Arbetsrapport

Från Skogforsk nr. 848–2014

Biomass Harvest and Drying Training Seminar Fond du Lac Reservation Cloquet, Minnesota

Utbildning i skörd och hantering av skogsbränsle för Fond du Lac Reservation Cloquet, Minnestota

Tomas Johannesson, Skogforsk; Steven Olson, Christian Nelson, Bruno Zagar, Fond du Lac Reservation Cloquet, Minnestota

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The Arbetsrapport series comprises background material, descriptions of methods, results, analyses and conclusions relating to both current and completed research.

Titel:
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Steve Olson, Forest manager at Fond du Lac Reservation Cloquet, Minnesota.

Christian Nelson, Forester at Fond du Lac Reservation in Cloquet, Minnesota, has been designing timber sales, fighting wildfires, assisting with prescribed burns, and controlling invasive species since 2002. His most recent interests include a black ash wetlands restoration project, and growing more resilient sugar maple trees in northern hardwood forests."

Bruno Zagar, Environmental Specialist/Energy Project Manager at Fond du Lac Reservation Cloquet, Minnesota.

Abstract

Since 2008 Skogforsk has been providing training courses in biomass harvest and vocational training for forestry professionals and machine operators. In Sweden wood chips are purchased by energy content, specifically by the megawatt hour (MWh) per ton. High quality is essential in order to achieve a good result – dry content, purity, and timing are three key factors in management of logging residues.

For a successful outcome, the entire chain must function together, since a single mistake can ruin the work done in previous stages. Appropriate and efficient handling increases revenues for both landowners and stakeholders in the supply chain. Most importantly, the fuel material must be treated as a product in its own right, i.e. not as a waste product, because ultimately payment is based on energy content. The drier the material, the less material is needed to supply the required energy. At the same time production costs per volume unit are normally the same, regardless of the moisture content. Correct handling throughout the production chain leads to drier fuel and lower cost per energy unit.

Preface

This report is the result of work completed during a training seminar for the Fond du Lac Logging & Timber Enterprise and Fond du Lac Resource Management staff. Tomas Johannesson, a forestry consultant with Skogforsk, the Swedish Forestry Research Institute, demonstrated and implemented techniques and methods used in Sweden for utilising logging residues for wood chip production. The work was funded by the Fond du Lac Band of Lake Superior Chippewa and the Office of Indian Energy and Economic Development as part of their work to replace fossil fuel used in thermal heating with renewable, sustainable and environmentally sound resources.

Strömsund in February 2014

Tomas Johannesson, Bruno Zagar, Steve Olson and Christian Nelson

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Sammanfattning

Sedan 2008 har Skogforsk drivit en kampanj inom svenskt skogsbruk i syfte att öka kvalitet och effektivitet i det praktiska arbetet med skogsbränslehantering. Utbildningarna riktas på olika sätt till tjänstemän och maskinförare i försörjningskedjan. I Sverige ersätts vanligtvis skogsbränsle med en affärsmodell baserad på energiinnehåll (MWh). Detta innebär i praktiken att en hög kvalitet på det bränsle som hanteras är ett grundläggande krav för en god affär för alla parter och tre viktiga nyckelfaktorer är – torrhalt, - renhet, - och leveransprecision.

För att erhålla en god ekonomi måste hela försörjningskedjan samarbeta och ett misstag hos någon av se olika aktörerna ger konsekvenser i efterkommande led. Professionell och effektiv hantering av bränslet är en förutsättning för lönsamhet hos producenter och förbrukare samt skäliga ersättningar till markägarna. Bland det viktigaste är att hantera skogsbränslet som ett fullvärdigt sortiment och inte med synen att det är ett avverkningsavfall. Affärsmodellen innebär att desto torrare material som levereras desto lägre volym behövs för att erhålla en viss energimängd. Samtidigt så är produktionskostnaden per volymenhet i stort sett oberoende av torrhalten. Korrekt hantering genom hela försörjningskedjan ger således ett torrare material och därmed en lägre produktionskostnad per MWh.

Denna rapport redogör för en utbildningskampanj som genomfördes 2014 för personalen hos Fond du Lac Logging & Timber Enterprise (avverkningspersonal) och Fond du Lac Resource Management (skogliga tjänstemän och ekonomiansvariga i Minnesota, USA). Tomas Johannesson, Skogforsk, demonstrerade och implementerade teknik och metoder som används inom skogsbränslehantering i Sverige. Arbetet finansierades av Fond du Lac Band of Superior Chippewa och Office of Indian Energy and Economic Development (de båda senare motsvarar styrelser för indianreservatet samt reservatets energi- och ekonomiavdelning) som en del i deras arbete med att ersätta fossila bränslen med förnyelsebara, hållbara och miljövänliga naturresurser. Rapporten redogör även för vissa anpassningar rörande avverkningsteknik som gjordes för att bättre stämma överens med de lokal förutsättningarna, som delvis skiljer sig från svenska förutsättningar. I kampanjen utfördes även ett försök för att undersöka effekterna av att täcka träddelsvältor med täckpapp. Detta försök är en repetition av motsvarande försök i Sverige. Analyserna av detta täckningsförsök kommer senare att rapporteras som en del av det etablerade kunskapsutbytet mellan Itasca Community College, Fond du Lac, University of Minnesota och Skogforsk.

