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# Current Prospects for Bioenergy Crop Production on Marginal Lands: Results from a Farm Survey in Southwestern Wisconsin

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# Current Prospects for Bioenergy Crop Production on Marginal Lands: Results from a Farm Survey in Southwestern Wisconsin

***Summary*****:** This report describes initial findings from the 2011 Bioenergy Crop Production Study, a mail survey of active farmers in southwestern Wisconsin. Overall, the near-term prospects for widespread bioenergy crop production appear limited, primarily due to on-going commitments that these farms have to their integrated crop and livestock enterprises. However, spatial agglomerations or 'hotspots' of bioenergy crop production, and the lower logistical biomass collection costs that come with it, may arise in locations where attitudes towards bioenergy policy and environmental stewardship are favorable.

## Introduction

Energy consumption in the United States is expected to increase into the foreseeable future, yet concerns about the sustainability of this path lie at the center of the energy debate today. Among the more prominent of these concerns are a perceived over-reliance on foreign energy sources and the harmful imprint of fossil fuels on the environment.

Our ability to meet this demand, and to do so sustainably, will depend in large part on the development of alternative energy sources. For example, natural gas, wind and solar power, and plant-based biomass sources, among others, are expected to provide for a growing share of our energy needs in coming decades.

Policy measures and research initiatives are currently underway with the hope that bioenergy crops grown on marginal lands might soon become important to the nation's agricultural and energy sectors (Box 1). However, markets for these crops are not yet well developed and farmer interest in growing them is not well understood. Among the benefits of bioenergy cropping on marginal land is alleviation of "food vs. fuels" concerns which have led to strong objections over bioenergy production on better land.

To address this gap, we assessed farmer willingness to grow three bioenergy crops—corn stover, switchgrass, and hybrid poplar—in southwestern Wisconsin, an area with rich agricultural resources and abundant marginal lands. In doing so, we sought to answer some basic questions about the near-term potential for sustainable bioenergy development in the region:

- What types of farm operations are most likely to grow bioenergy crops?
- Which bioenergy crops are they most interested in growing?
- Where in the farm landscape are bioenergy crops most likely to be planted?
- What demographic, environmental and social factors might enable or constrain these outcomes?

**Box 1. What do we mean by '*bioenergy crop*'?**

We use the term *bioenergy crop* to refer to plant residues, perennial grasses and short-rotation trees that serve as raw material or 'biomass' for the bioenergy sector. In most cases, this biomass would be combusted for heat and electricity generation or converted to a transportation fuel.

In this sense, we treat the term as synonymous with *biomass crop*, *cellulosic energy crop*, *second-generation biofuel crop*, and other similar terms. Note that this definition excludes corn grain for ethanol and oilseeds for biodiesel because they are grain- rather than biomass-based.

The findings reported here serve as an initial overview of these questions. Additional research that digs deeper into this survey data is currently underway, yet the take-home message is clear: widespread adoption of bioenergy crops in southwestern Wisconsin is unlikely in the near-term, given the current commitment of most farmers to activities that support their own and surrounding integrated crop-livestock operations and the relatively high returns associated with them.

## A Focus on Southwestern Wisconsin

Southwestern Wisconsin boasts some of the most abundant and biophysically diverse cultivable land in the state. Located along the northern edge of the Corn Belt, principal cropping activities in the region include corn, soybeans, small grains, alfalfa, hay and other forages. Integrated crop-animal operations cover the landscape, with dairy and beef cattle being the most important types of livestock raised. Cultural practices also vary widely, with many growers implementing long-term cropping rotations and reduced or no tillage rather than conventional tillage.

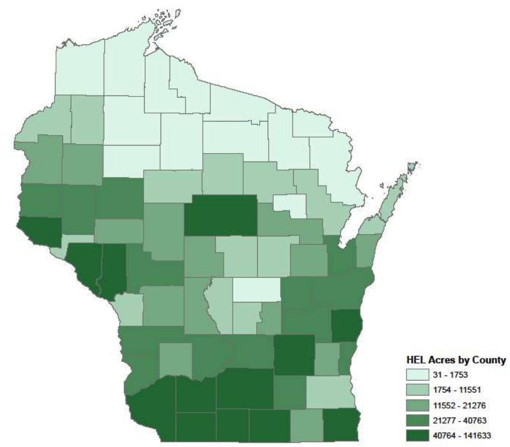
While much of the area's land is highly fertile, a significant proportion is considered *marginal* for agricultural production purposes. For instance, there are more farms and cropland area enrolled in the Conservation Reserve Program (CRP) in southwestern Wisconsin than any other part of the state. That much of the region lies in the un-glaciated Driftless Area helps to explain the juxtaposition of rich agricultural soils with rolling hills, winding ridges, steeply sloped ravines, and sandstone bluffs.

A recent University of Wisconsin study of the seventeen-county Driftless Area indicates that this region contains nearly 1.5 million acres of marginal land suitable for bioenergy crop production[1]. This includes approximately 1 million acres of marginal cropland (i.e., land currently under cultivation but classified as highly erodible) and 500 thousand acres of marginal non-cropland (i.e., potentially cultivable open land such as pasture, CRP and shrub land). As shown in Figure 1, these marginal lands are primarily concentrated in the southern and western halves of the state, respectively.

From a policy perspective, this overlap in agricultural production potential and marginal land availability make southwestern Wisconsin an attractive location for bioenergy development. For instance, the sale of crop residues from existing cropland may increase producer returns to conventional production and at the same time reduce competition for grain between the food and energy sectors. Similarly, perennial grasses and short-rotation trees planted in open areas or on less productive cropland offer an economic alternative where yields and returns are low and would similarly reduce competition for prime land between the two sectors.

