Developing Woody Biomass Harvesting Guidelines for Wisconsin's Forestland

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Summary. Higher energy prices and incentives to produce renewable energy have increased nationwide interest in bio-fuels, and demand for sources of biomass. The potential expansion of a wood-based bio-energy industry could benefit Wisconsin's economy by creating additional markets for forest products, creating jobs and reducing reliance on fossil fuels. However, concerns have been raised about sustainability and the environmental impacts of increased removal of woody biomass from Wisconsin's forests. The harvest of woody biomass for energy is not widespread in Wisconsin, but several bio-energy projects are developing which could quickly increase demand for the State's wood based resources. In response, the Wisconsin Council on Forestry sponsored the development of biomass harvesting guidelines designed to ensure that woody biomass is a sustainable forest product and that increased extraction does not compromise the long-term productivity of Wisconsin's forestland. Wisconsin's Forestland Woody Biomass Harvesting Guidelines provide recommendations and considerations applicable to stand and site-level management. The guidelines were developed to limit the impacts of increased harvesting of woody biomass on: a) biodiversity conservation, b) soil nutrient depletion, c) physical properties of soil, and d) water quality.

Keywords. *State Harvesting Guidelines, Wisconsin, Biomass, Bioenergy*

Introduction

In 2005, Wisconsin Governor Jim Doyle outlined the details of his bio-fuels initiative, with the goals of promoting energy independence and economic growth by reducing Wisconsin's reliance on fossil fuels and creating new markets for products produced by the state's agriculture and forestry industries. In 2006, the Governor created the Office of Energy Independence to promote efforts to reduce dependence on foreign oil and advance alternative energy initiatives within the state. The Governor's plan includes generating 25% of Wisconsin's electricity and 25% of our transportation fuel from renewable sources, including woody biomass, by 2025. The plan also calls for capturing 10% of the U.S. market share for renewable energy and bio-fuel products and utilizing Wisconsin's considerable research capability to increase the availability and affordability of alternative energy. The Wisconsin Energy Independence Fund, administered by the Department of Commerce, awards up to $15 million annually in grants and loans for research and development, commercialization or adoption of new technologies, and supply chain development to businesses and researchers.

Market development for woody biomass and other bio-fuels could have a significant impact on Wisconsin's economy. Wisconsin spends nearly $19.5 billion a year on primarily imported energy. Currently 3.5% of motor fuel and 5% of electricity are created from renewable sources; producing 25% of the state's electricity from Wisconsin-based renewable sources such as woody biomass could generate close to $1 billion for Wisconsin's economy, and replacing 25% of motor fuel with renewable fuels

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produced in the state could have an even greater impact. Wood from Wisconsin's nearly16 million acres of forestland is expected to provide a significant resource for the state's emerging renewable energy economy. New bio-energy markets for Wisconsin's forest products include woody biomass for energy utilities, ethanol production, industrial fuel, wood pellets, school heating, and the sale of carbon sequestration credits for storage in forests. Developing renewable energy markets means more competition for wood resources and increased demand on forests. Successful utilization of the economic potential of our forests depends on maintaining a high standard of ecological sustainability and protecting forest resources for future generations. Development of biomass harvesting guidelines is meant to forestall negative impacts associated with increased utilization and allay concerns about sustainability.

Forest certification is an important aspect of Wisconsin's ability to market forest products. About 45% of Wisconsin's 15.76 million acres of forest is in third-party forest certification under Forest Stewardship Council (FSC), Sustainable Forest Initiative (SFI) or American Tree Farm System standards.

Table 1 shows the distribution of certified land among the various programs.

Wisconsin Certified Acres - January 20, 2009

	Certification Standard				
	FSC Only	**Dual FSC/SFI**	**SFI Only**	**Dual Tree Farm/FSC**	**Tree Farm Only**
WI DNR State Forests & Land Division		1,541,187	57,225		
WI County Forests (DNR)	165,958	1,464,167	723,772		
WI Managed Forest Law Group (DNR)				2,239,205	
Private Land (Corporate, Tribal and Other)	361,635	5,411	342,096		194,427
Total by Standard	527,594	3,010,765	1,123,093	2,239,205	194,427

Total WI Certified Acres (All Standards)	**7,095,083**
Percent of WI Forestland Certified	**45.01%**

Efforts by Wisconsin and other Lake States are helping establish the region as a "forest certification economic hub", according to a 2008 Dovetail Partners report. Wisconsin, Minnesota, Michigan and neighboring Ontario represent 30% of all of the certified forestland in North America. The three states hold 50% of the FSC-certified land in the U.S. The concentration of certified sources is prompting paper, lumber, flooring and many other wood derivative primary and secondary industries in the region to develop certified product lines. For many businesses, certified products are the only source of growth in an otherwise tight economy. Carbon credit trading, intended to curb global climate change, may also provide regional economic benefits due to the large area of certified forests.

