FMA #9700035

Detailed Forest Management Plan

2004 - 2014

Appendix 6.5: Timber Supply Forecasting

Weyerhaeuser Company Ltd.

Edson, Alberta

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1 Timber Supply Forecasting

1.1 Introduction

The purpose of Timber Supply Forecasting 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 DFMP. The TSA includes the legal boundaries of FMA #9700035 and the embedded grazing dispositions (Figure 1.1), with the exception of Grazing Reserves, in Forest Management Units (FMUs) E1, E2, W5 and W6. For simplicity, the combined areas will be referred to as the FMA area.

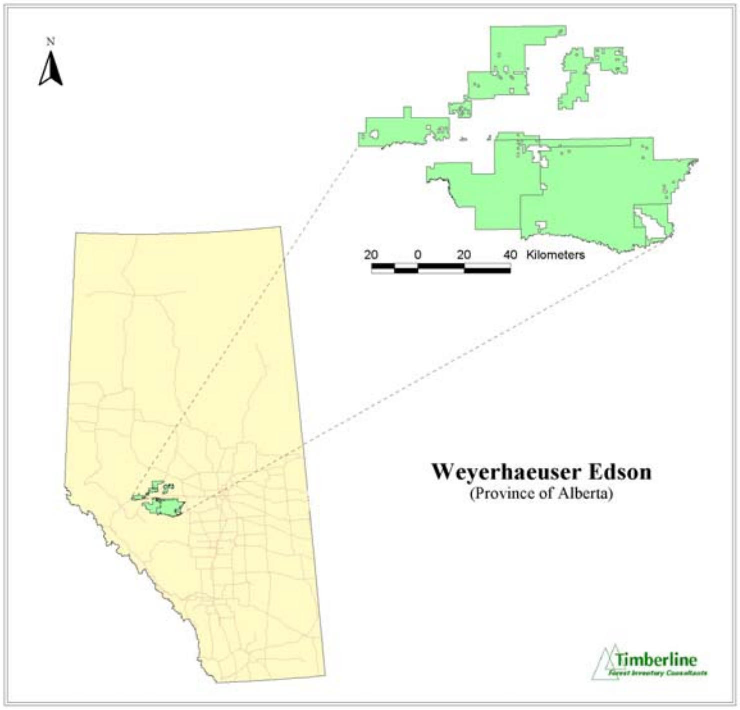


Figure 1.1 Location and Extent of FMA Area

Both the Forest Act and the Forest Management Agreement (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 FMA area.

1.2 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 1.2).

