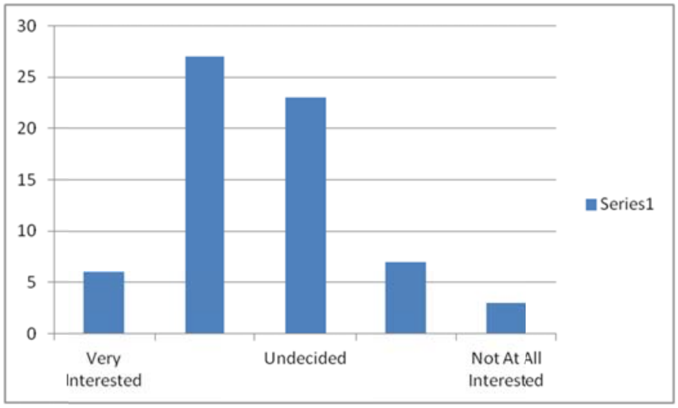
Contribution of Individual Counties to Corn Stover Biomass Available in Supply Radius							
Minnesota							
County	AREA (sq m)	Area in Radius (Acres)	Percent of County in Harvested Corn	Harvested Corn Acres	Corn Yield bu/acre	Tons Per Acre	Total Stover Produced Tons
Big Stone	1369122251	338,317	27.046%	91,500	110.8	3.1024	283,870
Chippewa	1522692593	376,265	38.457%	144,700	155.1	4.3428	628,403
Douglas	1865527010	460,981	12.647%	58,300	123.5	3.458	201,601
Grant	1491176569	368,477	27.763%	102,300	123.5	3.458	353,753
Kandiyohi	2196964624	542,881	27.273%	148,062	150	4.2	621,861
Lac Qui Parle	2016789244	498,359	34.915%	174,000	144.3	4.0404	703,030
Lincoln	78589453.23	19,420	31.824%	6,180	148	4.144	25,611
Lyon	224185138.2	55,397	38.173%	21,147	150.6	4.2168	89,171
Meeker	431764007.8	106,691	27.642%	29,492	144.6	4.0488	119,406
Morrison	225361604.7	55,688	9.516%	5,299	143.6	4.0208	21,307
Otter Tail	4340560732	1,072,574	10.211%	109,523	132.8	3.7184	407,249
Pope	1857211829	458,926	24.666%	113,200	136.3	3.8164	432,016
Redwood	16596276.81	4,101	41.997%	1,722	151	4.228	7,282
Renville	769642051.3	190,182	40.291%	76,627	146.1	4.0908	313,464
Stearns	*2264966484*	559,685	20.004%	111,962	137.9	3.8612	432,307
Stevens	1491043304	368,444	33.492%	123,400	139.6	3.9088	482,346
Swift	1948191311	481,408	36.643%	176,400	154.1	4.3148	761,131
Todd	2161799971	534,192	9.525%	50,880	131.7	3.6876	187,626
Traverse	1519622377	375,506	35.685%	134,000	111.7	3.1276	419,098
Wadena	52874302.57	13,066	5.724%	748	125.9	3.5252	2,637
Wilkin	1432180222	353,899	18.661%	66,043	120.9	3.3852	223,567
Yellow Medicine	1806491248	446,393	40.101%	179,010	155.6	4.3568	779,911
	Sub-total	**7,680,852**		**1,924,494**			**7,496,649**
Border States							
Codington	527565177.7	130,364	17.266%	22,509	143	4.004	90,127
Day	297959025	73,627	13.572%	9,992	145.8	4.0824	40,793
Deuel	940936091.4	232,510	20.001%	46,504	148.8	4.1664	193,755
Grant	1782689077	440,511	27.763%	122,299	123.5	3.458	422,909
Marshall	341771307.5	84,453	1.051%	887	114.5	3.206	2,845
Richland	1929071203	476,683	28.172%	134,292	96.4	2.6992	362,482
Roberts	2946180876	728,016	18.997%	138,300	122.8	3.4384	475,531
Sargent	12859243.13	3,178	18.503%	588	90.2	2.5256	1,485
	Sub total	**2,169,343**		**475,372**			**1,589,926**
	Grand Total	**9,850,195**	**Acres Corn-->**	**2,399,867**		**Total Tons -->**	**9,086,575**

GIS County Area Calculation Accuracy	
Radius	70
Total from GIS	9,850,195
Total in Radius (pi * R^2 *640)	9,852,035
Percent Error in Coverage	-0.02%

5. Olivia Supply Region Data

A. 50 Mile Radius

Number of surveys received from within radius that had a valid response for interest level was 62



Estimate	Percentage Interested	Groups included
Low	50.00%	Interested & very interested
High	67.42%	Interested, very interested, and half of undecided

Contribution of Individual Counties to Corn Stover Biomass Available in Supply Radius

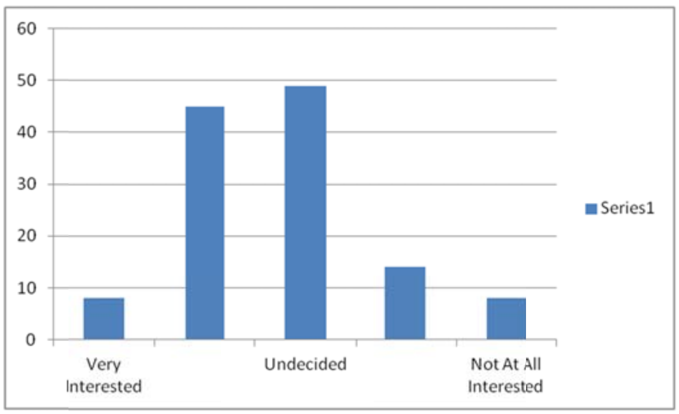
Minnesota County	AREA (sq m)	Area in Radius (Acres)	Percent of County in Harvested Corn	Harvested Corn Acres	Corn Yield bu/acre	Tons Per Acre	Total Stover Produced Tons
Blue Earth	20556282.42	5,080	39.734%	2,018	172.1	4.8188	9,726
Brown	1517548643	374,994	39.762%	149,105	164.2	4.5976	685,523
Carver	65157102.92	16,101	23.242%	3,742	154.8	4.3344	16,220
Chippewa	1447206433	357,612	38.457%	137,527	155.1	4.3428	597,251
Cottonwood	466590759.8	115,297	42.190%	48,644	165.7	4.6396	225,688
Kandiyohi	2233137027	551,819	27.273%	150,500	150	4.2	632,100
Lac Qui Parle	333520607.7	82,415	34.915%	28,775	144.3	4.0404	116,261
Lyon	961304821	237,543	38.173%	90,676	150.6	4.2168	382,363
McLeod	1308522916	323,343	34.329%	110,999	146.6	4.1048	455,630
Meeker	1668840859	412,379	27.642%	113,991	144.6	4.0488	461,526
Murray	39059140.02	9,652	38.034%	3,671	168.5	4.718	17,319
Nicollet	679869974.6	167,999	40.019%	67,231	161.6	4.5248	304,209
Pope	135303980.1	33,434	24.666%	8,247	136.3	3.8164	31,474
Redwood	2283741684	564,324	41.997%	237,000	151	4.228	1,002,036
Renville	2556211155	631,653	40.291%	254,500	146.1	4.0908	1,041,109
Sibley	1228301653	303,519	39.951%	121,258	159.1	4.4548	540,178
Stearns	632607491.7	156,320	20.004%	31,271	137.9	3.8612	120,744
Swift	1011627462	249,978	36.643%	91,598	154.1	4.3148	395,229
Watonwan	70870567.33	17,512	48.199%	8,441	178.5	4.998	42,188
Wright	375014259.1	92,668	15.951%	14,782	145.6	4.0768	60,262
Yellow Medicine	1286785532	317,971	40.101%	127,511	155.6	4.3568	555,540
	Total	**5,021,613**		**1,801,486**			**7,692,575**
Border States							