Through a recent certification audit, Wisconsin state and county land managers were encouraged to develop standards for biomass in normal harvesting operations. A significant FSC Corrective Action Request (CAR) from the 2007 County Forest and State Forest reviews required the development of standards for some level of coarse woody debris retention. Scientific Certification Systems cited a FSC standard that

harvests shall "mimic natural disturbance mechanisms". The auditors expressed concern that loggers harvesting “fuel rods” (mostly top wood or fine woody material <4”) for biomass could be interfering with natural processes and depleting soil nutrients. They recognized that regional interest in developing bio-energy plants could have a dramatic ecological impact as demand for fuel rods and other small-diameter woody material increases. The auditors issued a CAR for the state to develop guidelines for retention of coarse woody debris within two years, allowing time for public input and testing.

Several factors, including the Governor’s clean energy initiative, the projected increase in demand for woody biomass, the CAR regarding certified forests, and the overall concern about the impacts of increased removal of woody material from forests led the Wisconsin Council on Forestry to sponsor the development of woody biomass harvesting guidelines for Wisconsin.

Wisconsin’s Forestland Woody Biomass Harvesting Guidelines

Traditional timber harvests have generally removed wood or biomass greater than four inches in diameter from the bole of a tree. In non-traditional “biomass harvests”, where some or all of the material is used as bio-fuel, the entire aboveground portion of a tree may be removed, including trunk, branches, bark, and leaves or needles. Currently, tree boles are generally used in traditional forest products, while tops less than four inches in diameter (or other top diameters down to one inch, depending on type of equipment), along with branches, twigs, and sometimes foliage, are used for bioenergy. In addition, biomass harvests may include the removal of small-diameter trees and shrubs. The harvest of fine woody material from forests results in increased removals from a site as compared to traditional timber harvesting, and a higher level of nutrient export.

Wisconsin’s Forestland Woody Biomass Harvesting Guidelines provide recommendations and considerations applicable to stand and site-level management. Specifically, guidelines were developed to limit the impacts of increased harvesting of woody biomass on: a) biodiversity conservation, b) soil nutrient depletion, c) physical properties of soil, and d) water quality. The scope of the Guidelines was limited in order to target the most significant ecological issues. In the future other issues may also be addressed, including: woody biomass resource availability; economics and energy balances for harvesting, transporting, and processing woody biomass for energy; potential effects on carbon storage and climate change; short rotation intensive culture of woody biomass plantations; landscape planning and management; and monitoring strategies. Some of these topics could not be covered with adequate detail under the timeline set by the Council on Forestry for the development of the initial guidelines. In addition, some issues are already addressed by Wisconsin’s existing framework of regulations and guidelines for forest management and do not need to be reiterated in the biomass harvesting guidelines.

Conservation of Biodiversity

The conservation of biodiversity has been identified as one of Wisconsin’s statewide goals (WDNR 1995, WDNR 2004). As a result, addressing the potential impacts of woody biomass harvesting on biodiversity within forest ecosystems, including the sustainability of wildlife, plants, endangered resources, and exceptional communities and sites, is an important aspect of the biomass harvesting guidelines. The conservation of biodiversity in managed forest landscapes is most successful if a full range of conditions is perpetuated, and the compositional and structural disparity between managed stands and natural

(unmanaged) forests is reduced. Silvicultural systems that more closely emulate natural disturbance and stand development processes are more likely to sustain ecological complexity and biodiversity. In natural systems, severe disturbances that eliminate all trees and woody biomass are rare; biological legacies like live trees, snags, and coarse woody debris are usually retained. This material provides a "lifeboat" function that contributes significantly to the conservation of biological diversity. Some traditional forest management systems tend to create simplified ecosystems that may not include significant structural legacies. Retention of legacies is critical to the development and implementation of adaptive silvicultural methods that strive to integrate the conservation of biodiversity (Crow et al. 1994, Christensen et al.1996, Niemela 1997, Seymour and Hunter 1999, OMNR 2002, Hammond et al. 2004, Hura and Crow 2004, Woodley et al. 2006, Franklin et al. 2007, MFRC 2007, National Commission on Science for Sustainable Forestry 2007).