Bioenergy crops may also offer greater environmental benefits as compared to conventional crops. For example, the cultivation of perennial grasses and trees requires minimal tillage and chemical applications as compared to row crops. In addition they can enrich wildlife and pollinator habitat and improve nearby water quality. These possible benefits suggest that bioenergy crop production on a larger scale may enhance aesthetic landscapes and recreational opportunities (e.g., hunting, fishing, nature walks). Insofar as marginal lands are also most environmentally-sensitive, bioenergy crop production could be viewed as win-win for producers and society.

**(a) Marginal Cropland**




**b) Marginal Non-Cropland**

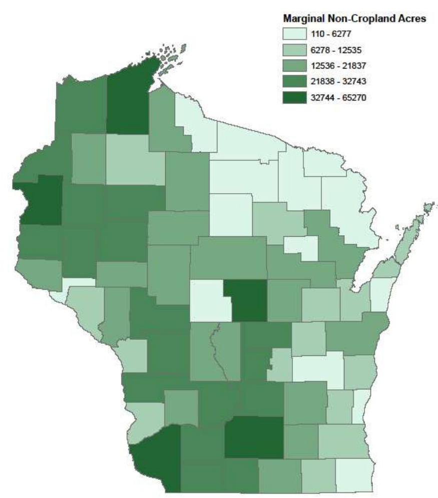



**Figure 1. Distribution of Cultivable Marginal Cropland and Non-Cropland in Wisconsin**

However, farmer acceptance and adoption of these bioenergy crops in this region is uncertain. Many farms such as dairies have large investments and other on-going commitments to competing activities. They also might not view bioenergy development in a positive light. Conversely, they could view bioenergy crops as complementary to what they currently do, or see it as a major step toward meeting the challenges of energy independence or environmental sustainability. We have been exploring what they think through mail surveys and present our initial findings below.

[1] S. Ventura and C. Garcia. "Bioenergy Cropland Data Layer," unpublished dataset. Land Information and Computer Graphics, University of Wisconsin, Madison, WI.

## Methods

In spring 2011, a research team in the College of Agricultural and Life Sciences at the University of Wisconsin-Madison conducted a mail survey of 1,543 farm landowners in Iowa, La Crosse, Richland and Sauk counties. This section describes the survey and sample selection process.

### *Study Survey*

The questionnaire had five sections: current land use, willingness to grow a bioenergy crop, bioenergy knowledge and attitudes, farm management practices, and socio-economic characteristics. The willingness to grow section asked respondents to consider a hypothetical market scenario for corn stover, switchgrass and hybrid poplar (Box 2), and to report whether they would reallocate any cultivatable land from its current use to a bioenergy cropping system[2].

A challenge in conducting this study is that markets for bioenergy crops do not exist, nor have they in the past. To overcome this, we adapted the well-developed contingent valuation (CV) approach to a pre-market assessment of agricultural production technology adoption (Box 3). The three crops selected each represent a broader group of related technologies: annual crop residues for corn stover, perennial grasses for switchgrass, and short-rotation trees for hybrid poplar. These crops are well-suited to the area of study, are likely to be among the first commercialized should bioenergy markets develop, and have sustainable production guidelines in place[3].

All respondents received identical questionnaires with the exception of the biomass purchase price offered. In total, three versions were mailed each with a different price range:

- *Low version*:
  Corn stover, \$20–\$45/dry ton
  Switchgrass, \$35–\$60/dry ton
  Hybrid poplar, \$35–\$60/green ton
- *Middle version*:
  Corn stover, \$50–\$75/dry ton
  Switchgrass, \$65–\$90/dry ton
  Hybrid poplar, \$65–\$90/green ton
- *High version*:
  Corn stover, \$80–\$105/dry ton
  Switchgrass, \$95–\$120/dry ton
  Hybrid poplar, \$95–\$120/dry ton

Low version prices were determined by reviewing existing literature on production costs (e.g., extension crop budgets, academic studies), and then setting the lowest price just under the average cost of production. High version prices were based on input from knowledgeable professionals in the field, at prices slightly above what a bioenergy conversion facility could pay and still break even relative to sourcing from other fuels (e.g., coal or natural gas).

The questionnaire provided basic descriptions of each crop, including agronomic information such as yield and management practices, expected environ-mental outcomes, and a photograph. This

**Box 2. Bioenergy Crop Descriptions**

*Corn stover* is the term given to non-grain parts of the corn plant (e.g., stalk, leaf, husk, and cob). When left in the field, stover helps maintain soil fertility by contributing organic matter and other nutrients. It also protects against wind and water erosion. To maintain soil fertility and guard against erosion, state guidelines typically recommend no more than 25–35% of total available stover (by mass) be removed. At these removal rates, an acre of land producing 150 bushels of corn grain could be expected to yield 1 dry ton of corn stover.

*Switchgrass* is a native warm-season grass that reaches 4-5 feet in height. As a perennial, there is no need to replant each year resulting in reduced soil erosion, nutrient runoff, and carbon emissions. It also can be managed to provide habitat for grassland birds, small mammals and beneficial insects. Fertilizer and pesticide recommendations are generally around 20 to 25% of that required for annual row crops. Annual yields for a mature stand range from 3–5 dry tons, a conservative average across local soil types.

