Potential economic benefits of air drying green non-merchantable timber for firewood production in Yukon

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ABSTRACT
The Yukon Government contracted FPInnovations to research moisture content reduction in green firewood timber piles. The study also investigated the potential cost savings that may result from clearcutting (harvesting both dead and living trees) of low quality stands and storing/seasoning the green stems for a year before using them for firewood. The assumption in this study was that, over a year, the moisture content in the green stems would be significantly reduced to produce high quality feedstock for firewood production. The results showed a decrease of moisture content values in observed log piles of 23% (from green logs at 50% moisture content) and indicated that cost savings of approximately $6/m³ may be achieved by seasoning the green logs over one summer. The results also revealed that no moisture intake was recorded over the winter months.

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1. INTRODUCTION

The most common timber use in the Yukon is for firewood production. Firewood timber volumes are currently deducted from the Allowable Annual Cut (AAC) volumes and a stumpage fee of $1/m$^3$ and a timber resource fee of $5/m$^3$ are applied to firewood timber volumes harvested from Yukon forests [1]. The common practice in firewood timber harvesting and production is to harvest dead trees that have low moisture content and produce good quality firewood. However, in many areas, dead trees are located in patches among living, green trees. The live, small diameter, poor quality trees have no value for either sawn timber or firewood; therefore, they are left standing. The practice of selective cutting for dead (firewood) trees involves higher harvesting costs than clearcutting and makes subsequent silvicultural treatments, such as planting, difficult and costly. This study investigates the potential cost savings that may result from clearcutting (harvesting both dead and living trees) of low quality stands and storing/seasoning the green stems for a year before using them for firewood. The assumption in this study was that over a year, the moisture content in green stems would be reduced significantly, producing the appropriate feedstock for firewood production.

2. METHODOLOGY

Two sites were selected for monitoring the moisture content of green logs:

- Site 1: Logging yard of Bear Creek Logging Inc. at Haines Junction
- Site 2: Logging road near Lewes Marsh

At each site, a large log pile of about 3-400 logs was divided with spray paint into five sections and sampled for a year, between May 2015 and May 2016. Every three months, discs (“cookies”) were cut from randomly selected logs in one pile section, at each location (see log sampling procedure in Appendix). Unfortunately, in September 2015, the pile at Site 2 was sold and sampling at that site was discontinued. The results from May 2016 sampling were not included here because this report was compiled before March 31, 2016; however, the report will be updated once the results become available.

Site 1
- The pile was located near Haines Junction (Yukon) in the log yard of Bear Creek Logging Inc. (Figure 1).
- Tree species: 100% white spruce
- The pile was subdivided in five sections, one for each sampling period.
- The logs in the pile were cut in October 2014. At the time of the first sampling, they had been stored for six months.
- To estimate what the original green moisture content of logs were, nearby trees were felled and samples (“cookies”) were collected.
- The total length of the pile (approximately 25 metres) was divided into five metre sections. The pile height was approximately 2.5 metres and the depth (i.e., average log length) was approximately five metres.
Figure 1. Location of log pile at Site 1: Haines Junction

Figure 2. Log pile at Site 1
Site 2
- The pile was located near Marsh Lake.
- Tree species: 100% lodgepole pine
- The pile was subdivided into five sections, one for each sampling period.
- The pile height varied slightly.
- The logs in the pile were cut in February 2015. At the time of the first sampling, they had been stored for three months. To estimate what the original green moisture content of the logs were, nearby trees were felled and samples ("cookies") were collected.

3. RESULTS AND DISCUSSIONS

Moisture content reduction
As the values in Figure 3 indicate, a significant reduction of moisture content in the analyzed piles was recorded between May 2015 and February 2016. From a green moisture content of 50%, a reduction in moisture content of approximately 23% was recorded in the pile at Site 1. The results also revealed that no moisture intake was recorded over the winter months (September 2015 – February 2016). At site 2, despite missing data, a reduction of moisture content of approximately 13% was recorded between green logs and semi-cured logs (September 2015, when measurements were discontinued).

![Graph showing moisture content reduction](Figure 3. Moisture content values through the seasoning period (one year) at the two sites)
The results suggest that the most considerable moisture content reduction occurred between May 2015 and September 2015. Afterwards, moisture content remained relatively constant and dropped slightly to 27% on February 2016. These results indicate that the micro-climate at Site 1 is appropriate for seasoning green logs and should be capitalized on, especially during the summer months, when most of the seasoning should occur.

**Cost savings**

Two major sources of cost savings may result from log seasoning (Table 1): harvesting and transportation cost savings. Harvesting cost savings may result from clearcutting as opposed to selective cutting prescriptions. Feller-buncher, skidded, and loader costs were generated with the FPInterface Express model and hauling costs were calculated with the FPInnovations truck costing model [1]. In the case of manual felling, harvesting costs presented below would increase by approximately $2/m³.