Scientific literature is reasonably clear on the benefits of retaining large coarse woody debris, snags, and green reserve trees. Structurally diverse large-diameter coarse woody debris provides a wide range of substrates and microhabitats, and the greatest array of benefits to a diverse array of wildlife species. Conversely, the potential impacts of removing fine woody debris during biomass harvests are poorly understood (Gunnarsson et al. 2004, MFRC 2007). Some suggest that fine woody materials do not provide critical wildlife habitat, and, compared to coarse woody debris, have less ecological value because of rapid decomposition (Fraver et al. 2002, Hura and Crow 2004). However, fine woody material can moderate the environment at and near the soil surface by providing shade, slowing wind, moderating temperatures, and reducing desiccation (McInnis and Roberts 1994, Astrom et al 2005, Hacker 2005). Slash retained following clear-cutting can affect microhabitat complexity and provide habitat for animals and plants (Ecke et al. 2002, Gunnarsson et al. 2004, Norden et al. 2004, Astrom et al. 2005).

Forest management recommendations pertaining to biodiversity and logging residues are varied; most emphasize the importance of large diameter coarse woody debris. Astrom et al. (2005) noted that slash harvesting is an intensification of forest management that reduces the woody substrate and alters the surface environment (reducing shelter). To mitigate potential negative impacts, they recommend the retention of clustered trees with intact undergrowth, the protection and creation of coarse woody debris, and the preservation of old forest stands. Brakenhielm and Liu (1998) recommend slash retention and spreading on dry, nutrient poor sites. In Sweden, it is recommended that 20% of slash be retained following stand harvest (Gunnarsson et al. 2004). In Finland, 30% of logging residue retention is recommended for biodiversity management (MFRC 2007). In Minnesota, biomass harvesting guidelines recommend the retention of about 33% of the fine woody debris on site (MFRC 2007). In Ontario, biodiversity considerations are addressed by significant retention of reserve trees, snags, and coarse woody debris; logging slash retention is recommended (i.e. avoid full-tree harvesting) on coarse-textured soils and shallow soils to conserve nutrients (OMNR 2002). Clearly, potential impacts of fine woody debris removal on the conservation of biodiversity are uncertain and recommended management techniques to avoid or mitigate negative impacts are variable.

Recommendations provided in Wisconsin's Forestland Woody Biomass Guidelines attempt to maintain a level of ecological and structural complexity and avoid or mitigate potential negative impacts of woody biomass harvesting at the stand level. The woody biomass harvesting guidelines recommend retaining some habitat elements and biological legacies within harvested stands, including retention of green trees and

snags, and existing coarse and fine woody debris, stumps, roots and the forest litter layer. Guidelines limit harvesting of fine woody material where federally or state-listed species occur, and provide recommendations for sensitive sites and sites with exceptional features.

Soil Nutrients

Sustainable forest management has been defined as meeting the needs of the present without compromising the ability of future generations to meet their own needs. Maintaining site productivity is essential to sustainable forest management. A portion of a site's nutrients are removed when trees are harvested, and concerns about effects of these removals on forest productivity have appeared in the scientific literature since the 1950's (Rennie 1955). Amounts of nutrients removed vary by tree species, site, stand age, rotation length (or frequency of entry in partial harvests), and type of harvest. Harvests that remove fine woody material, in addition to merchantable stems, export more of a site's nutrients.

