Commercial Thinning In Mule Deer Winter Range

Improving Habitat Through Forest Management

Technical Report, Forestry Innovation Investment Contract R2003-0216

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1. ABSTRACT

Clumpy single tree selection is the silvicultural system of choice for mule deer winter range in the Interior Douglas-fir (IDF) zone of the Cariboo Region. Absense of fire disturbance over many years has caused stand density to increase substantially. In many stands on those winter ranges stand structures are sub-optimal for mule deer habitat, and stand vigour and health are declining. The stands have a risk of a low-intensity but high-severity wildfire that could cause significant loss of productivity. Thinning from below in these stands (generally referred to as commercial thinning) is seen as an opportunity to improve stand structure in the medium term, and restore stand health and vigour. Because the harvest volumes are low and the piece size is small the financial viability of this treatment is marginal. Two case studies from the Knife Creek Block of the UBC/Alex Fraser Research Forest are described, where thinning was prescribed and implemented. Logging failed on one block, and succeeded on the other, because of pre-harvest stand conditions and prescribed cut/leave ratios. Sawlogs and pulplogs were recovered, allowing an estimation of the cost of harvesting pulpwood. A lumber conversion test was conducted, showing that Douglas-fir 2x4 lumber produced was within normal range of grade out-turn. Lumber recovery factor was 173.9 FBM/m^3 and average sawlog piece size was 0.136 m^3. Financial analyses show that conversion return is negative for both blocks given the cost structures provided and under current market conditions.

Keywords: Douglas-fir, mule deer winter range, fire, commercial thinning, single tree selection, uneven-aged management, lumber, pulpwood, pulplogs, valuation, conversion return

2. ACKNOWLEDGEMENTS

We gratefully acknowledge the financial support for this project from the Province of British Columbia, through Forest Innovation Investments. We are also grateful for funding support from West Fraser Timber Ltd. to allow us to conduct pre-commercial thinning operations on this project. West Fraser Timber Ltd. has supported this project from the woods through the mill, and we particularly acknowledge the support of Griff Hughes, Guy Burdikin, and Rick Welke. The success of this project rested largely in the hands of the contractors, and we are grateful for the willing cooperation of Rolf Scheutze and his crew and subcontractors. We are also grateful for the cooperation of Mike Pearson and Gord Hollingsworth and their crews. We appreciate Cathy Koot's diligent red pen. Undertaking this project is an additional step in the process of integrating timber and mule deer habitat, and we acknowledge the support and involvement of the Mule Deer Winter Range Committee, and particularly Rick Dawson and Harold Armleder.

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1. INTRODUCTION

Mule deer winter range management for the Cariboo Region is informed by research and analysis spanning a period of more than 20 years (Day 1998). Armleder *et al.* (1998) have studied and reported on the habitat ecology of mule deer, and Armleder *et al.* (1984, 1997) proposed and studied an approach that would allow the integration of mule deer habitat objectives with timber management objectives.

The Cariboo-Chilcotin Land Use Plan (CCLUP) (Province of BC 1994) and the Integration report (IAMC Integration Committee 1998) have described a process for managing mule deer winter range values and maintaining access to timber through the short term. The mule deer strategy includes drafting management plans for each mule deer winter range that spatially discuss the current condition of the winter range, and describe the long-term habitat objectives. In most mule deer winter ranges, the habitat condition has shifted, under the influence of timber harvest practices and the absence of fire, from predominately large old trees, towards a preponderance of small trees at very high densities. This current condition is sub-optimal for mule deer use, because these stands are poor at providing snow interception cover and do not provide good foraging opportunities.

Mule deer winter range management plans (Dawson *et al.* 2002) for the shallow and moderate snowpack zones (Bunch grass, Ponderosa pine, and Interior Douglas-fir biogeoclimatic zones) embrace single-tree selection as a means of managing mule deer winter range values. The plans place a heavy reliance on thinning in small diameter stands as a means of allowing some commercial harvest entries, while improving the future condition of the winter range. The Mule Deer Winter Range Working Group of the Cariboo Lumber Manufacturers Association have identified several issues germane to this direction (Day 2000), described below in Table 1. The principle issue is the lack of experience in performing this type of harvesting, and an uncertainty about the costs of the harvesting and the value of the logs and lumber produced.

By undertaking the project reported here, we have set out to develop some experience in harvesting small diameter Douglas-fir under a selection management approach.

Table 1: Issues and recommendations regarding commercial thinning from the Cariboo Lumber Manufacturers Association (Day 2000) .

	Problem Statement:
Issue 1: Define the limits of a commercial opportunity for thinning from below.	Thinning from below will produce very low volumes per hectare, and a significant amount of the volume to be cut is grade six. Some stands will not present a viable harvest opportunity, and should be treated as a pre-commercial thinning.
Issue 2: Merchantability of small Douglas-fir	At present, there is no identified market to absorb the significant flow of small pieces from commercial thinning operations. K. Day, through other work, estimates this volume to be 15 m^3/ha. That volume represents 1500 m^3/yr from Williams Lake-Chimney MDWR alone. Considering that there are 101 mule deer winter ranges in the Cariboo Forest Region, this volume represents a significant opportunity, or a liability if left on the ground as fuel for wildfires.
Issue 3: Policies impede implementation of thinning from below.	Although policy will not be allowed to stand in the way of implementation of this plan, appraisals, tenure and quota present institutional barriers. Successful implementation will require careful attention to policy issues. Barriers should be removed as implementation gathers momentum.
Issue 4: Pre-commercial thinning	Some stands with very low average diameters may well be better addressed by pre-commercial thinning, rather than commercial thinning. In particular, stands that have been harvested by diameter-limit cutting can benefit from this treatment. The benefit of PCT in these stands is to enhance mule deer habitat more quickly, and improve the economics of the next entry.
Issue 5: Work force training and equipment.	The current work force does not include sufficient numbers of contractors who are appropriately trained and equipped to achieve thinning objectives. Small piece size, low volumes, and an emphasis on residual stand quality dictate a need for new training for the harvesting work force.

1.1. LOCATION

The UBC/Alex Fraser Research Forest is comprised of two blocks of Crown Land operated under tenure by the UBC Faculty of Forestry, for the purpose of teaching and research in integrated resource management in the central interior of British Columbia (Day 1997).

Two cutblocks were selected in the Knife Creek Block of the UBC/Alex Fraser Research Forest[1] (refer to Figure 1 below). These two blocks were originally selected for preparation of model silviculture prescriptions in cooperation with mule deer habitat ecologists (Day *et al.* 2000). Both cutblocks are located on the transition from the xeric moist to the dry cool subzones of the interior Douglas-fir biogeoclimatic zone (IDFxm/IDFdk3).

Figure 1: Location of the UBC/Alex Fraser Research Forest (near Williams Lake, British Columbia) and the two study blocks at the Knife Creek Block.

2. OBJECTIVES

2.1. THE ENVIRONMENTAL OBJECTIVE

The character of dry forests of interior British Columbia (and much of western North America) has changed significantly over the past century. Due to changes in land use and

[1] The Knife Creek block of the UBC/Alex Fraser Research Forest is located in the Williams Lake Forest District, Cariboo Forest Region, British Columbia. Longitude 121°48' W, latitude 52°03' N.

settlement patterns, the frequency of forest fires has been drastically reduced. A recent study from the Lignum IFPA (Iversen *et al.* 2002) has shown historic fire intervals of 22 years, ranging from five to 48 years between fires. Currently most sample plots have not had a fire for a period exceeding the historic maximum, with significant ecological implications.

As a result of their lack of disturbance, many of the dry forests have accumulated very high densities of small trees and lack large trees. Because the forests are moisture-limited, the large numbers of small trees compete for soil water with large trees, and reduce the vigour of the large trees. This has been documented as a causal factor in bark beetle attacks in dry forests elsewhere (Larsson *et al.* 1983, Dolph *et al.* 1995), and is suspected of contributing to outbreaks of Douglas-fir bark beetle in the Cariboo.

Mule deer winter ranges cover approximately 275,000 ha in the Cariboo Forest Region, much of it in the interior Douglas-fir (IDF) biogeoclimatic zone. Since mule deer are reliant on the cover and forage provided by large Douglas-fir trees (Armleder *et al*. 1994), it is important for managers to ensure that a continuous supply of these trees is available throughout each winter range. Intense competition and bark beetle attacks both work to reduce the inventory of large old trees through time.

Management plans for mule deer winter ranges are currently being formulated, as part of the process to integrate the direction from the Cariboo Chilcotin Land Use Plan (IAMC Integration Committee 1998, Dawson *et al.* 2002). Those winter range plans will direct a significant harvesting program towards stands with a small average diameter. Such a program, described by Dawson *et al.* (2002) as "commercial thinning", is important because it will enhance mule deer habitat in the future, and because it allows access to some timber. Without such a program, large-tree mortality will continue, but very high densities of small trees will prevent release of residual stems, meaning that small trees will not become large in a timely way.

2.2. THE SOCIAL OBJECTIVE

Recent forest fires in BC, the Prairie Provinces, and the United States have had devastating impacts on communities. Evacuations, health risks, and property loss caused by forest fires at the urban interface have clearly shown that our communities are at risk. This problem is now of such importance that the Auditor General of British Columbia wrote a report assessing the management of interface fire risk (Office of the Auditor General 2001). In his report he states that BC has the highest risk of injury and property loss from interface fires in Canada. This is because there is a large population living in the interface, and the number is increasing. He points out that the presence of people in interface areas has led to aggressive fire suppression activities, disrupting the historical occurrence of frequent low-intensity fires. Yet the imperative of managing the urban interface fuel hazard is jeopardized by the economic reality of the small log size that exists in much of the forests of the dry interior.

We are therefore concerned that the slash created by thinning treatments described in the mule deer winter range management plans (Dawson *et al.* 2002) will cause an increase in the hazard posed by wildfires. In order to discuss that potential hazard, we have modeled fire behaviour before treatment. We expect to model fire behaviour again after treatment in future projects.

2.3. THE ECONOMIC OBJECTIVE

Douglas-fir forests in the Interior Douglas-fir (IDF) biogeoclimatic zone are an important component of the timber supply in much of interior British Columbia. These forests have traditionally been a source of large-diameter, slow-grown Douglas-fir that was prized for its size and strength. In addition, these forests tend to be near settlements and close to highways, making them accessible to sawmills at low transportation costs. Finally, these forests are self-regenerating, making the reforestation costs of operating in them relatively inexpensive. The harvest of Douglas-fir from these forests has supported a significant part of the forest industry for the past five decades or more, and there is a significant desire to continue operating in these forests, providing economic activity and marketable commodities for the foreseeable future. However, the nature of the timber has changed, as have the management objectives in place. Ensuring that the objectives can be met in an economically efficient manner is an important component of achieving land use objectives. For this reason, the process of integrating the CCLUP considers the impacts of land use decisions on short-term timber availability (IAMC Integration Committee 1998).

3. METHODS

3.1. PRE-TREATMENT FIRE HAZARD

Robert W. Gray (R.W. Gray Consulting Ltd. acted as a partner on this project, and more detailed discussion of this topic is available in Gray (2003). Analysis of potential fire behaviour and fire effects is an increasingly common activity in sites being managed for a wide range of objectives. This analysis is intended to characterize fire behaviour and effects for two planned commercial thinning units, in order to compare pre- and post-treatment conditions. This report details the pre-treatment conditions only, and post-treatment conditions will be studied in a future project.