*Hybrid poplars* are fast-growing trees closely related to cottonwoods and aspens. They are managed using techniques more similar to crop production than to traditional forest management practices. Poplar plantations also do not require annual tillage, resulting in reduced soil erosion, nutrient runoff and carbon emissions. However, a field of poplar will generally offer less habitat and biodiversity than switchgrass. When grown under short-rotation culture, stands can produce between 3 and 5 green tons of wood per acre per year, depending on soil productivity.

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[2] A copy of the questionnaire is included in the supplementary information file, available online at: http://aae.wisc.edu/sps

[3] Wisconsin Bioenergy Council. 2011. Wisconsin Sustainable Planting and Harvest Guidelines for Nonforest Biomass. Online at: http://datcp.wi.gov/about/boards_and_councils/bioenergy_council/

information allowed respondents to form an expectation of net returns and associated environmental benefits/costs for each crop to use when weighing each bioenergy option against their current portfolio of land uses. To provide a reference for the opportunity cost of land, respondents were asked to make their land allocation decision based on a corn grain price of $5.20 per bushel. This is well below recent prices, which means the results shown are probably higher than they would be when corn is around $7 per bushel.

Respondents indicated their willingness to grow the crops by agreeing to "enroll" in a market program. They could enroll in as few or as many of programs as they wished, or none at all. Once enrolled, respondents indicated where in their farm landscape they would plant the crop. The options given were[4]:

- Land in a short-term grain rotation (e.g., corn-soybean-corn-soybean)
- Land in a long-term forage rotation (e.g., corn, corn, small grain/alfalfa, alfalfa, alfalfa, alfalfa)
- Land enrolled in the CRP
- Land in permanent pasture
- Land that is cultivable but not currently cropped (e.g., unfarmed open space)
- Land that would be newly rented in

### *Study Sample*

Farm selection was conducted by the Wisconsin Agricultural Statistics Service (WASS) branch of the Wisconsin Department of Agriculture, Trade and Consumer Protection, and consisted of two steps. First, a subset of townships within each county was selected based on the relative abundance of marginal cropland and marginal non-crop land, and proximity to transportation corridors. This step relied on a geographic information system (GIS) and data layers from the USDA-NRCS soil survey (SSURGO) and from the USDA-NASS Cropland Data Layer.

Second, individual farms within these townships were selected using one of two sampling procedures. First, all farms enrolled in the CRP as of 2007 were automatically included in the study. Second, an additional set of farms were drawn at random from those remaining. The final sample comprised a total of 1,543 farm households, including 448 farms in Iowa County, 249 farms in La Crosse County, 397 farms in Sauk County, and 449 farms in Richland County.

[4] The category *unfarmed open space* included shrubland, fallow pasture, and non-CRP easements. For hybrid poplar, respondents were also asked to consider converting woodland acres.

**Box 3. The Contingent Valuation Method**

Contingent valuation (CV) is a standard approach used by environmental and natural resource economists to determine the economic value of non-market goods and services such as outdoor recreation, habitat or water quality. CV studies work by asking respondents to state whether or not they would agree to undertake a hypothetical action based on specific economic consequences.

A distinct advantage in our study is that most area producers grow grain and forage crops. Thus, they have highly relevant previous experience on which to base their land allocation decision when considering the hypothetical bioenergy crop alternatives such as corn stover and switchgrass.

Questionnaires were mailed in April 2011, with a reminder post card and two follow-up mailings conducted in May and June of the same year. Slightly over half of those contacted (n = 783) returned their questionnaire. Among the returns, a large share were unusable due to a change in farming status from active to inactive (n = 260), non-eligibility of the farm due to the type of farming activity pursued (n = 98), or because the respondent declined to participate (n = 121). Perhaps the chief reason for the large number of inactive responses is the amount of time that elapsed between compilation of the WASS mailing list (in 2007) and the time of this survey mailing (in 2011)[5].

This report summarizes data from 304 returned and completed questionnaires by active farm landowners. Note that because the number of CRP landowners in the sample is disproportionate to their population share, we weight the sample observations so as to present results that approximate the characteristics of all farms in the townships surveyed.

## Results

This section describes the farms responding to the survey and begins to answer the four main questions outlined in the Introduction.

### *Farm Types and Characteristics*

The farms responding to the questionnaire exemplify the diversity of crop and animal operations found in southwestern Wisconsin. To permit comparisons

[5] See Appendix A of the supplementary information file for a detailed summary of the survey mailing and returns, available online at: http://aae.wisc.edu/sps.

among them in the discussion that follows we define the following five farm types:

- *Crop farms* – Farms that grow grain or forage crops and do not raise livestock.
- *Dairy farms* – Farms that raise dairy cattle or breeding stock in combination with crop production or other livestock activities.
- *Livestock farms* – Farms that raise non-dairy livestock in combination with crop production. Here, we further distinguish by size:
    - *Small* – Livestock farms operating less than 80 acres of cropland and pasture.
    - *Large* – Livestock farms operating 80 or more acres of cropland and pasture.
- *Other/inactive* – Farms that rent out all farm acres or those with all farm acres in the CRP.

