Harvesting Fuel: Cutting Costs and Reducing Forest Fire Hazards Through Biomass Harvest

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EXECUTIVE SUMMARY

Project Background
The Institute for Agriculture and Trade Policy (IATP) received a Healthy Forest Restoration Biomass Utilization Grant (BUG) to conduct test biomass harvests to understand barriers to harvesting and utilizing biomass from the Superior National Forest in northeastern Minnesota. Partners in the project included the Laurentian Energy Authority (LEA), a logger's cooperative—Forest Management Systems (FMS)—and the Superior National Forest (SNF). Biological and physical research and analysis was led by a team from the University of Wisconsin—Stevens Point, while economic analysis was handled by researchers from the University of Minnesota.

Biomass is material in the forest not traditionally utilized in pulpwood or sawtimber markets, such as shrubs, small-diameter trees, tree branches and coarse woody debris. There is interest from the local to the national level in sustainable harvest of biomass. Sustainable harvest of biomass can provide renewable energy, create economic opportunities, slow the pace of climate change and improve forest health.

This study was designed to provide information on two sets of challenges to the development of biomass markets in and around the Superior National Forest: 1) economic and operational issues faced by loggers; and 2) environmental constraints of concern to land managers, scientists and policy-makers involved in developing and refining biomass harvest practices. In the course of our study, we determined that administrative systems and constraints formed a third and important set of challenges to the development of biomass markets.

The Superior National Forest (SNF) is a three million acre National Forest in northeastern Minnesota managed for multiple uses including water, wildlife, timber and recreation. In some areas of the Forest, fuel loads (dense understory vegetation, and standing and down dead material) in excess of historical norms have accumulated. These excessive fuel load areas in the SNF have created high fire hazards and risks on significant acreage. Many of these acres are within the growing “urban interface” areas of the forest, where a high-intensity wildfire could threaten homes and people. Reduction of fuel load in these areas in a timely manner under current budgetary and market conditions presents a challenge in forest management.

The SNF approached this project with the hope of encouraging the development of local markets for biomass and providing harvesters with experience in removing biomass. In addition, the SNF was interested in testing new and different prescriptions for harvesting biomass. It was anticipated that biomass harvest could be a viable treatment method and in some instances even generate positive revenue, while also increasing the opportunity to reduce fuels in these high-risk, fire-prone areas.

Test Harvest Sites and Prescriptions
Nine test harvests were conducted in the summer and fall of 2006. Environmental data were gathered on pre-harvest and post-harvest biomass quantities for each harvest site. Economic data were gathered on the various harvest, forwarding and processing systems used.

- The Caribou Trail tests had six sites. These stands had experienced heavy spruce budworm kill of understory balsam fir ten or more years previously. Most of the dead balsam had blown over, creating mats of fuel under young regenerating balsam fir and hazel. A broken canopy of old-age aspen was present over most test plots, along with standing dead snags and dead and down aspen trees ten inches and more in diameter.

Prescriptions varied on the six sites, but usually called for harvest of aspen species less than 6 inches in diameter four feet off the ground, or “diameter at breast height” (dbh), balsam fir less than 5 inches dbh and spruce less than 2 inches dbh. Prescriptions also included crushing or removing 80 percent of the dead and downed and standing dead material. Merchantable balsam fir, other submerchantable species and brush was included for treatment on specific sites. Breaking up the continuity of excessive fuel on sites near the urban interface was intended to reduce the risk of fires and lessen the intensity of fires if they occurred.
• The Pitch Lake location had three sites. This stand had a 60- to 80-year-old red and white pine overstory managed on a long rotation with a heavy understory growth of healthy balsam fir. The balsam provided continuous ladder fuels into the canopy, posing a high risk of a stand-replacing crown fire.

The prescription was to remove all balsam fir and spruce less than 5 inches dbh outside the marked leave areas. Small hardwoods that occurred together with the balsam fir could also be removed. The goal was to maintain and manage the stands for longer rotations, and manage ladder fuels to reduce crown fire risk.

**Equipment Selection**

The choice of harvest, forwarding and transportation systems was determined with a combination of research, creativity, availability and adaptive learning by the project participants. Loggers from Forest Management Systems led the effort, with significant research and coordination by the Institute for Agriculture and Trade Policy and recommendations from all Biomass Utilization Grant team members.

In some instances, commonly available logging equipment was used to harvest or handle biomass. In other instances, unique combinations of equipment or systems not often found in the region were tested. Team members traveled to Montana to observe the Ponsse EH-25 biomass harvest head in a Lodgepole pine thinning demonstration. Loggers met with TimberPro in Shawano, Wis., to discuss the development of a forwarder prototype. Many manufacturers were contacted to loan or provide access to equipment not commonly available in the region.

