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Influences on farmer and rancher interest in supplying woody biomass for energy in the US Northern Great Plains

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Abstract State and federal policy targets for renewable energy production in the US have prompted investigations into the feasibility of different biomass feedstock types for use in transportation fuels or electricity production. Woody biomass systems can be integrated strategically within 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 US Northern Great Plains region (North Dakota, South Dakota, Nebraska and Kansas), this begins with assessing relevant perceptions of farmers and ranchers. Results from a 2014 survey of farm and ranch operators managing agriculturally marginal farmland indicated 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 policy initiatives and management practices.

Keywords Agroforestry · Policy · Marginal farmland · Survey · Willingness · Perceptions

Introduction

Recent federal and state policy has shaped the potential for plant-based cellulosic (biomass) feedstocks to be used for electricity production or conversion for ethanol and other bio-chemicals (Tyndall et al. 2010; USDOE 2011; US-DSIRE 2013). The goals of the expanded Renewable Fuel Standard (RFS2) initially framed within the 2007 US Energy Independence and Security Act mandated a significant increase in the use of biomass for transportation fuels at a national scale (USDOE 2011). In addition, US state-level targets for renewable electricity production have guided efforts to identify opportunities for energy sources from crop residue, herbaceous and woody biomass (Hurlbut 2008; US-DSIRE 2013) with

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small-scale electricity generation being a particularly desirable as a way to incrementally advance bio-renewable infrastructure and enhance local economies (Lezberg et al. 2010).

The majority of current and potential biomass supply is dependent upon dedicated management for biomass materials on agricultural and forested land (USDOE 2011; USGS 2013; Milbrandt et al. 2014). Feasibility is limited by the cost associated with feedstock availability (production, processing, storage) and transportation (Jensen et al. 2011); thus, understanding potential supply at regional scales is crucial to encourage investment and development of local markets. As noted in regional biomass assessments, a key US agricultural region with considerable potential is the US 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 (Perlack et al. 2005; USDOE 2011) and dedicated crops such as sorghum and switchgrass have distinct agronomic potential (USDOE 2011; Xue et al. 2013). Yet, there is interest in exploring the niche potential of other biomass sources, particularly woody biomass (Rosenberg 2007; Rosenberg and Smith 2009; USDOE 2011). This is largely because relative to crop residue and dedicated herbaceous biomass systems, woody biomass systems offer various feedstock and ecosystem benefit advantages—e.g., material storage "on the stump", high energy output:input ratios, versatility as a feedstock, and critically for landowners, ecosystem service outcomes such as habitat, long-term below ground carbon sequestration, water quality protection, and soil protection (Tyndall et al. 2011a). Utilizing trees particularly in marginal land areas (e.g. land which produces lower crop yields relative to other cropped land or poses particular management challenges and has lower land-use opportunity costs) may provide landowners a wide variety of direct environmental and commodity benefits that exceed what row crops have to offer that same land area (Gelfand et al. 2013; Milbrandt et al. 2014). In the context of landowners producing biomass for bioenergy purposes, woody biomass represents the above ground portion of woody vegetation (trunk, branches, bark, leaves) that can be harvested once or on rotation, marketed, and variously processed into liquid or heat energy (Foster et al. 2007).

Yield trials in the NGP suggest high potential biomass tonnage across a variety of hardwood species and site conditions (e.g., Ranney 1986; Netzer et al. 2002; Geyer 2006). The Northern Great Plains (NGP; Kansas, Nebraska, South Dakota, and North Dakota) as a region also possesses a favorable policy climate for wood biomass utilization (Guo et al. 2012), a strong infrastructure to support biomass-bioenergy (Mabee et al. 2011; Guo et al. 2012), and a long history of utilizing trees in agricultural contexts; e.g., particularly tree-based practices such as windbreaks and riparian buffers utilized for both production and environmental benefits (Brandle et al. 2009; Gardner 2009; Jose 2009).

Despite the potential for the emergence of woody biomass systems in the NGP region, biomass markets (e.g., crop residue, herbaceous, woody) continue to be limited (DOE 2015), and woody biomass markets are particularly lacking (Atchison and Kansas Forest Service, pers comm. 2015). In US agricultural regions, private investment in regional biomass utilization has been contingent upon an understanding of landowner interests, capacity and willingness to supply feedstock (Jensen et al. 2011; Tyndall et al. 2011b; Tian 2013).

