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UNIVERSITY OF ALBERTA

**Analysis of Forest Land Aggregation Methods
for Timber Supply Modelling**

BY

Se-Kyung Chong

A THESIS

**SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND
RESEARCH IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR
THE DEGREE OF Doctor of Philosophy**

DEPARTMENT OF FOREST SCIENCE

EDMONTON, ALBERTA

SPRING, 1991



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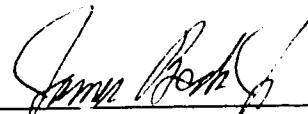
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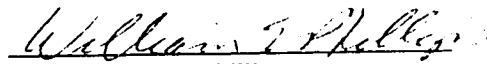
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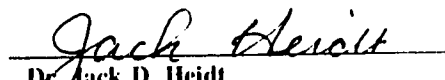
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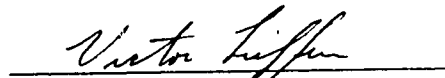
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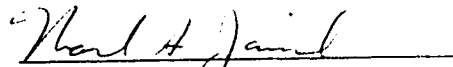
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FOR THE DEGREE OF Doctor of Philosophy


Dr. James A. Beck, Jr.


Dr. William E. Phillips


Dr. Jack D. Heidt


Dr. Victor J. Lieffers


Dr. Mark S. Jamnick

Date: November 2, 1990

Dedication

**To my parents, Dae-Sung and Song, my wife, Hyo-Sang
and my daughters, You-Sun and You-Jin.**

ABSTRACT

The difference in compartment based and stand based land classification on the predicted allowable cuts resulting from various timber supply models has recently been recognized as a potential problem. The only work on this problem is by Jamnick (Jamnick 1988 and Jamnick et al. 1990). Using a forest of about 1000 hectares, this research found that larger present values were predicted using stand based classification, but that the differences diminished as the number of management choices increased. A number of questions still remain on the applicability of these results to large forest management agreement (FMA) holders in Alberta: (1) are the results from the previous study appropriate for a large scale (10^6 hectares) industrial forest such as an FMA?, (2) what is the predicted loss in allowable cut of using compartment based management units instead of stand based management units?, (3) how important are forest road access constraints on the optimal timber harvest schedule?, (4) what are the differences between compartment based and stand based management units in regards to data aggregation and computer operation?, and (5) do upper limit constraints on costs per period affect the relationships above?.

In order to address some of these questions, an FMA in Alberta of about 10^6 hectares was used to examine the difference in the volume of the predicted allowable cut

between various scenarios of compartment based and stand based land classification and various scenarios of constraints over time on access, cost, and volume flow. Results of this study support those of Jamnick et al. (1990) in that larger allowable cuts (1.31 to 2.10%) are predicted using models with stand based units. Additionally, increases in predicted allowable cut of 1.33 - 2.13% were found if the five independent allowable cut units on the forest were condensed to one allowable cut unit. Removal of the current access constraints led to an increase of predicted cut of 15 - 16%. Maximum cost constraints per period were found to; (a) on average, increase predicted differences from unconstrained stand based versus compartment based analysis, (b) decrease differences found by reducing the number of allowable cut units, and (c) show no meaningful measurable results with access constraint analysis.

Differences in computer time (cost) for determining solutions and differences in data preparation effort were examined. Stand based analysis for this study led to larger problems, which took more computer time to solve. When logging and hauling cost are included in the analysis, data for these stand based methods are more difficult to develop as well. However, in spite of the increased costs and effort, it is estimated that the actual increase in cost is from one third to one half of a cent per cubic meter gain in allowable cut.

Use of the cost constraints led to the ability to develop marginal cost of allowable cut curves to compare stand based and compartment based analyses. Individual managers can use these curves as a policy decision making tool to determine which type of land classification analysis is best (most economical per cubic meter cut) as a function of allowable cut level. These curves can also help the individual manager to set a price policy for the external purchase of wood supplies.

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1. Introduction

1.1 Identification of the Problems

Forest land classification, in terms of stand aggregation versus area aggregation for timber management planning, has been questioned in recent years (Davis and Johnson 1987, Jamnick 1988). This concern has been raised because every aggregation of forest land has different physical, vegetative or developmental characteristics. Because boundary designations of management units to be managed for timber production are arbitrary, the final estimated timber volume depends on the spatial specifications of the aggregated areas. In the short-term and for forests composed of diverse types, the effect of boundary designations may be much more crucial than in forests composed of similar, generally homogeneous characteristics.

Managing a forest usually involves optimizing some goal (usually with an economic component) to best fulfill the need or desires of either the owners or users of the forest. Often the goal is to maximize the present net value, undiscounted value or volume of harvest output. These cases are often solved with constraints on cost, volume, and value per intra time period. In some cases, the goal, however, may be to provide specific harvest levels over time at minimum cost. To

handle these kinds of management problems, linear programming (LP) is often used because of its ability to optimize outputs under a variety of constraints (Nelson et al. 1988). Classifying the forest land area on the basis of geo-physical or biological characteristics has been essential in making reasonably sized problems for linear programming models for timber management planning. The problem size for an LP timber harvest scheduling model depends largely on the number of timber classes, which is a determining factor for the number of decision variables. This means that as the number of timber type classes increase, the decision variables in an LP model increase proportionately, requiring more costly runs to get a solution. Computer system capacity, as well as computer budget limitations, are crucial factors in setting up mathematical programming problems for optimal timber harvest scheduling of real, large-scale forest management areas.

Two approaches to forest land classification have been considered in the context of linear programming for timber harvest scheduling models. One approach is to use user-defined biological attributes to aggregate similar kinds of homogeneous stands. This kind of grouping is called stand or strata based aggregation and the pieces of this aggregation are usually non-contiguous. The other approach is to use user-defined spatial or economic information, such as drainage, topography, accessibility, merchantability and

logging chance, to aggregate areas based on similar characteristics. This kind of grouping is called compartment or area aggregation and the pieces of this aggregation are usually contiguous. For the remainder of this study, the terms stand and compartment will be used to describe these two types of aggregations, respectively.

Growth and yield predictions are normally more reliable for stand based aggregation, because the vegetation types tend to be more homogeneous with this method. Economic predictions or any other predictions, where spatial location is of importance, tend to be more reliable using compartment based aggregation, since each unit is at a known location. The obvious question is what is the trade-off between two sets of forest land classification methods, when they are incorporated into the LP models to be developed for optimal timber harvest scheduling. So far, only one study (Jamnick et al. 1990) has dealt with the effects of different forest land classification methods on timber harvest scheduling. Jamnick's (1990) study used a real, approximately 1000 ha forest, sub-divided into 26 stand types and 29 to 85 compartments to identify the differences between stand based aggregation and compartment based aggregation. One should note that the number of compartments were always greater than the number of stand types. In Canada, typical large forest areas managed by companies have many more stand types than compartments.

If one has a large scale industrial forest that has a large number of stand types which are a mixture of site productivities and species, organized into several compartment based working circles¹ each made up by many different compartments² : (1) what is the effect on allowable cut of switching from compartment based units to stand based units?, (2) what is the effect of elimination of working circle boundaries?, (3) what are the impacts of access constraints, reflecting road construction, on the optimal timber harvest schedule?, (4) what are the differences between compartment based and stand based forest land classification in regards to data manipulation and computer operation for LP models to be developed for timber management on a large-scale forest land base, with and without economic or access considerations?, and (5) how important are maximum average cost per period constraints related to the answers to the above questions? Do these cost constraints ameliorate or exaggerate the differences as compared to conditions with no cost constraints?.

¹ A working circle generally represents an independent forest administrative unit, and numerous practical advantages result from stabilization of wood flows within such unit (Ware and Clutter 1971). This is the smallest unit for which a sustainable allowable cut is calculated.

² A compartment is an area based subunit of working circle which is a operating management unit usually determined by vegetative characteristics, topographical features and operational considerations.

1.2 Organisation of the Thesis

Chapter 2 provides theoretical foundations on forest land aggregation for timber supply modelling and economic timber supply. Chapter 3 includes the objectives of this study, and chapter 4 contains a description of the methodology uniquely developed for this study. Chapter 5 contains descriptions of the case study area, data requirements and linear programming model structure which will be used to evaluate the problems. Chapter 6 contains a presentation of the effects of different forest land aggregation methods and access concerns on allowable cut, associated with timber operating costs and develops the timber supply curve, while chapter 7 contains final remarks.

2. Theoretical Foundations

2.1 Timber Supply Modelling and Forest Land Classification

Linear programming models have been one of the most common ways of evaluating long-term, large-scale timber supply problems. These timber supply problems are typically, as stated earlier, ones that maximize output subject to constraints or minimize costs subject to constraints (In certain special cases, the problems are the dual of each other). Computer-based linear programming models such as

TIMBER RAM (Navon 1971), Max-Million (Clutter 1968), and MUSYC (Johnson and Jones 1979) have focused on determining the optimal allocation of the timber resource.

Computer models have become more complex, as attempts to capture the essence of increasingly complicated, real world situations have evolved. This trend accelerated the development of FORPLAN (Johnson et al. 1986), a linear programming based model. FORPLAN was designed to handle other forest-related resources in addition to timber and, it was designed to take into account some spatial concerns by use of allocation zones. Jamnick et al. (1990) state that, because of the size of real forest problems, computational limitations allow only a few distinct choices to be considered for each of these allocation zones. Berck and Bible (1984) and Liittschwager and Tchong (1967) attempted to adopt an efficiency technique, based on decomposition, using the algorithm developed by Dantzig (1963) and Dantzig and Wolfe (1961) in order to reduce the computational burden in terms of time and computer storage.

Many other aspects of optimal timber harvest scheduling, using LP, have been examined. These aspects include optimal harvest scheduling (Curtis 1962, Leak 1964, Loucks 1964, McConnen et al. 1966, Beck 1977, Johnson and Scheurman 1977, and Johnson and Tedder 1983), optimal treatment regimes

(Wardle 1965, Buongiorno and Teeguarden 1978), flow constraints (Armstrong et al. 1984, Mcquillan 1986, Hof et al. 1986, and Allard et al. 1988), the effect of the length of planning horizon (Kristoff 1986), economic timber supply analysis (Nautiyal and Pearse 1967, Hrubes and Navon 1976, Michie and McCandless 1986, and Beck et al. 1989), the effect of age classes (Barber 1985), forest regulation (Kidd et al. 1966 and Hennes et al. 1971), budget allocation (Kirby 1978 and Hof et al. 1985), industrial forest management planning (Ware and Clutter 1971 and Walker and Lougheed 1985) and multiple use (Leuschner et al. 1975, Steuer and Schuler 1978, Mendoza et al. 1987, and Paredes and Brodie 1988).

In terms of size of area processed, Ware and Clutter (1971), from their empirical study, state that the aggregated total cutting schedule for several working circles is obviously a suboptimization in comparison to the schedule that would be prepared by scheduling the entire forest holding as a single unit. As well, they explain, based on past practical experience, the loss in present worth caused by the subdivisions of the forest as independent units can be negligible and the use of working circles as independent scheduling units can be justified.

Only recently, however, has anyone paid much attention to the effects of forest land classification (stand based versus

compartment based aggregation). Davis and Johnson (1987) state that forest land classification has received little attention historically, despite it being an important component in the determination of the number of decision variables in an LP harvest scheduling model, and that the most common way of aggregating inventory data for LP model use has been by use of stand type strata. This stand based aggregation tends to ignore spatial organization of stands and an analysis based on it produces a management plan that fails to account for the spatial dimension (Chappelle et al. 1976). Hokans (1983) states that such an omission may be important to private as well as public forest management and costs of moving harvesting crews and administering widely separated sales make spatial considerations important to commercial endeavors. Mealey et al. (1982) indicate that long-term forest-wide harvest level calculated by stand based aggregation tends to overstate timber harvest capability when additional multiple use objectives for the other uses besides timber must be met. Armel (1986) questioned how the allocations represented by the standard, stratum-based FORPLAN solution, in which homogeneous forest units are aggregated, can be implemented within a heterogeneous area represented by a given parcel of national forest land, when the actual operational considerations such as wildlife habitats and harvest adjacency constraints are necessary. There have been some attempts to overcome the above disadvantages of stand based aggregation use in LP models so

that the long-term forest wide planning results can be integrated into site specific project planning. These tools are a simulated stand selection method, a random search algorithm and a mixed integer programming or heuristic procedures (Hokans 1983, Tanke 1985, Gross et al. 1988, Meneghin et al. 1988, Connelly 1988, Nelson et al. 1988, O'Hara et al. 1989, Nelson et al. 1990, Torres-Rojo et al. 1990). With the advent of larger computers and geographic information systems (GIS), interest has revived regarding the effects of area based land classification systems. In direct comparisons of stand based aggregation with compartment based aggregation, Jamnick et al. (1990) state that forest land classification systems and the number of management choices considered in LP timber harvest scheduling models significantly influence the optimal harvest schedules. They found that: (1) as the management unit size increases, the objective function values decrease, (2) models using stand based decision variables have larger objective function values than models using compartment based management unit decision variables, and (3) as the number of management choices increase, the difference in objective function values between stand based and compartment based management unit models diminishes. Further, they found that the number of management choices was more important than the size of management unit or type of land classification unit in determining optimal present values.

2.2 Economic Timber Supply Development

Under a model of competitive supply, economic theory states that profit is maximized where marginal revenue (MR) equals marginal cost (MC), where the MC curve intersects the MR curve from below. Since the individual firm, as a perfect-competitor, can not affect price by output levels (price-taker), price is equal to marginal revenue. Marginal cost is the extra cost of producing each additional unit of output. Total profit is the difference between total revenue and total cost. Total profit increases as long as the extra revenue brought in from the last unit sold is greater than the extra cost incurred in producing the last unit and is maximized when there is no longer any extra profit to be earned by selling extra output. Therefore, the individual company will produce all units of output with a marginal cost less than price, where maximum profit equilibrium (price = marginal cost) arises (Samuelson 1980).

Applying this theory to a forest operation, and looking only at wood supply, price is essentially fixed in the short run and is given by what the company has determined is the value of wood delivered to the mill. This price would be based on the current market value of the wood products produced, minus processing costs, any fees or charges levied and some type of reasonable profit margin. Marginal cost of wood

delivered to the mill is primarily a function of logging and hauling costs.

A marginal cost curve of wood procurement can be derived using a timber supply linear programming based model. The usual way to do this is to minimize cost subject to maintaining a certain level of timber production over time. As a dual problem to this, an exact opposite formulation can be made by maximizing timber output subject to a constraint on timber production cost over time. Once the marginal cost (timber supply) curve is derived, the following considerations can be made.

In order to increase wood output, additional timber would be required and this timber would have to come from longer distances or modified utilization standards, increasing the marginal cost of supplying timber. However, it should be noted that timber may be obtained from sources other than the company's own land. Wood chips or logs could be purchased from other companies or contract loggers. At this point, the first question to a company is what quantities to produce itself and what quantities to purchase. This question can be answered by examining the individual marginal cost curve. If price is greater than the marginal cost of obtaining the extra wood, the company would produce or buy any wood less than this price. The second question would be whether it is worthwhile

for the company to increase output to this level. To do this, the company would need to know what the industry's aggregate timber supply curve is. This would be obtained by horizontally summing the individual supply curves. All of the above assumes that the company has the ability to vary levels of production to the amount where maximum profit equilibrium occurs. In this thesis, marginal cost curves in both stand and compartment configurations are developed and compared as part of the overall valuation of boundary designations.

3 Objectives of the Study

To look at the concerns expressed in the previous sections, six main objectives were established for this study;

(1) Identify the effects of working circle boundaries, within a large scale forest land base, on the allowable cut (both direction of change and magnitude of change), using both compartment based land units and stand based units,

(2) Identify the effect of compartment based unit boundaries, within a large scale forest land base, on the allowable cut (both direction of change and magnitude of change) compared to the allowable cut from the forest using stand based units,

(3) Examine the effects of access constraints on the allowable cut (both direction of change and magnitude of change), in order to illustrate the importance of forest road building schedules for timber management,

(4) Investigate how the different forest land classification methods differ in relation to data aggregation and computational efficiency for LP models to be developed for each case,

(5) Demonstrate how maximum average cost level constraints per planning period impact on objectives 1 to 3 above,

(6) Develop timber supply curves, using marginal costs which are derived from stand and compartment analyses.

4. Methodology

4.1 Model Development

The overall approach of this study can be viewed simply by looking at Table 4.1-1. The table indicates 8 different sets of computer runs based on having working circle boundaries considered (Y) or not considered (N), compartment boundaries considered (Y) or not considered (N), and capital

access forest road building concerns considered (Y) or not considered (N). Models 1 to 4, that do not include working circle boundaries, need only one LP run to determine a harvest level for the forest. Models 5 to 8, where working circle boundaries are considered, need one LP run for each working circle in the forest to determine a forest wide harvest level. With each of the eight possible models, multiple sets of runs are needed, with different maximum average cost per period constraint levels set, so as to determine the effect of maximum average cost per period on the analyses.

Table 4.1-1. Table of models to be considered

M o d e l s	Working circle boundaries	Compartment boundaries	Access concerns	# of LP runs to get forest wide AAC
1	N	N	N	1
2	N	N	Y	1
3	N	Y	N	1
4	N	Y	Y	1
5	Y	N	N	X
6	Y	N	Y	X
7	Y	Y	N	X
8	Y	Y	Y	X

X = # of working circles in forest

4.2 Design of Analysis

Comparison of any pair of model groups (1 with 5, 2 with 6, 3 with 7, or 4 with 8) will allow analyses of and identification of any major reductions in allowable cut due to working circle boundaries. Comparison of any pair of model groups (1 and 3, 2 and 4, 5 and 7, or 6 and 8) will allow examination of the effects of compartment boundaries on allowable cut. Finally, any pair in the sets (1 and 2, 3 and 4, 5 and 6, or 7 and 8) will allow analysis of any major reductions in allowable cut due to the proposed capital forest road building schedule.

5. Case Study

5.1 Introduction

This case study was designed to identify how different timber management boundary designations and forest road access constraints affect the allowable annual cut (AAC), recognizing the current timber management strategies of Weldwood's forest management agreement (FMA) area near Hinton, Alberta. The company has divided the FMA into 5 working circles. Each working circle is a major contiguous land area separated from other working circles by rivers and other major topographical features. An even-flow AAC is calculated for each working circle. If an even-flow AAC were calculated for the whole

forest, it is likely to be larger than the sum of the even-flow AACs from the 5 working circles because even-flow from the whole forest does not guarantee even-flow from each working circle (refer to Ware and Clutter 1971). The company has further divided the 5 working circles into 153 compartments¹. These compartments are contiguous areas of forest land which the company feels have roughly similar accessibility and broad forest maturity classes (20 - 40 years of age ranges). Each compartment is made up of many stand types in terms of species, stocking, and site index. Since Jamnick et al. (1990) have shown that stand based aggregation tends to give larger allowable cuts than compartment based aggregation, there is a possibility that use of compartments may be restricting allowable cuts. Since both working circle and compartment boundaries have been shown to restrict allowable cuts elsewhere, there is a strong possibility that working circle and compartment boundaries, used as forest subdivisions within the FMA, are restricting the sustainable harvest levels.

One major concern for the company is to maintain a sustainable harvest level, with relatively stable, acceptable annual operating costs for timber production. Thus, the

¹ The company has designated 135 compartments, but 18 of these are in the process of being harvested, and thus had to be split into 2 compartments (harvested and not harvested) for use in this study.

company needs to estimate sustainable harvest levels over the planning horizon at various maximum average cost levels and determine the effects of working circle boundaries, compartment boundaries and access constraints on these harvest levels. This study will attempt to determine the effects of each of these three constraints independently. The company can respond to significant boundary effects by modifying boundary designations or to significant access constraints by modifying their capital road building plans.

The answers to the problems above will be explored and evaluated through a case study of the FMA area, using the MUSYC (Johnson and Jones 1979) linear programming based model, which has been modified at the University of Alberta (Kristoff et al. 1987) to handle larger problems and to run on an IBM compatible main frame computer.

5.2 Description of the Study Area

The study area contains approximately 10^6 hectares of forest land located on the eastern slope of the Rocky Mountains. Figure 5.2-1 is a map of the study area and shows its location within Alberta. The net manageable area for conifer timber production is 737,700 ha. The main forest cover types are composed of white spruce (*Picea glauca* (Moench) Voss), black spruce (*Picea mariana* (Mill.) B.S.P.), lodgepole

pine (*Pinus contorta* Dougl.), alpine fir (*Abies lasiocarpa* (Hook.) Nutt.) and mixed hardwood-softwood stands, where the hardwood is some mix of trembling aspen (*Populus tremuloides* Michx.), balsam poplar (*Populus balsamifera* L.) and paper birch (*Betula papyrifera* Marsh.). Most of the area is well stocked and consists of the operating compartments, ranging in size from 150 to 23480 ha. The exact numbers of these subdivisions for the whole management area are shown in Table 5.2-1.

5.3 Yield Data

The 2,502 stand types were assigned by the company to one of 60 yield streams. Each of the 60 yield streams represented stands in terms of species, age, site and stocking and was developed by the company by analyzing 3,000 permanent sample plots (PSP) in the case study area. The stand based timber yield data is appended in Appendix I.

The yield streams reflect only one type of harvesting - clearcut. The company regeneration results per yield type are reflected in specific regeneration yield streams as well. Since the only management prescription considered by the company is clearcut and regenerate, the only prescription used in this study is clearcut and regenerate.

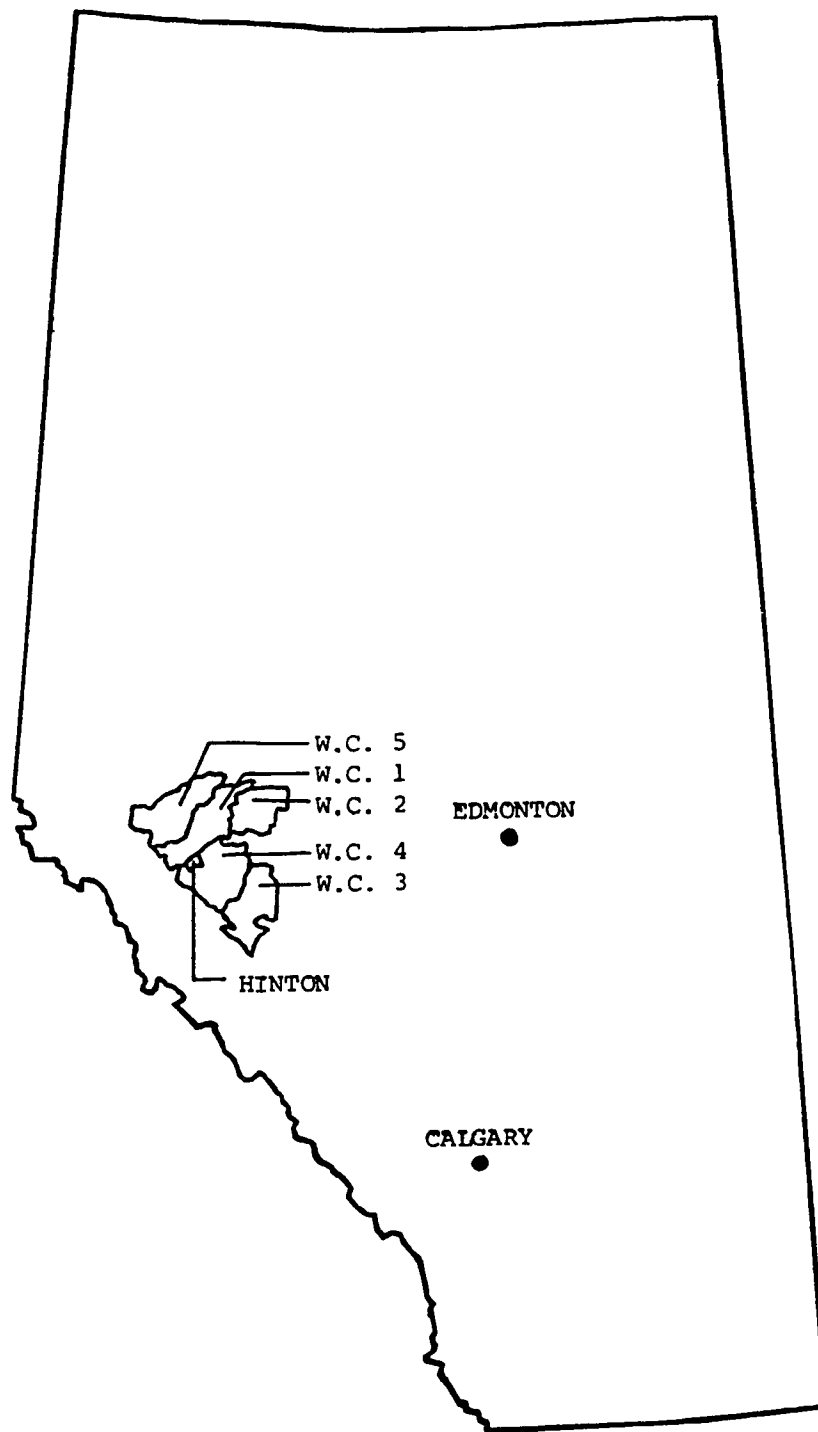


Figure 5.2-1 Map of Weldwood FMA in Alberta

Table 5.2-1. The number of subdivisions of the study area

Working Circles	Compartments	Stands
W. C. 1	37	601
W. C. 2	29	447
W. C. 3	20	422
W. C. 4	30	522
W. C. 5	37	510
Total	153	2,502

For each compartment, it was necessary to calculate an area weighted average age and an area weighted average timber yield table for the unit. In order to calculate the average ages and yield estimates of compartments, the following equations were used for combining stands within each compartment;

$$Y_c = \frac{\sum_{i=1}^s a_i Y_i}{\sum_{i=1}^s a_i} \quad (1)$$

for each age class

Y_c : the area weighted average per ha yield for each compartment

Y_i : yield per ha in stand i at each age class

s : the number of stands within a compartment

a_i: area of stand i in hectares

$$AA_c = \frac{\sum_{i=1}^s a_i A_i}{\sum_{i=1}^s a_i} \quad (2)$$

AA_c: the area weighted average age for each compartment

A_i : the age of stand i

A sample set of data and resulting average ages and average yield tables for the compartments in working circle 1 is given in Appendix II.