No Border States included in 50 Mile Radius						
	Total	**0**		**0**		**0**
	Grand Total	**5,021,613**	**Acres Corn-->**	**1,801,486**	**Total Tons -->**	**7,692,575**

GIS County Area Calculation Accuracy	
Radius	50
Total from GIS	5,021,613
Total in Radius (pi * R^2 *640)	5,026,548
Percent Error in Coverage	-0.10%

B. 70 Mile Radius

Number of surveys received from within radius that had a valid response for interest level was 124



Estimate	Percentage Interested	Groups included
Low	42.74%	Interested & very interested
High	62.50%	Interested, very interested, and half of undecided

Contribution of Individual Counties to Corn Stover Biomass Available in Supply Radius

Minnesota County	AREA (sq m)	Area in Radius (Acres)	Percent of County in Harvested Corn	Harvested Corn Acres	Corn Yield bu/acre	Tons Per Acre	Total Stover Produced Tons
Benton	16397687.65	4,052	14.759%	598	109.1	3.0548	1,827
Big Stone	148653486	36,733	27.046%	9,935	110.8	3.1024	30,821
Blue Earth	1059388206	261,780	39.734%	104,016	172.1	4.8188	501,235
Brown	1600959159	395,605	39.762%	157,300	164.2	4.5976	723,202
Carver	935472704.8	231,160	23.242%	53,725	154.8	4.3344	232,867
Chippewa	1522692593	376,265	38.457%	144,700	155.1	4.3428	628,403
Cottonwood	1679558888	415,027	42.190%	175,100	165.7	4.6396	812,394
Douglas	18670752.54	4,614	12.647%	583	123.5	3.458	2,018
Hennepin	320742607.3	79,257	3.144%	2,492	145.4	4.0712	10,144
Jackson	377390038.7	93,255	42.214%	39,367	164.6	4.6088	181,435
Kandiyohi	2233137027	551,819	27.273%	150,500	150	4.2	632,100
Lac Qui Parle	1637917138	404,738	34.915%	141,313	144.3	4.0404	570,959
Le Sueur	722666356.2	178,574	30.477%	54,424	159.2	4.4576	242,599
Lincoln	864625024.7	213,653	31.824%	67,994	148	4.144	281,765
Lyon	1870106397	462,113	38.173%	176,400	150.6	4.2168	743,844

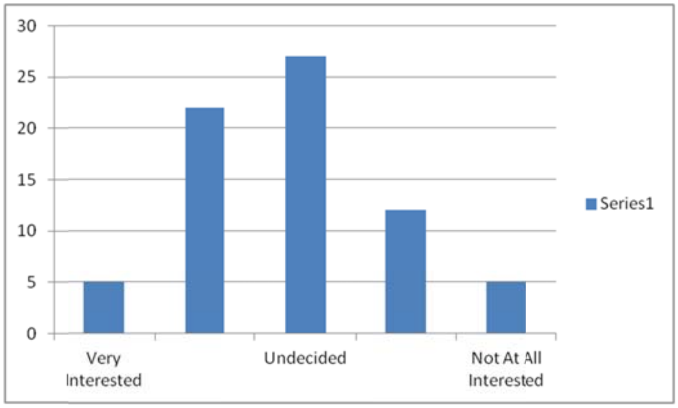
Martin	192012200.9	47,447	48.112%	22,828	175.9	4.9252	112,430
McLeod	1308529982	323,344	34.329%	111,000	146.6	4.1048	455,633
Meeker	1668975804	412,412	27.642%	114,000	144.6	4.0488	461,563
Murray	1368673898	338,206	38.034%	128,632	168.5	4.718	606,885
Nicollet	1207418370	298,359	40.019%	119,400	161.6	4.5248	540,261
Nobles	15257748.16	3,770	43.986%	1,658	176	4.928	8,172
Pipestone	38053090.35	9,403	33.334%	3,134	154.2	4.3176	13,533
Pope	1641763620	405,688	24.666%	100,068	136.3	3.8164	381,900
Redwood	2283741684	564,324	41.997%	237,000	151	4.228	1,002,036
Renville	2556211155	631,653	40.291%	254,500	146.1	4.0908	1,041,109
Scott	348084178.2	86,013	16.353%	14,066	162.8	4.5584	64,117
Sherburne	236095510.6	58,340	10.230%	5,968	144.9	4.0572	24,215
Sibley	1554907143	384,225	39.951%	153,500	159.1	4.4548	683,812
Stearns	3320963584	820,627	20.004%	164,162	137.9	3.8612	633,862
Stevens	363119212.7	89,729	33.492%	30,052	139.6	3.9088	117,467
Swift	1946453775	480,978	36.643%	176,243	154.1	4.3148	760,452
Todd	28145855.88	6,955	9.525%	662	131.7	3.6876	2,443
Watonwan	1135143924	280,500	48.199%	135,199	178.5	4.998	675,725
Wright	1689162400	417,400	15.951%	66,580	145.6	4.0768	271,435
Yellow Medicine	1914683585	473,128	40.101%	189,731	155.6	4.3568	826,621
	Sub-total	**9,841,148**		**3,306,830**			**14,279,284**
Border States							
No Border States Included in 70 Mile Radius							
	Sub total	**0**		**0**			**0**
	Grand Total	**9,841,148**	**Acres Corn-->**	**3,306,830**		**Total Tons -->**	**14,279,284**