**Biophysical Site Assessment**

A variety of sampling techniques were used to measure the total biomass on site. These measurements were repeated post-harvest (on harvested sites) and the resulting differences were analyzed to compare with gross biomass yield measurements taken by weighing material removed from the site on trucks. Sample techniques were based on or adapted from standard methods in common use by the United States Forest Service (USFS) whenever possible to facilitate comparisons with other sites and other research. Measurements were made of the materials that made up the overstory, midstory and understory, as well as snags, coarse and fine woody debris, duff and litter. Limited soil analysis was conducted in each area. Each site was tested for the presence of non-native earthworms and the species found on site were identified.

**Biophysical Results**

A great deal of concern has been expressed about the environmental impacts of biomass harvest. Much of this concern is based on the expectation of total removal of coarse woody debris and associated potential soil nutrient loss. Even on sites with a specific goal of removal of coarse woody debris, there were only low or moderate decreases of coarse woody debris after harvest, and in one case, an increase. The highest rate of coarse woody debris harvest only amounted to 39 percent removal.

Generally, efficiencies at removal of the specified biomass materials varied greatly. Many of the sites had areas that were not suitable to harvest (topography was rough or steep, overstory crop trees that were too dense for efficient biomass harvest or patchy distribution of the understory, which meant that some areas had little biomass material to harvest). The highest efficiency of harvest was 75 percent of the stems less than 1 inch dbh and 94 percent of stems greater than 1 inch dbh. Most sites fell well under this level of harvest.

The overstory had by far the largest volume of biomass on the sites. When any significant quantity of material greater than 5 inches in dbh will be removed, the bulk of the removals will be concentrated in this material. Some large stems may have more volume than entire acres of biomass 0-5 inches dbh. Materials from 1-5 inches in dbh generally held far more volume than smaller materials and were a significant source of biomass for these harvest operations.

Snags were far less impacted by the harvesting activity than expected. Generally, few snags were removed, even on sites where this was a goal.
Harvesting Economics
Analyses were conducted to determine the cost effectiveness of combining fuel load reduction with biomass harvesting for energy. All nine harvested sites were analyzed. Estimated costs of conventional mechanical fuel treatments (crush and/or pile and burn) were compared with the biomass treatment option. We analyzed the difference between biomass harvesting and delivery costs, and income from selling biomass. A number of harvesting and delivery systems, and transportation scenarios were examined to identify different opportunities for reducing mechanical treatment costs. Initially, only one test unit showed a reduction in fuel treatment costs using biomass harvest.

However, models were developed that optimized equipment mobilization and biomass transport, and projected economic costs of transporting biomass and machinery 25, 50, 75, 85, 100, 125 and 150 miles. Controlling for these factors, the models showed cost reductions for six of the nine test harvests for at least some of the modeled haul distances. These results showed that per acre, biomass treatment options can reduce costs in comparison with conventional fuel treatment costs. The amount of cost reduction varied with treatment equipment used and hauling distance to end users.

Harvesting Economics Observations
Certain factors appear to have a significant influence on whether a biomass harvest will reduce fuel management costs versus conventional treatments. These factors might be grouped in three categories: markets, management and operations. See the Recommendations section of the “Executive Summary” for a summary of these factors.

The Logger’s Voice
There is a large body of literature which has focused on biomass harvest for energy production, and on biomass removal as a hazardous fuel reduction method. However, the literature that assesses the lessons of these trials, based on the perspective of the operators who put these trials into practice, is not common.

To this end, project researchers interviewed the operators of the harvest, forwarding and transport equipment to obtain their observations and recommendations. The information in this chapter flows from primary research, collected using field-based, in-depth, semi-structured interviews and follow-up phone discussions with forest and road equipment operators who participated in these trials. Logistical concerns identified are based on the operators’ responses and input, and are intended to offer insights for future biomass harvesting research and operations. Data analysis identified two main logistics-related components in the operators’ responses: one related to harvesting and delivery challenges; and another related to planning and coordination challenges. See the Recommendations section of the “Executive Summary” for a summary of Loggers’ recommendations.

Administrative Systems
Timber harvest activities on National Forests are subject to a variety of federal laws, including the National Environmental Policy Act (NEPA). Before harvesting can commence, public involvement and other requirements of NEPA must be fulfilled. The NEPA process culminates in a decision document (a Record of Decision, Decision Notice or Decision Memo) that identifies the treatment objectives of the timber harvest and related activities. There is flexibility in adjusting site prescriptions after the decision document is issued, but only to the point that they still meet the treatment objectives identified and the scope and intensity of actions considered in the project analysis. Revision of site prescriptions to the point of meeting different treatment objectives generally requires additional public involvement and environmental effects analysis that consumes time and finances. See the “Recommendations” section of the “Executive Summary” for adjustments to site prescriptions and site layout features to consider during the planning phase (before the decision document is issued) that can help set up biomass harvest operations for success.
Discussion, Recommendations and Conclusions

Discussion
This study was designed to provide information to address two sets of challenges to the development of biomass markets in and around the Superior National Forest in northeastern Minnesota: 1) economic and operational issues faced by loggers, and 2) environmental constraints of concern to land managers, scientists and policy-makers involved in developing and refining biomass harvest practices. In the course of our study, we determined that administrative systems and constraints formed a third and important set of challenges to the development of biomass markets. While no definitive “right way” to harvest biomass for energy use can be identified as a result of these trials, important information has been uncovered which should be of value to land managers as they consider the use of biomass harvest as a tool to achieve their desired land management goals.

