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Stepping into the Midwest Bioeconomy: Stakeholder Engagement and Geospatial Tools to Assist in Perennial Bioenergy Crop Decision Making and Entrepreneurship

Environmental Science Division

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Stepping into the Midwest Bioeconomy: Stakeholder Engagement and Geospatial Tools to Assist in Perennial Bioenergy Crop Decision Making and Entrepreneurship

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ACRONYMS AND ABBREVIATIONS

AFT	American Farmland Trust
AOLC	Angelic Organics Learning Center
BETO	Bioenergy Technology Office
BIPOC	black, indigenous, or people of color
CAL	McHenry County College Center for Agrarian Learning
CRP	Conservation Reserve Program
ESMC	Ecosystem Services Market Consortium
ES	ecosystem services
HIFLD	Homeland Infrastructure Foundation-Level Database
NASS	National Agricultural Statistics Service
NCCPI	National Commodity Crop Productivity Index
NRCS	Natural Resources Conservation Service
SI	Savanna Institute
SSURGO	Soil Survey Geographic database
SUPERBEEST	Scaling Up Perennial Bioenergy Economics and Ecosystems Services Tool
SRWC	short-rotation woody crop
SWCD	Illinois Soil and Water Conservation District
TNC	The Nature Conservancy
TWI	The Wetlands Initiative
UIUC	University of Illinois Urbana-Champaign

1. INTRODUCTION

This project, "Ecosystem Services and Farm Entrepreneurship Technical Assistance," was a three-year project originally planned for FY22–FY24. Due to a late start and a few extensions, it is being completed in early FY25. This project explored opportunities to support the deployment of a bioeconomy with a circular, more sustainable supply chain. Using a tool developed by Argonne to identify agricultural areas suitable for use in the bioeconomy, we sought to create opportunities in the bioeconomy as biomass producers, bioenergy users, and environmental entrepreneurs. We proposed to focus at the beginning on enhancing the tool's capabilities, while engaging with key stakeholders to improve and expand the tool's functionality for all potential stakeholders in the bioeconomy.

We believe that expanding our tools and technologies, coupled with conversations in agricultural spaces, will be needed as we continue to explore how best to offer farmers whole-of-supply-chain opportunities to participate in the bioeconomy. Through this project we have continued to gain a better understanding of the ways in which farmers, landowners, bioenergy users, and environmental entrepreneurs may approach the bioeconomy. In addition, as we improve our analytic toolkit, we can continue to refine our communication and the ways in which we can valuate the bioeconomy. Refining these tools allows us to dive deeper into conversations around plausible policies and drivers for future bioeconomy investment and engagement by stakeholders.

By working with farmers and agricultural landowners to enable a sustainable bioeconomy business model, enhance their energy options, and recover resources from their waste streams, this project directly responds to the Bioenergy Technology Office's (BETO) priorities of building a resilient energy economy. It addresses BETO's focus on fostering the development and adoption of energy technologies that enable the conversion of waste to energy, efficient land use, and robust job creation.

By establishing a technical assistance program that develops capabilities and practices in agricultural areas to implement a bioeconomy future, this program will develop an important linkage between technology being developed at U.S. Department of Energy national laboratories and the agricultural communities of the Midwest. This project focuses on farmers with lower productivity farmland. Because less productive lands create a more difficult revenue stream for conventional crops, these farmers may therefore be more open to alternative agricultural land management regimes. Consequently, the technical assistance program and the methodologies for targeting perennial bioenergy crop application on marginal land provide a distinct opportunity to engage with and invest in the bioeconomy in these economically stressed areas.

Stakeholders in this project include farmers and landowners, local conservation organizations (NRCS, SWCS, etc.), universities, non-profit environmental and agricultural entities, farm consultants, environmental regulators, and industry, including the industries working on conversion technologies, anaerobic digestion, pyrolysis, and biochar generation, and the companies interested in trading or purchasing/supporting the valuation of ecosystem services (ES).

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2. APPROACH

Argonne has been conducting research in perennial bioenergy crops and their associated ecosystem services for over a decade. This work has included field, laboratory, modeling, and economic analyses, and technology development. One tool under development as part of a separate BETO project is the Scaling Up Perennial Bioenergy Economics and Ecosystems Services Tool (SUPERBEEST). SUPERBEEST is a free, online geospatial tool designed to assist with decision making for the adoption of perennial bioenergy crops. Its purposes are to identify marginal farmland that is optimal for a conversion from row crops to perennials, to determine the ecosystem services that would result from that change, and to estimate the net economics of the change.

As described below, in the current project Argonne is conducting outreach and providing technical assistance to farmers, landowners, and other stakeholders, and SUPERBEEST is a key part of the technical assistance. In order to provide this assistance and to bolster Argonne's long-standing outreach in the region, collaboration with outside partners with this skillset was prioritized.

2.1 AMERICAN FARMLAND TRUST PARTNERSHIP

To reach and engage with farmers, landowners, and those within the bioenergy market, Argonne partnered with American Farmland Trust (AFT), a national non-profit. AFT has a presence in the Midwest and is well-suited to connect Argonne with farming communities around the country. Through this partnership we performed a deep-scoping task that highlights both the opportunities to refine our tools and technologies to fit stakeholder needs as well as a realistic plan for technical assistance. We developed the foundations for region-wide implementation of a bioenergy system based on leveraging marginal agricultural and degraded land and locally generated biomass and organic wet waste to produce renewable energy that could be used locally. This would create an environmental entrepreneurship program to sell or trade the ecosystem services generated and enhance economic resiliency of the region.

Following a successful go/no-go decision in FY23, the subsequent years allowed AFT to focus on providing technical assistance through workshops and direct interactions. In these workshops and one-on-one farmer/landowner interactions, we gathered input to refine the SUPERBEEST tool; determined the feasibility of bioenergy production technologies at the farm-community scale; reached out to a range of government, non-profit, and industrial partners to promote tools and technologies for building the bioeconomy; and provided BETO with this final report on the approach, findings, conclusions, and recommendations of this study.

2.2 FARM ENERGY CONSUMPTION SURVEY

One of the first steps Argonne and AFT took in this project was a survey about on-farm energy use, energy consumption, and general interest in renewable energy technologies. This was sent out to landowners and farmers within Illinois in the summer of 2022. This survey was a

way for us to develop the groundwork in understanding farmer and landowner perspectives, preferences, and awareness of renewable energies, with a particular focus on bioenergy crops and related technologies. Additionally, this survey aimed to understand farmer opinion regarding the adoption of perennial bioenergy crops on marginal lands. Key demographic information was also an interest of this survey: age, gender, and type of farming were important information to learn for the project as we aim to conduct outreach to as many people in the agricultural space as we can.

The "Farm Energy Consumption Survey" was the first step in connecting with farmers to learn more about marginal land usage and individual capacity to create new economic pursuits in the renewable energy space. The purpose of the survey was to assess farmers' energy needs and opportunities for adoption of perennial bioenergy feedstock crops. Respondents had the opportunity to share energy consumption details about their current operation and indicate familiarity with and interest in adopting on-farm bioenergy systems. The survey also identified educational opportunities regarding perennial bioenergy crops that will allow AFT to refine outreach strategies for the duration of the project.

The survey also looked at how farmers and landowners would be willing to participate in the bioenergy market. There are many possible scales within the bioenergy market, from home and on-farm generation and consumption of the biomass to federal markets that operate similarly in function to conventional commodity crops. Knowing the different scales under which our farmers were most interested in operating could help us better refine our tools and tailor our planning on outreach materials over the course of the project.

AFT conducted this public outreach survey from July to September of 2022. AFT staff promoted the survey at various field days and agricultural events throughout Illinois. Additionally, social media campaigns helped promote the survey. Social media campaigns for the survey reached approximately 50,928 people with 878 post engagements.

2.3 SURVEY RESULTS

The results indicate the need for more education regarding renewable energy and relevant technologies. Explanations in survey responses show that many farmers in Illinois are not familiar with technologies related to anaerobic digestion and biochar production. Some respondents asked for workshops and seminars to learn more about them. Most of the farmers who participated in the survey indicated they did not produce any energy on their farm and rely on traditional sources for energy, such as electricity from the grid, propane, gas, and diesel, to power their farming operations. Aside from personal use, fuel for equipment and grain storage and drying operations were the primary energy needs on the farm. Of the 21% of respondents who indicated they were producing renewable energy on their farm, all of these systems were solar and wind technologies. Concerns were raised regarding capital expense, time, and labor related to installing and maintaining renewable energy systems on the farm.

Farmers reported the following when asked if they would prefer to use biomass feedstock on-farm or sell off to a biorefinery: "Solar is providing all of my current electric energy needs. Anaerobic digester and kiln sounds expensive" and "I am not familiar with on-site digestion

chamber or biochar kiln so I would need more information on those two options before considering. Mainly concerned with logistics and aesthetic of both options."

These results helped identify general farmer opinion regarding the adoption of on-farm renewable energy systems and willingness to adopt perennial bioenergy cropping systems across a variety of farms throughout Illinois. Additionally, the survey provided insight into why farmers are interested in these systems and why they may not be supportive of these technologies on their farms. Most respondents indicated the three most important considerations for the generation and use of renewable energy are to reduce energy bills (22%), supplement income (17%), and fight climate change (10%). Farmers in support of these technologies also showed interest in the application of biochar on their fields. The information gathered from this survey will allow AFT and Argonne to refine their outreach strategies to farmers and create opportunities for education on the topics addressed in the survey.

AFT's full survey methodology and findings are provided in Appendix A.

2.4 PERENNIAL BIOENERGY CROP OUTREACH AND ASSESSMENT PLAN

The goal of the Perennial Bioenergy Crop Outreach Assessment Plan (2024) was to develop a map for the identification of priority areas combining geospatial and economic analysis of integrating perennial bioenergy crops at the state and Midwest regional level. AFT then used the map to perform an assessment of key focus areas for outreach. This helped focus our efforts throughout the rest of the project.

This assessment analyzed social and agricultural land use GIS data to determine key areas suitable for the adoption of perennial bioenergy crops and to provide an additional income stream to producers, especially those in regions of less-productive farmland. All the data used in the Perennial Bioenergy Outreach Opportunity Assessment are publicly available. The list of criteria below was used in a GIS analysis to determine key geographic locations for targeted outreach in the Outreach Opportunity Assessment. Ranging from 1, being the highest priority, to 5, being lowest, these data were weighed and represented as a raster across the Midwest region.

Criterion	Source	Priority
Black, Indigenous, or People of Color (BIPOC) producers	National Agricultural Statistics Service (NASS)	1
Cropland	National Crop Land Database	2
Low crop productivity	National Commodity Crop Productivity Index (NCCPI)	3
High erodibility factor	SSURGO (Soil Survey Geographic database)	4
Ethanol plants	Homeland Infrastructure Foundation-Level Database (HIFLD)	5

The results of this assessment have identified priority areas for outreach in Illinois specifically (Figure 1) and the Midwest region identified in the SUPERBEEST tool in general

(Figure 2). In both cases, the geographic locations determined for priority outreach possessed at least 3 of the 5 criteria listed above. Recommendations were provided on how to approach outreach in these areas, along with explanations as to why these areas were best suited for the adoption of perennial bioenergy cropping systems. Other elements to consider, in relation to the five criteria, were agricultural flexibility of the region (what tools and equipment may be available in a region), the percentage of female farmers and/or landowners, or other existing markets (such as poultry, dairy, or other livestock), which could have implications for water quality, nutrient reduction lost, or general agricultural land use.

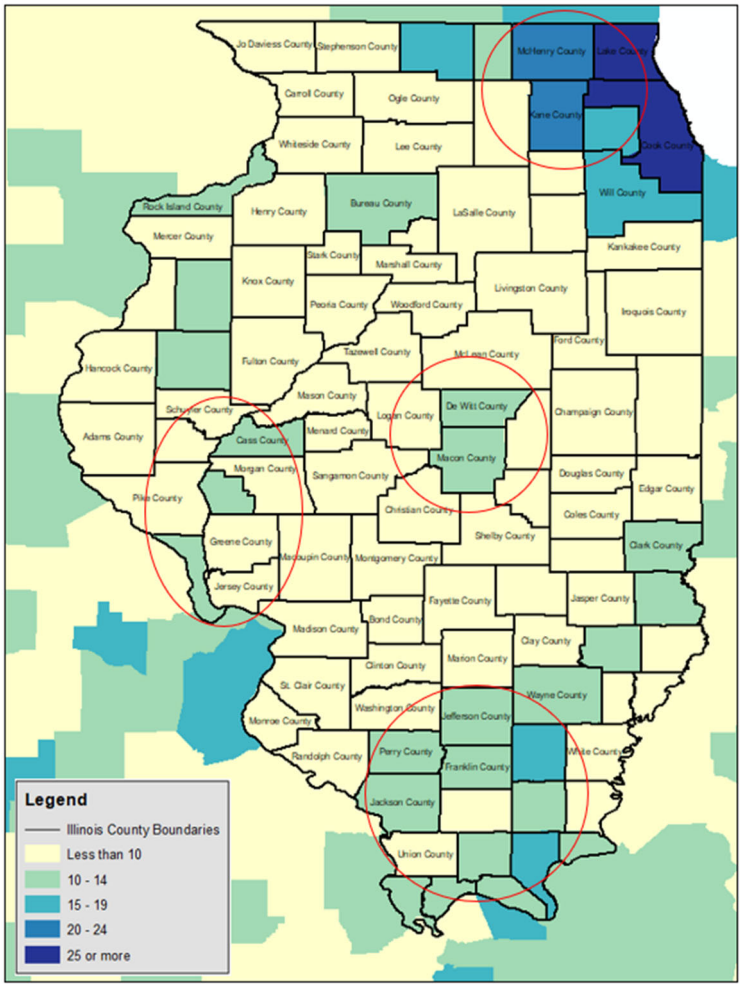

Figure 1. Outreach Regions of Illinois and the Percentage of Female Farmers/Landowners by County

Primarily, Illinois is the focal point of the project as a basis for our studies and included four regions for outreach within the state. Further, AFT's Midwest Region and Argonne National Laboratory are both located in Illinois. AFT is well connected to farmer and landowner networks in the state and, because of this, the organization was able to target outreach to specific counties identified in the GIS analysis. Areas included northern Illinois, southern Illinois, and the lower Illinois region (within the Illinois River watershed).

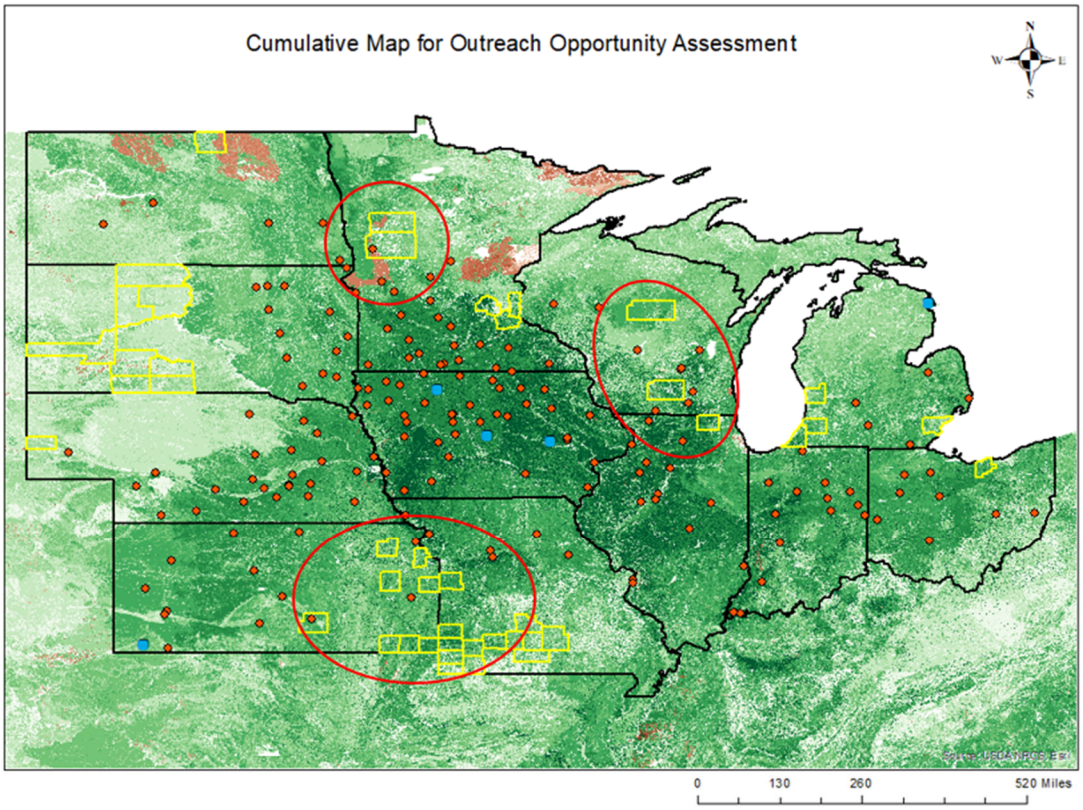

Figure 2. Cumulative Map of Outreach Opportunity Assessment

When exploring outreach opportunities in neighboring states, AFT targeted wider geographic areas for targeted outreach, with some areas spanning multiple counties. This offered more flexibility for outreach in areas suitable for the adoption of perennial bioenergy crops where AFT does not have as wide a presence. These areas included central Minnesota, central and Southern Wisconsin, and the Kansas and Missouri border region.

Following the assessment identifying these regions and the countries within these regions, demographic and agronomic information for these regions were further analyzed to prioritize outreach methodologies. The nature of the agricultural and demographic landscape would influence our outreach strategies and the type of perennial bioenergy crops workshops and other outreach would emphasize. In some instances, a high number of women non-operating land owners in an area provided a unique avenue for outreach. In others, an area with a high presence of hay/dairy farmers would suggest that herbaceous perennial bioenergy crops such as switchgrass or miscanthus may be of more use because of the similarity of harvest as conventional hay system.

Lastly, we considered psychographic tendencies. This was not a limiting factor but was considered as an opportunity to tailor technical assistance and outreach even further. Such tendencies included areas with high emphasis on regenerative agriculture, native plant stewardship, renewable energy, or sustainability/environmental focused regions. These are not hard-and-fast nor are they as refined as information such as demographics, but using AFT's

institutional knowledge on these matters helped provide additional context to initialize this engagement.

Factoring all these elements together, AFT created a list of relevant and potential partners within each region, as identified in Tables 1 and 2, respectively. Following this partnership development guideline, they then created a timeline of the goals inherent to our project, as shown in Figures 3 and 4. The full report is available in Appendix B.

Below is a list of partners AFT has engaged or worked with thus far, and with whom it has plans for continuing engagement in future years.

Table 1. Existing Partners

Partner	Rationale	Project Area
University of Illinois Extension	This organization's extensive farmer network provides many opportunities for collaboration.	Outreach and Engagement
Savanna Institute (SI)	SI has provided the opportunity to utilize their media channels and programming to promote the project with their networks.	Outreach and Engagement
University of Illinois Urbana-Champaign (UIUC)	Extensive research on perennial bioenergy cropping systems and economics are conducted at this institution.	Research, Outreach and Engagement
UIUC Energy Farm	A leading energy farm in bioenergy research. The farm has perennial bioenergy crop research plots and a biomass furnace to demonstrate small-scale bioenergy production.	Research, Outreach and Engagement
Angelic Organics Learning Center (AOLC)	Has farmer networks in northern Illinois and southern Wisconsin as well as training resources established for farmers in the Midwest.	Farm Scenarios/ Technical Assistance
Midwest CRAFT	This organization has a wide network of new and beginning farmers.	Outreach and Engagement
Land Conservancy of McHenry County	Regularly hosts events with effective programming in their community and has built an extensive network of farmers, landowners, and local agricultural organizations in north central Illinois.	Outreach and Engagement
Natural Resources Conservation Service (NRCS)	Knowledge of local agricultural and farm bill programs will provide insight into relevant cost-share opportunities.	Technical Assistance
Illinois Soil and Water Conservation District (SWCD)	Local districts have extensive farmer networks that will support the project outreach in targeted areas suitable for perennial bioenergy crop adoption.	Technical Assistance
McHenry County College – Center for Agrarian Learning (CAL)	Provides training and educational resources to local farmers and students focusing on small-scale, regenerative, and agricultural entrepreneurship.	Outreach and Engagement/ Technical Assistance

Table 2. Proposed New Partners (to Project)

Partner	Rationale	Project Area	Contact Date
Iowa Prairie STRIPS project	Iowa State University project with broad network and outreach statewide.	Project Expansion/ Collaboration	May 2023
The Nature Conservancy (TNC)	A good resource to connect with other Midwest conservation agriculture-related contacts.	Outreach and Engagement	Sept. 2023
The Wetlands Initiative (TWI)	Areas of synergy may include water quality improvement in impaired watersheds with the presence of perennial bioenergy crops.	Technical Assistance	April 2023
Ecosystem Services Market Consortium (ESMC)	Works on ecosystem services credit quantification and ways to fund scalable regenerative agriculture.	Technical Assistance	*Has not been contacted yet.*
Ecosystem Services/Carbon Market Companies	Consider exploring the potential to partner with these organizations on a demonstration project.	Funding	*Have not been contacted yet.*
Green Lands Blue Waters Initiative	GLBWI is Minnesota based and works on a variety of projects under the umbrella of "continuous living cover" ag and conservation practices.	Project Expansion/ Collaboration	August 2023
Illinois Agri-Women	An extensive network of Women in Illinois working in agriculture and will be beneficial to collaborate on outreach efforts.	Outreach and Engagement	March 2023
Women, Food and Agriculture Network WFAN)	Another network of women in agriculture, focused on the Midwest.	Outreach and Engagement	*Has not been contacted yet.*

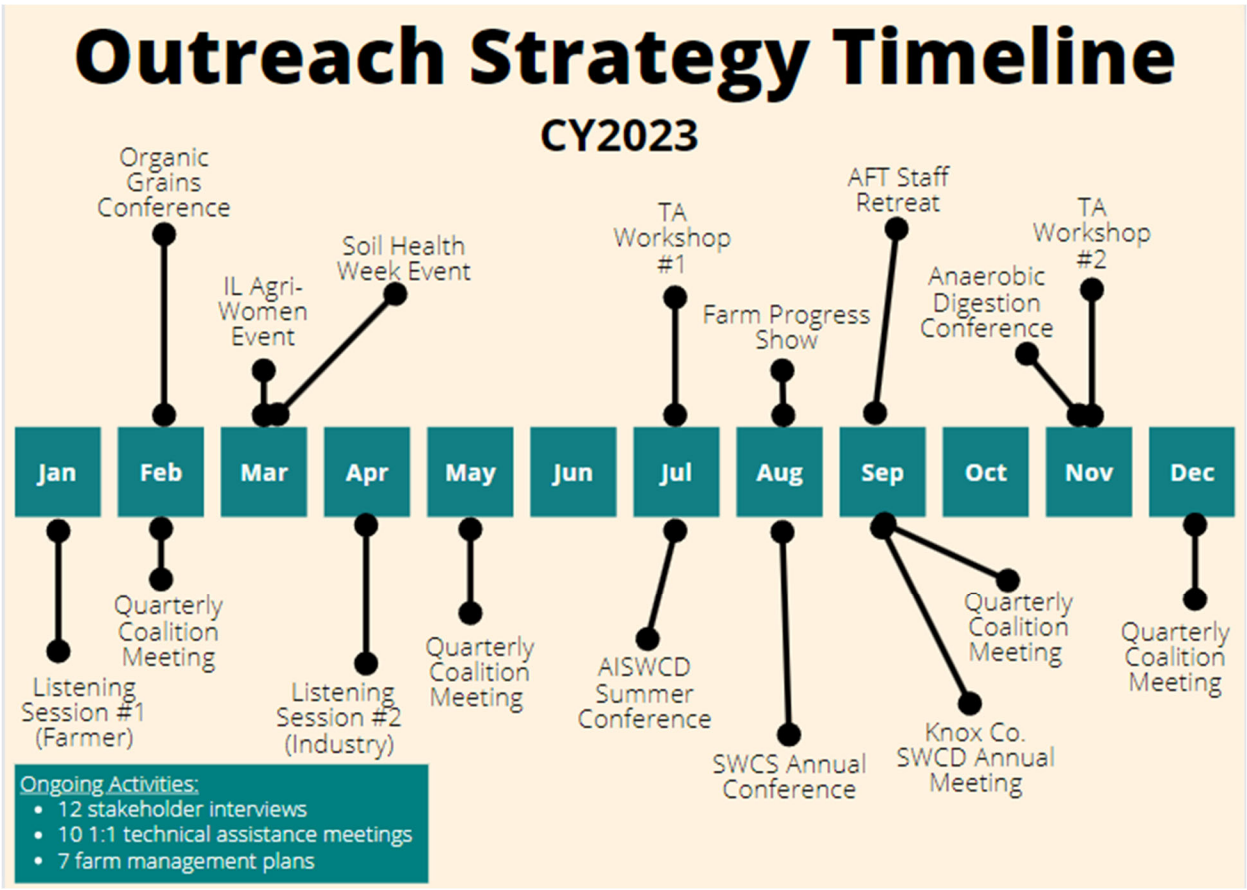

Figure 3. Outreach and Strategy Timeline, CY2023

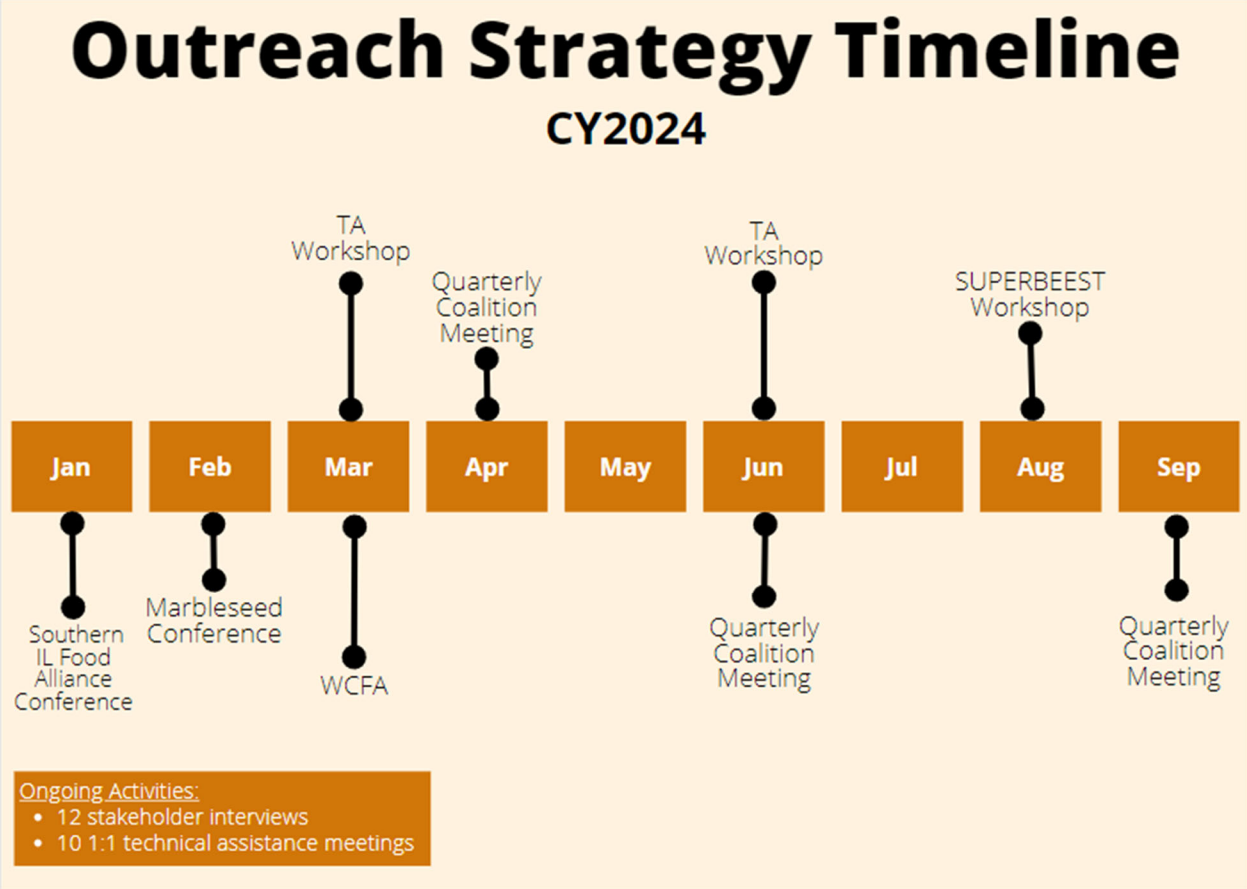

Figure 4. Outreach and Strategy Timeline, CY2024

2.5 GROUP TECHNICAL ASSISTANCE WORKSHOPS AND INFORMATION SESSIONS

Groups of farmers, landowners, and those in professions related to conservation and agriculture were invited to participate in group learning sessions and technical assistance workshops. These in-person workshops had two main goals. First, they were to provide relevant information to stakeholders regarding bioenergy market and the management of bioenergy crops. Second, the workshops served as feedback sessions to explore how SUPERBEEST can best serve those interested in bioenergy crops and/or the bioenergy market.

Four workshops were held in total. The first two of these workshops were held in Illinois, with the last two held in Minnesota and Wisconsin, respectively. A total of 37 attendees came to these workshops. All the workshop locations were identified in the outreach and engagement plan as desirable for this effort. AFT partners used their existing network and their outreach plan to attract interested stakeholders.

These workshops, generally three hours long, were managed by AFT, and jointly presented and facilitated by AFT and Argonne (Figure 5). Following a project overview, facilitators discussed crop selection, management, and market opportunities and were explained

to the stakeholders. While all perennial bioenergy crops were discussed in the presentations, each workshop was customized so that the emphasis was placed on crops and particular cultivars that are best suited for the region. Such information included hypothetical management plans.

Following this in-depth information regarding the crops, the market, and the concepts of targeted land application, landowners were provided with a worksheet on applying a targeted application of perennial bioenergy crops on their own farm if they had one, or on a hypothetical farm. This worksheet provided additional information on crop management and broke down the management plan by year and by season. Participants were able to take this worksheet home to continue working through it.

Lastly, the tool SUPERBEEST was presented to drive home the concepts of marginal land identification and uses, and the implications of bioenergy crops at various scales. Prior to each workshop, two to three clusters of fields were identified for SUPERBEEST analysis. These plots of land were generally representative of the regions and had varying marginalities to highlight the variety of data within SUPERBEEST. Using the composite weighting visualizer, weights were assigned to prioritize yield issues (NCCPI), drainage/water issues (drainage class, flooding frequency, ponding frequency) or erosion issues (runoff), or groundwater impacts (nitrate leaching, pesticide leaching). Participants were asked to discuss what they saw in these maps: if the data made sense with their perspectives or opinion of their area, and if these marginal areas were plausible for the design of an agricultural system involving perennial bioenergy crops.

Participants were then asked three questions to improve our understanding of SUPERBEEST and the ways it should be modified:

1. With the data that are currently presented in SUPERBEEST, how would you plan for and design for perennial bioenergy crops?

2. What other data would you like to see to make decisions about perennial bioenergy crops at the scale you would use it?

3. How would you want to use the information generated in SUPERBEEST in your agricultural planning?

Following these workshops, individual technical assistance was offered to anybody interested in generating a management plan for an area of their land.

Figure 5. Marlee Giacometti (AFT) Presenting at a Group Technical Assistance Workshop

2.6 INDIVIDUAL TECHNICAL ASSISTANCE

AFT works directly with farmers and landowners across the region to provide technical assistance for the adoption of regenerative farming via perennial bioenergy crops. This technical assistance is typically provided on a one-to-one basis as AFT recognizes that adoption of a new crop is not a "one size fits all" approach. Farmer goals and operations are typically very different across the region, so working on an individual basis allows AFT to provide service tailored specifically to that farm or landowner's goals. This makes the technical service more personalized and more feasible for adoption of a perennial bioenergy crop. The individual technical assistance also offers relationship-building opportunities for technical assistance (TA) providers to support farmers/landowners who are interested in these crops throughout the process as a reliable and trusted resource.

The report includes a SUPERBEEST assessment of the farm and the areas of interest indicated by the farmer/landowner. Then, the reports focus on soil type, size, and configuration of the marginal land to provide insight into possible perennial bioenergy crops to choose from and a resulting management plan. These management plans include insight into the timeline for establishment and harvesting, recommendations for tools and equipment to use, and regional information regarding the timing of harvesting and other regionalized information regarding establishment and local economic opportunities.

Customized seed mixtures were designed for those interested in using a native prairie mix for bioenergy crop application. These were generated by AFT and localized to the stakeholder. For each stakeholder, three sets of mixtures were generated: a set of 9, 15, and 21 species. These

mixtures focused more heavily on energy-rich grass species over forbs to ensure the energy density potential of these planted acres.

An example of an individual technical assistance report is provided in Appendix C.

2.7 SUPERBEEST REFINEMENT

Through workshops, webinars, and quarterly coalition meetings, feedback was generated regarding SUPERBEEST's existing and potential functionality. In addition to these public meetings, a questionnaire was developed and placed on SUPERBEEST's launch page in order to provide direct and discreet feedback on the tool.

This feedback was formal in the technical workshops, as outlined above, and informal in the other meetings and webinars. The intent was to generate conversations about SUPERBEEST and its various uses at different scales via direct engagement with the tool in a live, in-person setting. The wide range of potential users in the various in-person and virtual workshops and webinars provided a holistic perspective of potential users of the tool: farmers, landowners, bioenergy and biomass processors, conservation researchers, and soil and water conservation managers. The breadth of contact created distinct opportunities to explore as many possible use cases as feasible.

This information was collected and used to consider how to improve SUPERBEEST functionality and the underlying approach to the data. As a result, several key updates have been made with a list of other scheduled changes as well. Most importantly, SUPERBEEST was made publicly available in 2023.

2.8 MIDWEST BIOENERGY CROP COALITION

At the beginning of this project, we realized that much of the momentum in developing supply chains for lignocellulosic-based fuels and other biobased products had either died out due to the onset of corn ethanol in the early 2000s, or they were new and emerging markets. We learned of a few state-level coalitions focused on bioeconomy development, but geography was a limiting factor. We wanted to form a group focused on region-scale supply chain development as well as create a space for a variety of stakeholders to learn and share about perennial bioenergy crops and their end uses. Based on these needs, we formed the Midwest Bioenergy Crop Coalition to focus on market development, policy advocacy, and knowledge sharing for these feedstocks.

