Local Environmental Considerations Associated with Potential Biomass Energy Projects in Cook County and Ely, Minnesota

Dovetail Partners
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Executive Summary

There are a number of environmental considerations associated with any energy system, including the potential use of biomass energy in northern Minnesota. To identify concerns and potential benefits of additional woody biomass harvesting in northern Minnesota – particularly in the Ely and Cook County areas, the study team reviewed literature, research and environmental studies addressing biomass energy and biomass harvesting. To specifically identify local concerns, interviews were conducted with diverse stakeholders in the project areas. Approximately twenty stakeholders in the project area were interviewed, including natural resource professionals, land managers, citizens and community officials. These individuals represented Federal, State, and local governments and councils as well as private citizens and industry. All stakeholders (or their office/position) were recommended to the study team as individuals knowledgeable about the pros and cons of woody biomass harvesting. Interviewees were also invited to recommend additional contacts. This report investigates the diverse environmental considerations associated with the use of woody biomass for energy in northern Minnesota as identified in these interviews as well as in relevant literature. This study is sponsored by the Legislative Citizen Commission on Minnesota Resources (LCCMR) and is a component of an extensive investigation of biomass energy project feasibility in Cook County and Ely, Minnesota.

The ecological effects on soils, wildlife, fire regimes, and water quality of using biomass for bioenergy depend on the existing condition of the forest stand and the amount of biomass to be removed over a specific period. The results depend on such factors as the timing of removal, the volume removed, and the nature of the biomass (e.g., bolewood, fine or coarse woody debris, harvest residuals, etc). According to the *Journal of Forestry*[1] scientific evidence from sites across North America suggests that the productivity of most sites is largely resilient to removing harvesting residuals. Overall, documentation of negative effects on site productivity due to biomass removal is rare (Malmsheimer et al. 2011). The project scenarios under consideration in Cook County and Ely are relatively small in terms of total biomass demand; however, their development still represents a potential change in forestry practices in the region and it is important to consider the impacts of that change.

Sustainable forest management practices are well known and widely practiced in Minnesota, as evidenced by the widespread participation in third-party forest certification, use of harvesting guidelines and best management practices, and continuing education programs for natural resource managers and harvesting professionals. These tools help protect the forests' environmental and ecological values. A recent meta-analysis of the scientific literature suggests the effects of biomass harvest on biodiversity can vary by harvesting practices and other factors. Biomass harvesting guidelines are recognized as an important tool for taking a precautionary approach to making use of

[1] *Journal of Forestry*, October/November 2011, 109(7S):S24-S26.

this energy resource. With scientific evidence lacking for significant negative project level impacts, harvesting guidelines can allow managers the flexibility to tailor prescriptions to site conditions, address limiting factors and promote analysis of the impacts across a scale that includes numerous ownerships and projects (Malmsheimer et al. 2011). In 2007, Minnesota established biomass harvesting guidelines to help address long-term biomass sustainability considerations. A study done in Minnesota concluded that following the biomass harvesting guidelines established by the Minnesota Forest Resources Council (MFRC) should mitigate concerns about soil nutrients, structure and wildlife habitat (Arnosti et al. 2008). An important area of focus is on ensuring the guidelines are well understood and being consistently implemented. Training and monitoring programs can help support and improve guideline implementation.

The study team found that there are a number of local concerns about biomass harvesting, including the potential impacts to soil resources, wildlife habitats, water quality, tourism and other factors. The study team also found that there is local interest in some potential benefits from biomass harvesting, including reduced wildfire risks, improved forest health, economic benefits, and local energy self-reliance. The current amount of forest product harvesting in the region is significantly lower than what research has found to be sustainable and the forest stocks are not in decline (i.e., annual net forest growth is positive). Based on the review, it is believed that sufficient biomass material is currently available and can be responsibly harvested to support the community-scaled biomass energy projects being evaluated in Cook County and Ely. To ensure that biomass energy systems can be responsibly maintained over the long-term, it is important that programs to implement and monitor the effective use of harvesting guidelines and other environmental safeguards be continued and widely adopted.

Project Area Map

Common Conversions

Energy Heating Values

Energy source	Factor	Unit	Moisture by weight
Coal	19,000,000	Btu/ton	--
Electric	3,413	Btu/kWh	--
Off-Peak Electric	3,413	Btu/kWh	--
#2 Heating Oil	140,000	Btu/gal	--
Kerosene	136,000	Btu/gal	--
Natural Gas	100,000	Btu/therm	--
Natural Gas	91,600	Btu/th. cu.ft.	--
Propane	91,600	Btu/gal	--
Cordwood	9,400,000	Btu/ton	35%
Clean Chips	9,600,000	Btu/ton	40%
Hog Fuel	8,800,000	Btu/ton	40%
Pellets	16,600,000	Btu/ton	10%

Common Forest Biomass Conversions[1]

Unit	Conversion
1 truckload of wood	23-26 green tons
1 green ton of wood	0.60 dry tons of wood (40% moisture content)
1 cord of roundwood	1.2 dry tons of wood (128 cu ft)
1 megawatt (MW) per year	5,300 – 7,000 dry tons of wood per year 85,000 – 110,000 million Btu per year powers approximately 750-900 homes per year

[1] One ton equals 2,000 lbs

Introduction

This report focuses on the environmental impacts of implementing biomass energy projects in Grand Marais (and greater Cook County) and Ely, Minnesota. Issues and concerns identified in this report are the result of interviews conducted with diverse stakeholders located in the project area. The findings in this report address environmental impacts relating to the forest resources. Specifically, this report uses published papers, research results, state of Minnesota guidelines, and public input to assess the positive benefits and negative consequences of biomass harvest. Guidelines, including in-place environmental safeguards for avoiding negative impacts, are also presented.

Biomass Availability for Projects in Cook County and Ely

Biomass is typically removed from a forest as part of a traditional harvesting operation, and can include a wide variety of materials, such as tree tops, limbs, bark, and trunks (bolewood). To the extent that biomass fuels include the use of bolewood, they can compete with traditional forest production markets. Biomass is rarely removed as a stand-alone product because it is generally not economically viable to conduct an operation that will only yield low value biomass materials. Wildfire risk reduction treatments (e.g., Firewise) or other restoration efforts may include biomass removal, but often the material is not utilized because it is not economical to haul it to the existing markets. This material is often piled and open burned as a disposal method or left in piles in the woods to decompose. Biomass can also result from the removal of dead or dying trees, hazard tree removals, right-of-way clearings and other diverse tree and forest care activities. Because woody biomass is most commonly a by-product of traditional timber harvesting, an evaluation of biomass sustainability occurs within the context of overall timber and forest sustainability.

Minnesota's Ecological Classification System

The Minnesota Department of Natural Resources (MN DNR) and the U.S. Forest Service have developed an Ecological Classification System (ECS) for ecological mapping and landscape classification in Minnesota. This system is used to identify, describe, and map areas of land with identified ecological features. The system uses associations of biotic and environmental factors, including climate, geology, topography, soils, hydrology, and vegetation. ECS mapping enables resource managers to consider ecological patterns and identify areas with particular management opportunities or constraints.[2]

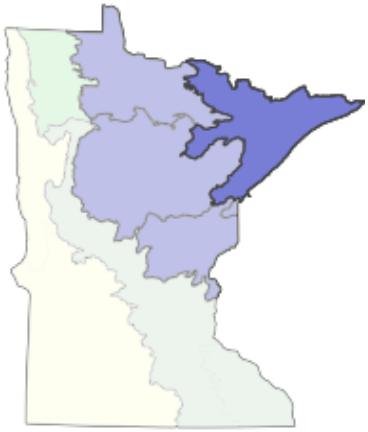
Northeastern Minnesota is encompassed by the Northern Superior Uplands Section which includes five subsections, the Border Lakes, Laurentian Uplands, Nashwauk Uplands, North Shore Highlands, and Toimi Uplands.

The underlying ecological conditions associated with this section and these subsections (described below) provide important context for understanding environmental impacts of changes in forest management, including potential increases in biomass harvesting.

[2] Information source: MN DNR, http://www.dnr.state.mn.us/ecs/index.html

Northern Superior Uplands Section

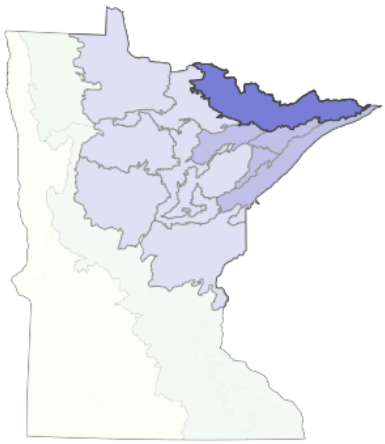
Figure 1. Northern Superior Uplands Section



The Northern Superior Uplands Section (NSU) largely coincides with the extent of the Canadian Shield in Minnesota. The NSU is characterized by glacially scoured bedrock terrain with thin and discontinuous deposits of coarse loamy till and numerous lakes. The section has high relief, reflecting the rugged topography of the underlying bedrock and receives more of its precipitation as snow than any other section in the state. This area also has the longest period of snow cover and the shortest growing season. The upland vegetation is remarkably uniform, consisting mostly of fire-dependent forests and woodlands. Forests with red and white pine were widespread in the past, mixed with aspen, paper birch, spruce, and balsam fir. Much of the pine was cut in the late 1800s and early 1900s, leaving forests dominated mostly by aspen and paper birch. Jack pine forests are present on droughty ridges and bedrock exposures, as well as on local sandy outwash deposits. The highlands along Lake Superior have a local climate moderated by the lake that favors forests dominated by sugar maple with some white pine, yellow birch and white cedar. Peatlands and wet forests are present as inclusions within broader upland forest areas. Sparsely vegetated cliffs and bedrock outcrops are common in the rugged terrain along Lake Superior and in the border lakes region of the northern part of the section.[3]

Border Lakes

Figure 2. Border Lakes Subsection

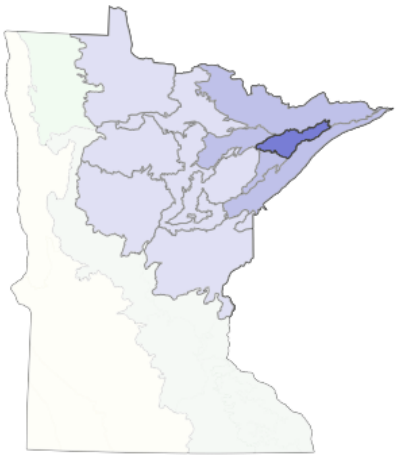


Lakes and rocky ridges characterize this landscape of glacially-eroded bedrock and poor soils. Historic forest types on uplands were mostly aspen-birch, aspen-birch-conifer, and on dry sites, jack pine barrens. Much of this subsection consists of the Boundary Waters Canoe Area Wilderness (BWCAW), an internationally known and locally important wilderness area. Recreation, tourism, and forestry are the major land uses. Most of the subsection remains forested, with most forest types persisting with stand composition and structure similar to that present originally (i.e., presettlement). Logging occurred within the subsection, but large areas remain unlogged. The average interval between significant fire years was about 4 years in presettlement time and a natural fire rotation of about 100 years was characteristic of the area. [4]

