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A Qualitative Investigation of Farmer and Rancher Perceptions of Trees and Woody Biomass Production on Marginal Agricultural Land

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Abstract

Bioenergy produced from perennial feedstocks such as woody biomass could serve as an opportunity to strengthen local and regional economies 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. We conducted a series of farmer and rancher oriented focus groups in North Dakota, South Dakota, Nebraska and Kansas to qualitatively explore opinions about the role that trees can play in agriculture and interest in woody biomass systems within existing Northern Great Plains (NGP) farms and ranches. Our findings suggest that farmer and ranchers generally value the role that trees, or tree-based practices like windbreaks can play in agriculture particularly on marginal farmland in terms of conservation or crop protection. Yet relative to the potential of trees as a biomass crop there is a distinct lack of knowledge and skepticism. Farmers and ranchers also noted variable degrees of risk concern and uncertainty regarding investing in tree-based systems, as well as a number of perceived external market related constraints to integrating trees within their managed systems. Most of the participants recognized that if biomass production or an increase in tree planting and management in general were to expand in the NGP region, government programs would likely be required to provide much needed technical guidance and financial incentives. As the NGP regional bioeconomy continues to emerge and expand, private and public investment relative to niche bioenergy feedstocks such as woody biomass should address the type of information needs that farmers and ranchers have relative to integrating biomass production into existing farm and ranch systems.

Keywords

Woody biomass, Northern Great Plains, farmers and ranchers, focus groups

Disciplines

Agriculture | Environmental Studies | Natural Resources Management and Policy | Regional Economics

Comments

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A Qualitative Investigation of Farmer and Rancher Perceptions of Trees and Woody Biomass Production on Marginal Agricultural Land

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Abstract: Bioenergy produced from perennial feedstocks such as woody biomass could serve as an opportunity to strengthen local and regional economies 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. We conducted a series of farmer and rancher oriented focus groups in North Dakota, South Dakota, Nebraska and Kansas to qualitatively explore opinions about the role that trees can play in agriculture and interest in woody biomass systems within existing Northern Great Plains (NGP) farms and ranches. Our findings suggest that farmer and ranchers generally value the role that trees, or tree-based practices like windbreaks can play in agriculture particularly on marginal farmland in terms of conservation or crop protection. Yet relative to the potential of trees as a biomass crop there is a distinct lack of knowledge and skepticism. Farmers and ranchers also noted variable degrees of risk concern and uncertainty regarding investing in tree-based systems, as well as a number of perceived external market related constraints to integrating trees within their managed systems. Most of the participants recognized that if biomass production or an increase in tree planting and management in general were to expand in the NGP region, government programs would likely be required to provide much needed technical guidance and financial incentives. As the NGP regional bioeconomy continues to emerge and expand, private and public investment relative to niche bioenergy feedstocks such as woody biomass should address the type of information needs that farmers and ranchers have relative to integrating biomass production into existing farm and ranch systems.

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1. 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 biomass in planted or natural settings are largely framed around their potential 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 (RFS2) [1]. While ethanol production from grain based sources (e.g., corn) has achieved the 15 billion gallon RFS2 annual production goal well ahead of the 2022 target date [1], targets for cellulosic ethanol have been reduced annually by the U.S. Environmental Protection Agency (EPA) due to unexpectedly low production volumes [2]. 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 [3, 4]. 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 [5, 6].

One key region with regard to biomass potential is the U.S. Northern Great Plains (NGP) [1, 7]. Recent research from the NGP has been dedicated to the agronomic potential of herbaceous biomass crops such as switchgrass (*Panicum virgatum L.*), miscanthus (*Miscanthus spp.),* forage sorghum (*Sorghum bicolor* L.) and others [8] as well as different biomass crop management strategies designed to enhance yields [e.g., 9, 10]. Crop residues (e.g., corn stover, wheat straw) are also widely abundant throughout the whole NGP region [1]. There is however, comparatively little information from the region regarding potential niche feedstock such as woody biomass. Woody biomass is the harvestable, above-ground wood and bark component of a regenerable tree system and is particularly suitable for combustion based electricity production [11, 12] and is increasingly being looked at to support small scale electricity generation [13].