The idea for the coalition was first identified through conversations with Agricultural Watershed Institute and other stakeholders. In these conversations, we learned that there once was a working group that met regularly to discuss perennial grasses and advocated for their adoption on the agricultural landscape, but there was no current organization to provide coordination and leadership for this work. It seemed like a great opportunity for AFT to bring this work back to the forefront, considering this project was our first time working in the bioenergy space.

Invitations to join the Midwest Bioenergy Crop Coalition were extended to key stakeholders that the team met with early in the project timeline. These stakeholders have important roles in the Midwest bioeconomy, including biomass processors, researchers, conservation professionals, farmers, and landowners. The farmers invited to join the coalition were already engaged in the project by participating in a listening session or receiving technical assistance and wanted to continue their involvement.

2.9 INFORMATIVE WEBINAR ON ANAEROBIC DIGESTION

On November 15, 2024, Argonne and AFT hosted a webinar, "Steps Toward a Bioeconomy: The Latest on Perennial Bioenergy Crops, Anaerobic Digestion, and Related Technologies." This webinar was focused on the current research and state of the market for anaerobic digestion, pyrolysis, biochar, and other related technologies. Of particular interest was the integration of perennial bioenergy crops within these technologies, as a way to explore current and potential market opportunities that include these technologies. Ultimately the goal was to present this information to stakeholders who are interested in bioenergy crops who may be interested in the variety of ways they can adopt bioenergy crops for anaerobic digestion and related technologies, whether they are farmers interested in growing the crops or managers of facilities that could integrate bioenergy crops into their anaerobic digestion systems.

Presenters represented a wide array of researchers and practitioners. A representative from the Bioenergy Technology Office spoke to explain BETO's approach and vision for the bioeconomy. SUPERBEEST and Argonne's overall project and approach were introduced. Extension agents discussed restoration agricultural practices and economic analysis of marginal land, and researchers explored current scientific assessments of the anaerobic and pyrolysis processes. Lastly, real-world applications of these technologies and products were discussed.

The conversation moved from bioplastic production, the current state and potential applications of biochar, and the potential revenue streams from carbon credits and government cost-share programs. This created a good opportunity to engage in the breadth of the current bioeconomy and the ways in which those in the Midwest can participate within it.

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3. FINDINGS

3.1 LACK OF INTEREST IN SMALL-SCALE, ON-FARM PERENNIAL BIOENERGY CROP APPLICATIONS

One of the earliest findings for this project was the preference farmers and landowners have for the scale of perennial bioenergy crops and bioenergy energy systems. Survey results and conversations with stakeholders indicated that on-farm energy systems, such as anaerobic digesters or furnaces, are not a priority for farmers and landowners and is not an avenue that would attract bioenergy crop adoption. The major concerns included high anticipated capital costs of investing in and managing this type of equipment, and the overall complexity of managing a small-scale bioenergy system. Uncertainty around this management and the availability of feedstock and the capacity to respond to any needs of these bioenergy systems were a major obstacle. A new set of crops for a new market with new equipment can be seen as stressful, risky, and consequently a significant barrier to entry into the perennial bioenergy market.

Instead, stakeholders indicated a preference for a bioenergy crop market that behaved similar to conventional commodity crops, where crops are grown, harvested, and shipped to a local distributor. In the stakeholders' eyes, this simplifies the transition from commodity crop to perennial bioenergy crops, as the process would be similar, the only burden being learning new crop establishment and harvesting requirements. Similarly, the stakeholders were interested in alternatives that complemented existing harvesting cycles of conventional crops. The intent is to complement the existing commodity crops and not take time and energy away from these crops when they are most needed. Consequently, the fall/winter harvesting schedule of many of these perennial bioenergy crops was of interest.

Finding this out early in the project helped shape our approach for the project's duration. Workshops, technical assistance, and webinars did not focus on on-farm infrastructure and small-scale anaerobic digester. Instead, the project focused on identifying larger market solutions. Exploring anaerobic digestion feasibility subsequently shifted gears away from on-farm, small-scale use and moved towards larger-scale facilities, such as dairy operations or wastewater treatment plants.

3.2 MARKET SAFETY AND RISK REDUCTION

Both sides of the bioenergy crop market—farmers and landowners on one side and bioenergy crop purchasers on the other—frequently expressed a need for a sense of stability before investing in something new. For growers, the concern is about the need to learn about a new crop and the uncertainty of any market to support it. For bioenergy market industries, expanding current or creating new facilities is limited by evidence of viable and interested growers.

Through further discussion with stakeholders, we discovered that there are opportunities to address the concerns for both ends of the spectrum in something we have called "mid-market" avenues. These are opportunities that can use perennial bioenergy crops for alternative

purposes—for example, as bedding in livestock operations, hay, a source of seedstock for plant distributors—that can provide economic returns from harvested biomass that are straightforward and local, and that tie into existing local markets. This can help solidify a region's ability to grow perennial energy crops, increase the perception and acceptance of perennial bioenergy crops, and support a scaling up of adoption so that biofuel industries or other associated bioenergy crop applications can reliably invest in an area once a certain threshold of bioenergy crops is in any given area.

These mid-market opportunities are desirable for several reasons. First, they are smaller in scale than the biofuel industry. The amount of land required to grow enough perennial bioenergy crops to satisfy these mid-market opportunities is less than what is needed at the industrial scale. For an individual grower, this means that the scale of investment on their own property can be comparatively lower.

Second, these mid-markets consist of actual purchasers of the perennial bioenergy crops that likely exist and are familiar to the farmers and landowners. These include horse stables, livestock operations such as dairy or poultry, and even some small-scale industries that burn or process biomass. This reduces any fear of risk in two ways. Primarily, concerns about new or unknown technology and its feasibility, in the case of biofuel technology, are irrelevant to mid-market opportunities, as these are conventional applications of a new crop. This captures the essence of the earlier findings in the project regarding the style of perennial bioenergy crop markets they would prefer. The other way this reduces a sense of riskiness is that the contracts are with other local and/or regional farmers/entrepreneurs rather than outside industries; the tangibility of the market and those involved can make the market seem more real and possible.

Third, there is a lower requirement for the quality of the bioenergy crop grown and the length of time needed to invest in the crop, greatly increasing flexibility on the farmer's behalf. Most of these mid-market opportunities are not concerned about energy richness of the product, as the qualities of interest for things like animal bedding are more about the texture and absorption of the material. This means that as farmers learn to grow the crop, they aren't at risk for an unsuccessful or low-quality harvest if they encounter any issues. Contracts would also be shorter than the contracts of bioenergy facilities, which need a significant length of time to ensure that their facilities can be supplied with viable feedstock over the course of many years. In contrast, mid-market opportunities could have contracts as short as two years, meaning that entering and fulfilling contract terms can be done with relatively little risk. In this way, growers can test the crop for a short time before deciding whether or not to continue, expand, or pull out of bioenergy crop production.

Less conventional than some of the other mid-market opportunities, existing anaerobic digestion facilities are a potential suitable step towards widescale perennial bioenergy crop adoption. While technologically these facilities can be considered less conventional and less familiar than animal bedding, existing anaerobic digestion facilities could use bioenergy crops as a co-digestate to regulate the digestion process and enhance the quality of the biogas. Suitable candidates are likely restricted to anaerobic digestors at livestock operations, such as dairy or swine, due to the manure content and scale of operation. These livestock operations could contract with local farmers to grow perennial bioenergy crops. While there is a certain quality

and energy richness necessary for the digestion process, the restrictions are lower than biofuel production, for example, and can be held with relatively short-term contracts.

3.3 TRANSPORTATION AND WATERWAYS

The cost of transporting biomass was one concern that repeatedly came up in conversations with stakeholders and within the coalition, regardless of user type. This is due to the fact that the cost per unit weight of unprocessed biomass is high, to the point that it is economically restrictive. Because of this, shipping via waterways has repeatedly been voiced as a plausible way to make transportation costs competitive. While geographically restrictive in the sense that proximity to navigable waterways is necessary, the cost reduction in using barges or other shipping infrastructure to move the biomass—processed or not—is significant enough to be of interest.

The cost of transporting biomass is, by unit weight, less expensive on barges and on rail as compared to truck transport. Consequently, farmgate prices can be reduced and the overall "fuelshed," or area where bioenergy facilities can afford to source their feedstock, can expand. The Midwest is well suited for this type of navigation; the Illinois, Ohio, and Mississippi rivers are all large navigable waterways that reach a bulk of the Midwest, and in Illinois alone connect most of the largest cities in the state, Chicago included, via canals. Market opportunities for barge shipping exists throughout the state, and the water system can provide shipping opportunities within Illinois and beyond.

Barge transport can extend as far south as the Gulf of Mexico. Despite transportation costs, this long-distance shipping may be worth it, at least in the short term. Current export of biomass is occurring in the United States, with biomass of wood pellets shipping internationally to Europe and eastern Asia. While local biomass production is desirable and of high interest in the domestic development of sustainable aviation fuel, mid-market opportunities as described above should be explored in the meantime. If such shipping proves to be of interest, it is another possible stepping stone for an investment in local bioenergy markets.

3.4 INTEREST IN SHORT-ROTATION WOODY CROPS

Many landowners and farmers in technical assistance workshops in all states have voiced clear interest in short-rotation woody crops (SRWCs), such as shrub willow, over that of herbaceous perennial bioenergy crops such as switchgrass. Regardless of region, even if technical assistance workshops did not outright recommend SRWCs as a suitable bioenergy crop, this apparent preference persisted throughout.

The basis of this focus on SRWCs is unclear, but presents both opportunities and potential issues. In areas where SRWCs are a good choice given climate and soil, this preference can make perennial bioenergy crop production more desirable and feasible in the eyes of landowners as they are already more likely to think highly of the bioenergy crop and anticipate beneficial returns.

Conversely, where conditions are not conducive to grow these crops, there may be a barrier to entry if native, herbaceous, perennial grasses are seen as less desirable albeit more suited for the area. Any unsuccessful attempts at SRWCs may be detrimental to future adoption, considering it may be viewed by the general public as more desirable and effective. Work needs to be done to correct this difference in perception of SRWCs and herbaceous crops.

Specific types of SRWCs may be non-native in much of the Midwest, although sterile hybrids are available so that no potentially invasive species is introduced. Stakeholders interested in a SRWC were previously unaware of the specialized equipment that may be needed to plant and harvest such a crop. Planters and harvested for shrub willow, for example, do not exist in the Midwest. Stakeholders found this an important limiting factor to adoption but found SWRC adoption compelling.

3.5 THREADING THE NEEDLE BETWEEN BIOENERGY CROPS AND CRP LAND

Another point of concern frequently brought up in conversations with stakeholders is the apparent conflict between growing bioenergy crops and having land enrolled in the Conservation Reserve Program (CRP). CRP land typically includes marginal or difficult-to-access areas of a farm, to address a myriad of concerns, such as runoff reduction or habitat enhancement. In the CRP program, landowners are paid an arranged sum of money to offset the cost of not producing anything in the areas under CRP. This is a financial incentive to provide environmental services. CRP is established in low-yielding portions of a field; this is similar in vision to the targeted application of bioenergy crops in marginal lands.

The overlap of purpose means that many of the same lands best suited for CRP would be desirable for perennial bioenergy crops. This prompted stakeholders to ask a simple question: if a landowner can be paid money to not actively farm a small amount of land at all under a preexisting government program to provide environmental services, why would they risk actively farming an entirely new crop instead? To make it appealing, the profit of perennial crops (which carries a risk just like any other crop) not only would have to match the CRP payment, but also would have to surpass the additional labor and equipment costs to ensure profitability.

Many stakeholders expressed that ecosystem services payments, such as CRP, are a viable means of achieving environmental goals and are successful in encouraging landowners and farmers to adopt desirable environmentally sound agricultural practices. They believe the same could be true about perennial bioenergy crops, the apparent counterintuitive competition with CRP notwithstanding. If payments for ecosystem services complemented the sale of perennial bioenergy crops, then landowners would take notice.

3.6 INTEREST IN FINANCIAL AND/OR PLANTING ASSISTANCE

Financial assistance for bioenergy crop adoption in any capacity was not included as part of the project. Many interested stakeholders inquired about the possibility of financial support for test plots, but the project was unable to provide this to them. This was often a barrier for implementation for farmers and landowners who were interested in adopting a perennial bioenergy crop. While this may be a barrier for most conservation management activities, the

risk associated with a lack of financial assistance in combination with a lack of familiarity with bioenergy crops in general may be particularly strong.

If financial assistance or other free services were offered to support the adoption of a perennial bioenergy crop, there may have been an increase in interest for technical assistance under this project.

3.7 DISCREPANCIES IN KNOWLEDGE, EXPERIENCE, AND GOALS OF BIOENERGY CROPS AND BIOENERGY TECHNOLOGY

One key takeaway regarding all stakeholders was a distinct variance in knowledge and/or experience of bioenergy crops and the developing technology of the bioenergy/biofuels industry.

Early in the development of the coalition, the intention was to cover many high-level needs to advance the adoption and policy advocacy related to perennial bioenergy crops. However, it was hard to refine goals to create actionable outcomes, given the large scope of the coalition and of the project itself, as well as the varying levels of expertise on the subject. This made coalescing around high-level goals and objectives difficult as the coalition needed to relate to the knowledge and experience of a large variety of stakeholders. In the future, focusing on a smaller number of key items and objectives may be a better solution to make meaningful progress.

There is a steep learning curve related to individual feedstocks, end use technology, and policy. Varying levels of knowledge across members in this coalition created challenges to move forward on key pieces related to policy advocacy. AFT recognizes that policy is often a driving force to incentivize farmers to adopt conservation practices, and many of the policies at play are centered around biofuel feedstocks like corn and soybean, but not perennial crops that provide environmental benefits and viable feedstocks for this same technology.

Regarding existing projects that are related to bioenergy crops and bioenergy technology, there are many inconsistencies across organizations and states related to projects, policy, and production of perennial bioenergy crops. This creates barriers to adoption and incentivization on a broad scale. Finding common ground across the coalition was a challenge because many members work across states in the Midwest region that have varying practice standards, policy incentives, etc., relating to the scaling up of the bioeconomy.

3.8 SUPERBEEST ACCEPTABILITY

Stakeholders found SUPERBEEST's data interesting and useful as a tool to explore perennial bioenergy crops and marginal land classifications, particularly because it is free to use and does not require registration. Participants have identified several key points regarding data comparison and the use of data outside of SUPERBEEST.

There were frequent requests for direct carbon valuation and GREET®-related assessments to be conducted within SUPERBEEST. The intent would be to understand the

effectiveness of adoption on a particular site, given various constraints on site and in regard to shipment.

Potential users also indicated that transportation network data could be informative in terms of access to and siting of facilities for industries that use biomass. This would include road, highway, and rail access and distance calculations using these networks.

Stakeholders have expressed interest in being able to export the report and associated raster generated by SUPERBEEST into a geospatial file. The most frequently suggested format for this, aside from the existing pdf report, is as a kml file. This way, the data can easily be used in other agricultural planning technology or geospatial software.

Stakeholders were also interested in data regarding potential markets, such as carbon credit trading or renewable natural gas figures.

3.9 MID-SIZE ANAEROBIC DIGESTION AND PYROLYSIS

Anaerobic digestion, pyrolysis, and other related technologies exist at multiple scales, from personal, on-farm work to heat a home or barn, up to an industrial scale of processing. Stakeholders have stated in workshops and surveys that small-scale implementation is not desirable. The associated costs and work to learn, operate, and maintain these technologies is not of interest. Expanding the scope and scale of these technologies increases their perceived suitability to our Midwestern stakeholders.

According to stakeholder engagement and feedback during Argonne's webinar "Steps Toward a Bioeconomy: The Latest on Perennial Bioenergy Crops, Anaerobic Digestion, and Related Technologies," there are scales of implementation that are of interest to Midwest farmers and related stakeholders. Primarily the interest lies in mid-market opportunities, reflecting intentions outlined previously. In these systems, likely livestock operations that need to manage manure and other waste, there is an incentive to use perennial biomass as a co-digestate. Whether the livestock operators grow the crops to add as co-digestate themselves or contract with local farmers to do so, there is a consistent demand for these crops.

Byproducts of anaerobic digestion and pyrolysis are also compelling to stakeholders—primarily biochar. This byproduct, which can be a soil amendment in lieu of, or in conjunction with, conventional fertilizers, can provide a local economic incentive for farmers. Biochar is becoming a larger focus of regenerative agricultural practices as a key opportunity to reduce leaching and enhance nutrient and soil retention in Midwestern farms.

An important benefit farmers and landowners see in anaerobic digestion and related technologies is the potential longevity of the investment. These facilities are perceived to be more stable than biofuel processors or other existing mid-market opportunities, as many stakeholders are familiar with such facilities, whether or not these facilities are currently utilizing perennial biomass in their digestion processes. In addition, contracts would extend across several years. This immediately offsets the trepidation regarding the fact that perennial bioenergy crops are generally not producing profit in the first 1–3 years of production, given the particular crops.

4. CONCLUSIONS

Overall, the project has proven fruitful in its engagement and in its tool development. The team has been flexible regarding the direction that stakeholders, whether they be coalition members, workshop attendees, or survey respondents, indicate where the bioeconomy can best serve them. We have worked to create a tool and a series of workshops that explain what we know, providing opportunities for us to share our knowledge with and to learn from stakeholders. We have integrated what we have learned into our approach towards analyzing marginal lands and their relationship to the bioeconomy, and we have developed a framework for charting a path forward in regard to policies and in support of farmers and other stakeholders. The following sections will explain this path further:

4.1 SUPERBEEST ACCESSIBILITY AND DATA

To best support decision making in a difficult, developing market, SUPERBEEST—with its developing economic capabilities—will need to make clear the conventional long-term and mid-term market opportunities of perennial bioenergy crops for all of those along the supply chain. Providing landowners and farmers with information about local and/or regional companies that use biomass in any capacity (whether for biofuels, anaerobic digestion, biochar or pyrolysis, bedding for livestock, etc.) is important to reduce uncertainty regarding the viability of any given perennial bioenergy crop. Integrating anaerobic digestion facilities to the list will also enhance these capabilities.

Transportation costs are very important regarding biomass and can be a limiting factor for cost viability. Consequently, analyzing and communicating these costs is important in decision making around bioenergy crops and bioenergy facilities. SUPERBEEST's next phase should integrate distance and transportation costs, particularly for rail and waterways, considering stakeholder feedback has shown heightened interest in these transportation methods.

Accessibility is also about making the tools intuitive. Through the course of this project we have noticed that SUPERBEEST may have two separate distinctions that should be represented by two different user interfaces: 1) SUPERBEEST analysis for individual farms and/or fields and 2) SUPERBEEST analysis for a large geospatial area. The prior framework is conducive for farmers and landowners who want to explore bioenergy crop production on their own land; the latter is for those in the bioeconomy or researchers interested in regional assessments of these regenerative agricultural measures. Streamlining the experience for these two different types of users can make the data more meaningful and easier to understand.

Refining the valuation is another important component to enhance in SUPERBEEST. Stakeholders across the board ask about the potential for ecosystem services or finer details regarding payments. Significant research and modeling are ongoing with regard to these estimates; the process is not straightforward. nor is there consensus on the valuation process. Despite that, creating ballpark estimates that are clearly accessible to the public may be beneficial and lend credence to the rest of the tool.

4.2 PERENNIAL BIOENERGY CROP MARKETS SHOULD MIMIC EXISTING COMMODITY CROP MARKETS

Farmers have indicated an interest in perennial bioenergy crops if the market and structure of growing, harvesting, and selling the crops are similar to the commodity crop market structures they are accustomed to. Consequently, the process should look like corn and soybean in that the producers are selling to a larger market. Producers are not interested in local, self-contained distribution systems and managing local energy systems. Similarly, there should be security across multiple years to protect from risk, especially in the establishment year(s) of these perennial bioenergy crops.

Farmers and landowners appear to be somewhat flexible regarding establishment and harvesting contracts. In regard to perennial bioenergy crops, opportunities exist for farmers to lease the land to a third party who can manage the crops on their land. This is similar to existing practices and is reflective of current biogas facilities using anaerobic digestion in places like Iowa and northern Missouri. This strategy is particularly attractive because it offsets uncertainties regarding unfamiliarity with the product; the landowners reduce the typical risks of a new crop by entrusting the care and management to a third party. As familiarity grows, interest in growing the crops directly may arise, but third parties provide stability and comfort through a guaranteed contract.

This practice will require a scaling up of the supply chain, as unprocessed biomass is expensive to transport due to the ratio of weight to energy. Smaller storage and processing facilities distributed across the landscape would minimize the landowner's cost of shipping harvested biomass to a processor. For the sake of biofuel processors as well, minimizing the weight of goods transported is cost- and energy-effective.

4.3 CRP AND PERENNIAL BIOENERGY CROPS ON MARGINAL LANDS SHOULD NOT BE AT ODDS WITH EACH OTHER

CRP is a highly normalized practice with farmers and landowners to allow them to engage in environmentally desirable management behavior without sacrificing profits or investing in novel management practices in marginal or undesirable tracts of land within a field. The targeted application of perennial bioenergy crops in marginal lands should be complementary or reconfigured in some manner to better synergize with CRP.

Feedback from technical assistance workshops, the Midwest Bioenergy Coalition, and other webinars have all raised the question regarding this accidental competition between CRP land and other regenerative agricultural methods. Stakeholders would often state that it did not seem worth the effort to improve environmental conditions through the risks of farming a new crop, when they could instead achieve similar benefits with a steady payment that involves little to no management on their end, particularly with no need to harvest and sell from CRP land.

Consequently, SUPERBEEST's efforts to explore other incentives for growing bioenergy crops on marginal lands, such as ecosystem service payments, will be valuable to offset, or at least make payments more compelling. In addition to market rate prices for biomass, such payment plans could make the adoption of biomass crops more compelling and more profitable

than entering land into CRP, prices of maintenance and harvest notwithstanding. Highly marginal lands would likely garner higher ecosystem service payments due to the likely higher reduction of nutrient loss, soil retention, and/or carbon sequestration. In other words, these highly marginal areas are where ecosystem service payments could pay more per acre because these regenerative practices have a greater impact. Therefore, these highly marginal lands with higher ecosystem service payments may be more likely to be converted to perennial bioenergy crops as the per-acre payment may be higher than CRP payments, while areas of low marginality may be more competitively paid by CRP.

4.4 THERE NEED TO BE POLICIES IN PLACE TO PROVIDE MULTI-YEAR STRUCTURAL SECURITY FOR FARMERS, WITH VISIBLE MARKETS

Policies should be developed to encourage the adoption of perennial bioenergy crops, regardless of whether the crops are currently being grown for biofuel or related bioenergy technologies. Farmers have indicated that this type of perceived security is valuable, as it is a tangible, visible offset to risks associated with growing biomass for bioenergy and related markets. The first risk is simply the risk of working with a new crop: growing, maintaining, and harvesting it. Farmers know they will have to acquire innumerable personal day-to-day and seasonal practices and strategies, regardless of the amount of technical assistance they receive. Second, working within a new market implies differences in harvesting techniques, schedules, learning and building new relationships, and exploring new opportunities as they arise. Compared to the well-reinforced structures of conventional corn and soybean, this certainly can appear risky.

Multi-year structural security is necessary to offset the unknowns and perceived risks and/or barriers. Stakeholders have stated that this type of security will allow them the flexibility to try something new, especially when first-year bioenergy crop harvest likely comes at a loss, if the crops can be harvested at all. Stakeholders also indicated that this security comes through contracts and market structures that are similar to preexisting agricultural markets. While small-scale, on-farm processing of biomass may provide ”security” in the sense of energy stability, this is not a type of security or resiliency stakeholders identified as necessary. Instead, multi-year contracts set up with a purchaser or distributor is highly desirable; farmers and landowners would like to see their crops grown, harvested, and transported off their farm.

Consequently, creating policies that support mid-market opportunities (or at least creating opportunities for existing mid-market opportunities to connect in a formal market) may be helpful for the bioeconomy in the long run. Creating a network or distribution hub for biomass may simplify the process, creating an easier way for potential purchasers of biomass (processors of biogas, biochar, or animal husbandry operations are interested in biomass for bedding or waste management, etc.) to reach out to farmers. Currently these markets rely heavily on person-to-person interaction to develop such relationships. A system or structure built to expedite these relationships can help encourage growth in this sector in straightforward ways. Identifiable structures and mechanisms for those interested in the bioeconomy is itself an advertisement of the faith and credibility of the market.

4.5 EXPLORE THE INTEREST IN SHORT-ROTATION WOODY CROPS

As previously mentioned, many stakeholders come to our workshops and webinars with an expressed interest in SRWCs. The same enthusiasm was not apparent for switchgrass and other herbaceous crops, though once they'd attended a technical assistance workshop, individuals were more open to explore miscanthus and switchgrass. This is evident in individualized technical assistance, where many landowners sought out these herbaceous crops. This is a fairly ubiquitous interest across all states in which we have worked.

Exploring how and why this opinion is so consistent may be necessary to better understand the perceived barriers, opportunities, and desirable elements of adopting perennial bioenergy crops. As a result, policies can be tailored to address these apparent enthusiasms about SWRCs; perhaps focusing bioeconomy investments in areas where SWRCs are practical or communicating herbaceous bioeconomy opportunities in ways that align with whatever makes SWRCs desirable to stakeholders. In order to do so, we recommend further workshops and webinars to explore stakeholder perceptions on biomass crops and regenerative agriculture as a whole.

4.6 GROWING THE MIDWEST BIOENERGY COALITION TO CONTINUE PURSUING THE GROWTH OF THE BIOECONOMY

Our collaboration with American Farmland Trust has proven fruitful in engaging with a wide audience. In particular, the Midwest Bioenergy Coalition has been an important component of this engagement. This coalition has created a collaborative space to share news, updates, and compelling research in the field, and fomented a dialogue with individuals representing a wide array of facets of the bioeconomy.

Continuing to attract more people to the coalition, strengthening its purpose and level of collaboration, and creating more tools for discussion are all important ways we can connect and enhance relationship building and strategies to strengthen the bioeconomy. These conversations will change as time goes on, but it is important for those interested or currently involved with the bioeconomy to stay up to date and aware of each other in the Midwest.

Appendix A

Farm Energy Consumption Survey Results Summary

Perennial Bioenergy Crop Diversification Project

Farm Energy Consumption Survey

Results Summary

January 2023

American Farmland Trust

Contents

Executive Summary

American Farmland Trust (AFT) is a national organization dedicated to protecting farmland, keeping farmers on the land, and promoting sound farming practices. AFT's Midwest regional team focuses on areas of conservation agriculture such as but not limited to farmland protection, ag policy, watershed focused conservation, smart solar siting, and crop diversification. AFT is collaborating with Argonne National Laboratory (ANL) to broaden crop diversification and farm resiliency efforts in Illinois. This collaboration will explore opportunities to support the Illinois agricultural community through the deployment of a bioenergy supply chain and to create opportunities for biomass producers, bioenergy users, and environmental entrepreneurs. These opportunities aim to provide economic and environmental resiliency to farms.

Energy Survey

In the first step in assessing the current state of the Illinois bioeconomy, AFT and Argonne National Laboratory employed the "Farm Energy Consumption Survey." This survey aimed to reach farmers in Illinois to assess the state of energy usage on farms throughout the state. Additionally, this survey sought to understand farmer opinion regarding the adoption of perennial bioenergy crops on marginal lands. Key demographic information was also an interest of this survey: age, gender, and type of farming were important information to learn for the project as AFT aims to conduct outreach to a wide variety of farmers and landowners in Illinois agriculture. The infographic below highlights the key findings of the survey.

KEY HIGHLIGHTS

ABOUT THE FARM ENERGY CONSUMPTION SURVEY

61

FARMER RESPONDENTS

Across 42 counties in Illinois.

Farmer Education

Results indicate the need for more education of renewable energy systems for on-farm use such as pyrolysis and anaerobic digestion.

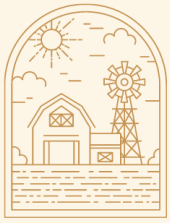
Renewable Energy on Farms

72% of farmer respondents do not produce any renewable energy on their farm. They rely on traditional fuel sources like electricity from the grid, diesel, gas, and propane.

54% of farmer respondents identified having marginal lands on their farms.

Barriers to Adopt

Farmer respondents identified (the lack of) availability of biomass off takers as the primary barrier to adopt bioenergy crops on farms.



- 47 farmer respondents would prefer to sell biomass feedstock to a biorefinery before implementing on-farm renewable energy systems.
- 5 farmers would prefer to use an onsite biochar kiln; 3 other farmers who would prefer to use an on-site anaerobic digestor to produce energy.

Median monthly energy costs on farms is $375.

Capital expense of investment & cost of labor and maintenance of on-farm renewable energy systems are a major concern for farmer respondents.

ACREAGE MATTERS

All farmer respondents with more than 1,000 acres indicated they would be willing to adopt renewable energy systems on their farms.

76% of farmer respondents identified as male & 18% identified as female.

THIS PROJECT IS SUPPORTED BY ARGONNE NATIONAL LABORATORY

Recommendations

The key findings of this survey will allow American Farmland Trust to refine its outreach strategies and recommendations for the Perennial Bioenergy Crop Diversification Project. The following recommendations will further goals and objectives throughout the duration of the project:

- Most farmers indicated they would rather sell biomass produced on their farm to biomass refineries. With this insight, AFT will refine its outreach strategy to recommend various biomass processing opportunities to farmers in the area and focus efforts to connect interested farmers with available biomass processing facilities.
- It is recommended that AFT and Argonne National Laboratory continue to promote the project while simultaneously educating farmers on areas of perennial bioenergy crop production and biomass utilization. Many farmer respondents indicated they are unfamiliar with concepts related to biomass feedstock processing.
- Due to lack of representation in Southern Illinois, it is recommended that AFT focus outreach efforts in that region to fully understand general farmer opinion on the concepts presented in the survey.

Limitations/Impact

Key limitations of this survey were primarily due to representation of survey respondents. Geographic range of the state was limited to the north and central regions of the state. Farmer representation was low in the southern half of the state. Additionally, the total number of respondents was a limitation to the representation of these survey results as it does not accurately represent the breadth of agriculture in Illinois. Going forward, these limitations can be mitigated through optimizing outreach and promotional efforts to maximize reach of survey completion.

Background

In recent years, there has been a noticeable increase in the diversification and installation of alternative energy sources. This increase also coincides with the emergence of the potential for a robust bioeconomy in the Midwest. This includes renewable power technologies and organic waste streams from agricultural activities to create energy through processes like anaerobic digestors for combined heat and power generation, biochar production for soil amendment and heat generation, and renewable natural gas (RNG). AFT's collaboration with Argonne National Laboratory strives to acknowledge this shift with a project that aims to connect with and provide technical assistance to farmers who wish to transition marginal or unproductive areas of their land to grow perennial bioenergy crops. This effort seeks to repurpose marginal lands using perennial crops to provide additional economic opportunities while boosting farm resiliency. The crops recommended for this transition include switchgrass, miscanthus, native prairie mixes, shrub willow, and poplar. These perennial bioenergy crops are harvested for their biomass feedstock to generate fuel for heating, electricity, and biochar. This feedstock offers farmers the opportunity to sell to biorefineries in the region or process the biomass on their farm with energy producing technologies.

Objectives

This project explores how to support the transition of marginal land to grow perennial bioenergy crops. This project also aims to provide additional economic opportunities for farmers in Illinois through the

adoption of these crops. The "Farm Energy Consumption Survey" was the first step in connecting with farmers to learn more about marginal land and individual farm capacity to create new economic pursuits in the renewable energy space. The purpose of the survey was to assess farmer needs and opportunities for adoption of perennial bioenergy feedstock crops. Respondents had the opportunity to share energy consumption details about their current operation and vocalize familiarity and interest in adopting on-farm bioenergy systems. The survey also identified educational opportunities in the agricultural community on perennial bioenergy crops that will allow AFT to refine outreach strategies for the duration of the project.

Methodology

To gather information about the energy needs and interests of Illinois farmers, AFT and Argonne National Laboratory conducted a survey on the energy production and consumption on Illinois farms. AFT conducted this public outreach survey from July to September of 2022. AFT staff promoted the survey at various field days and agricultural events throughout the state. Survey marketing encouraged participation by selecting four random farmers to receive honorarium for responding to the survey at the time of closing. Additionally, social media campaigns helped promote the survey. Social media campaigns for the survey reached approximately 50,928 people with 878 post engagements.

Results & Discussion

The survey was open to the public from July to September 2022. 61 farmers responded, answering 26 total questions. The majority (76%) of respondents identified as male farmers, while 18% identified as female farmers, and 5% preferred not to disclose their gender. Of the respondents,98% identified as white. The farmer respondents of this survey range widely in age diversity. The chart below indicates the broad range of age diversity amongst farmer respondents. Results indicate that younger farmers are more likely to produce energy on their farms and use on-farm renewable energy systems compared to respondents over the age of 55, who would prefer to sell biomass to an offsite refinery.

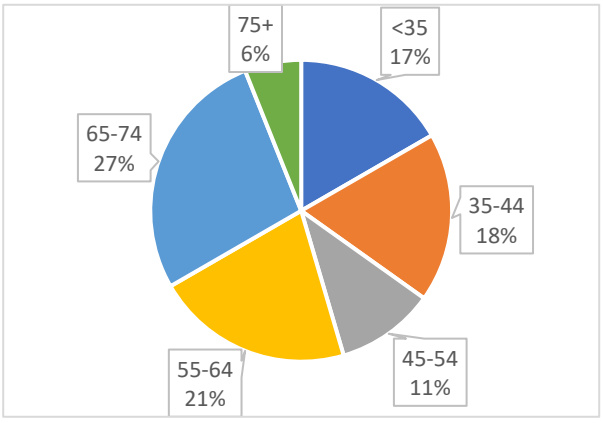


Figure 1 Chart showing age demographic of farmer respondents.

Farmers identified growing a diverse range of commodities such as corn and soy (56%) and livestock (11%) to a variety of other crops. Farming operations of respondents ranged widely in revenue, ranging

from under $10,00 annual gross sales, to over $1,000,000. Survey respondents operate farms located in 42 counties spanning a broad range of Illinois agriculture. Representation in southern Illinois counties was lesser than the northern half of the state. The map below identifies the counties that received at least one response.