We have used cruise information detailed in Day *et al*. (2000), weather trends from nearby fire weather stations and Environment Canada sources, and site specific measures of stand-structure and surface fuel, to drive the *Fuel Management Analyst*™ models. Surface fuels were measured at twenty randomly selected stand structure plots[2] on each

[2] Established by Rick Dawson (Cariboo Forest Region) and Claire Trethewey (UBC/Alex Fraser Research Forest) for monitoring response to treatment. These systematically located plots were established outside of the current project, but will monitor stand structure and vegetation response to the thinning treatment.

thinning unit. Planar-intersect transects were established on random bearings for a 15 m length from the plot centres. Fuels were measured in moisture timelag[3] size classes:

- One-hour timelag fuels (0 to 0.6 cm diameter) – first two metres of the transect
- Ten-hour timelag fuels (0.6 to 2.5 cm diameter) – first two metres of the transect
- Hundred-hour timelag fuels (2.5 to 7.5 cm diameter)– first 4 metres of the transect
- Thousand-hour timelag fuels (>7.5 cm diameter) – entire 15 m transect length

Ministry of Forests provided historical weather data from the Knife Creek fire weather station (owned by UBC, and operated by the Protection Branch) for the period from 1991 to 2002. The key weather variables of interest were daily indices of temperature, relative humidity, and windspeed.

3.2. TREATMENT

3.2.1. Prescriptions

The first block (Block 211) is 22.7 ha, including a 3.0-ha uncut control. There was no harvesting history, with the exception of repeated entries for control of Douglas-fir bark beetle (*Dendroctonus pseudotsugae*).

The second block (Block 212) is 33.3 ha, including a 4.0-ha uncut control. This stand had been cut by diameter-limit in 1959. The current stand had a very clumpy distribution of larger diameter classes, and old skid trails that were densely stocked with trees regenerated after the previous harvesting.

On each block, a test-area of 3.0 ha was marked out to test the prescription and the feasibility of the commercial thinning and pre-commercial thinning operation.

The silviculture prescriptions and supporting rationale are described by Day *et al.* (2000). The intention of the prescriptions was to thin from below, leaving a residual stand of the best-formed, highest-vigour trees extant in the stand. The target density was set at 75% of the pre-harvest basal area, and we intended to cut those trees that had the:

- Poorest form
- Least likelihood of releasing after treatment
- Poorest current habitat value

No trees greater than 37.5 cm dbh were allowed to be harvested, and harvesting concentrated on the trees in the 15, 20, and 25 cm classes.

[3] Timelag represents the rate of moisture change in dead forest fuels as influenced by the temperature, humidity, windspeed and time of year (Dunster and Dunster 1996). Larger fuels have longer timelags, so the division of fuels into timelag size classes helps to describe the fuel load in a way that aides prediction of fire behaviour. Regarding timelag fuels, Gray (2003) cites:
Fosberg, M.A. 1970. Drying rates of heartwood below fiber saturation. For. Sci. 16(1):57-63.

The blocks reside in the Knife Creek mule deer winter range, which has had long term objectives stipulated in a habitat management plan[4]. Those objectives influence both the long-term target stand and the prescribed stand, as shown below in Table 2.

Table 2: Prescription elements as determined by mule deer habitat direction, for two blocks before thinning (after Day *et al.* 2000).

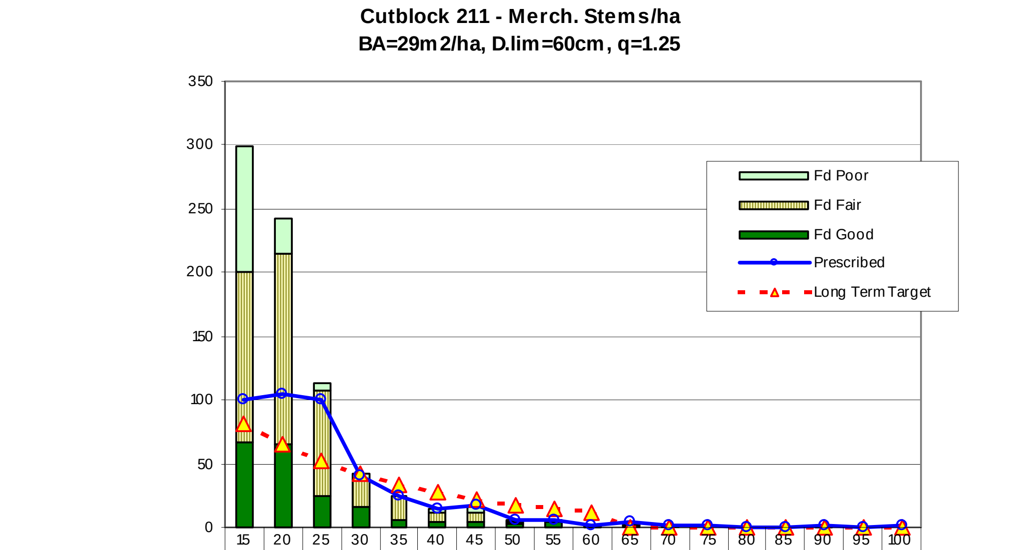
Prescription Element	Block 211	Block 212
Current Basal Area (m^2/ha, 12.5 cm dbh and greater)	34.4	27.4
Long-Term Target Basal Area (B)(m^2/ha) Maximum Diameter (D) (cm) Diminution Quotient (q)	29 60 1.25	22 60 1.25
Post Thinning Prescribed Basal Area[5] (m^2/ha)	25.7	20.5
Sawlog volume harvest (m^3/ha net merch.)	20.4	28.0
Cutting Limits	Nothing over 27.5 cm dbh	Nothing over 37.5 cm dbh

Harvest prescriptions are set by combining current stand condition with target stand structure, and determining a suitable step from current towards target. This step is termed "prescribed stand structure", and is depicted graphically for each block (Figure 2 below).

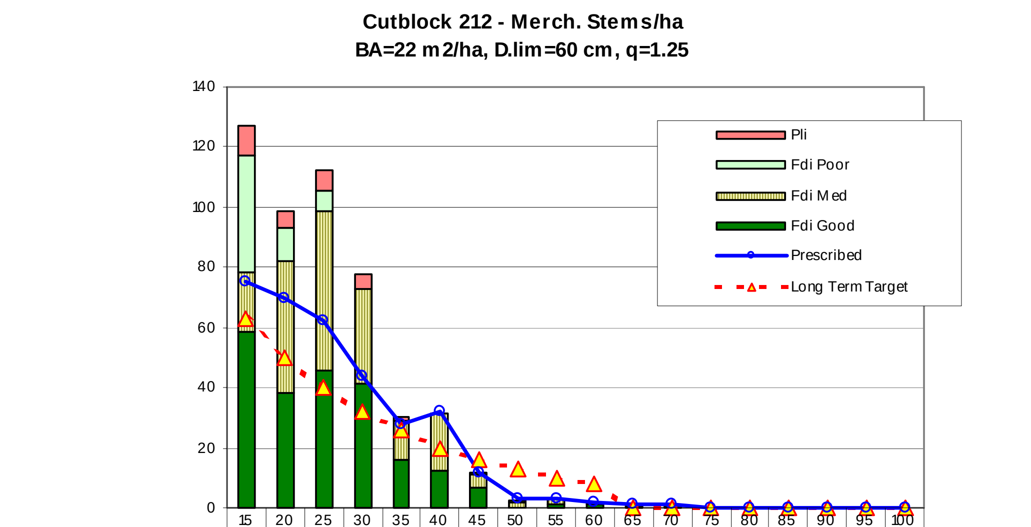
Tree selection was prescribed to be by faller's choice, due to the high cost of marking relative to the low value of the timber harvest. Guidance for tree selection (from Day *et al.* 2000) is shown below in Table 3.

A pre-commercial thinning treatment (also referred-to as juvenile spacing) was prescribed to take place after the commercial logs had been felled and skidded from the stand. The intention of this additional treatment was to ensure that small trees were thinned to enjoy adequate space for good vigour and growth. Post-spacing inter-tree distance was prescribed as shown in Table 4.

[4] Mule Deer Winter Range Committee, unpublished map product.
[5] Post-thinning prescribed basal area is defined by Mule Deer Winter Range Committee (2002) as 75% of current basal area.



	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
Fd Poor	100	28	6	4		2	6	2	1	1	3		1			1		0
Fd Fair	133	150	84	21	18	7	7	2			1	2						
Fd Good	67	65	24	17	6	5	4	3	5	1	0	0	0	0	0	0	0	0
Prescribed	100	105	100	41	24	14	17	6	6	2	4	2	1			1		1
Long Term Target	82	66	53	42	34	27	22	17	14	11	0	0						



	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
Pli	10	5	7	5	2													
Fdi Poor	39	11	7				1	1										
Fdi Med	20	44	53	32	13	19	4	2	1	1		0						
Fdi Good	59	38	46	41	16	12	7	0	1	1	1	0	0	0	0	0	0	0
Prescribed	75	70	62	44	28	32	12	3	3	2	1	1						
Long Term Target	63	50	40	32	26	20	16	13	10	8	0	0						

Figure 2: Stand tables for Blocks 211 and 212 showing pre-thinning condition, target stand structure, and prescribed stand structure.

Table 3: Decision rules for Blocks 211 and 212. Ratios of leave to total trees taken from stand table information, by comparing the prescribed stand (stems/ha) to present stand (stems/ha). (From Day *et al.* 2000)

<table>
<tr><th>Block 211 – Specific Rules</th><th>General Rules</th></tr>
<tr><td>1) Leave 1 in 5 trees in the 10 cm class.
2) Leave 2 in 5 trees in the 15 and 20 cm classes.
3) Cut only trees of poor vigour and high risk (class C) in the 25-35 cm classes.</td><td rowspan="3">• Leave all Douglas-fir 40 cm class and larger.
• Leave all class A1 trees.
• Leave Douglas-fir, and cut other species.
• Leave trees whose crowns are a part of a clump, and cut isolated trees.
• Thin from below, leaving the most vigorous and best formed trees.
• Leave up to 10 deciduous and class C trees per hectare.</td></tr>
<tr><td>Block 212 – Specific Rules</td></tr>
<tr><td>1) Leave 1 in 4 trees in the 10 cm class.
2) Leave 3 in 5 trees in the 15 to 30 cm classes.
3) Cut only trees of poor vigour and high risk (class C) in the 35 cm class.</td></tr>
</table>

Table 4: Recommended inter-tree distances for each diameter class within the range of classes considered for commercial thinning. The wide range allows a faller to leave trees very close together, or up to 1.5 times the average inter-tree distance, to permit selection of the best trees and creation of clumpy structure.

DBH	Inter-tree Distance (m)	
(cm)	Average	Range
5	2.84	1.0 - 4.26
10	3.18	1.0 – 4.77
15	3.55	1.0 – 5.33
20	3.97	1.0 – 5.95
25	4.44	1.0 – 6.66
30	4.96	0.5 – 7.44
35	5.55	0.5 - 8.33

3.2.2. Logging and Pre-Commercial Thinning

A three-hectare trial area was set up in each block, where trees were marked to leave at the desired density by Research Forest staff. This test area was intended to calibrate the logging contractor, and allow the contractors enough time to determine appropriate bid-rates for harvesting. Within the test area, pulpwood was harvested, as well as sawlogs.

Logging contractors were selected for their experience in both logging and stand tending. We felt that the logging contractor must foremost be able to accomplish our objectives for the residual stand, where we are asking the logger to choose the best trees to leave, and fall the remainder. Therefore, a critical skill set for successful performance of this work was leave-tree selection. In addition, the spatial arrangement of the residual stand is important, because the objective is to provide a clumpy stand where size classes are aggregated into small groups. Stand tending concentrates on both leave-tree quality and spatial distribution.

Two paradigms exist for harvesting small volumes. A contractor might be well capitalized, having current equipment (perhaps processors and forwarders) that can carry out the work efficiently but at a high daily cost. In this case the contractor is motivated to produce consistently high volume. Alternatively, a contractor might be working with relatively small capital investment (perhaps hand falling and small line skidders), which affords the contractor the opportunity to work at lower production. Our judgment was that the second paradigm was most effective for our purposes, because:

- It allowed us to work slowly, to ensure our objectives were achieved,
- It ensures that the contractor has time to make effective falling decisions based upon our objectives for the stand,
- It ensures that the contractor can take the time to consider input and devise solutions to logging issues as they emerge.

