Sustained Yield Unit R12

Detailed Forest Management Plan

2000- 2015

Appendix 4.3: Timber Supply Forecasting

Weyerhaeuser Canada Ltd.

Drayton Valley, Alberta

Table of Contents

List of Tables

List of Figures

List of Appendices

4 Timber Supply Forecasting

4.1 Introduction

The purpose of Chapter 4 is to present the methods and results used to select the preferred management scenario. The preferred scenario indicates current and future expected levels of outputs associated with meeting all management goals presented in the previous sections. Outputs include measures and indicators of a wide variety of forest resource values.

The timber supply analysis (TSA) component of the detailed forest management plan provides a focal point for a wide variety of objectives designed to address the sustainable use of timber resources within the Sustained Yield Unit R12. The Sustained Yield Unit (SYU) is defined as the legal boundaries of FMA #0500042 and the adjacent grazing dispositions, with the exception of Grazing Reserves.

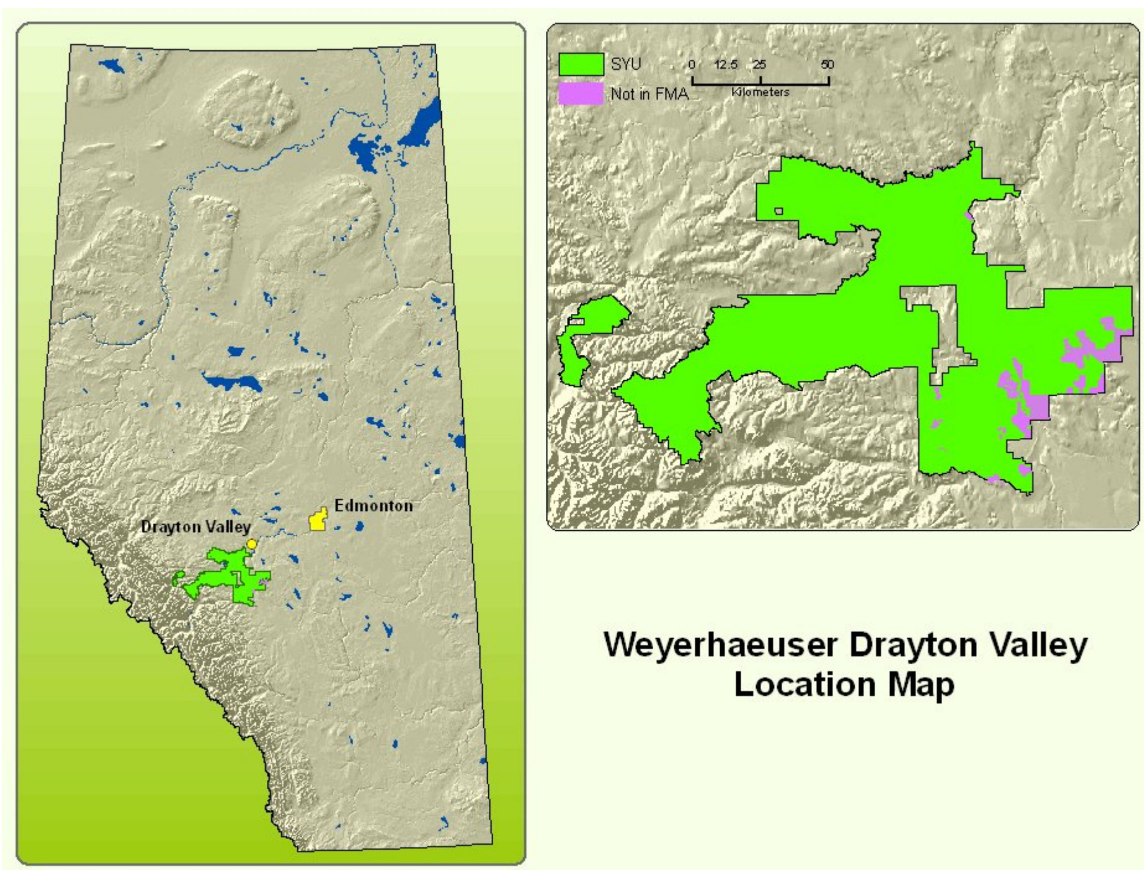


Figure 4.1 Location and Extent of Sustained Yield Unit R12

Both the Forest Act and the FMA between the Government of Alberta and Weyerhaeuser define the rights and responsibilities of Weyerhaeuser as the sole area-based forest land manager. The FMA defines an area-based tenure that requires Weyerhaeuser to fulfill timber supply objectives to sustain its own fibre requirements as well as to fulfill a number of other volume-based commitments to the Crown. The TSA will also quantify the other overlapping timber allocations upon the Sustained Yield Unit.

4.2 Overview of the Timber Supply Forecasting Process

Estimating long-term sustainable harvest levels is the culmination of data collection, data processing, stakeholder meetings, public consultation meetings, company philosophy, values, objectives, etc. It all comes together in the timber supply modeling process to determine the allowable harvest level, the various impacts on competing values, and the future forest condition.

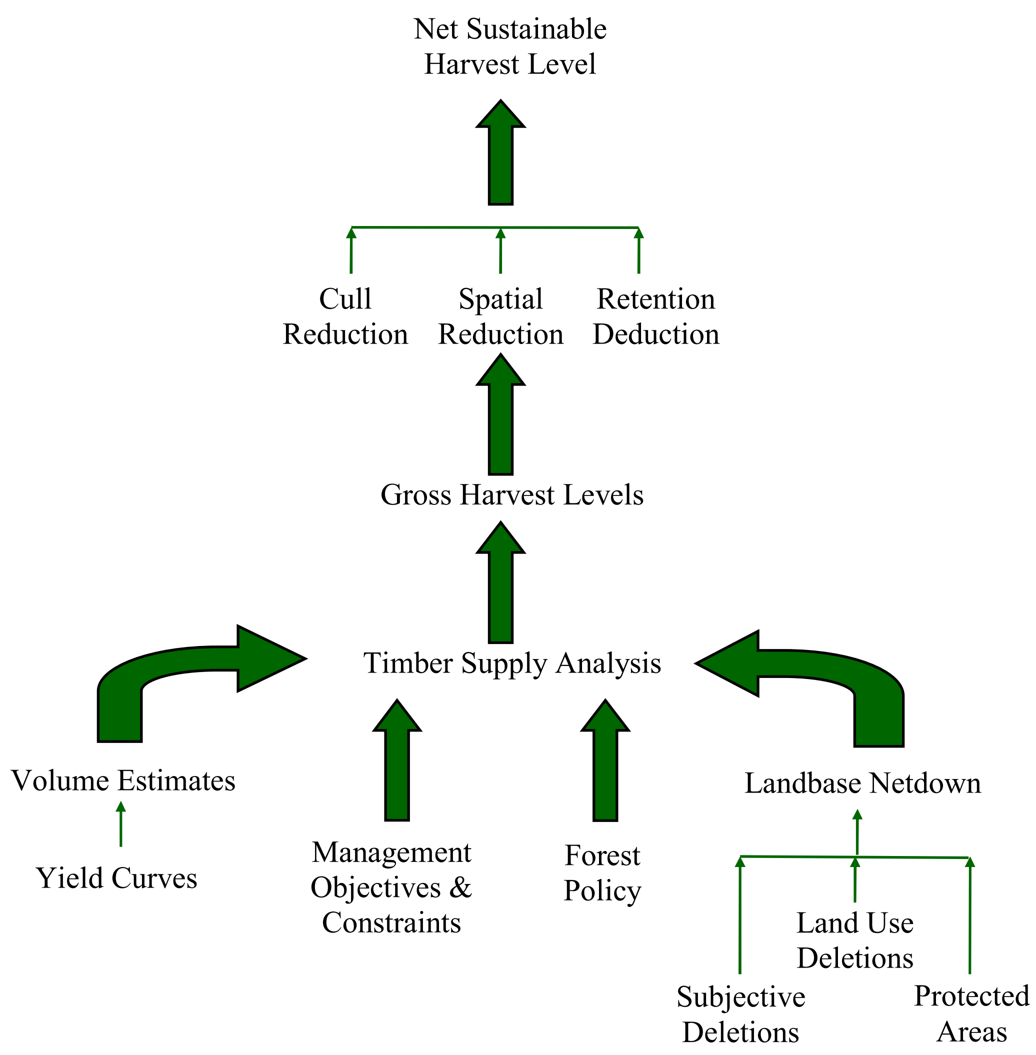


Figure 4.2 Overview of Timber Supply Forecasting Process

4.3 Defining the Net Harvestable Land base

The land base inventory includes information on both non-forested and forested areas. Parks, recreation areas, reserves for wildlife habitat, Indian Reserves, transportation and utility corridors, and other industrial sites are assigned as non-harvestable land base. These areas however, contribute to a variety of other management objectives. SYU R12 operates on a single combined coniferous and deciduous land base.

The total area of SYU R12 encompasses 520,877 hectares (ha). Of this area 453,205 ha (87%) are capable of supporting forest vegetation. Almost 144,899 ha (or 32 %) are excluded from the timber harvesting land base. As with non-forest areas that do not contribute to the timber harvesting land base, the forested area excluded from timber harvesting is maintained in the database, due to its significance in contributing to a variety of other forest management objectives.

Finally, about 59% (308,306 ha) of the SYU area is net harvestable land base. This is the land base from which sustainable harvest levels and Annual Allowable Cuts are determined. A detailed description of the net harvestable forested land base is in Appendix 4.1.

In addition to the current age class distribution and the levels of Broad Cover Groups, various attributes of the current status of the land base where observed. Although there is much anthropogenic history on the land base the current status serves as the starting point to which the today's forest management assumptions are applied. The model shows how the current status of the forest changes over time with those assumptions applied.

Many polygons could potentially be assigned to several deletion types. Therefore, a deletion hierarchy was ranked from "harder" to "softer" deletions. The "harder" deletions identified areas which can confidently be removed from the net land base because of productivity or land use criteria. "Softer" deletions such as subjective deletions are also excluded from the net harvestable land base. This method facilitated understanding of how much forested land is ultimately deleted under various criteria. Refer to Appendix 4.1 for further details regarding the types of features excluded and the process used to define the net harvestable land base.

A hierarchy of non-operable land base deletion rules was identified and applied to a composite land base resulting in the forested productive land base. The deletion hierarchy and net areas identified by deletion category are depicted in Table 4.1. This table summarizes the classification of the SYU R12 area and timber harvesting land base by land management units. The current timber harvesting land base is approximately 59% (ha) of the total area, and about 68% of the total forested area. The majority of forest land excluded from the timber harvesting land base (about 32% of all forested land) is either economically inoperable, or environmentally sensitive, or both.

Table 4.1 Classification of the SYU R12 Land base by LMU

Category	Baptiste	Blackstone	Elk River	IR	Marshy Bank	Medicine Lake	Nordegg River	O'Chiese	R1	Sand Creek	Tall Pine	Willesden Green	Total	%
1. Non-Forested														
01. Anthropogenic Non-Vegetated	729	106	414	0		94	317	449	124	1,071	341	545	4,191	0.80%
02. Naturally Non-Vegetated	1,210	1,735	753	0	180	486	1,300	2,634	80	689	1,299	826	11,193	2.15%
03. Anthropogenic Vegetated	2,317	33	1,070	0	6	57	279	356	3,239	1,656	729	823	10,566	2.03%
04. Non-Forested Vegetated	4,458	937	1,419	0	159	1,376	1,328	2,809	664	2,027	3,374	4,562	23,110	4.44%
Subtotal	**8,714**	**2,811**	**3,656**	**0**	**344**	**2,013**	**3,223**	**6,248**	**4,107**	**5,443**	**5,743**	**6,756**	**49,060**	**9.42%**
2. Dispositions														
05. Wapiabi Provincial Park		3,128											3,128	0.60%
06. O'Chiese Natural Area (NAA920002)								367					367	0.07%
07. Permanent Sample Plots	56	52	79		34		0	81		12	14	15	344	0.07%
08. I.R. 202 and 203				19,303									19,303	3.71%
09. Private Area	1,908					223	1	62	0	806	114	595	3,710	0.71%
10. Protected Notation (excluded)							138			15			153	0.03%
11. Prime Protection Area (defined by ESIP)		372			71								443	0.09%
13. Disposition Reservation (excluded)	1					105				0		63	170	0.03%
14. Crown Recreation Areas	3											17	20	0.00%
15. Land Use Dispositions	970	186	497		51	344	328	545	0	733	590	399	4,645	0.89%
17. Voluntary Dispostion Reservation (excluded)													0	0.00%
16. Voluntary Protective Notation (excluded)	2												2	0.00%
18. Landuse Lines	1,887	785	1,280		185	177	1,144	499	3	1,643	531	1,050	9,185	1.76%
19. Seismic Lines	823	310	1,308		162	442	722	965	122	698	666	761	6,979	1.34%
Subtotal	**5,651**	**4,833**	**3,165**	**19,303**	**502**	**1,292**	**2,335**	**2,519**	**125**	**3,907**	**1,915**	**2,901**	**48,449**	**9.30%**
3. Slopes, Buffers														
20. Steep Slopes	247	3,992	36		1,189		1,926	310	0	424	830	1,129	10,083	1.94%
21. Stream Buffer (30m or 60m)	986	2,053	1,073		1,365	67	1,988	1,382	89	654	607	561	10,824	2.08%
22. North Saskatchewan River Buffer (100m)	87								38	162	370	365	1,022	0.20%
23. Lake Buffer (100m)	248	31	449			191	206	308		62	122	35	1,653	0.32%
24. Highway Corridor Buffer (100m)	358					33			41			262	693	0.13%
Subtotal	**1,926**	**6,076**	**1,559**		**2,554**	**291**	**4,119**	**2,000**	**167**	**1,301**	**1,929**	**2,352**	**24,274**	**4.66%**
4. Subj. Deletions														
25. Unidentified Openning	136	152	36		32	416	0	130	9	178	155	386	1,632	0.31%
26. Invalid Ecosites (x,y,z) and Alpine NSR	180	201	53		140	9	10	14	60	42	9	6	722	0.14%
27. Larch Deletion	12,919	83	8,682		2	2,395	11,548	9,017	891	4,007	4,799	5,017	59,360	11.40%
28. Black Spruce Deletion	3,635	1,184	4,517		413	3,064	5,164	5,206	332	1,141	1,870	2,116	28,643	5.50%
29. Undefined	0	3	0		0	3	0	0	8	0		1	15	0.00%
30. Horizontal Stand Adjustment	59	55	19	0	1	50	13	8	30	45	29	107	416	0.08%
Subtotal	**16,928**	**1,678**	**13,307**	**0**	**589**	**5,937**	**16,734**	**14,375**	**1,330**	**5,413**	**6,861**	**7,633**	**90,787**	**17.43%**
Total Deletion Area	**33,220**	**15,398**	**21,686**	**19,303**	**3,990**	**9,534**	**26,412**	**25,142**	**5,730**	**16,065**	**16,448**	**19,642**	**212,571**	**40.81%**
5. Net Harvestable														0.00%
Coniferous	21,310	24,069	17,626		13,633	3,209	33,540	29,716	1,457	5,781	8,146	7,976	166,464	31.96%
Coniferous/Deciduous	4,945	3	4,187			1,089	5,586	7,158	496	3,736	4,959	3,384	35,542	6.82%
Deciduous	10,496	1	4,290		31	5,204	3,112	8,312	2,491	17,604	7,024	20,930	79,497	15.26%
Deciduous/Coniferous	5,063	9	3,231			1,563	2,665	2,940	829	3,078	3,650	3,775	26,803	5.15%
Subtotal	**41,815**	**24,082**	**29,334**		**13,665**	**11,065**	**44,903**	**48,125**	**5,274**	**30,200**	**23,780**	**36,064**	**308,306**	**59.19%**
Grand Total	**75,035**	**39,480**	**51,020**	**19,303**	**17,654**	**20,599**	**71,316**	**73,268**	**11,004**	**46,264**	**40,227**	**55,706**	**520,877**	**100.00%**

The following pie chart (Figure 4.3) depicts the same values as Table 4.1. The total sums between the chart and table differs slightly due to rounding errors.

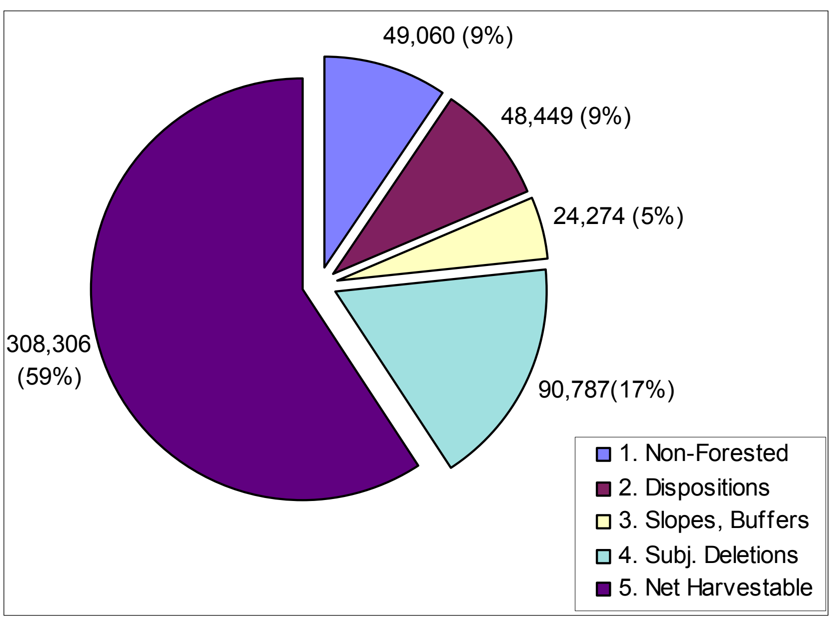


Figure 4.3 SYU R12 Area Overview

Productive forest land base composition by leading species groups is summarized in Figure 4.4. The most common leading species is lodgepole pine, followed by aspen, black spruce, and white spruce.

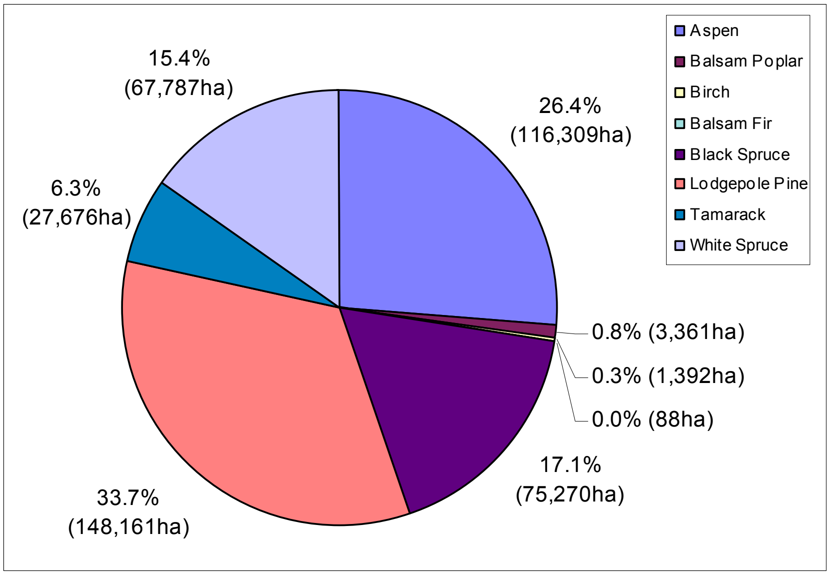


Figure 4.4 Productive Land base Division by Leading Species Group

4.3.1 Comparison to the 1992 DFMP

The differences in forest land base between the 1992 TSA and the current timber supply analysis (2005) can be summarized as follows:

- There have been dramatic changes in the FMA boundaries between management plans with the expansion into FMUs R3 and R4;
- Additional area was added to the FMA in FMU R2 from Sundre Forest Products;
- Parts of FMU R1 are included in the analysis;
- The timber harvesting land base area in the FMA has been reduced by withdrawals for industrial activities;
- Forest inventory measures for site productivity, ecosystem classification, and the species composition of current stands are key determinants for inclusion of forest in the timber harvesting land base. The current management plan is based on a new forest inventory known as the Alberta Vegetation Inventory Version 2.2 (AVI);
- The current management plan includes better information on the physical and economic operability to describe the net harvestable land base, such as the ecological land classification;
- In 1992, the total FMA area was 247,588 ha, compared to 520,877 ha (SYU) in 2005;
- In 1992, the productive forest land base was 187,682 hectares, compared to 308,306 in 2005;

- In 1992, average MAI was 1.45 m3/ha/year for deciduous (0.85 in 2005) and 1.2 m3/ha/year for conifer (1.51 in 2005);
- In 1992, deciduous utilization was 17/10 versus 15/10, while coniferous utilization has remained the same at 15/11;
- In previous analyses each FMU was managed individually, currently modeling a single Sustainable Yield Unit;
- In previous analyses, the land base was discrete, having both defined conifer and deciduous land bases. Now there is only a single land base resulting in no incidental volumes;
- Due to past modeling constraints, multiple rules sets (usually driven by different green up delays) when modeling the harvest sequence had to be implemented sequentially, providing some bias to the first land base modeled. Advancements in these models now permit concurrent modeling of groups with different rule sets.

