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A mixed-methods approach to understanding farmer and rancher interest in supplying woody biomass in the U.S. Northern Great Plains

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**A mixed-methods approach to understanding farmer and rancher interest in supplying
woody biomass in the U.S. Northern Great Plains**

by

Ashley M. Hand

A thesis submitted to the graduate faculty
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Co-Majors: Sustainable Agriculture, Forestry

Program of Study Committee:
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Richard C. Schultz

Iowa State University

Ames, Iowa

2014

DEDICATION

“it is a serious thing
just to be alive
on this fresh morning
in the broken world.”

— Mary Oliver
an excerpt from *Invitation*
in *Red Bird: Poems*
(2008)

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ABSTRACT

Bioenergy produced from cellulosic feedstocks could serve as an opportunity to strengthen local and regional economies, reduce fossil fuel energy consumption for transportation or electricity production, and also jointly produce various environmental services. In the U.S. Northern Great Plains, woody bioenergy crops can provide multifunctional benefits while building biomass supply capacity when established within existing farm and ranch systems. Understanding what facilitates or constraints potential biomass suppliers' level of interest in biomass production is essential to fully assess the regional potential of biomass-based bioenergy in the Northern Great Plains. Qualitative data from a regional focus group series illustrates the complexities associated with farmer definitions of marginality, attitudes towards trees and bioenergy production, while also characterizing influences on farmer/rancher interest in woody biomass production. Quantitatively, a region-wide representative survey of farmers and ranchers managing marginal land captures a snapshot of operator interest in woody biomass production. Results indicate that 61% of farmers and ranchers have some degree of interest in woody biomass production, while results from an ordered probit regression further illustrate how farm/ranch system attributes, individual farmer/rancher characteristics, relevant attitudes and knowledge significantly affect interest. Data from both methods allow us to highlight attributes of operators who are most likely to be early adopters of a woody biomass crop, can serve as an input to local or regional assessments of potential for renewable energy production, and have implications for the development of relevant policy initiatives and management practices.

CHAPTER I

GENERAL INTRODUCTION

Targets for renewable energy production set forth in the federal U.S. Renewable Fuel Standard 2 and state-level Renewable Portfolio Standards have led to the examination of multiple cellulosic feedstock types to understand how they could contribute to supply goals for use in transportation fuels and electricity production (USDOE, 2011; DSIRE 2013). As the feasibility of biomass is limited by the costs associated with transportation and processing of materials (Jensen et al. 2011), understanding potential supply at regional scales is important if biomass potential is to be realized. Enthusiasm for the potential of biomass feedstocks to offset fossil fuel use in transportation fuel and electricity production have spurred research and policy development efforts that primarily consider the role of agricultural producers on an instrumental level (Rossi and Hinrichs 2011). Developing policy tools designed to encourage developments in the bioeconomy or completing research into the feasibility of biomass feedstocks that is irrespective of the role of agricultural producers is a top-down approach that neglects the inherent dependency of such endeavors on the participation of biomass suppliers (Rossi and Hinrichs 2011; Villamil et al. 2012).

In their review of a decade of socioeconomic research into agroforestry, Montambault and Alavalapati (2005) note the importance of appropriate feedback loops between agricultural researchers and practitioners to understand what facilitates and constrains adoption of integrated tree and shrub systems within agricultural operations, and to appropriately guide future research. They place specific emphasis on the importance of interdisciplinary assessments of opportunities relating to agroforestry, as a developed

understanding of biophysical realities as well as landowner and land operator decisions are key in capturing drivers and shaping needs within the U.S. agricultural landscape. As such, this research is the foundational component for a larger multidisciplinary project funded by USDA-SARE concurrently investigating: biomass yield, potential income and investment parameters, spatial assessment of marginal land, and carbon sequestration opportunities within the U.S. Northern Great Plains states of Kansas, Nebraska, North Dakota, and South Dakota.

I elected to study the use of tree and shrub systems for our assessment of a regional biomass feedstock as agroforestry practices can be strategically targeted within existing agricultural systems to derive multi-scale environmental benefits (e.g., Jose 2009; Dosskey et al 2012), benefits to crop and livestock production systems (Brandle et al. 2004; Hernandez et al. 2012), and income diversification potential (Godsey et al. 2009; Workman et al. 2003). Utilizing a biomass crop that could be targeted towards “marginal acres” of an agricultural system, or those that perform poorly relevant to adjacent land or present unique management challenges, can additionally allow farmers and ranchers an opportunity to produce a biomass crop within existing agricultural systems.

This thesis presents insights from complementary qualitative and quantitative research conducted simultaneously in order to explore aspects of agricultural producer interest in establishing, harvesting, and marketing trees for biomass production in targeted areas within existing agricultural systems in the U.S. Northern Great Plains (NGP) region. Qualitatively, a series of regionally-based focus groups were completed to capture rich, narrative information relevant to the perceived benefits and problems associated with use of trees in an agricultural system. Results frame focus group discussion through an explorative

framework utilized to capture interactions of farmer and rancher perceptions of marginality, perceptions of the presence/use of trees and shrubs, and influences on participation as a biomass supplier which ultimately shape needs and interest in participating as a biomass supplier. Quantitatively, a region-wide representative survey of U.S. Great Plains farmers and ranchers managing marginal land was designed to gauge factors affecting interest in serving as a supplier of woody biomass. Survey results were analyzed through statistical description and through the use of an ordered probit regression designed to explore farmer and rancher interest in establishing, harvesting, and marketing trees for biomass production. Results are presented to address the interactions of farm attributes, individual farmer characteristics, relevant attitudes, knowledge, and perceived constraints on interest in producing woody biomass.

Outcomes from this research can support multiple actors within the Northern Great Plains regional bioeconomy. Identifying and addressing knowledge gaps and perceived barriers for farmers and ranchers relative to agroforestry and biomass production can assist conservation professionals in identifying knowledge gaps and targeting appropriate information diffusion to local farmers and ranchers. Additionally, policy development leaders can utilize outputs to modify or expand existing policy tools or form new tools that address key needs expressed by agricultural operators within the Northern Great Plains. This research will also serve to support industry efforts within the region through the parameterization of farmers and ranchers most likely to be interested in serving as suppliers of woody biomass, thereby serving as a transitional feedstock suppliers while markets for renewables continue to emerge.

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CHAPTER II

A QUALITATIVE INVESTIGATION OF FARMER AND RANCHER PERCEPTIONS
SURROUNDING WOODY BIOMASS PRODUCTION ON MARGINAL
AGRICULTURAL LAND

A paper to be modified for submission to *Small-scale Forestry*

Ashley M. Hand and John C. Tyndall

Abstract

Bioenergy produced from perennial feedstocks could serve as an opportunity to strengthen local and regional economies, reduce fossil fuel energy consumption, and also jointly produce various environmental services. In order to assess the potential for biomass-based bioenergy, it's essential to characterize the interest that potential biomass suppliers have in such an endeavor. In the U.S. Great Plains region, this largely means assessing relevant perceptions of farmers and ranchers. Similar to other agricultural regions in the U.S., the Great Plains dedicates the majority of its agricultural land to crop and livestock commodity production. All land is not qualitatively the same; however, as some acres produce lower yields relative to adjacent farmland or present unique management challenges. Perennial based bioenergy crops may well be a suitable alternative for these acres that have proven to be challenging to farm or graze while providing diverse on-farm revenue streams for agricultural producers. This study qualitatively investigates farmer and rancher interest in agroforestry systems for biomass production through a regional series farm/ranch operator focus groups completed to capture rich narrative data. Findings highlight the complexities associated with farmer definitions of marginality, attitudes towards trees and bioenergy

production, while also characterizing biophysical and institutional influences that facilitate or constrain farmer/rancher interest in woody biomass.

Introduction

The current focus in the United States on domestic energy independence and diversification of energy sources has led to an exploration of the potential offered by renewable, plant-based biomass crops. Contributions from renewables are largely framed around their potential for use in transportation fuels as well as in production of electricity. The 2007 U.S. Energy Independence and Security Act (EISA) encourages research and production of potential biomass feedstocks in order to advance goals for transportation biofuels production as outlined by the Renewable Fuel Standard 2 (RFS) (USDOE 2011). While annual ethanol production from grain based sources (e.g., corn) is close to achieving the 15 billion gallon RFS goal set for annual production for 2022 (USDOE 2011), targets for cellulosic ethanol are being annually reduced by the U.S. Environmental Protection Agency (EPA) due to unexpectedly low production volumes (USEIA 2013). Subsequently, lack of dedicated supply and undeveloped markets continue to be significant challenges for an emerging cellulosic liquid fuel industry. Despite the challenges in advancing biomass based (cellulosic) transportation fuels, biomass has the potential to contribute to state-level targets for electricity production (Hurlbut 2008; White et al. 2013). In some regions of the US, it is in this context that biomass may have the strongest potential for ongoing market development should there be continuing multi-scale efforts to reduce reliance on fossil sources for electricity production (Koppejan and Van Loo 2012; DSIRE 2013).

The majority of current and potential biomass supply is dependent upon dedicated management for biomass materials on agricultural and forested land (USDOE 2011; Milbrandt et al. 2014), as 40% of U.S. land area is used for agricultural purposes and 31% is forested (NASS 2012; USGS 2013). As the feasibility of such endeavors are limited in critical ways by the costs associated with feedstock availability (production, processing, storage) and transportation (Jensen et al. 2011), understanding potential supply at regional scales is crucial to encourage investment in and development of local markets. As noted in various speculative regional biomass feedstock assessments, a key US agricultural region with considerable bioenergy potential is the U.S. Northern Great Plains (NGP) region (USDOE 2011; Milbrandt et al. 2014). In the NGP, crop residues (e.g., corn stover, wheat straw, sorghum residue) comprise the most physically abundant bioenergy feedstock in the NGP region (Perlack et al. 2005; USDOE 2011) and dedicated crops such as energy sorghum and switchgrass have distinct agronomic potential (USDOE 2011).

Recently there has been interest in exploring the niche potential of other biomass sources that may exist in the region. Biomass materials that could be utilized in the context of small, biomass-based electricity generation that could help the region incrementally meet renewable energy goals, while reducing greenhouse gas emissions, advancing bio-renewable infrastructure and enhancing local economies are particularly desirable (Lezberg et al. 2010). As such, this study qualitatively assesses the regional supply potential through an investigation of influences on farmer and rancher interest in woody biomass systems targeted within existing NGP farm and ranch systems.

A role for woody biomass within prairie states

As biomass supply limitations can hinder industry development at local scales, identifying feedstocks that can contribute incrementally to meet existing renewable energy goals while simultaneously advancing bio-renewable infrastructure and enhancing local economies could prove critical. Additionally, the use of a feedstock that provides supplemental multifunctional and multi-scale outcomes could serve as an added incentive for biomass production and utilization. In the NGP region, intentionally targeted trees and shrubs (aka agroforestry systems) have long been utilized within existing agricultural systems for environmental purposes (Merwin 1997; Brandle et al. 2009). While these systems are broadly recognized for their role in enhancing the functionality of agricultural landscapes and in mediating broad arrays of ecosystem services (e.g., Jose 2009), the unrealized potential for these systems to provide utilizable volumes of biomass is strong (Jose and Bardhan 2012). For example, yields from woody biomass trials using coppice species in Kansas suggest high tonnage for at least three harvests over 15 years is likely feasible for black locust (*Robinia pseudoacacia*) and silver maple (*Acer saccharinum*) (Geyer 2006).

The multifunctional benefits associated with trees and shrubs utilized in agroforestry systems have led agricultural tree plantings in the NGP to be targeted for several primary purposes including economic diversification, benefits to crop and livestock production systems, and environmental enhancement/protection. Merwin (1997) notes an NGP inventory reflecting that field windbreaks represent 30% of regional agricultural tree plantings, 38% are farmstead/feedlot windbreaks, 29% are wildlife plantings, and 3% are for other purposes (e.g., living snow fences, Christmas trees, etc.). Agroforestry systems offer a host of positive biophysical contributions when targeted strategically within agricultural systems, including

reducing soil loss to streams, flood control, increasing carbon sequestration, increasing inputs of organic matter, serving as a windbreak, microclimate control, and mitigation of greenhouse gas emissions (Schultz et al. 2009; Jose 2009; Brandle et al. 2009; Dosskey et al. 2012; Gelfand et al. 2013). Most tree and shrub plantings in the NGP have occurred on land capability class II or III soils as they exhibit moderate to severe limitations to use compared to class I soils, thereby reducing the choice of cover or requiring moderate conservation practices to which agroforestry can offer benefits (Merwin 1997).

Agroforestry systems in the context of biomass production have been highlighted for potential benefits afforded by establishment on “marginal” agricultural land, as they would have a relatively low level of competition with existing food/energy crops and have the potential to mitigate resource concerns resulting from intensive grazing and cropping regimes (Gelfand et al. 2013; Skevas et al. 2014). The use of marginal land for biomass has been examined for the capacity to produce a variety of annual and perennial feedstocks including dedicated annual energy crops, use of crop residues, perennial grasses, and woody systems (Gelfand et al. 2013; Skevas et al. 2014). As markets for corn ethanol have resulted in extensive conversion of grass cover to corn and soybean cropping systems within the region (Wright and Wimberly 2013), land use alternatives utilizing perennial woody crops in marginal areas in the NGP may serve to provide biophysical benefits associated with agroforestry systems while simultaneously contributing feedstocks to a regional bioeconomy.

Social contexts for utilizing woody biomass in the NGP

The development of a viable regional bioeconomy with sufficient feedstock supply capacity is more than just a biophysical and infrastructural issue; it is a socio-technological

issue as well. Regional biomass feedstock potential is determined by agronomic capacity as well as by the existing or emergent capacity of the social infrastructure to support an industry (Tyndall et al. 2011; Rossi and Hinrichs 2011; Villamil et al. 2012). Since the majority of existing and potential biomass production in U.S. agricultural regions would be privately determined, it is imperative for feedstock supply and investment analysis to have a better understanding of the interests, concerns and needs of potential suppliers that could influence future intentions with regard to biomass production and management (Tyndall et al. 2011). Furthermore, the development of policy tools designed to encourage investment in a regional bioeconomy also requires a firm understanding of potential supplier needs, interests and concerns; all of which are often regionally unique (Tyndall et al. 2011; Caldas et al. 2014).

Agricultural producer interest in utilizing marginal land for biomass production is highly relevant and valuable in the context of supporting an emerging bioeconomy, and therefore associated concerns must be known and addressed if this opportunity is to be realized. Soil resource concerns resulting from removal of surface residues and higher erosion potential have shown to decrease farmer interest in harvesting annual bioenergy crops (Villamil et al. 2012; Caldas et al. 2014), however perennial bioenergy crops may be appealing to those oriented towards resource conservation or enhanced aesthetics (Skevas et al. 2014; Caldas et al. 2014). Additionally, some agricultural producers have demonstrated concerns with establishing energy crops as they could serve as a disamenity to currently valued non-monetary benefits associated with agricultural land (Skevas et al. 2014). The use of trusted sources of information through interactive, in-person knowledge sharing is a reportedly useful tool in engaging potential adopters of bioenergy crops (Villamil et al. 2012); however, some producers may be averse to establishing a new practice until they see

peer success elsewhere within their region and have the ability to draw comparisons to their own system (White & Selfa 2013).

In order to frame opportunities and constraints on developing supply within the NGP, we focus on investigating relevant perspectives of regional farmers and ranchers to form a qualitative assessment of factors affecting interest in participating as a supplier of woody biomass. As knowledge of the requirements associated with supplying woody biomass is likely limited while biomass markets emerge, we targeted our exploration to capture farmer/rancher perspectives on several factors that could influence interest in participation as a supplier. Specifically, we sought to answer three research questions to identify influences and needs associated with potential supplier interest:

1. How do farmers and ranchers define “marginal” agricultural land?
2. What benefits and problems do farmers and ranchers perceive with agroforestry systems?
3. What are farmer and rancher perceptions of biomass and bioenergy production systems?

Study Methods

Our study utilizes qualitative analysis as a methodological approach to framing influences on interest in producing woody biomass, as it allows us to capture and reflect the associated richness and complexity using findings that emerge directly from participant statements. Results are relevant to the success of a regional bioeconomy utilizing cellulosic biomass, as emergent concerns will need to be confronted and opportunities seized if farmers and ranchers are to participate as suppliers. We utilized focus groups as a way to qualitatively

probe NRP farmers and ranchers for knowledge and attitudes surrounding woody biomass systems. Focus groups allow for a targeted discussion among a group with a selected characteristic in order to gain understanding into a specific issue, allowing participants to offer their unique perspectives while building off of the perspectives of others (Krueger and Casey 2009).

