Harvesting Prairie Biomass: How Luther College Can Advance its Clean Energy Portfolio and Promote Landscape Sustainability

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"Founded where river, woodland, and prairie meet," Luther College proclaims to "practice joyful stewardship of the resources that surround" it.[1] Look out any office or dormitory window. Several small prairies, acres of forest and the majestic Upper Iowa River all lie within sight of Luther's central campus. As an institution, Luther recognizes a fundamental responsibility to preserve these features as well as pioneer a course towards larger models of sustainability. In January 2007, President Torgerson signed the American College and University President's Climate Commitment as a charter member. A few months later, the college's five year Sesquicentennial Strategic Plan identified campus sustainability as a major goal in Strategic Imperative III: Connecting Sustainability, Stewardship, and Global Citizenship. Evidence of these commitments stands out around campus. Strategic Imperative III claims that Luther pushes "to explore renewable energy production strategies" because drastic reductions in greenhouse gas emissions requires problem solving and innovation.[2] Figuring out how to alter Luther's energy consumption habits and implement new mitigation projects continue to puzzle those charged with accomplishing this task. Burning diverse prairie grass pellets in a central campus biomass boiler might become one part of Luther's clean energy portfolio in the future.

Though solar power and wind energy tend to take center stage in alternative energy discussions, "bioenergy" constitutes an integral part of America's plans to wean off of fossil fuels. Prairie grasses have been proposed as an exciting new bioenergy feedstock that, when

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[1] Luther College. "Mission Statement." http://www.luther.edu/about/mission/ (accessed October 4, 2010).

[2] Luther College. "Strategic Imperative III: Connecting Stewardship, Sustainability and Global Citizenship" Transformed by the Journey Strategic Plan. http://www.luther.edu/sustainability/commitments/strategicplan/ (accessed October 4, 2010).

coupled with persuasive arguments of energy independence and climate change mitigation, may spark a return of prairies and a semblance of sustainability to Northeast Iowa. In fact, some regard diverse mixes of perennial prairie grasses as a "new, tantalizing prospect of maximizing the amount of perennial grassland, land that could benefit wildlife, provide income to farmers, and contribute to domestic renewable energy production." [3] Like most novel ideas, however, many aspects of this breakthrough feedstock need to be thoroughly scrutinized before a working prairie grass bioenergy model can be brought to fruition. Important questions must be answered. What are the ecological benefits? Is it practical? Cost-effective? In hopes of laying out the benefits of implementing a prairie grass biomass energy model, this paper examines the ecological and energy issues involved, the heating fuel potential of grasses, and the availability of local land for growing these grasses. Then, the various economic and operational obstacles that institutions like Luther may face in such an endeavor are explored and evaluated.

Luther's institutional commitments to stewardship and sustainability are the products of an increased awareness about environmental problems as well as concerns over the college's operations in light of these problems. Luther's Strategic Imperative III reads, "As we look ahead to the next century and beyond, global environmental problems, resource scarcity, and climate change will threaten the health of the planet. They will also present economic and operational challenges for Luther."[4] In response to these concerns, the college has identified reducing greenhouse gas emissions and resolving fuel security concerns as clear priorities. Responsible land stewardship has also become a part of Luther's mission. Now more than ever, landscape

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[3] Fargione, Joseph E., Thomas R. Cooper, David J. Flaspohler, Jason Hill, Clarence Lehman, Tim McCoy, Scott McLeod, Erik J. Nelson, Karen S. Oberhauser and David Tilman. "Bioenergy and Wildlife: Threats and Opportunities for Grassland Conservation." *BioScience*, October 2009. http://www.jstor.org (accessed September 14, 2010). 775.

[4] Luther College, Strategic Imperative III.

health, climate change, and energy security are being seen as interconnected issues that must be considered simultaneously if Luther is to achieve true sustainability. Policies aimed at improving landscape health, achieving greenhouse gas reductions and enhancing energy security at once are possible, though more difficult to implement. According to the college, this sort of thinking "must also guide decision-making in operations through the adoption of sustainable practices and the continued care for this special place." [5]A working prairie grass energy model may be one way to integrate these concerns and successfully further institutional sustainability goals. On a larger scale, planting prairies for use as a biomass feedstock in Winneshiek County would reverse the harmful environmental impacts brought about by the precipitous loss of prairie and the heavy use of industrial agriculture in Iowa.

Luther sits nestled in what was historically the prairie-forest border. Here, tall grass prairies met open oak woodlands and upland forests to form a vegetation transition from grasslands to forests.[6] Throughout the rest of Iowa, vast, sweeping prairies filled the landscape with tall grasses, summer flowers and now vanishing animal species. Until European settlement in the early 1800s, 28 million acres of prairie blanketed 80 percent of the state with a diverse community of native perennial plants.[7] A few remnant prairies have become rare patches among seemingly endless rows of corn and beans. As a matter of fact, less than 0.1 percent of Iowa's prairies exist today, thus making it one of the rarest and most endangered ecosystems in the world.[8] The environmental consequences of this dramatic landscape transformation have been

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[5] Ibid.

[6] Mutel, Cornelia F. *The Emerald Horizon: The History of Nature in Iowa.* Iowa City: University of Iowa Press, 2008, 40.

[7] Ibid., 41.

[8] Ibid.

tremendous. According to Cornelia Mutel, ecologist and author of *The Emerald Horizon: the History of Nature in Iowa,* plowing virgin prairie for agricultural purposes initiated excessive water runoff, rapid soil erosion and many of the other environmental problems that Iowans struggle with today.[9] With the extirpation of Iowa's prairies for industrial cornfields, the vital ecological functions prairies previously performed disappeared and, as a result, the landscape's overall sustainability diminished.