5.4 Cost Data

Logging and hauling costs from woodlands to the mill were estimated using the models developed for economic timber supply analysis in Alberta (Beck et al. 1989). These cost functions represent an industry wide average for Alberta and are used to demonstrate the process, rather than using proprietary data for Weldwood. The woodlands costs are a function of the natural logarithm of average tree volume and the truck to mill costs are expressed as a function of total haul distance and the inverse of standard utilization stump diameter. In order to calculate average tree volume of each

timber yield stream at the stand level, the volume of each yield stream by age class was divided by the number of tree stems per ha that are derived from the PSP data of the study area (Appendix III and IV). Average haul distances to the mill were estimated for each compartment and grouped into 20 Km class intervals of haul distance for economic analyses for both stand and compartment analyses (Appendix V). The standard utilization stump diameter was assumed to be an average of 15 cm diameter inside bark as measured 30 cm above ground level. The following equation was used to calculate the average delivered wood costs of compartment based management units;

$$C_c = \frac{\sum_{i=1}^s a_i C_i}{\sum_{i=1}^s a_i} \quad - (3)$$

for each age class

C_c : the area weighted average per ha cost
for each compartment

C_i : cost per ha in stand i at each age class

s : the number of stands within a compartment

a_i : area of stand i in hectares

An example of the calculations for working circle 1 is given in Appendix VI.

5.5 Data Aggregation

5.5.1 Stand Based Analysis

With stand based analysis, a land unit is classified in terms of its' forest vegetation being of a particular age and is associated with a particular yield function. In this case study, there are 60 (Table 5.5-1) different yield functions, each having a possible 16 different age classes (0 to 150 years in 10 year class intervals). Since not all age classes are present for all yield functions, enumeration yields 407 (Table 5.5-2) different possible timber land classes with stand based data aggregation for Model 1, with no economic or access concerns. If one now looks at the 407 different classes in terms of the cost of logging and hauling products to the mill, the 407 classes expand to 1064 timber classes (Table 5.5-2) representing different forest types and ages and different distances from the mill. Additionally, if access concerns are taken into account, stands of the same type, same age and same total haul distance must be classified according to accessibility to the current and proposed future road system (to simulate the capital road building schedule of the company), then the 1064 classes must be expanded to 2,502 timber classes (Table 5.5-2) for Model 2.

If the forest is broken down into sub units (working

Table 5.5-1. The number of yield tables required for the selected models

	Timber yield tables		Economic tables	
	For exist.	For regen.	For exist.	For regen.
Stand based management units for whole area Model 1 & 2	60	60	284	101
Cmpt based management units for whole area Model 3 & 4	153	153	153	153
Stand based management units for each W. C. Model 5 & 6				
W. C. 1	60	60	125	42
W. C. 2	60	60	114	38
W. C. 3	60	60	147	54
W. C. 4	60	60	180	65
W. C. 5	60	60	123	43
Cmpt based management units for each W. C. Model 7 & 8				
W. C. 1	37	37	37	37
W. C. 2	29	29	29	29
W. C. 3	20	20	20	20
W. C. 4	30	30	30	30
W. C. 5	37	37	37	37

Cmpt: Compartment
 exist.:existing stands
 regen.:regeneration stands

Table 5.5-2. The possible number of timber classes to be considered

	Alternative 1	Alternative 2	Alternative 3
	Without logging & haul cost or access constraints	With logging & hauling costs	With logging and haul cost access and constraints
Stand based management units for whole forest area	(1) 407	(1) 1064	(2) 2502
Cmpt based management units for whole forest area	(3) 153	(3) 153	(4) 153
stand based management units for each working circles	(5)	(5)	(6)
W. C. 1	199	310	601
W. C. 2	167	264	447
W. C. 3	193	313	422
W. C. 4	204	391	522
W. C. 5	164	275	510
Cmpt based management units for each working circles	(7)	(7)	(8)
W. C. 1	37	37	37
W. C. 2	29	29	29
W. C. 3	20	20	20
W. C. 4	30	30	30
W. C. 5	37	37	37

() indicates the Table 4.1-1 model number.
Cmpt: Compartment

circles), a smaller, but similar pattern of increased number of forest classes occurs which can be seen in Table 5.5-2 for Models 5 and 6. An example of the classes for Model 5, Alternative 2, working circle 1 is given in Appendix VII.

5.5.2 Compartment Based Analysis

For this analysis, the forest has been divided into 153 compartments. Each compartment unit is considered to grow by a yield table that is an area weighted average of the stands included within that compartment and the age of the unit is the area weighted age of the stands within the unit. These processes were described in Sections 5.3 and 5.4. Since each compartment has only one age, there is no expansion of the 153 yield table types (Table 5.5-1) to get timber classes for Alternative 1 in Table 5.5-2.

As well, since the location of the compartment is fixed in one place, there is no necessary expansion of the timber classes in Alternative 1 to go to Alternative 2 or 3. Each compartment has a unique average logging and hauling cost and each is either accessible or not at any point in time. Thus, Models 3 and 4 from Table 5.5-2 use only 153 timber classes. Similar reasoning maintains the number of timber classes at a smaller fixed number for Models 7 and 8, when the forest is broken into 5 working circles each with a smaller number of

compartments (Table 5.5-2).

5.6 MUSYC as a Tool

Potential allowable cuts were calculated using the MUSYC linear programming model, to maximize timber volume output (m^3)¹ for a 150-year planning horizon of fifteen 10-year planning periods, and subject to the following constraints;

- (1) maximum average cost per period for the planning horizon,
- (2) even-flow (cut in period $i+1$ should be equal to cut in period i , for all i) or non-declining yield (cut in period $i+1$ is greater than or equal to cut in period i , for all i),
- (3) accessibilities reflecting the current forest road building schedule

The maximum per period cost constraints were chosen so as to ensure an upper limit of monetary cost per period for the company's timber operation for the whole planning horizon. The results of these constrained runs can then be used to obtain the marginal cost of allowable cuts to derive an individual

¹ MUSYC could have handled a formulation of minimize costs subject to maintaining a certain timber output over time, but AFS institutional policy constraints dictates the objective of maximizing the AAC subject to cost constraints. When the constraints are all confining, these two problems are the dual of each other.

timber supply curve. Even-flow harvest policy reflected the timber operation policy of the Alberta Forest Service. Since the even-flow harvest policy was a strict per period constraint for the level of timber harvest, a non-declining yield constraint was also used to examine a more flexible harvest flow policy. The access constraints are in effect for 4 decades, but are totally removed after 5 decades. MUSYC linear programming models developed for this study are all based on a Model I (Johnson and Scheurman 1977) formulation.

Assuming computer funding and computer memory size are not limiting, the modified MUSYC model (Kristoff et al. 1987) must be further modified to handle all possible run sets for the various scenarios by extending the upper limits of parameters (Tables 5.5-1 and 5.5-2). The changes in numbers of parameters for the MUSYC model are referred to in Table 5.6-1.

Table 5.6-1. Modifications to the MUSYC model

List of parameters	Previous version at U. of A.	Modified
Land classes	15	42
Timber classes	400	3000
Regeneration classes	100	3000
Management alternatives for existing stands	400	3000
Management alternatives for regeneration stands	200	3000
Existing yield tables	100	300
Regeneration yield tables	100	300
Economic tables for existing stands	50	300
Economic tables for regeneration stands	50	300

6. Results and Discussions

This section describes the results from the models developed for this study. First, using both compartment based forest units and stand based forest units, the impacts of working circle and compartment boundaries and access constraints on the allowable cuts are discussed. Second, the model sizes, computational difficulties, data aggregation problems and computer problems are discussed in relation to the different models used in this study. Third, the effects of maximum cost constraints per period on the allowable cut differences above are discussed. Finally, the timber supply curves using the average marginal cost are developed.

Of the eight model types or possible types of runs, it was found that, in spite of having modified MUSYC to handle all of these runs, the University of Alberta computer system LP optimization code could not handle all of the Models. Runs were completed for Models 3, 4, 5, 7, and 8 and Model 1 without incorporating economic and access constraints. The computer LP solution code was unable, due to memory size, to accept Model 1 with economic factors and Models 2 and 6, which consider both economic factors and access concerns. Therefore, the impacts of working circle and compartment boundaries and access constraints on the optimal timber harvest scheduling are examined using Models 3, 4, 5, 7, and 8 and Model 1

without economic or access concerns.

Examining the impact of working circle boundaries on allowable cut, using stand based Models 1 and 5, or compartment based Models 3 and 7, or 4 and 8, demonstrates the effects of more flexibility to meet even-flow requirements by expanding the size of allowable cut unit.

Examining the effect of compartment boundaries on timber harvest scheduling, looking at Models 1 and 3, or 5 and 7, provides any evidence of the real influences of forest land classification methods on timber production. In each paired example above, one uses stands and the other uses compartments as the management units.

The impact of access constraints on optimal timber harvesting are analyzed by comparing Models 3 and 4, or 7 and 8. These pairs evaluate the importance of the forest road access network on the level of optimal timber harvesting and examine the interaction effects of access constraints with both working circle and compartment boundaries.

Even though solutions to the complete Model 1, or Models 2 and 6 were unavailable due to model sizes, it is clear from the above that each of the first three objectives could still be analyzed by at least 2 different sets of models.

Finally, the effects of maximum average cost per period on the above analyses was examined by the multiple sets of runs of each model group, developed sequentially with different maximum average cost per period constraints. From analyses of these runs, marginal cost of allowable cut curves were developed.

6.1 The Effect of Working Circle Boundaries on Allowable Cut with no Access Constraints

6.1.1 At the Compartment Level

This sub-section illustrates the impact of working circle (consisting of area-based management units) boundaries on the allowable cut by comparing Models 3 and 7. The summarized results are shown in Table 6.1-1.

Comparing Model 3 with no working circles with Model 7 with working circle boundaries, there is a 2.13% increase in allowable cut with an even-flow harvest policy. Using a non-declining yield policy rather than even-flow gives an average increase of only 0.95% in allowable cut over the planning horizon, but gives a 2.13% increase in periods 1 to 11. In other words, removing the current working circle boundaries, gives an average increase of 0.95% to 2.13% in the level of timber volume to be harvested per period for the whole planning horizon.

Table 6.1-1.

The effect of working circle boundaries on AAC(10^6 m³)
with no access constraints using compartments

Even-flow constraint

Model 3 (No working circle boundaries, compartment boundaries):					
Total allowable cut for the planning horizon:	226.345 million m ³				
AAC per period :	15.090 million m ³				
Cut increased per period:	2.13 %				
Model 7 (Working circle boundaries, compartment boundaries):					
	W.C. 1	W.C. 2	W.C. 3	W.C. 4	W.C. 5
Total	49.876	34.269	44.156	44.546	48.774
AAC	3.325	2.285	2.944	2.970	3.252
Total allowable cut for the planning horizon:	221.621 million m ³				
Total AAC per period :	14.776 million m ³				

Non-declining constraint

Model 3:					
Total allowable cut for the planning horizon:	226.345 million m ³				
AAC per period :	15.090 million m ³				
Ave. cut increased per period:	0.95 %				
1st to 11th periods cut increase:	2.13 %				
Model 7:					
	W.C. 1	W.C. 2	W.C. 3	W.C. 4	W.C. 5
Total	49.876	34.269	45.846	44.546	49.679
Ave. AAC	3.325	2.285	3.056	2.970	3.312
Cut in per.					
1st to 11th	3.325	2.285	2.944	2.970	3.252
Total allowable cut for the planning horizon:	224.216 million m ³				
Total AAC per period :	14.948 million m ³				

6.1.2 At the Stand Level

This sub-section demonstrates the impact of working circle boundaries on the allowable cut by comparing Models 1 and 5 (consisting of stand-based units). The results are summarized in Table 6.1-2. With Model 1, without working circle boundaries, there is a 1.33% increase in allowable cut, given even-flow harvest policy. In other words, provided that working circle boundaries are present, removing the working circle boundaries gives a 1.33% increment in the allowable cut per period.

Table 6.1-2.

**The effect of working circle boundaries on AAC(10^6 m^3)
with no access constraints using stands**

Even-flow policy

Model 1 (No working circle boundaries, No compartment boundaries):

Total allowable cut for the planning horizon:	229.311 million m^3
AAC per period :	15.287 million m^3

Cut increased per period:	1.33 %
---------------------------	--------

Model 5 (Working circle boundaries, No compartment boundaries):

	W.C.1	W.C.2	W.C.3	W.C.4	W.C.5
Total	51.548	35.407	45.194	45.047	49.091
AAC	3.437	2.360	3.013	3.003	3.273

Total allowable cut for the planning horizon:	226.287 million m^3
Total AAC per period:	15.086 million m^3

6.2 The Effect of Working Circle Boundaries on Allowable Cut with Access Constraints

In this case, access constraints were added to the compartment analysis above, and one can see the results by comparing Models 4 and 8. The summary of the results are in Table 6.2-1. There is an 8.89% increase in allowable cut, given even-flow harvest policy, if working circle boundaries are removed. Since the previous results with no access constraints gave a 1.33%, or 2.13% increase, there is an obvious possible interaction effect here of access with working circle boundaries on the allowable cut.

Additional insight can be gained by comparing Model 7 from the previous analysis in section 6.1.1 with Model 8 of this analysis, given even-flow harvest policy. It becomes very obvious with this examination by working circle that access constraints have minor effects in working circles 1 and 2, major effects in working circles 3 and 4, and a very major effect in working circle 5.

Upon careful analysis of the individual runs, it was found that the even-flow requirement and restricted initial access in each of these three latter units was restricting harvest so much that considerable land base in each working circle was not being harvested. Actual operations would either open access earlier or allow a higher harvest at a later date.

Table 6.2-1.

The effect of working circle boundaries on AAC(10^6 m^3)
with access constraints

Even-flow constraint

Model 4 (No working circle boundaries, compartment boundaries):					
Total allowable cut for the planning horizon:	196.031 million m ³				
AAC per period :	13.069 million m ³				
Cut increased per period:	8.89 %				
Model 8 (Working circle boundaries, compartment boundaries):					
	W.C. 1	W.C. 2	W.C. 3	W.C. 4	W.C. 5
Total	49.505	33.910	32.332	36.280	28.011
AAC	3.300	2.261	2.155	2.419	1.867
Total allowable cut for the planning horizon:		180.038 million m ³			
Total AAC per period :		12.002 million m ³			

Non-declining constraint

Model 4:				
Total allowable cut for the planning horizon:	220.898 million m ³			
Average AAC per period :	14.727 million m ³			
1st period cut :	9.518 million m ³			
2nd - 3rd period cut :	15.099 million m ³			
Ave. cut increased per period:	1.02 %			
1st period cut increase:	-7.23 %			
2nd period cut increase:	18.50 %			
3rd period cut increase:	16.16 %			
Model 8:				
W.C. 1	W.C. 2	W.C. 3	W.C. 4	W.C. 5
Total 49.505	33.910	44.514	44.080	46.659
Ave. AAC 3.300	2.261	2.968	2.939	3.111
1st period cut		1.743	1.431	1.525
2nd period cut		2.617	2.980	1.584
3rd period cut		2.873	2.980	1.584
Total allowable cut for the planning horizon:		218.668 million m ³		
Average AAC per period :		14.579 million m ³		

Thus, the 8.89% increase here is not realistic and overestimates the increase by about 6.76 to 7.56% (8.89-2.13% or 8.89-1.33%). The 1.33 % to 2.13 % increase demonstrated earlier is a more probable figure for the effect of working circle boundaries.

Given a non-declining yield harvest policy, these effects disappear because of the gradual increases of the allowable cuts at later periods. The average difference for the planning horizon is an increase of only 1.02%. However, the difference is -7.23% in period 1, 18.50% in period 2 and 16.16% in period 3.

6.3 The Effect of Compartment Boundaries on Allowable Cut with no Access Constraints

6.3.1 At the Level of Whole Forest Area

The impact of compartment boundaries without working circles on the allowable cut can be examined by comparing Models 1 and 3, where Model 1 consists of stand based units and Model 3 consists of compartment based management units. The results are summarized in Table 6.3-1. The comparison shows a 1.31% increase in the allowable cut when the compartment boundaries are removed at the level of the whole forest area.

Table 6.3-1.

**The effect of compartment boundaries on AAC(10^6 m³)
with no access constraints or working circles**

Even-flow policy

Model 1 (No compartment boundaries):	
Total allowable cut for the planning horizon:	229.311 million m ³
AAC per period:	15.287 million m ³
Cut increased per period:	1.31 %
Model 3 (Compartment boundaries):	
Total allowable cut for the planning horizon:	226.345 million m ³
AAC per period:	15.090 million m ³

6.3.2 At the Level of Working Circles

The impact of compartment boundaries within working circles on the level of timber harvesting can be analyzed by comparing Models 5 and 7, where Model 5 is composed of stand based management units and Model 7 of compartment based management units. The summarized results are shown in Table 6.3-2. There is a 2.10% increase of the total allowable cut per period when the compartment boundaries are removed. This result, compared to the previous analysis at the level of the whole forest area, gives a slightly higher average increase because of a probable interaction effect of working circles on the compartment boundary analysis. Comparisons of individual

working circles indicates that the 2.10% increase overall is not uniform by working circle. Individual working circle increases vary from 0.65% to 3.37%. It appears that compartment boundaries are less important in working circles 4 and 5 and more important in working circles 1 to 3.

Table 6.3-2.

**The effect of compartment boundaries on AAC(10^6 m³)
with no access constraints
using working circles**

Even-flow constraint

Model 5 (No compartment boundaries, no access constraints):

	W.C. 1	W.C. 2	W.C. 3	W.C. 4	W.C. 5
Total	51.548	35.407	45.194	45.047	49.091
AAC	3.437	2.360	3.013	3.003	3.273
% Cut					
Increase	3.37	3.28	2.34	1.11	0.65

Total allowable cut for the planning horizon:	226.287 million m ³
Total AAC per period :	15.086 million m ³

Ave. cut increased per period:	2.10 %
--------------------------------	--------

Model 7 (Compartment boundaries, no access constraints):

	W.C. 1	W.C. 2	W.C. 3	W.C. 4	W.C. 5
Total	49.876	34.269	44.156	44.546	48.774
AAC	3.325	2.285	2.944	2.970	3.252

Total allowable cut for the planning horizon:	221.621 million m ³
Total AAC per period :	14.776 million m ³

6.4 The Effect of Access Constraints on Allowable Cut with no Working Circle Boundaries

The impact of access constraints on allowable cut without working circle boundaries is analyzed by examining Models 3 and 4, where Model 3 has no access restrictions and Model 4 does. The summary of the results is presented in Table 6.4-1.

These models, with an even-flow harvest policy, show a 15.46% difference which indicates that there is a significant relationship of access limits with the timber cutting level. It implies a large potential increase in the allowable cut when the access constraints are removed. Upon examination of the Model 4 runs, one finds that the large differences due to access constraints are caused by; (a) cuts in early periods being limited due to access concerns and (b) cuts in later periods being limited by the even-flow harvest policy in that they can not be larger than the early period harvests. This leads to a situation where not all of the FMA is used in Model 4. A possible solution to this would be to look at Models 3 and 4 using a non-declining yield constraint.

Model 3, using a non-declining yield constraint produces a solution which is the same as the even-flow version above and gives a 2.46% increase in the allowable cut, compared with Model 4 with access constraints and non-declining yield

constraints. However, this Model 4, non-declining yield run, is probably not acceptable from the manager's point of view because of the severe reduction of the allowable cut in the first period of Model 4 to only 9.518 million m³.

Table 6.4-1.

**The effect of access constraints on AAC(10⁶ m³)
with no working circle boundaries**

Even-flow constraint

Model 3 (No access constraints, compartment boundaries):		
Total allowable cut		
for the planning horizon:		226.345 million m ³
AAC per period	:	15.090 million m ³
Cut increased per period:		15.46 %
Model 4 (Access constraints, compartment boundaries):		
Total allowable cut		
for the planning horizon:		196.031 million m ³
AAC per period	:	13.069 million m ³

Non-declining constraint

Model 3:		
Total allowable cut		
for the planning horizon:		226.345 million m ³
AAC per period	:	15.090 million m ³
Ave. cut increased per period:		2.46 %
1st period cut increase	:	58.54 %
Model 4:		
Total allowable cut		
for the planning horizon:		220.898 million m ³
Average AAC per period	:	14.727 million m ³
1st period cut	:	9.518 million m ³

6.5 The Effect of Access Constraints on Allowable Cut using Working Circle Boundaries

The results from Models 7 and 8 allow analysis of the impact of access constraints on allowable cut, with working circle boundaries. The summarized results are in Table 6.5-1.

The total 23.11% difference in the levels of optimal timber harvesting between the models with access limits and the ones without access restrictions, given an even-flow harvest policy, indicates that there is a strong significant relationship of the access limits with the allowable cut.

However, in the discussion in Section 6.2 above, it was noted that the runs for Model 8 for working circles 3, 4, and 5 have major reductions for the whole planning horizon due to unrealistic access concerns. In that case, the overall reduction was overestimated to be about 6.76% to 7.56%. It is interesting to note that, if the 23.11% estimated increase in this case is reduced by these amounts, the resulting 15.55 to 16.35% is very close to the 15.46% increase estimated in section 6.4. Thus, it appears that access constraints are causing a real reduction in allowable cut of about 15 to 16%, given an even-flow harvest policy.

The models, with non-declining constraints, show only 2.53% difference between the average volume outputs. However,

Table 6.5-1.
The effect of access constraints on AAC(10^6 m³)
using working circle boundaries

Even-flow constraint

Model 7 (No access constraints, compartment boundaries):					
	W.C. 1	W.C. 2	W.C. 3	W.C. 4	W.C. 5
Total	49.876	34.269	44.156	44.546	48.774
AAC	3.325	2.285	2.944	2.970	3.252
% Cut Increase	0.76	1.06	36.61	22.78	74.18
Total allowable cut					
for the planning horizon:			221.621 million m ³		
Total AAC per period :			14.776 million m ³		
Ave. cut increased per period:				23.11 %	

Model 8 (Access constraints, compartment boundaries):					
	W.C. 1	W.C. 2	W.C. 3	W.C. 4	W.C. 5
Total	49.505	33.910	32.332	36.280	28.011
AAC	3.300	2.261	2.155	2.419	1.867
Total allowable cut					
for the planning horizon:			180.038 million m ³		
Total AAC per period :			12.002 million m ³		

Non-declining constraint

Model 7:					
	W.C. 1	W.C. 2	W.C. 3	W.C. 4	W.C. 5
Total	49.876	34.269	45.846	44.546	49.679
Ave. AAC	3.325	2.285	3.056	2.970	3.312
1st to 3rd period cut			2.944		3.252
Total allowable cut					
for the planning horizon:			224.216 million m ³		
Average AAC per period :			14.948 million m ³		
Ave. cut increased per period:				2.53 %	
1st period cut increase	:			43.84 %	
2nd period cut increase	:			15.82 %	
3rd period cut increase	:			13.54 %	

Model 8:					
	W.C. 1	W.C. 2	W.C. 3	W.C. 4	W.C. 5
Total	49.505	33.910	44.514	44.080	46.659
Ave. AAC	3.300	2.261	2.968	2.939	3.111
1st period cut			1.743	1.431	1.525
2nd period cut			2.617	2.980	1.584
3rd period cut			2.873	2.980	1.584
Total allowable cut					
for the planning horizon:			218.668 million m ³		
Average AAC per period :			14.579 million m ³		

the result is probably not acceptable to Weldwood because of the severe reductions of the timber volume cuts during the first to third periods with working circles 3, 4, and 5 in model group 8 because of access constraints.