While there are surveys regarding landowner attitudes, needs, and willingness to grow and market biomass in the US (e.g., Jensen et al. 2007; Smith et al. 2011; Tyndall et al. 2011b) and abroad (e.g., Roos et al. 2000; Paulrud and Laitila 2010; Gilthero et al. 2013), prior to this study very little was known about NGP landowner knowledge of or interests in woody biomass production. As such, this survey-based study broadly characterizes NGP farmer and rancher attitudes and knowledge regarding woody biomass production systems and quantitatively assesses interest in producing woody biomass within the US NGP. We also explore farmer interest in the potential for woody biomass systems to provide important ecosystem services within existing agricultural systems while biomass markets evolve. Specifically, our survey sought to characterize farmer/rancher: (1) attitudes associated with use of trees for biomass, (2) knowledge of the use of trees for environmental management and biomass production, and (3) perceived constraints associated with the adoption process and or management of woody biomass systems. Additionally, we quantify the degree to which these farmers/ranchers are interested in producing woody biomass and we identify and characterize key farm characteristics,

demographic factors, and farmer beliefs associated with this interest. Results will help extension and policy entities identify system or individual characteristics and preferences associated with farmers and ranchers who may serve as early adopters of woody biomass crops and highlight further information, outreach, and policy needs.

Methods

We conducted a telephone survey of farmers and ranchers managing marginal agricultural land within four states in the NGP region of the United States: Kansas, Nebraska, North Dakota and South Dakota (Fig. 1). The initial random 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. Phone interviews took place from 20 January 2014 through 12 March 2014 and lasted an average of 15–20 min. The final eligible sample was 1481, and a total of 454 interviews were completed with farmers and ranchers in the sample. Eligibility was based on the respondent being a farmer or rancher. Phone interviews were conducted only with farmers or ranchers who classified themselves as a primary decision maker with regard to their farm or range system. 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 and non-response rates. All survey data were collected and handled in compliance with the Iowa State University Institutional Review Board.

Our research and subsequent survey (see Supplemental File) was guided by regional landowner studies regarding biomass production or the purposeful use of trees in agricultural contexts. For example, demographics have been noted to influence farmer interest in establishing trees in general and in biomass production systems specifically. A number of studies found that found that as farmers' age, interest in biomass production tends to decrease (Villamil et al. 2012; Qualls et al. 2012). Land tenure has also been linked to the adoption of tree-based practices as farmers who own more land are more likely to be interested in utilizing tree-based practices in Nebraska (Skelton et al. 2005). Likewise, when farmers have specific resource and environmental concerns on their farms, this can positively affect interest in tree-based conservation practices, e.g., riparian forest buffers (Valdivia and Poulos 2008).

Fig. 1 Location of Northern Great Plains survey region (North Dakota, South Dakota, Nebraska, Kansas)

Additionally, the knowledge level of farmers regarding the use of trees in a farming system can be an important factor in gauging farmer interest in trees with negative farmer attitudes associated with relative risk and uncertainty related to tree-based practices have been shown to reduce interest in these practices (Strong and Jacobson 2006). Increasing knowledge of technical aspects of utilizing or growing biomass have been shown to positively influence farmer interest in biomass (Skelton et al. 2005; Strong and Jacobsen 2006; Wen et a. 2009; Tyndall 2009), as has increasing support from banking/lending institutions, which are known to influence landowner interest in tree-based conservation practices (Brewer 2002). Positive farmers attitudes, values and beliefs regarding perennial production and conservation systems in general (Tyndall 2009), or about renewable energy and the role that biomass can play (Wen et al. 2009; Sherrington et al. 2008) have been shown to have a significant and positive effect on interest in producing biomass. Farmer views on market or production risk can also strongly impact adoption behavior among farmers (Gronowska et al. 2008; Glithero et al. 2013).

Farm system characteristics also can influence interest in the use of tree-based practices. Various resource concerns (such as erosion) can positively affect interest in certain tree based conservation practices, e.g., riparian forest buffers (Valdivia and Poulos 2008). Operation size may also be important; operators of comparatively small farms have variously been shown to be more likely to be interested in utilizing tree buffers within their farm systems (Skelton et al. 2005; Valdivia and Poulos 2008). Some research has noted that landowners with a high percentage of marginal land in crop production may well be more interested in producing bioenergy crops relative to farmers managing fewer marginal acres (Skevas et al. 2014). Whereas landowners who have acres enrolled in the USDA Conservation Reserve Program (CRP), are often less likely to pursue biomass production (Altman et al. 2011).