Background

For several years, Sweden and the United States have been collaborating on improving energy efficiency and increasing the percentage of energy deriving from renewable resources. On a national level this collaboration has been taking place under the Swedish American Green Alliance (S.A.G.A.). One of the early missions of S.A.G.A. was to identify possible ways to reduce the use of fossil fuels in thermal heating plants by replacing them with fuels from renewable resources. Minnesota was found to be one of the states with great potential for producing woody biomass for energy purposes. The Bio Business Alliance of Minnesota (BBAM) and the Swedish Bioenergy Association (Svebio) used their networks to find expertise for various components of a more rational, efficient and environmentally friendly supply of energy.

Skogforsk was commissioned to carry out an on-site evaluation of the potential supply from the various forests in the state and to advice on designs of supply chains. Over a three-year period, there was an intense exchange of information and sharing of experiences. During this process an MOU (Memorandum of Understanding) was signed between the state of Minnesota and the Swedish Government to increase collaboration and funding to work on development of green energy use options.

One of the players identified in the survey of possible solutions for supplying and using woody biomass for thermal heating was the Fond du Lac Band of Lake Superior Chippewa Reservation, located southwest of Duluth, Minnesota. Other important players who became involved during the process were Itasca Community College (ICC) and the University of Minnesota Duluth campus (UMD).

Skogforsk and ICC started a dialogue on developing a training seminar based on Skogforsk experiences from vocational training in Sweden. The aim of the seminar was to offer biomass training within the ICC curriculum, where the 'Skogforsk backbone' would be adapted to Minnesota forestry and market conditions.

As the networking continued between the parties, a delegation comprising participants from ICC, UMD and Fond du Lac visited Skogforsk in Sweden. Several important topics were identified for improving the use of woody biomass for thermal heating in Minnesota. These included training loggers in methods for harvesting logging residue, and increasing the heating value of wood chips by drying the material over one summer season, covered with a biomass blanket purchased from Interwrap, a Canadian company. The same or similar blankets have been used in Sweden for many years and have proved effective in protecting residue stacks from snow and rain. This increases the dry matter content, resulting in more efficient combustion *(Skogforsk report 799-2013, Does it pay to cover forest residue stacks? Effect of tarpaulin width on the quality of forest chips. Björheden, R. Grönlund, Ö. Lundström, H.)*. Similar studies were planned in Minnesota in collaboration with Skogforsk and the UMD; Fond du Lac offered to be the first party to sponsor the trials. FDL contacted Tomas Johannesson of Skogforsk for vocational training for their logging crew, and FDL would provide materials and equipment for the study.

Aim of the training seminar

Through discussions between Skogforsk and Fond du Lac, the following topics were identified as important in Fond du Lac's work to develop utilisation of woody biomass for thermal heating.

- Exchange experience and knowledge regarding logistics of harvesting logging residues.
- Adapt some of the Swedish 'Best Practices' to fit FDL conditions.
- Identify paths to a more secure business model to increase the use of wood chips for thermal heating/other uses.
- Develop a platform, with theoretical and practical content, for further training and vocational training involving collaboration between Skogforsk/ICC/Fond du Lac/UMD.

Specific contract tasks

- Financial effects of dry/wet material (basic calculation on different scenarios).
- Variables that affect combustion (which to consider and to be aware of).
- Tools to calculate/predict chip volume from harvester data (software to read and use. PRI files).
- Adapt felling pattern for combined round wood/residue harvest (making logistical and operational improvements in the forest regarding biomass harvesting).
- Theoretical planning of logging operation.
- Interaction and optimising the supply chain (planning, harvest, drying, chipping, transport).
- Provide personal instructions to the FDL harvesting equipment operator (practical in field).
- Provide personal instructions to FDL forwarder operator (practical in field).
- Support and attend stacks study in order to assess the effectiveness of covering stacks to improve dry content/net energy in wood chips (practical in field).