6.6 Model size, Data Aggregation, Computing Relationships of the Various Models

From Tables 5.5-1 and 5.5-2, it is clear for this study that compartment based models (3, 4, 7, and 8) have fewer timber classes and fewer yield tables needed than models (1, 2, 5, and 6) that are stand based. Timber yield tables are more easily produced for the stand based models whereas economic yield tables are more easily produced for the compartment based models.

However, the differences between the two types of models in this study are really significant when one examines the matrix size of equivalent linear programs to determine optimal AAC's. Table 6.6-1 gives the matrix size of five Model 5 formulations and five Model 7 formulations. When these two models are used to examine the effects of compartment boundaries, for working circle one, the matrix is 355 rows by 17,682 columns or 6,277,110 cells for Model 5 while, for Model 7, the same working circle matrix is 82 rows by 1,948 columns or 159,736 cells. This means that Model 5 is 39 times the size of Model 7 for working circle 1. Thus, the models

using stand based management units which require many more constraints (rows) and many more decision variables (columns) will require a large computer capacity and be more expensive to solve. The LP matrix size for Model 1 with economic factors and Models 2 and 6 were too large for the solution code on the computer to produce solutions. As well, each of the 15 Model 5 solutions cost an average of \$300 to \$500 to obtain, while 25 Model 7 solutions varied from \$9 to \$29 each. However, as demonstrated in the section 6.10, the increased cost for analysis in this case study is on the order of one cent or less per cubic meter of the allowable cut and thus is probably not significant in the decision to use compartment based or stand based units. It is clear that it is easier for the analyst to use compartment based analyses when economic constraints and access concerns are part of the problem, but in the case study, this ease came at a cost of potential loss in allowable cut of 1.31 - 2.10 percent.

Table 6.6-1.
The differences of the problem sizes
between two forest land classification methods
within working circles

Working circles	Land classes	Model 5		Model 7	
		Stand based		Compartment based	
		Rows	Columns	Rows	Columns
	W. C. 1	355	17682	82	1948
	W. C. 2	309	14378	74	1575
	W. C. 3	358	18231	65	1195
	W. C. 4	436	23832	75	1813
	W. C. 5	320	15995	82	2058

6.7 The Effect of Maximum Cost per Period Constraints on Working Circle Boundary Analysis

By summing the 5 working circles in Model 7 to compare with Model 3, the results in Section 6.1 showed that there was a 2.13% increase due to removing working circle boundaries with no cost constraints. Table 6.7-1 indicates clearly that, as maximum cost constraints per period are imposed, the percentage increase in cut due to removal of working circles is reduced. Thus these constraints tend to reduce or eliminate possible gains from removal of working circle boundaries.

Table 6.7-1.

The percentage differences in the AACs of Models 3 and 7 with cost constraints¹

Max. Ave. Cost Const.	Model 7 (Sum)		Model 3		% Increase in AAC
	AAC M m ³ /per.	Total Ave. Cost M \$/Per.	AAC M m ³ /per.	Total Ave. Cost M \$/per.	
345	14.776	307.816	15.090	314.747	2.13
305	14.460	299.205	14.635	301.196	1.21
291	14.054	288.653	14.228	290.715	1.24
262	12.954	262.000	13.073	262.000	0.92

¹ M in this table and hereafter denotes 10⁶

6.8 The Effect of Maximum Cost per Period Constraints on Compartment Boundary Analysis

Unconstrained analysis gave an increase of 2.10 percent for the whole forest when considering compartment boundaries (Section 6.3, Table 6.3-2). When cost constraints per period are imposed, the differences between Models 5 and 7, in general, get larger (Table 6.8-1). Overall with costs constrained to 345 million dollars per period which constitutes no constraint, because costs never reach that level, elimination of compartment boundaries gives an increase in AAC of 2.10%. If costs are constrained to 305 or 262 million dollars per period, then compartment boundary removals at those levels give increases in AAC of 2.34% and 2.48%, respectively (Table 6.8-1). Analysis by each working circle indicates working circles 3, 4, and 5 tend to follow this increasing trend where as working circles 1 and 2 display distinctly opposite trends.

Table 6.8-2 presents an interesting view, if one examines the average cost per cubic meter figures using Model 7 in working circle 1, we get 3.210 million cubic meters for \$19.27 per cubic meter. Using Model 5 in working circle 1 at \$19.27 per cubic meter, we produce 3.437 million cubic meters. This represents a gain in yield of 227,000 cubic meters per period at the same cost per cubic meter, or a 7.07% increase in yield per period at the same cost per cubic meter without

Table 6.8-1.

The percentage differences in the AACs
of model group 5 and 7 with cost constraints¹

	Max. Cost Const. (M \$ /Per.)	Model 7	Model 5	% Increase in AAC
		AAC (M m3/Per.)	AAC (M m3/Per.)	
W.C.1	70	3.325	3.437	3.37
	65	3.268	3.352	2.57
	63	3.210		
	61	3.150		
	55	2.922	2.987	2.22
W.C.2	60	2.285	2.360	3.28
	50	2.260	2.315	2.43
	48	2.211		
	46	2.150		
	40	1.936	1.970	1.76
W.C.3	70	2.944	3.013	2.34
	63	2.888	2.955	2.32
	62	2.860		
	61	2.829		
	56	2.622	2.706	3.20
W.C.4	70	2.970	3.003	1.11
	60	2.946	2.983	1.26
	59	2.923		
	58	2.897		
	52	2.678	2.720	1.57
W.C.5	75	3.252	3.273	0.65
	67	3.098	3.194	3.10
	66	3.063		
	65	3.028		
	59	2.796	2.892	3.43
Whole forest	345	14.776	15.086	2.10
	305	14.460	14.799	2.34
	262	12.954	13.275	2.48

¹ The level of cost constraints used in each working circle was set at a value approximately equal to the average per period cost of the previous run. The upper limit in each working circle is nonconstraining in any period.

Table 6.8-2.

The AACs and the estimated 15 period average costs
in model groups 5 and 7

	Max. Cost Const. per Per.	Model 7			Model 5		
		AAC (M m3 /per.)	Total average (M \$ /per.)	Ave. cost (\$/m3)	AAC (M m3 /per.)	Total average (M \$ /per.)	Ave. cost (\$/m3)
W.C.1	70	3.325	64.988	19.54	3.437	66.219	19.27
	65	3.268	63.290	19.37	3.352	63.734	19.01
	63	3.210	61.845	19.27			
	61	3.150	60.355	19.16			
	55	2.922	55.000	18.82	2.987	55.000	18.41
W.C.2	60	2.285	48.650	21.29	2.360	50.299	21.31
	50	2.260	48.063	21.26	2.315	48.903	21.22
	48	2.211	46.695	21.12			
	46	2.150	45.146	20.99			
	40	1.936	40.000	20.66	1.970	40.000	20.31
W.C.3	70	2.944	64.214	21.81	3.013	64.257	21.33
	63	2.888	62.594	21.67	2.955	62.220	21.05
	62	2.860	61.887	21.64			
	61	2.829	61.000	21.56			
	56	2.622	56.000	21.36	2.706	56.000	20.69
W.C.4	70	2.970	59.717	20.11	3.003	59.737	19.89
	60	2.946	59.043	20.04	2.983	58.964	19.76
	59	2.923	58.331	19.95			
	58	2.897	57.580	19.86			
	52	2.678	52.000	19.42	2.720	52.000	19.12
W.C.5	75	3.252	70.247	21.60	3.273	68.922	21.06
	67	3.098	66.215	21.37	3.194	66.346	20.77
	66	3.063	65.411	21.35			
	65	3.028	64.572	21.33			
	59	2.796	59.000	21.10	2.892	59.000	20.40

compartment boundaries.

However, this comparison is not very useful to an operational manager because it uses the average cost per period (decade) over 5 periods. Of more interest to an operational manager would be the cost in the first period (10 years). Models (5 and 7) place an upper limit on cost in any period, thus the manager would make decisions primarily based upon the first period costs knowing that the remaining periods are reasonable. Table 6.8-3 is developed using the first period average cost data. Unlike Table 6.8-2, the average costs in Table 6.8-3 are not, in general, "well behaved". For example, in working circle 2, if costs per period are constrained at 60 million dollars per period (which is unconstraining because no period costs that much), Model 7 gives an AAC of 2.285 million cubic meters per period with a first period total cost of 48.223 million dollars and an average cost of \$21.10 per cubic meter. However, when cost per period is limited to 50 million dollars, cut drops to 2.260 million cubic meters per period with a total cost in the first period of 48.679 million dollars and an average cost of \$21.54 per cubic meter. Thus, less is cut at more total cost and a higher cost per cubic meter. The reason for this is that the volume of harvest was maximized over fifteen, ten-year periods in a manner that costs in no decade exceeded 60 or 50 million dollars, respectively. With the 60 million constraint, no

Table 6.8-3.

The AACs and the first period average costs
in model groups 5 and 7

	Max. Cost Const. per Per.	Model 7			Model 5		
		AAC (M m3)	1st per. Cost (M \$)	Ave. Cost (\$/m3)	AAC (M m3)	1st per. Cost (M \$)	Ave. Cost (\$/m3)
W.C. 1	70	3.325	64.535	19.41	3.437	63.213	18.39
	65	3.268	62.954	19.26	3.352	62.050	18.51
	63	3.210	61.893	19.28			
	61	3.150	60.552	19.22			
	55	2.922	55.000	18.82	2.987	55.000	18.41
W.C. 2	60	2.285	48.223	21.10	2.360	50.119	21.24
	50	2.260	48.679	21.54	2.315	48.977	21.16
	48	2.211	46.277	20.93			
	46	2.150	44.871	20.87			
	40	1.936	40.000	20.66	1.970	40.000	20.30
W.C. 3	70	2.944	62.137	21.11	3.013	60.072	19.94
	63	2.888	62.372	21.60	2.955	61.731	20.89
	62	2.860	61.858	21.63			
	61	2.829	61.000	21.56			
	56	2.622	56.000	21.34	2.706	56.000	20.69
W.C. 4	70	2.970	59.311	19.97	3.003	54.478	18.14
	60	2.946	58.092	19.72	2.983	54.886	18.40
	59	2.923	56.981	19.49			
	58	2.897	55.648	19.21			
	52	2.678	52.000	19.42	2.720	52.000	19.12
W.C. 5	75	3.252	71.415	21.96	3.273	70.374	21.50
	67	3.098	67.000	21.63	3.194	67.000	20.98
	66	3.063	66.000	21.55			
	65	3.028	65.000	21.47			
	59	2.796	59.000	21.10	2.892	59.000	20.40

decade's cost reached that level, but several were over 50 million dollars. When cut was maximized with a 50 million dollar per period limit, expensive potential harvest from the future was transferred to the first period to reduce future costs down to the limit and use up unused constraint dollars in the first period. In the other case, the equivalent harvest in the first several periods was achieved without reaching the cost constrained level. This kind of anomaly is also shown with working circle 3 in Model 7 and working circles 3 and 4 in Model 5. These same trends produce all kinds of anomalies in the average cost per cubic meter figures. Theoretically, total cost in the first period and average costs should go up with each increase in the allowable cut, but this occurs only if one optimizes or selects cuts based on cost. In the case study, cuts were selected to maximize volume harvested with an even-flow inter-period volume constraint subject to a maximum total cost constraint per period. Thus, if the even-flow harvest constraint is critical, or if total cost of harvest in period 13, for example, is critical, the first period costs may not "behave normally".

While the results of changing from compartment based units to stand based units shown in either Table 6.8-2 or 6.8-3 favour the stand based units (no compartment boundaries), one must note that specific moving and set up costs for forest equipment are included only at the average value for Alberta.

In general, companies in Alberta have logged using a compartment based aggregation; thus this average cost for set up and moving of logging equipment reflects compartment based aggregation. In this study, the number of the proposed logging areas for the first planning period using compartment based analysis were 3 to 12 compartments which is much smaller than the 34 to 77 stands used in stand based analyses. Even though stands will be aggregated for logging, it is unlikely that this aggregation will reduce the number of separate areas to be logged per period to that of a compartment based aggregation. In the analysis of Models 5 and 7, the increased cost of this function for Model 5 are not reflected in these analyses.

6.9 The Effect of Maximum Cost per Period Constraints on Access Constraint Analysis

Analysis of the effects of maximum cost constraints per period on Models 3 and 4 used to demonstrate access constraints is difficult. Table 6.9-1 shows the effects of cost constraints on each model. However, Model 4 is so constrained by management access concerns and a policy of even-flow that the cost per period constraints used in Model 3 hardly overlap those of Model 4. Due to the lack of significant overlap of harvest levels and cost constraint levels, marginal cost analysis is not attempted for this model comparison. With these constraints, the allowable cut is

dramatically restricted to, at most, the cut level of 13.069 million m³ per period with the 15 period average total cost of 274.11 million dollars per period as compared with the maximum cut level of 15.090 million m³ per period and a 15 period average total cost of 314.747 million dollars per period without access limits. It is also worthwhile to note that the most constrained harvest of 13.073 million m³ per period was achieved in Model 3 with no access constraints and a cost constraint per period and an average total cost per period of \$262 million. Model 4 with an unconstrained cost constraint per period, however, never reached that level of harvest due to the access constraints and even-flow policy.

The above results reveal that there is a large potential to increase the allowable cut by adjusting either the current forest road access schedule or the even-flow policy for timber production. However, since the adjustment of the flow policy (section 6.4) did not seem to produce acceptable solutions (very low 1st period harvests), modification of access limitations appears to be a logical way to get potentially large increases in the allowable cut.

Table 6.9-1.

The AACs and the costs in Models 3 and 4 with constraints on maximum per period cost¹

	Max. cost const. (M \$ /per.)	AAC (M m3 /per.)	15 per. average total cost (M m3/per.)	15 per. average cost (\$/m3)
M				
O	345	15.090	314.747	20.86
D	305	14.635	301.196	20.58
E	291	14.228	290.715	20.43
L	262	13.073	262.000	20.04
	0	0	0	0
3				
M				
O	290	13.069	274.11	20.97
D	275	13.067	273.12	20.90
E	270	13.019	269.35	20.69
L	262	12.676	261.75	20.65
	0	0	0	0
4				

6.10 Marginal Cost of Allowable Cut

To get a marginal cost of allowable cut curve, the wood supply available on each working circle was examined starting with a maximum cost of 0 and an allowable cut of 0. Using the output from the cost constrained runs of Models 5 and 7 shown in Table 6.8-3, a AAC from 0 to the maximum for each working circle was developed. Any and all intermediate outputs which gave an increasing average marginal cost, are displayed in Table 6.10-1. For example, with working circle 4, Model 5

Table 6.10-1.

The AACs and the first period average marginal costs
for model groups 5 and 7

	Max. Cost Const. per Per.	Model 7			Model 5		
		AAC (M m3)	1st per. Cost (M \$)	Ave. Mar. Cost (\$/m3)	AAC (M m3)	1st per. Cost (M \$)	Ave. Mar. Cost (\$/m3)
W.C. 1	70	3.325	64.535	27.74	3.437	63.213	18.39
	65	3.268	62.954	22.99			
	55	2.922	55.000	18.82			
	0	0.000	0.000		0.000	0.000	
W.C. 2	60	2.285	48.223	26.30	2.360	50.119	25.95
	48	2.211	46.277	23.05			
	46	2.150	44.871	22.76			
	40	1.936	40.000	20.66	1.970	40.000	20.30
	0	0.000	0.000		0.000	0.000	
W.C. 3	70	2.944	62.137	33.21	3.013	60.072	19.94
	62	2.860	61.858	27.68			
	61	2.829	61.000	24.15			
	56	2.622	56.000	21.36			
	0	0.000	0.000		0.000	0.000	
W.C. 4	70	2.970	59.311	49.57	3.003	54.478	18.14
	59	2.923	56.981	20.33			
	52	2.678	52.000	19.42			
	0	0.000	0.000		0.000	0.000	
W.C. 5	75	3.252	71.415	28.67	3.273	70.374	42.71
	67	3.098	67.000	28.57	3.154	67.000	26.49
	65	3.028	65.000	25.86			
	59	2.796	59.000	21.10	2.892	59.000	20.40
	0	0.000	0.000		0.000	0.000	

produced only one marginal cost entry going from 0 production to 3.003 million cubic meters AAC at an average marginal cost of \$18.14 per cubic meter (all other marginal costs between 0 and any other production output value produce marginal costs greater than \$18.14). Whereas Model 7 analysis for this same working circle produced three average marginal cost entries. Going from 0 to 2.678 million cubic meters is achieved at an average marginal cost of \$19.42 per cubic meter, going from 2.678 to 2.923 million cubic meters is achieved at an average marginal cost of \$20.33 per cubic meter and going from 2.923 to 2.970 million cubic meters is achieved at an average marginal cost of \$49.57 per cubic meter.

If the FMA is harvested by a rule which harvests least costly stands first, the data in Table 6.10-1 can be used to produce a marginal cost of allowable cut curve for both Model 5 and Model 7. Table 6.10-2 and Figure 6.10-1, respectively, represent a tabular representation and pictorial view of these supply curves.

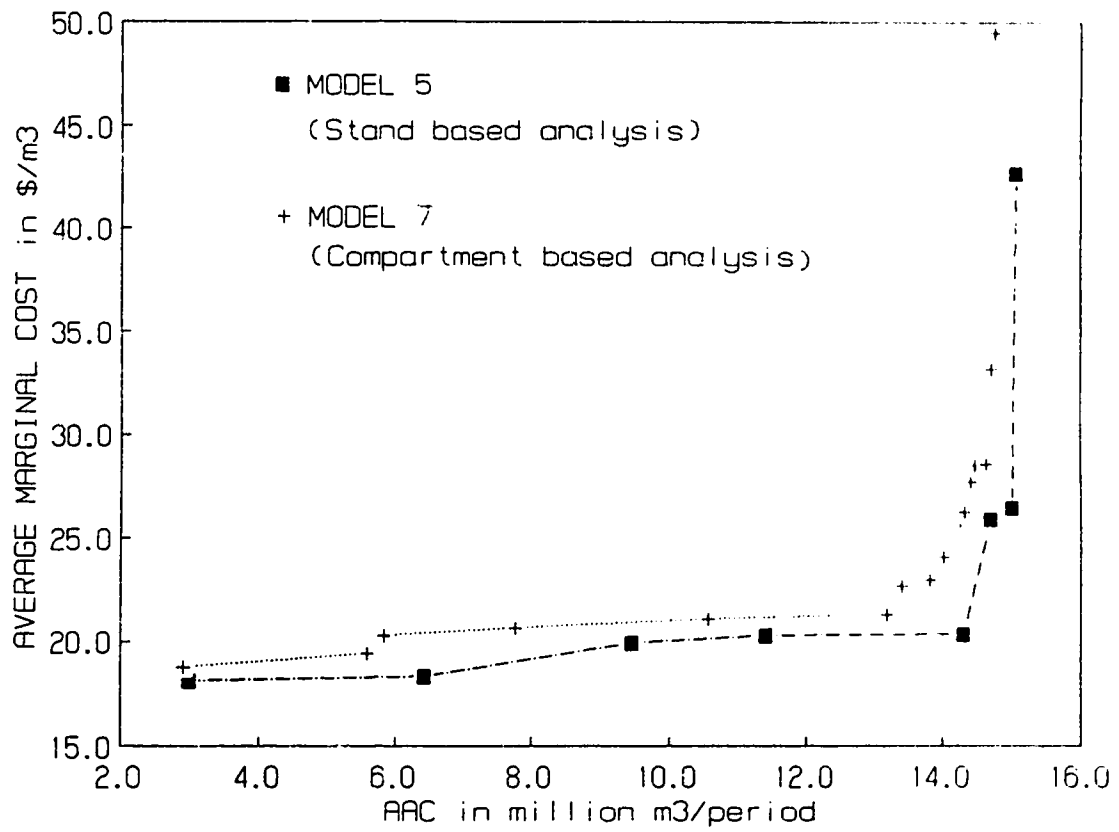
These curves can be used in two major ways; once a curve is selected for use by the company (Model 5 or 7), then that curve can be used as a guide for maximum unit cost for wood quantities purchased from off the lease. For example, at any production level (AAC), one can determine the average marginal cost of this timber supply and thus one would be willing to

Table 6.10-2.

The 1st period average marginal cost of allowable cut
for Models 5 and 7

Model 5			Model 7		
AAC (M m3)	Marginal increase in AAC (M m3)	Average marginal costs (\$/m3)	AAC (M m3)	Marginal increase in AAC (M m3)	Average marginal costs (\$/m3)
3.003		18.14	2.922		18.82
6.440	3.437	18.39	5.600	2.678	19.42
9.453	3.013	19.94	5.845	0.245	20.33
11.423	1.970	20.30	7.781	1.936	20.66
14.315	2.892	20.40	10.577	2.796	21.10
14.705	0.390	25.95	13.199	2.622	21.36
15.007	0.302	26.49	13.413	0.214	22.75
15.086	0.079	42.71	13.759	0.346	22.90
			13.820	0.061	23.05
			14.027	0.207	24.15
			14.259	0.232	25.86
			14.333	0.074	26.30
			14.364	0.031	27.68
			14.421	0.057	27.74
			14.491	0.070	28.57
			14.645	0.154	28.67
			14.729	0.084	33.21
			14.776	0.047	49.57

Figure. 6.10-1 The 1st Period AAC Supply Curves
for Models 5 and 7



purchase wood at any cost less than this cost. Large potential purchases would affect the level of the average marginal cost of allowable cut and thus you would have to look at the new average marginal cost of the reduced AAC harvested to ensure that you were not paying too much for the external purchase.

The second way these curves can be used is as an aid to the decision maker to select which Model, 5 or 7, to use. From Figure 6.10-1, it is clear that Model 7 costs more per cubic meter to produce equivalent outputs, however, Model 5 analyses are more expensive to produce. As well, as indicated above, the cost per cubic meter in Model 5 analyses is underestimated by the lack of an additional cost to reflect probable increased costs due to increased equipment movement and set-up costs for stand level management (Model 5) compared to area level management (Model 7). Thus, a manager, to make a valid comparison, would have to increase the cost per cubic meter for Model 5 for analysis expense and for the increased equipment movement cost per cubic meter. Since the analysis expense would be an increased fixed cost, it would increase an average marginal cost per m^3 in a decreasing amount as AAC increases. For example, assuming replanning at every period and increased analysis cost were \$50,000, marginal cost would increase $\$0.005/m^3$ at an AAC of 10 million cubic meters per period, but only $\$0.0033/m^3$ at an AAC of 15 million cubic meters per period. Since these costs for more costly analyses

give rise to an increase of less than one cent per cubic meter of harvest, they are probably insignificant.

The increase in cost due to increased equipment movement and set up charges is more likely to be expressed by the company in terms of a fixed additional charge per cubic meter logged and thus would result in an equal shift upward of the supply curve. The magnitude of this shift would be critical to the manager to decide whether stand or area based analysis were the best.

7. Conclusions

7.1 Case Study Results

This study shows that increases in allowable cuts ranging from 1.33% to 2.13% are possible by elimination of working circle boundaries for even-flow harvest schedule strategies. With non-declining yield harvest schedule strategies, the increases average 0.95% over the 150 year planning horizon with increases of 2.13% over the first 110 years of the planning horizon.

The effect of changing from compartment based management units to stand based management units is examined by removing compartment boundaries. The different comparisons, using an even-flow policy, result in increases in allowable cuts of 1.31% to 2.10%. When working circle boundaries are ignored, the increase was a 1.31%. When working circle boundaries are included, the overall increase is a 2.10%. In this latter example, results differed by working circle with increases from 0.65% to 3.37%. It appears compartment boundaries are less important in working circles 4 and 5 and more important in working circles 1 to 3.

Removal of access constraints, as interpreted in this

study, appears to lead to a 15 - 16% increase in allowable cut for cases where an even-flow policy is used. However, the above results should be examined carefully since the access relationship used here was an interpretation of the 5-year planning period constraints currently used by the company which were translated to the 10-year periods used in this study. Some of these access constraints may be operational priorities rather than real road problems and thus the potential increase shown may be too large.

