

1 A Qualitative Investigation of Farmer and Rancher Perceptions of Trees and Woody 2 Biomass Production on Marginal Agricultural Land

3
4 Ashley Hand, Independent farmer, Bernard, IA, 52032. amhand@gmail.com

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6 John Tyndall, Department of Natural Resource Ecology and Management, Iowa State University,
7 Ames, IA, 50010. jtyndall@iastate.edu
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9 **Abstract:** Bioenergy produced from perennial feedstocks such as woody biomass could serve as an
10 opportunity to strengthen local and regional economies and also jointly produce various
11 environmental services. In order to assess the potential for biomass- based bioenergy, it's essential to
12 characterize the interest that potential biomass suppliers have in such an endeavor. In the U.S. Great
13 Plains region, this largely means assessing relevant perceptions of farmers and ranchers. We
14 conducted a series of farmer and rancher oriented focus groups in North Dakota, South Dakota,
15 Nebraska and Kansas to qualitatively explore opinions about the role that trees can play in agriculture
16 and interest in woody biomass systems within existing Northern Great Plains (NGP) farms and
17 ranches. Our findings suggest that farmer and ranchers generally value the role that trees, or tree-
18 based practices like windbreaks can play in agriculture particularly on marginal farmland in terms of
19 conservation or crop protection. Yet relative to the potential of trees as a biomass crop there is a
20 distinct lack of knowledge and skepticism. Farmers and ranchers also noted variable degrees of risk
21 concern and uncertainty regarding investing in tree-based systems, as well as a number of perceived
22 external market related constraints to integrating trees within their managed systems. Most of the
23 participants recognized that if biomass production or an increase in tree planting and management in
24 general were to expand in the NGP region, government programs would likely be required to provide
25 much needed technical guidance and financial incentives. As the NGP regional bioeconomy continues
26 to emerge and expand, private and public investment relative to niche bioenergy feedstocks such as
27 woody biomass should address the type of information needs that farmers and ranchers have relative
28 to integrating biomass production into existing farm and ranch systems.

29 **Keywords:** Woody biomass; Northern Great Plains; farmers and ranchers; focus groups
30

31 1. Introduction

32
33
34 The current focus in the United States on domestic energy independence and diversification of
35 energy sources has led to an exploration of the potential offered by renewable, plant-based
36 biomass crops. Contributions from biomass in planted or natural settings are largely framed
37 around their potential in transportation fuels as well as in production of electricity. The 2007
38 U.S. Energy Independence and Security Act (EISA) encourages research and production of
39 potential biomass feedstocks in order to advance goals for transportation biofuels production as
40 outlined by the Renewable Fuel Standard 2 (RFS2) [1]. While ethanol production from grain
41 based sources (e.g., corn) has achieved the 15 billion gallon RFS2 annual production goal well
42 ahead of the 2022 target date [1], targets for cellulosic ethanol have been reduced annually by the
43 U.S. Environmental Protection Agency (EPA) due to unexpectedly low production volumes [2].
44 Subsequently, lack of dedicated supply and undeveloped markets continue to be significant
45 challenges for an emerging cellulosic liquid fuel industry. Despite the challenges in advancing

46 biomass based (cellulosic) transportation fuels, biomass has the potential to contribute to state-
47 level targets for electricity production [3, 4]. In some regions of the US, it is in this context that
48 biomass may have the strongest potential for ongoing market development should there be
49 continuing multi-scale efforts to reduce reliance on fossil sources for electricity production [5,
50 6].

51
52 One key region with regard to biomass potential is the U.S. Northern Great Plains (NGP) [1, 7].
53 Recent research from the NGP has been dedicated to the agronomic potential of herbaceous
54 biomass crops such as switchgrass (*Panicum virgatum* L.), miscanthus (*Miscanthus spp.*), forage
55 sorghum (*Sorghum bicolor* L.) and others [8] as well as different biomass crop management
56 strategies designed to enhance yields [e.g., 9, 10]. Crop residues (e.g., corn stover, wheat straw) are
57 also widely abundant throughout the whole NGP region [1]. There is however, comparatively
58 little information from the region regarding potential niche feedstock such as woody biomass.
59 Woody biomass is the harvestable, above-ground wood and bark component of a regenerable
60 tree system and is particularly suitable for combustion based electricity production [11, 12] and
61 is increasingly being looked at to support small scale electricity generation [13].

