DRAFT
Biomass Harvesting on Forest Management Sites in Minnesota

Prepared by

The Minnesota Forest Resources Council
Biomass Harvesting Guideline Development Committee

March 1, 2007

Developed as an additional chapter in *"Sustaining Minnesota Forest Resources; Voluntary Site-Level Forest Management Guidelines"*.

Forest Woody Biomass Harvesting

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Introduction

Interest in biomass energy in Minnesota has increased recently driven by higher energy prices and state-supported incentives to produce renewable energy. While a variety of wood-fired energy facilities have been in operation in the state for quite some time, recent expansion of the energy industry has raised concerns about the impact of increased removal of biomass from the state's forests. Projects such as the Laurentian Energy Authority municipal energy project on the Iron Range and the installation of a wood gasifier at the Central Minnesota Ethanol Cooperative in Little Falls are examples of new capacity in the renewable fuels industry. While there are numerous benefits of biomass energy such as providing jobs locally and reducing use of fossil fuels, increasing removal of biomass from forested sites has the potential to impact long-term site productivity, biodiversity, and wildlife populations.

In response to these concerns, the Minnesota State Legislature, as part of legislation on energy production from woody biomass, required the Minnesota Forest Resources Council (MFRC) and the Minnesota Department of Natural Resources (DNR) to develop guidelines or best management practices for "sustainably managed woody biomass" (MN Statute 216B.2424). The legislation specifically states that "*Guidelines …must be adopted….for logging slash, using the most recent available scientific information regarding the removal of woody biomass from forest lands, to sustain the management of forest resources as defined by section 89.001, subdivisions 8 and 9, with particular attention to soil productivity, biological diversity as defined by section 89A.01, subdivsion3, and wildlife habitat. "*
Biodiversity is defined in section 89A.01, subdivsion3 *as "the variety and abundance of species, their genetic composition, and the communities and landscapes in which they occur, including the ecological structures, functions, and processes occurring at all of these levels."*

For the purposes of these guidelines biomass harvesting includes the process of removing woody biomass from forested sites. Typically biomass harvesting is conducted in addition to roundwood harvesting on the same site, but is also conducted on sites not connected with a roundwood harvest. Biomass harvest might include the utilization of tops and limbs, small diameter trees, or stems which have historically been "non-merchantable" dead trees, down and dead woody material, and brush. Biomass harvest removes more woody material from a site than would be removed under typical roundwood harvest.

Rationale

Wildlife and Biodiversity

A general premise of forestry that considers wildlife and biodiversity is that silvicultural practices more closely resemble relevant natural disturbance regimes and natural stand development. Furthermore, there is a greater opportunity for sustaining biodiversity when the disparity between managed stands and their natural analogs is reduced.

Biological legacies are central to development of silvicultural systems that emulate natural models. Creating and leaving biological legacies maintains critical structural elements of managed stands, thereby sustaining many organisms and ecological processes dependent upon these structures (Franklin *et al*., 1997, 2000).

Natural disturbances rarely eliminate all structural elements from the preceding stand, even in the case of extreme or multiple disturbances (Franklin *et al*., 1995, 2002; Foster *et al*., 1997). The lack of significant structural legacies is a major difference between traditional even-aged harvesting methods and natural stand replacement disturbances, whether by fire, wind or insects (Lee and Crites 1999). Most prominent among the legacies lacking from harvested stands is remnant live trees, abundant snags, and down boles (with associated pit-and-mound topography) (Franklin *et al*. 1995). Many roundwood harvesting strategies involve the removal of most large trees from a site, but natural disturbance, even fire, does not. Therefore, recent forest management guidelines, including the MFRC Site-level Forest Management Guidelines, include recommendations to maintain minimum amounts of snags and down logs. Biomass harvesting following roundwood harvest increases the disparity between managed stands and their natural analogs by removing additional coarse woody debris (CWD) as well as slash; thus further challenging natural resource managers to manage sustainably.

These biomass harvesting guidelines in conjunction with existing forest management guidelines attempt to incorporate natural disturbance patterns and processes into any harvesting scheme. This can be accomplished by maintaining biological legacies through leave tree clumps, and maintaining structural complexity throughout the harvest area by retaining a level of snags, down CWD, and slash (or fine woody debris).

Role of Woody Debris in Maintaining Forest Biodiversity with Special Reference to Slash Harvests

There is an abundance of literature that shows the importance of standing and down CWD in providing habitat for vertebrate species. However, small life forms related to fine woody debris (FWD), particularly fungi, lichens, bryophytes, and arthropods, which are central to the health and productivity of forest ecosystems (Crow 1988; 1990), have not been as well studied. Woody debris, both CWD and FWD, provides habitat for many of these species (Samuelsson et al. 1994). Those relatively few studies of the importance of woody debris for invertebrates often reveal an immense diversity of species that require woody debris. For example, one three-year study in the Canadian boreal forest reported that 257 taxa (mostly species) of saproxylic beetles utilized decaying aspen logs

(Hammond et al. 2004). However, few studies have quantified amounts of woody debris needed to maintain specific populations, much less whole communities.