Table 1 summarizes major characteristics of these respondents, as organized by farm type. Livestock farms form the majority of the sample (52%) followed by crop farms (21%) and dairy farms (18%). The set of inactive farms represented only a fraction (9%) of those responding. Dairy farms and large livestock farms are the largest both in terms of average farm size and cropland area operated. Also of note is that dairy farms and large livestock farms are the most active in renting in acres of additional farmland. Inactive and crop farms are the most active

Table 1. Snapshot of farms responding to the 2011 Bioenergy Crop Production Survey

| | Farm type[a] | | | | | |
|---|---|---|---|---|---|---|
| | Crop | Dairy | Small livestock | Large livestock | Other | All |
| Number of survey respondents | 58 | 64 | 62 | 96 | 24 | 304 |
| Representative farm population | 527 | 452 | 513 | 806 | 250 | 2,548 |
| Share of farm population | 21% | 18% | 20% | 32% | 9% | 100% |
| Farm size (acres) | 181 | 327 | 80 | 246 | 159 | 205 |
| Cropland area (acres) | 79 | 186 | 21 | 117 | 63 | 97 |
| Pasture area (acres) | 30 | 57 | 17 | 54 | 20 | 39 |
| Woodland area (acres) | 41 | 45 | 26 | 47 | 24 | 39 |
| Unfarmed openspace (acres) | 6 | 3 | 4 | 4 | 3 | 4 |
| Other (acres) | 10 | 31 | 5 | 16 | 18 | 15 |
| Cropland characteristics: | | | | | | |
| Area operated (acres) | 111 | 260 | 8 | 141 | 0 | 116 |
| Rents in cropland (percent of farms) | 28% | 64% | 0% | 33% | 0% | 28% |
| Avg. area rented in (acres) | 197 | 150 | 0 | 141 | 0 | 156 |
| Rents out cropland (percent of farms) | 17% | 10% | 16% | 14% | 44% | 17% |
| Avg. area rented out (acres) | 44 | 189 | 23 | 78 | 67 | 70 |
| Enrolled in CRP[b] (percent of farms) | 25% | 10% | 18% | 21% | 62% | 23% |
| Avg. area in CRP (acres) | 58 | 53 | 36 | 43 | 49 | 48 |
| Pasture characteristics: | | | | | | |
| Area operated (acres) | 29 | 72 | 12 | 63 | 0 | 41 |
| Rents in pasture (percent of farms) | 0% | 28% | 2% | 15% | 0% | 10% |
| Avg. area rented in (acres) | 0 | 85 | 10 | 64 | 0 | 72 |
| Rents out pasture (percent of farms) | 2% | 5% | 5% | 2% | 49% | 8% |
| Avg. area rented out (acres) | 27 | 200 | 17 | 60 | 36 | 55 |
| Crop production (proportion of farms): | | | | | | |
| Grows grain or forage crops[c] | 100% | 99% | 67% | 97% | n.a. | 82% |
| Grows corn | 79% | 97% | 26% | 81% | n.a. | 65% |
| Grows forage | 61% | 95% | 64% | 95% | n.a. | 72% |
| Grows soybeans | 55% | 32% | 8% | 49% | n.a. | 34% |
| Grows small grains | 22% | 59% | 17% | 26% | n.a. | 27% |
| Livestock (proportion of farms): | | | | | | |
| Raise livestock | n.a. | 100% | 100% | 100% | n.a. | 69% |
| Raise dairy cattle | n.a. | 100% | n.a. | n.a. | n.a. | 18% |
| Avg. herd size (head) | n.a. | 154 | n.a. | n.a. | n.a. | 154 |
| Raise beef cattle | n.a. | 31% | 69% | 90% | n.a. | 48% |
| Avg. herd size (head) | n.a. | 40 | 9 | 42 | n.a. | 32 |
| Raise other livestock[d] | n.a. | 16% | 59% | 29% | n.a. | 24% |

a/ See text for farm type definitions.
b/ CRP = Conservation Reserve Program (CRP).
c/ n.a. = Not applicable.
d/ Includes horses, pigs, sheep, goats and llamas.

Table 2. Characteristics of cultivated cropland

| | Farm type | | | | All[a] |
|---|---|---|---|---|---|
| | Crop | Dairy | Small livestock | Large livestock | |
| Representative farm population | 527 | 452 | 513 | 806 | 2,298 |
| Representative cropland area (acres operated) | 58,497 | 117,520 | 4,104 | 113,646 | 295,568 |
| Primary crop rotation (share of cultivated acres) | | | | | |
| Short-term grain rotation[b] | 79% | 28% | 3% | 35% | 41% |
| Short-term grain & forage rotation | 4% | 14% | 8% | 29% | 18% |
| Long-term grain & forage rotation | 2% | 3% | 32% | 4% | 4% |
| Long-term forage rotation | 15% | 55% | 56% | 31% | 38% |
| Total: | 100% | 100% | 100% | 100% | 100% |
| Primary tillage practice (share of cultivated area): | | | | | |
| Conventional tillage | 37% | 49% | 54% | 27% | 41% |
| Reduced or no tillage | 63% | 51% | 46% | 73% | 59% |
| Total: | 100% | 100% | 100% | 100% | 100% |
| Physical characteristics of cultivated area: | | | | | |
| Has steep slopes (proportion of farms)[c] | 51% | 57% | 21% | 51% | 46% |
| Avg. sloped area (acres) | 19 | 73 | 6 | 50 | 46 |
| Has marginal soils (proportion of farms)[d] | 70% | 80% | 24% | 76% | 64% |
| Avg. marginal soil area (acres) | 34 | 142 | 11 | 53 | 73 |

a/ Includes all respondents except those in the "other" farm type category from Table 1.
b/ Short-term rotations last four years or less; long-term rotations last five years or more.
c/ Defined as cropland with a slope of 6% or higher (i.e., slope class 'C' from a soil survey map).
d/ Defined as having poor drainage, seasonal flooding, excessive stoniness, shallow bedrock or shallow water table.

in renting out acres and also have the highest rates of enrollment in the CRP[6].