62
63 Woody biomass production in the form of biomass specific tree plantings or in concert with tree
64 based conservation practices/ agroforestry (e.g., windbreaks, tree buffers) has been examined
65 throughout the world particularly in relation to alternative uses of marginal farmland, that is, low
66 yielding or difficult to manage land [e.g., 14-18]. Agroforestry systems used for woody biomass
67 production have been highlighted for their potential to jointly produce various environmental
68 services at field and landscape scales while being managed for long-term biomass production
69 over coppice rotations [16, 19, 20]. Results from a recent survey out of the NGP region indicated
70 that 61% of representative farm and ranch operators have some degree of interest in woody
71 biomass production for bioenergy purposes [21], particularly in the context of marginal land use
72 and integration with conservation oriented agroforestry systems such as windbreaks.

73
74 Since the majority of existing and potential biomass production/availability in all U.S.
75 agricultural regions would be privately determined, it is imperative for feedstock supply and
76 investment analysis to have a better understanding of the interests, concerns and needs of
77 potential suppliers that could influence future intentions with regard to biomass production and
78 management [22]. Furthermore, the development of policy tools designed to encourage
79 investment in a regional bioeconomy also requires a firm understanding of potential supplier
80 needs, interests and concerns; all of which are often regionally unique [22,23].

81
82 To date very little is known about the interests of farmland owners and managers in the NGP
83 regarding woody biomass production [21], as such we conducted a series of farmer and rancher
84 oriented focus groups to qualitatively explore farmer and rancher interest in woody biomass
85 systems targeted within existing NGP farms and ranches. Results reflect emergent values and
86 attitudes about woody systems, variable farmer/rancher knowledge about such systems and
87 markets, variable expressions of risk and uncertainty, as well as a number of perceived external
88 constraints that interact to shape (1) farmer/rancher attitudes towards the presence/use of trees
89 within their managed operation, and (2) farmer/rancher evaluation of various influences on
90 participation as a biomass supplier.

91

92 2. Materials and Methods

93

94 We utilized focus groups as a way to qualitatively probe NGP farmers and ranchers for
95 knowledge and attitudes surrounding woody biomass systems. Focus groups allow for a guided
96 but nuanced discussion among a group with a selected characteristic in order to gain
97 understanding into a specific issue, allowing participants to offer their unique perspectives while
98 building off of the perspectives of others [24]. Focus groups are not meant to provide
99 generalizable information across a specific population, yet can provide in-depth and nuanced
100 information regarding emergent topics in ways that more quantitative approaches (e.g., survey-
101 based) are unable to provide (Roesch et al. 2016).