Recommendations

Planning and Strategy
Biomass management activities must be considered and incorporated at early phases of the planning process in order to incorporate many of these recommendations, and to successfully utilize biomass harvest as a management tool on National Forest, state, county or private lands.

Site Prescription
Site prescriptions tailored to the practical and operational needs of biomass harvest are critical. These should, whenever possible, be flexible prescriptions that allow operator-determined options to lay out skid trails, reserve areas and permit a minimal removal of residual trees to facilitate harvest and forwarding.

Larger management units are preferred, as they will reduce administrative and harvest costs per unit area (e.g. equipment mobilization costs).

Combining roundwood and biomass harvest is one strategy to improve on-site maneuverability and harvest efficiency.

Focus biomass removals on larger materials and higher density areas (intensive or thorough removal across a variably-stocked site is impractical and expensive).

Site Layout
Skid trails arranged in an efficient layout are necessary to make harvesting operations efficient.

Clear site demarcation, using customary logging flags or painting, can speed up operations.

Demarcation signs (flags, paint) from previous management operations should be removed to avoid possible confusion with biomass energy harvesting demarcation.

Minimize forwarding distance to biomass yarding areas.

Communication
Emphasize communication and coordination between forest managers, purchasers and operators as early as possible in the project planning stages to ensure a more efficient and effective implementation of biomass harvesting operations.

It is vital for forest managers to communicate harvest requirements to purchasers (and where feasible operators) before work begins. Purchasers should do the same with their operators.

Communicating to purchasers and operators why certain prescriptions requiring specific exclusions or restrictions promotes a more informed understanding of the goals of the harvest by operators, and facilitates good communication.
## Operations

### Equipment

Select equipment suitable to the terrain and forest conditions, carefully considering visibility from the cab, maneuverability and flexibility of use such as a dual harvester/forwarder. Lower cost equipment (such as biomass processing heads in place of timber processing heads) can improve harvest economics for this low value material.

No adaptations to standard forwarding equipment are necessary for biomass. However, operators need to learn new techniques of loading and maneuvering to be successful.

Self-loading grinders should be employed to eliminate the need for a separate loader.

Material haul efficiency should be maximized with full chip van loads or by transporting both roundwood and biomass bundles on a load when practical.

### Techniques

Learning the techniques necessary to search for, harvest and recover smaller biomass material is a new practice for loggers in Minnesota. Operator proficiency is expected to improve over time, leading to increased efficiencies and reductions in the cost of operations.

Machine operators should visit a site prior to operations to properly understand the site conditions, expectations and challenges of the project.

Forwarding and bundling hours can be reduced if material is sized and arranged in organized piles for faster collection.

Delays in grinding can be avoided if root stumps and stones are removed from biomass before the grinder arrives on site.

### Season of Operation

Summer forwarding improves visibility of smaller biomass piles resulting in more efficient and complete recovery of harvested biomass. Forwarding of materials should take place right after material is cut to improve speed and total recovery of material forwarding; snow or vegetative regrowth can obscure smaller biomass piles.

## Environmental Considerations

### Biomass Harvest Guidelines

In Minnesota, where guidelines were recently developed, following the Biomass Harvesting on Forest Management Sites should mitigate concerns about soil nutrients, structure and wildlife habitat.

## Market Considerations

### Transport Distance

Distance to biomass markets should be no greater than 100 miles; preferably considerably less.

### Moisture

Payment should be per ton and should be adjusted for moisture content to reward on-site drying, and fairly compensated for transport of drier, more favorable materials.

### Storage

If bundles are desired for biomass storage reasons, payments must reflect this value.
Conclusion
Harvesting biomass to accomplish the goals of fuel reduction, improved forest health and supplying material for energy production is a new practice in Minnesota. Fuel reduction prescriptions need to be adjusted to address operational challenges, and planning and coordination concerns. Once biomass harvest is identified as a management option, incorporating an early understanding of production logistics into harvest plans and prescriptions can reduce fuels management and biomass production costs. Site prescriptions, distance to market, size and efficiency of operations and equipment all influence the economic viability of biomass harvests as a tool to manage forests. Environmental effects of biomass removal on soils, wildlife habitats and other natural features can be mitigated in Minnesota by following the Minnesota Forest Resource Council’s *Biomass Harvesting on Forest Management Sites*. Under the right combination of these circumstances, biomass harvest can reduce forest management costs.

Endnotes


3 ibid

The full report is available for download at forestrycenter.org