Several reviews have summarized information about site nutrients, nutrient cycling, availability to trees, and forest harvest effects (Rennie 1955, Boyle and Ek 1972, Boyle et al. 1973, Patric and Smith 1975, Vitousek and Reiners 1975, Hornbeck 1977, Likens et al. 1978, Malkonen 1976, Morrison and Foster 1979, Federer et al. 1989, Attiwill and Adams 1993, Grigal 2000, Hacker 2005). These reviews concluded that nutrient removal by conventional harvest of merchantable stems would not generally deplete site nutrients, as these would be replaced by mineral weathering and atmospheric deposition during the interval between harvests. Whole-tree harvests, shorter cutting rotations, and intensive utilization of fine woody material were identified by most reviewers to potentially threaten long-term soil productivity, particularly on sites of lower fertility, thus warranting ongoing monitoring of forest nutrition. Most summaries of nutrient status indicate that inputs of total nitrogen (N) and sulfur (S) from atmospheric deposition are of sufficient quantity, but available forms of these nutrients, as well as phosphorus (P) could potentially be removed through harvesting in amounts that could affect a regenerating forest; also, excess N inputs could contribute to leaching of cations (Boyle et al 1973, Grigal 2000, Bockheim and Crowley 2002). Potassium (K), calcium (Ca), and magnesium (Mg) are of concern, and on some sites estimated inputs are not sufficient to balance harvest removals when fine woody material is taken. Many reviews cite Ca as the element most likely to be depleted by harvesting (Boyle et al. 1973, Federer et al. 1989, Grigal 2000, Hacker 2005). However, the consequences of changes in nutrient status have not been studied sufficiently, largely because current methods of estimating nutrient inputs are inadequate, and ultimate effects on forest productivity are unclear (Grigal 2000). There are no studies that look at changes in forest productivity related to nutrient removals over more than a few decades, so it is not possible to say with certainty whether effects will or will not become apparent over time.

Nutrient removals in harvests were estimated from literature that reported the nutrient content of tree components (i.e. bole, bark, branches, and foliage). Other literature provided estimates of inputs from mineral weathering and atmospheric deposition, and accelerated leaching losses after rotation harvests. Nutrient balance equations showed negative balances for Ca and K for some scenarios. Nutrient capital for Wisconsin was estimated from a research database, and a threshold for nutrient-poor soils identified at approximately 900-1,000 lbs Ca per acre, enough for two to three rotations of a nutrient-demanding tree species. This Ca level was correlated with soils that had a clay content of 3% in the upper 40 inches of soil. A committee of forest soils experts met and developed decision rules for guidelines on nutrient-poor soils where harvest of FWM would be limited except in the case of jack pine. Of the tree species common to

nutrient-poor sites, jack pine does not accumulate large quantities of nutrients, thereby allowing fine woody material to be harvested with less concern for nutrient depletion. Nutrient-poor soils can be identified by soil map units, and the Natural Resources Conservation Service (NRCS) plans to develop an automated query function within Web Soil Survey to make it easy for users to determine whether their site is considered nutrient-poor.

Physical Properties of Soil

Maintaining soil quality is a recognized tenet of responsible forest management. Effects of harvest can include compaction, churning, rutting, mixing, displacement and removal of soil. Biomass harvesting for energy can lead to increased traffic on a site, worsening these effects. Biomass harvesting, in general, is expected to occur in conjunction with traditional timber harvesting operations. This means not only will the traditional processors, forwarders and skidders be on-site, but additional equipment for the biomass harvesting may also be on-site, resulting in more intensive use of roads, landings and skid trails (Hornbeck et al 1986). The goal of the guidelines, as they relate to the physical properties of soil, is to avoid or minimize potential adverse impacts on soil structure and soil processes. One of the primary methods to limit the effects of harvesting equipment on a site is to limit the land area devoted to roads, landings and skid trails. The extent of soil compaction is then confined to designated portions of the harvest area. In addition, harvesting activities on sites which are especially susceptible to soil disturbances should also be limited. Examples of sites with sensitive soil physical properties include shallow soils, wetlands and riparian zones (Pierce et al 1993).

Water Quality

Forests play a vital role in purifying and maintaining clean water for lakes, streams and wetlands. Forested areas adjacent to lakes, streams and wetlands help maintain water quality by:

- Providing shade and moderating stream temperatures
- Supplying large woody debris
- Filtering sediment, nutrients and other pollutants from surface water runoff (NCASI 2000).

