

Assessment of Biomass Resources for Energy Generation at Xcel Energy's Bay Front Generating Station in Ashland, Wisconsin

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Executive Summary

The purpose of this study is to identify potential sources of wood waste within a serviceable radius of Xcel Energy's Bay Front generating plant in Ashland, Wisconsin. A radius of 50 miles was chosen as a general guideline, which included the counties of Ashland, Bayfield, Douglas, Iron, Sawyer and Gogebic (Michigan). This study gathered information on mill and forest harvest residues generated in these counties. This information was supported through interviews with forest industry actors including government, NGO, academic researchers and business representatives. In order to switch to biomass as the sole fuel for generation at Bay Front, Xcel Energy estimates it would require approximately 360,000 tons per year of green chipped wood. The primary sources of wood residues were characterized as follows.

Harvest Residues. The wood left on site after timber harvest is termed harvest residue. This typically consists of tree tops and small diameter wood that are considered non-merchantable. Wisconsin Forest Management Guidelines¹ direct loggers on proper treatment of harvest sites in terms of biomass left for habitat. Forest administrators delineate through stumpage sales agreements the amount of biomass that can be removed based on soil replenishment needs. In most cases, these tree tops are not considered important for forest habitat or soil nutrition, and can be removed for other uses. In some cases, removal of harvest residues allows for quicker replanting and regrowth of the stand, and results in improved aesthetics.

The US Forest Service North Central Station estimates that about 860,000 tons of harvest residues are generated in the study region annually. Interviews with forest administrators and owner representatives provided additional insight into harvesting activities such as the intensity of harvest and fate of residues for their lands. Most indicated that additional removal of residues, especially tops, would be a welcome activity for their forests, particularly since this activity would not involve new road construction and could be accomplished during regular logging operations. Several logging contractors interviewed suggested that expanding their businesses to harvest and chip tops for sales to Bay Front is something they would pursue given sufficient guarantee of price and duration of contracts. This source alone appears sufficient to meet the fuel needs of Bay Front.

Mill Residues. Mill residues are generated through the primary processing of harvested timber. These residues are in three forms: fine (e.g., sawdust or wood flour), coarse (i.e., large enough to run through a chipper) and bark. The US Forest Service estimates annually generated mill residues in the study counties to be about 400,000 green tons. Because these residues are concentrated at mills, and can be a liability, mill owners have developed many options for beneficial use or merely disposal. Residues in this region are reported to be virtually all used for some other purpose (a large portion is currently delivered to Bay Front for fuel). Although regulators believe the use of residues is exaggerated, or at a minimum, some portion could be redirected for other uses if the price

¹ The Wisconsin Department of Natural Resources Division of Forestry provides specific directions in their Forest Management Guidelines. The guidelines can be downloaded from: <http://dnr.wisconsin.gov/org/land/forestry/Publications/Guidelines/toc.htm>.

is right, these residues are less likely to expand much beyond current agreements. Some reasons for this conclusion are:

1. Some of these residues are higher quality than harvest residues and may be in greater demand for competing uses such as animal bedding or wood pelleting
2. Unless the residues are currently being burned for disposal, they are now serving some competing purpose
3. A large proportion of these residues are not in a form that is optimal for Bay Front's operation, and may require additional processing before use
4. The quantities generated by any one entity, with the exception of Bay Front's current largest supplier, are relatively small and negotiations for these would entail many contract agreements with high transaction costs.

Dedicated Biomass. Contracting with local landowners to grow energy crops such as hybrid poplar may be a viable long-term strategy for wood fuel supply. Although there are negligible acres of Conservation Reserve Program lands, land rents are relatively low in this region. We estimate the poplars can be grown on these lands for somewhere between \$15 and \$30 per green ton, based on production estimates developed for Xcel's Minnesota Valley plant. Establishing plantations using non-native monocultures at production scale is a relatively new type of endeavor in Wisconsin, and environmental and regulatory waters have not yet been tested. While evidence suggests that a pilot plantation is justified, it would be prudent to wait for more information before moving into larger scale production. Experiences at Minnesota Valley plantations will provide valuable information on performance and implementation obstacles. Because of the nature of the Bay Front facility, non-woody biomass was not considered at length.

Introduction and Study Purpose

The combustion of wood to produce energy has a long history at industries that process wood and some electric utilities. Today, environmental, political and economic issues associated with fossil fuel use have driven home the importance of sustainability, and raised the profile of biomass as a viable sustainable fuel. Recent attention to the role of coal use in climate change has prompted utilities and other coal users to intensify their exploration of options for substituting biomass for coal. The key issue deterring substitution of biomass for coal in energy production is identifying a reliable, cost-effective and sustainable supply of biomass.

The purpose of this study is to identify potential sources of wood waste suitable for combustion at the Bay Front generating plant in Ashland, Wisconsin. Bay Front is a steam electric generating plant owned and operated by Northern States Power Company, a Wisconsin corporation and wholly-owned subsidiary of Xcel Energy, Inc. (d/b/a/ Xcel Energy).

Wood source examination is on a categorical level, intended to point Xcel Energy in the directions most likely to be fruitful in identifying sources of biomass fuel. In addition, the study includes examination of options to provide benefits to local environmental and sustainable forestry initiatives, while providing business opportunities for established or new wood harvest and processing businesses.

Xcel Energy currently plans to continue to burn wood and coal in the two spreader stoker boilers at Bay Front and is exploring options for converting all boilers to consume 100 percent biomass. This facility has used coal and wood for fuels since 1980, and has also burned railroad ties and shredded tires. Using wood for fuel instead of coal offers a number of emissions benefits, including reduced sulfur dioxide and nitrogen oxides emissions and short-cycle carbon dioxide.²

The use of wood for electricity generation can also benefit the timber industry in northern Wisconsin by providing another market for wood residues. Recent mill closings and production downsizings in Wisconsin, Minnesota and the Upper Peninsula of Michigan have hurt businesses and communities that rely on logging and timber processing. Increased demand for residues can help stimulate local businesses, with utility fuel purchases directly augmenting local and regional economies rather than leaving the state.

This report characterizes the types and quantities of wood wastes available within the six counties within a roughly 50-mile radius around the Bay Front plant. These counties include: Ashland, Bayfield, Douglas, Gogebic (Mich.), Iron, and Sawyer. This characterization relies on published and public data sources, and is bolstered by interviews with government and private actors. Figure 1 shows the study area.

² They have discovered that using either wood or coal fuel exclusively works best and avoids slag buildup on furnace walls (Wiltsee 2000). If not enough wood is available for eliminating coal use altogether, one option is to use coal during high energy demand periods (allowing the plant to operate at a higher output rating) and wood during lower demand periods.

Figure 1 - Study Area



Wood quantities and species are treated generally (i.e., as harvest residues and mill residues), since a variety of species are harvested and processed in the study region. Furthermore, moisture levels and quantities available are variable and not precisely inventoried. The data received from various sources required making some simplifying assumptions. Unless noted otherwise in the text, the assumptions are as follows:

1. Wood used at the plant is measured in “as-burned” form, with a moisture content between 35-45 percent, and an average heating value of 5,000 Btu/pound.
2. A cord of wood has a volume of 128 cubic feet and weighs about 5,500 pounds.³
3. Wood residues have an average weight of about 43 pounds per cubic foot.

Therefore, quantities and qualities of biomass discussed must be recognized as ballpark estimations. The variety of data sources and ages, variability in estimation methods, and wood characteristics all combined into a complex interplay that defies precision. The authors have made every effort to choose formulae and data we believe best approximate

³ This is taken as a rough average from Taras 1956, in which measurements for large volumes of pulpwood were used to develop profiles for different tree species with bark on.

reality, and to include explanations of estimation methods used and sources of data so that alternative methods can be used if desired.