[3] Information Source: MN DNR, http://www.dnr.state.mn.us/ecs/212L/index.html

[4] http://www.dnr.state.mn.us/ecs/212La/index.html

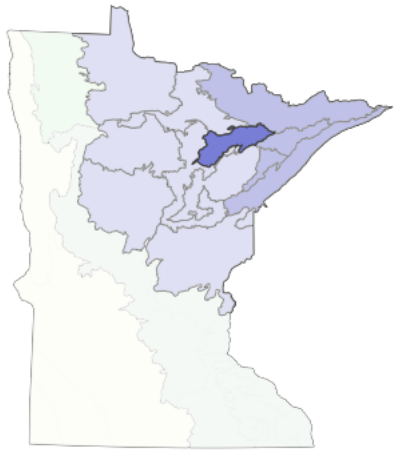
Figure 3. Laurentian Uplands Subsection



Laurentian Uplands

Brown glacial sediments form the parent material for much of this subsection. Landforms include till plains and outwash plains. Soils are varied and range from medium to coarse textures. This region consisted of forest communities dominated by aspen-birch, jack pine barrens, and red pine and white pine on the uplands, and conifer bogs and swamps on the lowlands. Forestry is the most important land use presently with some mining occurring on the northwest corner of the subsection. The major rivers in this subsection are the Cloquet and the St. Louis both of which flow to Lake Superior. The central two-thirds of the subsection drains north into the Rainy River. Presettlement vegetation was a mixture of deciduous and coniferous trees. Areas with sandy loam till were predominantly aspen-birch trending towards conifers with smaller areas of white pine-red pine forest. Jack pine barrens were present on areas with sandy subsoils. Wetland vegetation included conifer bogs and swamps. Forest management is the most important land use in this subsection. There are extensive areas of forested public land, which are managed for wood products and recreation. Quaking aspen is the dominant tree species presently. Fire appears to be the predominant disturbance historically.[5]

Figure 4. Nashwauk Uplands Subsection



Nashwauk Uplands

Brown glacial sediments form the parent material for much of this subsection. Landforms include end moraines, outwash plains, and lake plains. Soils are varied and range from medium to coarse textures. One unique aspect of this region is the Giants Range, where the majority of iron mining in Minnesota takes place. It is a high narrow ridge trending northeast to southwest and caused by bedrock. This region consisted of forest communities dominated by white pine, red pine, balsam fir, white spruce, and aspen-birch. Forestry and mining are the most important land uses presently. The Continental Divide follows the summit of Giant's Range. Water flowing north eventually goes into Hudson Bay. On the west side, waters flow into the Mississippi River watershed. To the south, water flows into Lake Superior. Presettlement vegetation was a mixture of deciduous and coniferous trees. White pine-red pine forest and jack pine barrens were common on outwash plains. Aspen-birch forest and mixed hardwood-pine forest were present on moraines and till plains. Wetland vegetation included conifer bogs and swamps. Land ownership is roughly equal between public and private in St. Louis County and mostly public or forest industry in Itasca County. Quaking aspen is the dominant tree species presently. Forest management and recreation are the most important land uses in this subsection. Mining is also an important land use. Windthrow had the strongest impact on the moraines. Fire had a lesser impact overall but was more prominent on the outwash plains.[6]

[5] http://www.dnr.state.mn.us/ecs/212Le/index.html

[6] http://www.dnr.state.mn.us/ecs/212Lc/index.html

Figure 5. North Shore Highlands Subsection

North Shore Highlands

This subsection occupies the area adjacent to Lake Superior. It is gently rolling to steep. Bedrock outcroppings are common and soils are commonly shallow. Soils are formed in red and brown glacial till and are very rocky. Lake Superior dominates this region. It moderates the climate throughout the year, acting as an air conditioner in summer and a heat sink in winter. Presettlement vegetation was forest, consisting of white pine, red pine, jack pine, balsam fir, white spruce, and aspen-birch. Glacial drift is thin over the entire subsection and bedrock is exposed or near the surface in large areas. The growing season on Lake Superior is about 10 days longer than at the equivalent latitude 6 miles inland. White pine-red pine forest was most common on the clay lake plain and on thin soil over bedrock in the southern half of the subsection. Mixed hardwood-pine forest, with sugar maple, was concentrated on the ridges of the dissected clay lake plain and the Highland Flutes. In the northern half of the subsection, aspen-birch was dominant, with very little white pine-red pine forest or mixed hardwood-pine forest. Mixed hardwood-pine forest persisted on ridgetops in areas within 6-10 miles of the shoreline. Following logging, the extensive white pine-red pine forests have been replaced by forests of quaking aspen-paper birch. Present land uses include recreation, tourism, mining and forestry. There are no mines within the subsection, but ports were set up to get ore from the iron range to distant steel mills. Fire was an important disturbance. This is readily apparent in the northern half of the subsection, where there was a dominance of aspen-birch stands, which are pioneer species. Spruce budworm defoliation was and continues to be a significant disturbance to stands of balsam fir and spruce.[7]

Figure 6. Toimi Uplands Subsection

Toimi Uplands

Topography is rolling, with a washboard-like pattern of ridge and troughs. Presettlement forests were a mixture of coniferous and deciduous trees. Soils are formed in medium to coarse-textured Superior and Rainy lobe glacial till. Forestry is the most common land use today. Drumlin ridges are typically about a mile long, ¼-mile wide, and 30 to 50 feet high. The drumlins are oriented in a southwest-northeast direction. Their parallel arrangement is like a landscape-scale washboard. Interdrumlin areas are usually poorly or very poorly drained. Streams are common and most flow southwest because of drumlin orientation. Upland soils on the drumlins are well-drained sandy loam with many stones. Between the drumlins are depressions with very poorly drained soils. The major forest type found on drumlin ridges was aspen-birch trending to conifers, with only small areas of white pine-red pine forest. Conifer swamp or bog occupied the depressions between most of the drumlins. This unit is still dominantly forested, most of

[7] http://www.dnr.state.mn.us/ecs/212Lb/index.html

which is in public ownership. The most important land use is forestry. Much of the upland is occupied by quaking aspen, either in relatively pure stands or mixed with balsam fir. Recreation is important around areas where there are lakes and rivers. Hunting is popular because of the extensive amount of public land in this unit. Fire occurred frequently enough to keep much of the unit in aspen-birch forest. The interdrumlin lowlands, with significant areas of sedge meadows, channeled fires in a southwest-northeast direction. When southwest winds were strong, fire would burn a significant portion of the uplands. Windthrow was another significant natural disturbance.[8]

Potential Bioenergy Projects in Cook County and Ely

The feasibility of biomass energy systems in Ely was first examined in 2010, in a study which included a district heating and combined heat-and-power (CHP) option for the residential and business core of the community. Five additional options for two smaller sites were analyzed by – the USDA Wood Education and Research Center during the spring of 2012. Drawing from these two studies, seven total options for biomass energy systems in Ely are under consideration (Table 1). Site 1 includes Vermillion Community College (VCC). Site 2 includes the Ely-Bloomenson Community Hospital (EBCH), Sibley Manor, and Independent School District 696 (ISD 696). The potential for combined heat and power (CHP) is also reviewed for Site 2. Site 3 looks at district heating and CHP options for larger community areas.

Table 1. Modeled systems, fuel types, and biomass demands for Ely.

Configuration	Fuel Type*	Annual biomass demand *dry tons (wet tons)*
Site 1: Vermillion Community College (VCC) Hot Water	Chips/Hog	527 (878)
Site 2: Steam & Hot Water	Chips/Hog	1,754 (2,924)
Site 2: Hot Water	Chips/Hog	1,754 (2,924)
Site 2: Backpressure Steam CHP	Chips/Hog	1,904 (3,174)
Site 2: ORC CHP	Chips/Hog	2,838 (4,730)
Site 3: Ely District Heating (base)[1]	Hog fuel	5,974 (9,957)
Site 3: Ely ORC CHP (base)[2]	Hog fuel	7,858 (13,096)

[1] Assumes 55-60% of heat load with peaking backup for coldest days.
[2]District heating portion of a CHP system; a stand-alone district heating system was not analyzed in the LHB report.
*Chips— a type of wood fuel. Clean chips are wood fiber processed by chipping and that is free of contaminants like bark and needles, and generally includes only the bolewood of a tree. Clean chips are suitable for residential and small industrial heating applications. Hog fuel— a type of wood fuel generated by grinding wood and wood waste, including bark, leaves, branches, and tops of trees. Wildfire fuels reduction treatments and whole tree harvesting produce hog fuel, which is used for industrial, district heating and CHP applications.

The considered Cook County options (Table 2) include four scenarios. The first option, referenced as M1, consists of the main building and guest cabins at Lutsen Resort on the south side of the Poplar River, approximately 20 miles south of Grand Marais on Hwy 61. Lutsen Resort serves as a proxy for similar sized, large resorts and small business clusters in the county. The second option, referenced as L3, consists of a distributed hot water heating system for the public buildings north of 5th Street in Grand Marais. The L3 scenario would serve 10 large customers, including the Cook County Hospital and Care Center, Sawtooth Mountain Clinic, Cook County Law Enforcement Center, and Cook County Schools. The third option, referenced as L6, consists of a distributed hot

[8] http://www.dnr.state.mn.us/ecs/212Ld/index.html

water heating system for the above described L3 option and the downtown business district, with 75 potential customers. The fourth option included in this report consists of a hybrid of the L3 and L6 options, and is referenced as Hybrid. A total of 21 customers could be served in the Hybrid while allowing for the addition of future customers in conjunction with other scenarios analyzed.

Table 2. Modeled systems, fuel types and biomass demands for Cook County.

Configuration	Fuel type*	Annual biomass demand *dry tons (wet tons)*
M1: Heat for main lodge and guest cabins at Lutsen Resort	Chips	390 (650)
L3: Public buildings north of 5th Street N and CC Courthouse	Chips/Hog	940 (1,567)
L6: District heat for downtown business district and L3	Chips/Hog	2,450 (4,083)
Hybrid: Combination of L3 and L6 scenarios for largest users	Chips/Hog	1,940 (3,233)

[1] Assumes 55-60% of heat load with peaking backup for coldest days.

*Chips— a type of wood fuel. Clean chips are wood fiber processed by chipping and that is free of contaminants like bark and needles, and generally includes only the bolewood of a tree. Clean chips are suitable for residential and small industrial heating applications. Hog fuel— a type of wood fuel generated by grinding wood and wood waste, including bark, leaves, branches, and tops of trees. Wildfire fuels reduction treatments and whole tree harvesting produce hog fuel, which is used for industrial, district heating and CHP applications.

In reviewing the potential impacts of these energy systems in Ely and Cook County, it is important to recognize that several of the options are mutually exclusive (e.g., the "Hybrid" option could replace L3 and L6 in Cook County). However, some of the options are additive (e.g., M1 and L3 could both be developed in Cook County). In other words, the total resulting biomass demand could be some combination of the numbers shown in the last columns of Tables 1 and 2. Even with an assumption that multiple projects are developed, the scale of the biomass demand is relatively small. For example, if M1, L3, and L6 were developed in Cook County, the total annual biomass demand would be approximately 6,300 wet tons or about 250 truckloads (equivalent to less than one truckload per day). The scale is similar in Ely, with the largest scenario equivalent to less than two truckloads per day. Thought of another way, the biomass demand for these projects represents less than two percent of the annual harvest activity currently occurring within the project area (e.g., within 60 miles of Ely and Grand Marais).[9] However, although the project scenarios are relatively small in terms of total biomass demand, their development still represents a potential change in forestry practices in the region and it is important to consider the impacts of that change.