Table 2 summarizes characteristics of cultivated cropland. Both the profile of primary cropping rotations and primary tillage practices varies substantially across farm types. Cultivated cropland on crop farms is heavily concentrated in short-term grain rotations. By contrast, small livestock farms utilize primarily long-term grain and forage rotations. Note that despite having relatively more land in short-term grain rotations, the majority of cultivated cropland on crop farms is sown using reduced or no tillage practices. Dairy farms and large livestock farms, which best represent the integrated crop-animal operations in the area, have land allocated more evenly across the different crop rotations considered. In terms of slope and marginal soil characteristics of cultivated cropland, dairy farms and large livestock farms appear relatively distinct from the other farm types. These integrated operations also have larger proportions of sloped acres.

## *Willingness to Grow a Bioenergy Crop*

We first explore the basic questions, "What types of farm operations are most likely to grow bioenergy crops?" and "Which crops are they most interested in growing?" While many factors are expected to influence this decision, price is expected to be among the more important. In this section, we assess the price responsiveness of the different farm types to each of the three bioenergy crops. Then, in later sections, we turn our attention to additional factors that may also influence farmers' bioenergy adoption decisions.

Figure 2 illustrates farmer willingness to grow corn stover, switchgrass, and hybrid poplar for a range of biomass prices[7]. The curved lines in these figures provide a simple measure of the price responsiveness of each farm type to market opportunities for the three crops. As expected, the overall share of farms willing-to-grow each bioenergy crop (vertical axis) increases as the biomass price offered (horizontal axis) increases. This general observation holds across all farm types and crops, yet closer inspection of the figure yields a number of additional insights into the expected behavior of farm landowners with respect to bioenergy crop adoption.

First, even at the highest biomass prices considered, the overall share of farms interested in growing a bioenergy crop is estimated to be below 30%. Again, this holds across farm types and bioenergy crops Thus, one possible outcome of

[6] The group of "inactive" farms lie outside the scope of the current study, but are included in Table 1 because they completed the survey. A companion survey of inactive farmers and non-farm rural landowners was conducted in Spring 2012.

[7] See Appendix B of the supplementary information file for the statistical estimation results used to construct Figure 2, available at: http://aae.wisc.edu/sps.