Table 4.2 Estimates of Conifer Land Base (CLB) and Deciduous Land Base (DLB) for the Current (2005) Timber Supply Analysis and 1992 Timber Supply Analysis

Land base	FMA / SYU R12 (ha)	
	1992	2005
Coniferous	91,979	202,006
Deciduous	74,759	106,300
Total	166,738	308,306

4.3.2 Age Class Distribution Area by SYU

Figure 4.5 shows the current age composition of the forested land base in the SYU R12 area. The age class distribution of forested area excluded from the timber harvesting land base can affect timber supply. In order to provide a suitable area for habitat and other non-timber values, certain portions of the forest area are reserved from harvesting. These attributes are facilitated by maintaining certain age ranges and patch sizes distributions across the landscape.

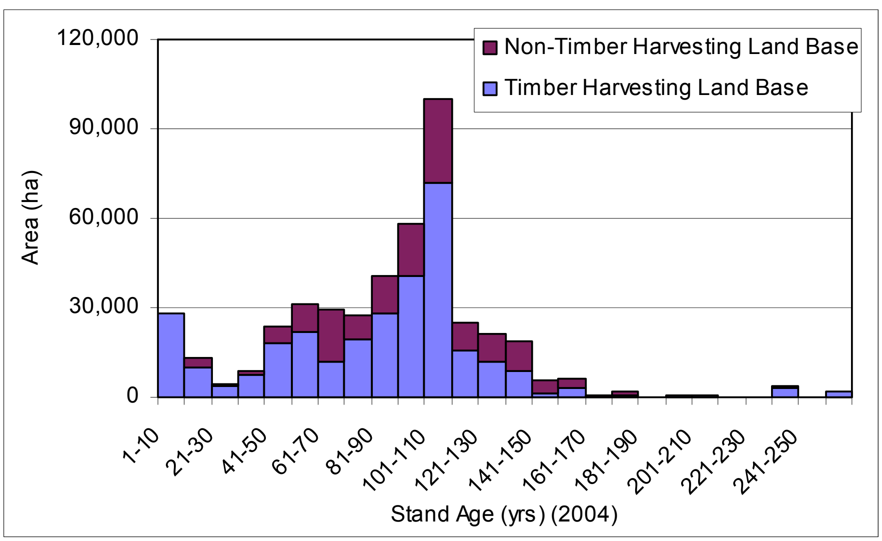


Figure 4.5 Current Age Class Distribution by Area – Forested Land Base

Tracking the distribution and prevalence of over-mature forest types across the land base is one of the strategies employed during the TSA modeling in an attempt to ensure that ecological values are met (others include removing riparian zones from the harvestable land base and delaying harvesting activities in some locations). Six seral stages were identified for both coniferous and deciduous broad cover groups (see Section 2.10.4 for more detail) in Appendix 4.1.

Figure 4.6 and Figure 4.7 represent age class distribution in productive forest land by broad cover groups and seral stages. The majority of conifer-leading stands are in late seral stage while most deciduous-leading stands are dispersed between late and very late seral stages.

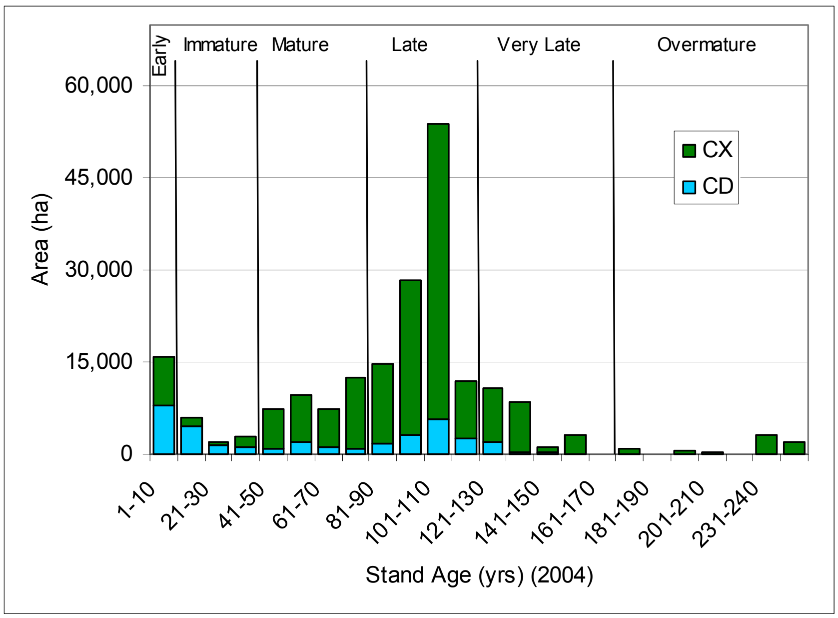


Figure 4.6 Coniferous Leading Productive Forest Land Age Class Distribution by Seral Stages

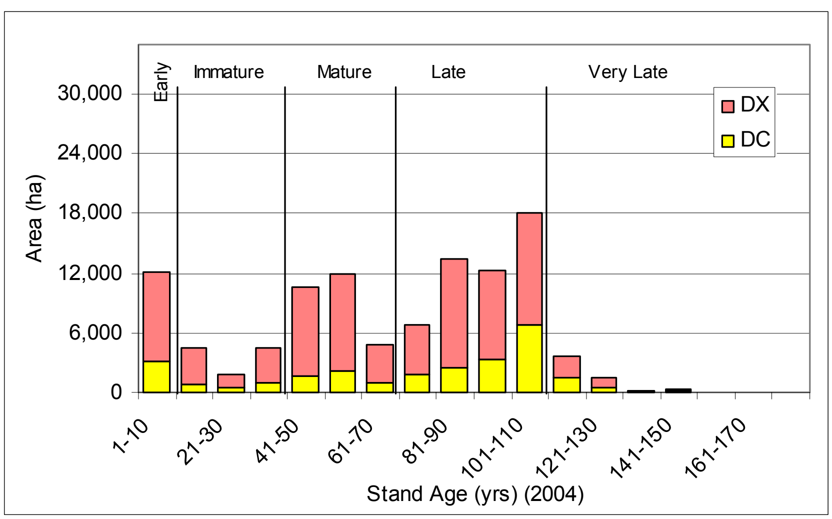


Figure 4.7 Deciduous Leading Productive Forest Land Age Class Distribution by Seral Stages

Timberline Forest Inventory Consultants

4.3.3 Site Productivity area by BCG

Figure 4.8 shows the distribution of three productivity classes by cover type group for the timber harvesting land base. Site productivity is a measure of site's inherent capacity to support the growth of certain tree species at some rate of growth. Stands classified as having "good" site productivity comprise 82% of the area of all sites in the timber harvesting land base. Fourteen percent of stands are defined as having "medium" (or moderate) site productivity and only 4% of sites are classed as having "fair" site productivity. A more detailed empirical definition for site productivity is presented in the description of volume estimation in Appendix 4.2

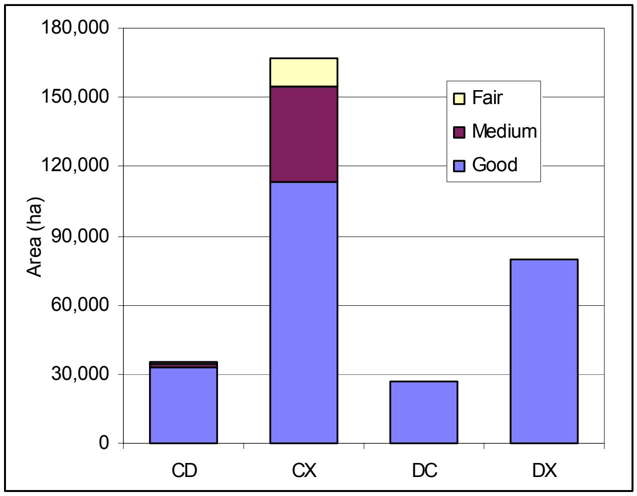


Figure 4.8 Area by Broad Cover Group and Site Productivity

Figure 4.9 shows the current composition of the timber harvesting land base by deciduous and coniferous cover types. The majority (66%) of the current timber harvesting land base is at or above the minimum harvest age (Decid: 80 for 1st rotation, 60 for 2nd rotation; Conifer: 100 for 1st rotation, 80 for 2nd rotation), although there is some variation around this proportion among the four cover type groups.

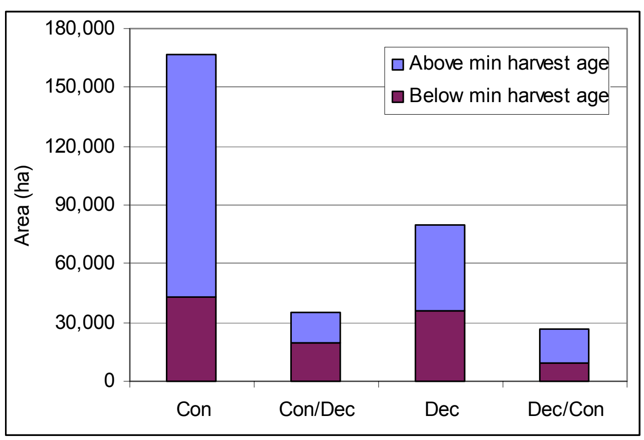


Figure 4.9 Area by Cover Type Group

4.4 Yield Curves

4.4.1 Yield Curve Development

Yield curves were developed by estimating volume as a function of age, site, crown closure, and coniferous composition. Coniferous volumes are based on a 15/11 utilization while deciduous was based on 15/10. Both assume a 15 cm stump height.

Most growth and yield models available for use in Alberta are equations developed from volume sampling data collected in the forests they will be used to analyze. Ideally, a growth and yield model, or the parameters that define a growth and yield equation, would be estimated with data that accurately capture a wide variety of ages, tree densities, states of management, and other such parameters. The reality is that much of the forest in Alberta has a very narrow and uneven age distribution, and many of the parameters used to define the forest are quite general. For example, stand density is represented by a cardinal index of four values – A, B, C, or D – where A is the sparsest and D is densest. So it is with site productivity where stands are classified by three categories – fair, medium, or good.

Timber volumes are estimated from equations with right-hand-side variables being various stand attributes. These attributes include species composition, density class, and site productivity class. Each unique combination of these attributes is called a yield stratum. For each yield stratum, a set of yield equations is produced in order to estimate total coniferous volume, total deciduous volume, and individual species volumes for larch, black poplar, aspen, and white birch. Table 4.3 summarizes the 35 yield strata within which the full set of yield curves was developed.

Area-weighted projections for 141 coniferous and 50 deciduous yield curves were weighted by estimated net harvestable area to produce four yield curves to represent yields from each broad cover group (C, CD, DC, and D). Yields are based on 15/11/15[1] coniferous utilization and 15/10/15 deciduous utilization. Four area-weighted yield curves are presented next as Figure 4.10 through Figure 4.13.

[1] 15/11/15 is the short form used to describe the utilization standard. It depicts the minimum diameter at breast height measured outside the bark (cm)/ minimum diameter of the top of the bole measured inside the bark (cm)/ stump height (cm)

Table 4.3 The 35 Yield Strata used in Forecasting Timber Supply

#	Dominant Covertype	Natural Subregion	Site	Crown Closure
1	Coniferous	Lower Foothills	Good	‘A’
2	Coniferous	Lower Foothills	Good	‘B’
3	Coniferous	Lower Foothills	Good	‘C’
4	Coniferous	Lower Foothills	Good	‘D’
5	Coniferous	Lower Foothills	Medium	‘A’
6	Coniferous	Lower Foothills	Medium	‘B’
7	Coniferous	Lower Foothills	Medium	‘C’
8	Coniferous	Lower Foothills	Medium	‘D’
9	Coniferous	Lower Foothills	Fair	All
10	Coniferous	Upper Foothills	Good	‘A’
11	Coniferous	Upper Foothills	Good	‘B’
12	Coniferous	Upper Foothills	Good	‘C’
13	Coniferous	Upper Foothills	Good	‘D’
14	Coniferous	Upper Foothills	Medium	‘A’
15	Coniferous	Upper Foothills	Medium	‘B’
16	Coniferous	Upper Foothills	Medium	‘C’
17	Coniferous	Upper Foothills	Medium	‘D’
18	Coniferous	Upper Foothills	Fair	All
19	Coniferous	Subalpine	Good	‘A’
20	Coniferous	Subalpine	Good	‘B’
21	Coniferous	Subalpine	Good	‘C’
22	Coniferous	Subalpine	Good	‘D’
23	Coniferous	Subalpine	Fair	All
24*	Coniferous	All	Good	All
25*	Coniferous	All	Medium	All
26*	Coniferous	All	Fair	All
27	Deciduous	Lower Foothills	Good	‘A’
28	Deciduous	Lower Foothills	Good	‘B’
29	Deciduous	Lower Foothills	Good	‘C’
30	Deciduous	Lower Foothills	Good	‘D’
31	Deciduous	Upper Foothills	Good	‘A’
32	Deciduous	Upper Foothills	Good	‘B’
33	Deciduous	Upper Foothills	Good	‘C’
34	Deciduous	Upper Foothills	Good	‘D’
35**	Deciduous	All	Fair	All

Yield Curves – For this project the terms Yield Curve and Yield Strata are not synonymous. Each yield strata has 6 associated yield curves (except *=1 yield curve, **=2 yield curves), all of which project the same total volumes. The 6 curves differ only in the relative coniferous/deciduous volume contribution, which is based on coniferous species composition. In total 191 yield curves were applied to the land base (138 for coniferous dominated stands, 50 for deciduous dominated stands, and 3 for coniferous dominated switch stands).