GIS County Area Calculation Accuracy	
Radius	70
Total from GIS	9,841,148
Total in Radius (pi * R^2 *640)	9,852,035
Percent Error in Coverage	-0.11%

6. Mankato

A. 50 Mile Radius

Number of surveys received from within radius that had a valid response for interest level was 71



Estimate	Percentage Interested	Groups included
Low	38.03%	Interested & very interested
High	57.04%	Interested, very interested, and half of undecided

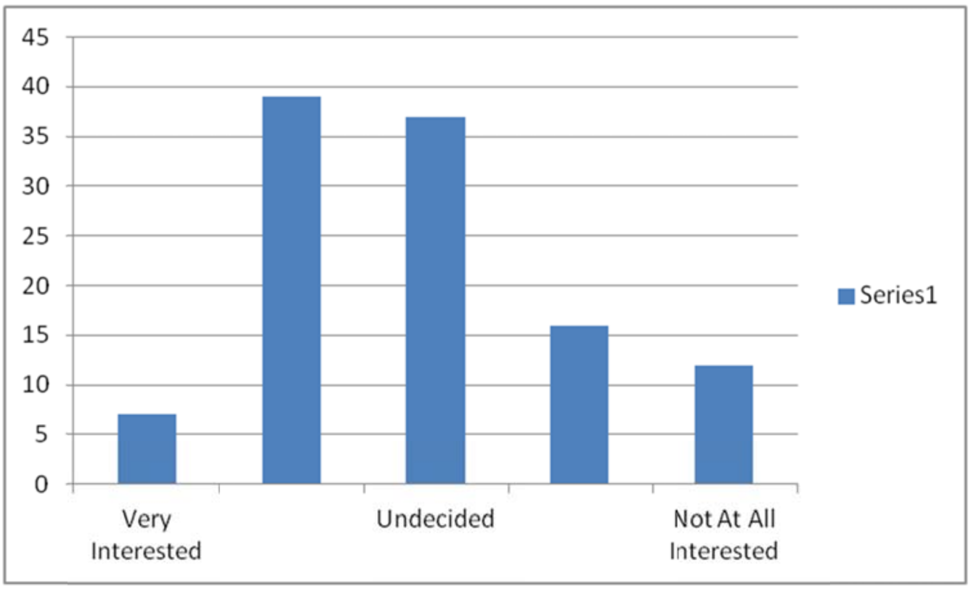
Minnesota County	AREA (sq m)	Area in Radius (Acres)	Percent of County in Harvested Corn	Harvested Corn Acres	Corn Yield bu/acre	Tons Per Acre	Total Stover Produced Tons
Blue Earth	1981964571	489,753	39.734%	194,600	172.1	4.8188	937,738
Brown	1443789689	356,768	39.762%	141,858	164.2	4.5976	652,204
Carver	639379292.5	157,994	23.242%	36,720	154.8	4.3344	159,160
Cottonwood	250105441	61,802	42.190%	26,074	165.7	4.6396	120,975
Dakota	201438423.9	49,776	22.667%	11,283	175.6	4.9168	55,476
Dodge	91501364.83	22,610	43.178%	9,763	183.2	5.1296	50,079
Faribault	1868578460	461,735	46.997%	217,000	175.1	4.9028	1,063,908
Freeborn	1139662888	281,616	43.619%	122,837	180.2	5.0456	619,788
Goodhue	49321718.31	12,188	31.113%	3,792	178.5	4.998	18,952
Jackson	16428023.88	4,059	42.214%	1,714	164.6	4.6088	7,898
Le Sueur	1226934089	303,182	30.477%	92,400	159.2	4.4576	411,882
Martin	1440814789	356,033	48.112%	171,293	175.9	4.9252	843,651
McLeod	767134210.4	189,563	34.329%	65,074	146.6	4.1048	267,118
Nicollet	1207418370	298,359	40.019%	119,400	161.6	4.5248	540,261
Redwood	162522229.5	40,160	41.997%	16,866	151	4.228	71,310
Renville	420359906.6	103,873	40.291%	41,852	146.1	4.0908	171,207
Rice	1316880180	325,408	26.881%	87,474	159.8	4.4744	391,395
Scott	871044917.4	215,240	16.353%	35,198	162.8	4.5584	160,445
Sibley	1554907143	384,225	39.951%	153,500	159.1	4.4548	683,812
Steele	1102926460	272,539	41.603%	113,384	170.5	4.774	541,296
Waseca	1120635074	276,915	43.696%	121,000	177.5	4.97	601,370
Watonwan	1138509666	281,331	48.199%	135,600	178.5	4.998	677,729
	Total	**4,945,129**		**1,918,682**			**9,047,653**
Border States							
Kossuth	157671935.4	38,962	51.587%	20,099	179	5.012	100,737
Winnebago	125928975.9	31,118	50.134%	15,600	176	4.928	76,879
	Total	**70,079**		**35,700**			**177,616**

Grand Total	**5,015,208**	**Acres Corn-->**	**1,954,381**	**Total Tons -->**	**9,225,270**

GIS County Area Calculation Accuracy	
Radius	50
Total from GIS	5,015,208
Total in Radius (pi * R^2 *640)	5,026,548
Percent Error in Coverage	-0.23%

B. 70 Mile Radius

Number of surveys received from within radius that had a valid response for interest level was 111



Estimate	Percentage Interested	Groups included
Low	41.44%	Interested & very interested
High	58.11%	Interested, very interested, and half of undecided

Stover Total Tons Within 70 Miles							
Minnesota County	AREA (sq m)	Area in Radius (Acres)	Percent of County in Harvested Corn	Harvested Corn Acres	Corn Yield bu/acre	Tons Per Acre	Total Stover Produced Tons
Blue Earth	1981964571	489,753	39.734%	194,600	172.1	4.8188	937,738
Brown	1600959159	395,605	39.762%	157,300	164.2	4.5976	723,202
Carver	973339343.3	240,517	23.242%	55,900	154.8	4.3344	242,293
Cottonwood	1450360169	358,391	42.190%	151,205	165.7	4.6396	701,532
Dakota	1460632669	360,930	22.667%	81,812	175.6	4.9168	402,255
Dodge	1137819130	281,161	43.178%	121,400	183.2	5.1296	622,733
Faribault	1868578460	461,735	46.997%	217,000	175.1	4.9028	1,063,908

