Energy Center of Wisconsin

Report Number 242-1

WOODY BIOMASS RESOURCE ASSESSMENT FOR PRESQUE ISLE POWER PLANT—FINAL REPORT

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Radius maps in this report were generated using Microsoft MapPoint North America 2006.

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EXECUTIVE SUMMARY

The Energy Center of Wisconsin evaluated the potential supply of biomass suitable for use as fuel at the We Energies Presque Isle Power Plant. We Energies is assessing the possibility of converting the No. 4 boiler at Presque Isle from coal to wood. To convert the No. 4 boiler to wood fuel, We Energies needs 450,000 green tons of biomass annually.

Among all possible sources for woody biomass (defined here as all constituents of a tree less than four inches in diameter), harvest residues show the most promise as boiler fuel. There is an estimated 1.45 million green tons of these residues generated annually (based on the level of harvest activity in 2004) on public and private harvested land in counties within a 90-mile radius of the Presque Isle facility.

The vast majority of harvest residues are left in the forest because there is insufficient economic incentive to remove them. Forest managers say much of this biomass is usable, and they are interested in finding ways to encourage its increased use. Supplying the Presque Isle facility with harvest residues can help establish a market for this product.

Because there is currently no formal market for woody biomass, determining a definitive price is problematic. However, industry interviews and analyses of established wood markets suggest that $30 per delivered green ton is a reasonable current price at which biomass suppliers can operate. This breaks out as follows: $6 for stumpage, $13.50 for harvest and $10.50 for delivery. This is below pulpwood prices, which are currently in the range of $31-37 per green ton delivered for Michigan.

Currently, biomass stumpage is often perceived to have no dollar value (it is free for the taking). However, a non-zero stumpage price for biomass will go a long way toward increasing available supply by demonstrating its value to landowners. And, to reward suppliers who have a superior product, utility payments for delivered biomass should be based on Btu value rather than weight.

Because pulp and sawtimber harvests generate harvest residues, a decline in markets for those products will significantly affect how much residue is generated. In such a scenario, biomass prices may have to increase to sustain harvest activities and may approximate the delivered price for pulpwood.

Loggers are a critical link to the success of all harvest residue collection efforts. Those currently working in the area have indicated an understanding of the opportunity that biomass harvesting presents, as well as a willingness to add that resource to their harvesting portfolio. Loggers welcome longer term contracts for supplying biomass because they can be used to finance equipment purchases. Those interviewed expressed the willingness and capability to expand operations to fully supply We Energies’ demand given an adequate price for delivered biomass.

Harvest residues can be sustainably removed from forests, and in fact many of the lands in the 90-mile radius of the Presque Isle facility are already being managed with sustainable forestry practices. These practices permit a great quantity of biomass to be removed annually without impairing the forest’s regenerative capability. Working only with Master Loggers, lands that are certified as being sustainably managed, or suppliers that include sustainability assurances in their purchase contracts ensures that a harvest residue biomass supply is sustainable.

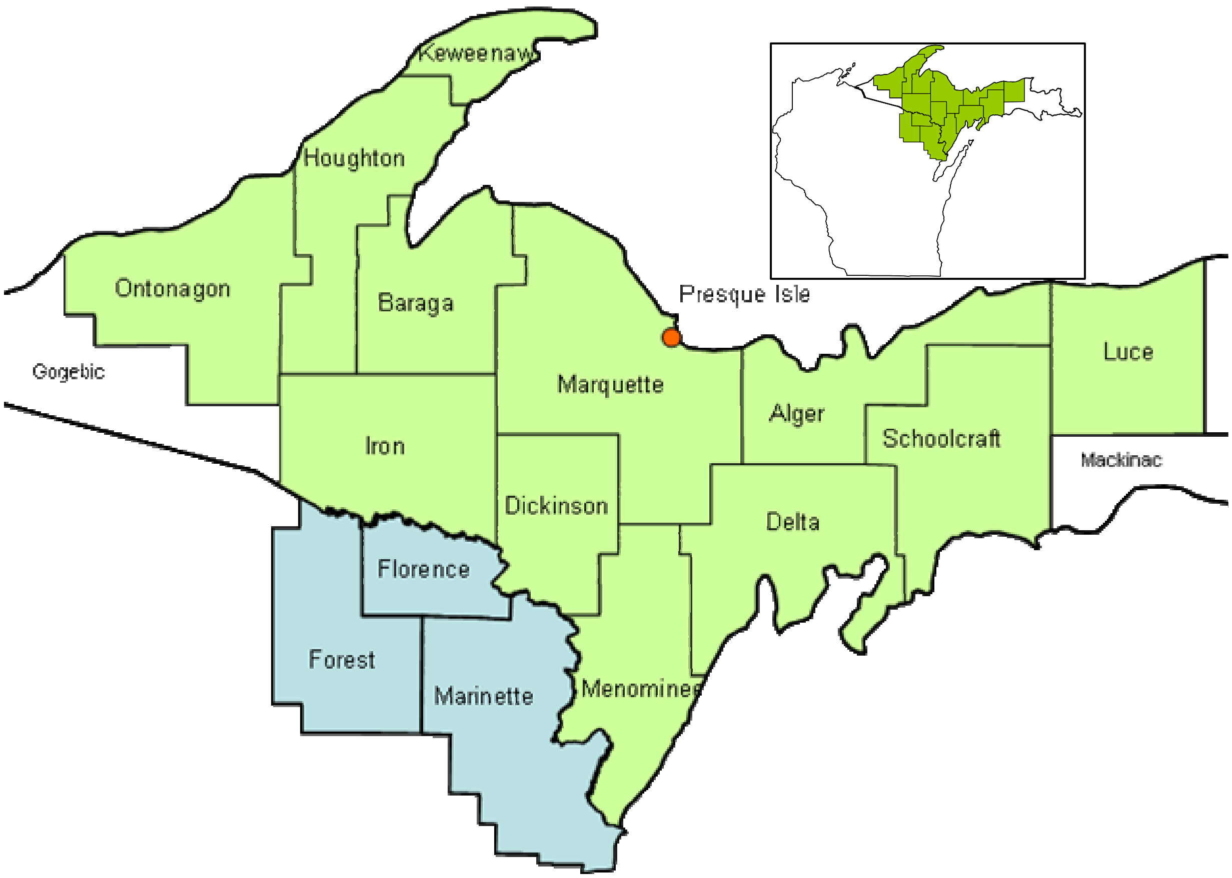
The Energy Center also assessed the possibility of using residues from primary and secondary wood processing facilities and dedicated biomass plantations as feedstock streams for the Presque Isle facility. Residues from primary and secondary wood processing facilities are a viable feedstock stream. These residues are largely already being beneficially used by generators or sold to others. Still, local businesses should be informed of We Energies' interest so that opportunities are not missed.

A third option, dedicated biomass plantations, can provide a hedge against market uncertainty, but the soil conditions in the study area limit productivity. In reasonably good soils, such as those in the 85-119 cu. ft. per acre per year site productivity class, the most favorable scenario using current prices and technology is $39 per delivered ton of green chips. This scenario would require 64,300 acres of hybrid poplar plantations in five-year rotations. Advanced harvesting technology not yet on the market could reduce those costs to $32 per ton. Native species such as red pine and aspen can also produce green chips in the range of $39-$56 per delivered ton using current technology, but require 15-30 year rotations and as much as 151,000-233,000 acres. In lower quality soils, more acres would be required.

INTRODUCTION AND PURPOSE

The purpose of this study is to evaluate the potential supply of biomass suitable for use as fuel at the We Energies Presque Isle Power Plant. This study is part of a preliminary investigation into the possibility of converting the No. 4 boiler at Presque Isle from coal to wood fuel. The target amount of chipped green wood that would allow such a conversion is estimated to be 450,000 green tons per year. The study area includes counties that lie within a 90-mile radius of Marquette, Mich. Figure 1 shows the counties included in this study.

FIGURE 1. COUNTIES INCLUDED IN THE STUDY AREA



The study area includes 12 counties in Michigan's Upper Peninsula (UP) and three counties in Wisconsin. These counties are heavily forested and include well established forest products industries that are vital to local and regional economies.

WEIGHTS AND MEASURES

Most of the data presented in this report are based on estimates by various government agencies and private sector experts. These numbers, out of necessity, must be built on assumptions and generalizations due to the variability of the resources, markets, and evolving technologies.

It is important to understand that numbers presented in this report, especially those associated with resource estimates, are very rough and should be treated as ballpark figures. In full knowledge of the oversimplification, the authors of this report have, out of convenience, adopted a standard volume-to-weight conversion of woody biomass harvest residues. Table 1 lists conversion factors used for this report.

TABLE 1. GENERALIZED VOLUME TO WEIGHT CONVERSION AND ASSUMPTIONS

POUNDS PER CORD[A]	TONS PER CORD	POUNDS PER FT^3	FT^3/TON	FT^3 PER CORD (AS STACKED)	FT^3 PER CORD (SOLID WOOD)[B]
5,500	2.75	42.96875	46.54545	128	72

a. Pounds-per-cord measurement is based on a rough average of weights measured in pulping experiments at the US Forest Products Laboratory (Taras, 1956).
b. Cord weights can vary considerably even within species due to stick diameter, length, density and moisture content.

These values were used primarily to convert harvest residues volume measures into biomass weight measures. As a check on the 46.5 ft^3/ton assumption, we compared it to the volume-to-weight conversions used by the US Forest Service for mill residues which ranged from 36 ft^3/ton for coarse residues to 54 ft^3/ton for bark. Given the abundance of uncertainties with estimation of these resources, the authors believe that this conversion is reasonable.

SUSTAINABLE FORESTRY

Long-term plans for wood use will need to be based on sustainable forest management and harvesting practices. Forests provide a number of ecosystem and economic services. Sustainable forestry guidelines include consideration of categories of services such as providing habitat for forest ecosystems, conserving soil, and limiting water runoff. In addition, forests are also highly valued by the public as recreational areas and have served as the anchor renewable feedstock for industries vital to the Great Lakes states. Sustainable forestry guidelines seek to balance these uses and insure that forests will be able to continue in these roles in both the near term and for future generations.

There are two primary recognized sustainable forestry certifications: Forest Stewardship Council (FSC) and Sustainable Forestry Initiative (SFI). The FSC is an independent forest certification system created in 1993 that is used worldwide. It is governed by business, environmental and social interests. The SFI was created by paper and forestry interests, is used in the US and Canada, and is governed by the Sustainable Forestry Board. A commonly held opinion of those familiar with sustainable forestry certifications is that FSC is more reflective of the interests of several international environmental non-governmental organizations while SFI is more aligned with landowners and the forestry industry (Hansen et al. 2002). The two standards share many similarities. One key difference is the FSC standard forbids growth of genetically modified trees and puts limitations on establishment of tree plantations. These standards (and others) continue to evolve over time.[1]

Both Wisconsin and Michigan are following Minnesota's (MFRC 2007) lead in developing sustainable forestry guidelines for their states. Once established, these guidelines will likely be voluntary, consisting of a menu of management options and providing considerable flexibility for landowners and harvesters. Therefore, determination of adherence to sustainable guidelines will need to be checked against owner or harvester policies or harvest contracts. Michigan forests and Wisconsin state and county forests are currently dual-certified under FSC and SFI.[2]

From a biomass user's standpoint, the primary effects of adhering to sustainable harvest provisions will be to reduce the quantity of available biomass from harvest sites by some percentage deemed appropriate to meet site-specific needs. This could be highly variable. For example, Minnesota's standards note that their forest soils typically have more than 20 times the nutrient capital than what a total clear-cut would remove (i.e., removal of all trees, tops, limbs, dead logs and snags, as well as all the brush on the site) (MFRC 2007). This means that a typical site could undergo 20 50-year growth and harvest rotations with these extreme harvests before the site would not be able to replenish the soil nutrients over the growth cycle. Sites with poorer or sandier soils may prohibit any removal of biomass other than the boles used for sawlogs. In general, the Minnesota guidelines recommend leaving about one-third of the fine woody debris generated during harvest on site.

Some steps a biomass user can take to use sustainably harvested biomass are to work strictly with certified Master Loggers,[3] work on lands that are certified as sustainably managed under either FSC or SFI, or include sustainability guidelines in their purchase contracts.