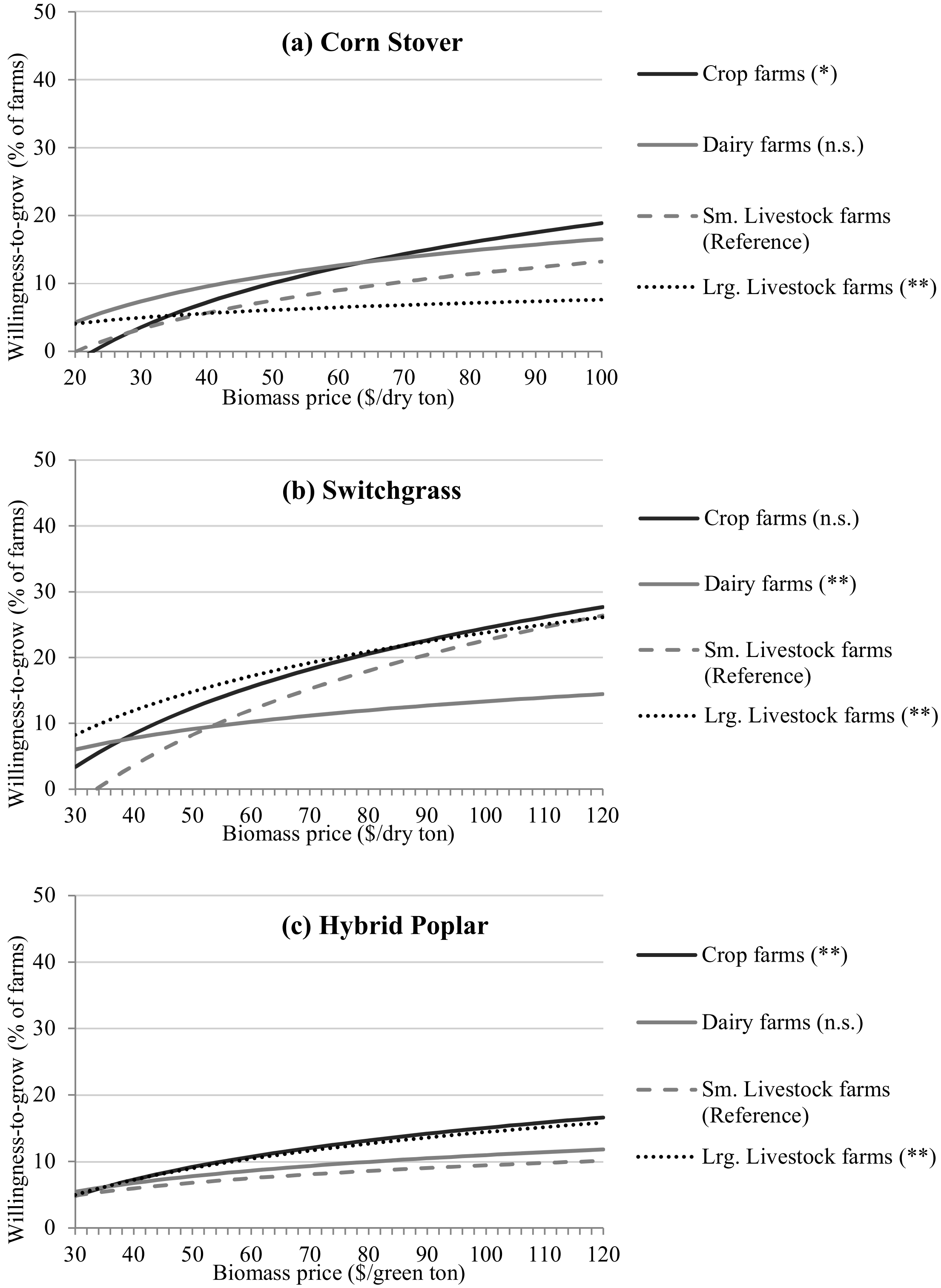


**Figure 2. Farmer willingness-to-grow corn stover, switchgrass, and hybrid poplar for bioenergy.** (*Note*: The above figures show within-sample estimates only. Symbols in parentheses indicate the statistical significance of the differential slope parameters by farm type using small livestock farms as the reference group; ** = significant at 1%; * = significant at 5*; n.s. = no significant difference).

bioenergy markets is for related crop production to occur only on small pockets of land, which may be widely dispersed over a large geographic area. Yet, the economic feasibility of locating a bioenergy facility in a particular area will depend critically on the availability of a stable supply of biomass that can be aggregated at low cost for conversion to energy. The collection costs of harvesting, bundling, and transporting loose and non-dense energy products will be very high for widely dispersed small biomass production areas.

Second, despite the apparent low overall interest across the respondents, there exists significant variability in terms of the price at which farms first enter bioenergy markets. Most strikingly, we find that some farms are willing-to-grow sustainable bioenergy crops even at very low prices. In particular we observe large livestock farms and dairy farms among the first to enter the market for all three crops.

One possible explanation is that these larger farms are more likely to have a parcel of land not currently devoted to their integrated operation. Another possibility is that these farms value the environmental outcomes of bioenergy crop adoption and are willing to tradeoff some economic gain for compensation in other areas such as improved soil or water quality, or enhanced wildlife habitat or recreational opportunities. For that reason, they may be willing to experiment with the new crop on a less important parcel. Also, these crops do not require specialized equipment and may be incorporated into the integrated operation (e.g., as forage or bedding) if bioenergy markets don't materialize which limits some of the risk that farms may face.

Third, variability is observed in terms of the overall price responsiveness. Dairy and large livestock farms are less responsive to price increases (i.e., the curved lines are flatter) as compared to crop farms and small livestock farms. This suggests that while these operators may have a low opportunity cost for a specific parcel of land, they are constrained in terms of the total area that they may allocate to bioenergy crops due to conflicts with on-going land uses that support the integrated operation.

By contrast, crop farms and small livestock farms appear better able to respond to higher prices, as evidenced by the increased price responsiveness (i.e., the curved lines are steeper) for these farm types. We surmise that these farm types are less likely to encounter land use conflicts because their crop-forage production is sold on the cash market and is not a critical input to livestock feeding or the manure management needs on-farm. They may therefore have more flexibility to switch to a new and potentially more profitable activity.

These later observations offer hope in light of the concerns raised earlier about the potentially negative impacts of a highly dispersed production process. In this case, finding that integrated farm operations tend to be less price-responsive than cropping and related operations suggests that it may be possible to find particular regions or clusters of farms (i.e, pockets of crop farmers) where the introduction of bioenergy crops may indeed be feasible and serve as a potential hot spot for the siting of a bioenergy facility.

## *Land Use Change*

Next, we turn attention to the question, "Where within the farm is land use change likely to occur?" The survey data permit an analysis of likely land use changes that would follow the introduction of biomass markets. In table 3, we compare current land use among farmers in the sample (the first three columns) with their projected land use changes to corn stover, switchgrass, and hybrid poplar. These responses are based on respondents' willingness to grow decisions and the acres they identified to be converted.

First, note that in terms of current land use on these farms about two-thirds of the land is currently cultivated cropland with about three-fourths of the remaining land in permanent pasture. Overall, more than 90% of the respondents' land is currently in crop or pasture. A liberal estimate for the amount of land that respondents would be willing to place into biomass crops is provided on the bottom row of Table 3. Of the nearly 58,000 total cultivable acres in the sample, respondents stated they would convert 5.7% (3,280 acres) to corn stover, 4.7% (2,506 acres) to switchgrass, and less than 1% (477 acres) to hybrid poplar, respectively. Combined, this is about 6,300 acres of land (assuming no overlap between the acres allotted), which is a bit under 11% of the total acreage in our sample. With some degree of overlap, it is safe to say that respondents were willing to offer about 10% of the lands they operate to biomass cultivation at going prices, with half of this total coming from the use of corn stover (as a by-product along with corn grain production) and half from dedicated perennials, primarily switchgrass. The results in Table 3 also reveal that the dedication of land to biomass cultivation is likely to occur in relatively small plots as alluded to above. For example, consider the average land holdings in short-term grain and short-term grain and forage rotations, at 158 and 171 acres per farm, respectively.