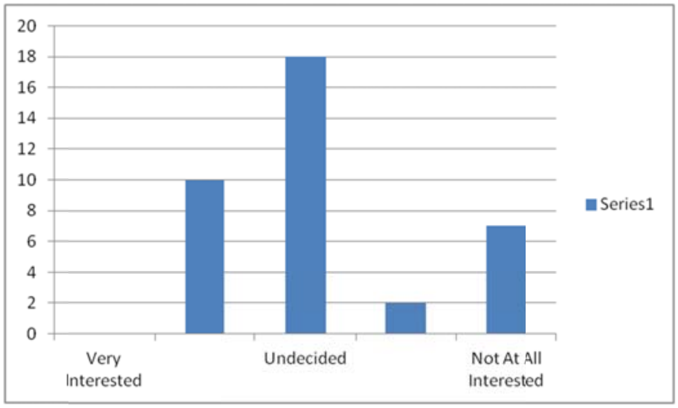
Freeborn	1869480672	461,958	43.619%	201,500	180.2	5.0456	1,016,688
Goodhue	1295485922	320,121	31.113%	99,598	178.5	4.998	497,793
Hennepin	1218225557	301,030	3.144%	9,463	145.4	4.0712	38,528
Jackson	1149146236	283,960	42.214%	119,872	164.6	4.6088	552,465
Kandiyohi	123909591.6	30,619	27.273%	8,351	150	4.2	35,073
Le Sueur	1226934089	303,182	30.477%	92,400	159.2	4.4576	411,882
Martin	1888362249	466,624	48.112%	224,500	175.9	4.9252	1,105,707
McLeod	1308529982	323,344	34.329%	111,000	146.6	4.1048	455,633
Meeker	720319691.1	177,995	27.642%	49,202	144.6	4.0488	199,208
Mower	855313561.4	211,352	45.054%	95,222	178.1	4.9868	474,855
Nicollet	1207418370	298,359	40.019%	119,400	161.6	4.5248	540,261
Olmsted	215137963.8	53,162	27.822%	14,790	183	5.124	75,786
Ramsey	63335822.09	15,651	0.000%	0	0	0	0
Redwood	1490110406	368,214	41.997%	154,639	151	4.228	653,815
Renville	1897176287	468,802	40.291%	188,886	146.1	4.0908	772,693
Rice	1335333685	329,968	26.881%	88,700	159.8	4.4744	396,879
Scott	952767735.9	235,434	16.353%	38,500	162.8	4.5584	175,498
Sibley	1554907143	384,225	39.951%	153,500	159.1	4.4548	683,812
Steele	1118644775	276,423	41.603%	115,000	170.5	4.774	549,010
Waseca	1120635074	276,915	43.696%	121,000	177.5	4.97	601,370
Washington	70679870.1	17,465	7.757%	1,355	178.4	4.9952	6,767
Watonwan	1138509666	281,331	48.199%	135,600	178.5	4.998	677,729
Wright	845882794.7	209,022	15.951%	33,341	145.6	4.0768	135,927
	Sub-total	**8,683,245**		**3,155,038**			**14,751,041**
Border States							
Cerro Gordo	20753805.52	5,128	50.001%	2,564	169	4.732	12,134
Hancock	342158774.6	84,549	54.709%	46,256	179	5.012	231,837
Dickinson	75874622.84	18,749	37.637%	7,057	169	4.732	33,392
Palo Alto	43830862.14	10,831	49.544%	5,366	174	4.872	26,143
Worth	787448936	194,583	47.191%	91,826	173	4.844	444,804
Kossuth	1412585377	349,057	51.587%	180,069	179	5.012	902,505
Mitchell	27631348.82	6,828	51.618%	3,524	180	5.04	17,763
Emmet	875462203.6	216,331	45.859%	99,208	169	4.732	469,452
Winnebago	1039688347	256,912	50.134%	128,800	176	4.928	634,726
	Sub total	**1,142,968**		**564,670**			**2,772,756**
	Grand Total	**9,826,213**	**Acres Corn-->**	**3,719,708**		**Total Tons -->**	**17,523,797**

GIS County Area Calculation Accuracy	
Radius	70
Total from GIS	9,826,213
Total in Radius (pi * R^2 *640)	9,852,035
Percent Error in Coverage	-0.26%

7. Worthington

A. 50 Mile

Number of surveys received from within radius that had a valid response for interest level was 37



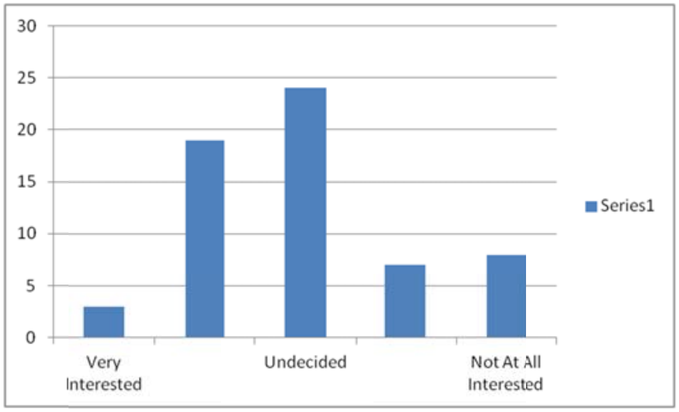
Estimate	Percentage Interested	Groups included
Low	27.03%	Interested & very interested
High	51.35%	Interested, very interested, and half of undecided

