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BIOMASS HARVESTING AND CHIPPING IN A TOLERANT HARDWOOD STAND IN CENTRAL NEW BRUNSWICK

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BIOMASS HARVESTING AND CHIPPING IN A TOLERANT HARDWOOD STAND IN CENTRAL NEW BRUNSWICK

by

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ABSTRACT

Four 2-ha blocks were harvested after the completion of a total biomass inventory. Three blocks were harvested by the Koehring Feller-Forwarder and chipped by a Model 22 Morbark Chiparvester, while the remaining block was cut using conventional cut and skid techniques to produce 2.5 m roundwood. The productivity and costs of harvesting each block were measured accurately. On two blocks the costs of harvesting the residual biomass after completion of the normal harvest were also determined. The feasibility and economics of harvesting this residual biomass are briefly discussed.

RESUME

Quatre blocs de 2 ha ont été récoltés après qu'on eut complété un inventaire de la biomasse totale. La récolte de trois blocs a été faite à l'aide d'une abatteuse-débusqueuse Koehring et la mise en copeaux effectuée par une Morbark Chiparvester Modèle 22 alors que le dernier bloc était coupé selon les méthodes classiques de coupe et débusquage pour produire du bois rond de 2,5 m. On a mesuré avec précision la productivité et les coûts de récolte de chaque bloc. Sur deux blocs, les coûts de récolte de la biomasse résiduelle après la récolte normale complétée ont aussi été déterminés. Cet article traite brièvement de la faisabilité et de la rentabilité de récolter cette biomasse résiduelle.

FOREWORD

ENFOR is the bilingual acronym for the Canadian Forestry Service's ENergy from FORest (ENergie de La FORêt) program of research and development aimed at securing the knowledge and technical competence to facilitate in the medium to long term a greatly increased contribution from forest biomass to our nation's primary energy production. This program is part of a much larger federal government initiative to promote the development and use of renewable energy as a means of reducing our dependence on petroleum and other non-renewable energy sources.

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INTRODUCTION

Whole-tree harvesting and chipping and conventional chain saw/skidder operations are being widely used in the Maritimes for harvesting wood fibre. These types of equipment might also be used for harvesting fibre for energy production or for conventional products plus energy purposes. The study reported here was designed to provide quantitative data on the additional fibre that could be obtained by harvesting the residual material below the current minimum diameter limits, and on the costs and economic feasibility of doing so with conventional logging equipment. A report describing the test stand and its biomass before and after harvesting will be published separately; this report presents the results of only the harvesting operation and its costs.

TEST AREA

The test was carried out on a 8-ha block of mixedwood/tolerant hardwood forest about 15 km west of the Trans-Canada Highway at Pokiok near Flat Top Mountain in central New Brunswick. The stand was of fire origin and about 60 years old. It was composed of beech, (*Fagus grandifolia* Ehrh.), red maple (*Acer rubrum* L.), striped maple (*A. pensylvanicum* L.) yellow birch (*Betula lutea* Michx. f.), witch-hazel (*Hamamelis virginiana* L.), sugar maple (*A. saccharum* Marsh), poplar (*Populus* L.), red spruce (*Picea rubens* Sarg.) and white birch (*B. papyrifera* Marsh.). Average stand diameter at breast height was 22.4 cm (Fig. 1). The stand was very suitable for the Koehring Feller-Forwarder (KFF)/chipper system, but because of the high number of small diameter stems was considered marginally operable by the conventional cut and skid method.

LOGGING SYSTEMS

The test was carried out using two "in-place" logging systems. One was a Koehring Feller-Forwarder (whole tree harvester) and Model 22 Morbark Chiparvester operation, and the other a power saw cut-and-skidder operation with 2.5-m wood being piled at roadside.

Figure 1. View of stand which was harvested.