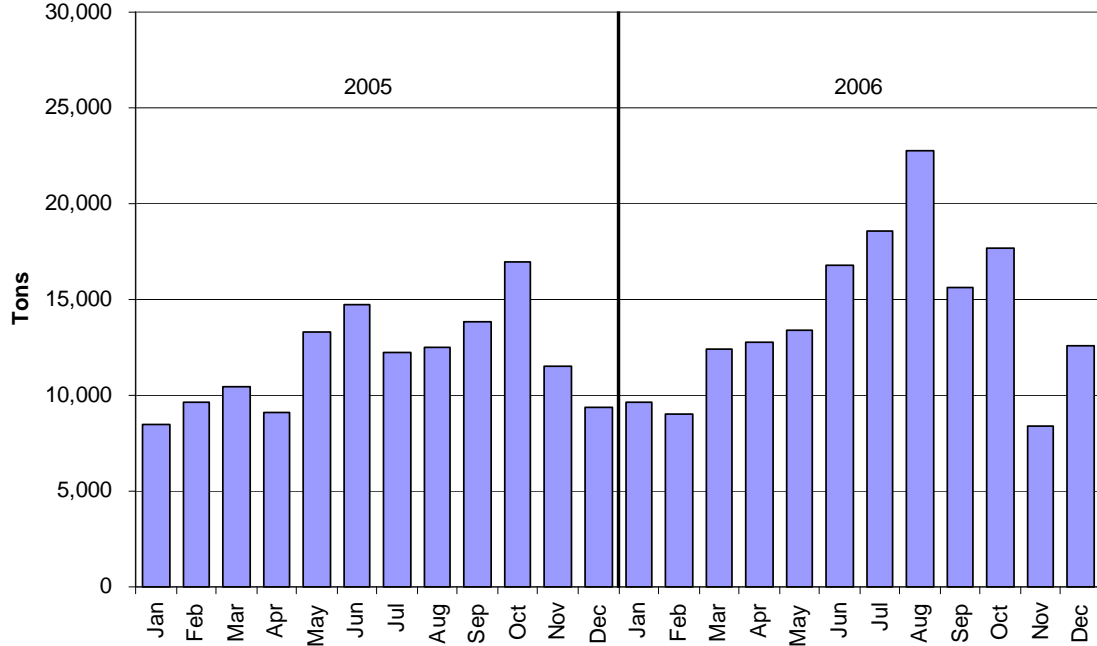
Demand Profile and Current Supply

Xcel Energy representatives have indicated that they could use as much as 360,000 tons⁴ of woody biomass annually for energy production. This supply would allow the plant to operate both boilers year round exclusively on biomass. On-site storage is limited to about 7,000 tons, but could be expanded if coal storage space can be reduced.

The preferred physical form for the wood is chips that are roughly square and 2”x 2”x 0.5”. Typical fuels received are chipped treetops, bark, railroad ties, sawdust and wood pieces from wood using industries. Wood received is further reduced by running it through an onsite hammermill before it is fed into the boilers. The facility can accept a limited amount of larger pieces or fines, but in order to not overwhelm equipment and cause processing disruptions, the large majority of wood must be in chip form. This limitation puts a premium on sources that can supply chipped wood.

Currently, Xcel Energy’s biomass is being supplied by about 18 haulers ranging from a forest products company which has contracted to supply a minimum of 65,000 tons of wood wastes per year, to smaller companies that periodically deliver wood wastes. Figure 2 shows monthly delivered quantities of wood to Bay Front for 2005 and 2006.

Figure 2 – Bayfront Biomass Deliveries for 2005-6



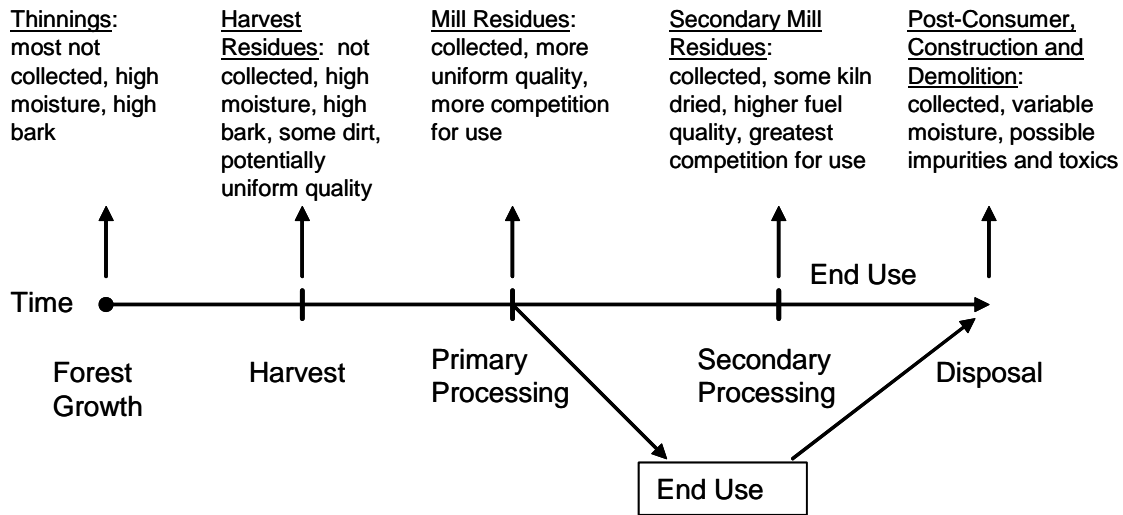
⁴ The weight of biomass used at Bay Front generating station is in terms of “as-burned” tons, which may encompass residues with moisture content anywhere from about 35 to 45 percent (Donovan 2007). The residues received by Xcel Energy in 2006 measured between an average heating value per pound of 4,800 Btu for one source, to an average of 7,500 Btu for another (per Bay Front delivery records).

In 2006, the facility burned nearly 170,000 tons of biomass (with about 94,000 tons from the largest supplier), and 142,000 tons in 2005. To have a steady supply and operate at capacity exclusively with biomass, the monthly deliveries would need to be 30,000 green tons (i.e., top of the chart).

Potential Supply

The forest industry is the largest source for wood residues in the region. Figure 3 illustrates the typical pattern of wood use. Points in the growth, harvest and processing sequence are noted where residues are generated that have the potential for other uses.

Figure 3 – Wood Use and Residue Generation

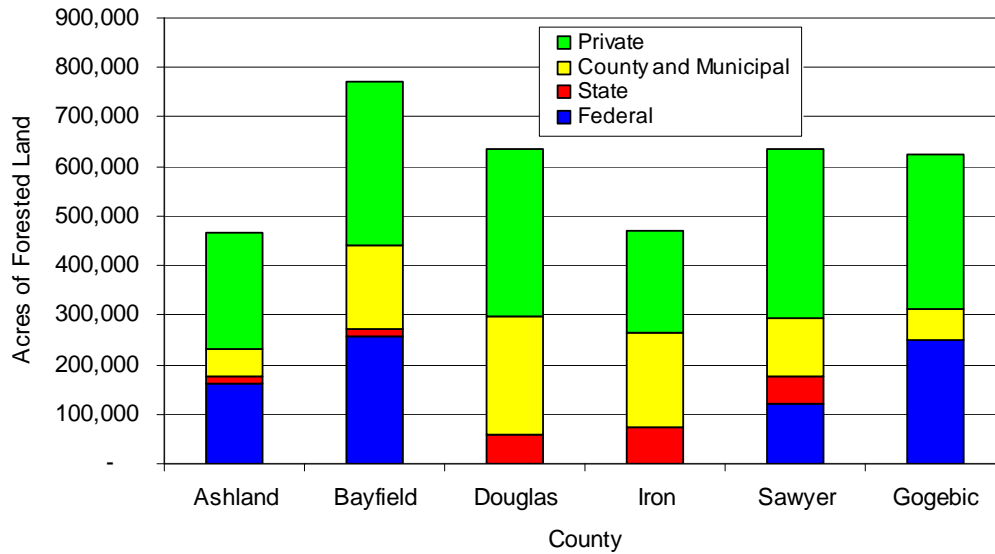


For this study we focused on harvest and primary processing (mill) residues because these activities are most likely to produce both low-value and high-quantity feedstocks. In addition, we examined the potential for establishing woody biomass plantations in the study area as a means of developing a long-term stable supply.

Forest Resources

The forest resources in the study area fall under four primary types of ownership. Figure 4 shows the ownership makeup of forested lands in each county as well as the overall forest acreage.