Summary of training seminar

Participants:

Fond du Lac Forestry Programme
Steve Olson, Reservation Forester
Bruno Zagar, Environmental Specialist/Energy Project Manager
Christian Nelson, Forester
Scott Grover, GIS/Forestry Technician

Fond du Lac Logging & Timber Enterprise
Donny Shabiash, Timber Manager/Operator
Jeff Saddler, Equipment Operator
Tony Savage, Truck Driver

Financial effects of dry/wet material

One of the topics of discussion was the effects of purchasing or selling wood chips on a green ton basis, which is standard in the region, versus the Swedish business model where the price is based on the heating value of the delivered wood chips. This was discussed during a meeting on 27 January at the Fond du Lac office. Arguments used for implementing the business model based on heating value were:

- Profit opportunities for supplier delivering a high-quality fuel.
- Reduced risk for the purchaser, by paying only for the measured energy content received.
- Lower transportation costs per delivered energy unit. We-Calc was used for calculations of heating value. http://biofuelcalc.sites.djangoeurope.com/

The calculation shows the relationship between different levels of dry content and heating value (Figure 1). This should not be confused with similar calculations for bone-dry tons (BDT), since wet wood loses weight as it dries.

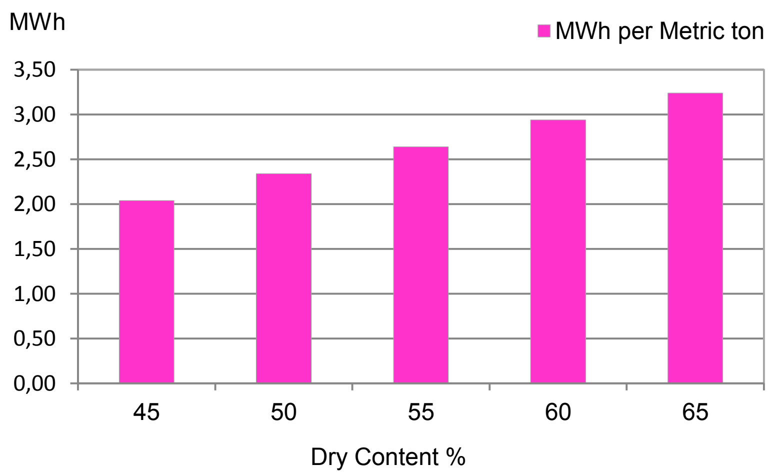

Figure 1.
The figure shows a virtually linear relationship between dry content and heating value for wet wood.

Most users of wood chips demand a dry product for efficient combustion, which gives a high level of efficiency in their boilers. Since a wet fuel uses large amounts of energy to start the combustion process, the energy output from the boiler will decrease if the fuel has a low dry content (i.e. wet wood).

A business model based on the heating value of the delivered load would reduce the risks. The supplier has an incentive to deliver the fuel that is most suitable for the boiler. A dry fuel would increase the supplier's profits by generating greater revenues per delivered ton (on a wet basis) and also reduce transportation cost if this is based on delivered energy quantity. The cost per MWh for the purchaser depends on dry content percentage of the delivered material.

Table 1.
Business model where the basis for payment is weight.

Dry content %	MWh per ton	Dollar ($) per ton	Dollar ($) per MWh	Dollar ($) per load
45	2.04	27	13.24	810
50	2.34	27	11.54	810
55	2.64	27	10.23	810
60	2.94	27	9.18	810
65	3.24	27	8.33	810

Green tons are generally "recently cut woody biomass that has not been specifically dried". On average the moisture content of green wood is 50% (50% water weight, 50% biomass weight). Dry content (DC) is a common value for this kind of material, with some minor changes depending on the time of year. If current price is assumed to be $27 per ton for green wood, this generates a cost of $11.54 per MWh. Using this as a basis for calculation, it would be beneficial for both parties if a model based on heating value were implemented. The supplier would have a greater incentive to deliver a dry fuel and thereby receive more revenue per delivered ton (Table 2). This business model also lowers transportation costs. Typically a truck will hit the weight limit permitted on roads before the trailer is filled to capacity. By hauling less water weight, more wood (therefore more energy) can be delivered per truckload.

Table 2.
Business model where the basis for payment is the energy content.

Dry content %	MWh per ton	Dollar ($) per ton	Dollar ($) per MWh
45	2.04	23.54	11.54
50	2.34	27.00	11.54
55	2.64	30.46	11.54
60	2.94	33.92	11.54
65	3.24	37.38	11.54

As the material dries out and reaches a higher DC, the weight per cubic meter (or per unit volume) decreases (Figure 2), calculated as a dry mass density of 420 kg and a solid mass of 50%.

