Biomass Harvesting of Native Grasslands in West Central Minnesota: A production scale pilot study

by

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As the cost of fossil fuels has increased and their supply tightened, alternative sources of energy are being sought for heating, transportation, and electricity. A potential source is biomass energy derived from agricultural residues, forestry by-products, and refuse derived fuels. Although not a completely new idea, the suggested scale required for biomass to make a meaningful contribution to our current energy needs is unlike any previous use of biomass. New technologies and paradigms will be needed to transition even a portion of our current energy needs to this new energy source.

An important area of research for the biomass energy field is identifying and supplying biomass on the scale needed. Based on 2005 estimates, there are a combined total of roughly 194 million tons of biomass available each year from the agricultural sector (Perlack et al. 2005). However under projections by the USDA, over 1 billion tons of biomass would be needed from agricultural sector to replace 30% of petroleum use with biomass by 2030. Supplying biomass on that order of magnitude will require that all potential sources of biomass be considered.

One suggested biomass source is native grassland biomass from areas currently managed as native grassland/conservation areas. In 2006, there were approximately 35.9 million acres of land in the federal conservation reserve program (Hart 2006) Though harvesting is not currently permitted on most federal and state conservation lands, collecting material from these area could provide millions of tons of additional biomass. However, many in the agricultural community express concerns that these lands are too rough and will damage standard harvesting equipment. The biggest problems cited are rocks brought to the surface by frost heave, general roughness, and excavation by animals such as gophers. Therefore, a basic question that needs to be answered to determine the viability of biomass removal from these areas is the suitability of currently used agricultural equipment and techniques for harvest conservation lands.

In addition, the economics of harvesting native grasslands are poorly documented. The time and difficulty of harvesting from these lands is felt by some to result in a higher cost that would likely make such harvesting economically unattractive. However, native grasslands typically need a management regime that removes biomass periodically to eliminate encroachment by woody vegetation. Grasslands are typically managed with prescribed burns, which are costly due to the training, equipment, and insurance required. Thus, biomass harvesting may be an economical or even profitable alternative to prescribed burns.

This pilot study was undertaken to examine the feasibility of biomass harvesting using commonly available agricultural harvesting equipment and techniques. Attention was paid to the technical, logistical, and economic hurdles that exist in harvesting native grasslands in typical West Central Minnesota conservation areas.

Materials and Methods

Five Stevens County, Minnesota (Lat 45.58º N, Long 95.91º W) sites under either United States Fish and Wildlife Service (FWS) or Minnesota Department of Natural Resources (DNR) management were selected for harvest (Table 1, Fig. 1A). All sites had formerly been in agricultural production, but had been planted with native mixes between 5 to 10 years ago (S. Delehanty and K. Kotts, personal communication). As is typical of government owned and managed conservation areas in the region, these sites are poorly drained and often have standing water in low spots. Each site was unique due to variations in landscape, planting methods, seed mixes, hydrology, and management regime. As is common of most local wildlife management sites, plant species composition and management history for the sites has not been closely monitored or documented.

Harvesting was done using conventional agronomic practices and equipment (Fig 1B). A local custom baler was hired, who provided all equipment and labor for cutting, raking, baling, and transporting. Cutting was done using a haybine cutter, with biomass left in rough rows. Harvesting was begun the first week of October 2007; however, extensive rain combined with cloudy wet conditions delayed further activities. Before harvesting resumed, standing biomass was allowed to dry, while cut biomass was raked and then allowed to dry.   Though it had been decided at the beginning of the project that biomass be baled in large square bales, for reasons described below, most of the biomass was packaged in round bales (Figure 1C and D). Bale weight for large round bales (72 inch by 60 inch, 183 cm x 152cm) was estimated at 900-1200 lbs (408-544 kg) and 900-1100 lbs (408-499 kg) for the large square bales (48 inch by 48 inch by 8 ft, 122 cm x 122 cm x 243 cm). Once baled, the biomass was left in the field until such time as the contractor could remove it.   Biomass was delivered to the University of Minnesota, West Central Research and Outreach Center.

Results

Harvest of the native grasslands was done successfully using conventional equipment, with the contractor reporting no problem due to rough terrain. Once cleared of biomass, the harvested areas showed little evidence of rocks or animal burrows/mounds. This is in contrast to many local pastures and farm fields, which show abundant evidence of animal excavations and rocks

The average biomass yield over the five sites was 1.7 tons per acre (Table 2). Yields varied considerably with the Lamprecht site having the lowest yield (1.20 tons/acre, 2.69 Mg/ha) and Geise having the highest (2.78 tons/acre, 6.23 Mg/ha). Visually obvious differences in species composition, stand age, moisture levels, and management likely resulted in yield difference both with-in and between sites. Additional evidence of the species composition differences was noted in stem size and seed heads seen in the baled material.