<table>
<thead>
<tr>
<th>Cost component</th>
<th>Firewood selective harvesting ($/m³)</th>
<th>Firewood clear-cut ($/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feller-buncher</td>
<td>7.00</td>
<td>3.70</td>
</tr>
<tr>
<td>Skidding</td>
<td>3.50</td>
<td>3.00</td>
</tr>
<tr>
<td>Loading</td>
<td>3.50</td>
<td>3.50</td>
</tr>
<tr>
<td>Hauling (40 - 60 km)</td>
<td></td>
<td>16.64</td>
</tr>
<tr>
<td>Unloading</td>
<td></td>
<td>3.00</td>
</tr>
<tr>
<td>Stumpage fee</td>
<td></td>
<td>1.00</td>
</tr>
<tr>
<td>Reforestation fee</td>
<td></td>
<td>5.00</td>
</tr>
<tr>
<td><strong>TOTAL COST</strong></td>
<td>39.64</td>
<td>35.84</td>
</tr>
<tr>
<td>Cost savings – harvesting ($/m³)</td>
<td></td>
<td>3.80</td>
</tr>
<tr>
<td>Cost savings – transportation ($/m³) a</td>
<td></td>
<td>&gt; 2.00</td>
</tr>
<tr>
<td><strong>TOTAL COST SAVINGS ($/m³)</strong></td>
<td></td>
<td>&gt; 5.80</td>
</tr>
</tbody>
</table>

* a transportation costs savings from hauling logs located over 100 km (as dead trees are located increasingly further from the firewood operation)

The two cost calculations (harvesting and transportation) revealed potential cost savings of about $6/m³ as a result of utilizing green timber that was seasoned over the summer. Other cost savings and benefits of using seasoned logs to produce firewood also include:

- High quality firewood that can be sold at a premium
- Reduced cost of firewood delivery (more wood can fit on a flat bed or pick-up truck because it is lighter)
- Access to increased volumes of timber located in nearby forests that may promote value-added initiatives in Yukon communities (e.g., sawmilling, wood carving, rustic furniture).
4. CONCLUSIONS AND RECOMMENDATIONS

The results of this study showed a decrease of moisture content in observed log piles of 23% (from green logs at 50%) and indicated that cost savings of approximately $6/m³ may be achieved by seasoning the green logs over one summer. However, it is recommended that logs are covered over the winter with a breathable tarp or stored under a shed to reduce interaction with snow and to maintain the reduced moisture content in the seasoned logs.

5. REFERENCES


6. APPENDIX – LOG PILE SAMPLING PROCEDURE

See attached Info Note: Procedure to Sample for Moisture Content in Log Piles
PROCEDURE TO SAMPLE FOR MOISTURE CONTENT IN LOG PILES
Marien Marinescu and Stu Spencer

The following is a step by step procedure for setting up log piles and sampling of wood disks ("cookies") for log pile moisture content analysis.

OBJECTIVE

To find the average moisture content(s) (% wet basis) of one or more log piles at various time intervals (e.g., every month, every 3 months, etc.).

METHODOLOGY

To reduce statistical bias, all log piles from which wood samples are taken should be similar in size and species/diameter/length composition. Consequently, some pile re-configuration or construction may be required. Two situations may occur in practice:

Sampling from different log pile(s) in each time period

This procedure is recommended when full control of the design and implementation of the sampling methodology exists in the field. The procedure involves, in each time period, extracting sample logs from different piles (replicates) than in previous periods. Consequently, enough piles will have to exist or to be configured to cover the whole time horizon in which the moisture content analysis is undertaken. For example, if samples are taken over five time periods and three randomly selected piles (replicates) are sampled in each time period, a total of 15 similar piles are required.

Sampling from the same log pile(s) in each time period

This procedure is recommended when not enough log piles exist or can be reconfigured in the field to cover the whole time horizon of the moisture content analysis. For example, if only three piles exist in the field and there are no resources (e.g., equipment, people, etc.) to reconfigure them into more piles, all three piles will be sampled again during each time period. Consequently, there will be three piles (replicates) sampled during each time period. This procedure should be avoided, if possible, because extracting sample logs from piles disturbs log locations within the piles, introducing statistical bias.
LOG PILE SETUP

Proper locations for log pile sampling are large, flat, dry, and clean areas. Log piles should be raised 30 cm - 50 cm from the ground, on brow logs laid transversally under the log piles (~ every 2 meters), so water and snow will not interfere with the logs. Wooden stakes (e.g., small diameter logs) may be drawn into the ground to hold the logs together (Figure 1 left) or wooden/metal brackets can be manufactured and used (Figure 1 center). This will ensure that the width and the height of each pile are consistent for all piles. Appropriate room should be left between the piles so equipment may maneuver easily. To ensure uniform air-drying on all sides, logs should be oriented pointing toward the prevailing winds (Figure 1 right).