The KFF is a rubber-tired tree forwarder equipped with a multiple-tree accumulating shearhead. The boom and felling head have been modified to enable the machine to cut up to 35-cm butt diameter "hard" hardwoods such as beech and yellow birch and up to 50-cm butt diameter poplar and softwoods. The double-armed accumulating head allows the machine to cut small trees down to 6-cm butt

diameter without serious loss of production, resulting in almost total fibre utilization. A load ranging from 5 to 10 cunits, depending on tree height, is forwarded to roadside and dumped alongside the chipper (Fig. 2). The "chipper" is a Model 22 Morbark Chiparvester equipped with a line heel-boom loader and three 75-inch (190 cm) three-knife discs with dirt separator set to produce 7/8 inch (2.2 cm) chips. The log bolts are placed under the top crush-roller, which together with two side rollers, the bed chain and the chipper itself, pull the tree through the machine (Fig. 3).

Conventional cutting consists of felling and limbing with chain saws, skidding tree-lengths to roadside, followed by slashing to 2.5 m pulpwood and sawlogs.

HARVESTING METHODS

The 8-ha block was divided into four separate 2-ha units on which the different harvesting trials were conducted. For ease of harvesting, a 2-chain wide buffer zone was left between the blocks (Fig. 4). This buffer strip was harvested first so that the wood cut from each block could more readily be kept separate.

The blocks were harvested in the following manner:

Block 1: Conventional logging, using chain saws and skidder, to normal standards (10 cm top) in the area.

Block 2: Koehring Feller–Forwarder, operating to normal standards in use in the area.

Block 3: Same as Block 2, but attempting to harvest everything possible with the KFF, and followed by a second operation to remove as much as possible of the residual material (standing and on ground) using a power saw and skidder.

Block 4: Same as Block 3.

RESULTS

Results are summarized in Tables 1 to 4.

While direct comparison of the amount of fibre harvested cannot be made between the blocks because of variability in stand density, the 100-tonne increase in yield from Block 2 as compared to Block 1 falls well within the range of 25–35% increase expected with whole tree harvesting and chipping as compared to conventional harvesting.

The clean-up operation on Block 3 resulted in an additional yield of 8.43 t of chips or 4.2 t/ha. This amounted to only 1.9% of the total harvest. On Block 4 the clean-up netted 22.92 t of chips or 11.46 t/ha, representing 5.6% of the total harvest. On Blocks 3 and 4 combined, the clean-up operation produced 3.7% of the total harvest.

The Morbark Chipper is equipped with a ground discharge spout. As the tree goes into the chipper most of the twigs, leaves, and loose bark are removed by aggressive paddles on the feed side of the chipper, and the chips are discharged onto the ground. The amount of material discharged was measured for one van load of chips.

The discharged material weighed 1,690 kg for one van load of 33,220 kg of chips or 4.8% of the total material fed into the Morbark Chipper. If this discharge percentage is applied to the total chip production for each of Blocks 2, 3, and 4, the amount of fibre which was discharged back into the woods would be estimated as:

Figure 2. Koehring Feller-Forwarder in operation.

Figure 3. Model 22 Morbark Chiparvester in operation.