Weather had a significant impact on the biomass harvest at the different sites. The areas of each site to be harvested were selected in mid-September, after a significant summer drought. Rainfall shortly after starting the harvest filled some of the formerly dry pot-hole wetlands and made the ground much softer. This reduced the areas of some sites that could be harvested (Table 3) and likely made some patches of high yielding grass unharvestable.   Early in the harvest, equipment got stuck in the soft ground and the contractor changed from a heavier square baler to a lighter round baler. Therefore, most of the bales produced were round bales. Soft wet ground is also prone to rutting and compaction from vehicle traffic, so bales remained on some sites until the ground had dried sufficiently to allow their safe removal using large trucks (Figure 1C).

Harvest costs were calculated using the contractors standard rates for collecting and baling straws and stover. At the onset of the project, the contractor stated that he did not have a problem charging his standard cutting and baling prices although the work involved sites significantly different than typical crop or pasture land. He had prior experience with conservation reserve program type lands and understood the possible challenges of harvesting these areas. Each step of the harvesting process was billed separately (Table 2), with costs based on acres cut, bales made, tons hauled, or fixed cost for the project. Therefore, it was difficult to get a fixed harvest price per acre. In a breakdown of costs per ton at the different sites (Table 4), the higher producing sites had significantly lower per ton costs because the fixed costs were lower per unit of biomass and less acreage was cut per ton baled.

The contractor indicated in post project discussions that he was satisfied that he would see a reasonable profit on his work and that he would be willing to perform additional harvesting for the same rates and could perhaps lower his rate (R. Rinkenberger, personal communications). He suggested that by using different equipment, his time and fuel expenses might be lowered. Additionally, lighter and/or tracted equipment would be able to harvest in wetter areas without getting stuck or causing rutting and compaction.

Discussion

The study demonstrated that many conservation areas in West Central Minnesota can be harvested using standard agricultural equipment and practices. The concerns of rough terrain limiting the ability to harvest these lands did not appear to be valid at the selected harvest sites. It is likely that the combination of tall, deep rooted vegetation and soils that are typically near saturation discouraged many of the animals associated with creating burrow holes or mounds of soil at these sites. Although rocks were not a problem in this study, that may be due to the fact that these fields were cleared of surface rocks during their use in agricultural production and new rocks have not yet been brought to the surface. Remnant prairies or grasslands that have been out of agricultural production for a longer period may need to be investigated to identify whether rocks or other rough terrain may be a problem for harvesting equipment.

An important part of this pilot study was examining the economics of native grass harvesting at wildlife management areas. The variability of yields and harvesting expenses across the different sites (Table 4) indicates that the site selection is an important consideration for affordably harvesting native grass biomass. As expected, the fixed costs with mobilizing equipment and labor make smaller sites less cost effective. On larger sites, the amount of vegetation and the efforts required to remove it will determine the profitability of harvesting.

The market value of biomass feedstocks in this emerging biofuels has not yet been firmly set. Therefore, it is difficult to say what the long-term breakeven price for biomass will be. In fact, predictions by the U.S. Department of Energy indicate that biomass prices will likely fall as biomass harvesting becomes more common and new more efficient technology is brought to the market (DOE 2003). For the purposes of this study, the University of Minnesota, Morris (UMM) was interested in obtaining biomass at roughly $45 per ton ($49 per Mg) to supply their biomass heating and research facility. As illustrated in the results (Table 4), the average price for biomass could have been reduced by selecting the highest yielding sites. The two largest site harvested (Eldorado and Geise) were well under the benchmark set by UMM.

There is a significant potential for cost savings by substituting biomass harvesting for prescribed burns. An estimated cost for prescribed burns from the regional DNR office was $30 per acre by the time labor, equipment, training, and mobilization costs were considered (K. Kotts, personal communication). This could lead to a situation where biomass harvesting is not only allowed, but actively encouraged, possibly in the form of a 'habitat management fee' paid for biomass removal (Figure 4). This would be especially beneficial in cases where sites had a low yield and would be marginally profitable to harvest for the sale of biomass alone. For example, the Pepperton site may not be economically harvestable based solely on the value of biomass, but may allow the harvester to break even with a $10 per acre ($24.71 per hectare) management fee paid to the harvester.

Aside from examining the feasibility of harvesting native grasslands and the economics behind collection biomass from these sites, this project was designed as a starting point for examining issues both the DNR and FWS feel are important. Both organizations are concerned about how harvesting affects native habitats and whether it is an environmentally sound management technique for replacing prescribed burning. A few prairie management studies have shown that spring mowing and removal of vegetation may produce similar results to conducting prescribed burns (Tix and Charvat 2005, Hulbert 1969). Removal of biomass promoted many of the same functional groups of species whether by burning or mowing and harvesting. However, these studies were fairly short term studies conducted during the spring. They may not have the sensitivity to show long-term biomass removal affects on plant and animal communities or how harvests during different times may alter the ecosystems.   While, it is beyond the scope of this study to fully explore the ecological ramifications of native grass harvesting, the harvested sites will be monitored over the next season to provide general information on plant and animal species changes at the sites. It is hoped that the ecological data can be used to design further studies examining the long term affects of biomass harvests.