Results of runs in Model 8, working circle 3, 4, and 5, clearly demonstrate, if LP is used with an even-flow requirement, that early access constraints that are severe will lead to unrealistic results. Clearly, if access is as limited early, as was modeled, one would either modify the even-flow requirement to allow an increase in cut as access improved or one would remove some of the early access problems by a more aggressive road building program.

Using a non-declining yield flow policy, increases due to removal of access constraints average 2.53% to 2.46% for the planning horizon. However, these results are probably not acceptable from the manager's point of view because of the severe reduction of the allowable cut in the first period to only 9.518 to 10.260 million m³.

Placing a constraint on maximum cost per planning period has different effects on each of the analyses above. The effect of removing working circle boundaries tends to diminish as cost constraints become more severe. Thus, the 2.13% increase reported earlier is reduced as costs become constraining.

In the stand based versus compartment based analysis (compartment boundary analysis), the effect of increasing cost constraints on this analysis tends overall to increase the percentage effect of removal of boundaries. Thus, the 2.10% increase reported earlier is increased as costs become constraining. However, the result is not uniform by individual working circles, ranging from 0.65% to 3.37%. By incrementally examining increases in AAC generated on the working circles at different cost constraints, an average marginal cost of allowable cut curve was developed for each type of analysis (stand and compartment based). Careful use of this curve will permit Weldwood managers to select the least costly method of analysis for any particular desired allowable cut. As well the selected curve can aid Weldwood managers to set upper limits on off lease wood purchase prices.

7.2 General Study Results

The results of this study support those of Jamnick et al. (1990) that stand based land unit classifications give

higher objective values than compartment based land unit classifications, but these large values are percentage wise not very much larger. To get them, increased costs are incurred in the planning model formulation and solution. As well, logging cost to move and set up equipment more frequently would be increased using stand based operations compared to compartment based operations for forest with larger number of stand types than that of compartments.

If maximum cost constraints per period and access considerations are desirable in the planning model, then it is easier to use compartment based management units for the analysis since the locational data for economic analysis and access concerns can be easily obtained. As well, significant reductions in model sizes and costs for solutions are achieved this way, but at a loss of a gain in allowable cut possible by using stand based forest units.

Finally, when cost constraints per period are used, the method of developing marginal cost of supply curves from section 5.7.1 can be adopted by others to develop timber supply curves which permit managers to select which type of land classification is best or most appropriate for their particular planning problem.

8. References

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9. Appendix I - Stand based timber yield data

11-11-11

Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Lodgepole pine	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
White spruce	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100																																							
Black spruce	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100																																																		
Alpine fir	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100																																																						
Mixed	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100																																																									

Density, percent crown closure class:

Potentially productive lodgepole pine all density classes

	Site	Index	30	Lodgepole pine density classes of B, C and D
U	6	6	0	0 9 26 44 52 79 97 113 129 143

4	Site Index	35	100	epole	pine	density	class	C
5		0	13	35	59	83	106	128 146 167 184 200

```

7      Site Index 40. lodgepole pine, density class 0
0      0      0      6      35      53      88      111      132      150      165      179      191      201      211

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8      Site Index 40, lodgepole pine, density class D
0      0      0      0      11      52      91      128      160      188      215      236      255      271

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1      site index 45 lodgepole pine, density class B
0      0      22 56 88 117 142 163 184 197 210 221 231 238

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11 Site Index 45, lodgepole pine, density class D

Site	Index	50	lodgepole	pine	density	class	C							
0	0	0	14	57	104	148	189	224	254	278	297	313	327	338

7 Potentially productive, lodgepole pine and other softwoods, all density classes

1 site index 25 - 30, lodgepole pine and other softwoods, density class A
0 0 0 0 5 13 21 29 38 48 54 62 70 77 84

21 Site Index 35 - 40, lodgepole pine and other softwoods, density class A
0 0 0 3 12 23 34 45 56 67 77 88 99 103 112

71 Site Index 40, lodgepole pine and other softwoods, density class 8
0 0 0 8 21 47 88 88 108 127 144 160 176 189 202

25 Site Index 40, lodgepole pine and other softwoods, density class 0
0 0 0 7 31 57 84 110 135 160 182 203 223 241

27 Site Index 45, lodgepole pine and other softwoods, density class 8
0 0 0 18 42 86 94 118 142 163 183 201 217 231 244

29 Site Index 45, lodgepole pine and other softwoods, density class D
0 0 0 0 25 57 81 124 156 184 214 239 263 283 302

Site index 50, lodgepole pine and other softwoods, density class 8

Site index 50, lodgepole pine and other softwoods, density class D

34	Potentially productive, lodgepole pine and hardwoods, all density classes
0	0 0 0 0 0 0 0 0 0 1 3 5 7 9 11
35	Site Index 25 - 40, lodgepole pine and hardwoods, density class A
0	0 0 0 1 5 11 18 26 34 42 50 58 65 72 78
36	Site Index 25 - 40, lodgepole pine and hardwoods, density classes of B, C and D
0	0 0 0 2 8 18 29 40 53 66 78 91 103 115 127
37	Site Index 45 - 50, lodgepole pine and hardwoods, density class A
0	0 2 12 25 41 58 74 89 102 113 122 130 138 142
38	Site Index 45 - 50, lodgepole pine and hardwoods, density classes of B, C and D
0	0 4 19 39 64 91 119 145 170 191 211 227 242 254
39	Site Index 55, lodgepole pine and hardwoods, density classes of C and D
0	0 8 30 59 93 128 162 192 218 240 262 274 287 297
40	Potentially productive, white spruce, all density classes
0	0 0 0 0 0 0 0 0 0 0 2 8 17 26 36
41	Site Index 20 - 50, white spruce, density class A
0	0 0 0 4 14 24 33 41 49 56 62 68 73 78
42	Site Index 20 - 50, white spruce, density class B
0	0 0 0 6 16 27 37 47 57 66 74 81 87 92 97
43	Site Index 20 - 50, white spruce, density classes C and D
0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
44	Potentially productive, white spruce and other softwoods, all density classes
0	0 0 0 0 0 0 0 0 0 0 0 0 4 18 33 49
45	Site Index 20 - 50, white spruce and other softwoods, density class A
0	0 0 0 1 7 15 27 41 58 78 101 124 148 171 193
46	Site Index 20 - 50, white spruce and other softwoods, density classes of B, C and D
0	0 0 0 11 34 59 85 111 137 162 186 209 229 248
47	Site Index 60, white spruce and other softwoods, density class A
0	0 4 20 47 84 128 178 220 267 302 337 364 385
48	Potentially productive, white spruce and hardwoods, all density classes
0	0 0 1 2 2 3 4 5 6 7 8 12 14 18 22
49	Site Index 20 - 50, white spruce and hardwoods, all density classes
0	1 3 8 12 20 32 49 70 96 128 167 189 222 253
50	Site Index 63, white spruce and hardwoods, density classes C and D
0	2 5 12 25 46 77 116 162 210 267 300 339 373 401
51	Potentially productive, black spruce, all density classes
0	0 0 0 0 0 1 2 3 4 5 7 9 12 15
52	Site Index 20 - 50, black spruce, all density classes
0	0 0 0 0 3 14 25 37 50 63 77 90 102 115
53	Potentially productive, black spruce and other softwoods and hardwoods, all density classes
0	0 0 0 0 0 0 0 1 4 8 12 17 22 27 32

54	Site Index 20 - 50, black spruce and other softwoods and hardwoods, all density classes
0	0 0 0 0 4 27 49 70 88 108 124 140 164 186
55	Site Index 20 - 50, balsam (subalpine) fir and other softwoods and hardwoods, all density classes
0	5 16 30 48 60 78 93 117 130 144 168 171 188 195
56	Potentially productive, hardwoods and softwoods, all density classes
0	0 0 0 0 0 0 0 0 0 1 3 5 8 10
57	Site Index 25 - 50, hardwoods and softwoods, density class A
0	0 0 5 13 21 28 36 41 48 60 84 87 89 91
58	Site Index 25 - 50, hardwoods and softwoods, density classes of B, C and D
0	0 0 4 15 27 38 49 58 66 72 77 82 85 88
59	Site Index 60, hardwoods and softwoods, density classes of C and D
0	0 0 7 19 32 45 56 65 73 78 84 88 91 93
60	Site Index 58, hardwoods and softwoods, density classes of A and B
0	0 12 28 43 56 68 78 83 89 93 98 99 101 103

**10. Appendix II - The average ages and yield estimates
for compartment based management units
of working circle 1**

WORKING CIRCLE 1

First column	the identity of each stand
Second column	the identity of each compartment
Third column	the area of each stand in hectares
Fourth column	the age of each stand
Fifth column	the yield stream identity for existing stand
Sixth to Eighteenth columns	the yield stream in3/ha/ for existing stand from 3 to 15 decades
Nineteenth column	the yield stream identity for regeneration stand
20th to 32th columns	the yield stream in3/ha/ for regeneration stand from 3 to 15 decades

The total area of compartment, average age and yield estimates are below each compartment

1	1	412	95	2	0	0	0	0	0	0	11	24	37	50	63	75	87	16	0	0	37	97	153	201	240	271	286	316	331	344	354	
2	1	412	95	2	0	0	0	0	0	0	11	24	37	50	63	75	87	16	0	0	37	97	153	201	240	271	286	316	331	344	354	
3	1	103	125	2	0	0	0	0	0	0	11	24	37	50	63	75	87	16	0	0	37	97	153	201	240	271	286	316	331	344	354	
4	1	103	125	2	0	0	0	0	0	0	11	24	37	50	63	75	87	16	0	0	37	97	153	201	240	271	286	316	331	344	354	
5	1	103	205	2	0	0	0	0	0	0	11	21	37	50	63	75	87	16	0	0	37	97	153	201	240	271	286	316	331	344	354	
6	1	103	205	2	0	0	0	0	0	0	11	24	37	50	63	75	87	16	0	0	37	97	153	201	240	271	286	316	331	344	354	
7	1	103	75	3	0	0	0	0	0	0	26	44	62	79	97	113	129	143	18	0	0	37	97	153	201	240	271	286	316	331	344	354
8	1	103	75	3	0	0	0	0	0	0	26	44	62	79	97	113	129	143	18	0	0	37	97	153	201	240	271	286	316	331	344	354
9	1	103	145	3	0	0	0	0	0	0	26	44	62	79	97	113	129	143	18	0	0	27	97	153	201	240	271	286	316	331	344	354
10	1	103	145	3	0	0	0	0	0	0	26	44	62	79	97	113	129	143	16	0	0	37	97	153	201	240	271	286	316	331	344	354
11	13090	95	5	0	0	0	13	35	59	83	106	128	148	167	184	200	16	0	0	37	97	153	201	240	271	286	316	331	344	354	354	
12	13090	95	5	0	0	0	13	35	59	83	106	128	148	167	184	200	16	0	0	37	97	153	201	240	271	286	316	331	344	354	354	
13	1	103	115	5	0	0	13	35	59	83	106	128	148	167	184	200	16	0	0	37	97	153	201	240	271	286	316	331	344	354	354	
14	1	103	115	5	0	0	13	35	59	83	106	128	148	167	184	200	16	0	0	37	97	153	201	240	271	286	316	331	344	354	354	
15	1	206	125	5	0	0	13	35	59	83	106	128	148	167	184	200	16	0	0	37	97	153	201	240	271	286	316	331	344	354	354	
16	1	206	125	5	0	0	13	35	59	83	106	128	148	167	184	200	16	0	0	37	97	153	201	240	271	286	316	331	344	354	354	
17	11030	95	8	0	0	0	0	0	0	0	40	71	100	128	153	175	195	213	16	0	0	37	97	153	201	240	271	286	316	331	344	354
18	11030	95	8	0	0	0	0	0	0	0	40	71	100	128	153	175	195	213	16	0	0	37	97	153	201	240	271	286	316	331	344	354
19	1	515	95	10	10	20	33	48	68	84	102	116	135	149	162	173	184	16	0	0	37	97	153	201	240	271	286	316	331	344	354	
20	1	515	95	10	10	20	33	48	68	84	102	116	135	149	162	173	184	16	0	0	37	97	153	201	240	271	286	316	331	344	354	
21	1	412	95	14	0	39	79	115	146	172	193	211	228	238	249	266	284	16	0	0	37	97	153	201	240	271	286	316	331	344	354	
22	1	412	95	14	0	39	79	115	146	172	193	211	228	238	249	266	284	16	0	0	37	97	153	201	240	271	286	316	331	344	354	
23	1	618	95	15	0	14	57	104	149	189	224	257	287	315	327	338	16	0	0	37	97	153	201	240	271	286	316	331	344	354		
24	1	618	95	15	0	14	57	104	149	189	224	257	287	315	327	338	16	0	0	37	97	153	201	240	271	286	316	331	344	354		
25	1	103	95	16	0	37	97	153	201	240	271	286	316	331	344	354	16	0	0	37	97	153	201	240	271	286	316	331	344	354		
26	1	103	95	16	0	37	97	153	201	240	271	286	316	331	344	354	16	0	0	37	97	153	201	240	271	286	316	331	344	354		
27	1	206	35	18	0	0	0	0	0	0	0	7	16	35	50	64	77	28	0	0	11	56	97	135	168	197	223	246	266	283	299	
28	1	206	35	18	0	0	0	0	0	0	0	7	16	35	50	64	77	28	0	0	11	56	97	135	168	197	223	246	266	283	299	
29	1	927	95	22	0	0	0	8	29	50	70	80	110	129	147	164	180	28	0	0	11	56	97	135	168	197	223	246	266	283	299	
30	1	927	95	22	0	0	0	8	29	50	70	80	110	129	147	164	180	28	0	0	11	56	97	135	168	197	223	246	266	283	299	
31	1	309	105	22	0	0	0	8	29	50	70	80	110	129	147	164	180	28	0	0	11	56	97	135	168	197	223	246	266	283	299	
32	1	309	105	22	0	0	0	8	29	50	70	80	110	129	147	164	180	28	0	0	11	56	97	135	168	197	223	246	266	283	299	
33	1	103	205	22	0	8	27	57	88	108	127	144	160	176	188	202	28	0	0	11	56	97	135	168	197	223	246	266	283	299		
34	1	103	205	22	0	8	27	57	88	108	127	144	160	176	188	202	28	0	0	11	56	97	135	168	197	223	246	266	283	299		
35	1	206	205	24	0	0	20	56	89	119	147	171	193	213	231	247	28	0	0	11	56	97	135	168	197	223	246	266	283	299		
36	1	206	205	24	0	0	20	56	89	119	147	171	193	213	231	247	28	0	0	11	56	97	135	168	197	223	246	266	283	299		
37	1	309	95	31	3	30	60	92	123	152	178	202	223	241	257	272	284	28	0	0	11	56	97	135	168	197	223	246	266	283	299	
38	1	309	95	31	3	30	60	92	123	152	178	202	223	241	257	272	284	28	0	0	11	56	97	135	168	197	223	246	266	283	299	
39	1	208	115	32	0	43	94	141	181	216	247	273	298	318	333	347	28	0	0	11	56	97	135	168	197	223	246	266	283	299		
40	1	208	115	32	0	43	94	141	181	216	247	273	298	318	333	347	28	0	0	11	56	97	135	168	197	223	246	266	283	299		
41	1	103	95	35	0	1	5	11	18	26	34	47	50	58	68	72	78	28	0	0	11	56	97	135	168	197	223	246	266	283	299	
42	1	103	95	35	0	1	5	11	18	26	34	47	50	58	68	72	78	28	0	0	11	56	97	135	168	197	223	246	266	283	299	
43	1	103	95	35	0	19	33	64	81	119	145	170	191	211	227	242	254	39	8	30	59	93	128	162	192	216	240	258	274	287	297	
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237	8	58	205	38	0	2	9	19	29	40	53	66	78	91	103	115	127	38	0	30	59	93	128	162	192	218	240	258	274	287	297														
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1972157																				3	28	57	86	112	137	158	178	194	208	220	230														
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337	11	110	205	54	0	0	0	4	27	49	70	89	108	124	140	154	168	54	0	0	0	4	27	49	70	89	108	124	140	154	168
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		180	189		0	0	5	15	30	46	62	79	98	116	132	148	162		1	5	22	62	103	143	178	208	234	246	274	290	303
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1440145	1	8	21	38	60	82	104	126	148	169	189	208	226	4	11	29	54	83	120	158	188	218	240	261	279	284									
457	15	672	95	5	0	0	0	13	35	59	82	105	128	148	167	184	200	18	0	0	0	0	0	0	37	97	153	201	240	271	288	316	331	344	354
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1392115																																
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3278108																																
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746	22																															

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8174103.																																	1.	11.	28.	51.	78.	101.	124.	145.	164.	182.	198.	210.	221.	2.	9.	36.	84.	128.	168	200.	226	250.	266	283	295	305	308
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1038	29	140	105	14	0	39	79	115	146	172	193	211	225	238	249	258	264	18	0	0	37	97	153	201	240	271	298	316	331	344	354																															
1039	29	210	115	14	0	39	79	115	146	172	193	211	225	238	249	258	264	18	0	0	37	97	153	201	240	271	298	316	331	344	354																															
1040	29	210	115	14	0	39	79	115	146	172	193	211	225	238	249	258	264	18	0	0	37	97																																								

[illegible]

1105	30	177	108	38	4	18	39	84	91	118	145	170	191	211	237	242	264	38	8	30	89	93	128	162	182	218	240	268	274	287	289																										
1106	30	177	108	38	4	18	39	84	91	118	145	170	191	211	237	242	264	38	8	30	89	93	128	162	182	218	240	268	274	287	289																										
1107	30	88	115	38	4	18	38	84	91	118	145	170	191	211	237	242	264	38	8	30	89	93	128	162	182	218	240	268	274	287	289																										
1108	30	88	115	38	4	18	38	84	91	118	145	170	191	211	237	242	264	38	8	30	89	93	128	162	182	218	240	268	274	287	289																										
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1110	30	88	115	43	0	0	0	0	0	48	88	128	184	196	225	261	274	43	0	0	0	0	48	88	128	184	196	225	261	274	43																										
1111	30	88	115	48	0	0	11	34	58	85	111	137	182	188	208	229	248	47	4	20	47	84	128	178	220	257	288	312	330	344	388																										
1112	30	88	115	48	0	0	11	34	58	85	111	137	182	188	208	229	248	47	4	20	47	84	128	178	220	257	288	312	330	344	388																										
1113	30	88	105	52	0	0	0	3	14	28	37	50	83	77	90	102	115	52	0	0	0	3	14	28	37	50	83	77	90	102	115																										
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1118	30	88	78	68	0	0	0	4	27	48	70	88	108	124	140	164	188	84	0	0	0	4	27	48	70	88	108	124	140	164	188																										
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1123	30	88	115	58	0	4	15	27	38	48	58	65	72	77	82	85	88	59	0	7	19	32	48	58	65	73	79	84	88	91	93																										
1124	30	88	115	58	0	4	15	27	38	48	58	65	72	77	82	85	88	59	0	7	19	32	48	58	65	73	79	84	88	91	93																										
7080 88.																																0.	8.	25.	47.	71.	95.	117.	137.	155.	171.	185.	187.	208.	0	4	32.	78.	122.	161.	184.	221.	243.	261.	278.	288.	298.
1131	31	188	105	5	0	0	0	13	35	59	83	108	128	148	167	184	200	18	0	0	37	87	163	201	240	271	298	316	331	344	364																										
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1135	31	124	105	10	10	2	32	48	58	64	102	119	135	149	162	172	184	18	0	0	37	87	163	201	240	271	298	316	331	344	364																										
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1156	31	62	115	43	0	0	0	0	0	48	88	128	184	196	225	261	274	43	0	0	0	0	48	88	128	184	196	225	261	274	43																										
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1171	33	58	105	10	10	20	33	48	64	84	102	118	135	149	162	173	184	18	0	0	37	97	153	201	240	271	298	316	331	344	354
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1177	32	118	115	14	0	39	79	115	146	172	193	211	225	238	248	258	264	16	0	0	37	97	153	201	240	271	298	316	331	344	354
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1181	32	59	95	16	0	0	37	97	153	201	240	271	298	316	331	344	354	16	0	0	37	97	153	201	240	271	298	316	331	344	354
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1184	32	59	105	16	0	0	37	97	153	201	240	271	298	316	331	344	354	16	0	0	37	97	153	201	240	271	298	316	331	344	354
1185	32	59	115	22	0	0	0	0	0	0	0	0	0	0	0	0	0	28	0	0	37	97	153	201	240	271	298	316	331	344	354
1186	32	59	115	22	0	0	0	0	0	0	0	0	0	0	0	0	0	28	0	0	37	97	153	201	240	271	298	316	331	344	354
1187	32	59	135	28	0	0	0	0	0	0	0	0	0	0	0	0	0	28	0	0	37	97	153	201	240	271	298	316	331	344	354
1188	32	59	135	28	0	0	0	0	0	0	0	0	0	0	0	0	0	28	0	0	37	97	153	201	240	271	298	316	331	344	354
1189	32	177	115	32	0	0	0	0	0	0	0	0	0	0	0	0	0	28	0	0	37	97	153	201	240	271	298	316	331	344	354
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1191	32	59	105	35	0	0	0	0	0	0	0	0	0	0	0	0	0	28	0	0	37	97	153	201	240	271	298	316	331	344	354
1192	32	59	105	35	0	0	0	0	0	0	0	0	0	0	0	0	0	28	0	0	37	97	153	201	240	271	298	316	331	344	354
1193	32	118	105	38	4	19	39	64	91	119	145	170	191	211	227	242	254	39	8	30	59	93	128	162	192	218	240	258	274	287	297
1194	32	118	105	38	4	19	39	64	91	119	145	170	191	211	227	242	254	39	8	30	59	93	128	162	192	218	240	258	274	287	297
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1196	32	59	115	38	4	19	39	64	91	119	145	170	191	211	227	242	254	39	8	30	59	93	128	162	192	218	240	258	274	287	297
1197	32	59	105	43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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1199	32	59	115	43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1200	32	59	115	43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1201	32	59	115	46	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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1203	32	177	115	51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1204	32	177	115	51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1205	32	59	105	51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1206	32	59	105	51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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1208	32	59	95	52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1209	32	59	105	52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1210	32	59	105	52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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1212	32	59	115	52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1213	32	59	205	53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1214	32	59	205	53	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1215	32	118	115	54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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1217	32	59	95	54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1218	32	59	95	54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1219	32	59	105	54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1220	32	59	105	54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1221	32	59	115	58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1222	32	59	115	58	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

1223	33	285	95	5	0	0	0	13	35	59	83	108	128	148	167	184	200	18	0	0	37	97	153	201	240	271	298	316	331	344	354
1224	33	285	95	5	0	0	0	13	35	59	83	108	128	148	167	184	200	18	0	0	37	97	153	201	240	271	298	316	331	344	354
1225	33	188	98	14	0	39	78	115	148	172	183	211	225	238	249	256	284	18	0	0	37	97	153	201	240	271	298	316	331	344	354
1226	33	188	98	14	0	39	78	115	148	172	183	211	225	238	249	256	284	18	0	0	37	97	153	201	240	271	298	316	331	344	354
1227	33	53	98	18	0	0	0	0	0	0	0	2	18	35	50	64	77	28	0	0	11	56	97	135	168	187	223	246	288	283	298
1228	33	53	98	18	0	0	0	0	0	0	0	2	19	35	50	64	77	28	0	0	11	56	97	135	168	187	223	246	288	283	298

**11. Appendix III - The number of trees per ha
for the main species**

The number of trees per hectare as a function of age was determined by fitting a least squares straight line to PSP data from the company for each species below:

Lodgepole pine: # of TREES/HA = $2374 - 103 \text{ AGE}/10$

White spruce: # of TREES/HA = $1105 - 50.4 \text{ AGE}/10$

Black spruce: # of TREES/HA = $1643 - 18.0 \text{ AGE}/10$

Alpine/Balsam fir: # of TREES/HA = $1405 - 45.6 \text{ AGE}/10$

Mixed softwood: # of TREES/HA = $351 - 20.0 \text{ AGE}/10$

**12. Appendix IV - The tree sizes and woodlands costs
for each yield stream by age class**

First row: the identity of yield streams
 Second row: the tree sizes (m³/tree) from 1 to 15 decades
 Third row: woodlands costs (\$/m³) from 1 to 15 decades

Woodlands cost = 8.8488 + 2.8288 * LNLOG(TREE SIZE)
 * LNLOG: Natural logarithm

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1
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0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 27.434 21.717 19.989 18.718

2
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0078 0.0178 0.0295 0.0441 0.0612 0.0809 0.1057
0.000 0.000 0.000 0.000 0.000 0.000 0.000 21.768 19.521 18.172 17.150 16.292 15.557 14.854

3
0.0000 0.0000 0.0000 0.0000 0.0085 0.0188 0.0305 0.0453 0.0639 0.0855 0.1097 0.1392 0.1738
0.000 0.000 0.000 0.000 22.648 19.688 18.124 17.025 16.178 15.408 14.756 14.131 13.547

4
0.0000 0.0000 0.0081 0.0217 0.0370 0.0524 0.0682 0.0873 0.1067 0.1289 0.1534 0.1812 0.2163
0.000 0.000 21.814 19.070 17.615 16.700 15.955 15.356 14.828 14.333 13.875 13.436 12.972

5
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0.000 0.000 0.000 21.840 18.078 17.534 16.455 15.816 14.910 14.297 13.729 13.197 12.685

6
0.0000 0.0000 0.0000 0.0000 0.0048 0.0259 0.0492 0.0746 0.1035 0.1350 0.1699 0.2104 0.2588
0.000 0.000 0.000 0.000 22.955 18.955 18.886 18.789 18.810 18.270 17.606 17.045 16.500

7
0.0000 0.0031 0.0188 0.0359 0.0533 0.0718 0.0914 0.1119 0.1334 0.1560 0.1854 0.2168 0.2554
0.000 24.184 19.386 17.891 16.862 16.872 16.236 15.703 15.242 14.787 14.376 13.965 13.525

8
0.0000 0.0000 0.0048 0.0217 0.0412 0.0640 0.0888 0.1157 0.1455 0.1783 0.2148 0.2567 0.3074
0.000 0.000 22.967 19.020 17.320 16.173 15.318 14.817 14.012 13.479 12.993 12.521 12.047

9
0.0000 0.0000 0.0000 0.0083 0.0315 0.0588 0.0888 0.1184 0.1528 0.1898 0.2291 0.2751 0.3283
0.000 0.000 0.000 22.279 18.035 18.394 18.316 18.533 18.865 19.316 19.820 20.339 20.867

10
0.0088 0.0102 0.0178 0.0274 0.0400 0.0543 0.0705 0.0888 0.1081 0.1315 0.1573 0.1866 0.2236
12.959 20.989 19.841 18.408 17.406 16.805 16.813 16.312 15.770 15.279 14.809 14.369 13.884

11
0.0000 0.0112 0.0302 0.0502 0.0708 0.0918 0.1129 0.1351 0.1593 0.1853 0.2146 0.2482 0.2804
0.000 20.749 18.161 16.813 16.903 16.225 15.681 15.209 14.778 14.377 13.993 13.629 13.287

12
0.0000 0.0000 0.0187 0.0388 0.0642 0.0924 0.1219 0.1530 0.1867 0.2224 0.2631 0.3085 0.3645
0.000 0.000 19.705 17.490 16.183 15.208 14.479 13.882 13.358 12.898 12.458 12.038 11.639

13
0.0000 0.0000 0.0011 0.0288 0.0612 0.0944 0.1281 0.1634 0.1997 0.2383 0.2806 0.3290 0.3864

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0.366 0.000 28.811 18.188 18.280 18.182 18.348 18.768 19.182 19.717 20.287 20.889 21.446
14
0.0000 0.0189 0.0426 0.0688 0.0885 0.1112 0.1337 0.1578 0.1819 0.2101 0.2417 0.2762 0.3208
0.000 19.244 17.248 16.109 15.321 14.721 14.237 13.808 13.427 13.048 12.678 12.329 11.935
15
0.0000 0.0071 0.0307 0.0593 0.0903 0.1222 0.1551 0.1886 0.2247 0.2621 0.3038 0.3528 0.4107
0.000 21.937 18.104 16.374 15.268 14.473 13.846 13.318 12.871 12.486 12.078 11.686 11.288
16
0.0000 0.0000 0.0189 0.0583 0.0927 0.1289 0.1682 0.2022 0.2383 0.2789 0.3214 0.3711 0.4301
0.000 0.000 19.240 18.857 18.188 18.311 18.864 19.148 19.708 20.203 20.831 21.562 22.364
17
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0008 0.0071 0.0185 0.0248 0.0377
0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 0.000 27.885 21.987 18.895 16.864 17.886
18
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0000 0.0018 0.0184 0.0308 0.0485 0.0880 0.0938
0.000 0.000 0.000 0.000 0.000 0.000 0.000 26.083 19.824 18.088 16.859 16.873 16.178
19
0.0000 0.0000 0.0027 0.0074 0.0127 0.0187 0.0283 0.0343 0.0437 0.0547 0.0680 0.0831 0.1021
0.000 0.000 24.902 21.840 20.419 19.401 18.809 17.810 17.178 16.584 16.015 15.487 14.946
20
0.0000 0.0000 0.0000 0.0000 0.0038 0.0138 0.0249 0.0388 0.0542 0.0724 0.0942 0.1197 0.1507
0.000 0.000 0.000 0.000 23.712 20.248 18.851 17.488 16.811 16.849 16.167 15.626 15.122
21
0.0000 0.0015 0.0085 0.0131 0.0208 0.0281 0.0388 0.0500 0.0622 0.0759 0.0922 0.1111 0.1361
0.000 25.987 22.200 20.340 19.182 18.246 17.490 16.822 16.248 15.724 15.212 14.723 14.190
22
0.0000 0.0000 0.0000 0.0051 0.0178 0.0323 0.0485 0.0672 0.0889 0.1139 0.1427 0.1759 0.2167
0.000 0.000 0.000 22.807 19.870 17.868 16.903 16.048 15.308 14.658 14.084 13.500 12.942
23
0.0000 0.0041 0.0145 0.0268 0.0412 0.0589 0.0746 0.0948 0.1184 0.1412 0.1708 0.2038 0.2454
0.000 23.408 20.088 18.481 17.330 16.483 15.783 15.141 14.600 14.092 13.581 13.127 12.639
24
0.0000 0.0000 0.0000 0.0114 0.0338 0.0575 0.0824 0.1097 0.1382 0.1703 0.2068 0.2482 0.3001
0.000 0.000 0.000 20.708 17.840 16.453 15.808 14.788 14.148 13.589 13.090 12.698 12.110
25
0.0000 0.0000 0.0038 0.0177 0.0348 0.0543 0.0782 0.1007 0.1293 0.1605 0.1971 0.2406 0.2828
0.000 0.000 23.817 18.855 17.794 16.808 15.718 14.860 14.323 13.784 13.218 12.692 12.175
26
0.0008 0.0077 0.0172 0.0278 0.0408 0.0543 0.0693 0.0851 0.1035 0.1227 0.1458 0.1715 0.2041
29.012 21.766 19.822 18.382 17.388 16.806 15.985 15.424 14.910 14.462 14.011 13.581 13.124
27
0.0000 0.0092 0.0228 0.0388 0.0570 0.0783 0.0983 0.1216 0.1478 0.1774 0.2107 0.2492 0.2965
0.000 21.278 18.907 17.490 16.479 15.711 15.044 14.485 13.970 13.493 13.041 12.599 12.143
28
0.0000 0.0000 0.0088 0.0318 0.0588 0.0873 0.1163 0.1470 0.1803 0.2171 0.2583 0.3053 0.3633

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0 000 0 000 22 428 16 00 16 396 15 351 14 602 13 988 12 480 11 987 10 507 9 001 8 608
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0 000 0 000 20 271 17 984 16 564 15 581 14 796 14 138 13 859 12 037 12 535 12 086 11 582
30
0 0029 0 0117 0 0237 0 0371 0 0521 0 0685 0 0866 0 1045 0 1248 0 1485 0 1718 0 2006 0 2367
24 302 20 837 18 785 17 809 16 712 15 993 15 379 14 884 14 424 13 895 13 576 13 168 12 748
31
0 0015 0 0153 0 0323 0 0525 0 0745 0 0983 0 1233 0 1507 0 1803 0 2127 0 2495 0 2934 0 3451
26 124 18 934 17 870 16 896 15 772 15 046 14 450 13 821 13 450 13 015 12 596 12 170 11 743
32
0 0000 0 0000 0 0232 0 0536 0 0855 0 1170 0 1496 0 1843 0 2207 0 2613 0 3058 0 3592 0 4216
0 000 0 000 18 845 16 839 15 413 14 567 13 941 13 392 12 919 12 475 12 061 11 638 11 217
33
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0 000 22 822 18 556 16 813 15 647 14 752 14 053 13 457 12 938 12 469 12 003 11 562 11 106
34
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0 000 0 000 0 000 0 000 0 000 0 000 0 000 27 875 24 777 23 203 22 068 21 130 20 280
35
0 0000 0 0005 0 0027 0 0063 0 0108 0 0168 0 0235 0 0313 0 0404 0 0512 0 0631 0 0777 0 0948
0 000 28 875 24 502 22 279 20 824 19 888 18 801 18 049 17 381 16 780 16 210 15 654 15 141
36
0 0000 0 0010 0 0048 0 0108 0 0176 0 0259 0 0367 0 0493 0 0631 0 0803 0 1000 0 1241 0 1543
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37
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27 190 22 342 20 271 18 820 17 748 16 938 16 272 15 717 15 237 14 805 14 388 13 992 13 586
38
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25 388 21 124 19 102 17 650 16 564 15 689 14 969 14 374 13 858 13 366 12 922 12 477 12 037
39
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23 545 19 934 18 014 16 867 15 667 14 878 14 251 13 720 13 257 12 836 12 428 12 029 11 626
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41
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42
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0 000 0 000 0 000 0 000 0 000 16 188 14 207 13 012 12 127 11 408 10 788 10 185 9 583
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45
0 0000 0 0011 0 0082 0 0187 0 0358 0 0584 0 0906 0 1314 0 1838 0 2480 0 3269 0 4286 0 5530
0 000 26 837 21 572 19 407 17 892 16 413 15 258 14 281 12 402 12 812 11 870 11 174 10 504
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47
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23 338 18 962 16 568 14 878 13 581 12 883 11 798 11 180 10 847 10 188 9 782 9 336 8 902
48
0 0000 0 0011 0 0023 0 0025 0 0040 0 0057 0 0082 0 0116 0 0164 0 0240 0 0311 0 0451 0 0630
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49
0 0031 0 0085 0 0141 0 0248 0 0428 0 0698 0 1075 0 1597 0 2273 0 3140 0 4200 0 5564 0 7248
24 094 22 127 20 155 18 850 17 248 16 345 14 809 12 788 12 841 11 992 11 227 10 468 9 782
50
0 0062 0 0133 0 0283 0 0574 0 1024 0 1652 0 2488 0 3494 0 4873 0 6000 0 7533 0 9348 0 1 1490
22 751 20 305 18 226 16 481 14 937 13 879 12 803 11 711 10 847 10 289 9 691 9 124 8 581
51
0 0000 0 0000 0 0000 0 0000 0 0007 0 0013 0 0020 0 0027 0 0035 0 0049 0 0084 0 0086 0 0108
0 000 0 000 0 000 0 000 28 201 26 348 25 252 24 483 23 844 22 827 22 231 21 443 20 820
52
0 0000 0 0000 0 0000 0 0020 0 0052 0 0187 0 0260 0 0342 0 0438 0 0539 0 0639 0 0733 0 0838
0 000 0 000 0 000 25 344 21 264 19 708 18 847 17 824 17 164 16 623 16 178 15 817 15 466
53
0 0000 0 0000 0 0000 0 0000 0 0000 0 0007 0 0027 0 0085 0 0083 0 0119 0 0158 0 0194 0 0233
0 000 0 000 0 000 0 000 28 170 24 498 22 641 21 543 20 894 19 881 18 311 16 828
54
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0 000 0 000 0 000 24 588 19 837 17 938 16 871 16 308 15 767 15 371 15 018 14 734 14 501
55
0 0126 0 0245 0 0408 0 0631 0 0718 0 0884 0 1177 0 1370 0 1585 0 1841 0 2106 0 2412 0 2768
20 441 18 892 17 387 16 668 16 870 15 283 14 671 14 172 13 773 13 394 13 042 12 886 12 344
56
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0 000 0 000 0 000 0 000 0 000 0 000 0 000 21 782 18 429 16 574 14 686 13 228
57
0 0000 0 0185 0 0518 0 0808 0 1327 0 1832 0 2388 0 3045 0 3817 0 4685 0 5264 0 6310 0 1 1081
0 000 18 442 16 729 15 260 14 255 13 407 12 701 12 071 11 478 10 841 10 178 9 433 8 476
58
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0 0000 0 0268 0 0767 0 1385 0 2133 0 2932 0 3841 0 4834 0 6031 0 7568 0 9670 1 2617 1 8235
0 006 16 568 16 731 14 143 12 009 12 172 11 469 10 857 10 276 9 879 9 035 8 294 7 367

0 0
0 0412 0 1032 0 1713 0 2424 0 3223 0 3978 0 4884 0 5894 0 7089 0 8649 1 0879 1 8225 2 0186
17 328 14 914 13 564 12 872 11 923 11 369 10 867 10 336 9 847 9 328 8 725 8 020 7 089