RESOURCE ASSESSMENT

This section describes wood resources in the study area including: growing timber, location, ownership and changes in the resource volume, and information gleaned from harvesters who operate in the area.

FORESTED LAND CHARACTERISTICS

The United States Department of Agriculture Forest Service's Forest Inventory Analysis database was used to characterize the 15 counties in the study. Table 2 describes the acres of forested land, estimated volume of growing stock, annual harvest volumes, and the net change in wood volume

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[1] More information on forest sustainability certifications can be found at: http://www.yale.edu/forestcertification/faq.html.

[2] Per WDNR Web site: http://dnr.wi.gov/forestry/certification/, June 2008, and per MDNR, Web site, http://www.michigan.gov/dnr/0,1607,7-153-10368_22594-60263--,00.html, May 2008.

[3] More information on Master Logger certification can be found at: http://www.wpla.org/master.html.

for these counties. The “proximity tier” column is a rating of how close the resource is to Marquette, Mich. This rating goes from 0 for Marquette County in which Presque Isle resides, to 1 for counties that border Marquette, to 3 for counties that are more than one county span distant.

Taken together, there is a total of over 12 billion cubic feet of growing stock in these counties. This amount, net of removals and mortalities, increases each year by nearly 293 million cubic feet, or about 6.3 million green tons per year. They estimate nearly 179 million cubic feet of wood is removed from these lands each year. Counties in the 0-1 proximity tiers, which are those closest to Presque Isle, have annual net growth of about 142 million cubic feet, and annual removals of about 98 million cubic feet.

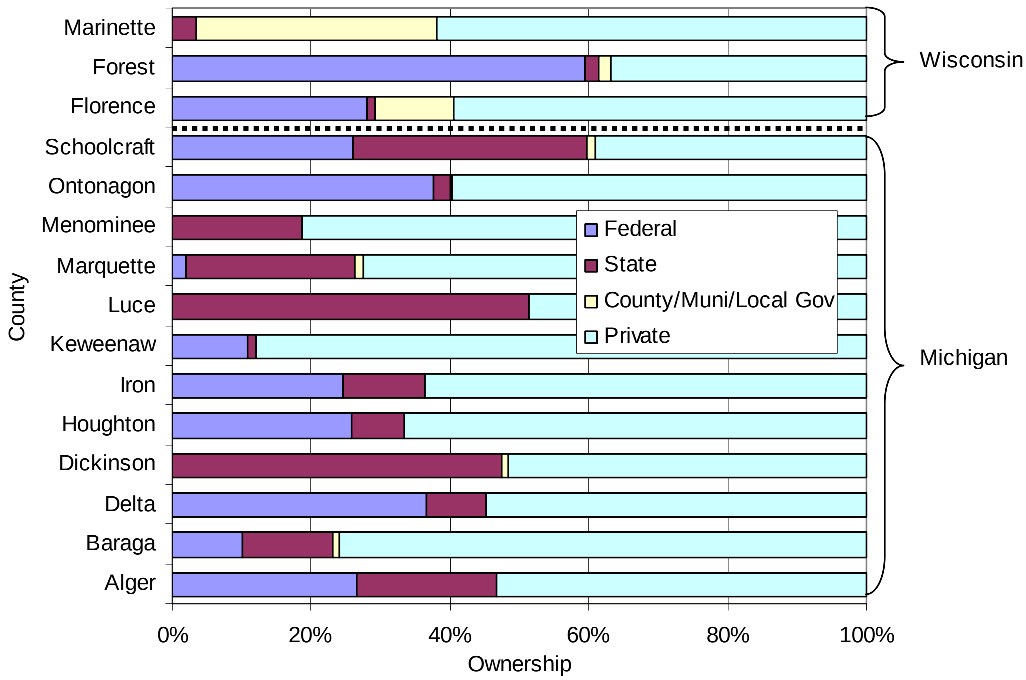
TABLE 2. STUDY AREA COUNTIES' FOREST RESOURCES

COUNTY	PROXIMITY TIER	ACRES OF FORESTLAND	GROWING STOCK IN FT^3	ANNUAL REMOVALS IN FT^3	NET ANNUAL GROWTH IN FT^3
Alger	1	509,100	904,065,083	12,012,314	26,496,684
Baraga	1	516,590	907,069,781	9,187,096	15,460,473
Delta	1	602,770	777,471,064	9,031,928	20,490,469
Dickinson	1	401,388	589,273,174	5,294,133	10,066,592
Houghton	2	511,154	923,139,207	20,404,410	22,252,676
Iron	1	681,792	960,709,141	18,142,041	25,831,548
Keweenaw	3	198,123	352,292,762	14,211,014	10,337,247
Luce	3	491,832	683,230,323	5,494,774	29,825,304
Marquette	0	983,615	1,469,487,438	37,364,108	22,764,100
Menominee	1	499,595	662,749,724	7,388,601	21,381,743
Ontonagon	3	682,199	1,077,728,076	8,095,883	12,068,206
Schoolcraft	2	562,164	608,422,961	8,596,815	17,666,406
Florence	2	275,685	406,238,310	5,067,994	6,987,631
Forest	3	551,607	848,280,296	4,882,315	19,359,753
Marinette	3	696,792	845,978,461	13,560,431	31,951,529
Total		8,164,404	12,016,135,798	178,733,855	292,940,358

Source: USFS Forest Inventory Mapmaker 3.0, using data from 2002-6.

The forested lands in the study counties are owned predominantly by private interests, although some counties have mostly government-owned forests. Figure 2 below shows the percentages of forested land owned by the various sectors.

FIGURE 2. FORESTED LAND OWNERSHIP BY SECTOR



Source: USFS Forest Inventory Mapmaker 3.0, using data from 2002-6.

Overall about 60 percent of the forested land in the study area is privately owned. The composition of federal, state and local government ownership is quite variable by county. This complexity of ownership underscores the need for differentiated approaches to data gathering by region. For example, information on harvesting on county-owned lands could be significant in Marinette County, Wis. In contrast, there is virtually no county-owned land in the Michigan study area. Some counties have national forests whereas others have no federal forestland at all.

Another important aspect of forested lands is the degree to which they are stocked with trees. Table 3 lists the stocking levels of forest lands by county.

TABLE 3. FORESTED LANDS BY COUNTY AND STOCKING CLASS

	OVER-STOCKED	FULLY STOCKED	MEDIUM STOCKED	POORLY STOCKED	NON-STOCKED	OVER AND FULLY
Alger	6.9%	53.8%	29.1%	9.0%	1.1%	60.8%
Baraga	11.4%	58.7%	24.8%	5.2%	0.0%	70.0%
Delta	9.7%	40.9%	38.5%	10.2%	0.7%	50.6%
Dickinson	10.9%	49.0%	26.5%	13.6%	0.0%	59.9%
Houghton	9.3%	53.7%	29.5%	6.2%	1.3%	63.0%
Iron	4.7%	49.9%	33.4%	11.1%	0.9%	54.6%
Keweenaw	3.2%	55.5%	31.0%	10.3%	0.0%	58.7%
Luce	4.9%	45.9%	36.9%	10.7%	1.6%	50.8%
Marquette	11.7%	48.0%	27.7%	12.3%	0.3%	59.7%
Menominee	7.4%	51.4%	29.8%	10.6%	0.9%	58.7%
Ontonagon	12.8%	49.0%	31.1%	6.3%	0.8%	61.8%
Schoolcraft	6.4%	37.5%	36.9%	16.4%	2.8%	43.8%
Florence	10.3%	44.3%	35.1%	9.0%	1.2%	54.6%
Forest	10.0%	50.4%	33.9%	4.9%	0.7%	60.4%
Marinette	6.0%	38.6%	41.5%	13.6%	0.3%	44.6%
Overall	8.7%	47.9%	32.5%	10.1%	0.9%	56.6%

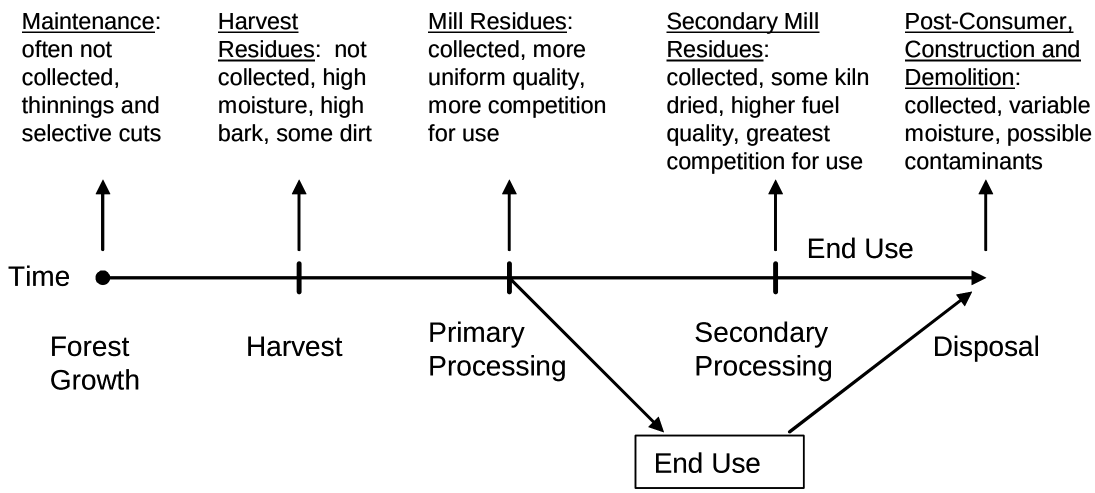
Source: USFS Forest Inventory Mapmaker 3.0 using data from 2002-6

Overall, nearly 57 percent of the forested lands in the study area are considered fully stocked or overstocked. By county, this ranged from about 70 percent in Baraga County, to almost 44 percent of forested lands in Schoolcraft.

WOOD USE

Michigan's Upper Peninsula and northern Wisconsin have well established markets for sawlogs and pulpwood. Primary wood-using industries use raw materials direct from harvest such as logs and pulpwood, and produce lumber, veneer and pulp for papermaking. Secondary wood using industries use primary mill products to manufacture other goods. Both groups of wood-using industries have evolved efficient operations over the years, minimizing the need for residue disposal. Figure 3 below illustrates the process of wood harvest and use, as well as points at which residues, and possible opportunity fuels, are generated.

FIGURE 3. WOOD USE TIMELINE



During forest growth, standard **maintenance** procedures occur such as thinning, culling of genetic inferiors, fire suppression measures, and removal of mortalities and diebacks due to pests such as emerald ash borer or jackpine bud worm. These cuttings are sometimes removed but are usually left on the forest floor. **Harvest residues**, by definition, are left on the forest floor. These can include tree tops, branches and undersized trees that were cut down to enable removal of the targeted trees. There is not currently a market for these residues. **Primary mill residues** occur at the point of roundwood processing and the mills must use or dispose of them. Because these are available at a central location, and tend to be of a more uniform consistency, they are in greater demand than harvest residues for use in other applications. **Secondary mill residues** tend to have even higher consistency because the wood has undergone some processing and possibly even kiln drying. Little is known about what these residues are used for, but they are likely to be smaller in volume and generally unavailable for other uses, especially lower end uses such as for boiler fuel. **Post-consumer and construction and demolition wastes** represent the end of the line for wood. These residues are often landfilled. Although these could represent essentially “free” feedstocks (but for the price of transportation), when used for boiler fuel, they could offer challenges related to chemical contamination (i.e., treated wood), foreign objects, and renewable energy eligibility. For these reasons, the search for wood fuel for Presque Isle focused primarily on harvest and mill residues and woody energy crops.

HARVEST RESIDUES

Harvest residues are generated during timber harvest. These include tree tops, slash (i.e., smaller diameter pieces cut during harvest), and cut non-merchantable trees. Therefore, the generation of harvest residues is directly related to the level of harvest activity in a given area. Some smaller amount of residues may be generated during maintenance thinnings and selective cuts, or during land clearing for development. Table 4 lists numbers on harvest activity by county generated by the US Forest Service Forest Inventory Mapmaker. These estimates are based on established formulas by species for the volume of materials typically found in the merchantable versus non-merchantable portions of the trees, and also by the product harvested—sawlogs versus pulpwood (Blyth and Smith 1980, Piva 2008).