GEIS as an "Umbrella Approach" to Evaluate Environmental Impacts from Forestry

In Minnesota, there is a long history of evaluating timber sustainability and many resulting reports, studies, guidelines and best practices. A citizens' petition was brought before the Minnesota Environmental Quality Board (EQB) in July 1989 that requested the EQB to prepare a Generic Environmental Impact Statement (GEIS) on the cumulative impacts associated with timber harvesting and forest management in Minnesota. The final document (GEIS) was prepared via a

[9] Data derived from the report "Supply and Preliminary Financial Analysis of Potential Biomass District Energy Systems – Ely and Cook County, MN (DRAFT UMN Report to Dovetail Partners)"

multiple year effort and released in April 1994.[10] The Department of Forest Resources, University of Minnesota, published a follow-up analysis of the GEIS in August 2005.[11] There are current efforts underway to provide another update to this information as well.

The GEIS evaluated environmental impacts of three possible annual statewide harvesting scenarios: a base scenario (4 million cords), medium (4.9 million cords), and high (7.0 million cords). The evaluation considered a range of sustainability indicators (described below) and offered recommendations to support forest sustainability in the state.

This report for Ely and Cook County uses the GEIS as a framework to explore potential environmental impacts relating to biomass harvesting. The GEIS is only one approach (one source of information) to frame the environmental impacts of increased biomass harvests. As noted in the section addressing Local Concerns, the GEIS has limitations. Additional sources of information, including input from stakeholder interviews, published research, guidelines and reports are also referenced.

Baseline Harvest

In the GEIS, a baseline statewide harvest for Minnesota was "set" at 4 million cords per year (4 million cords was the actual statewide harvest in 1990). This harvest level was determined through research, forest growth data, and modeling to be well below the estimated biological maximum level of sustainable yield over a 50-year planning horizon. Although it may seem obvious to some, it is important to clearly state that the Grand Marais/Cook County and Ely scenarios (Tables 1 and 2) require a volume of wood and level of harvesting activity (in combination with other existing timber harvests) well below the baseline scenario evaluated in the GEIS.

Timber harvesting activity in Minnesota has declined since the 1990s, in large part due to declines in the housing market in recent years. In 1990, the statewide harvest was 4 million cords. In 2009, total wood harvest in Minnesota was 2.73 million cords. Preliminary data suggest that harvest levels for 2010 and 2011 are also within the 2.6 to 2.9 million cord range. Inventory data also show that forest growth greatly exceeds wood harvest in the state. Minnesota is experiencing annual net timber growth of approximately 5.6 million cords (approximately twice as much as the current annual harvest rate). The net growth is calculated after subtracting for mortality and harvesting. Forest stocks are increasing across Minnesota, and within the project area of northeastern Minnesota. These data support the belief that there are significant volumes of wood potentially available for additional harvest.[12]

Indicators of Sustainability

There are a number of sustainability indicators (impacts) relating to timber harvests and forest management that can be extended to apply to biomass harvesting. The following impacts were evaluated within the GEIS and the summary below reflects outcomes associated with a baseline harvest scenario as reported in the original GEIS as well as updates from recent research.[13]

[10] http://iic.gis.umn.edu/download/geis/main/geisf_con.pdf

[11] http://iic.gis.umn.edu/documents/Staffpaper182.pdf

[12] Data derived from the report "Minnesota's Forest Resources, 2011" published in June 2012 and available at: http://www.dnr.state.mn.us/forestry/um/index.html

[13] This section was adapted from the GEIS Executive Summary, published in April, 1994.

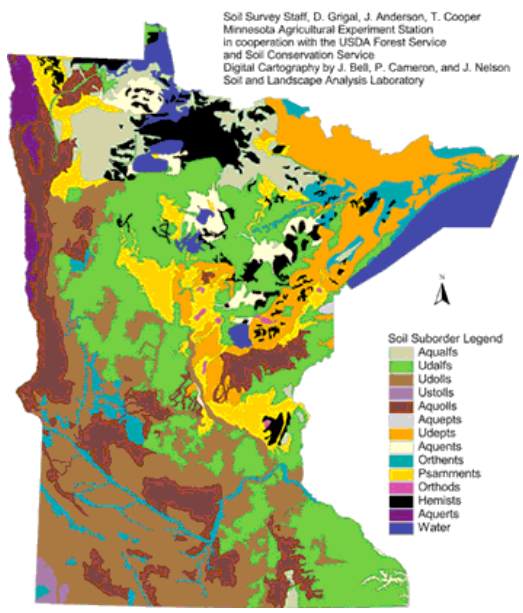
Soil Resources: Soils are a vital resource and protecting them is essential to forest sustainability. Research has found that harvesting the merchantable bole (the main stem of the tree) does not significantly impact soil nutrients in most situations. Harvesting trees from a site once every several decades does not remove either nitrogen or phosphorous beyond their rates of replenishment. These nutrients are replenished by annual leaf fall and other nutrient cycling processes in the forest. Harvesting can have greater impact on sites with poor soils or on micronutrients that may be limited in some situations. Sites with poor soils are generally less productive (e.g., slower rates of tree growth) and therefore not a primary focus of active forest management and harvesting. Areas at risk for loss of calcium are most closely associated with harvest of aspen-birch and upland hardwoods on medium-textured soils and especially on coarse-textured soils. Loss of magnesium beyond rates of replenishment is associated with harvest on coarse-textured soils and organic soils. Potassium loss is primarily associated with harvest of aspen-birch on coarse-textured soils and the harvest of all deciduous types on organic soils. When biomass harvesting is combined with traditional harvesting, it can be characterized as full tree harvesting. During full tree harvesting (removal of the main stem of the tree as well as large and small branches), calcium losses increase slightly compared to merchantable bole harvest (traditional timber removals) and losses for magnesium and potassium are significantly increased under these conditions. It is for these reasons that biomass harvesting is restricted or not allowed on sites with lower nutrient (poorer) soils. The figure (Figure 7) illustrates a decision-tree approach to evaluating site quality and determining strategies for nutrient management and the appropriateness of harvesting materials for bioenergy production. Minnesota's biomass harvesting guidelines follow a similar approach that results in limiting bioenergy production for sites with low or very-low fertility.

Figure 7. Decision Tree Approach to Bioenergy Production and Nutrient Management

Source: *WIREs Energy Environ* 2012, 1: 152–164 doi: 10.1002/wene.3

The effects of nutrient losses on long-term site productivity (LTSP) are uncertain per the 1994 GEIS. A 2012 paper prepared for the Minnesota Forest Resources Council (MFRC) reported, "Evaluation of three LTSP experiments for medium-term impacts of biofuels harvests on forest site productivity suggest slash removal impacts vary by soil type. Overall, results indicate that the impacts of biomass harvests are persistent even after 15 years and may influence the sustainability and resilience of aspen-dominated forest communities in the future, particularly on less productive sites." Impacts were found to be neutral to positive on clay and loam soils, and negative on sandy soils.[14] Compaction and related disturbances would be most frequent on the well-drained medium-textured soils, and the poorly-drained medium and poorly-drained fine soils which have the lowest strength. Surface erosion rates were significant on less than 1 percent of the statewide area plus haul roads; and the significant impact was predominantly outside of northeastern Minnesota.

Figure 8.



The soils of northeastern Minnesota (Figure 8) are dominated by Udepts, which are described as "…soils of the mixed conifer-deciduous forest. These soils primarily occur under forest vegetation in the northern two-thirds of the state. The parent material of these soils is primarily glacial till from the rocky northeastern part of the state, and so these soils are low in lime and contain many large boulders. Now they are primarily covered by aspen forests, although they once were dominated by red and white pine. Aspen on these soils does not grow quite as well as aspen on the alfisols." The region also has areas of "Orthents" which are "…shallow or poorly developed soils. In northeastern Minnesota, they occupy tops of ridges where outcrops of rock are common. The trees that are present are usually pine."[15]

A study done in Minnesota concluded that following the biomass harvesting guidelines established by the Minnesota Forest Resources Council (MFRC) should mitigate concerns about soil nutrients, structure and wildlife habitat (Arnosti et al. 2008). Using the guidelines, biomass collection is restricted on sites with deep organic soils, low soil nutrients, or other limiting factors.

By following the biomass harvesting guidelines, the amount of biomass that can be responsibly harvested in an area is potentially significantly less than the total forest biomass growing in that area. For example, land managers have reported that in recent harvest planning approximately one-third of timber sales administered by the Tower office of DNR-Forestry (Orr, Cook, Tower, Ely area) do not allow biomass harvest due to sites with organic, very shallow, or infertile (fine sand) soils (in addition to other protocol addressing wildlife habitat and water quality as outlined in the

[14] http://www.frc.state.mn.us/documents/council/MFRC_RAC_Impacts_BiomassHarvest_Aspen_2012_Report.pdf

[15] Figure 8 and additional soil descriptions are available at:
http://www.extension.umn.edu/distribution/cropsystems/dc2331.html

MFRC Voluntary Site Level Biomass Harvesting Guidelines). The U.S. Forest Service also restricts biomass harvest on these types of sites on National Forest System lands.

As an example of the impact of the guidelines on limiting biomass and protecting sensitive sites, a recent (2012) timber auction in the project area is summarized in the following table (Table 3). Just over half (53%) of the sites excluded or did not include biomass harvesting due to site limitations and application of the guidelines. It is also interesting to note that in this one auction, a total of 3,025 green tons of biomass were offered, which would be sufficient for meeting the *annual* needs of several of the bioenergy projects being evaluated in Cook County and Ely.

Table 3. Example of Biomass Supply and Harvesting Guideline Use in a Recent Public Lands Timber Auction in Northern Minnesota (2012)

	# of sites	**Area** *(acres)*	**Estimated available biomass** *(green tons)*
Excluded or did not include biomass harvesting	9	560	*Not applicable*
Included allowable biomass harvesting	8	286	3,025
Total	17	846	3,025

Source: Data compiled by the authors from MN DNR timber auction data, June 2012

Figure 9. Forest Types within 60-mile supply zone of Grand Marais, MN

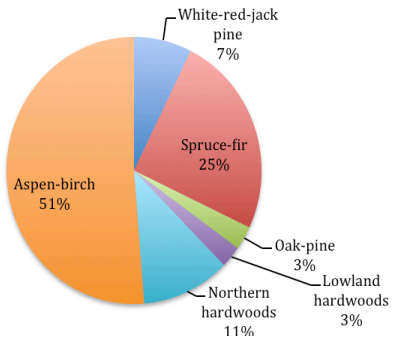
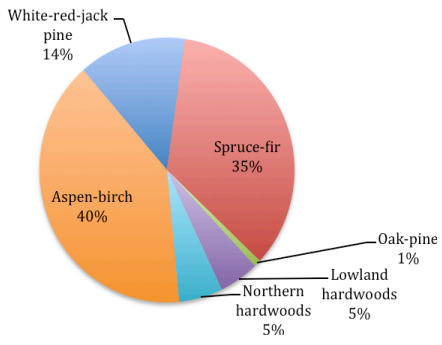


Figure 10. Forest types within 60-mile supply zone of Ely, MN



Forest Health: For most forest types, insect and disease problems are closely related to the age class structure and overall tree vigor. In general, the forests of Minnesota, and within northeastern Minnesota, are dominated by mature tree stands, including many aspen forests that are over 50 years old. For example, in a supply zone of 60-miles around Grand Marais the aspen-birch forest type occupies 415,659 acres (51% of timberland) and spruce-fir occupies 200,027 acres (25% of timberland) (Figure 9). Of those acres, 53% and 42%, respectively, are greater than 60 years old and are either at or beyond their target harvest rotation age and are experience health declines (Table 4). Similar data is shown for the region around Ely, MN (Figure 10, Table 5). Designated wilderness areas, old-growth reserves, wildlife management areas, state parks, and towns are not included in this analysis. Within the 60-miles around Grand Marais and Ely there are approximately 68,000 and 117,000 acres, respectively, that are in various protected categories of land use and have been removed from the analysis.