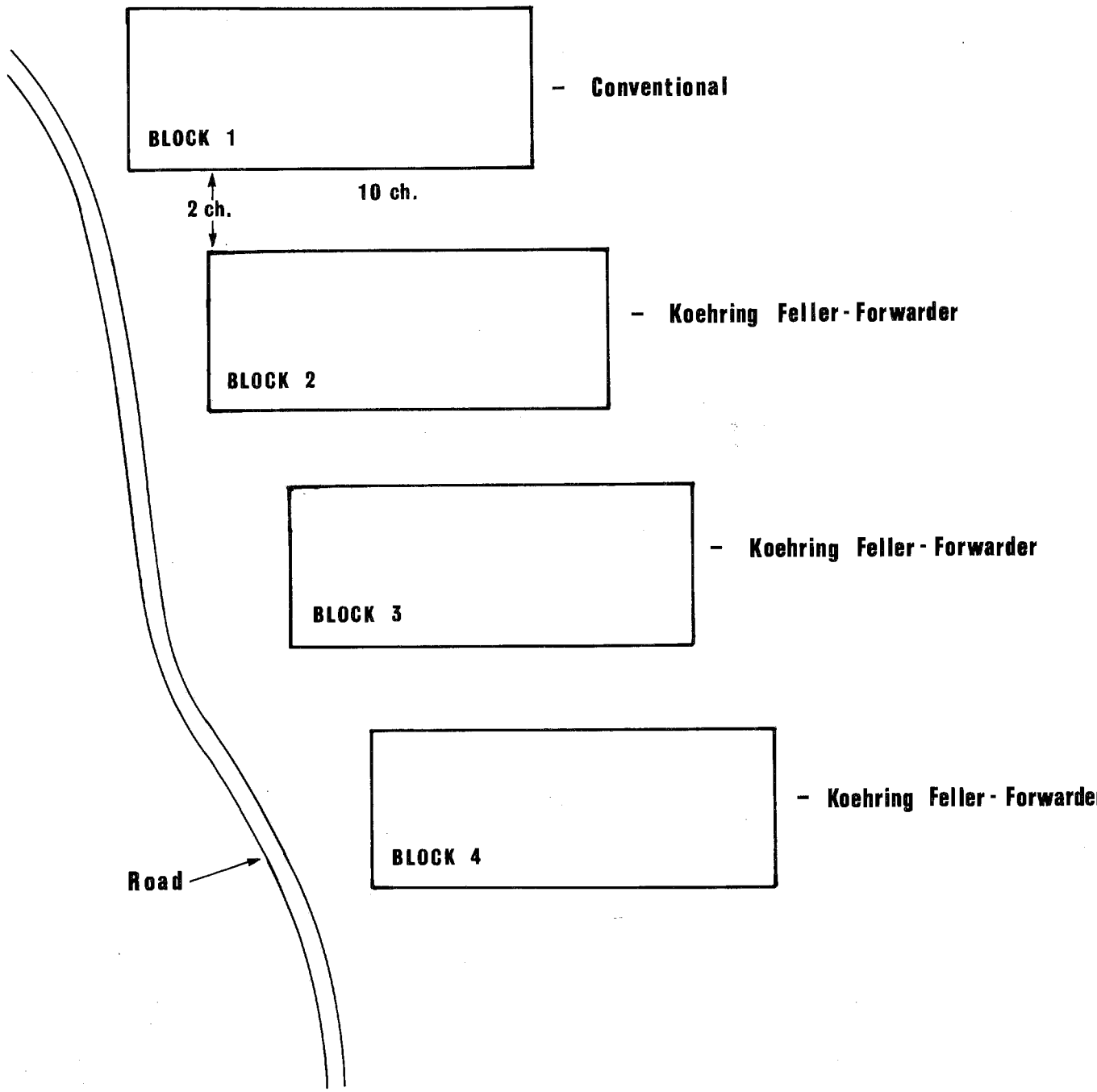

Figure 4. Map showing block locations and 2-chain buffer strips between blocks.

Block 2: 419.73 t x .048 = 20.14 t

Block 3: (424.7 + 8.43)t x .048 = 20.79 t

Block 4: (367.76 + 22.92)t x .048 = 18.75 t

In addition to this material, a small percentage of biomass in the form of leaves and broken branches remains around the chipper site. This is estimated at about 2% of the material forwarded to roadside by the KFF.

Samples were also taken during the course of the test to determine the moisture content of chips and discharge fibre. The average moisture content (dry weight basis) of chips was 93.6% and of the discharge fibre, 78.2%.

DISCUSSION

This harvesting trial was set up so that the amount of fibre harvested by two "in-place" logging systems (cut and skid versus whole tree harvest and chipping) could be compared. In addition, a comparison was made of the amount of logging waste left by these two systems which could be harvested at reasonable cost.

The KFF - Chipper full-tree harvesting system leaves a relatively clean logging site compared to a conventional limb-and-top system. Few stems greater than 6 cm dbh remain after the KFF passes over the area. The cost of this full-tree harvest with the wood chips in vans at roadside averages $7.89 per tonne, as compared to roundwood roadside at $6.95 per tonne.