The history of Iowa's prairies resembles tragedy. David Faldet laments how "Iowa's prairies were swallowed by an ecological holocaust" that is now being carried out by modern corn hybrids and conventional farming methods[10]. In his book *Oneota Flow: the Upper Iowa River and its People*, Faldet examines historical environmental problems the Upper Iowa River valley, Northeast Iowa and the greater Driftless Area. He points out that soil degradation, soil erosion, water pollution, water runoff and the loss of wildlife habitat afflict the landscape where prairies once met forests. Faldet explains that every spring tons upon tons of soil, fertilizer and pesticides are flushed into the Upper Iowa River due to the widespread use of imprecise and destructive farming methods in the Oneota valley. According to Faldet, "the single most important way to slow soil runoff" and, therefore, improve landscape health "is to put down permanent roots" where annual tilling currently takes place.[11] If native prairies, oak savannas and forests still covered the hillsides, soil erosion and polluted water runoff could be reduced by up

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[9] Ibid., 115.

[10]Faldet, David S. *Oneota Flow: the Upper Iowa River and its People.* Iowa City: University of Iowa Press, 2009, 44.

[11] Ibid., 34.

to 75 percent.[12] Soils anchored by deep prairie roots would strain and absorb the water and sediment that presently runs right past row crops, down the Upper Iowa drainage basin.

It appears that the "ecological holocaust" brought about by modern agriculture in Iowa can be seen and felt outside of the Oneota valley. In fact, connections between the prairie's decline in Iowa and global environmental problems have become clear.[13] For example, the same water runoff and soil degradation Faldet describes in *Oneota Flow* are causing key nutrient compounds used in row crop production to not only show up in other places, but have harmful ecological consequences there too. The Driftless Area Initiative (DAI), a regional non-profit organization focused on natural resource conservation and sustainable economic development in Northeast Iowa, Southeast Minnesota, Southwest Wisconsin and Northwest Illinois, states that an estimated ninety percent of the nitrogen lost from this area is delivered to the Northern Gulf of Mexico.[14] Extensive fertilizer application, excessive water runoff and the loss of both native plant communities and healthy soil properties have caused chemical phosphates and nitrates to trickle into the Upper Iowa River, as Faldet describes, flow into the Mississippi and pour into the Gulf of Mexico. Large accumulations of these nutrients over the years have created an oceanic dead zone where virtually no marine life can survive. Keeping this in mind, the larger ecological health issues associated with modern agriculture and the prairie's demise does, indeed, constitute

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[12] Husley, Brett. *Cellulose Prairie: Biomass Fuel Potential in Wisconsin and the Midwest.* Better Environmental Solutions, 2007. http://dnr.wi.gov/environmentprotect/gtfgw/documents/CellulosePrairie.pdf (accessed March 23, 2011), 21.

[13] Mutel, *the Emerald Horizon*, 115.

[14] Driftless Area Initiative. "Defining the 'Driftless Area.'" http://www.driftlessareainitiative.org/aboutus/strategic_plan.cfm (accessed March 23, 2011).

an ecological tragedy. Furthermore, Faldet, Mutel and the DAI all seem to agree that the tragedy of the prairie has had severe implications for the landscapes beyond Iowa's geopolitical boundaries.

Modern agricultural practices don't only disrupt soil structure and watershed health. Industrial agriculture is also an enormous polluter of our atmosphere. Part of the "ecological holocaust" that Faldet describes certainly includes the gigantic amount of greenhouse gases that have come from the conversion of prairies to industrial agriculture nationwide. Greenhouse gases like carbon dioxide (CO_2) spew from all ends of the U.S. agricultural industry and thus contribute greatly to global climate change, or what some are calling the "climate crisis." Although the consequences are still largely speculative, the scientific community now agrees that anthropogenic climate change will dramatically alter the environment and have enormous implications for human life. Outspoken climate change activist and former Vice President Al Gore reports in his latest book, *Our Choice: a Plan to Solve the Climate Crisis* that the domestic agricultural industry contributes nearly 20 percent of U.S. CO_2 emissions.[15] This figure includes direct emissions from farm equipment as well as the indirect emissions associated with fertilizer and pesticide manufacturing, for instance. The Environmental Protection Agency claims that the U.S. agricultural sector directly contributed 419.3 teragrams of CO_2 equivalents, or approximately six percent of total U.S. greenhouse gas emissions in 2009 through manure fermentation, fertilizer application and soil management techniques.[16] Clearly, this level of greenhouse gas emissions is unsustainable and demands that Iowa farmers rethink their methods.

[15] Gore, Al. *Our Choice: A Plan to Solve the Climate Crisis.* New York: Rodale Inc, 2009, 204.

[16] U.S. Environmental Protection Agency. "2011 Inventory of Greenhouse Gas Emissions and Sinks: 1990-2009." Washington, DC: National Service Center for Environmental Publications, 2011.

Iowa farmers occupy a unique position in the climate crisis. By participating in conventional farming methods, farmers have contributed significantly to greenhouse gas emissions over the last century. At the same time, it's the farmer who might be in the best position to make some of the greatest strides in reducing future emissions. It's ironic, as Gore points out, that some of "the greatest opportunities for sequestering CO_2 in the soil are on already degraded lands."[17] Iowa has thousands of acres of highly degraded farmland. Emission trends might slow if farmers began converting these massive carbon sources back to native plant communities. Mutel says that tallgrass prairies, unlike cornfields, "produce more than they consume for centuries on end, and store significant amounts of the greenhouse gas carbon dioxide as underground organic matter."[18] This biological fact forms the bases of Gore's claim and suggests that "the restoration of prairie grasslands throughout the world represents an unparalleled opportunity to pull CO_2 out of the atmosphere and into the soil."[19] The deep, carbon-storing root systems of prairie plants may simultaneously reduce greenhouse gas emissions and promote a healthier landscape. It may also provide some local energy security.

When Americans think of fuel, oil from the Middle East usually comes to mind. Similarly, when we think food we often think of the Midwest. It turns out that concentrated reserves of fossil fuel and high quality farmland share a lot in common. Heavy use of these resources has damaged our landscape and our atmosphere. Both oil and good soil are being depleted more rapidly every year due to exhaustive use. As a result, these activities are producing dramatic

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http://www.epa.gov/climatechange/emissions/downloads11/US-GHG-Inventory-2011-Chapter-6-Agriculture.pdf (accessed April 20, 2011).