Harvest of slash and other woody debris for biomass as part of or following timber harvest decreases the amount of decaying wood on the forest landscapes and changes the chemical and physical environment in clear-cuts (Astrom et al. 2005). Astrom also reported that slash harvests in Sweden significantly reduced the species richness of liverworts with one third of the species disappearing (but didn't affect the species richness of vascular plants) (Astrom et al. 2005).

In clear-cuts, slash or FWD

- provides shelter, reducing wind velocity and fluctuations in ground surface temperature (Mahendrappa and Kingston 1994; Proe et al. 1994)
- provides habitat for small mammals (Eckeet al. 2002) and ground-active beetles (Gunnarsson et al. 2004)
- may shelter plants sensitive to desiccation, immediately following clearcuts (cf. McInnis and Roberts 1994; Brakenhielm and Liu 1998).

The development of a market for woody biomass means that much of coarse woody debris and slash (or fine woody debris) that would have remained on site following timber harvest for roundwood is likely to be removed. Although a certain amount of woody debris retention is essential for sustaining biodiversity and wildlife populations, science does not tell us how much woody debris can be sustainably removed from forest harvest sites. The science is clear, however, that natural disturbances create and retain considerably more woody debris than commercial timber harvest and that this difference is increased by woody biomass harvest. These guidelines provide a best scientific judgment, tempered by the consensus process of a broad group of forest management interests, at practices that will sustain a high level of biodiversity.

Water Quality

The existing Site-Level Forest Management guidelines focus on retaining water quality by avoiding sediment and nutrient movement into wetlands and waterbodies through the use of filter strips and water diversion practices. Current guidelines also focus on minimizing impacts to wetland form and function by avoiding direct damage to wetlands due to trafficking, drainage or filling.

However, re-entry into sites increases the potential for sediment movement into wetlands through disturbance of erosion control features and rehabilitated infrastructure. Re-entry into sites for the purpose of recovering biomass is not covered in the current guidelines. Nor is removal of stand components such as small diameter trees, CWD, and brush, within filter strips addressed in the current guidelines. Increased biomass harvest activity in filter strips increases the potential of filter strip disturbance. Consideration must be given to how much non-merchantable and residual coarse woody debris material should be harvested or retained in filter strips.

Riparian Management Zones (RMZs)

RMZ guidelines in the current Site-Level Forest Management guidelines deal with most issues related to harvest of biomass in or near RMZs. However, they do not specifically address removal or disturbance of brush, small trees, or CWD in RMZs. Current guidelines use residual basal area (BA) as a measure of how much roundwood should be retained in RMZs. BA does not work well as a measure of residual brush and small diameter trees. Issues related to biodiversity mentioned in previous sections have particular relevance to management within riparian zones.

Soil Productivity

These guidelines are designed to maintain the productive capacity of forest soils in Minnesota during biomass harvesting activities. A decrease in soil productivity could affect the level of timber harvesting (including biomass harvesting) the forest can sustain, as well as other forest values, such as wildlife habitat and biodiversity. Identifying and reducing impacts to this resource should be an essential part of any strategy to achieve sustainable forest management.

In *most* cases biomass harvesting *may not* create additional or increased physical impacts to soil productivity as compared to conventional forest harvesting if guidelines are followed. Where biomass harvesting may create an increased impact compared to conventional forest harvesting, is with respect to nutrient removals. Removing more biomass from a site inevitably removes more nutrients. However, even in the case of biomass harvesting where more nutrients are removed than in conventional forest harvesting, new research resulting in updated nutrient budgets and the results of long-term studies indicate that for most mineral soils in Minnesota the nutrient capital is sufficient to tolerate a large number of such harvest rotations without deleterious effects (Grigal, 2004). The current MFRC Site-Level Forest Management Guidelines are adequate to protect that resource. On deep organic soils (ombrotrophic sites), however, potassium and phosphorus fertilization may be required if aggressive biomass removal is practiced over multiple rotations. Very shallow to bedrock mineral soils are also susceptible to nutrient loss.

The current MFRC Site-Level Forest Management Guidelines with respect to nutrient depletion were developed using information in the Minnesota's Generic Environmental Impact Statement on Timber Harvesting and Forest Management (GEIS). The portion of the GEIS dealing with soils was completed in 1992, and the nutrient budgets in the report were based on state-of-the-science information available at that time (Grigal and Bates 1992). Over a decade has passed since the GEIS was published, and an update of the nutrient portion of the GEIS was recently completed (Grigal 2004) based on research that has been published since 1992.