We conducted five focus groups total, one per state in Kansas, Nebraska, and North Dakota, and two in South Dakota (Figure 2.1) between August 6, 2013 and April 10, 2014. Eligible participants included individuals who reported responsibility for on-farm decision making for their crop or livestock production system. Those livestock producers who only managed feedlots or confinements were not considered eligible for participation in the focus groups. Focus group participants in the different states were selected through nominations from local and state resource professionals (e.g., associated with the USDA Natural Resource Conservation Service; district-level State Foresters, etc.) and agricultural NGOs, as well as through snowball sampling. An incentive payment of \$100 per individual was offered for participation in a focus group. Participants were provided advance information regarding project goals and anticipated topics of exploration, were contacted by a researcher to discuss their farm operation and information regarding focus group participation, and were additionally provided a link via email with further information regarding the larger research goals associated with the project in which this study is embedded. Participants were notified of the voluntary nature of participation in the focus groups during initial contact through a confirmation letter, and prior to the beginning of the focus group discussion. Consent to participate in the research project was implied by each participants' presence at the voluntary focus group. Focus group locations in each state were selected to accommodate the highest

number of interested participants. Iowa State University's Institutional Review Board approved our research approach and data management protocols prior to data collection.

As local or regional markets for woody biomass within the NGP are relatively undeveloped, we utilized a structured interview protocol to channel focus group discussion through an explorative framework, providing context for biomass production on managed land assuming markets existed. Marginality has been conceptualized within the context of biomass production in a variety of ways (Niu and Dukier 2006; Hatfield and Morton 2013; Gelfand et al. 2013; Milbrandt et al. 2014); however, for our research we queried farmers and ranchers on the conditions that constitute marginality relative to their land base and associated management strategies within their farm system, allowing their self-determined definitions to provide context for subsequent discussion. We then explored farmer and rancher knowledge, attitudes, and beliefs associated with agroforestry, and subsequently woody biomass, allowing those questions to frame their discussion regarding interest in participating as a biomass supplier.

Data coding

Following the focus group discussion, participants were asked to complete a short questionnaire to capture relevant demographic information. Focus groups were audio recorded, transcribed, and results were coded using NVivo 10 (QSR 2014). Preliminary open coding (identifying and labeling content) was used to categorize statements made to ensure our protocol appropriately garnered relevant information. A second cycle of hierarchical axial coding (establishing relationships between codes) was completed to explore categories and draw data into overarching themes, and to explore nuances within a given theme. Both

cycles were coded using grounded theory; a theoretical approach allowing findings to emerge from primary field data collected with specific research processes (Corbin and Strauss 1990). During the second cycle coding, data from the first two focus groups was coded into thematic categories by two researchers to develop a code book, with repeat coding on themes with a kappa coefficient >0.40 , denoting poor inter-rater reliability. Themes with an initially low kappa coefficient were either eliminated as thematic categories, absorbed into related themes, or were further defined for both coders with subsequent recoding into the theme. The lead author completed the second cycle coding for the subsequent three focus groups; with no modifications to overarching themes in order reflect statements made by participants.

Results

In total, 35 farmers and ranchers participated in our focus group series. A summary of participant demographic information is presented in Table 2.1. Cumulatively, focus group participants manage 51,500 acres across 32 counties in the NGP. Reported land use on participants' property included crop production, woodlands, land enrolled in the Conservation Reserve Program (CRP), shelterbelts/windbreaks, ponds, wetlands, pastureland, and grassland. Reported crops produced in the region include corn, soybeans, wheat, oats, hay, barley, millet, milo, sugar beets, sunflowers, canola, flax, peas, and safflower.

Data collected during the focus groups reflected the highly complex and often contradictory nature of agricultural land management in the NGP and, more specifically, of their individual social-psychological processes in evaluating the opportunity to participate in an emerging bioeconomy. The design of our explorative study allowed participant

perspectives to emerge relevant to our interest in understanding farmer/rancher views on the potential to utilize marginal land for the production of woody biomass, both in terms of their own land as well as regionally. As our conceptual framework elicits insights relevant to farmer and rancher interest in agroforestry for woody biomass production within a specified context, we present our insights from the focus group discussions using a similarly channeled approach (Figure 2.2). Results reflect emergent values and attitudes, farmer/rancher knowledge, expressions of risk and uncertainty, as well as perceived external constraints that interact to shape (1) participants' definition of marginality, (2) farmer/rancher knowledge of agroforestry systems and attitudes towards the presence/use of trees within their managed operation and in relation to the larger rural landscape in their region, and (3) farmer/rancher evaluation of various influences on participation as a biomass supplier. The relationship between these three components of our context further interact to provide (4) a framework for understanding the perceived opportunities as well as needs of farmers/ranchers who may be interested in participating as a biomass supplier.

Conceptualizing marginality and managing marginal land

The use of marginal land for the purposes of biomass production could serve to simultaneously enhance both economic and environmental objectives for an agricultural system. For this study, the qualities and determinants of what constitutes "marginal" land from the perspective of farmers and ranchers was an initial topic explored in-depth within each focus group. The resulting discussion served to frame their overall evaluation of benefits/problems associated with trees integrated within in an agricultural system, as well as the participants' explorations of biomass generally. Understanding the nuances associated

with participants' definition of marginal land is therefore key to an appropriate interpretation of perspectives on the potential of woody biomass within their farm or ranch system.

Largely, three interrelated ways that farmers and ranchers perceive marginal agricultural land emerged from discussion, including biophysical factors, economic/behavioral drivers of marginality, and marginality relative to other land-use options.

Discussion throughout the focus group series reflected that marginal land is largely conceptualized upon physical factors perceived either on farmer's/rancher's managed land or within their region, including salinity, rockiness, amount of organic matter, and excessive or poor soil drainage causing chronic and/or large scale flooding or issues with erosivity. Substantial discussion was dedicated to the interrelated issues posed by the influence of climate, topography, and human use impacts to soil quality. Variable regional precipitation (specifically, the limited precipitation in the western portion of the NGP) was cited as a contributor to landscape-scale marginality, as was the increasing variability in the amount of annual precipitation within a localized area. Farmers and ranchers in Kansas initially focused on the effects of limited precipitation to define marginality, and many agreed that there was not any marginal land within northeastern Kansas, an area of the state dominated by corn and soybean production. In this regard, participants offered:

Participant 1: "In [my] county there is no marginal ground. It's either farmed or it's creek bank."

Participant 2: "You get your marginal ground when you go south and west."

Topography was also repeatedly noted as an issue that could impact management in various ways. For example, participants in western South Dakota highlighted topographical issues in terms accessing land due to slope percentage. They noted how many of the trees within their area grow within steep wooded draws, and as such they are unable to easily

manage or remove woody vegetation. In the other states, topography was referenced in relation to increased erosion from improper management of crop or grazing systems on steeper slopes. Lack of significant slope was also noted as being potentially problematic when combined with effects of climate. Within North Dakota, the relatively flat topography of the central region was discussed relevant to flooding on poorly drained soils and erosional impacts from intense wind.

Erosion within row crop fields, pasture, and of stream banks was the most widely cited attribute contributing to the marginal nature of certain land and was noted in all focus groups. Many participants noted that concerns over erosion have largely dictated some of their management trajectories to better protect and improve soil resources. Human-use impact was often tied to discussions of erosion, with participants noting ways in which agricultural management can exacerbate or mitigate erosion. Participants in Kansas specifically noted how resource concerns associated with intensive cropping systems are easily masked by increased external inputs, therefore not reflecting the impacts of degradation that would be realized without the use of chemicals. Two farmers offered:

Participant 1: “Well I would argue that most of our marginal soils, at least for Kansas, are due to human use and chemicals are just a mask of the problem. They hide the damage done by loss of organic matter.

Participant 2: “We’re putting a Band-Aid on an issue is all we’re doing chemically.”

Additionally, the over-emphasis of conservation benefits associated with reduced tillage or no-till practices was cited as a barrier to general interest from agricultural producers in utilizing further efforts to protect soil. One Kansas farmer noted:

“Another thing I’m hearing farmers saying, the ones that have been doing no-till for a while, [they] do not see the conservation practices needed anymore. They’re already doing it. They’re no-till. Their soil is not getting washed away. Their soil is

improving; they don't need terraces, they don't need trees. They don't need all that because they're no-till now."

A farmer in North Dakota echoed this notion in the context of wind erosion, stating:

People say that [North Dakota farmers] don't need trees because we've minimum tilled, but the reality is we still till a lot... [T]his winter was a hard one in North Dakota. The dirt in the air...I've got pictures where you couldn't see a quarter mile and it wasn't from the snow, it was from the dirt.

As farmers and ranchers were concerned about human use implications on soil resources or management of land with other biophysical challenges, the utilization of perennial cover offered by woody biomass could serve as an attractive land use option to mitigate some concerns.

Reported biophysical and climate-related factors were noted for their combined effect manifesting as economic impacts, and specifically noted were the considerable challenges posed when managing for a high-value crop on land considered to be marginal. The ways that marginality contributes to economic outcomes were expressed in terms of low yields relative to input costs, particularly when input costs are elevated due to specific management challenges of a piece of land (e.g., access issues, slope, moisture conditions, low organic matter, etc.). Within North Dakota for example, excess moisture or flooding of agricultural land created a "prevented planting" situation, that is preventing farmers from planting a given crop before the final planting date specified by an insurance policy. Farmers and ranchers noted that crop insurance can serve as a potential hedge against risk associated with marginal land, however many farmers/ranchers expressed concerns with crop insurance programs and their utilization as a further driver of marginality. Woody biomass, in this regard, offers potential as an alternative land use that could serve to offset opportunity costs when targeted to acres that are problematic for production of annual crops.

Although most participants discussed marginality relative to an intended use (e.g., grassed pasture, haying, row-crop farming), three focus groups (KS, NE, central SD) used discussion to form a more relative definition of marginality. For example, when asked to define marginal agricultural land, one Nebraska farmer initially stated: “[M]y concept has been, living in Nebraska, that if you can’t grow corn on it, it’s marginal.” Subsequent discussion framed biophysical conditions and behavioral drivers, leading the participant to ultimately challenge his previous definition and offer a new frame for the concept. He stated,

“I’ve been kinda struggling with this in my mind since you brought it up. We gotta remember marginal is not a noun it’s an adjective, and so marginal has gotta be in relation to what? So some of our land would be marginal for growing trees, some would be marginal for growing crops, and some would be marginal for pasture. So maybe we had oversimplified it when I... said that it’s relative to corn.”

This flexible definition received both verbal and non-verbal expressions of agreement from several other participants within the Nebraska focus group, and was referenced subsequently when discussing agroforestry and interest in biomass as a potential land use opportunity. Within Kansas and South Dakota focus groups, discussion on agroforestry and biomass crop establishment also continued to reference a relative definition of marginality.

The good trees and the weed trees: Perceptions of agroforestry

After previously engaging participants to collectively define marginality, conversation within the focus groups shifted to the use of trees to enhance the environmental quality of a farm system. Across all states there was a broad general interest stated for the establishment and management of trees for multifunctional outcomes within participants’ farm/ranch systems. Agroforestry, as the integration of tree and shrub systems within agriculture, can afford a variety of benefits when targeted within existing systems. Within

this section, farmers and ranchers qualify what benefits they perceive agroforestry to offer and additionally offer discussion on trees generally within the Northern Great Plains.

Farmers and ranchers articulated the potential utilitarian benefits of woody systems within their existing agricultural systems largely in the context of positive contributions to financial viability; that is, utilizing biomass systems to enhance profit potential of their existing cropping systems or as a way to expand profit potential through income diversification (e.g., selling biomass). Tree-related benefits noted in the context of enhancing current cropping systems centered upon potential yield benefits to crop production through various effects such as improving microclimate conditions, managing moisture and protection from wind erosion; as well as wind protection, shade, and extended forage opportunities for livestock. One North Dakota farmer noted her knowledge on production benefits of establishing trees on the periphery of cornfields, stating:

“...You have your spot right out from the tree row where your corn is going to be stunted and shorter, but the next two to three tree heights out your corn production is going to be at least double in that area... There is an increase over the whole field just based on that forty to sixty feet out from the tree row, because of the moisture, the snow that comes off of the trees... it’s all that much moisture for the corn.”

One rancher in western South Dakota noted how trees serve to improve moisture conditions within his operation, stating:

“Everything that we’ve done, all the tree belts we’ve planted and everything, have all been to conserve water [managing moisture for crop use]... to catch snow.”

In addition to potential benefits for the enhancement of their agricultural systems, farmers and ranchers noted environmental and cultural benefits offered by trees. These benefits were sometimes discussed relative to aforementioned crop and livestock benefits, and farmers and ranchers noted a process of prioritization while engaging in management activities. One rancher from Kansas noted a trade-off he made in order to enhance wildlife habitat at the

expense of utilizing his woodlands for a location to overwinter his cattle. He describes this decision, stating:

“The previous landowner had grazed his livestock [to where] there was no understory brush... I do a lot of bird watching and it’s got habitat that should be conducive to a lot of migratory species and they’re just, they weren’t there. Wildlife enhancement was part of [my management priorities] and it has helped substantially keeping livestock out of there... Most livestock producers would look at that and say ‘man, that is a great place to winter cattle’ ... but best usage? No, I don’t think so.”

Farmers/ranchers broadly reflected on both an appreciation for intangible benefits of trees such as existence value and contributions to well-being, as well as more concrete benefits presented to their agricultural operation including protection and improvement of water and soil resources, enhanced wildlife habitat, recreation opportunities, biodiversity, carbon sequestration, and aesthetics. Although benefits in this regard were typically expressed simply and largely agreed upon, subsequent discussion bounded the realization of these benefits through an exploration of potential issues with woody vegetation.

Problems associated with trees were largely characterized by their growth or lack thereof. Participants within the South Dakota and Kansas focus groups noted the biophysical difficulty of growing trees within the western portion of their states as a major barrier to utilizing trees for biomass or any other purpose within their farm/ranch system. Within our focus group in eastern Kansas, for example, farmers and ranchers discussed general limitations for tree growth due to limited rainfall and the widespread need for intensive irrigation in many agricultural activities. Within our groups in central and western South Dakota, while not a universal concern, a number of farmers and ranchers noted biophysical limitations as their primary hesitancy in interest as a woody biomass producer when considering that opportunity. One western South Dakota rancher stated bluntly:

“If you can find a tree that'll grow in my country, that'll get whatever height it needs to get in a reasonable time, the [I would look into woody biomass]. Right now, I don't know what that tree is.”

Some farmers and ranchers isolated this issue to trees they attempted to intentionally establish within their agricultural system, noting that they still had unintended invasive species on their managed land.

Conversely, farmers and ranchers in all focus groups noted problems resulting from unintended tree growth. In this regard, a considerable amount of concern centered on trees being considered a “nuisance” within their agricultural operation or with some species considered broadly as being “weeds” that challenge primary agricultural activities. However, these issues were often couched in the overall value provided by trees, as one Kansas rancher illustrated when noting the value of many of the naturally occurring trees in his agricultural operation, stating:

“I mean cedar is a big problem... We're constantly cutting cedar out. But in places you have to have trees. It's just good farming practice.”

Participants discussed trees such as Eastern red cedar (*Juniperus virginiana*) or Siberian elm (*Ulmus pumila*) that have a tendency in this region to invade rangeland and grasslands thus requiring periodic and at times, costly removal. Nevertheless, there was a clear distinction between volunteer trees (problem/weed trees) and “good trees,” which are planted or naturally occurring in a manner that offered desired benefits to farmers and ranchers.

Evaluating the influences on participation as a biomass supplier

When focus group discussion steered from exploring farm/ranch trees generally to exploring trees as a biomass crop, interest in trees began to reflect a spectrum of perspectives

regarding the impact financial interests play in evaluating an opportunity within their operation. Statements reflected two orientations towards interest in supplying biomass; with some farmers expressing that their interest in a multifunctional system is tempered by financial need, while others noted a deliberate weighing of perceived trade-offs between financial benefits and non-monetary benefits afforded by woody systems. Many participants illustrated their approach to evaluating new opportunities by offering examples of and motivations for current land use choices. One Nebraska rancher noted how the financial interest of his farm system takes precedence within his operation, guiding him to explore a diversity of land use options:

“[When] managing as a whole... you want to recognize those areas that would be marginal for crop or grass and they happen to be, on my farm, good for trees. I’ve got some that’s marginal for growing corn or soybeans because but it just happens to be premium for growing grass. A then I’ve got some other areas that I... just set aside more or less for wildlife.”

When discussing motivations for management, he goes on to state:

“The actual choices I made probably had a lot to do with my personal value system, but the bottom line was if I had land that was not producing well on an annual basis for corn then I had to figure out some way to get it to produce well because I had a mortgage.”

An additional farmer from Kansas offered how non-monetary values influence his management decisions for his grazing operation, stating:

“We got a couple pieces of land [with] springs that feed into [a creek]... In some respects it’s good grazing area but you can just see that if you graze this without any special precautions... the land degrades pretty rapidly... It has an environmental value much higher than its commercial value and [I’m] trying to figure out how to manage and balance those two interests.”