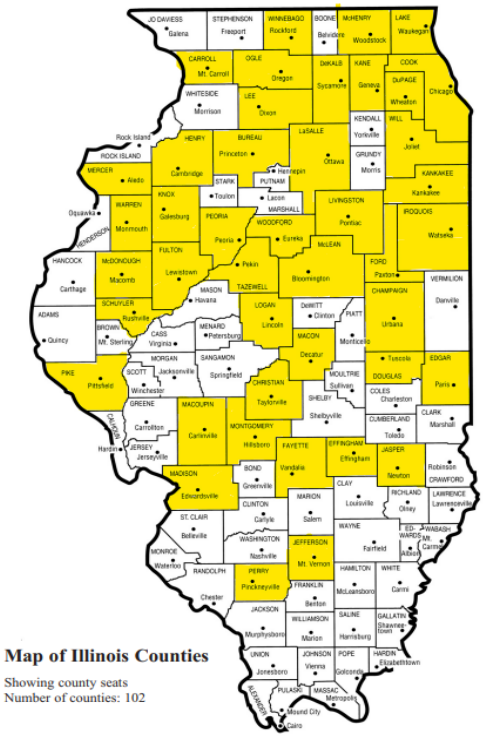


Figure 2 Highlighted Illinois Counties showing geographic range of survey respondents.

The results indicate the need for more education regarding renewable energy and relevant technologies. Explanations in the survey responses show that many farmers in Illinois are not familiar with technologies related to anaerobic digestion and bio-char production. Some respondents asked for workshops and seminars to learn more about them.

Most of the farmers who participated in the survey indicated they did not produce any energy on their farm and rely on traditional sources for energy such as electricity from the grid, propane, gas, and diesel to power their farming operations. Aside from personal use, fuel for equipment and grain storage and drying operations were the primary energy needs on the farm. Of the 21% of respondents who indicated they were producing renewable energy on their farm, most of these systems were solar and wind technologies. Concerns were raised regarding capital expense, time, and labor related to installing and maintaining renewable energy systems on the farm. Farmers reported the following when asked if they would prefer to use biomass feedstock on-farm or selling off to a biorefinery: "Solar is providing all of my current electric energy needs. Anaerobic digester and kiln sounds expensive" and "I am not familiar with on-site digestion chamber or biochar kiln so I would need more information on those 2 options before considering. Mainly concerned with logistics and aesthetic of both options."

NOTE: The opinions expressed in this survey are not representative of all farmers in Illinois. This data is also subject to rounding errors as a result of multiple-choice formatting. Therefore, some questions will have a total percentage above 100 percent.

The key findings from this survey are as follows:

- The median monthly energy cost of farmer respondents is $375.
- Most respondents (71%) do not produce energy on their farm.
- Of the 31% of farmers who claim to generate renewable energy on their farms, only 6% generate between 75-100% of the energy needed for their farm operations.
- Most farmers (73%) would prefer to sell their biomass harvest to a processor over using an anaerobic digestor or biochar kiln.
- Primary barrier to the adoption of bioenergy crops is (lack of) availability of biomass off takers.

- 44% of farmers indicated they would only consider siting renewable energies on land not suitable for crop production or pasture as well as on marginal fields. The other 56% of respondents noted they would consider investing in renewable energy if it provided additional income or if it provided other benefits to their farms such as soil health and resiliency.
- 54% of respondents identified having marginal lands on their farms.

These results helped identify general farmer opinion regarding the adoption of on-farm renewable energy systems and willingness to adopt perennial bioenergy cropping systems across a variety of farms throughout Illinois. Additionally, it provided insight into why farmers are interested in these systems, as well as why they may not be supportive of these technologies on their farms. Most respondents indicated the three most important considerations for the generation and use of renewable energy are to reduce energy bills (22%), supplement income (17%), and to fight climate change (10%). Farmers in support of these technologies vocalized interest in the application of biochar on their fields. The information gathered from this survey will allow AFT and Argonne National Laboratory to refine their outreach strategies to farmers and create opportunities for education on the topics addressed in the survey.

Appendices

A. Survey Responses

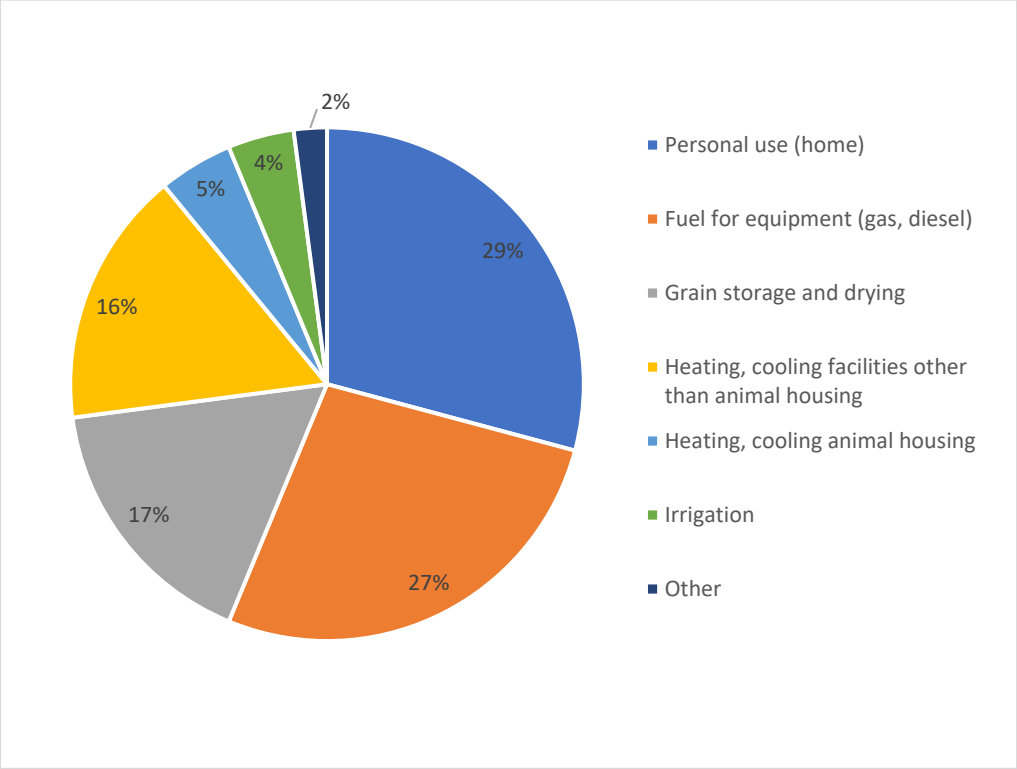
1. In what county is your farm located? If multiple, please choose additional counties in the following questions.

Montgomery
Jasper
Peoria
Bureau
Woodford
Will, Cook
Dekalb, Lee
LaSalle, Livingston
Jefferson, Perry
Douglas, Edgar
Henry, Mercer, Knox
Macoupin
Macoupin
Fulton
Macoupin
Iroquois
McDonough
Effingham, Christian
Effingham, Fayette
Carroll, Ogle
Fayette
Will
Cook
Montgomery
Douglas, Champaign
Henry
Cook, Carroll
Bureau
Livingston, Woodford
Kane
Winnebago
Macoupin
Madison
Warren
Kankakee
LaSalle
Bureau
Macon
Lasalle
Peoria
McDonough, Schuyler
Dekalb, DuPage
Champaign
Logan, McLean
McHenry, Lake
Ogle
Christian
Henry
Ford, Chatsworth
McHenry

McHenry
Lake
Livingston, Pike
Livingston
Tazewell
Iroquois, Ford
Ford

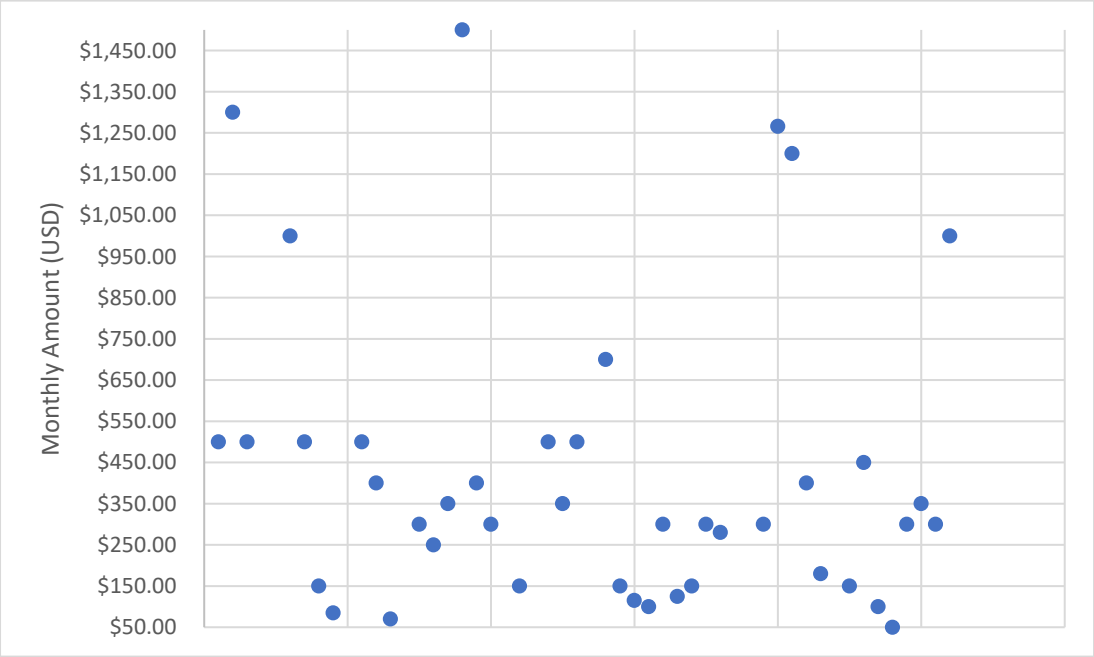
2. How do you use energy on your farm? Please select all that apply.

Figure A-2. Energy Produced on Farm



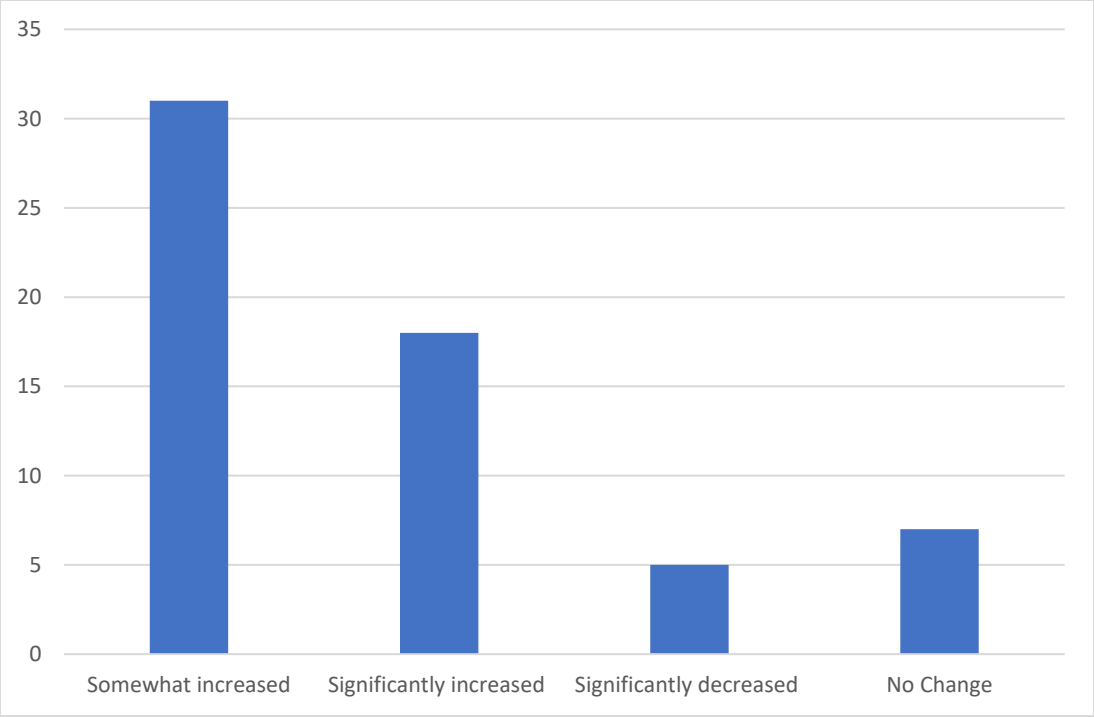
3. How much do you spend per month on average for energy consumption on your farm?

Figure A-3. Monthly Energy Costs



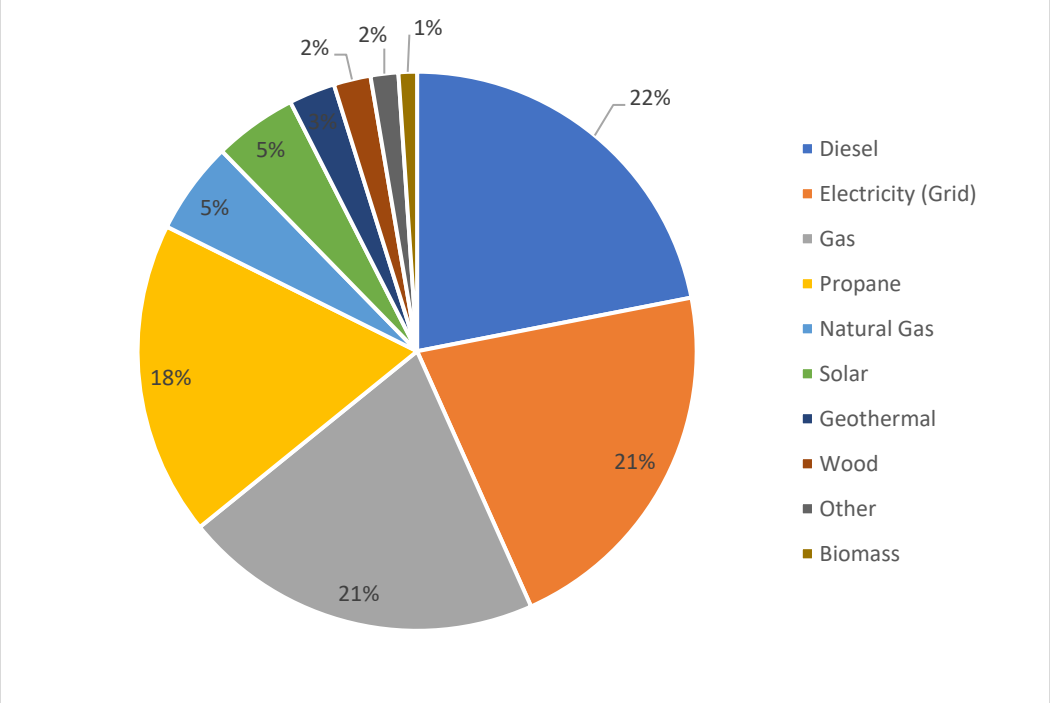
4. How has the average cost per kWh of your farm operation changed in recent years?

Figure A-4. Energy Cost Change



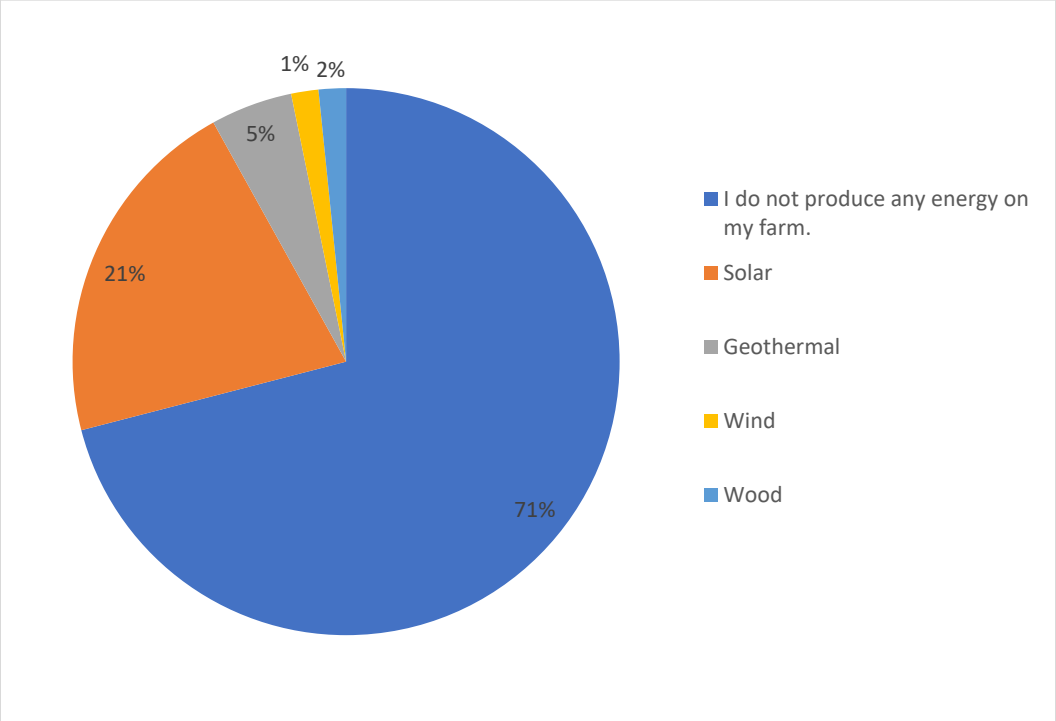
5. What kind of energy do you consume on the farm? Please check all that apply.

Figure A-5. Type of Energy Consumed on Farm



6. Do you generate any renewable energy on your farm? Please check all that apply.

Figure A-6. Type of renewable energy produced on farm.



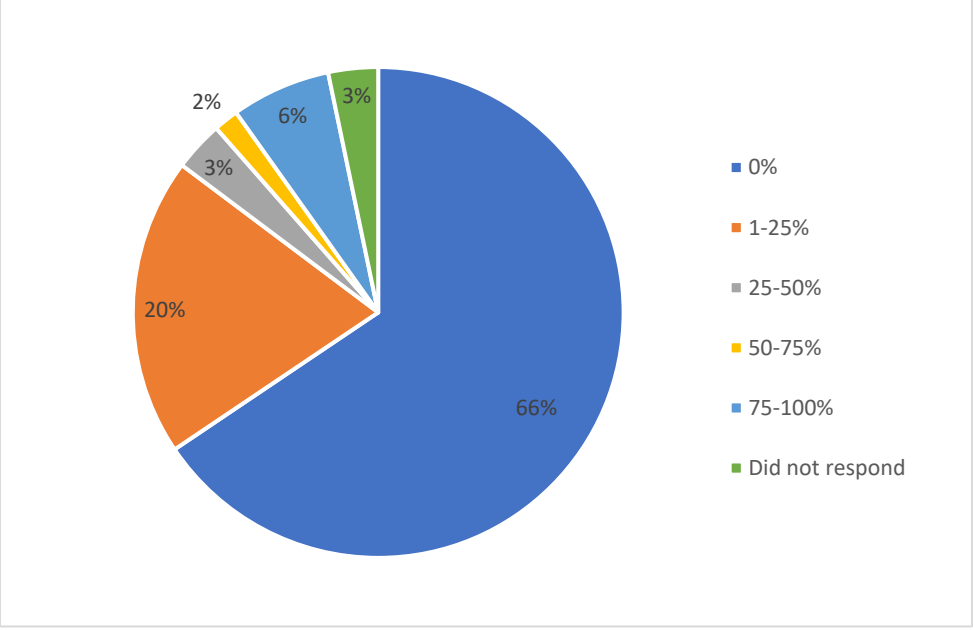
7. Please provide a short summary of your renewable energy operation (if any). Examples include size, typical energy production, equipment.

Table A-7. Explanation

17kw solar
most land is now timbered, either old growth or planted in the last 20 years of so.
Solar system
Just recently installed solar panels at 2 farm locations
Solar panel on side of shop
17kw solar system
250 kW solar array
We have solar panels and are in a net metering agreement with Ameren IP so that we are credited for extra power produced during daytime and those credits are available for use when we're not generating enough with the solar panels. This is typically only at night or on very overcast days. We typically generate 30 to 45KWH per day except on the shortest days of winter.
We have a 20Kilowatt solar system to offset electrical and heating options for the house and sheds
We have a recently installed solar array that provides ~50% of our electricity needs since our electricity supplier has unfavorable net metering terms and we don't have a battery system. The house has a geothermal heating/cooling system. We also use diesel for our equipment and have shop heated by a wood burning furnace.
Solar panels on house
None, but interested
Roof solar on home, connected to grid. Small solar battery for electric fences
Use wood burning stove to heat farm shop through renewable wood

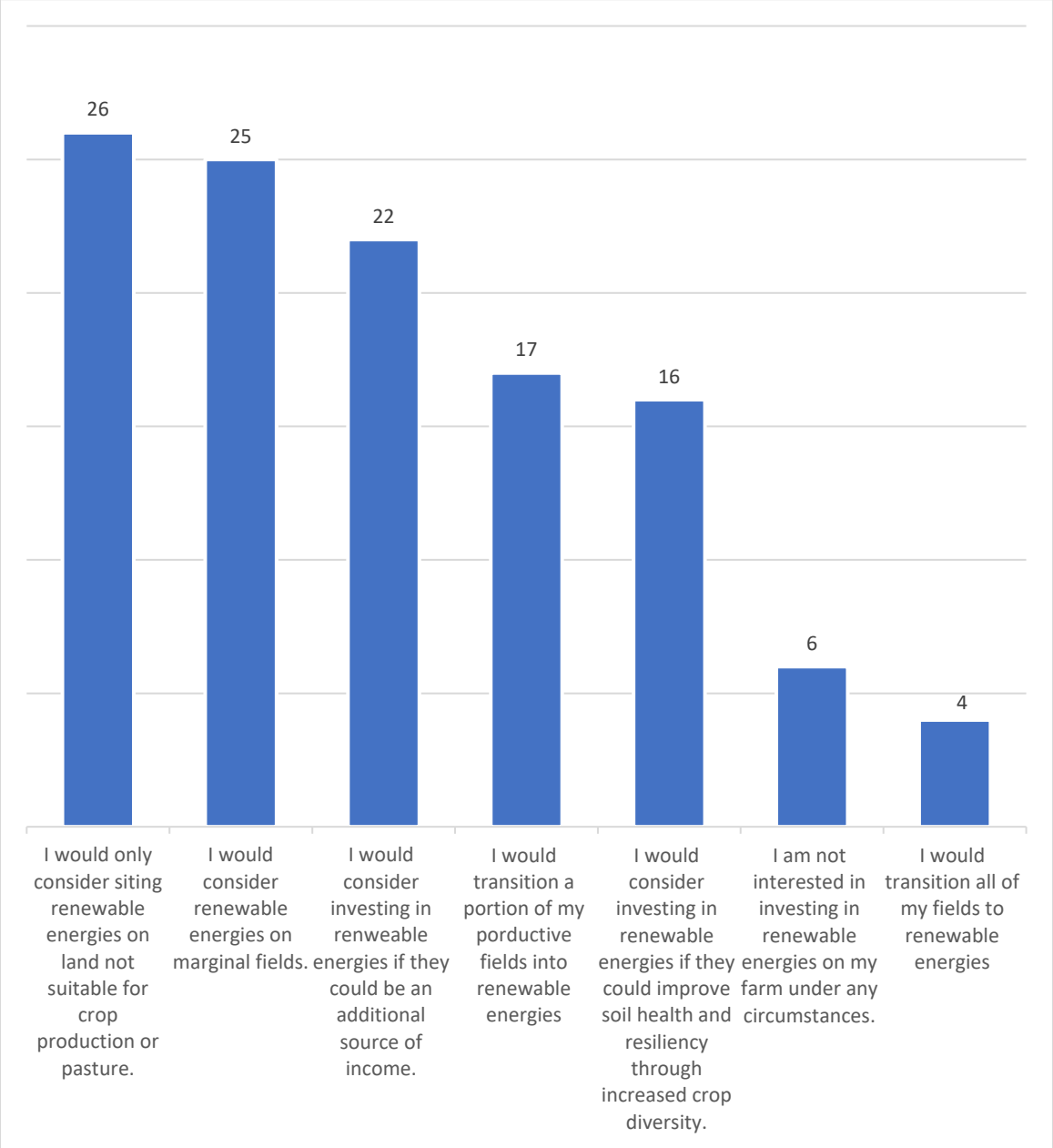
8. If you generate renewable energy on your farm, what percentage of the energy consumed on your farm is renewable energy? This can be solar, wind, biomass/wood pellets, biogas, geothermal, etc.

Figure A-8. Amount of renewable energy consumed on farm



9. Please check any of the following that apply to using renewable energies on your farm to generate electricity for on- and off-farm use:

Figure A-9. Use preference of renewable energy on- and off-farm



**Please note this data is a result of multiple choice formatting.*

10. Do you have any marginal farmland that is typically low-yielding and unprofitable, and that you would consider for other uses, such as bioenergy crops (e.g., switchgrass, miscanthus, willow, poplar).

Figure A-10. Identification of Marginal Land

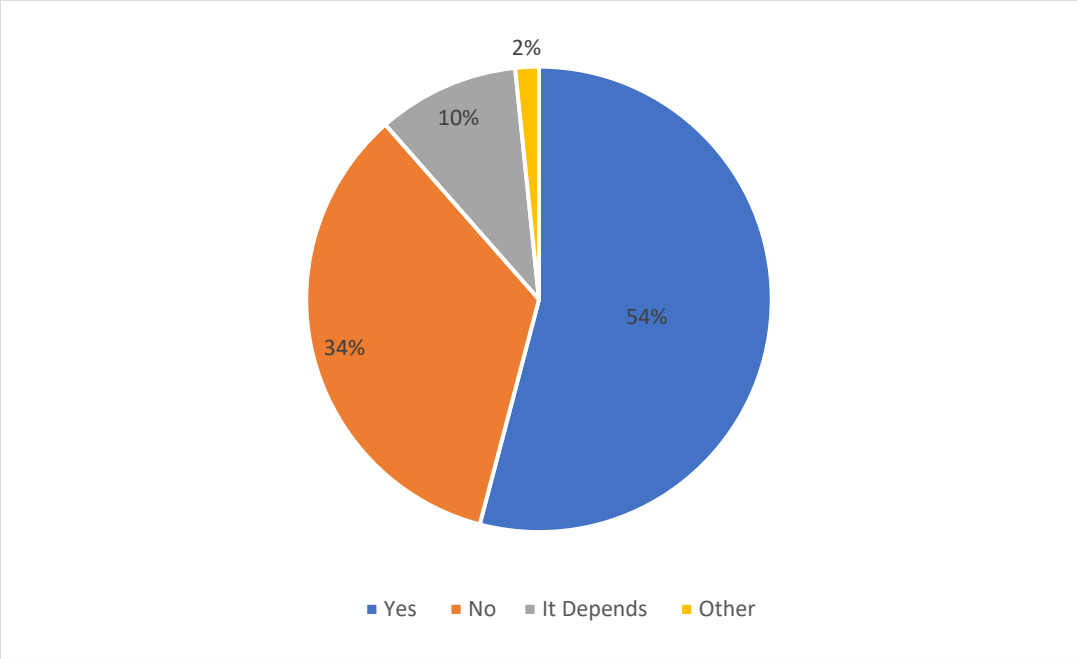


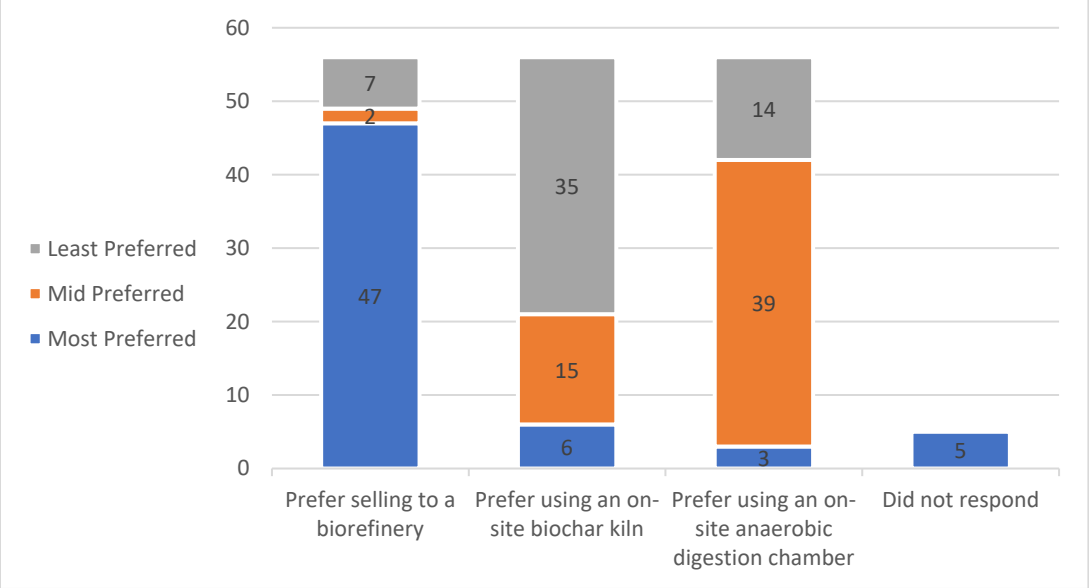
Table A-10. Explanation

We have 20 acres of prairie grass currently;
Land is in a suburban area that also is hilly. Not sure if land would work?
Market availability
I would consider areas of fields that are very difficult to manage with large equipment
In Pike Co. used for hunting
Very wet flooded acres. Landlord would probably not approve or would want income from it.
Already enrolled in CRP

11. Bioenergy crops (e.g., switchgrass, miscanthus, willow, and poplar) can be converted into biofuel at a refinery, which can be used as a fuel source similar to gasoline, or they can be used in an on-farm anaerobic digestion chamber or biochar kiln to generate heat and/or electricity directly.

    If these opportunities were available to you, which would you be more interested in investing in? Please rank your choice from most preferred (1) to least preferred (3).

Figure A-11. Ranking of Biomass Utilization.



**Please note this data is a result of multiple choice formatting.*

12. Please explain your ranking choices in the previous question.

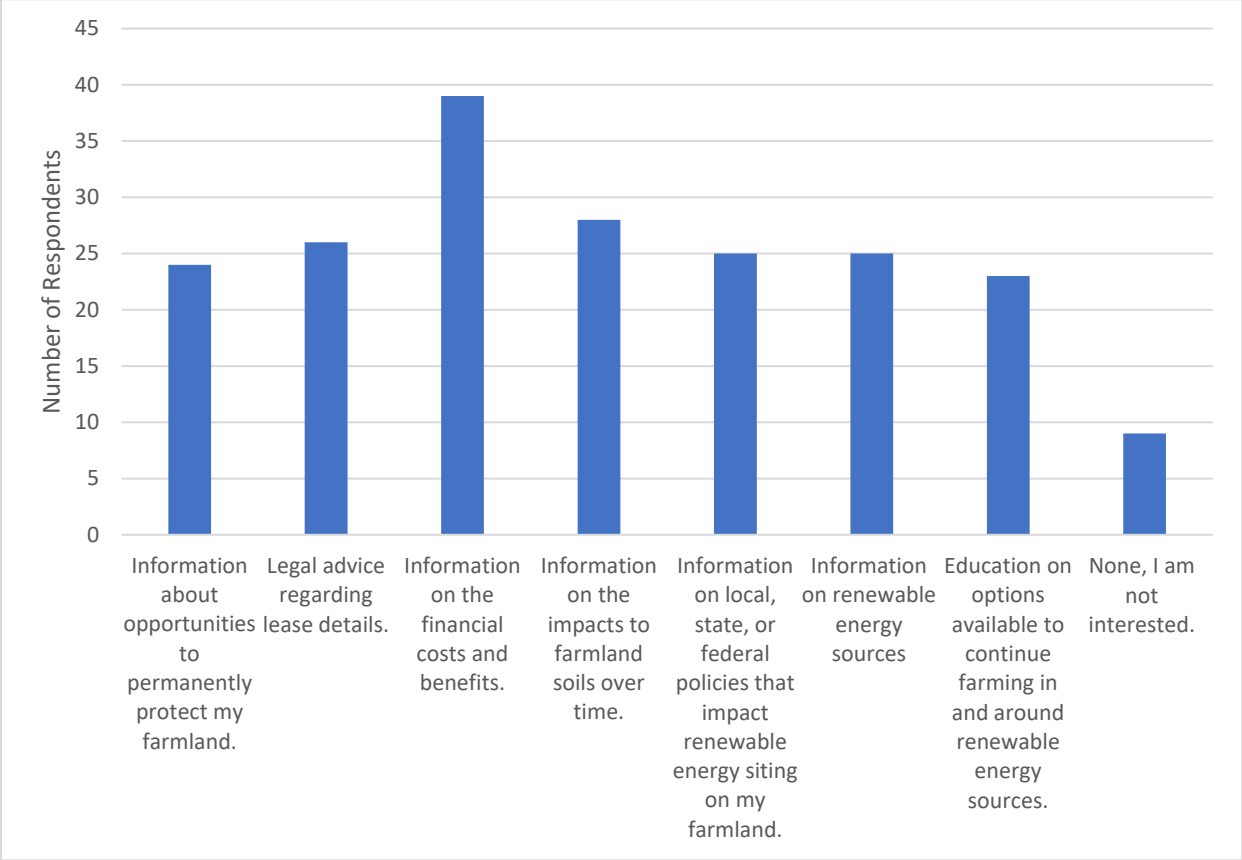
Table A-12. Explanation

3 sounds complicated
I would prefer to be energy self-sufficient and not have to rely on anything else so when the SHTF my family and I will still be ok.
I do not have extra time
Do not want anything extra placed on the farm even though in the long run it may make me more money, it is just a space issue on the farm.
not interested in on site usage
I don't have the time to manage on on-site source
I'm not interested in investing in infrastructure that I'm not familiar with. I would rather provide raw material to someone who knows how to make the infrastructure work.
Would prefer not to have to deal with another process on farm.
No use for Wind turbines or solar .
I don't have time or money to invest in stuff like that.
Convert that biochar close to home and use biochar to recharge the soil.
Would prefer to sell off farm and not have additional infrastructure
Possibly to be used for old blueberry plants and pine bark.
Bio refiner to generate income. An anaerobic digester to generate energy.
Use what is easy.
Don't want to process on my farm.