Woody biomass production in the form of biomass specific tree plantings or in concert with tree based conservation practices/ agroforestry (e.g., windbreaks, tree buffers) has been examined throughout the world particularly in relation to alternative uses of marginal farmland, that is, low yielding or difficult to manage land [e.g., 14-18]. Agroforestry systems used for woody biomass production have been highlighted for their potential to jointly produce various environmental services at field and landscape scales while being managed for long-term biomass production over coppice rotations [16, 19, 20]. Results from a recent survey out of the NGP region indicated that 61% of representative farm and ranch operators have some degree of interest in woody biomass production for bioenergy purposes [21], particularly in the context of marginal land use and integration with conservation oriented agroforestry systems such as windbreaks.

Since the majority of existing and potential biomass production/availability in all 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 [22]. 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 [22,23].

To date very little is known about the interests of farmland owners and managers in the NGP regarding woody biomass production [21], as such we conducted a series of farmer and rancher oriented focus groups to qualitatively explore farmer and rancher interest in woody biomass systems targeted within existing NGP farms and ranches. Results reflect emergent values and attitudes about woody systems, variable farmer/rancher knowledge about such systems and markets, variable expressions of risk and uncertainty, as well as a number of perceived external constraints that interact to shape (1) farmer/rancher attitudes towards the presence/use of trees within their managed operation, and (2) farmer/rancher evaluation of various influences on participation as a biomass supplier.

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2. Materials and Methods

We utilized focus groups as a way to qualitatively probe NGP farmers and ranchers for knowledge and attitudes surrounding woody biomass systems. Focus groups allow for a guided but nuanced 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 [24]. Focus groups are not meant to provide generalizable information across a specific population, yet can provide in-depth and nuanced information regarding emergent topics in ways that more quantitative approaches (e.g., survey-based) are unable to provide (Roesch et al. 2016).

2.1 Data Collection and Analysis

We conducted five focus groups total, one per state in Kansas, Nebraska, and North Dakota, and two in South Dakota (Figure 1) between August 6, 2013 and April 10, 2014. We initially planned for two focus groups per state as a way to capture a high degree of emergent themes [e.g., 26], but logistical complications made this goal untenable. Considering the lack of farmer-oriented studies from this region we believe that our data is informative, nevertheless. 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.

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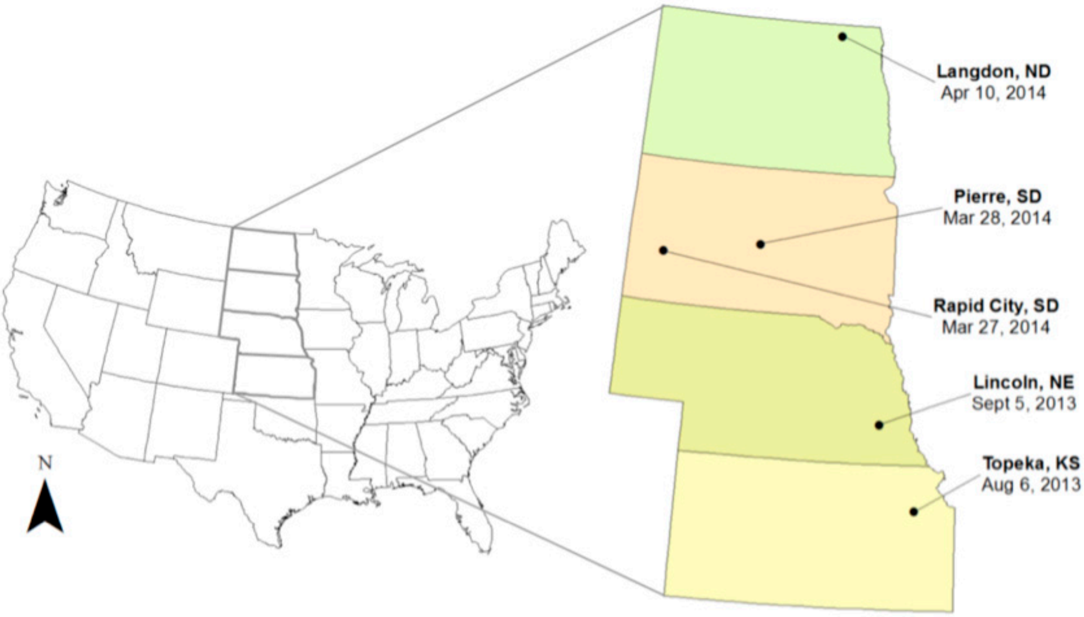