One of the basic principles of sustainable forestry is to ensure that forest management activities do not adversely affect water quality. Following Wisconsin's Best Management Practices (BMPs) for Water Quality provides foresters, loggers and landowners with practical and cost-effective methods to help protect clean water (Holaday 1995). Whole-tree harvests can remove up to twice the biomass of bolewood-only clearcuts and there is increased potential for soil disturbance and erosion (Pierce et al 1993). Several guidelines were initially drafted to address the impact of increased disturbance on water quality. However, the Advisory Committee decided that these issues would be better addressed by revision of the water quality BMPs and elected to send a request to the Water Quality BMP Advisory Committee to consider enhancement of the existing BMPs.

Scientific Uncertainty and Research Needs

The purpose of developing guidelines now, in advance of widespread biomass harvesting in Wisconsin, is to help forestall impacts that could adversely affect forest ecosystem sustainability. Draft guidelines are based on the best available information regarding harvesting effects on forest ecosystems and will be subject to periodic review and revision as better information becomes available. Furthermore, in instances

where there is uncertainty regarding possible impacts, the precautionary principle was considered as guidelines were created. However, there are several areas where gaps in available scientific data make impacts of biomass harvesting particularly uncertain. A list of research needs was developed and refined during the process of guideline development, and included the following summarized topics:

- Coarse and fine woody debris
    - Existing amounts and variation by forest and site types, and by stand age
    - Amount and variability of deposition and decomposition rates
    - Effects of retention levels and patterns on wildlife habitat and biodiversity, and on soil nutrient cycling
- Tree and snag retention
    - Effects on biodiversity, regeneration, stand growth and yield
- Better information on nutrients removed under different harvesting systems, and variation by forest types, seasons, and sites
- More information on soil nutrient capital
- Biomass harvesting life cycle analysis, addressing different harvesting options, biodiversity factors, carbon, and nutrients
- Refine measurement protocols and tools for assessing amounts of down woody debris
- Long-term monitoring: soil nutrients, presence/abundance and site utilization by selected animal and plant species

Guideline Development Process

Stakeholder support is critical to the consistent and effective implementation of technical guidance. To help ensure successful implementation, the Wisconsin Council on Forestry's Woody Biomass Harvesting Guidelines were developed using best available science with significant input from stakeholder groups and experts. The process began with the development of a document outlining the scope of the project, identifying the different teams, laying out the responsibilities and relationships of the participants, and defining the process by which guidelines would be approved. This document has proved invaluable to the continued success of the guideline development process. The scope document identified a number of teams and groups including the technical team, experts and the advisory committee:

Technical Team

Guidelines were drafted by a technical team comprised of WDNR Forestry staff. This team gathered relevant information, completed a literature review, drafted initial guidelines and a white paper detailing the scientific rationale behind the guidelines, responded to comments from expert reviewers and Advisory Committee members, and drafted revisions based on those comments and discussions. Technical team members worked with expert reviewers and Advisory Committee members to provide relevant background information, address concerns, and develop detailed guidelines for review and refinement.

Expert Review

The technical and scientific aspects of the initial guidelines and their rationale were reviewed by experts in various fields. Experts were selected with input from the Advisory Committee for their expertise in the

following areas: Wildlife Ecology and Management, Endangered Resources, Silviculture, Forest Management, Forest Economics, Harvest Systems, Wood Utilization, Forest Health, Forest Hydrology, Forest Soils, Forest Vegetation Ecology, Forest Microbiology, Fire Management.

Advisory Committee

The Advisory Committee was selected by the Wisconsin Council on Forestry and was comprised of representatives from affected stakeholder groups, including industry, government, landowners, conservation organizations, and non-profit organizations. After expert review and technical team revision, the Advisory Committee reviewed and discussed the draft guidelines at length. Advisory Committee comments were used by the technical team for further refinement of the guidelines. With some exceptions, primarily on the recommended retention level of residual fine woody material, the Advisory Committee reached consensus on the guidelines and sent them to the WI Council on Forestry for further discussion in September 2008. Following a period of public comment requested by the Council on Forestry, the Advisory Committee reconvened to revise the guidelines in light of the comments received. The revised guidelines were approved by the Council on Forestry in December 2008.

Guideline Implementation

Wisconsin's Forestland Woody Biomass Harvesting Guidelines focus on the sustainable harvest of woody biomass from forested areas within the context of generally accepted forestry practices. The guidelines provide considerations and recommendations applicable to stand and site-level management and facilitate informed decision-making regarding the harvest of woody biomass and potential impacts on other forest resources. Site-level resource management decisions are based on many different factors, including landowner objectives, site capabilities, existing regulations, economics and the best information available at any given time. It is unlikely that all of the guidelines will apply to a particular site. Instead, landowners, resource managers or loggers will consider many different factors in determining which combination of guidelines are appropriate for a particular site. There are a variety of ways in which guideline implementation and utilization will facilitate management and decision making.

