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Guidelines for harvesting forest biomass for energy: A synthesis of environmental considerations

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ABSTRACT

Interest in the utilization of forest biomass for energy is growing. A search into existing forest biomass harvesting and regeneration guidelines was carried out to identify how biomass energy can be environmentally sustainable. Findings have shown that there are only a few guidelines that specifically address harvesting and regenerating biomass for bioenergy or other bio-based products. Of these few, there are guidelines developed for dedicated energy plantations such as the Scottish Agricultural College guidelines, as well as some Finnish and Swedish guidelines recommending management practices for both timber and biomass extraction. Most of the existing small woody material guidelines emphasize the retention, disposal, redistribution, burning and mulching of biomass material on-site in a more detailed manner than forest and timber management guidelines. This study synthesizes and classifies existing biomass-related guidelines based on an in-depth literature review of existing guidelines in Europe and North America involved with biomass energy harvesting. Biomass guidelines are classified according to those applicable to systems producing biomass commercially for energy versus those that are applicable to systems managing this material for non-commercial purposes. Biomass guidelines are analyzed with respect to how they address issues of sustainability related to soil, water and habitat. Recommendations are offered for developing guidelines for biomass harvesting.

1. Introduction

Several international and national policies have been put in place to promote large-scale biomass utilization for energy (e.g., EC Communication Biomass Action Plan 2005, US Energy Policy Act 2005 [1,2]), because of growing energy needs, concerns for carbon dioxide emissions from burning fossil fuels, and the price of oil. However, the contribution that biomass can make to future global energy demand is not clear and has been inconsistently addressed [3]. An increase in

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demand for biomass energy has raised serious concerns about the long-term effects of forest residue removal on soil productivity [4–6], water quality [7,8] and habitat [9,10]. This is because harvest and removal of biomass is expected to have a greater impact on soil, water and habitat than conventional forest practices. Relying entirely on general forest management guidelines for the management of biomass harvest operations is unlikely to be sufficient [8,11], and the development of specific biomass guidelines is therefore necessary to ensure sustainability.

2. Study objective and methodology

This study investigates and evaluates criteria for harvesting biomass from forestlands for energy purposes. The objectives are to identify and classify existing forest biomass guidelines that promote sustainability, analyze existing environmental concerns, and offer recommendations for developing biomass harvesting guidelines.

This study synthesizes available biomass harvesting guidelines through a review of current literature and discussions with forest biomass professionals in North America and Europe, to investigate current and potential guideline development efforts.

3. Study scope

Energy feedstock from managed forests and energy plantations can be derived from above and below ground biomass material. For this synthesis, biomass includes forest residue extractions from forest management operations, stumps, and biomass from dedicated plantations. In general, biomass for energy has a lower bulk density and value than wood for timber or the pulp and paper industry.

The supply chain of biomass energy from forests and plantations extends from activities at the harvest site to the power plant. Biomass energy guidelines can therefore address recommendations for on-site and off-site activities. This study covers on-site harvest activities only. This does not include activities such as road transportation, energy used in extraction, or emissions. On-site activities cover biomass removal practices from harvest site to landing (the area dedicated to handling and processing material on a harvest site).

4. Purpose of guidelines

In general, guidelines are developed to protect resources of interest and value for future generations through regulation of their use. Forest management guidelines offer a balanced framework to contribute to the goal of sustainability of forested lands and forest resources by protecting soil productivity, water quality, habitat and ecosystem services [12].

Potential for biomass harvesting is site-specific. Utilization depends on the preferences of landowners and associated primary management goals for a site. Many site-specific management goals favor retaining forest residues over extracting them, because forest residues are important for providing site nutrients, maintaining site physical properties, protecting water quality and providing habitat [13–15]. However, if implemented properly, harvesting biomass and logging residues can improve conditions for site preparation. If the quality of site preparation is improved, planting becomes easier and faster to carry out and regeneration can be improved as well [16]. Once biomass extraction is intended, biomass guidelines should apply to provide forest machine operators with guidance for conducting specific biomass harvest operations. If there are no guidelines available, harvesting biomass for energy is left to the discretion of forest land owners and machine operators at the time of harvest.

5. Biomass guidelines

With the rapidly increasing interest in biomass for energy, guidelines are necessary to ensure the sustainable use of this resource in a manner that does not impair both its commercial and non-commercial services. For example, over-extracting biomass can reduce soil productivity and hence reduce the sustainable supply of this material for future generations. On the other hand, if implemented properly, biomass removal can benefit overall forest management and energy goals.

There are only a few guidelines in the Europe and North America that specifically address removing biomass for energy; practitioners therefore often recommend guidelines for biomass harvesting based on traditional forest best management practices [8], often known as forest management guidelines [17]. Basing biomass-harvesting guidelines on forest management guidelines is a logical starting point to develop biomass-specific guidelines. However, forest management guidelines alone may not be sufficient to ensure sustainable harvesting of biomass for energy for the following reasons:

- because of the high nutrient concentration in branches, roots and leaves, biomass harvesting has the potential to have a greater impact on soil productivity, water quality and habitat than current traditional timber harvesting practices;
- conventional guidelines offer guidance on how to conduct harvesting practices, largely for timber production, but do not address removing more of the residue and small material from a site. Guidelines do offer recommendations for how to arrange logging residue material on skid trails to minimize soil compaction and damage, and in some cases recommend the redistribution of residues on a site after harvest;
- forest management guidelines recommend dealing with residues by disposing of, redistributing, burning, retaining, shearing and mulching this material for forestry and timber goals, while biomass guidelines need to address the repeated harvest of this material sustainably.

6. Classification of existing guidelines

This section provides a classification of existing biomass-related guidelines. Existing guidelines address the management of