Older stands often, but not always, are the most susceptible to outbreaks of insect and disease. Consequently, harvesting as it affects age class structure and tree vigor, is an important factor in managing forest health. Forest management can be preventative and help keep retained trees healthy and in good condition to withstand insect or disease stresses. Forest management can also be reactionary and implemented in response to a forest health

problem to reduce further spread of the threat or reduce the risk of wildfire or secondary problems related to increased fuel loading and dead or dying trees. Aside from unanticipated catastrophic outbreaks of pest problems, forest health is generally manageable and can be improved through stewardship. Markets for biomass may provide new opportunities for managing forest health where appropriate and compatible with other land use objectives.

Table 4. Timberland acres by age class and forest type in the Grand Marais 60-mile biomass supply zone (2006-20010 inventory cycle; non-stocked areas excluded).

Age class	White-red-jack pine	Spruce-fir	Oak-pine	Lowland hardwoods	Northern hardwoods	Aspen-birch
0-10	8,680	2,625	6,449	2,495	4,531	47,766
11-20	11,606	17,706	0	0	3,240	34,578
21-30	12,597	25,040	5,095	0	5,440	29,803
31-40	4,940	19,860	0	0	3,450	15,894
41-50	5,202	21,754	6,136	0	2,912	18,437
51-60	6,971	29,900	0	0	3,641	48,540
61-70	5,461	15,291	0	3,383	22,091	93,417
71-80	0	9,957	2,682	5,093	23,848	68,548
81-90	0	7,200	0	9,559	11,218	35,570
91-100	728	17,763	2,912	0	0	8,875
100+	3,370	32,931	0	993	10,346	14,231
Total	**59,555**	**200,027**	**23,274**	**21,523**	**90,717**	**415,659**

Table 5. Timberland acres by age class and forest type in the Ely, MN 60-mile biomass supply zone (2006-20010 inventory cycle; non-stocked areas excluded).

Age class	White-red-jack pine	Spruce-fir	Oak-pine	Lowland hardwoods	Northern hardwoods	Aspen-birch
0-10	2,355	21,116	2,184	1,620	18,979	73,276
11-20	14,819	24,463	3,061	6,852	6,212	102,385
21-30	33,409	34,537	1,670	2,487	5,501	67,327
31-40	34,669	30,376	2,912	3,826	6,990	60,465
41-50	33,893	40,139	0	6,131	8,120	43,238
51-60	12,938	60,551	0	728	5,013	57,996
61-70	18,639	103,918	728	12,089	8,886	106,335
71-80	13,263	66,059	0	28,933	14,711	79,573
81-90	27,535	39,867	0	10,834	2,912	22,207
91-100	0	29,938	0	3,889	2,184	15,973
100+	28,343	109,683	3,061	3,982	10,117	17,955
Total	**219,863**	**560,647**	**13,616**	**81,371**	**89,625**	**646,730**

Wildlife: Changes in forest conditions result in direct changes to wildlife habitats. When the forest changes, there are some species that will benefit from the change and other species that will see their preferred habitat reduced. Whether the change in forest conditions is the result of natural disturbance or planned management activities, there are impacts to wildlife that can be predicted based on what is known about their habitat requirements. Impacts on specific state or federal-listed wildlife species (birds, mammals, reptiles and amphibians) were assessed by several criteria in the GEIS.

Birds

There were four state- or federal-listed, forest-dependent bird species considered in the GEIS analysis that either breed or migrate through northeastern Minnesota. At the base level of harvesting, these bird species were impacted in the following manner:

> Osprey – An overall statewide increase is predicted, both on timberland and for all forest lands.
> Bald Eagle – Stable populations are predicted.
> Red-shouldered hawk – An overall statewide decrease is predicted on timberland and on all forestlands.
> Loggerhead Shrike – A significant increase in statewide populations on timberlands and all forest ands is predicted.

Mammals

For mammals, one state-listed, forest dependent small mammal—the pine marten—was considered in the analysis. It was found to have stable or increasing populations at the base level of harvesting. The threatened large mammal (state and federal)—timber wolf—was expected to have no appreciable direct impact at the base level.

Reptiles and Amphibians

For reptiles and amphibians, there were four state-listed forest-dependent species considered in the base-level harvesting analysis. Only one species—the wood turtle—is found in Northeastern Minnesota. It is predicted to have a stable or slightly increasing habitat statewide.

The less sensitive populations for non-listed species of game and non-game wildlife are unlikely to be significantly affected either positively or negatively at the baseline level of harvest, as this level of activity does not significantly alter the overall distribution of habitat types. Monitoring the population trends of more sensitive wildlife species is an important way to evaluate long-term land use impacts. Minnesota's biomass harvesting and site-level guidelines, as discussed in the Safeguards section, also restrict timber or biomass harvesting in sensitive habitat areas, including riparian areas and wetlands.

Water Quality and Fisheries: Timber harvesting is, by nature, a disturbance to the forest and the landscape. The degree to which a given disturbance (e.g., timber harvesting) represents an *impact* is a matter of scale. Specific changes that occur during and after harvesting can impact water quality and associated fisheries. These changes include the quantity and rate of runoff, increased sedimentation, and water temperature increases. The scale of these changes can be mitigated through the use of best management practices and Minnesota's Voluntary Site-Level Forest

Management Guidelines,[16] which protect riparian areas, provide for buffer strips and help prevent soil erosion associated with access roads and skid trails. Maintaining trees and vegetation along tributary streams helps prevent changes in water temperatures and captures sediment or runoff from the site before it enters the stream channel. Properly constructed roads and well-maintained culverts further reduce negative impacts to water quality or fish movement. Timber harvest that complies with Minnesota's Voluntary Site-Level Forest Management Guidelines will have significantly fewer local water resource impacts than timber harvest carried out in the absence of such practices. These guidelines are mandatory on public lands in Minnesota, including the state and county lands, which represent major land ownerships in northeastern Minnesota. Federal lands, including the national forests in northeastern Minnesota are managed using similar federal guidelines that protect water resources by requiring buffer strips and set-aside areas around streams, wetlands, and other water features. The guidelines also reduce impacts to soil resources, wildlife and other important forest conditions. Research and monitoring has shown a high level of compliance with the site-level guidelines addressing water quality protections.

Recreation and Aesthetics: Many parts of Minnesota, including the Arrowhead Region benefit from tourism associated with outdoor recreation and enjoyment of nature. Visitors to the Boundary Waters, National forests, and various parks, trails and recreation areas help provide jobs and economic benefits in northeastern Minnesota. Changes in land use and forest management activities can impact the visitor's experience. Changes in aesthetics can also impact the experience of full-time residents and property owners in the region.

Harvesting and road development to access timber or to support forest management can result in an increased level of disturbance. Improved access provides opportunities for additional use by people who depend on motorized access. However, this can displace a proportion of existing users who are adversely affected when the level of human contact increases (e.g., cross county skiers vs. snowmobile riders). The GEIS found that less than one-third of the primitive and semi-primitive non-motorized areas on timberland[17] would be significantly impacted by the base level of harvest.

The GEIS investigated the use of visual management guidelines (VMGs), which are planning tools used by land managers to reduce visual impacts due to timber harvesting. Significant impacts can be avoided if visual planning is used to identify where and how harvesting and associated forest operations should take place (i.e., road location, use of buffers, size and shape of cut, and slash and debris disposal). Harvesting can reduce the aesthetic experience for some users, as well as create additional recreational opportunities of a more developed type (i.e., road and access development). Significant visual impacts can occur when timber harvesting and forest management activities do not follow VMGs.

Guidelines for reducing negative visual impacts are included in the Voluntary Site-Level Guidelines for Forest Management. These guidelines are followed by public land managers as well as private lands enrolled in the Sustainable Forestry Incentives Act (SFIA) program (see below for description of SFIA). Also, visual management guidelines are addressed in certification (see Safeguards section) programs used to manage state, county, and many industrial lands in northeastern Minnesota.

[16] http://files.dnr.state.mn.us/forestry/biomass/biomassHarvestingGuidelines.pdf

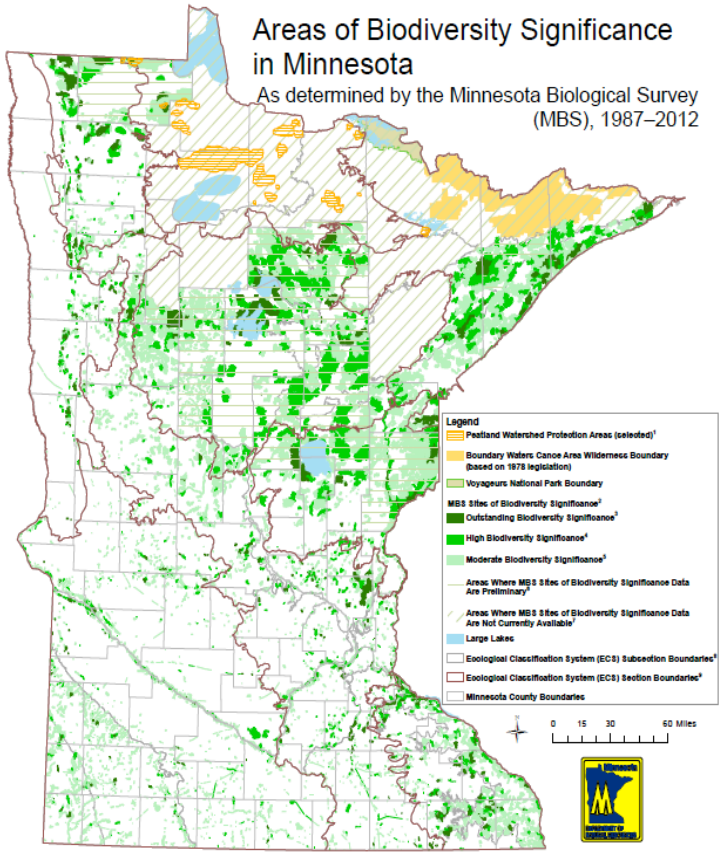
[17] Timberland is forestland available for harvest and is a portion of total forestland. As an example, the BWCAW is NOT designated as timberland (not available for harvest) although the area is considered forestland.

Unique Cultural and Historic Resources: Insufficient data was available at the time of the original GEIS to prepare even a qualitative assessment of the extent to which cultural and historical sites could be impacted by various harvesting rates. Since the original GEIS was completed, the Voluntary Site-Level Guidelines for Forest Management were completed. The guidelines include steps to be taken to effectively minimize and avoid negative impacts to these resources, including training for land managers and harvesting professionals on the field identification of cultural and historic sites. A statewide database is maintained by Minnesota's State Historic Preservation Office (SHPO) to record known locations and monitor conditions. Land managers utilize this database in management planning and contribute to its maintenance.

Local Environmental Concerns in Cook County and Ely

Biomass harvesting raises diverse environmental concerns. Whereas the GEIS provides a broad framework to evaluate potential impacts, it is also important to look at specific local concerns. The following discussion focuses on issues that have been voiced regarding increasing biomass harvests in northeast Minnesota and/or are based on common concerns (e.g., frequently asked questions) raised during the environmental evaluation of community-scaled bioenergy projects.

Figure 11. Minnesota County Biological Survey



In an effort to identify local concerns or potential benefits of additional woody biomass harvesting in northern Minnesota – particularly in the Ely and Cook County areas, interviews were conducted with diverse stakeholders in the region. Approximately twenty stakeholders in the project area were engaged in the interviews including natural resource professionals, land managers, and community officials. These individuals represented Federal, State, and local governments and councils as well as private citizens and industry. All stakeholders (or their office/position) were recommended to the study team as individuals knowledgeable about the pros and cons of woody biomass harvesting. Interviewees were also invited to recommend additional contacts. The following sections report and discuss local concerns raised through these interviews.