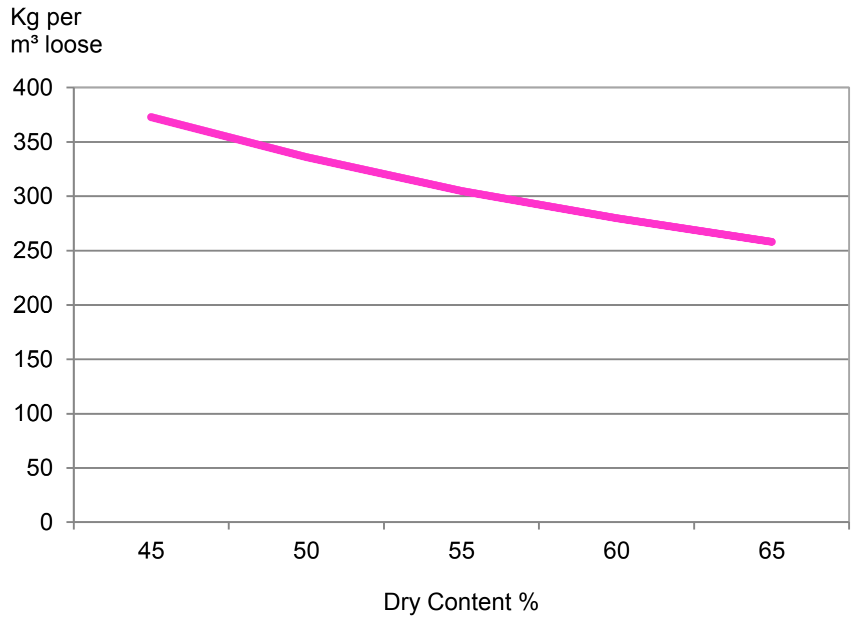

Figure 2.
Relationship between weight per cubic meter loose and dry content %. Assuming that the permitted payload on an average chip truck is 30 metric tons, and the load volume capacity is 115 m^3, a wet load will not 'hit the roof' (Figure 3) due to weight regulations. Dry material increases the load volume capacity.

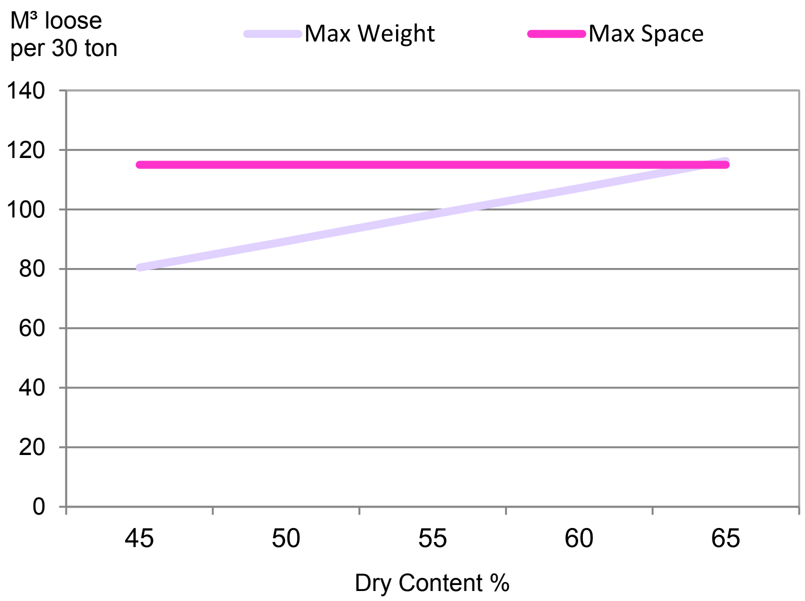

Figure 3.
Load limitations due to different dry content %.

If a business model based on energy amount is used, the combination of dry material (high revenue) and low cost of transportation is important (high use of load volume capacity). If the contract is based on delivery of a certain amount of energy on a monthly or annual basis, the number of delivered loads required will be reduced if the energy amount per load is high. Also the value (revenue) per load will increase when high energy content per unit and maximum use of load volume capacity are combined. The costs per truck load are often the same since they are generally calculated by delivered ton. If the basis for payment is energy content, assuming $11.54 per MWh, the total value per truckload varies with dry content % (Table 3) compared to when the basis for payment is weight (Table 1).

Table 3.
Value per load when the basis for payment is energy content, combined with increased load volume capacity.

Dry content %	MWh per ton	MWh per 30 ton	Dollar ($) per MWh	Dollar ($) per load
45	2.04	61.2	11.54	706
50	2.34	70.2	11.54	810
55	2.64	79.2	11.54	914
60	2.94	88.2	11.54	1 018
65	3.24	97.2	11.54	1 122

A contract for annual delivery of a certain amount of energy makes it easy to calculate the total revenue by multiplying the payment per MWH by contracted number of MWh. To maximise total revenue, the number of truck loads must be minimised. This can also be considered as number of truck loads or number of timber sales.