Until I have more knowledge on these options I will stay with this ranking.
Solar is providing all of my current electric energy needs. anaerobic digester and kiln sounds expensive.
moving the crop offsite would be easiest
I'm assuming I could use the biproduct of the first 2 as fertilizer.
Not really interested in any of the above
Simplicity
Can add biochar to fields
Easiest and least labor.
None of these sound attractive.
Any new crop would have logistics and storage problems that I would not want to deal with. Biochar could be used on farm
Whatever is the LEAST labor-intensive!
I would prefer another source of income and then would consider it for personal use.
I am not familiar with on-site digestion chamber or biochar kiln so I would need more information on those 2 options before considering. Mainly concerned with logistics and aesthetic of both options.
I am looking at building more on-farm energy systems to offset more use.
Sounds like the least work.
I'm not really sure what any of these are or how they would work. This is just a guess on my part at this time.
The size of field and distance for machinery needed.
My operation is too small to make anything other than selling to a biorefinery feasible.
We already have a relatively energy efficient operation and room to expand our solar array if it makes financial sense, so the biggest benefit we would see is using marginal land for a different use. We probably have 70~140 acres that would be a better fit for a perennial biomass crop instead of annual crops. If there was an available market that made economic sense we switch to that system.
I think it's proven that this is not an economically successful venture.
Simplest and lowest capital investment.
Easier to sell it than have infrastructure to process it.
Streamline
I'd prefer anything on a small scale - a kiln or chamber.
Unsure of particular ranking; all seem very useful.
Assuming the cost to set up systems, ranked by capital investment (cost)
Don't have available labor for digester or kiln.
Nearing retirement - not looking for MORE work.

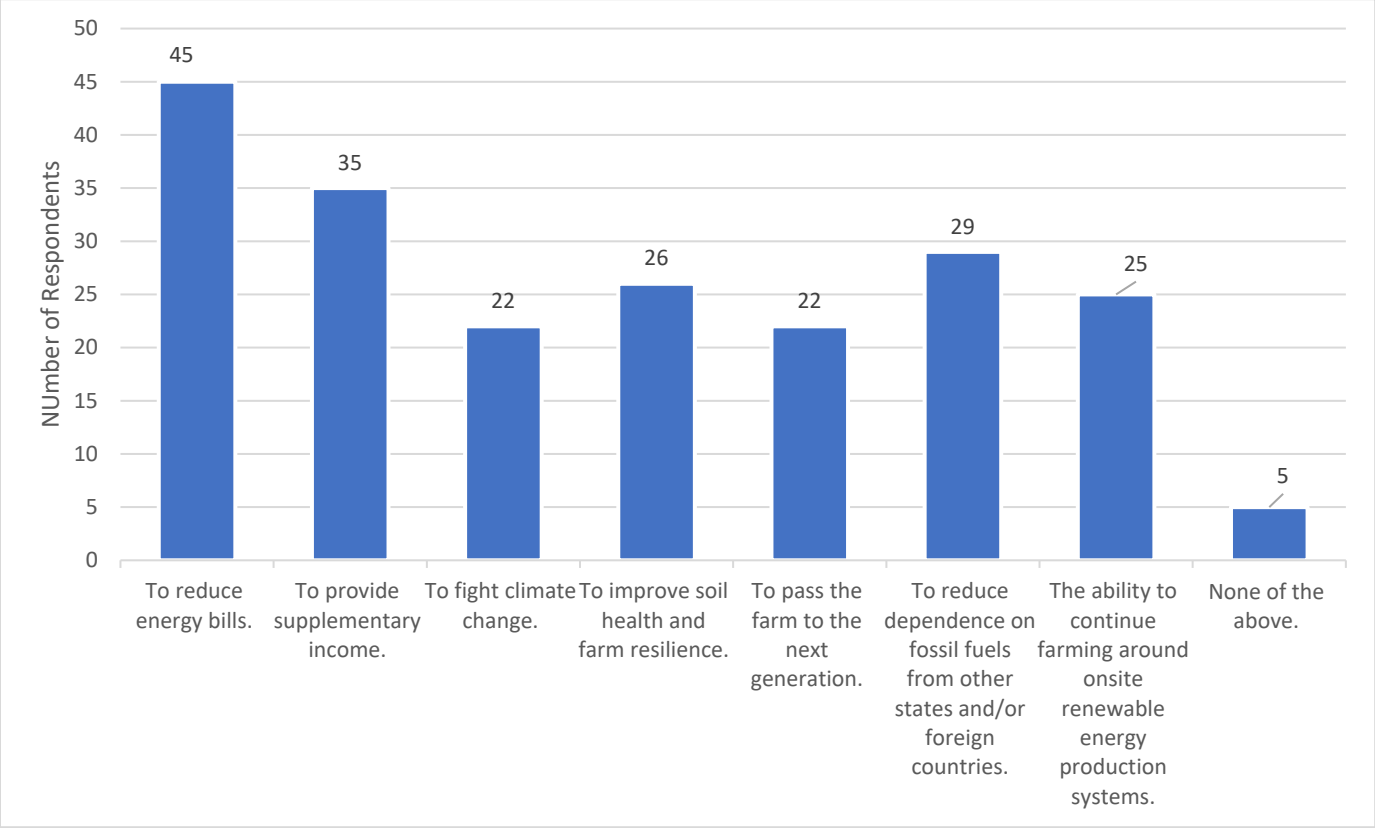
13. Which of the following services or information would help you decide whether to use energy sources other than those you are currently using? Please check all that apply.

Figure A-13. Information needed for renewable energies decision making.



14. Which factors are most important to you when considering the generation and use of renewable energy on your farm? Please select all that apply.

Figure A-14. Most important factors of renewable energy.



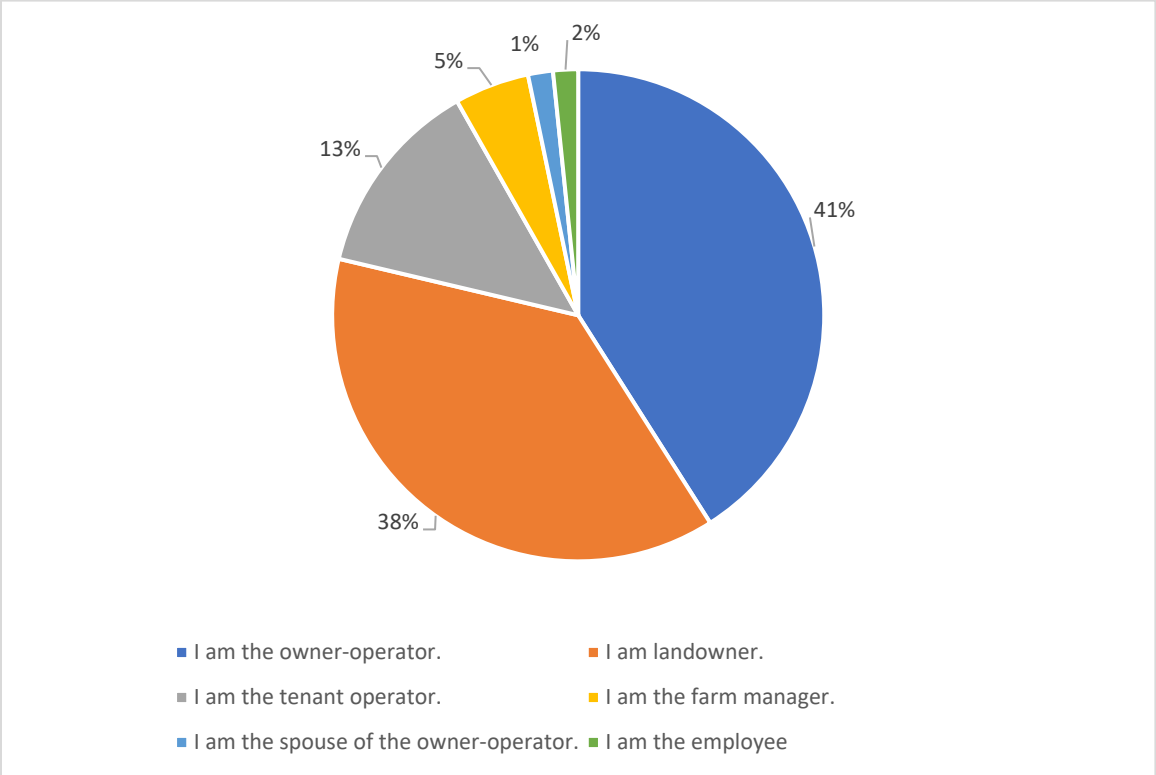
15. Please add any other questions or comments that you might have on this subject or subjects relating to onsite renewable energy production that you would like to see more of.

Table A-15. Explanation

No use for Wind Turbines or Solar.
$
Not a fan of windmills or large-scale solar panel farms. These have too many long term drawbacks.
Full life cycle analysis of various renewable and "clean" energy sources as well as recycling and what happens after the useful life of some of these structures.
This is great!
I am interested in solar farms designed with grazing of small ruminants among the solar panels to generate additional production of food while generating electricity.
Energy systems and wildlife impacts.
Would like to learn more about all of this. Don't know much about anything like this right now.
I might consider installing solar panels to offset some electric costs or participating in a wind farm project.
Need to be shown opportunities of energy sources via seminars, zoom.

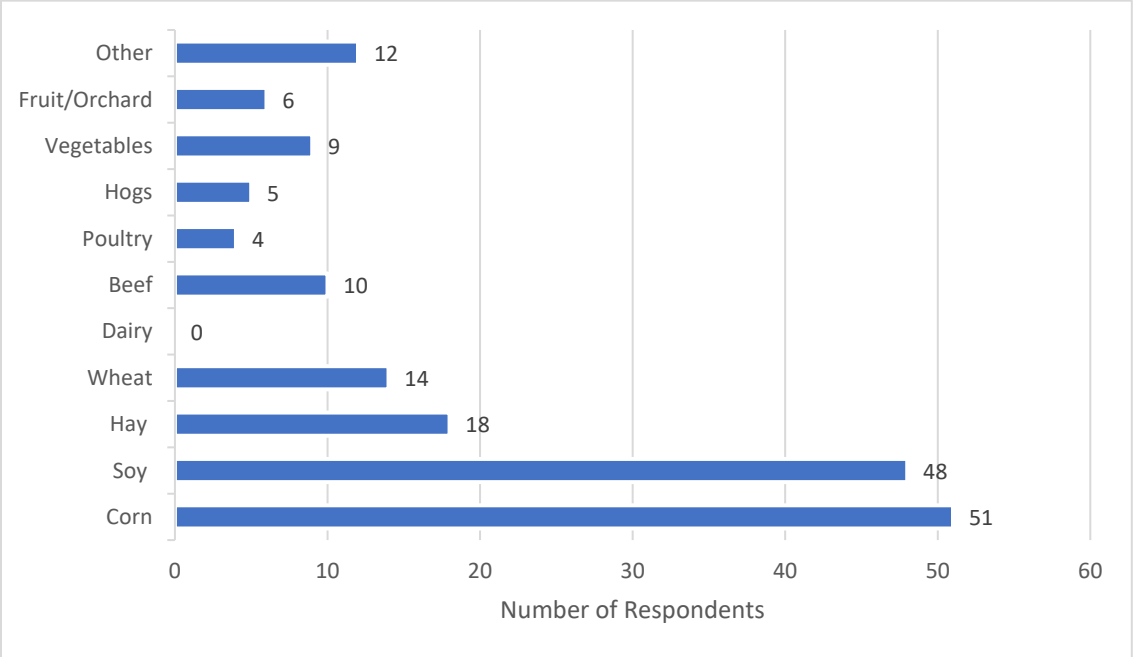
16. Please choose the option that best describes your role in the farm operation:

Figure A-16. Most important factors of renewable energy.



17. Which of the following do you primarily grow or raise on your farm? Please check all that apply.

Figure A-17. Crops & livestock grown by respondents.



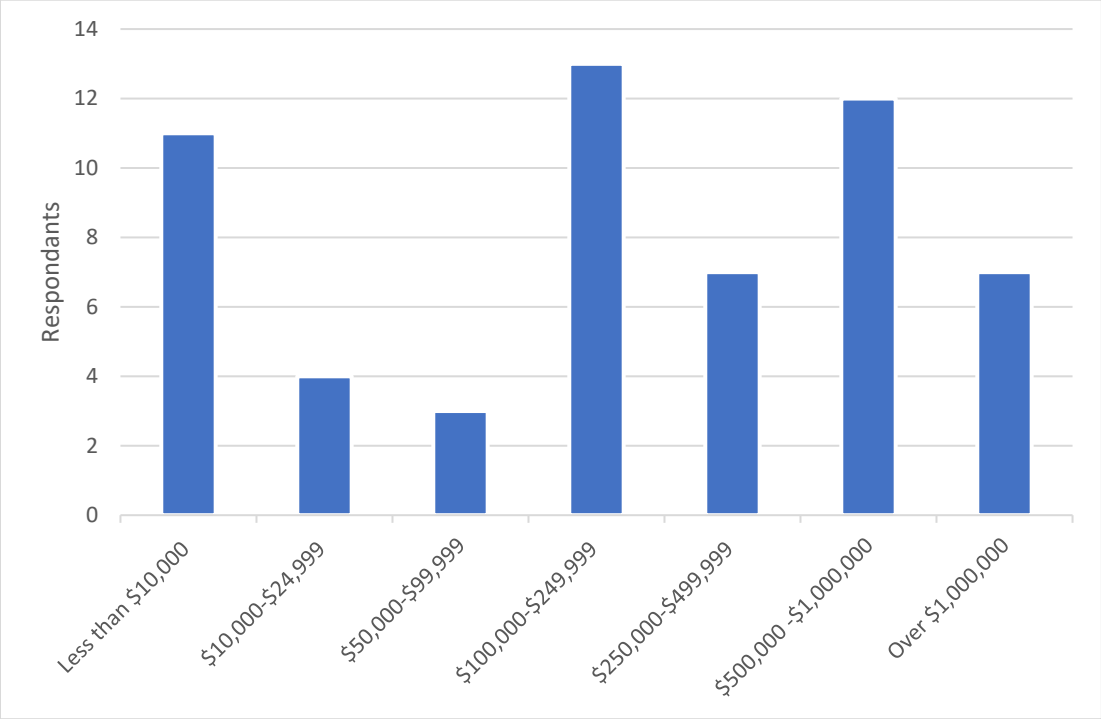
18. If you have livestock, please provide details on what kind and the amount.

Table A-18. Explanation

I don't have any yet but looking to get animals in the near future
70 head beef cow calf
Beef and sheep and horses
Organic
24 Black angus cows
Hogs 3600 finisher; Beef cows 80
Cows
Farrow to finish 220 sows
10 head of cows
In CRP currently
Alfalfa
60 stock cows, finish around 80 fat cattle/yr
Beef steers 5. Sheep 10 hogs 10
I don't own the cattle but during the grazing season I have between 70 and 80 head of yearling heifers and other stocker cattle.
6 stock cows graze the pasture
50 cow calf, 3sows and pigs, 50 chickens
Not right now but I plan for 100% pastured hogs in 2023.
Chickens
small sheep flock; 15-20 head of breeding ewes
Custom feed pigs, 4100 nursery pigs

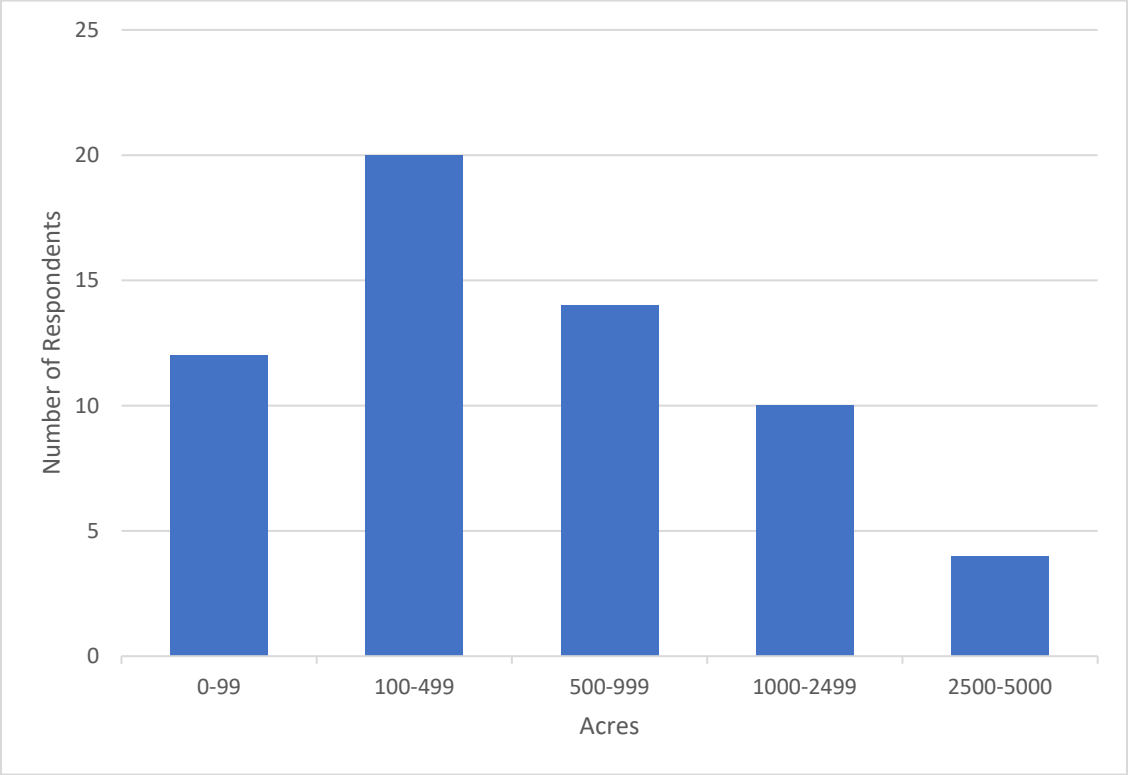
19. In 2021, what was your approximate gross revenue from farm sales?

Figure A-18. Annual gross farm sales revenue.



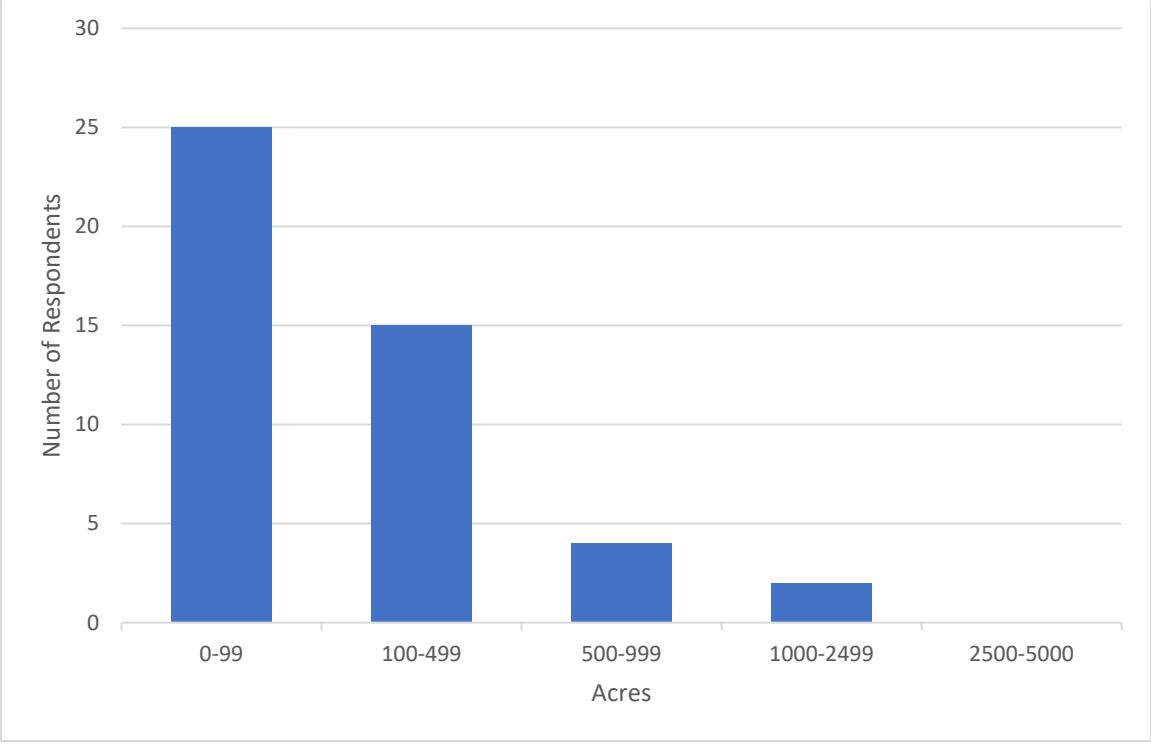
20. How many acres, on average, were a part of the farm operation over the past 3 years?

Figure A-20. Total acreage of farm operations.



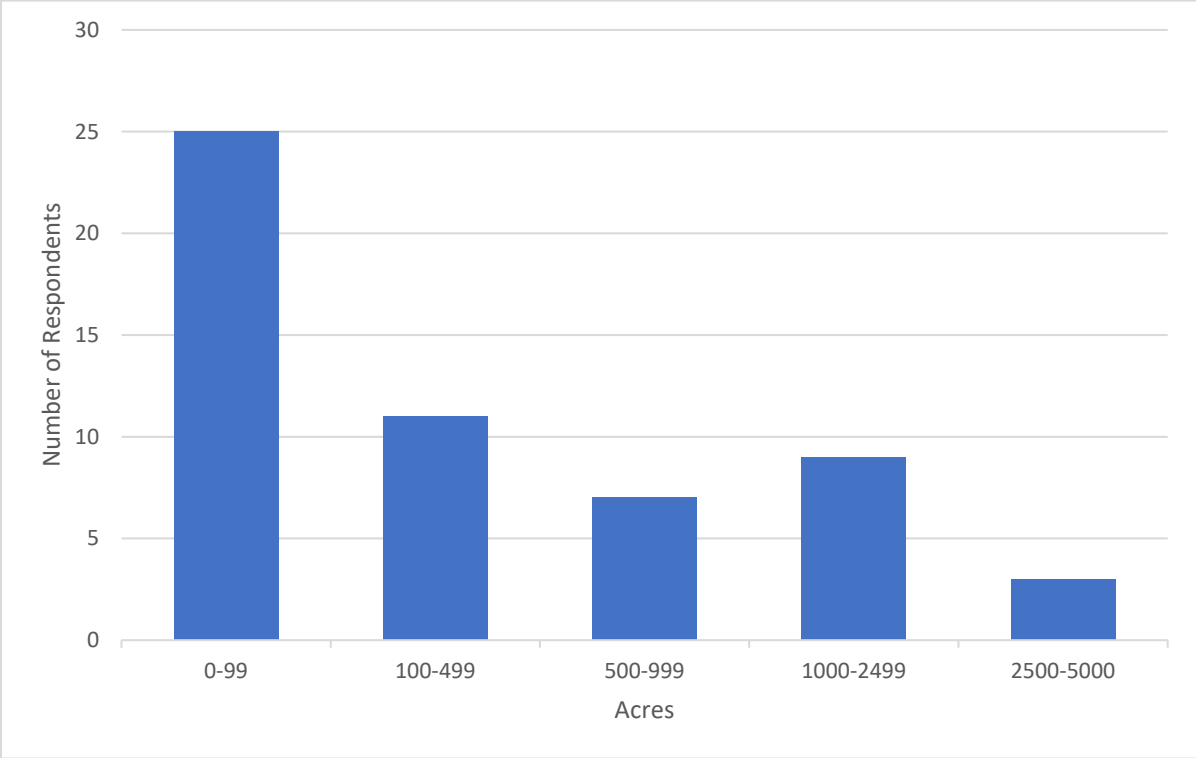
21. Of those total acres, how many are owned?

Figure A-20. Total owned acres.



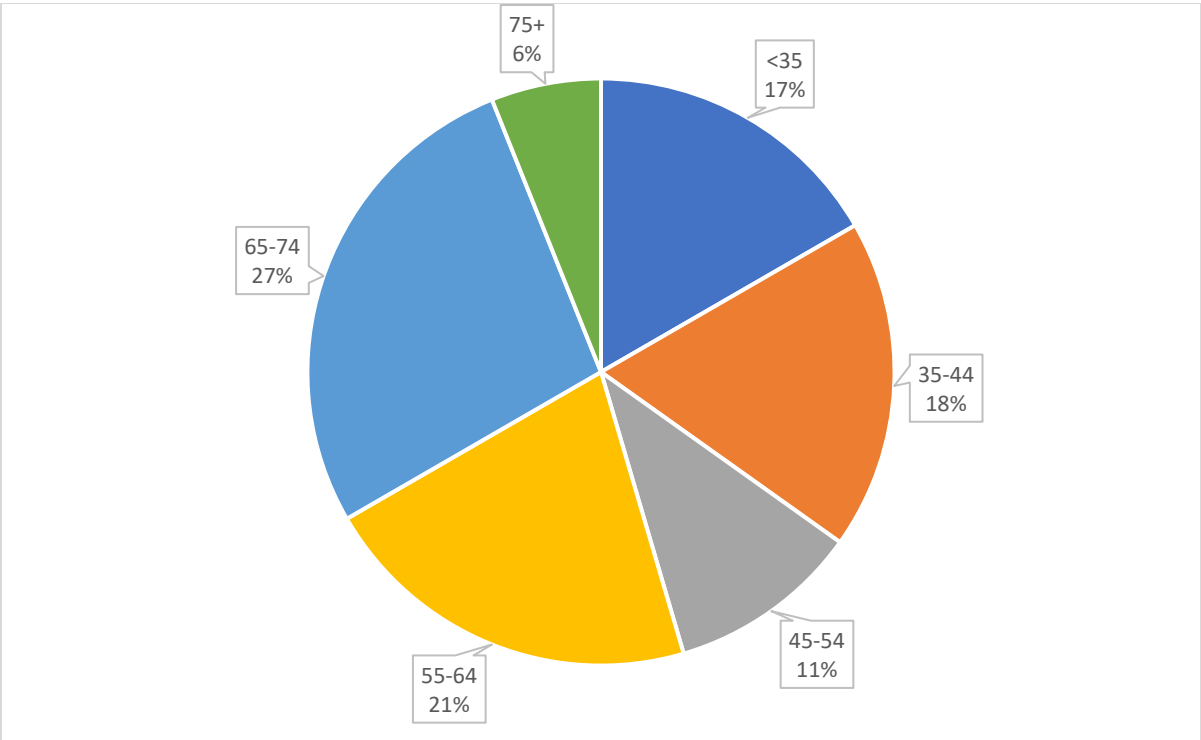
22. Of those total acres, how many are rented?

Figure A-21. Total rented acres.



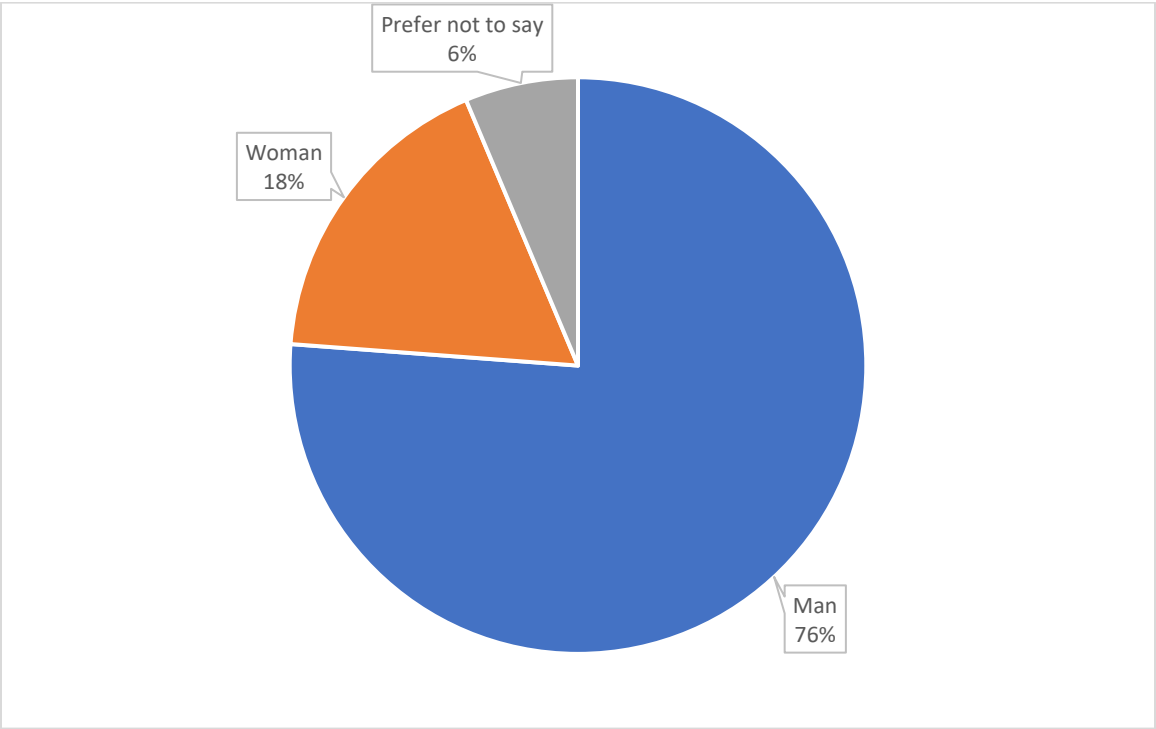
23. Please select your age from the ranges below.

Figure A-23. Age demographics of respondents.



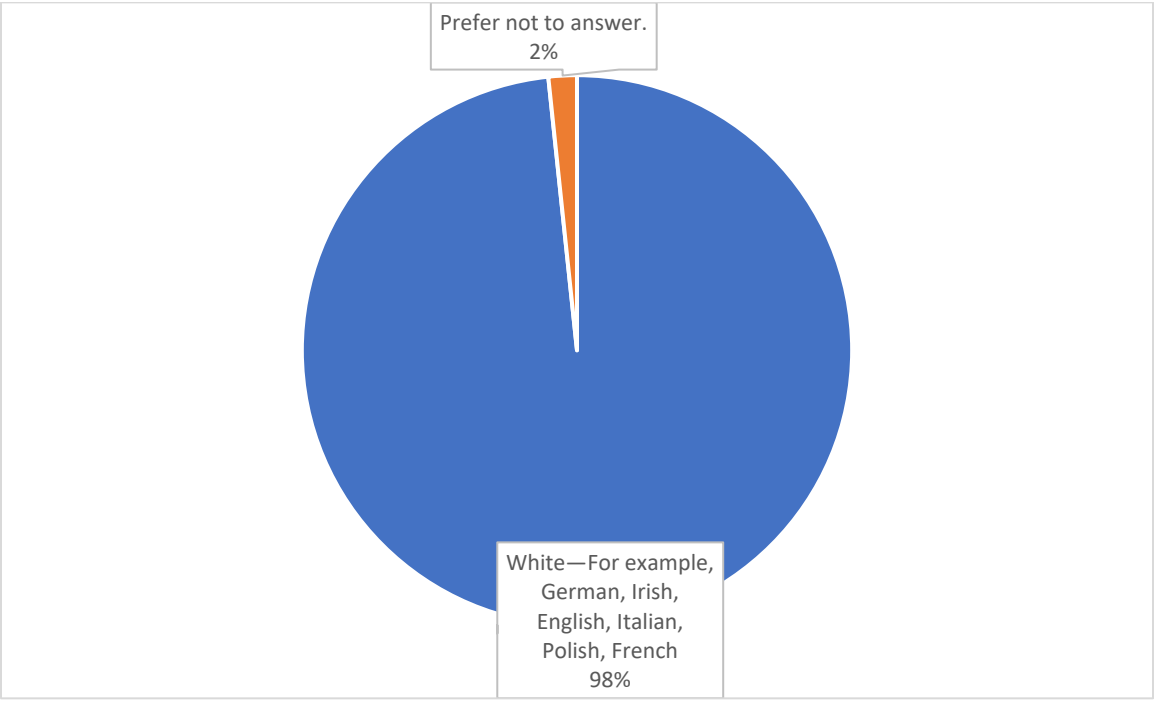
24. How would you describe your gender identity?

Figure A-24. Gender demographics of respondents.



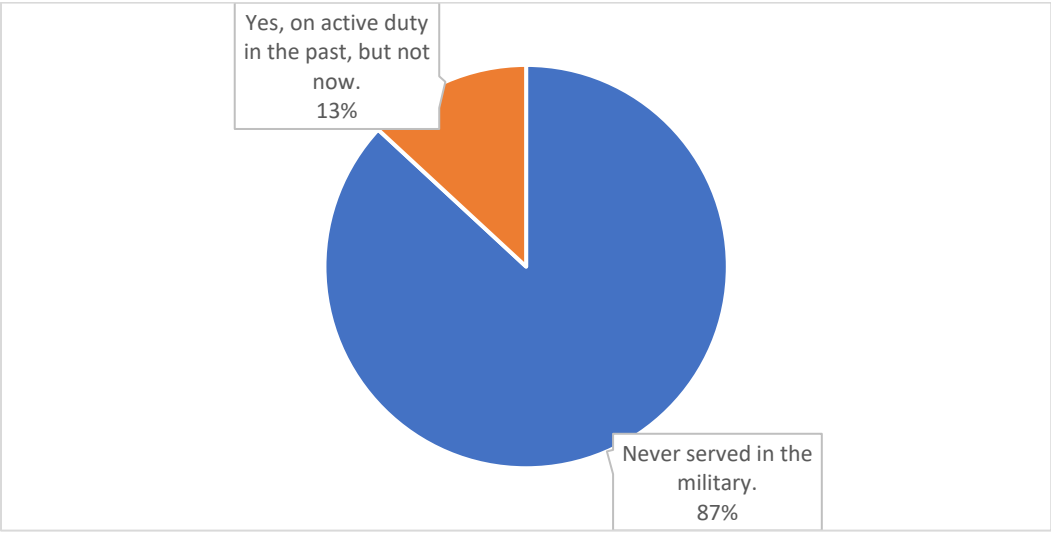
25. What categories best describe you?