Location of Harvests and Supply

A common concern is that biomass harvesting may negatively impact specific sensitive sites and locations or result in overharvesting of the forest. While these risks are difficult to eliminate completely, there are several tools in place and being further developed to protect these sites and address this concern.

The Minnesota County Biological Survey (MCBS) is one example of a process currently underway to identify sites containing a high occurrence of rare plants, rare native plant communities, and/or large/important functional landscapes (Figure 11). The MCBS has identified numerous locations in northeast Minnesota that fit these criteria and therefore have been classified as having "outstanding" or "high" biodiversity significance. The "Outstanding" sites contain populations of the rarest species, examples of the rarest native plant communities, and/or the largest, most ecologically intact or functional landscapes. The "High" sites contain occurrences of the rarest species, rare native plant communities, and/or important functional landscapes. Initially, the boundaries of these sites are determined by review of aerial photography to identify potential areas of native biodiversity based on native vegetation. In subsequent field investigations, MBS assesses the ecological characteristics of the site and the presence of rare species. Following field investigations, site boundaries sometimes are revised, or sites added, to incorporate critical habitat for rare plants and rare animals.[18] Land managers plan harvests and avoid negatively impacting the identified sites by using the information from the MCBS. Many of the sites are on public lands (including parks and protected areas). Identification of an area of biodiversity significance does not necessarily preclude forest management, timber harvesting or biomass collection. However, activities undertaken in these areas need to be compatible with the maintenance of the features for which the site has been identified. Field surveys are still being conducted to complete and refine the identified areas of biodiversity significance in northeastern Minnesota.

Impact on Structure of Native Plant Communities

There are a range of related concerns associated with the potential for biomass harvesting to impact the overall structure of the forest and its native plant communities, including timing of harvests, retention of woody debris, stand structure, direct impacts and long-term impacts.

Timing of Biomass Harvests: Similar to risks associated with roundwood harvests, the *timing* of biomass harvests could negatively impact the environment. Harvesting during the growing season (or when soils are wet) has the potential for greater impact to soils through compaction that is less likely to occur in winter and under frozen or dry ground conditions. Harvesting during the summer can also impact nutrient cycling if more leaves and green materials are removed as part of the biomass collection. The majority of timber harvesting in Minnesota occurs during the winter or during dry conditions so that environmental impacts are minimized. Because biomass harvesting is closely associated with traditional harvesting activities, it is reasonable to expect that biomass harvesting will also primarily occur in the winter or under frozen or dry ground conditions.

Woody Debris Remaining on Harvest Site and Impacts to Forest Soils: To protect soils, support nutrient cycle, and to provide other benefits, it is important to retain an appropriate amount of woody debris on harvest sites. The general requirement in Minnesota is to retain 20% or more of

[18] Figure 11 and additional information available at: http://www.dnr.state.mn.us/eco/mcbs/biodiversity_guidelines.html

the fine woody debris (tops and limbs) at the site where biomass is harvested. Material that naturally falls during harvesting (incidental breakage) should also be kept on site and not collected or removed. Additional information about biomass harvesting guidelines and woody debris retention is addressed in the Environmental Safeguards section.

Structure of Stand Possibly Different from Natural Changes: Stand structure (after harvest) might be different from changes typical of natural disturbance regimes to which species and native plant communities are adapted. For example, fire can have a great deal of variability in its severity and scope of impacts within a particular landscape and landscape position. The structural legacy following biomass harvest might be different from what would occur following a wildfire or windstorm. Requirements with the state's harvesting guidelines include retention of structural components of the stand (snags, legacy trees, etc) to help mitigate these concerns.

Potential for Direct Impact on Specific Plant Communities and Species: Unlike other types of forest products, biomass harvesting is generally not specific to any species. Biomass harvesting generally involves the collection of the by-products of traditional timber harvesting and will include a full range of tree species. Biomass harvesting may include some additional collection of understory and smaller-diameter materials, including balsam fir and species that can create ladder fuels and are known to increase wildfire risks. Given the range of biomass materials that could be collected and the fact that it could include a broader range of species, there is potential that a biomass harvest could have no impact on one species but significantly impact another species (this relates to some of the "unknowns" of biomass harvest). Silvicultural activities can impact specific rare plants, such as (upland) *Osmorhiza berteroi* (blunt-fruited sweet cicely) and (bottom-land) *Geocaulon lividum* (false toadflax) and *Polemonium occidentale* (Western Jacob's ladder). Biomass harvests could impact these plants if sites and important habitats are not adequately identified and protected. As discussed in the "Location of Harvests and Supply" section, the Minnesota County Biological Survey (MCBS) has identified native plant communities and areas of biodiversity significance in Minnesota and this information is used in conjunction with the biomass harvesting guidelines to restrict management activities on sensitive sites.

Long-Term Impacts are Unknown: Although biomass utilization is not entirely new (i.e., firewood collection is a well-established practice in northern Minnesota), long-term studies of woody biomass removals on wildlife species and/or native plant communities are not common and therefore the long-term impacts are not well understood. Where biomass harvesting is associated with the collection of the by-products of traditional timber harvesting, the impacts should be similar to those associated with timber harvesting. If biomass harvesting occurs at a shorter interval than timber harvesting (e.g, more frequent stand entries) the impacts could be increased due to greater site disturbance. In order to learn more about biomass harvesting impacts, it is important to have adequate resources for site evaluations and field surveys before harvesting occurs and for monitoring and evaluation over time. The Minnesota County Biological Survey and its continued development is an important resource for providing information about identified natural communities and sensitive resources.

Negative Impacts on Specific Wildlife Species

In addition to consideration of the native plant communities, it is also important to consider how changes in the forest might affect wildlife species. Canada lynx, snowshoe hare and timber wolf are some of the wildlife species that could be negatively impacted if biomass harvests are carelessly

implemented. The U.S. Fish and Wildlife Service has determined that the critical habitat for the lynx includes most of the Superior National Forest and other lands in Northeastern Minnesota.[19] Management plans for species such as lynx and wolves have been developed, and impacts to their habitat needs are considered in harvesting restrictions and the biomass limits that are applied in Minnesota. As discussed in the section about Indicators of Sustainability, research has shown that current rates of timber harvesting are unlikely to significantly affect the distribution of wildlife habitats; however, continued research and monitoring are essential to evaluating long-term wildlife population changes.

Water Quality

Impacts to water are important considerations when evaluating timber or biomass harvesting activities. Water quality assessments that look beyond the site level and are conducted at a sub-watershed scale to protect water quality in identified reaches of larger rivers can be beneficial. It is also important to use local data that aligns with the local conditions in these evaluations. Data collected from outside the region might not be appropriate to use (apply) in local landscapes. Although Minnesota does have site-level guidelines that protect water resources, these practices are not regulatory and there is a risk that they won't be implemented or that their implementation will vary between different agencies, land mangers, or land owners.

Collaboration Between Different Owners

The forests of northern Minnesota are owned and managed by a number of different organizations, including the DNR, Forest Service, County Land Departments, Native American Tribes, forestry industries, and private citizens. In the absence of collaborative planning, multiple owners can unwittingly create problems in a watershed. For example, one owner might have a management objective for certain species or tree ages that is very different or conflicts with the goals of other landowners in the same watershed. Programs such as the Landscape Committees operated through the Minnesota Forest Resources Council help identify landscape goals that can inform management across ownerships. A wide range of public and private organizations and individuals have participated in these committees in northeastern Minnesota and the development of landscape management goals within the project area.

Do People (Community) Understand What They are Accepting?

It is difficult for citizens to read the necessary materials, attend various meetings and understand all the implications of biomass as an energy source. Most citizens rely on information presented to them by consultants and others that may have a "stake" in the project. It is easier for an informed citizen to form an opinion and accept decisions (whether they agree or not) if it is apparent that due diligence has been done in looking at all aspects of the project (pros and cons). Given the potential significant impacts of adopting renewable energy systems, Cook County/Grand Marais and Ely have committed to a deliberative process of evaluating these systems. The communities have supported greater understanding of the systems through their citizen advisory groups, public meetings, independent research and other information gathering and sharing methods.

[19] http://www.fws.gov/mountain-prairie/pressrel/08-20.htm

GEIS has Limitations

Mitigation Strategies: Many stakeholders acknowledge that following GEIS guidelines will minimize negative impacts to the environment. However, if mitigation strategies (as outlined in the GEIS) are not applied, then the environment won't be effectively protected. According to some individuals, mitigation strategies are not being effectively applied in many instances (or may not be applied in the future), leading to negative environmental impacts. Examples of specific mitigation strategies that may or may not be applied evenly across northern Minnesota include (1) inventory of old-growth forests across all ownerships, (2) funding of a research program to investigate the effects of timber harvesting on the tourism and travel industry in Minnesota, (3) significantly enhanced research to address all forest sustainability key issues, (4) measures to accommodate increased water flows downstream from clearcuts, (5) evaluation of changes in snowmelt peak discharge, and (6) a regional, cross-ownership wildlife management and protection database on habitats and populations. In addition, climate change and invasive species were not included in the original GEIS and could be negative "wild cards" in the future.

Need to Look at More Current Studies (post-GEIS): Other documents (Superior National Forest Plan, DNR Subsection Forest Management Plans, etc.) are more current than the GEIS, and specifically address biomass harvests in various forest ecosystems. These plans are periodically updated (e.g., every 10-15 years) and include the collection of new information, public meetings and comment periods, and application of the best available science. The current plans include consideration of the biomass harvesting guidelines and limits on biomass harvesting on sites with low nutrient or deep organic soils and other concerns. These documents and meetings with these land managers have been an important part of reviewing the biomass energy systems that could be used in Northeastern Minnesota.

Use of Roundwood in the Future

There is nothing (legally) that would prevent roundwood from being used to provide biomass energy. To the extent that people harvest roundwood as firewood, this is already occurring in the region. Roundwood is also used in the production of pellets. Although this report primarily addresses *residual* material being used as biomass fuel, the future is unknown. Some stakeholders are uneasy with the possibility of roundwood, trees or higher quality material being used to provide biomass energy. Use of this material for energy may create competition with other markets and/or increase harvest pressure on the forest. As long as viable markets for roundwood (e.g., pulp and timber markets) exist in the region, it is likely to be economically limiting to chip quality roundwood for biomass systems. Low quality or degraded roundwood, including wood salvaged from windstorm events, wildfire, or insect or disease outbreaks may not be suitable for pulp or timber markets and could potentially be utilized in a biomass system.

Forest as a Carbon Sink

A concern that arises from discussions about biomass harvests relates to the carbon dioxide (CO_2) tradeoff between retaining biomass on-site versus the CO_2 emitted to the atmosphere during biomass removal, transport and use. Some stakeholders contend that the value of a forest as a carbon sink outweighs the removal of woody biomass for energy generation. Others contend that the carbon stored in the forest will be released when the trees die. Wildfire can also release large amount of carbon. Current research is further exploring the interactions between harvesting and carbon emissions and carbon storage. One way that carbon emissions associated with biomass

energy can be minimized is by reducing transportation distances and utilizing local sources of fuel. (Also see Appendix I for a discussion of carbon pool results from a life cycle inventory study.)