Minnesota County	AREA (sq m)	Area in Radius (Acres)	Percent of County in Harvested Corn	Harvested Corn Acres	Corn Yield bu/acre	Tons Per Acre	Total Stover Produced Tons
Brown	173442064.8	42,858	39.762%	17,041	164.2	4.5976	78,349
Redwood	510967657.6	126,263	41.997%	53,027	151	4.228	224,197
Murray	1864170324	460,646	38.034%	175,200	168.5	4.718	826,594
Pipestone	1003622504	248,000	33.334%	82,669	154.2	4.3176	356,931
Lyon_MN	511207821.1	126,322	38.173%	48,220	150.6	4.2168	203,335
Lincoln_MN	31658684.54	7,823	31.824%	2,490	148	4.144	10,317
Rock	1251378998	309,222	43.076%	133,200	180.6	5.0568	673,566
Nobles	1872286323	462,651	43.986%	203,500	176	4.928	1,002,848
Martin	763336698.2	188,624	48.112%	90,750	175.9	4.9252	446,962
Jackson	1862648373	460,270	42.214%	194,300	164.6	4.6088	895,490
Watonwan	287688776.1	71,089	48.199%	34,265	178.5	4.998	171,255
Cottonwood	1679558888	415,027	42.190%	175,100	165.7	4.6396	812,394
	Total	**2,918,796**		**1,209,762**			**5,702,238**
Border States							
Cherokee	17859586.64	4,413	40.817%	1,801	176	4.928	8,877
Clay_IA	1155574389	285,548	41.616%	118,833	185	5.18	615,557
Dickinson	1046202851	258,522	37.637%	97,300	169	4.732	460,424
Emmet	557311885.8	137,715	45.859%	63,155	169	4.732	298,849
Lincoln_SD	3137359.464	775	38.968%	302	143.2	4.0096	1,211
Lyon_IA	1456248821	359,846	47.913%	172,414	185	5.18	893,107
Minnehaha	398798521.7	98,545	31.228%	30,773	163.1	4.5668	140,535
Moody	64040067.26	15,825	40.089%	6,344	185.4	5.1912	32,932
O'Brien	1475935110	364,711	45.207%	164,875	185	5.18	854,055
Osceola	1034766065	255,696	44.936%	114,900	184	5.152	591,965
Palo Alto	140403027.2	34,694	49.544%	17,189	174	4.872	83,745
Sioux	1133636715	280,127	51.261%	143,595	177	4.956	711,658
	Total	**2,096,418**		**931,483**			**4,692,915**
	Grand Total	**5,015,214**	**Acres Corn-->**	**2,141,245**		**Total Tons -->**	**10,395,153**

GIS County Area Calculation Accuracy	
Radius	50
Total from GIS	5,015,214
Total in Radius (pi * R^2 *640)	5,026,548
Percent Error in Coverage	-0.23%

B. 70 Mile Radius

Number of surveys received from within radius that had a valid response for interest level was 61



Estimate	Percentage Interested	Groups included
Low	36.07%	Interested & very interested
High	55.74%	Interested, very interested, and half of undecided

Contribution of Individual Counties to Corn Stover Biomass Available in Supply Radius

Minnesota County	AREA (sq m)	Area in Radius (Acres)	Percent of County in Harvested Corn	Harvested Corn Acres	Corn Yield bu/acre	Tons Per Acre	Total Stover Produced Tons
Yellow Medicine	187331747.8	46,291	40.101%	18,563	155.6	4.3568	80,876
Brown	1339807654	331,073	39.762%	131,641	164.2	4.5976	605,232
Redwood	2145694251	530,212	41.997%	222,674	151	4.228	941,465
Murray	1864170324	460,646	38.034%	175,200	168.5	4.718	826,594
Pipestone	1207956610	298,492	33.334%	99,500	154.2	4.3176	429,601
Lyon_MN	1783379771	440,682	38.173%	168,219	150.6	4.2168	709,348
Lincoln_MN	1012573694	250,212	31.824%	79,628	148	4.144	329,979
Rock	1251378998	309,222	43.076%	133,200	180.6	5.0568	673,566
Nobles	1872286323	462,651	43.986%	203,500	176	4.928	1,002,848
Martin	1888362249	466,624	48.112%	224,500	175.9	4.9252	1,105,707
Jackson	1862648373	460,270	42.214%	194,300	164.6	4.6088	895,490
Watonwan	1138494146	281,328	48.199%	135,598	178.5	4.998	677,720
Cottonwood	1679558888	415,027	42.190%	175,100	165.7	4.6396	812,394
Blue Earth	178772728	44,176	39.734%	17,553	172.1	4.8188	84,584
Faribault	129149983.5	31,914	46.997%	14,998	175.1	4.9028	73,534
	Sub-total	**4,828,819**		**1,994,175**			**9,248,937**
Border States							
Brookings	327328339.6	80,884	24.443%	19,770	159.1	4.4548	88,073
Buena Vista	1033151350	255,297	46.293%	118,184	180	5.04	595,648

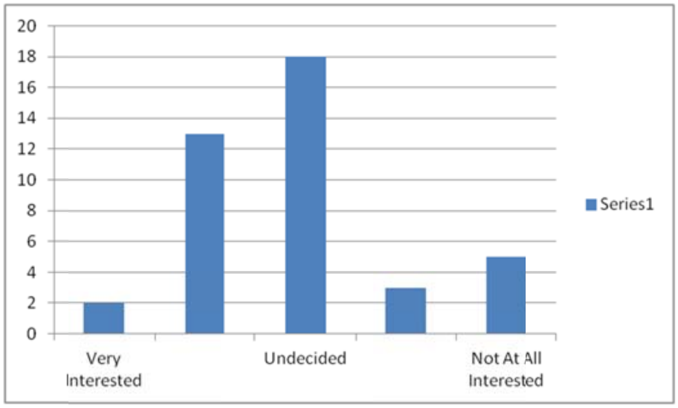
Cherokee	1257084277	310,632	40.817%	126,792	176	4.928	624,831
Clay_IA	1482960239	366,447	41.616%	152,500	185	5.18	789,950
Dickinson	1046202851	258,522	37.637%	97,300	169	4.732	460,424
Emmet	1042175613	257,527	45.859%	118,100	169	4.732	558,849
Kossuth	589178680.1	145,589	51.587%	75,105	179	5.012	376,428
Lake_SD	53085089.36	13,118	30.721%	4,030	157.7	4.4156	17,794
Lincoln_SD	1363667739	336,969	38.968%	131,311	143.2	4.0096	526,506
Lyon_IA	1523696837	376,513	47.913%	180,400	185	5.18	934,472
Minnehaha	1656314943	409,284	31.228%	127,809	163.1	4.5668	583,679
Moody	1241361888	306,747	40.089%	122,971	185.4	5.1912	638,368
O'Brien	1485106314	366,977	45.207%	165,900	185	5.18	859,362
Osceola	1034766065	255,696	44.936%	114,900	184	5.152	591,965
Palo Alto	1375162251	339,809	49.544%	168,356	174	4.872	820,232
Plymouth	1138518709	281,334	42.744%	120,254	164	4.592	552,205
Pocahontas	259304281	64,075	49.619%	31,794	181	5.068	161,131
Sioux	1993403679	492,580	51.261%	252,500	177	4.956	1,251,390
Turner	56027873.38	13,845	37.741%	5,225	149.4	4.1832	21,858
Union	298452075.9	73,749	40.317%	29,733	148.2	4.1496	123,380
	Sub total	**5,005,593**		**2,162,936**			**10,576,546**
	Grand Total	**9,834,412**	**Acres Corn-->**	**4,157,110**		**Total Tons -->**	**19,825,483**