Figure A-24. Race demographics of respondents



26. Have you ever served on active duty in the U.S. Armed Forces, Reserves, or National Guard?

Figure A-25. Military service of respondents



Appendix B

American Farmland Trust's Outreach and Engagement Strategy

American Farmland Trust

Perennial Bioenergy Crop Diversification Project

Outreach Opportunity Assessment Results

May 5, 2025

Contents

Abstract

The Outreach Opportunity Assessment was conducted by American Farmland Trust to determine the best geographic locations to conduct targeted outreach for the Perennial Bioenergy Crop Diversification Project. This assessment analyzed social and agricultural land use GIS data to determine key areas suitable for the adoption of perennial bioenergy crops and to provide an additional income stream to producers from historically underserved groups. The results of this assessment have identified priority areas for outreach in Illinois and the broader Midwest region. **Priority areas for outreach in Illinois were identified in the Northern, Southern, and the lower Illinois River regions of the state. As the project expands to the broader Midwest region, key areas identified for targeted outreach were the border region of Kansas and Missouri, Northern Illinois and Southern Wisconsin, and Central Minnesota.** Recommendations were provided on how to approach outreach in these areas, along with explanations as to why these areas were best suited for the adoption of perennial bioenergy cropping systems.

Executive Summary

American Farmland Trust (AFT) is a national organization dedicated to protecting farmland, keeping farmers on the land, and promoting sound farming practices. AFT's Midwest regional team focuses on areas of conservation agriculture such as but not limited to farmland protection, policy, watershed focused conservation, smart solar siting, and crop diversification. AFT is collaborating with Argonne National Laboratory (ANL) to broaden crop diversification and farm resiliency efforts in Illinois. This collaboration will explore opportunities to support the Illinois agricultural community through the deployment of a sustainable supply chain and to create opportunities in the bioeconomy for biomass producers, bioenergy users, and environmental entrepreneurs. These opportunities aim to provide economic and environmental resiliency to farms and agricultural communities.

The Perennial Bioenergy Crop Diversification Project is currently in its second year of a three-year funded project timeline. While outreach efforts have been conducted broadly across the state of Illinois, as the project furthers, outreach will be refined to specific geographic areas to reach farmers most effectively in geographic areas best suited for the adoption of perennial bioenergy cropping systems. Crops such as switchgrass, miscanthus, native prairie mixes, and shrub willow are perennial bioenergy crops promoted for this project. Outreach for this project is still focused within the borders of the state of Illinois. As the project evolves, outreach efforts may expand to the broader Midwest region as this is an area of the United States that is most suitable for perennial bioenergy crop production and in most need of improved conservation agriculture practices to reach regional sustainability goals. To determine these geographic areas, AFT conducted an outreach opportunity assessment to best support and identify outreach efforts to recommend as the project timeline furthers.

Assessment Description & Rationale

To determine the best geographic locations to target for continued meaningful outreach and farmer technical assistance, AFT conducted a basic GIS analysis called the "Perennial Bioenergy Crop Outreach Opportunity Assessment." This assessment will help AFT utilize Department of Energy funds effectively and efficiently while accomplishing the project goals. The goals of the assessment were to analyze data parameters specifically related to land suitability for perennial bioenergy crop diversification in Illinois and the Midwest region. Additionally, this assessment explored the potential to offer additional economic opportunity to historically underserved farmers in the region. Demographic data was also

analyzed in relation to existing biomass conversion facilities that may accept perennial biomass as a feedstock.

Assessment Parameters/Criteria

Farmers and rural homeowners can grow, harvest, and use or sell perennial bioenergy crops to help accomplish several goals outlined in Argonne's Technical Assistance Operating Plan. These goals aspire to improve upon environmental and socio-economic areas as well as achieve diversity, equity, inclusion, and justice goals to address historical and present-day inequities in society and in agriculture. AFT identified the following parameters or criteria below to represent these goals and guide the outreach assessment.

1. Geographic Boundaries

Illinois

Illinois is the primary state in the analysis due to the central location of Argonne National Laboratory and the AFT Midwest Team. AFT has a strong network of partners in Illinois, which allows for many outreach opportunities.

Other Midwest States

Other states reviewed in the assessment include the remaining Midwest states identified in Argonne's project proposal: Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin.

2. Agricultural Producers Likely to Adopt Non-Conventional Methods

AFT used the National Agricultural Statistics Service (NASS) operator database to identify women and minority farmers and non-operating landowners (NOLs) to prioritize outreach and technical assistance. Nearly 50% of farmland in the U.S. is owned or co-owned by NOLs, AFT explored options for identifying women non-operating landowners (WNOLs), as they may be interested in encouraging their farmer operators to grow perennial bioenergy crops. Evidence suggests that these farmer groups are also more likely to adopt conservation and/or non-conventional commodity crop methods.

3. Marginal Land Characteristics

AFT incorporated marginal land data from various public sources to provide the marginality criteria for the analysis to address existing environmental challenges associated with underproductive farmland. The marginal types of data included in this assessment are:

- USGS SSURGO Highly erodible lands (HELs)
- National Commodity Crop Productivity Index (NCCPI)

4. Ethanol Facilities / Biomass Processing Locations

To encourage large scale use of perennial bioenergy crops as an alternative feedstock to corn ethanol, AFT has identified and prioritized ethanol and biomass processing locations in this assessment. While most ethanol manufacturing facilities currently do not accept perennial feedstocks from dedicated energy crops, these locations are still considered in this analysis for the potential of alternative feedstock adoption in the future. As market demand and policy incentive for more sustainable feedstocks increase, so does the adoption of perennial bioenergy

crops that can produce needed biomass. This can provide a local feedstock supply to facilities in priority areas to meet a new or growing demand.

5. National Land Cover Database – Agriculture Crops

AFT collected agricultural crop information from the National Land Cover Database to identify locations of pastureland and cultivated crops in the Midwest. Hay and pasturelands are in consideration for this assessment because it is understood that the equipment needed to manage and produce hay are synergistic with the equipment and storage needs of perennial bioenergy crops like switchgrass, miscanthus, and native prairie mixes. While this project does not seek land use change, these areas were included in the assessment to better understand available resources in locations suitable for adoption.

6. Impaired Watersheds

To address water quality problems in local waterbodies (streams or lakes) that are associated with agricultural sources of nutrients, sediment, pesticides, etc., AFT identified and prioritized watersheds that are on the EPA's 303d List of Impaired Waterbodies.

Results & Recommendations

The Outreach Opportunity Assessment allowed AFT to identify key geographic areas of interest to prioritize outreach efforts. The below results are separated by Illinois and the Midwest region, respectively.

Illinois Outreach Opportunity Assessment

The following geographic locations are priority areas of interest that were identified in the assessment. A geographic area of interest matrix was created to analyze overlap in results of data criteria. This matrix highlights priority areas of overlap found in the Illinois and Midwest spatial analysis maps. Analysis

criteria that is present in both maps, highlighted in Figure 1 in gold, are geographic areas that AFT will prioritize for outreach in Illinois.

Assessment Matrix	Illinois Geographic Regions				
Analysis Criteria	Northwestern Illinois	Northeastern Illinois	Central Illinois	Southern Illinois	Western IL
High Erodibility Factor					
Land Cover & Ethanol Plants					
Impaired Waters					
Crop Productivity					
Demographic - Female Principal Producers					
Demographic - Black Principal Producers					
Demographic - Latinx Principal Producers					
Demographic - Indigenous Principal Producers					

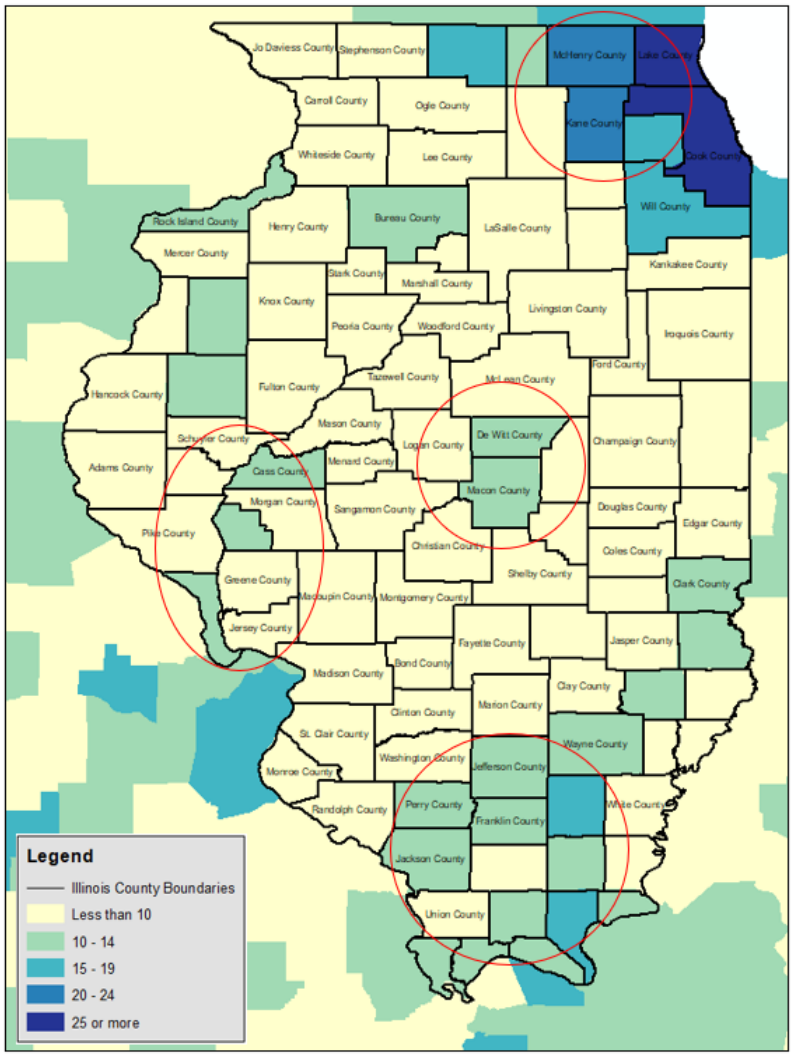
Priority	Map Results
low	Illinois Map Priority Area
medium	Midwest Map Priority Area
high	Midwest & Illinois Map Priority Areas
	Null or No Priority

This matrix identifies priority areas of overlap found in the Illinois maps and Midwest maps created for the purposes of this assessment. Analysis criteria that is present in both maps are geographic areas that will be prioritized for outreach efforts.

Figure 1. Illinois Assessment Results Matrix

Area of Interest #1: Southern Illinois

The results of the analysis suggest AFT conducts a portion of its outreach for this project in Southern Illinois. The results further indicate that this geographic region has land suitable for perennial bioenergy crop production. The landscape and soils in this region have a high erodibility factor, impaired water quality, and moderate crop productivity. According to the National Land Cover Database, the current land cover in this region is a combination of cultivated crops, pasture and hay fields, and deciduous forest. When considering the production of these cultivated crops as well as pasture management, it is expected that farmers in this region may have the capacity to adopt leafy perennial bioenergy crops such as switchgrass and miscanthus. The equipment needed to produce these crops is very similar to hay production and may be available to hay and livestock farmers and other producers in the area. The integration of perennial crops may offer farmers in this region the ability to improve water quality and boost crop productivity. Please see the maps located in the Illinois Maps Appendices 2 and 3 to review the GIS analysis of agricultural land that provided these recommendations.



The Southern Illinois region also has producers of interest to the study. Southern Illinois has 13 counties with a range of 12-18% of principal producers being female. The map to the left shows the highlighted counties with the most principal female producers in the region. Four counties in this region have a large presence of African American principal producers.

Counties recommended for targeted outreach in this region include but are not limited to:

- Jefferson County
- Franklin County
- Hamilton County
- Johnson County
- Perry County
- Jackson County
- Pope County
- Alexander County
- Massac County

Figure 2. Percentage of Illinois Farms with Principal Female Producers

While there is an absence of ethanol or biomass processing facilities in this region, there are two locations to the east near the Indiana border and two near the St. Louis area that may offer additional economic opportunity with transportation logistics taken into consideration.

Area of Interest #2: Northern Illinois

AFT recommends that continued outreach in Illinois is also focused on the Northern region of the state. NLCD data reflects that land in this region of the state is a combination of hay and pastureland, cultivated crops, and deciduous forest. It is understood that hay and dairy farmers in this region may have the capacity to adopt perennial bioenergy crops such as switchgrass and miscanthus because the equipment needed would already be present and available to hay and livestock farmers and other producers. This region is also adjacent to the Mississippi River and has impaired waters within the watershed. Moderate crop productivity according to NCCPI and high soil erodibility are characteristic of agricultural land in this region as well. The integration of perennial crops may offer farmers in this area the opportunity to improve water quality and boost crop productivity while providing the potential for ethanol facilities in the area to purchase local perennial biomass feedstocks. This would alleviate

transportation and other related logistics for farmers who wish to sell their harvests to processors. The map below shows land cover and locations of ethanol facilities in Illinois.

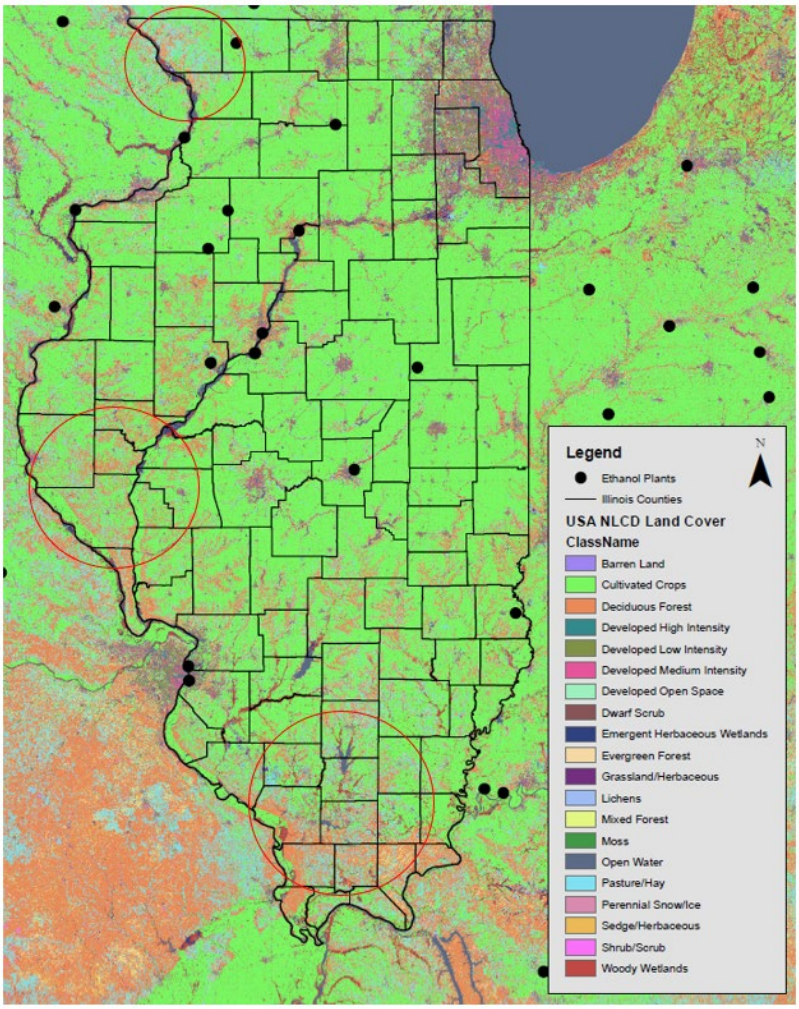


Figure 3. Illinois Land Cover & Ethanol Facilities

Demographic data analysis also supports targeted outreach in this area. NASS operator data did not indicate a large presence of principal farm operators of interest. However, in Northeastern counties in the state have a large presence of female principal operators. While this may be a limitation to reaching farmers from this demographic, there are still opportunities in this area for the adoption of perennial crops by farmers in this area that should not be overlooked. Counties recommended for targeted outreach in this region include but are not limited to:

- Jo Daviess County
- Stephenson County
- Carroll County
- Winnebago County
- Boone County
- McHenry County

Area of Interest #3: Central Illinois – Lower Illinois River region

AFT recommends that continued outreach in Illinois is focused on the lower Illinois River region of central Illinois. NLCD data reflects that land in this region of the state is a combination of hay and pastureland, cultivated crops, deciduous forest, and woody wetlands. It is suspected that hay and dairy farmers in this region may have the capacity to adopt perennial bioenergy crops such as switchgrass and miscanthus because the equipment needed would already be present and available to hay and livestock farmers and other producers.

This region is within the watershed of the lower Illinois River that flows directly to the Mississippi River and has impaired waters due to pesticide, sediment, and nutrient runoff. Moderate crop productivity and high soil erodibility are characteristics of agricultural land in this region. The integration of perennial crops may offer farmers in the area the opportunity to improve water quality and boost crop productivity. The region may benefit from the ecosystem services provided by perennial bioenergy crops such as preventing soil erosion and sediment loading to nearby waterways and improvement of overall water quality. The map in Figure 4 below shows SSURGO's erodibility factor of Illinois soils.

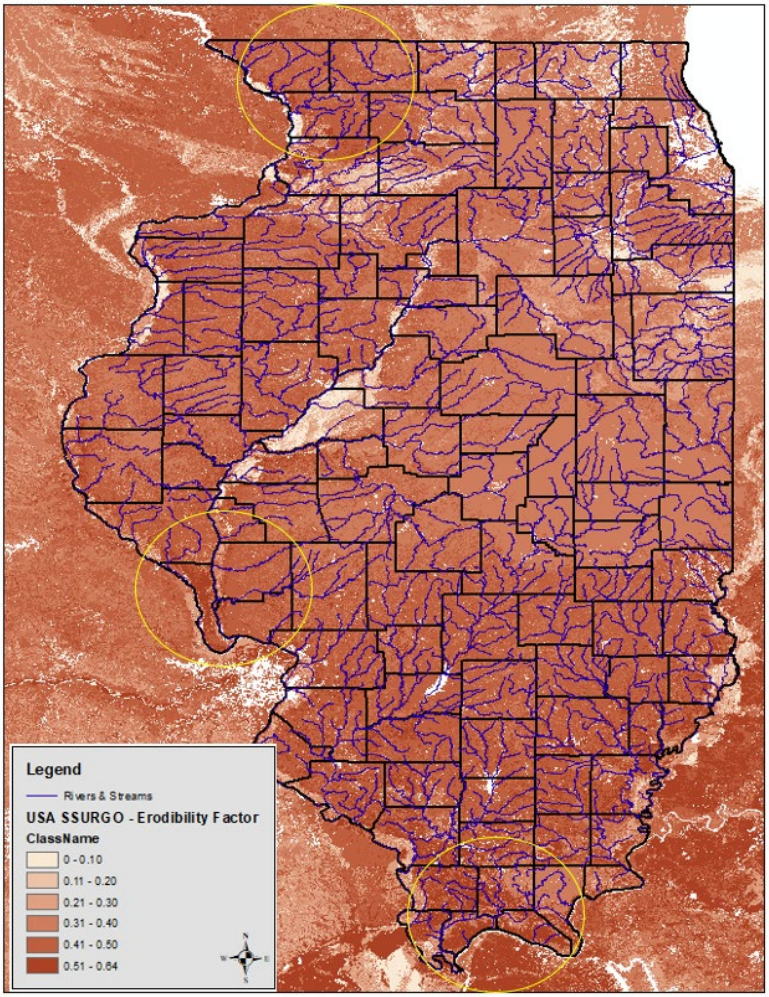


Figure 4. Erodibility Factor of Illinois Soils

Results of demographic analysis of NASS operator data support outreach efforts in the region, as three counties (Cass, Green, and Scott) have a moderate presence of principal female operators. There is also a large presence of African American producers just outside of the region in the greater St. Louis area that may also benefit from targeted outreach in this part of the state.

Counties recommended for targeted outreach in this region include but are not limited to:

- Brown County
- Cass County
- Calhoun County
- Greene County
- Pike County
- Scott County

Midwest Outreach Opportunity Assessment

The following geographic locations are priority areas of interest identified in the assessment that AFT may use when expanding the project beyond Illinois. Areas chosen as priority outreach areas were determined by sighting areas of overlap found in the various GIS maps created for this assessment. Details on the geographic areas below will help AFT conduct meaningful and targeted outreach in the Midwest region. It is important to note that this analysis identified areas with larger populations of indigenous communities and other underrepresented groups of principal farm operators that fell outside of the selected priority regions. These locations were not included in the priority list for outreach in the region due to project feasibility and environmental characteristics that present challenges for productive perennial bioenergy cropping systems such as temperatures, short growing season, and dry land. Due to feasibility and budget restrictions, Michigan's upper peninsula and northern Minnesota were also excluded from the priority areas. A cumulative map was created to identify key priority areas related to data criteria that was analyzed in this assessment.

Table 1 below includes data used in the GIS analysis to determine key geographic locations for targeted outreach in the Outreach Opportunity Assessment. Ranging from 1, the highest priority, to 5, the lowest,

this data was weighed subjectively and represented in Figure 5. This subjective weighing of the data was based on key goals the project aims to achieve through outreach. The geographic locations determined for priority outreach will possess at least 3 of the 5 data criteria.

Data	Priority
BIPOC producers – NASS	1
Cropland – NCLD	2
High Erodibility factor – SURGO	4
Low Crop Productivity - NCCPI	3
Ethanol Plants	5

Table 1. List of data prioritized for representation in the cumulative map.

BIPOC Producers

The presence of BIPOC producers is the highest priority since reaching these producers is one of the key goals of the Perennial Bioenergy Crop Diversification Project. This project aims to support these groups of agricultural producers, including but not limited to African- American, Indigenous, women, and veterans, by providing additional economic opportunities and boosting farm productivity.

Cropland

The analysis listed cultivated cropland as the second priority. This project does not aim for land use change or the replacement of corn, soy, or other cultivated crops. Including cropland in this assessment will identify areas suitable for outreach and the adoption of perennial bioenergy crops without disrupting other cultivated crop production.

High Erodibility Factor

Areas most suitable for adoption of perennial bioenergy crops may possess marginal site characteristics such as high erodibility. Geographic areas selected for targeted outreach have marginalities such as high erodibility factor that may be remediated by perennial bioenergy cropping systems.

Low Crop Productivity

Perennial bioenergy cropping systems can increase crop productivity in areas that typically are low yielding due to marginal characteristics. Areas of low crop productivity are prioritized in this assessment because the implementation of a perennial crop can potentially boost overall farm productivity. Perennial bioenergy crops provide high yields of biomass on poorly productive soils that negatively affect yields of other cultivated crops.

Ethanol Plant Locations

While the presence of existing corn and cellulosic ethanol refineries is the lowest ranked priority for targeted outreach, it is valuable to include this data in this exercise. Most of the facilities included in this dataset currently do not accept perennial bioenergy feedstocks, it is important to note their geographic locations in relation to key outreach geographies. As market demand and policy incentive for more sustainable feedstocks increase, so does the adoption of perennial bioenergy crops that can produce needed biomass. This can provide a local feedstock supply to facilities in priority areas to meet a new or growing demand in the future.

The three geographic areas identified in the analysis were central Minnesota, northern Illinois and southern Wisconsin, and the Missouri-Kansas border region. This analysis prioritized National Agricultural Statistics Service (NASS) principal operator data, which weighs the presence of BIPOC producers against other principal agriculture producers and general population data. The county boundaries highlighted in yellow represent the largest numbers of BIPOC producers. While there are many agricultural communities around the Midwest region with diverse groups of agricultural landowners and operators, the project scope and feasibility require focusing efforts on specific areas. The cumulative Midwest map and legend are found in Figure 5 below.

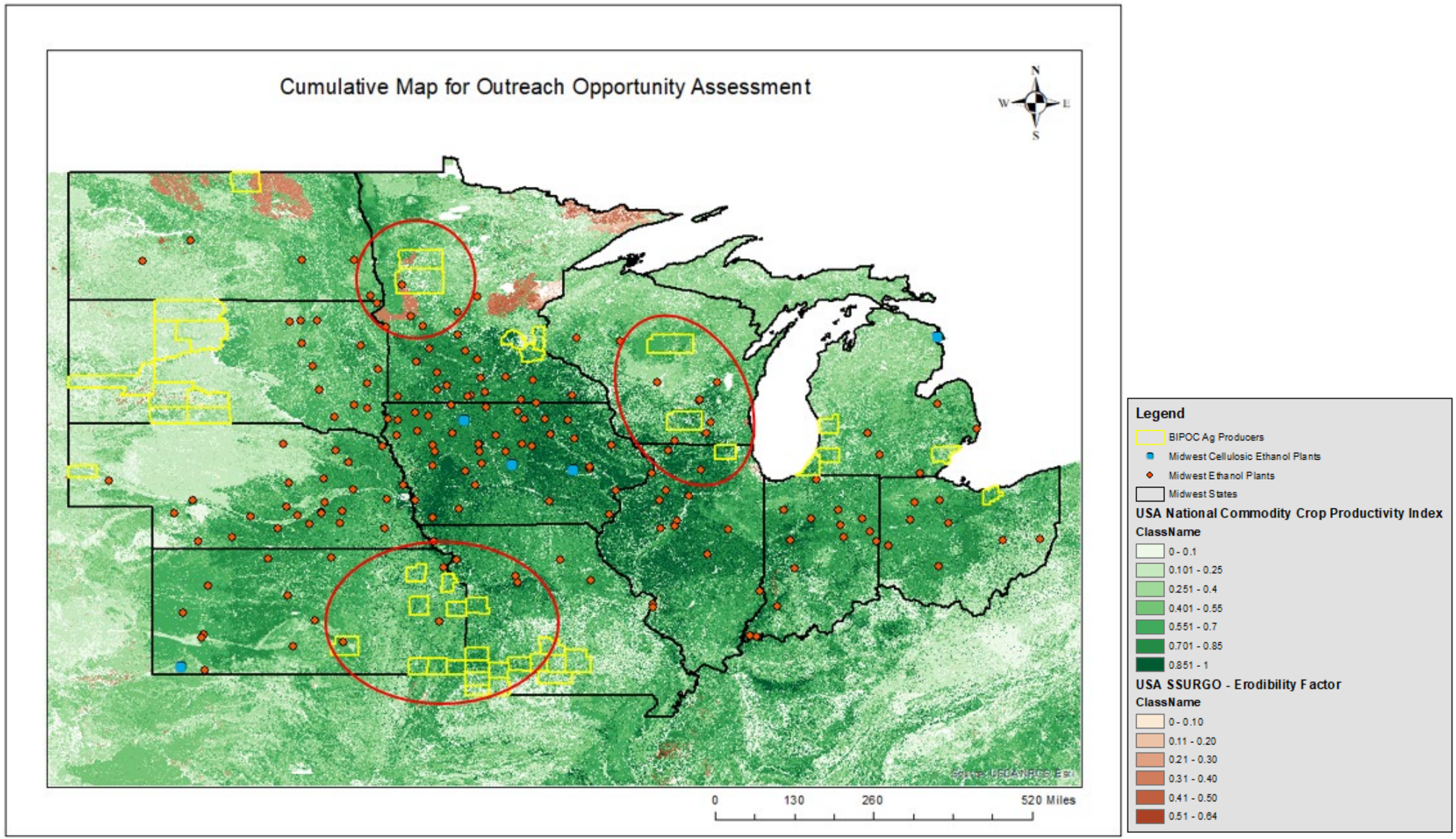


Figure 5 Midwest Cumulative Map for Outreach Opportunity Assessment

Ramifications of variance in data representation

Changing the priority levels of this data may result in a variance of geographic areas selected for targeted outreach. For example, subjectively weighing BIPOC producers less than the rest of the data criteria may result in target outreach areas with minimal presence of priority farm and landowner groups, but larger areas suitable for perennial bioenergy crop adoption. This data was analyzed by assessing visual characteristics present on the map rather than a spatial or statistical analysis. The cumulative map does not include all the priority areas identified within Illinois due to the regional scope of this portion of the assessment. As the project expands beyond Illinois, it is understood that there are other key areas of the region that are more suitable for adoption of these cropping systems and targeted outreach. Thus, many areas in Illinois were not included because they did not contain all the criteria that were considered for selecting priority outreach areas.

Individual maps of the Midwest region representing key areas of outreach based on specific data criteria were created to provide context to the selected regions. These maps address priority areas related to farmer demographics, impaired water quality, erodibility, and other data included in this assessment. However, not all data is represented in the cumulative map. Please see individual Midwest maps in the Appendix for additional detail.

Midwest Area of Interest #1: Central Minnesota

It is recommended that AFT prioritizes outreach efforts to central Minnesota as the project expands beyond the scope of Illinois. This area of the Midwest is optimal for perennial bioenergy crop diversification due to a variety of land and farmer demographic characteristics.

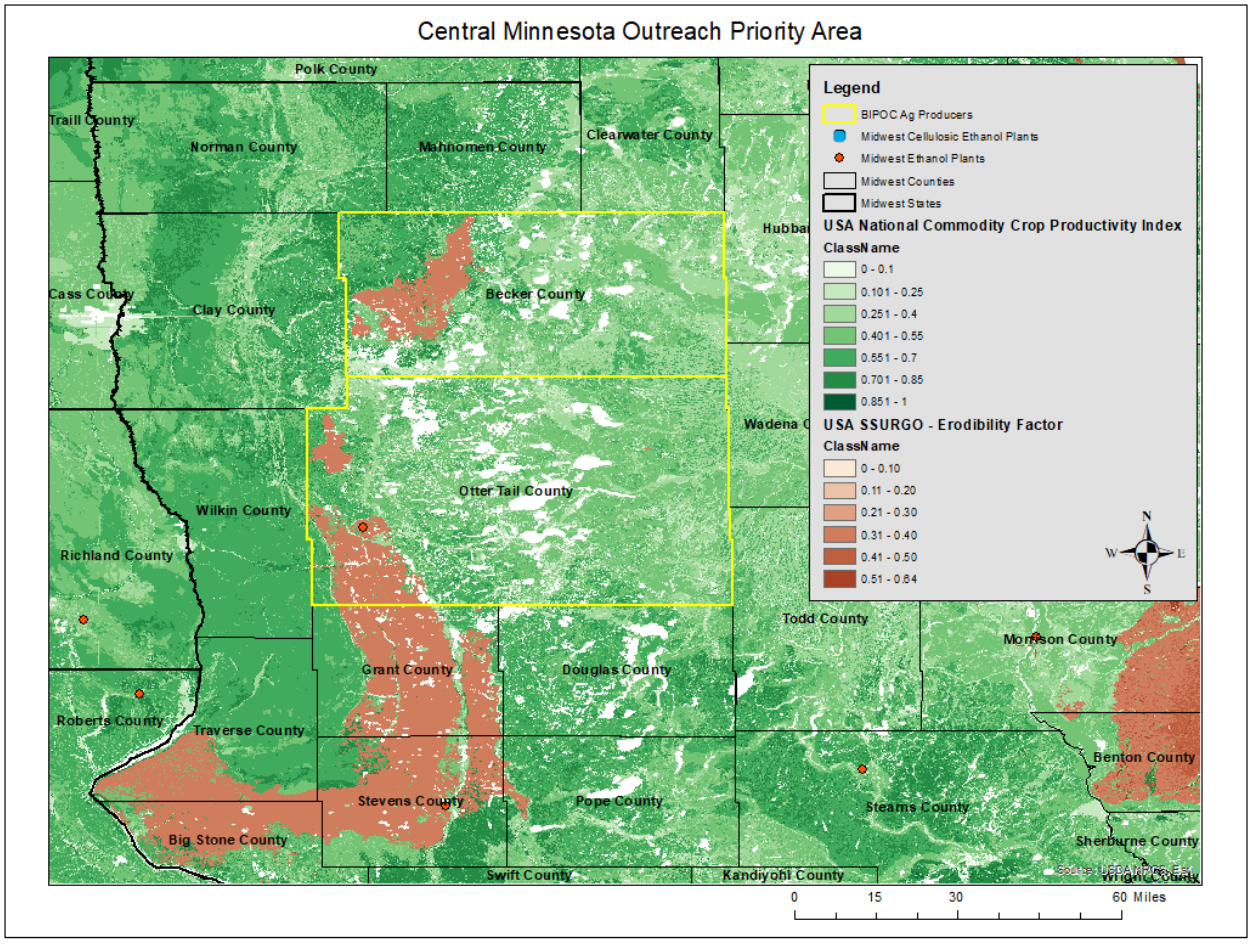


Figure 6 Central Minnesota Outreach Priority Area

The priority outreach area located in Minnesota includes Otter Tail and Becker Counties and surrounding agricultural areas. This analysis found that two of these two counties have a large population of BIPOC producers, according to the National Agricultural Statistics Service (NASS). Becker and Otter Tail counties overlap with the southern half of the White Earth Reservation, home to the indigenous peoples of the White Earth Band. Cropland in this region has a variety of cultivated rice, birch, maple, corn, soybeans, and other specialty crops. Most of the land area in these counties is uncultivated due to marginal land characteristics. The land in this area is characterized by low crop productivity according to NCCPI, and high erodibility factor according to SSURGO data. Ecosystem services realized by perennial bioenergy crops may address soil erosion, nutrient and sediment runoff, and other adverse effects to water quality while boosting crop productivity and overall farm resilience to economically stressed communities in this region.

There is an ethanol plant located within the selected area determined in this analysis as well. Green Plains Otter Tail, LLC located in Fergus Falls, Minnesota is a corn ethanol manufacturing facility. While

this facility does not currently accept perennial biomass feedstock, it is still considered in this analysis for the potential of alternative feedstock adoption as the demand and incentive for more sustainable feedstocks become prevalent. The adoption of perennial bioenergy crops for the use of cellulosic ethanol production can provide a local supply to this facility as it aims to meet a new or growing demand.

Midwest Area of Interest #2: Northern Illinois – Southern Wisconsin Region

AFT recommends this project prioritizes outreach efforts in the border region of northern Illinois and central and southern Wisconsin. This area of the Midwest is optimal for perennial bioenergy crop diversification due to a variety of land and farmer demographic characteristics. As previously mentioned, this region contains many landscape characteristics and marginalities that provide optimal conditions for the adoption of perennial bioenergy crops that may improve the local environment and boost farm resilience in a moderately productive agricultural region of the Midwest. NLCD data indicates this is a diverse landscape containing swaths of deciduous forest, cultivated crops, and hay and pastureland. The presence of many rivers and streams in this area also increases the erodibility factor of soils in this region. The integration of perennial bioenergy crops would benefit this region due to the enhanced ecosystem services provided by crops such as shrub willow, switchgrass, miscanthus, and native prairie mixes.