Figure 4 – Ownership Profiles for Forested Lands by County

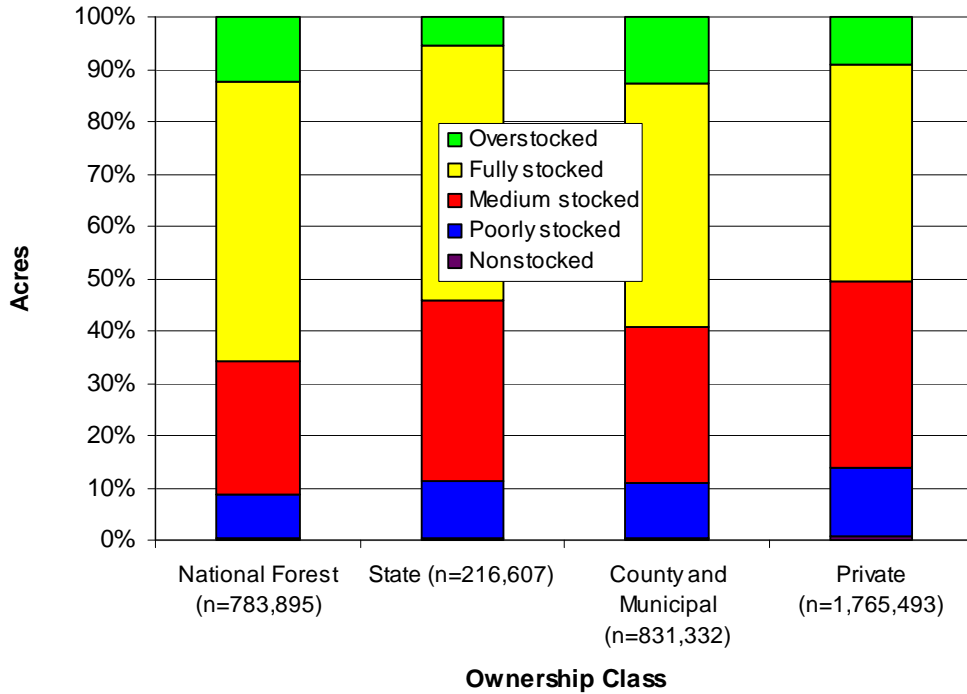


Source: US Forest Service Forest Inventory Mapmaker Version 2.1, 2005.

Bayfield County has the most forested acreage with nearly 773,000 acres. Douglas, Sawyer and Gogebic counties each have between 625,000 and 634,000 acres. Ashland and Iron Counties have about 466,000 and 471,000 acres of forested land respectively. For the combined counties in the study area, private parties own nearly half (1.76 million acres) of the forested land. County and municipal forests and federally owned forests (almost entirely in the form of national forests) make up 23 (830,000 acres) and 22 percent (790,000 acres) of the forested lands, respectively.

The density of biomass on the land can suggest opportunities for harvest that may benefit forest health. Issues specific to ownership class such as absentee ownership of private lands or stilted maintenance of federal lands due to litigation may lead to suboptimal densities. Figure 5 shows the measured stocking levels for forests by ownership class.

Figure 5 – Stocking Levels for Ownership Classes



Source: US Forest Service Forest Inventory Mapmaker Version 2.1, data for Ashland, Bayfield, Douglas, Gogebic, Iron and Sawyer Counties, 2005.

According to the US Forest Service, forested lands under each of these types of ownership are between six and 12 percent overstocked. All ownership categories have more than half of their forests at the “fully stocked” level or higher. The “National Forest” and “County and Municipal” owned lands had the highest percentage of acreage that was listed as overstocked.

Harvest Residues

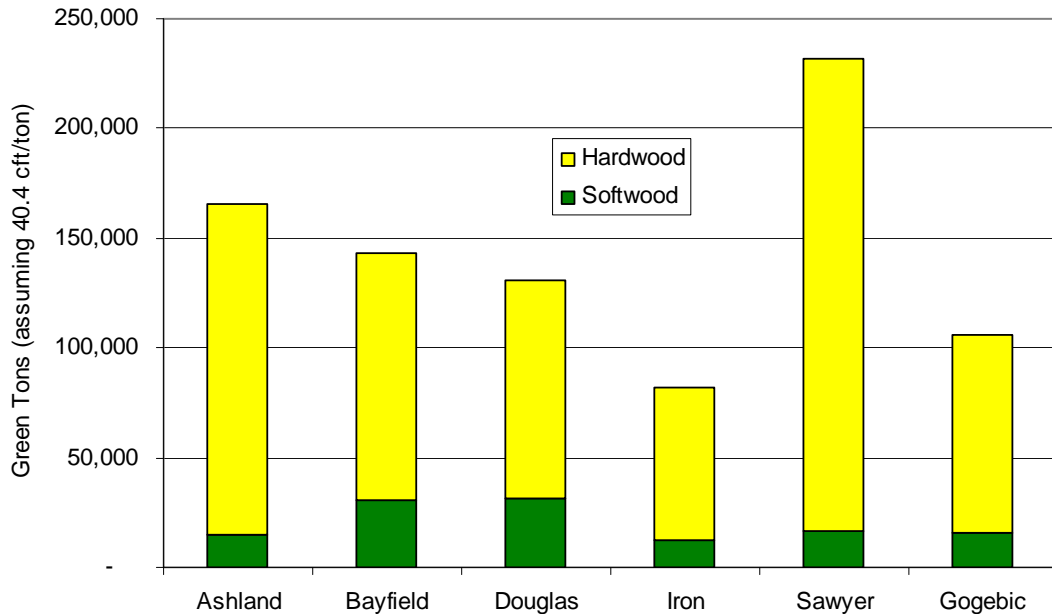
Harvest or logging residues are generated as a result of logging operations. Since these materials are defined as any unused tree parts that are left in the forest,⁵ collection must be added to delivery as a key cost consideration. These residues are considered non-merchantable. Emergence of a market for them, such as fuel, would make them merchantable and loggers would need to pay stumpage fees to remove them from the harvest lands. Ideally, loggers would be financially motivated to remove residues as part of their operation (i.e., the sale price for the harvested residues would need to exceed stumpage fees, collection, and processing and transportation costs). This could help improve the profitability of these logging operations, allowing them to harvest more volume at each site before equipment relocation.

⁵ The definition used by the US Forest Service for the data used in this report is: “the unused portion of trees cut or destroyed during logging operations including stumps, tops, limbs, cull sections of central stem, saplings, rough, rotten or dead trees.”

The Forest Service North Central Research Station produces estimates of harvest residues based on amount of wood harvested. Estimates of harvest residues should be taken as general approximations, and will vary considerably with logging activity in the region.

Figure 6 shows the estimated annual amount of residues generated in each of the study area counties during the period of 2000-4.

Figure 6 – Estimated Harvest Residues Generated Annually by County



Source: North Central Research Station, United States Department of Agriculture, 2000-2004.

The six-county study area had an estimated harvest residue generation rate of about 860,000 tons, including 121,000 tons from softwoods and 739,000 tons from hardwoods. The fact that residues are generated, however, does not mean there are practical means of harvesting them. Removal of residues from harvested lands often requires addressing environmental, economic, regulatory and social issues. Finding a service provider that can, or already has, addressed these issues, and that has access to the biomass, is a significant benefit to the end user.

Sustainable Harvest of Residues in Wisconsin

Wisconsin loggers, in particular those who are members of the Great Lakes Timber Professionals Association, pledge to observe sustainable harvesting practices through adherence to the Wisconsin Sustainable Forestry Initiative annual training standard.⁶ Those who obtain Master Logger certification have attained the highest level of training and expertise and have their practices reviewed by a board of industry experts “knowledgeable about the practice of sustainable forestry.” Federal, state, county and local forest administrators, and in some cases nonprofit forest sustainability organizations, oversee harvest practices and contractually delineate what is to be removed

⁶ See the Wisconsin Professional Loggers Association (now Great Lakes Timber Professionals Association) Web site at: <http://www.wpla.org/wplacode.html>.

for each site. In addition, the Department of Natural Resources Division of Forestry provides some more specific directions in their Wisconsin Forest Management Guidelines. For example, these include the recommendations that loggers create at least two to five bark-on downed logs greater than 12 inches in diameter per acre on harvested sites, and that they leave existing downed trees and standing dead trees undisturbed to the greatest extent possible.

Willyard and Tikalsky (2006) provide a literature review of ecosystem and biodiversity issues associated with collecting harvest residues. Studies suggest that the amount of biomass that must remain on a harvest site varies greatly based on the quality of the soils; poorer quality soils will require higher levels of biomass left on site to replenish them. The literature contains no formulas for predicting the percentage of generated residues that can be removed on any given site based on soil quality. Decaying fine woody debris defined as leaves, twigs and branches less than six inches in diameter, can help poorer soils maintain beneficial nutrient and carbon levels. Larger coarse woody debris such as fallen trees, standing dead trees (a.k.a. snags), and branches six inches or larger in diameter, provide important structures for smaller animal species and create microenvironments vital to forest ecosystems. Conversely, leaving all harvest residues on the land can impede replanting and natural regeneration of forest.