Guidelines will facilitate management planning by aiding landowners or managers in deciding which sites are appropriate for biomass harvest. The guidelines, as currently developed, restrict the harvest of fine woody material from areas classified as dry nutrient-poor sandy soils and dysic histosols, and areas with shallow soils less than 20" to bedrock. In addition, managers or landowners may decide to limit biomass harvest on some sites due to exceptional features or wildlife concerns. On other sites biomass harvest may be a useful management tool. For example, some restoration efforts may be enhanced by the removal of invasive shrubs for biomass, and some silvicultural prescriptions may benefit from the removal of slash. The guidelines will help landowners and managers evaluate sites and use biomass harvests appropriately.

The guidelines are also designed to aid bio-energy interests in the efficient assessment of resource availability in Wisconsin. The proposed guidelines provide specific information regarding areas where biomass harvest is limited due to nutrient concerns. Potential industries will know where woody material will be available and what parts of their resource areas will be limited. Guidelines also provide managers with specific prescriptions for down woody material and green tree retention, which will limit the potential

for overharvesting as new industries compete for resources. The guidelines will facilitate site level planning by helping loggers determine what harvest system will maximize efficiency for the site.

During the guideline development process, stakeholders indicated that training and education will be key to the successful implementation of the woody biomass harvesting guidelines. Guideline implementation is expected to include development of a training curriculum along with rules-of-thumb and other tools to help loggers and other practitioners assess levels of fine woody material and other compliance measures. Furthermore, the guidelines themselves will serve to educate and inform citizens and industry on the issues related to the decision to remove additional biomass from forest ecosystems. Woody biomass harvesting is not yet widespread in Wisconsin, but demand could increase quickly if new industrial capacity comes on-line. Many woodland owners and forest-dependent communities may lack information about types and scales of biomass harvest appropriate for their area. The guidelines will help inform these choices. In addition, some bio-energy interests may be unfamiliar with sustainability issues associated with increased woody biomass utilization in Wisconsin and may overestimate the amount of wood available in a particular area. Training and education is essential to consistent implemention of the guidelines and will help communities, landowners, and industry to make informed decisions about the utilization of woody biomass and the development of bio-energy facilities in proximity to appropriate forest resources.

Wisconsin's Forestland Woody Biomass Harvesting Guidelines were drafted using the best available scientific information regarding the impacts of biomass extraction; where significant research gaps exist, the precautionary principle was considered. During the guideline development process stakeholders indicated that mechanisms would have to be developed to address this uncertainty, specifically investment in research, development of a monitoring program, and the periodic review and revision of the guidelines to incorporate new information. As a result, one focus of the guideline implementation program is the development of a monitoring protocol, contingent on available resources, to determine whether guidelines are consistently implemented and whether they are effective in maintaining forest sustainability and productivity. In addition, guidelines will be revisited regularly (after 3 years initially) to determine if new information warrants any revision. The development of a reasonable and consistent monitoring program and review schedule along with continued research into the effects of biomass harvest will ensure that the guidelines remain effective and relevant into the future.

The development of biomass harvesting guidelines in Wisconsin is the first step in an adaptive process that will hopefully serve to deepen our understanding of woody biomass utilization, harvest impacts, and the management of forest resources for a new bio-energy economy. We recognize that guideline implementation will require a policy of adaptive management, diligent monitoring of guideline effectiveness, and strategic investments in research. Information gained from monitoring efforts, new research, and similar processes underway in other states will be used to periodically refine and update the guidelines to reflect current knowledge and practices. Guideline development is the beginning of an on-going process of learning and knowledge creation which will give Wisconsin's forestry community and emerging bio-energy industry decision-making flexibility and facilitate an understanding of ecological systems that underlie the sustainability, productivity, and economic potential of Wisconsin's forest resources.

Wisconsin's Draft Forestland Woody Biomass Harvesting Guidelines along with other relevant documents are available on the Wisconsin Council on Forestry's website: http://council.wisconsinforestry.org/biomass/

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