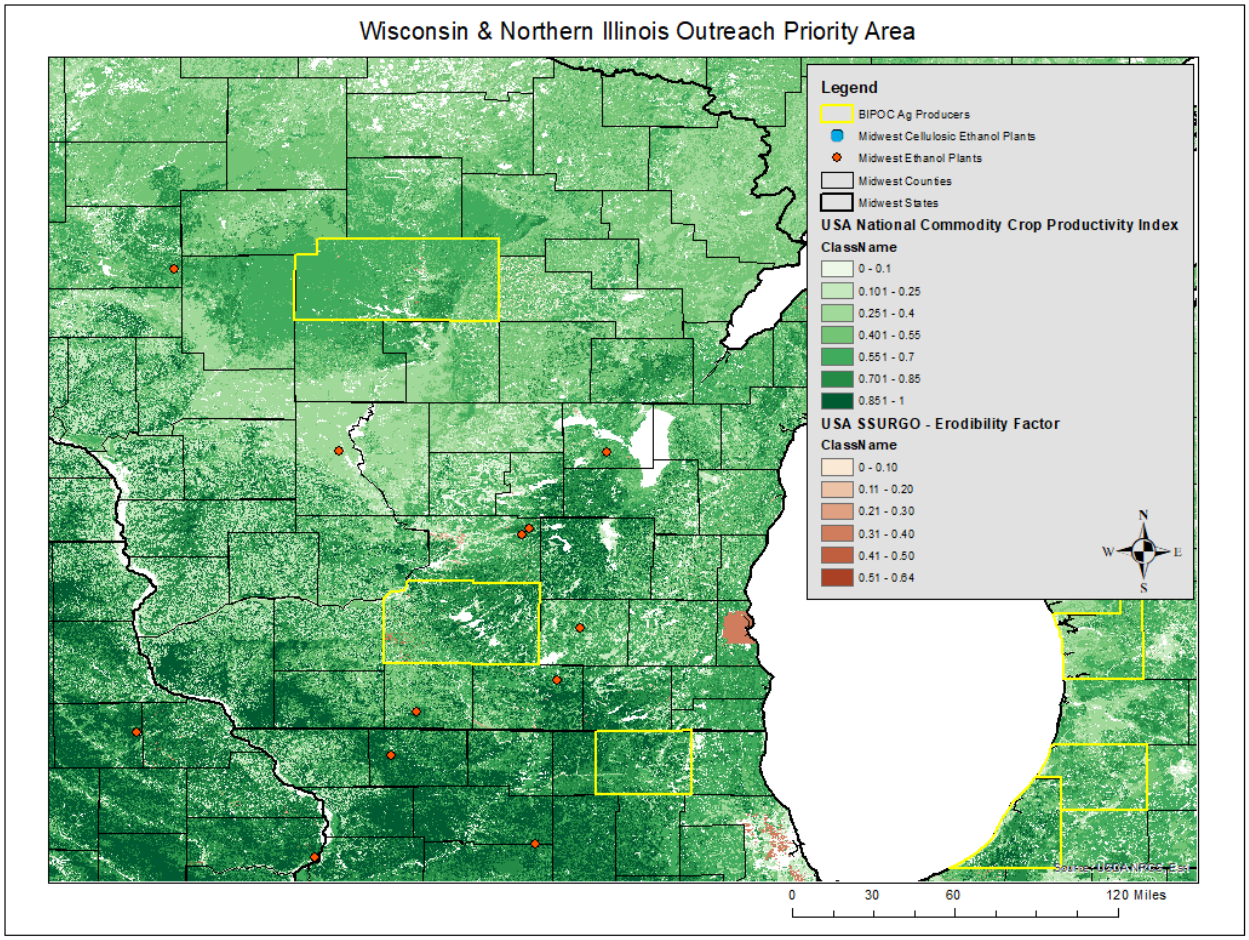


Figure 7 Wisconsin & Northern Illinois Outreach Priority Area

The assessment indicated that targeted areas for outreach in this region include Dane and Marathon Counties in Wisconsin, and McHenry County in Illinois. These counties have the highest populations of BIPOC principal producers in the region and have variable marginal land characteristics that negatively impact crop productivity.

Nine ethanol manufacturing facilities are located within this region that primarily accepts corn feedstocks. While these facilities do not currently accept perennial biomass feedstock, it is still considered in this analysis for the potential of alternative feedstock adoption as the demand and incentive for more sustainable feedstocks become prevalent. The adoption of perennial bioenergy crops for the use of cellulosic ethanol production can provide a local supply to this facility as it aims to meet a new or growing demand.

Midwest Area of Interest #3: Missouri- Kansas Border Region

AFT recommends prioritizing outreach efforts in the border region of Missouri and Kansas as well. This area of the Midwest is optimal for perennial bioenergy crop diversification due to a variety of land marginalities, diverse agricultural landscape, and key farmer demographic characteristics that align with project goals and objectives. This region contains many landscape characteristics and marginalities that provide optimal conditions for the adoption of perennial bioenergy crops that may improve the local environmental and boost farm resilience in a low productivity agricultural region of the Midwest.

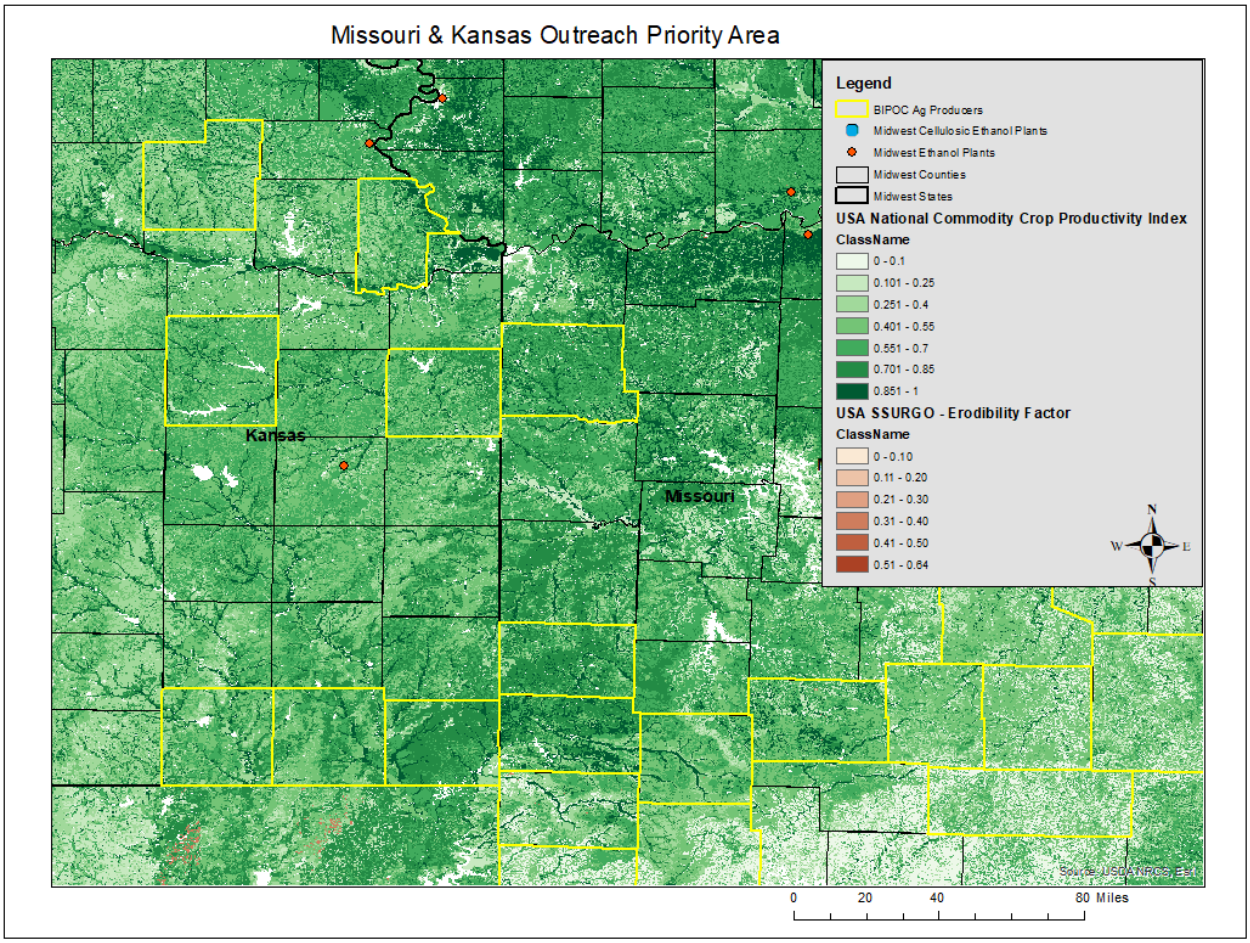


Figure 8 Missouri & Kansas Outreach Priority Area

The assessment indicated outreach target areas in this region for Barry, Barton, Douglas, Miami, Osage, Webster, Cass, and Lawrence Counties. This region's cultivated cropland consists primarily of corn and soybeans with cover crops, and other small grain rotations. Deciduous forest and grassland are also two other notable land covers for this area that also support this region's suitability for the adoption of perennial bioenergy crops.

US EPA has reported that nearly every waterway in the region is impaired in some way due to anthropogenic causes. The adoption of perennial bioenergy crops on this landscape such as switchgrass, miscanthus, shrub willow, and native prairie mixes may offer a variety of ecosystem services that will improve water quality in the region while introducing new economic opportunities to a diverse range of producers. This will boost farm resilience from an environmental and economic perspective.

Eight ethanol manufacturing facilities are located within this region that primarily accept corn feedstocks. While these facilities do not currently accept perennial biomass feedstock, it is still considered in this analysis for the potential of alternative feedstock adoption as the demand and incentive for more sustainable feedstocks become prevalent. The adoption of perennial bioenergy crops for the use of cellulosic ethanol production can provide a local supply to this facility as it aims to meet a new or growing demand.

Economic opportunities provided by the adoption of perennial bioenergy crops may benefit a large diverse range of produces from economically stressed populations. NASS operator data supports the prioritization of outreach in this region due to the large presence of principal female and African American farm operators.

Conclusion

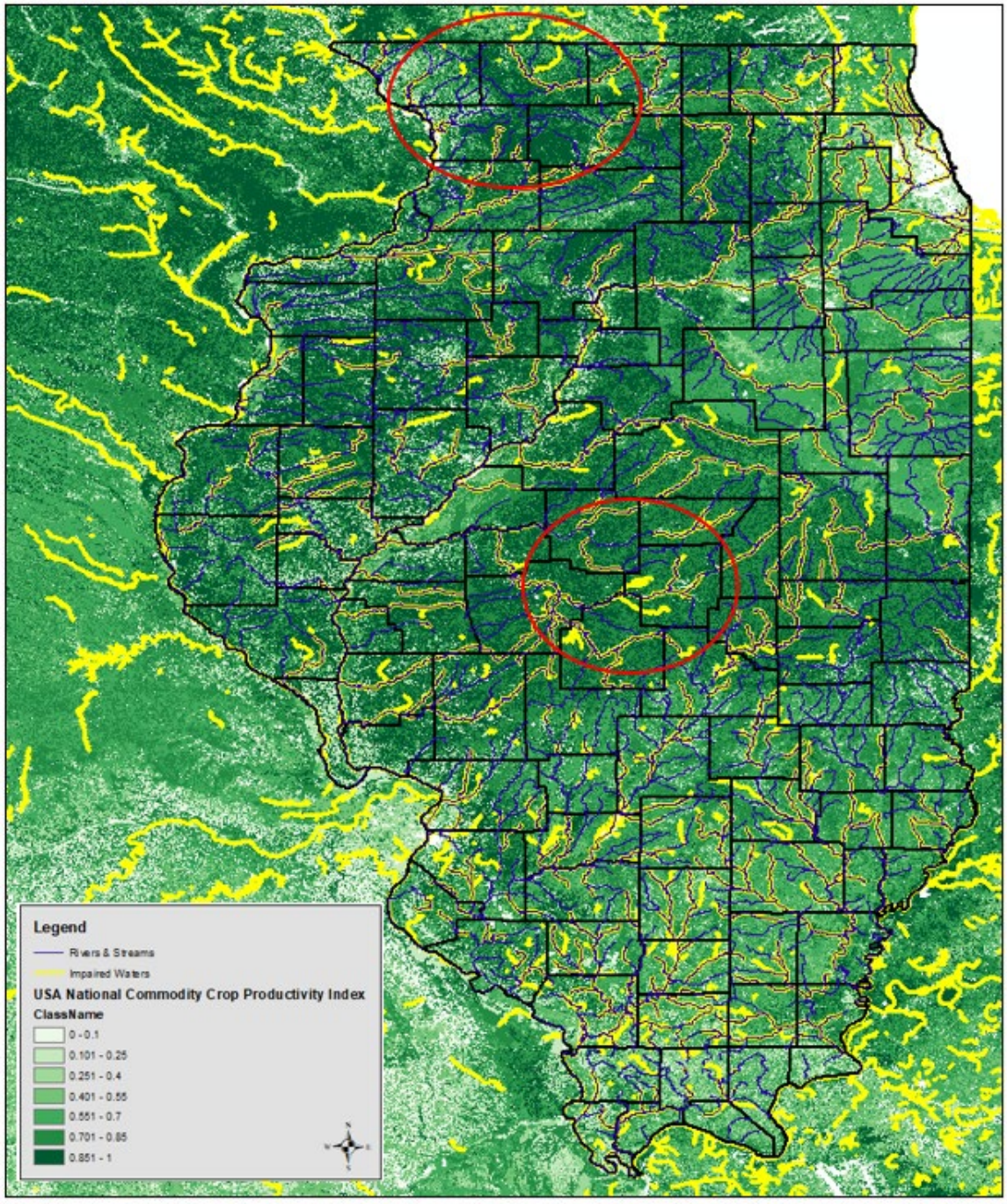
This assessment has identified key priority areas for targeted outreach in Illinois to be the Northern, Southern, and lower Illinois River regions of the state. As the project expands to the Midwest region, this assessment recommends AFT conducts targeted outreach to central Minnesota, northern Illinois and southern Wisconsin, and the border region of Missouri and Kansas. These areas were determined to be the most suitable locations for the adoption of perennial bioenergy crops because of present land characteristics. Farmer demographics of these areas also present the opportunities to provide economic and environmental resiliency to farms and agricultural communities of various groups. Results from this assessment will be incorporated into an outreach and engagement strategy that AFT has developed for conducting outreach for the remainder of this project.

Outreach Opportunity Assessment Maps Appendix

Illinois Maps

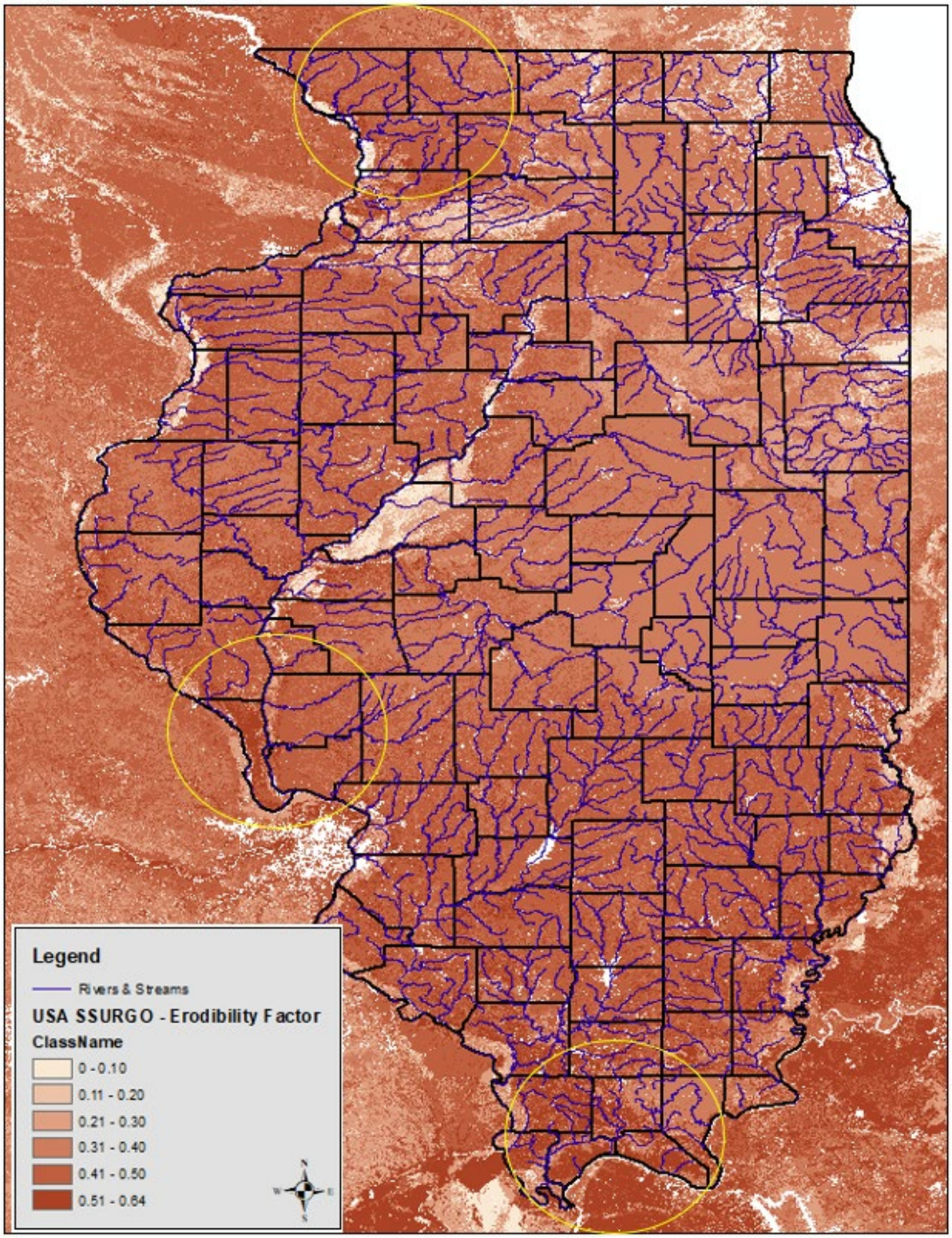
**Please note Illinois maps were created using different projections which may change the overall shape of the state, but do not affect the outcome of the analysis.*

1. Illinois Crop Productivity and Impaired Waters



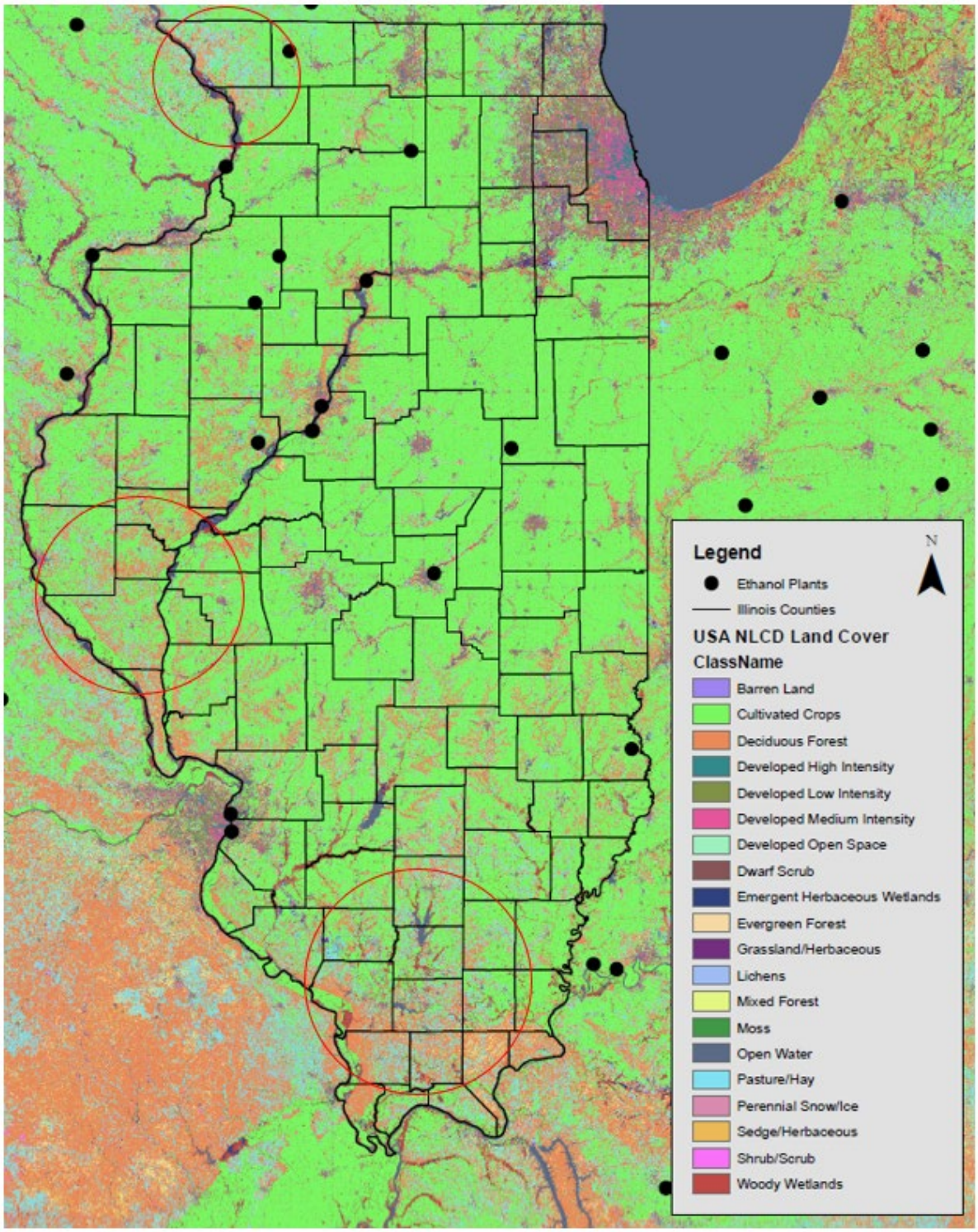
Geographic areas circled in red indicate priority areas for outreach based on moderate to high crop productivity near areas with impaired waterways.

2. Erodibility Factor of Illinois Soils



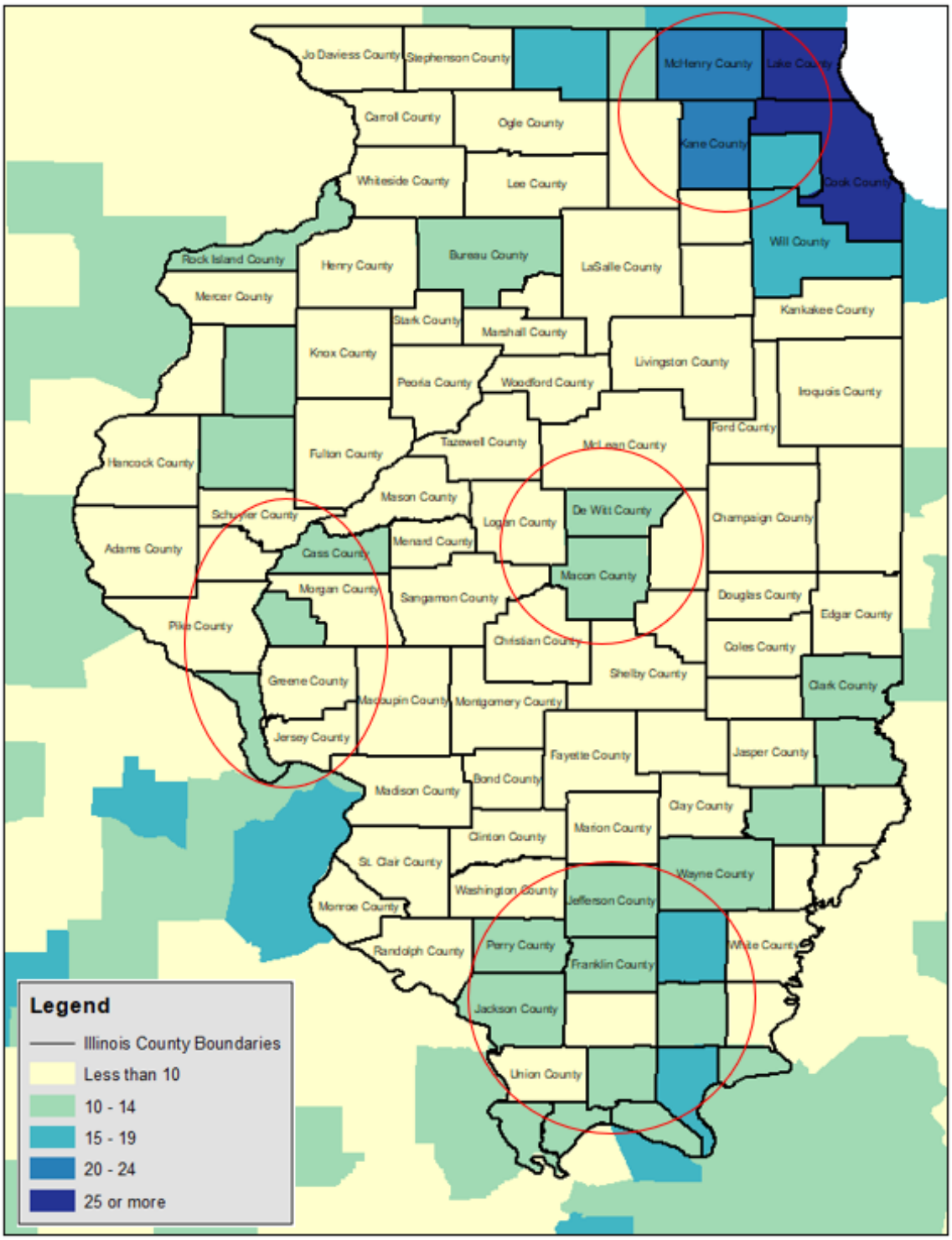
Geographic areas circled in yellow indicate priority areas for outreach based on high erodibility factor that may be improved by the implementation of perennial bioenergy cropping systems.

3. Illinois Land Cover & Ethanol Plants



Geographic areas in red indicate priority areas for outreach based on land use variability and location of ethanol plants. Priority areas were determined based on presence of hay and pastureland and cultivated crops.

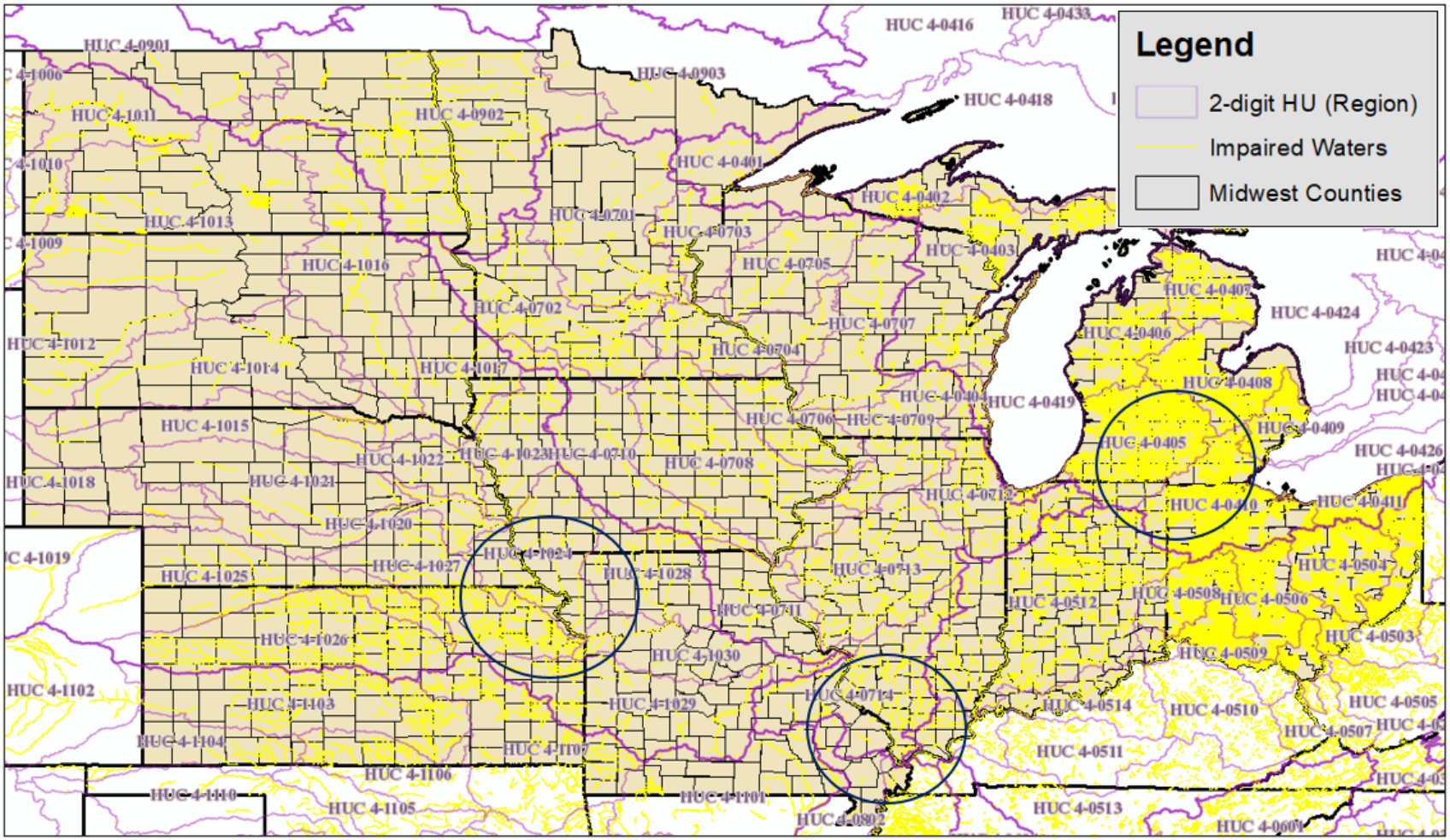
4. Percentage of Illinois Farms with Female Principal Operators



Geographic areas in red indicate priority areas for outreach based on presence of female principal farm operators per county. Priority areas were determined based on areas with multiple neighboring counties with more than 10% of the farmer population being female. Priority areas selected took large urban areas into consideration but were limited to the Chicagoland area.

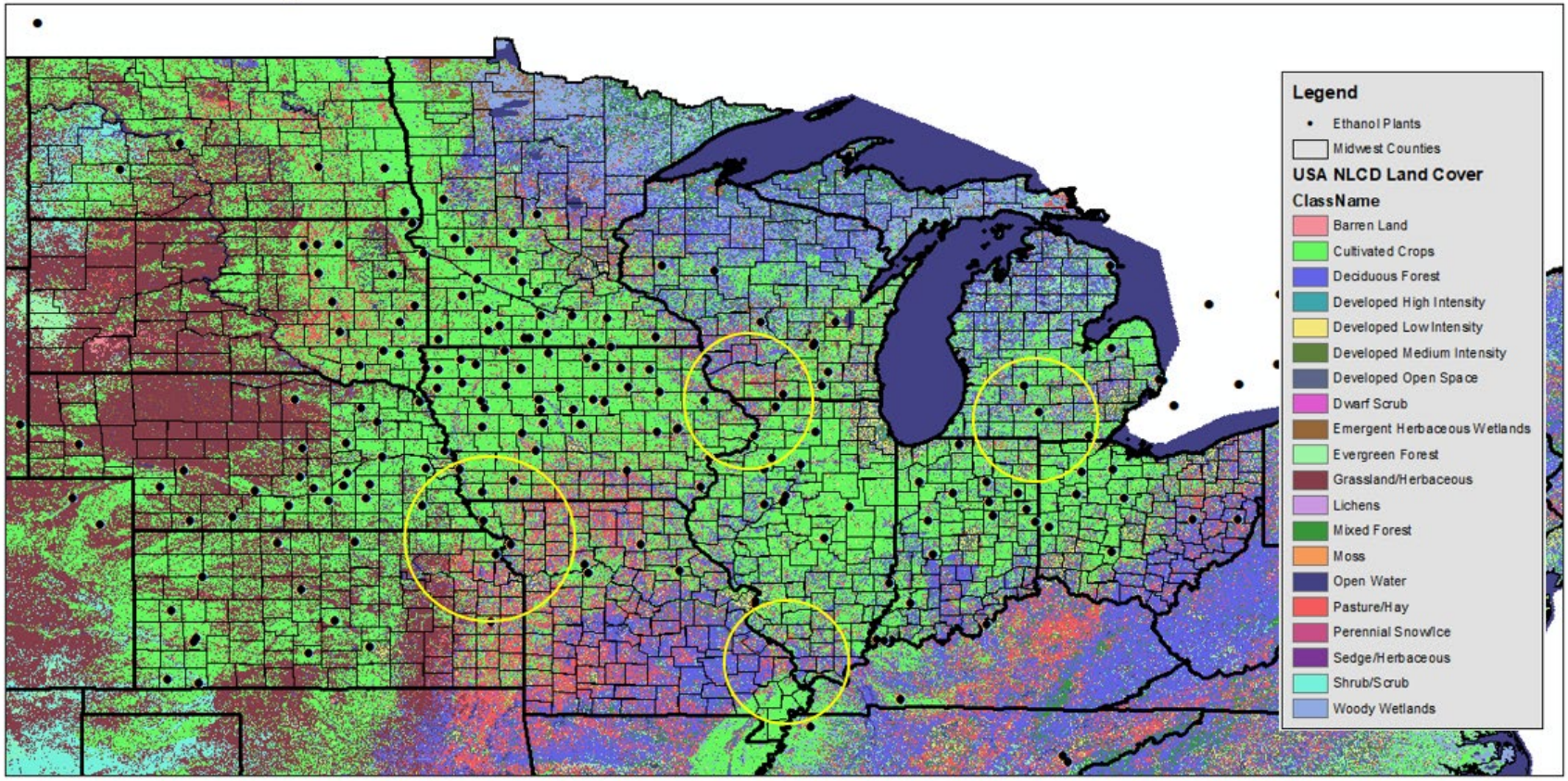
Midwest Maps

1. HUC4 Watersheds & Impaired Waters of the Midwest



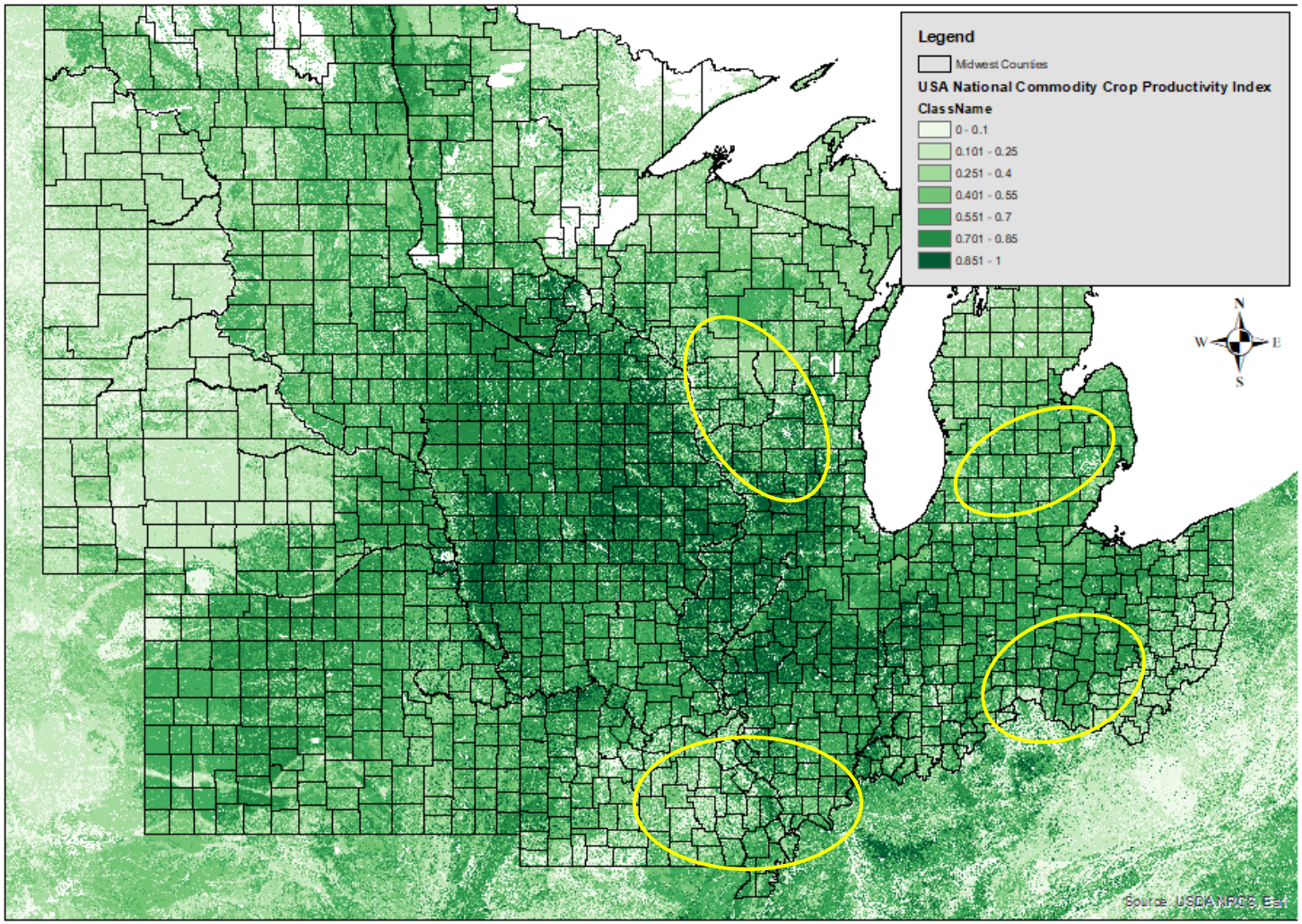
Circled geographic areas indicate priority locations for outreach based on degree of water quality impairment. Priority areas were determined based on presence of EPA 303d impaired waters. The level of EPA water quality assessment completion was considered in order to understand the disproportionate cases of impaired waterways in Michigan and Ohio.