Regardless of whether a farmers’/ranchers’ interest in an opportunity was driven by profit seeking or a balanced approach with non-monetary benefits, focus group participants drew attention towards external constraints that limit management choices regarding biomass

opportunities. The participants in KS, NE, and central SD spent considerable time discussing the challenges to biomass management associated with a regional rise in land values, as well as taxation resulting from current local and state policies. In addition to the general rise in land value due to relatively high recent commodity prices, participants in the Nebraska focus group noted how suburban sprawl is abutting against agricultural land bordering municipalities, subsequently driving up the value of neighboring farms as land becomes more attractive for development. Additionally, farmers and ranchers from Kansas and South Dakota reported constraints on decision-making from agricultural taxation policy, as individuals are taxed using metrics for productive capacity, which they perceive to disincentivize land use diversification.

When exploring the possibility of establishing a biomass crop, pressure from lending institutions was also reported by farmers and ranchers as an important financial constraint to management. Combined pressures of lending institutions and those from taxes were highlighted to potentially lead profit objectives to supersede other objectives within an agricultural operation. Across all focus groups, participants highlighted how financial pressures can be a problem particularly relevant to younger farmers with higher debt to asset ratios. For instance, one farmer from Kansas stated:

When I purchased this property... I was leveraged way more than I ever wanted to be leveraged on that, so it was a financial decision for me. I had to earn cash but... the older you get the less leveraged you are. I own the property now; I can do what I want. The bank doesn't tell me [what I can and can't do anymore].

Another farmer from South Dakota echoed this concern with his personal experiences, describing difficulty receiving a loan when he began his current farming operation within the

last 15 years, noting his eventual participation in a program dedicated to providing assistance to beginning farmers which he views as instrumental to his success.

Farmer/Rancher views on incentive programs and market subsidies

As high opportunity costs of biomass management and other complexities (such as limited information) challenge interest in participating as a supplier, the use of policy tools such as subsidies or technical service programs to encourage management for a specific objective is commonplace within the realm of agricultural production. Naturally, our focus group discussions often steered towards the utilization of such programs in their region when discussing biomass management strategies within their agricultural operation. Within our first focus group in Kansas, broad discussion regarding environmental management in agriculture highlighted the use of incentive programs or working with local resource professionals (e.g., USDA NRCS) as a collaborative relationship whereby farmers/ranchers could obtain financial or technical resources to achieve farm-level goals. The Kansas focus group participants noted various key relationships formed and programs utilized in the process of managing their farm system. One farmer/rancher queried the group on how to handle an ecologically sensitive area on his property through the use of tree systems, and a rancher offered “I started working with the Kansas [Forest Service] about six or eight years ago and they have helped me tremendously with knowing what to do with things like that.” Another Kansas farmer discussed his positive attitude towards available programs as well as the need for broader availability specifically in the context of managing for bioenergy biomass and its associated opportunity costs, offering:

“[The] Biomass Crop Assistance Program... has a lot more flexibility. It has a five-year contract instead of a ten- or fifteen-year contract, it pays for establishment of

perennial grasses, so there's a lot of conservation funding that has been available but people aren't aware of it. Now it doesn't pay as much as corn when corn's seven or eight dollars a bushel..."

Nevertheless, despite a general awareness of various governmental biomass and environmental incentive programs, farmers and ranchers within other states in the NGP expressed hesitancy to participate in programs. Overall, what emerged from discussions in Nebraska, South Dakota, and North Dakota was a rich, subjective history from many participants regarding the often-negative consequences of participating in a government program. Some of the reluctance was simply tied to a general aversion to financial assistance of any kind if it was tied to government programs. Reasons cited ranged from more individualistic challenges such as general mistrust of the government, as well as the quantity of paperwork and other "red tape" associated with state and federal government programs; to more systemic consequences such as exploring who ultimately benefits from land enrolled in a conservation program. In Nebraska, two participants explored their history with CRP, offering their perspectives on the cyclical nature of conservation program use that is often driven by markets, and unintended consequences of the program:

Participant 1: "People put land in [a conservation program] of some sort, prices go up, [the conservation practice] comes out, [and the] people that get the money are the people that ripped it out."

Participant 2: "And it just goes round and round and round, and if you've lived as long as [Participant 1] and I have, you've seen about three cycles; soil bank and land bank, CRP; they just change the names and everything stays the same."

An additional systemic problem discussed regarding the structure of government incentives included whether or not programs have the ability to meet their objectives, or whether they cause harm to people or the land as a result of their existence. Commonly cited in this regard was U.S. crop insurance policy and resulting incentivization of annual

production systems (e.g., row crops) as opposed to perennial systems like woody biomass.

One farmer/rancher within one South Dakota focus group offered:

“We’ve seen that in our area, where somebody came in and it had already been... all native grasses, and then this person came in and wanted to farm it, and he just drained it off and he’s planted crops in it for two years. They both failed. And now there’s no cover out there, and it’s blowing... And then the insurance pays him and.... He can get more money... with the programs and insurance than he can anything else.”

Participants largely noted that they would prefer to participate in a non-governmental organization or industry sponsored incentive or subsidy programs over governmental programs if they were to utilize a program to offset costs associated with woody biomass production. They viewed programs external to the government as often serving to better offer mutual benefits to involved parties, as well as having less associated requirements for enrolled farmers and ranchers. Several participants did, however, note benefits afforded by all incentive programs (governmental and non-governmental), including technical assistance when engaging in a new opportunity such as establishing trees for biomass production, or in supplemental financial management training required of some governmental programs. Still; while appearing to strongly prefer the existence of local, sustainable, independent markets to any incentive program; farmers and ranchers expressed an understanding that start-up subsidies may be required to support emerging markets. As one farmer stated:

If an industry can stand on its own, it's a viable industry. And, maybe it's okay to subsidize something for a little while; corn ethanol's okay for a few years, to get it on its feet. But then at some point, corn ethanol has to make or break it on its own, and that's kind of how I feel about anything.

Aligned with that notion, one South Dakota rancher noted a strong preference for local processors for woody biomass, offering, “if there's not a functioning facility somewhere

reasonably close by for you to take [harvested trees] to, then that's going to make a whole lot of difference.”

Interestingly, it was noted that various incentive programs might well encourage innovation in the context of land use, thereby facilitating adoption of woody biomass. For instance, a South Dakota rancher discussed the value he perceived in governmental programs to encourage farmers and ranchers to try new opportunities. In regards to the Conservation Stewardship Program, he offered “you get some support, it helps you open your mind and try something new rather than doing it the same old way that we've always done it.” This benefit of incentive programs was referenced to combat the tendency to adhere to tradition within the agricultural community, an implication associated with perceived social norms. One Nebraska farmer noted the mental difficulty in positioning yourself to do something different within a given locale. Regarding his potential interest in establishing trees within his agricultural system for biomass, he stated:

One issue is your neighbors will say ‘well that’s crazy, because the next guy’s gotta come along and put a lot of dozer work into pushing it all out so that he can put corn in there,’ which is the assumption is that it will all go back to corn. ...It’s kinda hard psychologically to get yourself to go in and start planting trees on ground that you used to farm.

In addition to the influence of tradition within agriculture, several farmers/ranchers commented on how social norms influence the use of incentive programs as they can impact relationships with neighbors. Several participants felt the utilization of incentive or subsidy programs could help them to compete economically. One farmer offered:

“The reason we're enrolled in some of the programs and take the money is because our neighbors are doing it too, and we're competing with them... If I have a way to increase and get paid for practices that I'm already doing, I'll take it. I have to say, I almost feel guilty taking it, but if I don't, the next guy down the road is going to do it, and he's going to beat me. I have to compete with that person.”

The inverse perspective was also offered, as one farmer noted a desire for collective benefit with neighbors, rather than competition. That farmer stated:

"There's parties that actually get hurt in those situations... even like CRP, it might be between me and the government, but what will it do to the rental rates to the guy next door, that was renting the piece of property? ... When I had land in CRP, that wasn't good for everybody in the country. It was good for some people and it wasn't good for other people."

Overall, participants expressed skepticism of incentive or subsidy programs and framed concerns regarding the social implications of program participation secondary to their aforementioned concern regarding market sustainability for woody biomass and regulations associated with programs that could potentially offset costs associated with biomass production.

Participation as a biomass supplier: Benefits, concerns, and information needs

While opinions regarding the need or value of incentive programs varied within the focus groups, one issue was fairly uniform in evidence. In order for farmers/ranchers to participate as suppliers of woody biomass, they require a greater degree of information in order to assess the reality of the opportunity within the context of their existing agricultural system. Information needs expressed by participants in all focus groups fit into three broad categories (1) technical information relevant to the establishment, growth, harvesting, and marketing of woody biomass, (2) the environmental sustainability of producing biomass on marginal land, and (3) the economic sustainability of producing a biomass crop within their farm system. This section additionally notes opportunities shared by farmers/ranchers during discussion relevant to the potential for woody biomass within their farm system or state.

Participants in the focus groups expressed low-to-no knowledge regarding the technical aspects of biomass production, which would need to be remedied if they were to consider participation as a woody biomass supplier. Many participants expressed their visions of how agroforestry systems could exist within their operation for biomass production, but still expressed hesitancy given the amount of unknowns they felt are associated with woody biomass production. One farmer from South Dakota reflected his vision and concerns, stating:

“Coming here, I had envisioned something more or less on the lines of... on these cropland acres, planting strips through 'em, of trees, and then taking advantage of the hunting... and they give shade, you could set 'em up so they'd hold snow too... keep some of that moisture there to get through them later-on months. I mean, I'd be interested in something like that, but the management side of it would have to be absolutely nailed down so that it didn't turn into these fast-spreading trees, and have a mess.”

Information needs noted by participants relevant to serving as a woody biomass supplier include specifics centering upon planting guidelines and requirements such as appropriate species, ideal soil type and soil moisture requirements, and the degree and timing of management necessary for a desirable biomass crop. There were also considerable questions regarding the end use and logistics thereof. Questions in this area included the amount of biomass required for use by an end user and the corresponding acres of land required to grow that amount, technical specifications and capital requirements for harvest, and information on typical post-harvest land conditions to better understand action needed to continue producing a biomass crop or to convert the land to an alternative use.

Although a concern was expressed by a few participants towards establishing woody biomass systems that might create extensive management needs resulting from undesired tree/shrub growth elsewhere in their operation, many focus group participants noted a strong

potential for woody biomass within their farm systems should they be able to capture and control growth of “weed trees” to productively serve as a woody biomass crop. This idea was framed by participants in two different ways, either as harvesting undesired growth from within a farm system, or intentionally establishing “weed” species within a farm system to enhance characteristics desired by biomass processors for those species which are able to establish on a farmer’s/rancher’s land. Discussion in this regard was particularly focused as an ideal opportunity for areas with biophysical challenges affecting tree establishment and the rate of tree growth. One South Dakota rancher offered:

“I can see the potential of growing weed trees, I mean elms, and these kinds of things. But... it'd be three to four to five years before you'd get any return on your investment, which isn't necessarily a bad thing.”

Similarly, a Kansas farmer commented on a possibility for those in western Kansas who face ongoing issues with soil moisture and productivity as a result of limited precipitation:

“Now if you had a brushy biomass crop that you could grow with limited water in poor soil, you could find enough ground out [west]. People would be interested in growing something that they could sell on.”

Interest in growing and managing biomass for harvest on marginal agricultural land was tempered for several participants by the need to be environmentally sustainable and not exacerbate existing resource concerns. All focus groups in our regional series offered discussion on the importance in protecting or improving soil quality, often with an emphasis on increasing organic matter. This was framed around the ability to sustain land’s productive capacity to grow grass or crops, as well as expressed as an overall duty of farmers/ranchers as land stewards. This focus on soil led some farmers/ranchers to express concern with other forms of cellulosic feedstock production, including corn stover and switchgrass, and to

speculate as to whether or not woody biomass systems would be similar. Participants from focus groups in the Dakotas stated:

“Even with switchgrass--you're pulling minerals out, and you're hauling them away, and you're mining and you're not replacing it.” – farmer, central South Dakota

“I would prefer to see trees harvested for biomass than people using wheat straw for biomass, or even corn stover... because the trees would grow on a specific area over time. The corn stover, you start taking that residue off the land and you've got less there to build future organic matter for your soil. And, I mean, once it's gone, it's gone.” – farmer, North Dakota

Several participants additionally noted concerns with ethanol production generally, reporting hesitancy to act as a supplier in that capacity as there may be unintended negative consequences from an evolving bioeconomy. One western South Dakota rancher noted his uncertainty regarding the consequences a developed biomass industry may have on future generations, specifically noting how utilizing subsidies to spur development has unknown future economic and environmental costs. A central South Dakota farmer commented on his concerns surrounding the financial cost of cellulosic ethanol production, offering:

“If it costs more to get the product to the final stage than what it's worth, what comes out at the end, I'm not interested. I think that when you mentioned cellulosic ethanol, I'm thinking there's some logistical problems with that industry that scare me.”

Coupled with the uncertain industry-level financial feasibility of producing cellulosic biofuels, one South Dakota focus group discussed concerns regarding unknown consequences the development associated with biomass processing facilities would have on local communities. Two participants noted implications of local development, stating:

Participant 1: “A bigger question might be... are we ready for a co-fired [coal and biomass] plant or an ethanol plant to be developed in our neighborhood? Are we ready to see that?... If it's economically feasible, I think people would participate. The bigger question is, do we want to be intruded by having that development there?”

Participant 2: “It's kind of like the ethanol plants back east. They planted more corn, and that brought the price of the corn up, so everybody benefited. But then, when you

drive into the town--which is where I grew up--the ethanol plant was in town, and you opened the windows and went [coughing] 'Oh my!'"

Farmers and ranchers noted value, however, in contributing on a broader scale to landscape-level biodiversity, as well as contributing renewable resources to alleviate concerns relating to climate change and to promote domestic energy independence. One South Dakota rancher noted the value he perceives in reducing foreign oil interests, stating:

"I think it's a wonderful thing for energy. I hate to see us worried about what's going on in the Middle East, and about ninety percent of it is because we gotta worry because they have oil."

In addition to information needs as well as perceived benefits and concerns regarding biomass, uncertainty surrounding economic profit and a desire for significant information on profitability permeated discussion in all of our focus groups. The lack of quick profit resulting from a biomass crop compared to annual cropping systems was a common and significant barrier. When parameterizing interest in serving as a biomass supplier, one Kansas farmer offered her perspective general to agricultural producers in her state:

"I think overall our agricultural producers are into what the rest of our society is; which is instant gratification and there's no instant gratification with trees."

Similarly, a North Dakota farmer offered:

"To me that would be the biggest mental hurdle if you're looking at it as dollars and cents: Will [markets] actually be here in fifteen years, or am I going to hire a bulldozer to take [the trees] out?"

Several opportunities were cited to alleviate concerns relevant to financial profitability and management activities associated with producing woody biomass within the NGP, including the use of demonstration sites, available technical assistance, contractual production agreements, and most notably - developed independent local markets. When evaluating priorities and selecting whether or not to

establish a woody biomass crop, producers will ultimately have to weigh uncertainties with potential benefits and available resources, and within the context of external constraints present within their area. One South Dakota farmer/rancher offered his simple view on how producers must direct management decisions within their agricultural system, stating:

“Bottom line: we've got to make it as a business. We've got to bring in more than the cost to produce, and we've got to be able to do it year after year.”

Discussion

This study serves as a qualitative investigation into influences and needs associated with interest in establishing woody biomass systems. Our analysis of data from farmer/rancher focus groups conducted in the U.S. Northern Great Plains was targeted to capture farmer and rancher perspectives on “marginal” land and associated management, as well as those associated with agroforestry systems and biomass production generally. Our findings suggest that individual farmer and rancher knowledge, values, and attitudes; perceptions of risk and uncertainty; as well as external constraints often interact to shape perspectives. These in turn influence farmer/rancher individual needs as it relates to their interest in serving as a supplier of woody biomass to an emerging regional bioeconomy. Agroforestry practices have the potential to serve as a multifunctional, transitional feedstock source that can be targeted for establishment within the periphery of existing agricultural systems while local infrastructure for biomass utilization develops. Therefore, exploring opportunities and constraints to woody biomass production through the lens of potential suppliers is critical if this opportunity is to be realized.

Results from our exploratory study align with previous research, suggesting that farmers and ranchers can negotiate between seemingly contradictory attitudes when engaging in management decision-making (Rossi and Hinrichs 2011). Farmers/ranchers reported a belief in their role as land stewards the value of resource conservation, however they simultaneously engage in management practices contradictory to those attitudes due to the reported influence of external constraints. The conversion of grasslands within the NGP to corn and soybean production (e.g., Wright and Wimberly 2013) serves as an example of the profit motivations influencing regional land use conversion and demonstrates that farmers are willing to convert land for perceived short-term increased profitability (Swinton et al. 2011). Nevertheless, targeting outreach to communicate the variety of benefits afforded by the establishment of trees as a biomass crop may be essential to marketing this opportunity to potential suppliers. Our research points to the appeal of multifunctional outcomes to NGP farmers/ranchers and additionally, it has been shown that farmers have at times been willing to face higher risk when there is an associated benefit with an activity or behavior (Chouinard et al. 2008; Hatfield and Morton 2013). Also, agricultural operators' value orientation has been shown to influence subsequent management decisions relating to conservation, resource protection, and required profit outcomes (Barbieri and Valdivia 2010; Rossi and Hinrichs 2011); therefore highlighting aspects of woody biomass production that can serve to mediate farmers' and ranchers' value system and financial needs could prove beneficial to increase interest.