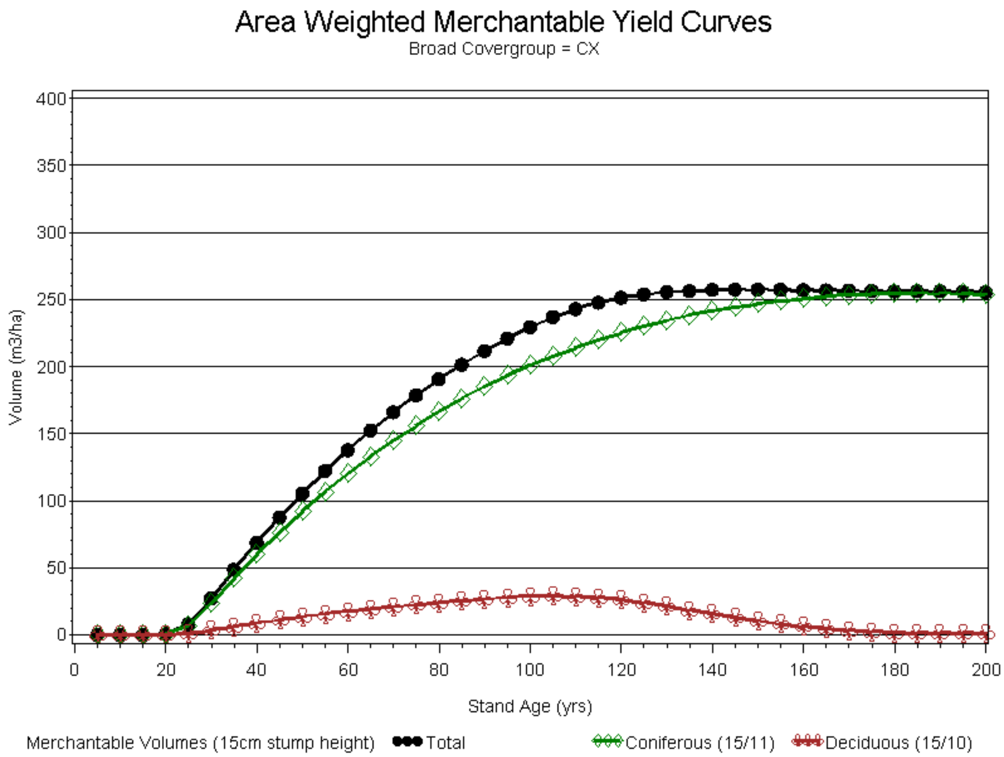


Figure 4.10 Area weighted Yield Curve for the 'C' BCG

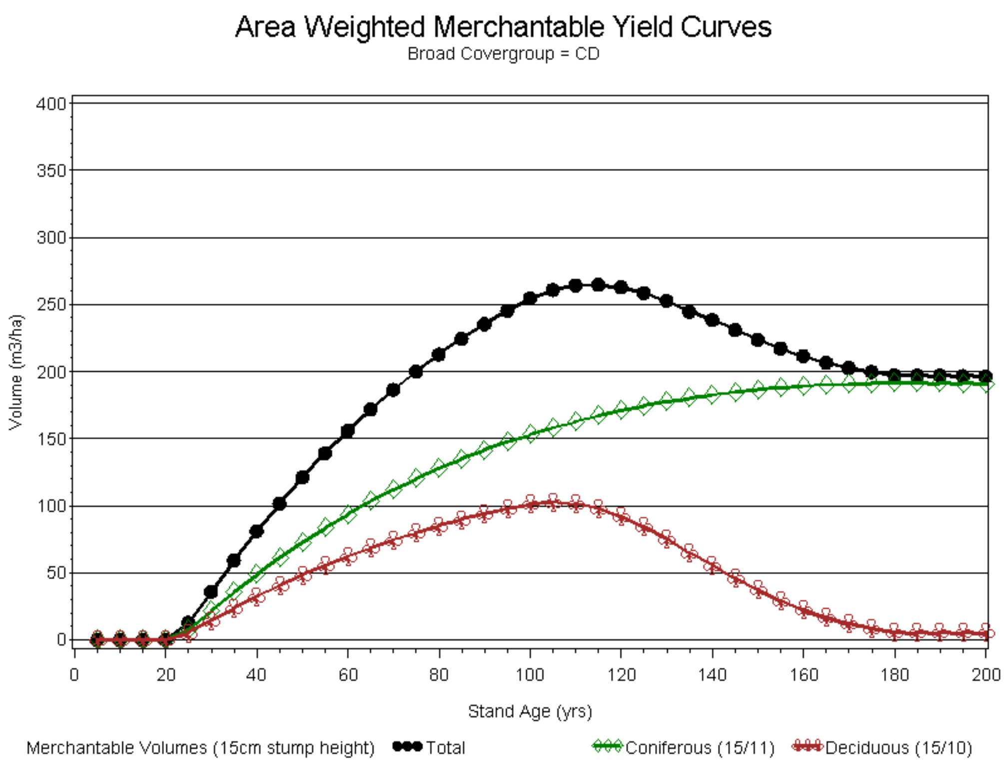


Figure 4.11 Area Weighted Yield Curve for the 'CD' BCG

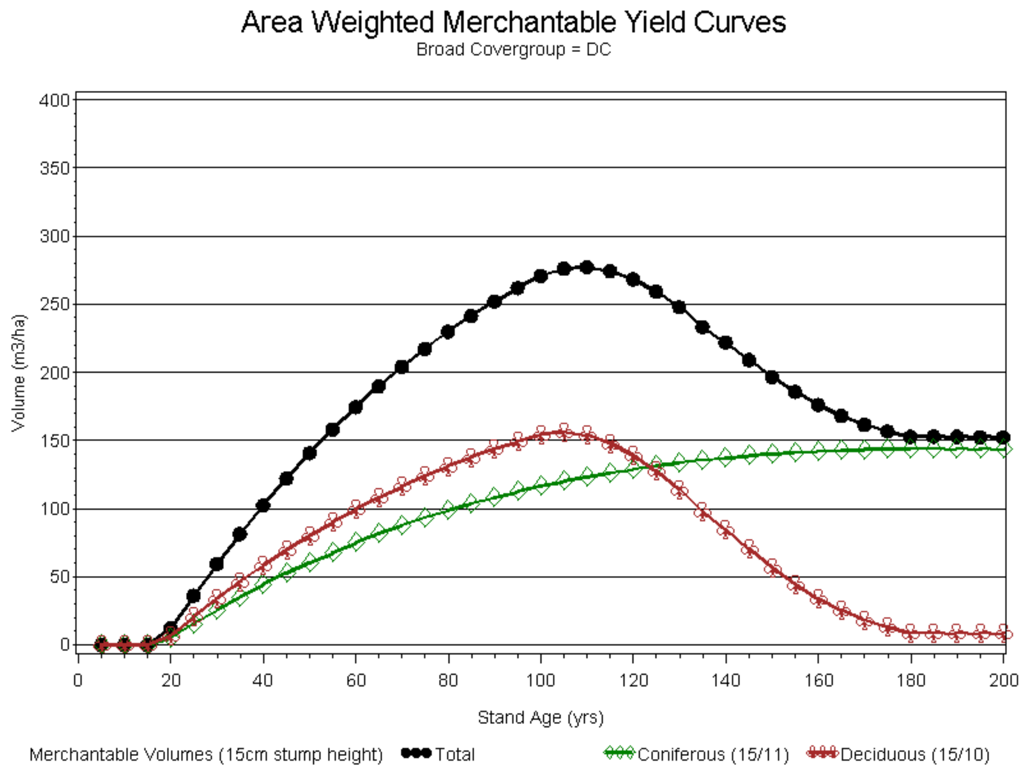


Figure 4.12 Area Weighted Yield Curve for the 'DC' BCG

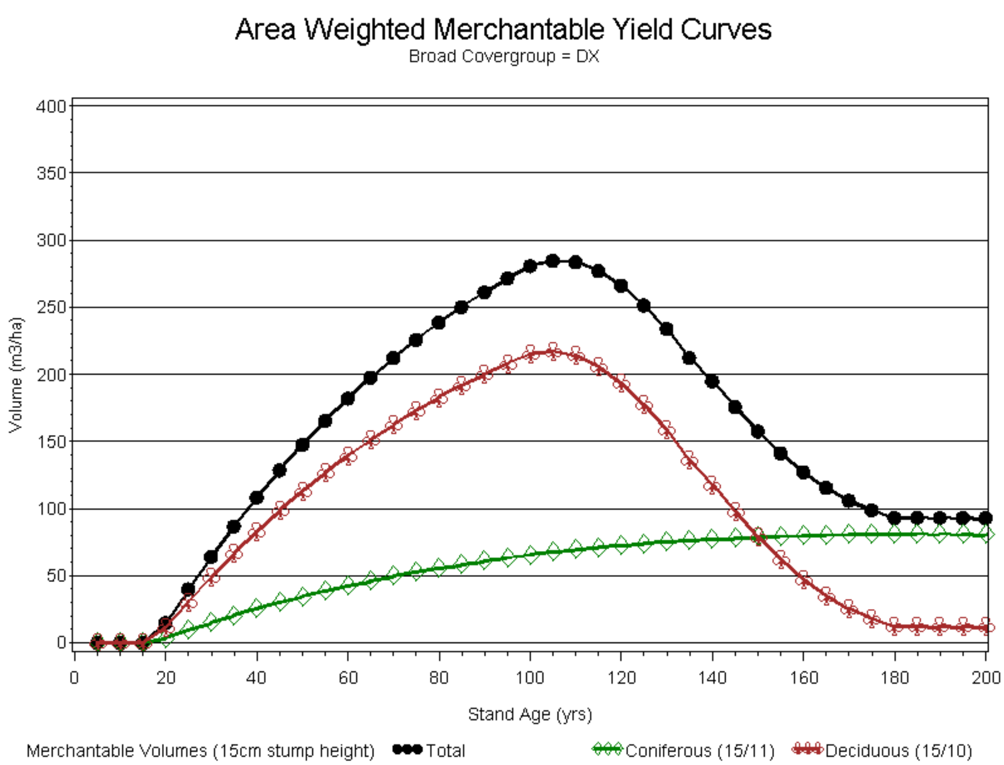


Figure 4.13 Area Weighted Yield Curve for the 'D' BCG

4.5 Linking the Yield Curves to the Land Base

Each stand that is eligible for forest management activities is assigned a yield curve based on broad cover group, natural subregion and site quality, crown closure, percentage coniferous composition, and overstory or understory AVI call used for the primary story of management. During the process of defining the net harvestable land base each forested stand is assigned to a yield stratum using the exact same definitions used to stratify the plot data. The land base netdown process was also applied to the plot data such that the final yield curves actually model the net harvestable land base. This ensures that the estimated volumes are appropriately assigned to delineated stands of the same composition. In the timber supply model each yield curve is given a unique label. This unique label is also assigned to each stand in the land base definition process, and is carried forward into the model.

4.6 Forecasting Model

4.6.1 Remsoft Spatial Planning System

Established in 1992 and located in Fredericton, NB, Remsoft is dedicated to the creation and support of software for integrated, spatial forest management planning. Its flagship products - Woodstock™, Spatial Woodstock™, Stanley™ and the Allocation Optimizer™ are collectively referred to as the Remsoft Spatial Planning System (RSPS, see Figure 4.14). This system is used by companies in the forest industry and leading public agencies and interest groups throughout North America, Australia, New Zealand and Southeast Asia for a host of different strategic and tactical planning issues (Remsoft 2005). This software lets you make resource allocation decisions that meet commercial objectives while ensuring the trade-offs from timber and other non-timber resources are assessed and considered. In the DFMP analysis for the Sustainable Yield Unit R12, the RSPS (without the Allocation Optimizer) was used to forecast sustainable harvest volumes.

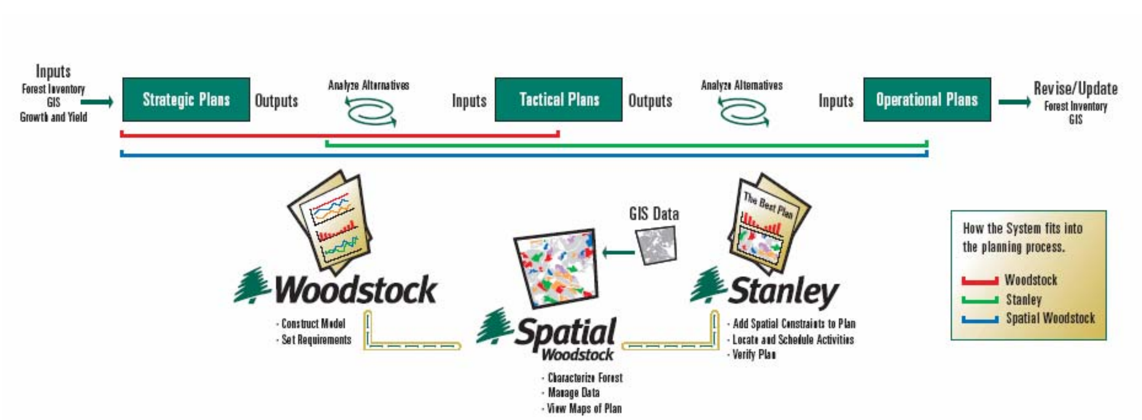


Figure 4.14 Overview of Remsoft Spatial Planning System (Remsoft 2005)

The first module of the RSPS is called Woodstock. Woodstock is an aspatial model that is used for strategic-level planning and is designed to address forest management planning questions. It is a user-defined model that is commonly used to estimate expected harvest volumes over time and to assess trade-offs from other values and objectives. Woodstock also allows the user to define a wide variety of expected output levels such as growing stock volumes, harvested areas, age class distributions, and many others.

The second module is Spatial Woodstock. Spatial Woodstock provides the spatial connection between Woodstock and Stanley. Spatial Woodstock was used to create the area files (land base to be modeled) and to generate time specific spatial characteristics of the land base.

The third module utilized in the RSPS is Stanley. Stanley is a tactical-level planning tool that is used to define both where and when the timber volumes projected with Woodstock will be harvested. Unlike Woodstock, Stanley is a simulation-based spatial activity allocation model. Stanley takes the planned blocks created from our harvest planning team, as well as the Woodstock schedule, and spatially allocates the schedule subject to minimum, maximum, and target opening sizes, adjacency, green-up and other spatial constraints.

4.6.2 MOSEK

MOSEK was established in 1997 by Erling D. Andersen and Knud D. Andersen and it specializes in creating advanced software for solution of mathematical optimization problems. In particular, the company, based in Copenhagen, Denmark, focuses on solution linear, quadratic, and nonlinear convex optimization problems. MOSEK is a provider of optimization software which helps the customers to make better decisions. The customer base consists of financial institutions and companies, universities, and software vendors, among others (MOSEK, 2005). MOSEK is a commercial partner of Remsoft.

The MOSEK optimization software is designed to solve large-scale mathematical optimization problems.

Problems MOSEK can solve:

- Linear problems (integer constrained variables allowed).
- Conic quadratic problems.
- Quadratic and quadratically constrained problems (integer constrained variables allowed).
- General convex nonlinear problems.

Technical highlights of MOSEK are:

- For continuous problems MOSEK implements the simplex and interior-point based algorithms.
- For mixed integer problems MOSEK implements a branch & bound & cut algorithm.
- The MOSEK interior-point optimizer is capable of exploiting multiple processors.

Table 4.4 Versions of the Various Models used in Forecasting

Model	Version
Woodstock	2005.6.0
Spatial Woodstock	2005.6.0
Stanley	2005.6.0
MOSEK	3.0

4.7 General Description of the Modeling Process

Once interim approval has been received from Alberta Sustainable Resource Development for both the net harvestable land base and the Growth and Yield Forecasts, the land base is prepared for the RSPS. The necessary fields for modeling are added which include preblocks and themes. These attributes are populated where necessary so that planner-defined harvest blocks and previously harvested areas are appropriately sequenced with the correct period and action (so the correct rule sets may be applied).

Spatial Woodstock was then used to create area file and LP schedule (of all the planned blocks) files. The modeling approach used in this analysis followed the pathway shown in Figure 4.15 and is outlined in this section.

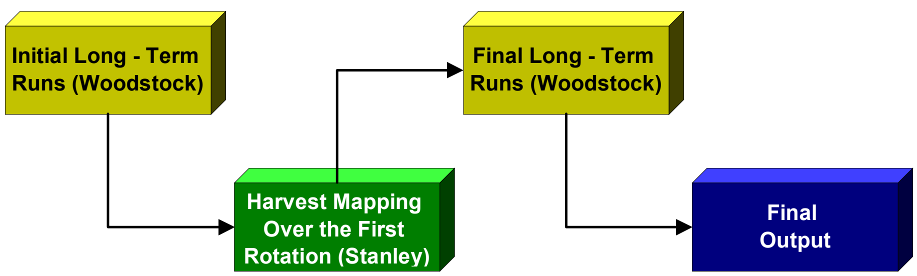


Figure 4.15 Overview of the Modeling Approach

4.7.1 Initial Long Term Strategic Runs (Woodstock™)

The Woodstock model was designed to achieve the maximum harvest volume within the objectives for operability and sustainability of both timber and non-timber resources. Yield relationships were applied to specific forest types (or yield strata) over a specified planning horizon. Harvest activities were applied to the forest based on specified objectives and parameters such as minimum harvest age, and minimum merchantable volume. Woodstock creates a matrix of the Linear Programming problem (the collection of the objective and constraints, in consideration of the land base, yield curves, and other management protocols (refer to section 4.11.1 for an overview of the modeling protocols). The linear optimization solver, MOSEK is used to solve the matrix, returning an optimized harvest schedule to Woodstock. Woodstock then uses this harvest schedule to calculate various outputs over the planning horizon. A list of outputs/indicators included in the analysis is presented in Table 4.5.

Table 4.5 Outputs / Indicators Modeled in Woodstock

Indicators / Outputs
Growing Stock
Operable Growing Stock
Age Class Structure
Volume Harvested
Average Harvest Age
Average Harvested Volume per Hectare
Late, Very Late, and Extremely Late Seral Stages
Area Harvested
Piece Size
Mortality

4.7.2 Harvest Mapping (Stanley™)

Harvest mapping ensured that forest/landscape pattern constraints were met over the first 60 years of the planning horizon and that green-up and adjacency requirements were met. Primary hardwood and softwood harvest objectives (softwood from conifer land base and hardwood from deciduous land base) were blocked simultaneously using weightings in Stanley. Spatial harvest scheduling was applied in a stepwise approach:

- First, all existing (prior to November 2004) conifer and deciduous harvest blocks were identified. They were pre-blocked to ensure that green up delays in these blocks would be considered for subsequent blocks.
- Previously planned blocks were incorporated as preblocks into the harvest schedule during periods 1 through 5.
- The coniferous and deciduous land bases were blocked simultaneously, with the objective of maximizing the spatial allocation of the conifer and deciduous harvest level.

Stanley, the spatial harvest scheduling component of the suite, allocates the Woodstock schedule to specific polygons on the land base subject to spatial modeling parameters (refer to section 4.11.2 for a summary of the modeling protocols). Considering all of the pre-blocks created by the planning team, Stanley creates additional blocks in order to achieve the aspatial volumes generated in Woodstock. Following a period of time when there appears to be no “better” solutions created, the model is stopped and the spatial harvest sequence is written to the shapefile (a storage format for storing geometric location and associated attribute information). Maps of the areas scheduled for the 25 year Spatial Harvest Sequence were generated with Stanley. The map of expectations was repeatedly assessed and refined by the operations planning staff to create a harvest design to be used operationally for the first 15 years and somewhat less for the following ten years (years 16 to 25).

4.7.3 Final Long Term Runs (Woodstock™)

The preferred spatial harvest schedule produced by Stanley was then incorporated into the long-term Woodstock run, providing a direct linkage between the operationally feasible spatial harvest schedule and long-term sustainability. The harvest schedule in periods 13 to 40 was re-optimized to account for adjustments made by Stanley in the first 12 periods of harvest and to incorporate these into the long-term harvest schedule. All modeling outputs displayed herein are based on this harvest schedule unless otherwise specified.

Woodstock is then used again to re-calculate the outputs based on the spatial harvest schedule developed using Stanley. This schedule considers both the operationally planned blocks (preblocks) as well as the Stanley generated openings. This tactical level sequence then becomes the "hard-wired" sequence for the tactical portion of the final Woodstock run. Woodstock is re-deployed to calculate the final (post spatial) values of the indicators defined in the model. To ensure additional blocks are not sequenced in the first tactical portion of the planning horizon the object is set to minimize volume. For the remainder of the planning horizon the objective is returned to the original setting.

Once the final outputs are calculated the aspatial reduction factors (cull and in-block retention) are applied to the estimated harvest volumes. These final numbers are the proposed sustainable harvest volumes for the SYU.

The Weyerhaeuser planning team spent considerable effort in making the Spatial Harvest Sequence (SHS) generated by Stanley for the first 15 years as operational as possible. Planned blocks made up a large portion of the volume required over the SHS.

4.8 Assumptions and Uncertainties

It is impossible to model all natural processes; however, to create realistic models, it is necessary to make certain key assumptions about natural forest processes. Many of these assumptions deal with the complexities of forest succession, stand modifying disturbances and forest growth rates. These are difficult to accurately predict (especially the timing, extent and severity of stand modifying events).

4.8.1 Successional Dynamics

As the planning horizon for the Woodstock™ model exceeds the lifespan of most tree species in SYU R12, Woodstock™ requires rules by which complex changes over time in stand species composition and density can be modeled. This requires two main assumptions about how Woodstock™ will "grow" these stands from their present state to the end of their lifespan. The first assumption for stand dynamics is straightforward: stands are assumed to retain the same species composition until death/senescence. The second assumption is that as a stand dies or is harvested, it regenerates back to that same species composition and structure as it develops over time.

As regenerating stands develop within the model's planning horizon, these stands grow at the pace defined by the model's yield curves. These curves have been developed under natural forest conditions, without silvicultural intervention. Thus, this model grows the individual stands as they have previously grown, as indicated by the natural yield curve. It is important to model transition and have stands regenerate back to their previous condition, even for harvested areas, to reduce or eliminate the notion of stand conversion to other forest types. Stand conversion or alterations to regenerating yield curves is unreliable without supporting empirical evidence and for this area, empirical information of this nature is inadequate.

4.8.2 Natural Disturbance

One major assumption within the TSA was that the current volume losses due to the incidence of fire, insect and disease outbreaks are representative of future volume losses. Due to the large fluctuations in damage these disturbances cause and the unpredictability of the timing, location and the extent to which they will affect the land base, it is difficult to apply an accurate average deduction over the planning horizon. In addition, in many of these areas, the volume could be salvaged, albeit at a reduced recovery and quality factor. In the event of a large scale impact (>= 2.5% of the harvestable land base) a re-calculation of the AAC will occur. Stands lost to recent fire that have not regenerated, have been excluded from the harvestable land base until a time when a new inventory, update or survey can verify that they are producing forest species. As such this serves as a proxy aspatial deduction for fire on the land base.

4.9 Long Run Sustainable Yield

Long Run Sustainable Yield Calculation (LRSY) is the theoretical estimate of the yield attainable once a regulated state has been achieved and all stands are harvested at the point of a stand's maximum net-volume production (Mean Annual Increment (MAI)-culminating rotation age). The LRSY provides the theoretical maximum AAC that the forest can sustain. If the land base and yield information are accurate and the harvest and succession assumptions are reasonable, the model will provide a realistic estimate of the maximum sustainable AAC. Employing similar assumptions, the use of a more sophisticated model will not yield a sustainable AAC that is greater than the LRSY estimate, in theory, but should be more realistic.

The LRSYs are calculated by multiplying the initial net area in each broad cover group by the maximum, area weighted MAI for that cover group. The sum of all yield calculations for each land base is the LRSY derived AAC for the analysis area and is summarized in Table 4.6.

Table 4.6 Long Run Sustainable Yield

Broad Cover Group	Area (ha)	Age (yrs)	M.A.I. (m^3/ha/year)			LRSY (m^3/year)		
			Deciduous	*Coniferous*	*Total*	*Deciduous*	*Coniferous*	*Total*
Conifer	166,464	90	0.3	2.1	2.4	49,939	349,574	399,513
Conifer Mixedwood	35,542	90	1.0	1.6	2.6	35,542	56,867	92,409
Deciduous Mixedwood	26,803	70	1.7	1.3	3.0	45,565	34,844	80,409
Deciduous	79,497	70	2.3	0.7	3.0	182,844	55,648	238,492
Total	308,306					313,890	496,933	810,823

4.10 Model Structure

The analysis was conducted using five-year modeling periods with planning horizons of twice the expected rotation age. The overview of the modeling structure is listed in Table 4.7.

