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An outlook for sustainable forest bioenergy production in the Lake States

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ABSTRACT

The Lake States region of Minnesota, Wisconsin and Michigan offers significant potential for bioenergy production. We examine the sustainability of regional forest biomass use in the context of existing thermal heating, electricity, and biofuels production, projected resource needs over the next decade including existing forest product market demand, and impacts on price and feasibility. Assuming $36 per dry tonne at roadside, 4.1 million dry tonnes of forest biomass could be available region-wide. However, less is likely available due to localized environmental and forest cover type constraints, and landowner willingness to harvest timber. Total projected demand of 5.7 million dry tonnes, based on current and announced industry capacity, exceeds estimates of biomass availability, which suggests that anticipated growth in the forest-based bioeconomy may be constrained. Attaining projected demand will likely require a combination of higher cost feedstocks, integration of energy and non-energy uses, and careful management to meet environmental constraints. State distinctions in biomass harvest guidelines and the propensity for third-party forest certification will be critical in providing environmental safeguards. The cumulative effect of policy initiatives on biomass competition are discussed in the context of an emerging Lake States bioeconomy.

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1. Introduction

Agriculture feedstocks producing about 176 million dry tonnes annually in the United States are a critical source of biomass for energy production but are insufficient to meet growing demand (Perlack et al., 2005). Forest-derived biomass when combined with agriculture residues has the potential to significantly increase supply by diversifying feedstock procurement. Matching the volume of forest biomass sustainably available from more than 21 million hectares (52 million acres) of public and private forestland in the Lake States region of Minnesota, Wisconsin, and Michigan (Butler, 2008) is the focus of this analysis.

The Lake States region represents an area of the United States uniquely characterized by a significant mix of agriculture and forest production. The bioenergy industry is rapidly evolving and currently includes a number of electricity and thermal heating facilities, corn-based ethanol processing plants, and prospects for next generation biofuels such as cellulosic ethanol production (Dovetail, 2007). State policy has also evolved significantly to influence investments in bioenergy production capacity (Aguilar, In press).

Despite the potential for growth, little is known of the collective physical, economic, and environmental availability of forest biomass in the region or the cumulative effects of increased demand, both for energy and non-energy uses. We therefore characterize available biomass in Minnesota, Wisconsin, and Michigan and implications for sustainability in the context of an emerging bioeconomy, which broadly includes thermal heating, electricity, transportation fuels, and related bioproducts from forest residues (Duchesne and Wetzel, 2003). Assessment of forest biomass availability, the economics of removal, existing and projected demand, and corresponding policy incentives may provide a useful framework for other regions of the country. The propensity for third-party forest certification and adoption of biomass harvest guidelines are also highlighted to illustrate the use of environmental safeguards in unison with bioenergy development.

2. Lake States regional distinctions

The primary forest products industry in the Lake States is comprised of three main sectors: pulp and paper, engineered wood products, and lumber. Combined, about 4000 primary and secondary wood manufacturing companies produce about USD $40 billion of product shipments each year, and as of 2005 total

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direct employment exceeded 200,000 jobs. In Wisconsin, approximately 96,000 individuals are employed in primary forest manufacturing making it Wisconsin's largest manufacturing workforce. An additional 150,000 indirect jobs are created by Wisconsin's forest products industry (Mace et al., 2004). In Michigan, the industry is the fourth largest sector overall employing about 69,000 individuals with an annual payroll of USD $2.9 billion (Berghorn, 2005). An additional 150,000 jobs are created from indirect and induced impacts (USDA Forest Service, 2008). In Minnesota, the forest products industry employs about 40,000 individuals, 14,000 in primary manufacturing and logging and 26,000 in secondary manufacturing having a combined total annual payroll of USD $1.92 billion (Minnesota DNR, 2008a).

Not unlike other regions, the Lake States forest products industry has declined in recent years due to global economic factors. The average stumpage price paid for aspen pulpwood in Minnesota was USD $59.70/cord on public timber auctions in 2005 compared to USD $28 in 2008 (Minnesota DNR, 2008b, 2006). Just when companies were entering into higher-priced contracts the demand and value for forest products declined. A consequence has been the closing or idling of many long-standing companies, as well as a significant decrease in the volume of wood harvested. Subsequentially the availability of harvest residues has also declined, which makes up the majority of existing feedstock for bioenergy production in the region.