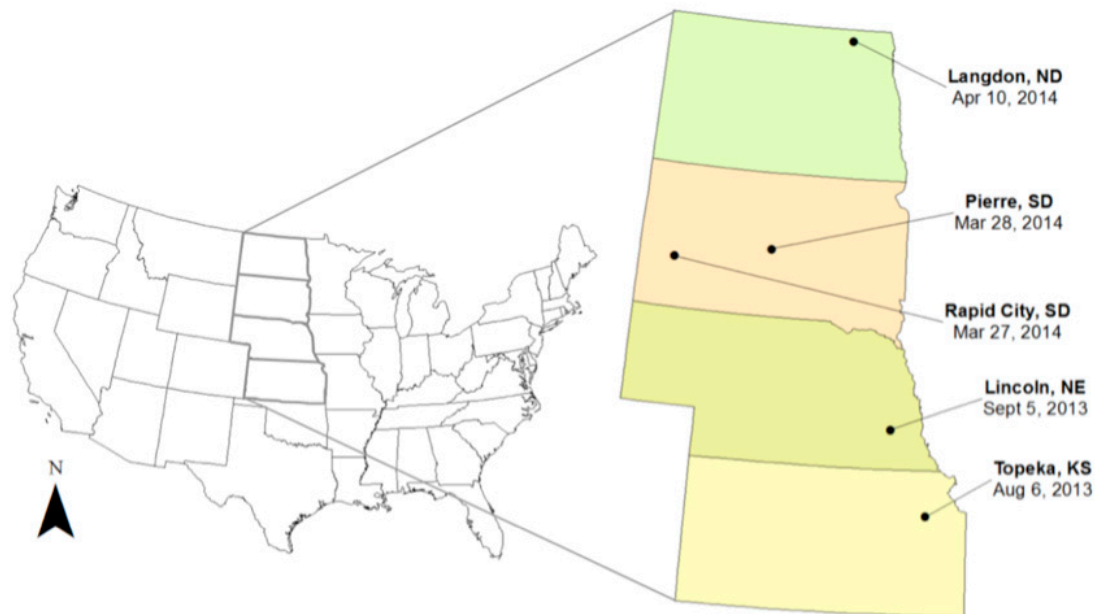
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103 2.1 Data Collection and Analysis

104

105 We conducted five focus groups total, one per state in Kansas, Nebraska, and North Dakota, and
106 two in South Dakota (Figure 1) between August 6, 2013 and April 10, 2014. We initially planned
107 for two focus groups per state as a way to capture a high degree of emergent themes [e.g., 26],
108 but logistical complications made this goal untenable. Considering the lack of farmer-oriented
109 studies from this region we believe that our data is informative, nevertheless. Eligible
110 participants included individuals who reported responsibility for on-farm decision making for
111 their crop or livestock production system. Those livestock producers who only managed feedlots
112 or confinements were not considered eligible for participation in the focus groups. Focus group
113 participants in the different states were selected through nominations from local and state
114 resource professionals (e.g., associated with the USDA Natural Resource Conservation Service;
115 district-level State Foresters, etc.) and agricultural NGOs, as well as through snowball sampling.
116 An incentive payment of \$100 per individual was offered for participation in a focus group.
117 Participants were provided advance information regarding project goals and anticipated topics of
118 exploration, were contacted by a researcher to discuss their farm operation and information
119 regarding focus group participation, and were additionally provided a link via email with further
120 information regarding the larger research goals associated with the project in which this study is
121 embedded. Participants were notified of the voluntary nature of participation in the focus groups
122 during initial contact through a confirmation letter, and prior to the beginning of the focus group
123 discussion. Consent to participate in the research project was implied by each participants'
124 presence at the voluntary focus group. Focus group locations in each state were selected to
125 accommodate the highest number of interested participants. Iowa State University's Institutional
126 Review Board approved our research approach and data management protocols prior to data
127 collection.

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130

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

133

134 Guide questions were used for all focus groups, and involved general queries about 1) regional
135 land use and “marginal” land, 2) opinions and experiences with trees in agricultural landscapes,
136 and 3) views on woody biomass as a marketable product. Following the focus group discussion,
137 participants were asked to complete a short questionnaire to capture relevant demographic
138 information. Focus groups were audio recorded, transcribed, and results were coded using NVivo
139 10 [27]. Preliminary open coding (identifying and labeling content) was used to categorize
140 statements made to ensure our protocol appropriately garnered relevant information. A second
141 cycle of hierarchical axial coding (establishing relationships between codes) was completed to
142 explore categories and draw data into overarching themes, and to explore nuances within a given
143 theme. Both cycles were coded using grounded theory; a theoretical approach allowing findings
144 to emerge from primary field data collected with specific research processes [28]. During the
145 second cycle coding, data from the first two focus groups was coded into thematic categories by
146 two researchers to develop a code book, with repeat coding on themes with a kappa coefficient
147 >0.40 , denoting poor inter-rater reliability. Themes with an initially low kappa coefficient were
148 either eliminated as thematic categories, absorbed into related themes, or were further defined for
149 both coders with subsequent recoding into the theme. The lead author completed the second
150 cycle coding for the subsequent three focus groups; with no modifications to overarching themes
151 in order reflect statements made by participants. The results are written as a narrative around the
152 common thematic findings.