Noise Pollution in BWCAW

The Boundary Waters Canoe Area Wilderness (BWCAW) is the largest un-roaded forest area east of the Rocky Mountains and a key component of the internationally-renown Quetico-Superior Ecosystem. The BWCAW is one of the most popular and heavily used wilderness areas in the entire Wilderness Preservation System. People travel to the BWCAW seeking solitude, peace, quiet, and a natural, untrammeled and undeveloped environment. Noise from logging and road building activities is not compatible with these experiences and can create conflicts as well as reductions in local economic opportunities associated with tourism.

Public land managers, including the Forest Service, Minnesota DNR, and County Land Departments, manage the majority of the forestland in the vicinity of the BWCAW. These public land managers have considered the BWCAW and impacts to the wilderness user experience in the development of their management plans and the planning of their forest management activities. Winter is the predominant season for timber harvesting (and associated biomass harvesting) in Northern Minnesota and this corresponds to a time of lower recreational use in the BWCAW

Air Pollution and Ash Disposal

Although these impacts occur outside of the forest, the potential for air pollution from biomass combustion and the question of responsible ash disposal are common concerns about these systems. Bioenergy facilities can have higher onsite combustion emissions as compared to fossil energy systems. In contrast, fossil energy systems include higher emissions offsite in association with mining, refineries and other production steps. High quality engineering, proper location selection and maintenance are important to minimizing air emissions in bioenergy systems. With these considerations addressed, bioenergy facilities can be non-disruptive to the community and compatible with high standards for air quality. For example, District Energy is a large heat and power generating facility in the heart of downtown St. Paul that utilizes wood waste and trees in its operations and has done so for many decades. The studies being done for Ely and Cook County include a separate analysis that is available as a companion paper to this report and addresses the life cycle impacts and air emissions associated with different energy systems.

Ash disposal from biomass energy facilities is the topic of a great deal of research and evaluation.[20] In general, wood ash from bioenergy is not a disposal challenge, especially if the facility is not mixing the wood with other materials. The amount of ash that is generated will depend on the type of wood fuel being burned. Clean chips containing no bark will have a low ash content, typically less than 0.5 percent. Wood chips or Hogged fuel that includes bark will have a higher ash content of around 1 percent. Softwoods will also have higher ash contents than hardwoods.[21] Ash is commonly utilized in overland applications (e.g., fertilizer or soil treatments for farmers or land owners). There are also efforts to utilize the ash in commercial applications (e.g., in cement production). Where these opportunities don't exist, ash from bioenergy facilities is commonly landfilled.

[20] For example, see "Conference on Recycling of Biomass Ash, 2012, Program and Abstract book" available at: http://www.biotreat.eu/ViewDownloadsExec.php?targetid=320&fileid=49

[21] http://www.window.state.tx.us/specialrpt/energy/renewable/wood.php

Local Environmental Benefits in Grand Marais and Ely

In addition to the local concerns discussed above, there were also a number of potential local benefits to using woody biomass identified in the stakeholder interviews, and they are reported and discussed in the following sections.

Renewable (non-fossil based) Energy

Wood is a renewable, non-fossil based energy source. Wood (via forests) is abundant in northeastern Minnesota where forest growth exceeds current harvest levels. Energy self-sufficiency based upon locally-available resources is one reason for pursuing the development of woody biomass-to-energy initiatives.

Fuels such as oil, coal and propane are fossil-based and non-renewable. These (and other) fossil fuels are non-local, requiring transportation of many miles to reach end-users in Ely and Grand Marais/Cook County. Also, continued use of fossil fuels does not help address interests in local energy self-sufficiency and long-term energy security.

Air Emissions, Climate Change and Life Cycle Impacts

The objective of reducing global greenhouse gas (GHG) emissions requires increasing carbon storage in pools other than the atmosphere. Growing more forests, keeping forests healthy, and reducing wildfire risks[22] are part of the solution. The substitution effect, where wood displaces fossil fuels as an energy source is also part of the solution. Substituting renewable energy for fossil energy can positively contribute to reducing the build-up of GHG when fossil fuel consumption and the flow of fossil carbon to the atmosphere are reduced.

All forms of combustion result in the release of air emissions and greenhouse gases, including various forms of carbon gases. Because wood is a less concentrated source of energy (i.e., fewer Btus per ton), the amount of emissions at the combustion site will be proportionally greater per unit of energy as compared to sources such as oil, coal or natural gas. However, fossil fuel energy sources require other environmental impacts at the source where they are mined, pumped and refined. Unlike the harvesting of woody biomass, the collection of oil and gas resources can include off-shore drilling, impacts in the Arctic, oil-shale mining, fracking, global transportation and international military conflicts.

In studies of the life cycle impacts from diverse energy sources, it has been found that woody biomass results in lower global warming potential than fossil energy sources. The benefits of woody biomass are greatest when local sources are used (with minimized transportation impacts) and when the type of biomass includes the by-products of traditional timber harvesting.

[22] Nationally (continental US), wildfire emissions are equal to 5% of total GHG emissions (Malmsheimer et al. 2011).

Hazardous Fuel Reductions

Wildfires can have severe consequences. A case in point for northeast Minnesota is the Pagami Creek Fire in 2011 that impacted 93,000 acres and threatened homes, businesses, and cabins as it expanded outside of the BWCAW and into the vicinity of the town of Isabella.

Hazardous fuel reduction efforts seek to minimize the risks and negative economic, ecological and social consequences of wildfires. Firewise projects—including creating defensible space around homes and businesses—remove woody debris from fuel reduction projects. Much of this woody material is non-marketable in the traditional sense and is often piled and open burned. Using material from hazardous fuel reduction projects as a feedstock in a bioenergy system could be a win-win scenario in that it would generate fewer emissions than open burning and provide a local energy source while reducing wildfire risks.

Forest Restoration Initiatives

The forests of northeastern Minnesota are adapted to disturbance. Land managers look for ways to mimic disturbance patterns that will support biodiversity and forest health. Natural disturbance events like windstorms and lightning-caused wildfire create changes in forest conditions and available wildlife habitats. For example, following the Pagami Creek Fire it is expected that plants like fireweed, shrubs such as raspberry and blueberry, and trees including paper birch and pin cherry, jack pine, aspen, and red pine may increase in abundance in the areas impacted by the fire. Animals such as the black-backed woodpecker may also benefit from increased habitat resulting from the fire.

Given that windstorms and wildfires aren't predictable or manageable methods for creating desired forest conditions, land managers attempt diverse forest management and harvesting practices to mimic a variety of disturbance types and intensities. Timber harvesting can create changes in forest conditions that favor certain tree, plant and wildlife species. Biomass harvests as part of a timber harvest can further influence the types of habitats that are created. Biomass harvesting can also be part of a strategy to change the understory conditions of a forest (e.g., removal of small diameter trees and shrubs) to reduce the risk of catastrophic wildfire and create diversified habitat conditions.

A case in point where biomass can help achieve forest restoration initiatives is the Fernberg Corridor (near Ely) administered by the U.S. Forest Service. The "corridor" includes jack pine sites dominated by mixed-stands of conifer and hardwood (including aspen). In order to accomplish jack pine forest restoration in these areas, timber sales were designed and offered to the forest products industry. However, at least two of the four sale areas have low merchantable volume (non-commercial sites), resulting in questionable economic viability to conduct a traditional harvest. Biomass markets could potentially make it economical for loggers to harvest these sites, resulting in much needed forest restoration work by removal of select tree species. Without biomass markets, the sites would likely be unmanaged from a silvicultural perspective and no forest restoration work would be accomplished.

Biomass as a Forest Management Tool

Forest management is an important activity in northeastern Minnesota. Forestry provides ecological and environmental benefits to forest health and the management of insect and disease threats. There are also social and economic benefits provided through the jobs and local-businesses that are

involved in the forest products sector. Land managers are always concerned about losing markets for the products that result from their forest management. Without markets, it is impossible to accomplish management and address forest stewardship goals. This is especially true in northeastern Minnesota where the loss of roundwood markets (pulp and timber) would be devastating for managers as they attempt to implement on-the-ground management and restoration. Without a market that is willing to buy the wood, the practices for addressing forest health, reducing wildfire risks, and other efforts would need to be paid for in other ways. Biomass markets increase the economic value of forested areas. This, in turn, can lead to better overall wood markets and, provide land managers with a tool for practicing active forest management. Simply put, harvests are a management tool; if markets are lost, then this tool is lost.

Biomass as an Opportunity to Tap Into Non-Traditional Sources of Raw Material

Biomass as an energy source has the opportunity to tap into non-traditional sources of raw material. Many businesses and homes throughout the U.S., as examples, are using community trees (trunks, tops, brush, etc.) and local wood-debris (construction waste, damaged pallets and shipping containers, etc.) to fuel small or large-scale energy plants. Opportunities in Ely and Grand Marais/Cook County also exist.

Community Trees and Related Wood Debris: The City of Ely, as an example, operates its own "brush pile." The quantity of tree trunks, limbs, and brush that are disposed in the pile varies by year depending on the local situation (trees blown over in storms, trees removed due to pest outbreaks, etc.). One estimate of annual woody material disposals is 300 to 450 green tons per year. The information below (Table 6) compares brush pile disposals with raw material requirements for the small-scale Ely biomass scenario (878 green tons per year). If the brush pile in Ely offers 300 to 450 green tons of material per year it could provide 37-50% of the supply for the small-scale scenario.

Table 6. Potential for Community Trees and Wood Debris to Supply Bioenergy Materials

Brush Pile Quantity *(green tons)*	**Brush Pile Quantity** *(dry tons)*[1]	**% of Supply for the Ely Site 1 Scenario***
50	33	6 %
100	65	12 %
200	131	25 %
300	196	37 %
450	295	50 %

[1]Assumes 3.6 dry tons = 5.5 wet (green) tons

* Scenario is estimated to require 878 green tons/ 527 dry tons per year

County-Based Wood: The counties of Cook, Lake and St. Louis generate sizable quantities of wood every year as a result of necessary tree removal activities (in addition to regular forestry operations). Opportunities to use some of this "waste" wood as a bioenergy raw material is possible.

For example, St. Louis County handles a sizable portion of woody material (trunks, tops, brush, etc.) at 10 transfer sites (collection yards) in the county (disposal at these sites is free; no tipping charge). Material collected at these sites comes from a range of sources including community trees, lake property trees, landscape operations, blow-downs (around homes), and other residential and commercial areas. Wood typically collected at these sites is ground and sold to Hibbard Power in

Duluth. Seven of the 10 transfer sites in St. Louis County are within 60 miles of Ely[23] so a possibility exists of obtaining raw material from one or more of these sites for a bioenergy plant in Ely. One estimate is that between 1,200 and 1,500 green tons of waste wood (trunks, tops, brush, etc.) per year are collected at the 10 local transfer sites. The low end of this estimate (1,200 tons) equates to about 785 dry tons of material and exceeds the annual fuel requirements of the Ely small-scale scenario.

Other Non-Traditional Sources: In addition to these community and county sources of wood, new bioenergy plants in Grand Marais (greater Cook County) and Ely could develop markets for other non-traditional sources of raw material. Woody debris from power and telephone line clearings, highway construction, road widening projects, commercial land-clearing, residential land-clearing, dunnage recovery (pallets and crates), etc., can contribute in a significant way to providing biomass for energy needs. However, it is also important to use appropriate caution with any sources that could include chemically treated wood or other materials that require specific combustion or disposal methods.[24] Salvaging dead and dying trees for biomass energy may also be possible where it is compatible with sound forestry practices. In areas impacted by wildfire, charred wood and other material not suitable for traditional markets could potentially be removed and transported to a biomass energy plant. The ability to utilize wood that is being disposed of or that is low quality reduces waste and contributes to the management options available across a forested landscape.