The update revisited the assumptions that were used in the original GEIS and modified them based on current knowledge. Major changes included (a) slightly modifying the magnitude of atmospheric inputs, (b) reducing the magnitude of nutrient inputs by weathering (by 2 to 3 times), (c) adding inputs via groundwater flow to organic soils (peatlands), (d) eliminating leaching of nutrients to groundwater during the normal silvicultural rotation, (e) increasing the estimated removal of nutrients associated with merchantable bole harvesting and reducing the removal associated with whole tree-

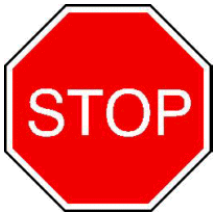
harvesting, (f) increasing nutrient capital for mineral soils by assuming uniform nutrient availability to 40 inches depth and by calculating release of nutrients from soil organic matter over 10 years rather than over one year, and (g) altering nutrient capital for organic soils and forest floor by calculating release of nutrients from organic matter over 10 years.

Specifically with respect to biomass harvesting, the update assumed that 100% of the logging residue would not be removed following conventional harvest. The material that remains would primarily be high-nutrient small branches and leaves. On the average, about 25% of the above-ground nutrients in the pre-harvest stand would be retained following residue removal, compared to about 40% retained following conventional harvest. On an average Minnesota mineral forest soil, harvest plus residue removal would result in the loss of less than 2% of the system potassium and considerably less than 0.5% of the calcium in each 50-year rotation. These trivial amounts would be undetectable using standard analytical and statistical techniques, and it is unlikely that they would affect system productivity. This conclusion has been affirmed by the results of long-term studies that have been published in the last decade. Nutrient storage in coarse-textured (sandy) soils is lower than in an "average" mineral soil. For example, the calcium capital for an average soil is about 15,000 lb/ac while that for coarse-textured soils is about half, or 7,000 lb/ac. Even on those soils, however, less than 3% of the system potassium and less than 1% of the calcium would be removed in each 50-year rotation, *including* residue removal. The situation is more problematic for some organic soils (ombrotrophic sites) which appear to be more susceptible to loss of nutrients (especially potassium and phosphorus), and very shallow mineral soils, (which appear to be more susceptible to loss of calcium).

Soils provide an environment suitable for a vast array of plant and animal populations ranging from microscopic bacteria to small mammals. Careful guideline implementation that sustains the physical and chemical characteristics of the soil will, in large part, maintain the biological characteristics as well as organic material at the soil surface; the forest floor, and leaf litter that might be targeted for biomass removal under some intensive harvesting scenarios. Most biological activity in the soil takes place in the surface soil or litter layers. Although this is a potential source of biomass, it is extremely important to maintaining a wide variety of ecosystem functions such as nutrient supply, erosion control, water retention, and rooting medium and should not be removed without strong overriding silvicultural reasons. This is true for all sites, not just the nutrient-sensitive sites.

Additional trafficking by biomass harvesting or collection equipment may, increase physical impacts to the soil. Existing guidelines such as keeping equipment on trails & infrastructure, avoidance of rutting, and operating on frozen ground should be adequate for biomass harvest as well. However, re-entry into the general harvest area of a site to collect forest residue (slash) may be problematic and is discouraged. Re-entry while operating equipment on existing infrastructure (roads & landings) is best. Any re-entry onto a site may impact regeneration and disturb rehabilitated infrastructure. Restoring erosion control features and rehabilitating infrastructure is necessary.

GUIDELINES



■ Have you identified your objectives?
■ Have you conducted a site inventory?
■ Considered the suitability of the site for biomass harvest as it relates to presence of endangered or threatened species, sensitive sites.
■ For ALL activities review and implement the **General Guidelines**
■ For all biomass harvest on forest sites review and implement the **Timber Harvesting guidelines**
■ If an access road will be constructed / utilized for this biomass harvest – review and implement the **Forest Roads guidelines**
■ For TSI activities follow applicable guidelines in this chapter as well as the guidelines found in the TSI chapter.

Biomass Harvest on Sensitive Sites

Reminder – Review General Guidelines and Timber Harvest guidelines, especially those relating to checking for the presence of known ETS species, sensitive plant communities or cultural resources.

In addition:

- ✓ Avoid harvest of woody biomass within areas identified by the Minnesota County Biological Survey (MCBS) as Sites of High or Outstanding Biodiversity Significance.
  - o Boundaries for these sites can be downloaded from the DNR's Data Deli at http://deli.state.mn.us. OR by consulting local DNR Wildlife Manager, Regional Nongame Specialist, or DNR Regional Plant Ecologist.