Following these studies, our survey was designed to better understand factors that influence the interest of NGP farmers and ranchers in growing woody vegetation on marginal land for biomass production and asked about attitudes and opinions on potential benefits, profitability, and practicality of planting and harvesting trees. Additional questions were included to capture key demographic and farm/ranch characteristics as noted above. 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.

To directly quantify farmer and rancher level of interest in producing woody biomass, we asked: "How interested would you be in growing trees and selling them as woody biomass if it were profitable for you?" on a rising 5-point ordinal scale (1 = no interest and a level of 5 = very interested). The notion of "profitability" was left to the respondent to define as to avoid having to present a potentially confounding pretext. In the absence of a current market or market data regarding woody biomass in this region, keeping the idea of profitability open ended and personal, served as a way for all respondents to be able provide an answer to this question, and not have their answer influenced by a threshold that would have been somewhat arbitrarily provided by the researchers.

An ordered probit regression (Greene 2012) was used to assess the relationship between independent variables and the dependent variable, the level of farmer/rancher interest in growing and selling woody biomass. Seventeen explanatory variables were selected from key factors informed by our literature review (described above) and included age, sex, education level and if they operated full-time (variables are listed and described in Table 3 of the results section). With regard to farm characteristics, we included variables about production scale (in hectares), primary crops, enrollment in conservation programs and potential resource concerns (such as erosion, water quality, etc.).

Also included in the regression was an index aggregating a respondent's reported levels of importance ascribed to potential ecosystem benefits of trees on their property. The index was created following the protocol described in Tindall (2003), and the list of potential tree-related ecosystem benefits (e.g., wind protection, enhanced crop production, aesthetics, habitat, water and soil quality, carbon, biomass) was guided by Jose (2009, 2012), and Brandle et al. (2009). Variables reflecting economic perceptions of woody biomass (perceived compatibility with their current farming operation, production experience, and level of influence from banks or lending institutions) were also included in the model.

The model was compliance tested for the effects of multicollinearity by examining variance inflation factors in Stata 15.1, for heteroskedasticity using the Davidson and Mackinnon (1984) test for probit and logit models in Shazam 11.1, and to ensure adherence to the assumption of proportional odds using the Brant (1990) test of parallel regression assumption in Stata 15.1. In addition, regression models were estimated using robust standard errors to account for possible misspecification in the model (White 1980). Ordered probit model coefficients cannot be directly interpreted, so we examined the marginal effects of each independent variable at its mean for each interest level to estimate the probability of an average respondent selecting a given interest level (See Supplemental Table 1 for marginal effects at individual interest levels). Statistical analysis was completed using Stata (Version 15.1, StataCorp 2017), Shazam (Verison 11.1.14, Shazam Analytics, 2011), SPSS (Version 22, IBM, 2013), and Microsoft Excel 2016.

Results

Demographic and farm system characteristics show that 81% of survey respondents were full-time farmers and/or ranchers (2012 US Agricultural Census (USDA-NASS 2012) shows 55% of principal operators regionally report farming as their primary occupation). Male farmers represented 95% of the survey participants (census average was 94% male (USDA-NASS 2012)). Average respondent age was 58 years (census average was 57 years (USDA-NASS 2012)) and the average career length was 34 years (census average was 27 years (USDA-NASS 2012)). Three-quarters of those surveyed intended to continue farming for at least another 10 years. Ninety-seven percent of the respondents had either a high school education, some college or had completed college or graduate education. On average, respondents received about 22% of their income from off-farm sources in 2013 and just over half of the respondents reported receiving $250,000 or less in gross farm sales for 2013.

On average 747 hectares were managed in 2013 (including cropland and pasture) (larger than the regional average of 433 hectares (USDA-NASS 2013)). Over half of this farmland was owned by the operators. The majority of the respondents (66%) managed an average of land 130 hectares that they consider to be "marginal". Almost a third managed an average of 40 hectares enrolled in the Conservation Reserve Program (CRP); only 2% of which was planted in trees or shrubs. Interestingly, 43% of farmers/ranchers with CRP land planned on returning an average of about 12 hectares to production when their contract was finished (as opposed to re-enrolling).

There was a significant presence of tree-based conservation practices on the farms represented as over 80% of the respondents have windbreaks and 23% have woody riparian buffers. Over half of the respondents have an average of 26 hectares of natural woodland as part of their farm systems. A majority of surveyed farmers and ranchers reported that they have dealt with wind, rain or snowmelt-based erosion on fields they manage. Nearly half (49%) have also experienced unwanted growth of woody plants in their farm system. Less than fifteen percent of farmers noted issues associated with loss of wildlife habitat or chemical runoff from their farm system.