Table 4.7 Overview of the Forest Model Structure

Basic Forest Modeling Principles	Description	WOODSTOCK™/STANLEY ™ STRUCTURE (Input files: []=WK, {}=STAN)
Landbase Description	Netdown/Stratification	[AREAS] [LANDSCAPE]
Development Patterns	m^3/ha	[YIELDS]
Treatments: Types	Harvesting Activity	[ACTIONS]
Treatments: Eligibility	Operability Windows	[ACTIONS] [LIFESPANS]
Treatments: Responses	Succession	[TRANSITIONS]
Resource Indicators	Growing Stock	[OUTPUTS] [REPORTS] [GRAPHICS]
Model Control	Planning Horizon	[CONTROL], [GRAPHICS] [OPTIMIZATION]
Integration of Existing Plans	Cut Blocks / 5yr Plan	{SHAPEFILE}, [LPSCHEDULE]
Spatial Constraints	Block Size / Green-up	{PARAMETERS}, {AREAS}

4.11 Summary of Model Variables

4.11.1 Woodstock™

A wide variety of input parameters and management assumptions must be specified prior to projecting harvest schedules with Woodstock. These are specified in order to reflect both the biological processes of the forest, as well as the current realities of operational forest management practices. Table 4.8 shows a detailed description of these Woodstock harvest projection parameters.

Table 4.8 Summary of Input Parameters and Assumptions for Woodstock

Parameter / Criteria	Value	
Planning Start Year	18-Nov-2000	
Planning Horizon	the planning horizon is 32 periods or 160 years, and therefore the implicit average harvest age is 80 years. The planning time step (period length) is 5 years.	
Sustainability	+/- 5% on net (after spatial sequencing) conifer & deciduous harvest levels was the overall target. To achieve this, a strict even-flow harvest was set for the first 12 periods, and then the harvest was permitted to deviate +/- 5% for the remainder of the planning horizon anchored to period 12 values. In the Stanley, the flow tolerance was set to 7% for the 60 year horizon. When played back in the final Woodstock phase, the Stanley generated sequence was strictly adhered to for the first 12 periods, then the subsequent aspatial flows were constrained to +/- 4.5% of the midpoint of the harvest levels from the tactical phase (periods 1 thru 12). Non-declining total growing stock for final 40 years of planning horizon and non-declining operable growing stock for final 15 years of planning horizon. Even-flow conifer for Rose Creek (Jack Knife HDA)	
Objective	Maximize total volume harvest over planning horizon. The timber supply objective is to maximize the sum of coniferous and deciduous harvest volumes over the entire planning horizon. The value of the objective function is in cubic metres.	
Harvest Constraints	Area harvested in Marshy Bank <= 500ha / period in period 1	
	Area harvested in Blackstone <= 1,000ha / period in period 1	
	Area harvested in Chungo Lookout <= 0 ha / period in periods 1 & 2	
	Various Harvest Design Areas aggregated for preferred sequence	
	Maintain a range of late, very late, and extremely late seral stages in the main yield strata – D, DC, CD, Se (Sw), Pl, Sb.	
Minimum Harvest Ages	Deciduous Minimum Harvest age: 80 for 1st rotation, 60 for 2nd rotation; Coniferous Minimum Harvest age: 100 for 1st rotation, 80 for 2nd rotation	
Regeneration Lag	C - 2.3 years	DC - 2.3 years
	CD - 2.4 years	D - 0.4 years
Succession after harvest	All yield classes regenerate to pre-harvest yield class at age zero (adjusting for regeneration lag)	
	All harvested stands of 'A', 'B', 'C', or 'D' come back to a "C" density	
Natural Break-up Ages	Deciduous - 200 years	CD Mixedwood - 300 years
	DC Mixedwood - 200 years	Coniferous - 300 years
Succession after break-up	All Yield Classes maintain original Yield Class at age zero	
	Except non-harvestable forested areas that break-up and return to the curve @ 170 yrs of age	

4.11.1.1 Start Date

November 18, 2000 was selected as the start date as this was the beginning of the existing cutting quadrant. The start date is defined as the point in time that best reflects the forest attributes at the beginning of the TSA model. Therefore, every reasonable attempt was made to have all input data sets consistent with Nov 18, 2000. Additionally, the five years of management activities that have occurred since the start date were incorporated into the TSA model as preblocks.

4.11.1.2 Strategic Level Planning Horizon and Period Length

The planning horizon used in this analysis was 160 years or 32 periods. The period length was set as five years. This was designed so that the harvest projection runs parallel to Weyerhaeuser's cutting quadrants.

4.11.1.3 Objective and Strategic Level Sustainability Criteria (Constraints)

The primary objective of the forecasting model was to maximize the total volume harvested over planning horizon. The timber supply objective is to maximize the sum of coniferous and deciduous harvest volumes over the next 160 years.

Constraints have been incorporated into the model to ensure that the level of forest management is sustainable over time. One measure constrained was flow tolerance. A flow +/- 5% on net conifer & deciduous harvest levels was the overall target. To achieve this, a strict even-flow harvest was set for the first 12 periods, and then the harvest was permitted to deviate +/- 5% for the remainder of the planning horizon anchored to period 12 values. In the spatial scheduling phase, the flow tolerance was set to +/-3.5% for the 60 year tactical level planning horizon. When this sequence was played back in the final Woodstock phase, the Stanley generated sequence was strictly adhered to for the first 12 periods, then the subsequent aspatial flows were constrained to +/- 4.5% of the midpoint of the harvest levels from the tactical phase (periods 1 thru 12). This achieved the overall target of +/-5% for the net harvest volume flows.

Other sustainability constraints incorporated into the model included:

- A non-declining growing stock, for both the conifer and deciduous, for final 40 years of planning horizon and non-declining operable growing stocks, for both the conifer and deciduous, for the final 15 years of planning horizon;
- A minimum (floor) of 40,250 m3/yr (before spatial & aspatial reductions) conifer harvest levels from the TallPine LMU for the duration of the 25 year SHS;
- There was no harvesting in Chungo Lookout for the first 2 periods (2000 – 2009);
- The area harvested in Blackstone was limited to no more than 1,000 ha in period one;
- The area harvested in Marshy Bank was limited to no more than 500 ha in period one;
- Even-flow conifer for Lodgepole CTP (Jack Knife HDA);
- Various Harvest Design Areas aggregated for preferred timing during sequence.

4.11.1.4 Seral Stages

Another sustainability measure implemented by Weyerhaeuser is the maintenance of various seral stages over time. A more detailed description of seral stages is located in Section 1.2.3.1 and 6.2.2. A range of late, very late, and extremely late seral stages in the main yield strata – D, DC, CD, Se (Sw), Pl, Sb was maintained. Due to the number of seral constraints the model initially had a very difficult time processing. It was determined that aggregations of cover types could be made without removing any integrity of the constraints or the amount of older seral stages in the future. More specifically the constraints include:

In the Lower Foothills Natural Subregion:
During the first 40 years;

- Deciduous dominated cover types were constrained to have at least 5% area greater than 70 years of age and 1% greater than 110 years of age
- Deciduous mixedwood cover types were constrained to have at least 5% area greater than 70 and 1% greater than 110 years of age
- Coniferous mixedwood cover types were constrained to have at least 5% area greater than 90 and 1% greater than 120 years of age
- Lodgepole pine dominated cover types were constrained to have at least 5% area greater than 90 and 1% greater than 120 years of age
- White spruce dominated cover types were constrained to have at least 10% area greater than 90 years of age and 2% area greater than 120 years of age
- White spruce/lodgepole pine mixed stands were constrained to have at least 5% area greater than 90 and 1% greater than 120 years of age
- Conifer cover types other than those mentioned above were constrained to have at least 5% area greater than 90 and 1% greater than 120 years of age

During the remainder of the planning horizon (years 45 thru 160);

- Deciduous dominated and Deciduous mixedwood cover types were aggregated and were constrained to have at least 5% area greater than 70 years of age
- Coniferous mixedwood cover types were constrained to have at least 5% area greater than 90 years of age
- Lodgepole pine dominated cover types were constrained to have at least 5% area greater than 90 years of age
- White spruce/lodgepole pine mixed stands were aggregated with “other” conifer cover types and were constrained to have at least 5% area greater than 90 years of age
- White spruce dominated cover types were constrained to have at least 10% area greater than 90 years of age

In the Upper Foothills Natural Subregion:
During the first 40 years;

- Deciduous dominated cover types were constrained to have at least 5% area greater than 70 years of age and 2% greater than 110 years of age
- Deciduous mixedwood cover types were constrained to have at least 5% area greater than 70 and 2% greater than 110 years of age
- Coniferous mixedwood cover types were constrained to have at least 5% area greater than 90 and 2% greater than 120 years of age
- Lodgepole pine dominated cover types were constrained to have at least 2% area greater than 90, 1% greater than 120, and 0.5% greater than 170 years of age
- White spruce dominated cover types were constrained to have at least 15% area greater than 90 years of age, 5% area greater than 120, and 2.5% greater than 170 years of age
- White spruce/lodgepole pine mixed stands were constrained to have at least 10% area greater than 90 years of age, 5% area greater than 120, and 2.5% greater than 170 years of age
- Conifer cover types other than those mentioned above were constrained to have at least 10% area greater than 90 years of age, 5% area greater than 120, and 2.5% greater than 170 years of age

During the remainder of the planning horizon (years 45 thru 160);

- Deciduous dominated and Deciduous mixedwood cover types were aggregated and were constrained to have at least 5% area greater than 70 years of age

- Coniferous mixedwood cover types were constrained to have at least 5% area greater than 90 years of age
- Lodgepole pine dominated cover types were constrained to have at least 2% area greater than 90 years of age
- White spruce/lodgepole pine mixed stands were aggregated with "other" conifer cover types and were constrained to have at least 10% area greater than 90 years of age
- White spruce dominated cover types were constrained to have at least 15% area greater than 120 years of age

In the Subalpine Natural Subregion:
During the first 40 years;

- Lodgepole pine dominated cover types were constrained to have at least 5% area greater than 90, 2% greater than 120, and 1% greater than 170 years of age
- White spruce dominated cover types were constrained to have at least 20% area greater than 90 years of age, 10% area greater than 120, and 5% greater than 170 years of age
- White spruce/lodgepole pine mixed stands were constrained to have at least 10% area greater than 90 years of age, 7.5% area greater than 120, and 5% greater than 170 years of age
- Conifer cover types other than those mentioned above were constrained to have at least 10% area greater than 90 years of age, 5% area greater than 120, and 2.5% greater than 170 years of age

During the remainder of the planning horizon (years 45 thru 160);

- Lodgepole pine dominated cover types were constrained to have at least 5% area greater than 90 years of age
- White spruce/lodgepole pine mixed stands were aggregated with "other" conifer cover types and were constrained to have at least 10% area greater than 90 years of age
- White spruce dominated cover types were constrained to have at least 20% area greater than 120 years of age

4.11.1.5 Periodic and Quadrant Reconciliation Volumes

Tall Pine Timber Products has an estimated 33,144 m3 (~6,629 m3/yr) of under-production that has been accounted for in the first period. This volume was added to Tall Pine's portion of their SYU volume in the first period and additional period one blocks were designated accordingly in the SHS.

Weyerhaeuser has an estimated 88,417 m3 (~17, 684 m3/yr) of coniferous over-production. This volume was removed from Weyerhaeuser's period one harvest level and from the SHS. Tables showing the over and under-production levels, as well as the adjusted harvest levels for period one and the remainder of the DFMP are located in Appendix 4.7. The SHS by Disposition Holder is located in Appendix 4.8 (Map A).

For operational reasons, harvest of all the first period blocks in the SHS may not be completed by the end of the first period. If this is the case, any un-harvested first period blocks will be harvested in the second period.

4.11.1.6 Treatment Types

The stand-level treatments are described in Table 4.9. Treatment responses were based on clear-cut harvest treatment; a constant aspatial, reduction factor was removed from the calculated AAC in the end to account for residual, in cut-block stand structure retention. Within the model, this action was referred to as a "HARVEST" action. In the model, "DEATH/SENESCENCE" is a treatment that models the natural break-up of a stratum at the end of its life span. This function is required by Woodstock™ as not all the merchantable timber volume can be harvested before it reaches a defined senescence age. Senescence for the deciduous cover types was defined as 200 years; senescence for coniferous cover types is species-specific. The senescence age for predominantly conifer and conifer leading mixedwood stands was 300 years, and senescence limits of 200 years were established for deciduous leading mixedwoods and stands that were predominantly deciduous. Table 4.10 outlines the lifespans used in this plan.

Table 4.9 Stand Level Treatments

Treatments	Description	Purpose
Death / Senescence	Removal of all merchantable stems through natural break-up	(a) Mimicking natural stand break-up
Clearcut Harvest	Removal of all merchantable stems of all species, followed by reforestation	(a) Even-aged management (b) Timber extraction

Table 4.10 Lifespan for Broad Cover Groups

BCG	Lifespan (years)
Deciduous	200
DC Mixedwood	200
CD Mixedwood	300
Coniferous	300

4.11.1.7 Treatment Eligibility

Operability ages were used to define a "window" when a stratum meets the minimum age requirement for harvest. Lower operability limits were defined for each land base type based on various components such as tree growth, volume, product sizes, harvesting practices and systems. The operability ages for the land base groups to be harvested by Weyerhaeuser were as follows:

- Deciduous Minimum Harvest age: 80 for 1st rotation, 60 for 2nd rotation;
- Coniferous Minimum Harvest age: 100 for 1st rotation, 80 for 2nd rotation.

The rationale for the decrease in minimum harvest age for second rotation is based on two points:

- The density of regenerating stands allows for an earlier culmination age of Max MAI;
- Considering improvements in piece size utilization that has occurred over the last 50 to 80 years it is reasonable to expect the trend for improvement to continue on in the future. The actual volumes that will be achieved for these second rotation stands is a very

conservative estimate because the volumes assigned will still be based on the same utilization standards for the first rotation.

There were no upper operability limits for timber harvest eligibility in the timber supply model.

4.11.1.8 Transition Development Patterns (Responses)

The development patterns implemented in this model reflect those of basic transitions. Stands that are harvested are assumed for the purposes of modeling to regenerate to the fully-stocked pre-treatment stratum and are assigned an age of zero. Thus, 'A', 'B', 'C', or 'D' density strata are assumed, within the model, to regenerate back to a "C" density strata. Transitions in strata are supported with firm commitments to conduct the necessary silviculture treatments to provide sufficient assurance that the transitions proposed are practical and reasonable.

Stands that are not harvested are subject to a mortality function. Stands that are on the harvestable land base and are removed through death/senescence are assumed for the purposes of modeling to return to the pre-treatment stratum (including density) and are assigned an age of zero. Stands that are within the non-harvestable forested areas (i.e. buffers) break-up and return to the same yield curve @ 170 yrs of age.

4.11.1.9 Regeneration Lag

Regeneration lag is the time (number of growing seasons, expressed in years) following harvest required for a new stand of trees to initiate growth as compared to the natural yield curve. The regeneration lag is equivalent to the time a harvested area remains fallow without regenerating trees. The regeneration lag assessment used the timing of historical reforestation activities and the regeneration survey status as the basis for establishing the regeneration lag assumed in the timber supply analysis (TSA). Table 4.11 documents the regen lags used in this plan.

As the harvest projection output is recorded in five-year time periods, this was implemented such that a calculated regen lag value of 2.3 years would have 46% (2.3 yrs / 5 yr period) of the area (ha) delayed one five-year period and 54% of blocks regenerate with no delay. This is represented in the transition rules.

Table 4.11 Regeneration Lag for Broad Cover Groups

BCG	Lag (years)
Deciduous	0.4
DC Mixedwood	2.3
CD Mixedwood	2.4
Coniferous	2.3

4.11.2 Stanley

4.11.2.1 Blocking and Sequencing Parameters Analysis

The blocking analysis explored the sensitivity of baseline spatial constraints to wood supply. These baseline parameters are described throughout this section and are summarized in Table 4.12.

Table 4.12 Summary of Input Parameters and Assumptions Required for Stanley

Parameter / Criteria	Value	
Planning Horizon	25-year stand-level sequence(2000-2025), **15-**year harvest plan (2000-2015), (60 year planning horizon)	
Green-up Delays	D, DC, CD	10 years (1 period)
	C	15 yrs (2 periods)
Block Size	Minimum	Maximum
Block Size	2 ha	360 ha
Target Block Size	75 ha	
Adjacency distance	55 meters	(Distance between same strata blocks)
Proximity distance	21 meters	(Green-up distance between blocks)
Timing Deviations	20 years, 4 periods	
Spatial Flow Tolerance	Conifer = 7%, Deciduous = 7% (+/- 3.5%)	
Allow multi-period openings	No	

During the spatial sequencing of the aspatial harvest levels, sensitivity analyses of identified blocking and the effects of various sequencing parameters were analyzed. Blocking parameters, such as adjacency distance, target block size, proximal distance, and desired flow tolerances were individually assessed.

The analysis was based on a standard blocking approach developed to address multiple objectives across multiple geographic areas. The following sections describe the blocking approach and present the results of the analysis for each of the critical and blocking parameters.

4.11.2.2 General

The planning horizon was twelve five-year periods, or 60 years from the present. The SYU R12 was modeled as a single unit. In past analysis this was impossible to accomplish but due to advancement in hardware and software large areas can now be modeled simultaneously. The objective was to block the primary conifer and primary deciduous volumes. Advancements in the RSPS now permit different rule sets to be modeled simultaneously. The spatial sequencing allowed Weyerhaeuser to model both the coniferous and deciduous blocks at the same time while applying different green-up constraints.

4.11.2.3 Adjacency Distances (Distance between same stratum blocks)

Adjacency describes the ways that polygons are spatially related to other polygons in the forest. Within the Stanley™ environment, adjacent polygons can be, and are, combined to form harvest blocks. This adjacency value dictates the maximum distance between polygons that Stanley™ would be allowed to group into a harvest block. The adjacency distance assigned for the constraint was 55 meters. The distance selected will allow polygons to be grouped into blocks that are separated by relatively narrow non-eligible features such as seismic lines, trails or other narrow linear features, but will prevent the grouping of polygons separated by landscape features that would, in reality, prohibit the harvest of the group as a single unit. In past analyses, the percentage harvest achieved was relatively insensitive to modifications to adjacency distances, as many non-eligible features are too narrow to be captured as individual polygons within the inventory. As a result, these features do not often act as block boundaries, whereas a 55-meter separation would usually denote a watercourse or a large right-of-way that would preclude these polygons from being grouped.

The adjacency distance is the maximum distance between stands that allows Stanley to combine the stands as one harvest opening. The greater the adjacency distance, the further away stands can be combined to form harvest openings. Any stand that is as close as or closer than the adjacency distance away from another stand can be included in a harvest opening, or block, provided other relevant criteria are met.

4.11.2.4 Minimum and Maximum Block Sizes

Minimum block size is a constraint within the Stanley™ modeling environment that sets the minimum acceptable harvest block size created using the adjacency distance. Single-polygon or composite-polygon blocks that are smaller than the minimum are identified as impossible area and become isolated stands.

The minimum block size can have significant effects on the spatial harvest levels; the larger the minimum block size, the greater the negative impact on the spatial harvest level. A size of two hectares was selected as the minimum block size for this analysis. Block sizes of less than two hectares are not operationally feasible. Conversely, setting the minimum block standards at some higher area, e.g. ten hectares may remove a large portion of productive land base and consequently constrain the Stanley™ model.

The maximum block size for modeling was selected to be the same as the largest block planned by the operational planning team. The maximum block size was set at 360 hectares.

4.11.2.5 Target Block Sizes

The target block size parameter establishes the desired block size. It is very useful if the average block size differs greatly from the desired block size. Various scenarios were analyzed and due to the fragmented nature of the land base it was very difficult to create average disturbance patches in the vicinity of the desired patch sizes. The target block size was eventually raised to 75 ha. This meant the model would attempt to aggregate polygons until the patch was close to 75 ha in size. Even with this parameter in place the average block size for the duration of the Spatial harvest Sequence was only 13.5 ha (the average planned block was 13.9 ha and the average Stanley generated block was 13.2 ha).

4.11.2.6 Proximal Distances (Green-up distance between blocks)

Spatial blocking within the Stanley™ environment requires a value to represent the proximal distance (zero to some arbitrary maximum) within which Stanley™ would be allowed to place harvest blocks that have not achieved green-up. In this case, proximity represents how close each created opening can be to another (either existing, planned or both).