```

13. Appendix V - The hauling costs from truck to mill

Delivery Cost= 0.7616 + 0.03795(Haul Distance) +
65.7272(1/INSDIAM)

Units: Haul Distance: Km
INSDIAM: Cm (the utilization standard stump
diameter inside bark)
Delivery Cost: \$/m³

Determination of representative haul distances:

If(0 < Haul Distance <= 20) then

Haul Distance = 10 Km

Elseif(20 < Haul Distance <= 40) then

Haul Distance = 30 Km

Elseif(40 < Haul Distance <= 60) then

Haul Distance = 50 Km

Elseif(60 < Haul Distance <= 80) then

Haul Distance = 70 Km

Elseif(80 < Haul Distance <= 100) then

Haul Distance = 90 Km

Elseif(100 < Haul Distance <=120) then

Haul Distance = 110 Km

Endif

**14. Appendix VI - The average delivered wood costs
for compartment based management units
in working circle 1**

WORKING CIRCLE 1 (20km class grouped data for hauling cost)

First column the identity of stand
 Second column the identity of compartment
 Third column the area of stand in hectares
 Fourth column the age of stand
 Fifth column the yield stream identity for existing stand
 Sixth to Fifteenth the cost stream (\$/m3) for existing stand from 6 to 15 decades
 Sixteenth column the yield stream identity for regeneration stand
 Seventeenth to thirty the cost stream (\$/m3) for regeneration stand from 6 to 15 decades

The average delivered wood costs (woodlands cost + hauling cost) are below each compartment from 6 to 15 decades

1	1	412	95	2	0	0	0	0	0	0	28	1	25	8	24	5	23	4	22	6	21	8	21	1	16	22	8	21	5	20	5	19	9	18	4	19	0	18	6	18	2	17	8	17	4		
2	1	412	95	2	0	0	0	0	0	0	0	28	1	25	8	24	5	23	4	22	6	21	8	21	1	16	22	8	21	5	20	5	19	9	18	4	19	0	18	6	18	2	17	8	17	4	
3	1	103	125	2	0	0	0	0	0	0	0	0	28	1	25	8	24	5	23	4	22	6	21	8	21	1	16	22	8	21	5	20	5	19	9	18	4	19	0	18	6	18	2	17	8	17	4
4	1	103	125	2	0	0	0	0	0	0	0	0	28	1	25	8	24	5	23	4	22	6	21	8	21	1	16	22	8	21	5	20	5	19	9	18	4	19	0	18	6	18	2	17	8	17	4
5	1	103	205	2	0	0	0	0	0	0	0	0	28	1	25	8	24	5	23	4	22	6	21	8	21	1	16	22	8	21	5	20	5	19	9	18	4	19	0	18	6	18	2	17	8	17	4
6	1	103	205	2	0	0	0	0	0	0	0	0	28	1	25	8	24	5	23	4	22	6	21	8	21	1	16	22	8	21	5	20	5	19	9	18	4	19	0	18	6	18	2	17	8	17	4
7	1	103	75	3	0	0	28	9	28	0	24	4	23	3	22	5	21	7	21	0	20	4	19	8	16	22	8	21	5	20	5	19	9	18	4	19	0	18	6	18	2	17	8	17	4		
8	1	103	75	3	0	0	28	9	28	0	24	4	23	3	22	5	21	7	21	0	20	4	19	8	16	22	8	21	5	20	5	19	9	18	4	19	0	18	6	18	2	17	8	17	4		
9	1	103	145	3	0	0	28	9	28	0	24	4	23	3	22	5	21	7	21	0	20	4	19	8	16	22	8	21	5	20	5	19	9	18	4	19	0	18	6	18	2	17	8	17	4		
10	1	103	145	3	0	0	28	9	28	0	24	4	23	3	22	5	21	7	21	0	20	4	19	8	16	22	8	21	5	20	5	19	9	18	4	19	0	18	6	18	2	17	8	17	4		
11	1	3090	85	5	28	1	25	4	23	8	22	7	21	9	21	2	20	6	20	0	19	5	18	8	16	22	8	21	5	20	5	19	9	18	4	19	0	18	6	18	2	17	8	17	4		
12	1	3090	85	5	28	1	25	4	23	8	22	7	21	9	21	2	20	6	20	0	19	5	18	8	16	22	8	21	5	20	5	19	9	18	4	19	0	18	6	18	2	17	8	17	4		
13	1	103	115	5	28	1	25	4	23	8	22	7	21	9	21	2	20	6	20	0	19	5	18	8	16	22	8	21	5	20	5	19	9	18	4	19	0	18	6	18	2	17	8	17	4		
14	1	103	115	5	28	1	25	4	23	8	22	7	21	9	21	2	20	6	20	0	19	5	18	8	16	22	8	21	5	20	5	19	9	18	4	19	0	18	6	18	2	17	8	17	4		
15	1	208	125	5	28	1	25	4	23	8	22	7	21	9	21	2	20	6	20	0	19	5	18	8	16	22	8	21	5	20	5	19	9	18	4	19	0	18	6	18	2	17	8	17	4		
16	1	208	125	5	28	1	25	4	23	8	22	7	21	9	21	2	20	6	20	0	19	5	18	8	16	22	8	21	5	20	5	19	9	18	4	19	0	18	6	18	2	17	8	17	4		
17	1	1030	85	8	0	0	28	2	24	8	23	1	22	1	21	2	20	5	19	9	18	3	16	8	16	22	8	21	5	20	5	19	9	18	4	19	0	18	6	18	2	17	8	17	4		
18	1	1030	85	8	0	0	28	2	24	8	23	1	22	1	21	2	20	5	19	9	18	3	16	8	16	22	8	21	5	20	5	19	9	18	4	19	0	18	6	18	2	17	8	17	4		
19	1	515	95	10	24	7	23	7	22	9	22	2	21	6	21	2	20	6	20	1	19	5	19	2	16	22	8	21	5	20	5	19	9	18	4	19	0	18	6	18	2	17	8	17	4		
20	1	515	95	10	24	7	23	7	22	9	22	2	21	6	21	2	20	6	20	1	19	5	19	2	16	22	8	21	5	20	5	19	9	18	4	19	0	18	6	18	2	17	8	17	4		
21	1	412	95	14	22	4	21	6	21	0	20	5	20	1	19	7	19	3	19	0	18	6	18	2	16	22	8	21	5	20	5	19	9	18	4	19	0	18	6	18	2	17	8	17	4		
22	1	412	95	14	22	4	21	6	21	0	20	5	20	1	19	7	19	3	19	0	18	6	18	2	16	22	8	21	5	20	5	19	9	18	4	19	0	18	6	18	2	17	8	17	4		
23	1	518	95	15	22	7	21	6	20	8	20	1	19	6	19	2	18	7	18	4	18	0	17	6	16	22	8	21	5	20	5	19	9	18	4	19	0	18	6	18	2	17	8	17	4		
24	1	518	95	15	22	7	21	6	20	8	20	1	19	6	19	2	18	7	18	4	18	0	17	6	16	22	8	21	5	20	5	19	9	18	4	19	0	18	6	18	2	17	8	17	4		
25	1	103	95	16	22	8	21	5	20	6	19	8	19	4	19	0	18	6	18	2	17	8	17	4	16	22	8	21	5	20	5	19	9	18	4	19	0	18	6	18	2	17	8	17	4		
26	1	103	95	16	22	8	21	5	20	6	19	8	19	4	19	0	18	6	18	2	17	8	17	4	16	22	8	21	5	20	5	19	9	18	4	19	0	18	6	18	2	17	8	17	4		
27	1	208	35	18	0	0	0	0	0	0	0	32	3	28	2	24	4	23	2	22	3	21	5	28	24	3	22	7	21	5	20	5	19	9	18	4	19	0	18	6	18	2	17	8	17	4	
28	1	208	35	18	0	0	0	0	0	0	0	32	3	28	2	24	4	23	2	22	3	21	5	28	24	3	22	7	21	5	20	5	19	9	18	4	19	0	18	6	18	2	17	8	17	4	
29	1	827	85	22	29	1	25	9	24	3	23	2	22	3	21	6	20	9	20	3	19	8	18	2	28	24	3	22	7	21	5	20	5	19	9	18	4	19	0	18	6	18	2	17	8	17	4
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31	1	308	105	27	28	1	25	9	24	3	23	2	22	3	21	6	20	9	20	3	19	8	18	2	28	24	3	22	7	21	5	20	5	19	9	18	4	19	0	18	6	18	2	17	8	17	4
32	1	309	105	27	28	1	25	9	24	3	23	2	22	3	21	6	20	9	20	3	19	8	18	2	28	24	3	22	7	21	5	20	5	19	9	18	4	19	0	18	6	18	2	17	8	17	4
33	1	103	205	23	24	7	23	6	22	8	22	0	21	4	20	8	20	4	19	9	19	4	18	9	28	24	3	22	7	21	5	20	5	19	9	18	4	19	0	18	6	18	2	17	8	17	4
34	1	103	205	23	24	7	23	6	22	8	22	0	21	4	20	8	20	4	19	9	19	4	18	9	28	24	3	22	7	21	5	20	5	19	9	18	4	19	0	18	6	18	2	17	8	17	4
35	1	208	205	24	27	0	24	1	22	7	21	8	21	0	20	4	19	9	18	4	18	9	18	4	28	24	3	22	7	21	5	20	5	19	9	18	4	19	0	18	6	18	2	17	8	17	4
36	1	208	205	24	27	0	24	1	22	7	21	8	21	0	20	4	19	9	18	4	18	9	18	4	28	24	3	22	7	21	5	20	5	19	9	18	4	19	0	18	6	18	2	17	8	17	4
37	1	309	85	31	23	0	22	1	21	3	20	7	20	2	19	7	19	3	18	9	18	5	18	0	28	24	3	22	7	21	5	20	5	19	9	18	4	19	0	18	6	18	2	17	8	17	4
38	1	309	85	31	23	0	22	1	21	3	20	7	20	2	19	7																															