Three contractors were offered an opportunity to submit a proposal on pricing and production rates, and two contractors were selected:

- **Block 211 –** Gord Hollingsworth, doing business as Hollingsworth contracting, of Williams Lake. Gord operates a John Deere 440 line skidder, skidding for a hand faller and processing at a landing.
- **Block 212 –** Rolf Scheutze, doing business as Romar Contracting, of Williams Lake. Rolf operates a 30 HP Ford New Holland tractor with a Farmi winch, skidding for a hand faller and processing at the stump. His tractor is equipped with a front-end loader grapple for decking logs.

The contract was designed to allow each contractor to log his three-hectare test area on a day-rate. The test area had been marked to leave to train the faller in tree selection. Skid trails were laid out in advance by the contractors, and approved by the supervisor before felling commenced. When sawlogs and pulplogs had been harvested, pre-commercial thinning was conducted on the test-area. Day-rate costs were compared to volume shipped to the mill.

After the completion of the test area the contractor provided a piece-rate bid for the completion of the block, including all phases of the logging from falling to delivery in the mill yard. Pre-commercial thinning was an extra cost, paid on a per-hectare basis over and above logging costs. A decision was made at that time to proceed or stop the harvesting.

Outside the test-area the faller selected leave trees, with the aid of a prism relascope to measure residual basal area. Logging supervisors worked with the crews to train workers in tree selection and the use of the prism.

The Forest Engineering Research Institute of Canada (FERIC) has acted as a partner in this project, to study the costs of thinning treatments. More detailed discussion of this topic is available in Mitchell (2003). FERIC studied costs and productivities for both logging and pre-commercial thinning by, both shift-level monitoring and detailed timing. Scheduled and productive hours were documented for each contractor by mounting a Servis recorder on the skidder/tractor. Contractors recorded daily operating times on time cards. FERIC supplemented the shift-level information for each crew with detailed timing using a hand-held data logger.

FERIC summarized daily operating time from time cards and Servis recorder charts, by machine and contractor, to determine scheduled and productive machine hours. Hourly machine operating costs were calculated using FERIC's standard costing procedures for each machine. Wages for the crew were based on local rates for BC, with an estimate of fringe benefits added. This information was used to develop relative production costs ($\$/m^3$) in order to compare the two contractors and blocks.

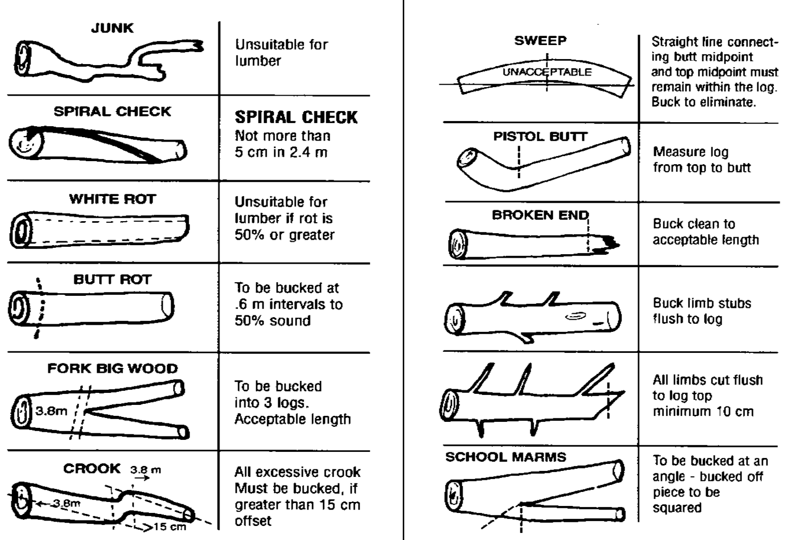
3.3. LOG SALES AND SCALING

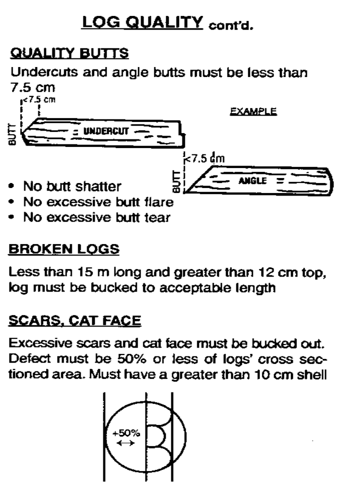
West Fraser Timber Ltd. (Williams Lake Division) has acted as a partner in this project, and has purchased the logs produced by the thinning treatments. Utilization limits were varied from the contractual obligations under the Research Forest tenure document; West Fraser agreed to purchase all logs that could make a sawlog (10 cm top and 3.3 m long) regardless of the size of the tree. In this way we were able to produce sawlogs from trees that are optional utilization under our license.

Logs were bucked on the landing (block 211) or in the bush (block 212) to West Fraser's bucking specifications, shown below in Table 5 and clarified for commercial thinning in Table 6. Bucking was a critical activity for finding merchantable logs in poorly formed trees. The principle issue was to manufacture straight logs, and remove the crooked or flared butt. Where logs were being bucked from grade 6 trees (those trees with a diameter at stump height less than 20 cm, optional utilization) care was taken to identify those logs after bucking, by marking the large end with a saw cut to avoid confusion with top logs from larger trees.

Table 5: Bucking specifications for West Fraser Timber Ltd. (Williams Lake Division).

West Fraser Bucking Card
November 2002





DEFINITIONS:

- **School Marm** – buck off marms any length (not less then 3.8m) but evidence of marm to be left.
- **Short log** – no log under 3.8 m is acceptable and will be scaled as manufacturing waste.
- **Catface (scars)** – the cat face is to be bucked to where the defect occupies 50% or less of the log's cross sectional area. Must have a >10cm shell. Any crook or sweep must be bucked out.
- Crook – for crook 7.6cm or less offset, no bucking required, but there must be at least a 3.8 bottom log and 3.8m top log.

Grade Definitions:

SAWLOG:
Green log normally produce 2 & better lumber.

GRADE 3:
Dead/dry sawlog:
- deteriorated cambium**
- loose/shredding bark**
- sap rot**
- wood borers**

** Requires only one (1) of these indicators

GRADE 4:
Green log: produces green downgraded lumber but not reject.
- twist of grain but not cracked
- multiple knots or large knots

GRADE 5:
Dead/dry grade 4:
- primarily cracked, twist grain but not end-checked
- pulp

GRADE 6:
Trees but under the harvest specifications:
- less then 15cm on butt for Pine
- less then 20cm on butt for Sp.,F.,Ba.,He.,and Ce.
- no rot
- 3.8m or longer in length
- straight and defect free
- 10cm top (inside bark)

** NO LONG BUTTING

Specifications Log Lengths Preferred Log Lengths		
METRIC		
5	9.9	15
Acceptable Log Lengths		
3.8	4.4	5
6.9	7.5	8.1
8.7	9.3	9.9
10.8	11.4	12
12.6	13.2	13.8
14.4	15	19.3
Tolerance All Lengths		
.05m		

Table 6: Addendum to West Fraser bucking specifications for commercial thinning.

<table>
<tr><th colspan="2">West Fraser Bucking Card
Addendum to, November 2002, card. Modified on January 23, 2003</th></tr>
<tr><td>**SAW LOGS:**
• Bucked to a preferred length of 5.0 metres (16’) or 4.4 metres (14’), or a minimum of 3.8 metres (12’).
• Random saw log lengths are acceptable @ 2’ intervals or to a 4” top.
• Grade 6 logs can be shipped as sawlogs regardless of butt diameter. Buck at 4 ¼ ” top and 16’ logs are preferred.
• Acceptable to buck the swept butt off the bottom of the log.</td><td>• Allowable log sweep. As per a discussion with Log Purchaser a long sweep is better than a sharp sweep. One sweep on one plane is okay. The tape can leave the log slightly depending on the length of the sweep.
• Lodgepole pine logs must have the cat face bucked off at the butt. May leave cat-face further up the log if there are no indications of rot.
SORTING:
• Sort by species unless the lodgepole pine is less than 10% of the deck</td></tr>
</table>

Logs were delivered to West Fraser by truck, and loads were weight-scaled. Sample loads were selected and stick-scaled according to the BC scaling manual[6]. Each block was scaled separately by providing a unique timber mark and block number combination to each. Sample scale and weight-scale summaries were provided from West Fraser according to normal operational procedures. Conversion ratios (weight to cubic volume kg/m^3) were allowed to float in accordance with results of sample scaling.

3.4. CONVERSION TEST

West Fraser staff selected a single load of logs shipped from block 212 (sample load 0911) to be run as a conversion test in West Fraser’s sawmill. The load was scaled on February 13, 2003. Figure 3 below shows the load spread out for scaling, and gives a visual impression of the nature of the logs produced from both blocks. Table 7 below shows the results of the scaling for load 0911.

A description of the process for the conversion test follows, and is depicted in Figure 4 below.

[6] http://www.for.gov.bc.ca/revenue/manuals/scaling/

B

A

Figure 3: Sample load 0911 spread for stick scaling before conversion test at West Fraser Timber Ltd. Williams Lake. Note short length and sweep (A) and small diameters (B) of the logs.

Table 7: Sample load 0911 scaled in preparation for conversion test.

Volume (m^3)	Number of Pieces	Vol/Piece (m^3)	Species Composition (%)	Log Grade (%)					
				2 & Better	3	4	5	6	Z
41.13	299	0.137	Douglas-fir 100%	65.0	0	0	0	34.8	0.1
				Green Sawlog	Dead & Dry Sawlog	Lumber Reject	Dead & Dry Lumber Reject	Under-sized sawlogs	Waste

At the end of the sawmill shift on March 7, 2003, the mill was cleaned out of lumber and all the computers were reset. The logs were then fed into the mill on March 7, 2003 across the bucking table. On March 9, 2003 at the beginning of the shift the logs were barked and sent through the canter. The canter has a computerized scaling and optimization function, which scales the volume of each piece optically, and then determines the optimal cutting pattern and log orientation for each piece. A vertical double-arbor edger breaks down the cants according to the solution from the canter.