Figure 1. Locations and dates of farmer and ranchers focus group interviews exploring woody biomass potential in the U.S. Northern Great Plains.

Guide questions were used for all focus groups, and involved general queries about 1) regional land use and “marginal” land, 2) opinions and experiences with trees in agricultural landscapes, and 3) views on woody biomass as a marketable product. 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 [27]. 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 [28]. 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. The results are written as a narrative around the common thematic findings.

3. Results

In total, 35 farmers and ranchers participated in our focus group series. A summary of participant demographic information is presented in Table 1. Cumulatively, focus group participants manage 20,850 hectares (51,500 acres) across 32 counties in the NGP; an average of 559 hectares (1,381 acres). On average the participants were 52 years old, had about 26 years of experience with farming or ranching. Female farmers/ ranchers made up 21 percent of total participants. Just over 91% of the participants planned on continued farming/ranching for at least the next 10 years. Reported land use on participants' property included crop production, woodlands, land set-aside with the Conservation Reserve Program (CRP) land, 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.

Table 1. Summary of participant and farm system characteristics from a farmer and rancher focus group series from the Northern Great Plains exploring woody biomass potential, 2013 - 2014.

	North Dakota (n = 8)	South Dakota (n = 11)	Nebraska (n = 7)	Kansas (n = 9)
Average hectares of land managed	383	932	212	710
Average age in years	47	57	55	49
Average years farming or ranching	17	29	30	29
Percent of female participants	12	36	14	22
Percent planning to continue farming for the next 10 years	86	90	100	89

3.1 Agricultural Value of Trees

Across all focus groups there was a broad general stated interest for the establishment and management of trees within their farm/ranch systems for multiple ecosystem service values. Farmers and ranchers articulated the potential utilitarian benefits of planted trees within their existing agricultural systems largely in the context of utilizing trees to indirectly enhance existing cropping systems or as a way to directly expand profit potential through income diversification (e.g., selling biomass). Tree-related benefits centered upon potential crop yield benefits through the use of field windbreaks that bring about various effects such as improved microclimate for crops, better soil moisture conditions, and soil and plant protection from wind erosion. Other specific production benefits broadly described during focus groups included winter wind protection for livestock, as well as extended forage opportunities. One North Dakota farmer noted her knowledge regarding production benefits from 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." A rancher in western South Dakota also 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 [for crop use]... to catch snow."

Farmers and ranchers also noted non-crop environmental and cultural benefits (e.g., recreation, wildlife) offered by trees, but largely in the context of prioritizing management activities. For example, one Kansan rancher acknowledged a trade-off in enhancing wildlife habitat at the expense of utilizing woodlands to overwinter his cattle, 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."

Interestingly some farmers noted the value of trees in the landscape relative to their absence or loss from the landscape (e.g., windbreak removal) due to the increase usage of reduced tillage or no-till practices and concomitant perceptions that windbreaks are no longer needed. A farmer in North Dakota illustrated this observation in the context of wind erosion, stating: "People say that [North Dakota farmers] don't need trees [windbreaks] 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."

Despite the benefits noted, farmers and ranchers in all focus groups also discussed disamenities associated with undesirable "nuisance" or "weed" trees. 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. As one Kansas rancher illustrated when noting the value of many of the naturally occurring trees in his agricultural operation, stating: "I mean [Eastern red] cedar is a big problem... We're constantly cutting cedar out. But in places [on the farm] you have to have trees. It's just good farming practice."