The Forest Service estimates that over 1.4 million green tons of harvest residues were produced in the study region, based on harvesting activity in 2004. The amount generated year to year will be directly related to the current harvesting activity.

TABLE 4. HARVESTING ACTIVITY BY COUNTY

	PROXIMITY TIER	AVG. ANNUAL REMOVALS IN FT^3	AVG. ANNUAL REMOVALS IN GREEN TONS [a]	ESTIMATED 2004 RESIDUES GREEN TONS [b]
Marquette	0	37,364,108	802,744	186,441
Alger	1	12,012,314	258,077	59,018
Baraga	1	9,187,096	197,379	105,188
Delta	1	9,031,928	194,045	70,684
Dickinson	1	5,294,133	113,741	74,787
Iron	1	18,142,041	389,770	107,229
Menominee	1	7,388,601	158,739	64,969
Houghton	2	20,404,410	438,376	90,020
Schoolcraft	2	8,596,815	184,697	82,393
Florence	2	5,067,994	108,883	98,313
Keweenaw	3	14,211,014	305,315	35,900
Luce	3	5,494,774	118,052	79,965
Ontonagon	3	8,095,883	173,935	98,119
Forest	3	4,882,315	104,893	149,488
Marinette	3	13,560,431	291,337	145,406
Total	-	178,733,855	3,839,985	1,447,918

a. Removals are contracted removals of pulpwood and sawlogs from forested lands regardless of ownership class and are generated with the USFS Forest Inventory Mapmaker software version 3.0 using data from 2002-6.
b. Harvest residues estimates are generated by industrial roundwood harvesting by Forest Inventory Unit, county, and species group, Michigan, 2004.

National Forests

Federally owned forest land, primarily in national forests, represents about 19 percent of the forests in the study area. National forests are managed for multiple purposes including timber, wilderness, recreation, minerals, water, grazing, and wildlife. There are three national forests that have lands within the study area for this project: Hiawatha, Ottawa and Nicolet.

Hiawatha National Forest. The Hiawatha National Forest, shown in Figure 4, is located in the eastern Upper Peninsula. The portion in the study area lies largely in Alger, Delta and Schoolcraft counties. The federal forester indicated that they typically have about 40 million board feet harvested per year, which amounts to about 20 mbf in the study area sold as either pulpwood or sawtimber. They would like to move that up as high as 50-60 mbf, and their capacity shows they could sustainably allow harvest of approximately 109 mbf. The amount of acreage they can make available for harvest is limited by their Forest Service funding—they must be funded to prepare and mark lands for harvest, contract, and file National Environmental Policy Act papers. They currently have 150 million board feet of removals contracted. Small independent bidders, under contract with larger mills, do most of the bidding (Gimler 2008).

FIGURE 4. HIAWATHA NATIONAL FOREST WITH 90-MILE RADIUS

Limitations on removals, typically down to 4-inch diameter, are mostly due to convention (i.e., harvest size that has proven to be traditionally useful), unless soils need additional carbon. For some sandier or drier soils, they will sometimes require additional biomass be left on site to improve the soils, but this does not apply to the majority of hardwood stands. The 4-inch diameter restriction results in more biomass left on site in hardwood stands than conifers due to tree shape differences. Weather and land conditions can put limitations on wood availability. There are also some whole tree harvest operations which leave a smaller amount of biomass on harvest sites.

Foresters at Hiawatha have timber stand improvement activities in which they do thinning or culling of non-merchantable species when they are smaller. Operators in the last 18 months or so are dabbling with biomass left on sites. The Forest Service can sometimes allow contractors to take the “junk” off site if it is important to their economics. Some mills are also increasing their use of bark and junk wood for fuel. Although the biomass market is still developing, the forest managers think there is a significant opportunity out there to use more biomass and they are letting more of it be removed from the land (Howlett 2008).

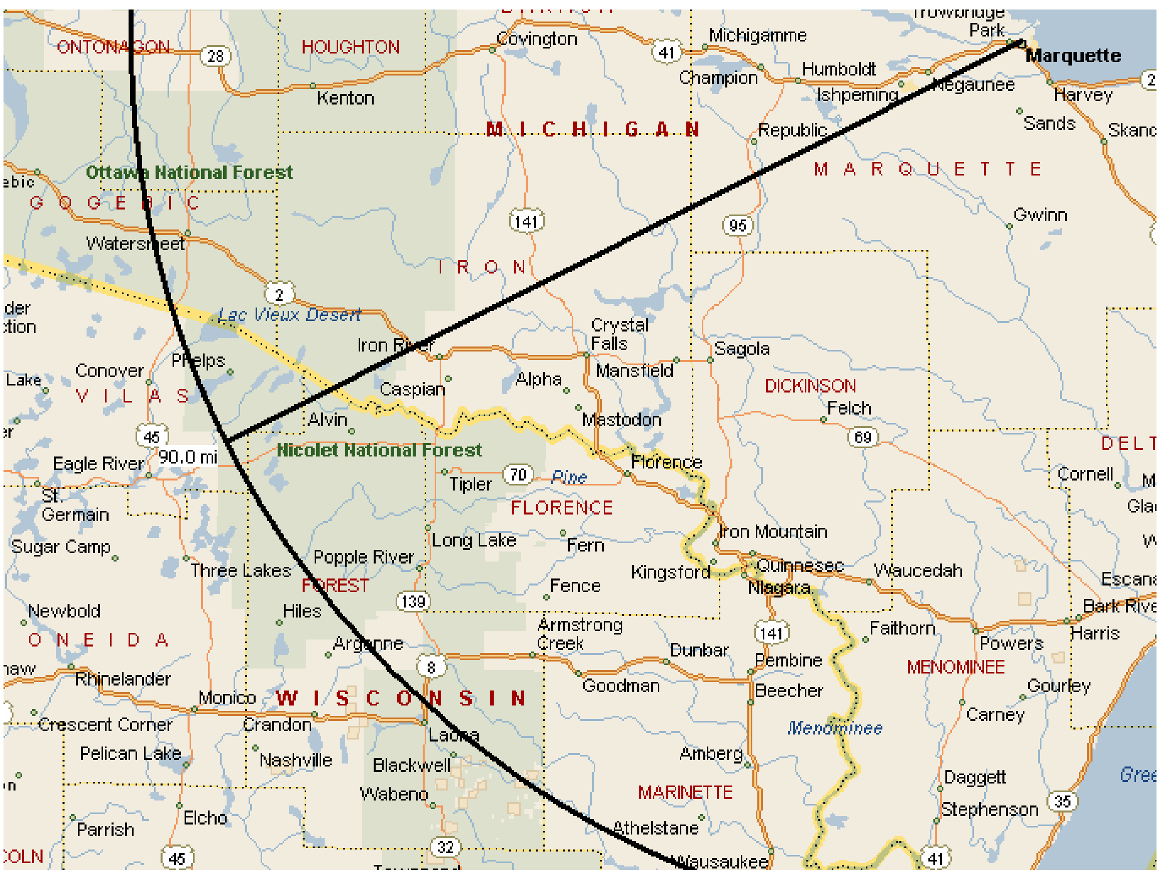
Ottawa National Forest. The Ottawa National Forest, shown in Figure 5, is in Baraga, Houghton, Iron and Ontonagon counties on the western end of the study area. Forest managers estimate that there are few trees that are more than 80 years old and that much of the forest is just now moving into good sawlog quality. They strive to sell 50-70 million board feet per year to harvesters.

FIGURE 5. OTTAWA NATIONAL FOREST AND 90-MILE RADIUS

They have a good amount of pulpwood, but they also have significant timber stand improvement to cull genetic inferiors. Recently they have had less harvesting due to a downturn in prices so they have held off on some sales. Purchasers sign 3-5 year contracts and much of the forest is restricted to winter harvest only, or summer and winter operations, to minimize soil disturbance and runoff. In response to harvesters seeking to take more wood during harvest, some of their contracts allow cutting down to 2 inches in diameter from the top. They have recently instituted new cruising guidelines that can take into account full tree biomass for contract harvest. This lays the contractual groundwork for full tree chipping harvests and other operations removing additional biomass when it is compatible with prescribed management plans (Sobrack 2008).

Nicolet National Forest. The portion of Nicolet National Forest relevant to the study area, shown in Figure 6, sells about 35 million board feet of timber per year. Harvest has been slowed by litigation in recent years. They occasionally get large amounts of biomass available due to insects or tornados. Much of the harvest is centered on aspen, pine and hardwoods. Most sales recently have been tied in with red pine because people are less concerned about the environmental implications of harvesting pine stands than mixed hardwoods. Environmental groups would like to see less pine plantations and more diversity in species due to habitat benefits.

FIGURE 6. NICOLET NATIONAL FOREST AND 90-MILE RADIUS



The Forest Service contracts for down to 4 inches in diameter inside the bark. Wherever they can, they have been allowing removal of the smaller diameter wood for biomass uses. Harvesters have typically not taken all of it due to economics—they cannot always get enough for it to make it worth collection. The current forest plan does not address use of biomass for energy and fuels, so most sales are based on timber prices for the traditionally merchantable portions of the tree. They expect that the next forest plan will include guidelines on when and where additional biomass can be removed, and will include estimates of biomass volume availability beyond the timber estimates they currently use. They have just put together a new set of cruising directions to better estimate biomass including tops, in an attempt to bring these estimatess in line with the much more refined and accurate merchantable wood estimates. They also are following Minnesota's best management practices for biomass harvest and expect to adhere to Wisconsin guidelines when they are finalized.

In summary, the national forests' management strategies recognize that there is a large quantity of biomass left after harvest that could be sustainably harvested. In addition, insects and weather damage offer periodic opportunities for removal of large quantities. Biomass harvests on federal lands are limited by federal budgets—increased funding of federal forest management would allow preparation of additional acreage for harvest.

State and County Lands

State-owned forest land represents about 17 percent of the forest in the study area and is almost entirely in Michigan. The Michigan Department of Natural Resources offers 600 to 900 timber sales contracts per year on about 60,000 out of a total of over 1.3 million acres of state-owned forest lands. These harvests typically include: sugar maple, red pine, red oak, red maple, jack pine, aspen, mixed hardwood and mixed softwood (TimberBuySell.com). In addition to managing forests for continuous production in support of the Michigan wood using industries, state forests are managed to provide food and habitat for wildlife, to reduce fire hazards, and to provide recreational opportunities.[4] The MDNR operates in accordance with Operational Management Guidance requiring state-owned forest lands to be managed using sustainable forest management principles (MDNR, 2005). All Michigan state-owned forest land is certified as sustainably managed under both Sustainable Forestry Initiative (SFI) and the Forestry Stewardship Council (FSC).

Timber harvest sales on Michigan state forest lands are typically grouped into one of three categories: commercial sales, fuelwood permits, and non-commercial cultural treatments. Contracts for harvest are on a lump sum basis, based on estimates of the weight/volume of merchantable wood. There is no explicit amount charged for non-merchantable biomass and its removal is usually not restricted, although some contracts may include restrictions due to sustainability issues (e.g., soil, habitat, runoff) (Heym 2008). In general, however, non-merchantable biomass is not being removed from sites, reflecting an insufficient market for it.

State-owned forest accounts for only three percent or less of the forested land in the Wisconsin study counties. County-owned forest lands make up a much higher percentage of forested lands in

[4] MDNR, http://www.michigan.gov/dnr/0,1607,7-153-10368_22594-60263--,00.html, May 2008.

Florence and Marinette counties, and programs in Wisconsin counties are FSC-certified. Marinette County has over 240,000 acres of forested land under management. Their harvest contracts are scaled at the site—harvesters are charged for the weight of material they harvest and biomass (i.e. pieces less than four inches in diameter) would be valued accordingly. They have recently had 140 acres of brush pine that was stacked into piles that they put out to bid, but they did not receive any offers (Schwantes 2008). The forester for Florence County, which has nearly 32,000 acres under management, also reports that they are not seeing a lot of top utilization with their harvests, but they are selling sawlogs and pulpwood (Sullivan 2008). Their last sale of chipped tops was at a stumpage rate of about 50¢ to $1 per ton.