Increased Attention and Public Understanding of Forest Management

The use of woody biomass for energy in Ely and Cook County could draw more attention to forest management decisions in the region. This increased focus on woody biomass would expand the network of involved stakeholders. This is viewed as a positive situation since for many years foresters and others in land management positions have sought opportunities to communicate the benefits of active forest management. Woody biomass utilization for local energy needs can contribute to an expanded dialogue on, and greater public understanding of, the management of local forest resources.

Environmental Safeguards

In addition to the work completed in conjunction with the GEIS and associated research efforts, there are several environmental safeguards in place in Minnesota that focus directly on the sustainability of Minnesota forests. These safeguards include forest certification, biomass harvesting guidelines, and the master logger certification program. In addition to these "big three," numerous other programs and activities are being implemented that strive for long-term forest sustainability.

Forest Certification

Certification is a market-based, non-regulatory forest conservation tool designed to recognize and promote environmentally-responsible forestry and sustainability of forest resources. The certification process involves an evaluation of management planning and forestry practices by a

[23] Personal communication, St. Louis County Environmental Services Department, July 25, 2012.

[24] http://www.epa.gov/pesticides/factsheets/chemicals/creosote_prelim_risk_assess.htm

third-party auditing firm and in accordance to an agreed-upon set of standards. Certification standards address social and economic welfare as well as environmental protection.[25]

Forest certification, therefore, can be viewed as an environmental safeguard for the sustainability of a forested landscape. Within Minnesota, there is a total of over 8.4 million acres certified to the standards of FSC (Forest Stewardship Council) and SFI (Sustainable Forestry Initiative).[26] The vast majority of certified forestland is located in northern Minnesota and several landowners are certified under more than one program.

Table 7. Certified public forestland in Cook, Lake, and St. Louis Counties, Minnesota.

	County Land *(Acres)*	**State Land** *(Acres)*	**Total** *(Acres)*
Cook County	--000---	99,670	99,670
Lake County	151,216	140,069	291,285
St. Louis County	895,174	401,660	1,296,834
Total	1,046,390	641,399	1,687,789

Sources: County land data from MN DNR, Minnesota Forest Certification Data; accessed on 6/26/12 http://www.dnr.state.mn.us/forestry/certification/certifiedforest_data.html; State land estimates from R. Bernard, MNDNR, personal communication, 6/26/12

The counties of Lake and St. Louis have certified all of the lands that they manage (Table 7). Also, a sizable certified acreage exists in bordering counties of Koochiching, Itasca, Aitkin and Carlton. All of the lands managed by the Minnesota DNR are also certified. There is a total of approximate 915,000 acres of private land certified in Minnesota, nearly all of which is located in the Northeastern region. It is difficult to estimate certified private land acreages in the specific counties because the data is not generally reported at this scale.

Forest certification is a comprehensive process that investigates all aspects of the current management as well as plans for future management, The certification auditors use three major sources of information in their evaluation of the management: 1) what they see in the field during the site inspections; 2) what they read in the land manager's documents, plans, records and management systems; and 3) what they hear from stakeholders, community members and others who may be affected by the management operations. Forest certification looks very closely at key measures of sustainability, including review of environmental safeguards, forest regeneration and replanting operations, soil and water quality protections, wildlife habitat and rare species, cultural and historic resources, and long-term management planning and monitoring.

Biomass Harvesting Guidelines

In December 2007 the MFRC completed development of Minnesota's *Biomass Harvesting Guidelines for Forestlands, Brushlands, and Open Lands*.[27] These guidelines are an addition to MFRC's 2005 forest management guidebook titled *Sustaining Minnesota Forest Resources: Voluntary Site-Level Forest Management Guidelines for Landowners, Loggers and Resource*

[25] http://www.pinchot.org/project/59

[26] http://www.dovetailinc.org/content/certified-forests-minnesota

[27] See http://files.dnr.state.mn.us/forestry/biomass/biomassHarvestingGuidelines.pdf (accessed 7/18/12)

Managers.[28] The following table summarizes the guidelines (Table 8) and Appendix II provides additional information about the scope of the guidelines.

Table 8. Summary of Minnesota's Biomass Harvesting Guidelines

DO'S	DON'TS
During Biomass Harvesting:	***Avoid Biomass Harvesting:***
• Plan roads, landings and stockpiles to occupy a minimized amount of the site • Ensure that landings are in a condition to regenerate native vegetation after use, including tree regeneration • Avoid site re-entry to collect biomass after harvesting *(this reduces potential for soil compaction and damage to regeneration)* • Install erosion control devices where appropriate to reduce sedimentation of stream, lakes and wetlands • Retain and scatter at least one third of the fine woody debris on the site • Encourage native seed mixes and avoid introduction of invasive species • Retain slash piles that show evidence of use by wildlife • Leave all snags, retain stumps and limit disturbance of pre-existing coarse woody debris	• Within 25 feet of a dry wash bank, except for tops and limbs of trees • On nutrient-poor organic soils deeper than 24 inches *(These sites typically have sparse (25-75%) cover that is predominantly (>90%) black spruce and stunted (<30 feet high).)* • On aspen or hardwood cover types on shallow soils (8 inches or less) over bedrock • On erosion-prone sites (e.g. steep slopes of 35% or more) • In areas that impact sensitive native plant communities and where rare species are present • In riparian areas or leave tree retention clumps • In a manner that removes the forest floor, litter layer or root systems; these resources must be left within the forest

The *Biomass Harvesting Guidelines* (in conjunction with the *Site-Level Guidelines*) outline benefits to cultural resources; soils; riparian areas; water quality, water quantity, and wetlands; and wildlife habitat. Specific recommendations include mitigations for biomass harvests (or no harvesting) (1) on sensitive sites (such as those containing selected native plant communities or where plant or animal species are listed as threatened or endangered), (2) in riparian zones, (3) for areas with soil productivity concerns (such as on different soil types, slopes, and removal of fine woody debris), (4) to manage and retain wildlife habitat and structural diversity (e.g. coarse woody debris including snags and "leave trees"), and (5) to avoid re-entry into previously harvested sites to remove biomass (e.g., traffic restrictions, erosion control measures, non-frozen wetlands). The *Guidelines* also emphasize the importance of retaining fine woody debris (FWD), and provide recommendations for biomass harvesting as a fuel (widfire) reduction strategy and tool for silvicultural management.

The *Biomass Harvesting Guidelines* are a "living" document in the sense that as new information becomes available, new technology is adopted, and then the *Guidelines* will be adapted by the MFRC with input from stakeholders and the public. There is also an active monitoring program to measure compliance with the guidelines and continually identify opportunities for improvement. Use of the *Guidelines* in Northeast Minnesota provides a level of confidence in knowing that land managers are following best practices and planning for the future health of diverse forest resources.

[28] The Biomass Harvesting Guidelines are one part of the broader MFRC efforts, which were initiated in 1995 by the Sustainable Forest Resources Act to promote long-term sustainable management of Minnesota's forests.

Recent statewide monitoring by DNR Forestry[29] evaluated implementation of the biomass harvesting guidelines. The monitoring included review of 84 harvest sites across the state. Of the 84 sites monitored, 23 (27%) included biomass removal as part of the operations. Contractors judged that 39% of these sites had ≥20% of the fine woody debris (FWD) retained & scattered on the site and 70% had evidence that incidental breakage was retained. The monitoring found that only 3 of the 23 biomass harvest sites monitored contained specific language in the contract to address the requirement to retain 20% or more of slash. Although this sounds like a very negative finding of the monitoring, because contracts may be established years before the harvest occurs, it is possible that many of the sites were operated under contracts that were put in place before the guidelines were fully implemented. Clearly, the effectiveness of the guidelines depends upon their appropriate and consistent application. Continued training programs and monitoring efforts are important for supporting the goals of the guidelines.

Master Logger Certification Program

As of December 31, 2011, there were 47 Minnesota Certified Master Loggers in Minnesota. Many of these loggers harvest timber in the projected supply zones for Grand Marais/Cook County and Ely. At least one dozen (12) Certified Master Loggers (over 25%) have their business headquarters in the 3-County area of northeast Minnesota.[30]

The Minnesota Master Logger Certification (MMLC) program provides added confidence to customers and the public that the person performing a harvest has the training and experience to do the job correctly. MMLC is an independent, third-party verification of a logging operator's harvest, safety and business practices.

A logger participating in the program undergoes a third-party audit of his or her business practices and harvest sites. Independent auditors who have been trained on the MMLC standard conduct field audits on a sample of sites the applicant has harvested within the last 12 months. The logging business and harvest practices are evaluated against 138 practices in eight major areas of responsibility. Based on their findings, the auditors provide the certifying board a recommendation for or against certification. An eight member certifying board, which represents a broad range of forestry interests, reviews the audits and recommendations and makes the final determination on whether the applicant's business can be certified. To be certified, a logging business must pass all eight areas of the MMLC standard on all audited sites.

The certification status for a logging business is good until the next recertification audit which will occur within five years. During any given year, the certified business may be randomly selected for recertification. As each year passes, the probability that the business will be selected for recertification increases. No Minnesota Master Logger will go longer than five years without being recertified.

Also, the MMLC operates under the umbrella of the Minnesota Logger Education Program (MLEP). Established in 1995, MLEP provides training to over 400 logging businesses, including training that addresses the biomass harvesting guidelines. Twenty-four (24) hours of training are required every two years. To-date, MLEP has sponsored over 730 training and education workshops

[29] Final monitoring report is available at: http://www.frc.state.mn.us/documents/council/site-level/MNDNR_FMG_monitoring_2011_report.pdf

[30] See http://www.mlep.org/documents/mmlcannualrept2011.pdf (accessed 7/3/12)

with a total combined attendance of approximately 18,000 including nearly 15,000 loggers with the remainder being public and private sector natural resource managers.[31] Nearly 25% (91) MLEP members are headquartered in the 3-County region of northeast Minnesota.

Northeast Minnesota Forest Resources Council Landscape Planning Committee

In addition to analyzing site-level impacts of forest management activities, the MFRC is responsible for planning at the landscape level (program begun in 1997). In 2003, committee members in Carlton, St. Louis, Lake and Cook Counties approved a Northeast Minnesota regional landscape (long range) plan. Part of the landscape planning committee's role is to recommend pilot projects, integrate the broader landscape plan into more localized plans (county, DNR and Federal plans, for example), and provide education and support where appropriate.

The Northeast Minnesota Forest Resources Council Landscape Planning Committee serves as a regional forum (meetings held quarterly) to address local, on-the-ground, forest-related issues. An updated landscape plan is outlined for 2013; this is an opportunity for local residents and others to provide input regarding biomass harvesting concerns.

Field Monitoring of Biomass Harvests

The Minnesota DNR-Forestry, through their office of Best Management Practices (BMPs), conducts every-other-year field monitoring of forest harvest sites (and publishes a written report the following year). The most recent field monitoring was the first to include documenting compliance with the biomass guidelines, including slash retention on biomass harvest sites (final report not yet published). Pros and cons (environmental impacts) of harvested sites are noted in the report with the goal of continually improving forest harvest practices.

Sustainable Forestry Incentives Act

The Sustainable Forestry Incentive Act[32] (SFIA) was enacted in Minnesota in 2002. The SFIA creates an incentive for private landowners to practice sustainable forest management by offsetting a portion of their property taxes. Anyone who owns 20 or more contiguous acres, 50% of which are forested, may apply.

One requirement to join the SFIA is that landowners must agree to use the forest management guidelines developed by the Minnesota Forest Resources Council. Also, the land must be enrolled for a minimum of eight years, and have an active forest management plan less than 10 years old, prepared by an approved plan writer.