Another issue in which the DNR and FWS have expressed interest is how biomass harvesting could affect the overall conservation efforts of native grasslands. Should ecological studies show that periodic harvesting has little affect on vegetation or is beneficial to grassland habitats, there would likely be a major push by conservation groups to increase grassland conservation acreage as a means of both supplying biomass and conserving habitat. However, grasslands under direct state and federal control are not nearly sufficient to supply biomass to the emerging bioenergy market. Therefore, private stakeholders with native grassland would likely play the greater role in supplying biomass.   Already, plans are being discussed in Minnesota for state funded incentive payments for new conservation lands, which could be harvested for biomass. Current state and federal programs could also be changed to allow harvesting on land already in conservation or set-aside programs. These types of programs may induce private land holders to remain in or begin conservation plantings. Currently, many habitat management professionals are worried that conservation acreage may decrease dramatically as farmers see high grain prices and bring crop land back into production. Conservationists see adding biomass harvesting as an additional revenue that could keep people in conservation programs.

There is a distinct possibility that the demand for biomass in the energy sector will affect conservation efforts, whether it is in reduction of grasslands due production of other bioenergy crops or the increase of grassland conservation for biomass production. Pilot studies such as this are important to identify issues related to these changes. By conducting this research before the demand exists, it will be possible to better manage changes in the conservation and agricultural arenas. Proper management will reap environmental, financial, and sustainability rewards.

Conclusions

This pilot study demonstrated that biomass can, from a practical standpoint, be successfully be harvested from native grasslands. A land manager/owner could see an economic benefit from harvesting biomass depending on the yields and harvesting costs at their sites. However, as a management practice, biomass harvesting shows promise as a cost effective tool versus the expense of a prescribed burn. While the financial benefits of harvesting biomass will likely be quickly determined with additional harvesting projects, the full ecological affects of harvesting will take much more in depth research to be well understood.

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Table 1 Research Sites

Site	Description
Eldorado	Gently rolling low land with pothole wetlands in several spots
Geise	Mixed landscape with permanent ponds and fairly dry uplands
Klason	Flat sandy delta land along the Pomme de Terre River
Pepperton	Flat wet ground with some channels for water movement
Lamprecht	Mostly flat area bording a marsh

Table 2 Biomass Yield Data

	Predicted Acres	Harvested Acres	Tons Harvested	Yield Ton/Acre	
Eldorado	45	47	103.86	2.21	
Geise	51	51	141.64	2.78	
Klason	20	16	17.26	1.08	
Pepperton	72	7	8.78	1.25	
Lamprecht	45	25	30.08	1.20	
Total	233	146	301.62	1.70 ± .75	Average

Table 3 Total Harvests Costs

	Quantity	Price	Units	Total
Custom Cutting	146	$ 12.00	Per Acre	$ 1,752.00
Square Bales	114	$ 8.00	Per Bale	$ 912.00
Round Bales	506	$ 12.00	Per Bale	$ 6,072.00
Hauling	301	$ 10.00	Per Ton	$ 3,010.00
Extra Equipment	1	$ 620.00	Flat Fee	$ 620.00
Scale Fees	25	$ 5.00	Per trip	$ 125.00
			Total Cost for Harvest	$ 12,491.00
Barter Payment to DNR	70	$ 10.00	Per Acre	$ 700.00
			Total	$ 13,191.00

Table 4 Harvests Costs Per Acre At Conservation Areas

Harvest Site	Cost Per Ton	Cost per Ton With Land Payment: $10 Per Acre	$20 Per Acre	$30 Per Acre	Cost Per Ton With $10 Per Acre Management Fee
Eldorado	$ 39.51	$ 44.07	$ 48.56	$ 53.09	$ 34.99
Geise	$ 39.00	$ 42.60	$ 46.20	$ 49.81	$ 35.40
Klason	$ 55.02	$ 64.29	$ 73.56	$ 82.83	$ 45.75
Pepperton	$ 60.17	$ 68.06	$ 75.95	$ 83.84	$ 52.28
Lamprecht	$ 46.10	$ 54.41	$ 62.73	$ 71.04	$ 37.79

Figure 1 Biomass Harvesting
A) Map showing the five biomass harvest sites located in West Central Minnesota (see inset) near the City of Morris.
B) Harvesting with the square baler at the Eldorado site. (photo courtesy of J. Strege, Minnesota Department of Natural Resources)
C) Unloading and stacking of the bales at the West Central Research and Outreach Center using a skid loader to transfer materials from over the road tractor trailers.
D) Comparison of round and square bale stacks. Square bales are 8' x 4' x 4', round bales are roughly 60" long x 72" diameter.