103	2	54	85	45	25	7	24	0	22	7	21	5	20	6	19	7	18	9	18	2	17	5	16	4	7	21	2	19	9	18	9	18	1	17	5	16	9	16	5	16	0	15	6	15	2																																																																																																																																																																																																																																																																																					
104	2	54	85	45	25	7	24	0	22	7	21	5	20	6	19	7	18	9	18	2	17	5	16	4	7	21	2	19	9	18	9	18	1	17	5	16	9	16	5	16	0	15	6	15	2																																																																																																																																																																																																																																																																																					
105	2	162	95	46	23	5	21	9	20	4	19	9	19	1	18	4	17	8	17	3	16	7	16	1	47	21	2	19	9	18	9	18	1	17	5	16	9	16	5	16	0	15	6	15	2																																																																																																																																																																																																																																																																																					
106	2	162	95	46	23	5	21	9	20	4	19	9	19	1	18	4	17	8	17	3	16	7	16	1	47	21	2	19	9	18	9	18	1	17	5	16	9	16	5	16	0	15	6	15	2																																																																																																																																																																																																																																																																																					
107	2	216	125	46	23	5	21	9	20	4	19	9	19	1	18	4	17	8	17	3	16	7	16	1	47	21	2	19	9	18	9	18	1	17	5	16	9	16	5	16	0	15	6	15	2																																																																																																																																																																																																																																																																																					
108	2	216	125	46	23	5	21	9	20	4	19	9	19	1	18	4	17	8	17	3	16	7	16	1	47	21	2	19	9	18	9	18	1	17	5	16	9	16	5	16	0	15	6	15	2																																																																																																																																																																																																																																																																																					
109	2	54	205	46	23	5	21	9	20	4	19	9	19	1	18	4	17	8	17	3	16	7	16	1	47	21	2	19	9	18	9	18	1	17	5	16	9	16	5	16	0	15	6	15	2																																																																																																																																																																																																																																																																																					
110	2	54	205	46	23	5	21	9	20	4	19	9	19	1	18	4	17	8	17	3	16	7	16	1	47	21	2	19	9	18	9	18	1	17	5	16	9	16	5	16	0	15	6	15	2																																																																																																																																																																																																																																																																																					
111	2	54	55	49	24	8	23	5	22	2	21	1	20	1	19	1	18	3	17	5	16	8	16	1	50	22	7	21	2	20	0	18	9	18	0	17	2	16	8	16	0	15	4	14	9																																																																																																																																																																																																																																																																																					
112	2	54	55	49	24	8	23	5	22	2	21	1	20	1	19	1	18	3	17	5	16	8	16	1	50	22	7	21	2	20	0	18	9	18	0	17	2	16	8	16	0	15	4	14	9																																																																																																																																																																																																																																																																																					
113	2	54	55	49	24	8	23	5	22	2	21	1	20	1	19	1	18	3	17	5	16	8	16	1	50	22	7	21	2	20	0	18	9	18	0	17	2	16	8	16	0	15	4	14	9																																																																																																																																																																																																																																																																																					
114	2	54	55	49	24	8	23	5	22	2	21	1	20	1	19	1	18	3	17	5	16	8	16	1	50	22	7	21	2	20	0	18	9	18	0	17	2	16	8	16	0	15	4	14	9																																																																																																																																																																																																																																																																																					
115	2	54	75	49	24	8	23	5	22	2	21	1	20	1	19	1	18	3	17	5	16	8	16	1	50	22	7	21	2	20	0	18	9	18	0	17	2	16	8	16	0	15	4	14	9																																																																																																																																																																																																																																																																																					
116	2	54	75	49	24	8	23	5	22	2	21	1	20	1	19	1	18	3	17	5	16	8	16	1	50	22	7	21	2	20	0	18	9	18	0	17	2	16	8	16	0	15	4	14	9																																																																																																																																																																																																																																																																																					
117	2	270	95	49	24	8	23	5	22	2	21	1	20	1	19	1	18	3	17	5	16	8	16	1	50	22	7	21	2	20	0	18	9	18	0	17	2	16	8	16	0	15	4	14	9																																																																																																																																																																																																																																																																																					
118	2	270	95	49	24	8	23	5	22	2	21	1	20	1	19	1	18	3	17	5	16	8	16	1	50	22	7	21	2	20	0	18	9	18	0	17	2	16	8	16	0	15	4	14	9																																																																																																																																																																																																																																																																																					
119	2	126	125	49	24	8	23	5	22	2	21	1	20	1	19	1	18	3	17	5	16	8	16	1	50	22	7	21	2	20	0	18	9	18	0	17	2	16	8	16	0	15	4	14	9																																																																																																																																																																																																																																																																																					
120	2	216	125	49	24	8	23	5	22	2	21	1	20	1	19	1	18	3	17	5	16	8	16	1	50	22	7	21	2	20	0	18	9	18	0	17	2	16	8	16	0	15	4	14	9																																																																																																																																																																																																																																																																																					
121	2	54	205	52	31	6	27	5	26	0	24	9	24	1	23	5	22	8	22	5	22	1	21	7	52	31	6	27	5	26	0	24	9	24	1	23	5	22	8	22	5	22	1	21	7																																																																																																																																																																																																																																																																																					
122	2	54	205	52	31	6	27	5	26	0	24	9	24	1	23	5	22	8	22	5	22	1	21	7	52	31	6	27	5	26	0	24	9	24	1	23	5	22	8	22	5	22	1	21	7																																																																																																																																																																																																																																																																																					
123	2	54	85	55	22	9	22	2	21	6	20	9	20	5	20	1	19	7	19	3	19	0	18	6	55	22	9	22	2	21	6	20	9	20	5	20	1	19	7	19	3	19	0	18	6																																																																																																																																																																																																																																																																																					
124	2	54	85	55	22	9	22	2	21	6	20	9	20	5	20	1	19	7	19	3	19	0	18	6	55	22	9	22	2	21	6	20	9	20	5	20	1	19	7	19	3	19	0	18	6																																																																																																																																																																																																																																																																																					
125	2	54	75	55	22	9	22	2	21	6	20	9	20	5	20	1	19	7	19	3	19	0	18	6	55	22	9	22	2	21	6	20	9	20	5	20	1	19	7	19	3	19	0	18	6																																																																																																																																																																																																																																																																																					
126	2	54	75	55	22	9	22	2	21	6	20	9	20	5	20	1	19	7	19	3	19	0	18	6	55	22	9	22	2	21	6	20	9	20	5	20	1	19	7	19	3	19	0	18	6																																																																																																																																																																																																																																																																																					
127	2	54	205	55	22	9	22	2	21	6	20	9	20	5	20	1	19	7	19	3	19	0	18	6	55	22	9	22	2	21	6	20	9	20	5	20	1	19	7	19	3	19	0	18	6																																																																																																																																																																																																																																																																																					
128	2	54	205	55	22	9	22	2	21	6	20	9	20	5	20	1	19	7	19	3	19	0	18	6	55	22	9	22	2	21	6	20	9	20	5	20	1	19	7	19	3	19	0	18	6																																																																																																																																																																																																																																																																																					
129	2	106	95	57	21	5	20	5	19	7	19	0	18	4	17	8	17	1	16	5	15	7	14	8	60	19	0	18	2	17	7	17	1	16	8	1	15	6	15	0	14	3	13	4																																																																																																																																																																																																																																																																																						
130	2	106	95	57	21	5	20	5	19	7	19	0	18	4	17	8	17	1	16	5	15	7	14	8	60	19	0	18	2	17	7	17	1	16	8	1	15	6	15	0	14	3	13	4																																																																																																																																																																																																																																																																																						
131	2	54	125	57	21	5	20	5	19	7	19	0	18	4	17	8	17	1	16	5	15	7	14	8	60	19	0	18	2	17	7	17	1	16	8	1	15	6	15	0	14	3	13	4																																																																																																																																																																																																																																																																																						
132	2	54	125	57	21	5	20	5	19	7	19	0	18	4	17	8	17	1	16	5	15	7	14	8	60	19	0	18	2	17	7	17	1	16	8	1	15	6	15	0	14	3	13	4																																																																																																																																																																																																																																																																																						
133	2	54	75	58	20	9	19	7	18	8	18	1	17	4	16	8	16	2	15	5	14	8	13	8	59	20	4	19	3	18	5	17	8	17	1	16	6	16	0	15	3	14	8	13	7																																																																																																																																																																																																																																																																																					
134	2	54	75	58	20	9	19	7	18	8	18	1	17	4	16	8	16	2	15	5	14	8	13	8	59	20	4	19	3	18	5	17	8	17	1	16	6	16	0	15	3	14	8	13	7																																																																																																																																																																																																																																																																																					
135	2	324	95	58	20	9	19	7	18	8	18	1	17	4	16	8	16	2	15	5	14	8	13	8	59	20	4	19	3	18	5	17	8	17	1	16	6	16	0	15	3	14	8	13	7																																																																																																																																																																																																																																																																																					
136	2	324	95	58	20	9	19	7	18	8	18	1	17	4	16	8	16	2	15	5	14	8	13	8	59	20	4	19	3	18	5	17	8	17	1	16	6	16	0	15	3	14	8	13	7																																																																																																																																																																																																																																																																																					
137	2	54	125	58	20	9	19	7	18	8	18	1	17	4	16	8	16	2	15	5	14	8	13	8	59	20	4	19	3	18	5	17	8	17	1	16	6	16	0	15	3	14	8	13	7																																																																																																																																																																																																																																																																																					
138	2	54	125	58	20	9	19	7	18	8	18	1	17	4	16	8	16	2	15	5	14	8	13	8	59	20	4	19	3	18	5	17	8	17	1	16	6	16	0	15	3	14	8	13	7																																																																																																																																																																																																																																																																																					
		6372	111				24	282	22	822	21	498	20	522	18	718	18	893	18	598	17	883	17	246	16	585																																																																																																																																																																																																																																																																																																								</

164	3	59	205	45	25.7	24.0	22.7	21.8	20.8	19.7	18.9	18.2	17.5	16.8	16.1	15.4	14.7	21.2	18.9	18.9	18.1	17.8	16.8	16.5	15.6	14.8	13.7
165	3	58	205	46	25.3	21.9	20.8	19.9	19.1	18.4	17.8	17.3	16.7	16.1	15.4	14.7	21.2	18.9	18.9	18.1	17.5	16.8	16.5	15.6	14.8	13.7	
166	3	58	205	46	25.3	21.9	20.8	19.9	19.1	18.4	17.8	17.3	16.7	16.1	15.4	14.7	21.2	18.9	18.9	18.1	17.5	16.8	16.5	15.6	14.8	13.7	
167	3	59	5	54	30.9	25.8	24.2	23.3	22.6	22.1	21.7	21.3	21.0	20.8	54	30.9	25.8	24.2	23.3	22.6	22.1	21.7	21.3	21.0	20.8		
168	3	59	5	54	30.9	25.8	24.2	23.3	22.6	22.1	21.7	21.3	21.0	20.8	54	30.9	25.8	24.2	23.3	22.6	22.1	21.7	21.3	21.0	20.8		
169	3	59	55	58	20.9	19.7	18.8	18.1	17.4	16.8	16.2	15.5	14.8	13.8	59	20.4	19.3	18.5	17.8	17.1	16.6	16.0	15.3	14.6	13.7		
170	3	59	55	58	20.9	19.7	18.8	18.1	17.4	16.8	16.2	15.5	14.8	13.8	59	20.4	19.3	18.5	17.8	17.1	16.6	16.0	15.3	14.6	13.7		
171	3	59	5	58	20.4	19.3	18.5	17.8	17.1	16.6	16.0	15.3	14.8	13.7	59	20.4	19.3	18.5	17.8	17.1	16.6	16.0	15.3	14.6	13.7		
172	3	59	5	58	20.4	19.3	18.5	17.8	17.1	16.6	16.0	15.3	14.8	13.7	59	20.4	19.3	18.5	17.8	17.1	16.6	16.0	15.3	14.6	13.7		
		2596	142.		24.881	22.944	21.848	21.830	20.772	20.073	18.485	18.874	18.318	17.739													
					22.828	21.092	20.211	19.417	18.797	18.288	17.798	17.384	16.908	16.440													
173	4	62	35	2	0.0	0.0	0.0	28.1	25.8	24.5	23.4	22.6	21.8	21.1	18	22.8	21.8	20.8	19.9	18.4	18.0	16.8	16.2	17.8	17.4		
174	4	62	35	2	0.0	0.0	0.0	28.1	25.8	24.5	23.4	22.6	21.8	21.1	18	22.8	21.8	20.8	19.9	18.4	18.0	16.8	16.2	17.8	17.4		
175	4	124	105	22	28.1	25.8	24.3	23.2	22.3	21.6	20.8	20.3	19.6	19.2	28	24.3	22.7	21.6	20.8	20.3	19.7	19.2	18.8	18.3	17.9		
176	4	124	105	22	28.1	25.8	24.3	23.2	22.3	21.6	20.8	20.3	19.6	19.2	28	24.3	22.7	21.6	20.8	20.3	19.7	19.2	18.8	18.3	17.9		
177	4	62	125	31	23.0	22.1	21.3	20.7	20.2	19.7	19.3	18.9	18.5	18.0	28	24.3	22.7	21.6	20.8	20.3	19.7	19.2	18.8	18.3	17.9		
178	4	62	125	31	23.0	22.1	21.3	20.7	20.2	19.7	19.3	18.9	18.5	18.0	28	24.3	22.7	21.6	20.8	20.3	19.7	19.2	18.8	18.3	17.9		
179	4	62	205	41	25.8	24.3	23.3	22.5	21.8	21.2	20.7	20.2	19.7	19.2	43	0.0	0.0	22.5	20.5	19.3	18.4	17.7	17.1	16.4	15.8		
180	4	62	205	41	25.8	24.3	23.3	22.5	21.8	21.2	20.7	20.2	19.7	19.2	43	0.0	0.0	22.5	20.5	19.3	18.4	17.7	17.1	16.4	15.8		
181	4	62	205	42	25.8	23.1	21.7	20.5	19.8	18.8	18.1	17.4	16.8	16.2	43	0.0	0.0	22.5	20.5	19.3	18.4	17.7	17.1	16.4	15.8		
182	4	62	205	42	25.8	23.1	21.7	20.5	19.8	18.8	18.1	17.4	16.8	16.2	43	0.0	0.0	22.5	20.5	19.3	18.4	17.7	17.1	16.4	15.8		
183	4	126	125	43	0.0	0.0	22.5	20.5	19.3	18.4	17.7	17.1	16.4	15.8	43	0.0	0.0	22.5	20.5	19.3	18.4	17.7	17.1	16.4	15.8		
184	4	126	125	43	0.0	0.0	22.5	20.5	19.3	18.4	17.7	17.1	16.4	15.8	43	0.0	0.0	22.5	20.5	19.3	18.4	17.7	17.1	16.4	15.8		
185	4	62	205	43	0.0	0.0	22.5	20.5	19.3	18.4	17.7	17.1	16.4	15.8	43	0.0	0.0	22.5	20.5	19.3	18.4	17.7	17.1	16.4	15.8		
186	4	62	205	43	0.0	0.0	22.5	20.5	19.3	18.4	17.7	17.1	16.4	15.8	43	0.0	0.0	22.5	20.5	19.3	18.4	17.7	17.1	16.4	15.8		
187	4	62	205	44	0.0	0.0	0.0	0.0	0.0	0.0	27.8	23.7	21.8	20.4	44	0.0	0.0	0.0	0.0	0.0	0.0	27.8	23.7	21.8	20.4		
188	4	62	205	44	0.0	0.0	0.0	0.0	0.0	0.0	27.8	23.7	21.8	20.4	44	0.0	0.0	0.0	0.0	0.0	0.0	27.8	23.7	21.8	20.4		
189	4	188	35	46	23.5	21.9	20.8	19.9	19.1	18.4	17.8	17.3	16.7	16.1	47	21.2	18.9	18.9	18.1	17.5	16.8	16.5	15.6	14.8	13.7		
190	4	188	35	46	23.5	21.9	20.8	19.9	19.1	18.4	17.8	17.3	16.7	16.1	47	21.2	18.9	18.9	18.1	17.5	16.8	16.5	15.6	14.8	13.7		
191	4	188	115	46	23.5	21.9	20.8	19.9	19.1	18.4	17.8	17.3	16.7	16.1	47	21.2	18.9	18.9	18.1	17.5	16.8	16.5	15.6	14.8	13.7		
192	4	188	115	46	23.5	21.9	20.8	19.9	19.1	18.4	17.8	17.3	16.7	16.1	47	21.2	18.9	18.9	18.1	17.5	16.8	16.5	15.6	14.8	13.7		
193	4	188	125	46	23.5	21.9	20.8	19.9	19.1	18.4	17.8	17.3	16.7	16.1	47	21.2	18.9	18.9	18.1	17.5	16.8	16.5	15.6	14.8	13.7		
194	4	188	125	46	23.5	21.9	20.8	19.9	19.1	18.4	17.8	17.3	16.7	16.1	47	21.2	18.9	18.9	18.1	17.5	16.8	16.5	15.6	14.8	13.7		
195	4	62	205	46	23.5	21.9	20.8	19.9	19.1	18.4	17.8	17.3	16.7	16.1	47	21.2	18.9	18.9	18.1	17.5	16.8	16.5	15.6	14.8	13.7		
196	4	62	205	46	23.5	21.9	20.8	19.9	19.1	18.4	17.8	17.3	16.7	16.1	47	21.2	18.9	18.9	18.1	17.5	16.8	16.5	15.6	14.8	13.7		
197	4	62	55	49	24.9	22.2	21.5	20.9	19.1	18.3	17.5	16.8	16.1	15.0	22	7.7	21.2	20.0	18.9	18.0	17.2	16.8	16.0	15.4	14.8		
198	4	62	55	49	24.9	22.2	21.5	20.9	19.1	18.3	17.5	16.8	16.1	15.0	22	7.7	21.2	20.0	18.9	18.0	17.2	16.8	16.0	15.4	14.8		
199	4	62	205	55	24.9	22.2	21.5	20.9	20.6	20.7	19.3	19.0	18.5	18.0	22	8.9	22.2	21.6	20.9	20.5	20.1	19.7	19.3	19.0	18.6		
200	4	62	205	55	24.9	22.2	21.5	20.9	20.6	20.7	19.3	19.0	18.5	18.0	22	8.9	22.2	21.6	20.9	20.5	20.1	19.7	19.3	19.0	18.6		
201	4	62	75	58	20.9	19.7	18.8	18.1	17.4	16.8	16.2	15.5	14.8	13.8	59	20.4	18.3	18.5	17.8	17.1	16.6	16.0	15.3	14.6	13.7		
202	4	62	75	58	20.9	19.7	18.8	18.1	17.4	16.8	16.2	15.5	14.8	13.8	59	20.4	18.3	18.5	17.8	17.1	16.6	16.0	15.3	14.6	13.7		
203	4	62	55	58	20.9	19.7	18.8	18.1	17.4	16.8	16.2	15.5	14.8	13.8	59	20.4	18.3	18.5	17.8	17.1	16.6	16.0	15.3	14.6	13.7		
204	4	62	55	58	20.9	19.7	18.8	18.1	17.4	16.8	16.2	15.5	14.8	13.8	59	20.4	18.3	18.5	17.8	17.1	16.6	16.0	15.3	14.6	13.7		
205	4	124	125	58	20.9	19.7	18.8	18.1	17.4	16.8	16.2	15.5	14.8	13.8	59	20.4	18.3	18.5	17.8	17.1	16.6	16.0	15.3	14.6	13.7		
206	4	124	125	58	20.9	19.7	18.8	18.1	17.4	16.8	16.2	15.5	14.8	13.8	59	20.4	18.3	18.5	17.8	17.1	16.6	16.0	15.3	14.6	13.7		
		3348	122.		23.777	22.144	21.285	20.507	19.643	18.818	18.634	17.882	17.244	16.592													
					21.735	20.435	20.184	19.123	18.371	17.749	17.593	16.849	16.379	15.802													
207	5	130	85	41	25.1	23.5	22.5	21.7	21.1	20.5	20.0	19.4	18.9	18.4	43	0.0	0.0	21.7	19.7	18.5	17.7	16.8	16.3	15.7	15.1		
208	5	130	85	41	25.1	23.5	22.5	21.7	21.1	20.5	20.0	19.4	18.9	18.4	43	0.0	0.0	21.7	19.7	18.5	17.7	16.8	16.3	15.7	15.1		
209	5	85	55	48	24.2	22.8	21.5	20.9	20.3	19.7	19.0	18.5	18.0	17.5	22	0.0	18.9	18.0	17.2	16.8	16.0	15.4	14.8	14.1			
210	5	85	55	48	24.2	22.8	21.5	20.9	20.3	19.7	19.0	18.5	18.0	17.5	22	0.0	18.9	18.0	17.2	16.8	16.0	15.4	14.8	14.1			
		390	95		24.789	23.273	22.181	21.270	20.470	19.772	19.143	18.542	17.981	17.377													
					21.564	20.480	20.862	19.196	18.102	17.257	16.558	15.933	15.341	14.772													
211	6	60	65	22	28.3	25.1	23.5	22.4	21.6	20.8	20.2	19.6	19.0	18.5	28	23.5	21.8	20.9	20.1	19.5	19.0	18.5	15.0	17.8	17.1		
212	6	60	65	22	28.3	25.1	23.5	22.4	21.6	20.8	20.2	19.6	19.0	18.5	28	23.5	21.8	20.9	20.1	19.5	19.0	18.5	18.0	17.8	17.1		
213																											

344	13	126	5	14	22	4	21	6	21	0	20	5	20	1	19	7	19	3	19	0	18	6	18	2	16	22	6	21	5	20	6	19	9	19	4	19	0	18	5	18	2	17	8	17	4
346	13	126	5	14	22	4	21	6	21	0	20	5	20	1	19	7	19	3	19	0	18	6	18	2	16	22	6	21	5	20	6	19	9	19	4	19	0	18	5	18	2	17	8	17	4
382	13	63	5	54	30	9	25	8	24	2	23	3	22	6	22	1	21	7	21	3	21	0	20	8	54	30	9	25	8	24	2	23	3	22	6	22	1	21	7	21	3	21	0	20	8
381	13	63	5	54	30	9	25	8	24	2	23	3	22	6	22	1	21	7	21	3	21	0	20	8	54	30	9	25	8	24	2	23	3	22	6	22	1	21	7	21	3	21	0	20	8
349	13	63	15	14	22	4	21	6	21	0	20	5	20	1	19	7	19	3	19	0	18	6	18	2	16	22	6	21	5	20	6	19	9	19	4	19	0	18	5	18	2	17	8	17	4
350	13	63	15	14	22	4	21	6	21	0	20	5	20	1	19	7	19	3	19	0	18	6	18	2	16	22	6	21	5	20	6	19	9	19	4	19	0	18	5	18	2	17	8	17	4
359	13	126	15	28	24	3	22	7	21	6	20	8	19	0	19	7	19	3	19	0	18	6	18	2	16	22	6	21	5	20	6	19	9	19	4	19	0	18	5	18	2	17	8	17	4
368	13	126	15	28	24	3	22	7	21	6	20	8	19	0	19	7	19	3	19	0	18	6	18	2	16	22	6	21	5	20	6	19	9	19	4	19	0	18	5	18	2	17	8	17	4
369	13	126	15	46	23	5	21	9	20	8	19	9	19	1	18	4	17	17	17	17	17	17	17	17	47	21	2	19	9	18	1	17	5	16	9	16	5	16	0	16	15	2			
367	13	126	15	46	23	5	21	9	20	8	19	9	19	1	18	4	17	17	17	17	17	17	17	17	47	21	2	19	9	18	1	17	5	16	9	16	5	16	0	16	15	2			
376	13	63	15	50	22	7	21	2	20	8	19	9	18	0	17	2	16	6	16	0	15	4	14	9	50	22	7	21	2	20	0	18	1	16	0	17	2	16	5	16	0	16	14	9	
375	13	63	15	50	22	7	21	2	20	8	19	9	18	0	17	2	16	6	16	0	15	4	14	9	50	22	7	21	2	20	0	18	1	16	0	17	2	16	5	16	0	16	14	9	
361	13	252	25	15	22	7	21	6	20	8	20	1	19	5	19	2	18	7	18	4	18	0	17	6	16	22	6	21	5	20	6	19	9	19	4	19	0	18	5	18	2	17	8	17	4
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358	13	315	25	27	23	21	8	5	20	8	19	8	18	4	19	0	18	6	16	2	17	8	16	22	6	21	5	20	6	19	9	19	4	19	0	18	5	18	2	17	8	17	4		
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377	13	189	25	50	22	7	21	2	20	8	19	9	18	0	17	2	16	6	16	0	15	4	14	9	50	22	7	21	2	20	0	18	1	16	0	17	2	16	5	16	0	16	14	9	
384	13	126	25	54	30	9	25	8	24	2	23	3	22	6	22	1	21	7	21	3	21	0	20	8	54	30	9	25	8	24	2	23	3	22	6	22	1	21	7	21	3	21	0	20	8
383	13	126	25	54	30	9	25	8	24	2	23	3	22	6	22	1	21	7	21	3	21	0	20	8	54	30	9	25	8	24	2	23	3	22	6	22	1	21	7	21	3	21	0	20	8
387	13	63	25	55	22	8	22	2	21	6	20	8	20	5	20	1	19	7	19	3	19	0	18	6	55	22	8	22	2	21	6	20	8	20	5	20	1	19	7	19	3	19	0	18	6
386	13	63	25	55	22	8	22	2	21	6	20	8	20	5	20	1	19	7	19	3	19	0	18	6	55	22	8	22	2	21	6	20	8	20	5	20	1	19	7	19	3	19	0	18	6
372	13	189	25	46	23	5	21	9	20	8	19	9	18	1	18	4	17	8	17	3	16	7	16	1	47	21	2	19	9	18	1	18	1	17	5	16	9	16	5	16	0	16	15	2	
371	13	189	25	46	23	5	21	9	20	8	19	9	18	1	18	4	17	8	17	3	16	7	16	1	47	21	2	19	9	18	1	18	1	17	5	16	9	16	5	16	0	16	15	2	
380	13	252	35	50	22	7	21	2	20	8	19	9	18	0	17	2	16	6	16	0	15	4	14	9	50	22	7	21	2	20	0	18	1	16	0	17	2	16	5	16	0	16	14	9	