Private Lands

As a group, private interests hold about 60 percent of the forested land in the study area counties, and in some counties as much as 88 percent. Because of the diverse makeup and large number of private landowners, information for this group was gathered through interviews with some of the largest owners and with harvesters who tend to work on lands in multiple ownership sectors.

Plum Creek Timber Company. Plum Creek Timber Company is a land management company that purchased the former Mead Paper timberlands in the UP. The company bought the land in 2005 and now manages it for sustainable production. All of Plum Creek's 650,000 acres of forests spread over 13 counties in the UP were recently certified as sustainably managed by the Sustainable Forestry Initiative (SFI). The amount of wood harvested on Plum Creek-owned lands in the UP has typically been between 650,000 and 1.1 million tons, with recent harvests being toward the higher end. They ship wood to about 60 customers in Michigan and Wisconsin, including NewPage with whom they have a contractual fiber sales agreement per the original land purchase. They estimate that 85-90 percent of the non-merchantable biomass is now being left on the land because there is no market for it. They are looking into options to sell additional biomass from harvested sites and believe their harvests could play a large role in supplying biomass to new markets such as Presque Isle. They plan to conduct some tests to determine whether they can make estimates of biomass based on the amount of roundwood harvested (Becker 2008). A company representative gave a rough estimate that the ratio of roundwood to biomass is 4:1.

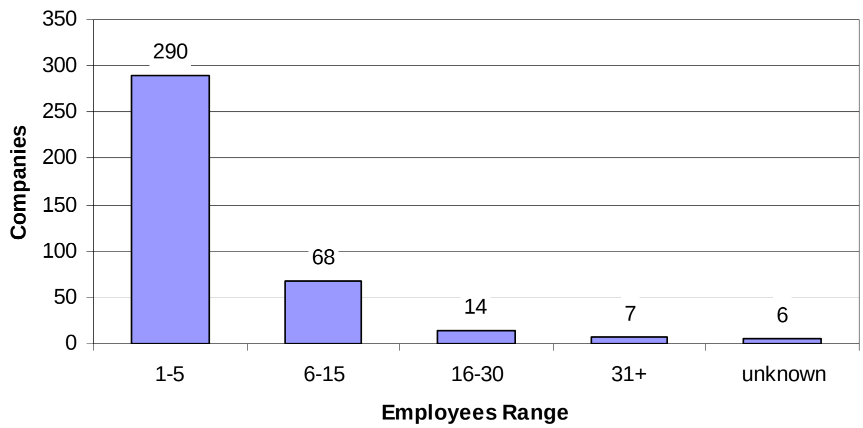
Plum Creek is a significant potential supplier. They manage their lands according to a coordinated plan, meeting with loggers once a year to delineate what they will be harvesting—essentially giving them their assignments. The harvests are already managed for multiple products and clients, and they are amenable to pulling out biomass whenever it can be economically and sustainably done, and supplying it to end users.

J.M. Longyear. J.M. Longyear holds about 60,000 acres of mostly hardwood forest north of Marquette and another 20,000 acres in the west. Their annual allowable harvest is about 38,000 cords of pulpwood and 3.5 to 4 million board feet of logs. They have not yet had contract agreements for removal of additional biomass from their lands because their lands have been considered too far from the mills that would use the biomass as hog fuel. (Mills have been able to get the biomass closer to their operations.) They have markets for all of their wood and good client relationships. They feel there are some opportunities for use of the tree tops and have developed some information on yields from selective harvests. In addition to harvest agreements on their own lands, they have a stumpage procurement program in which they buy standing timber from private, state and federal lands, and contract with private parties to harvest. Last year they cut about 1.6 million board feet on stumpage. For these private lands, the landowner determines whether they can remove additional biomass, but if there is some additional income for the landowner (i.e., a stumpage fee for biomass removal), it is believed they would generally be amenable to allowing tops removal with harvest. They have a procurement team that buys and sells wood, serving as an aggregator for clients (Hayrynen 2008).

Harvesters

There are approximately 385 harvesting operations in the UP study counties (similar information was not available for the three Wisconsin counties). Figure 7 below shows the breakdown of logging companies by number of employees.

FIGURE 7. LOGGING COMPANIES IN MICHIGAN STUDY COUNTIES BY EMPLOYEE NUMBERS



Source MDNR Forest Products Industry Online Database, May 2008.

According to the Michigan DNR, there are seven firms with 31 or more employees, 14 with between 16 and 30 employees, and 358 with 15 or fewer employees (six firms did not have information on number of employees). It should be noted that any company that does any amount of harvesting is included on this list regardless of the scale of those activities. Therefore, some of the larger companies that are listed as harvesters actually only do minimal harvesting. Based on a preference expressed by We Energies, some of the larger logging operations active in the study counties were interviewed to shed additional light on current harvesting activity.[5] In addition, some smaller harvesters known to gather and deliver biomass were interviewed.

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[5] Some of the larger companies in this category only have harvesting as a small portion of their business, and are primarily buyers rather than suppliers of biomass.

Similar information for Wisconsin logging companies was not available. However, the Wisconsin Professional Loggers Association Web site lists 38 logging operations with certified Master Loggers who operate in one or more of the Wisconsin study counties.[6]

Most of the loggers harvest one or more of the following categories of raw wood products: sawlogs, pulpwood, and biomass. Harvesters have indicated that they log throughout the year, but hauling restrictions are in place during "spring break," from roughly March 15 through May 5. During this time they are forbidden to haul wood on any roads other than those that are Class A.

Loggers bid, either independently or on behalf of a customer, to harvest stands of trees based on the products they expect and market conditions. Veneer quality sawlogs or roundwood are the highest value, and pulpwood is the lowest value category for which a market exists. Contracts are either set up based on an initial estimate of the merchantable wood that is harvestable (i.e., lump sum bid) or based on the weight of what is actually removed from the site (i.e., scaled). Numbers are available for sawlog and pulpwood contracts that can give a good indication of recent stumpage prices, but the biomass not falling into those categories has traditionally been considered nonmerchantable. Further analysis of market prices for wood products is included in Section 4.

The characteristics of trees largely determine who will buy and use them. Figure 8 illustrates distinctions in one characteristic—the diameter—and typical uses of harvested wood.

Sawmills are limited to using larger diameter logs, usually a minimum of eight to ten inches in diameter. Pulp mills, on the other hand, can use a broader range of tree/limb sizes and typically will buy down to about four inches in diameter. Pulp mills can also use the larger diameter pieces, but are generally priced out because lumber mills are willing to pay more for the larger pieces. Biomass—the term increasingly used for smaller diameter pieces, tree tops and slash—does not currently have a formal market. Biomass applications can use the whole tree. The market for biomass, however, is expected to continue to develop to meet growing demand.

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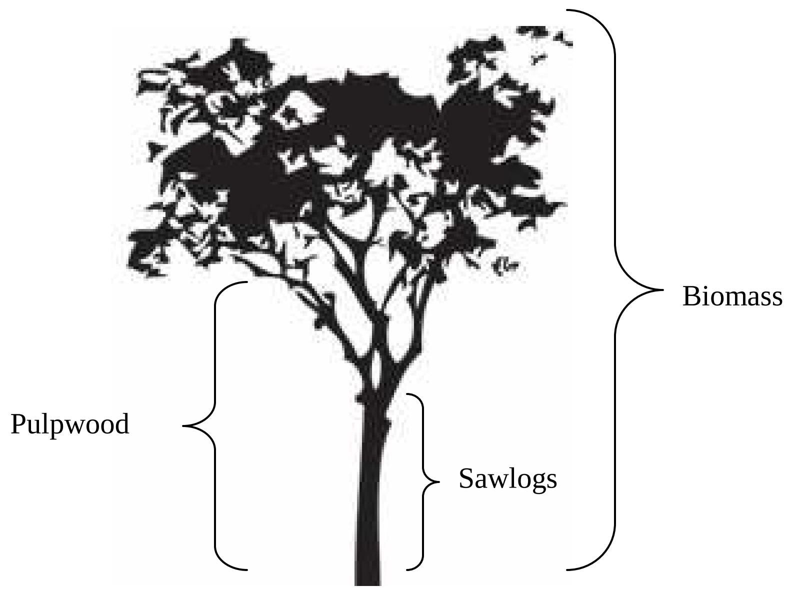
[6] Wisconsin PLA, http://www.wpla.org/master.html, June 5, 2008.

FIGURE 8. WOOD DIAMETER AND USES



Sawlogs: minimum of 8-10 in. diameter

Pulpwood: minimum of 4 in. diameter

Biomass: can use smaller

Note: Sawtimber demand is typically down to 8" diameter for softwood, and 10" diameter for hardwoods. These can vary depending on availability and demand.

Interviews with loggers and others suggest a number of things regarding harvesting activity in the study area. First, despite indications that many landowners and managers are open to the prospect of removing biomass in addition to the merchantable products, few companies are regularly doing so. This condition is largely reflective of the lack of a sufficiently strong and stable market for biomass to justify making the capital investments to harvest, process and deliver it. Currently the primary users of biomass in the form of hog fuel are pulp mills, which have grown accustomed to receiving it at very low cost.

Second, harvesters have weathered a number of market expansions and contractions, and retain some capacity and willingness to increase production should opportunities arise. Business owners are wary, however, about the turbulence a newly forming biomass market will bring. Some referenced the boom-and-bust cycle during the 1970s energy crisis, and the numerous proposed biomass-using projects in the UP, which they see as cause for both optimism and alarm. There are, however, emerging businesses that are entering the market with the prime purpose of collecting and supplying biomass. Several harvesters have expressed interest in supplying biomass if the price and contract conditions are right.

Finally, some harvesters are worried that public policies promoting use of biomass for energy and fuel production might displace traditional wood-using businesses such as pulp mills which will not be able to compete for feedstocks. This concern points toward the desirability of utility biomass users focusing on feedstocks that are not directly competing with other established industries.

PRIMARY WOOD-USING INDUSTRIES

Table 5 below shows wood-using industries in the study counties. Because information on residues generated by secondary wood-using industries is generally not available, and believed to be smaller in volume than primary industry residues, this study focuses on residues generated by primary wood-using industries. Primary wood-using industries are often very competitive and have long been a part of the regional economy. Market forces have whittled away wasteful practices over time and encouraged them to use purchased resources to the greatest extent possible, and to find cooperative means of handling residues they create. Table 6 below shows estimated primary wood using industry residues generated for study counties, and the reported uses.

TABLE 5. WOOD USING INDUSTRIES BY COUNTY

	PRIMARY MANUFACTURERS	SECONDARY MANUFACTURERS
Alger	4	4
Baraga	5	1
Delta	13	18
Dickinson	5	5
Houghton	4	7
Iron	5	9
Keweenaw	0	4
Luce	3	2
Marquette	6	13
Menominee	17	22
Ontonagon	1	3
Schoolcraft	2	3
Florence	3	2
Forest	9	4
Marinette	22	12
Total	99	109

Source: MDNR Forest Products Industry Online Database, May 2008, Wisconsin Primary and Secondary Wood Using Industries Databases, April 2008.

TABLE 6. WOOD INDUSTRY RESIDUE TYPES AND USES FOR STUDY COUNTIES

	COARSE	FINE	BARK	THOUSAND GREEN TONS	PORTION OF TOTAL
Fiber products	86.1%	22.5%	0.0%	515.08	32.6%
Charcoal	0.0%	2.7%	0.0%	11.9	0.8%
Industrial fuel at mill	2.8%	48.0%	61.1%	627.02	39.7%
Industrial fuel-sold	6.3%	13.2%	24.2%	247.79	15.7%
Domestic fuel	0.5%	0.1%	0.3%	4.39	0.3%
Miscellaneous	4.2%	12.7%	14.0%	168.15	10.6%
Not used	0.0%	0.9%	0.4%	6.7	0.4%
Total				1581.03	100.0%

Source: USDA Forest Service, North Central Research Station, data period 2004.