153

154 3. Results

155

156 In total, 35 farmers and ranchers participated in our focus group series. A summary of

157 participant demographic information is presented in Table 1. Cumulatively, focus group
 158 participants manage 20,850 hectares (51,500 acres) across 32 counties in the NGP; an average of
 159 559 hectares (1,381 acres). On average the participants were 52 years old, had about 26 years of
 160 experience with farming or ranching. Female farmers/ ranchers made up 21 percent of total
 161 participants. Just over 91% of the participants planned on continued farming/ranching for at least
 162 the next 10 years. Reported land use on participants' property included crop production,
 163 woodlands, land set-aside with the Conservation Reserve Program (CRP) land,
 164 shelterbelts/windbreaks, ponds, wetlands, pastureland, and grassland. Reported crops produced
 165 in the region include corn, soybeans, wheat, oats, hay, barley, millet, milo, sugar beets,
 166 sunflowers, canola, flax, peas, and safflower.

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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

172
 173
 174

3.1 Agricultural Value of Trees

175 Across all focus groups there was a broad general stated interest for the establishment and
 176 management of trees within their farm/ranch systems for multiple ecosystem service values.
 177 Farmers and ranchers articulated the potential utilitarian benefits of planted trees within their
 178 existing agricultural systems largely in the context of utilizing trees to indirectly enhance
 179 existing cropping systems or as a way to directly expand profit potential through income
 180 diversification (e.g., selling biomass). Tree-related benefits centered upon potential crop yield
 181 benefits through the use of field windbreaks that bring about various effects such as improved
 182 microclimate for crops, better soil moisture conditions, and soil and plant protection from wind
 183 erosion. Other specific production benefits broadly described during focus groups included
 184 winter wind protection for livestock, as well as extended forage opportunities. One North Dakota
 185 farmer noted her knowledge regarding production benefits from establishing trees on the
 186 periphery of cornfields, stating: "...You have your spot right out from the tree row where your
 187 corn is going to be stunted and shorter, but the next two to three tree heights out your corn
 188 production is going to be at least double in that area... There is an increase over the whole field

189 just based on that forty to sixty feet out from the tree row, because of the moisture, the snow that
190 comes off of the trees... it's all that much moisture for the corn." A rancher in western South
191 Dakota also noted how trees serve to improve moisture conditions within his operation, stating:
192 "Everything that we've done, all the tree belts we've planted and everything, have all been to
193 conserve water [for crop use]... to catch snow."
194

195 Farmers and ranchers also noted non-crop environmental and cultural benefits (e.g., recreation,
196 wildlife) offered by trees, but largely in the context of prioritizing management activities. For
197 example, one Kansan rancher acknowledged a trade-off in enhancing wildlife habitat at the
198 expense of utilizing woodlands to overwinter his cattle, stating: "The previous landowner had
199 grazed his livestock [to where] there was no understory brush... I do a lot of bird watching and
200 it's got habitat that should be conducive to a lot of migratory species and they're just, they
201 weren't there. Wildlife enhancement was part of [my management priorities] and it has helped
202 substantially keeping livestock out of there... Most livestock producers would look at that and
203 say 'man, that is a great place to winter cattle'... but best usage? No, I don't think so."
204

205 Interestingly some farmers noted the value of trees in the landscape relative to their absence or
206 loss from the landscape (e.g., windbreak removal) due to the increase usage of reduced tillage or
207 no-till practices and concomitant perceptions that windbreaks are no longer needed. A farmer in
208 North Dakota illustrated this observation in the context of wind erosion, stating: "People say that
209 [North Dakota farmers] don't need trees [windbreaks] because we've minimum tilled, but the
210 reality is we still till a lot... [T]his winter was a hard one in North Dakota. The dirt in the
211 air...I've got pictures where you couldn't see a quarter mile and it wasn't from the snow, it was
212 from the dirt."
213