With regard to potential benefits of trees and tree-based farm practices, a high percentage of respondents regarded wind protection (80%) and various livestock or crop benefits (65%) as being of "high importance" (Table 1). The ability of trees to enhance general aesthetics and farm privacy also were noted to be important with $\geq$ 64% of the respondents stating these were at least moderately important. The contribution of trees to enhancing hunting, fishing, or other recreation was deemed as being of high importance by 39% of the respondents. The majority of respondents rated a number of environmental benefits such as enhancing water and soil quality and carbon storage as being at least moderately important. On the other hand, benefits associated with timber and non-timber products derived from trees within an agricultural landscape were shown to be of little importance to farmers and ranchers, as over three-quarters of farmers and ranchers ranked them as low importance (non-timber products in the NGP region could involve tree nuts, berries, marketable foliage, etc.).

Despite generally positive views on the importance of benefits provided by trees, the respondents did indicate that there would be challenges with integrating tree-based biomass systems into their farm systems (Table 2). Only 20% of farmers and ranchers agreed that growing trees for use in energy production would

Table 1 Percentage of farmers and ranchers who reported a given level of importance of benefits to having trees on their property

Benefit	High importance[a]	Moderate importance[a]	Low importance[a]	n
Wind protection	80	11	9	448
Livestock or crop benefits	65	16	19	448
Beauty or scenery	41	32	27	449
Privacy	41	23	36	447
Hunting, fishing, or other recreation	39	28	33	447
Enhancing water quality	34	32	34	442
Enhancing soil quality	30	28	41	441
Carbon storage	30	29	41	442
Production of sawlogs, pulpwood, firewood, biomass or other timber products	10	15	76	444
Cultivation or collection of non-timber forest products	4	10	86	444

[a]% values are rounded up

Table 2 Farmer and rancher opinions regarding various aspects of woody biomass production

Aspects of woody biomass production	Strongly disagree[a]	Dis-agree[a]	Un-sure[a]	Agree[a]	Strongly agree[a]	N	Mean[b]	SE
Growing trees for use in energy production would be compatible with my current farm operation	12	46	21	19	1	453	2.51	0.0474
I have the technical knowledge necessary to harvest woody biomass from my land	15	51	18	15	1	453	2.38	0.0460
I have the technical knowledge necessary to market woody biomass from my land	19	60	15	6	0	453	2.07	0.0357
The production risk for trees is lower than for other crops or products I currently produce	9	26	37	26	2	443	2.88	0.0477
It takes too long to make a profit from trees	12	62	22	5	1	451	2.21	0.0346

[a]% values are rounded up

[b]Scale is *1* strongly disagree, *3* unsure, *5* strongly agree

be compatible with their current farm operations. Overall knowledge regarding biomass systems also appeared to be lacking, with 16% believing they have the knowledge to harvest woody biomass from their land and only 6% claiming to have the technical knowledge needed to market woody biomass materials. With regard to potential production risk associated with growing trees for biomass relative to other crops, a plurality of respondents (37%) are unsure of whether or not there are risk advantages to growing trees. A majority of respondents (74%) however, disagree that trees would take too long to make a profit suggesting that rotation ages or the oft-periodic nature of biomass revenues would not be problematic.

Across the whole sample, 61% of farmers and ranchers expressed some level of interest in producing woody biomass (that is, selecting an interest level of 2 or greater), with 23% of respondents reporting they were interested to very interested (13% were interested, 10% were very interested; see Fig. 2). Only 38.5% stated that they no interest at all. Nebraska had the highest percentage of respondents reporting some interest (68%), followed closely by South Dakota (66%) and Kansas (62%). North Dakota had the lowest percentage, with just under half of respondents reporting any interest (49%).

Results from the ordered probit (model variables described in Table 3 and results summarized in Table 4) reflect the directional relationship of a

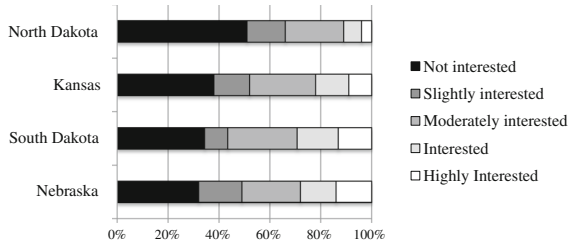

Fig. 2 Farmer and rancher interest in producing woody biomass by state

specific variable on the probability of increasing the level of interest a farmer/rancher has in growing trees and selling them as woody biomass if it were profitable. Additional conclusions relevant to the influence specified variables have on interest are highlighted by examining marginal effects at the variable means, reflecting the percentage probability of selecting a given interest level for a specified variable holding other variables constant. The marginal effects summary table generated for this study have been added as supplemental material. There was no evidence of multicollinearity (all VIFs < 2.2), heteroskedasticity ($p > 0.23$), or failure of the assumption of proportional odds ($p > 0.316$).