2. Midwest Land Cover Types & Land Cover



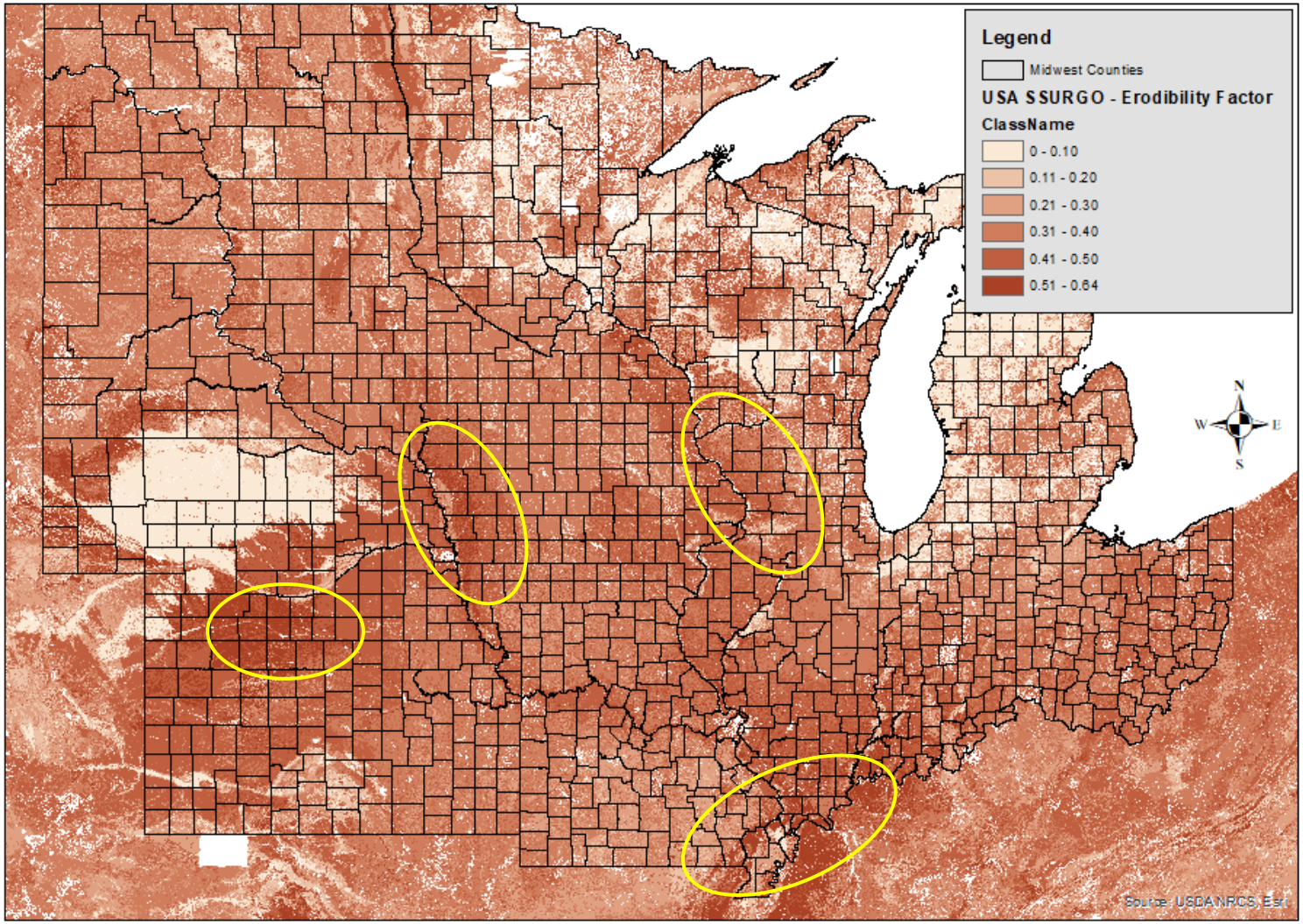
Geographic areas circled in yellow are priority areas based on land use variability and presence of nearby ethanol and biomass processing facilities. Areas were chosen that had diverse agricultural landscapes consisting of cultivated crops, grassland, and hay and pastureland. Locations and number of ethanol plants in the area were also considered when prioritizing key outreach locations.

3. Midwest Crop Productivity Priority Outreach Areas



Geographic areas circled in yellow indicate priority areas for outreach based on low crop productivity using NCCPI data. While some selected areas have moderate crop productivity compared to other areas in central Illinois and Iowa, for example, considerations were made for the potential adoption of perennial bioenergy cropping systems. Adoption will boost in agricultural productivity in these regions.

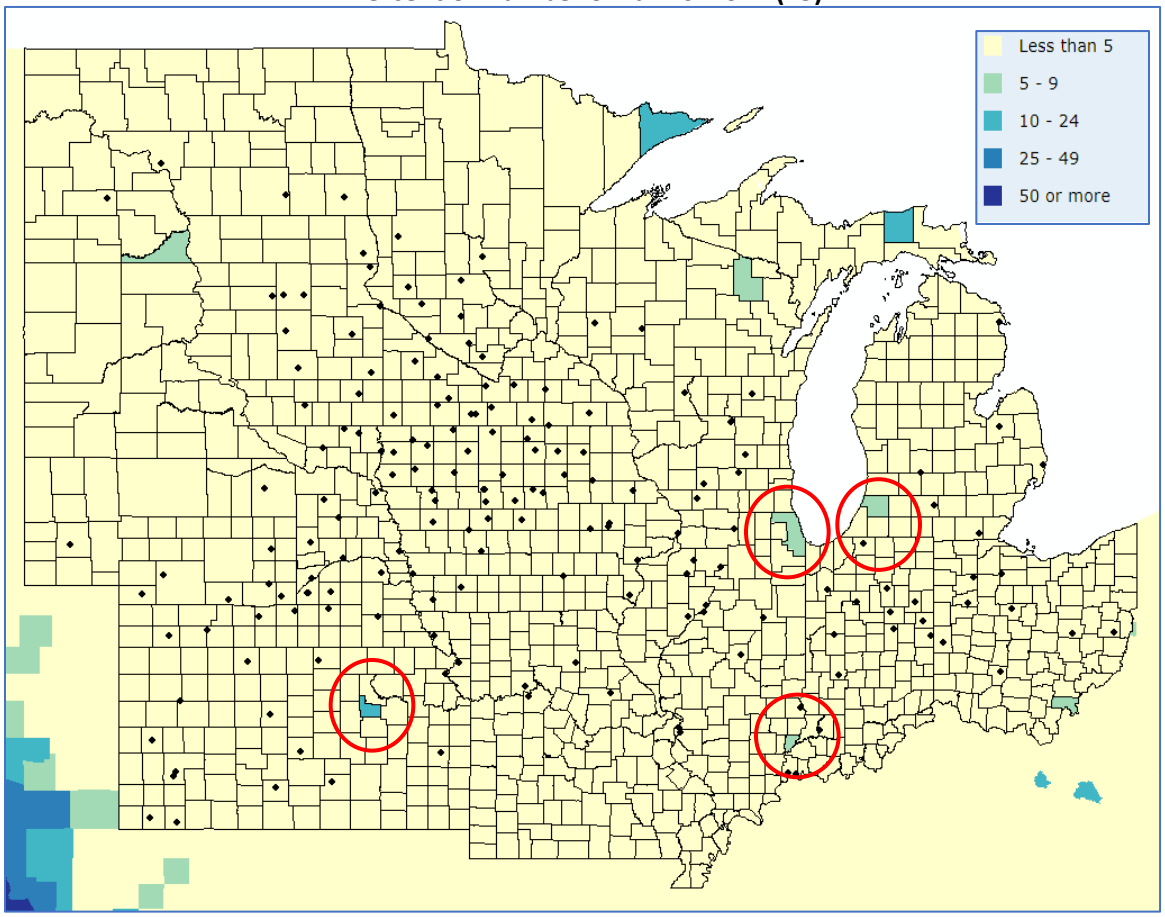
4. Erodibility Factor of Midwest Soils



Geographic locations circled in yellow were determined to be key priority areas in the Midwest based on high erodibility factor of soils in the areas. These areas were selected due to the ecosystem services and erosion prevention that could be realized by adopting perennial bioenergy crops in areas highly susceptible to erosion.

5. Midwest Farms with Operators of Spanish, Hispanic, or Latin Origin

Number of Farms with Spanish, Hispanic, or Latino Origin Operators as Percent of Number of Farms: 2012 (25)

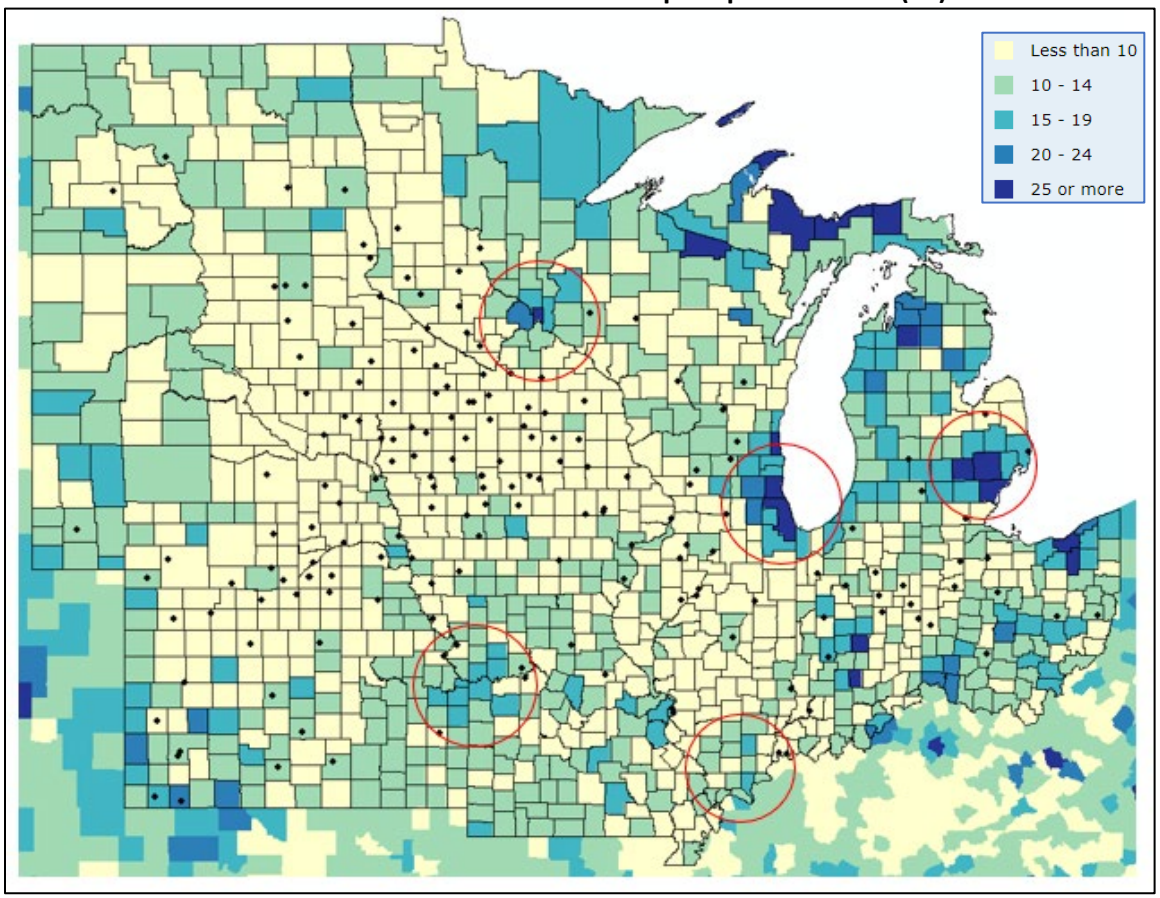


**Data points represent locations of ethanol plants in the Midwest.*

Geographic areas in red indicate priority areas for outreach based on presence of Latino principal farm operators on a county basis. Priority areas were determined based on areas with multiple neighboring counties with record of 5 of more farm operators of Hispanic or Latino origin. While this analysis identified areas with larger populations of farm operators, project feasibility and funding was considered in identifying priority areas, therefore excluding northern Minnesota and Michigan's upper peninsula.

6. Midwest Farms with Female Principal Operators

Percent of Farms with a Female Principal Operator: 2012 (19)

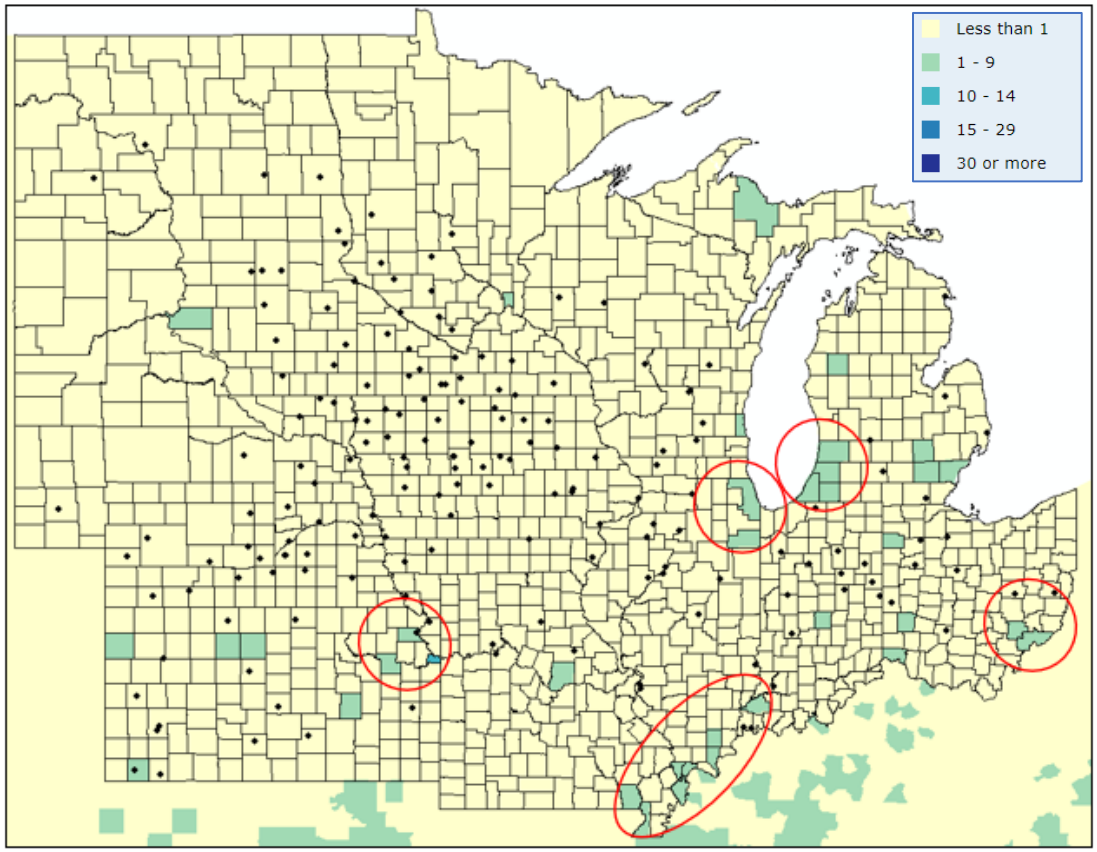


**Data points represent locations of ethanol plants in the Midwest.*

Geographic areas in red indicate priority areas for outreach based on presence of female principal farm operators on a county basis. Priority areas were determined based on areas with multiple neighboring counties with record of 15% or more female farm operators in the agricultural community. While this analysis identified areas with larger populations of farm operators, project feasibility and funding were considered in identifying priority areas, therefore excluding northern Minnesota and Michigan's upper peninsula.

7. Midwest Farms with Black Principal Operators

Number of Farms with Black or African American Operators as Percent of Number of Farms: 2012 (22)

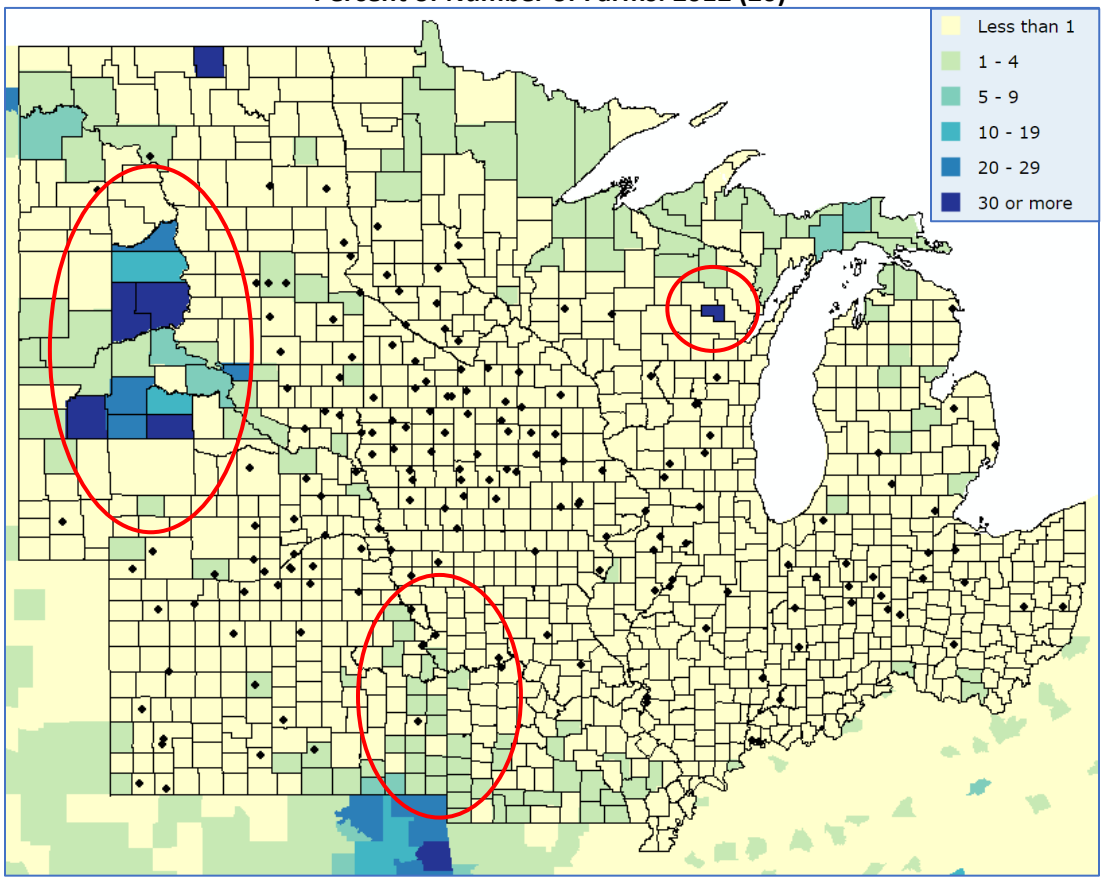


**Data points represent locations of ethanol plants in the Midwest.*

Geographic areas in red indicate priority areas for outreach based on presence of African American principal farm operators on a county basis. Priority areas were determined based on areas with multiple neighboring counties with record of at least one farm per county with principal African American operators in the agricultural community. While this analysis identified areas with larger populations of farm operators than the selected priority regions, project feasibility and budget were considered in identifying priority areas, therefore excluding Michigan's upper peninsula.

8. Midwest Farms with Principal Operators of Indigenous Origin

Number of Farms with American Indian or Alaska Native Operators as Percent of Number of Farms: 2012 (20)



**Data points represent locations of ethanol plants in the Midwest.*

Geographic areas in red indicate priority areas for outreach based on presence of indigenous principal farm operators on a county basis. Priority areas were determined based on areas with multiple neighboring counties with record of at least one farm per county with Indigenous principal operators in the agricultural community. While this analysis did identify areas with larger populations of Indigenous principal farm operators than the selected priority regions, project feasibility and budget were considered in identifying priority areas, therefore excluding Michigan's upper peninsula and northern Minnesota.

Appendix C

Sample Individual Technical Assistance

Perennial Bioenergy Crop Diversification Project

Farm Management Plan

Date: April 25, 2024

Client Name – [Redacted]

Site Location - [Redacted]

Perennial Bioenergy Crop – Native Prairie and Switchgrass

Table of Contents

Summary

This farm management plan is prepared for [redacted] by American Farmland Trust to provide technical assistance for the adoption of native prairie mixes and switchgrass for the potential end use of bioenergy feedstock production. The intended end use of native prairie mixes and switchgrass is to produce biochar and improve environmental conditions with the end-use goal of offsite bioenergy feedstock processing as well as feedstock production for on-site kiln usage.

This plan outlines the recommended steps to be taken to grow a mix of native prairie species along with switchgrass within a perennial biomass cropping system for the intended use of on- or off-farm energy production over a 5-year timeline. The client is interested in converting six acres of unmanaged marginal land to produce native prairie and switchgrass biomass for bioenergy generation and ecosystem service benefits.

The table below indicates soil and site constraints present on the client's property as well as their goals and desired end use of harvested perennial bioenergy crops.

Soil & Site Constraints	Check if applies	Landowner Goals	Check if applies	Desired End Use of Biomass	Check if applies
Low crop productivity		Improve soil health	✓	On-farm use: biomass heating	✓
Pooling/ponding water	✓	Water quality improvement		On-farm use: Anaerobic Digestion	
Highly Erodible Land (HEL)	✓	Increase biodiversity	✓	On-farm use: pyrolysis/biochar	✓
Water Holding Capacity (WHC)	✓	Reduce erosion & runoff	✓	Off-farm use: Sell to processor	
Nutrient leaching		Economic boost		Not interested in harvesting biomass	
Drought/Dry spots		Reduction of inputs			

Table 1 This table identifies with a check mark the present soil & site constraints alongside landowner goals and desired biomass end-use.

The estimated acreage of the constraints identified above is approximately 6 acres. Please view site maps in the Soils & Site Information section of this plan to view where these constraints are located.

Project Overview

American Farmland Trust (AFT) is a national organization dedicated to protecting farmland, keeping farmers on the land, and promoting sound farming practices. AFT is collaborating with Argonne National Laboratory (ANL) to broaden crop diversification and farm resiliency efforts in Illinois. The Perennial Bioenergy Crop Diversification Project provides technical assistance to producers who wish to adopt a perennial bioenergy cropping system. Crops such as switchgrass, miscanthus, native prairie mixes, and shrub willow are the current perennial bioenergy crops of interest to produce bioenergy feedstock. The ecosystem services that may be realized on marginal, unproductive lands using perennial bioenergy crops may enhance conservation agriculture practices to reach regional sustainability goals. These efforts may also provide additional economic opportunities for rural communities create the potential for a circular bioeconomy and reach domestic fuel and energy production goals.

Technical assistance is provided by this project to any farmer in the Midwest interested in adopting a perennial bioenergy crop into their farm operations. Technical assistance includes this 5-year management plan in addition to a site assessment and market feasibility report for the perennial bioenergy crop of interest. This farm management plan is a guide to growing perennial bioenergy crops on marginal areas of farmlands unsuitable for cultivated row crops or pastureland.

Background

The client's farming operation includes 10 acres of vegetable production as well as fruit and nut tree production located in [Redacted]. The client participates in conservation agriculture practices such as no-till practices, cover crops, wildlife habitat, and water management. Adopting native prairie and switchgrass will help alleviate marginal site characteristics such as soil erosion, flooding, and ponding. Historically, this farm has produced diversified vegetable food crops.

Land adjacent to the property boundaries are:

Neighboring properties adjacent to the farm are primarily agricultural fields and residential areas. Adjacent fields are in row crop agricultural production. Crops produced in these fields are corn and soybeans. The use of conservation agriculture practices such as cover crops and no-till on neighboring fields is unknown.

The client's farm operation currently owns infrastructure and equipment on the farm included in the table below.

Buildings	Equipment	Other Infrastructure
1 Shed	Traditional hand tools	2 hoop houses
	22 hp tractor with finishing mower and finishing deck	
	Grillo walk-behind tractor	

Table 2. Buildings, equipment, and other infrastructure on-site.

The client's farm operation also has access to highway and interstate systems nearby for contracted services. Custom services for farm operations include items listed in the table below.

Task/Service	Contracted Company	Timeframe of Service
One-time till	[Redacted]	Fall
Planting	[Redacted]	Late January to Early February

Table 3. Practices that are offered for site preparation.

Farm Map

Figure 1. Aerial image of overall property boundary highlighted in orange and proposed perennial bioenergy crop in yellow.

Soil & Site Information

The 10-acre property consists of two types of soils. Soil information provided by USDA's Soil Survey indicates that these soils range from moderately well-drained silt loam soil to poor-draining silty clay loam. The site has a sloping topography ranging from 0-6%. Figure 2 shows the soil classification map below. The area under consideration for the adoption of native prairie mix consists of soils primarily categorized as 531C2, Markham silt loam 4-6%, moderately well-drained loam soil, and 232A, Ashkum silty clay loam 0-2%. The composition of this soil makes it an optimal site for the establishment of native prairie and switchgrass.

Results of past soil testing on this property indicate variability across the site.

Figure 2. Map of soil types present on client's farm generated from Web Soil Survey.

Marginal lands are areas that are low in production and have reduced economic return or several limitations for agricultural practices (Kang et al. 2013). They are defined by land uses and characteristics that are on the verge of losing economic viability in conventional cropping regimes, such as frequent flooding, high erosion potential, or low soil quality. As a result, Perennial Bioenergy Crop adoption on these marginal lands may offset the higher costs and lower yields associated with conventional crops, potentially becoming competitive with conventional crops (Ssegane et.al, 2016). Further, these perennial crops will improve the conditions of these lands by reducing nutrient exports or preventing erosion through soil stabilization. The presence of marginal site characteristics in the areas outlined in the table and map below may be improved upon by the adoption of the desired perennial bioenergy crop.

SUPERBEEST Analysis

The Scaling Up PERennial Bioenergy Economics & Ecosystems Services Tool (SUPERBEEST) is a geospatial decision-making tool developed by Argonne National Laboratory. The tool assists by identifying economically and/or environmentally marginal areas that are suitable for the adoption of perennial bioenergy crops. A future capability will be to assess the potential ecosystem services that may be realized by adopting a perennial bioenergy crop in marginal areas of corn and soybean row crop land and the net economic effect of the change.

When analyzing land for economic and environmental marginalities, SUPERBEEST considers only row crop land. This includes corn and soy rotations under the USDA's Cultivated Layer, which uses satellite imagery collected in 2014. If a farmer or landowner is considering a conversion to perennial bioenergy crops in a field that is not identified as corn, soybean, or pasture in the dataset, then it will not appear as marginal land of any kind on the SUPERBEEST web map. This does not mean that the land in question contains no marginalities; it could very well already not be under a corn, soybean, or pasture regime because of underlying marginalities. Converting agricultural land to a perennial bioenergy system, even if it is not converted from conventional row crops, may still improve soil, water, and habitat and is of interest to the project team and partners.

In instances where the land in consideration does not fall into the 2014 Cultivated Layer footprint for corn, soybean, or pastureland, SUPERBEEST can be used as a guide by assessing neighboring lands for their marginalities and soil conditions. However, the tool will not be a primary driver of generating the management plan.

SUPERBEEST Raster Map

Analysis Report

Generated: *March 11, 2024*

Version: *master.20240101.7010*

Areas

Marginal Lands	
NCCPI	10.01ac
Drainage Class	35.36ac
Flooding Frequency	0ac
Ponding Frequency	0.9ac
Runoff	59.82ac
Nitrate Leaching	44.26ac
Pesticide Leaching	44.26ac
Saturated Bioenergy Buffers	
Suitable	0.22ac

Figure 3. SUPERBEEST analysis report for lands surrounding area of interest.

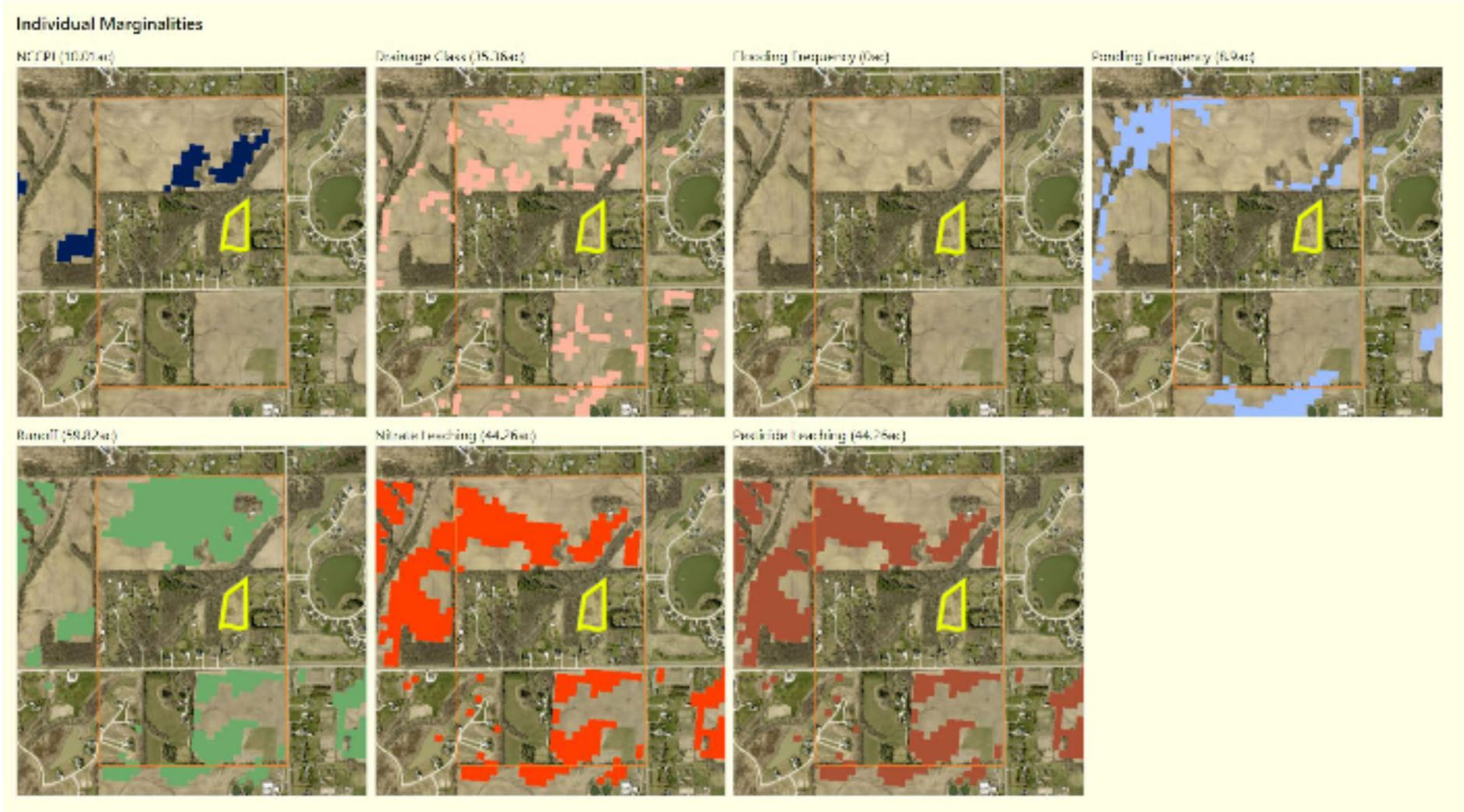


Figure 4. SUPERBEEST Individual Soil Marginality Analysis.