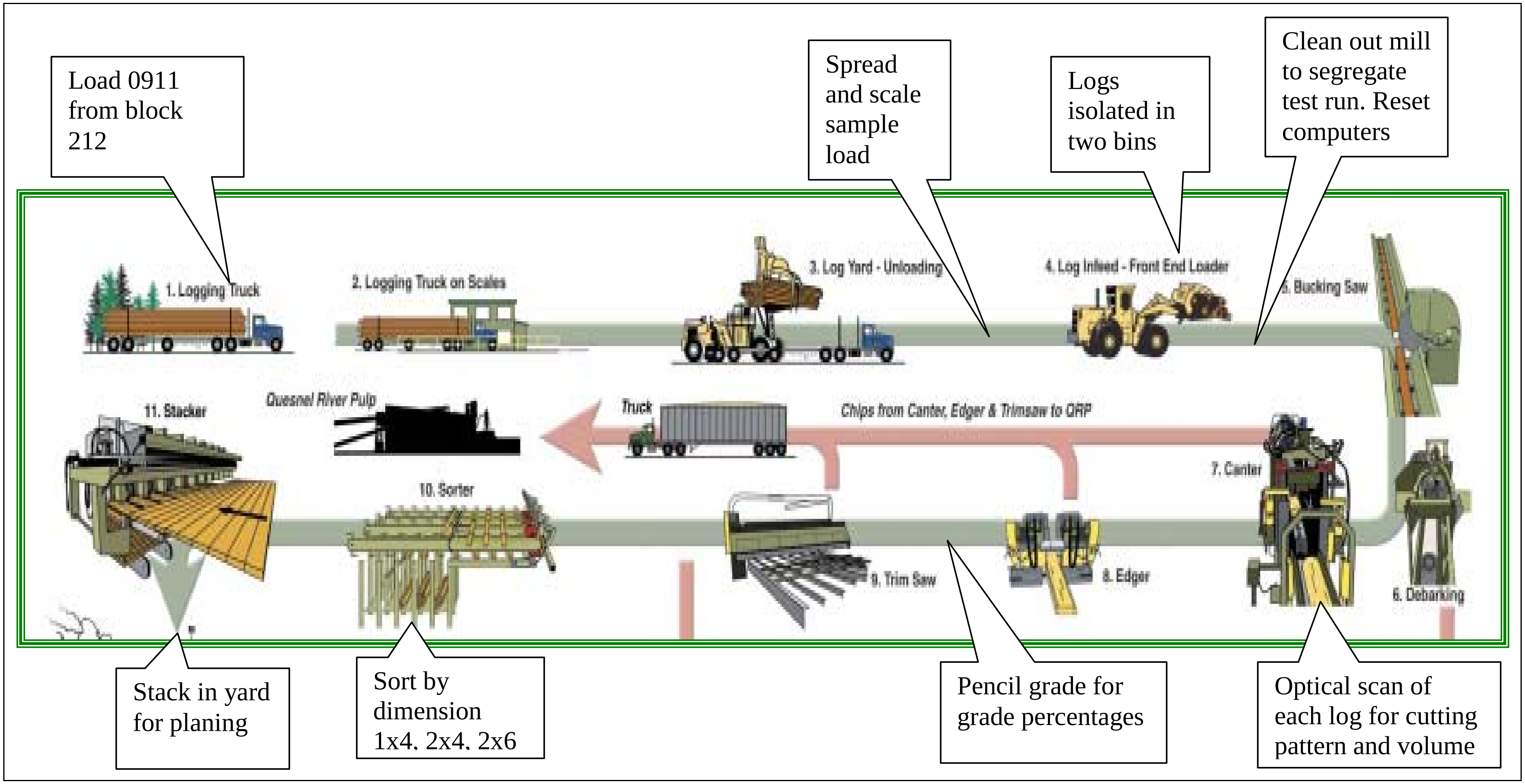


Figure 4: Schematic representation of West Fraser Timber Ltd. mill flow, showing critical points for conversion testing.

Experienced personnel performed a visual grading (referred to as pencil grading) of each piece of lumber before the lumber went to the trim saws. After trimming the lumber was sorted by size and stacked outside.

Data from the canter scale are compared to the stick scale to determine log-trimming losses. Lumber recovered (number of pieces and their dimensions) is tabulated by the sorter, and calculated into foot board measure (FBM). When foot board measure is divided by cubic metres of logs input, a calculation of lumber recovery factor is accomplished. Visual pencil grading tabulates the quality of the lumber in percentages.

3.5. PULP PROPERTIES

Increased utilization of thinnings by the pulp and paper industry is inevitable. It is therefore important to understand the effects of thinnings on pulp properties.

In the pulp and paper industry wood density is one of the most important characteristics of raw material. High *wood density* is associated with high throughput in processing, or fibres per tonne. Wood density, however, is not necessarily correlated with fibre properties.

Fibre length and coarseness are fundamental determinants of final pulp properties and quality. *Fibre length* affects sheet strength and formation. Shorter fibres produce higher pulp tensile strengths. *Fibre coarseness* affects almost all sheet properties (strength, structure, and optical). Finer fibres produce better sheet strength, structure, and optics (measured by light scattering coefficient).

Intensive pulp-properties sampling and analysis was scheduled in this 2002/2003 project plan but was cancelled due to time and resource constraints. The pulp properties results presented in this report are from a pilot project that was implemented outside the timeframe and funding of this integrated project.

The pilot pulp properties study was conducted on both project blocks in 2001, two years before commercial thinning. The Pulp and Paper Research Institute of Canada (PAPRICAN) funded the pilot study under the direction of Paul Watson. Hussein *et al.* (2002) reported the project.

Three representative Interior Douglas-fir commercial thin trees were selected from each study site block for sampling. One tree was sampled from each of three diameters at breast height (7.5, 12.5, and 17.5 cm DBH) on each block. Trees were marked and transported to the PAPRICAN Vancouver laboratory where they were frozen until pulp trial processing.

3.5.1. Chip Preparation

Trees were debarked and chipped separately using a disc chipper. A portion of the chips from each tree were air-dried to about 90% solids content and later screened to obtain accept chips ranging from 2-6 mm. Accept chips were mixed and representative samples were taken for kraft pulping, chip wood density, and chip-packing density determinations.

The remaining green chips were screened to a chip size ranging from 8-31 mm and then homogenized for mechanical pulping. Representative samples were taken from each of the chip samples for solids content determination. Chip solids content ranged from 64.3 to 76.6%, on an oven-dried wood basis.

3.5.2. Packing and Chip Density

Packing density was determined by dividing the oven-dried weight of the chips by the volume. Chip density was determined by a modified PAPTAC method A.1H.

3.5.3. Pulping

More detailed pulping methodology and refining conditions may be found in Hussein *et al.* (2002)

Kraft Pulping

Three representative aliquots of accept chips from each of the six samples were kraft cooked in bombs (50 gram, oven-dried charge) within a B-K microdigester assembly. All pulps were washed, oven dried, and weighed to determine pulp yield. Large quantities of kraft pulp were produced in a 28L Weverk laboratory digester and then disintegrated, washed and screened through an 8-cut screen plate.

The fibre length and coarseness of the pulps produced were analyzed using a Fibre Quality Analyzer (FQA). Hand sheets were formed and tested for physical and optical properties using standard PAPTAC methods.

All pulps were tested over a range of PFI Mill beating levels (0, 3000, 6000, and 10000 revolutions) to determine relationships between fibre and pulp properties.

Thermomechanical Pulping (TMP)

Only 12.5 and 17.5 cm DBH trees from each of the two blocks were available for thermomechanical pulping.

A Sunds Defibrator TMP 300 single disc laboratory refiner was used in first-stage refining. A Labview PC system was used to control and monitor the refining variables. A high freeness pulp sample from each of the primary TMP pulps was given one or two further passes in a 30.5 cm Sprout Waldron open-discharge laboratory refiner. Each sample was refined at three energy levels to give pulps ranging in freeness from 69-152 mL CSF. Each pulp was screened after latency removal on a 6-cut laboratory flat screen and screen rejects were determined.

Bauer-McNett fibre classifications were conducted and fibre lengths were determined with a FQA. Handsheets were prepared and tested for bulk, physical and optical properties using PAPTAC standard methods.

3.6. FINANCIAL ANALYSES

The information provided by the lumber recovery test, when combined with selling price for the lumber produced, provides an analysis of average market value. If component costs (delivered log cost, milling costs, and allowance for profit and risk) are deducted, then the financial return of the harvesting can be calculated.

3.6.1. Revenue Estimates for This Case Study

Using the results of the conversion test, a spreadsheet of lumber dimension, grade, and value was built. By applying the lumber recovery factor developed in the conversion test, a revenue estimate is created.

3.6.2. Costs For This Case Study

Some cost information is sensitive, and we consider it to be proprietary information. We have treated such costs as aggregates, reported costs for a test area only, or omitted the costs from this report.

This study has documented costs for the categories described below in Table 8.

Table 8: Cost categories and information sources for financial analyses.

Cost Category	Based Upon	Compared With	
Harvest planning	Time spent on layout, cruising, marking, and prescription writing	Appraisal allowance	
Harvest supervision	Time spent	Appraisal allowance	Other harvest operations in Knife Creek
Logging	FERIC time studies	Appraisal allowance	Cost experience for test area
Trucking	Actual costs	Appraisal allowance	
Road Use	Actual cost	Appraisal allowance	
Pre-commercial thinning	FERIC time studies	Cost experience for test area	
Sawmilling	Appraisal allowance		

3.6.3. Application of Appraisal Allowances

The Interior Appraisal Manual provides cost estimates for all phases of the conversion process, from layout to milling. Using data developed in this project and from Day *et al.* (2000), staff at West Fraser Timber Ltd. have run both blocks through the "Interior Stumpage Appraisal Program" (© Industrial Forestry Services Ltd.) to develop appraisal cost estimates for each cutblock.

4. RESULTS

4.1. PRE-TREATMENT FIRE HAZARD

4.1.1. Weather

We developed two weather system scenarios representing “normal” and “extreme” conditions for July and August from the Knife Creek fire weather records. The normal scenario was calculated as the 90^{th} percentile values of temperature, relative humidity, and windspeed for all years, and the extreme scenario was calculated as the 90^{th} percentile values for 1998, the only El Niño year in the weather data. The resulting scenarios are described below in Table 9.

Table 9: Weather indices input to the fire behaviour and fire effects model for 2 weather system scenarios.

Scenario	Temperature (ºC)	Relative Humidity (%)	Windspeed (km/h)
Normal	27	30	5
Extreme	30	15	7

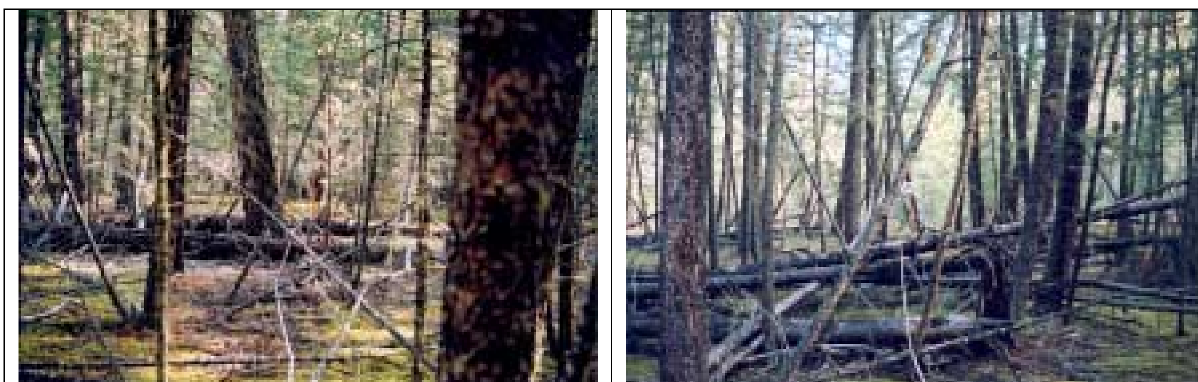
4.1.2. Fuels

Surface fuel loading is summarized below inTable 10. Aerial fuel loading consists of canopy fuel loading and canopy bulk density, which are a function of stand structure. Typical fuel conditions are shown below in Figure 5. Stand structure characteristics of density, uniformity of density, species composition and growth patterns over time influence the likelihood of a fire making the transition from surface fuels to crown fuels.

Using stand structure data collected in the field in conjunction with cruise data, *Fuel Management Analyst*™ sub-models estimate the canopy fuel loading and crown bulk density, as shown in Table 11. Both blocks exceed the critical threshold value of crown bulk density (0.1 kg/m3/ha) by a small margin, indicating that a crown fire is possible given maximum potential windspeeds.

Table 10: Mean surface fuel loading by size and type for two thinning units before treatment.

Fuel Type	Pre-Thinning Mean Fuel Loading (kg/m^2)	
	Block 211	Block 212
Round Woody Fuels		
One-Hour (<0.6 cm)	0.14	0.18
Ten-Hour (0.6-2.5 cm)	0.17	0.12
Hundred-Hour (2.5-7.5 cm)	0.48	0.54
Thousand-Hour (>7.5 cm)	3.18	1.96
Sub-Total Round Woody Fuels	3.97	2.80
Forest Floor Fuels		
Litter (incl. moss and grass)	0.85	0.91
Duff	2.96	3.01
Sub-Total Forest Floor Fuels	3.81	3.92
Total Surface Fuels	7.78	6.72



A **B**

Figure 5: Heavy fueld loads typical of (A) block 211 and (B) block 212 in the pre-treatment condition. (R.W. Gray photos.)

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Table 11: Estimated aerial fuel loading for two blocks before thinning.