  Unless:

  1) Management plans specifically include strategies to maintain habitat for rare species or

  2) Biomass harvest is used as a tool to restore degraded native plant communities

- ✓ Avoid biomass harvest in native plant communities that are ranked as critically imperiled or imperiled at the state level (See Appendix J).

- To determine whether these native plant communities are known to occur on the site, consult with the local DNR Area Forestry Office and the MCBS native plant community polygon layer, which can be downloaded from the DNR's Data Deli at http://deli.state.mn.us.

- Biomass harvest may be appropriate in some rare native plant communities if used as a tool to restore degraded native plant communities (e.g., overgrown savanna plant communities). Consult appropriate DNR Wildlife Manager and DNR Ecological Services Regional Manager.

✓ Avoid biomass harvest within sites known to support populations of ETS species (plant and animal species listed as endangered, threatened, or special concern at the state or federal level), with the exception of gray wolves and Canada lynx, unless harvest has been demonstrated to maintain or improve habitat for these species.
- To determine whether these species are known to occur on the site, consult the local DNR Area Forestry Office.
- If a bald eagle nest occurs on or near the site, see Recommendations for Avoiding and Minimizing Impacts http://files.dnr.state.mn.us/natural_resources/animals/birds/eagles/factsheet.pdf).

Managing Water Quality and RMZs

Reminder - It is important to follow the water quality and RMZ management guidelines found in the General Guidelines as well as the Timber Harvesting guidelines in previous chapters.

In addition:

✓ Avoid removal of CWD and snags from within filter strips.

✓ Avoid harvest of additional biomass from within RMZs over and above the tops and limbs of trees normally removed in a roundwood harvest under existing timber harvesting guidelines.

When managing near a dry wash in SE Minnesota:

✓ Avoid additional biomass removal within 25 feet of the dry wash bank except tops and limbs of trees normally removed in a roundwood harvest under existing timber harvesting guidelines.

Managing Soil Productivity

Reminder - Review the General Guidelines and Timber Harvesting guidelines relating to soil productivity including infrastructure management, nutrient conservation and avoiding impacts to physical properties.

In addition:

✓ Avoid biomass harvesting (over and above bolewood utilization) on:

- Organic soils deeper than 24 inches that are ombrotrophic.
  - Ombrotrophic sites typically have over 90% of the basal area in black spruce with no alder or willow in the understory. These sites fit the Northern Spruce Bog (APN80) and Northern Poor Conifer Swamp (APN81) described in "*Field Guide to the Native Plant Communities of Minnesota – The Laurentian mixed Forest Province"*, MN DNR 2003.

- Aspen or hardwood cover types on shallow soils (8 inches or less) over bedrock.

PHOTO FIGURE representing an ombrotrophic site (APN80)

■ **Additional Consideration**
For soils with 8-20 inches of soil over bedrock, consider retaining one third or more of the fine woody debris (FWD) on the site. Slash and residue (FWD) should be relatively evenly distributed throughout the site rather than piled (see also section titled Managing /Retaining Wildlife Habitat and Structural Diversity)

✓ Do not remove the forest floor including soil surface, litter layer, and root systems for utilization as biomass.

- Some silvicultural prescriptions may call for disturbance of forest floor, but removal of this material or piling should be avoided

✓No more than 3% of the site should be taken up by roads, landings and stockpiles.

✓ Avoid additional biomass harvest from erosion-prone sites (e.g., those sites on steep slopes of 35% or more) over and above the tops and limbs of trees normally removed in a roundwood harvest under existing timber harvesting guidelines.

✓ Ensure that landings or on-site areas used to store biomass are in a condition that favors regeneration and growth of native vegetation and trees.

■ **Additional Consideration**

When biomass products are piled on landings for the majority of one growing season or longer, natural regeneration will usually be reduced.

Re-entry into Previously Managed Sites

Residue from timber harvests and other forest management activities often remain piled on-site after activities are completed. Caution should be used if re-entering these sites so that future forest regeneration is not reduced and infrastructure rehabilitation efforts are not compromised.

■ Re-entry into the general harvest area of a site by a second operation for the purpose of harvesting biomass should be avoided.

■ Re-entry into a site using existing infrastructure (roads and landings) may be permitted as long as roads and landings are rehabilitated and erosion control features re-established.

✓ Re-establish erosion control measures if necessary (features) if re-entering a site for biomass harvest

✓ Avoid re-entry of sites across non-frozen wetlands

✓ Avoid trafficking over the general harvest area including skid trails or over regeneration.

■**Additional Consideration**
Piles left on site for an extended period may be inhabited by species such as Canada lynx, black bears, and other wildlife known to den in slash piles. Retain the slash piles showing evidence of use and consider retaining those that are difficult to access.

PHOTO FIGURE representing piles with good access versus piles at difficult access location and surrounded by re-generation.