214 Despite the benefits noted, farmers and ranchers in all focus groups also discussed disamenities
215 associated with undesirable "nuisance" or "weed" trees. Participants discussed trees such as
216 Eastern red cedar (*Juniperus virginiana*) or Siberian elm (*Ulmus pumila*) that have a tendency in
217 this region to invade rangeland and grasslands thus requiring periodic and at times, costly
218 removal. Nevertheless, there was a clear distinction between volunteer trees (problem/weed
219 trees) and "good trees," which are planted or naturally occurring in a manner that offered desired
220 benefits to farmers and ranchers. As one Kansas rancher illustrated when noting the value of
221 many of the naturally occurring trees in his agricultural operation, stating: "I mean [Eastern red]
222 cedar is a big problem... We're constantly cutting cedar out. But in places [on the farm] you have
223 to have trees. It's just good farming practice."
224

225 *3.2 Trees and Biomass Management*

226

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

235 potential of growing weed trees in areas I don't farm, I mean elms, and these kinds of things.
236 But... it'd be three to four to five years before you'd get any return on your investment, which
237 isn't necessarily a bad thing." Similarly, a Kansas farmer commented on a possibility for those in
238 western Kansas who face ongoing issues with soil moisture and productivity as a result of
239 limited precipitation: "Now if you had a brushy biomass crop that you could grow with limited
240 water in poor soil, you could find enough ground out [west]. People would be interested in
241 growing something that they could sell." One farmer from South Dakota reflected his vision but
242 also concerns (that were echoed by other participants), stating: "I had envisioned something
243 more or less on the lines of... on these cropland acres, planting strips [of trees for harvest], and
244 then taking advantage of the hunting... and they give shade, you could [use trees] so they'd hold
245 snow too... keep some of that moisture there to get through them later-on months. I mean, I'd be
246 interested in something like that, but the management side of it would have to be absolutely
247 nailed down so that it didn't turn into these fast-spreading trees, and have a mess."
248

249 A few farmers did note that trees may also have specific advantages over other potential biomass
250 crops particularly in the context of protecting soils. For example a farmer from South Dakota
251 stated, "Even with switchgrass--you're pulling minerals out, and you're hauling them away, and
252 you're mining and you're not replacing [nutrients]." While a farmer from North Dakota offered,
253 "I would prefer to see trees harvested for biomass than people using wheat straw for biomass, or
254 even corn stover... because the trees would grow on a specific area over time. The corn stover,
255 you start taking that residue off the land and you've got less there to build future organic matter
256 for your soil. And, I mean, once it's gone, it's gone."
257

258 *3.3 Barriers and Facilitators to Woody Biomass Production*

259

260 Across all focus groups, when exploring the possibility of establishing a biomass crop (woody or
261 otherwise) various participants highlighted access to credit as a problem particularly relevant to
262 younger farmers with higher debt to asset ratios. The farmers and ranchers broadly discussed
263 how pursuing a new crop such as biomass is a risky venture even on marginal land and access to
264 capital or ways to hedge risk are needed. For instance, one farmer from Kansas illustrated how
265 his financial constraints have changed over time, positioning him to explore new markets
266 associated with woody biomass if he chose to: "When I purchased this property... I was
267 leveraged way more than I ever wanted to be leveraged on that, so it was a financial decision for
268 me. I had to earn cash but... the older you get the less leveraged you are. I own the property now;
269 I can do what I want. The bank doesn't tell me [what to do anymore]". Another farmer from
270 South Dakota echoed this concern with his personal experiences, describing difficulty receiving
271 a loan 15 years ago to begin his current conventional farming operation let alone pursuing
272 something new like woody biomass, noting his eventual participation in a program dedicated to
273 providing assistance to beginning farmers which he views as instrumental to his ability to get
274 into farming in the first place.