Aerial Fuel Component	Pre-Thinning Estimate	
	Block 211	Block 212
Canopy Fuel Loading (kg/m^2)	0.72	0.69
Canopy Bulk Density ($kg/m^3/ha$)	0.16	0.17

Surface fuel inventory data were entered into *Fuel Management Analyst*™ sub-models, linked to a database of fuel models and then combined with stand structure data. Fuelbed properties (depth, loading by size class) lead to predictable outputs of rate of spread, fireline intensity, and flame length, given a particular set of fuel moisture and weather inputs.

Fire behaviour for model outputs for both blocks and for both weather scenarios produced “fairly low-intensity” surface fires with a rate of spread of less than 1 m/minute and a flame length of less than half a metre. Fireline intensities were also low, and three orders of magnitude lower than the critical value that would increase the likelihood of crown fires.

4.1.3. Fire Effects

Mortality due to fire is a function of

- tree diameter – increasing diameter increases resistance to girdling by heat
- tree height – taller trees are less likely to be have their crowns scorched
- tree species – Douglas-fir is less likely to be girdled by heat than lodgepole pine due to their respective bark characteristics
- fire intensity

We forecast mortality would be restricted to the smallest trees in the stand, when a low-intensity surface fire is combined with the preponderance of Douglas-fir in both stands. Model results provide estimates of mortality depicted in Table 12. We predict that the probability of mortality falls below 20% for trees exceeding 5 cm dbh.

Fire can also have significant impacts on site productivity through soil heating, since high temperatures volatilise essential nutrients, and can kill belowground plant tissues, stored seeds, and soil biota. Using a model called First Order Fire Effects Model, we found similar soil impacts between the two blocks, but different impacts given different weather scenarios, as described in Table 13.

Table 12: Forecast tree mortality by species, for two thinning blocks, given two different weather scenarios.

Weather Scenario	Forecast Mortality (% of stems/ha)			
	Block 211		Block 212	
	Douglas-fir	Lodgepole pine	Douglas-fir	Lodgepole pine
Normal	71.6	Not Present	75.5	85.0
Extreme	77.0	Not Present	79.8	87.5

Table 13: Estimated soil impacts for pre-thinning fire, given two weather scenarios. Soil impacts between blocks were found to be insignificant.

Weather Scenario	Soil Impacts	
	Lethal Heat Flux Depth (cm)	Mineral Soil Exposure (%)
Normal	3	31
Extreme	6	41

4.2. TREATMENT

4.2.1. Prescriptions

After treatment was completed, we returned to the original cruise plots and re-sampled to determine the stand structure after treatment (Figure 6, Figure 7 below).

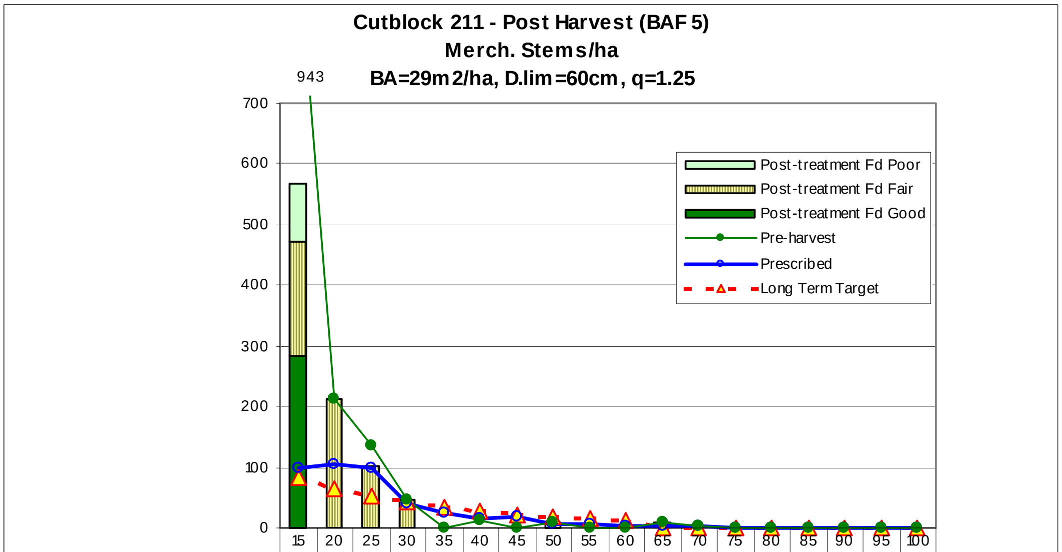
Block 211

The test-area of block 211, which was logged and pre-commercially thinned (Figure 6 A), consists of only three cruise plots. The results of the re-measurement indicate that we undercut in the 15 and 20 cm classes compared to the prescribed stand. However, the prescription was set for the whole block, and we treated only 3 plots. It is likely that those three plots did not contain the average condition, and we could not, therefore, meet the average prescription.

The prescribed stand structure is a useful guide that is meaningful for the stand as a whole, but retaining appropriate density of the most vigorous trees on each hectare is the more critical objective. It is more important to ensure each hectare has the prescribed basal area than to worry that each diameter class has the optimum number of trees.

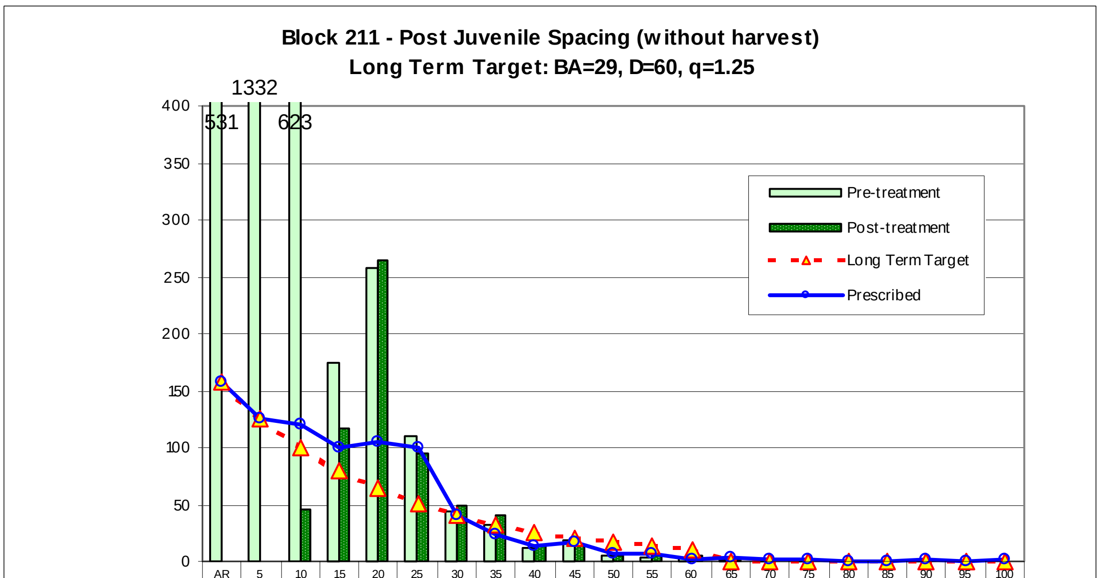
The pre-thinning density of this portion of the stand (by three cruise plots) was 34.4 m^2/ha, and post-thinning density was 31.6 m^2/ha. By the marking tally (pre-treatment complete inventory) the pre-treatment density was 33.4 m^2/ha and the leave trees were marked at a density of 29.7 m^2/ha. Allowing for 5% loss to skid trails, which were established after marking, we expect the actual density on the test-area is 28.2 m^2/ha. The prescribed density was 25.7 m^2/ha.

A



	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
Post-treatment Fd Poor	94							9			5							
Post-treatment Fd Fair	189	212	102	47							5	4						
Post-treatment Fd Good	283	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pre-harvest	943	212	136	47	0	13	0	9	0	0	10	4	0	0	0	0	0	0
Prescribed	100	105	100	41	24	14	17	6	6	2	4	2	1			1		1
Long Term Target	82	66	53	42	34	27	22	17	14	11	0	0						

B



	AR	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
Pre-treatment	531	1332	623	174	257	110	43	32	12	19	6	3	3	2	1	1	0	0	1	0	1
Post-treatment	0	0	46	118	264	94	49	41	13	13	5	6	5	2	1	1	0	0	1	0	0
Long Term Target	157	125	100	80	64	51	41	33	26	21	17	13	11	0	0						
Prescribed	157	125	120	100	105	100	41	24	14	17	6	6	2	4	2	1			1		1

Figure 6: Post-treatment conditions for block 211, showing post harvest stand structure as compared to pre-harvest, long-term target, and prescribed stand structure for (A) the test area, and (B) the pre-commercial thinning area.

The balance of block 211, which was pre-commercially thinned only (Figure 6 B), has been under-cut in 20 cm DBH trees and over-cut in trees less than 15 cm DBH, to the point where no advanced regeneration remains in sample plots. This is a result of changing to a pre-commercial thinning prescription. In the pre-commercial thinning prescription we restricted ourselves from cutting any stems that would be mandatory utilization (17.5 cm DBH and greater). Since none of the 20 cm trees were cut (the dominant diameter class in the stand), smaller trees remained under the canopy and were therefore cut.

Thinning from below removes smaller trees, and our objective for spatial arrangement is to remove regeneration from under larger trees to reduce the damage done by spruce budworm. Practically speaking, we now lack the 5 cm DBH class, and have a shortage in the 10 cm DBH class. New regeneration will bring us sufficient stocking in the regeneration class over the next re-entry period (30 years).

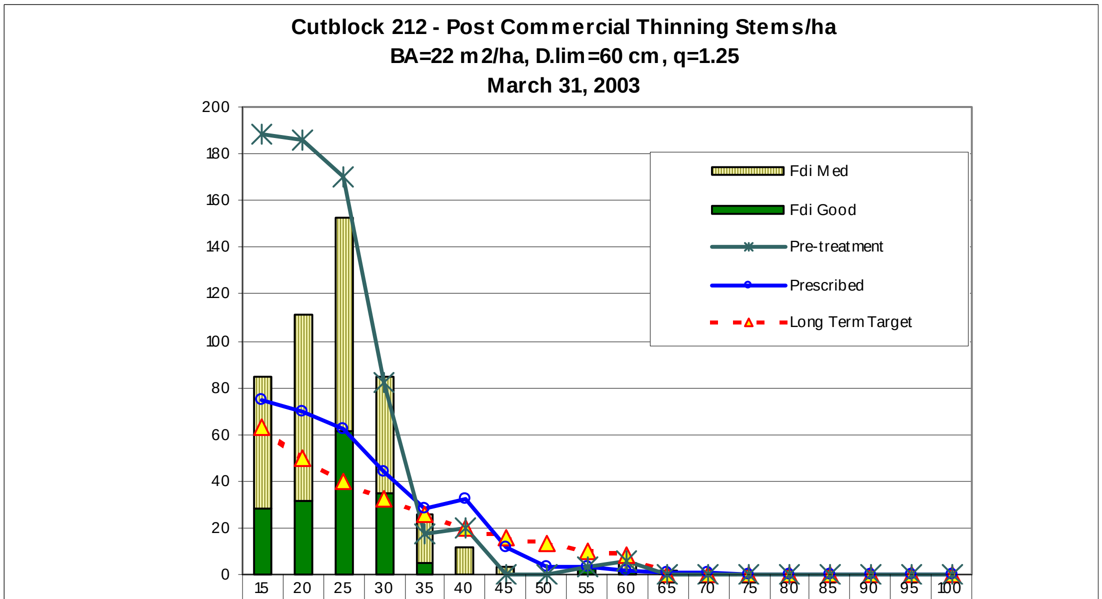
On the balance of the block, our target residual basal area remained 25.7 m^2/ha. Pre-commercial thinning only reduced the stand from 32.7 m^2/ha to 32.3 m^2/ha, because we concentrated the cutting on stems less than 12.5 cm DBH.