Managing / Retaining Wildlife Habitat and Structural Diversity

Reminder – Review and incorporate leave tree, snag, and CWD guidelines in the Timber Harvesting and General Guidelines chapters. The intent of these biomass harvesting guidelines is to leave all existing CWD and snags.

In addition:

✓Leave all snags possible standing in harvest areas.

- Snags cut for safety reasons should be left where they fall

✓Retain and limit disturbance to all CWD (except those in skid trails or landings).

✓ Retain stumps and uprooted stumps

✓Avoid removal of CWD material from the forest floor in filter strips (see filter strip guidelines)

✓ Avoid biomass harvest in leave tree clumps except tops and limbs of trees normally removed in a roundwood harvest under existing timber harvesting guidelines.

- Consider retaining leave trees in clumps or islands, in preference to scattered leave trees (see pages 33-39 of the Timber Harvesting chapter for leave tree guidelines).

✓ Avoid biomass harvest from within RMZs over and above the tops and limbs of trees normally removed in a roundwood harvest under existing timber harvesting guidelines.

✓Retain and scatter tops and branches from 20% of trees harvested in the general harvest area (1 out of every 5 trees harvested.

The over-all goal for FWD retention is to retain about 1/3 of the FWD on a site. This is achieved by intentionally retaining 20% of the FWD (tops and limbs from 1 in 5 trees harvested), with an additional 10 –15% achieved by incidental breakage during skidding. Usually more breakage occurs in winter than in summer.

Examples

■ When using a cut – to – length system, the tops and branches from 1 tree out of 5 should be processed and left on the site. The tops and limbs from the remaining 4 trees could be piled for utilization as biomass.

■ When utilizing a full tree skidding operation, the tops and limbs from 1 in 5 trees processed at the landing should be hauled back out and scattered on the general harvest area.

✓ Avoid removing tops and limbs resulting from incidental breakage from the general harvest area

✓ If harvesting brush and small trees for biomass associated with a timber harvest, leave 20% of this material on the site (this material can be run over or cut, but should remain on the site).

PHOTO FIGURE depicting acceptable methods of brush retention (both standing and run over).

Biomass Harvest for Fuel Reduction

(To be used when harvesting understory vegetation for purposes of mechanical fuel reduction)

- ✓ Retain understory vegetation in several reserve patches that total at least 20% of the harvest unit.
- ✓ Reserve patches should represent all soil moisture conditions within the harvest unit
- ✓ Retain snags >12-inch dbh and down logs where at least one end is >12-inch in diameter and 6 feet in length.
- ✓ Modify management activities to maintain, promote, or enhance ETS species (endangered, threatened, or special concern) on the site.

PHOTO FIGURE depicting fuel reduction research (reserve patches, snags, etc.) at Superior National Forest.

Biomass Harvest for Salvage Following Blowdown or Fire with No Roundwood Harvest

- ✓ Retain several reserve patches that total at least 20% of the harvest unit.
- ✓ When present, retain at least 20 snags >12-inch dbh per acre outside reserve patches (if fewer large snags are present, retain 20 snags per acre of the largest dbh).
- ✓ When present, retain at least 20 sound logs >12-inches in diameter and 6 feet in length per acre (if fewer down logs are present, retain 20 logs per acre of the largest diameter).
- ✓ Modify management activities to maintain, promote, or enhance ETS species (endangered, threatened, or special concern) on the site.

PHOTO FIGURE depicting blowdown salvage that has reserved some patches equal to approximately 20% of the harvest area with snags and CWD present.

Biomass Harvest Considerations as a tool for Silviculture Management

Harvesting of biomass may provide an excellent tool to help accomplish various silvicultural management objectives on some sites, but on other sites biomass harvesting may not fit within management strategies. Utilization standards and harvesting techniques may need to be modified to fit site conditions and management objectives. Some brief examples are given below where biomass harvest may or may not help accomplish management objectives.

■ **Swamping** Removal of woody vegetation may temporarily increase the wetness of some sites due to decreased transpiration. When harvesting lowland hardwood stands, consider retaining understory vegetation and non-merchantable stems. Retention of transpiring vegetation reduces the potential for "swamping" of some sites, which may increase the chances of poor regeneration due to increased wetness.

■ **Artificial Regeneration** If planning for artificial regeneration of a site, consider biomass utilization as a means of preparing or improving a site for planting. Utilization of biomass from a site can reduce the need for some site preparation practices such as brush raking or shearing. These practices require intensive trafficking of the site by heavy equipment, may require burning of piles, and may result in depositing topsoil in windrows. Use of biomass harvesting may eliminate the need for this practice, thereby reducing soil impacts and reducing the cost for site preparation, as well as improving conditions for planting.