Another literature review conducted by Jan Hacker (2005) concluded that although little research has been done on habitats and tree species native to the Great Lakes states, research on a wide variety of forest types and soils suggests that effects of slash removal on nutrient budgets is short term. However, if the site does not have adequate reserves or will not obtain additional reserves, and is already nutrient poor, the impact will be more severe and long-term. Site-specific determinations of appropriate levels of residue removal must be made by qualified foresters with good knowledge of the land and the habitats. Conversations with foresters suggest they do base harvesting parameters on soil considerations (e.g., a forest with poorer soils may have stumpage quotes allowing harvest only down to 6 inches in diameter, whereas with rich soils, there may be no limitation on residue removal).

There are examples of assumptions in the literature, and standard requirements in some countries for residues left on site, but these appear to be done for convenience and do not reflect the site-specific nature of this relationship. From a practical standpoint, and perhaps providing a firmer number, the DOE/USDA's *Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply* (2005) study states that current technologies only enable on average a maximum harvest of 65 percent of residues from sites (i.e., 35 percent of residues are not practically harvestable), without consideration of soil conditions.

Wisconsin logging operations, with the exception of some whole tree harvest operations, tend to leave treetops on site, largely due to the lack of a market for the lower quality wood (i.e., it is nonmerchantable). In time they will decay and could provide soil benefits. But structurally they are not nearly as important for habitat and diversity.

Therefore, should a market for this wood develop, loggers can add removal of treetops to their existing operations with little negative effect on harvest lands.

This combination of influences, while not amounting to a legal requirement for sustainable harvest, points to the feasibility of sustainable removal of treetops from logged lands in Wisconsin.

Current Harvest and Management Activities

An increase in Xcel Energy's demand for wood chips could mesh well with ongoing harvest and management activities in the region. The ability to "piggyback" harvest of treetops with traditional merchantable lumber harvests⁷ would mean minimal environmental disturbance and better site conditioning for regrowth. Following are some summaries of current activities in regional forests.

National Forests. In recent years, much of the maintenance thinning and new harvest initiatives on national forest lands have been opposed by environmental groups. However, logging operations under existing contracts have continued. The US Forest Service would be interested in exploring options to have companies remove treetops from harvested trees which are currently left to decompose on the forest floors (Theisen, 2007). The Forest Service would be amenable to negotiating more favorable stumpage rates with companies who want to remove and use tops from harvested trees. Similarly, the Forest Service is currently paying contractors to go in and cut down undesirable species which are then left on the site. They would be interested in exploring agreements to have contractors cut and remove these for a fee, creating conditions more conducive to regrowth.

County Forests. Counties in the study area have varying degrees of logging activity on their county forest lands as described below.

- Ashland County has experienced a slowdown in harvesting on county land, which could pick up after the spring thaw. Contracts are set up on a per-cord basis and competitively bid, with harvest down to 4 inches. Much slash is left behind.
- Bayfield County estimates contractors are harvesting 30-50,000 cords per year and are growing 90-100,000 cords. They project that they could harvest 600 forested acres per year sustainably for the foreseeable future. Their contracts require that the loggers take all that is above 8 inches in diameter, and most of the treetops are left on site.
- Douglas County contracts for harvesting of about 5,000 acres per year, with harvesters processing down to 2-inch diameter treetops. The loggers do substantial chipping and are often permitted to take the tops (although not when on poorer soils requiring carbon and nutrient supplementation). Chips are sold to "Fuels for Schools" participants, mills, and businesses in Minnesota. The county is planning to market scrub oak chips for fuel.

⁷ According to one logger, this would literally mean the tops could be hauled out on the skids on top of the lumber they are harvesting. No new roads would be made and loggers would have improved efficiency because they could remove more wood before having to relocate their equipment.

- Iron County has approximately five contracts out for harvest and tops are generally left on site.
- Sawyer County sees about 2,600 acres harvested per year, and contracts cutting down to 4 inches in diameter, although some go down to 2 or 3 inches. Some harvesters do whole tree chipping. Nonmerchantable tops are left on site.
- Gogebic County estimates they have about 750 (of their total of about 50,000) acres of mostly hardwoods currently under active harvest. They have very few loggers that do whole tree chipping, but most harvests are down to about 3-inch diameter, leaving smaller tops on site. They do not have restrictions on removal of biomass, so tops could be removed.

Forests on Tribal Lands. The Bad River reservation has 125,000 acres of forested lands owned by the tribe and individuals. This forest is managed under their integrated resource management plan and approximately 400 acres are harvested each year. The Bureau of Indian Affairs (BIA), the federal organization charged with managing assets on tribal lands, estimates that harvest residues of about 15 tons per acre, or a total of 6,000 tons, are left on the land each year. While both tribal and BIA representatives saw increased use of these residues as positives for the landowners, they pointed out that current BIA contracting practices limit these possibilities. Currently, harvesters are charged a cordwood rate for residues removed from harvested lands which does not reflect the lower value. Changing this practice will require that the Council of Elders request BIA reduce the amount charged to harvesters for residue extraction. Removal of tops from harvest lands can clear the way for tribal initiatives such as re-establishment of white cedar forests.

Local and Private Landowner Healthy Forest Initiatives. A number of localities in the study area have Healthy Forest Initiatives. In addition, a member-owned forestry-based cooperative, the Living Forest Cooperative, helps owners of forested lands develop sustainable forest management plans for their properties to generate income and improve the health of the forest. The cooperative is also encouraging landowners and farmers to take a more active role in managing their forests. As long as long-term soil quality issues are monitored, they see increased demand for traditionally nonmerchantable wood as a means of helping private landowners finance active forest management. A cooperative representative said he would like to see wood fuel pricing based on fuel value so that less marketable but high fuel content wood such as oak could be cost effectively harvested as well.

Commercial Loggers

Loggers interviewed for this project present the single most promising and direct option for increasing wood fuel use at Bay Front. These operations already do harvesting on federal, county, local and privately-owned forest lands. Negotiation for delivery of harvest residues with these loggers offers an apparent direct route through the more complex negotiations that would be required to work with the multitude of forest owners. Interviews suggest some loggers have interest in expanding their operations to include residue extraction, processing (chipping) and delivery to wood chip users (and some are already planning to do this). Current wood chip users include school districts, industrial

users and Xcel Energy. By all accounts, many harvesting operations leave an ample quantity of biomass on the land in the form of treetops that could be harvested if there was a financial incentive to do so. Some loggers have suggested that prices at or above break-even per delivered ton for wood chips, and contracts for a year or more, may be enough to get them (and others) involved, and that with slight expansions to their operations they could supply more than enough chipped wood to meet Bay Front's needs. Increased demand for chipped residues may also allow loggers to negotiate with landowners to return to recently logged sites to chip and remove treetops left on the land, thus improving both the aesthetics and regrowth conditions for these lands.

Mill Residues

In this section we characterize the current generation and fate of harvest and primary wood using industry residues in the counties within a 50-mile radius of the Bay Front plant. Primary wood-using mills take raw products from the forest such as logs and chips and produce lumber, utility poles, oriented strand board, veneer, and sawdust. Secondary wood-using industries use products from the primary wood-using mills and produce anything from flooring, furniture, and cabinets to log homes. The US Forest Service North Central Station has gathered information on residues from primary industries, but there are no centralized records of residues produced from the secondary wood-using businesses. Therefore, while they may offer a significant source of biomass for Xcel Energy, the secondary wood using industry residues are not examined in this study.

Production (of wood products, not residues) and organizational data on primary and secondary wood-using industries are available from the Wisconsin Primary and Secondary Forest Industries Databases created by the University of Wisconsin Department of Forest Ecology and Management.⁸ Figure 7 shows a plot of the locations of Wisconsin primary and secondary wood processing industries in counties that fall within the study region.⁹

⁸ The databases can be downloaded from the following site: <http://www.woodindustry.forest.wisc.edu/>.

⁹ Plotted points in Gogebic County and Price County are included because these firms had a Wisconsin study area county listed as their county of operation but coordinates put them where they appear on the map. Some industries did not have coordinates in the database and so are not included on this map.

Figure 7 – Wisconsin Primary and Secondary Wood Using Industries



Map generated using Microsoft Map, and location data from the Wisconsin Primary and Secondary Forest Industries Databases, University of Wisconsin, 2006.