The companies surveyed reported that virtually all residues generated in their processes were used or sold. Coarse residues, those large enough to send through a chipper, were used predominantly for production of other fiber products such as oriented strand board. Fines, such as sawdust and wood flour, were used mostly for fuel at the mill, but also for fiber products, sold to other industrial users as fuel or other miscellaneous uses. Bark was used predominantly for fuel at the mill with some sold for fuel at other mills. While it is possible that some of these residues could be used for other purposes, and some may be currently burned just to dispose of them, it is clear that a secondary market is functioning for these residues. Establishing utility demand for mill residues will likely displace another use. Still, opportunities may exist for using mill residues. It would make good sense to get word out that We Energies is interested in talking with local businesses about use of their wood residues so that local opportunities are not missed. Other wood-using entities that could be direct competitors with the Presque Isle wood use are discussed in more detail in the following section on the market.

DEDICATED BIOMASS

Tree plantations are stands designed and managed to provide a reliable, consistent supply of wood. This wood supply offers a different set of considerations than those of purchasing wood. Rather than dealing with short-term contracts, fluctuating market prices and uncertain competitors, agriforesters must consider land management practices, real estate values and appropriate harvesting schedules.

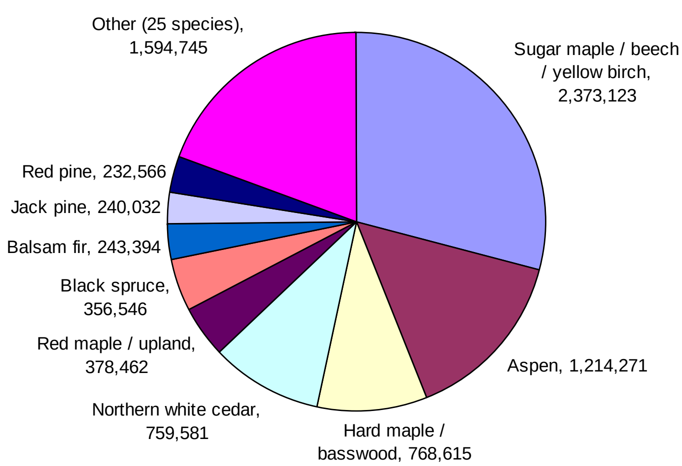
The most significant limiting factor to the output of any such plantation is the frequency of harvest, which is why plantations frequently seek out short-rotation woody crops (SRWC).

The most studied SRWC is hybrid poplar, a fast-growing tree hybridized from various poplar and cottonwood species that can provide merchantable pulpwood in 6 to 12 years on high-quality soils. Because they are, by definition, non-native, some caution against converting significant amounts of forestland to such a crop. (As earlier noted, both hybrid species and plantations altogether fall afoul of the Forest Stewardship Council's sustainable forestry guidelines.) We therefore compared possible production scenarios for both native and non-native species in the study area. We found that native species would be competitive with hybrid poplars in terms of cost per ton of delivered wood chips, but that to deliver an equivalent volume of wood annually, plantations of native species would need to be two to three times larger because of slower rates of growth.

SPECIES COMPOSITION OF THE STUDY AREA

To understand what native species might thrive on plantations in the study area, we first look at which species already thrive there. As shown in Figure 9, nine species make up more than three-quarters of all forested acres in the study area: sugar maple (sometimes in association with American beech or yellow birch), aspen, sugar and/or other hard maples (in association with basswood), northern white cedar, red maple, black spruce, balsam fir, jack pine and red pine.

FIGURE 9. ALL FORESTED LAND IN THE STUDY AREA BY SPECIES (TOTAL ACRES: 8,161,335)



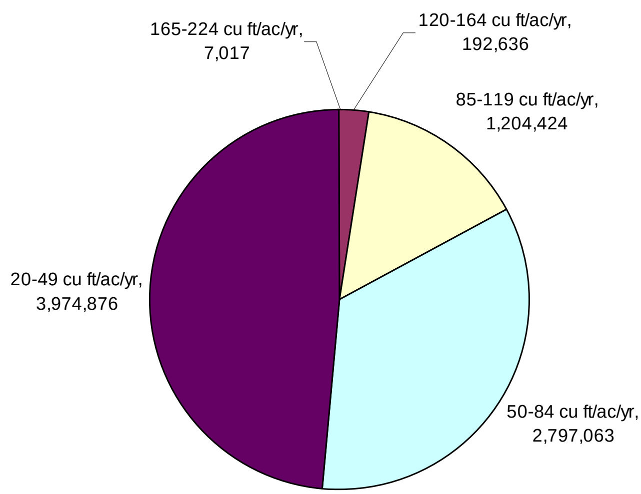
Source: US Forest Service Forest Inventory Data Online.

Of these native species, we consider aspen and red pine to be the most compelling options for an energy crop plantation because of their relatively rapid growth.

SUITABILITY OF THE STUDY AREA FOR AGRIFORESTRY

The viability of a plantation of fast-growing trees is primarily dependent on the quality of its land. Two commonly used indicators of land quality are site productivity, expressed as the expected annual volume of growth per acre, and site index, expressed as the expected height of a tree on that land at age 50. These metrics are based on foresters' assessments of the inherent properties of the site—soil, location, drainage—without regard for management practice or existing use. Site productivity is used to more broadly characterize land, while the site index for that same land depends on the species of interest. Figure 10 shows the site productivity of the study area. In the 15-county study area, 83 percent of the forested land has a site productivity of less than 85 cubic feet per acre per year.

FIGURE 10. FORESTED LAND IN STUDY AREA BY SITE PRODUCTIVITY (TOTAL ACRES: 8,176,012)

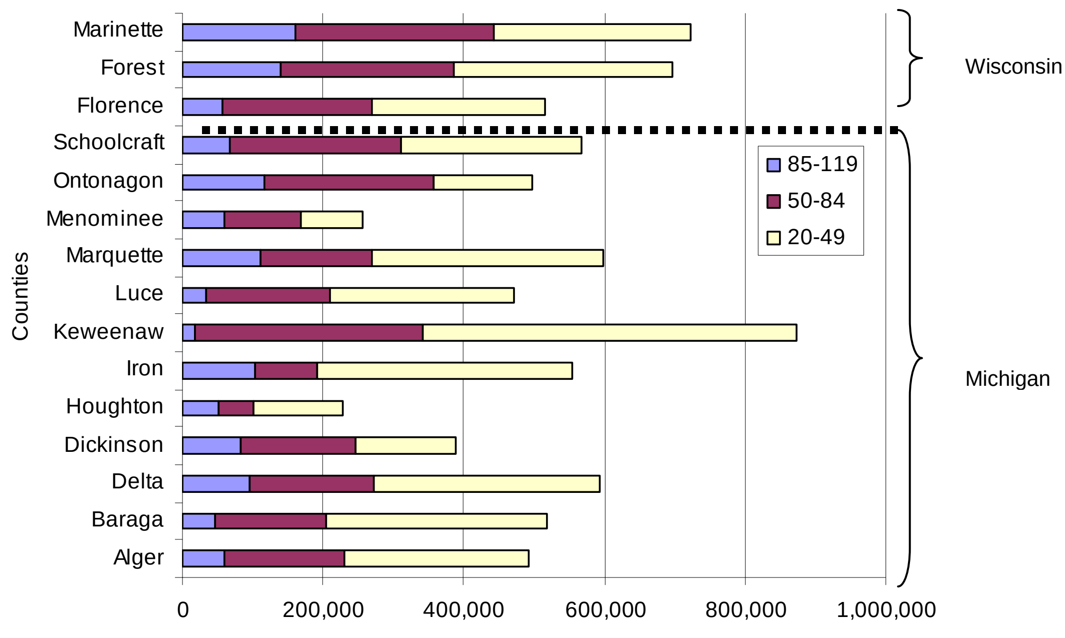


Source: US Forest Service Forest Inventory Data Online.

Highly productive soils make the most sense for short-rotation woody crops, but the most productive site classes are scarce in the study area: only two percent of all forested land is rated at more than 120 cubic feet of growth per acre annually, and the majority of that land is in Wisconsin.

Given this limited availability of the most productive soils, we will conduct an analysis looking at the three more prominent site productivity classes: 20-49 cu ft/ac/yr, 50-84 cu ft/ac/yr and 85-119 cu ft/ac/yr. Figure 11 shows the total number of acres in each soil class per county. In all forested land in the study area, each class represents 4.0, 2.8 and 1.2 million acres of the total 8.2 million acres, respectively.

FIGURE 11. FORESTED LAND BY COUNTY AND SITE PRODUCTIVITY CLASS (IN CU FT/AC/YR)



Source: US Forest Service Forest Inventory Data Online.

Land Rents

For the region of Michigan that includes the Upper Peninsula, the average rental rate for non-tiled land for field crops was $36 per acre. For the Wisconsin counties in the study area, cropland was $30 per acre in Florence and Forest and $55 in Marinette, and pasture land was $10 for Florence and Forest and $25 in Marinette (Wittenberg 2007). Data about rental rates dedicated to non-orchard trees are not collected, but given general demand for land in the Upper Peninsula, the rental rate for non-tiled agricultural land is a reasonable estimate for the rental rate for desirable plantation land (Wittenberg 2008). As such, we will use $36 per acre as the assumed rental rate in our analysis.

POTENTIAL PRODUCTION SCENARIOS

We consider hybrid poplar as well as two native species for energy crop production—red pine and quaking aspen. Generally speaking, very dense plots of these crops result in weaker, skinnier trees, but because we are more interested in total quantity of biomass than in meeting sawtimber standards, it is possible for short rotations to make up in volume what the trees lack in diameter.

While this report seeks to provide We Energies with strategies to supply the Presque Isle facility with a flat 450,000 green tons per year, we will note that, as shown in Table 7, the three species under consideration do have appreciably different higher heating values.[7]

TABLE 7. APPROXIMATE HIGHER HEATING VALUES OF SELECTED WOODY CROPS

SPECIES	HIGHER HEATING VALUE (BTU/LB)
Hybrid poplar	7900
Pine	9000
Aspen/poplar	8500

Source: Compiled from many sources.

When discussing red pine and aspen, we characterize the nature of the stand in terms of its average height and its basal area. Basal area is the cumulative cross-sectional area of all the trees in an acre, where the cross-section is based on breast height (that is, 4.5 ft above the ground). This approach helps describe the nature of a plantation more fully than just a volume measurement—for instance, compared to a same-aged site with the same site index, the site with fewer trees per acre may very well have the larger basal area because its trees have grown larger. A basic forester's formula for the total tree weight (including bark and branches) of an acre in green tons is

basal area * height / 70 * 96% (Perala 1977)

Because aspen and red pine energy plantations are somewhat new concepts, reliable numbers about establishment costs to achieve the desired density are not available, and so we use as a baseline the costs to establish poplar plantations. Year 1 costs include site preparation and seedling or cutting purchases; Year 2 costs include weeding or clearing as necessary. For hybrid poplar it is assumed that the canopy will be sufficient at this point that no further site maintenance will be necessary. For aspen and pine we double this "Year 2" cost with the expectation that one additional season of further weeding, clearing or other maintenance will be required at some point prior to harvest. For all species, we use the estimates from the Minnesota Valley hybrid poplar study of $227 per acre in Year 1, and a one-time cost of $66 per acre for hybrid poplar and $132 per acre for aspen and red pine to cover all later years (Ostlie 2003).

[7] The red pine value presented is the average HHV across all pine species, and the aspen value is the average HHV across all native (i.e. non-hybrid) poplar species, because poplar is very similar to aspen and insufficient data was available regarding aspen-specific HHV. These values are drawn from a multitude of sources.

Hybrid Poplar

Hybrid poplar is the most studied short-rotation woody crop because of its rapid growth. In agricultural quality soils, harvestable trees can be grown in five years at yields exceeding 50 green tons per acre. These trees are bred to find the most compatible, productive species for a given environment, and the best available genetic line can typically only be found through actual on-site trials. A hybrid poplar plot will consist of genetically identical clone trees, making disease a major concern. Weed control is necessary until the canopy has developed. Once harvested, the plantation will regrow from the stump, a practice known as coppicing. As better hybrid poplar strains are developed, however, it may make more sense to dig up those stumps after harvest and restart the plantation with an improved genetic line. The magnitude of the improvement would need to be weighed against the implantation costs, which is relatively simple to evaluate if the genetic improvement is just an increase in biomass, but is more complicated to compare if the improvement relates to factors such as greater disease resistance.