To offset losses, investment and expansion of bioenergy production to meet growing demand could be a boost to the forest products industry. At the same time, there is heightened awareness of the need for environmental safeguards for sustainable production, and also to grow the biomass industry in such a way that it complements, as opposed to competes with, the existing forest products industry. Within this context, regional efforts are underway that illustrate the complex linkages involved in growing a sustainable bioeconomy.

2.1. Renewable energy standards

The growing demand for forest biomass in the Lake States is in part a result of state Renewable Portfolio Standards (RPS) requiring utility companies to obtain certain percentages of renewable feedstocks to generate electricity. Almost two thirds of states across the country have adopted some form of mandatory RPS, with each of the Lake States specifying forest-derived biomass as an eligible feedstock. Michigan is the most recent RPS in which 10% of energy production must originate from renewable sources by the year 2015. Wisconsin has a similar RPS of 10% by 2015, and a non-binding goal of 25% by 2025 announced in 2008. The Minnesota RPS was updated in 2007 expanding renewable energy production to a mandatory 25% by the year 2025 (30% by 2020 for Xcel Energy) (Becker and Lee, 2008).

2.2. Regional fuels standards

State incentives encouraging development of first generation biofuels, like corn ethanol, generally also apply to advanced biofuels like cellulosic ethanol, of which forest-derived cellulosic ethanol generally qualifies. In Minnesota, current mandates require that nearly all gasoline in the state contain a minimum of 10% ethanol blend (E10 gasoline) rising to 20% by 2013 (US DOE, 2009). By 2015, all gasoline sold in the state is also to include a 5% blend of cellulosic ethanol. Minnesota also has about one-fifth of all E85 gasoline pumps in the United States and all gasoline stations are required to sell E10.

Michigan does not specify a requirement nor is there a goal to blend gasoline with ethanol. In Wisconsin, however, there exists a non-binding goal of 25% renewable transportation fuels by 2025 (US DOE, 2009). About 75% of gasoline stations there provide E10 (Wisconsin Office of Energy Independence, 2008). Wisconsin is also pursuing plans to encourage gasoline stations to provide E85 along major highway corridors. All three states are also signatories to the Midwest Energy Security and Climate Stewardship Platform Plan (US DOE, 2009), which includes commitments to research and infrastructure development to establish cellulosic ethanol manufacturing by the year 2012.

2.3. Biomass harvest guidelines

Expansion of a forest-based bioeconomy could potentially benefit the Lake States by expanding markets for biomass products, creating rural jobs, and reducing reliance on fossil fuels. However, concerns have been raised about the sustainability and environmental impacts to soils (Grigal, 2000) and biodiversity from increased biomass removal (Robertson et al., 2008). Understanding these impacts and implementing environmental safeguards is a high priority among groups like the Wisconsin Council on Forestry (http://council.wisconsinforestry.org/sfp/), Great Lakes Forest Alliance (www.greatforests.org) and the Minnesota Forest Resources Council (http://www.frc.state.mn.us/), which were all involved in development of the biomass harvest guidelines for their respective areas.

Such efforts have led to the development and implementation of biomass harvesting guidelines in Minnesota and Wisconsin, which were among the first such guidelines in the United States to address sustainable removal of biomass for energy production (Evans and Perschel, 2009; MFRC, 2007; WDNR, 2008). Working in consultation with industry, agency, university, tribal and environmental experts, the respective guidelines include provisions for the retention of snags, down woody debris, and remnant live trees to sustain wildlife diversity. Included are considerations for forest management practices in riparian areas, maintenance of soil productivity, and leaching of nutrients on sensitive soils. A handful of states have followed suit, including Michigan, which is in the process of creating their own guidelines.

Minnesota and Wisconsin have also implemented comprehensive state environmental review procedures requiring the analysis of cumulative impacts, including on biomass sustainability, resulting from public and private actions like the siting of a forest bioenergy facility (Ma et al., In press). Michigan also requires such analyses but only for certain development activities and assessments of biomass availability are generally not included.