3565	13	63	205	21	26	6	25	4	24	5	23	8	23	1	22	5	22	0	21	5	21	0	20	5	28	24	3	22	7	21	8	20	9	20	3	19	7	18	2	18	6	18	3	17	9
3566	13	63	205	21	26	6	25	4	24	5	23	8	23	1	22	5	22	0	21	5	21	0	20	5	28	24	3	22	7	21	8	20	9	20	3	19	7	18	2	18	6	18	3	17	9
3567	13	126	205	42	25	6	23	1	21	7	20	5	18	6	18	8	1	17	4	16	8	16	2	43	2	0	22	5	22	0	20	5	28	24	3	18	4	17	7	1	16	4	15	9	
3568	13	126	205	42	25	6	23	1	21	7	20	5	18	6	18	8	1	17	4	16	8	16	2	43	2	0	22	5	22	0	20	5	28	24	3	18	4	17	7	1	16	4	15	9	
3569	13	126	205	42	25	6	23	1	21	7	20	5	18	6	18	8	1	17	4	16	8	16	2	43	2	0	22	5	22	0	20	5	28	24	3	18	4	17	7	1	16	4	15	9	
3570	13	126	205	42	25	6	23	1	21	7	20	5	18	6	18	8	1	17	4	16	8	16	2	43	2	0	22	5	22	0	20	5	28	24	3	18	4	17	7	1	16	4	15	9	
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3573	13	126	205	42	25	6	23	1	21	7	20	5	18	6	18	8	1	17	4	16	8	16	2	43	2	0	22	5	22	0	20	5	28	24	3	18	4	17	7	1	16	4	15	9	
3574	13	126	205	42	25	6	23	1	21	7	20	5	18	6	18	8	1	17	4	16	8	16	2	43	2	0	22	5	22	0	20	5	28	24	3	18	4	17	7	1	16	4	15	9	
3575	13	126	205	42	25	6	23	1	21	7	20	5	18	6	18	8	1	17	4	16	8	16	2	43	2	0	22	5	22	0	20	5	28	24	3	18	4	17	7	1	16	4	15	9	
3576	13	126	205	42	25	6	23	1	21	7	20	5	18	6	18	8	1	17	4	16	8	16	2	43	2	0	22	5	22	0	20	5	28	24	3	18	4	17	7	1	16	4	15	9	
3577	13	126	205	42	25	6	23	1	21	7	20	5	18	6	18	8	1	17	4	16	8	16	2	43	2	0	22	5	22	0	20	5	28	24	3	18	4	17	7	1	16	4	15	9	
3578	13	126	205	42	25	6	23	1	21	7	20	5	18	6	18	8	1	17	4	16	8	16	2	43	2	0	22	5	22	0	20	5	28	24	3	18	4	17	7	1	16	4	15	9	
3579	13	126	205	42	25	6	23	1	21	7	20	5	18	6	18	8	1	17	4	16	8	16	2	43	2	0	22	5	22	0	20	5	28	24	3	18	4	17	7	1	16	4	15	9	
3580	13	126	205	42	25	6	23	1	21	7	20	5	18	6	18	8	1	17	4	16	8	16	2	43	2	0	22	5	22	0	20	5	28	24	3	18	4	17	7	1	16	4	15	9	
3581	13	126	205	42	25	6	23	1	21	7	20	5	18	6	18	8	1	17	4	16	8	16	2	43	2	0	22	5	22	0	20	5	28	24	3	18	4	17	7	1	16	4	15	9	
3582	205	25	670	22	810	21	818	20	648	18	653	18	217	20	187	18	591	18	683	16	573	16	691	16	685	16	228	17	788	17	368														

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707	21	63	125	5	28	9	26	1	24	6	23	5	22	7	22	0	21	3	20	8	20	2	19	7	16	23	8	22	2	21	4	20	7	20	2	19	7	19	3	19	0	18	6	18	2	
708	21	63	125	5	28	9	26	1	24	6	23	5	22	7	22	0	21	3	20	8	20	2	19	7	16	23	8	22	2	21	4	20	7	20	2	19	7	19	3	19	0	18	6	18	2	
709	21	63	98	11	23	2	22	4	21	6	23	5	20	8	20	2	20	1	19	7	18	3	18	0	18	2	22	2	21	4	20	7	20	2	19	7	19	3	19	0	18	6	18	2		
710	21	63	98	14	23	2	22	4	21	6	23	5	20	8	20	2	20	1	19	7	18	3	18	0	18	2	22	2	21	4	20	7	20	2	19	7	19	3	19	0	18	6	18	2		
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712	21	63	105	15	23	2	22	4	21	6	23	5	20	9	20	4	19	8	19	1	18	7	18	3	18	2	22	2	21	4	20	7	20	2	19	7	19	3	19	0	18	6	18	2		
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714	21	63	125	22	28	9	26	8	26	0	23	9	23	1	22	4	21	7	21	1	20	5	20	0	28	26	0	23	4	22	4	21	6	21	0	20	5	20	0	19	5	19	1	18	7	
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1156	31	62	115	43	0	0	0	0	0	0	22	5	20	5	19	3	18	4	17	7	17	1	16	5	15	7	14	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1157	31	62	105	57	21	5	20	5	19	7	19	0	18	4	17	8	17	1	16	5	15	7	14	8	0	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1158	31	62	105	57	21	5	20	5	19	7	19	0	18	4	17	8	17	1	16	5	15	7	14	8	0	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1159	31	124	105	58	20	9	19	7	18	8	18	1	17	4	16	8	16	2	15	5	14	8	13	8	59	20	4	19	3	18	5	17	8	17	1	16	6	16	0	15	3	14	6	13	7					
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1162	31	82	115	58	20	9	19	7	18	8	18	1	17	4	16	8	16	2	15	5	14	8	13	8	59	20	4	19	3	18	5	17	8	17	1	16	6	16	0	15	3	14	6	13	7					
3477	110	23	614	22	528	21	500	20	699	20	511	20	114	19	425	18	857	18	317	17	753																													
		22	598	21	369	20	552	19	639	19	265	19	171	18	560	18	087	17	600	17	085																													

1167 32	118	115	5	28	8	28	1	24	6	23	5	22	7	22	0	21	3	20	8	20	2	19	7	16	23	8	22	2	21	4	20	7	20	2	19	7	19	3	19	0	18	6	18	2
1168 32	118	115	5	28	8	28	1	24	6	23	5	22	7	22	0	21	3	20	8	20	2	19	7	16	23	8	22	2	21	4	20	7	20	2	19	7	19	3	19	0	18	6	18	2
1169 32	59	115	6	0	0	30	0	25	8	23	9	22	8	22	0	21	3	20	8	20	1	19	5	16	23	8	22	2	21	4	20	7	20	2	19	7	19	3	19	0	18	6	18	2
1170 32	59	115	6	0	0	30	0	25	8	23	9	22	8	22	0	21	3	20	8	20	1	19	5	16	23	8	22	2	21	4	20	7	20	2	19	7	19	3	19	0	18	6	18	2
1171 32	59	105	10	25	4	24	5	23	6	23	0	22	4	21	8	21	3	20	8	20	4	19	9	16	23	8	22	2	21	4	20	7	20	2	19	7	19	3	19	0	18	6	18	2
1172 32	59	105	10	25	4	24	5	23	6	23	0	22	4	21	8	21	3	20	8	20	4	19	9	16	23	8	22	2	21	4	20	7	20	2	19	7	19	3	19	0	18	6	18	2
1173 32	59	135	11	23	8	22	9	22	3	21	7	21	3	20	8	20	4	20	0	19	8	18	2	16	23	8	22	2	21	4	20	7	20	2	19	7	19	3	19	0	18	6	18	2
1174 32	59	135	11	23	8	22	9	22	3	21	7	21	3	20	8	20	4	20	0	19	8	18	2	16	23	8	22	2	21	4	20	7	20	2	19	7	19	3	19	0	18	6	18	2
1175 32	59	105	14	23	2	22	4	21	8	21	3	20	8	20	5	20	1	19	7	18	4	19	0	16	23	8	22	2	21	4	20	7	20	2	19	7	19	3	19	0	18	6	18	2
1176 32	59	105	14	23	2	22	4	21	8	21	3	20	8	20	5	20	1	19	7	18	4	19	0	16	23	8	22	2	21	4	20	7	20	2	19	7	19	3	19	0	18	6	18	2
1177 32	118	115	14	23	2	22	4	21	8	21	3	20	8	20	5	20	1	19	7	18	4	19	0	16	23	8	22	2	21	4	20	7	20	2	19	7	19	3	19	0	18	6	18	2
1178 32	118	115	14	23	2	22	4	21	8	21	3	20	8	20	5	20	1	19	7	18	4	19	0	16	23	8	22	2	21	4	20	7	20	2	19	7	19	3	19	0	18	6	18	2
1179 32	118	105	15	23	4	21	8	21	3	20	8	20	5	20	1	19	7	18	4	19	0	16	23	8	22	2	21	4	20	7	20	2	19	7	19	3	19	0	18	6	18	2		
1180 32	177	105	15	23	4	21	8	21	3	20	8	20	5	20	1	19	7	18	4	19	0	16	23	8	22	2	21	4	20	7	20	2	19	7	19	3	19	0	18	6	18	2		
1181 32	59	95	16	23	8	22	2	21	4	20	7	20	2	19	7	19	3	19	0	18	6	18	2	16	23	8	22	2	21	4	20	7	20	2	19	7	19	3	19	0	18	6	18	2
1182 32	59	95	16	23	8	22	2	21	4	20	7	20	2	19	7	19	3	19	0	18	6	18	2	16	23	8	22	2	21	4	20	7	20	2	19	7	19	3	19	0	18	6	18	2
1183 32	59	105	16	23	8	22	2	21	4	20	7	20	2	19	7	19	3	19	0	18	6	18	2	16	23	8	22	2	21	4	20	7	20	2	19	7	19	3	19	0	18	6	18	2
1184 32	59	105	16	23	8	22	2	21	4	20	7	20	2	19	7	19	3	19	0	18	6	18	2	16	23	8	22	2	21	4	20	7	20	2	19	7	19	3	19	0	18	6	18	2
1185 32	59	115	22	29	8	26	6	25	0	23	8	23	1	22	4	21	7	21	1	20	5	20	0	28	25	0	23	4	22	4	21	8	21	0	20	5	20	0	19	5	19	1	18	7
1186 32	59	115	22	29	8	26	6	25	0	23	8	23	1	22	4	21	7	21	1	20	5	20	0	28	25	0	23	4	22	4	21	8	21	0	20	5	20	0	19	5	19	1	18	7
1187 32	59	135	28	25	0	23	4	22	0	21	6	21	0	20	8	20	0	19	8	19	1	18	7	28	25	0	23	4	22	4	21	8	21	0	20	5	20	0	19	5	19	1	18	7
1188 32	59	135	28	25	0	23	4	22	0	21	6	21	0	20	8	20	0	19	8	19	1	18	7	28	25	0	23	4	22	4	21	8	21	0	20	5	20	0	19	5	19	1	18	7
1189 32	177	118	32	23	7	22	6	21	6	19	2	20	0	20	19	19	19	18	18	17	18	3	28	25	0	23	4	22	4	21	8	21	0	20	5	20	0	19	5	19	1	18	7	
1190 32	177	118	32	23	7	22	6	21	6	19	2	20	0	20	19	19	19	18	18	17	18	3	28	25	0	23	4	22	4	21	8	21	0	20	5	20	0	19	5	19	1	18	7	
1191 32	59	105	35	29	3	27	9	26	7	25	8	25	1	24	4	23	23	3	22	7	22	2	29	23	7	22	7	21	9	21	3	20	8	20	3	19	9	19	5	19	1	18	7	
1192 32	59	105	35	29	3	27	9	26	7	25	8	25	1	24	4	23	7	23	3	22	7	22	2	29	23	7	22	7	21	9	21	3	20	8	20	3	19	9	19	5	19	1	18	7
1193 32	118	105	38	24	7	23	6	22	7	22	0	21	4	20	8	20	4	20	0	19	8	19	1	38	23	7	22	7	21	9	21	3	20	8	20	3	19	9	19	5	19	1	18	7
1194 32	118	105	38	24	7	23	6	22	7	22	0	21	4	20	8	20	4	20	0	19	8	19	1	38	23	7	22	7	21	9	21	3	20	8	20	3	19	9	19	5	19	1	18	7

1252	33	106	85	82	32	4	28	3	28	8	25	7	24	8	24	2	23	7	23	2	22	8	22	5	52	32	4	28	3	28	8	25	4	24	9	24	2	23	4	23	2	22	9	21	4
1253	33	83	85	84	31	6	26	6	25	0	24	0	23	4	22	8	22	4	22	1	21	8	21	5	54	31	8	26	6	25	0	24	0	23	4	22	8	22	4	22	1	21	8	21	4
1254	33	83	85	84	31	6	26	6	25	0	24	0	23	4	22	8	22	4	22	1	21	8	21	5	54	31	8	26	6	25	0	24	0	23	4	22	8	22	4	22	1	21	8	21	4
1255	33	53	115	84	31	6	26	6	25	0	24	0	23	4	22	8	22	4	22	1	21	8	21	5	54	31	8	26	6	25	0	24	0	23	4	22	8	22	4	22	1	21	8	21	4
1256	33	53	115	84	31	6	26	6	25	0	24	0	23	4	22	8	22	4	22	1	21	8	21	5	54	31	8	26	6	25	0	24	0	23	4	22	8	22	4	22	1	21	8	21	4
1257	33	854	95	84	21	6	20	5	19	6	18	8	18	2	17	6	17	0	16	3	15	5	14	8	58	21	2	20	1	19	2	18	5	17	9	17	3	16	1	15	3	14	4		
1258	33	854	95	84	21	6	20	5	19	6	18	8	18	2	17	6	17	0	16	3	15	5	14	8	58	21	2	20	1	19	2	18	5	17	9	17	3	16	1	15	3	14	4		
		6042	101			24	788	23	982	22	821	21	875	21	321	20	546	19	881	18	253	18	623	17	945																				
						23	374	22	856	21	918	21	016	20	304	19	700	19	122	18	574	18	003	17	389																				

**15. Appendix VII - Stand based management units
for Model 5 in working circle 1**

Stand-based management units of Working Circle 1
based on age, site productivity, and
haul distance in 20 Km class intervals (0 - 20, 21 - 40, 41 - 60, etc.)

310 number of timber classes

First column : the identity of stand
Second column : the identity of compartment
Third column : the area of stand in hectares
Fourth column : the age of stand
Fifth column : the yield stream identity of the existing stand
Sixth column : the yield stream identity of the regeneration stand
Seventh column : the actual haul distance

74	2	54	205	1	1	35.3
73	2	54	205	1	1	35.3
174	4	82	35	2	16	30.6
173	4	82	35	2	16	30.6
1	1	412	95	2	16	33
2	1	412	95	2	16	33
942	28	192	105	2	16	38.6
941	28	192	105	2	16	38.6
893	27	300	105	2	16	40.3
894	27	300	105	2	16	40.3
1066	30	59	105	2	16	42.3
1065	30	59	105	2	16	42.3
858	28	63	105	2	16	48.9
857	28	63	105	2	16	48.9
744	22	60	105	2	16	54.4
743	22	60	105	2	16	54.4
3	1	103	125	2	16	33
4	1	103	125	2	16	33
513	16	58	205	2	16	28.1
514	16	58	205	2	16	28.1
324	11	110	205	2	16	28.6
323	11	110	205	2	16	28.6
5	1	103	205	2	16	33
6	1	103	205	2	16	33
144	3	118	205	2	16	33.2
143	3	118	205	2	16	33.2
7	1	103	75	3	16	33
8	1	103	75	3	16	33
1068	30	354	75	3	16	42.3
1067	30	354	75	3	16	42.3
10	1	103	145	3	16	33
9	1	103	145	3	16	33
11	1	3090	95	5	16	33
12	1	3090	95	5	16	33
145	3	118	95	5	16	33.2
146	3	118	95	5	16	33.2
943	28	64	95	5	16	38.6
944	28	64	95	5	16	38.6
895	27	60	95	5	16	40.3
896	27	60	95	5	16	40.3
457	15	672	95	5	16	44.4
458	15	672	95	5	16	44.4
1223	33	265	95	5	16	54.4
1224	33	265	95	5	16	54.4
1132	31	185	105	5	16	28.3

1131	31	188	105	5	16	28.3
1034	28	70	105	5	16	30.6
1033	28	70	105	5	16	30.6
948	28	84	105	5	16	38.6
945	28	84	105	5	16	38.6
897	27	350	105	5	16	40.3
898	27	350	105	5	16	40.3
610	19	82	105	5	16	42.3
1069	30	58	105	5	16	42.3
1070	30	58	105	5	16	42.3
809	19	82	105	5	16	42.3
822	24	280	105	5	16	47.5
821	24	280	105	5	16	47.5
859	28	587	105	5	16	48.9
860	28	587	105	5	16	48.9
745	22	540	105	5	16	54.4
746	22	540	105	5	16	54.4
1036	29	70	115	5	16	30.6
1035	29	70	115	5	16	30.6
14	1	103	115	5	16	33
13	1	103	115	5	16	33
947	28	64	115	5	16	38.6
946	28	64	115	5	16	38.6
1168	32	118	115	5	16	41.9
1167	32	118	115	5	16	41.9
15	1	206	125	5	16	33
16	1	206	125	5	16	33
565	17	67	125	5	16	38.6
566	17	67	125	5	16	38.6
900	27	420	125	5	16	40.3
899	27	420	125	5	16	40.3
707	21	63	125	5	16	41.9
706	21	63	125	5	16	41.9
489	15	112	125	5	16	44.4
490	15	112	125	5	16	44.4
823	24	85	125	5	16	47.5
824	24	85	125	5	16	47.5
461	26	83	125	5	16	48.9
462	26	83	125	5	16	48.9
747	22	60	125	5	16	54.4
748	22	60	125	5	16	54.4
18	1	1030	95	6	16	33
17	1	1030	95	6	16	33
1134	31	82	105	6	16	28.3
1133	31	82	105	6	16	28.3
902	27	240	105	6	16	40.3
901	27	240	105	6	16	40.3
825	24	195	105	6	16	47.5
826	24	195	105	6	16	47.5
864	28	128	105	6	16	48.9
863	28	128	105	6	16	48.9
749	22	120	105	6	16	54.4
750	22	120	105	6	16	54.4
1170	32	88	115	6	16	41.9
1169	32	88	115	6	16	41.9
811	19	124	125	6	16	42.3
812	19	124	125	6	16	42.3
828	24	85	125	6	16	47.5
827	24	85	125	6	16	47.5
227	8	58	205	7	16	14.2

922	6	64	205	7	16	14	2
782	23	57	205	7	16	30	4
787	23	57	205	7	16	30	4
229	8	58	205	8	16	14	2
230	8	58	205	8	16	14	2
854	28	63	85	10	16	53	1
853	28	63	85	10	16	53	1
1071	30	177	75	10	16	42	3
1072	30	177	75	10	16	42	3
19	1	518	95	10	16	23	
20	1	518	95	10	16	23	
78	2	54	95	10	16	35	3
78	2	54	95	10	16	35	3
948	28	64	95	10	16	38	6
947	17	134	95	10	16	38	6
950	28	64	95	10	16	38	6
946	17	134	95	10	16	38	6
903	27	180	95	10	16	40	3
904	27	180	95	10	16	40	3
461	15	168	95	10	16	44	4
462	15	168	95	10	16	44	4
1135	31	124	105	10	16	28	3
1136	31	124	105	10	16	28	3
1172	32	59	105	10	16	41	9
1171	32	59	105	10	16	41	9
814	19	62	105	10	16	42	3
1073	30	59	105	10	16	42	3
1074	30	59	105	10	16	42	3
613	18	62	105	10	16	42	3
829	24	65	105	10	16	47	5
830	24	65	105	10	16	47	5
751	22	60	105	10	16	54	4
752	22	60	105	10	16	54	4
951	28	64	115	10	16	38	6
952	28	64	115	10	16	38	6
616	19	62	205	10	16	42	3
615	19	62	205	10	16	42	3
77	2	54	75	11	16	35	3
78	2	54	75	11	16	35	3
1076	30	364	75	11	16	42	3
1075	30	364	75	11	16	42	3
1174	32	59	135	11	16	41	9
1173	32	59	135	11	16	41	9
79	2	54	75	12	16	35	3
80	2	54	75	12	16	35	3
1078	30	531	75	12	16	42	3
1077	30	531	75	12	16	42	3
1078	30	177	75	13	16	42	3
1080	30	177	75	13	16	42	3
347	13	128	5	14	16	20	8
348	13	128	5	14	16	20	8
146	3	59	5	14	16	32	2
147	3	59	5	14	16	32	2
348	13	63	15	14	16	20	8
350	13	63	15	14	16	20	8
515	16	116	15	14	16	29	1
515	16	116	15	14	16	29	1
618	19	62	15	14	16	42	3
617	19	62	15	14	16	42	3
1082	30	59	65	14	16	42	3

1081	30	59	65	14	16	42	3
259	9	59	95	14	16	19	3
260	9	59	95	14	16	19	3
22	1	412	95	14	16	33	
21	1	412	95	14	16	33	
954	28	64	95	14	16	38	6
953	28	64	95	14	16	38	6
905	27	300	95	14	16	40	3
906	27	300	95	14	16	40	3
710	21	63	95	14	16	41	9
709	21	63	95	14	16	41	9
464	15	168	95	14	16	44	4
463	15	168	95	14	16	44	4
884	26	128	95	14	16	49	9
885	26	128	95	14	16	49	9
1226	33	188	95	14	16	54	4
1226	33	188	95	14	16	54	4
231	8	58	105	14	16	14	2
232	8	58	105	14	16	14	2
1136	31	188	105	14	16	28	3
1137	31	188	105	14	16	28	3
392	14	60	105	14	16	28	7
391	14	60	105	14	16	28	7
1038	29	140	105	14	16	30	6
1037	29	140	105	14	16	30	6
959	28	128	105	14	16	38	6
955	28	128	105	14	16	38	6
908	27	120	105	14	16	40	3
907	27	120	105	14	16	40	3
1176	32	59	105	14	16	41	9
1175	32	59	105	14	16	41	9
620	19	188	105	14	16	42	3
619	19	188	105	14	16	42	3
1084	30	59	105	14	16	42	3
1083	30	59	105	14	16	42	3
832	24	260	105	14	16	47	5
831	24	260	105	14	16	47	5
867	26	128	105	14	16	49	9
868	26	128	105	14	16	49	9
886	26	63	105	14	16	53	1
885	26	63	105	14	16	53	1
784	22	180	105	14	16	54	4
783	22	180	105	14	16	54	4
1040	29	210	115	14	16	30	6
1039	29	210	115	14	16	30	6
1178	32	118	115	14	16	41	9
1177	32	118	115	14	16	41	9
1066	30	59	115	14	16	42	3
1065	30	59	115	14	16	42	3
465	15	58	115	14	16	44	4
466	15	58	115	14	16	44	4
789	23	57	125	14	16	30	4
790	23	57	125	14	16	30	4
149	3	59	125	14	16	33	2
150	3	59	125	14	16	33	2
670	17	67	125	14	16	38	6
669	17	67	125	14	16	38	6
393	14	60	15	15	16	28	7
394	14	60	15	15	16	28	7
518	16	58	15	15	16	29	1

517	16	53	15	15	16	28	1
522	19	248	15	15	16	42	3
521	19	248	15	15	16	42	3
352	13	252	25	15	16	20	8
351	13	252	25	15	16	20	8
358	14	180	25	15	16	28	7
355	14	180	25	15	16	28	7
518	16	280	25	15	16	28	1
520	16	280	25	15	16	28	1
523	18	372	25	15	16	42	3
524	18	372	25	15	16	42	3
23	1	618	85	15	16	32	3
24	1	618	85	15	16	32	3
572	17	67	95	15	16	38	6
571	17	67	95	15	16	38	6
903	27	60	95	15	16	40	3
910	27	60	95	15	16	40	3
466	15	382	95	15	16	44	4
467	15	382	95	15	16	44	4
1140	31	248	105	15	16	28	3
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367	14	60	105	15	16	28	7
368	14	60	105	15	16	28	7
1042	29	140	105	15	16	30	6
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958	25	64	105	15	16	38	6
957	25	64	105	15	16	38	6
911	27	480	105	15	16	40	3
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712	21	188	105	15	16	41	9
1179	32	177	105	15	16	41	9
711	21	188	105	15	16	41	9
1180	32	177	105	15	16	41	9
625	19	434	105	15	16	42	3
626	19	434	105	15	16	42	3
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432	24	910	105	15	16	47	5
434	24	910	105	15	16	47	5
469	26	441	105	15	16	49	9
470	26	441	105	15	16	49	9
756	22	1500	105	15	16	54	4
755	22	1500	105	15	16	54	4
1141	31	124	115	15	16	28	3
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1044	29	140	115	15	16	30	6
859	28	84	115	15	16	38	6
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1080	30	59	115	15	16	42	3
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792	23	171	125	15	16	30	4
791	23	171	125	15	16	30	4
81	2	54	125	15	16	35	3
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913	27	80	125	15	16	40	3
914	27	80	125	15	16	40	3
828	19	310	125	15	16	42	3
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784	23	87	15	15	16	30	4