Once Stanley™ assigns a block to a harvest period; proximal stands will not be scheduled until the regenerating trees within the harvested area have achieved green-up. In the absence of a proximal distance, Stanley™ could place blocks as close together as the adjacent distance without causing a violation. However, under most management strategies this may be inappropriate; thus, by setting the proximal distance greater than or equal to the desired width of exclusion zones, Stanley™ will separate the proposed blocks by at least this amount within the green-up interval (Remsoft, 1999).

Results achieved in past analyses indicate that proposed harvest levels have been relatively insensitive to a changing proximal distance up to 21 meters, after which achievement of proposed aspatial harvest levels have decreased noticeably. Thus, in this analysis a proximal distance of 21 meters was selected. Two stands separated by a buffered small permanent stream (60 m width) would not be in violation of green-up.

Proximal distance defines the minimum distance that a stand must be away from another stand in order that the two stands as part of separate blocks can be scheduled for harvest in the same period.

4.11.2.7 Timing Deviation

The maximum timing deviation sets the maximum number of periods that harvest scheduling can deviate from the aspatial timings. The Stanley modeling process attempts to assign treatments to polygons such that deviations from the optimal timings outlined in the strategic schedule are minimized. However, it may be necessary to advance or delay activities to facilitate block allocation. A higher setting allows for greater flexibility in the allocation process at the expense of a greater divergence from the goals and objectives reconciled in the strategic schedule (Remsoft, 1999).

As discussed above, a maximum deviation of zero was used in some areas in the first 3 periods of the spatial planning horizon to ensure that operational objectives set up in Woodstock were not compromised by Stanley. The remainder of the spatial analysis used a maximum deviation of four periods.

Past analyses have shown that percentage harvest, especially for conifer land base, is highly sensitive to a changing maximum timing deviation. This stands to reason as the timing deviation allows for increased flexibility for the model to allocate the aspatial harvest level over a number of periods.

Stanley assigns treatments to polygons such that deviations from the scheduled timing in Woodstock are minimized. It may be necessary to advance or delay the timing of a scheduled activity. The periodic deviation parameter specifies the maximum number of periods away from the optimal schedule the activity can be blocked. For all runs this was set to four periods, or 20 years. The rationale for this is that all the forest is initially quite old, and this allows for greater flexibility in scheduling harvest.

4.11.3 Aspatial Post-Modeling Harvest Level Reductions

4.11.3.1 Stand Structure Retention

The volumes in this analysis were compiled using a flat rate volume reduction to account for the retention of merchantable volume left standing. A flat-rate volume reduction of five percent was deducted from the AAC volume to account for in-block retention. This reduction rate was done as a flat-rate aspatial deduction. Refer to Table 4.13 for the quantitative reduction factors.

4.11.3.2 Cull Deductions

Cull deductions are applied as a method of accounting for non-merchantable volume loss due to defect, substandard and/or marginal quality of the harvested trees. In this analysis the cull deductions were removed as an aspatial deduction to the calculated harvest level and were removed after the stand structure retention was deducted. Refer to Table 4.13 for the quantitative reduction factors.

Table 4.13 Aspatial Post-Modeling Harvest Level Reductions

Reduction Factor	BCG	% Applied
Cull	Conifer	3.06%
	Deciduous	5.83%
Block Retention	Conifer	5.00%
	Deciduous	5.00%

4.12 Preferred Management Strategy

4.12.1 Management Objectives and Model Constraints

Following consultation with other timber operators and SRD and various sensitivity analyses, a preferred scenario that best represented the collective goals and objectives was modeled to estimate sustainable harvest levels for the Sustained Yield Unit R12. The scenario was based on the preferred scenario “FMA_10” from the December 22, 2000 draft DFMP submission for the Weyerhaeuser Drayton Valley FMA and was used as the basis to establish the AAC (Refer to Appendix 4.6 for an overview of scenario “FMA_10” and the related sensitivity analyses). Like its predecessor, this scenario was constructed to observe non-declining yields on the operable growing stock on both the conifer and deciduous dominated stands as a sustainability constraint. This will ensure the model does not liquidate volume at the close of the planning horizon but instead will ensure forest timber volume will be present beyond the conclusion of the planning horizon. Additional components of the management strategy modeled by this scenario include:

- Maximization of primary deciduous and coniferous volume;
- An operationally base Spatial harvest Sequence, including maintaining quota volumes within targeted geographic areas;
- Maintenance of older seral stages;
- Adequate average blocks size;
- Varying block sizes between 2 and 360 ha; and,
- Harvesting across the profile.

The harvest sequence selected provides a flexible operationally based scenario that allows Weyerhaeuser and the embedded quota holders to economically and sustainably harvest volume from SYU R12. A large portion of the blocks (47% of the total panned area) in the 25 year spatial harvest sequence were manually planned by the Weyerhaeuser planning team in Drayton Valley. This increases the expected congruency between the Spatial Harvest Sequence and the operational harvesting activities. Over the first 12 periods (60 years), the spatial harvest sequence achieved 98.9% of the primary conifer and 95.8% of the primary deciduous optimum harvest levels suggested by Woodstock™.

Modeling protocols are summarized in Table 4.14 through Table 4.16. The yield forecast was constructed using the 15/11/15 coniferous utilization and 15/10/15 deciduous utilization standards. Table 4.17 summarizes the final Stanley parameters and Table 4.18 sets out the final aspatial harvest reduction factors.

Table 4.14 Summary of Forecasting Tools

Model	Version
Woodstock	2005.6.0
Spatial Woodstock	2005.6.0
Stanley	2005.6.0
MOSEK	3.0

Table 4.15 Summary of Woodstock Protocols

Parameter / Criteria	Value
Planning Start Year	18-Nov-2000
Planning Horizon	the planning horizon is 32 periods or 160 years, and therefore the implicit average harvest age is 80 years. The planning time step (period length) is 5 years.
Sustainability	+/- 5% on net (after spatial sequencing) conifer & deciduous harvest levels was the overall target. To achieve this, a strict even-flow harvest was set for the first 12 periods, and then the harvest was permitted to deviate +/- 5% for the remainder of the planning horizon anchored to period 12 values. In the Stanley, the flow tolerance was set to 7% for the 60 year horizon. When played back in the final Woodstock phase, the Stanley generated sequence was strictly adhered to for the first 12 periods, then the subsequent aspatial flows were constrained to +/- 4.5% of the midpoint of the harvest levels from the tactical phase (periods 1 thru 12). Non-declining total growing stock for final 40 years of planning horizon and non-declining operable growing stock for final 15 years of planning horizon. Even-flow conifer for Rose Creek (Jack Knife HDA)
Objective	Maximize total volume harvest over planning horizon. The timber supply objective is to maximize the sum of coniferous and deciduous harvest volumes over the entire planning horizon. The value of the objective function is in cubic metres.
Harvest Constraints	Area harvested in Marshy Bank <= 500ha / period in period 1 Area harvested in Blackstone <= 1,000ha / period in period 1 Area harvested in Chungo Lookout <= 0 ha / period in periods 1 & 2 Various Harvest Design Areas aggregated for preferred sequence Maintain a range of late, very late, and extremely late seral stages in the main yield strata – D, DC, CD, Se (Sw), Pl, Sb.
Minimum Harvest Ages	Deciduous Minimum Harvest age: 80 for 1st rotation, 60 for 2nd rotation; Coniferous Minimum Harvest age: 100 for 1st rotation, 80 for 2nd rotation
Regeneration Lag	C - 2.3 years; DC - 2.3 years CD - 2.4 years; D - 0.4 years
Succession after harvest	All yield classes regenerate to pre-harvest yield class at age zero (adjusting for regeneration lag) All harvested stands of 'A', 'B', 'C', or 'D' come back to a "C" density
Natural Break-up Ages	Deciduous - 200 years; CD Mixedwood - 300 years DC Mixedwood - 200 years; Coniferous - 300 years
Succession after break-up	All Yield Classes maintain original Yield Class at age zero Except non-harvestable forested areas that break-up and return to the curve @ 170 yrs of age

Table 4.16 Seral Stage Constraints Applied to the Timber Forecasting Model

Seral Constraints for Periods 1 Thru 8	age definitions (>=)(years)			Landbase Constraints (% of total BCG that must be maintained over time)								
	Late	Very Late	Over Mature	Lower Foothills			Upper Foothills			Sub Alpine		
Broad Cover Groups	(L)	(VL)	(OM)	L%	VL%	OM%	L%	VL%	OM%	L%	VL%	OM%
Dec	71	111	---	5	1	---	5	2	---	---	---	---
DC	71	111	---	5	1	---	5	2	---	---	---	---
CD	91	121	171	5	1	---	5	2	---	---	---	---
Pine (Pl)	91	121	171	5	1	---	2	1	0.5	5	2	1
CX	91	121	171	5	1	---	10	5	2.5	10	5	2.5
Spruce/Pine (Sw/Pl)	91	121	171	5	1	---	10	5	2.5	10	7.5	5
Spruce (Sw)	91	121	171	10	2	---	15	5	2.5	20	10	5

Seral Constraints for Period 9 on	age definitions (>=)(years)			Landbase Constraints (% of total BCG that must be maintained over time)								
	Late	Very Late	Over Mature	Lower Foothills			Upper Foothills			Sub Alpine		
Broad Cover Groups	(L)	(VL)	(OM)	L%	VL%	OM%	L%	VL%	OM%	L%	VL%	OM%
Dec (D and DC)	71	---	---	5	---	---	5	---	---	---	---	---
CD	91	---	---	5	---	---	5	---	---	---	---	---
Pine (Pl)	91	---	---	5	---	---	2	---	---	5	---	---
Spruce/Pine/mixedconifer (Sw/Pl/CX)	91	---	---	5	---	---	10	---	---	10	---	---
Spruce (Sw)	91	---	---	10	---	---	15	---	---	20	---	---

Table 4.17 Summary of Stanley Protocols

Parameter / Criteria	Value	
Planning Horizon	25-year stand-level sequence(2000-2025), **15-y**ear harvest plan (2000-2015), (60 year planning horizon)	
Green-up Delays	D, DC, CD	10 years (1 period)
	C	15 yrs (2 periods)
Block Size	Minimum	Maximum
Block Size	2 ha	360 ha
Target Block Size	75 ha	
Adjacency distance	55 meters	(Distance between same strata blocks)
Proximity distance	21 meters	(Green-up distance between blocks)
Timing Deviations	20 years, 4 periods	
Spatial Flow Tolerance	Conifer = 7%, Deciduous = 7% (+/- 3.5%)	
Allow multi-period openings	No	

Table 4.18 Summary of Aspatial Harvest Reduction Factors

Parameter / Criteria	Value	
Cull Reduction	Conifer	3.06%
	Deciduous	5.83%
Block Retention Reduction	Conifer	5.00%
	Deciduous	5.00%

4.12.2 Harvest Levels and Resulting Forest Conditions

The volumes that the company has calculated as the proposed net sustainable harvest levels are provided in Table 4.19. Figure 4.16 and Figure 4.17 show the pattern of harvest flows over the planning horizon.

Table 4.19 Proposed Harvest Levels for SYU R12 – FMA and Non-FMA Land bases

Source	Coniferous AAC (m^3/yr)	Deciduous AAC (m^3/yr)
Total	489,291 (100%)	286,149 (100%)

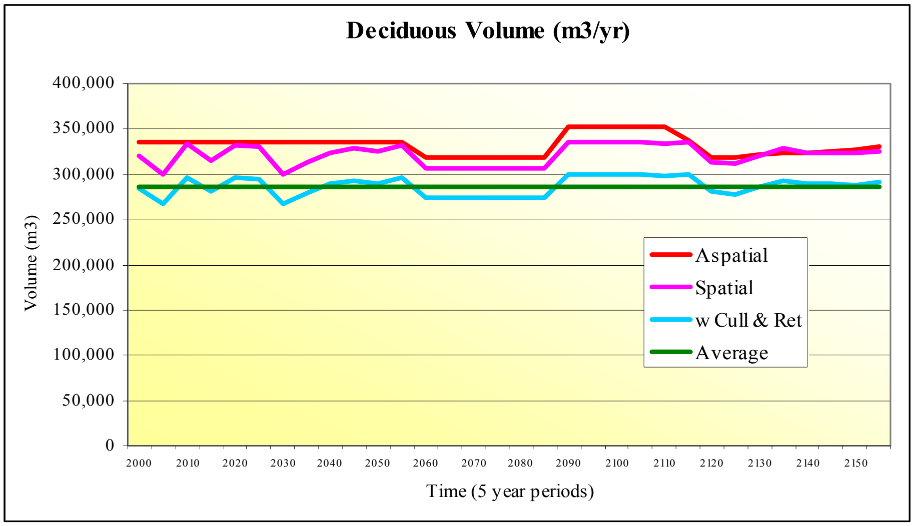


Figure 4.16. Deciduous Harvest Flows

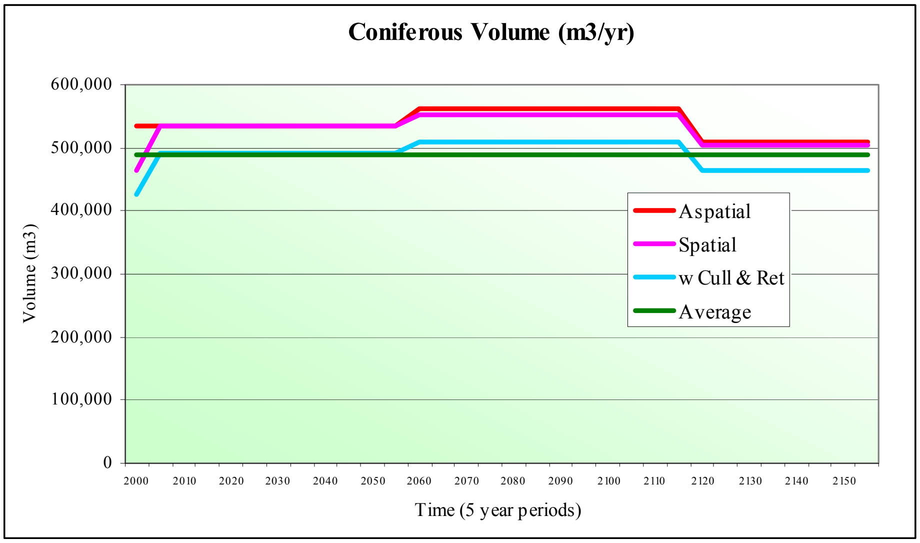


Figure 4.17 Coniferous Harvest Flows

Table 4.20 Detailed Harvest Volume Projections for SYU R12

Period		Coniferous Harvest Levels (m^3/year)			Deciduous Harvest Levels (m^3/year)		
		Aspatial	Spatial	w Cull & Ret	Aspatial	Spatial	w Cull & Ret
Spatially Sequenced	2000 - 2005	535,251	462,862	425,555	335,001	319,588	284,977
	2005 - 2010	535,251	535,232	492,093	335,001	299,341	266,922
	2010 - 2015	535,251	535,253	492,112	335,001	332,798	296,756
	2015 - 2020	535,251	535,243	492,103	335,001	314,121	280,102
	2020 - 2025	535,251	535,255	492,113	335,001	331,916	295,969
	2025 - 2030	535,251	535,242	492,102	335,001	330,261	294,494
	2030 - 2035	535,251	535,224	492,085	335,001	299,956	267,471
	2035 - 2040	535,251	535,249	492,108	335,001	313,132	279,220
	2040 - 2045	535,251	535,225	492,086	335,001	324,208	289,097
	2045 - 2050	535,251	535,244	492,103	335,001	327,705	292,214
	2050 - 2055	535,251	535,230	492,091	335,001	324,570	289,419
	2055 - 2060	535,251	535,253	492,112	335,001	332,719	296,686
Aspatial Volumes (period 13 thru 32)	2060 - 2065	562,014	553,024	508,450	318,251	306,421	273,235
	2065 - 2070	562,014	553,024	508,450	318,251	306,421	273,235
	2070 - 2075	562,014	553,024	508,450	318,251	306,421	273,235
	2075 - 2080	562,014	553,024	508,450	318,251	306,421	273,235
	2080 - 2085	562,014	553,024	508,450	318,251	306,421	273,235
	2085 - 2090	562,014	553,024	508,450	318,973	306,421	273,235
	2090 - 2095	562,014	553,024	508,450	351,751	335,298	298,985
	2095 - 2100	562,014	553,024	508,450	351,751	335,298	298,985
	2100 - 2105	562,014	553,024	508,450	351,751	335,298	298,985
	2105 - 2110	562,014	553,024	508,450	351,751	335,298	298,985
	2110 - 2115	562,014	553,024	508,450	351,751	333,795	297,645
	2115 - 2120	562,014	553,024	508,450	337,058	335,298	298,985
	2120 - 2125	508,489	505,395	464,660	318,251	314,007	280,000
	2125 - 2130	508,489	505,395	464,660	318,251	311,016	277,333
	2130 - 2135	508,489	505,395	464,660	320,925	320,267	285,582
	2135 - 2140	508,489	505,395	464,660	323,531	327,933	292,418
	2140 - 2145	508,489	505,395	464,660	323,387	323,873	288,797
	2145 - 2150	508,489	505,395	464,660	325,746	323,988	288,900
	2150 - 2155	508,489	505,395	464,660	326,848	322,874	287,906
	2155 - 2160	508,489	505,395	464,660	329,461	325,830	290,543
Average		538,597	532,186	489,292	331,639	320,903	286,150

- The average harvest levels reported in the table above differs slightly from the suggested values in the rest of the documentation as due to rounding.

4.12.3 Indicators from the Preferred Management Strategy

The preferred management strategy was designed to achieve the maximum harvest volume within the objectives for operability and sustainability of both timber and non-timber resources. As always, it is prudent to understand the tradeoffs and impacts that competing values, objective, and goals have on one another. The remainder of this section will provide a thorough look at the various indicators established and tracked to assess the sustainability of the preferred scenario.

4.12.3.1 Average Volume per Hectare

The area-weighted average harvest volumes fluctuated in the range of 197 to 307 m^3/ha for the coniferous and 174 to 351 m^3/ha for the deciduous dominant cover types (Figure 4.18 and Figure 4.19).