2.4. Third-party forest certification

In recent years, third-party forest certification, such as that provided by the Sustainable Forestry Initiative and Forest Stewardship Council, has become a popular tool for verifying sustainable forest management practices as well as the potential for marketing biomass products. Both ensures that forest managers consider multiple use values of forestland, encourage harvesting techniques that minimize the disturbance to the environment, and requires monitoring and management for regeneration after harvest operations (Meridian Institute, 2001). As of December 2008, a combined 6.4 million hectares (15.9 million acres) had been certified in the Lake States by one or both systems, representing some 29% of all certified forests in the United States and nearly all of the public forestlands, excluding federal land, across the three states. Minnesota has 1.9 million hectares (4.8 million acres) of state land dual certified and an additional 1.1 million hectares (2.7 million acres) of county and private timberlands certified under one or the other programs. A

total of 2.0 million hectares (5.0 million acres) of Michigan forests are dual certified, as are 1.4 million hectares (3.4 million acres) of Wisconsin forests. An additional 0.9 million hectares (2.2 million acres) of non-industrial private forests are certified in Wisconsin, lands that were already certified by the American Tree Farm System (Fernholz, 2008). The magnitude of certified forests offers a potential competitive advantage for certified-sustainable biomass. Where combined with electricity and biofuels mandates, and safeguards for sustainable harvest practices, the result is a unique combination of policy incentives for biomass development.

3. Methods

3.1. Forest biomass supply

Forest biomass supply was calculated by aggregating the volume available from integrated harvest operations, other forest removals like land clearing and cultural operations, and unused mill residue. Supply estimates were made for each county in Minnesota, Wisconsin and Michigan and focus most on the largest and least expensive source of biomass – integrated harvesting operations – where sawlogs are utilized in traditional timber and pulpwood markets and the residuals for bioenergy and related biomass applications. In this way, we modeled biomass utilization in association with existing forest product industries as opposed to in direct competition for available supply, which more closely represents the current market situation in the region.

Supply from integrated harvesting was estimated as the average of two estimation methods (BRDI, 2008). The first estimated supply as a fraction of annual logging residue (55% from public land, 60% on private land) calculated from the USDA Forest Service Timber Product Output database (USDA Forest Service, 2009). The second method estimated supply from simulated thinnings of Forest Service, Forest Inventory and Analysis (FIA) field plots (http://www.nrs.fs.fed.us/fia/). Thinning simulations used uneven-aged treatments with harvest removals across all size classes on plots having a stand density index greater than 30% of the maximum of the corresponding forest type (Sheppard, 2007). Biomass was estimated as the portion of the thinnings coming from trees 2.5–12.7 cm dbh and tops and branches of all trees. Thinnings were assumed to occur every 30 years (Perlack et al., 2005) but were limited to provide no more pulpwood and sawlogs than provided by harvests in the year 2006. A decrease or increase in availability may be achieved by altering rotation lengths.

Roadside costs were estimated as the total of harvest and chipping costs and projected stumpage price, which were calculated using the Fuels Reduction Cost Simulator (Fight et al., 2006) as modified for northern forests (BRDI, 2008). The Fuels Reduction Cost Simulator incorporates standardized estimates of harvest equipment productivity, transportation costs and labor with estimates of sawlog and biomass volumes for different tree species types. A conventional whole-tree harvesting system was modeled in which logging operations were done in conjunction with chipping and biomass removal.

The stumpage price paid for biomass on public lands assumed USD $4 per dry tonne while the price on private lands began at that price and increased until pulpwood and sawlogs would be chipped for biomass markets. At the point where all operations are integrated, biomass stumpage price reached 90% of pulpwood stumpage price. Estimated supply in the region therefore focused on amounts from integrated harvesting, as supplemented by other removals and unused mill residue. But supply would be higher if mill residue is drawn away from conventional pulpwood markets or sawlogs were chipped as the demand and price for biomass increased. Corresponding supply–cost curves were estimated by Perlack et al. (2005) and refined for the purposes of this study (Kenneth Skog, pers. comm., USDA Forest Products Laboratory, June 8, 2009).