Still, the most pervasive constraint present in the focus group interviews was the need for profit above most other objectives for their farm system. This constraint was often nested within a recurrent focus on participant concerns of a viable local market for woody biomass

developing within their region, a finding consistent with previous explorations of emergent bioenergy supplier opportunities (Rossi and Hinrichs 2011; Villamilet et al. 2012). Our focus group participants also echoed findings in previous research when noting struggles with requirements from lending institutions (Arbuckle et al. 2009), as agricultural producers often face stringent guidelines on allowable land use practices in order for them to receive financial assistance. Previous research exploring policy options is consistent with the broad preference among farmers and ranchers in our study for participating in free markets over engaging with governmental entities for subsidies due to associated regulations and general skepticism (Atwell et al. 2009; Delshad et al. 2010; White and Selfa 2013). Legislative and policy interventions could serve to alleviate financial issues relevant to taxation and lending pressures; however, policy tools would hinge on farmer and rancher participation in subsidy or incentive programs. Additionally, the broad social context of specific programs noted within our results positions use of government incentive programs such as CRP as a driver of competition within a community. Whether or not a farmer or rancher has a positive or negative evaluation of competition can therefore influence their participation in programs. Those who are disincentivized by the potential for participation in a program to act as a barrier to collaborative relationships with neighbors may seek other options to relieve any financial pressures they face.

The NGP region does have demonstrated experience with farmer participation in a biomass incentive program, as two areas of Kansas participate in the Biomass Crop Assistance Program (BCAP). BCAP is a federal financial incentive policy tool providing subsidies to participating landowners and biomass processing facilities to address regional supply issues posed by developing markets for cellulosic biomass (FSA 2011). Additionally,

the NGP has existing policy structure encouraging the increasing utilization of renewables for electricity production from sources such as wind, solar, and biomass. As part of their Renewable Fuels Portfolios (RFP), Kansas set a legally binding Renewable Fuels Standard to have 20% of electricity production from renewable resources by 2020, the Dakota states each set a more flexible goal of 10% by 2015, while Nebraska has not set formal targets (DSIRE 2013). North Dakota has already surpassed their original target, with 16.7% of retail electricity from renewable energy sources (Lein 2011). Kansas is about three-quarters of the way to meeting their renewables standard (KCC 2014), while South Dakota is about halfway to meeting their voluntary targets (SDPUC 2013). U.S. state rankings on policy-readiness for woody biomass utilization position North Dakota as a state with a relatively developed policy structure (ranked 13th) (Guo et al. 2012). Rankings for the rest of the NGP (Kansas, 25th; South Dakota, 31st; and Nebraska, 41st) suggest a need for further development of financial incentives (tax incentives, subsidies and grants, financing and contracting) and non-financial incentives (rules and regulations, education and consultation) to better facilitate utilization of woody biomass (Guo et al. 2012).

Although biomass utilization policy structures and tools are available regionally, whether or not farmers and ranchers will participate in those depends on how they evaluate both a given policy tool, as well as woody biomass production generally. Previous qualitative research exploring biofuel options demonstrated public concern with corn-based energy crops likely driven by negative attitudes associated with using grain as a fuel source, and a preference for cellulosic materials (Delshad et al. 2010). Farmers and ranchers in the NGP mirror concerns with ethanol from corn, however, report support for cellulosic biomass with the exception of crop residues due to concern for preserving soil health. Most farmers and

ranchers in our study who were attracted to biomass production were interested largely because woody biomass crops were more often than not viewed as complementary to their existing system; an important belief also captured within previous research on the use of perennial vegetation (Strong and Jacobsen 2006, Atwell et al. 2009). Participants within our research noted this compatibility both operationally and for the potential of tree and shrub systems to provide multifunctional and multi-scale benefits. However, farmers and ranchers noted a distinct need for increased information on the ecological sustainability of utilizing marginal land for biomass production, tempering their interest if information they receive replicates their concerns with annual biomass crops and crop residues. Disseminating information on management standards for woody biomass production (e.g. Janowiak and Webster 2010) relevant to protecting on-farm natural resources, as well as the net gain of energy producing SRWC systems compared to intensive agriculture (Volk et al. 2004) could alleviate these concerns.

As widely documented and mirrored within our study, agricultural producers broadly value on-farm demonstration sites and the ability to learn from peers and trusted sources in their region (Atwell et al. 2009; Villamil et al. 2012; White and Selfa 2013). Participants noted the value of seeing an opportunity in action in order to visualize its capacity to fit with their objectives for their existing farm system, however this carries a connotation of disinterest in being an early adopter. Absent of significant regional adoption, resource professionals can intervene to share technical expertise and fill knowledge gaps on establishing, growing, and harvesting woody biomass to improve self efficacy for potential early adopters.

Conclusion

Results from this study have implications for those engaging in policy development efforts designed to further encourage the use of a variety of feedstocks within an emerging bioeconomy within the Northern Great Plains, as well as for resource professionals sharing relevant knowledge to agricultural operators on available or emergent opportunities. Insights drawn from our study, while bound by our contextual framework and to the individuals within our focus group series, shed light on the level of awareness and associated concerns of farmers and ranchers on various drivers of landscape change within their states. Additionally, our research highlights the complexity associated with evaluating a potential endeavor that is largely hypothetical due to the emerging nature of markets for woody biomass in the Northern Great Plains, capturing a rich picture of how farmers and ranchers seek to both parameterize and reduce associated risks and uncertainties. Further research that seeks to guide multi-scale efforts to alleviate the barriers to choosing diversified systems reported by farmers and ranchers within our study could serve both to facilitate the realization of an operator's ideal farm system, as well as to aid in the development of regional efforts to produce energy from renewable resources.

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Figures and Tables

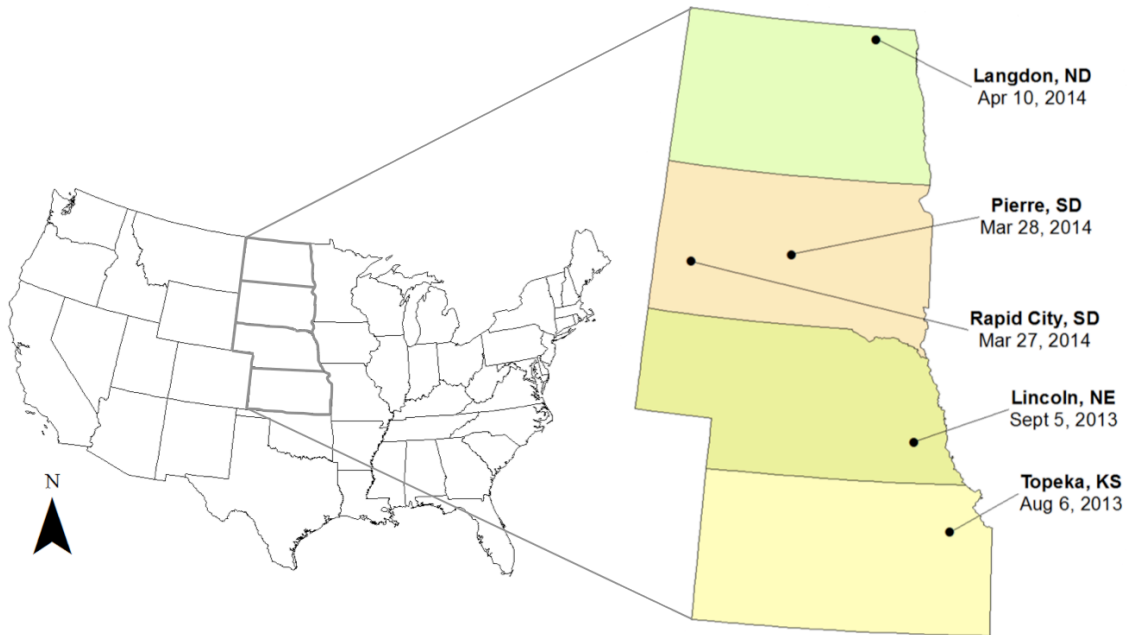


Figure 2.1. Locations and dates of focus group interviews exploring woody biomass within the U.S. Northern Great Plains. Data: U.S. state data accessed from Iowa State University Geospatial Technology Program. U.S. cities data access from National Weather service OST/SEC GIS Map Group.

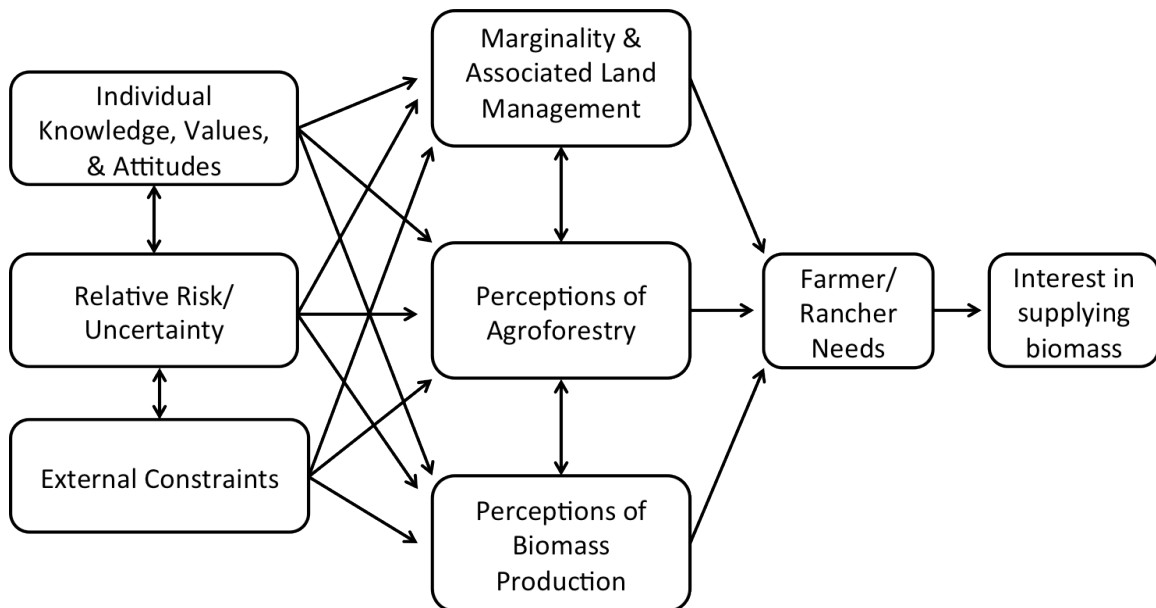


Figure 2.2: Analytical framework representing influences on farmer and rancher interest in supplying woody biomass within the U.S. Northern Great Plains from a focus group series, 2013/2014

Table 2.1. Summary of participant and farm system characteristics from a farmer and rancher focus group series the Northern Great Plains exploring woody biomass potential, 2013/2014.

	KS (n)	NE (n)	ND (n)	SD (n)
Average acres of land managed	1,753 (8)	523 (7)	946 (8)	2,302 (11)
Average age in years	49 (8)	55 (7)	47 (8)	57 (11)
Average years farming or ranching	29 (9)	30 (7)	17 (8)	29 (11)
Percent of female participants	22 (9)	14 (7)	12 (8)	36 (11)
Percent planning to continue managing for the next 10 years	89 (9)	100 (7)	86 (7)	90 (10)

CHAPTER III

INFLUENCES ON FARMER AND RANCHER INTEREST IN SUPPLYING WOODY BIOMASS IN THE U.S. NORTHERN GREAT PLAINS

A paper to be modified for submission for publication to *Agroforestry Systems*

Ashley M. Hand, Troy Bowman, and John C. Tyndall

Abstract

State and federal level policy targets for renewable energy production in the U.S. have prompted investigations into the feasibility of different biomass feedstock types for use in transportation fuels or electricity production. As biomass markets in the U.S. have been slow to emerge despite policy initiatives, it is relevant to examine the potential of biomass sources that have the capacity to provide considerable ancillary benefits to farmers and ranchers while also contributing biomass to developing regional markets. Biomass from woody vegetation could be well suited in this capacity, as woody systems can be targeted strategically within existing agricultural systems for multifunctional benefits while building regional biomass supply capacity. In order to assess the potential for biomass-based bioenergy, it is essential to characterize the interest that potential suppliers have in such an endeavor. In the U.S. Northern Great Plains region, this largely means assessing relevant perceptions of farmers and ranchers. Results from a region-wide representative survey of farm and ranch operators managing marginal land indicate that 61% of operators have some degree of interest in woody biomass production. An ordered probit regression was utilized to further investigate how farm system attributes, individual farmer/rancher characteristics, relevant attitudes, knowledge, and perceived constraints affect interest. This study highlights attributes of operators who are most likely to be early adopters of a woody biomass crop and

has implications for the development of relevant regional policy initiatives and management practices.

Introduction

Recent federal and state policy developments have shaped potential for plant-based cellulosic feedstocks to be utilized in energy systems, including co-firing with coal for electricity production, conversion for ethanol and other bio-chemicals, and thermal energy production (Tyndall et al. 2011b; USDOE 2011; DSIRE 2013). The Renewable Fuel Standard (RFS) goals set within the 2007 U.S. Energy Independence and Security Act mandated a significant increase in plant-based renewable feedstock production and utilization within transportation fuels at a national scale (USDOE 2011). Additionally, U.S. state-level targets for renewable electricity production have shaped efforts to identify and utilize potential opportunities for energy sources from natural resources, including woody biomass (DSIRE 2013).

The viability of biomass-based energy systems necessitated by policy is in part dependent upon management changes to land currently utilized for agriculture. One significant challenge to the emergence of biomass-based systems in certain regions of the U.S. is posed by the often-high opportunity costs (e.g., high farmland values and commodity prices) associated with biomass management (James et al. 2010; Manatt et al. 2013). In U.S. agricultural regions where land values are comparatively low, emerging biomass markets may allow biomass crop establishment and management to compete with opportunity costs while increasing the scope of farm-level production (Kells and Swinton 2014). Additionally, biomass markets hinge on the need for dedicated regional biomass supply due to high transportation costs (Hess et al. 2007), positioning a need for small-scale production and

utilization. As local and regional supply systems and production infrastructure develop, the ability for woody biomass to be targeted for integration within existing agricultural systems positions it as an ideal transitional feedstock that could help the region incrementally meet renewable energy goals, while reducing greenhouse gas emissions, advancing bio-renewable infrastructure and enhancing local economies (Brown and Mann 2008). This study serves to quantitatively characterize influences on farmer and rancher interest in producing woody biomass within the U.S. Northern Great Plains, specifically within the context afforded by the potential to target woody biomass production within existing agricultural systems while biomass markets evolve.

Strategically locating wood biomass production systems on marginal land (e.g. land which provides challenges to management or produces lower crop yields relative to adjacent land) could provide a suitable land use opportunity that offers a variety of direct benefits to agricultural producers and the systems they manage. Recent research on biomass production as a function of agroforestry systems has centered on the potential for agroforestry to jointly produce biomass as well as enhanced environmental function in agricultural landscapes (e.g., Gruenwald et al. 2007; Atwell et al. 2011; Jose and Bardhan 2012; Holzmuller and Jose 2012; Thevathasan et al. 2014). Agroforestry consists of a suite of practices with broad applications within the United States and globally (Montambault and Alavalapati 2005; Nair 2011), however this study places particular emphasis on two practices: windbreaks and riparian buffer systems. Specific environmental benefits afforded by these practices include benefits to soil through decreased soil loss from wind and water erosion, increased organic matter inputs above and below ground, and increased carbon sequestration; air quality benefits through potential reductions in nitrous oxide or methane emissions; and water

quality improvements through reducing soil and nutrient inputs into streams (Niu & Duiker 2006; Schultz et al. 2009; Jose 2009; Dosskey et al. 2012; Schoeneberger et al. 2012). In addition, agroforestry has the potential to positively contribute to existing crop and livestock production systems through crop yield increases with reduced external inputs, control of flood events and stream morphology, microclimate control, and odor mitigation associated with livestock confinements (Schultz et al. 2009; Brandle et al. 2009; Hernandez et al. 2012); improvement to wildlife habitat and farm system aesthetics (Grala et al. 2010); as well as increased recreation opportunities (Arbuckle et al. 2009; Barbieri and Valdivia 2010). Targeting additionally offers the potential for biomass produced from agroforestry systems to incrementally contribute to supply needs at local and regional scales while infrastructure and markets develop. This will ultimately aid in addressing production and use targets set forth by various federal and state renewable energy goals (e.g., U.S. Renewable Fuel Standard; state-level Renewable Portfolio Standards) while additionally providing multifunctional benefits (James et al. 2010; Manatt et al. 2013).