3.2 Trees and Biomass Management

When focus group discussions shifted from exploring the value of farm/ranch trees relative to their primary crops to trees being used specifically as a biomass crop, focus group participants in all states drew attention to the potential to utilize "weed trees". The majority of participants in all states framed this idea as clearing/harvesting undesired trees that currently exist on farms/ranches, or intentionally establishing fast growing, site hardy "weed" species as a crop. Discussion was particularly focused on woody biomass being an income opportunity for marginal land areas that are either unused or as a way to gain periodic income while improving overall site conditions. As an example, one South Dakota rancher offered: "I can see the

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potential of growing weed trees in areas I don't farm, 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." One farmer from South Dakota reflected his vision but also concerns (that were echoed by other participants), stating: "I had envisioned something more or less on the lines of... on these cropland acres, planting strips [of trees for harvest], and then taking advantage of the hunting... and they give shade, you could [use trees] 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."

A few farmers did note that trees may also have specific advantages over other potential biomass crops particularly in the context of protecting soils. For example a farmer from South Dakota stated, "Even with switchgrass--you're pulling minerals out, and you're hauling them away, and you're mining and you're not replacing [nutrients]." While a farmer from North Dakota offered, "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."

3.3 Barriers and Facilitators to Woody Biomass Production

Across all focus groups, when exploring the possibility of establishing a biomass crop (woody or otherwise) various participants highlighted access to credit as a problem particularly relevant to younger farmers with higher debt to asset ratios. The farmers and ranchers broadly discussed how pursuing a new crop such as biomass is a risky venture even on marginal land and access to capital or ways to hedge risk are needed. For instance, one farmer from Kansas illustrated how his financial constraints have changed over time, positioning him to explore new markets associated with woody biomass if he chose to: "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 to do anymore]". Another farmer from South Dakota echoed this concern with his personal experiences, describing difficulty receiving a loan 15 years ago to begin his current conventional farming operation let alone pursuing something new like woody biomass, noting his eventual participation in a program dedicated to providing assistance to beginning farmers which he views as instrumental to his ability to get into farming in the first place.

Prompted by these potential barriers associated with access to credit, focus group discussions in all states turned to the use of alternative ways to defray financial risk and gain entry into new land use ventures via policy tools such as United States Department of Agriculture (USDA) subsidies or technical service programs that facilitate tree planting and/or biomass production. There was broad participant familiarity with current USDA conservation programs (specifically, the Conservation Reserve Program; CRP) that support tree planting and management. Several participants noted benefits afforded by government conservation programs, including technical assistance when engaging in a new opportunity such as establishing trees for biomass production, and in supplemental financial incentives. A number of farmers shared positive experiences in working with the USDA Natural Resource Conservation Service and/or other government entities. 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 [e.g., CRP]."

Interestingly, it was mentioned by a number of participants that various incentive programs might well encourage land use innovation in nuanced ways, thereby facilitating adoption of woody biomass. A number of farmers/ ranchers in all states noted that a barrier to planting trees (or any "alternative" crop) on even marginal land is the tendency for farmers to adhere to the production status quo and perceived social norms within their agricultural community. For example, a Nebraska farmer regarding his potential interest in establishing trees within his agricultural system for biomass, 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". Yet a few farmers with experience with USDA programs stated that this type of social constraint could be mitigated by the personalized, farm-specific technical advice that many governmental programs offer along with financial incentives toward new land use opportunities. Farmers noted that benefits of this interaction involve a higher degree of informed decision capacity and increased confidence in the innovation. In regards to the USDA Conservation Stewardship Program, a farmer from South Dakota offered his experience, "…you get some [farm specific] support, it helps you open your mind to try something new rather than doing it the same old way that we've always done it."