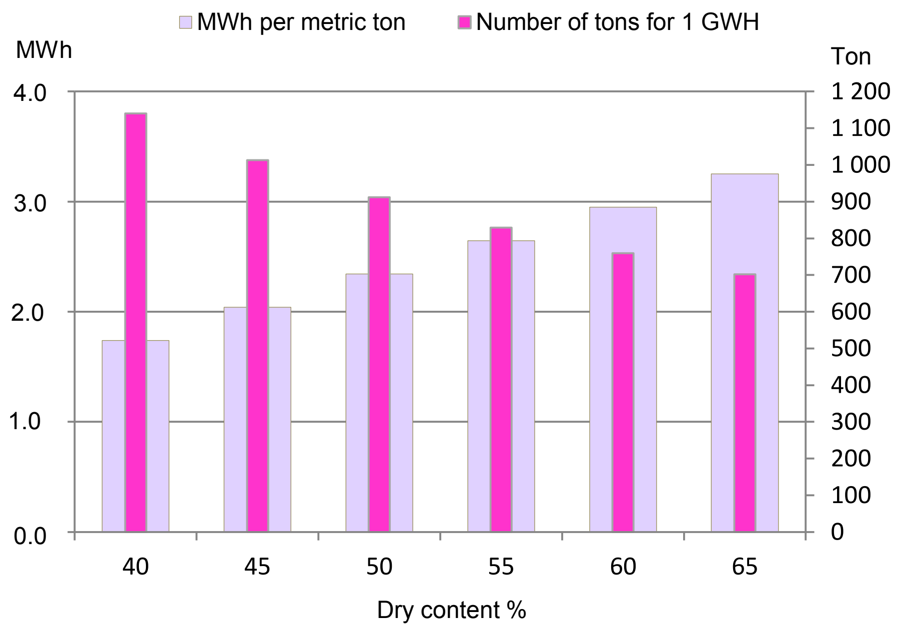

Figure 4.
Relationship between DC and required volume.

Variables affecting combustion

When aiming to supply any kind of combustion process with fuel, it is important that fuel is within the specifications of the combustion unit.

There are many different designs for combustion units and the efficiency rate can depend a lot on fuel quality. In general, a pellet boiler is efficient when burning a high-quality wood pellet, but the same boiler may perform poorly when burning wood chips with an inappropriate size or moisture content. Combustion units often have different tolerances for different types of contamination, such as gravel, soil or ash content. Most boilers require a clean fuel free from contamination, and within a certain DC interval, to run efficiently and reliably.

With a business model based on energy content, the amount of ash in the fuel becomes more important. Most timber sale contracts in Sweden contain a price penalty for ash content, increasing the incentive for the supplier to aim for clean and dry material. One common source of contamination when running a cut-to-length (CTL) harvesting system results from a high number of understorey shrubs or tree seedlings and saplings in the timber stand. If the logging residue is stacked on top of some understorey, there is a high risk that the forwarder uproots the understorey by accident. The root often contains a lot of soil or even stones that could damage the chipper or the boiler. It is therefore important that all operations aim to deliver a high-quality fuel. It is also important that the forwarder operator is diligent when loading, and avoids grabbing pieces of soil or moss from the ground.

Tools to calculate and/or predict chip volume from harvester data

Most of the existing CTL harvesters are equipped with computers to help the operators in their work. Information available includes GIS/GPS data, machine operating time, fuel consumption, time-in-motion, idling time, and the volume and specifications of timber harvested, itemised by species or product.

The computers produce files that summarise production over time or per timber sale. Information can also be retrieved about each individual stem ID and X and Y coordinates. Knowing products, volumes, and position allows maps to be generated for the forwarder and, based on stem data, allows prediction of the logging residue volume. Skogforsk developed a Windows based application named hprAnalys for calculating logging residue.

The Fond du Lac harvester computer was not set up to collect all necessary information, so the residue volume from the timber sale could not be determined.

Adapted felling pattern for combined roundwood/residue harvest

To avoid contamination and improve the efficiency of the residue harvest, it is important that the harvester operator works in a way that helps the forwarder to easily collect and transport the material. Since all forests are different, the methods may have to be adjusted according to the situation, but a general approach has been determined.

A felling pattern that places the logs and logging residue along the track (Figure 5) improves the efficiency of collecting both logs and residues. However this method proved difficult at the Hardwood Lake timber sale since the stand was very diverse in terms of species and many trees were to be left (Appendix 1). Another problem was that the tops were, in general, relatively long, since crooked and branched tops were common. Consequently, the operator adjusted the method to make it more appropriate for the site conditions (Figure 7). By placing the logs along one side of the track, and the tops along the opposite side, the operator felt this would make the work of the forwarder easier. This method was probably correct in view of the site conditions, but was slightly more time consuming.