The model indicates that several individual farmer/rancher characteristics have a significant effect on interest in woody biomass. A part-time farmer/rancher was 4.4% more likely to report they are highly interested than those who are full-time, while full-time farmers and ranchers had a 12.7% higher likelihood of reporting no interest at all. Other studies have noted that part-time farmers (or "hobby" farmers), or farmers who obtain a significant amount of their income from off-farm sources have different profit expectations regarding land use, and might be expected to dedicate more land to biomass production than full-time farmers (Jensen et al. 2007; Qualls et al. 2012). Another contributing factor may be that the part-time farmers/ranchers (representing 19% of the respondents in this study), rated the importance of tree related benefits higher than full-time farmers. Age appears to have an inverse relationship with interest. The younger a farmer or rancher is, the more likely they are to be interested in producing biomass, as the marginal effects showed a 0.8% increase per year of age in the likelihood they will report no interest. This finding is a fairly consistent in regional biomass studies (e.g., Jensen et al. 2007; Tyndall et al. 2011a), suggesting that younger farmers are more willing to invest in emerging markets that may take time to develop. Male operators were shown to have a higher probability of interest than female operators, with males being 8.1% more likely to report high interest and 4.0% more likely to report very high interest in producing woody biomass. Though to be fair, this may well be due to the fact that 94% of the farmers in the NGP region (and 95% of our respondents) are male (USDA NASS 2012). In addition, farmers and ranchers who had completed college were shown to have a higher level of interest in producing biomass compared to those who had not completed college. Having a college degree has often been noted to be an indicator of farmer interest in agricultural innovations in general and biomass production, in particular (e.g., Jensen et al. 2007; Hoque et al. 2015) suggesting that such farmers are able to acquire and utilize information and be better equipped to manage risk, yet there are also examples of where higher education was not found to be a statistically significant factor in biomass interest (Qualls et al. 2012; Wilson et al. 2014).

Our model also contained two significant results relevant to attributes of farmer/rancher agricultural operations. Those who reported more resource or environmental concerns on their land were more likely to report high interest in establishing biomass. A finding that seems consistent with studies examining landowner use of tree based conservation practices (e.g., Valdivia and Poulos 2008). While enrollment in CRP programs was indicated to be an insignificant factor, farmers and ranchers with land enrolled in non-CRP conservation programs were 4.6% more likely to report that they were very interested in producing woody biomass compared to those who do not, and conversely, those not enrolled in a non-CRP program had a 12.9% higher probability of reporting no interest. This is an interesting finding in that participation in CRP has been shown to negatively influence farmer willingness to grow biomass like switchgrass (Jensen et al. 2007; Altman et al. 2011). This may be because CRP has contractual restrictions on material harvesting (Jensen et al. 2007), thus having other conservation land not under those types of restrictions may indicate an interest in co-locating production and conservation.

Attitudes relevant to producing woody biomass were also shown to significantly affect interest. Farmers and ranchers who reported a higher

Table 3 Variables included in an ordered probit regression on farmer/rancher interest in growing trees for biomass

Variable	Scale	Mean	SE
Interest level in producing woody biomass	5 pt Likert[a]	2.43	0.067
Operation attributes			
Operation size	ln (hectares)	747[b]	0.053
Corn producer	Yes/no; 0/1	0.73	0.022
Wheat producer	Yes/no; 0/1	0.50	0.025
2013 CRP enrollment	Yes/no; 0/1	0.31	0.023
Other conservation program enrollment	Yes/no; 0/1	0.17	0.018
Identified resource concerns on managed land (#)[c]	0–7	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	5 pt Likert[d]	3.06	0.051
Agreement that woody biomass would be compatible with current system	5 pt Likert	2.52	0.048
Agreement that woody biomass use will increase	5 pt Likert	2.90	0.046
Agreement that it does not take too long to profit from trees	5 pt Likert	2.23	0.036
Reported importance of benefits of trees (index, $\alpha = 0.846$)[e]	5 pt Likert	2.95	0.045
Knowledge			
Previous biomass production (sum)[f]	1–5	0.66	0.039
Constraints			
Reported level of bank/lender influence	5 pt Likert[g]	2.15	0.055