17 Gore, *Our Choice,* 204.

18 Mutel, *the Emerald Horizon,* 121.

19 Gore, *Our Choice, 204.*

ecological consequences. Biofuels have been proposed as one way to resolve "energy security" concerns, or the idea that America jeopardizes its national security by depending on petroleum produced in the Middle East and other politically unstable nations. To this day, "energy security" remains a major concern on the national political stage and, for the most part, corn-based ethanol has become a featured energy security "solution" for many conservative agendas.

In the late 1990s, corn-based ethanol hit the ground running and began blurring popular notions of energy and food with new concepts of homegrown and ecologically responsible biofuel. The primary rationale for corn-based ethanol came from politics, foreign relations and popular anti-Middle East petroleum outcries following September 11th. Support has started to turn against corn-based ethanol however. Although estimates tend to vary greatly, it is widely thought that corn ethanol produces only about 1.34 units of energy for every one unit of input when every step of ethanol production is taken into account.[20] A net gain of 0.34 isn't very efficient yet it comes at a heavy price. Whether it is used for food or fuel, corn is still a product of industrial agriculture and, as a result, it generates a huge toll on the land. Widespread pesticide and fertilizer applications, extensive tilling and the heavy use of monocultures make people question the true sustainability and effectiveness of corn ethanol as a solution to landscape-scale environmental problems. Many environmentalists and scientists, now, view corn ethanol as exceedingly harmful to the environment regardless of the amount of oil and coal it offsets.

Besides its poor energy input to output ratio, corn ethanol's competition with food production has also become a huge issue. For some, it is not only imprudent, but even ridiculous to dedicate food crops and some of the most productive agricultural land in the word for fuel.

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[20] Enshayan, Kamyar. *Living Within Our Means: Beyond the Fossil Fuel Credit Card.* Cedar Falls, IA: Congdon Printing and Imaging, 2005, 35.

Even Congress appears to have recognized "that converting crops to fuel production in, say, Iowa, will cause farmers elsewhere in the world to clear virgin land to meet the demand for food, causing additional [greenhouse gas] emissions" and other negative environmental consequences.[21] In 2007, Congress passed the Energy Independence and Security Act and updated the Renewable Fuel Standard (RFS), which mandates that the United States produce 36 billion gallons of renewable fuel by 2022. Despite ferocious pressure from prominent corn lobby groups, much of the bioenergy production called for in the RFS is supposed to be derived from domestic, advanced, nonfood sources including perennial grasses. According to a February 2010 *New York Times* editorial, titled "Sensible Rules for Ethanol," the RFS act will address the need for a next-generation of bioenergy feedstocks from sources that do not generate the damaging environmental effects produced by industrial agriculture and corn-based ethanol.[22]

Non-food sources of bioenergy like perennial prairie grasses are being advocated at a frenetic pace. While offering his solutions to the climate crisis and clean energy era, Al Gore outlines several important criteria to make sure that biomass feedstocks are produced sustainably. He says: biomass should not cause further habitat destruction, CO2 emissions should be minimized, plants other than food crops should be used, water use should be sustainable, soil fertility should be preserved and enhanced and the economic wellbeing of stake holders should be respected and improved.[23] Although Vice President Gore's book mainly focuses on second generation cellulosic ethanol technologies that aim to replace gasoline, the same principles can and ought to be applied to biomass intended for central heating boilers. In the same manner,

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[21] "Sensible Rules for Ethanol" Editorial. *New York Times,* February 10, 2010, http://www.nytimes.com/2010/02/11/opinion/11thu3.html?ref=biofuels.

[22] Ibid.

[23] Gore, *Our Choice, 116.*

Vanadana Shiva defines sustainable energy in her latest book, *Soil Not Oil: Environmental Justice in an Age of Climate Crisis*. Shiva says, "Energy can only be considered sustainable if it does not compete with the food supply, does not divert organic matter from the maintenance of the essential ecosystem, is decentralized and based on decisions by local communities, and is based on biodiversity, not monocultures."[24] These are very tall orders, but diverse communities of prairie grasses on marginal farmland may well resolve the food versus fuel debate and leapfrog corn ethanol as the most desirable source of domestic biofuel.

Some people think that prairie grasses offer an ecologically responsible answer to energy security concerns. They believe prairie grass could be part of a more sustainable energy portfolio for the long-term future. Unlike corn-based ethanol, which focuses solely on reducing the dependence on foreign energy sources, perennial prairie grasses produce cleaner, homegrown energy and promote landscape health simultaneously. Congress, Gore, Shiva and the environmentalists who are against corn ethanol all appear to emphasize the need for these concurrent benefits. Cornelia Mutel also seems to be an advocate. She says that "promoting perennial polycultures of native plants for use as biofuels could profit the farmer while leading to partial restoration of ecosystems and ecological functions on far more land."[25] Furthermore, she argues that biofuel production could lead to healthier agricultural landscapes since it is able "to mimic the self-sufficient processes and structure of diverse tallgrass prairie communities and interweave them with livestock production and row crops."[26] This, it seems, is especially true if biofuels can be produced on marginal and abandoned agricultural lands.

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[24] Shiva, Vandana. *Soil Not Oil: Environmental Justice in a Time of Climate Crisis.* Cambridge, MA: South End Press, 2008, 93.

[25] Mutel, *the Emerald Horizon, 244.*

[26] Ibid., 121.

David Tilman, a widely renowned Professor of Ecology at the University of Minnesota, led a study looking at the energy production and fuel potential of low input, high diversity grasses on agriculturally degraded land. Like Mutel, Tilman thought, "biofuels need neither compete for fertile soil with food production nor encourage ecosystem destruction."[27] Published in the November 2006 issue of *Science*, this study made a tremendous splash among the scientific community, prairie enthusiasts and alternative energy supporters alike. At the time, some readers hailed the study as gospel while others remained dubious. Of course, this divide is by no means surprising.