The second pass over the cut-over area by the "clean-up" operation using a chain saw and choker skidder removes any dropped trees or trees greater than or equal to 6 cm dbh (Fig. 5) not cut by the KFF. Because of the scattered nature of these trees and the relatively small volume

Figure 5. Block 3, after KFF cutting prior to residual clean-up.

per hectare, the cost of transporting these trees to roadside is substantially greater than by the KFF. (In this case, $9.91/tonne versus $4.10/tonne average for the three KFF harvested blocks). By itself, the cost per tonne of the clean-up is high, but if combined with the KFF harvesting cost, the resultant average total cost at roadside is still quite acceptable at $8.32 per tonne.

On Block 1, cut conventionally, all small bolts less than 3.6 m in length and with less than 10 cm top diameter were left along with limbs and tops of the merchantable trees. Unfortunately, the trial to harvest this residual material was not carried out. However, from past experience with a disc-type chipper such as the Morbark, it it known that the productivity of the chipper drops by about 60% when handling only small trees and tops. If this 60% drop in chipping productivity is applied to the average cost of chipping ($3.85/t), then chipping this residual material would cost $9.62/t. The extra chipping cost added to the labor and skidding cost, would make the cost of harvesting residual material from a convential operation $19.52 per tonne, at a very conservative estimate. In fact, the cost would probably be higher because of higher labor and skidding costs incurred while picking up tops and large limbs.

In conclusion, it is clear from this study that stands, particularly hardwood stands, that are now marginally operable by chain saw and skidder can be harvested for pulp fibre or feed stock for fuel by KFF or similar whole-tree harvesting techniques, at acceptable cost and with a significant increase in total fibre yield.

Table 1. Block 1, Conventional cut and skid; summary of production and costs

Item	Production (tonnes)	Cost incurred ($)	Unit cost ($/tonne)
Hardwood roundwood			
Labor	319.2	1,487.48	4.66[1]
Skidder		730.97	2.99[2]
Total		2,218.44	6.95

[1] Includes bonus of $0.34/t for greater than normal cutting and skidding distance.

[2] Includes bonus of $0.17/t.

Table 2. Block 2, Koehring Feller-Forwarder; summary of production and costs

Item	Production (tonnes)	Hourly rate ($)	Operating hours	Cost incurred ($)	Unit cost ($/tonne)
Hardwood chips					
KFF	419.73	65.00	21	1,365.00	3.25
Operator		7.95	27	214.00	0.51
Chipper		80.00	14	1,120.00	2.67
Operator & Helper		15.61	27	421.47	1.00
Total				~~1,541.47~~ 3120.47	7.43

Table 3. Block 3, Koehring Feller-Forwarder with residual clean-up; summary of production and costs

Item	Production (tonnes)	Hourly rate ($)	Operating hours	Cost incurred ($)	Unit cost ($/tonne)
Hardwood Chips					
KFF	424.7	65.00	24.5	1,592.00	3.75
Operator		7.95	27.0	214.65	0.51
Chipper		80.00	16	1,280.00	3.01
Operator & helper		15.61	27.0	421.47	0.99
Total				3,508.62	8.26
Clean-up					
Labor	8.43			51.42	6.10[1]
Skidder				32.12	3.81[1]
Chipping		95.61	0.35	33.72	4.00
Total				117.26	13.91

[1] Standard piece-work rate.

Table 4. Block 4, Koehring Feller-Forwarder with residual clean-up; summary of production and costs

Item	Production (tonnes)	Hourly rate ($)	Operating hours	Cost incurred ($)	Unit cost ($/tonne)
Hardwood chips					
KFF	367.76	65.00	21	1,365.00	3.71
Operator		7.95	27	214.65	0.58
Chipper		80.00	13.5	1,080.00	2.94
Operator & helper		15.61	18	280.98	0.76
				2,940.63	7.99
Hardwood roundwood					
Labor	2.27			10.58	4.66
Skidder				5.20	2.29
Total				15.78	6.95
Softwood roundwood					
Labor	14.52	6.81	18	122.58	8.44
Skidder		10.00	6	60.00	4.13
Total				182.58	12.57
Clean-up					
Labor	22.92			139.81	6.10
Skidder				87.33	3.81
Chipping		95.61	0.87	84.80	3.70
Total				~~321.94~~ 311.94	13.61