Tree spacing. In the short term, hybrid poplar growth rates actually increase as spacing decreases, making them an ideal short-rotation woody crop—they are most productive when grown densely and harvested frequently. In a feasibility study for hybrid poplar production for energy generation at Xcel Energy's Minnesota Valley facility, it is recommended that poplars be planted on 5.3 ft centers, although that study's author now suggests that 5.0 ft centers are preferred (Ostlie 2003, 2007). We will assume that such density is possible for a plantation in the study area.

Tree size. In the Minnesota Valley feasibility study, trees are to be harvested at 5 years, when they are expected to be 6 to 8 in. in diameter and 30 to 35 ft. tall. On 5.0 ft centers, this translates to 53 green tons per acre. These are assumed to be grown in prime agricultural soils. In order to model this for the study area, we look at USDA FIA data relating site index and site productivity in the north central United States. Using eastern cottonwood as a proxy for hybrid poplar, we see in Table 8 below that cottonwoods achieve their maximum height in soils in the 120 to 164 cu ft/ac/yr growth class, reaching 66 percent of that maximum in the 85 to 119 cu ft/ac/yr growth class, and so forth. Applying those same limits to hybrid poplar volume, we see that we might expect 35, 28 and 23 green tons per acre, respectively, for the three site productivity classes under consideration.

TABLE 8. ADJUSTED TONS OF HYBRID POPLARS PER ACRE BY SITE PRODUCTIVITY CLASS

EASTERN COTTONWOOD SITE INDEX	% OF MAX	SITE PRODUCTIVITY (CU FT/AC/YR)	GREEN TONS PER ACRE AT MATURITY
150	100%	120-164	53
99	66%	85-119	35
80	53%	50-84	28
65	43%	20-49	23
33	22%	<20	12

Source: FIA Site Productivity Class Assignment for the North Central FIA Unit – Lake States, Ostlie 2003.

Red Pine

Red pine is a long-lived species that was once extremely prevalent in the region. It thrives in sandy and sandy loam soils. It grows to commercial maturity in 60 to 120 years, and stands can live 200 years. Red pine stands should be clear-cut and then directly seeded, either in existing red pine stands and other forest types or in nonstocked areas (Benzie 1977).

Red pine saplings require slightly more direct protection from competition and blight than those of other species, and cutting competitive species in year three may be necessary. Deer predation is considered especially threatening to red pine stands.

Our assessment of harvest volumes does not include any associated species that may grow in the stand, and the need for such stands to be weeded is directly related to their soil quality. Intermediate thinnings of these may benefit the stand overall and provide useful biomass, but because they have to be selectively harvested rather than clear-cut, the economics of such a harvest relative to ultimate yield must be considered.

We will consider 15-year and 20-year red pine rotations. Shorter rotations are not likely to provide sufficient harvests to justify the expense.

Tree spacing. For pulpwood or sawtimber stands, it is recommended that no more than 1,100 seedlings be planted per acre, but a denser 2,000 seedlings per acre is possible if no traditionally merchantable trees are needed. This tight spacing creates a tree canopy that hinders growth of competing species. If planting from seeds, a rate of 15,000 seeds per acre is recommended. Our assessment assumes 2,000 trees per acre.

Tree size. At 20 years, the respective height and basal area per acre (that is, the cumulative cross-sectional area of all the trees in an acre at breast height, or 4.5 ft from the ground) of a plantation ranges from 18 ft and 92 sq ft in the 20-49 cu ft/ac/yr site class to 30 ft and 171 sq ft in the 85-119 cu ft/ac/yr class. Potential harvest volumes are given in Table 9.

TABLE 9. TONS OF RED PINE PER ACRE BY SITE PRODUCTIVITY CLASS AND AGE AT 2,000 TREES PER ACRE

SITE PRODUCTIVITY (CU FT/AC/YR)	SITE INDEX	GREEN TONS PER ACRE @ 15 YEARS	GREEN TONS PER ACRE @ 20 YEARS
85-119	75	29	56
50-84	60	17	35
20-49	48	10	18

Derived from Benzie 1977.

Aspen

Aspen is a fast-growing species from the same genus as hybrid poplars. Aspen grows to full maturity in 30 to 70 years, but hardier species typically out-compete unmanaged stands. Aspens grow in all soil types, but thrive in deep, well-drained soils. Like hybrid poplars, aspen clones can regrow from coppice. It is recommended that a prospective aspen plantation begin with an existing aspen stand, which should be clear-cut at maturity and then fully stocked by clones. (The height of trees in the existing stand can be used to make adjustments to the site index.) Thinning is only recommended if sawlogs or veneer are desired, and such plantations are only recommended for site indices greater than 60, which are sites in the 50-84 cu/ft/ac productivity class (Perala 1977).

When harvesting aspen, full-tree harvesting often eliminates the need for further site preparation for the next restock. Properly managed, aspen will out-compete other species—while it is difficult to grow aspen and exclude conifers such as white spruce and balsam fir from the understory, they do not regenerate as quickly following a clear-cut.

The recommended rotation for pulpwood-quality aspen is 30 to 35 years. We will consider a both a 20-year and a 30-year aspen rotation. It is not clear whether earlier harvest of aspen will negatively impact coppicing and, resultantly, establishment costs for the next rotation.

Tree spacing. Dense stands are more pest-resistant and have higher yields. They do not achieve sawtimber diameters, but if a plantation is being managed for energy or pulpwood this is not an issue. Our analysis corresponds to a site that has roughly 1500 to 3000 trees per acre at 20 years, and 900 to 2000 trees per acre at 30 years, depending on the site productivity. (More productive sites grow bigger trees and therefore have, on a per-acre basis, an increase in basal area despite having fewer trees.)

Tree size. At 20 years, the respective average height and basal area per acre (that is, the cumulative cross-sectional area of all the trees in an acre at breast height, or 4.5 ft from the ground) of a plantation ranges from 30 ft and 68 sq ft in the 20-49 cu ft/ac/yr site class to more than 49 ft and 88 sq ft in the 85-119 cu ft/ac/yr class. At 30 years, this grows to 41 ft and 85 sq ft in the lower class to more than 59 ft and 110 sq ft in the upper class. Potential harvest volumes are given in Table 10.

TABLE 10. TONS OF ASPEN PER ACRE BY SITE PRODUCTIVITY CLASS AND AGE AT 2,000 TREES PER ACRE

SITE PRODUCTIVITY (CU FT/AC/YR)	SITE INDEX	GREEN TONS PER ACRE @ 20 YEARS	GREEN TONS PER ACRE @ 30 YEARS
85-119	99	53	89
50-84	90	47	79
20-49	72	31	51

Derived from Perala 1977.

Harvesting and Transportation Costs

A 2008 study of Michigan forestland finds an average delivered cost of $33 per green ton for hardwood pulpwood and $37.50 per green ton for softwood pulpwood. Of this, approximately $14 per ton is harvest cost and approximately $11 per ton is transportation cost (Prentiss 2008). By contrast, a 2006 study of the Great Lakes region found costs of $6.41 per ton to harvest non-merchantable aspen and $8 per ton to transport it (Peterson 2006). The most significant difference between these prices is probably that of pulpwood versus non-merchantable wood—the latter of which can be harvested and handled less carefully, but which is also less dense and therefore less efficient to transport. When considering traditional harvesting in this study, we will split the difference between these harvesting costs and estimate $10 per ton to harvest. For transportation, given the escalation in fuel prices, we will use the 2008 study's $11 per ton estimate.

An important potential technological innovation is an SRWC rapid harvester being developed by Energy Performance Systems, the same company that performed the Minnesota Valley feasibility study. The harvester, which is estimated to operate for $101/acre, should work for plantations with spacings as closely packed as 40 in. The company expects to use the harvester later this year. For economic harvesting using any harvesting practice, these crops should not be grown on sloping soils.

Because chipping is not expected to be conducted on site at Presque Isle, we also include a chipping cost of $4.27 per green ton (Peterson 2006).

ANALYSIS

Our first-cut analysis suggests that, on a delivered cost basis, native species can perform competitively with hybrid poplars. Table 11 considers the three site productivity classes of interest, and also whether rapid harvesting or traditional harvesting is employed. Note that rapid harvesting technology is still being developed, and that even those models currently being designed may not be appropriate for larger trees, such as 30-year-old aspens. Therefore, while both traditional and rapid harvesting costs are presented for all plantations to show the impact of different harvesting schema, the practicality of rapid harvesting remains in the future for all species. Chipped wood is being made from the entire tree—bole, bark and branches.

TABLE 11. TOTAL DELIVERED COST PER TON OF CHIPPED WOOD BY SITE PRODUCTIVITY AND HARVESTING METHOD

		SITE PRODUCTIVITY CLASS					
		20-49 CU FT/AC		50-84 CU FT/AC		85-119 CU FT/AC	
SPECIES	PERIOD (YR)	RAPID	TRADITIONAL	RAPID	TRADITIONAL	RAPID	TRADITIONAL
Hybrid poplar	5	$ 40.26	$ 45.87	$ 35.58	$ 42.00	$ 31.68	$ 38.79
Red pine	15	$ 115.75	$ 115.60	$ 74.84	$ 78.83	$ 49.79	$ 56.31
	20	$ 81.78	$ 86.09	$ 49.04	$ 56.15	$ 36.25	$ 44.46
Aspen	20	$ 53.33	$ 60.08	$ 40.16	$ 48.03	$ 37.53	$ 45.63
	30	$ 45.47	$ 53.49	$ 34.86	$ 43.58	$ 32.57	$ 41.44

Equally if not more important than cost per ton is the acreage required for a perpetual supply of biomass to the Presque Isle facility, as shown in Table 12.

TABLE 12. ACRES REQUIRED TO DELIVER 450,000 TONS ANNUALLY

SPECIES	PERIOD (YR)	20-49 CU FT/AC	50-84 CU FT/AC	85-119 CU FT/AC
Hybrid poplar	5	97,968	79,599	64,322
Red pine	15	678,224	402,114	233,043
	20	634,091	321,923	200,048
Aspen	20	290,323	189,873	169,811
	30	264,706	171,756	151,685

These figures should provide a reasonable illustration of the relative merits of each configuration. For comparison, Milwaukee County is 155,000 acres, Racine County is 213,000 acres and Waukesha County is 356,000 acres. It is important to emphasize that these findings are provisional insofar as plantations of native crops have not typically been rotated so quickly, and plantations of hybrid poplars have not been extensively tested in the study area. Furthermore, all costs are based on 2008 figures without any accommodation for inflated gas or land prices, although such changes should affect all choices equally. The figures in Table 11 regarding delivered cost are independent of the acres required in Table 12, such that these values hold if We Energies is interested in providing only a portion of its needed biomass via plantations.

Short-rotation woody crop plantations are primarily of interest because they hedge against volatile wood prices. By the same token, these plantations could be managed instead for pulpwood or sawlogs should the market develop in such a way that low-value biomass remains more affordable than plantation-grown wood. In many cases the switch would require different management strategies including additional thinning and clearing, but this “hedge against the hedge” adds important flexibility that allows We Energies to sell merchantable wood if it is most profitable to do so. Stumpage prices for these and other species are given in the following section. Should the merchantable wood be sold from the land, We Energies could still use the harvest residue for energy generation, which is estimated to be 17 percent of the total tree volume.

The question of pursuing dedicated woody energy crops is ultimately one about risk—whether biomass prices on the open market will increase past the expected production price of SRWC, and how much the factors that go into that price might change. The investment in land necessary to supply Presque Isle’s total load may be prohibitively large, even under the highly productive hybrid poplar stand, but the findings can be scaled to any size, allowing We Energies to have a mixed portfolio of biomass options for Presque Isle.

If SRWC is to be seriously considered for Presque Isle, an important first step will be establishing trial plantations of the species of interest and using that on-the-ground experience to understand the confluence of species, site, management practice and yield.

CHARACTERIZING AN EMERGING MARKET

Harvest residues appear to be the most promising source of wood fuel for Presque Isle. They are abundant, low valued, and have suitable fuel characteristics. Throughout the region, these are rarely collected, but both harvesters and land managers indicate that they are generally available. The USDA Forest Service estimates over 1.4 million green tons were generated in the study area based on 2004 harvest activities for sawlogs and pulpwood. Slowdowns in logging for these products (due to mill closings or economic downturn) will mean smaller amounts of residues are generated.