Tilman's results are staggering and have far-reaching implications for new industries if confirmed. Their results suggest high diversity mixtures of prairie plants may join corn, switchgrass and soybean monocultures as well as waste biomass products like corn stover and wood chips as a third major source of biofuel biomass.[28] They found that a mixture of sixteen prairie plant species produced 238 percent more energy than plots planted with only a single species. There was 51 percent more usable energy observed in this prairie biomass than can be produced from corn-based ethanol on fertile land. Over a decade of observation, 160 percent more carbon dioxide was captured and sequestered in the roots of the sixteen species plots than was captured in the single species plots. Carbon sequestration occurred even though all above ground organic matter was burned every spring. These results are significant. It should be noted too that these results were obtained on agriculturally degraded land with virtually no input of fertilizers, herbicides, pesticides, or irrigation beyond a few treatments during the initial

[27] Tilman, David, Jason Hill and Clarence Lehman. "Carbon-Negative Biofuels from Low-Input High-Diversity Grassland Biomass." *Science*. December 8, 2006. http://www.jstor.org (accessed September 14, 2010).

[28] Ibid.

establishment period. Only some additional phosphorus replacement was required for these plots. The potential for energy production increases once more fertile land enters into the equation.

Numerous private research institutions and several Midwest universities have launched efforts to replicate Tilman's work. But in order to properly verify Tilman's study, extensive multi-year experiments must be conducted. However, these studies require time to develop. Tilman's research, for example, started planting plots in 1994. Due to this lag, Tilman's work is almost exclusively cited in the literature concerning diverse grasses and bioenergy. There is, at present, only a small pool of concrete data available to entities who may be interested in pursuing this technology further.

Switchgrass, a perennial grass often found intermixed within most tallgrass prairies, is currently being investigated as a biomass feedstock with a remarkable potential for both biomass and cellulosic ethanol production. Estimates of the energy content within switchgrass provides some insight into what diverse prairie grasses may be able to generate even though switchgrass is typically grown and burned in monocultures. In 2007, Better Environmental Solutions, a private energy and environmental consulting firm, published a report on biomass for the Wisconsin Department of Natural Resources. They reported that switchgrass could produce 8,000 British thermal units (Btus) per dry pound or 16 MBtus per dry ton.[29] It is thought therefore that switchgrass contains roughly 90% of the energy produced by coal firing. Since diverse prairie communities contain grasses, forbs and legumes alike, the energy content of these mixtures will be less than a monoculture of switchgrass, a crop identified for its energy potential. How much less remains to be seen. This lack of information represents a major gap in current knowledge and calls for greater study. Still, the good news is that more and more research is underway.

[29] Husley, Cellulose Prairie, 22.

Most of the focus has not been on calculating the energy percentage achievable from diverse grasses however. Determining whether low input, high diversity prairie grasses can be made into a feasible form of biomass energy also depends on how efficiently grasses can be grown on local farms. After all, we already know that burning grasses, like burning fossil fuels, will generate heat and electricity. Quantifying the expected yields per acre of growing diverse grasses, then, appears to be just as, if not more important than knowing the potential energy available in diverse prairie grass plots. Yields per acre will automatically determine the heating fuel potential of grasses before the actual energy conversions enter into the equation. Therefore, in addition to replicating Tilman's work, scientists across the Midwest are interested in studying the expected yields per acre from trial fields of diverse prairies.

In 2008, the Southwest Badger Resource Conservation and Development Council (Southwest Badger RC&D) began planting switchgrass and prairie grass plots to explore the viability of growing grasses for biomass production in the Driftless Area. Funded by Driftless Area Initiative and Alliant Energy grants, Southwest Badger's research has tried to determine "best management practices" or "BMPs" for harvesting both switchgrass and diverse prairie grasses in the Driftless Area as well as quantify yields per acre from those practices.[30]Though preliminary, the research demonstrates that the maximum yield for diverse prairie grasses was 1.39 tons per acre during their second year of production, which was only about half of the average yield per acre harvest of their monotypic switchgrass plots.[31] Similarly, in the Decatur area of central Illinois, winter harvests of diverse prairie grasses yielded roughly 1.8 tons per

[30] Bertjens, Steve. "Biomass—Switchgrass Establishment and Harvesting Demonstration Project." *Badger Report*, February 2010. http://www.swbadger.com/2009annualweb.pdf (accessed December 18, 2010).

[31] Ibid.

acre.[32] Yet it is estimated that 2.5 tons per acre could be achieved on these plots if grasses were harvested before the winter snow and ice mat grasses down. Obviously these numbers are premature. Even so, they indicate the potential yields per acre and thus provide useful information to the growing biomass industry.

Right now, there isn't any large-scale commercial production of prairie grasses for biomass fuels anywhere in the world.[33] Rather, the grasses that are currently being grown remain within the realm of research and development. Once scientists and biomass business executives become confident in energy content and yields per acre figures, institutions can expect to see a clearer direction of where the prairie grass biomass industry might go. Until then, institutions like Luther may begin assessing available data, estimated costs, expected benefits and possible problems.

Uncertain science is not the only thing standing in the way of a prairie grass energy model. The obstacles preventing Luther from using prairie grasses in a biomass boiler in its central heating plant are several and varied. The major difficulties, however, arise from basic economic theory and common sense. For example, farmers will not convert agriculturally productive land to diverse prairie grasses if there is not a market made up of reliable consumers willing to buy grasses. At the same time, potential consumers will not invest in prairie grass biomass burning technology if a consistent supply base with predictable prices does not exist.

[32] John, Steven and Adam Watson. "*Establishing a Grass Energy Crop Market in the Decatur Area.*" The Agricultural Watershed Institute. August 2007. http://www.agwatershed.org/PDFs/Biomass_Report_Aug07.pdf (accessed September 14, 2010).

[33] Cornell University, College of Agriculture and Life Sciences. "GrassBioenergy.org FAQs." http://forages.org/bioenergy/faq_bio.php (accessed September 15, 2010).