3.2. Resource demand

Current industry demand for forest biomass was collected from a variety of sources to estimate thermal heating, electricity, and biofuels production. Resource specialists in each state were contacted to obtain a list of existing forest products users by type. Data obtained from the Department of Commerce and Department of Natural Resources for each state was used to verify company names, locations, and annual resource needs. Discrepancies and incomplete data were resolved through direct industry contacts.

Projected demand was estimated by combining the total number of officially announced projects in the region, which included projects currently in state or federal environmental review, seeking air quality and other types of operating permits, or actively being constructed. There are no assurances that announced projects will ultimately be completed, but they provide an estimate of build-out potential. Sources of data included previously identified industry and state contacts, review of state filling records for permits and environmental review, and a search of local and regional newspapers of industry press releases.

4. Forest biomass resources and availability

4.1. Source and growing stock

The ability to meet growing demand for bioenergy production will rely in part on recovering new sources of biomass. Harvest residues, or the tops and branches of trees and trees too small for other markets, are the largest unused source in the Lake States. They are also the least expensive to collect when integrated with commercial timber harvesting operations where the roundwood, or sawlog portion of the tree, are removed for higher-valued markets and the biomass is removed subsequent to commercial operations (Peterson, 2005). Several other types of forest biomass offer significant potential but are underutilized or largely unavailable for various reasons. Mill waste from primary and secondary wood manufacturing provides a clean high quality chip but is mostly already used in existing energy applications (Perlack et al., 2005). Dedicated energy crops like hybrid poplar plantations and switch grass are regularly discussed but have been slow to materialize because of inadequate markets and competing agricultural uses of the land (Public Service Commission of Wisconsin, 2006). Forest brushlands and commercial thinning of industrial timberlands also offers significant potential but are constrained by high removal costs relative to the volume and value extracted (Berguson and Buchman, 2009). Similarly, biomass from urban wood wastes and land clearings offer potential but are situationally constrained by high collection and sorting costs, though in some urban areas this material is already widely used for energy or landscape applications.

When compared to annual growth, sawlog and biomass availability far exceeds removals. Total growing stock in Michigan is estimated at 9.3 million dry tonnes annually compared to 4.3 million harvested in 2005 (USDA Forest Service, 2008). Wisconsin reports 7.3 million dry tonnes of annual growth and 4.4 million harvested (USDA Forest Service, 2007), and Minnesota harvested approximately 3.7 million dry tonnes in the same year on 6.9

million in growth (Minnesota DNR 2007). Based on these estimates, there appears to be a significant volume of biomass that could be recovered from additional harvesting. However, complete utilization of net growing stock is unlikely given site-level environmental and physical constraints and because the economics of removal relative to the proximity of processing facilities limits its feasibility.

4.2. Economics of availability

To examine economic availability, total stumpage cost and cost of removal were simulated using the Fuels Reduction Cost Simulator for public and private timberlands in the three states (Fight et al., 2006). Environmental safeguards were imposed on the volume of biomass that could be recovered from integrated harvest operations to better reflect actual availability (55% on public land, 60% on private land). Total unused mill residues were also included. Assuming no financial constraints, annual biomass availability was estimated to be 4.1 million dry tonnes. Michigan would contribute 1.2 million dry tonnes in this scenario, and Wisconsin and Minnesota with 1.7 and 1.2 million dry tonnes, respectively (Fig. 1). Imposing a roadside price of USD $36 per dry tonne (USD $40 per dry ton), much of that would still be available. Total supply would be approximately 1.0 million, 1.5 million and 1.1 million dry tonnes, respectively, or 3.6 million dry tonnes region-wide. Much less is available at a price below USD $27 per dry tonne (USD $30 per dry ton).