275
276 Prompted by these potential barriers associated with access to credit, focus group discussions in
277 all states turned to the use of alternative ways to defray financial risk and gain entry into new
278 land use ventures via policy tools such as United States Department of Agriculture (USDA)
279 subsidies or technical service programs that facilitate tree planting and/or biomass production.
280 There was broad participant familiarity with current USDA conservation programs (specifically,

281 the Conservation Reserve Program; CRP) that support tree planting and management. Several
282 participants noted benefits afforded by government conservation programs, including technical
283 assistance when engaging in a new opportunity such as establishing trees for biomass production,
284 and in supplemental financial incentives. A number of farmers shared positive experiences in
285 working with the USDA Natural Resource Conservation Service and/or other government
286 entities. One farmer/rancher queried the group on how to handle an ecologically sensitive area on
287 his property through the use of tree systems, and a rancher offered “I started working with the
288 Kansas [Forest Service] about six or eight years ago and they have helped me tremendously with
289 knowing what to do with things like that [e.g., CRP].”

290
291 Interestingly, it was mentioned by a number of participants that various incentive programs
292 might well encourage land use innovation in nuanced ways, thereby facilitating adoption of
293 woody biomass. A number of farmers/ ranchers in all states noted that a barrier to planting trees
294 (or any “alternative” crop) on even marginal land is the tendency for farmers to adhere to the
295 production status quo and perceived social norms within their agricultural community. For
296 example, a Nebraska farmer regarding his potential interest in establishing trees within his
297 agricultural system for biomass, stated: “One issue is your neighbors will say ‘well that’s crazy,
298 because the next guy’s gotta come along and put a lot of dozer work into pushing it all out so that
299 he can put corn in there,’ which is the assumption is that it will all go back to corn. ...It’s kinda
300 hard psychologically to get yourself to go in and start planting trees on ground that you used to
301 farm”. Yet a few farmers with experience with USDA programs stated that this type of social
302 constraint could be mitigated by the personalized, farm-specific technical advice that many
303 governmental programs offer along with financial incentives toward new land use opportunities.
304 Farmers noted that benefits of this interaction involve a higher degree of informed decision
305 capacity and increased confidence in the innovation. In regards to the USDA Conservation
306 Stewardship Program, a farmer from South Dakota offered his experience, “. . .you get some
307 [farm specific] support, it helps you open your mind to try something new rather than doing it the
308 same old way that we’ve always done it.”

309
310 Overall however, farmers and ranchers expressed general hesitancy to participate in government
311 programs. Some of the reluctance was tied to a general aversion to government financial
312 assistance of any kind. Reasons cited ranged from individual objections such as general mistrust
313 of the government, the typical quantity of paperwork involved and other “red tape” associated
314 with state and federal government programs. Nevertheless there was a broad assumption that if
315 there was going to be an increase in tree planting within the NGP, working with government
316 programs will likely be required on some level because participants in all focus groups expressed
317 significant lack of knowledge regarding trees in general and information about woody biomass
318 systems specifically. Information needs noted by participants relevant to woody biomass
319 production include specifics centering upon tree planting guidelines and requirements such as
320 appropriate species, the total amount of land needed to have a viable operation, harvest methods
321 and equipment needs, availability of custom growers/harvesters, and information on typical post-
322 harvest land management for sustainable production or to convert the land to an alternative use.

323
324 A small number of farmers did mention the USDA Biomass Crop Assistance Program (BCAP)
325 which contractually connects biomass producers with an end user (energy producer) and
326 provides technical advice, cost share funding and subsidized biomass prices to biomass

327 producers, A farmer from Kansas offered: “[The] Biomass Crop Assistance Program... has a lot
328 more flexibility. It has a five- year contract instead of a ten- or fifteen-year contract [like with
329 CRP], it pays for establishment of [biomass], so there’s a lot of funding that has been available
330 but people aren’t aware of it. Now it doesn’t pay as much as corn when corn’s seven or eight
331 dollars a bushel...” Nevertheless, it was recognized among a number of participants that a
332 program such as BCAP would be needed to bridge the likely time involved in investing in trees
333 (it should be noted that the vast majority of focus group participants in all states had not heard of
334 BCAP). The lack of quick or the periodic nature of profit resulting from a biomass crop
335 compared to annual cropping systems was broadly noted in all focus groups as a barrier that
336 would likely need to be addressed either through subsidies or an otherwise well-developed
337 market.
338