Herein lies the problem. Which comes first, the prairie grass field or the prairie grass boiler? It is a tricky question without a straightforward solution. Besides this classic chicken and the egg or, more aptly, the grass or the boiler problem, other questions also persist. Land availability, sustainable supply sources, price stability, as well as management and handling issues need to be resolved. Fortunately, none of these obstacles are insurmountable. In fact, there are clear solutions which would enable Luther to pursue this model to its fullest extent.

One way the federal government has worked to address the classic chicken and the egg problem associated with bioenergy production has been through the Department of Agriculture's Biomass Crop Assistance Program (BCAP). Established in the 2008 Farm Bill, BCAP "is a primary component of the domestic agriculture, energy, and environmental strategy to reduce U.S. reliance on foreign oil, improve domestic energy security, reduce carbon pollution, and spur rural economic development and job creation." Most importantly, it "reduces the financial risk of producers who support emerging biofuel markets" by providing the financial assistance to private landowners who establish and produce biomass feedstocks.[34] Using establishment payments and matching production payments, the program offers critical incentives to establish large-scale energy crop sources so that commercial-scale biomass facilities may have adequate feedstock supplies. At the same time, BCAP guarantees viable and predictable consumer bases to purchase grasses from producers.

Specifically, producers may receive up to 75 percent of the costs associated with establishing a perennial crop. These payments are available for up to five years for grassy crops. Matching payments are given to eligible producers "at a rate of $1 for each $1 per dry ton paid

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[34] U. S. Department of Agriculture Farm Service Agency. "The Biomass Crop Assistance Program (BCAP) Fact Sheet." Washington, DC, October 2010. http://www.fsa.usda.gov/Internet/FSA_File/bcap2010.pdf (accessed December 18, 2010).

by a qualified biomass conversion facility, in an amount up to $45 per dry ton."[35] These payments assist in collection, harvesting, storage and transportation of feedstock to conversion facilities. Under the current program design, matching payments are only available to producers for two years. Although it's technically another agricultural subsidy program, the goal of BCAP's matching payments is not to make prairie grass production profitable in the long run. Rather BCAP helps farmers and potential buyers clear certain establishment hurdles so that it may become profitable. An additional 45 dollars per ton would certainly turn prairie grasses into a competitive production crop and provide the incentive to start growing it. For these reasons, it seems BCAP will become an instrumental piece of any prairie grass energy model in its beginning.[36]

The grass or the boiler problem depends largely upon the perceptions of risk or loss that landowners and consumers may have. Included in this risk are some substantial monetary costs including prairie establishment and production start-up costs as well as opportunity costs. Besides purchase seeds and possess the adequate equipment, farmers will face considerable opportunity costs. Based on current studies, it looks like appropriate communities of diverse and perennial prairie grasses will take two years to become established before the first harvest can be carried out. During this time, the converted land will not generate any income for the farmers or landowners. Moreover, maximum yields, and thus maximum revenue, wouldn't be realized until the third year of production. Without consumers already in place, it may be difficult to convince a landowner to stop planting familiar crops and receiving a guaranteed income to investing in prairie establishment and several years of reduced income. Meanwhile, potential grass consumers need to build infrastructure and investments will have to be made in boiler technology,

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[35] Ibid.

[36] Berland, Paul., Personal interview with author, October 22, 2010.

storage space, and possibly additional workers or feedstock managers. Depending on the institution, these costs will be significant and require budget allocation or fund raising.

Perceived risk, then, will continue to be problem for prairie grass energy models until the right programs, concrete costs and incentives are available. Fortunately, several solutions already exist to alleviate the monetary impacts of establishment costs and overcome the barriers presented by perceived risk. The financial assistance provided by BCAP will help to mitigate these costs and kick-start production. Private contracts between landowners/farmers and consumers could also reduce any concerns surrounding perceived risk. These contracts could be drafted by farmers and consumers themselves or facilitated by a middle-man that might act as a central supplier or biomass conversion facility, for example.

Before Luther can seriously consider developing a prairie grass energy model, the availability of suitable local farmland for prairie grass production must be assessed. After all, what good is it to know heating fuel potential or expected yields and not have any land to grow grass on? Moreover, in order to keep transportation and fossil fuel emissions low, Luther will need to set standards, define “local” and determine an area within which it can secure enough grass and efficiently conduct business. Limiting “local” to the boundaries of Winneshiek County seems to be an appropriate geographic area for this project, but other metrics may prove to be more useful. In application, appropriate local boundaries may depend on the number and location of willing and sizable suppliers rather than geopolitical lines.

Industrial agriculture is the dominant land use across Iowa. Winneshiek County is no exception. County wide, approximately 220,000 acres have been planted annually to monoculture row crops in recent years. This is roughly half of the county’s total land area. But, as far as Iowa is concerned, this is a fairly low ratio. Generally speaking, the steeper, more rugged topography that characterizes the Driftless Area translates into less productive corn and bean fields than many other parts of the state. According to the Iowa State University Department of Agronomy, Winneshiek County has an average corn suitability rating, or CSR, of 57. [37]A "corn suitability rating" or "CSR" refers to an index that rates different soils and slopes for potential crop productivity. Rankings closer to 100 indicate very productive land while lower rankings suggest poorer quality farmland. By comparison, Polk County has a CSR of 74 and is accordingly home to what Michael Pollan calls "the University of Corn."[38]

Much of the talk surrounding biofuel production finds itself wrapped up in a controversial food versus fuel debate. As a result, many proponents of biomass and cellulosic ethanol believe that a way around this competition is marginal land. Converting marginal corn-producing land (land with lower CSR rankings) to perennial grasses for biomass production would restore ecological health, produce local energy and, at the same time, leave the highest quality farmland in corn and bean production. Alas, there isn't a single accepted definition of marginal land, but many people seem to think CSR values beneath 55 or 50 may be used with confidence. Under the definition of marginal land as land with a corn suitability rating (CSR) of less than 50, the Driftless Area Initiative found roughly 25,000 acres of marginal land in row crop production in Winneshiek County.[39] This definition of marginal land in combination with an estimated yield figure of 1.39 tons of grasses per acre (recall the Southwest Badger's second year figure for prairie grass production) indicates that Winneshiek County could produce 34,750 tons of grasses annually. If estimated yields of 2.5 tons per acre are achieved, 62,500 tons may

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[37] Iowa State University Extension. *Corn Suitability Ratings—An Index to Soil Productivity.* Ames, IA: February 2005. http://www.extension.iastate.edu/publications/pm1168.pdf (accessed March 25, 2011).