In reality, available biomass may be less because of localized differences in the distribution of small trees and tops, guidelines for leaving logging residues on site, frequency of forest thinnings, projected future harvest for pulpwood and sawlogs as a function of market conditions, willingness of private landowners to harvest timber, and other ecological, social, and practical considerations. For instance, some forest types included in the analysis are less likely to be harvested, or as frequently, as commercial species like red pine and aspen. Markets for low-value species and the ability to efficiently recover biomass, some of which is located in lowland bogs, will influence their availability and can only be accurately assessed on a project-by-project basis.

Assuming biomass markets are stable, landowners can expect to receive a price of USD $33–45 per dry tonne (USD $36–50 per dry ton) for delivered chips for energy production (Terry Mace, pers. comm., Wisconsin Department of Natural Resources, October 20, 2008). Assuming a 56 km (35 miles) one-way transport distance, the delivered cost of forest residuals start at about USD $51 per dry tonne (USD $56 per dry ton) when integrated with a traditional timber sale and small trees and tops are provided at roadside for no additional cost. They increase to more than USD $76 per dry tonne (USD $84 per dry ton) for the same distance for stand-alone whole-tree chipping on an aspen site having no sawlog or pulpwood market (Kenneth Skog, pers. comm., USDA Forest Products Laboratory, June 8, 2009). The challenge is that many sites are further than 56 km (35 miles) from existing or proposed processing facilities, site access is constrained by the time of year, and the composition of species may include less desirable forest types. Each increases total procurement costs, which in effect decreases total availability.

4.3. Diversity of forest ownership

Private landowners, including tribal lands, own the majority of productive forests in the region, more than 12.3 million hectares (30.3 million acres) (Fig. 2). State lands are the next largest with about 3.9 million hectares (9.6 million acres), followed by 3.0 million hectares (7.3 million acres) of federal forestland, which are primarily administered by the USDA Forest Service. County and local government forestlands are an additional 2.0 million hectares (5.0 million acres) (Butler, 2008).

A challenge, and an opportunity, with procuring biomass in the Lake States is the diversity of ownership types and variability in landowner objectives. On the one hand, the range of ownerships diversifies potential sources of feedstock, which are broadly distributed across Wisconsin and more concentrated in the upper peninsula of Michigan and northeast Minnesota. However, availability is constrained by uncertainties about the willingness of a large segment of private landowners to harvest timber and remove biomass. Private forestlands are being divided into ever-smaller parcels and increasingly new landowners are absentee and less engaged in forest management, which may further reduce harvest levels (Butler, 2008). Between 1984 and 1997, for example, the total number of non-industrial private landowners increased 20% in Wisconsin, and each year an additional 3500 new parcels were created (Finan 2000). A similar trend exists in Minnesota and Michigan where ownership size is decreasing. Data in Minnesota indicates that the average tract size of forestland sold decreased from 29.0 to 23.9 hectares (72–59 acres) (18%) from 1989 to 2003 and an even more severe decline since 2007 (30%) (Mundell et al., 2007). This phenomenon of parcelization threatens total availability as well as the consistency of delivery.

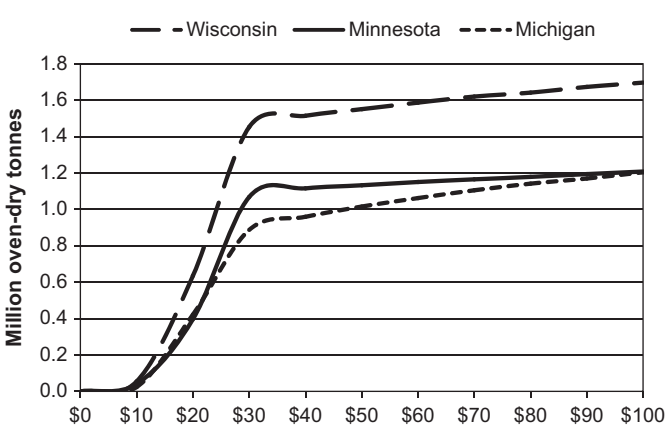

Fig. 1. Estimated biomass supply from integrated forest harvesting and unused primary mill residues (USD $ per oven-dry tonne at roadside).