These northern Wisconsin and Michigan counties have historically had thriving forest product industries. The Wisconsin Primary and Secondary Wood Using Industries databases and Michigan Department of Natural Resources Forest Industry Database¹⁰ list 46 operating primary and 33 secondary wood-using businesses in these counties. Table 1 lists the numbers of primary and secondary wood using industries in each study county.

¹⁰ The database can be accessed at: <http://www.dnr.state.mi.us/wood/quermain.asp>.

Table 1 – Wood Using Industries in the Study Area

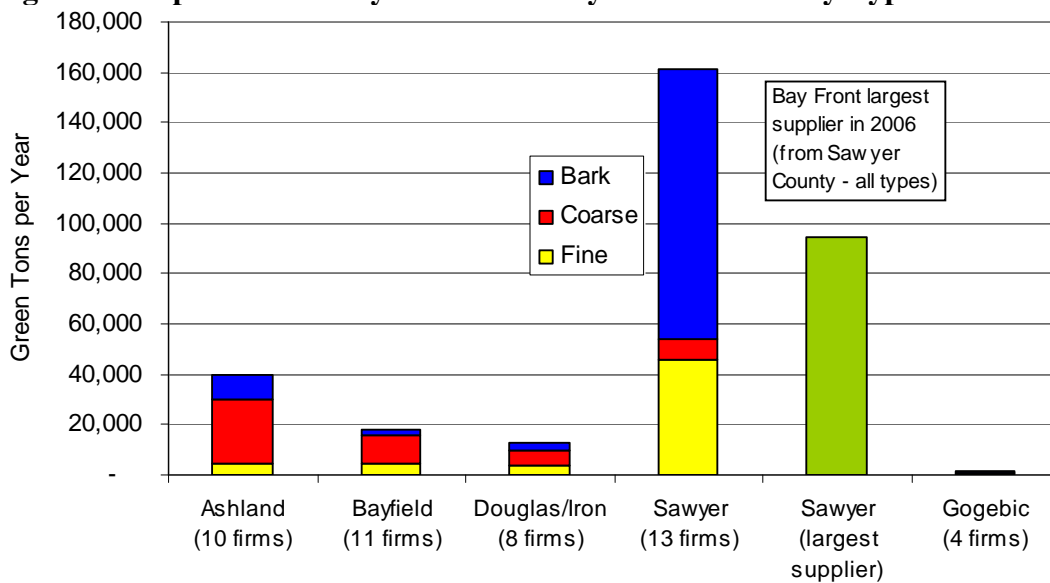
	Primary	Secondary
Ashland	10	6
Bayfield	11	3
Douglas	4	6
Iron	4	2
Sawyer	13	11
Gogebic	4	5
Total	46	33

Many of the records in these data sets do not have a reported volume of production. For those that do, the largest reported outputs are a veneer producer in Ashland County that processes between five and seven million board feet of wood per year, and three sawmills, two in Ashland county and one in Sawyer County, that each manufacture between three and five million board feet of lumber per year.

Primary Wood-Using Industry Wastes

Mill residues from primary wood-using industry production are categorized as fine, coarse and bark. Fines are too small to be suitable for chipping. Coarse residues are larger pieces that could be fed through a chipper. Bark is considered the lowest value wood residue from these operations and is most often removed before other processing occurs. Figure 8 shows the overall volume of reported residues produced in these counties from primary industries, broken down into residue types. In addition, the total quantity of residues from the largest current supplier to Bay Front is included (as a solid green bar).

Figure 8 - Reported Primary Wood Industry Mill Residues by Type



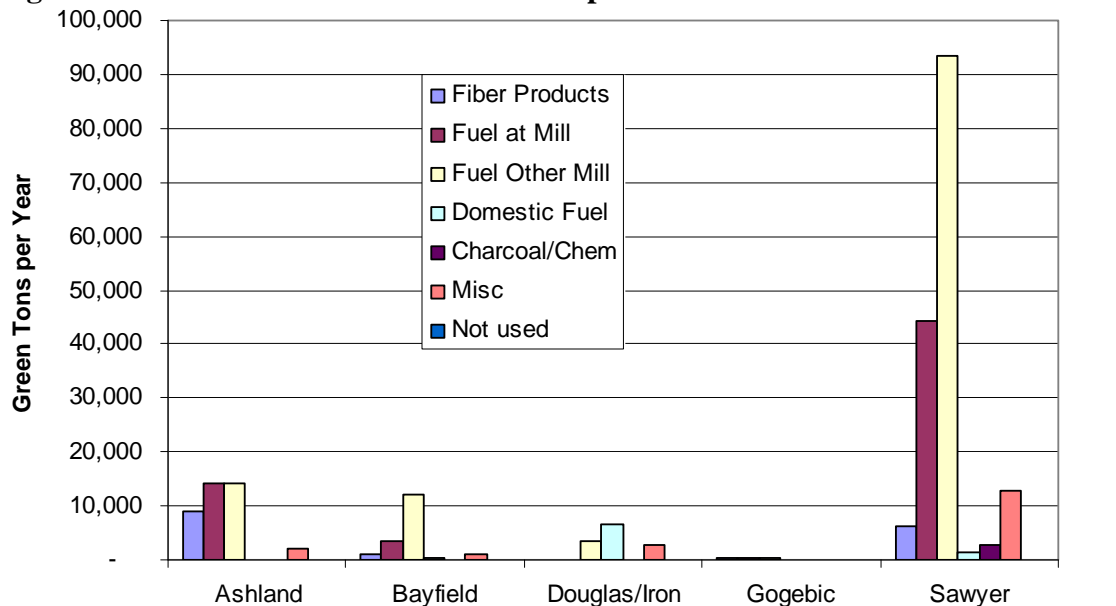
Source: North Central Research Station, United States Department of Agriculture unpublished data from 2000-2004, obtained 2007. Douglas and Iron counties are combined by USDA to reduce potential for identification of residue amounts with individual businesses. The Sawyer (largest supplier) bar is some combination of residue types and so is not subdivided into bark, coarse and fine.

Sawyer County has by far the largest amount of reported mill residue generation at about 161,000 tons per year. However, Xcel Energy has already tapped into the largest residue generator, which supplied 94,000 tons of biomass to Bay Front in 2006. This provides some perspective on the limited potential for expanding residue use from this sector.

Current Reported Uses of Mill Residues

A study by researchers at the U.S. Forest Products Laboratory on mill residues generated in the United States from primary timber processing operations found that about 98 percent was reportedly used for other products or energy (McKeever and Falk, 2004). This suggests that just about two percent are available for other uses. Recent data on Wisconsin primary wood-using industry mill residues shows even lower residue availability. Figure 9 shows residue volumes and recorded uses for counties in the study area.

Figure 9 – Mill Residues Generated and Reported Uses



County	Fiber Products	Fuel at Mill	Fuel Other Mill	Domestic Fuel	Charcoal/Chemicals	Misc. Uses	Not used
Ashland	8,920	14,343	14,259	-	-	1,961	2
Bayfield	1,092	3,471	12,042	235	-	903	-
Douglas/Iron	-	-	3,535	6,523	-	2,676	-
Sawyer	6,265	44,369	93,567	1,555	2,787	12,918	-
Gogebic (MI)	505	375	322	5	-	3	-

Source: North Central Research Station, United States Department of Agriculture unpublished data from 2000-2004.

Of the estimated 232,000 green tons of mill residues generated by primary wood-using industries in the study region, only two tons were reported to be “not used.”¹¹

¹¹ Communications with forest industry experts suggest that reports of mill residue use may be exaggerated, meaning there are likely to be more residues available for alternative uses than these data sources indicate.

Xcel Energy currently has a number of agreements with wood industry businesses to buy residues for Bay Front (see discussion under Demand Profile and Current Supply). With the exception of the largest supplier, these agreements do not have minimum quantity requirements. They are relatively informal, offering a fixed rate for biomass delivered. Competing wood-using industries for some of these residues, such as wood pelleting operations, are expanding in the state and region, and will offer higher value market alternatives that will contribute to increased competition, reduced biomass supplies, and higher biomass prices for electric generating plants like Bay Front.

Securing a reliable fuel supply into the future is an important goal. In light of this, it appears that mill residues, unless amounts given by industry are substantially underreported, may not be a viable source much beyond existing agreements.

Dedicated biomass

The long-term availability of secondary biomass supplies such as wood waste from milling or clearing operations is subject to market conditions as well as potentially variable output from the suppliers. A more stable solution is to create a dedicated supply of primary biomass. This can be done on land that Xcel Energy owns or leases, or by entering into contracts with farmers who both own the land and will cultivate the crops. While this does not provide complete insulation from market pressures, dedicated energy plantations provide a predictable, uniform, secure supply of biomass.