■ **Browse Deterrent** Consider the use of heavy slash, or strategically placed slash as a deterrent to browsing by large ungulates (deer and moose). For example, when working in oak stands with the goal of natural oak regeneration – consider leaving heavy oak tops and branches that form a "cage" type structure when felled to the ground. This technique has been shown to reduce deer browse within the "cage" and increase survival of oak regeneration from seed. Heavy slash loads (even on clearcut sites) can be a used as a deterrent to browsing.

■ **Natural Regeneration** Consider modifying biomass harvest if planning natural regeneration of conifers from seed (especially serotinous cones) by retaining all or some cone bearing slash to provide a seed source. Timing of harvest, site conditions, and species being managed for will influence strategies. In some cases, prior removal of understory brush (such as hazel or balsam fir) may facilitate natural regeneration by removing competition and scarifying the seedbed.

■ **Bark Beetles** Biomass harvesting may promote management strategies for insect and disease control. For example, consider the utilization of slash and non-merchantable stems in red pine thinnings to prevent bark beetle build-ups. In red pine harvests, biomass removals could benefit nearby and residual pines by preventing or mitigating bark beetle populations only if these pines are not wounded by biomass and harvesting machinery. During the late summer, fall, winter and early spring, removal of fresh slash and non-merchantable stems, and logs from abandoned piles and log decks on harvested

sites will prevent bark beetle build-up during the following season. Complete all removals by June 1st. If necessary during the late spring or summer, bark beetle populations can be directly controlled by harvesting the infestation pockets, removing slash and non-merchantable stems on the site and removing logs from abandoned piles and log decks. Complete removals within 3 weeks of initial cutting. If biomass retrieval is likely to cause wounding of red pine stems or root systems, then it should not be allowed.

■ **Thinning Stands** Many plantations may benefit from pre-commercial thinning - before individual stems are large enough to provide traditional roundwood products. Consider biomass harvest as a means of marketing early thinning in these plantations. For example, some studies show that thinning white spruce plantations at age 25 yields the best growth response in the residual stand, but typically there is not enough pulp volume at that age to make a commercial sale. Biomass harvesting may provide a commercial avenue to accomplish the thinning in these stands. Benefits of thinning stands early include better growth and form of residual crop trees and improved in-stand structure for some wildlife species. Damage to residual stems and root systems should be strongly avoided.

Glossary

Biomass: The organic materials produced by plants, such as leaves, roots, seeds, and stalks. In some cases, microbial and animal metabolic wastes are also considered biomass. The term "biomass" is intended to refer to materials that do not directly go into foods or consumer products but may have alternative industrial uses. Common sources of biomass are (1) agricultural wastes, such as corn stalks, straw, seed hulls, sugarcane leavings, bagasse, nutshells, and manure from cattle, poultry, and hogs; (2) wood materials, such as wood or bark, sawdust, timber slash, and mill scrap; (3) municipal waste, such as waste paper and yard clippings; and (4) energy crops, such as poplars, willows, switchgrass, alfalfa, prairie bluestem, corn (starch), and soybean (oil). (***McGraw-Hill Encyclopedia of Science and Technology*, 5th edition, published by The McGraw-Hill Companies, Inc.)**

Coarse Woody Debris (CWD): Stumps and fallen trunks or limbs of more than 6-inches in diameter at the large end.

Fine Woody Debris (FWD) - Tops, limbs and woody debris less than 6-inches at the large end.

Ombrotrophic: A condition where minerals and nutrients are received solely from precipitation and dust fall and not from runoff or groundwater; characteristic of bogs. (source; Field Guide to the Native Plant Communities of Minnesota – The Eastern Broadleaf Forest Province.

Roundwood harvest: Roundwood harvest refers to a timber harvest were only the main stem of trees are removed from the site.

Sustainably Managed Woody Biomass: For purposes of biomass guideline development and in accordance with MN Statute 216B.2424 subd.1(d) "sustainably managed woody biomass" is defined as:

(1) brush, trees, and other biomass harvested from within designated utility, railroad, and road rights-of-way (guidelines will not be developed for this category of biomass);

(2) upland and lowland brush harvested from lands incorporated into brushland habitat management activities of the Minnesota Department of Natural Resources;

(3) upland and lowland brush harvested from lands managed in accordance with Minnesota Department of Natural Resources "Best Management Practices for Managing Brushlands";

(4) logging slash or waste wood that is created by harvest, by precommercial timber stand improvement to meet silvicultural objectives, or by fire, disease, or insect control treatments, and that is managed in compliance with the Minnesota Forest Resources Council's "Sustaining Minnesota Forest Resources: Voluntary Site-Level

Forest Management Guidelines for Landowners, Loggers and Resource Mangers" as modified by the requirement of this subdivision; and

(5) trees or parts of trees that do not meet the utilization standards for pulpwood, posts, bolts, or sawtimber as described in Minnesota Department of Natural Resources Division of Forestry Timber Sales Manual, 1998, as amended as of May 1, 2005, and the Minnesota Department of Natural Resources Timber Scaling Manual, 1981, as amended as of May 1, 2005, except as provided in paragraph (a), clause (1), and this paragraph, clauses (1) to (3).