339 Many of the participants expressed preferences for the existence of local, sustainable,
340 independent markets to a subsidized market (such as that offered by a program such as BCAP),
341 yet there was an broad belief that start-up subsidies would likely be required to support emerging
342 energy markets. As one Nebraska farmer stated: “If an industry can stand on its own, it's a viable
343 industry. And, maybe it's okay to subsidize something for a little while...to get it on its feet [like
344 grain ethanol]. But then at some point, corn ethanol has to make or break it on its own, and that's
345 kind of how I feel about anything”. When considering whether or not trees would make for a
346 competitive cropping system, one Kansas farmer offered her perspective general to agricultural
347 producers in her state: “I think overall our agricultural producers are into what the rest of our
348 society is; which is instant gratification and there’s no instant gratification with trees.” Outside of
349 government subsidy start-up programs, however, there were focus group wide concerns about the
350 sustainability and regional nature of any biomass based bioenergy market. Broad concern about
351 market sustainability was succinctly summarized by a North Dakota farmer who offered: “To me
352 that would be the biggest mental hurdle if you’re looking at it as dollars and cents: Will
353 [markets] actually be here in fifteen years, or am I going to hire a bulldozer to take [the trees]
354 out?” Relatedly, numerous farmers and ranchers noted how important local physical markets
355 were in their region, a sentiment captured by one South Dakota rancher who acknowledged a
356 strong preference for local processors for woody biomass, offering, “if there's not a functioning
357 facility somewhere reasonably close by for you to take [harvested trees] to, then that's going to
358 make a whole lot of difference.”
359

360 Beyond market and production questions, a number of farmers and ranchers had fundamental
361 biological questions. Participants within the South Dakota and Kansas focus groups specifically
362 noted the biophysical challenge of growing trees within the western portion of their states as a
363 major barrier to utilizing trees for biomass or any other purpose within their farm/ranch system.
364 Within our focus group in eastern Kansas, for example, farmers and ranchers discussed general
365 challenges for tree growth in the state due to limited rainfall and the widespread need for
366 intensive irrigation in many agricultural activities. Within our groups in central and western
367 South Dakota, while not a universal concern, a number of farmers and ranchers noted
368 biophysical limitations as their primary hesitancy in interest as a woody biomass producer when
369 considering that opportunity. One western South Dakota rancher stated bluntly: “If you can find
370 a tree that'll grow in my county, that'll get whatever height it needs to get in a reasonable time,
371 then [I would look at growing trees]. Right now, I don't know what that tree is.”
372

373 4. Discussion

374

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

393

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

414

415 A few of our focus group farmers questioned the biophysical capacity to grow trees in certain
416 locations in the NGP. Throughout the NGP region however, there is strong bio-physical potential
417 for woody biomass production, though yields will vary considerably across suitable species due
418 to regional differences in precipitation (timing and quantity) as well as length of periods between

419 precipitation events and number of frost-free days in spring [40]. Nevertheless, woody biomass
420 trials in the Central Great Plains suggest high potential biomass tonnage across a variety of
421 hardwood species [e.g., 41,42]. Work is currently underway to explore an expanded role for
422 eastern red cedar, one of the “weed trees” specifically mentioned by a number of our focus group
423 participants [43].