In order to produce biomass at a sufficiently low cost to compete with other fuel sources, a biomass plantation must produce crops that require minimal cultivation. Two different kinds of biomass are typically considered for this purpose: short-rotation woody crops and grasses. We will consider how successfully energy crops can be grown in the study area, and outline potential production scenarios.

Short-rotation woody crops

Short-rotation woody crops (SRWC), including such species as cottonwood/poplar, willow, silver maple and red pine, can grow to merchantable size in 5 to 15 years, depending on the application, species and plantation. The most studied crop, as well as the one considered most suitable for this region, is the hybrid poplar. We will use poplars as our main example in this section.

SRWC can serve as a combustible fuel for power plants, although they were first investigated as a source of lumber and fiber for papermaking, and later as a source of cellulose for advanced biomass processing. Xcel Energy's Minnesota Valley power plant is investigating a conversion to Whole Tree Energy (WTE) using hybrid poplars, cottonwoods and willows (Ostlie 2003). WTE requires a plant retrofit and uses the trees as cut with minimal further processing; the Bay Front model of using wood chips is a significantly different operation.

To understand all of the factors that influence whether SRWC can be profitably grown in the study area, we will outline issues related to establishment, harvesting and handling, combustion and the environmental impacts of growing.

Establishment

Successful establishment of a SRWC plantation is dependent on many variables—most critically soil moisture, but also acidity, soil texture and nutrient availability.

Table 2. Recommended soil characteristics for hybrid poplar plantations

<i>Soil characteristic</i>	<i>Parameter</i>
Texture	Loams, not clays (Ostlie 2003)
Water-holding capacity	10 in. or greater in top 60 in. of soil (Hansen 1993)
Water table depth	1 to 6 ft. (Hansen 1993)
pH	5 to 7.5 (Hansen 1993)
Slope	Less than 12% (Riemenschneider 2007)

Hybrid crops are bred to emphasize particular qualities in order to find the most compatible species for a given environment. Researchers warn that current soil classifications are insufficient to consistently predict how a tree from a specific genetic line will perform in a given soil, and that common indicators such as crop equivalency rating (CER) have not correlated to successful planting (Ostry 2007). However, soybean performance has been noted as a reasonable indicator of poplar suitability (Riemenschneider 2007). Some trial-and-error may be required to arrive at the genetic line that will generate the most Btu/acre for a given plot.

The model of a successful SRWC plantation is a single species of tree in evenly spaced rows. Spacing for energy density is another variable that may require successive plantings to optimize for the plantation. A peculiar characteristic of hybrid poplars is that biomass per tree does not decline, but stays constant or may even increase, the closer the trees are spaced—albeit at a cost of tree longevity.¹² This makes them ideal as an energy crop—they can be grown densely so long as they are harvested frequently.

The feasibility study for the Minnesota Valley plant estimates that by growing poplars, cottonwoods or willows on 5.3 ft. centers, the plantation will yield 24.5 dry tons/acre, or 47 green tons/acre, after five years. This spacing is predicated on the use of high-productivity harvesters such as those proposed by Energy Performance Systems (EPS), which also developed the Whole Tree Energy plant model. L. David Ostlie, president of EPS and author of the Minnesota Valley study, says that he has determined through his most recent growing trials that 5.0 ft. spacing is ideal (Ostlie 2003, 2007).

Other sources which consider more traditional harvesting methods recommend 8 or 10 ft. centers (Hansen 1993). If we carry forward the other assumptions from Minnesota Valley study, the yield changes to 11 and 7 dry tons/acre, respectively.

¹² This phenomenon is popularly demonstrated through an experiment called the Nelder Wheel. For a look at poplars planted under such a strategy, see DeBell, Dean S. and Constance A. Harrington. 1997. "Production of *Populus* in Monoclonal and Polyclonal Blocks at Three Spacings." Canadian Journal of Forest Research. Available online at <http://bioenergy.ornl.gov/reports/debell/chapter5.html> (accessed March 2007)

With hybrid poplars, the initial planting is done with cuttings all from the same clone species, typically less than a foot long and roughly 0.5" in diameter. Weed control is required for the first three years, and may not be necessary once the tree canopy has developed (Ostlie 2003). Cultivating the plantation in its early years is critical to its future health and optimum yield.

Once a hybrid poplar plantation has been cut down, the trees will sprout again from their stumps. While weed control will again be necessary, the trees' root systems are already established and will grow for another harvest, possibly in less time than the first plantation. In practice, however, it is likely that during the maturation period for the first planting, a better genetic line will have been developed and that farmers will be better served by pulling up the old stumps and planting new cuttings (Stanosz 2007). The same is likely to be true for any monoculture SRWC for the foreseeable future. These future costs, i.e., stump removal and avoided establishment costs due to stump resprouting, are fuzzy and were not estimated.

Harvesting and handling

The intended harvesting method limits how densely you can seed a plantation. Energy Performance Systems is developing a rapid harvester for use on SRWC plantations that they expect to offer for sale in 2008. The harvester, which is estimated to operate for \$101/acre, is designed to handle plantations with spacing as low as 40". As described in the Minnesota Valley study, "The harvester is a large, rubber-tracked machine designed to continuously travel down each row of trees at relatively high speed. Each tree is cut off, guided into an accumulation area and batch-dumped onto a trailer towed behind the harvester." After a 5-year growing season with 5.3 ft. centers, a typical hybrid poplar is roughly 6-8" in diameter and 30-35 ft tall (Ostlie 2003, 2007). For economic harvesting using any type of harvester, it is recommended that SRWC not be grown on sloping soils.

Short-rotation woody crops have been specifically selected as a potential feedstock for the Bay Front plant because it already consumes wood chips as a fuel and has wood handling systems in place. Bay Front does not chip its own wood, however, so the facility would need to be expanded or a third party would have to provide these services. As previously discussed, established loggers are interested in expanding their operations to include chipping and delivery.

Combustion

Chipping SRWC as harvested will create green wood chips. Bay Front currently uses a mix of wood chips as fuel, including green chips, which burn at a lower Btu than oven-dried wood because energy spent during combustion to drive the moisture from the wood does not contribute to power output. In a scenario where Bay Front uses all biomass fuel, the amount of fuel needed could be significantly reduced if excess heat exhausted by the plant were used to dry the chips. Green wood chips (assuming 50% moisture) burn at

5.74 MMBtu/ton; air-dried wood chips burn at 13.7 MMBtu/ton; and oven-dried wood chips burn at 17.2 MMBtu/ton.¹³

Environmental impacts

Compared to row crops, SRWC require very little cultivation and greatly reduced demand for chemicals such as fertilizer or pesticides. Also unlike row crops, SRWC can provide significant erosion control and are expected to grow exceptionally well in soils traditionally reserved for row crops.

Studies have concluded that monoculture SRWC plantations do not exhibit the species richness of forests or pasturelands, but are also not “biodiversity deserts” as suggested by some critics. These plantations show greater overall diversity than lands planted with row crops, and they also outperform shrublands and grasslands in some characteristics.¹⁴ Willyard and Tikalsky (2006) provide a review of biodiversity studies related to monoculture plantations.

Beyond biodiversity, establishment of SRWC plantations will have to balance known environmental benefits (e.g. displacing coal in power plant operations with a short-cycle carbon fuel) with concerns about introduction of non-native species and possible effects on surrounding ecosystems. Some environmental questions may not have clear answers even after plantations have been established.¹⁵

As emphasis shifts in our region toward energy independence both from other nations and from other states, owners of marginal croplands that are currently in reserve will feel increasing pressure to bring that land back into production for energy crops. With their multi-year growing seasons, SRWC may prove to be an ideal middle ground between intensive cultivation for commodity products and nonproductive CRP-style management.

Grasses

Because the material handling systems in place at the Bay Front plant require biomass in the form of wood chips, we will not consider the use of grass energy crops at length. However, as research into energy crops progresses, it may be that grass crops will be a more successful choice for energy plantations than woody crops, and if this should be the

¹³ 2004. “Fuel Value Calculator.” USDA Forest Products Laboratory Techline. July 2004. Available online at <http://www.fpl.fs.fed.us/documnts/techline/fuel-value-calculator.pdf> (accessed March 2007)

¹⁴ More specifically, a review of research has suggested that monoculture SRWC plantations have greater avian abundance and species richness than shrublands, and greater small mammal abundance and species richness than grasslands (Willyard and Tikalsky 2006).