[38] Pollan, Michael. *The Omnivore's Dilemma.* New York: Penguin Group Inc, 2007.

[39] Berland, Paul., E-mail message to author, December 21, 2010.

be harvested. These are significant amounts of biomass! In fact, the land within Winneshiek County may easily fulfill the land requirements needed for a prairie grass boiler on Luther's campus.

At one time Luther College planned to address the carbon emissions from its campus heating through the installation of a wood biomass boiler. Luther commissioned a regional engineering firm named Sebesta-Blomburg to conduct a feasibility study for a biomass boiler project that would use local wood chips and wood scraps as its primary feedstock. The study was completed in the spring of 2008, but did not materialize for several reasons. One of them had to do with the potential wood chip supply that the college might be able to purchase. Even though Sebesta-Blomburg was able to identify a sufficient quantity of wood chips from logging and milling operations within 75 miles of the college, many of these operations started using waste wood to fuel their own operations. Fortunately, the supply set-backs of a wood biomass model probably would not arise with a prairie grass energy model. Unlike wood chips, which are waste products of energy intensive processes, grasses can be grown specifically for biomass production and thus sold in larger quantities with a fairly uniform quality. The major problems associated with the supply of grasses revolve around the question of how best to go about securing enough grass and ensuring that the grasses have been grown and harvested in a sustainable manner.

According to the 2008 wood biomass study, known as "the Sebesta Blomburg Renewable Energy Evaluation Report," the annual fuel requirement of campus steam production was about 96,000 MBtus from natural gas.[40] After this study was published, however, Luther's natural gas consumption slightly increased. Almost 108,000 and 105,000 MBtus were needed in 2008 and

[40] Sebesta-Blomburg. "Final Report Revised: Renewable Energy Evaluation—Luther College" Roseville, MN: Sebesta-Blomburg & Associates Inc. May 8, 2008.

2009 respectively. In 2010, Luther consumed nearly 112,000 MBtus.[41] The greenhouse gas emissions from this steam production are about 6,000 metric tons. Because these increases can be mostly explained by the addition of Sampson-Hoffland Laboratories and several fairly cold winters, higher consumption levels might be here to stay.[42] If these levels persist, Luther will need a lot more grass to fuel a boiler than it would have just three years ago.

Recall the energy content of switchgrass. If diverse prairie grasses generated 16 MBtu per dry ton, Luther would need to secure roughly 7000 tons of it to meet its current annual natural gas demand. Due to the mixture of grasses, forbs and legumes, polycultures of prairie grasses will definitely produce less energy than 16 MBtu per dry ton and so more tons would be needed. It could be the case that Luther might require 11,200 tons or more to completely offset its natural gas consumption. That's a lot of grass; perhaps even an unattainable or unrealistic amount of grass. To put it in perspective, Luther would require roughly one third of the grasses produced on all of Winneshiek County's marginal land (land with a CSR of less than 50 at 1.39 tons per acre) to meet this demand. Even if all that marginal land was converted to prairie grass (and that's a big if) Luther would need to work with a large number of area landowners to secure grass supplies. This is no small task. How, then, could Luther be able to secure enough grasses to meet these feedstock quantity requirements? The absolute domination of row-crop agriculture in Iowa almost certainly means that Luther will not be able to offset its entire natural gas consumption with prairie grasses in the near future.

If previous biomass studies can be used as indicators of what Luther may decide to pursue, any biomass energy model implemented at Luther will probably only be used to reduce

[41] Martin-Schramm, Jim. E-mail message to author, April 9, 2011.

[42] Ibid.

fossil fuel consumption, not eliminate it entirely. According to Sebesta-Blomburg's final report, the wood biomass boiler technology it examined would have worked in tandem with Luther's existing heating plant. In doing so, wood chips would have displaced 62 percent of Luther's natural gas consumption and, in turn, reduced Luther's peak campus carbon emissions by 14.2 percent.[43] Sebesta-Blomburg's study suggested that Luther could have burned wood chips almost exclusively during the warmest parts of the year and/or periods with low heat requirements. When heat demand was high though, a combination of natural gas and wood chips could have been utilized. A similar set up could be arranged with prairie grasses and may be one way to phase in prairie grass energy while reducing greenhouse gas emissions incrementally. Additionally, having prairie grasses fuel a substantial percentage of the college's heating requirements would sharply decrease Luther's dependence and use of natural gas as well as reduce the quantity of grasses Luther would need to purchase, transport, and store. Of course, Luther won't invest in prairie grass boiler infrastructure if it didn't reduce its environmental footprint considerably. Though a balance of costs and benefits would probably determine the exact scope of the project, lots of grasses of will be required regardless.

Maintaining an adequate and sustainable supply may still be problematic even if a smaller amount of grasses is used. The quantity of grasses Luther might need will require the college to work with many suppliers in the market. Luther simply can't afford to go around drafting contracts with landowners on an individual basis. This is inefficient and difficult to carry out. Ideally, the college would be able to purchase feedstocks from a central supplier. This central supplier would act more like a distributor and could be a for-profit company or, better yet, a cooperative business. Besides simply securing enough grasses, a central distributor, in the form of a biomass conversion facility for example, would resolve several of the other key obstacles

[43] Sebesta-Blomburg, Final Report, 7.

related to monitoring sustainable supply sources, price stability, and even some of the transportation, storage and management issues. As a result, a central distribution entity appears to be the most desirable solution to the problems and pitfalls associated with the prairie grass energy model.