Table 3. Parcel-level snapshot of stated land use conversion to bioenergy crop production

| Land type & primary use | Current land use among farms in the sample[a] | | | Parcels converted from current land use to a bioenergy crop | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Corn stover | | Switchgrass | | Hybrid poplar | |
| | Total parcels (number) | Total area (acres) | Average area (acres) | Parcels (% of total)[b] | Average area (acres)[c] | Parcels (% of total) | Average area (acres) | Parcels (% of total) | Average area (acres) |
| Cultivated cropland: | | | | | | | | | |
| Short-term grain rotation | 92 | 14,573 | 158 | 21% | 55 | 16% | 36 | 4% | 9 |
| Short-term grain & forage rotation | 43 | 7,357 | 171 | 19% | 100 | 12% | 74 | 5% | 23 |
| Long-term grain & forage rotation | 132 | 15,784 | 120 | 15% | 53 | 16% | 28 | 2% | 11 |
| Long-term forage rotation | 52 | 1,561 | 30 | 6% | 33 | 17% | 11 | 6% | 13 |
| Non-cropped cultivable land: | | | | | | | | | |
| Permanent pasture | 232 | 14,107 | 61 | 2% | 10 | 13% | 17 | 5% | 11 |
| CRP acres | 60 | 2,571 | 43 | 11% | 46 | 23% | 33 | 3% | 93 |
| Unfarmed open space | 52 | 1,404 | 27 | 0% | n.a. | 0% | n.a. | 0% | n.a. |
| Group subtotals: | | | | | | | | | |
| Cultivated cropland | 319 | 39,275 | 140 | 16% | 60 | 16% | 32 | 4% | 13 |
| Non-cropped cultivable land | 344 | 18,082 | 56 | 3% | 31 | 13% | 22 | 4% | 22 |
| Total: | | | | | | | | | |
| All cultivable area | 663 | 57,357 | 87 | 9% | 55 | 14% | 27 | 4% | 18 |

a/ Includes all farms in Table 1 except "other". The 280 farms in the sample comprise a total of 653 cultivable parcels, for an average of 2.4 parcels per farm.
b/ Indicates the percent of total parcels that respondents listed for conversion to a bioenergy crop, either in full or in part (unweighted).
c/ Indicates the average acres per parcel that respondents listed for conversion to a bioenergy crop (unweighted).

For the approximately 20% of respondents who were willing to put some of those lands into corn stover production, they were willing to assign 55 acres and 100 acres, respectively. This is less than one-third of their short-term grain and a bit less than two-thirds of their short-term grain and forage rotation lands.

Likewise, for the 16 and 12% of respondents with those same land types that were willing to convert to switchgrass cultivation, the average acreages converted were 36 and 74 or about 20% and 40%, respectively, of the average parcel size. Similar patterns emerge all throughout the table, and it is these relatively small proportions of land allocated, along with 20% or less willingness to participate rates across respondents, that leads us to envision a highly fragmented pattern of bioenergy cultivation.

While it is conceivable that farmers would expand their biomass acreage over time, thereby creating potentially larger areas for cultivation and harvesting, it is also fair to say that this initial low level of participation could understate the degree of fragmentation even on a given farm if the land totals in turn included a combination of non-contiguous parcels. Suffice it to say that a highly fragmented and low level of biomass cultivation and supply would pose significant logistical costs for machinery set-up and biomass collection across the rural landscape.

## *Bioenergy Knowledge and Attitudes*

This section discusses the final question that we posed, “What economic, environmental, demographic and attitudinal factors might enable or constrain these choices?” Initially, note that the unwillingness of most farmers to participate in bioenergy crop markets does not appear to be based on a lack of basic familiarity with the biomass crops themselves.

In Table 4, the vast majority of respondents, 67% and 74%, respectively, were aware of corn stover and switchgrass as potential feedstocks for bioenergy prior to the survey. In addition, the differences between those expressing a willingness to participate in stover and switchgrass under the price and contract terms offered did not differ much based on prior awareness. For example, 66% of those responding ‘no’ to the corn stover supply questions had previous knowledge of the bioenergy crop as compared to 67% who said ‘yes’.

More pronounced differences become evident when we compare likely adopter and non-adopter attitudes about bioenergy policy and certain stewardship principles. This is also shown in Table 4 with respect to two different sets of questions which ask respondents for their perceptions about the potential benefits of energy development and their preferences regarding environmental outcomes.

Table 4. Respondent awareness, knowledge, and attitudes by willingness-to-grow a bioenergy crop

| | All | Corn stover | | Switchgrass | | Hybrid poplar | |
|---|---|---|---|---|---|---|---|
| | | No | Yes | No | Yes | No | Yes |
| Representative farm population | 2,298 | 1,855 | 443 | 1,520 | 778 | 1,928 | 370 |
| Prior awareness (% of respondents) | | | | | | | |
| Corn stover | 67% | 66% | 67% | 59% | 82% | 66% | 71% |
| Switchgrass | 74% | 71% | 86% | 66% | 90% | 72% | 85% |
| Hybrid poplar | 38% | 37% | 46% | 33% | 49% | 36% | 52% |
| Production and marketing risk (% of respondents) | | | | | | | |
| Perceive stover to be riskier than corn grain | 73% | 78% | 55% | 77% | 67% | 76% | 60% |
| Perceive switchgrass to be riskier than hay | 80% | 83% | 70% | 79% | 82% | 81% | 77% |
| Bioenergy/renewable energy attitudes (% of respondents) | | | | | | | |
| Agree that government should be involved in bioenergy development | 72% | 68% | 92% | 64% | 89% | 69% | 89% |
| Agree that renewable energy development promotes rural economic growth | 64% | 57% | 91% | 54% | 83% | 60% | 84% |
| Agree that renewable energy development will help slow climate change | 49% | 45% | 64% | 40% | 67% | 47% | 59% |
| Agree that renewable energy development will reduce our dependence on foreign energy | 77% | 74% | 89% | 71% | 87% | 74% | 89% |
| Environmental/stewardship beliefs (% of respondents) | | | | | | | |
| Willing to trade economic returns for improved soil quality | 35% | 31% | 54% | 26% | 53% | 31% | 56% |
| Willing to trade economic returns for improved wildlife habitat | 49% | 44% | 67% | 36% | 73% | 45% | 67% |
| Willing to trade economic returns for improved water quality | 31% | 27% | 47% | 25% | 42% | 27% | 53% |
| Willing to trade economic returns for reduced greenhouse gas emissions | 45% | 42% | 59% | 39% | 58% | 42% | 65% |
| Willing to trade economic returns for reduced labor or managerial effort | 37% | 36% | 39% | 27% | 56% | 33% | 57% |