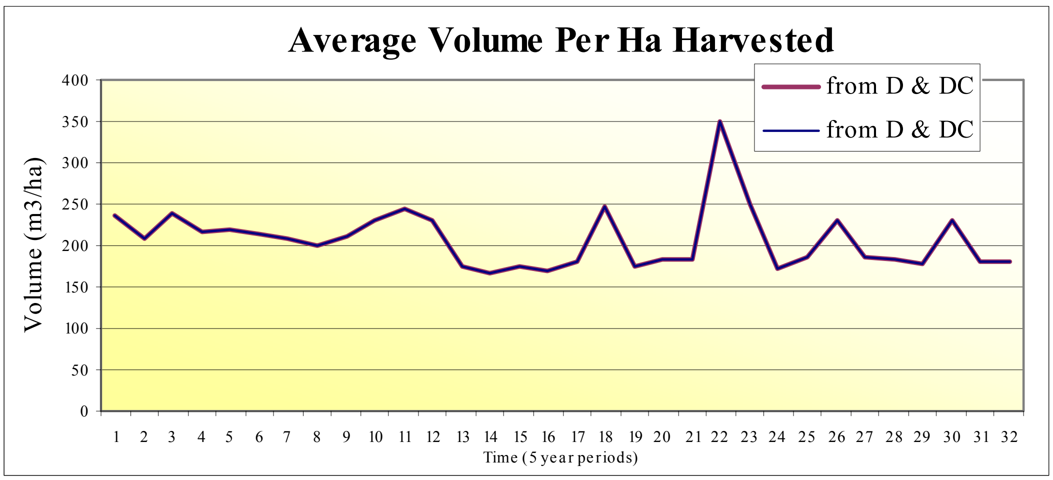


Figure 4.18 Average Volume per Hectare of Harvest from D & DC Cover Types

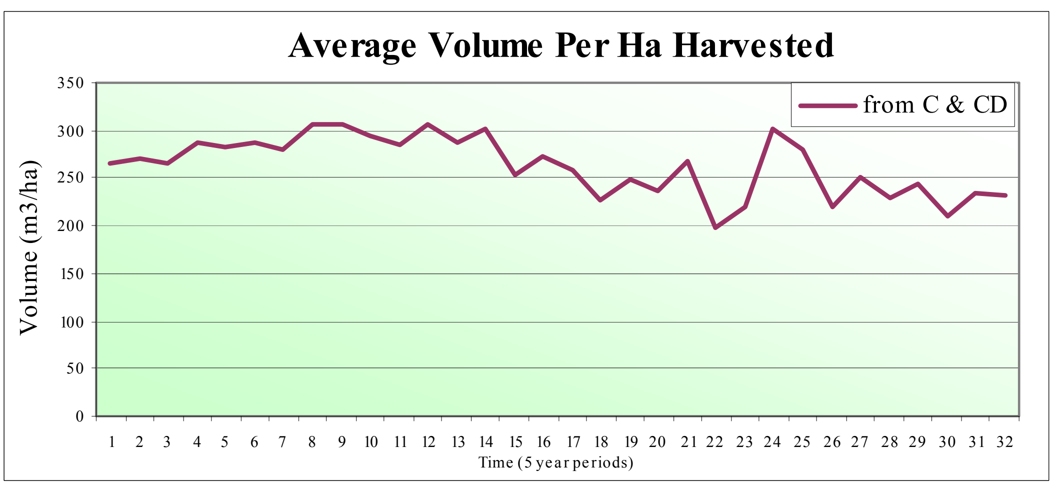


Figure 4.19 Average Volume per Hectare of Harvest from C & CD Cover Types

4.12.3.2 Average Harvest Age

The average harvest age of deciduous initially fluctuates between 103 and 121 over the first 60 years. It then drops down to 68 at the 70th year and stabilizes between 63 (lowest point) and 74 for the remainder of the planning horizon. The conifer starts at 113 then continues to steadily climb to 186 at T = 80, then continues to decline and stabilizes by the 130th year. The average harvest age for the conifer cover types does not drop below 89 over the planning horizon (Figure 4.20 and Figure 4.21).

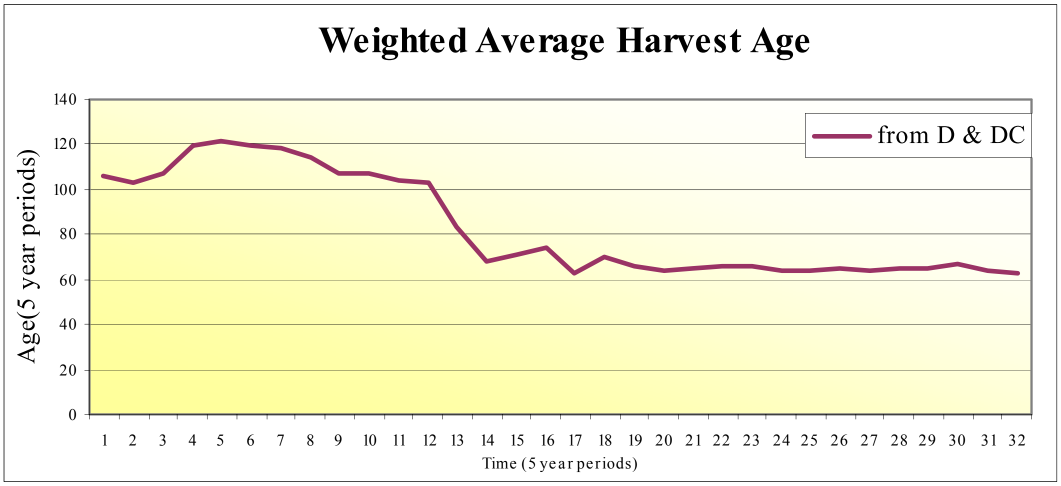


Figure 4.20 Average Age of Harvest Over Time from D & DC Cover Types

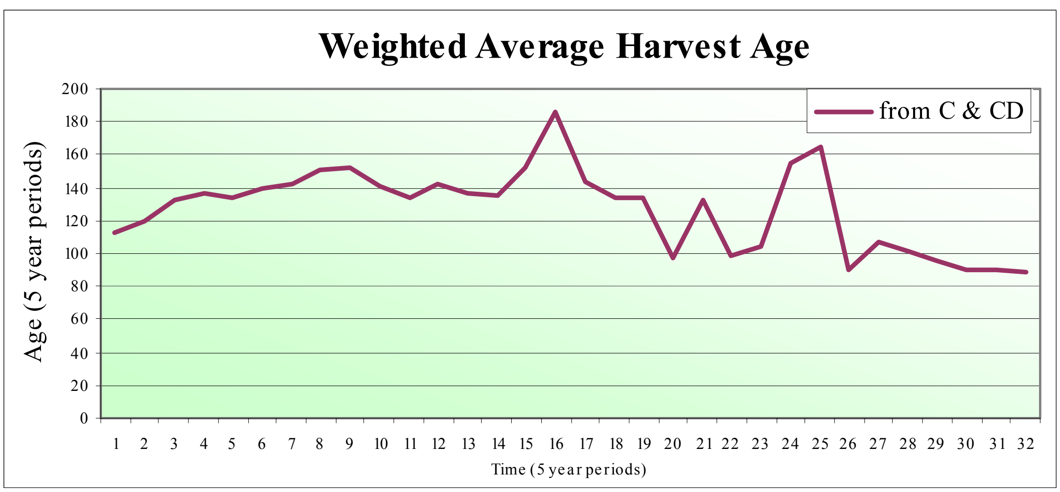


Figure 4.21 Average Age of Harvest Over Time from C & CD Cover Types

4.12.3.3 Piece Size Determination

Previous analyses assessed various options for modeling piece size. It was determined that piece size modeled through a surrogate variable quadratic mean diameter (DBHq) was stronger than the piece size estimate using trees/m^3 for all the major strata. Both the conifer and deciduous piece sizes are stable throughout the planning horizon. The deciduous remains above 28 cm for the first 95 years, drops to 26 cm at the 100th year and then stabilizes for the rest of the planning horizon. The conifer is very stable throughout with a minimum of 23 cm and a maximum average piece size of 25 cm. Figure 4.22 and Figure 4.23 show the piece size (DBHq) trends over the planning horizon.

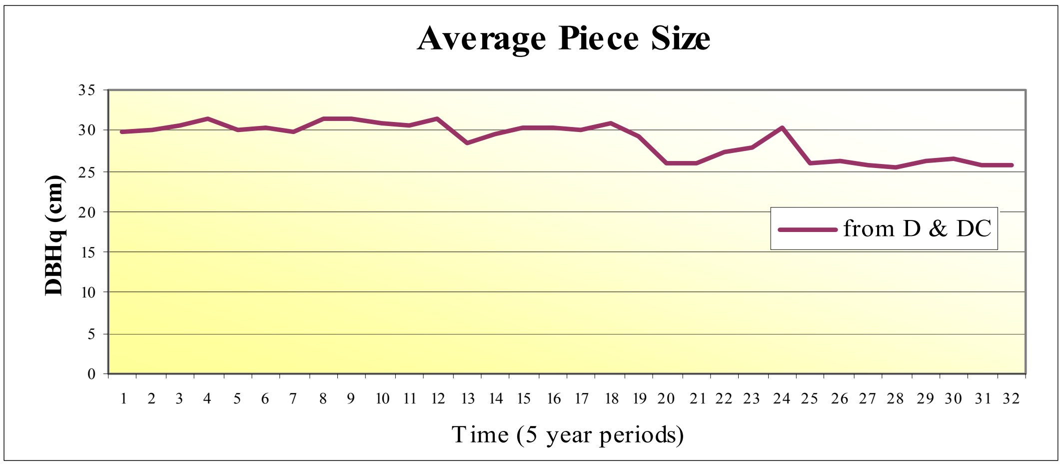


Figure 4.22 Deciduous Piece Size throughout the Planning Horizon

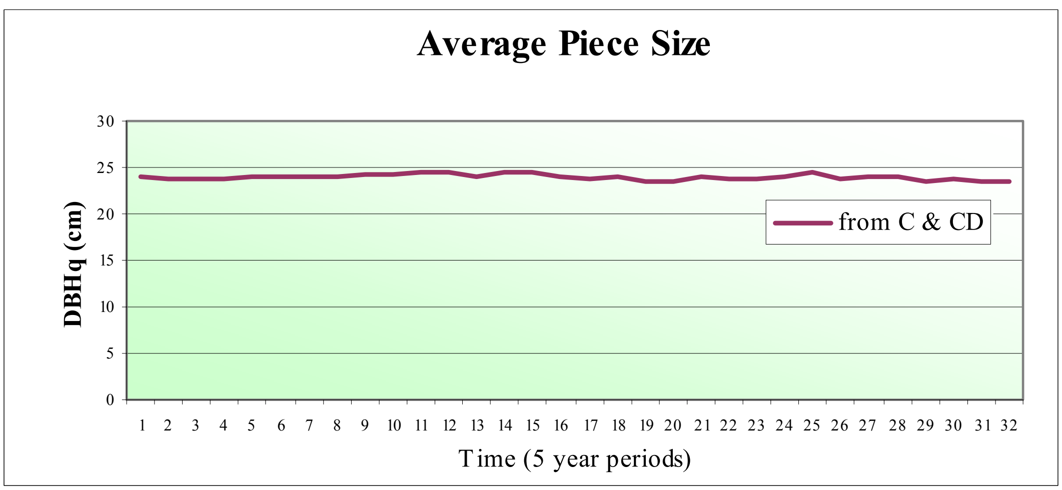


Figure 4.23 Coniferous Piece Size throughout the Planning Horizon

4.12.3.4 Growing Stock

Both softwood and hardwood growing stocks exhibited a declining trend over the majority of the planning horizon (Figure 4.24 and Figure 4.25), but stabilized at approximately 120 years. These patterns are typical of mature forest with plenty of standing merchantable volume at the beginning of the modeling start date. The deciduous operable growing stock declines until the 55th year then is relatively stable for the rest of the planning horizon. The conifer operable growing stock exhibits a much more gradual decline and then flattens out at the 140th year.

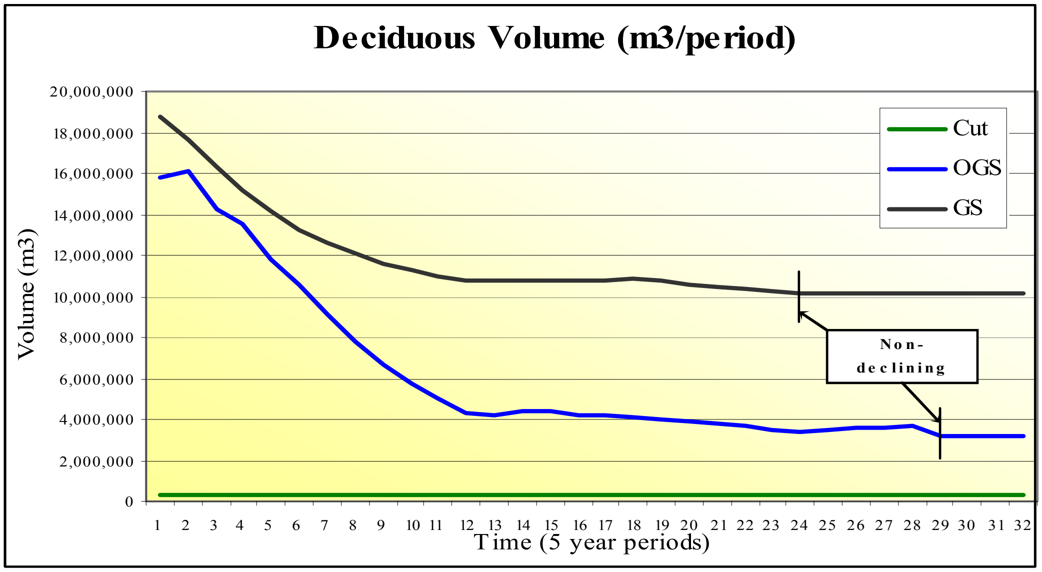


Figure 4.24 Growing Stock Projections from D & DC Cover types

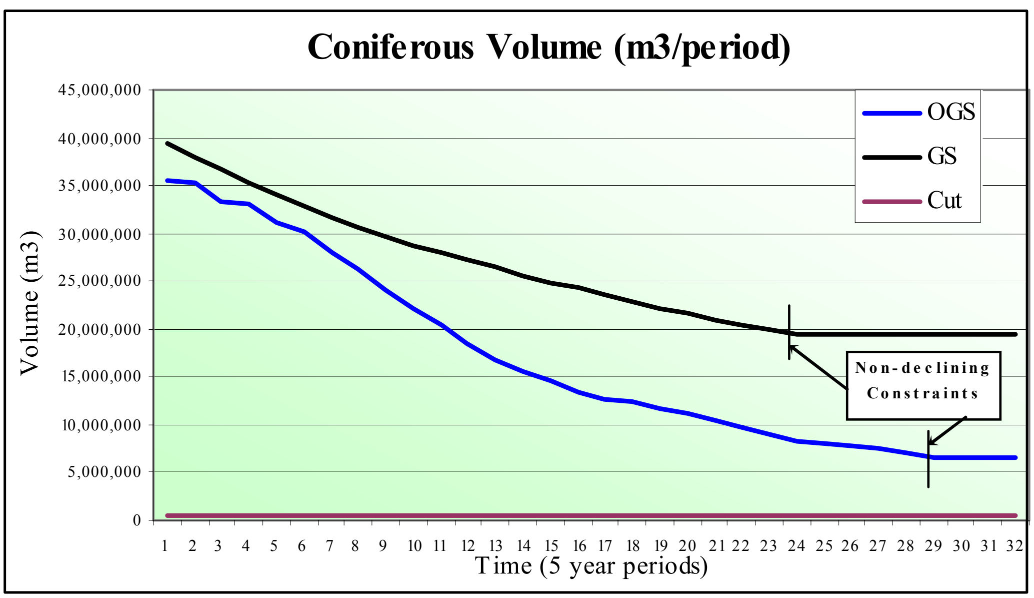


Figure 4.25 Growing Stock Projections from C & CD Cover types

4.12.3.5 Seral Stage Retention

Future forest conditions were modified under the management scenario modeled. Retention of late, very late, and extremely late seral stages for the various natural subregions over time is shown in Table 4.21 through Table 4.23, and Figure 4.26 through Figure 4.28. Overall, the seral constraints were easily met with the exception of the extremely late "other" conifer in the early portion of the planning horizon. A few of these constraints had to be postponed until period 7 (year 35) when those cover types matures enough to contribute to those specific constraints.

Table 4.21 Area of Older Seral Stages Retained in the Lower Foothills Natural Subregion

Lower Foothills	Target Minimum Area		Time from Start Date (years)				
Seral Stage	(%)	(ha)	0	10	50	100	160
Late Decid	5.0	4,527	44,198	40,534	24,424	13,878	13,739
Very Late Decid	1.0	905	3,397	11,462	8,366	12,337	12,515
Late DC	5.0	1,409	17,039	14,053	6,433	4,834	4,074
Very Late DC	1.0	282	1,844	5,819	2,965	3,079	3,129
Late CD	5.0	1,783	14,299	12,887	5,641	9,427	4,272
Very Late CD	1.0	357	2,945	3,867	3,055	3,083	3,529
Late PL	5.0	2,461	33,578	32,907	24,264	6,701	8,121
Very Late PL	1.0	492	2,741	4,560	15,947	5,068	4,470
Late PS	5.0	862	10,991	9,785	4,232	6,013	1,721
Very Late PS	1.0	172	2,851	3,595	3,212	2,228	1,439
Late SW	10.0	1,661	10,360	10,539	7,378	5,080	3,930
Very Late SW	2.0	332	3,684	5,106	5,684	4,473	3,516
Late 'other' Con	5.0	5,066	57,098	65,575	89,203	86,390	86,535
Very Late 'other' Con	1.0	1,013	20,982	28,027	63,238	84,823	85,647

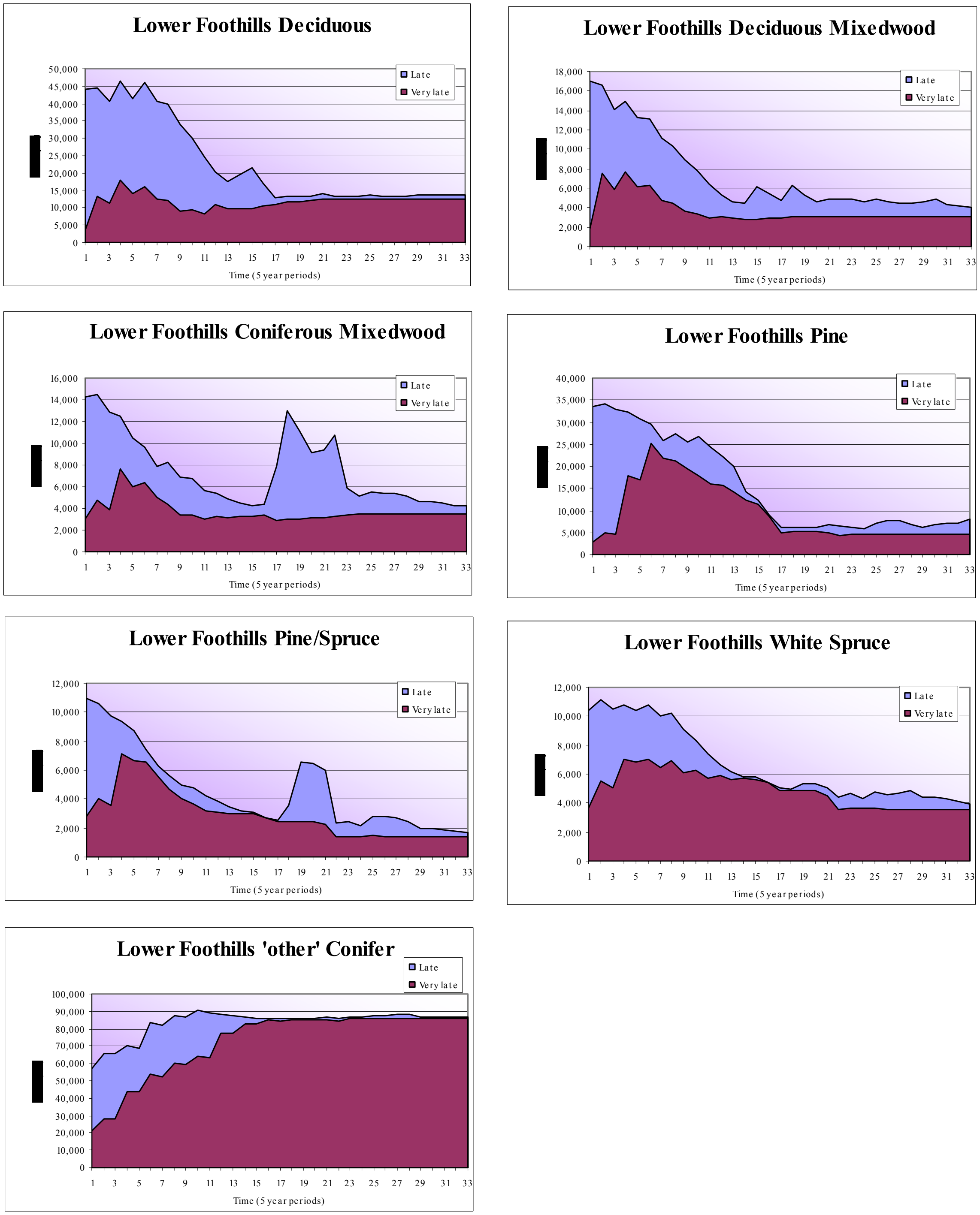
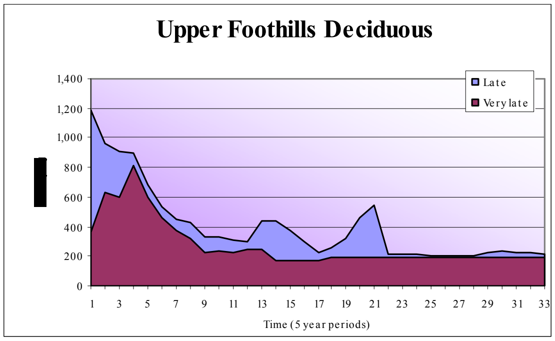
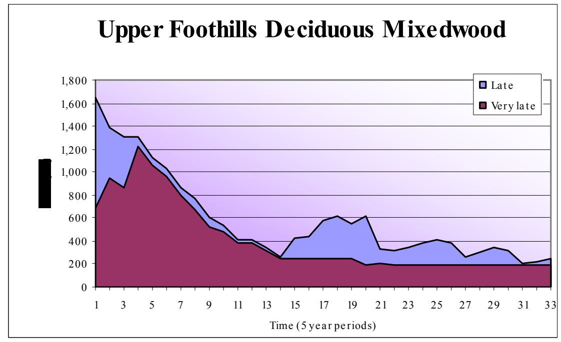