783	23	87	15	15	16	30	4
354	13	83	25	15	16	20	8
353	13	83	25	15	16	20	8
630	19	124	25	15	16	42	3
629	19	124	25	15	16	42	3
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1184	32	59	105	15	16	41	9
1183	32	59	105	15	16	41	9
436	24	85	105	15	16	47	5
435	24	85	105	15	16	47	5
471	26	83	105	15	16	49	9
472	26	83	105	15	16	49	9
438	24	85	115	15	16	47	5
437	24	85	115	15	16	47	5
574	17	67	85	17	17	38	6
573	17	67	85	17	17	38	6
522	16	58	205	17	17	28	1
521	16	58	205	17	17	28	1
468	15	55	205	17	17	44	4
470	15	55	205	17	17	44	4
28	1	208	35	18	28	33	
27	1	208	35	18	28	33	
262	9	59	95	18	28	19	3
261	9	59	95	18	28	19	3
575	17	87	95	18	28	38	6
576	17	87	95	18	28	38	6
1228	33	83	95	18	28	54	4
1227	33	83	95	18	28	54	4
1144	31	82	105	18	28	28	3
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1045	29	70	105	18	28	30	6
1046	29	70	105	18	28	30	6
840	24	130	105	18	28	47	5
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473	26	128	105	18	28	49	9
474	26	128	105	18	28	49	9
1047	29	140	115	18	28	30	6
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577	17	67	125	18	28	38	6
578	17	67	125	18	28	38	6
917	27	180	125	18	28	40	3
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832	18	82	125	18	28	42	3
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233	8	58	205	18	28	14	2
234	8	58	205	18	28	14	2
287	10	124	205	18	28	24	2
288	10	124	205	18	28	24	2
824	18	58	205	18	28	29	1
823	18	58	205	18	28	29	1
325	11	185	205	18	28	29	6
326	11	185	205	18	28	29	6
1082	30	59	75	19	28	42	3
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328	11	55	205	19	28	29	6

977	17	86	208	15	28	28	6
1083	30	116	75	20	28	42	3
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1085	30	59	65	21	28	42	3
1096	30	59	65	21	28	42	3
162	3	59	95	21	28	33	2
161	3	59	95	21	28	33	2
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356	13	83	205	21	28	20	8
163	3	59	205	21	28	33	2
164	3	59	205	21	28	33	2
212	8	80	65	22	28	13	
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83	2	54	65	22	28	35	3
64	2	54	65	22	28	35	3
680	17	67	65	22	28	38	6
679	17	67	65	22	28	38	6
29	1	927	95	22	28	33	
30	1	927	95	22	28	33	
472	15	58	95	22	28	44	4
471	15	58	95	22	28	44	4
1148	31	62	105	22	28	28	3
1145	31	62	105	22	28	28	3
1048	29	140	105	22	28	30	6
175	4	124	105	22	28	30	6
1050	29	140	105	22	28	30	6
178	4	124	105	22	28	30	6
32	1	308	105	22	28	33	
31	1	308	105	22	28	33	
962	28	256	105	22	28	38	6
961	28	256	105	22	28	38	6
919	27	120	105	22	28	40	3
920	27	120	105	22	28	40	3
833	19	82	105	22	28	42	3
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474	15	58	105	22	28	44	4
473	15	58	105	22	28	44	4
842	24	260	105	22	28	47	5
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758	22	300	105	22	28	54	4
757	22	300	105	22	28	54	4
964	28	128	115	22	28	38	6
963	28	128	115	22	28	38	6
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329	11	55	125	22	28	28	8
86	2	108	125	22	28	35	3
85	2	108	125	22	28	35	3
922	27	240	125	22	28	40	3
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712	21	63	125	22	28	41	9
711	21	63	125	22	28	41	9
635	19	186	125	22	28	42	3
636	19	186	125	22	28	42	3
843	24	65	125	22	28	47	5
844	24	65	125	22	28	47	5
875	25	126	125	22	28	48	8

876	25	126	125	22	28	48	8
759	22	180	125	22	28	54	4
760	22	180	125	22	28	54	4
289	10	124	205	23	28	24	2
290	10	124	205	23	28	24	2
625	18	58	205	23	28	29	1
626	18	58	205	23	28	29	1
331	11	55	205	23	28	29	6
332	11	55	205	23	28	29	6
34	1	103	205	23	28	33	
33	1	103	205	23	28	33	
156	3	59	205	23	28	33	2
155	3	59	205	23	28	33	2
636	19	82	205	23	28	42	3
637	19	82	205	23	28	42	3
475	15	58	205	23	28	44	4
476	15	58	205	23	28	44	4
334	11	55	205	24	28	29	6
333	11	55	205	24	28	29	6
35	1	208	205	24	28	33	
36	1	208	205	24	28	33	
400	14	180	5	27	28	28	7
399	14	180	5	27	28	28	7
628	18	118	5	27	28	29	1
627	18	118	5	27	28	29	1
640	19	186	5	27	28	42	3
639	19	186	5	27	28	42	3
402	14	120	15	27	28	28	7
401	14	120	15	27	28	28	7
630	18	58	15	27	28	29	1
629	18	58	15	27	28	29	1
642	19	82	15	27	28	42	3
641	19	82	15	27	28	42	3
358	13	315	25	27	28	20	8
357	13	315	25	27	28	20	8
662	20	58	25	27	28	28	3
664	20	58	25	27	28	28	3
631	18	58	25	27	28	29	1
632	18	58	25	27	28	29	1
643	19	124	25	27	28	42	3
644	19	124	25	27	28	42	3
380	13	126	15	28	28	20	8
389	13	126	15	28	28	20	8
403	14	120	15	28	28	28	7
404	14	120	15	28	28	28	7
634	18	232	15	28	28	29	1
633	18	232	15	28	28	29	1
786	23	57	15	28	28	30	4
785	23	57	15	28	28	30	4
645	19	62	15	28	28	42	3
646	19	62	15	28	28	42	3
381	13	189	25	28	28	20	8
382	13	189	25	28	28	20	8
405	14	180	25	28	28	28	7
406	14	180	25	28	28	28	7
635	18	622	25	28	28	29	1
636	18	622	25	28	28	29	1
787	23	57	25	28	28	30	4
788	23	57	25	28	28	30	4
648	19	620	25	28	28	42	3

847	19	820	25	28	28	42.3
408	14	80	25	28	28	28.7
407	14	80	25	28	28	28.7
882	17	87	85	28	28	38.8
881	17	87	85	28	28	38.8
1087	30	88	75	28	28	42.3
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1188	32	88	135	28	28	41.9
1187	32	88	135	28	28	41.9
838	18	84	15	28	28	28.1
837	18	84	15	28	28	28.1
383	13	83	25	29	28	20.8
384	13	83	25	29	28	20.8
158	3	89	95	30	28	33.2
157	3	89	95	30	28	33.2
824	27	80	95	30	28	40.3
823	27	80	95	30	28	40.3
478	15	86	95	30	28	44.4
477	15	86	95	30	28	44.4
850	18	82	205	30	28	42.3
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38	1	308	95	31	28	33
37	1	308	95	31	28	33
883	17	87	95	31	28	38.8
884	17	87	95	31	28	38.8
479	15	112	95	31	28	44.4
480	15	112	95	31	28	44.4
885	20	88	105	31	28	28.3
886	20	88	105	31	28	28.3
1051	29	70	105	31	28	30.8
1052	29	70	105	31	28	30.8
885	28	84	105	31	28	38.8
886	28	84	105	31	28	38.8
925	27	120	105	31	28	40.3
926	27	120	105	31	28	40.3
718	21	126	105	31	28	41.9
719	21	126	105	31	28	41.9
877	26	128	105	31	28	49.9
878	26	128	105	31	28	49.9
762	22	180	105	31	28	54.4
761	22	180	105	31	28	54.4
340	12	59	125	31	28	20.1
339	12	59	125	31	28	20.1
800	23	57	125	31	28	30.4
799	23	57	125	31	28	30.4
177	4	62	125	31	28	30.8
178	4	62	125	31	28	30.8
651	18	62	205	31	28	42.3
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481	15	86	95	32	28	44.4
482	15	86	95	32	28	44.4
1232	33	83	95	32	28	54.4
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238	8	88	105	32	28	14.2
239	8	88	105	32	28	14.2
1147	31	124	105	32	28	28.3
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887	28	84	105	32	28	38.8
888	28	84	105	32	28	38.8
884	18	82	105	32	28	42.3

883	18	82	105	32	28	42.3
848	24	130	105	32	28	47.8
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783	22	80	105	32	28	54.4
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1149	31	82	115	32	28	28.3
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40	1	206	115	32	28	33
39	1	206	115	32	28	33
868	28	182	115	32	28	38.8
870	28	182	115	32	28	38.8
1189	32	177	115	32	28	41.9
1190	32	177	115	32	28	41.9
802	23	87	125	32	28	30.4
801	23	87	125	32	28	30.4
786	22	120	125	32	28	54.4
785	22	120	125	32	28	54.4
1100	30	89	75	34	34	42.3
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483	15	88	95	35	38	44.4
484	15	88	95	35	38	44.4
42	1	103	95	35	38	33
41	1	103	95	35	38	33
828	27	120	95	35	38	40.3
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1192	32	88	105	35	38	41.9
1191	32	88	105	35	38	41.9
1102	30	89	75	36	38	42.3
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87	2	84	95	36	38	28.3
88	2	84	95	36	38	28.3
485	15	88	95	36	38	44.4
486	15	88	95	36	38	44.4
1104	30	89	105	36	38	42.3
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238	8	88	205	36	38	14.2
237	8	88	205	36	38	14.2
291	10	82	205	36	38	24.2
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89	2	84	95	37	38	35.3
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871	28	84	95	37	38	38.8
872	28	84	95	37	38	38.8
828	27	80	95	37	38	40.3
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488	15	112	95	37	38	44.4
487	15	112	95	37	38	44.4
880	28	128	95	37	38	49.9
879	28	128	95	37	38	49.9
788	22	80	105	37	38	54.4
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408	14	180	15	38	38	28.7
410	14	180	15	38	38	28.7
840	18	116	15	38	38	28.1
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804	23	87	15	38	38	30.4
803	23	87	15	38	38	30.4
856	19	124	15	38	38	42.3
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888	20	88	25	38	38	28.3

647	56	58	25	38	39	28	3
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647	19	310	25	38	39	42	3
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644	18	58	25	38	39	28	1
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488	15	58	55	38	39	44	4
480	15	58	55	38	39	44	4
264	8	59	55	38	39	18	3
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689	20	58	55	38	39	28	3
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44	1	103	55	38	39	33	
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91	2	54	55	38	39	38	3
92	2	54	55	38	39	38	3
584	17	134	55	38	39	38	6
574	24	64	55	38	39	38	6
573	28	64	55	38	39	38	6
585	17	134	55	38	39	38	6
932	27	180	55	38	39	40	3
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718	21	126	55	38	39	41	9
717	21	126	55	38	39	41	9
491	15	56	55	38	39	44	4
492	15	56	55	38	39	44	4
882	26	378	55	38	39	49	9
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788	22	180	55	38	39	54	4
1233	33	212	55	38	39	54	4
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770	22	180	55	38	39	54	4
1151	31	124	105	38	39	28	3
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975	28	64	105	38	39	38	6
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720	21	441	105	38	39	41	9
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719	21	441	105	38	39	41	9
1108	30	177	105	38	39	42	3
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880	19	62	105	38	39	42	3
889	18	62	105	38	39	42	3
847	24	65	105	38	39	47	5
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884	26	315	105	38	39	49	9
883	26	315	105	38	39	49	9
772	22	600	105	38	39	54	4
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1198	32	59	115	38	39	41	9
1199	32	59	115	38	39	41	9
1107	30	59	115	38	39	42	3
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773	22	60	125	38	39	54	4
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1154	31	62	205	40	40	28	3
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207	5	130	55	41	43	16	6

208	5	130	55	41	43	16	6
294	10	82	105	41	43	24	2
293	10	82	105	41	43	24	2
978	28	64	105	41	43	38	6
977	28	64	105	41	43	38	6
1063	29	70	115	41	43	30	6
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494	15	56	125	41	43	44	4
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218	7	59	205	41	43	18	3
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268	8	59	205	41	43	19	3
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295	10	82	205	41	43	24	2
296	10	82	205	41	43	24	2
892	20	58	205	41	43	28	3
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178	4	82	205	41	43	30	6
180	4	82	205	41	43	30	6
214	6	120	55	42	43	13	
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267	9	59	55	42	43	19	3
268	9	59	55	42	43	19	3
288	10	62	55	42	43	24	2
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1235	33	83	55	42	43	54	4
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289	9	59	105	42	43	19	3
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980	28	128	115	42	43	28	6
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45	1	103	125	42	43	33	
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95	2	182	125	42	43	35	3
96	2	182	125	42	43	35	3
687	17	67	125	42	43	38	6
688	17	67	125	42	43	38	6
934	27	60	125	42	43	40	3
933	27	60	125	42	43	40	3
721	21	63	125	42	43	41	9
722	21	63	125	42	43	41	9
271	9	118	205	42	43	19	3
272	9	118	205	42	43	19	3
341	12	59	205	42	43	20	1
342	12	59	205	42	43	20	1
388	13	126	205	42	43	20	6
389	13	126	205	42	43	20	6
300	10	124	205	42	43	24	2
299	10	124	205	42	43	24	2
411	14	120	205	42	43	28	7
412	14	120	205	42	43	28	7
181	4	82	205	42	43	30	6
182	4	82	205	42	43	30	6
180	3	59	205	42	43	33	2

169	3	58	205	42	43	33	2
97	2	162	205	42	43	35	3
98	2	162	205	42	43	35	3
981	28	64	205	42	43	38	6
989	17	67	205	42	43	38	6
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982	28	64	205	42	43	38	6
662	18	124	5	43	43	42	3
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414	14	60	25	43	43	28	7
413	14	60	25	43	43	28	7
216	6	180	85	43	43	13	
215	6	180	85	43	43	13	
274	9	116	65	43	43	18	3
273	9	116	65	43	43	18	3
343	12	118	65	43	43	20	1
344	12	118	65	43	43	20	1
546	16	58	85	43	43	25	1
545	16	58	85	43	43	25	1
100	2	54	65	43	43	35	3
99	2	54	65	43	43	35	3
984	28	64	95	43	43	38	6
983	28	64	95	43	43	38	6
1240	33	158	95	43	43	54	4
1239	33	158	95	43	43	54	4
302	10	82	105	43	43	24	2
301	10	82	105	43	43	24	2
985	28	128	105	43	43	38	6
982	17	67	105	43	43	38	6
986	28	128	105	43	43	38	6
991	17	67	105	43	43	38	6
1187	32	58	105	43	43	41	9
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1155	31	62	115	43	43	28	3
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48	1	208	115	43	43	33	
47	1	208	115	43	43	33	
987	28	128	115	43	43	38	6
888	28	128	115	43	43	38	6
1200	32	58	115	43	43	41	9
1199	32	58	115	43	43	41	9
1110	30	58	115	43	43	42	3
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184	4	188	125	43	43	30	6
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102	2	54	125	43	43	35	3
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50	1	103	135	43	43	33	
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275	9	58	205	43	43	18	3
304	10	82	205	43	43	24	2
303	10	82	205	43	43	24	2
185	4	62	205	43	43	30	6
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217	8	60	205	44	44	13	
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182	3	58	55	48	47	33	2
103	2	54	55	48	47	35	3
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683	20	58	55	48	47	28	3
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306	10	82	205	48	47	24	2
183	3	58	205	48	47	33	2
184	3	58	205	48	47	33	2
666	18	62	205	48	47	42	3
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416	14	240	5	48	47	28	7
547	18	58	5	48	47	28	1
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568	18	188	5	48	47	42	3
567	18	188	5	48	47	42	3
368	13	126	15	48	47	20	8
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417	14	240	15	48	47	28	7
418	14	240	15	48	47	28	7
549	18	58	15	48	47	28	1
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370	13	441	25	48	47	20	8
369	13	441	25	48	47	20	8
308	10	82	25	48	47	24	2
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419	14	600	25	48	47	28	7
551	18	280	25	48	47	28	1
552	18	280	25	48	47	28	1
670	18	310	25	48	47	42	3
669	18	310	25	48	47	42	3
372	13	188	35	48	47	20	8
371	13	188	35	48	47	20	8
310	10	62	35	48	47	24	2
309	10	62	35	48	47	24	2
421	14	120	35	48	47	28	7
422	14	120	35	48	47	28	7
189	4	188	35	48	47	30	6
190	4	188	35	48	47	30	6
277	9	58	65	48	47	18	3
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423	14	80	65	48	47	28	7
424	14	80	65	48	47	28	7
805	23	57	85	48	47	30	4
806	23	57	85	48	47	30	4
51	1	208	85	48	47	33	
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990	28	128	95	48	47	38	6
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495	15	58	95	48	47	44	4
496	15	58	95	48	47	44	4
1241	33	53	95	48	47	54	4
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891	28	128	105	48	47	38	6

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182	4	188	118	46	47	30.6
83	1	308	118	46	47	33
84	1	308	118	46	47	33
883	28	320	118	46	47	38.8
884	28	320	118	46	47	38.8
1202	32	88	118	46	47	41.8
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183	4	188	128	46	47	30.8
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838	27	80	128	46	47	40.3
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486	16	88	128	46	47	44.4
487	16	88	128	46	47	44.4
85	1	103	138	46	47	33
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240	8	88	208	46	47	14.2
239	8	88	208	46	47	14.2
227	7	88	208	46	47	16.3
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426	14	120	208	46	47	28.7
426	14	120	208	46	47	28.7
583	18	88	208	46	47	28.1
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338	11	220	208	46	47	28.8
339	11	220	208	46	47	28.8
188	4	82	208	46	47	30.8
188	4	82	208	46	47	30.8
87	1	208	208	46	47	33
88	1	208	208	46	47	33
188	3	384	208	46	47	33.2
188	3	384	208	46	47	33.2
108	2	84	208	46	47	35.3
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888	17	87	208	46	47	38.8
888	17	87	208	46	47	38.8
872	19	82	208	46	47	42.3
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888	17	87	88	48	80	38.8
118	2	84	78	48	80	38.3
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80	1	103	88	48	80	33
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242	8	88	108	48	80	14.2
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223	7	88	108	48	80	18.3
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887	20	88	108	48	80	28.3
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430	14	80	108	48	80	28.7
428	14	80	108	48	80	28.7
887	28	84	108	48	80	38.8
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728	21	83	108	48	80	41.8
728	21	83	108	48	80	41.8
888	28	84	118	48	80	38.8
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727	21	83	128	48	80	41.8
728	21	83	128	48	80	41.8
244	8	88	208	48	80	14.2
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346	12	88	208	48	80	20.1
345	12	88	208	48	80	20.1
312	10	82	208	48	80	24.2
314	10	82	208	48	80	24.2
888	17	87	208	48	80	38.8
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378	13	83	18	80	80	20.8
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431	14	180	18	80	80	28.7
432	14	180	18	80	80	28.7
888	18	88	18	80	80	28.1
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873	18	82	18	80	80	42.3
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377	13	188	28	80	80	20.8
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380	13	252	35	50	50	20	8
378	13	252	35	50	50	20	8
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1001	28	128	115	51	51	38	6
1203	32	177	115	51	51	41	9
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1250	33	212	115	51	51	54	4
1249	33	212	115	51	51	54	4
1205	32	58	205	51	51	41	9
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438	14	60	15	52	52	28	7
437	14	60	15	52	52	28	7
1003	28	84	95	52	52	38	6
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1207	32	59	95	52	52	41	9
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498	15	112	95	52	52	44	4
500	15	112	95	52	52	44	4
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439	14	60	105	52	52	28	7
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729	21	63	105	52	52	41	9
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730	21	63	105	52	52	41	9
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775	22	60	105	52	52	54	4
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1211	32	59	115	52	52	41	9
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778	22	60	125	52	52	54	4
777	22	60	125	52	52	54	4
81	1	412	145	52	52	33	
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248	8	58	205	52	52	14	2
689	20	58	205	52	52	28	3
700	20	58	205	52	52	28	3
558	16	116	205	52	52	29	1
557	16	116	205	52	52	29	1
810	23	57	205	52	52	30	4
809	23	57	205	52	52	30	4
1082	29	70	205	52	52	30	6
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121	2	54	205	52	52	35	3
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676	19	62	205	52	52	42	3

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559	16	58	205	53	53	29	1
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678	19	62	205	53	53	42	3
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381	13	63	5	54	54	20	6
382	13	63	5	54	54	20	6
186	3	59	5	54	54	33	2
187	3	59	5	54	54	33	2
680	19	124	5	54	54	42	3
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482	14	180	25	54	54	28	7
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561	16	58	35	54	54	29	1
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502	15	112	95	54	54	44	4
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732	21	63	105	54	54	41	9
731	21	63	105	54	54	41	9
850	24	85	105	54	54	47	5
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1016	28	128	115	54	54	38	6
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1215	32	118	115	54	54	41	9
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1255	33	53	115	54	54	54	4
1256	33	53	115	54	54	54	4
563	16	58	125	54	54	29	1
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813	23	57	125	54	54	30	4
814	23	57	125	54	54	30	4
779	22	60	125	54	54	54	4
780	22	60	125	54	54	54	4
85	1	309	145	54	54	33	
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385	13	126	205	54	54	20	6
386	13	126	205	54	54	20	6
315	10	62	205	54	54	24	2
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702	20	58	205	54	54	28	3
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338	11	110	205	54	54	29	6

357	1	116	205	54	54	28	6
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936	27	60	205	54	54	40	3
937	27	60	205	54	54	40	3
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123	2	54	55	55	55	28	3
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125	2	54	75	55	55	35	3
126	2	54	75	55	55	35	3
504	15	56	95	55	55	44	4
503	15	56	95	55	55	44	4
852	24	85	105	55	55	47	5
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1015	28	84	145	55	55	38	6
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446	14	60	205	55	55	28	7
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817	23	57	205	55	55	30	4
818	23	57	205	55	55	30	4
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200	4	62	205	55	55	30	6
127	2	54	205	55	55	35	3
128	2	54	205	55	55	35	3
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781	22	170	205	55	55	64	4
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129	2	108	95	57	60	35	3
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885	26	83	95	57	60	48	9
886	26	83	95	57	60	48	9
248	8	118	105	57	60	14	2
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446	14	60	105	57	60	28	7
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131	2	54	125	57	60	35	3
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87	1	103	75	58	59	33	3
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282	9	118	95	58	59	19	3
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317	10	124	95	58	59	24	2

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703	20	58	95	58	59	28	3
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203	4	62	95	58	59	30	6
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70	1	103	95	58	59	33	3
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135	2	124	95	58	59	35	3
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506	15	168	95	58	59	44	4
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887	26	189	95	58	59	48	9
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1219	32	59	105	58	59	41	9
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1220	32	59	105	58	59	41	9
733	21	126	105	58	59	41	9
1121	30	238	105	58	59	42	3
1122	30	238	105	58	59	42	3
889	28	83	105	58	59	49	9
890	28	83	105	58	59	49	9
764	22	180	105	58	59	54	4
763	22	180	105	58	59	54	4
1161	31	82	115	58	59	28	3
1162	31	82	115	58	59	28	3
1021	28	256	115	58	59	38	6
1022	28	256	115	58	59	38	6
1221	32	59	115	58	59	41	9
1222	32	59	115	58	59	41	9
1123	30	59	115	58	59	42	3
1124	30	59	115	58	59	42	3
205	4	124	125	58	59	30	6
206	4	124	125	58	59	30	6
137	2	54	125	58	59	35	3
136	2	54	125	58	59	35	3
1023	28	54	145	58	59	38	6
1024	28	54	145	58	59	38	6
285	8	58	205	58	59	14	2
286	8	58	205	58	59	14	2
283	9	59	205	58	59	19	3

284	8	58	205	58	58	18.3
319	10	124	205	58	58	24.2
320	10	124	205	58	58	24.2
1028	28	64	205	58	58	38.6
1028	28	64	205	58	58	38.6
171	3	58	5	58	58	33.2
172	3	58	5	58	58	33.2
448	14	300	15	58	58	28.7
450	14	300	15	58	58	28.7
818	23	57	15	58	58	30.4
820	23	57	15	58	58	30.4
706	20	58	25	58	58	28.3
706	20	58	25	58	58	28.3
481	14	120	25	58	58	28.7
482	14	120	25	58	58	28.7
380	13	63	35	58	58	20.8
388	13	63	35	58	58	20.8