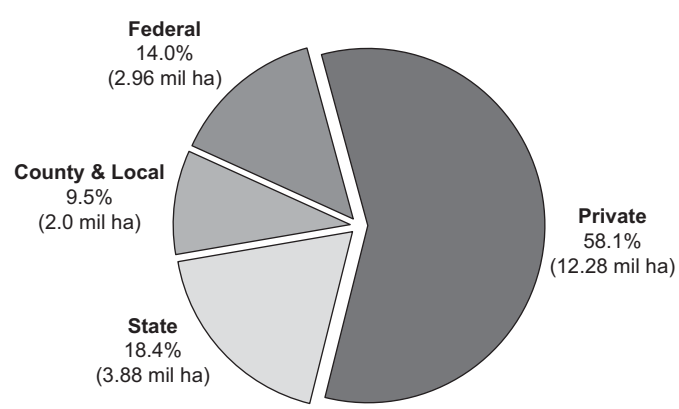

Fig. 2. Combined land ownership in Minnesota, Wisconsin and Michigan (Butler 2008).

5. Competition for forest biomass

5.1. Costs and opportunities

The supply of biomass is highly price-sensitive up to the point where roadside prices become competitive for pulpwood. Currently, only the lowest-value material is typically used in thermal or energy applications to be competitive with natural gas or coal fuel sources. The roadside price paid for biomass is also determined by its proximity to processing facilities and the extent of competing uses. Increased demand created by incentives for renewable energy could create increased competition and expansion into feedstocks with higher roadside prices and haul distances. Examples include federal subsidies for cellulosic ethanol production and state assistance programs to offset transportation costs, which were not included in the analysis but could affect regional markets. The pulp and paper industry, in particular, is at risk of increased competition for feedstocks while simultaneously facing increasing competition from China and parts of Europe for finished products. Industry experts have expressed concern that as demand for forest residues increases, chip prices could approach or even surpass current pulpwood prices, resulting in upward price pressure on delivered sawlogs (Hawkins Wright, 2008).

Alternatively, increased chip prices would create opportunities for commercial thinning of timberlands, which could provide added feedstock. It could also increase the productivity of forests and related biomass supplies over time. Research in red pine stands, for example, has demonstrated that thinnings every ten years beginning at age 25–35 can salvage volume otherwise lost to natural morality resulting in 150–170% more merchantable volume than unthinned stands (Buckman et al., 2006). The high level of mortality and deadwood in the region suggests that fire risk may also be reduced and that subsequent forest health, growth, and yield may be enhanced (Brown et al., 2007).

5.2. Projected demand

Current and projected industry demand for forest biomass was collected from a variety of previously identified sources (e.g., state and industry resource specialists), and estimated by combining the total number of announced projects with existing uses. Actual build-out may differ but provide a useful benchmark for assessing resource availability. Thermal heating, electricity generation, and biofuels production are the most frequently discussed options, but other non-energy uses are also important to consider.

Thermal heating using densified wood pellets and briquettes, and wood chips represents a significant portion of renewable energy generation in the region, and in particular in Wisconsin and Michigan (Table 1). Approximately 22% of current biomass production is attributed to thermal heating applications. Densification makes transportation over long distances feasible because of the high-energy content per unit and ease of handling (Pellet Fuels Institute, 2008). North American production of densified fuels reached approximately 3.6 million dry tonnes in 2008 driven largely by European demand for district heating and combine-power-heat facilities. Global capacity during the same time reached about 9.6 million dry tonnes (Swaan, 2008). Lake States pellet production using forest biomass could grow to 1.6 million dry tonnes annually within the next decade, with much of that being proposed in northeastern Minnesota (William Luppold, pers. comm., USDA Northern Research Station, May 20, 2009).

In terms of forest-derived and mixed biomass used for electricity, there exists a combined annual generating capacity of 3137 MWh in the region (EIA, 2008), which is roughly equivalent to providing electricity to some 2.4 million homes each year. Michigan generates more than half this amount with 1713 MWh produced annually, followed by Wisconsin and Minnesota with 838 and 586 MWh, respectively. Total forest biomass used in this production is about 1.9 million dry tonnes annually from harvest and mill residues (Table 1). The outstanding portion of generating capacity utilizes other types of biomass and co-generation not specifically tracked (EIA, 2008). Usage is expected to increase because of new state renewable energy mandates (Becker and Lee, 2008), which could increase an additional 0.8 million dry tonnes-equivalent, 2.7 million dry tonnes total, from six new biomass electricity plants proposed in the region. Of course, realizing these levels of production will depend on the financial viability of feedstocks within a particular supply area, continued demand for biomass energy, the ability to secure financing and necessary state and federal permits to build facilities.