Another distinct supply issue Luther will likely encounter involves ensuring the quality and ecological integrity of the grasses used in its facility. In other words, the college would need a way to make certain that grasses were being planted and harvested in an ecologically responsible manner. Landscape sustainability, one of the major arguments for implementing a biomass energy model, cannot be guaranteed without some sort of monitoring and quality control for producers and feedstocks. BCAP has recognized this point and has attempted to address this concern. In order to guarantee that the environmental benefits of using perennial grasses for biomass are actually being realized, BCAP has laid some important qualifications for the projects it funds. They are as follows:

1. Biomass must be certified to have been collected and harvested only with an approved conservation plan to protect soil and water quality and future land productivity.
2. Harvesting must be done in accordance with that plan.
3. Projects areas can occur only on former agricultural land, not native sod.
4. All projects must be in strict compliance with invasive plant species protection.[44]

Luther would not be in a position to make sure that BCAP's environmental guidelines were followed by grass producers. The college simply doesn't have the resources to accomplish this. A central distributor, however, could serve in this capacity. Without some means of

[44] U.S. Depart. of Agriculture, "BCAP Factsheet," 2.

accomplishing BCAP's qualifications, a local prairie grass energy model wouldn't be able to live up to its full potential for promoting landscape health. It seems this is another persuasive argument in favor of setting up some sort of central distribution entity.

All energy markets tend to be fairly volatile nowadays. Almost unpredictable price behavior of natural gas was one reason why Luther began looking into alternative heating fuels in 2008. However, a drop in natural gas prices was also a chief reason why Luther chose not to pursue a wood biomass boiler. Thomas Friedman appears to speak truthfully when he says that "energy innovation is hugely expensive and you are always competing against an existing cheap—dirty—alternative."[45] Bearing this in mind, another clear concern surrounding prairie grasses is its price stability as an energy source. This goes back to "the prairie grass field or the grass boiler" problem discussed earlier. Unstable prices signal greater risk to producers and consumers. After all, what would happen if prices suddenly become too low or too high? Higher price instability discourages producers from entering the market and forming transactions with consumers. Consumers also leave the market in favor of substitutes (i.e. oil and natural gas). Competitive prices prompt farmers to plant more grasses and consistent prices will encourage consumers to buy them. Without competitive and relatively predictable prices, the energy model won't function. The problem or question, then, is how to keep prices stable or, at least, predictable so that both farmers and consumers will have sufficient incentives to enter the marketplace. A central distributor may be just the answer to this question.

Basic economic theory says that supply and demand determines price. A central distributor in the area would be in the position to secure supplies, meet demand and negotiate

[45] Friedman, Thomas L. *Hot, Flat and Crowded: Why We Need a Green Revolution and How it Can Renew America.* New York: Farrar, Straus and Giroux, 2008, 257.

sales to settle industry prices. Set standards and multi-year contracts between grass producers, the distribution center and consumers would not only stabilize prices for all, but also make them predictable. Some wiggle room would need to be built in the system though. Like most forms of biomass, the annual supply of grasses ultimately depends on several environmental conditions like precipitation levels and seasonal temperatures. The beauty of diverse prairie grass communities, however, lies in their resilience to changing environmental conditions and their ability to survive. Barring widespread drought or an uncontrollable fire, supplies may vary only slightly and prices could be kept stable under normal conditions. Moreover, central distributors could act as conduits for BCAP's matching payments in the first two years. These payments would set prices for producers until sufficient demand exists to set prices through market forces alone. Furthermore, multi-year contracts would make prices predictable for energy planning and budgetary decisions on the part of consumers. In effect, this solves the "prairie grass field or grass boiler problem" inherent in the price stability of biomass commodities. The combination of a central distributor and the financial assistance provided by BCAP offers the best way to troubleshoot unstable prairie grass biomass markets.

The mass in "biomass" translates into several feedstock management and handling issues that steam powered heat and coal-fired electricity frankly don't have. Tons and tons of grasses need to be transported from the field to the distribution center and on to the consumer's heating plant. Grasses also may need to be stored for months at a time. As a result, the management and handling of grass feedstock, therefore, involves whole subset of problems that will likely be dealt with differently by different systems and entities. At present, there are two major options or methods that institutions may pursue when it comes to the physical form prairie grasses might take as a biomass feedstock. One option is simply to burn bales of grasses. These resemble hay bales and, in fact, can be made from regular hay baling equipment. The other option involves the densification of grasses (from bales) into a more highly concentrated form of energy. Usually, this means grasses are turned into some sort of grass pellet. It is unclear as to which would be more cost effective or desirable since both bales and pellets have their pros and cons. In large part, the method that works best depends on the institution using them.

Bales of grasses are big. It takes nearly thirty one 65 pound bales to equal one ton. If 7000 tons of grasses are needed to meet Luther's heating requirements, the college would be responsible for managing over 217,000 bales of grass every year. Luther may need to manage 347,000 bales if 11,200 tons are necessary. This number would probably fluctuate with heating requirements and the actual amount of energy contained in grasses. Obviously, the sheer volume of grass bales may become a huge logistical issue considering the transportation, storage, and fueling of the boiler. It's difficult to even envision this much grass let alone store it. Even if the central distributor could provide some storage, on-site storage space, adequate transportation vehicles and a full-time feedstock manager would all be necessary investments in order to make this method work. Grass bales also don't generate the same burning consistency as pellets due to the diversity of plants, moisture content and air spaces within the bale. In other words, more tons of baled grasses may be needed than pelletized grass. Despite these cons, bales do have some clear advantages over pellets. Bales are cheaper to produce than pellets, which first need to be processed from bales. Directly burning bales avoids this costly step and, therefore, makes a prairie biomass energy model more readily available and easier to implement. These benefits are significant and should not be dismissed in light of storage issues.