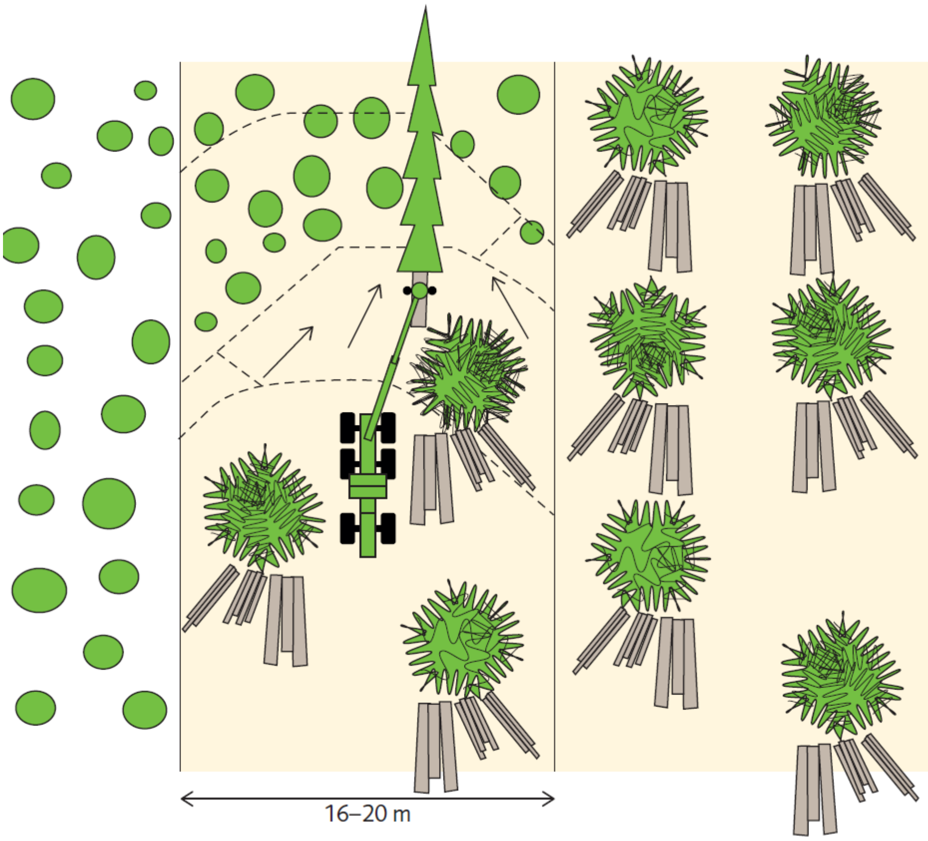

Figure 5.
Normal felling pattern for residue harvest.

Theoretical planning of logging operation

This was discussed during the indoor training session, with more in-depth discussions in the field. Depending on contracts and the market situation for wood chips and various round-wood products, a rough calculation is needed before every single timber sale. However, some major factors were identified as being important for successful residue harvest.

- Access to the logging site when it is time for chipping.
- Site conditions that allow efficient storage:
  - Exposure to wind and sun.
  - Dry ground.
  - Sufficient space for stacking.
  - Sufficient space for chipping operations.
- Liberate hauling distance to landing (forwarder).
- Liberate hauling distance to consumer (chip truck).
- Sufficient quantity of wood chips per site to cover start-up costs of chipping operation.
- Clear cuts preferable before thinning operations.
- Consider the shape of the tops in the stand due to chipper capacity (If possible leave the worst as *CWD* to fulfil Biomass Harvest Guidelines).
- Liberate amount of understory to avoid contamination.
- Consider ground power lines.
- Consider forwarder width when planning.
- Respect Biomass Harvest Guidelines.

Interaction and optimising the supply chain – planning, harvest, drying, chipping, and transport

Dry content, purity and timing are three key factors in residue management. High quality is essential in order to achieve a good result. To achieve this, the entire chain must function together, since a single mistake can ruin the work done in previous stages. Correct handling increases revenues for both landowners and stakeholders in the supply chain. The drier the material, the less material is needed to deliver the required energy. At the same time, production costs per unit of volume are normally the same, regardless of the dry content. Correct management of the entire production chain gives drier fuel and lower cost per energy unit.

It is important for people to be aware of their roles within the supply chain, understanding what to deliver to the next player, and communicating requirements and feedback both upstream and downstream. This must be done consistently, although this may sometimes be difficult since the time frame for a residue operation can be quite long if the residues are left to dry for one summer.

One recommendation is to improve assessment of production costs and revenues. With energy content as a basis for payment, it is important to keep track of all DC measurements carried out at delivery. If moisture content in the wood varies, it is important to determine why.

Even with the existing business model, there is still good reason to keep a close watch on costs and revenues. This should be standard procedure for each individual timber sale.

Instructions for operators

Operators of the harvester and forwarder machinery were asked to explain some of their methods. Both operators were skilled and experienced, and easily found ways to improve the operation.

Figure 6.
JD 1070 harvesting roundwood and residues in a diverse thinning stand.