Table 1
Volume of oven-dry tonnes of existing and projected forest biomass use (000's).

Biomass use	Minnesota	Wisconsin	Michigan	Total
Densified fuels/pellets				
Existing demand	36	317	186	539
Announced[a]	635	109	68	812
Subtotal	671	426	254	1351
Electricity[b]				
Existing demand	332	262	1,343	1937
Announced[a]	381	435	0	816
Subtotal	713	697	1343	2753
Liquid biofuels				
Existing demand	0	0	0	0
Announced[a]	408	408	771	1587
Subtotal	408	408	771	1587
Total demand	1792	1531	2368	5691

[a] Represents projects that are in environmental review, seeking permits, or actively being constructed. Not all projects are guaranteed to be completed.
[b] Includes dedicated electricity generation from combined cycle, gasification, and co-firing with coal. Generation of electricity for on-site/co-generation use is not included.

Demand for liquid biofuels is driving the third area of anticipated growth. State mandates have led to the production of some 6.1 billion liters (1.6 billion gal) per year of corn-based ethanol in the region. Minnesota has the greatest capacity with 3.7 billion liters (984 million gal) annually and Wisconsin and Michigan producing about 1.7 (485 million gal) and 0.8 billion liters (210 million gal), respectively (Renewable Fuels Association, 2009). Growth of corn-based production has slowed, but the prospects for second-generation advanced biofuels are expected to increase. On the horizon, but not yet commercially realized is cellulosic ethanol using, among other feedstocks, forest-derived biomass. Multiple challenges will need to be overcome including the ability to combine feedstocks to maximize supply, scale and location of processing facilities relative to feedstocks, and the timing of feedstocks. But there exists an array of state and federal policies to facilitate development (Solomon et al., 2007), and in each of the three Lake States there is at least one serious project in development. All would use forest biomass as the primary feedstock (Table 1).

Recent studies indicate support for biofuels development in the region (Halvorsen et al., 2009), which is important because it will likely require continued state and federal support and financing during the initial investment period. The benefits may be substantial. A recent economic assessment found that one 76 million liter (20 million gal) per year cellulosic ethanol plant could gross USD $45 million per year (REMI, 2006). If biofuels

production is done in a way that it creates new jobs, as opposed to replacing existing forest products jobs the Lake States could be uniquely positioned to be a significant producer of biofuels and biochemical manufacturing, particularly where such processing could be done in conjunction with pulp production.

The concern, however, is that biorefining and cellulosic ethanol production could alter demand for forest biomass. Assuming a favorable production rate of 313 l per dry tonne (91 gal per dry ton) (Lynd et al., 2007), each proposed facility in Wisconsin and Minnesota would require upwards of an additional 408,000 dry tonnes and 771,000 dry tonnes in Michigan. Assuming an average of 0.9 dry tonnes of biomass-equivalent removed per hectare of productive timberland (2.5 dry tons per acre) (approximately 20% of standing volume in slash) (Sorensen, 2006), a minimum of 72,000 ha (178,000 acres) of integrated harvest operations would be required for every 152 million liters (40 million gal) of cellulosic ethanol production. As the yield per acre decreases, as it will in many areas, or as recover rates are lower significantly more hectares will be required.

6. Implications for a Lakes States bioeconomy

There are high expectations for a Lake States bioeconomy. Prospects exist for increased employment and economic benefits but they hinge financially on the ability to procure, transport, and utilize forest biomass in conjunction with agricultural residues. There is also potential for enhanced forest productivity through commercial thinning, which could increase the volume of biomass available for thermal heating, electricity, and biofuels production; all of which offers opportunities for reduced dependence on fossil fuels. The fundamental question, however, is whether a forest-based bioeconomy, and of what configuration, is sustainable in the Lake States.