[a]Scale is *1* not at all interested, *3* moderately interested, *5* very interested

[b]Unadjusted mean

[c]The total number of resource concerns identified out of the following: soil loss from water, soil loss from wind, unwanted woody plants, poor drainage, stream bank erosion, loss of wildlife habitat, and chemical runoff

[d]Scale is *1* strongly disagree, *3* unsure, *5* strongly agree

[e]Chronbach'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 2). An index with $\alpha > 0.80$ is regarded as having an acceptable degree of i*nter-item homogeneity* and therefore is a satisfactory construct (Bland and Altman 1997)

[f]Proxy variable for farmer knowledge. Sums up various personal experiences with producing woody biomass for some end use, e.g., fodder, bedding, fuel wood, other uses

[g]Scale is *1* no influence, *3* some influence, *5* considerable influence

willingness to accept self-defined "risk" also have increased interest in producing biomass. A farmer/rancher with a higher level of agreement that growing trees for energy production would be compatible with their existing farm/ranch system are shown to have a 3.2% higher probability of reporting they are highly interested, while those who may view woody biomass as incompatible with their farm system are 12% more likely to report no interest. Farmers and ranchers who more strongly agree that woody biomass markets will expand and biomass use will increase greatly over the next few years are more likely to express a higher level of interest. The time required to profit from woody biomass investment was shown to be important with individuals who report that the time required was "too long" have a 9% higher likelihood of reporting no interest. Our summation variable reflecting the level of experience producing biomass was also significant showing that individuals with more experiences in biomass production for livestock or firewood use had a

Table 4 Ordered probit regression on farmer/rancher interest in growing trees for biomass

Variable	Coef.	SE (Rbst)	t	p > t
Operation size	0.074	0.072	1.020	0.308
Corn producer	0.113	0.145	0.780	0.434
Wheat producer	0.275	0.128	2.140	0.033
2013 CRP enrollment	−0.036	0.125	−0.290	0.774
Other conservation program	0.384	0.152	2.520	0.012
Identified resource concerns on managed land	0.140	0.037	3.810	0.000
Full time operator	−0.377	0.178	−2.120	0.035
Age	−0.023	0.005	−4.750	0.000
Sex (male)	0.691	0.262	2.640	0.009
Completed college or higher	0.228	0.114	2.000	0.046
State (Kansas)	0.179	0.172	1.040	0.299
State (Nebraska)	0.279	0.190	1.470	0.143
State (South Dakota)	0.413	0.178	2.320	0.021
Reported willingness to take risk compared to other farmers	0.181	0.059	3.050	0.002
Agreement that woody biomass would be compatible with current system	0.333	0.074	4.500	0.000
Agreement that woody biomass use will increase	0.134	0.071	1.870	0.062
Agreement that it does not take too long to profit from trees	0.251	0.089	2.820	0.005
Benefits of trees (index, $\alpha = 0.846$)	0.120	0.083	1.440	0.151
Previous biomass production	0.198	0.077	2.570	0.011
Reported level of bank/lender influence	−0.042	0.058	−0.730	0.468
Cut1	2.775	0.712	3.90	0.000
Cut2	3.287	0.715	4.60	0.000
Cut3	4.213	0.721	5.84	0.000
Cut4	4.912	0.744	6.60	0.000

n = 412 F(20,386) = 7.64 Prob > F = 0.00

higher probability of expressing interest. These findings are not surprising in that biomass compatibility and farmer beliefs in market expansion as well as personal experience in biomass systems have been show to be strong indicators of biomass interest (Tyndall et al. 2011a).

In an effort to explore the incentives or market conditions that farmers and ranchers would find to be desirable in the context of fostering production and market entry, survey respondents were asked to what degree a series of situations would increase their interest in growing and selling woody biomass (Table 5). The top three incentives or market conditions that are most broadly desired are having local facilities to process biomass for energy production, sustainable, non-subsidized private markets for biomass, and free technical advice. Overall, those farmers and ranchers who have little interest in producing woody biomass would not be influenced with any incentives or favorable market conditions. Those farmers who are at least moderately interested in woody biomass on the other hand are much more interested in various incentives and market conditions; across the board, the farmers who noted that the incentives/situation would increase their interest "a great deal" had the highest mean degree of interest in woody biomass. Thus, for the most interested farmers and ranchers, market entry, material handling/processing and technical incentives along with sustainable local markets are strongly desired. For the respondents who rate the highest degree of interest in woody biomass production (see mean interest columns in Table 5), having access to free technical advice, the existence of a sustainable, non-subsidized private biomass markets are the most desirable situations. In terms of easing the start-up process and