The ultimate supply of wood for harvest does not appear to be a limiting factor. Foresters and land managers have stated that current harvest levels are well below their maximum sustainable harvest rates. Likewise, harvesters have indicated that they can and are willing to expand production given sufficient and stable demand for biomass. Therefore, while a decrease in the demand for pulpwood could mean more of it is available for biomass uses and less hog fuel is both generated and used by pulp mills, the more pertinent outcome would be an increase in fuel cost for biomass users. When biomass harvesting is not an add-on to pulpwood or sawlog harvest, biomass buyers will need to pay at a level that supports the harvesting activity (i.e., the cost of biomass could equal the cost of pulpwood).

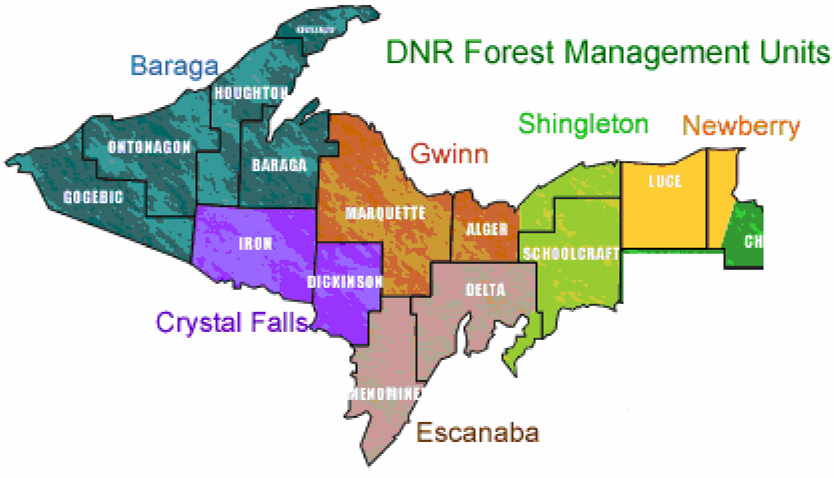
A formal market for biomass of the type likely to be used as boiler fuel does not yet exist. Some pulp mills are seeking additional hog fuel for their boilers due to a rise in fossil fuel prices. Some loggers who have been supplying this fuel, usually as an added service with pulp harvests, have said that the prices they are selling it for are not supportable. In fact, pulp mills are putting a low price on what they are willing to pay for hog fuel and are then unable to get the quantity they want (e.g., one pulp mill is offering $24/ton and cannot get enough delivered). Therefore, instead of relying on established prices for biomass, other sources and indicators must be used to infer market information.

PULPWOOD PRICES

Biomass has not been assigned a value at the stumpage contracting stage. The closest surrogate for a biomass stumpage price is that paid for pulpwood. Whereas biomass is usually harvested as a secondary action following harvest of higher value wood, pulpwood is sufficiently valuable to prompt its own harvest. Also, should competition for biomass grow, biomass users could start buying pulpwood. Therefore, the price of pulpwood represents the maximum price the market would bear for biomass at any given time.

The Michigan Department of Natural Resources publishes 12 month price reports on stumpage sales for pulpwood and for sawtimber. Stumpage prices are the amount paid by the harvester for the right to remove the wood from the land. The price paid by the end user will be higher reflecting costs of harvest and transport. The contract prices were taken from forest management units (FMUs) that roughly match up with study area counties. These units are shown in Figure 12.

FIGURE 12. DNR FOREST MANAGEMENT UNITS USED FOR STUMPAGE DATA

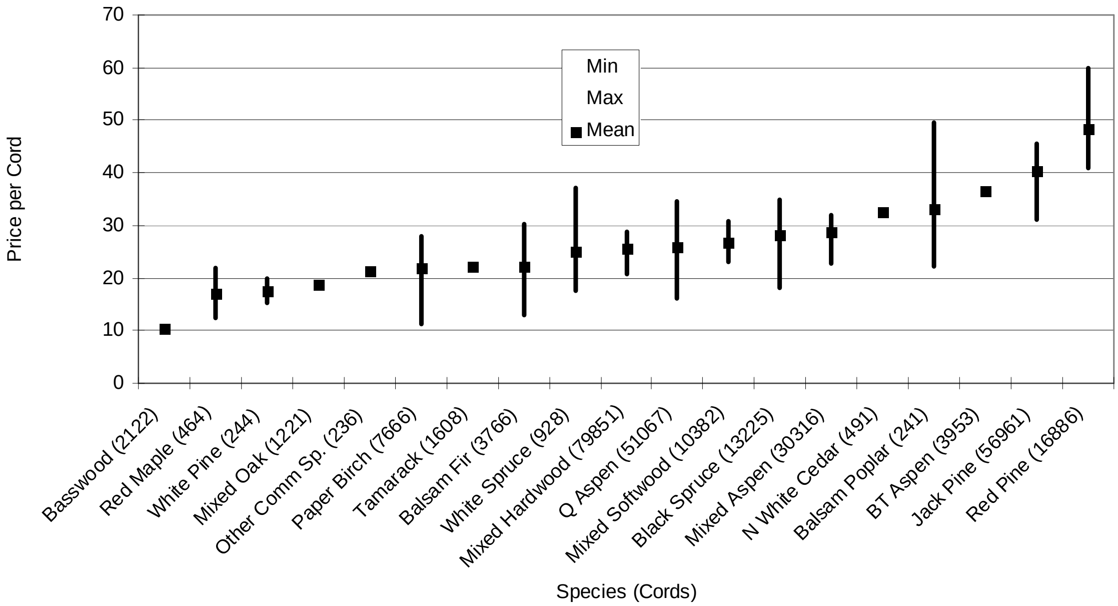


Source: Michigan Department of Natural Resources

Figure 13 shows the mean prices and ranges for pulpwood stumpage sales in each of these FMUs over the last year. Without regard to species, the average stumpage price for pulpwood was between $22 and $31 per cord. If a cord of wood is assumed, on average, to equal about 2.75 tons, the average stumpage price per green ton for pulpwood was between $8 and $11.

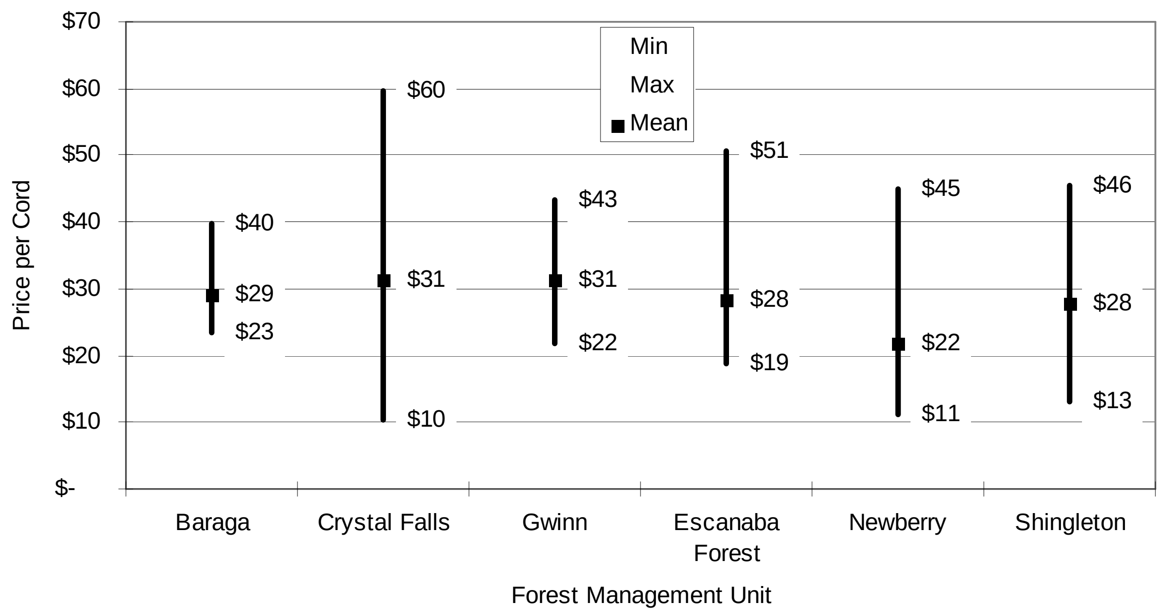
In recognition that different species used for pulpwood are valued differently, Figure 14 shows the price variation between (and within) these species for these same forest management units over the last year.

FIGURE 13. PULPWOOD STUMPAGE PRICES FOR STUDY AREA FOREST MANAGEMENT UNITS



Source: MDNR Average Stumpage Price Report for 04/01/2007-03/31/2008

FIGURE 14. PULPWOOD STUMPAGE PRICES BY SPECIES FOR STUDY AREA FOREST MANAGEMENT UNITS



Source: MDNR Average Stumpage Price Report for 04/01/2007-03/31/2008

The stumpage price contracted for pulpwood harvest on Michigan state-owned forest lands varied considerably by species. On the lower end, basswood stumpage was priced at about $10 per cord, and at the high end, red pine had a mean stumpage price of about $48. These translate into average stumpage prices of between $4 and $18 per green ton. For the state as a whole, the weighted average stumpage price per green ton for pulpwood (i.e., weighted based on volume of wood sales) was about $11. There may be opportunities for focusing on lower-priced wood that is less desirable for pulping.

Purchases for delivered pulpwood are private transactions and information on prices paid is limited. One source of published data derived from industry surveys has information on pulpwood delivery contracts. In the first quarter of 2008, Prentiss and Carlisle estimated the average delivered cost of hardwood pulpwood in Michigan to be about $33, and softwood to be about $37.50 per green ton (Prentiss & Carlisle 2008). This estimate is for the state of Michigan as a whole, not limited to the UP study area. Interviews with loggers provided similar estimates for pulpwood sales prices.

The costs of harvest and delivery will be specific to the logistics of individual harvest contracts, dependent on such factors as ease of access for cutting and removal, and distance to delivery point. Prentiss & Carlisle analyzed the breakdown of cost components that go into the delivered cost for Michigan hardwood pulpwood (Prentiss & Carlisle 2008). This breakdown is summarized in Table 13 below.

TABLE 13. DELIVERED COSTS PER GREEN TON FOR HARDWOOD PULPWOOD IN MICHIGAN

WOOD TYPE	STUMPAGE	HARVEST	TRANSPORT	TOTAL
Mixed Hardwood	$7.00	$13.50	$10.50	$31.00
Aspen	$10.00	$14.00	$11.00	$35.00
Mixed Hardwood Percentages	23%	44%	34%	100%
Aspen Percentages	29%	40%	31%	100%

Prentiss & Carlisle, Update, 1st Quarter 2008, referencing a study for MDNR conducted in 2007.

For these wood types, the cost associated with harvest and transportation for delivered wood products is between 71 and 78 percent of the total delivered cost. Knowledge of these cost components can be useful in assessing costs of delivered biomass in either the absence of stumpage charges (as is currently the practice) or with the addition of new biomass-based stumpage charges (as landowners and harvesters suggest will be necessary).

Applying these numbers to biomass harvests, we should assume that harvest and transportation costs for biomass are at least equivalent, and probably slightly higher. This assumption is based on the fact that biomass tends to be less dense than pulpwood, and the processes for gathering and processing it are less refined. In addition, biomass stumpage prices should be lower than pulp prices, reflecting fewer options for use.

The new market for biomass is in its infancy (or perhaps in the last stages of birth). Without sales information for biomass stumpage, we can only look to prices in existing markets and make educated guesses as to eventual biomass prices. To provide the best picture possible at this stage of development and with the information we have, we can say:

- average stumpage prices for biomass should be less than the $7 to $11 per green ton range we see reported for pulpwood delivery,
- harvest costs should be equal to or higher than the $13.50 to $14 per green ton currently observed for pulpwood harvest, and
- delivery costs should be equal to or higher than the $10.50 to $11 per green ton currently observed for pulpwood delivery.