One region where agroforestry may well have strong potential in the context of biomass production is Kansas, Nebraska, North Dakota, and South Dakota, collectively referred to as the Northern Great Plains (NGP). The NGP region currently has the capacity to provide multiple cellulosic feedstocks, and the inclusion of wood biomass produced in targeted areas within existing systems could serve as an additional source for an emerging bioeconomy. Current forecasts suggest that dedicated energy crops, including herbaceous vegetation and short rotation wood crops (SWRC) such as poplar (*Populus sp.*) and willow (*Salix sp.*), could contribute between 400 and 799 million dry tons of biomass nationally by 2030 assuming establishment beginning in 2014 (USDOE, 2011). In addition, the NGP

possesses a generally favorable policy climate for wood biomass utilization (Guo et al. 2012), a strong infrastructure to support multiple forms of renewable energy (Mabee et al. 2011; Guo et al. 2012), and a fairly long history of agroforestry utilization (Gardner 2009).

As a large percentage of NGP land is dedicated to row-crop agriculture and grazed pastureland (Figure 3.1), agroforestry can additionally offer ecosystems services to mitigate some of the resource concerns resulting from intensive agricultural land use. These concerns include impacts to water quality and quantity; soil health, including the loss of soil carbon; and the loss of aboveground carbon sinks (Parton et al. 2007). Water quantity issues are of particular concern as agricultural practices in the more arid western portion of the NGP rely directly on depleting inputs from the Ogallala aquifer (Beattie 1981; Parton et al. 2007). Additionally, conversion of permanent vegetation to corn/soybean production systems in the western Corn Belt (ND, SD, NE, MN, IA) is occurring at a rate between 1-5.4% annually, particularly in ND and SD east of the Missouri River in the transition zone between climates (Wright and Wimberly 2013). Ecological impacts posed by this conversion include habitat reduction, reduced capacity for carbon storage, reduction of native biodiversity, and threats to water quality through sediment and nutrient inputs (Wright and Wimberly, 2003; Johnston 2013).

To assess the potential for biomass-based bioenergy and the role that agroforestry-based systems could play, it is critical to characterize the interest of individuals who could serve as potential biomass suppliers, such as regional agricultural landowners and operators (Tyndall et al., 2011b; Rossi and Hinrichs 2011; Villamil et al. 2012). Understanding the regional context of producer interest is critical due to relatively high costs associated with biomass production and transportation, as well as varying biophysical conditions across

agricultural areas within the U.S. (Hess et al. 2007; Tian 2013). Linking renewable energy goals with regional environmental interests (Jensen et al. 2011) and capturing potential supplier interest in producing biomass are requisite in the further development of appropriate policy and in targeting potential regional suppliers and end users.

Regional bioenergy policy framework

Current policy frameworks at state and federal levels offer targeted goals for plant-based biomass production within the NGP, as significant federal policies focus on biomass use in transportation fuels while state-specific Renewable Fuels Portfolios (RFPs) target biomass production for retail electricity sales. The Renewable Fuel Standard 2 (RFS) set targets for transportation fuel with annually increasing goals for renewable biofuels production from 2007 – 2022 (USDOE 2011). Total U.S. annual production of corn ethanol for 2010 was 13.2 billion gallons, only 1.8 billion gallons shy of the 2022 annual RFS goal for corn-based ethanol (USDOE 2011). States in the NGP along with states in the U.S. Corn Belt (MN, IA, MO, MI, WI, IL, IN, and OH) have the highest production capacity for corn ethanol at 251 million gallons or more per year per state (USDOE 2011). National supply potential for cellulosic ethanol is far from reaching the original RFS goals outlined in 2007, however, with annual EPA volume requirements being regularly reduced due to fuel unavailability (USEPA 2013). These are in part driven by high transportation costs and needed technological improvements for commercial production (Hess et al. 2007; USEIA 2013).

State policy also serves as a driver of renewable energy production and could serve to incentivize wood biomass within the NGP. State RFP standards are legally binding and

require adherence to a set schedule to reach specified targets for retail electricity sales from renewable sources. Renewable portfolio goals are similar although not legally binding (DSIRE 2013). Kansas established a renewable fuels portfolio standard requiring 20% of electricity production from renewable resources by 2020, and the Dakota states each adopted a renewable fuels portfolio goal of 10% by 2015 (DSIRE 2013). Kansas is currently three-quarters of the way to their goal, with 15% of electricity demand supplied by renewable electricity as of 2014 (KCC, 2014). A South Dakota Public Utilities Commission Report (2013) states that retail utility partners in the state have the capacity to meet voluntary renewables targets by 2015, although it's noted that many partners are currently choosing not to comply with specified timelines thusly leaving targets currently unfulfilled. North Dakota, however, surpassed targets in 2010 and more recent reports note over 16% of electricity sales from renewables (Lein, 2011). Nebraska is the only NGP state with no specified standards or goals for renewable energy sources.

Hurlbut (2008) notes a need for complements to state RFPs, including in-state or regional resource assessments and an examination of transmission capabilities from supply areas to production facilities. Guo, Hodges, and Young (2012) rank U.S. state wood utilization policies, focusing on financial (tax incentives, subsidies and grants, financing and contracting) and non-financial incentives (rules and regulations, education and consultation) offered by policy tools relevant to wood biomass. States in the NGP are ranked with North Dakota 13th, Kansas 25th, South Dakota 31st, and Nebraska 41st, demonstrating relatively developed policy structure for North Dakota, and needed improvements elsewhere in the region to better facilitate utilization of wood biomass.

Interest in agroforestry for wood biomass

Despite potential farm system and landscape benefits, agroforestry still has yet to see high rates of adoption within the US. Supplier interest and adoption potential in the context of wood biomass is further constrained by infrastructural capacity and market limitations. Previous research has indicated that there are a number of key factors typically associated with agricultural operator/landowner interest within the context of an emerging bioeconomy: 1) agricultural system and farmer/rancher characteristics, 2) relevant attitudes associated with use of trees for biomass, 4) knowledge of agroforestry or biomass production, and 5) perceived constraints.

Farmer demographics have been captured within previous research efforts to demonstrate the influence one's individual characteristics might have on interest in establishing trees and in biomass production systems generally. Age is an influential factor with increasing age associated with decreasing interest in agroforestry or biomass production (Valdivia and Poulos 2009; Villamil et al. 2012). Land ownership is also linked to adoption of agroforestry practices with a higher ownership percentage being indicative of higher interest in agroforestry (Skelton et al. 2005). Additionally, previous research has noted the influence of sex on bioenergy crop type with women generally demonstrating an aversion to bioenergy from corn and one SRWC species (Skevas et al. 2014).

Characteristics associated with someone's agricultural system can also serve to indicate interest in or adoption of agroforestry practices. Perception of a resource concern present on agricultural land can positively affect interest in agroforestry (Valdivia and Poulos 2009). Operation size is also important, as agricultural landowners or producers with smaller operations may be more likely to be interested in adopting agroforestry practices (Skelton et

al. 2005; Arbuckle et al. 2009; Valdivia and Poulos 2009). Amount of land planted to corn and has previously been shown to negatively influence adoption of riparian buffers (Skelton et al. 2005), however, additional research suggests landowners with a high percentage of land in crop production may also be more interested in producing bioenergy crops including corn and poplar (*Populus sp.*) (Skevas et al. 2014). As the NGP states are on the western periphery of the U.S. Corn Belt, producers with corn as a primary crop may face higher opportunity costs associated with higher prices for corn and further driving grassland conversion (Wright and Wimberly 2013).

Attitudes reflecting values or feelings relevant to agroforestry or biomass have also been shown to have a significant effect on interest in producing biomass (Leitch et al. 2013). Values reflecting an appreciation for temporally situated benefits including the sustainability of land use practices or benefits to future generations generally are associated with positive interest in the adoption of tree systems (Strong and Jacobsen 2006; Valdivia and Poulos 2009). Interest in the establishment of trees can also be hindered by attitudes towards the time required to generate revenue from biomass production (Skelton et al. 2005; Strong and Jacobsen 2006). Chouinard et al. (2008) explore the dynamics associated with land-use trade offs through a model demonstrating agricultural producers' behavior orientation along a continuum of profitability, conservation, and stewardship; demonstrating that some farmers are willing to forgo monetary gain for environmental benefits, and would be interested in additional personal benefits such as hunting or other recreation. However, individuals who value the recreation services offered by their agricultural land may be skeptical of the impact of biomass production (Skevas et al. 2014). Feelings associated with relative risk and uncertainty have been shown to impact interest in agroforestry practices (Strong and

Jacobsen 2006; Dosskey et al. 2012), however potential exists for the targeted marketing of agroforestry as a tool for enhancing objectives for their current system (Strong and Jacobsen 2006).

Increasing knowledge of technical aspects of agroforestry systems including establishment, management, product harvesting, and marketing have been shown to have a strong influence on improving levels of interest in producing biomass and in establishing agroforestry, reducing relative uncertainty associated with practice adoption and management (Skelton et al. 2005; Strong and Jacobsen 2006; Valdivia and Poulos 2009; Dosskey et al. 2012; Villamil et al. 2014). Additionally, programmatic efforts to improve farmer self-efficacy through supportive services such as technical assistance, conferences, and field-based workshops are suggested to be effective at increasing adoption of agroforestry and interest in biomass production (Skelton et al. 2005; Dosskey et al. 2012; Villamil et al. 2014).

Intended and unintended outcomes from policy initiatives or programs designed to provide information and assistance to agricultural producers can have positive or negative effects on farmer/rancher adoption of agroforestry or participation in a bioeconomy. Financial constraints on management choices resulting from lending practices can hinder one's ability to realize their ideal farm system by limiting available options (Arbuckle et al. 2009), and possibly contributing (along with profit motivations) to lower rates of adoption for those with higher levels of income from grain production (Skelton et al. 2005). However, relief through financial assistance can positively impact adoption of agroforestry practices (Skelton et al. 2005; Dosskey et al. 2012), although this relief is constrained by farmer perspectives on participation in government programs (Skelton et al. 2005).

Study objectives

As farmers and ranchers perspectives as potential suppliers are critical to the development of a regional bioeconomy within the NGP, our study is designed to statistically explore various factors influencing farmer and rancher interest in agroforestry for biomass production. We frame results to reflect influences on interest as well as to reflect a measure of likelihood of farmer and rancher interest given certain individual and system characteristics or perceptions associated with wood biomass production. We specifically highlight farm attributes, farmer characteristics, attitudes, knowledge, and perceived constraints as they relate to farmer/rancher interest in establishing trees for biomass. We chose to build a statistical model to further explore the degree to which variables influence the probability of interest in growing and selling biomass within that context. We approach our assessment of NGP farmer and rancher interest in producing woody biomass through a telephone-based survey instrument. Results will help identify system or individual characteristics and preferences associated with farmers and ranchers who may serve as early adopters of woody biomass crops, as well as highlight further information and outreach needs or policy development opportunities.

Survey Methods

Survey questions were designed to gather information on the interest of Great Plains farmers and ranchers in growing and harvesting woody vegetation on marginal land for biomass production. Questions asked for attitudes and opinions about potential benefits, profitability, and practicality of planting and harvesting trees. Additional questions were included to identify the size and type of farming and ranching operations. We elected to

utilize a telephone survey to have a higher degree of response control to more accurately capture needed information, as well as to avoid limitations associated with mail survey response given the size of our region (Thomas & Purdon, 1994). Our survey was informed by previous survey instruments utilized to assess producer perceptions of agroforestry and biomass feedstocks, including Tyndall et al. (2011a), Tyndall et al. (2011b); Valdivia and Poulos (2009); and Qualls et al. (2012).

Telephone survey administration

The target population for this project consisted of farmers and ranchers in four states in the Northern Great Plains region of the United States: Kansas, Nebraska, North Dakota and South Dakota. The sample frame for this study's survey component consisted of a list of farmers and ranchers purchased from Survey Sampling International (SSI). The main sample included 1600 farmers/ranchers (400 from each state) with a replicate sample of 400 (100 from each state), for a total sample of 2000. The SSI sampling frame is compiled primarily from records of government farm program participants obtained from the USDA National Agricultural Statistics Service and Farm Services Agency. The farm types requested for the sample were wheat, corn, soybeans, milo (sorghum), oilseed crops (including sunflower, flaxseed, canola, etc.), hay, and beef cattle excluding feedlots. Within each state, the sample was selected proportionately by farm type in order to ensure a representative mix of farms.

Data collection was facilitated by Iowa State University's Survey and Behavioral Research Services (SBRS). Dillman's Tailored Design Method was utilized throughout the data collection phase (Dillman et al. 2008). Standard interviewing protocols were followed throughout the project. The survey was programmed and tested using Snap software (Snap

Surveys Ltd. 2010) and all telephone interviewers were trained and supervised during the data collection phase. Data collection took place from January 20, 2014 through March 12, 2014. Interviews lasted an average of 15-20 minutes. The project received approval prior to data collection from the Iowa State University Institutional Review Board (IRB).

A total of 454 interviews were completed with farmers and ranchers in the sample. Response rates calculated as the percentage of eligible sample interviewed for each state are as follows: Kansas 32%, Nebraska 33%, North Dakota 27%, and South Dakota 31%; overall response rate was 31%. Observations were stratified based on state and farm operation type as classified by the North American Industry Classification System (NAICS) and were weighted based upon each stratum's sampling probability; calculated using estimated strata population size and adjusted based upon non-response rates.

Survey questions were designed to gather information on NGP farmer and rancher interest in growing and harvesting trees as wood biomass on marginal land for energy production if it were profitable. Preliminary questions used to identify the size, type, relevant physical and land use characteristics, as well as management strategies for farming and ranching operations were typically measured on continuous or dichotomous (yes/no) scales. Subsequent questions utilized Likert scales for ordinal questions to explore various attitudes surrounding farmer/rancher benefits afforded by trees in an agricultural landscape, as well as associated perceptions relevant to the use of wood biomass for energy production. Final questions explored pertained to characteristics of farmers/ranchers themselves, which were measured as continuous, dichotomous, or ordinal as warranted by the given question.

Survey analysis

Descriptive statistics were used to characterize survey respondents, assess general trends in farmer intentions regarding biomass production, and explore general beliefs about the process and potential outcomes. Nonparametric group comparisons were conducted as appropriate to explore the relationship between interest level and individual variables relevant to farmer/rancher attitudes, beliefs, knowledge, system characteristics, and individual characteristics. Pairwise comparisons for non-dichotomous group tests were performed using Dunn's (1964) procedure with a Bonferroni correction for multiple comparisons.

An ordered probit regression was used to assess the relationship between independent variables and level of interest in growing and selling woody biomass. The ordered probit model (estimated using maximum likelihood) is the best approach for estimating effects of variables given the discrete and ordinal nature of the scaled data (Greene 2003). Eighteen explanatory variables (Table 3.2) were selected from key factors informed by our literature review (described above) as well through utilization of a stepwise regression procedure to eliminate confounding or insignificant variables. The model was compliance tested for the effects of multicollinearity and heteroskedasticity, and to ensure adherence to the assumption of proportional odds. We examined the marginal effects of each independent variable at its mean for each interest level to estimate the probability of a respondent selecting a given interest level. Statistical analysis was completed using Stata (Version 11.2, StataCorp, 2009), SPSS (Version 22, IBM, 2013), and Microsoft Excel.

The ordered probit model

Several farmer/rancher and farm characteristics were included in the probit regression (Table 3.2). Farmer demographic characteristics including full vs. part time agricultural operators, age, sex, and education level (no college vs. college or higher) were included in the model. With regard to farm characteristics, production scale (in acres) of agricultural operation managed by a farmer/rancher was included in the regression. Whether or not an operator had corn as a primary crop was additionally included, as was a variable for farmers who produce wheat as a main crop for a basis of comparison (wheat is the most abundantly produced crop in the region second to corn). We also included variables noting if farmers and ranchers were enrolled in conservation programs, including a variable for participation in the Conservation Reserve Program (CRP) and a variable for other (non-CRP) conservation program participation. Given the resource concerns common within NGP agricultural systems, we also created a summation variable out of responses regarding the presence or absence of seven common resource concerns (Table 3.3).

A number of variables that can be categorized as farmer/ rancher beliefs and as an extension of belief, attitudes were included in the regression. Farmer/rancher's level of agreement that regional biomass use will increase greatly over the next few years, as well as attitudes towards the immediacy of economic return were additionally included. Farmer/rancher attitudes towards risk were also explored through their reported level of willingness to accept risk compared to other farmers; as per the survey, "risk" was self-contextualized by each respondent and not defined within the survey question. Additionally, a "benefit of trees" index was created by summing the reported levels of importance respondents ascribed to ten potential benefits of trees on their property (Table 3.1), dividing

by the number of individual questions asked for the set, and utilizing Chronbach's alpha to assess reliability ($\alpha=0.846$). We also included a variable reflecting farmer/rancher perceived compatibility of woody biomass production within their current farming operation.