Table 5 Farmer and rancher opinions regarding various incentives or market situations that increase interest in the production of woody biomass

How much would each of the following situations increase your interest in growing and selling woody biomass?	Not at all		A little		Some		Quite a bit		A great deal		N	Mean	SE
	%[a]	Interest mean[b] (SE)	%	Interest mean (SE)	%	Interest mean (SE)	%	Interest mean (SE)	%	Interest mean (SE)			
Having a third-party responsible for harvesting, material processing, and transportation	29%	1.20 (0.059)	17%	2.22 (0.116)	26%	2.79 (0.118)	16%	3.54 (0.116)	11%	3.53 (0.186)	453	2.64	0.0650
Having free technical assistance	29%	1.13 (0.051)	15%	2.16 (0.118)	27%	2.69 (0.117)	20%	3.57 (0.097)	10%	3.86 (0.175)	453	2.66	0.0633
Having a sustainable, non-subsidized private market for biomass	26%	1.16 (0.058)	14%	1.88 (0.128)	27%	2.51 (0.107)	22%	3.62 (0.098)	11%	3.75 (0.151)	450	2.77	0.0646
Having local facilities to process biomass for energy production	23%	1.04 (0.029)	12%	1.82 (0.139)	23%	2.45 (0.120)	26%	3.15 (0.104)	16%	3.80 (0.126)	453	2.99	0.0673
Receiving government subsidy payments for establishing, harvesting, processing, and transporting woody biomass	43%	1.80 (0.088)	13%	2.50 (0.170)	24%	2.70 (0.122)	12%	3.29 (0.166)	7%	3.89 (0.180)	452	2.27	0.0632
Receiving payment for environmental benefits associated with trees (e.g., carbon credits, soil improvement, water quality, habitat improvement, etc.)	31%	1.58 (0.094)	14%	2.23 (0.167)	26%	2.58 (0.125)	20%	3.27 (0.118)	10%	3.45 (0.188)	453	2.64	0.0643
Being allowed to harvest trees and shrubs from land enrolled in conservation programs	37%	1.66 (0.097)	13%	2.29 (0.150)	29%	2.77 (0.113)	15%	3.25 (0.130)	6%	3.80 (0.222)	452	2.41	0.0618

[a]Whole sample percentage

[b]Mean woody biomass production interest level for farmers and ranchers who are in the columned response categories (*1* not at all interested, *5* very interested). A *Kruskal–Wallis* one-way ANOVA showed significant differences ($p < 0.001$) between all market incentives/situations and farmer/rancher interest in producing woody biomass

then minimizing post-establishment activities for those farmers who are at least moderately interested in producing woody biomass, government subsidy payments for establishing, harvesting, processing, and transporting woody biomass and having a third-party responsible for harvesting, material processing, and transportation are also desirable.

Discussion

Sixty-one percent of the farmers and ranchers surveyed expressed at least a moderate level of interest in producing woody biomass, with 23% of respondents reporting they were interested to very interested (the highest two levels of interest in our scale). General interest in woody biomass appears strong enough to suggest latent NGP market capacity in the context of woody biomass as a feedstock. Still, in order for formal markets to develop it is highly likely that a significant amount of demand and supply oriented "market fostering" will be required.

State and regional biomass policies can be drivers of renewable energy production and could operate to incentivize woody biomass demand within the NGP. One possibility could be through state designated Renewable Portfolio Standards (RFPs) or through state level renewable energy goals. State RFP standards are legislated requirements that schedule specified targets for retail electricity sales from renewable sources; renewable portfolio goals, on the other hand, are not legally binding, but provide a framework for incentivizing production for the fulfillment of said goal (US DSIRE 2013).

More directly related to development of local/regional biomass markets, the Federal USDA Biomass Crop Assistance Program (BCAP) is designed to address supply issues presented for industry entities seeking to establish a regional bioenergy production facility (USDA FSA 2011). Within USDA approved "project areas", BCAP facilitates a cooperative hub of feedstock producers (e.g., farmers, forestland owners) and a biomass end-use facility via contracts that involve structured payments and technical support.