Block 212
On block 212, 11.3 ha of the 29.3 ha net harvest area has been completed between December 2002 and March 31 2003. The results of that harvest are depicted in Figure 7 below. Once again, one must bear in mind that the prescription was created for all 29.3 ha, and it is evident from Figure 7 that the 11.3 ha accomplished does not have the average stand structure. This accounts for the discrepancy between prescribed and pre-treatment lines in the 40, 45, and 50 cm classes. If large-diameter classes are short of trees on a given hectare, then the space must be left occupied by smaller diameter classes. This, in part, explains the surplus of trees in the 20-30 cm classes as compared to the prescribed stand.

As discussed above, leaving the prescribed density of the most vigorous trees is more critical than achieving the prescribed condition on each hectare. On block 212, our prescribed residual basal area was 20.5 m^2/ha. On the 11.3 ha completed, we started with 30.0 m^2/ha and we have left 25.5 m^2/ha.

4.2.2. Logging and Pre-Commercial Thinning

Block 211
Block 211 had a pre-harvest cruise estimate of 20.4 m^3 of sawlog volume (greater than 17.5 cm DBH) available for harvest (Table 2 above). In addition, there were no trees greater than 27.5 cm DBH available for harvest. Upon completion of the harvest of the test area, the contractor delivered 22.9 m^3/ha of sawlogs to the mill, and 6.4 m^3/ha of pulpwood. The small size of the logs (average piece size from the cruise was 0.07 m^3) made the harvesting extremely laborious.



	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
Fdi Med	57	80	92	49	21	12	3			4	2							
Fdi Good	28	32	61	35	5	0	0	0	2	2	0	0	0	0	0	0	0	0
Pre-treatment	189	186	170	82	17	20	0	0	4	6	0	0	0	0	0	0	0	0
Prescribed	75	70	62	44	28	32	12	3	3	2	1	1						
Long Term Target	63	50	40	32	26	20	16	13	10	8	0	0						

Figure 7: Post-treatment conditions for block 212, showing post harvest stand structure as compared to pre-harvest, long-term target, and prescribed stand structure.

For the 3-ha test area, the daily rate invoiced by the contractor, divided by volume produced, indicated a logging cost[7] of $91.05/m^3 (refer to section 4.6.2 below for more discussion of costs). This information clearly indicated to us that logging block 211 was economically unfeasible, at least with the logging system chosen. We chose not to continue the harvesting program, and modified the prescription to complete pre-commercial thinning only.

Productivity and cost estimates prepared by FERIC for block 211 (Table 14 below) supported the information provided by the test area.

[7] Logging costs are shown from stump to landing, attributed to sawlog volume only.

Table 14: Logging cost and productivity estimates from FERIC.

Cost Component ($/m³) **Productivity Variables**	**Block 211** (3 ha Test Area Only)	**Block 212** (11.3 ha)
Falling Cost ($/m³)	46.10	31.30
Productivity (m³/productive work hour)	1.0	1.3
Utilization (%)	84	90
Assumed daily rate (all found rate, 8 hour shift)	300	300
Skidding Cost ($/m³)	50.00	33.00
Productivity (m³/productive work hour)	1.4	1.8
Utilization (%)	77	85
Assumed hourly rate (all found rate, per scheduled machine hour)	55	50
Total Cost Stump to Roadside ($/m³)	96.10	61.30

The selection of the particular logging method for block 211 brought several problems.

- Line skidder was too large for the small wood, carrying heavy mainline and chokers
- Width of skidder required that it stay on designated trails and pull line to felled trees, reducing productivity
- Skidding damage on trail-side trees was significant because of skidder size and tree-length skidding – rub trees needed to be sizable.
- Tree-length skidding meant some waste was skidded to landing
- Use of landing entailed extra skidding distance when roadside was available at each trail
- Skidder only had a blade, and was not suitable for sorting small logs after bucking
- Landing quickly became filled with partially sorted logs, and there was insufficient room to buck and deck logs

Outside the test area, pre-commercial thinning was the only treatment applied. The prescription was modified to allow cutting up to 17.5 cm DBH, and to thin from below, leaving trees in a clumpy pattern. A new contractor (Mikegrosite Consulting Ltd. of Quesnel) was selected to carry out the work on a piece-rate contract. The new contractor was familiar with the terms of the pre-commercial thinning contract, having carried out similar work for the Research Forest in the past. The crew completed 15.4 ha of pre-commercial thinning in 444 hours for a productivity of 29 scheduled worker hours per hectare. The utilization rate for the pre-commercial thinning crew was 75%, meaning 25% of their time was involved in unavoidable delay.

Block 212

Block 212 had a pre-harvest cruise estimate of 28.0 m^3/ha of sawlog volume (greater than 17.5 cm DBH) available for harvest (Table 2 above). There were some trees up to 32.5 cm DBH available for harvest. The contractor was only able to complete 11.3 ha of logging and 9.2 ha during the logging season allowed him. Upon completion of the harvest the contractor delivered 635.5 m^3 of logs to the mill (56.3 m^3/ha from 11.3 ha), including 41.2 m^3 of pulpwood (13.7 m^3/ha from 3 ha).

For the 3-ha test area, the daily rate invoiced by the contractor, divided by volume produced, indicated a logging cost[8] of \$37.35/m^3 for sawlogs (refer to section 4.6.2 below for more discussion of costs). This information indicated to us that logging block 212 was economically feasible. We chose to continue the harvesting program.

Examining the volume produced from the test area and the sample scales for all of block 212 (refer to Table 15 and Table 16 below), we estimate the average piece size for pulplogs at 0.028 m^3 for sawlogs at 0.136 m^3. When we divided the cost invoiced for the test-area by the estimated number of pieces produced, we find that the average cost per piece for falling, bucking and skidding was \$5.08/piece. This number implies that the cost of logging pulplogs[9] is \$181.43/m^3, and the cost of logging sawlogs is \$37.35/m^3. The blended cost for logging the test area was \$76.66/m^3.

We concluded that logging pulpwood significantly increases our logging cost. At the same time, the value of Douglas-fir pulplogs is low, so selling pulplogs reduces the average market value of the logs produced. In short, the harder the contractor works to bring pulpwood to the roadside, the poorer is the economic viability of the project. On the basis of this analysis we chose to stop logging pulplogs. Trees designated for cutting that would not make a grade 6 sawlog were felled to waste in the balance of block 212.

Productivity and cost estimates prepared by FERIC for block 212 (Table 14 above) supported the information provided by the test area, but disagree with the information for the balance of the block. This disagreement is being examined further, and this document will be updated when resolved.

The particular logging method selected for block 212 had primarily positive outcomes:

- The tractor/winch/loader combination was effective for the multiple tasks of skidding, sorting and decking
- The winch was loaded with light mainline and light chokers, allowing the operator to pull line well off the trail
- The hourly cost of the machine was relatively low
- The small size of the tractor made it maneuverable and kept skid trails narrow (about 2 m)

[8] Logging costs are shown from stump to landing, attributed to total volume delivered (including pulpwood).
[9] Pulplog cost is probably over-estimated because some of the pulplogs would come to the road-side attached to a sawlog.

- The low power of the machine meant that damage to trail-side trees could be minimized, and small trees or stumps could serve as effective rub points
- Low power also meant that maximum turn size was small, and some large logs were problematic
- Limbing, topping and bucking in the bush reduced the amount of waste skidded to the roadside.
- Skidding to roadside ensured that skid distance was minimized, and decking space was available at all times
- The contractor took the time to protect important leave trees, and arrange skid trails to minimize damage.

Upon the completion of logging, pre-commercial thinning was conducted. In total, 9.2 ha was completed using clearing saws. The crew only reported 49 hours for thinning 9.2 ha, or a productivity of 5.3 scheduled work hours per hectare. This is inconsistent with detailed timing results, which indicated 10 scheduled work hours per hectare.

4.3. LOG SALES AND SCALING

Sample load results are summarized below in Table 15. Scale returns for all the volume shipped to West Fraser Timber Ltd. are summarized below in Table 16.

Grade 6 logs (optional utilization) were upgraded in the woods as necessary to remove defects such as crooks and heavy sweep, or butt flares. As described earlier, those logs that were upgraded were marked with a saw cut on the butt end, to show that the log originated from a small tree and not from the top of a large tree. Grade 6 logs constituted 32% of the volume of all sample loads. Almost 6% of the volume in sample load 0911 was from grade 6 logs that would have been scaled as green sawlogs, if the logger had not marked them.

Table 15: Sample loads summary from West Fraser Timber Ltd. scale. All samples from block 212.

Date	Load #	Pro-duct	# Pieces	Net Weight (kg)	Net Volume (m3)	Ratio (kg/m3)	Species %		Grade % (refer to Table 5)					
							Doug-las-fir	lodge-pole pine	2 & better	3	4	5	6	Z
16-Jan	1026	Pulp	508	12,420	14.06	883.36	69	31	33.3	0.1	5.7	0.4	39.4	20.3
27-Jan	1544	Sawlog	319	31,190	32.87	948.89	99	1	50.5	0.6	0.8	-	48.0	0.1
13-Feb	911	Sawlog	299	34,150	41.13	830.29	100	-	65.0	-	-	-	34.8	0.1
18-Mar	1144	Sawlog	197	30,060	33.11	907.88	100	-	92.8	-	1.0	-	6.1	-

Table 16: Scale return summary from West Fraser Timber Ltd. by cutblock.

Cut Block	Statement Date	Stra-tum	# Loads	Product	Conversion (kg/m^3)	Weight	Volume (m^3)
		Fir					
212	31-Jan	1	2	Sawlog	890	54,970	61.76
212	31-Jan	1	1	Sawlog	890	28,150	31.63
212	31-Jan	1	1	Sawlog	890	30,860	34.67
212	31-Jan	1	1	Pulp	890	23,860	26.81
212	15-Feb	1	1	Sawlog	890	34,150	38.37
212	28-Feb	1	2	Sawlog	890	67,700	76.07
212	15-Mar	1	5	Sawlog	890	155,690	174.93
212	coming	1	2	Sawlog	890	55,460	62.31
212	coming	1	0.5	Pulp	890	12,800	14.38
			15.5		890	463,640	520.94
		Pine					
212	31-Jan	2	2	Sawlog	950	38,820	40.86
212	28-Feb	2	Correction	Sawlog	808		7.16
212	28-Feb	2	1	Sawlog	806	31,250	38.79
212	coming	2	1	Sawlog	808	22,390	27.71
			4		867	92,460	114.52
211	coming	1	2.5	Sawlog	890	60,970	68.51
211	coming	1	1	Pulp	890	19,320	21.71
			3.5		890	80,290	90.21

4.4. CONVERSION TEST

The results of the conversion test[10], run March 9 on sample load 0911, follow in Table 17. Net lumber recovery on the scale volume was 173.9 FBM/m^3. The lumber recovery measurements show that there is a significant fall-down in volume between the scale and the canter. We think this is attributable to the very small piece size, for several reasons:

- Breakage in handling, in the debarker and in the mill since the wood was frozen, debarked poorly, and seemed to be somewhat brittle
- Bucking off-length in the bush to achieve utilization standards, resulting in 74% of load 0911 being bucked off-length, and incurring an estimated waste of 0.933 m^3 – each tree was bucked to a 10 cm top regardless of the log length as a condition of utilization standards
- Errors at the bucking table, since small logs are often bucked two at a time.

Over 95% of the lumber cut from sample load 0911 was “two by four,” with lengths ranging from 8 ft to 16 ft (Table 18, below). The quality of the lumber (Table 19 below)

[10] West Fraser Timber Ltd. manufactures lumber primarily for the US market, and units for lumber are therefore given in imperial measure. *Note*: FBM is Foot Board Measure.

would be typical for West Fraser's Douglas-fir after it is planed. By way of comparison, in 2001 West Fraser Timber Ltd. (Williams Lake) cut 8.1 million FBM of Douglas-fir, which graded as shown in Table 19 below.