GIS County Area Calculation Accuracy	
Radius	70
Total from GIS	9,834,412
Total in Radius (pi * R^2 *640)	9,852,035
Percent Error in Coverage	-0.18%

8. Austin

A. 50 mile

Number of surveys received from within radius that had a valid response for interest level was 41



Estimate	Percentage Interested	Groups included
Low	36.59%	Interested & very interested
High	58.54%	Interested, very interested, and half of undecided

Contribution of Individual Counties to Corn Stover Biomass Available in Supply Radius

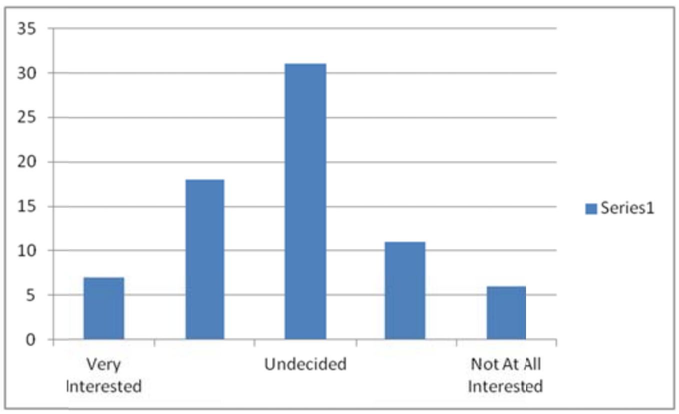
Minnesota County	AREA (sq m)	Area in Radius (Acres)	Percent of County in Harvested Corn	Harvested Corn Acres	Corn Yield bu/acre	Tons Per Acre	Total Stover Produced Tons
Goodhue	745668684.6	184,258	31.113%	57,328	178.5	4.998	286,524
Wabasha	220289139	54,435	24.956%	13,585	181.3	5.0764	68,962
Blue Earth	229425608.5	56,692	39.734%	22,526	172.1	4.8188	108,549
Winona	48322310.62	11,941	18.279%	2,183	179.1	5.0148	10,945
Steele	1118644775	276,423	41.603%	115,000	170.5	4.774	549,010
Dodge	1137819130	281,161	43.178%	121,400	183.2	5.1296	622,733
Olmsted	1641554724	405,636	27.822%	112,855	183	5.124	578,268
Faribault	982540626.6	242,791	46.997%	114,103	175.1	4.9028	559,427
Fillmore	1441465535	356,193	33.041%	117,691	179.3	5.0204	590,857
Freeborn	1869480672	461,958	43.619%	201,500	180.2	5.0456	1,016,688
Mower	1841366119	455,011	45.054%	205,000	178.1	4.9868	1,022,294
Le Sueur	42153277.26	10,416	30.477%	3,175	159.2	4.4576	14,151
Rice	632062190.8	156,186	26.881%	41,985	159.8	4.4744	187,857
Waseca	1075423920	265,743	43.696%	116,118	177.5	4.97	577,108
	Total	**3,218,843**		**1,244,449**			**6,193,375**
Border States							
Cerro Gordo	1169405158	288,966	50.001%	144,485	169	4.732	683,701
Hancock	313667015	77,509	54.709%	42,405	179	5.012	212,531
Howard	1162384304	287,231	42.260%	121,383	185	5.18	628,762
Chickasaw	377042446.5	93,169	46.353%	43,186	188	5.264	227,332
Floyd	1056838833	261,150	46.035%	120,220	181	5.068	609,273
Worth	1040203481	257,039	47.191%	121,300	173	4.844	587,577
Mitchell	1215200973	300,282	51.618%	155,000	180	5.04	781,200
Winnebago	848708629.7	209,720	50.134%	105,141	176	4.928	518,134
Winneshiek	60901001.62	15,049	33.414%	5,028	186	5.208	26,188
	Total	**1,790,116**		**858,147**			**4,274,700**

Grand Total	5,008,959	Acres Corn-->	2,102,596	Total Tons -->	10,468,075

GIS County Area Calculation Accuracy	
Radius	50
Total from GIS	5,008,959
Total in Radius (pi * R^2 *640)	5,026,548
Percent Error in Coverage	-0.35%

B. 70 Mile Radius

Number of surveys received from within radius that had a valid response for interest level was 73



Estimate	Percentage Interested	Groups included
Low	34.25%	Interested & very interested
High	55.48%	Interested, very interested, and half of undecided

Stover Total Tons Within 70 Miles of Austin, MN

Minnesota County	AREA (sq m)	Area in Radius (Acres)	Percent of County in Harvested Corn	Harvested Corn Acres	Corn Yield bu/acre	Tons Per Acre	Total Stover Produced Tons
Dakota	751143874.7	185,611	22.667%	42,073	175.6	4.9168	206,863
Goodhue	1997481366	493,588	31.113%	153,569	178.5	4.998	767,535
Nicollet	173535244.8	42,881	40.019%	17,161	161.6	4.5248	77,649
Wabasha	1422124445	351,414	24.956%	87,700	181.3	5.0764	445,200
Blue Earth	1631083140	403,049	39.734%	160,149	172.1	4.8188	771,724
Winona	1223579644	302,353	18.279%	55,267	179.1	5.0148	277,152
Steele	1118644775	276,423	41.603%	115,000	170.5	4.774	549,010
Dodge	1137819130	281,161	43.178%	121,400	183.2	5.1296	622,733
Olmsted	1694576820	418,738	27.822%	116,500	183	5.124	596,946
Martin	367262370.8	90,752	48.112%	43,662	175.9	4.9252	215,046
Houston	457369620.8	113,018	14.810%	16,738	172	4.816	80,611
Faribault	1868578460	461,735	46.997%	217,000	175.1	4.9028	1,063,908
Fillmore	2231559872	551,430	33.041%	182,200	179.3	5.0204	914,717
Freeborn	1869480672	461,958	43.619%	201,500	180.2	5.0456	1,016,688
Mower	1841366119	455,011	45.054%	205,000	178.1	4.9868	1,022,294
Scott	206465996.5	51,019	16.353%	8,343	162.8	4.5584	38,031
Le Sueur	1094823943	270,536	30.477%	82,451	159.2	4.4576	367,533