Regarding energy attitudes, both non-adopters and adopters responded positively on average, but there is about a 20-30% point gap between them, with those willing to adopt more likely to express positive attitudes about bioenergy. This is not a surprising outcome. One might expect that adopters would tend to be more positive about the broader social impacts of bioenergy development.

Perhaps more interesting, however, is the final set of questions in Table 5 that ask respondents about their willingness to trade economic returns with land and resource stewardship outcomes. For example, farmers were asked whether they would be willing to tradeoff economic returns for improved soil quality, water quality, and wildlife habitat outcomes.

Here again we see significant gaps between likely adopters and non-adopters. For example, 53% of likely switchgrass adopters report being willing to tradeoff economic returns to improve soil quality as compared to only 26% of non-adopters. Similar gaps are evident across Table 4, and they illustrate a strong positive association between stewardship attitudes and bioenergy crop adoption. This potentially strong link is an important finding that could inform future private and public initiatives on this and other agricultural sustainability themes.

A quick look at other demographic and economic factors in Table 5 does not reveal any significant differences between likely adopters and non-adopters of bioenergy crops. Age, education, family labor, share of income from farming, and years of farming are all similar across likely adopters and non-adopters.

While this descriptive look at the data does not 'control' for variation in a complete way, it is striking how close most of these factors appear across likely adopters and non-adopters. We are left with the main factors explaining differences in likely participation in bioenergy crop programs being the enterprise type (less likely on dairy and livestock farms than crop-only farms), and attitudes toward bioenergy policy and environmental stewardship possibilities (more likely among those with a positive outlook about the social benefits of alternative energy and those with who self-identify as land stewards).

## Concluding Remarks

This report analyzes the near-term prospects for sustainable bioenergy crop production on marginal lands in southwestern Wisconsin, based on responses provided by actual farm decision makers in the

5. Socio-demographic characteristics by willingness-to-grow a bioenergy crop

| | All | Corn stover | | Switchgrass | | Hybrid poplar | |
|---|---|---|---|---|---|---|---|
| | | No | Yes | No | Yes | No | Yes |
| Representative farm population | 2,298 | 1,855 | 443 | 1,520 | 778 | 1,928 | 370 |
| Age (years) | 57 | 58 | 54 | 58 | 56 | 58 | 53 |
| Education (% with college degree) | 24% | 21% | 37% | 20% | 33% | 23% | 30% |
| Work off-farm (% of respondents) | 57% | 55% | 66% | 56% | 60% | 57% | 57% |
| Share of farm labor provided by farm family (%) | 88% | 88% | 87% | 88% | 87% | 89% | 81% |
| Share of household income from farming (%) | 32% | 30% | 38% | 34% | 27% | 31% | 35% |
| Amount of time farm has been held in family (years) | 45 | 45 | 43 | 42 | 49 | 46 | 40 |

region. Further analysis of the topics discussed is currently underway by the UW-Madison research team, yet the initial findings described here provide several insights.

First, adoption possibilities appear least promising among dairy and other large integrated crop and livestock operations. This likely stems from on-going commitments and large investments these farms have in competing activities. By comparison, cash-grain farms appear better to respond to new bioenergy cropping opportunities. Additionally, farms that are willing to grow bioenergy crops would do so only on a small portion of their land. Thus, absent certain policy interventions, bioenergy crop production patterns across the agricultural landscape will likely emerge with a high degree of spatial fragmentation.

Another insight is that attitudes towards bioenergy policy and land stewardship can shift adoption prospects. This provides the basis for some optimism, suggesting the prospect for spatial agglomerations or 'hotspots' of bioenergy crop production, and the lower logistical costs that come with it, may arise in locations where these factors are strongest. Identifying pockets of farmers with similar enterprise types and attitudes is one activity that might be conducted with the help of others in the industry.

Ultimately, the actual bioenergy cropping outcomes to be realized will depend on a number of factors in addition to farmer acceptance and adoption, such as technological breakthroughs in production, harvesting and conversion processes. Advances in other sectors and more general economic conditions will also play a large role.

As mentioned, a deeper and more systematic analysis of several items in the report is a topic of active research. On one front, we are developing behavioral models of bioenergy crop supply response that account for economic factors, policy attitudes and stewardship values. On another, we are engaged in ecological modeling to better understand the environmental impacts of land use change associated with bioenergy crop adoption at both the farm and landscape scale. We have also followed up with a about two dozen survey respondents for kitchen-table interviews to discuss their views in greater depth on bioenergy cropping prospects in person.

A final factor to consider is that farm landowner views might differ from those of farm operators. We will report on that later this year, based on data from a companion survey to this one that was targeted at non-farm rural landowners. However, we have some doubts that landowner patterns of likely biomass crop adoption would be much higher in the near-term given that dairy and livestock farmers are most likely to 'rent-in' farmland acres from these landowners, and that long standing arrangements associated with their enterprises may limit conversion possibilities

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