Table 17: Lumber recovery from conversion test on sample load 0911, West Fraser Timber Ltd.

Measure	Stick Scale	Canter Scale
Scale Volume (m^3)	41.13	31.99
Volume Lost (m^3)	9.14 (22.2%)	
Number of Logs	299	477
Volume per piece (m^3)	0.138	0.067
Lumber Produced (Foot board measure (FBM)) Gross Estimated Trim Loss Net	 7,861.0 707.5 7,153.5	
Lumber Recovery Factor (LRF) (FBM/m^3) Gross Net	 191.1 173.9	 245.7 223.6

Table 18: Piece-size distribution from conversion test on sample load 0911, West Fraser Timber Ltd.

Dimension (inches)	Number of Pieces by Length (feet)							
	8	10	12	14	16	Total	FBM Total	%
1x4	29	10	8	0	0	47	142	1.8
1x6	0	0	0	0	0	0	0	0
2x4	110	224	264	185	150	933	7519	95.7
2x6	3	5	4	1	4	17	200	2.5
Total	142	239	276	186	154	997	7861	100.0
%	14.2	24.0	27.7	18.7	15.4	100.0		

Table 19: Lumber grade (pencil grade of sample of rough lumber) from conversion test on sample load 0911, West Fraser Timber Ltd.

Dimension (inches)		Number of Pieces by Grade (Un-planed)							2001 Experience (Planed) (%)
		8	10	12	14	16	Total	%	
2x4	#2	38	50	51	37	23	199	70.3	80
	Util.	6	13	11	5	9	44	15.5	14
	Econo.	1	16	4	8	11	40	14.2	6
Total 2x4		45	79	66	50	43	283	100.0	100
2x6	#2	3	4	1	0	0	8	80.0	
	Util.	1	0	0	0	1	2	20.0	
	Econo.	0	0	0	0	0	0	0	
Total 2x6		4	4	1	0	1	10	100.0	

4.5. PULP PROPERTIES

4.5.1. Chip Packing and Chip Density

There were no differences in chip density or packing density between field site blocks. Within the blocks, chip packing density and packing density increased slightly with increasing tree diameter/age. Generally, older trees contain more high-density mature wood.

4.5.2. Kraft Pulping

Fibre Length and Coarseness

The interior Douglas-fir wood fibres were found to be much shorter and finer than average fibre lengths and coarseness values reported for juvenile and mature wood from coastal tree samples. Fibre length and coarseness values increased significantly with increasing tree diameter and age, as expected, due to more mature-wood fibre content of those pulps.

Pulping Properties

The smaller (7.5 cm DBH) tree chips were more difficult and required more chemicals to pulp than the larger diameter trees. Pulp yields from the smaller diameter trees were also significantly lower than those from the larger diameter trees. Sample compression wood content was assessed and it is concluded that differences in fibre properties and pulping characteristics can be attributed to juvenile wood content and not compression wood content.

Sheet consolidation

Sheet density and smoothness decreased with increasing tree diameter. This is expected as both fibre length and coarseness increased with increasing tree diameter and age.

Pulp Strength
The shorter finer fibres from the smaller diameter trees produced pulps with higher tensile strength than those from the larger diameter trees. Finer fibres are known to produce a better-bonded sheet, which was confirmed by sheet density/tensile index relationships. The shorter fibre length and better bonding of the smallest DBH tree pulps gives the lowest tear strength for a given tensile strength.

Optical Properties
The smallest DBH trees exhibited higher light-scattering properties at a given tensile index when compared to the larger DBH trees.

4.5.3. Thermomechanical Pulping

Baseline values of freeness and specific refining energy are the parameters used to monitor the mechanical and optical properties of thermomechanical pulps.

Energy Consumption
The 12.5 cm DBH trees required 11-23% more energy than the 17.5 cm trees to reach a given level of freeness.

Fibre Properties
At a given freeness the 12.5 cm DBH trees produced pulps with finer and shorter fibres than the 17.5 cm DBH trees. These fibre property differences would have significant implications for optical properties and segregation of incoming wood by tree diameter would be beneficial for optimizing end-product quality.

Sheet Consolidation
At a given energy level, the 17.5 cm DBH trees produced denser sheets than the 12.5 cm DBH trees. Sheet density increased with decreasing freeness, however, tree diameter had no significant effect on sheet density at a given freeness.

Pulp Strength
The tensile index values of the 12.5 cm DBH trees were higher than those from the 17.5 cm DBH trees. This is contrary to previous work done on second growth softwood species. At a given refining energy, tear index values of the shorter and finer fibres from the 12.5 cm DBH trees were slightly lower than those from the 17.5 cm DBH trees.

Optical Properties
There was no relationship between tree diameter and scattering coefficient or brightness at a given freeness or refining energy. Thermomechanical pulps from interior Douglas-fir thinnings would be suitable for use in newsprint and other wood-containing papers because they exhibit good smoothness, high light scattering coefficient and good printing opacity.

4.5.4. Summary of Results

Chip density, chip packing density, fibre length, and coarseness values increased with increasing tree diameter in accordance with tree age and increasing mature wood fibre content of the larger diameter stems.

Small diameter trees (7.5 cm DBH) required more chemicals to pulp and gave lower pulp yields. Kraft pulps from smaller diameter trees were smoother, gave higher tensile index, sheet density, air resistance, and light scattering coefficient than those from the larger diameter 12.5 and 17.5 cm DBH trees.

In thermomechanical pulping, refining energy increased with decreasing tree diameter, as finer and shorter fibres from small diameter trees were able to absorb more energy than the corresponding longer and coarser fibres from large diameter trees. The smaller diameter trees produced a better product but at a higher processing cost.

Tensile and tear indices and light scattering coefficient values of themomechanical pulps from interior Douglas-fir thinnings suggest that these pulps would be suitable for use in newsprint and other wood containing printing papers.

These results suggest that segregation of incoming round wood by diameter class would have significant implications for controlling pulp properties variability and end-product use.

Further information about this study can be obtained from the PAPRICAN final research report (Hussein *et al.*, 2002).

4.6. VALUATION OF BLOCKS 211 AND 212

4.6.1. Revenue Estimates for This Case Study

Based upon the results of the conversion test, we were able to estimate the value of a cubic metre of timber from commercial thinning. Table 20 shows the results of this analysis. As a result of the very high proportion of 2x4 cut (over 95%) the revenue estimate is insensitive to the value of 2x6 or 1x4, and we have therefore simplified the analysis by considering the stands will produce only Douglas-fir 2x4.

Table 20: Estimated revenue per cubic metre as determined from conversion test at West Fraser Timber Ltd.

Revenue	**LRF (FBM/m^3)**	**Product**	**%**	**Grade**	**%**	**FBM**	**Value (US$ /MFBM)**	**Value (CDN$ /MFBM)**	**Value (US$/m^3)**	**Value (CDN$ /m^3)**
Lumber	173.9	Douglas-fir 2x4	100.0%	2 & Better	70.3%	122.252	322.00	486.22	39.37	59.44
				Util.	15.5%	26.955	215.00	324.65	5.80	8.75
				Econo.	14.2%	24.694	130.00	196.30	3.21	4.85
Total Lumber						173.900			48.37	73.04
Chips	Chip Conversion Rate (ODT/m^3)[1]							Value (CDN$ /ODT)		Value (CDN$ /m^3)
	0.236							50.00		11.80
Total Revenue										**84.84**

US Exchange% 51.00%

[1]ODT = Oven dry tonnes

4.6.2. Costs For This Case Study

Costs are reported below for each of the two blocks, including an allowance for profit and risk (see Table 21 and Table 22 following). Actual logging costs for block 211 are reported for the test area only, since the harvesting did not continue on the balance of the block. It is logical, therefore, that actual costs for block 211 are overestimated, but we are confident that, even given further experience, the stump to dump cost would have exceeded the value of the lumber produced.

We can reasonably expect that any licensee would require some allowance for profit and risk. Day (2000) stated that licensees expect a minimum of 5% return on capital employed, and this is the value applied to the cost side of the valuation.

In order to protect proprietary information, milling cost is reported in all cases as the appraised manufacturing cost for Douglas-fir.

Table 21: Cost estimates for thinning Block 211 (test area only) including an allowance for profit and risk.

		Cost ($/m^3)					
Costs		Published Actual Cost	FERIC Time Study	Jan 1 2003 Appraisal Allowance	Test Area	Harvest Area (ha)	Total Vol. (m^3/ha)
Stump To Dump	Planning	5.45	5.45	12.86	5.45	3.00	29.37
	Logging	96.50	96.50	27.73	91.05		
	Trucking	8.00	8.00	6.51	8.00		
	Roads	0.20	0.20	1.15	0.20		
	Supervision	3.18	3.18		3.18		
	Silviculture	13.62	13.62	4.22	13.62		
	Stumpage	0.25	0.25	0.25	0.25		
Sub Total		127.20	127.20	52.72	121.75	Note: Grey cells have data imputed from other columns.	
	Sawmill	55.88	55.88	55.88	55.88		
	Profit & Risk (5% of all costs)	9.15	9.15	5.43	8.88		
Total Costs		183.08	183.08	108.60	177.63		

Table 22: Cost estimates for thinning Block 212 (11.39 ha completed), including an allowance for profit and risk.

Costs		Cost ($/m^3) Published Actual Cost	FERIC Time Study	Jan 1 2003 Appraisal Allowance	Test Area	Harvest Area (ha)	Total Vol. (m^3/ha)
Stump To Dump	Planning	2.84	2.84	9.53	2.84	11.29	56.29
	Logging	37.35	63.90	25.04	76.67		
	Trucking	8.00	8.00	6.51	8.00		
	Roads	0.20	0.20	1.15	0.20		
	Supervision	3.18	3.18		3.18		
	Silviculture	7.11	7.11	4.22	7.11		
	Stumpage	0.25	0.25	0.25	0.25		
Sub Total		58.93	85.48	46.70	98.25	Note: Grey cells have data imputed from other columns.	
	Sawmill	55.88	55.88	55.88	55.88		
	Profit & Risk (5% of all costs)	5.74	7.07	5.13	7.71		
Total Costs		120.55	148.43	107.71	161.83		

4.6.3. Conversion Return

The final step in the financial analysis is to compare expected revenues and costs, to determine if the thinning operation is financially viable (Table 23 below). Given the cost and revenue data reported above, none of the cost structures provide an economically viable opportunity.

This valuation is constrained by the necessity of holding proprietary milling cost information confidential, and by the startup nature of the project, which placed everyone on a steep learning curve.

Table 23: Expected conversion return calculated from two thinning blocks for several cost structure scenarios. Data represent the period from January 1 to March 31, 2003.

Item	Block 211	Surplus or (Deficit)	Block 212	Surplus or (Deficit)
Revenue ($/m^3)	84.84		84.84	
Cost ($/m^3)				
Published Actual Cost	183.08	(98.24)	120.55	(35.71)
FERIC Time Study	183.08	(98.24)	148.43	(63.59)
Jan 1 2003 Appraisal Allowance	108.60	(23.76)	107.71	(22.87)
Test Area Experience	177.63	(92.79)	161.83	(76.99)

5. DISCUSSION

5.1. PRE-TREATMENT FIRE HAZARD

Dry Douglas-fir forests present significant fire hazards in their current unmanaged condition, as discussed above (page 4). We expected to find that the two stands sampled would support crown fires in the pre-treatment condition, but this expectation is not supported by the model results, under the 90th percentile condition for DAILY weather indices. However, under extremely high winds, such as might be expected for a portion of a given day, these stands would support a crown fire.

Fire intensity differs from fire severity. Fires with low intensity can have high severity, due to the residence-time of the heating. High severity fires result in significant site changes following the fire, such as high tree mortality, extensive soil heating, and increased susceptibility to soil erosion. These impacts are not always readily apparent immediately after the passage of a fire. Measuring fire severity has relied on ocular estimates of characteristics of charring or quantified organic layer reduction. Causative agents of fire severity include heavy fuel loadings (in both round woody material and organic layers), shallow mineral soil layers, and high stand density of relatively fire-intolerant species or structural stages (young, thin-barked, short Douglas-fir versus older, thick-barked, tall Douglas-fir).