As noted prior, for farmers who are at least moderately interested in producing woody biomass, government subsidy payments for establishing, harvesting, processing, and transporting woody biomass and having a third-party responsible for harvesting, material processing, and transportation are desirable. Currently there are two BCAP production areas within the NGP that are producing switchgrass (USDA FSA 2015). 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. Nevertheless, based on our survey, BCAP awareness was somewhat low, with 48% of the respondents from Kansas, but only between 25 and 35% of respondents from other NGP states being familiar with the program.

There still will likely need to be different types of incentives to encourage adoption at farm scales (supply-side support) based on this study's findings. There was a fairly low overall knowledge base among our respondents regarding woody biomass systems (production and marketing) as well as limited collective direct experience in managing trees for biomass (for any purpose); for example, only 16 and 6% of our respondents consider themselves to be knowledgeable regarding woody biomass production and marketing, respectively. As such, 57% of the survey respondents stated that having free technical assistance would increase their interest in producing woody biomass (Table 5). Previous research has highlighted the potential for increased interest in or adoption of tree-based practices given access to technical assistance (Skelton et al. 2005; Strong and Jacobson 2006).

Risk management will be an important aspect of any emerging biomass system. Farmers and ranchers in our study who reported a higher willingness to accept "risk" (self-defined) have increased interest in producing biomass compared to those who are less willing to take on risk. However, only 40% of the respondents self-identified as risk takers. There are a number of other unique risk related aspects of woody biomass systems. There are also challenges found in establishment, natural mortality, pests, pathogens, and environmental conditions (e.g., flooding) along with the periodic nature of revenue (e.g., James et al. 2010; McConnell and Burger 2011); though, our respondents seemed largely unconcerned about the timing of revenue. The perceived compatibility of woody biomass production within a farm system was shown in our study to be an important component in boosting farmer interest; a finding also noted in similar research (Strong Jacobson 2006).

Our probit regression suggests that linking biomass production to the environmental benefits afforded by tree-based farm practices would boost farmer/rancher interest in woody biomass. Still, there are questions on how this joint outcome might be facilitated. The role that conservation programs and technical conservation planning via the USDA NRCS (and other agencies and conservation oriented non-governmental organizations) might play in expanding biomass feedstock opportunities in the NGP is ambiguous. Based on our data, participation specifically in the Conservation Reserve Program within the NGP region was shown to have no appreciable impact on farmer/rancher interest in tree systems; a finding echoed in previous studies (Strong Jacobson 2006; Valdivia and Poulos 2008). Yet, those farmers and ranchers currently participating in non-CRP conservation programs tend to be more interested in establishing trees for biomass productions. These programs have the capacity of not only cost-sharing establishment costs and in some cases pay, for opportunity costs (e.g., annual rental payments). Often, they are often designed to seek ways to target multiple outcomes in farmed landscapes (Secchi et al. 2008). There can, however, be restrictions on material harvesting while in a conservation contract.

There are other types of additional payments that may prove to have a role in supplementing emerging or limited market prices for the biomass feedstock. For example, 56% of farmers and ranchers in our survey noted that ancillary environmental subsidies and emerging ecosystem service markets (e.g., carbon credits, soil improvement, water quality, habitat improvement, etc.) can increase their interest in producing and selling woody biomass (Table 5). Khanna (2008) and James et al. (2010) both noted the potential of market driven carbon payments to supplement feedstock markets as well as tie-in with policies that pay for environmental services (e.g., US Conservation Security Program). Other ecosystem service payments such as those associated with hunting leases also can be appealing to farmers (Rossi and Hinrichs 2011).

Still the most influential incentive is associated with technical advice. As such complimenting interest in minimizing the risk of integrating trees into farm systems and/or minimizing other types of farm risk via the planed use of trees (e.g., environmental concerns). Other than direct or indirect start up and technical service incentives, farmers desire biomass oriented infrastructure and robust market conditions (summarized in Table 5).

Conclusion

This study assessed NGP farmer and rancher outlining the influence of producer and system characteristics, attitudes, knowledge, and perceived constraints and highlighting the variables influencing farmer and rancher interest in producing biomass. This provides insights into the profile of producers who are or are not interested in pursuing woody biomass production and who would be suitable for targeted outreach information aimed at illuminating available biomass market opportunities.

As policy continues to develop alongside market needs, perspectives of potential suppliers will be critical if bioenergy goals are to be realized. Multiple feedstock types will be required for a dedicated annual biomass supply within the NGP. Woody biomass systems can contribute toward with multifunctional benefits and our results provide an understanding of influences affecting producer interest in woody biomass, which can guide further policy development and outreach efforts.

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