At first, the harvester operator found it difficult to use the suggested felling pattern because of the stand conditions. He chose to place the tops on the opposite side of the track from the logs, or somewhere where they did not affect harvester operations.

Figure 7.
Tops placed along the track, away from the felling zone.

The forwarding operation was efficient because of the large amount of logging residue. The average length of the tops (8–10 metres) sometimes proved difficult to manage, since a lot of trees were to be left in the stand. In the training session, the forwarder bunk was not enlarged for residue handling. Average load capacity was estimated to be roughly 5 metric tons.

Figure 8.
Tigercat 1 055 loading residues.

The collected residues were part of a drying study (to be reported separately). The residues were stacked in a location that allowed exposure to wind and sun, and the stack was then covered with a 4 meter wide biomass cover to resist snow and rain.

Figure 9.
Covering a stack of residue with a biomass blanket.

Discussion and comments

The training programme had several objectives. The main aim was to exchange experiences and know-how to secure a high-quality wood chip product at Fond du Lac. A second aim was to learn more about a business model based on energy content, and how such a model could benefit Fond du Lac Logging & Timber as suppliers, and the Fond du Lac Community as future purchasers should residential or community scale biomass boilers be installed. Some possible paths for improvement and development were identified and discussed. For some of these paths, further collaboration between Skogforsk and Fond du Lac would be fruitful for both parties.

The logging crew should be considered key players. Their importance as suppliers for a future thermal installation at Fond du Lac, or for a growing external market of wood chips, is not to be underestimated. It is important to remember that this project is a pilot study and, as such, did not necessarily have the perfect conditions, nor were the machines equipped with the proper equipment such as a residue grapple or a larger bunk for the forwarder. In the future, this could easily be arranged and would rapidly improve efficiency. Selecting the right stands for residue harvest would also lower the operational costs. Greater use of the harvester computer would help the crew's work situation and improve productivity, and be particularly helpful in producing an accurate assessment of financial factors relating to operations, such as equipment operating time and idle time.

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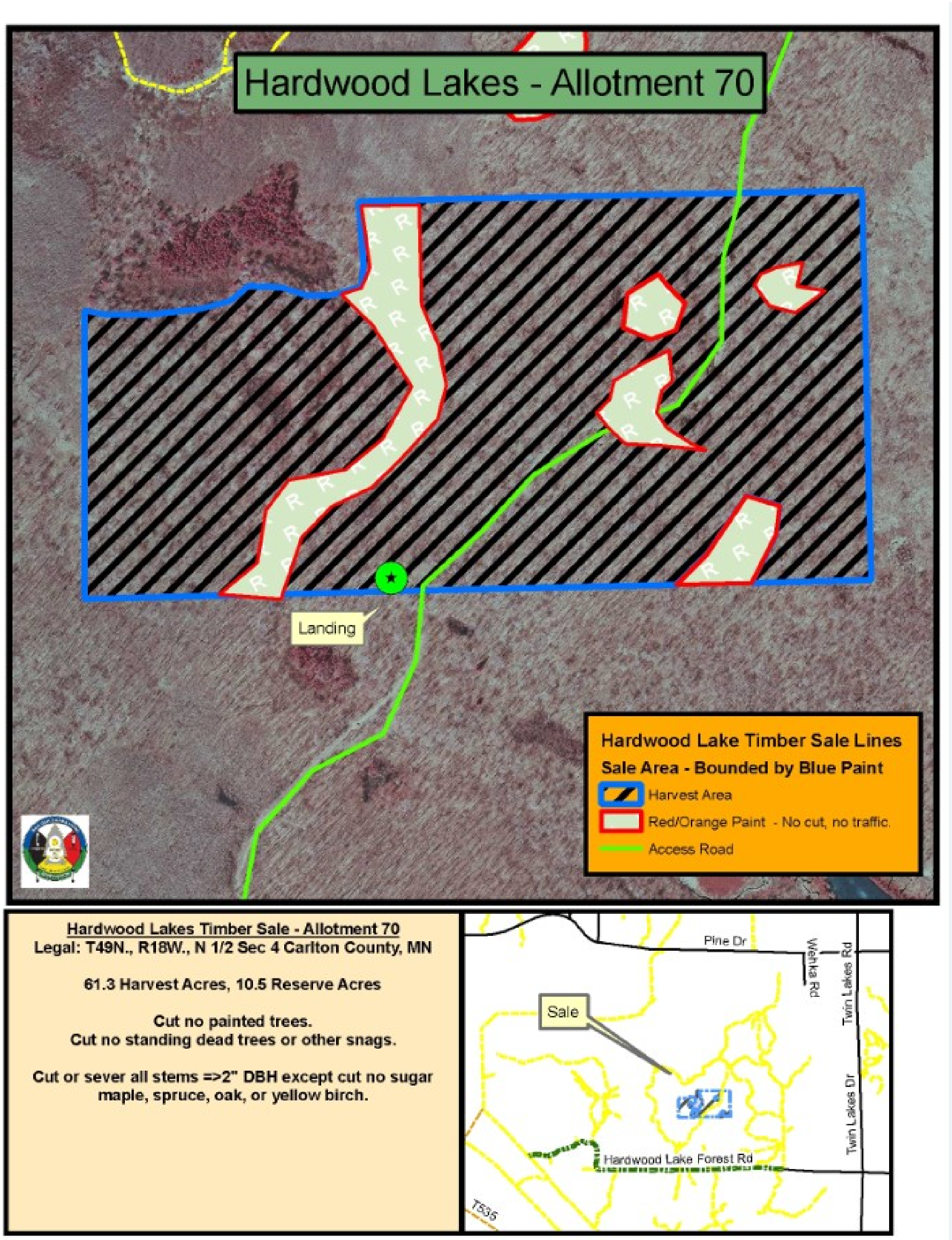
Appendix 1