The result of this analysis indicates that significant volumes exist but that availability depends on several interrelated factors. Key among them is the cost of biomass procurement, which we simulated as a function of biomass removal in conjunction with commercial sawlogs and pulpwood markets. Assuming a roadside price of USD $36 per dry tonne for biomass, upwards of 3.6 million dry tonnes may be available, which is sustainable at current levels. However, new prospects for thermal, electricity, and biofuels production increases demand to 5.7 million dry tonnes annually. That could increase even more as the ability to ship biomass feedstocks in and out of the region becomes profitable, particularly for meeting growing demand for pellets in Europe, Canada, and the northeastern US. Projected demand in Michigan and Minnesota of 2.4 and 1.8 million dry tonnes annually exceeds currently available supplies of 1.0 and 1.1 million dry tonnes, respectively. In Wisconsin, projected demand of 1.5 million dry tonnes is roughly equivalent to estimated availability. However, available volume is likely less because of differences in harvest rates by forest type, reluctance of private landowners to harvest timber, and local considerations for ecological, social, and practical concerns for procuring biomass.

Care must also be taken when comparing aggregate differences in projected demand with estimated biomass availability. First, not all announced projects are likely to be completed. As more facilities come on line and supply regions become established, projects still in development may be abandoned or moved to new locations with less competition. Second, the location of facilities and size of subsequent supply areas must be considered. Where procurement overlaps state or national boundaries and where multiple types of feedstocks may be used, aggregate state-level estimates may be inadequate for project-level planning, and where inaccurate they could undermine sustainability. State and region-wide estimates are useful for modeling the direct and indirect market impacts across emerging and existing forest products industries, but alone are insufficient.

From the perspective of existing forest products industries, increased demand for biomass, and subsequentially pulpwood, is a concern. Where subsidies for the production of cellulosic ethanol or other types of renewable energy are provided, for instance, subsequent increases in biomass demand to the price that it is competitive with pulpwood could have unintended impacts on existing markets and result in favoring one industry over another. A key issue is determining the highest and best use or value of biomass. Using wood for energy helps states meet their renewable energy mandates, thereby potentially reducing carbon emissions and creating jobs. The trade-off is that to the extent that using wood for energy displaces conventional forest industries, there may be a decrease in conventional forest products production and jobs, which could result in fewer trees harvested from which biomass is currently derived in an integrated harvesting operation. Dedicated whole-tree harvesting for stand-alone biomass extraction is an option but is financially viable only if users are able to pay more than current market prices.

It is estimated that an energy plant using 365,000 dry tonnes of biomass employs about 30 people (100 indirect jobs) and USD $20 million in economic value. That same 365,000 dry tonnes used in one existing pulp and paper mill employs about 500 people (2200 indirect jobs) and USD $328 million in direct product value (PFIC, 2006). One 76 million liter (20 million gal) cellulosic ethanol plant would contribute USD $45 million a year using 227,000 dry tonnes (REMI, 2006). However, optimizing the end use to maximize economic benefit is just one consideration. Values associated with environmental protection, recreation, wildlife habitat, and carbon sequestration, including the emergence of carbon markets also must be considered when determining the highest and best use. Informed public policy must in turn consider the impacts of financial and non-financial assistance on the range of forest industries.

7. Conclusion

The outlook for thermal heating, electricity, and biofuels production in the Lake States holds promise, but questions remain. When looking to the future with a focus on sustainability, the most significant need is accurate assessments of biomass availability. Statewide estimates, including the ones in this study, provide useful information but do not fully reflect local constraints and resource demands. The economics of harvesting and transportation, the value of different feedstocks, environmental site factors, and the social acceptability and availability on private and public lands must be better understood to gauge the extent to which a Lake States bioeconomy may expand, and subsequentially the role of policy incentives. This has important implications for other regions of the country where environmental safeguards like biomass harvest guidelines and third-party forest certification are less prevalent, but where there is interest in the creation and revision of policies encouraging the highest and best use of the available resource. Making this information available to bioenergy producers serves everyone's needs.

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