¹⁵ Some common questions emerge concerning use of native versus nonnative species and mixed forest versus monoculture. SRWC plantations tend to consist of clones of a hybrid bred for qualities that have been determined to complement the characteristics of the plantation. These hybrids are, by definition, not native species, and some object to the introduction of such species for fear of the effect they might have on ecosystems. Pathologists have been deeply involved in SWRC research because disease resistance is an obvious virtue for an energy crop. One concern, however, is that planting hybrid poplars too near to native cottonwoods will result in cottonwoods being hybridized with the nonnative species, and that an infestation or disease that is trivial to one species could be troublesome for the other (Ostry 2007).

case, the time horizon may be sufficient for handling equipment to be installed at Bay Front.

While switchgrass is the best-known potential energy crop, there are many native and non-native grasses that are of interest for their ability to produce fiber and fuel, including such exotic species as sorghum and miscanthus. The major issue with using grasses in power plant operations is the state of the harvesting technology, combined with greater handling difficulty at the plant and greater silica deposits during combustion (i.e. compared to woody biomass and coal). Also, SRWC can be harvested year-round, while grasses generally cannot be harvested once there is snow accumulation. This can create problems related to storage needed because of cyclical harvesting. Alternately, grasses regrow to relative fullness during the summer, meaning that if the biomass harvests are timed appropriately, there is little to no significant habitat disruption. Like SRWC, native grasses can thrive with relatively little cultivation after they are first established.

Land in the study area

Biomass plantations thrive as soil quality increases, but it is not feasible to seek out the highest quality farmland to grow energy crops. If we were to achieve 100 percent of Bay Front’s 360,000 ton fuel need from SRWC and assuming 47 green tons/acre per the Minnesota Valley study, we would need to harvest 7,700 acres each year; assuming a five-year growing period, we would need 38,500 acres. While the goals presented in the Minnesota Valley study are aggressive, that is the scale needed to justify energy crops for power plant use. The assumptions in the Minnesota Valley study are reasonable, despite being predicated on technologies that are not yet commercially available.

Agricultural land use in the region is described in Tables 3 and 4.

Table 3. Farmland and cropland in study area, 2002

	Total county land area (acres)	Total county land area in farmland (acres)	Average farm size (acres)	Cropland (acres)	Harvested cropland (acres)	Non-harvested cropland (acres)
Ashland	668,103	58,746	259	29,353	22,536	6,817
Bayfield	944,902	111,851	239	59,867	44,490	15,377
Douglas	837,924	84,858	217	39,248	25,626	13,622
Gogebic	944,640	4,024	82	1,984	1,127	857
Iron	484,660	12,741	218	5,904	withheld	n/a
Sawyer	804,180	54,056	235	28,740	21,716	7,024
<i>Total</i>	4,684,409	326,726	--	165,096	115,495	43,697

Source: 2004. “2002 Census of Agriculture Volume 1, Geographic Area Series.” Parts 22 and 49. US Department of Agriculture. Available online at <http://www.nass.usda.gov/census/census02/volume1/mi/MIVolume104.pdf> and <http://www.nass.usda.gov/census/census02/volume1/wi/WIVolume104.pdf> (accessed March 2007).

Table 4. Agricultural land cover in study area, 1997

	Total county land area (acres)	Percent of county land in farms	Percent of farmland in ...		
			Cropland (non-pastured)	Pasture (all types)	Woods (non-pastured)
Ashland	668,103	7.0%	40.6%	22.4%	30.7%
Bayfield	944,902	8.9%	47.2%	19.7%	28.9%
Douglas	837,924	8.5%	33.2%	31.2%	29.1%
Gogebic	944,640	0.4%	<i>unavailable</i>		
Iron	484,660	2.0%	38.0%	16.8%	40.9%
Sawyer	804,180	6.0%	42.4%	29.9%	21.4%

Source: 1997. "Agricultural Land Cover by Wisconsin Counties." Program on Agricultural Technology Studies, Madison, Wis. Available at <http://www.pats.wisc.edu/databook%20spreadsheets/Page03.htm> (accessed March 2007)

The differences suggested by these charts indicate an increase in cultivated acres between 1997 and 2002.

By considering land use, we can consider scenarios where Xcel Energy tries to capture fractions of existing cropland. For instance, if five percent of all cropland in the study area were converted to SRWC, that would be 8,300 acres. If 50 percent of non-harvested cropland were converted to SRWC, that would be 22,000 acres.

The other critical factor in these scenarios is the land rental rates, which are shown in Table 5. The weighted average cash rent (based on the cropland listed in Table 3 and the rates in Table 5) is \$18.50 per acre, and the unweighted average pasture rent (based only on the rates in Table 5) is \$10.20 per acre.

Table 5. Soil rental rates, 2006

	Cash rent [\$ /acre]	Pasture rent [\$ /acre]
Ashland	18	15
Bayfield	15	12
Douglas	12	10
Gogebic	<i>unavailable</i>	
Iron	6	4
Sawyer	38	10

Source: 2006 Land Value Survey. Courtesy of Andrew Halada, Appraiser/Farm Loan Specialist, Wisconsin Farm Service Agency office, March 2007.

In addition to croplands, we want to consider uncultivated grasslands. Carl Beckman, USDA Farm Service Agency County Executive Director for Ashland County, suggests that at least 90 percent of managed non-croplands are currently harvested for hay to prevent them from reverting to brush (Beckman 2007). If we look at hay harvest numbers

in the region, then, we should have a conservative estimate of grassland acreage with active owners. (This is a different value from non-harvested cropland in Table 3, although there will be some overlap in cases where hay is being grown on non-harvested cropland.)

Table 6. Acres growing hay (all kinds), 2005

<i>County</i>	<i>Acreage</i>
Ashland	21,100
Bayfield	36,700
Douglas	29,100
Gogebic	1,025
Iron	3,000
Sawyer	14,200
<i>Total</i>	105,125

Source: USDA National Agricultural Statistics Service Statistics by State. Available at http://www.nass.usda.gov/Statistics_by_State/Wisconsin/index.asp (accessed March 2007), except Gogebic county, which is based on 2000 census data

This total acreage exceeds our estimate of what is needed to provide SRWC fuel to Bay Front. Hay grown in the study area is used for local livestock. Because the primary concern of the landowner is keeping the land somewhat cultivated, Beckman notes that landowners rent this land out for costs ranging from \$5/acre to free, provided that the lessee harvests the hay. While SRWC grow best in the best soil, marginal croplands and grasslands can successfully support these crops, depending on the type of soil at the location. Soils throughout this region are catalogued by the USDA Natural Resources Conservation Service’s Soil Survey Manuscripts (soils.usda.gov/survey/online_surveys), so specific locations can be researched as landowners express interest.

According to 2002 agricultural statistics, no short-rotation woody crops are being grown agriculturally in the study area, although test plots of crops such as hybrid poplar have been successfully established in the area.

CRP land in the study area

There is essentially no Conservation Reserve Program (CRP) land in our study area. Too little of this land has a history of cropping, so there is little incentive to use CRP to reduce cultivation (Butler 2007). Likewise, when the USDA offered a Grassland Reserve Program (GRP) in 2005, no or almost no acres in the study area were signed up (Peña 2007). The GRP rate offered was \$5.50/acre for the Wisconsin counties in the survey area.¹⁶ The Wisconsin FSA estimates that the majority of grasslands in the study area are primarily used for forage. The lack of CRP eligibility may make the landowner base in the study area especially receptive to SRWC cultivation as a minimal-effort way to make money off of grasslands.

¹⁶ “Rental rates for rental agreements.” USDA Natural Resources Conservation Service. Available online at http://www.wi.nrcs.usda.gov/programs/grp_rentalrates.html (accessed March 2007)

CRP lands cannot currently be used to harvest woody energy crops or to grow hybrid species, although some expect changes to these rules in future US Farm Bills.¹⁷

Potential production scenarios

We will consider various production scenarios, modeling our approach on the Minnesota Valley study as one of the most complete models for a power plant operation. SRWC used for fuel is a significantly different approach than growing trees for timber or fiber—those applications require wood with characteristics that could be incompatible with the closely spaced, short-lived planting model that could make power plants feasible. The following are the critical variables.

Tree spacing. We will consider 5.0 ft., 5.3 ft. and 8.0 ft. spacings. We will assume uniform biomass per tree over those spacings, but in reality, the trees tend to be larger when they are more closely spaced.