A variable on biomass production experience was formed from a summation of "yes" responses (yes = 1 and no = 0) to five questions assessing their experience producing biomass for livestock use, firewood for themselves or others, and experience producing biomass for other reasons. Finally, a variable reflecting reported level of influence from a farmer/rancher's bank or lending institution was also included in the model.

Results

Descriptive analysis of farmer and farm characteristics

The following is a descriptive overview of respondent and represented farm system characteristics; a summary of these descriptive characteristics is presented in Table 3.4. Nearly 81% of survey respondents were full-time farmers and ranchers. Sixty-six percent produced both crops and livestock, while 30% produced solely crops and 4% only produced pastured livestock. Male farmers represented 95.1% of the survey participants (U.S. Agricultural Census data shows that 94% of NGP region farmers are male). Average respondent age was 58 years, while the US Agricultural Census average for the region was 57 years. The respondents appear to be on average slightly more experienced than the Census regional average, with an average length of time respondents had been in charge of the farming operation equaling 34 years for our sample relative to the 27 years as reported by the US Census. Three-quarters of those surveyed reported intention to continue farming for at least another 10 years or more. A plurality of respondents had a high school education

(34.5%), while slightly less had completed college or graduate education. On average, respondents received 21.7% of their income from off-farm sources in 2013. About half of the respondents (51.4%) reported receiving \$250,000 or less in gross farm sales for 2013. Average acres managed by a farmer or rancher in 2013 (including cropland and pasture) was 1,845 acres including land owned and rented by the operator surveyed, which is larger than the U.S. Agricultural Census average farm size for the region (1,069 acres).

Over half of surveyed farmers and ranchers reported soil erosion from rain or snow melt, and nearly half noted soil erosion from wind as well as unwanted growth of woody plants in their farm system (Table 3.3). However, less than fifteen percent of farmers noted issues associated with loss of wildlife habitat or chemical runoff from their farm system. A high percentage of farmers and ranchers reported a higher level of importance to wind protection and livestock or crop benefits afforded by trees on their property (Table 3.1). Benefits associated with products derived from trees within an agricultural landscape (cultivation or collection of non-timber products as well as production of timber products) were shown to be of little importance to farmers and ranchers, as over three-quarters of farmers and ranchers ranked them as low importance.

To assess farmer and rancher level of interest in producing woody biomass, we utilized a 5-point ordinal scale, with an interest level of 1 = no interest and an interest level of 5 = very interested. Overall, 61% of farmers and ranchers expressed various levels of interest in producing woody biomass, with 10% of respondents reporting they were very interested. As our dependent variable is ordinal, we completed several non-parametric group comparisons to explore how interest may differ given various system and individual characteristics (Table 3.5). Relative to the location of one's farm system, interest level was

statistically significantly different between the different states ($p = 0.0005$) (Figure 3.2). *Post-hoc* analysis revealed statistically significant differences in level of interest between those located in ND and those located in NE, and SD. There is also a suggestive difference in the level of interest between ND and KS. Results also demonstrate a difference in interest based on percentage of land owned ($p=0.007$), with a higher interest level among farmers and ranchers who own between zero and fifty percent of their land compared to those who own more than half their land. Farmers and ranchers who identified the presence of marginal acres, or those which produce poorly or require special management relative to other acres they manage, were shown to have a significantly higher level of interest compared to those who don't perceive any of their managed land as marginal ($p=0.002$).

Our analysis demonstrated some variables relevant to knowledge and experience with woody systems have an impact on interest. Individuals who have previous experience planting trees or shrubs for conservation purposes at their own expense had a higher level of interest in producing woody biomass compared to those who did not ($p=0.0005$). Additionally, farmers and ranchers who had any previous experience producing wood for utilization as firewood or for livestock had a higher level of interest than those who had no experience with wood utilization in that context ($p=0.021$). Reported level of knowledge regarding the harvesting and marketing of woody biomass was not shown to impact level of interest.

Interest level in producing biomass was also shown to differ based upon individual characteristics. Those over age 66 were shown to have a significantly lower level of interest compared to those under 35 and those between 36 and 50 years old ($p=0.004$). Results also suggest male operators may be more likely to be interested than female operators ($p=0.07$).

Level of education was also shown to impact interest, as those who completed college were shown to have a higher level of interest compared to those who did not ($p=0.003$). Gross farm sales from 2013 and percentage of income from off-farm sources were not shown to significantly impact level of interest.

Individual attitudes on the importance of specific values afforded by trees also impacted level of interest. Those who ascribed a higher degree of importance to carbon storage by trees were shown to have a significantly higher level of interest in establishing woody biomass than those who reported no to moderate interest ($p=0.0005$). Differences in interest were also shown to be different based upon the level of value ascribed to trees for hunting, fishing, or other recreation. *Post hoc* analysis demonstrated a difference in interest between those who reported no importance for recreation and those who reported moderate to high importance, as well as a difference between those who reported little or moderate importance and moderately-high importance for recreation. An individual's level of agreement that the production of energy from wood biomass will create new economic opportunities for farmers and ranchers in their state was also shown to significantly impact interest ($p=0.0005$). Individuals who strongly disagreed or disagreed regarding the potential for economic opportunities were significantly different from those who were unsure, agreed, or strongly agreed.

Ordered probit results

Results from the ordered probit (Table 3.6) reflect the directional relationship of the probability of increasing the level of interest in growing trees and selling them as woody biomass if it were profitable, given a specific variable within the model. Additional

conclusions relevant to the influence specified variables have on interest are highlighted using results from our examination of marginal effects, reflecting the percentage probability of selecting a given interest level for a specified variable.

All of the variables relevant to farmer/rancher individual characteristics that were included in the model were significant. A part-time farmer/rancher was 6% more likely to report they are somewhat interested (interest level = 4) than those who are full-time, while full-time farmers and ranchers had a 13% higher likelihood of reporting no interest (interest level = 1). Increased age was shown to negatively affect interest; with a 0.8% increase per year of age in the likelihood they will report no interest (interest level = 1). Thusly, a farmer/rancher's probability of reporting no interest will increase 20% from age 25 to 50, and 40% by the time that farmer reaches age 75. Male operators were shown to have a higher probability of interest than female operators, with females being 28% more likely to report no interest (interest level = 1) in producing woody biomass. Farmers and ranchers who had completed college reported a lower level of interest in producing biomass and were 8% more likely to report no interest (interest level = 1) compared to those who did not complete college.

Our model contained two significant results regarding probability of interest relevant to attributes of farmer/rancher agricultural operations. Those who reported perceiving fewer resource concerns on their land were 5% more likely to report no interest in establishing biomass compared to those who reported experiencing more resource concerns (see Table 3.3). Farmers and ranchers with land enrolled in non-CRP conservation programs had a greater level of interest compared to those who do not, and were 4% more likely to report that they were very interested in producing woody biomass (interest level = 5). Conversely,

those not enrolled in a non-CRP program had a 12% higher probability of reporting no interest (interest level = 1).

Variables included in the model reflecting attitudes relevant to producing woody biomass were also shown to significantly affect interest. Farmers and ranchers who reported a higher willingness to accept risk also have increased interest in producing biomass compared to those who were self-reported as less willing to take on risk. A farmer/rancher with a higher level of agreement that growing trees for energy production would be compatible with their existing practices on their farm/ranch system are shown to have a 5% higher probability of reporting they are somewhat interested (interest level = 4), while those who may view woody biomass as incompatible with their farm system are 12% more likely to report no interest (interest level = 1). Farmers and ranchers who more strongly agree that woody biomass use will increase greatly over the next few years are more likely to express a higher level of interest. Individuals who report that the time required until they receive profit from producing biomass is “too long” have a 9% higher likelihood of reporting no interest (interest level = 1), while those who don’t perceive an issue with the time until profit are 4% more likely to be somewhat interested (interest level = 4). Our summation variable reflecting knowledge gained by level of experience producing biomass was also significant in the model. Individuals with fewer experiences in biomass production had a 7% higher probability of expressing no interest (interest level = 1) compared to those with more biomass experience.

The ordered probit model also suggests other variables may have an influence on probability of interest but are ultimately statistically inconclusive ($0.05 \geq p \geq 0.1$). Farmers and ranchers producing wheat as a main crop are suggested to have a higher interest level

than those who do not produce wheat. Additionally, our variable assessing the importance of benefits of trees on their property (Table 3.1) suggests those who ascribe high importance to the benefits of trees on their property have a higher interest level compared to those who perceive trees on their property of lower importance. Additionally, some variables included in the model were not shown to affect the probability of interest, including the size of the operation managed by the farmer or rancher, if corn was a main crop on managed land, participation in CRP, and reported level of influence from a bank or lending institution.

As a supplemental component of our assessment on interest in producing woody biomass, we explored several variables that could potentially increase farmer interest by examining means and associated confidence intervals by state. Only “having local facilities to process biomass for energy production” was reported by farmers and ranchers to increase interest level “some” within all states. Additionally, existence of a sustainable, non-subsidized private market for biomass could increase interest level “some” for farmers and ranchers in all states with the exception of those in North Dakota, who reported that it would increase interest “a little.” South Dakota farmers and ranchers are shown to have additional preferences that could increase interest “some” including receiving payments for environmental benefits associated with trees, as well as the availability of free technical assistance. Additional variables which were shown only to increase interest level “a little” within all states in our study include: third party assistance in harvesting, marketing, processing and transportation; receiving government subsidy payments for associated costs; and the allowance to harvest woody biomass from land enrolled in conservation programs.

Discussion

This study assessed Northern Great Plains farmer and rancher interest in participating as a biomass supplier if it were profitable through the use of a regionally representative telephone survey designed to outline the influence held by producer and system characteristics, attitudes, knowledge, and perceived constraints. Results from an ordered probit regression highlight that many variable characteristics influence farmer and rancher interest in producing biomass if it were regionally profitable. This analysis provides insight into the types of producers who are or are not generally interested in pursuing woody biomass production as a way to either diversify farm output or otherwise better utilize marginal farmland. The findings of this research provide insights into the types of producers who would be suitable for targeted outreach information aimed at illuminating available opportunities to serve as a supplier of biomass while regional biomass markets and infrastructure develop.

Results capture individual and system characteristics of producers who may have a higher level of interest and are therefore likely ideal candidates as early adopters of woody biomass within the NGP. Those who own less of their managed land, have identified resource concerns or the presence of marginal acres, produce wheat as a main crop, or are enrolled in a non-CRP program may benefit from targeted outreach. Additionally, those under age 50, who have completed college, and have previous experience with wood utilization or who have planted trees for conservation at their own expense may likely be receptive to information on producing a woody biomass crop.

Results from our study largely indicate that many factors have the potential to drive interest down; however, none of the variables included in our model have strong influence in

increasing level of interest. This could be in part a result of the hypothetical nature of participating as a supplier of biomass, as markets and industry infrastructure are still relatively non-existent for cellulosic biomass utilization. Hesitancy towards establishing woody biomass could also result from lack of user knowledge regarding practices and associated management and product markets, leading to missed opportunities for the management of multifunctional benefits if counter information is not offered within the region (Skelton et al. 2005; Strong and Jacobsen 2006; Valdivia and Poulos 2009; Dosskey et al. 2012).

NGP farmers and ranchers note that the presence of local processing facilities will increase level of interest region wide, with additional potential for increased interest in some states from the existence of independent markets, as well as the availability of technical assistance or financial assistance tied to environmental benefits afforded by trees. Although Skevas et al. (2014) note the potential to harvest from land enrolled in conservation programs for landowners who utilize non-crop marginal land for conservation purposes, our study results don't find this to be a strong factor that would increase interest for agricultural operators in the NGP. Previous research has also highlighted the potential for increased interest in or adoption of agroforestry given access to technical assistance (Skelton et al. 2005; Strong and Jacobsen 2006); however, only South Dakota farmers and ranchers report that would impact their level of interest more than just "a little." The significant differences among groups of producers as well as the likelihoods associated with various interest levels in our model shed some light on who may be best suited for targeting as potential early adopters while opportunities to participate in a regional bioeconomy continue to emerge.

Decreasing the economic burden associated with tree establishment and offsetting some costs for those engaging in biomass production have potential to increase interest in establishing woody biomass systems within an agricultural setting (Skelton et al. 2005; Strong and Jacobsen 2006; Hess et al. 2007). Although previous research demonstrated that influences from an individual's bank or lending institution affect interest in agroforestry among non-operator landowners (Arbuckle et al. 2009), reported level of influence from a bank or lending institution was not shown to significantly affect interest level of operators in our study. This finding is encouraging in the respect that influence of lenders does not drive interest down, reflecting that operators might not generally perceive lending practices as an institutional barrier to agricultural management. Regional development of additional policy tools designed to incentivize establishment of trees for biomass production could serve to facilitate interest for early adopters with financial barriers. The Biomass Crop Assistance Program (BCAP) is a federal financial incentive policy tool designed to address supply issues presented for industry entities seeking to establish a regional bioenergy production facility (FSA 2011). The NGP currently hosts two BCAP project sites in Kansas that supply biomass crops from native grass species to local processing facilities for energy, ethanol, animal feed and other biomass products. BCAP could serve as a framework for subsequent policy development that supports utilization of woody biomass as well as a diversity of additional perennial bioenergy crops within the NGP.

Environmental subsidies and emerging markets for ecosystem services have been noted for their potential role in supplementing low market prices for perennial feedstocks, such as through payments for carbon storage and sequestration (James et al. 2010). Farmers and ranchers in South Dakota specifically noted that payments for environmental benefits

associated with trees could increase their level of interest some, while regionally interest level was shown to be higher for farmers and ranchers who value carbon storage and potential for recreation afforded by trees. Previous research suggests that biomass production could potentially serve as a disamenity for those who value the non-monetary benefits associated with trees (Skevas et al. 2014). Results from our study suggest that may not be the case for NGP farmers and ranchers, as those who value trees for recreation report some interest in producing biomass while those who don't value recreation potential offered by trees generally report no interest in woody biomass production.

As our study demonstrated that individuals who report the presence of marginal acres or a high number of resource concerns on their managed land, the potential exists for targeting the environmental benefits afforded by agroforestry. Our results suggest that those currently participating in non-CRP conservation programs are likely more interested in establishing trees for biomass productions, which aligns with previous research on conservation program participation's influence on interest in agroforestry (Skelton et al. 2005). Interestingly, participation in CRP has been demonstrated to have no impact on interest in tree systems in our analysis or in previous studies on agroforestry (Strong and Jacobsen 2006; Valdivia and Poulos 2009). This discrepancy on the influence of program enrollment on interest between CRP and other conservation programs suggests that there may be a difference between producers who are electing to participate in CRP and those who are selecting other conservation programs. Within the context of our research, this suggests that targeting opportunities for biomass systems as an alternative land use opportunity with associated environmental benefits to those participating in non-CRP conservation programs could be an effective strategy for soliciting supplier participation. Additionally, further

examination into the experiences of both CRP and non-CRP conservation program enrollees may highlight potential considerations for the development of financial incentive programs for biomass suppliers, if, for example, enrollees report their chosen program is facilitating or constraining the realization of goals for their farm system.

Operation size did not have a significant effect on reported interest level among surveyed operators in our study, however farm size has previously been demonstrated to impact interest in and potential adoption of agroforestry for landowners and farmers (Arbuckle et al. 2009; Valdivia and Poulos 2009). However, location of a given farm system was shown to affect level of interest in producing woody biomass. Results suggest that individuals in North Dakota have a lower interest level than that of other states within the NGP, with a median of 1, indicating no interest. Given relatively developed policy structure for woody biomass utilization within the region (Guo et al. 2012) and specifically within North Dakota, further research into potential social, cultural, institutional, or other barriers to policy use within North Dakota may be warranted.

Producing corn as a main crop was not shown to have a significantly different probability of interest than those who do not produce corn within our probit model, but wheat producers were suggested to have a higher level of interest in supplying woody biomass. As land in corn has been shown to negatively affect interest in agroforestry, while amount of land in crop production generally has been shown to increase interest in producing bioenergy crops, the utilization of agroforestry as an income-supplementing biomass crop may serve to incentivize those engaging in crop production. As corn producers likely face higher economic opportunity costs from high corn prices (Wright and Wimberly 2003), they may have further economic influences guiding their land use practices that weren't captured in our

study. As low knowledge on woody biomass systems may be hindering interest for farmers and ranchers prioritizing economic gain, emphasizing growth and associated profit potential from woody biomass could serve to offset perceived opportunity costs. Yields from wood biomass trials using coppice species in Kansas suggest high tonnage for at least three harvests at 2m spacing is likely feasible, given 92-97 Mg ha⁻¹ for first harvest at 5 years and 64-67 Mg ha⁻¹ for third harvest at 15 years for black locust (*Robinia pseudoacacia*) and silver maple (*Acer saccharinum*), allowing for lower establishment costs and preserved longevity compared to more closely-spaced SWRC systems (Geyer 2006).