Rice	1335333685	329,968	26.881%	88,700	159.8	4.4744	396,879
Waseca	1120635074	276,915	43.696%	121,000	177.5	4.97	601,370
	Sub-total	**5,817,559**		**2,035,412**			**10,031,890**
Border States							
Bremer	542130655.6	133,963	45.158%	60,495	196	5.488	331,994
Buffalo	114711825	28,346	13.814%	3,916	160	4.48	17,542
Butler	1020581361	252,191	47.818%	120,593	186	5.208	628,048
Cerro Gordo	1488418719	367,796	50.001%	183,900	169	4.732	870,215
Chickasaw	1308719468	323,391	46.353%	149,900	188	5.264	789,074
Fayette	237220118.7	58,618	42.307%	24,800	186	5.208	129,157
Floyd	1297536616	320,628	46.035%	147,600	181	5.068	748,037
Franklin	970417931.2	239,795	55.968%	134,209	189	5.292	710,236
Hancock	1467491865	362,625	54.709%	198,390	179	5.012	994,329
Howard	1225753366	302,890	42.260%	128,000	185	5.18	663,040
Kossuth	1178332880	291,172	51.587%	150,208	179	5.012	752,840
Mitchell	1215200973	300,282	51.618%	155,000	180	5.04	781,200
Pepin	123206237.1	30,445	18.358%	5,589	158	4.424	24,726
Pierce	98738257.57	24,399	19.022%	4,641	166	4.648	21,572
Winnebago	1039688347	256,912	50.134%	128,800	176	4.928	634,726
Winneshiek	1473087348	364,007	33.414%	121,630	186	5.208	633,451
Worth	1040203481	257,039	47.191%	121,300	173	4.844	587,577
Wright_IA	369268330	91,248	49.307%	44,991	189	5.292	238,094
	Sub total	**4,005,747**		**1,883,961**			**9,555,857**
	Grand Total	**9,823,306**	**Acres Corn-->**	**3,919,373**		**Total Tons -->**	**19,587,747**

GIS County Area Calculation Accuracy	
Radius	70
Total from GIS	9,823,306
Total in Radius (pi * R^2 *640)	9,852,035
Percent Error in Coverage	-0.29%

Minnesota County Data

County	Area (acres)	Harvested Corn Acres	% of Land in Corn	2011 Yield	Tons per Acre	Value of Land Ag 2bTillable
Aitkin	1,275,844	--	--	--	--	$1,075
Anoka	285,143	6,700	2.350%	119.4	3.3432	$7,542
Becker	925,091	42,400	4.583%	121.5	3.402	$2,245
Beltrami	1,955,075	--	--	--	--	$846
Benton	264,244	39,000	14.759%	109.1	3.0548	$2,638
Big Stone	338,317	91,500	27.046%	110.8	3.1024	$3,282
Blue Earth	489,753	194,600	39.734%	172.1	4.8188	$5,665
Brown	395,605	157,300	39.762%	164.2	4.5976	$5,809
Carlton	559,674	--	--	--	--	$1,289
Carver	240,517	55,900	23.242%	154.8	4.3344	$6,739
Cass_MN	1,544,332	--	--	--	--	$1,521
Chippewa	376,265	144,700	38.457%	155.1	4.3428	$5,043
Chisago	283,045	26,700	9.433%	134.5	3.766	$2,689
Clay	674,328	113,500	16.832%	113.7	3.1836	$2,916
Clearwater	658,826	2,400	0.364%	104.2	2.9176	$829
Cook	1,027,591	--	--	--	--	
Cottonwood	415,027	175,100	42.190%	165.7	4.6396	$5,396
Crow Wing	739,772	8,000	1.081%	109.1	3.0548	$1,922
Dakota	374,993	85,000	22.667%	175.6	4.9168	$6,440
Dodge	281,161	121,400	43.178%	183.2	5.1296	$5,607
Douglas	460,981	58,300	12.647%	123.5	3.458	$2,118
Faribault	461,735	217,000	46.997%	175.1	4.9028	$5,331
Fillmore	551,430	182,200	33.041%	179.3	5.0204	$4,755
Freeborn	461,958	201,500	43.619%	180.2	5.0456	$5,233
Goodhue	499,153	155,300	31.113%	178.5	4.998	$4,874
Grant	368,477	102,300	27.763%	123.5	3.458	$2,800
Hennepin	388,078	12,200	3.144%	145.4	4.0712	$21,458
Houston	363,938	53,900	14.810%	172	4.816	$3,533
Hubbard	639,542	--	--	--	--	$2,216
Isanti	288,811	31,200	10.803%	126.9	3.5532	$3,211
Itasca	1,872,277	--	--	--	--	$1,430
Jackson	460,270	194,300	42.214%	164.6	4.6088	$5,969
Kanabec	341,248	12,300	3.604%	125.2	3.5056	$1,447
Kandiyohi	551,819	150,500	27.273%	150	4.2	$4,618
Kittson	707,307	--	--	--	--	$1,312
Koochiching	2,018,220	--	--	--	--	$691
Lac Qui Parle	498,359	174,000	34.915%	144.3	4.0404	$3,524
Lake	1,463,898	--	--	--	--	$1,502
Lake of the Woods	1,134,958	--	--	--	--	$638
Le Sueur	303,182	92,400	30.477%	159.2	4.4576	$5,709
Lincoln	351,304	111,800	31.824%	148	4.144	$3,940
Lyon	462,113	176,400	38.173%	150.6	4.2168	$5,059
Mahnomen	373,431	--	--	--	--	$1,762
Marshall	1,161,025	12,200	1.051%	114.5	3.206	$1,413
Martin	466,624	224,500	48.112%	175.9	4.9252	$6,217
McLeod	323,344	111,000	34.329%	146.6	4.1048	$5,087
Meeker	412,412	114,000	27.642%	144.6	4.0488	$4,037
Mille Lacs	435,736	17,100	3.924%	101.2	2.8336	$2,211
Morrison	737,712	70,200	9.516%	143.6	4.0208	$2,634
Mower	455,011	205,000	45.054%	178.1	4.9868	$5,306
Murray	460,646	175,200	38.034%	168.5	4.718	$4,915