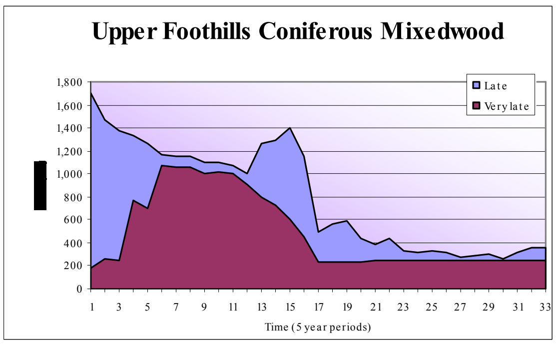
Figure 4.26 Area of Seral Stages within the Lower Foothills Natural Subregion

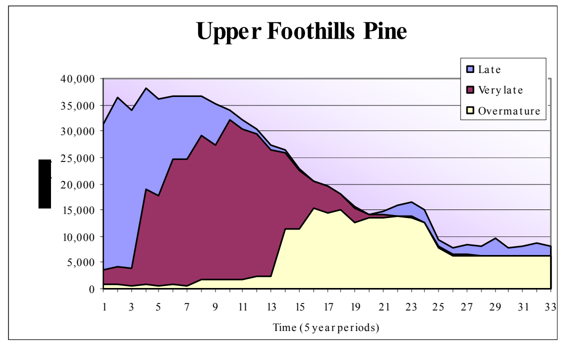
Table 4.22 Area of Older Seral Stages Retained in the Upper Foothills Natural Subregion

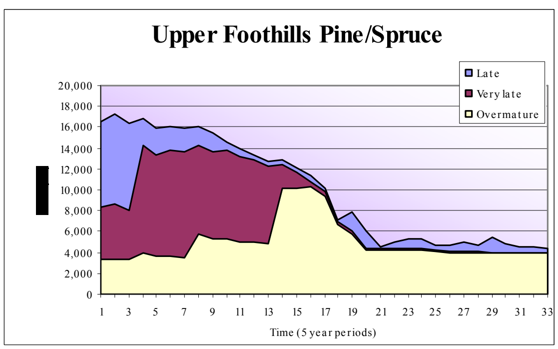
Upper Foothills	Target Minimum Area		Time from Start Date (years)				
Seral Stage	(%)	(ha)	0	10	50	100	160
Late Decid	5.0	83	1,186	914	313	550	217
Very Late Decid	2.0	33	358	595	224	194	196
Late DC	5.0	97	1,653	1,304	417	335	241
Very Late DC	2.0	39	691	872	391	200	194
Late CD	5.0	183	1,704	1,367	1,077	389	356
Very Late CD	2.0	73	179	244	998	241	247
Late PL	2.0	950	31,413	33,931	32,169	14,786	8,143
Very Late PL	1.0	475	3,716	3,921	30,432	14,042	6,302
Overmature PL	0.5	238	766	733	1,817	13,594	6,300
Late PS	10.0	2,221	16,527	16,338	13,910	4,588	4,328
Very Late PS	5.0	1,111	8,277	8,059	13,189	4,328	4,010
Overmature PS	2.5	555	3,374	3,342	4,957	4,168	4,005
Late SW	10.0	1,687	8,170	8,086	7,941	3,166	2,805
Very Late SW	5.0	562	5,671	5,822	6,917	3,040	2,718
Overmature SW	2.5	281	1,640	1,582	3,618	2,555	2,717
Late 'other' Con	10.0	1,752	12,066	13,021	16,046	14,197	13,411
Very Late 'other' Con	5.0	876	3,620	5,109	13,218	14,126	13,327
Overmature 'other' Con	2.5	438	375	615	3,266	12,142	13,324

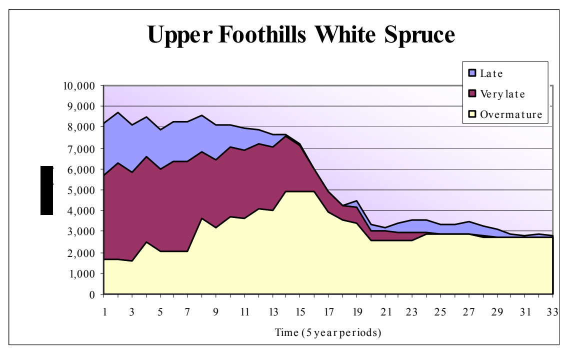












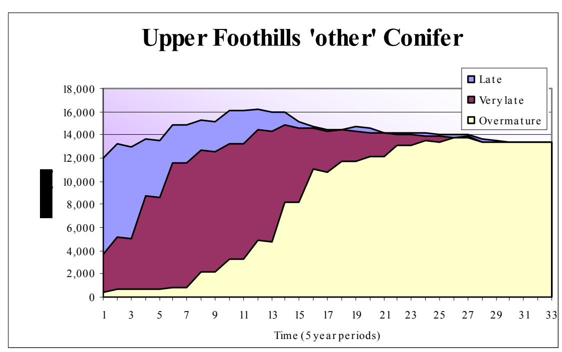


Figure 4.27 Area of Seral Stages within the Upper Foothills Natural Subregion

Table 4.23 Area of Older Seral Stages Retained in the Subalpine Natural Subregion

Subalpine	Target Minimum Area		Time from Start Date (years)				
Seral Stage	(%)	(ha)	0	10	50	100	160
Late PL	5.0	64	1,181	1,118	1,131	713	301
Very Late PL	2.0	26	216	216	1,040	687	301
Overmature PL	1.0	13	70	70	163	592	301
Late PS	10.0	369	3,079	3,025	2,553	2,475	1,273
Very Late PS	7.5	277	2,121	2,067	2,542	2,260	1,261
Overmature PS	5.0	184	1,137	1,107	1,187	2,253	1,261
Late SW	20.0	494	2,433	2,429	1,901	1,678	1,093
Very Late SW	10.0	247	2,254	2,236	1,887	1,674	1,053
Overmature SW	5.0	123	1,046	1,048	1,687	1,661	1,053
Late 'other' Con	10.0	75	615	623	742	722	591
Very Late 'other' Con	5.0	37	332	394	644	718	591
Overmature 'other' Con	2.5	19	0	0	325	621	591

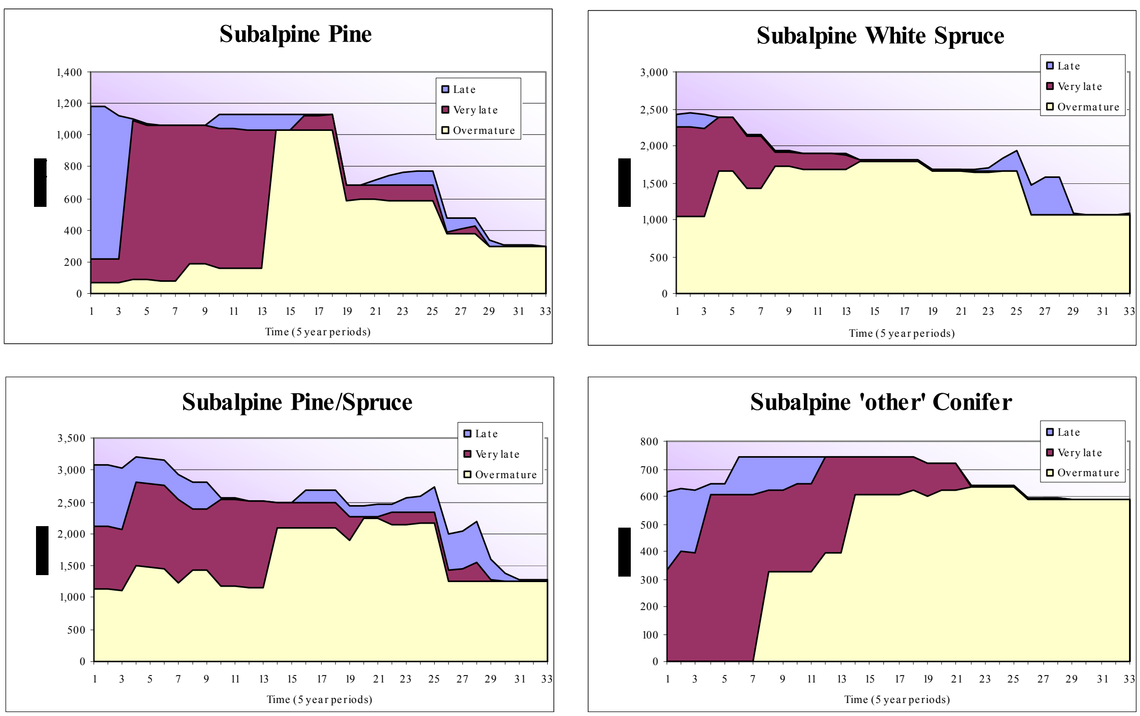


Figure 4.28 Area of Seral Stages within the Subalpine Natural Subregion

4.12.3.6 Patches

Patches, the areas of contiguous forest (Broad Cover Group and Seral Stage) during the spatial harvest sequence, were analyzed in periods 0 (initial), 2 (10 years), and 10 (50 years). As anticipated, patch sizes across the SYU varied. The average patch size, depending on planning period and seral stage, (Table 4.24) ranged from approximately 1.1 to 34.8 ha. The range of average patch sizes decreases over the spatial harvest planning horizon (i.e. the minimum increases and the maximum decreases). Similar tables showing individual BCGs are shown in Appendix 4.7.

Table 4.24 Patch Size Distribution

Time from now (yrs)	Seral Stage	# of Patches	Total Patch Area (ha)	Avg Patch Area (ha)
0	Early	25,371	28,257.3	1.1
	Immature	18,601	26,826.5	1.4
	Mature	16,938	129,466.7	7.6
	Late	24,968	201,112.4	8.1
	Very Late	5,864	56,676.5	9.7
	Over Mature	271	9,430.6	34.8
	Total	92,013	451,770.0	4.9
	Average of Stages	16,557	79,354.3	10.5
10	Early	28,961	31,595.1	1.1
	Immature	18,917	30,872.5	1.6
	Mature	20,026	105,702.0	5.3
	Late	24,922	184,168.1	7.4
	Very Late	17,041	89,589.8	5.3
	Over Mature	379	9,842.6	26.0
	Total	110,246	451,770.0	4.1
	Average of Stages	19,830	79,354.3	7.8
50	Early	16,124	33,098.8	2.1
	Immature	50,678	101,601.0	2.0
	Mature	44,743	61,972.5	1.4
	Late	18,260	73,377.3	4.0
	Very Late	47,608	138,277.8	2.9
	Over Mature	8,976	43,442.5	4.8
	Total	186,389	451,770.0	2.4
	Average of Stages	31,065	75,295.0	2.9

Table 4.25 and Table 4.26 summarize the average block size and the total area for the planned block within the SHS. The blocks have been displayed so that the areas planned by the Weyerhaeuser planning team can be contrasted to those generated by Stanley. Note the average Stanley block size in each period even though the target block size was set to 75 ha.

Table 4.25 Average Block Size (ha) During the SHS

	Period					
Planned by	1	2	3	4	5	Average
Timber Operators*	13.2	11.6	7.9	11.3	4.7	10.5
STANLEY	11.5	11.1	14.5	14.7	13.7	13.6
Total	12.7	11.5	10.0	13.4	12.7	11.9

*Weyerhaeuser, Tall Pine Timber and Dale Hansen Ltd

Table 4.26 Total Area of Blocks During the SHS

	Period					
Planned by	1	2	3	4	5	Total
Timber Operators	10,984	14,732	9,093	5,201	745	40,754
STANLEY	4,492	2,427	7,971	11,347	16,327	42,564
Total	15,476	17,158	17,064	16,548	17,072	83,318

Patches of Interior Older Forest (IOF) were also analyzed. Interior older forests were defined by SRD as contiguous forested area greater than 100 ha with no part of the area less than the following distance from a forest edge:

- 60 m from a linear disturbance greater than 8 m in width
- 30 m from the line which cover group changes
- 30 meters from the line which forest seral stage changes

Age classes included in the definition were defined as:

- Deciduous - 100 years or older
- Mixedwood - 100 years or older
- Pine leading - 100 years or older
- White Spruce leading - 120 years or older
- Black Spruce leading - 140 years or older

Table 4.27 looks at the amount of interior older forest at 0, 10, and 50 years both ignoring and incorporating seismics as hard edges. The total area of IOF decreases over time, but the average IOF patch size did not exhibit a similar declining trend. Maps of the interior older forest are located in Appendix 4.8.

Table 4.27 Area of Interior Older Forest

Interior Older Forest Summary by BCG

		Ignoring Seismics			Incorporating Seismics		
Time from now (yrs)	Cover Type	# of Patches	Total Patch Area (ha)	Avg Patch Area (ha)	# of Patches	Total Patch Area (ha)	Avg Patch Area (ha)
0	Decid	9	1,877.6	208.6	1	137.5	137.5
	MX	5	577.8	115.6			
	Pine	68	29,482.8	433.6	55	12,701.7	230.9
	SB	4	456.8	114.2			
	Spruce	20	8,255.8	412.8	17	4,679.3	275.3
	Total	106	40,650.6	383.5	73	17,518.5	240.0
	Average	21	8,130.1	256.9	37	8,759.2	214.6
10	Decid	3	751.8	250.6	1	121.8	121.8
	MX	2	231.4	115.7			
	Pine	65	27,537.7	423.7	54	12,452.5	230.6
	SB	4	456.8	114.2			
	SW	20	8,255.8	412.8	17	4,679.3	275.3
	Total	94	37,233.4	396.1	72	17,253.5	239.6
	Average	19	7,446.7	263.4	36	8,626.8	209.2
50	Decid	2	310.4	155.2			
	Pine	68	22,756.1	334.6	56	10,671.4	190.6
	SB	23	3,636.1	158.1	3	361.5	120.5
	Spruce	13	4,143.3	318.7	10	2,696.0	269.6
	Total	106	30,845.8	291.0	69	13,728.9	199.0
	Average	27	7,711.5	241.7	23	4,576.3	193.6

4.12.3.7 Area Harvested

The area harvested over time is fairly consistent. The area of conifer harvested ranges from 7,976 ha (year 60) to 11,409 (year 115). The area of deciduous harvested ranges from 6,134 ha in the 90th year up to 8,362 ha in the 95th year (Figure 4.29).

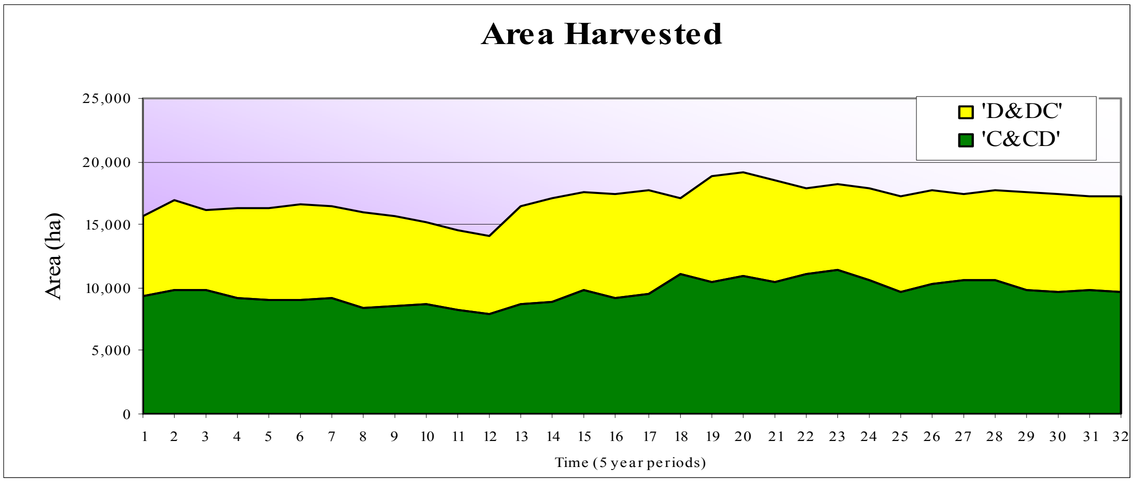


Figure 4.29 SYU R12 Area Projected Harvest Levels

4.12.3.8 Age Class Distribution

The initial age class structure of the net harvestable land base is skewed towards the late seral stages. The is a large concentration of merchantable timber between 90 and 110 years of age and a relative shortage of younger (> 50 years) stands (Figure 4.30). This large spike (age 105) is the primary focus area of much of the harvest until enough area is converted to younger stands and the forest age class distribution becomes more balanced. Refer to Figure 4.30 thru Figure 4.34 for snapshots of the age class distribution over time.

The initial age class distribution for all forested stands is presented in Figure 4.35. The pattern looks almost exactly the same as the net land base but has much more area. The pattern of development over time (Figure 4.35 thru Figure 4.39) is similar as well as the large spike of mature timber diminishes over time as the merchantable component is harvested and is reforested into younger age classes. The apparent difference is that as the merchantable portion of the forest becomes regulated, the productive, but non-harvestable component continues to age over time.

These age class distributions only account for forest management activities and forest dynamics. They do not model the effects of other industries or natural disturbances.