Appendix

A: MCBS Statewide biodiversity significance ranking (to be put into appendices

1.Outstanding
Sites containing the best occurrences of the rarest species, the most outstanding examples of the rarest native plant communities, and/or the largest, most intact functional landscapes present.

Sites with one or more of A, B or C as follows:
A. *An area of C or higher rank native plant communities, except for special circumstances where plant communities are not present--e.g. bat cave/mussel bed, containing:*

an A-B rank occurrence of a G1-G2 species;

or *one of the best occurrences of a S1-S2 species;*

or *a concentration (4+) of excellent or good occurrences (A or B ranked) of co-occurring S1-S3 species,*
- *at least 1 of which is a S1-S2 species,*
- ***or*** *with at least two classes of organisms represented (e.g. special animal & special plant).*

B. *One of the highest quality examples in an ECS subsection (based on EO rank, size and context) of the rarest (S1-S3) native plant community types;*

or *a group of important native plant communities (S1-S3) that together are of sufficient size and quality to constitute one of the highest quality natural areas in an ECS subsection.*

C. *One of the largest, least-fragmented, least-developed landscape areas in an ECS subsection that has the full spectrum of matrix to small patch native plant communities (any S rank; mostly A-BC quality), the highest potential for intact ecological functioning (e.g. fire, natural patch dynamics, natural water level fluctuations), and high potential for supporting regional-scale organisms.*

2. HIGH
Sites containing the "best of the rest," such as sites with very good quality occurrences of the rarest species, high quality examples of the rarest native plant communities, and/or important functional landscapes.

Sites with one or more of A, B or C as follows:
A. *An area of native plant communities, except for special circumstances where plant communities are not present--e.g. bat cave/mussel bed, containing:*

a BC-C rank occurrence of a G1-G2 species;

***or** a B-C rank occurrence of a S1-S2 species;*

***or** a concentration (4+) of A to B rank occurrences of co-occurring S3 species.*

***B.** A high quality example (with EO rank of B or higher, and also based on size and context) , though not among the best in an ECS subsection, of one of the rarest (S1-S3) native plant community types.*

***C.** A little-fragmented, little-developed landscape area that has the full spectrum of matrix to small patch native plant communities (any S rank), high potential for intact ecological functioning, and high potential for supporting regional-scale organisms, **but** also fits one of the following descriptions:*

it is mostly composed of A-BC rank native plant communities but is not one of the largest landscape areas in the ECS subsection;

***or** it is one of the largest landscape areas in the ECS subsection but has significant amounts of human-induced disturbance so that native plant communities are mostly less than BC rank.*

3. MODERATE
Sites containing significant occurrences of rare species, and/or moderately disturbed native plant communities and landscapes that have a strong potential for recovery.

Sites with one or more of A, B or C as follows:
A. An area of native plant communities, except for special circumstances where plant communities are not present--e.g. bat cave/mussel bed, containing:

A D rank occurrence of a G1-G2 or S1-S2 species;

or a single A-B rank occurrence of a S3 species;

or a concentration (4+) of co-occurring occurrences of BC-C rank S3 species.

B. A good quality example (C rank or higher) of any native plant community type;

or a CD rank occurrence of a S1-S2 community that is among the largest for the type within the ECS subsection.

C. A little-developed landscape area that is not among the largest in an ECS subsection and is not mostly composed of A-BC rank communities, but has high potential for

recovery of the full spectrum of matrix to small patch native plant communities, intact ecological functioning, and regional-scale organisms.

Literature Cited

M. Astrom, M. Dynesius, Hylander *(what are the initial(s)?)*, and C. Nilsson. 2005. Effects of slash harvest on bryophytes and vascular plants in southern boreal forest clear-cuts. Journal of Applied Ecology 42: 1194-1202.

Brakenhielm, S. and Q. Liu. 1998. Long-term effects of clear-felling on vegetation dynamics and species diversity in a boreal pine forest. Biodiversity and Conservation 7: 207-220.

Crow, T. R. 1988. Biological diversity: Why is it important to foresters? In: Managing north-central forests for non-timber values. Duluth. MN SAF.

Crow, T. 1990. Old growth and biological diversity: a basis for sustainable forestry. In: Old-growth forests: What are they? How do they work? Toronto, Canada. Canadian Scholar's Press.