Nicollet	298,359	119,400	40.019%	161.6	4.5248	$6,495
Nobles	462,651	203,500	43.986%	176	4.928	$5,880
Norman	561,639	73,800	13.140%	117.8	3.2984	$2,386
Olmsted	418,738	116,500	27.822%	183	5.124	$4,594
Otter Tail	1,423,927	145,400	10.211%	132.8	3.7184	$1,858
Pennington	395,790	--	--	--	--	$1,064
Pine	917,456	13,000	1.417%	133.8	3.7464	$1,490
Pipestone	298,492	99,500	33.334%	154.2	4.3176	$4,687
Polk	1,279,618	60,300	4.712%	124.6	3.4888	$2,025
Pope	458,926	113,200	24.666%	136.3	3.8164	$2,743
Ramsey	108,718	--	--	--	--	$62,974
Red Lake	277,055	14,000	5.053%	120.7	3.3796	$1,016
Redwood	564,324	237,000	41.997%	151	4.228	$5,845
Renville	631,653	254,500	40.291%	146.1	4.0908	$6,180
Rice	329,968	88,700	26.881%	159.8	4.4744	$5,406
Rock	309,222	133,200	43.076%	180.6	5.0568	$6,464
Roseau	1,074,067	7,900	0.736%	105.6	2.9568	$721
Saint Louis	4,312,080	--	--	--	--	$913
Scott	235,434	38,500	16.353%	162.8	4.5584	$7,679
Sherburne	288,362	29,500	10.230%	144.9	4.0572	$4,259
Sibley	384,225	153,500	39.951%	159.1	4.4548	$5,686
Stearns	889,301	177,900	20.004%	137.9	3.8612	$3,235
Steele	276,423	115,000	41.603%	170.5	4.774	$5,022
Stevens	368,444	123,400	33.492%	139.6	3.9088	$3,671
Swift	481,408	176,400	36.643%	154.1	4.3148	$3,876
Todd	626,789	59,700	9.525%	131.7	3.6876	$1,534
Traverse	375,506	134,000	35.685%	111.7	3.1276	$3,603
Wabasha	351,414	87,700	24.956%	181.3	5.0764	$4,142
Wadena	347,638	19,900	5.724%	125.9	3.5252	$1,596
Waseca	276,915	121,000	43.696%	177.5	4.97	$5,179
Washington	270,735	21,000	7.757%	178.4	4.9952	$11,716
Watonwan	281,331	135,600	48.199%	178.5	4.998	$5,445
Wilkin	481,206	89,800	18.661%	120.9	3.3852	$2,937
Winona	410,309	75,000	18.279%	179.1	5.0148	$3,992
Wright	457,019	72,900	15.951%	145.6	4.0768	$5,202
Yellow Medicine	488,760	196,000	40.101%	155.6	4.3568	$4,864

Border State County Data

State	County	Area (acres)	Harvested Corn Acres	% of Land in Corn	2011 Yield	Tons per Acre
Iowa	Bremer	281,016	126900	196	45.16%	5.488
	Buena Vista	371,332	171900	180	46.29%	5.04
	Butler	372,035	177900	186	47.82%	5.208
	Cerro Gordo	367,796	183900	169	50.00%	4.732
	Cherokee	369,450	150800	176	40.82%	4.928
	Chickasaw	323,391	149900	188	46.35%	5.264
	Clay	366,447	152500	185	41.62%	5.18
	Dickinson	258,522	97300	169	37.64%	4.732
	Emmet	257,527	118100	169	45.86%	4.732
	Fayette	467,770	197900	186	42.31%	5.208
	Floyd	320,628	147600	181	46.03%	5.068
	Franklin	372,532	208500	189	55.97%	5.292
	Hancock	366,482	200500	179	54.71%	5.012
	Howard	302,890	128000	185	42.26%	5.18
	Kossuth	623,216	321500	179	51.59%	5.012
	Lyon	376,513	180400	185	47.91%	5.18
	Mitchell	300,282	155000	180	51.62%	5.04
	O'Brien	366,977	165900	185	45.21%	5.18
	Osceola	255,696	114900	184	44.94%	5.152
	Palo Alto	364,320	180500	174	49.54%	4.872
	Plymouth	553,292	236500	164	42.74%	4.592
	Pocahontas	370,218	183700	181	49.62%	5.068
	Sioux	492,580	252500	177	51.26%	4.956
	Winnebago	256,912	128800	176	50.13%	4.928
	Winneshiek	441,428	147500	186	33.41%	5.208
	Worth	257,039	121300	173	47.19%	4.844
	Wright_IA	372,364	183600	189	49.31%	5.292
North Dakota	Barnes	971,373	99700	110.6	10.26%	3.0968
	Cass_ND	1,133,451	206000	101.6	18.17%	2.8448
	Grand Forks	923,065	77800	101.5	8.43%	2.842
	Griggs	459,920	23000	108.7	5.00%	3.0436
	Ransom	554,085	69700	116.6	12.58%	3.2648
	Richland	926,444	261000	96.4	28.17%	2.6992
	Sargent	556,125	102900	90.2	18.50%	2.5256
	Steele	458,964	67500	110.9	14.71%	3.1052
	Trail	552,909	91800	108.1	16.60%	3.0268
South Dakota	Brookings	515,900	126100	159.1	24.44%	4.4548
	Codington	459,852	79400	143	17.27%	4.004
	Day	699,993	95000	145.8	13.57%	4.0824
	Deuel	407,982	81600	148.8	20.00%	4.1664
	Grant	440,589	88800	126.3	20.15%	3.5364
	Lake	368,805	113300	157.7	30.72%	4.4156
	Lincoln	370,301	144300	143.2	38.97%	4.0096
	Marshall	568,506	86900	116.4	15.29%	3.2592
	Minnehaha	521,655	162900	163.1	31.23%	4.5668
	Moody	333,759	133800	185.4	40.09%	5.1912
	Roberts	728,016	138300	122.8	19.00%	3.4384
	Turner	396,117	149500	149.4	37.74%	4.1832
	Union	299,380	120700	148.2	40.32%	4.1496
Wisconsin	Buffalo	453,886	62700	160	13.81%	4.48
	Burnett	562,939	12600	118	2.24%	3.304
	Pepin	159,062	29200	158	18.36%	4.424
	Pierce	378,512	72000	166	19.02%	4.648
	Polk	611,646	54100	157	8.84%	4.396