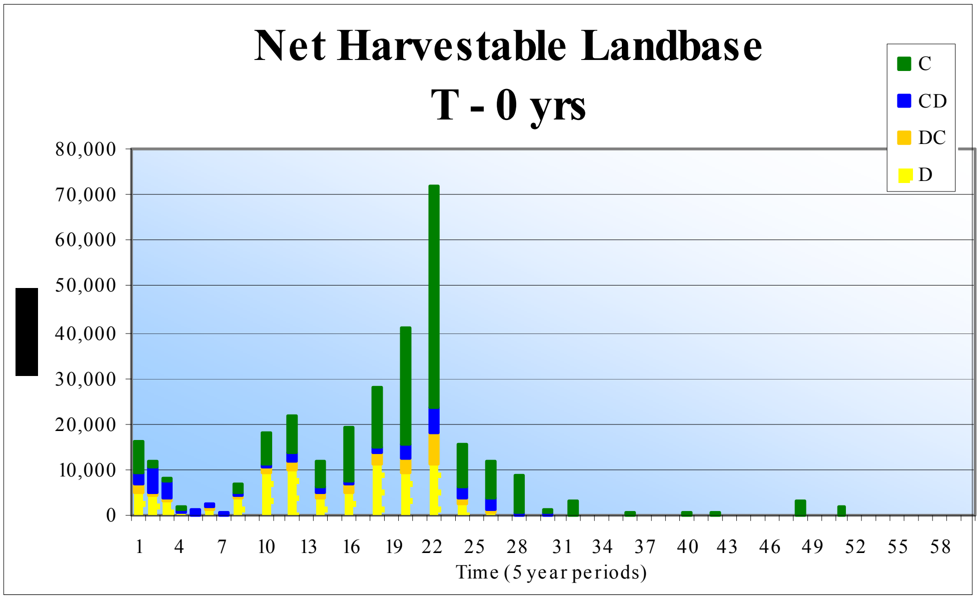


Figure 4.30 Age Class Distribution of the Net Harvestable Land Base at T = 0 years

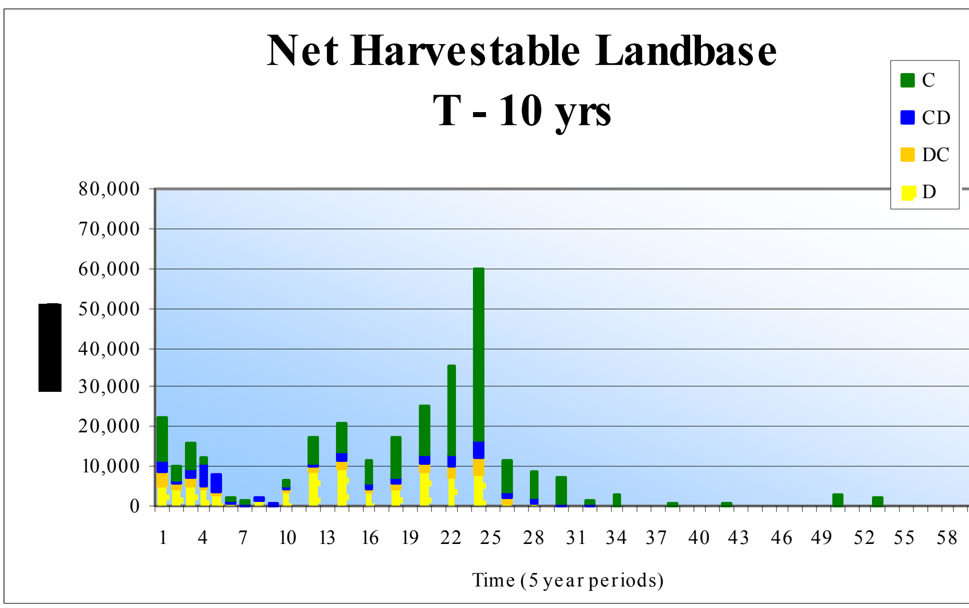


Figure 4.31 Age Class Distribution of the Net Harvestable Land Base at T = 10 years

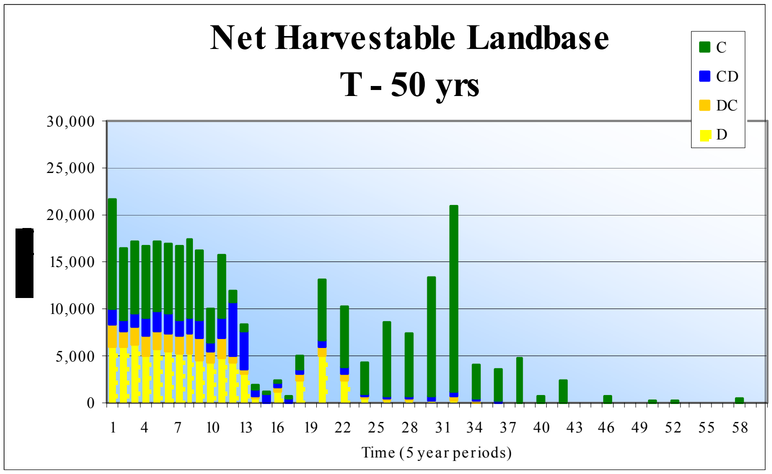


Figure 4.32 Age Class Distribution of the Net Harvestable Land Base at T = 50 years

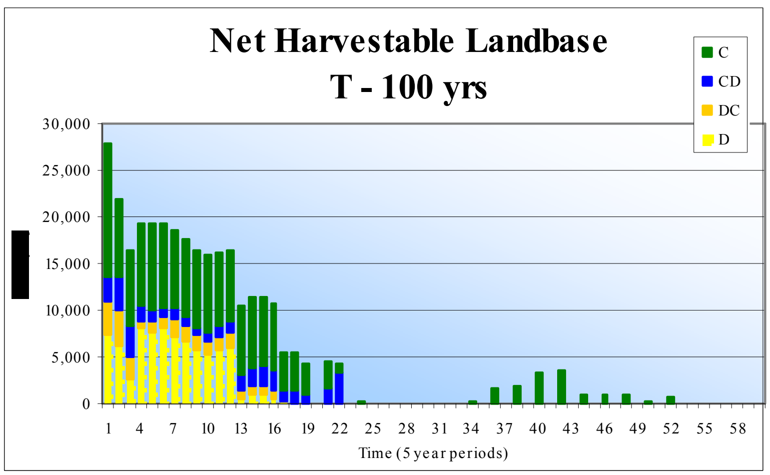


Figure 4.33 Age Class Distribution of the Net Harvestable Land Base at T = 100 years

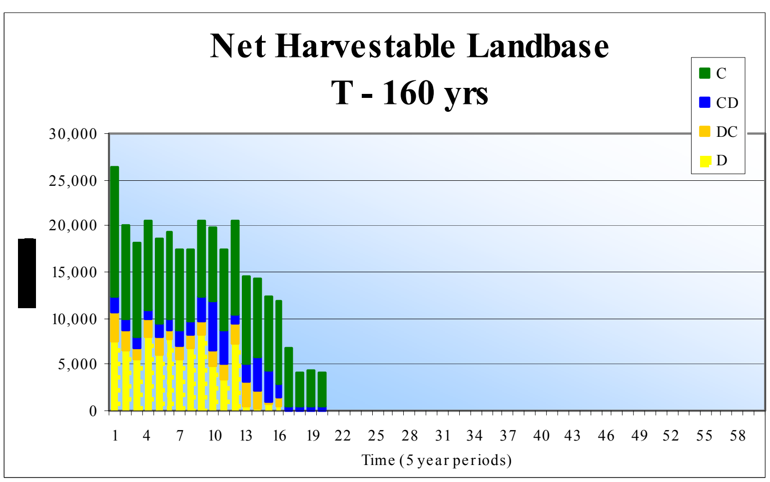


Figure 4.34 Age Class Distribution of the Net Harvestable Land Base at T = 160 years

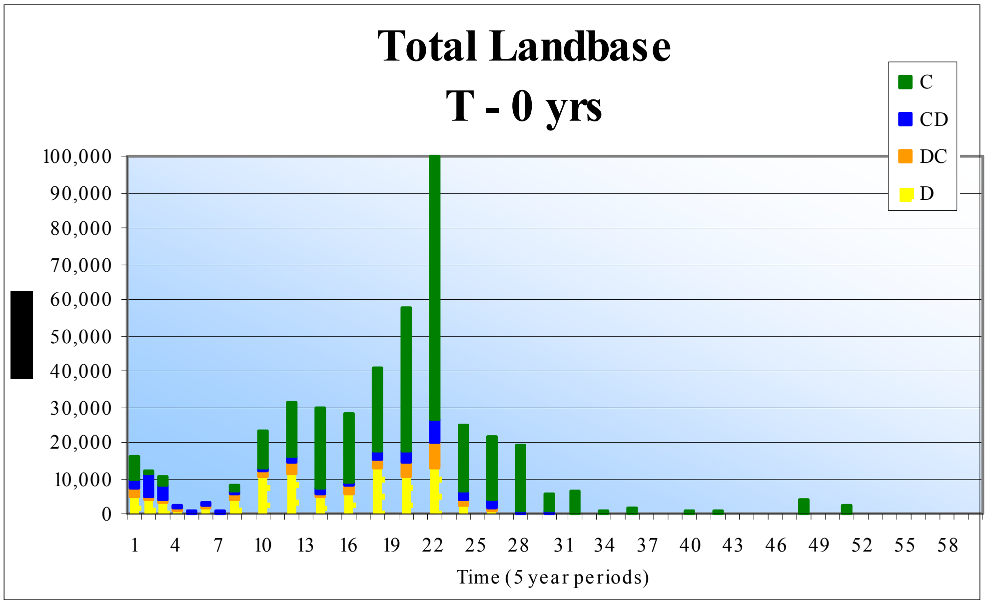


Figure 4.35 Age Class Distribution of the Gross Land Base at T = 0 years

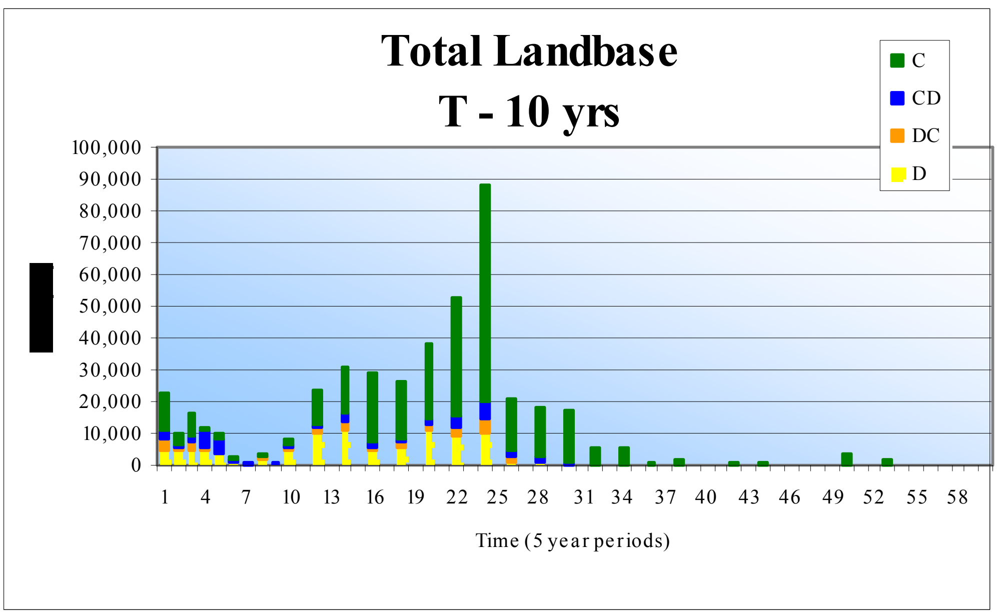


Figure 4.36 Age Class Distribution of the Gross Land Base at T = 10 years

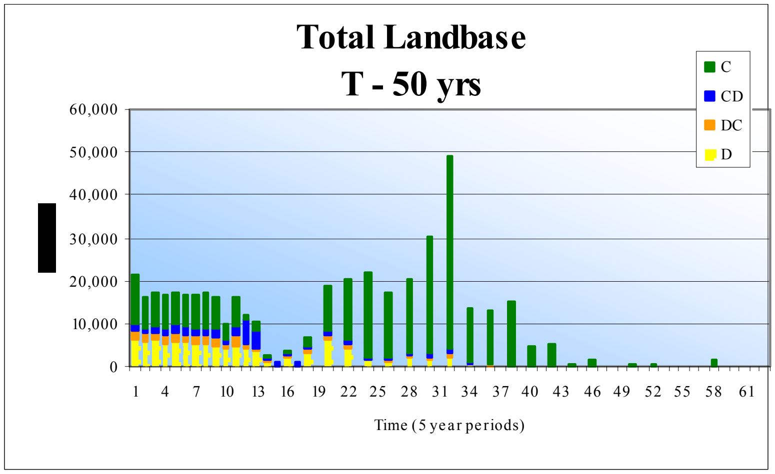


Figure 4.37 Age Class Distribution of the Gross Land Base at T = 50 years

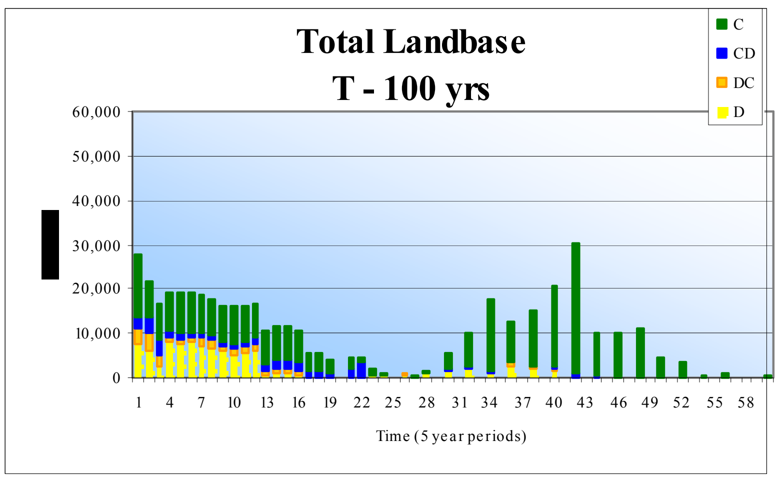


Figure 4.38 Age Class Distribution of the Gross Land Base at T = 100 years

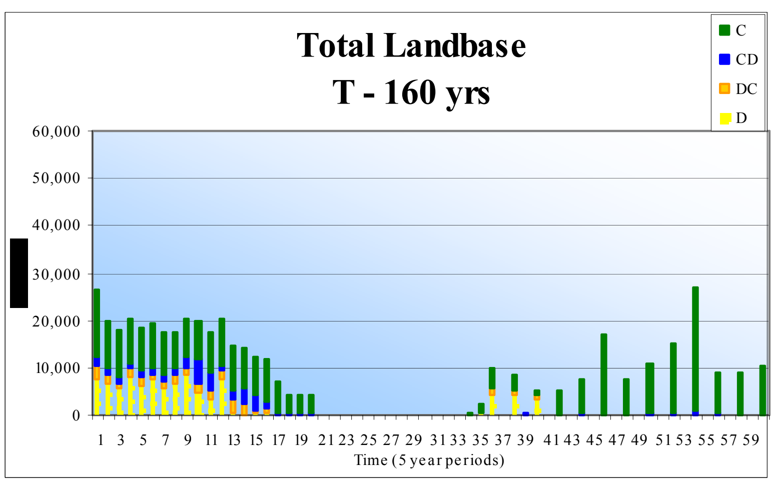


Figure 4.39 Age Class Distribution of the Gross Land Base at T = 160 years

Data shown graphically in Figure 4.16 thru Figure 4.39 are shown in tabular form in Appendix 4.7. Appendix 4.7 also contains more detailed information about the harvest levels by strata and age class. Maps of the spatial harvest layout can be found in Appendix 4.4. A patch size database for periods 0, 2, and 10 can be found on the accompanying DVD.

Table 4.28 shows the area harvested by both Land Management Unit and Harvest Design Area (HDA) for the duration of the SHS.

Table 4.28 LMU and HDA Sequenced Area by Five Year Cut Period (ha)

Land Management Unit	Harvest Design Area	Area (ha) by Harvest Period					
		1	2	3	4	5	Total
Marshy Bank	Canyon Creek		379	410	1,054		1,842
	Chungo Lookout			690	694	105	1,489
	Race Creek				422	235	657
Marshy Bank Total		0	379	1,100	2,169	340	3,988
Baptiste	Brewster Creek	348	237		967	150	1,702
	Buster Creek		237		310	87	634
	Chambers Creek	840	319		776	251	2,185
	Crimson	291	903	321	260	729	2,504
	Diamond Hill	127	115	32	38	144	455
	Grace Creek	193	160			531	883
	Louis Lake		271	200	103	122	695
	No Name Creek	137	357			1,057	1,551
	Omni		466		227	67	760
	Prentice Creek	438	131			596	1,165
	Sunchild	299	667			598	1,565
Baptiste Total		2,673	3,863	553	2,680	4,331	14,099
Blackstone	Beaver Flats		387	781			1,168
	Black Mountain		338				338
	Lookout Creek		378				378
	North False Gap			139	547	287	973
	South False Gap		376				376
	The GAP			766			766
	Trunk Road		683			16	699
Blackstone Total		0	2,161	1,687	547	303	4,698
Elk River	Broken Arm	423	243		121	111	898
	North Dismal Creek	171	280		653	440	1,544
	Poacher's Creek	235	138		321	348	1,042
	South Dismal Creek	100	189		118	236	643
	Wolf Lake East	240	149		315	499	1,202
	Wolf Lake West	663	267		153	84	1,166
Elk River Total		1,832	1,266	0	1,680	1,718	6,496
Medicine Lake	Gosling Lake		572			464	1,036
	Medicine Creek		179			182	361
Medicine Lake Total		0	751	0	0	646	1,397
Nordegg River	East Rundell	830	388	405	569	32	2,223
	Elke Summers			1,510			1,510
	South Brazeau	452	15		807	614	1,889
	South Reservoir		616	1,123	1,307	962	4,007
	Wawa Creek	589	772	268	17	8	1,655
	West Rundell	472	272	362	21	57	1,183
Nordegg River Total		2,343	2,063	3,668	2,720	1,672	12,466
O'Chiese	Boundary	219			1,578	1,257	3,053
	Doc's Lake	286	1,071	388	658	1,134	3,538
	Grey Owl Creek	1,188	204				1,392
	North Canal	231	51	361	2	45	690
	Rapid Creek			842	1,103	6	1,951
	South Canal	406	84	452	132	392	1,466
	Stevens Creek	270	595	525		13	1,402
O'Chiese Total		2,600	2,005	2,569	3,473	2,846	13,493
R1 outside FMA	OR1	846	60	301	21	114	1,343
R1 outside FMA Total		846	60	301	21	114	1,343
Sand Creek	Brazeau Tower	130	168	473	85	63	919
	Cathedral Grove	640	115	1,709	96	229	2,788
	Jack Knife	1,214	244	2,022	575	524	4,579
	Lodgepole	341	32	432	6	89	900
	Pembina	503	290	1,135	154	418	2,500
SAN Total		2,827	849	5,771	916	1,323	11,686
Tall Pine	Big Bend	477	804	130	382	632	2,425
	Little One	2		62			64
	Norm's Throw	210	322	363	16	194	1,104
	North Brazeau	344	150	821	9	106	1,430
	Power House	179	192	358	62	45	837
	Saskatchewan	416	861	138	39	699	2,153
Tall Pine		1,629	2,328	1,871	508	1,676	8,013
Willesden Green	Alder Flats	33	19	53	137	307	548
	Dominion Lake	87	174		694	337	1,293
	Open Creek		168		171	224	563
	South Deer Corner		189		62	165	416
	Strawberry Mountain	825	705		795	1,669	3,994
	Wolf Creek		221		254	114	589
Willesden Green Total		945	1,475	53	2,113	2,816	7,403
Grand Total		15,695	17,201	17,571	16,827	17,786	85,081

4.13 Conclusion

This timber supply analysis has focused on defining expected harvest levels that can conceivably be maintained over a long period of time (the next 160 years). The basis for this is largely the relative certainties of outcome inherent in current management practices, which are supported by a significant quantity of empirical evidence. This analysis purposely avoided speculation in the realm of potential management practices in terms of "what could be, or, what should be". This is consistent with at least two major tenets of the management objective of demonstrating sustainability:

- Sustainability should be based on what we do know at present from an empirical perspective about the condition of the forest and our ability to manage it.
- Sustainability should resist making decisions and value judgments today regarding choices and decisions that future generations may or may not make regarding their values and uses of forests. In other words, we can not know today how future generations will value the impacts of today's management practices that affect the state of the forest in their time.

It is expected that more and better information will be used to conduct subsequent analyses of timber supply for the Sustained Yield Unit R12 area. Examples of this would be the explicit inclusion of apparently stochastic events such as fire, a greater understanding of the relationship between reserves for wildlife habitat and their use by wildlife, and improved empirical relationships for stand mortality and succession over a wider range of ages and stand condition.

4.14 References

Remsoft. 2005. www.remsoft.com Site visited on July 7th, 2005

MOSEK 2005. www.mosek.com Site visited on July 7th, 2005

Appendix 4.3A: Stanley Outputs

Appendix 4.3B:
Timing Specifications by HDA for Stanley Blocks

Appendix 4.3C: SHS Shapefile Preparation Code

Timberline
Forest Inventory Consultants

Appendix 4.3D:
SHS Shapefile Data Library

Appendix 4.3E:
Individual FMU Scenarios