Ecke, F., O. Lofgren, and D. Sorlin. 2002. Population dynamics of small mammals in relation to forest age and structural habitat factors in northern Sweden. Journal of Applied Ecology 39: 781-792

Foster, D.R., J.D. Aber, J.M. Melillo, R.D.Bowden, and F.A.Bazzaz. 1997. Temperate forest response to natural catastrophic disturbance and chronic anthropogenic stress. BioScience 47: 437-445.

Franklin, J.F., P.M. Frenzen, and F.J. Swanson. 1995. Recreation of ecosystems at Mount St. Helens: contrasts in artificial and natural approaches. In: Cairns Jr., J. (Ed.), Rehabilitating Damaged Ecosystems, 2nd Edition. CRC Press, Boca Raton, FL, pp. 287-333.

Franklin, J.F. *(need names)*. 2002. Disturbances and structural development of natural forest ecosystems with silvicultural implications, using Douglas-fir forests as an example. Forest Ecology and Management 155: 399- 423.

Fridman, J. and N. Walheim. 2000. Amount, structure, and dynamics of dead wood on managed forest land in Sweden. Forest Ecology and Management 131: 23-36.

Grigal, D.F. 2004. An update of "Forest soils. A technical paper for a generic environmental impact statement on timber harvesting and forest management in Minnesota." Submitted to Laurentian Energy Agency, Virginia, MN. 32 p. (mimeo)

Grigal, D.F. and P.C. Bates. 1992. Forest soils. A technical paper for a Generic Environmental Impact Statement on Timber Harvesting and Forest Management in Minnesota. Jaakko Poyry Consulting, Inc. Tarrytown, NY 155 p.

Minnesota Department of Natural Resources. Field Guides to the Native Plant Communities of Minnesota. Ecological Land Classification Program, Minnesota County Biological Survey, and Natural Heritage and Nongame Research Program. St. Paul, Minnesota.

Minnesota Forest Resources Council. 2005. Sustaining Minnesota Forest Resources: Voluntary Site-Level Forest Management Guidelines for Landowners, Loggers and Resource Managers. St. Paul, Minnesota

Gunnarsson, B., K. Nitterus, and P. Wirdenas. 2004. Effects of logging residue removal on ground-active beetles in temperate forests. Forest Ecology and Management 201: 229-239.

Hammond, H.E.J., D.W. Langor, and J. R. Spence. 2004. Saproxylic beetles (Coleoptera) using *Populus* in boreal aspen stands of western Canada: spatiotemporal variation and conservation of assemblages. Canadian Journal of Forest Resources 34:1-19.

Hunter, M.L., Jr. 1999. Maintaining biodiversity in forest ecosystems. Cambridge Univesity Press.

International Energy Association. 2002. Sustainable Production of Woody Biomass for Energy. A Position Paper Prepared by IEA Bioenergy. 12pp

Kohm, K.A., and J.F. Franklin. 1997. Creating a forestry for the 21st century: The Science of Ecosystem Management. Island Press, Washington DC USA.

Kruys, N. and B.G. Jonsson 1999. Fine woody debris is important for species richness in logs in managed boreal spruce forests of northern Sweden. Canadian Journal of Forest Resources 29: 1295-1299.

Lee, P. and S. Crites. 1999. Early successional deadwood dynamics in wildfire and harvest stands. Pages 65-85 in Lee, P., editor. Fire and harvest residual project: the impact of wildfire and harvest residuals on forest structure and biodiversity in aspen-dominated boreal forests of Alberta. Alberta Research Council, Vegreville, AB.

Mahendrappa, M.K. and D.G.O. Kingston. 1994. Intensive harvest impacts on soil temperature and solution chemistry in the maritimes region of Canada. New Zealand Journal of Forest Science (*need volume number)* 402-414.

McInnis, B.G. and M.R. Roberts. 1994. The effects of full-tree and tree-length harvest on natural regeneration. Northern Journal of Applied Forestry 11: 131-137.

Norden, B., M. Ryberg, F. Gotmark, and B. Olausson. 2004. Relative importance of coarse and fine woody debris for the diversity of wood-inhabiting fungi in temperate broad-leaf forests. Biological Conservation 117: 1-10.

Proe, M.F., J. Dutch, and J. Griffiths. 1994. Harvest residue effects on micro-climate, nutrition, and early growth of Sitka spruce (Picea sitchensis) seedlings on a restock site. New Zealand Journal of Forest Science: 24: 390-401.

Samuelsson, J., L. Gustafsson, and T. Ingelog. 1994. Dying and dead trees – a review of their importance for biodiversity. Swedish Threatened Species Unit, Uppsala.

Siitonen, J. 2001. Forest management, coarse woody debris and saproxylic organisms: Fennoscandian boreal forests as an example. Ecological Bulletin 49: 11-41.