Pellets have numerous pluses and minuses as well. Thirty one grass bales will yield slightly less than one ton of pellets. This discrepancy is due to moisture loss during the pelletizing process and appears to be relatively negligible given how pellets burn.[46] Because pellets contain higher densities of grass and smaller moisture contents, they burn more consistently and efficiently than bales. For these reasons, the amount of grass pellets needed to meet Luther's heating requirements probably will not necessitate as much physical space as an equivalent amount of bales. Keeping that in mind, a smaller amount of pellets, tonnage wise, may generate the same amount of heat without filling an entire barn with bales. In contrast to bales, pellet burning entails an additional production step that may call for serious investments in a densification facility and greater investments in an advanced technological system for the campus central heating plant. A system could be set up so that the boiler would be fed directly from a hopper of pellets connected to a thermostat and the heat load.[47] By using this system, the boiler would be self-feeding and may eliminate the need to hire additional facilities personnel to manage bales and operate the boiler full time. With this system in place, pellets could be stored more easily and could be fed less frequently than if bales of grasses had to be directly placed into the boiler. Of course, this technology would be more expensive to purchase and install.

The advantage of the baling method is the obvious disadvantage of pellets. Pellet production will necessitate some type of biomass conversion facility and additional production steps before any heat can be generated. The densification process will increase the cost of prairie grass energy and will require substantial start-up investments in equipment and other capital. According to the College of Agriculture and Life Sciences at Cornell University, it may cost around 25 dollars per ton just to turn bales into pellets.[48]In addition, new hay densification equipment for a biomass conversion facility could cost as much as 400,000 dollars while used

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[46] Cornell University, GrassBioenergy. org

[47] Berland, Paul, personal interview with author, October 22, 2010.

[48] Cornell University, GrassBioenergy.org.

hay pelletizing equipment could cost around 150,000 dollars. A private entrepreneur might be discouraged by these tremendous costs, but cooperatively held pellet production equipment may spread them out among members. Unfortunately, there aren't yet any large scale businesses producing pellets that Luther could look to for more accurate cost estimates.

Another apprehension Luther may have involves the amount of ash production and boiler maintenance that go along with burning grasses. In the study conducted by Better Environmental Solutions, a 6% ash content was reported from burning switchgrass.[49] This is approximately three percent higher than wood biomass. Grass bales and pellets would both generate significant amounts of ash, though bales would probably produce more considering the differences in efficiencies between the two methods. Either way, dark smoke and soot would most certainly emit from the grass boiler unless a special smokestack was installed. Regular boiler maintenance would also be required to clear the boiler of ash build up. An ash disposal site would be necessary and air quality permits would probably need to be secured as well. Since there aren't any large-scale boilers for diverse prairie grasses in full-time operation, it is difficult to say what the full extent of these obstacles will look like. Preliminary switchgrass burning trials, though, suggest that relatively high ash content will pose some challenges for operations. It may be the case that the science and technology isn't yet available to address these issues in a cost-effective manner.

Gaps in scientific knowledge and expensive infrastructural systems appear to be major hang ups preventing a more widespread use of prairie grass as a form of biomass energy. Tools to establish working biomass markets already exist, however. For now, a prairie grass energy model is not a feasible initiative for the college to undertake. Once further study has been done to quantify yields per acre and the potential energy production of diverse prairie grasses, Luther

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[49] Husley, *Cellulose Prairie, 21.*

College might prove to be in the best position to spearhead a local initiative to catapult a biomass conversion facility and distribution center, and thus a prairie grass energy model, into reality. A cooperative biomass conversion facility that bought grasses from producers, turned bales into pellets and sold pellets to consumers may offer the most viable solution looking forward. The conversion facility and distribution center could resolve the “prairie grass or the boiler” problem, ensure sufficient quantities for college operations as well as the overall sustainability of the grass feedstock. It would also settle price stability problems and many of the management and handling issues identified. Moreover, this type of model may be in best position to take full advantage of BCAP funding and may bolster local economies through the production of grasses and the operation of a cooperatively-owned conversion facility and distribution center. This type of middleman unlocks the potential for a working prairie grass biomass energy model in Winneshiek County. It is likely that Luther College would be instrumental in establishing this entity given the amount of business and benefits the college would receive through the cooperative.

Every human activity has an effect on the environment, but some are more harmful than others. The question Luther seeks to answer is which actions are not only the most environmentally responsible, but also the most efficient and sustainable. Undeniably, Luther has made great strides in fulfilling its “call to be good stewards of God’s creation and responsible citizens in the global community.”[50] Yet more needs to be done. Soon, Luther will need to start tackling larger, more costly and more holistic initiatives if it hopes to achieve institutional commitments to responsible landscape stewardship, larger greenhouse gas reductions and more renewable energy production strategies. Tackling each of these goals individually will not

[50] Luther College, Strategic Imperative III.

efficiently or effectively solve the complex and systematic questions surrounding sustainability. Furthermore, Luther says that “our commitment to relevant and transformative experiences for students pushes us to seek sustainability through greater efficiencies and new policies in operations” and that we must “be bold in our efforts and become a leader within the educational community.”[51] Participating in a local prairie grass energy model would also produce other potential benefits not yet considered like enhanced educational opportunities, support for rural economies and a greater reputation for environmental leadership among institutions of higher learning. A prairie grass energy model may serve as one part of a larger plan to accomplish a number of these objectives.

There are several ways in which Luther could explore the possibilities of a prairie grass energy model further. First, Luther could commission Sebesta-Blomburg, or another engineering firm, to conduct a more thorough feasibility study looking at the potential for a prairie grass boiler in Luther’s heating plant. There may be funding available through organizations like the Driftless Area Biomass Initiative or the Rocky Mountain Institute to do this. Secondly, Luther ought to make connections and pursue partnerships within the regional biomass community. The college could work in close association with the Driftless Area Biomass Initiative, the Northeast Iowa RC&D and/or the Tallgrass Prairie Center at the University of Northern Iowa, for instance. These organizations are already heavily involved prairie grass energy efforts and may prove to be valuable sources of information, funding and collaboration. Thirdly, the college ought to encourage further in-house research projects and grant writing to determine if biomass is right for Luther. Finally, and most importantly, Luther should remain open to new, innovative opportunities for incorporating biomass energy into its operations and actively look around to see

[51] Ibid.

what other people are doing, share ideas and participate in larger conversations. Prairie biomass or not, increased communication and collaboration will be essential if Luther College is to achieve its prescribed institutional goals and, someday, total sustainability.

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