Perceived system compatibility is shown to be an important attitude within our study and within previous research (Strong and Jacobsen 2006), suggesting that framing information to highlight that biomass plantings can be targeted to fit within existing agricultural systems will likely increase interest among farmers and ranchers. This key feature allows farmers and ranchers to participate on a limited scale as biomass suppliers, establishing trees for multifunctional benefits within their farm system without the burden of completely altering current land use practices. Additionally, attitudes demonstrating that producers may have concerns with the time necessary to profit from trees (Skelton et al. 2005; Strong and Jacobsen 2006) shows a need for outreach efforts to highlight the timeframes associated with SWRC systems. Similar targeting efforts that engage those who offer potential as early adopters will be critical in the further development of a regional bioeconomy utilizing woody biomass.

Conclusion

As policy continues to develop alongside market and infrastructural needs for an emerging bioeconomy, perspectives of potential suppliers will be critical if national and regional energy goals are to be realized. Multiple feedstock types will be required for a dedicated annual biomass supply within the NGP, of which agroforestry is positioned to provide multifunctional benefits in targeted areas of existing agricultural systems. Our results provide a framework for understanding influences affecting regional potential supplier interest, which can be utilized to guide further policy development and outreach efforts.

Of note are two relatively significant findings reflecting a need for further research into social or cultural barriers to interest in woody biomass production. Female operators were shown within our model to be 28% more likely to express no interest, a finding echoed by Skevas et al. (2014) regarding marginal land for biomass production. Further research into the role gender has on the perceptions of agroforestry within the context of woody biomass would be beneficial to highlight any social or cultural influences driving aversion to supplying woody biomass for renewable energy. Additionally, as farmers and ranchers in North Dakota were shown to have a significantly lower level of interest than the rest of the region, further research contextualized to that state would help highlight existing social or structural barriers to policy use. Our study shows that there are several factors which are likely to influence farmers and ranchers to report no or low interest in agroforestry for biomass production, but none of the factors we explored were highly influential in increasing the likelihood of a farmer or rancher to be interested or very interested. Results indicate that certain characteristics may shed light on individuals who could serve as early adopters,

however there is a need for local market and infrastructure development before others will become interested.

Further research efforts are needed to fully parameterize the opportunities available relevant to an emerging bioeconomy within the Northern Great Plains. Specifically, further examination of the feasibility of industry production and consumer consumption, including industry and municipality benefits/constraints regarding use of biomass feedstocks, would allow insights to guide needed legislative and policy efforts. Additionally, a regional examination of farmer and rancher perceptions of existing policy tools and associated use relevant to woody biomass production would be beneficial to guide structure of future incentive policies designed to encourage woody biomass growth and utilization.

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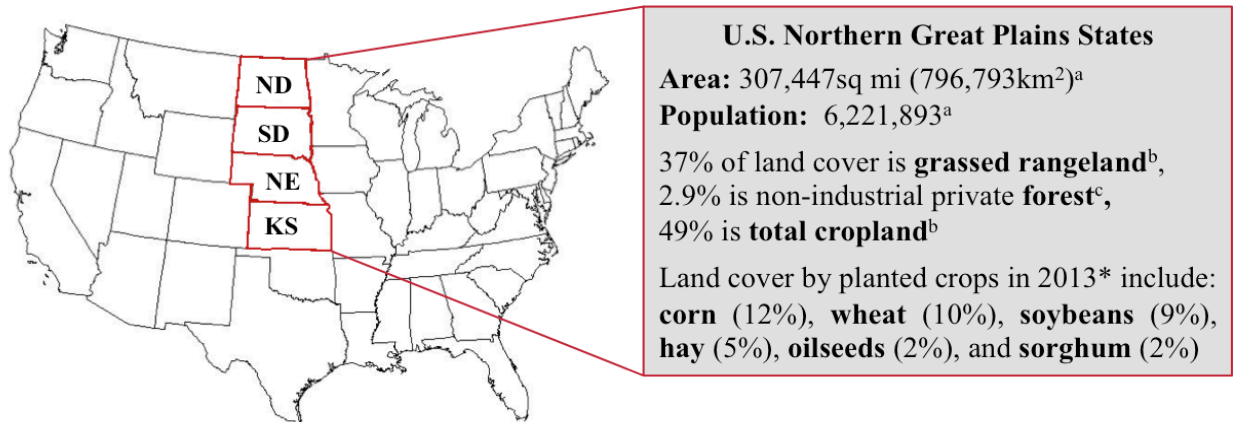
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Figures and Tables



*2013 acres planted to principal crops including corn, sorghum, oats, barley, winter wheat, Durum wheat, other spring wheat, soybeans, sunflower, cotton, dry edible beans, potatoes, sugarbeets, canola, and proso millet. Harvested acreage is used for all hay.^d

^a United States Census Bureau (USCB). (2010). *State area measurements and internal points coordinates*. Retrieved Jan 3, 2013 from www.census.gov/geo/reference/state-area.html

^b National Agricultural Statistics Service (NASS). (2012). Table 8. Land: 2012 and 2007. In *2012 Census of Agriculture – State Data*. Washington, DC: U.S. Department of Agriculture. Retrieved June 2, 2014 for KS, NE, ND, & SD from www.nass.usda.gov/Statistics_by_State/

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^d National Agricultural Statistics Service (NASS). (2013). *Acreage* (ISSN: 1949-1522). Washington, DC: U.S. Department of Agriculture.

Figure 3.1. Major land cover and land use in the U.S. Northern Great Plains region.

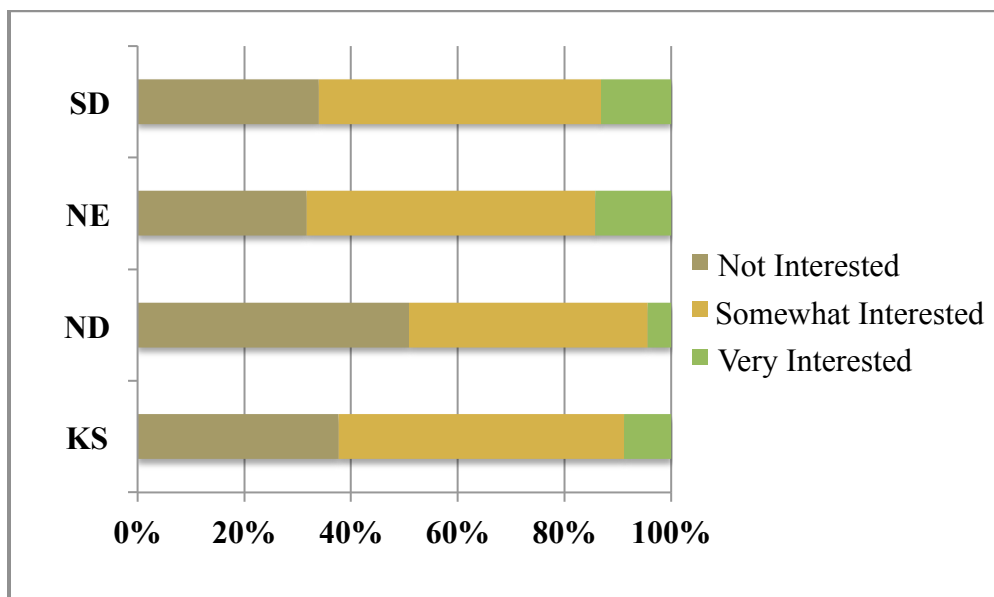


Figure 3.2: Interest in producing woody biomass by state as captured in a survey of Northern Great Plains farmers and ranchers, 2014.

Table 3.1: Percentage of farmers and ranchers who reported a given level of importance of benefits to having trees on their property in the Northern Great Plains, 2014.

Benefit	High Importance	Moderate Importance	Low Importance	n
Beauty or scenery	40.5	32.3	27.2	449
Enhancing water quality	33.7	31.9	34.4	442
Wind protection	80.1	10.7	9.2	448
Enhancing soil quality	30.4	28.3	41.3	441
Livestock or crop benefits	65.4	16.1	18.5	448
Privacy	41.4	23	35.6	447
Production of sawlogs, pulpwood, firewood, biomass or other timber products	9.6	14.9	75.5	444
Cultivation or collection of non- timber forest products	4.3	9.7	86	444
Hunting, fishing, or other recreation	39	27.7	33.3	447
Carbon storage	30.1	28.5	41.4	442

Table 3.2: Variables included in an ordered probit regression on farmer/rancher interest in growing trees and selling them as biomass if it were profitable in the Northern Great Plains, 2014.

Variable	Scale	Mean	Std.Err.
Interest Level	5pt Likert	2.43	0.067
Operation Attributes			
Operation size	ln(acres)	7.11	0.053
Corn producer	0/1	0.73	0.022
Wheat producer	0/1	0.50	0.025
2013 CRP Enrollment	0/1	0.31	0.023
Other conservation program enrollment	0/1	0.17	0.018
Identified resource concerns on managed land (sum)	1 - 7	2.59	0.078
Farmer/Rancher Characteristics			
Full time operator	0/1	0.81	0.019
Age	years	57.78	0.581
Sex (male)	0/1	0.95	0.010
Completed college or higher	0/1	0.31	0.023
Attitudes			
Reported willingness to take risk compared to other farmers	5pt Likert	3.06	0.051
Agreement that woody biomass would be compatible with current system	5pt Likert	2.52	0.048
Agreement that woody biomass use will increase	5pt Likert	2.90	0.046
Agreement that it does not take too long to profit from trees	5pt Likert	2.23	0.036
Reported importance of benefits of trees (index, $\alpha=0.846$) ¹	5pt Likert	2.95	0.045
Knowledge			
Previous biomass production (sum)	1 - 5	0.66	0.039
Constraints			
Reported level of bank/lender influence	5pt Likert	2.15	0.055

¹Chronbach's alpha assessment of the reliability of the scale utilized to assess the level of importance of various benefits to one's property afforded by the presence of trees (Table 3.1) demonstrated a high level of internal consistency ($\alpha=0.846$).

Table 3.3: Percentage of surveyed farmers and ranchers who reported the presence of a given resource concern on their farmland in the Northern Great Plains, 2014.

Resource Concern	Present on farmland	n
Soil erosion caused by wind	48.6	449
Soil erosion caused by rain or snow melt	65.5	449
Stream bank erosion	30.3	449
Excessively poor soil drainage or flooding	39.4	449
Chemical runoff from fertilizer, pesticide, or herbicide	11.6	428
Unintended loss of wildlife habitat	14.9	448
Unwanted growth of woody plants	45	449

Table 3.4: Reported respondent characteristics from a representative survey of farmers and ranchers in the Northern Great Plains, 2014.

	Mean or percent of sample	n
Full-time operator	80.6%	362
Part-time operator	19.4%	87
Operation type		
Both crops and livestock	66.4%	298
Crops only	29.2%	131
Pastured livestock only	4.5%	20
Operation size	1845 acres	443
Cropland	1173 acres	435
Pasture/rangeland	686 acres	435
Time as an operator	34 years	445
Age	58 years	445
Sex		
Female	4.9%	22
Male	95.1%	427
Education		
Some high school or less	2.5%	11
Completed high school	35.3%	158
Some college	30.9%	138
Completed college or more	31.3%	140
Percentage of income from off-farm sources	21.8%	422
2013 Gross farm sales		
\$250k or less	51.1%	209
More than \$250k	48.9%	200

Table 3.5: Select result attributes from non-parametric group comparisons utilizing data from a farmer/rancher survey on interest in supplying woody biomass, U.S. Northern Great Plains, 2014.

Characteristic	Test statistic	<i>p</i>	Median Interest	n
State	$\chi^2(2)=18.1416$	0.0005		449
NE			3	
SD			3	
KS			2	
ND			1	
Ownership	$z=12.711$	0.007		441
0-50% owned			3	
51-100% owned			2	
Have marginal land	$z=3.148$	0.002		448
Yes			3	
No			2	
Trees or shrubs for conservation	$z=4.882$	0.0005		449
Yes			3	
No			2	
Livestock or firewood wood utilization	$z=2.315$	0.021		449
Yes			3	
No			2	
Age	$\chi^2(2)=13.535$	0.004		425
Under 35			3	
36-50			3	
51-65			2	
Over 65			1	
Sex	$z=1.182$	0.07		449
Females			1	
Males			2	
Education	$z=2.961$	0.003		447
Completed college			3	
Some college or less			2	
Importance of carbon storage	$\chi^2(2)=27.51$	0.0005		442
No			1	
Low			2	
Moderate			2	
Moderately high			3	
High			3	

Table 3.5 Continued

Importance of recreation	$\chi^2(2)=48.802$	0.0005	447
No			1
Low			2
Moderate			2
Moderately high			3
High			3
Create economic opportunities	$\chi^2(2)=48.802$	0.0005	446
Strongly Disagree			1
Disagree			1
Unsure			3
Agree			3
Strongly Agree			3

Table 3.6: Ordered probit estimation of farmer/rancher interest in growing trees and selling them as woody biomass if it were profitable in the U.S. Northern Great Plains, 2014.

Variable	Coef.	SE	t	P>t
Operation size	0.057	0.070	0.81	0.418
Corn producer	0.186	0.137	1.36	0.175
Wheat producer	0.205	0.118	1.74	0.083
2013 CRP enrollment	-0.003	0.125	-0.03	0.979
Other conservation program	0.363	0.153	2.38	0.018
Identified resource concerns on managed land	0.140	0.037	3.75	0.000
Full time operator	-0.376	0.174	-2.17	0.031
Age	-0.023	0.005	-4.77	0.000
Sex (male)	0.735	0.254	2.89	0.004
Completed college or higher	0.235	0.114	2.07	0.039
Reported willingness to take risk compared to other farmers	0.186	0.059	3.14	0.002
Agreement that woody biomass would be compatible with current system	0.324	0.075	4.35	0.000
Agreement that woody biomass use will increase	0.150	0.069	2.17	0.031
Agreement that it does not take too long to profit from trees	0.254	0.089	2.85	0.005
Benefits of trees (index, $\alpha=0.846$)	0.142	0.082	1.73	0.085
Previous biomass production	0.201	0.074	2.73	0.007
Reported level of bank/lender influence	-0.039	0.058	-0.68	0.497
n = 412 F(17,392) = 8.09 Prob>F = 0.00				
Cut 1	2.610	0.699		
Cut 2	3.119	0.703		
Cut 3	4.033	0.712		
Cut 4	4.725	0.736		

CHAPTER IV

CONCLUSIONS

The goal of this research was to understand influences on farmer and rancher interest in supplying woody biomass to an emerging regional bioeconomy within the Northern Great Plains states of Kansas, Nebraska, North Dakota, and South Dakota. Our use of convergent parallel mixed methods to assess interest allowed us to gain both a representative snapshot of farmer and rancher interest through a regional phone survey, as well as to more deeply explore nuances associated with interest which emerged from focus group discussions within the region. Results highlighted both challenges and opportunities perceived by farmers relative to their interest, which could be utilized in combination with subsequent research to aid in increasing the regional capacity for biomass production.

Outcomes from this component combined with subsequent components of analysis for this regionally-based, USDA-SARE funded project exploring agroforestry potential for biomass production will provide farmers and ranchers a more accurate assessment of income potential, conservation benefits, and risks for investing in agroforestry plantings. Outcomes will also assist conservation professionals, as regional data from research will highlight farmer/rancher perceived benefits and constraints, as well as reported information needs for potential suppliers. Lastly, outcomes can inform rural development leaders and industry stakeholders through a comprehensive social and biophysical regional analysis of feedstock potential of woody biomass for those shaping regional policy development and assessing investment opportunities for future energy needs.

Future insights into the social infrastructure associated with an emerging regional bioeconomy could benefit from utilizing our investigative approach to understanding supply

potential. There are; however, modifications to this approach that would offer researchers the ability to further parameterize and contextualize regional interest in woody biomass. First, our survey instrument captured interest relative to respondents' individual definitions of what they would consider to be "profitable" relevant to a woody biomass crop. Further integrating an econometric component to explore an operator's willingness to accept various profit thresholds for woody biomass would allow for a more comprehensive understanding of regional profit expectations for woody biomass crops. Many regions in the U.S., including the Northern Great Plains, have undeveloped markets for woody biomass, thereby posing a challenge when investigating various profit scenarios. Second, our use of a telephone survey instrument constrained our ability to ask complex questions surrounding marginality and associated land management strategies. Use of a mail survey or strategic scenario-based framing for focus groups could allow for research to characterize interest relative to different management scenarios for woody biomass establishment on marginal land that would not be easily communicated via telephone. Further explorations could also modify our approach to engage farmers and ranchers to evaluate the structure of various policy tools, allowing researchers to identify the attributes of policies with broad appeal to regional operators.