Tree size. The Minnesota Valley study cites 4.9 dry tons/acre as the expected annual growth for hybrid poplars with 5.3 ft. centers, with 1,551 plantings per acre (Ostlie 2003). This translates to 6.3 dry lb/tree-year, or 12.2 green wet lb/tree-year. After five years, this is 61 green lb/tree, or 47 tons/acre. If we assume this size for a poplar regardless of spacing, then at 5.0 ft. we will see 1742 trees, for 53 green tons/acre, and at 8.0 ft. we will see 680 trees, for 21 green tons/acre.

Land rent. We will use the weighted average crop rental rate of \$18.50 per acre. If less desirable land is used, the rental rate should be less, although yield may also decline.

Annual costs. The Minnesota Valley study assumes \$227/acre in costs in the first year for land preparation, planting and other start-up costs, and \$66/acre in the second year (Ostlie 2003). Weed control costs are built into these numbers. No costs are included after year two.

Harvesting cost. With a rapid harvester, the Minnesota Valley study assumes \$101/acre (Ostlie 2003). A cost estimate for other harvesting methods is \$6.41/ton (Peterson 2006).

¹⁷ CRP contracts are mostly incompatible with energy crop cultivation. The CRP program does allow harvesting of grasses once every three years, but severely limits harvesting of tree stands. For instance, conifers can be grown at the same time that a landowner is trying to establish a hardwood tree stand, but when those conifers are harvested, the land loses its CRP status during that period. This practice is permitted, primarily because even after harvest, a hardwood tree stand remains. In Wisconsin, only native species can be grown on CRP land—although prior to implementation of this rule in the mid-‘90s, hybrid poplars were occasionally planted on CRP land.

The future of CRP programs is unclear. In the time that has elapsed between the 2002 Farm Bill and the pending 2007 Farm Bill, the opportunities presented by bioindustry have created an intense reevaluation of the value of farmland. In the short term, this is mostly driven by corn prices in excess of \$4 a bushel. To the extent that SRWC and grasses are considered preferable to row cropping, the Farm Bill might be structured to promote such plantations.

Transportation and chipping costs. Given the 50 mile radius of our study area, the average transportation distance is 25 miles, as we assume a loaded cost of \$1.70/mi, at a capacity of 27 green tons/load (Ostlie 2003). We will assume on-site chipping, since we are aware of interested providers of that service in the study area, but use of stationary chippers will increase the average transportation distance by the fixed distance between the chipper and the plant, and will put a higher value on lands near the chipping operation. Chipping is estimated at \$4.27/green ton (Peterson 2006).

Table 7. Hybrid poplar production scenarios

	5.0' spacing	5.3' spacing	8.0' spacing
Spacing [inches]	60	63.6	96
Planting density [sq ft/tree]	25	28.1	64
Trees/acre	1742	1551	681
Tree growth [green lbs/tree-year]	12.2		
Land rent [\$/acre]	18.50	18.50	18.50
Years	5	5	5
Yields [green tons/acre]	53	47	21
First-year costs [\$/acre]	227		
Second-year costs [\$/acre]	66		
Rapid harvesting costs [\$/acre]	101		
Traditional harvesting costs [\$/ton]	6.41		
Traditional harvesting costs [\$/acre]	341	303	133
Shipping volume [green tons/loaded truck]	27		
Transportation cost [\$/loaded truck-mile]	1.70		
Average distance [miles]	25		
Transportation cost [\$/truck]	47.5		
Transportation cost [\$/ton]	1.57		
Chipping cost [\$/ton]	4.27		
Tons needed	360,000		
Total acres needed	6,774	7,611	17,342
<i>Rapid harvesting</i>			
Total cost [\$/harvested acre]	487	487	487
Total cost [\$/ton w/ transportation & chipping]	15.0	16.1	29.3
<i>Traditional harvesting</i>			
Total cost [\$/harvested acre]	726	689	519
Total cost [\$/ton w/ transportation & chipping]	19.5	20.4	30.8

These results indicate that SRWC are a promising avenue to pursue, and that a pilot plantation is fully warranted. When discussing a production-scale scenario, however, it seems very prudent to wait and see what happens with the Minnesota Valley facility and plantations. If the estimates of tons per acre and harvesting cost proposed by EPS for the Minnesota Valley facility are indeed achievable, then this is a wood source that is cost-competitive with current sources. Until that has been determined, however, other wood sources should be pursued.

Conclusions

Source Summaries

Harvest Residues – The volume of these residues is estimated to be quite large but is not regularly collected. Collection, chipping and delivery of these residues are essential services which will be added to the cost of the fuel. Prices would need to be negotiated with individual logging operations, but some expressed optimism that an agreeable price per delivered ton of chips could be found that would enable them to expand their operations so they are capable of providing all of the 360,000+ tons of chipped treetops for use at Bay Front.

Primary Mill Residues – These are reportedly all being used (some for fuel at Bay Front), although some industry regulators believe this use is over-reported. The degree to which residues could be diverted from current uses to fuel for Bay Front is unknown, but under the most optimistic scenario would be less than 100,000 tons per year, and would involve substantial amounts in forms not ideal for use at Bay Front.

Secondary Mill Residues – The total volume of these and degree to which they are currently used for other purposes is unknown. However, given that they are more uniform in quality and have better fuel value than wetter primary mill residues, it is reasonable to assume they are at least as well used as primary mill residues.

Forest Thinnings – Although this category was not directly examined in this report, it should be noted that expansion in the demand for logging services through demand for chipped treetops would enable more active maintenance thinnings and selective cutting to improve the health of existing stands.

Hybrid Poplar Plantations – Plantations are very promising, but with a separate Xcel Energy facility already undertaking a commercial-scale plantation, it would be worthwhile to wait to see if those results meet expectations in terms of yield per acre and cost before committing similar resources. A pilot plantation is well-justified, and should be taken as an opportunity to identify specific parcels of qualified land in the study area.

Discussion

An increased appetite for biomass at Bay Front, such as would occur under a scenario eliminating the use of coal, would provide multiple opportunities for environmental and economic benefit to the surrounding region. Logging operations were hurt by recent pulp and paper mill closings and the commensurate drops in the demand for pulpwood. Many of these loggers see the opportunity to supply chipped treetops and slash to Xcel Energy as a way to expand their businesses and make more efficient use of their equipment, their time, and the trees they fell.

Removing treetops from sites they are currently logging does not involve making new roads or disturbing more land, and has few if any negative environmental consequences, and some marked aesthetic and regrowth benefits when done properly. Making these businesses stronger could provide a much needed boost to local economies and minimize

the loss of these industry specialists whose skills and knowledge will be much needed as our economy comes to rely more on biomass and less on fossil fuels.

Contracting with professional logging businesses for delivered wood chips will take advantage of their experience and expertise in negotiating stumpage contracts, harvesting, skidding, chipping and transporting fuel to the plant. The loggers want the same thing Xcel Energy wants: longer-term agreements for biomass with guaranteed prices. Some loggers interviewed were eager to speak with Xcel Energy representatives about this and were confident they would be able to expand their businesses to meet demand. They also stressed that the extractable biomass in the form of treetops, in more than sufficient quantities to meet the fuel needs of Bay Front, was being left on fields solely because of a lack of an established market.

The increase in demand for wood chips can also allow active sustainable forestry practices in situations where only sale of the traditionally “merchantable” timber would provide insufficient funding. This holds true especially for private landowners, who tend to default to “non-management” of their forest lands if they cannot afford to investigate and implement sustainable management practices such as selective thinning. The elevation of chipped treetops to “merchantable” status could also enable projects to move forward to clear cut stands to reestablish forests with native species.

Based on current land rents, one or more hybrid poplar plantations could be used to generate wood at a cost as low as \$15 per ton, although these estimates should be adjusted as actual operating data from the Minnesota Valley plantations are available—this is likely to be at least five years out. Pursuing short-rotation woody crop plantations at a production scale means tackling such issues as species diversity, wildlife habitat and plant pathology, but current research indicates that these issues can be resolved to the satisfaction of most parties.

Finally, a less recognized benefit of Xcel Energy’s increase in demand for wood chips would be the strengthening of the infrastructure needed for other incremental increases in production. Wood chips are currently used in the “Fuels for Schools” program and may act as the feedstock for biorefineries using advanced energy generation technologies such as biomass gasification or cellulosic ethanol. Establishing networks, strengthening existing core businesses, and enhancing biomass supply all are key steps in promoting transition to a healthy bioeconomy (Weitner et al. 2006).

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