Forest management plans must include the landowner's goals for the property, a legal description, an inventory of the forest cover types, a map of the vegetation and boundaries, the proposed future conditions, an activity timetable, and other information pertinent to the management of the forest. Each plan includes a calendar of activities, and to remain eligible for reimbursement, the timetable must be followed.

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[31] See http://www.mlep.org/documents/mlepannualrept2011.pdf (accessed 7/3/12)

[32] Information obtained from http://www.myminnesotawoods.umn.edu/wp-content/uploads/2009/11/SFIAFAQ.pdf. (Accessed June 26, 2012)

Two-hundred seventy-eight (278) forest landowners (100,383 acres) in Cook, Lake, and St. Louis counties are enrolled in the program (the majority of these lands - over 80,000 acres - are in St. Louis county).[33] Since sustainable forest management is the goal of the program, the SFIA is one indicator that the resources and values of the property (ecological, social and economic) are being maintained.

Recommendations

Investigating the idea of moving from a fossil-fuel based energy system to one of dependence on woody biomass for thermal and/or electrical power entails a thorough analysis of what is *known* and *unknown*. The communities of Grand Marais/Cook County and Ely have engaged in an extensive exploratory stage—evaluating current science and technology (the known) and comparing it with a future that might look different from today's perspective (the unknown).

The following recommendations for protecting forest sustainability while developing bioenergy, many of which were highlighted in the original GEIS report, are edited to reflect a northeastern Minnesota perspective.[34] The recommendations are offered in three categories: site-level, landscape-level, and research.

Site-Level

- Follow the Site-Level Guidelines, including:
    - Retaining at least 20% of the slash (including bark where appropriate) as well as incidental breakage. This strategy reduces the loss of nutrients from harvested sites and maximizes habitat values for small animals.
    - Minimizing compaction by following the site-level guidelines and identifying susceptible sites and limiting operations on those sites to periods when the risk of compaction is lowest.
    - Retaining key habitat requirements in harvest areas – examples include snag trees and trees with cavities; in deciduous forests, retain conifer patches and isolated trees.
    - Retaining cavity trees or wildlife trees in stands that are harvested.
    - Protecting sensitive sites – nest sites, habitats, and rookeries should be identified and protected by buffers.

Landscape Level

- Follow the Site-Level Guidelines, including:
    - Maintain riparian corridors – Harvesting may occur in riparian corridors; however, thinning or uneven-aged management are the most appropriate silvicultural systems. Riparian corridors are key in that they connect landscapes such as patches of old growth, research natural areas, and scientific areas.
    - Protect sensitive sites for plant species – Harvesting should be modified or excluded in known locations of rare plant species and rare plant communities.

[33] Personal communication, MN Department of Revenue, Property Tax Division, July 25, 2012.

[34] Since the original release of the GEIS, the MFRC has developed specific guidelines for biomass harvesting on forestlands, brushlands and open lands in Minnesota. See Appendix II for a specific list of recommendations pertaining to biomass harvests in Minnesota.

- Follow Visual Guidelines within the Site-Level Guidelines – Visual Management Guidelines give attention to the important social attributes and long-term benefits of primitive recreation opportunities (such as in the BWCAW) and reduce the likelihood of adverse visual impacts

- Develop landscape-based road and trail plans – This includes planning and coordination between ownerships.
- Utilize the results of the landscape planning efforts undertaking by the MFRC Committees.

Research

- Continue efforts through the Minnesota County Biological Survey (MCBS) to inventory information regarding the state's biodiversity features – This research supports the identification of the occurrences of rare plant and animal species and communities (including old-growth areas), and key habitat features for wildlife species.
- Monitor the impacts of timber harvesting and forest management activities on the tourism and travel industry in Northeastern Minnesota.
- Continue to develop and utilize the listing of known heritage resource sites in the state through the work of the State Historic Preservation Office.

Conclusions

The ecological effects on soils, wildlife, fire regimes, and water quality of using biomass for bioenergy depend on the existing condition of the forest stand and the amount of biomass to be removed over a specific period. The results depend on such factors as the timing of removal, the volume removed, and the nature of the biomass (e.g., bolewood, fine or coarse woody debris, harvest residuals, etc). According to the *Journal of Forestry*[35] scientific evidence from sites across North America suggests that the productivity of most sites is largely resilient to removing harvesting residuals. Overall, documentation of negative effects on site productivity due to biomass removal is rare (Malmsheimer et al. 2011). The project scenarios under consideration in Cook County and Ely are relatively small in terms of total biomass demand; however, their development still represents a potential change in forestry practices in the region and it is important to consider the impacts of that change.

Sustainable forest management practices are well known and widely practiced in Minnesota, as evidenced by the widespread participation in third-party forest certification, use of harvesting guidelines and best management practices, and continuing education programs for natural resource managers and harvesting professionals. These tools help protect the forests' environmental and ecological values. A recent meta-analysis of the scientific literature suggests the effects of biomass harvest on biodiversity can vary by harvesting practices and other factors. Biomass harvesting guidelines are recognized as an important tool for taking a precautionary approach to making use of this energy resource. With scientific evidence lacking for significant negative project level impacts, harvesting guidelines can allow managers the flexibility to tailor prescriptions to site conditions, address limiting factors and promote analysis of the impacts across a scale that includes numerous

[35] *Journal of Forestry*, October/November 2011, 109(7S):S24-S26.

ownerships and projects (Malmsheimer et al. 2011). In 2007, Minnesota established biomass harvesting guidelines to help address long-term biomass sustainability considerations. A study done in Minnesota concluded that following the biomass harvesting guidelines established by the Minnesota Forest Resources Council (MFRC) should mitigate concerns about soil nutrients, structure and wildlife habitat (Arnosti et al. 2008). An important area of focus is on ensuring the guidelines are well understood and being consistently implemented. Training and monitoring programs can help support and improve guideline implementation.

The study team found that there are a number of local concerns about biomass harvesting, including the potential impacts to soil resources, wildlife habitats, water quality, tourism and other factors. The study team also found that there is local interest in some potential benefits from biomass harvesting, including reduced wildfire risks, improved forest health, economic benefits, and local energy self-reliance. The current amount of forest product harvesting in the region is significantly lower than what research has found to be sustainable and the forest stocks are not in decline (i.e., annual net forest growth is positive). Based on the review, it is believed that sufficient biomass material is currently available and can be responsibly harvested to support the community-scaled biomass energy projects being evaluated in Cook County and Ely. To ensure that biomass energy systems can be responsibly maintained over the long-term, it is important that programs to implement and monitor the effective use of harvesting guidelines and other environmental safeguards be continued and widely adopted.

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Appendix I: Carbon Pools

Carbon Pools

An indicator of sustainability is the amount of carbon retained, and removed, from a forest site following a timber harvest. Table A (below) provides estimates of carbon residuals and carbon removals (thinnings and harvest) for typical hardwood and softwood sites in the region (based on a life cycle inventory study for north central and northeastern US forests).

The estimates in Table A were developed as multipliers of carbon weight per merchantable volume. Although volume estimates of the merchantable stem represent estimates of the wood content, the multiplier includes an estimate of carbon in both the stem and attached bark.

For softwoods, the average of harvested carbon in stem and bark is greater than 64 metric tons/ha (removals) with over 53 tons remaining on site. For hardwoods, the average of harvested carbon in stem and bark is about 101 metric tons/ha with 87 tons as harvest residual. In both instances, the study found that approximately 46% of total carbon is retained on-site as residuals in a typical harvest.

Note that hardwood residuals (slash) are greater than softwood residuals. In the long-term, decomposition of slash may release carbon to the same extent as slash burning, but estimating time-dependent impacts is difficult because of large uncertainties around the extent of complete combustion in slash burning and any soil carbon interactions.

If biomass harvesting is done in addition to a typical harvest, then some of the carbon associated with harvest residuals will be reduced and the carbon in the harvest removals will increase. Biomass harvesting in Minnesota could include collection of additional stem, bark, or crown material. The collection of roots is not included within biomass harvesting in Minnesota.

Table A. Carbon Pools in Softwood and Hardwood Forest Harvest Residuals and Removals (kg/ha)

Harvest Residual *(kept in forest)*	Carbon in Softwoods *(kg/ha)*	Carbon in Hardwoods *(kg/ha)*		**Harvest Removals**	Carbon in Softwoods *(kg/ha)*	Carbon in Hardwoods *(kg/ha)*
Stem + Bark	6,510	10,200		Stem	58,600	91,600
				Bark (stem)	5,600	9,700
Crown	25,300	45,200		Crown	0	0
Roots	21,700	31,800		Roots	0	0
Total *(kg/ha)*	53,600	87,200		Total *(kg/ha)*	64,200	101,300

(Source: Oneil et al., 2010, Table 5C, p. 45)

Appendix II: Biomass Harvesting Guidelines for Forestlands, Brushlands and Open Lands

Biomass Harvesting Guidelines for Forestlands, Brushlands and Open Lands, December 2007, was developed by the Minnesota Forest Resources Council (MFRC) and is available at: http://files.dnr.state.mn.us/forestry/biomass/biomassHarvestingGuidelines.pdf.

The following considerations are addressed by the Guidelines:

1) Biodiversity
   The guidelines address the potential impacts of woody biomass harvesting on the sustainability of game and non-game wildlife, plants, endangered resources, and sensitive and exceptional sites. Specific topics include:
   - Slash (logging residues and salvage)
   - Reserve trees and patches
   - Coarse woody debris
   - Fine woody debris
   - Vertical structure and brush
   - Mast producing trees and shrubs
   - Cavity trees and snags
   - Landings and access roads
   - Natural Heritage Inventory (NHI) and endangered, threatened, and special concern species
   - Sensitive and exceptional sites
   - Wildlife Habitat
   - Endangered Resources

2) Soil Productivity
   The guidelines address the protection of long-term soil productivity, and changes in chemical, physical, and biological characteristics resulting from biomass harvesting, including:
   Site Variation:
   - Productivity
   - Limitations (exclusion of sites, e.g. organic, shallow)

   Chemical:
   - Nutrient budget
   - Nutrient availability
   - Nutrient removal
   - Growth limiting nutrients

   Physical:
   - Compaction
   - Rutting
   - Erosion/sedimentation
   - Infrastructure
   - Hydrology
   - Stockpiling

- Harvest methods and equipment
- Landings and access roads
- Multiple stand entries

Biological:

- Role of vegetation
- Role of microorganisms
- Nitrogen mineralization
- Nutrient uptake (fine roots, mycorrhizae)
- Decomposition and nutrient cycling
- Carbon sequestration and storage

3) Wetland and Water Quality Management

While recognizing Minnesota's site level guidelines, the biomass harvesting guidelines also address water quality considerations as they relate to the harvest of biomass from forests. Additional considerations are due to the increased level of traffic on stands, the potential for increased runoff, and the possibility of swamping of stands. Topics include:

- Increased traffic
- Forested wetlands
- Hydrologic alterations

4) Silviculture

The guidelines address vegetation management considerations, silvicultural adaptations, and generally accepted practices as they relate to the harvest of biomass from forest stands. Topics include:

- Sustainable forestry goals and generally accepted silvicultural practices
- Property goals and stand management objectives
- Silvicultural systems and methods
    - Even-aged management systems
    - Uneven-aged management systems
    - Rotation lengths
    - Regeneration
        - Natural
        - Artificial
        - Swamping
    - Thinning and release
    - Pruning
    - Sanitation
    - Salvage
    - Season of harvest

5) Other Forest Management Objectives
    - Aesthetics and recreation
    - Fuel reduction
    - Forest tree health
    - Forest economics
    - Social Issues