Broad adoption of perennial woody vegetation as a biomass crop or otherwise could serve to offer multifunctional benefits to individual farm and ranch systems as well as to the larger Northern Great Plains landscape, but there are challenges to achieving broad adoption. The realization of a greater supply of woody biomass within the region largely hinges upon a multi-scale effort to diverge, first, from the utilization of oil and gas resources that that promote devastating environmental consequences both domestically and internationally; and second, from the ongoing incentivization of intensive crop and livestock production which

constrains agricultural operators/landowners from engaging in alternative land uses or production systems. An approach that engages producer, resource professional, and industry stakeholders aided by adjustments to, or creation of, policy tools and legislative efforts are needed to promote diversified agricultural systems that meet multifunctional outcomes. It is my hope that this research serves as a catalyst for regional communication on how to address barriers and seize noted opportunities expressed by farmers and ranchers within the Northern Great Plains.

APPENDIX A
FOCUS GROUP PROTOCOL

Q1: What is [state] known for agriculturally?

Q2: What is your definition of marginal agricultural land?

- Probe: What soil conditions are marginal?
- Probe: What about in relationship to slopes on your land?

Q3: Do you manage your marginal land differently?

- Probe: Why do/don't you manage it the same?
- Probe: For those of you who are doing something different, what motivated you to choose that option?

Q4: Agroforestry is using trees strategically on land being used for agriculture. What do you know about agroforestry practices?

- Probe: In general, what are some possible benefits of agroforestry?
- Probe: In general, what are some possible challenges of using agroforestry?

Q5 Intro: Some individuals choose to grow trees for biomass production, which means their trees are harvested and the wood from the tree is used for energy production. This occurs in many different landscapes, from predominantly forested areas to plantations in different parts of the US, and sometimes from agroforestry practices.

Q5: What do you know regarding growing trees for biomass production?

Q6: Let's assume markets for woody biomass exist, for example having woody biomass co-fired with coal to produce electricity. Would this market be of interest to you?

- Probe: What information would you need to understand this opportunity?

Q7: Would you be more or less inclined to grow woody biomass if there was a subsidy?

- Probe: What about a different financial incentive like cost share or rental rate payments?

Q8: Do you have concerns about biomass (woody or other) as a renewable fuel in your state?

- Probe: What have you heard/read about renewable fuels?

Q9: What do you know about storing carbon long term, or carbon sequestration?

- Probe: Is sequestering carbon important?

APPENDIX B

PHONE SURVEY INSTRUMENT

First I have some questions about you and your farming operation:

1. In 2013 did you farm full time, part time or not at all? [IF ONLY CRP, CODE AS 3 = NOT AT ALL]

1 = Full time

2 = Part time

3 = Not at all IF Q1 = 3, GO TO CLOSE

4 = [DK/REF.] IF Q1 = 4, GO TO CLOSE

2. How many acres did you farm last year, in 2013, including pasture? [99999 = DK / REF.]

_____ # Acres farmed

3. How many of those acres did you **own**?

_____ # Acres owned

4. How many of those acres did you **rent**?

_____ # Acres rented (in)

5. In 2013, did you raise crops, livestock, or both?

1 = Crops only

2 = Pastured livestock only

3 = Feedlot livestock only IF Q5 = 3, GO TO CLOSE

4 = Both crops and livestock

5 = [DK/REF.]

6. Do you have any acres that you consider to be marginal, that don't produce as well or require special management?

1 = Yes

2 = No GO TO Q9

3 = [DK/REF.] GO TO Q9

7a. If Q6=1, ASK: How many marginal acres do you currently own? [99999 = DK / REF.]

_____ # Marginal acres

7b. If Q6=1, ASK: How many marginal acres do you currently rent from others? [99999 = DK / REF.]

_____ # Marginal acres

We are interested in how you manage the marginal land you own:

8a. If Q7a > 0, ASK:

	Yes	No	[DK/REF.]
a. Do you plant different crops on any of the marginal land you <u>own</u> than you plant on the rest of your land?	1	2	3
b. Do you use any of the marginal land you <u>own</u> for conservation purposes (including CRP)?	1	2	3
c. Do you leave any of it fallow? (no crop planted on the marginal land you <u>own</u>)	1	2	3

We are (also) interested in how you manage the marginal land you rent:

8b. If Q7b > 0, ASK:

	Yes	No	[DK/REF.]
a. Do you plant different crops on any of the marginal land you <u>rent</u> than you plant on the rest of your land?	1	2	3
b. Do you use any of the marginal land you <u>rent</u> for conservation purposes (including CRP)?	1	2	3
c. Do you leave any of it fallow? (no crop planted on the marginal land you <u>rent</u>)	1	2	3

9. If Q5 = 1 or 4, ASK: Over the past five years what have been your main crops?
[CHECK ALL THAT APPLY, PROBE FOR UP TO FOUR]

- 1 = Wheat
- 2 = Corn
- 3 = Soybeans
- 4 = Hay (including alfalfa)
- 5 = Milo/Sorghum
- 6 = Canola
- 7 = Other
- 8 = [DK/REF.]

9_Spec. IF Q9 = 7 (Other), ASK: Please specify other:

[OPEN TEXT]

10. Do you have any woodlands on your farm?

- 1 = Yes
- 2 = No GO TO Q12a
- 3 = [DK/REF.] GO TO Q12a

11. If Q10 = 1, ASK: How many acres (of woodland do you have on your farm)?

_____ # Woodland Acres [99999 = DK / REF.]

12a. How many acres of pastureland do you have?

_____ # Pastureland Acres [99999 = DK / REF.]

12b. **[IF Q12a > 0, ASK:]** Do you have any animals grazing on pastureland?

1 = Yes

2 = No **[GO TO Q13a]**

3 = [DK/REF.] **[GO TO Q13a]**

12_c1. What animals graze?

12_c2. What animals graze?

12_c3. What animals graze?

12_c4. What animals graze?

12_c5. What animals graze?

12_d1. How many of them graze?

12_d2. How many of them graze?

12_d3. How many of them graze?

12_d4. How many of them graze?

12_d5. How many of them graze?

13a. Did you have any land in CRP in 2013? (Conservation Reserve Program)

1 = Yes

2 = No **[GO TO Q14]**

3 = [DK/REF.] **[GO TO Q14]**

13b. **[IF Q13a = 1:]** How many acres do you have in CRP? [99999 = DK / REF.]

_____ # CRP Acres

13c. **[IF Q13a = 1:]** How many of those CRP acres are planted in **grass**?

_____ # CRP Acres in grass

13d. **[IF Q13a = 1:]** How many of those CRP acres are planted in **trees or shrubs**?

_____ # CRP Acres in trees

13e. **[IF Q13a = 1:]** How many of your CRP acres would you say are marginal farmland? [99999 = DK / REF.]

_____ # Marginal CRP Acres

13f. **[IF Q13a = 1:]** At the end of your CRP contract, do you expect to put any acres back into production?

1 = Yes

2 = No **[GO TO Q14]**

3 = [DK/REF.] **[GO TO Q14]**

13g. IF Q13f = 1: How many acres (currently in CRP will you put back into production)? [99999 = DK / REF.]

_____ # CRP Acres going back into production

14. Do you have land enrolled in any other conservation programs?

- 1 = Yes
- 2 = No
- 3 = [DK/REF.]

15. Have you planted any grasses, trees or shrubs for conservation purposes at your own expense?

- 1 = Yes
- 2 = No
- 3 = [DK/REF.]

16. Have you heard of the USDA Biomass Crop Assistance Program (BCAP)?

- 1 = Yes
- 2 = No GO TO Q18
- 3 = [DK/REF.] GO TO Q18

17. IF Q16 = 1 (Yes) and KANSAS SAMPLE, ASK: Do you currently participate in the USDA Biomass Crop Assistance Program (BCAP)?

- 1 = Yes
- 2 = No
- 3 = [DK/REF.]

18. Do you currently have windbreaks that were planted on any of the land you farm?

- 1 = Yes
- 2 = No GO TO Q20
- 3 = [DK/REF.] GO TO Q20

19. If Q18 = 1 (Yes): How useful are the windbreaks on your farm, on a scale from 1 to 5 where 1 is not at all useful and 5 is very useful?

Not at all useful					Very Useful	[DK/REF.]
1	2	3	4	5	6	

20. Do you have a woody riparian buffer on the land that you farm; that is, plantings of trees and shrubs alongside a stream or creek?

- 1 = Yes
- 2 = No GO TO Q22
- 3 = [DK/REF.] GO TO Q22

21. **If Q20 = 1 (Yes):** How beneficial is that riparian buffer, on a scale from 1 to 5 where 1 is not at all beneficial and 5 is very beneficial?

Not at all beneficial					Very Beneficial	[DK/REF.]
1	2	3	4	5	6	

22. Have trees or shrubs been planted on the land that you farm for any other reason?

1 = Yes
 2 = No **GO TO Q24**
 3 = [DK/REF.] **GO TO Q24**

23. **If Q22 = 1 (Yes):** For what reason?

[OPEN TEXT]

24. Please tell me if you have experienced any of the following problems on your farmland. Have you experienced...

	Yes	No	[DK/REF.]
a. soil erosion caused by wind?	1	2	3
b. soil erosion caused by rain or snow melt?	1	2	3
c. chemical runoff, from fertilizer, pesticide, or herbicide?	1	2	3
d. stream bank erosion?	1	2	3
f. unintended loss of wildlife habitat?	1	2	3
g. excessively poor soil drainage or flooding?	1	2	3
h. unwanted woody growth?	1	2	3

25. Next I'll read several potential benefits to having trees on your property. For each one, please indicate how important it is to you by using a scale from 1 to 5, where 1 means not important at all, 3 means moderately important, and 5 means very important.

How important is it to you to have trees on your property for...

Benefit	Not at all Important		Moderately Important		Very Important	[DK/REF.]
a. beauty or scenery?	1	2	3	4	5	6
b. enhancing water quality?	1	2	3	4	5	6
c. wind protection?	1	2	3	4	5	6
d. enhancing soil quality?	1	2	3	4	5	6
e. livestock or crop benefits?	1	2	3	4	5	6
f. privacy?	1	2	3	4	5	6
g. production of sawlogs, pulpwood, firewood, biomass or other timber products?	1	2	3	4	5	6
h. cultivation or collection of non-timber forest products?	1	2	3	4	5	6
i. hunting, fishing or other recreation?	1	2	3	4	5	6
j. carbon storage, as trees store carbon from the atmosphere over time?	1	2	3	4	5	6

26. Recently new ways of using plants to produce energy have been explored, including the use of annual crops, grasses, trees or other woody plants. Trees can be grown as part of a plantation or conservation practice such as a windbreak or riparian buffer. Biomass from these trees can be used to produce electricity or liquid fuels such as ethanol.

I will read several statements regarding the establishment and growth of trees on agricultural land. For each statement, please indicate whether you strongly disagree, disagree, you are unsure, agree, or strongly agree.

	Strongly Disagree	Disagree	Unsure	Agree	Strongly Agree	[DK/REF.]
a. Growing trees for use in energy production is a responsible way to use marginal agricultural lands.	1	2	3	4	5	6
b. Growing trees for use in energy production is a good way to achieve environmental goals.	1	2	3	4	5	6
c. Growing trees for use in energy production is a good way to achieve production benefits for my agricultural operation. (reducing erosion, cover for livestock, protection of crops)	1	2	3	4	5	6
d. I would like to see more trees across the agricultural landscape in my state.	1	2	3	4	5	6
e. I think it is important to have trees as habitat for native wildlife species.	1	2	3	4	5	6

27. Next I will read some statements regarding the use of woody biomass from trees to produce alternative forms of energy. For each statement, please indicate whether you strongly disagree, disagree, you are unsure, agree, or strongly agree.

	Strongly Disagree	Disagree	Unsure	Agree	Strongly Agree	[DK/REF.]
a. Growing trees for use in energy production would be compatible with my current farm operation.	1	2	3	4	5	6
b. I have the technical knowledge necessary to harvest woody biomass from my land.	1	2	3	4	5	6
c. I have the technical knowledge necessary to market woody biomass from my land.	1	2	3	4	5	6
d. The production risk for trees is lower than for other crops or products I currently produce.	1	2	3	4	5	6
e. It takes too long to make a profit from trees.	1	2	3	4	5	6
f. The use of woody biomass to produce energy will increase greatly over the next few years.	1	2	3	4	5	6
g. The production of energy from woody biomass will create important new economic opportunities for landowners in my state.	1	2	3	4	5	6

28. Have you ever produced woody biomass . . .

	Yes	No	[DK/REF.]
a. to use as fodder or bedding for <u>your</u> livestock?	1	2	3
b. to sell to <u>others</u> for livestock fodder or bedding?	1	2	3
c. for <u>your</u> personal firewood or energy use?	1	2	3
d. to sell firewood to <u>others</u> ?	1	2	3
e. for any other reason?	1	2	3

- 28_Spec. IF Q28e = 1 (Yes), ASK: Please specify other reason:

[OPEN TEXT]

29. How interested would you be in growing trees and selling them as woody biomass if it were profitable for you? On a scale of 1 to 5, where 1 means not at all interested and 5 means very interested, which number would you choose?

1 = Not at all interested GO TO Q33

2 =

3 =

4 =

5 = Very interested

6 = [DK/REF.] GO TO Q33

30. IF Q29 = 2, 3, 4, or 5: What is the minimum **net** profit per acre you would need to get, in order to consider growing trees for woody biomass? [99999 = DK / REF.]

\$ _____/acre

31. IF Q29 = 2, 3, 4, or 5: If you could get that profit per acre, how many acres of trees for woody biomass would you consider planting? [99999 = DK / REF.]

_____ # acres

32. IF Q29 = 2, 3, 4, or 5: How many of those acres do you consider to be marginal? [99999 = DK / REF.]

_____ # marginal acres

33. What are the main factors, other than financial considerations, that could increase your interest in growing and selling woody biomass from trees?

[OPEN TEXT]

34. How much would each of the following situations increase your interest in growing and selling woody biomass? Would [INSERT STATEMENT] increase your interest not at all, a little, some, quite a bit or a great deal?

	Not at all	A little	Some	Quite a bit	A great deal	[DK/REF.]
a. having a third-party responsible for all the harvesting, material processing, and transportation	1	2	3	4	5	6
b. having free technical assistance available	1	2	3	4	5	6
c. having a sustainable, non-subsidized private market for biomass	1	2	3	4	5	6
d. having local facilities to process biomass for energy production	1	2	3	4	5	6
e. receiving government subsidy payments for establishing, harvesting, processing, and transporting woody biomass	1	2	3	4	5	6
f. receiving payment for environmental benefits associated with trees such as carbon credits, soil quality improvement, water quality improvement, habitat improvement, etc.	1	2	3	4	5	6
g. being allowed to harvest trees and shrubs from land enrolled in conservation programs	1	2	3	4	5	6

35. How much influence does your bank or lending institution have on your farming activities? Would you say it has no influence, a little, some, quite a bit, or a great deal of influence on your farming activities?

- 1 = No influence
- 2 = A little
- 3 = Some
- 4 = Quite a bit
- 5 = A great deal of influence
- 6 = [NO BANK]
- 7 = [DK/REF.]

36. For each of the following statements, please indicate whether you strongly disagree, disagree, you are unsure, agree, or strongly agree.

	Strongly Disagree	Disagree	Unsure	Agree	Strongly Agree	[DK/REF.]
a. Farmers must be willing to take substantial financial risks to be successful.	1	2	3	4	5	6
b. You are more willing to take financial risks than other farmers.	1	2	3	4	5	6
c. You are reluctant to adopt new production methods or crops until you see them working for others.	1	2	3	4	5	6
d. You are more concerned about a large loss to your farming operation than about missing a substantial gain.	1	2	3	4	5	6

Finally, I have some questions about you.

37. Are you male or female?

- 1 = Male
- 2 = Female
- 3 = [DK/REF.]

38. What is your current age?

_____ # years [99 = DK / REF.]

39. About how many years have you been farming (in charge of the operation)?

_____ # years [99 = DK / REF.]

40. Do you plan to continue farming for at least the next 10 years?

- 1 = Yes
- 2 = No
- 3 = Maybe
- 4 = [DK/REF.]

41. What is the highest level of education you have completed?

- 1 = Some high school or less
- 2 = High school graduate
- 3 = Some college
- 4 = College graduate
- 5 = Post graduate
- 6 = [DK/REF.]

42. Which of the following categories best describes your gross farm sales in 2013? Would you say...

- 1 = Less than \$50,000
- 2 = From \$50,000 up to \$250,000
- 3 = From \$250,000 up to \$1 million or
- 4 = More than \$1 million?
- 5 = [DK/REF.]

43. What percent of your household's gross income came from **off-farm** sources in 2013? [999 = DK / REF.]

_____ % of household income

44. Do you have any additional comments you'd like to make about supplying woody biomass for energy production?

[OPEN TEXT]

That's all the information we need from you. Iowa State University thanks you for your time today.