Residue was primarily collected on the west end of the site. A haulage road ran through the reserve west and north of the landing, and a separate residue landing was established northeast of the timber landing.

The tree species composition was diverse and the topography comprised gentle hills. The diversity of species is shown in Figures 10 and 11.

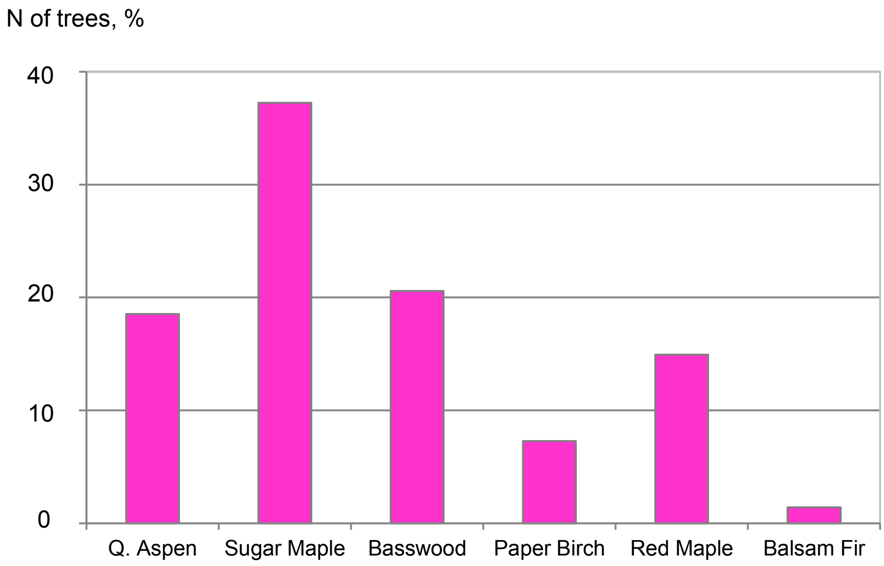


Figure 10.
Distribution of trees species, in percentages, per acre in the stand.

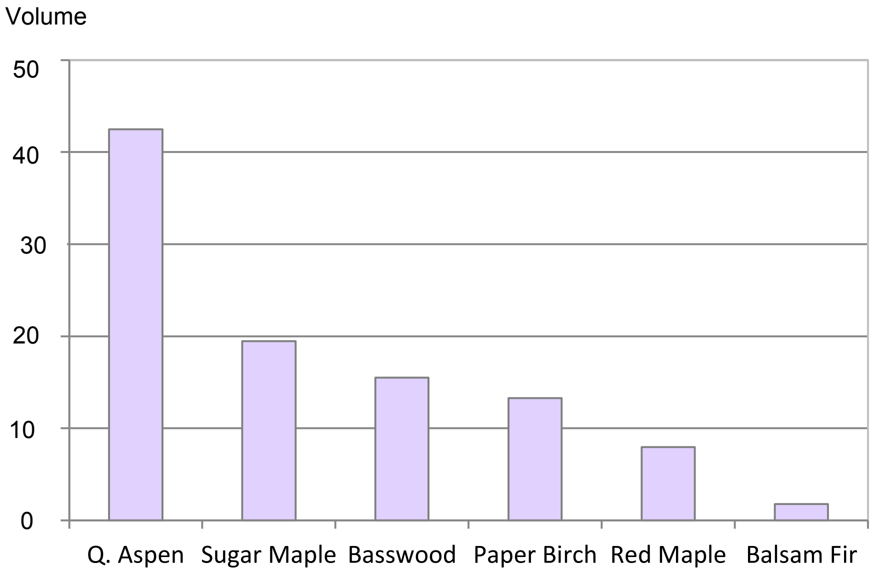


Figure 11.
Volume, by species, per acre in the harvest area.

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