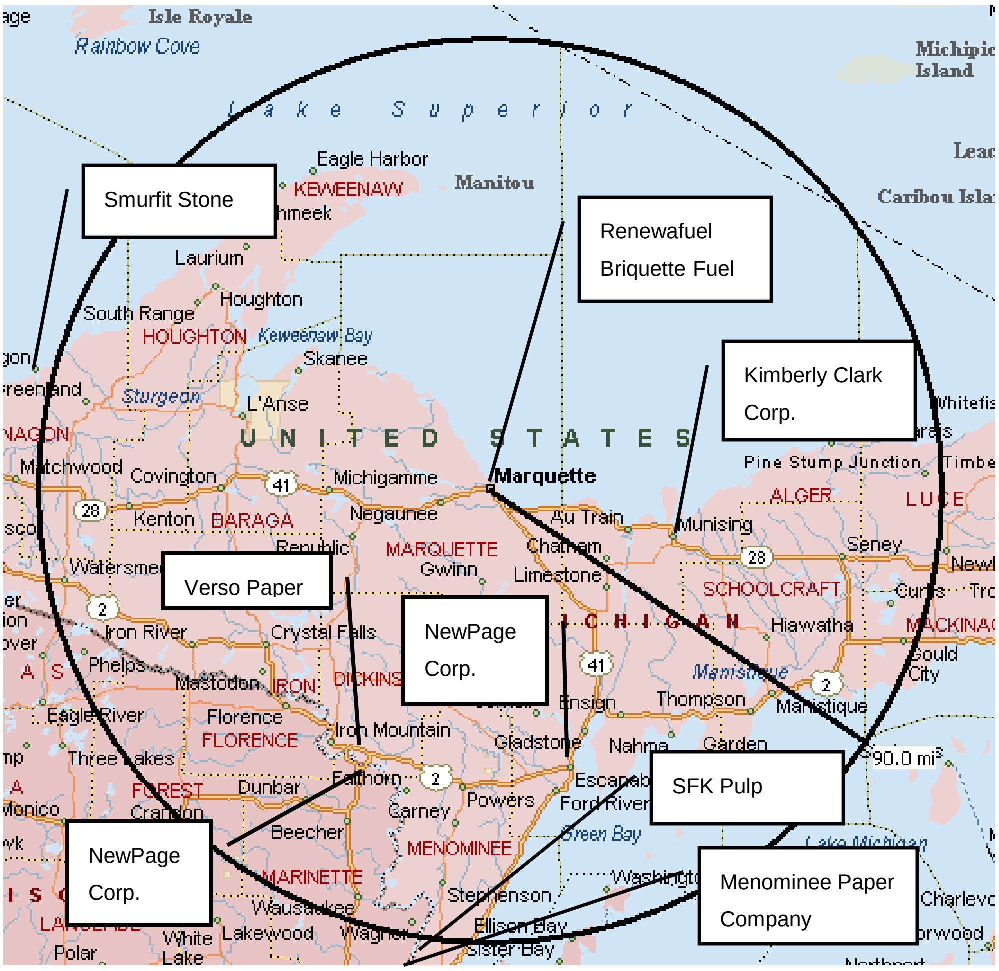
These conditions point to delivered biomass prices, under the most favorable conditions, of about $30 per green ton, assuming stumpage of $6 per green ton and harvest and transportation costs equivalent to hardwood pulpwood.

Competing Biomass Users

Traditional wood users are maintaining or expanding their appetite, and several new potential biomass users are on the drawing board.

Traditional Biomass Users. Figure 15 shows the locations of some existing pulpwood-using industries in and near the study area.

FIGURE 15. EXISTING AND NEAR-TERM BIOMASS USERS



In addition to using pulpwood, pulp mills have increasingly turned to wood "hog fuel" to replace coal and natural gas. Some harvesters have established trade agreements in which they supply hog fuel (wood and bark pieces that can be processed through a hogger for size reduction) to pulp mills. Several loggers expressed the view that current prices pulp mills are willing to pay for hog fuel are not sustainable. The result has been that pulp mills are in some cases unable to get the amount of biomass they want based on what they are willing to pay. Another aspect of the low prices offered is that pulp mills end up drawing hog fuel from only the closest harvest operations, because hauling over longer distances is too costly.

Within the 90-mile study radius there are three Michigan pulp mills: Verso Paper in Norway, NewPage in Escanaba, and Kimberly Clark in Munising. These facilities are about 87, 67 and 44 miles away from Marquette, respectively. There is also a NewPage mill in Niagara, Wis., 83 miles from Marquette, that will be closing in July 2008 (NewPage Corporation 2008). The closing of the NewPage mill may have a depressing effect on both pulpwood and biomass (hog fuel) demand in the area. Harvesters who had been servicing that mill may have commitments for harvest, and may be looking for new supply arrangements.

Energy and Fuel Production

There are also some proposed and existing energy and fuel production facilities that could compete for the same pool of feedstocks as Presque Isle. These are summarized in Table 14 below.

TABLE 14. EXISTING AND PROPOSED WOOD ENERGY FACILITIES

FACILITY	LOCATION	FEEDSTOCKS	STATUS
Renewafuel Briquetting Facility	Marquette, MI	wood waste (~300k tons/year), several other feedstocks, will use bark for fuel	likely to proceed
L'AnseWarden Electric Power, 18MW capacity, cogen	White Pine, MI	wood waste and several other feedstocks	possibly operational
Ripley Heating Plant, 10MW capacity, cogen	Marquette, MI	wood industry wastes, 200k green tons/year	project has permits, litigation and delays expected
Timberland Power Company, 100MW power plant at former KI Sawyer AFB	Gwinn, MI	wood-fired cogeneration facility, 100MW capacity, demand	unknown

The Renewafuel – Cleveland Cliffs biomass briquette production facility is planned to be built at the Telkite Technology Park in Marquette (Cleveland Cliffs 2008). They expect to use waste paper, waste cardboard, crop residues, construction and demolition wastes, energy crops and wood. They predict that they will require about 300,000 tons of green wood per year and expect to produce about 300,000 tons of fuel briquettes per year. They currently plan to use about a third of this in place of pulverized coal at the mine facilities and the rest will be sold (Byrne 2008). They are set to begin production in the first quarter of 2009. This facility could be both a competitor for feedstocks, and a supplier for biomass fuel for the Presque Isle facility. Pricing information and other details are needed to evaluate these possibilities further.

The L'Anse Warden Electric Power power plant in White Pine, Mich., has a new biomass-fueled boiler that is either currently or imminently operational. The boiler is an 18MW (20MW gross output), one-unit steam generating power plant addition to the J.H. Warden Generating Station. Wood and other opportunity fuels (railroad ties, tire derived fuel, paper mill sludge, mill ash, fines and bark) will be used for electricity and heat generation. Steam from the generation will be used by a neighboring manufacturer (Schneider 2007). One source of fuel will be Smurfit Stone Container mill wastes.

Northern Michigan University has proposed converting their coal-fueled Ripley Heating Plant into a CFB cogeneration facility that would use wood waste as a primary fuel (with coal capability). This facility would have a capacity of 10MW, and would require about 200,000 tons of wood waste per year. It has received the required air permits from the State of Michigan, but further litigation from environmental groups is expected before it moves forward.

There is rumored to be a planned 100MW biomass fired cogeneration plant in Gwinn, Mich., on the site of the former K.I. Sawyer Air Force Base. Timberland Power Company is rumored to be the developer. The MDNR has not received any applications for permits and the developer Web site is listed as “under construction.” The development status of this project is uncertain.

Table 15 summarizes the market forces discussed in this section.

TABLE 15. MARKET ACTORS IN STUDY AREA

FACILITY	STATUS	EFFECT DEMAND	EFFECT SUPPLY	OVERALL
NewPage Niagara Mill	closing	reduce	reduce	uncertain
3 Remaining Pulp Mills	ongoing	increasing	steady	increasing demand
Renewafuel Briquetting Plant	pre-construction	increase	none	large competitor, potential supplier
L’Anse Warden PP	operational	increase	none	small competitor
Ripley Heating CHP	proposed	increase	none	delays expected
Timberland Power CHP	uncertain	very large increase	none	not progressing

CONCLUDING POINTS

Forest managers say that a high percentage of usable biomass is being left in the forest and they are interested in finding ways to encourage its increased use.

Loggers see opportunity to supply biomass to the budding fuel and energy markets but caution new entrants to not rush in with unrealistic expectations (e.g., biomass stumpage price remaining at $0). They like the idea of longer term contracts for supplying biomass that they can use to finance equipment purchases. These contracts should also have diesel fuel cost adjustment clauses.

Primary wood industry may have opportunity fuels from their production processes that are not reported or that are currently underutilized. These are worth exploring but are expected to be very limited.

Harvest residues show the most promise as boiler fuel due to their volume, low cost, fuel characteristics and supply industry.

Near term biomass prices should be below pulpwood prices, which are currently in the range of $31-37 per green ton delivered for Michigan.

Pulp and sawtimber harvests generate harvest residues. Should either diminish, biomass prices may have to increase to sustain harvest activities and may approximate the delivered price for pulpwood.

Utility payment for delivered biomass should be based on Btu value rather than weight to reward the suppliers with superior product.

Dedicated biomass solutions can provide a hedge against market uncertainty, but the conditions of soils in the study area limit productivity and would require a significant amount of land to be converted to plantations to satisfy all of the Presque Isle facility's demands.

REFERENCES

Becker C, Plum Creek Timber Company, personal communication, April 2008.

Benzie, John W. 1977. Aspen in the North-Central States. USDA Forest Service North Central Forest Experimentation Center. St. Paul, Minn.

Blyth J and Smith B, Minnesota Logging Utilization Factors, 1975-1976 - Development, Use, Implications, USFS Research Bulletin NC-48, 1980.

Byrne D, Cleveland Cliffs Corporation, personal communication, May 2008.

Cleveland-Cliffs Inc., Press Release June 3, 2008, http://www.b2i.us/profiles/investor/ResLibraryView.asp?ResLibraryID=24847&GoTopage=1&BzID=1041&Category=1250.

Gimler B, Hiawatha National Forest, personal communication, April 2008

Hansen E, R Fletcher, B Cashore and C McDermott, "Forest Certification in North America," *EC 1518*, Oregon State University Extension Service, Revised February 2006.

Hayrynen J, J M Longyear, personal communication, April 2008.

Heym D, MDNR Timber Sales Specialist, personal communication, May 2008.

Howlett D, Hiawatha National Forest, personal communication, April 2008.

Michigan Department of Natural Resources, Forest Products Industry Database, http://www.dnr.state.mi.us/wood, May 2008.

Michigan Department of Natural Resources, *Operational Management Guidelines for State-Owned Forest Lands*, IC 4250 (rev. 08/24/2005).

Minnesota Forest Resources Council, "Biomass Harvesting Guidelines for Forestlands, Brushlands and Open Lands," December 2007.

NewPage Corporation, "NewPage Taking 25,000 Tons Of Market-Related Downtime And Shutting Down Niagara, Wisconsin Paper Machines July 2008," Press Release, June 6, 2008, www.newpagecorp.com.

Ostlie L, "Economic and Technical Feasibility of Modifying the Minnesota Valley Power Plant to Utilize Whole Trees as the Primary Fuel Source." Energy Performance Systems, Maple Grove, MN. May 2003.

Ostlie L, Energy Performance Systems, interviews 2007-2008.

Perala, Donald A. 1977. Aspen in the North-Central States. USDA Forest Service North Central Forest Experimentation Center. St. Paul, Minn.

Peterson, D. "Resource Availability: Analysis of Extraction Method, Available Sources and Delivery Costs of Wood Residues." Renewable Resource Solutions, LLC. 2006.

Piva R, US Forest Service North Central Research Station, personal communication April, June 2008.

Prentiss & Carlisle Update, 1st Quarter, 2008, http://www.prentissandcarlisle.com/assets/PCnwslttr_1QTR-08.pdf.

Schneider D, "L'anse Power Plant To Get Green (Biomass): New owner plans transition to biomass fuel," Michigan GREEN, http://michigangreen.org/article61.html.

Schwantes J, Wisconsin Department of Natural Resources, personal communication, May 2008.

Sobrack J, Timber Program Manager, Ottawa National Forest, personal communication, June 2008.

Sullivan H, Florence County Forester, personal communication, May 2008.

Wittenberg, Eric and Stephen Harsh. 2007. 2007 Michigan Land Values and Leasing Rates. Michigan State University Department of Agricultural Economics.

Wittenberg, Eric. 2008. Interview with Sean Weitner, June 2008.