424
425 A few of our focus group participants offered that trees may have certain resource management
426 advantages over other biomass feedstocks in certain situations, a finding that is consistent with
427 other farmer-based studies. Relative to collection of crop residues for bioenergy purposes,
428 farmers have expressed that strong concerns regarding the loss of nutrients and increased soil
429 erosion decrease their interest in marketing residue [22,23,44]. Trees on the other hand are well
430 known for their ability to protect soil fertility and provide erosion control [45]. Additionally,
431 woody biomass systems may also have relative feedstock advantages over herbaceous biomass
432 or crop residue in terms of versatility as a feedstock, storage capacity, and feedstock logistics.
433 For example, woody materials have very high energy output:input ratios, trees can be stored “on
434 the stump” or at field edges more easily than herbaceous materials, and harvests can be
435 scheduled easily [39]. Advantages such as these may well be important relative to potential
436 landowner interest in woody biomass as a commodity because of the typical periodic nature of
437 harvests; this periodicity being an distinct issue for some of our focus group participants (e.g.,
438 “...there’s no instant gratification with trees”), though at least a few farmers were unconcerned
439 (e.g., “...it'd be three to four to five years before you'd get any return on your investment, which
440 isn't necessarily a bad thing”).

441
442 Another pervasive constraint present in the focus group discussions was financial uncertainty
443 relative to getting started at the farm-scale but also in terms of market sustainability. This
444 constraint was partially nested within a recurrent focus on participant concerns of a viable local
445 market for woody biomass developing within their region. Both findings being consistent with
446 previous explorations of emergent bioenergy supplier opportunities [29,36, 44, 46]. Our focus
447 group participants also echoed findings in previous research noting struggles with access to
448 capital and various requirements from lending institutions relative to farm-level investing in tree
449 based land use in agricultural regions [47, 48]. There were also distinct questions and concerns
450 among our focus group participants about investing in an emerging market that may be
451 dependent upon subsidies. Previous research exploring policy options is consistent with the
452 broad preference among farmers and ranchers in our study for participating in free markets over
453 engaging with governmental entities for subsidies due to concerns about the ability of markets to
454 mature on their own or always being dependent upon extra-market support as well as potentially
455 constraining contractual requirements [34, 49,50].

456
457 The NGP region does have demonstrated experience with farmer participation in a biomass
458 incentive program, as two areas of Kansas participate in the Biomass Crop Assistance Program
459 (BCAP). BCAP is a federal financial incentive policy tool providing subsidies to participating
460 landowners and biomass processing facilities to address regional supply issues posed by
461 developing markets for cellulosic biomass [51]. Additionally, the NGP has existing policy
462 structure encouraging the increasing utilization of renewables for electricity production from
463 sources such as wind, solar, and biomass. As part of their Renewable Fuels Portfolios (RFP),
464 Kansas set a legally binding Renewable Fuels Standard to have 20% of electricity production

465 from renewable resources by 2020, the Dakota states each set a more flexible goal of 10% by
466 2015, while Nebraska has not set formal targets [6]. North Dakota has already surpassed their
467 original target, with 16.7% of retail electricity from renewable energy sources [52]. Kansas is
468 about three-quarters of the way to meeting their renewables standard [53], while South Dakota is
469 about halfway to meeting their voluntary targets [54]. U.S. state rankings on policy-readiness for
470 woody biomass utilization position North Dakota as a state with a relatively developed policy
471 structure (ranked 13th) [55]. Rankings for the rest of the NGP (Kansas, 25th; South Dakota, 31st;
472 and Nebraska, 41st) suggest a need for further development of financial incentives (tax
473 incentives, subsidies and grants, financing and contracting) and non-financial incentives (rules
474 and regulations, education and consultation) to better facilitate not just the establishment and
475 utilization of woody biomass but to foster robust markets that feature long-term private
476 investment and infrastructure development [55]. Although biomass utilization policy structures
477 and tools are available regionally, whether or not farmers and ranchers will participate in those
478 depends on how they evaluate both a given policy tool, as well as woody biomass production
479 generally.

480
481

482 **5. Conclusion**

483

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

499

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505 **Author Contributions**

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507 Analysis, A.M.H., J.C.T.; Resources, J.C.T.; Writing-Original Draft Preparation, A.M.H., J.C.T.;
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510

511 **Conflicts of Interest**

512 The authors declare no conflict of interest.

513

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