Pre-harvest ecological assessments indicate that productive soils are shallow on both blocks:

- Block 212 -- Rooting depth 15 cm to coarse fragments, with 10% of the block having shallow soils over bedrock
- Block 211 -- Rooting depth 25 cm to clay deposits (Bt horizon)

Luvisolic soils occur on both blocks, as is typical for the Knife Creek Block (Day 1997) and the IDF biogeoclimatic zone more generally (Hope *et al.* 1991). Since these Luvisols have shallow rooting zones above Bt horizons, we expect the severity of the fires to be high. If soils are heated to lethal temperatures to a depth of 6 cm (deeper than the bulk of the fine roots, soil organic matter, and the soil biota) the long-term productivity of these sites could be significantly impacted.

Considering the heavy fuel loading in scattered areas of both blocks, the shallow mineral soil layer, and high stand density, we would expect to measure fairly high fire severity following a July/August wildfire in these blocks.

We estimate that 70-80% of the number of Douglas-fir trees would be killed in a low-intensity surface fire. The probability of mortality falls rapidly from 100% for regeneration to below 20% for trees of 5 cm dbh. When we examine the pre-harvest stand structure (Figure 2 page 8) we find:

- for block 211 – 57% of the pre-thinning stems/ha are in the 5 cm class and smaller, and
- for block 212 – 71% of the pre-thinning stems/ha are in the 5 cm class and smaller

The use of prescribed fire as a low-cost means to thin these stands might be considered possible. However, examination of the prescriptions indicates that we wish to reduce the densities in all sizes up to the 30 cm class. It is apparent that this objective is unachievable given the pre-thinning fuel and stand structure conditions, and the propensity for fire (even carefully applied prescribed fire) to cause random effects.

The thinning treatment has had a significant impact on the potential fire intensity, because it changes both fuel loads and stand structure. The thinning treatment has created a significant amount of fuels in all size classes, but particularly in the small classes. It has reduced the density of the stand, greatly reduced the number of small diameter and short trees, and has changed the spatial arrangement of the stand. Creation of skid trails has interrupted the spatial continuity of the surface fuel bed and reduced both the canopy fuel loading and canopy bulk density. We suspect that the net result will be much higher intensity surface fires, with lower likelihood of crown fires. It is important that we follow up on the potential impacts of fires in the post-thinning condition, to truly understand the risks we have created through the treatments.

Issue 1: Thinning treatment alters potential fire intensity.	**Discussion:** Thinning treatments increase the fuel loads, change fuel distribution, and change stand structure. Consequences to potential fire intensity and severity have not been quantified. **Recommendation:** Further study is necessary to follow up on the potential impacts of fires in the post-thinning condition, to truly understand the risks we have created through the treatments.

5.2. LOGGING AND PRE-COMMERCIAL THINNING METHODS

Logging small volumes per hectare comprised of small trees is expensive, because a logger has to make many trips with lots of pieces but little volume. The opportunities to improve the economic efficiency are to:

- Increase the volume on each trip,
- Reduce the cycle time by making loading, unloading, and handling more efficient
- Reduce the falling and bucking time by simplifying tree selection and bucking rules,
- Increase the value of each log by increasing top diameter and minimizing waste in the mill
- Keep capital investment and operating costs low
- Minimize waste skidded to the roadside

The skidder used on block 212 was an effective tool, but it was limited by the maximum number of pieces it could forward on a given trip. Other configurations of partial cutting equipment are possible, but not widely available in the contracting workforce. One possible approach to modify the approach on block 212 would be to add a forwarding trailer to the tractor. Mitchell (1998) describes such an operation in Alberta, where the tractor uses both a Farmi winch and a forwarding trailer. The winch is used to bunch wood at trailside, and then the tractor puts down the winch and picks up the trailer to forward the wood to roadside. The grapple on the forwarding trailer would improve the efficiency of roadside decking. Such an approach might increase the efficiency of the operation substantially.

Issue 2: Seek methods to increase skidding efficiency	**Discussion:** The tractor and Farmi winch used on block 212 was effective, but limited by the number of logs it could forward on each cycle. **Recommendation:** Consider using a forwarding trailer that could increase the number of pieces on each trip, and improve the decking efficiency at roadside.

Pre-commercial thinning has been conducted as a separate entry after falling and skidding merchantable logs. If fallers could complete the thinning in conjunction with logging activities, then a significant saving is possible. In this way, a separate crew is not required, with attendant savings in transportation, equipment, and administration.

Issue 3: Pre-commercial thinning has been done as a separate pass after logging is completed.	**Discussion:** Hiring a crew to complete the thinning after logging adds overhead expenses. It would be more efficient for the faller to complete the pre-commercial thinning function in phase with his logging functions. **Recommendation:** Faller should complete pre-commercial thinning function while carrying out falling and bucking for logging.

5.3. LOG SCALING

The financial viability of commercial thinning is enhanced if every log that can be sawn is delivered to the mill. In general, sawmills in the Cariboo do not purchase grade 6 logs (less than 20 cm diameter at the stump), since they are optional utilization. However, those logs do make marketable dimension lumber, provided they have a minimum top size of 10 cm. Grade 6 logs contributed 32% of the sawlog volume harvested, according to the sample loads. This amounts to a considerable volume which is optional utilization, and it is sensible then that we have some latitude to increase minimum top diameter, or buck out defects.

Failing to segregate the grade 6 logs in some way means that they will be mixed with grade 2 sawlogs. If that is the case, the licensee will pay the appraised stumpage and attribute the volume against their allowable cut. At least two options for avoiding this problem exist:

- Create a unique stratum for commercial thinning, so that sample loads attribute an accurate proportion of the volume to grade 6
- Carry out cruise-based stumpage so that the grade 6 component is subtracted from the appraised volume of the stand. Once a stand is cruised, the total volume within the block is available to the licensee according to the prescription, and stumpage is payable on the cruise volume, rather than on scale volumes. This requires levels of accuracy in the appraisal cruising that might not be attainable in drybelt Douglas-fir stands.

Many of the grade 6 logs were upgraded by bucking off a defect at the butt end. According to the scaling manual, doing so turns the rest of the log into a grade 2 sawlog, because the falling cuts have been removed. On one sample load the scaler noted which logs had been upgraded in this fashion, as indicated by the faller making a saw nick in the butt end. This amounted to 5.6% of the total volume on that load.

Issue 4: Grade 6 logs are outside quota and bear minimum stumpage, but cannot be tracked by the scaling rules.	**Discussion:** Such trees are optional utilization, bear minimum stumpage, and are not attributed to allowable harvest. If felled and utilized, this tree in its entirety becomes a grade 6 log. The licensee pays minimum stumpage, and the volume is not attributed to the licensee's allowable harvest. **Recommendation:** Licensees undertaking this type of harvesting should consider creating a unique stratum for such timber, or employing cruise-based stumpage appraisal methods. The volume of upgraded grade 6 logs being attributed to grade 2 should be monitored.

5.4. FINANCIAL VIABILITY

The financial viability of a commercial thinning entry is always marginal, because the volume removed has a low selling price and a high harvesting cost. However, future selling prices will be higher and logging costs will be lower (Clutter *et al.* 1992). Our valuation of the two cutblocks discussed in this report show that the conversion return is expected to be negative, given the financial information employed.

Few things are constant in the valuation; only lumber dimension and quality is expected to be relatively static. All other factors vary:

- Revenue varies through time
  - lumber selling prices
  - pulp selling prices
  - US currency exchange rates
  - lumber import duties
  - new products demand raw material
- Revenue varies through space
  - stand quality and species
- Cost varies through space
  - logging cost differs by stand
  - hauling cost varies by proximity to the mill
- Cost varies through time
  - technology
  - learning and improving
  - competition in contractor workforce

composition
- prescribed cut and leave
- ownership or tenure rights
- management objectives

workforce

- Cost varies through operators
  - logging cost differs by contractor
  - manufacturing cost varies by mill
  - margin for profit and risk

According to our valuation, conversion return is most sensitive to milling and logging cost, which together comprise 75% to 82% of the cost equation for block 212. The milling cost used in our valuation was derived from the January 1, 2003 interior appraisal allowances. Milling costs will vary from plant to plant.

Lumber recovery factor is very low in this wood, and made more so by significant losses to waste and breakage in the mill. Milling this wood when it is not frozen might reduce breakage. Reducing waste in the mill would also improve lumber recovery, and could be accomplished by bucking trees to preferred lengths rather than minimum top diameters. Processing logs to shortwood might improve lumber recovery, but would also increase logging costs.

The wood being manufactured has some excellent qualities, including tight grain and small knots. It is quite possible that some of this wood has a higher-value use than 2x4 lumber, and we should actively pursue developing those products locally.

Issue 5: The valuation presented in this report only provides a snap-shot.	**Discussion:** Costs and revenues are variable in time and space. Also, cost structures vary by operator. **Recommendation:** The process of calculating a conversion return for a stand should be conducted for each stand at each time a decision is required.

6. SUMMARY AND CONCLUSIONS

Mule deer winter range in the Interior Douglas-fir forests of the Cariboo are managed according to the management direction stemming from the Cariboo Chilcotin Land Use Plan. This direction is based upon more than two decades of research and development of systems to integrate mule deer habitat and timber values. Uneven-aged management is required, and clumpy single-tree selection is the preferred approach.

Many stands in the IDF have poor stand structure for both mule deer habitat and for timber production. These stands have had a lack of fire disturbance over several decades, and have grown into an over-dense condition that limits timber growth and jeopardizes future habitat values. Such stands have been designated for a low-volume thinning from below, referred to in plans as commercial thinning.

In the pre-treatment condition, these stands have heavy fuel loads. Model results indicate that wildfires in the pre-treatment condition would be low intensity, but high severity. Significant reductions to productivity would likely result. It is important that we return to these stands after harvest to re-analyze fuel loadings, and understand the implications of the new fuel condition.

Harvesting prescriptions were designed and implemented on two blocks with significantly different pre-harvest stand structures. One block failed because of very high logging costs, and the prescription was converted to pre-commercial thinning alone. The other block was logged according to the prescription and was pre-commercially thinned afterwards. Logging productivity information was gathered and analyzed, yielding the opportunity to examine costs of the activity. Logging costs were high (estimated at $37.35/m^3 from stump to roadside). Average piece size was very low (0.14 m^3/piece for sawlogs) and a small skidder was used. About 35% of the sawlogs produced were grade 6 logs (below the utilization limits for Douglas-fir). Fallers were able to select good leave trees with training and the use of a prism relascope.

A load of the logs was run in the mill in a conversion test. All of the logs were Douglas-fir, and almost all of the lumber produced was 2x4. The lumber graded in proportions within the normal quality range for West Fraser Timber Ltd.

A valuation of the two blocks was conducted to look at the financial viability of the approach. The conversion return was negative for all cost structures examined, but costs and revenues are variable. Each manager considering this treatment should carry out a valuation for each block they are considering. Alternatively, each manager could know what their cost structure is for a range of stands, and know what threshold lumber prices make the stand financially operable.

It is clear that, under current conditions the financial viability of this activity is marginal for most stands, and negative for many. However, the benefits of conducting this operation extend beyond the short-term wood supply, by improving stand and tree vigour, improving future mule deer habitat, and restoring stands to a condition nearer their natural stand structure. Many of these benefits are to society in general, and do not vest in the licensee. Government will need to find innovative means to induce licensees to pursue this opportunity.

Work on this project is ongoing, including

- Further analysis of fire behaviour after thinning
- Pulping characteristics of small Douglas-fir
- Analysis of logging costs
- Development of logging methods
- Responses of trees to treatment – stand structure and growth and yield
- Responses of understory vegetation to treatment

This report will be updated, as new information is available.

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