Overall however, farmers and ranchers expressed general hesitancy to participate in government programs. Some of the reluctance was tied to a general aversion to government financial assistance of any kind. Reasons cited ranged from individual objections such as general mistrust of the government, the typical quantity of paperwork involved and other "red tape" associated with state and federal government programs. Nevertheless there was a broad assumption that if there was going to be an increase in tree planting within the NGP, working with government programs will likely be required on some level because participants in all focus groups expressed significant lack of knowledge regarding trees in general and information about woody biomass systems specifically. Information needs noted by participants relevant to woody biomass production include specifics centering upon tree planting guidelines and requirements such as appropriate species, the total amount of land needed to have a viable operation, harvest methods and equipment needs, availability of custom growers/harvesters, and information on typical post-harvest land management for sustainable production or to convert the land to an alternative use.

A small number of farmers did mention the USDA Biomass Crop Assistance Program (BCAP) which contractually connects biomass producers with an end user (energy producer) and provides technical advice, cost share funding and subsidized biomass prices to biomass producers, A farmer from Kansas offered: "[The] Biomass Crop Assistance Program... has a lot more flexibility. It has a five- year contract instead of a ten- or fifteen-year contract [like with CRP], it pays for establishment of [biomass], so there's a lot of 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, it was recognized among a number of participants that a program such as BCAP would be needed to bridge the likely time involved in investing in trees (it should be noted that the vast majority of focus group participants in all states had not heard of BCAP). The lack of quick or the periodic nature of profit resulting from a biomass crop compared to annual cropping systems was broadly noted in all focus groups as a barrier that would likely need to be addressed either through subsidies or an otherwise well-developed market.

Many of the participants expressed preferences for the existence of local, sustainable, independent markets to a subsidized market (such as that offered by a program such as BCAP), yet there was an broad belief that start-up subsidies would likely be required to support emerging energy markets. As one Nebraska 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...to get it on its feet [like grain ethanol]. 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". When considering whether or not trees would make for a competitive cropping system, 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." Outside of government subsidy start-up programs, however, there were focus group wide concerns about the sustainability and regional nature of any biomass based bioenergy market. Broad concern about market sustainability was succinctly summarized by a North Dakota farmer who 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?" Relatedly, numerous farmers and ranchers noted how important local physical markets were in their region, a sentiment captured by one South Dakota rancher who acknowledged 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."

Beyond market and production questions, a number of farmers and ranchers had fundamental biological questions. Participants within the South Dakota and Kansas focus groups specifically noted the biophysical challenge 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 challenges for tree growth in the state 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 county, that'll get whatever height it needs to get in a reasonable time, then [I would look at growing trees]. Right now, I don't know what that tree is."

4. Discussion

Our analysis of data from farmer/rancher focus groups conducted in the U.S. Northern Great Plains was targeted to capture perspectives on the value of trees in agriculture and woody biomass production generally. Our findings suggest that individual farmer and ranchers value the role that trees can play in agriculture particularly on marginal or unused farmland, but have a distinct lack of knowledge regarding their potential as a biomass crop. There is uncertainty about financial and technical risk. Most of the participants recognized that if biomass production (or an increase in tree planting and management in general) where to expand in the NGP region, that government programs would likely be needed to provide much needed technical guidance and financial incentives. Nevertheless, many of the farmers/ranchers also expressed reluctance to work with government programs. As the NGP regional bioeconomy continues to emerge and expand, based on the experiences of other regions within the US and abroad [e.g., 29-32] facilitating entities (public and private) will likely need to consider desired information needs relative to expanding the potential of tree systems in this context. Targeting information and technical outreach to communicate the variety of benefits and potential risks of tree establishment as a biomass crop may be essential to allowing landowners and bioenergy investors to more fully explore opportunities. As such, this research highlights a number of contextual insights and information gaps related to the purposeful integration of trees into agricultural landscapes and/or production systems that are relevant to market development.