When sampling is done from large piles, piles may be subdivided into smaller areas that will be sampled in each period (Figure 2). However, this pile set up will increase the risk of introducing bias into the sampling process, as logs in the center of the piles will dry differently than those on the sides.
LOG SAMPLING FOR MOISTURE CONTENT

Sample Size and Location
To ensure a representative moisture content sample, wood samples ("cookies") should be cut and collected from various parts of the pile and the log. Increasing the sampling size will significantly reduce the sampling error, but sampling size should always be balanced with sampling cost. As a general rule, about 10% of logs per pile should be sampled. To guarantee that all sources of moisture content variation are represented in the average, samples should be taken from logs located at the top, center, and bottom layers of the pile (Figure 3).

![Side View of Pile with Layers](image)

**Figure 3 – Sampling from a pile**

![Sampling from a Log](image)

**Figure 4 – Sampling from a log**

Also, three wood samples ("cookies") should be cut from each sampled log: one approximately 20 cm from each end and one from the center (Figure 4).

**NOTE:** A special case occurs when logs cannot be extracted from piles (replicates) due to lack of equipment or manpower. In such cases, disks may be extracted approximately 20 cm from the sampled log ends. This variant procedure may generate less accurate estimates because disks are not sampled from the center of the pile, where moisture content values may vary from those from the pile surface.
Sampling Frequency and Replications
To analyze log moisture content over time, the number of sampling periods should be established at the beginning of the experiment. Sampling frequency (number of sampling periods) depends generally on seasonal weather patterns (e.g., winter-summer, rainy-dry) that need to be captured in the analysis and on the overall sampling cost. At least one pile (replicate) should be sampled in each period; therefore, the number of piles (replicates) should be equal or greater than the number of sampling periods. When more than one pile (replicate) is available in each period, random replicates should be selected. For example, Figure 5 shows an experiment in which two piles (replicates) are sampled randomly in five periods: P1 - P5.

![Figure 5 - Pile sampling replications](image)

MATERIALS AND EQUIPMENT
- Chainsaw – to cut log samples (“cookies”) approximately 1 inch (2.5 cm) thick.
- Tape measure or logger’s tape – to measure the sample locations on the log and in the pile
- Loader with grapple head – to move logs from piles (when available)
- Winch with chain – to extract logs from pile (when available)
- Large Ziploc bags – to store each wood sample (“cookie”) when sample weighing is done in the lab rather than the trial site
- Permanent marker or lumber crayon – to mark the sample number and sample location on the “cookie” or bag
- Digital scale with a capacity of at least 2,000 g and accuracy of 0.1g – to weigh the green wood sample in the field
- Pencils and waterproof paper – to record the green wood sample in the field
- Drying oven – to dry the samples in the lab
- Drying trays – to contain all the material from the sample through the drying process (sometimes bark falls off the cookie as it heats)
MOISTURE CONTENT ANALYSIS OF WOOD SAMPLES

Objective: to find the moisture content percentage \(mc(\%)\) (% by weight, wet basis) of green wood samples.

Materials and equipment:
- Digital scale with a capacity of at least 2,000 g and accuracy of 0.1g
- Drying oven
- Drying trays
- Ziploc bags

Procedures:

Step 1. Weigh the bagged green sample (either in the field or laboratory) and record its weight \(m_{\text{wet+bag}}\).

DO NOT OPEN THE BAG BEFORE WEIGHING!

Step 2. Weigh the drying tray and record its weight \(m_{\text{tray}}\)

Step 3. Open the bag and let the condensation dry out. Place the green wood sample and all fine wood pieces (without bag!) into the drying tray. Place the tray in the oven and set to 105\(^\circ C\). Keep the wood sample in the oven until constant mass is obtained (usually 24 hours).

Step 4. Weigh the dry wood sample and all wood pieces in the tray \(m_{\text{dry+tray}}\)

Step 5. Weigh an unused, dry bag and record its weight \(m_{\text{bag}}\)
Step 6. Calculate moisture content $mc$ (%) according to the following formula:

$$mc \text{ (}) \%\text{) = } \left[ \frac{\text{sample wet} - \text{sample dry}}{\text{sample wet}} \right] \times 100$$

or

$$mc \text{ (}) \%\text{) = } \left[ \frac{\text{m}_{\text{wet+bag}} - \text{m}_{\text{bag}} - (\text{m}_{\text{dry+tray}} - \text{m}_{\text{tray}})}{\text{m}_{\text{wet+bag}} - \text{m}_{\text{bag}}} \right] \times 100$$

**EXAMPLE IN EXCEL:**

<table>
<thead>
<tr>
<th>mc</th>
<th>$f_{c}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$m_{\text{wet+bag}}$</td>
<td>$m_{\text{bag}}$</td>
</tr>
<tr>
<td>595.4</td>
<td>90.7</td>
</tr>
</tbody>
</table>