Due to the area of interest not having a history of row crops, the SUPERBEEST image shows the marginalites that surround the property. The yellow highlighted area of interest is currently unmanaged grassland with unwanted Japanese honeysuckle, brambles, and dogwood. The client

would like to remove these unwanted species and plant native prairie and switchgrass. The client will also plant a small plot of switchgrass in a riparian area that is not shown in this figure due to its small size.

Marginal Site Characteristics	Present In-field	Present out-of-field
Low crop productivity		
Pooling/ponding water	x	x
Flooding		x
Highly Erodible Land (HEL)		x
Water Holding Capacity (WHC)	x	x
Nutrient leaching		x
Drought/Dry spots		
Sloping		x
Other/ Write in:		

Table 4. Table illustrating marginal site characteristics present in and out-of-field.

Proposed 5-Year Plan

Clients' goals for this farming operation are to:

The client's operational goals are focused on creating a diverse native prairie along with switchgrass to produce biochar and increase biodiversity on their property. The property is an operational vegetable farm in addition to producing fruit and nut varieties. The client envisions native prairie biomass being grown to produce biochar feedstock, improve soil health, and provide an additional crop for harvest.

With the implementation and end use of native prairie mix and switchgrass biomass, the client is interested in preparing the site and managing the establishment on their own with the support of local contract services if needed. The client greatly values the implementation of these crops for the soil health benefits, biodiversity, and long-term farm viability that may be realized on the property.

Figure 5. Timeline of steps to adopt a perennial bioenergy crop.

Year 1: Site Preparation

Site preparation will be prioritized during the first year of perennial bioenergy crop adoption for bioenergy production. This includes the tasks outlined for both native prairie mix and switchgrass crops in the table below.

Year 1 Tasks	Native Prairie Mix/Switchgrass	Timeframe
Task 1	Removal of undesired trees & brush	Fall
Task 2	Site prep-till	Fall
Task 3	Seed procurement	Fall
Task 4 Optional	Prescribe burn	Fall – early Spring. *(optional)*

Table 5. Site preparation tasks in year 1.

While American Farmland Trust does not recommend tillage as a sound conservation agricultural practice, it may be beneficial to till before establishing perennial bioenergy. Tilling the area that will produce the desired perennial bioenergy crop will ensure good establishment for the crop's approximate 20-year lifespan. This will ensure that tilling or other soil-eroding site preparation tasks will be limited to the one-time establishment event. After the successful establishment of the desired perennial bioenergy crop, tilling will not be required.

Seed procurement for the desired perennial bioenergy crop should take place within Year 1 as well. It is important to confirm that the seed mix being purchased is the desired perennial bioenergy crop and variety outlined in this plan.

It is also important to note that contaminated, misidentified, or mislabeled seeds may lead to unintentional spread to undesired locations of the farm or neighboring properties. Recommended species mix for native prairie and switchgrass biomass production are listed in the Year 2 management section of the plan below.

Additional Details: The information in the section below provides guidance on on-site preparation and removal of undesired trees and invasive species present in the area of interest for the adoption of a native prairie biomass plot.

Removal of unwanted plant species & upkeep recommendations:

Japanese honeysuckle trees & brush removal:

It is recommended that the client removes unwanted trees and brush before planting takes place. The use of manual brush saws or chainsaws will be the most accessible method to remove trees. Herbicide stump treatment and prescribed burning are two options that produce the best results. Trees should be cut no more than six inches above the ground. Apply stump treatment herbicide to the top of the stump immediately after cutting. Always follow herbicide and handling instructions and proper PPE should be worn during application. The client should ensure the herbicide is intended for these species.

Figure 6. Image showing unwanted Japanese Honeysuckle, Bramble, and dogwood stand in proposed area of interest.

Prescribed burns & fire management recommendations:

The client should follow the below criteria if they would like to use prescribed burns and fire management strategies as a site preparation tool. Obtaining a Prescribed Burn Plan that is prepared by a qualified professional is strongly encouraged for a detailed recommendation on fire management. Due to the proximity to valuable property and forested areas, requesting site preparation to limit the spread of fire beyond the intended boundary is highly recommended. Calling the non-emergency line to inform authorities of a prescribed burn should occur. General guidance for prescribed burns includes:

Timeframe

- The Illinois EPA recommends that prescribed burns be conducted between October 1st and April 30th. Prescribed burns on prairie should occur every 1 to 3 years to promote growth and weed suppression (Illinois.gov). If the goal is to harvest the prairie, prolonged time between burns is ideal. Allowing more time between burns will promote the growth of flowering forbs.

Figure 7. Photo of a prescribed burn in a prairie

Weather conditions

- Illinois Extension recommends following the 60-40 rule. Perform prescribed burns when the air temperature is below 60 degrees Fahrenheit, and the relative humidity is greater than 40 percent. The wind speed must be between 5 and 15 miles per hour measured at 6 feet above the surface.

Local resources that can support tree removal and prescribe burns:

- ILM Environments - Safe Prescribed Burns in Illinois | ILM Environments

- McConnell Environmental - McConnell Environmental - certified wetland specialists and certified professionals in erosion and sediment control
- Precise Tree Care- Commercial and residential tree removal
- Chalsey Landscaping and Tree Service

Year 2: Planting & Establishment

Seeding of desired perennial bioenergy crop will occur in the spring of the second year of this management plan.

Bioenergy Crop	Ideal Planting/Seeding Time	Seeding Rate
Native Prairie Mix (9 species)	Broadcast in late Jan. – early Feb.	10 lbs./acre
Native Prairie Mix (19 species)	Broadcast in late Jan. – early Feb.	10 lbs./acre
Native Prairie Mix (35 species)	Broadcast in late Jan. – early Feb.	10 lbs./acre

Table 6. Seeding recommendations for native prairie mixes as a perennial bioenergy crop.

Note that not all native prairie mix seeds will sprout upon first seeding. Some species require cold stratification and will germinate the following season if conditions are ideal. Sometimes seeds do not germinate, animals pick them up, or mechanical issues that plug seeders can cause this. This requires the farmer to go back in and reseed in target areas to ensure consistent establishment. Field skips will require re-planting in years two or three to ensure a fully established stand.

Switchgrass Variety	Cultivar Details	Ideal Planting/Seeding Time	Seeding Rate	Notes
Shawnee	Upland	Broadcast in late Jan. - early Feb. Drill in mid-November - mid-April.	6 lbs./acre	Evenly spread-out growing style
Liberty	Upland/lowland Hybrid	Broadcast in late Jan. - early Feb. Drill in mid-November - mid-April.	6 lbs./acre	Clumping growing style-may appear to grow patchy upon establishment

Table 7. Seeding recommendations for switchgrass as a perennial bioenergy crop.

These two cultivars have different establishment patterns. Depending on soil type, Shawnee will establish without bare spots, has longer rhizomes, and will typically produce lower yields compared to Liberty. Liberty tends to grow in clumps and is slower to fill in the area, but typically produces higher yields. Although Shawnee was developed for livestock feedstock, it provides high-value biomass for bioenergy production. The client can reach out to seed dealers for shorter upland cultivars if the height of these two cultivars doesn't fit their needs. Shorter cultivars could result in lower yields.

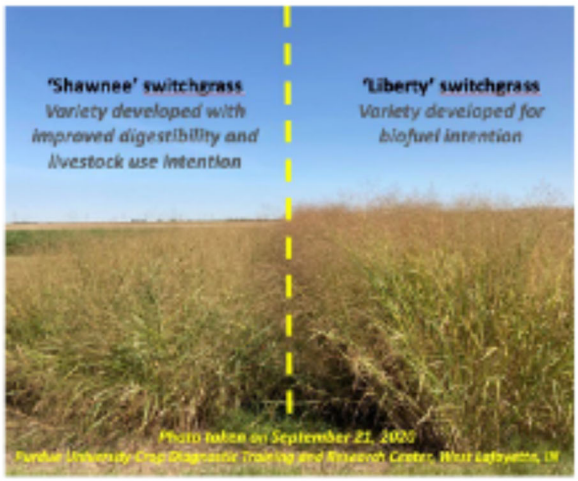


Figure 8. Comparison between Shawnee vs Liberty switchgrass.

Biomass Species Mixes

The tables below identify notable species that are recommended for native prairie mixes grown for biomass production.

9-Species Mix	Big Bluestem	Switchgrass (Cave-in-Rock)	Switchgrass (Chippewa)
	Switchgrass (Kanlow)	Partridge Pea	Ox-eye Sunflower
	Showy Tick Trefoil	Wild Senna	Common Milkweed

**Note this seed mix will be the most cost-effective, but will not provide the broad environmental benefits provided by higher species count mixes.*

19-Species Mix	Big Bluestem	Little Bluestem	Indiangrass
	Side Oats Grama	Canada Wild Rye	Purple Prairie Clover
	Partridge Pea	Common Milkweed	Black Eyed Susan
	Ox-eye Sunflower	Wild Bergamot	White Prairie Clover
	Purple Coneflower	Yellow Coneflower	Stiff Goldenrod
Smooth Blue Aster	Canada Milkvetch	Maxmillion Sunflower	Switchgrass (Chippewa)

35-Species Mix	Big Bluestem	Side Oats Grama	Sand Lovegrass
	Switchgrass	Little Bluestem	Indiangrass
	Leadplant	Canada Milkvetch	Partridge Pea
	Illinois Bundleflower (Prairie Mimosa)	White Prairie Clover	Purple Prairie Clover
	Wild Bergamot	Showy Tick Trefoil	Stiff Goldenrod
	Common Milkweed	Common Mountain Mint	Narrowleaf Mountain Mint

	Prairie Cinquefoil	Foxglove	Gray-headed Coneflower
	Black-eyed Susan	Gray Goldenrod	Smooth Blue Aster
	Calico Aster	New England Aster	Ohio Spiderwort
	Hoary Vervain	Culver's Root	Golden Alexander
	Common Milkweed	Butterfly Milkweed	Lance leaf Coreopsis
	Marsh Blazing star		

Table 8. Recommended native prairie species mix.

Note this seed mix will be the most expensive, but successful establishment will ensure the highest environmental benefits of lower species count seed mixes.

Seed Procurement

The table below provides seed mixes available for multi-species native prairie seed mixes that are available online for the establishment of a perennial bioenergy crop.

Seed Dealers	Seed Mix Name	Price	Total Cost (6 acres)
Pheasants Forever	IL CRP CP21 Native Filter Strip	$74.00/acre	$444.00
	IL CP43 Prairie Strip Tallgrass Pheasant Safe	$79.00/acre	$474.00
	IL CRP Plateau Tolerant Tallgrass	$91.00/acre	$546.00
Ernst Seed Co.	9-species Biodiverse Polyculture Mix for Biomass Production & Wildlife Habitat	$14.92/lb. *(10 lbs./acre)*	$895.20
Elk Mound Seed	Native Prairie 16-species Mix	$41.99/lb. (10lbs./acre)	$2,519.40
Seed Dealer	**Seed Mix Name**	**Price**	**Total Cost (6 acres)**
Ernst Seed Co.	Shawnee (Panicum Virgatum)	$13.20/lb. (6 lbs./acre)	$475.20
	Liberty (Panicum Virgatum)	$16.80/lb. (6 lbs./acre)	$604.80

Table 9. Table of available seed dealers and approximate cost of various native prairie mixes.

Additional details for switchgrass:

When drilling switchgrass seed that is less than one year old and non-stratified, the mid-November to mid-April timeframe allows for some stratification to occur. Seed that has been stratified and stored for one year should be planted when the soil temperature reaches 60 degrees F. To avoid dormancy, frost the seed in January or February and expose at least 30 percent of the soil. To frost the seed, you spread it during January or February and let the natural freezing and thawing of the soil work it into the ground. Seed should be planted at a depth between ¼ inch to ½ inch deep followed by a press wheel to ensure good soil-to-seed contact. If the drill does not have a press wheel, you should use a roller to compress the soil. One to two passes should sufficiently pack the soil around the seed (Teel, et al. 2003).

Year 3: Maintenance (Establishment Year)

Overview of Nutrient Management Plan for new crop:

Nutrient inputs for the management of native prairie may not be necessary. Native prairie strategically implemented in runoff areas may intercept nutrients being lost from adjacent fields. Depending on landscape design, buffers can be implemented to intercept leached nutrients from adjacent fields of corn and soybean nutrient applications.

Given the current inflated price for nitrogen and other macronutrient inputs, it is recommended the client not use additional fertilizer as it would increase the overall cost of production for biomass. The use of inputs may improve biomass yield, which could potentially increase net profit. However, keeping costs low to produce native prairie is recommended due to the potential high costs of specialized equipment rentals and unstable market opportunities in the region. Additional costs of nutrient inputs will increase the overall cost of production and narrow the profitability margin of harvested biomass.

Nutrient inputs for the management of switchgrass may not be necessary. Switchgrass strategically implemented in runoff areas may intercept nutrients being lost from adjacent fields. Switchgrass grows well in low-fertility soils, occasional nitrogen applications may occur after establishment pending soil tests. Depending on landscape design, buffers can be implemented to intercept leached nutrients from adjacent fields of corn and soybean nutrient applications.

Bioenergy Crop	Nutrients Needed	Application Method	Application Time	Application Rate
*Native Prairie	Nitrogen	Broadcast	After harvest	**Not recommended for this plan.**
**Switchgrass	Nitrogen	Broadcast	After harvest	12-14lbs/acre

Table 10. Fertilization rate for native prairie and switchgrass.

****Note that it is not recommended to apply fertilizer to native prairie.***

*****Note that higher-yielding biomass cultivars may require a higher nutrient application rate. Nitrogen prices are so high that it may discourage some farmers from applying nutrients, especially if the market is uncertain.***

Potential Management Needs for Switchgrass:

Weed control will need to occur during the establishment of switchgrass. It takes approximately two to three years for switchgrass to produce enough biomass for harvest. It can be helpful to apply a pre-emergent or post-emergent herbicide to control weeds during the initial establishment phase. One to two quarts per acre of glyphosate should help control broadleaf weeds (Kane, et al.). If the client does not wish to apply herbicides, then mowing one to three times during the first growing season when weeds are 6-10 inches tall will allow switchgrass to develop an extensive root system and have good establishment. Mowing will help mitigate high weed pressure from cool season grasses like foxtail.

Potential Management Needs for Native Prairie:

It is important to note that in the summer after seeding, native prairie establishment will be slower than weed growth, which is expected. Native prairie should be the dominant species by the end of the third year following this timeline. It is not recommended to use herbicide for weed control in native prairie. Removing old growth after seeding will help the prairie establish. Mowing during the growing season will promote more diversity and allow sunlight to reach the base of the perennial plants, promoting tillering. Mowing the old-growth areas in mid-March will speed the establishment of native prairie (Owensby, Fick 2015).

Year 4: Harvest

The initial harvest and storage of desired perennial bioenergy crops will occur during the 4th year of this implementation plan.

Harvest timeline and other considerations for native prairie:
If the client wishes to perform a harvest in year 4, a prescribed burn should occur in early spring. For optimal biomass yields, the recommended harvest timeframes for native prairie mix should occur in the fall after September.

This timeframe allows roots to expand for the next season to ensure consistent regrowth. The harvest recommendation also acknowledges the preservation of grassland bird nesting habitats that may be present in the native prairie biomass plot. Nesting season generally occurs from April to August. Harvesting outside of this time window ensures that nests and fledglings will not be negatively impacted by harvest activities (Sahcadmin, 2019).

Harvest practices recommended to support grassland bird habitat:

- Set the mower/harvester as high as possible: 4-8 inches above ground can help support grassland birds and other wildlife.
- Leave borders and field edges uncut for bird and wildlife cover.
- Harvest from the inside of the field moving outwards. Harvesting the center of the field outward can provide cover for birds as they escape the edges of the field and prevent them from being trapped during harvest.
- Reduce harvest speed. This allows birds and wildlife enough time to react and escape.
- Only harvest during daylight hours. Birds are less likely to escape during the night (Sahcadamin 2019).

Harvest timeline and other considerations for switchgrass:
An early spring-prescribed burn will promote early emergence, allowing more sunlight to reach the soil surface. The growth of switchgrass occurs from June to August. Harvest should take place during the winter months after the plant senesces in the fall and their nutrients translocate to the root system. This will reduce the need for fertilizer inputs the following season and allow moisture levels in the plant to reduce to 15% or lower, which is ideal for harvest (Mitchell et al.). This also allows the ground to be frozen enough to prevent damaging ruts and compaction.

Year 5: Storage & Processing

The final year of this management plan will focus on the desired end use of harvested perennial bioenergy crop biomass. Based on the landowner's preferences, this will include local market opportunities and on-farm uses.

As previously mentioned, the client's goals for end use of harvested biomass of perennial bioenergy crop include:

Goals & Potential Market Opportunities:

The client values growing this crop for potential ecosystem services, on-farm furnace, and biochar feedstock that may be realized with the implementation of native prairie mix and switchgrass. With the implementation and end use of perennial biomass, the client would prefer to manage harvest activities on their own with the support of local contract services if needed.

For additional resources on growing desired perennial bioenergy crop, please see the "Perennial Bioenergy Crop Growing Guide" in the Appendix of this plan.

Harvest, Storage, & Processing of a Perennial Bioenergy Crop

Harvest

Harvest of native prairie mix as a perennial bioenergy crop should occur in the fall after September when conditions are dry and impacts on wildlife are minimal.

Harvest of switchgrass as a perennial bioenergy crop should occur from January through March for optimal moisture content. Moisture content will depend on the desired end use of the harvested biomass. See the table below highlighting target moisture content and expected biomass yields.

Bioenergy Crop	Harvest Timeframe after Establishment	Moisture Content	Expected Biomass Yield (dry tons per acre)
Native Prairie	Annually	45%	2.5-4 tons of dried material (DM) per acre
Switchgrass	Annually, Every third year	12-15%	2.5-6 tons of dried material (DM) per acre

Table 11. Expected harvest details of perennial bioenergy crops.

Figure 9. Example of a John Deere hay mower suitable for harvest of native prairie & switchgrass.

Equipment needed to harvest desired perennial bioenergy crops consists of a hay cutter, baler, and haul trailer.

Storage

Perennial Bioenergy Crops can be harvested and baled with commercially available haying equipment in most cases. Details that should be considered for storage of perennial bioenergy crops include desired end use, whether it is on- or off-farm, storage timeframe, and whether the harvest is chipped or baled. Options are available for packaging harvested perennial bioenergy crops for storage and transportation, however, large bales or rectangular bales are the most readily available in the Midwest. Large round bales tend to have fewer storage losses than large rectangular bales when stored outside, but rectangular bales tend to be easier to handle and load a truck for transport without road width restrictions.

The desired end use of the perennial bioenergy crop biomass will affect the timeframe and conditions of storage for harvested biomass. Harvested biomass may be stored indoors in a storage building or outdoors and covered depending on the desired end-use.

On-farm Processing

Biomass feedstock can be best used on the farm using the following biomass conversion technologies for the intended use of harvested desired perennial bioenergy crop feedstock:

- *Biomass furnace*
- *Pyrolysis & Gasification System*
- *Anaerobic Digester*

Details on End-Use Technology for Harvested Biomass:
(harvest/baling equipment, harvest timing & conditions, storage location, protection, transportation)

The client will use harvested biomass as a feedstock for the woodburning stove and biochar production. The client currently heats their home with a wood-burning stove and would like to expand the heating potential to their 40-foot by 20-foot hoop house for plant propagation. The biomass feedstock will also support the production of biochar on-site.

Off-farm Processing

Off-farm processing and market opportunities for desired perennial bioenergy crop feedstock may include processors who accept feedstock for conversion to renewable energy as well as other bioproducts such as compostable packaging, pet food, livestock bedding, and others. Market opportunities for the client's desired perennial harvested biomass include:

Local Opportunities:

- Synata Bio- Home: Synata Bio Warrenville, IL
- Honeywell UOP: UOP Home (honeywell.com) Mc Cook, IL
- GTI Energy: Home • GTI Energy Des Plaines, IL

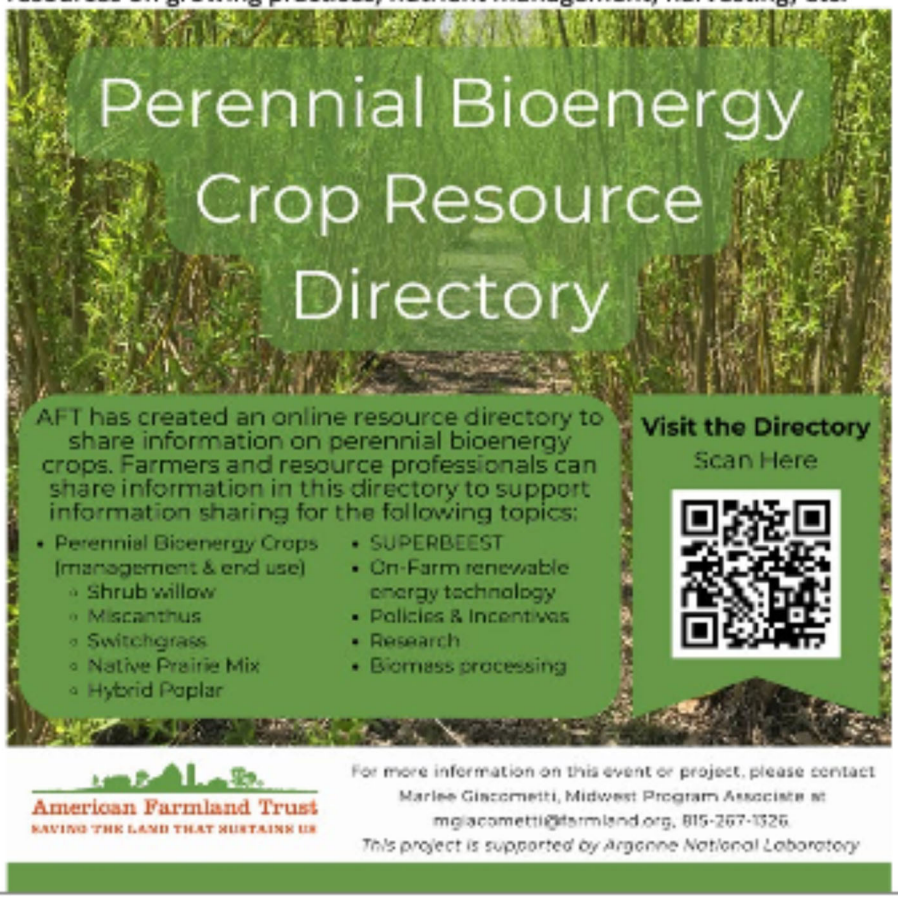
While these market opportunities have been identified, it is not confirmed that transport logistics will make this a profitable endeavor. These locations may not be in the market for certain biomass feedstocks. Not all biomass feedstocks are not being processed on a commercial scale. Storage, transportation, and required hauling equipment of feedstock are the most important logistics details that need to be determined prior to committing to a market end-use.

**Market opportunities identified in this plan are not endorsed by Argonne National Laboratory or American Farmland Trust.*

Appendices

A. Technical Resources

- Perennial Bioenergy Fact Sheet – This factsheet provides high-level information on the benefits of perennial bioenergy cropping systems and energy independence opportunities on-farm.
- Switchgrass Growing Guide – A comprehensive guide for the adoption of switchgrass
- On-Farm Biomass Conversion Technology Factsheet -
- Perennial Bioenergy Resource Directory – This Google drive houses research and technical resources for a variety of perennial bioenergy crops, market opportunities, biomass conversion, and landscape design. There is a folder titled "Shrub Willow" that includes resources on growing practices, nutrient management, harvesting, etc.



- Prairie Power Project Final Report – This is a report on the research and end use of native prairie used for bioenergy end use by the Tallgrass Prairie Center in Iowa.
- Perennial Bioenergy Crop Diversification Project Webpage – This is the official project webpage for which this technical assistance is provided.

B. Perennial agriculture costs and benefits compared to conventional systems.

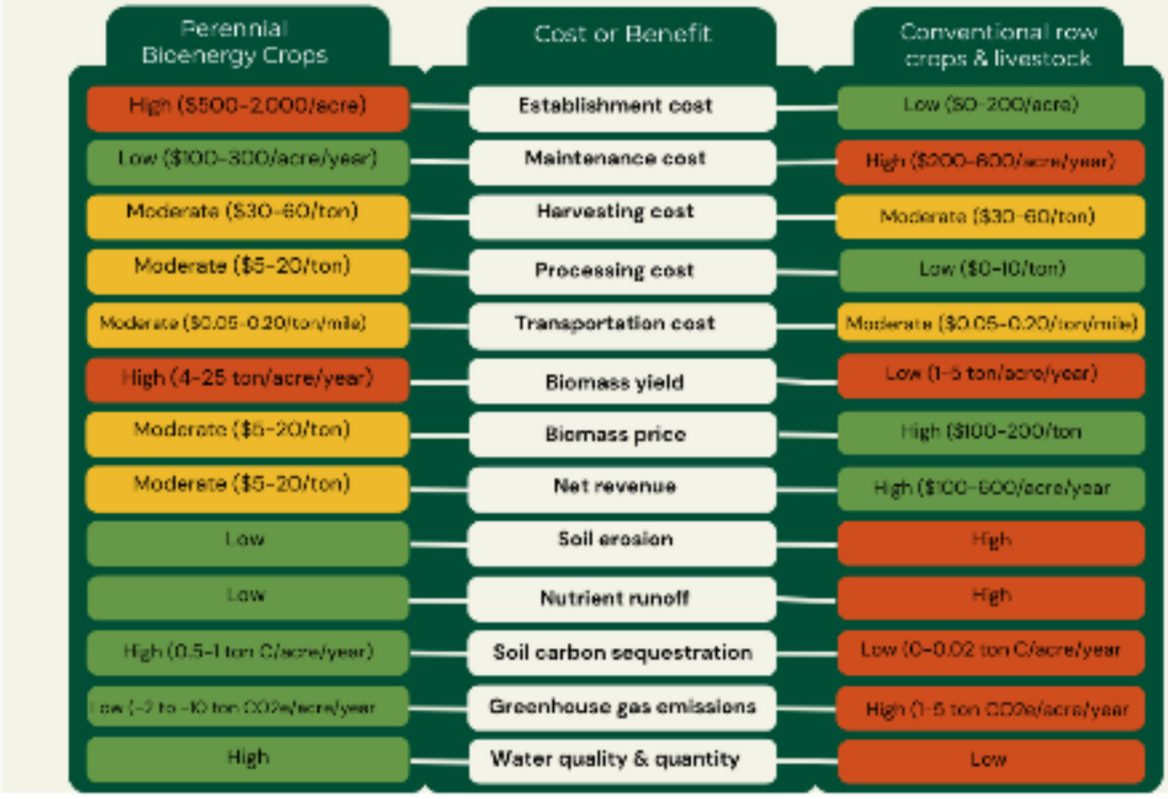


Figure 10. Comparison table provided by Sierra View Solutions in their bioenergy market analysis conducted for the Perennial Bioenergy Crop Diversification Project.

C. Web Soil Survey Map

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other

Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:12,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Will County, Illinois
Survey Area Data: Version 19, Aug 28, 2023

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jul 5, 2020—Jul 6, 2020

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

D. SUPERBEEST Analysis of Whole Farm

Analysis Report

Generated: *March 11, 2024*

Version: *master.20240101.1016*

Areas

Marginal Lands	
NCCPI	10.01ac
Drainage Class	35.36ac
Flooding Frequency	0ac
Ponding Frequency	8.9ac
Runoff	59.82ac
Nitrate Leaching	44.26ac
Pesticide Leaching	44.26ac
Saturated Bioenergy Buffers	
Suitable	0.22ac

Composite Marginalities

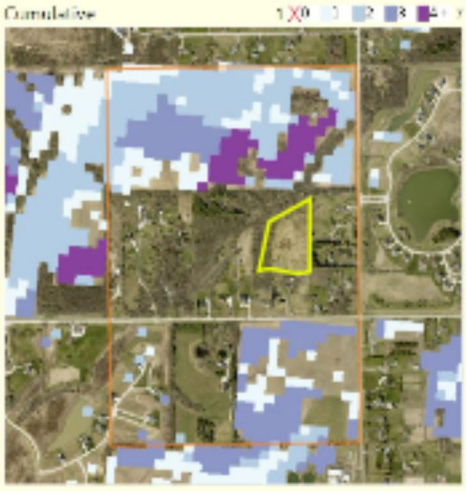


Figure 11. SUPERBEEST map showing a composite view of marginalities on the property surrounding the area of interest outlined in yellow.

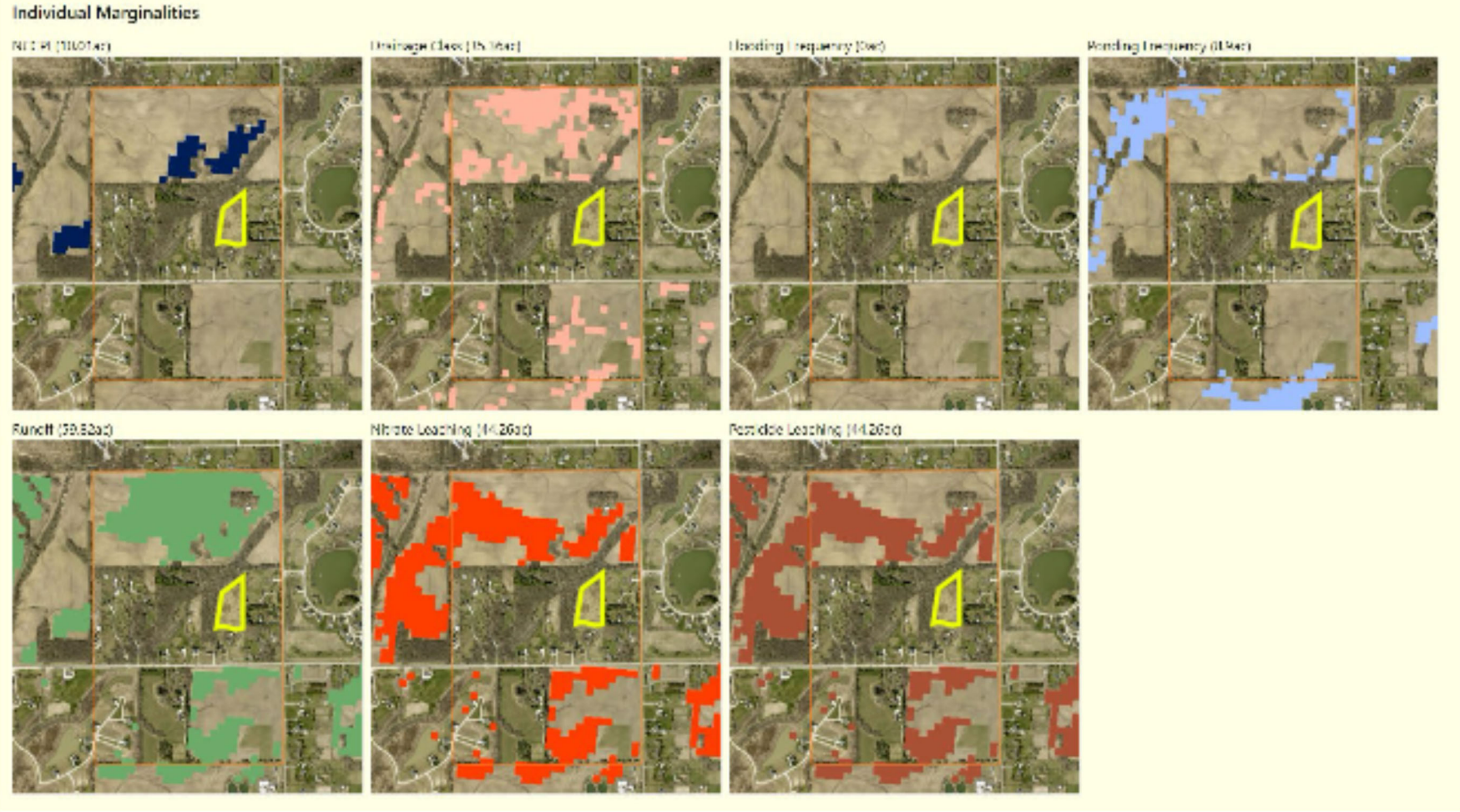


Figure 12. A collection of maps showing individual marginalities on the property surrounding the area of interest is outlined in yellow.

E. Financial Resources

Estimated costs of establishing and managing switchgrass in Illinois.

Activity	Item	Year 1	Year 2	Year 3	Year 4	Years 5-10
Planting ($/acre)	Seed	$31.93	$3.19	-	-	-
	Seed drilling	$17.65	$7.14	-	-	-
	Pre-emergence herbicide	$8.93	-	-	-	-
	Subtotal	***$58.51***	***$10.34***	-	-	-
Management ($/acre)	Post-emergence herbicide	$8.53	$8.53	$8.53	-	-
	Spraying application	$6.69	$3.36	$3.36	-	-
	Fertilizer	-	$9.70	$9.70	$9.70	$9.70
	Fertilizer application	-	$2.23	$2.23	$2.23	$2.23
	Subtotal	***$15.21***	***$23.81***	***$23.81***	***$11.93***	***$11.93***
Harvesting ($/acre)	Swathing	$15.61	$15.61	$15.61	$15.61	$15.61
	Baling	$66.94	$78.49	$100.96	$72.92	$89.71
	Transport to storage	$17.53	$20.56	$26.44	$19.10	$23.50
	Subtotal	***$100.08***	***$114.66***	***$143.01***	***$107.62***	***$128.81***
Total ($/acre)		**$173.80**	**$148.81**	**$166.83**	**$119.55**	**$140.74**

This came from an internal analysis. If pre-post emergent herbicide applications are skipped, then the cost will be lower. End-use also affects cost structure.

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