Most farmers and ranchers in our study who expressed interest in biomass production were interested largely because woody biomass crops were more often than not viewed as complementary to their farming systems in that they benefited existing cropping systems or would be a good alternative use for marginal land areas; an important factor also captured within previous research on the use of perennial vegetation [33,34]. Our research points out that NGP farmers/ranchers appreciate environmental outcomes associated with on-farm trees along with the possibility of marketing the biomass at some point in time; thus joint production of environmental and commodity benefits. This is potentially an important finding as the value orientations of agricultural operators has been shown to broadly influence farm management decisions relating to conservation, resource protection, and required profit outcomes particularly in the context of strategic use of trees and or in biomass contexts [e.g., 35,36]. More specifically, farmers have at times been willing to face higher financial risk in a farming endeavor when there is an associated environmental benefit [37,38]. Other studies have also noted that perennial bioenergy crops may be appealing to those farmers and landowners oriented towards bio-physical resource conservation such as protecting soils or more cultural benefits such as enhanced aesthetics or habitat related recreation [18,23]. Woody biomass systems have been highlighted for their capacity to provide or otherwise mediate myriad environmental services such as long term below ground carbon sequestration, habitat and habitat connectivity (e.g., corridors), and efficient nutrient and water cycling particularly in landscapes dominated by row-crops [39].

A few of our focus group farmers questioned the biophysical capacity to grow trees in certain locations in the NGP. Throughout the NGP region however, there is strong bio-physical potential for woody biomass production, though yields will vary considerably across suitable species due to regional differences in precipitation (timing and quantity) as well as length of periods between precipitation events and number of frost-free days in spring [40]. Nevertheless, woody biomass trials in the Central Great Plains suggest high potential biomass tonnage across a variety of hardwood species [e.g., 41,42]. Work is currently underway to explore an expanded role for eastern red cedar, one of the "weed trees" specifically mentioned by a number of our focus group participants [43].

A few of our focus group participants offered that trees may have certain resource management advantages over other biomass feedstocks in certain situations, a finding that is consistent with other farmer-based studies. Relative to collection of crop residues for bioenergy purposes, farmers have expressed that strong concerns regarding the loss of nutrients and increased soil erosion decrease their interest in marketing residue [22,23,44]. Trees on the other hand are well known for their ability to protect soil fertility and provide erosion control [45]. Additionally, woody biomass systems may also have relative feedstock advantages over herbaceous biomass or crop residue in terms of versatility as a feedstock, storage capacity, and feedstock logistics. For example, woody materials have very high energy output:input ratios, trees can be stored "on the stump" or at field edges more easily than herbaceous materials, and harvests can be scheduled easily [39]. Advantages such as these may well be important relative to potential landowner interest in woody biomass as a commodity because of the typical periodic nature of harvests; this periodicy being an distinct issue for some of our focus group participants (e.g., "...there's no instant gratification with trees"), though at least a few farmers were unconcerned (e.g., "...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").

Another pervasive constraint present in the focus group discussions was financial uncertainty relative to getting started at the farm-scale but also in terms of market sustainability. This constraint was partially nested within a recurrent focus on participant concerns of a viable local market for woody biomass developing within their region. Both findings being consistent with previous explorations of emergent bioenergy supplier opportunities [29,36, 44, 46]. Our focus group participants also echoed findings in previous research noting struggles with access to capital and various requirements from lending institutions relative to farm-level investing in tree based land use in agricultural regions [47, 48]. There were also distinct questions and concerns among our focus group participants about investing in an emerging market that may be dependent upon subsidies. 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 concerns about the ability of markets to mature on their own or always being dependent upon extra-market support as well as potentially constraining contractual requirements [34, 49,50].

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 [51]. 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 [6]. North Dakota has already surpassed their original target, with 16.7% of retail electricity from renewable energy sources [52]. Kansas is about three-quarters of the way to meeting their renewables standard [53], while South Dakota is about halfway to meeting their voluntary targets [54]. 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) [55]. 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 not just the establishment and utilization of woody biomass but to foster robust markets that feature long-term private investment and infrastructure development [55]. 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.

5. 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 the qualitative nature of the research 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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Conflicts of Interest

The authors declare no conflict of interest.

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