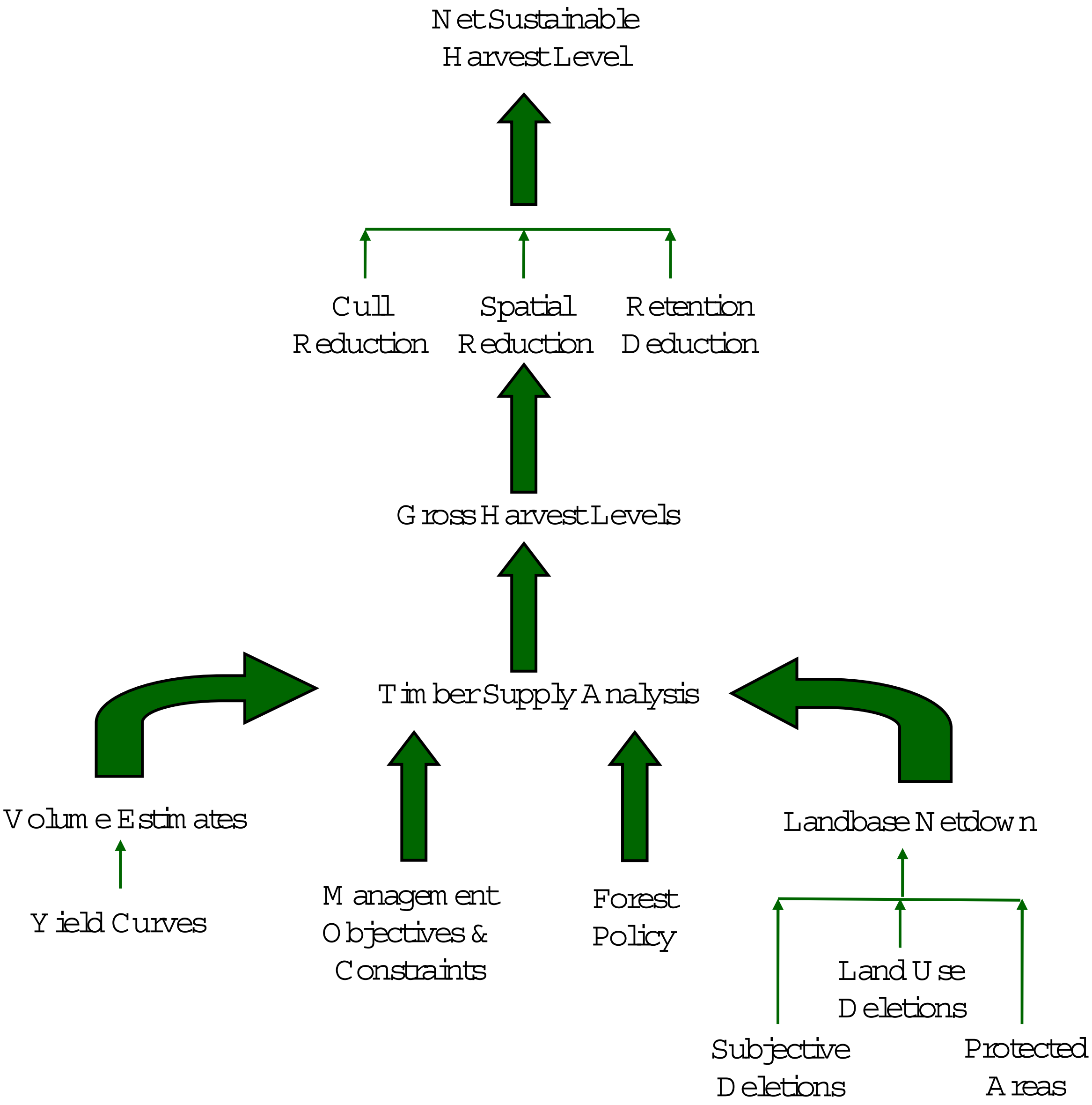


Figure 1.2 Overview of Timber Supply Forecasting Process

1.3 Current Status of FMA Area

1.3.1 Forest Inventory

The land base inventory includes information on both non-forested and forested areas. Parks, recreation areas, reserves for wildlife habitat, 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. The FMA area is composed of four Forest Management Units (FMUs): E1, E2, W5 and W6. They are treated as separate sustained yield units in the timber supply analysis.

The total area of FMA encompasses 509,373 hectares (ha). Of this area 468,209 ha (92%) are capable of supporting forest vegetation. Almost 188,094 ha (or 37%) are excluded from the timber harvesting land base (with the exception of marginal stands as described in Section 5.6.1). 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 55% (280,115 ha) of the FMA 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 6.1 of Volume II.

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.

1.3.2 Growing Stock

Growing stock is the amount of standing merchantable volume within the net harvestable land base. This is further refined to the operable growing stock which is that portion of the growing stock that is currently harvestable as defined by the operability limits (refer to section 1.11.1.8). The amount of growing stock and operable growing stock at the beginning of the planning horizon are summarized in Table 1.1.

Table 1.1 Summary of Growing Stock at the Beginning of the Planning Horizon

		Initial Growing Stock (m³)					
LMU		Coniferous	% of Total C	Deciduous	% of Total D	Total	% of Total T
E1	Total	6,055,616	100.0%	2,563,681	100.0%	8,619,298	100.0%
	Operable	5,442,040	89.9%	2,337,184	91.2%	7,779,223	90.3%
E2	Total	4,817,487	100.0%	6,166,938	100.0%	10,984,425	100.0%
	Operable	4,258,771	88.4%	5,786,560	93.8%	10,045,331	91.5%
W5	Total	1,750,060	100.0%	2,739,484	100.0%	4,489,544	100.0%
	Operable	1,413,312	80.8%	2,351,867	85.9%	3,765,179	83.9%
W6	Total	10,108,472	100.0%	8,498,538	100.0%	18,607,011	100.0%
	Operable	8,837,697	87.4%	7,220,794	85.0%	16,058,491	86.3%
FMA	Total	22,731,636	100.0%	19,968,642	100.0%	42,700,277	100.0%
	Operable	19,951,820	87.8%	17,696,404	88.6%	37,648,224	88.2%

1.3.3 Defining the Net Harvestable Land Base

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 6.1 of Volume II 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 1.2. An expanded version of this table is located in Appendix 6.1 (Table 3-1). This table summarizes the classification of the FMA area and timber harvesting land base by forest management units. The current timber harvesting land base is approximately 55% (ha) of the total area, and about 59% of the total forested area. The majority of forest land excluded from the timber harvesting land base (about 37% of all forested land) is either economically inoperable, or environmentally sensitive, or both.

Table 1.2 Classification of the FMA Land Base by FMU

			Forest Management Units Area (ha)				
Category			FMU E1	FMU E2	FMU W5	FMU W6	FMA Total (ha)	FMA % Total
Total Non-Forested Area			5,495	9,091	5,660	20,918	41,164	8.08%
Total Dispositions and Protection/Park Area			4,834	9,890	3,708	13,461	31,893	6.26%
Total Water Course Buffers and Operational Removal Area			3,006	2,344	937	3,518	9,805	1.92%
Total Poor Tree Growth Potential or Difficult Reforestation			39,835	24,780	16,280	65,501	146,396	28.74%
Total Deletion Area			53,170	46,105	26,585	103,398	229,258	45.01%
Timber Harvesting Land base								
	Deciduous	Deciduous	6,394	30,832	16,578	37,026	90,830	17.83%
		Deciduous/Coniferous	5,239	8,577	598	1,915	16,329	3.21%
		Coniferous/Deciduous	5,131	6,554	111	0	11,796	2.32%
		Coniferous	299	340	63	0	702	0.14%
Deciduous Land base Totals			17,063	46,303	17,350	38,941	119,657	23.49%
	Coniferous	Coniferous	31,911	17,544	7,120	55,891	112,466	22.08%
		Coniferous/Deciduous	5,195	3,346	4,795	19,582	32,918	6.46%
		Deciduous/Coniferous	0	0	3,413	11,661	15,074	2.96%
		Deciduous	0	0	0	0	0	0.00%
Coniferous Land base Totals			37,106	20,890	15,328	87,134	160,458	31.50%
Total Harvestable Area			54,169	67,193	32,678	126,075	280,115	54.99%
Grand Total			107,339	113,298	59,263	229,473	509,373	100.00%

The following pie chart (Figure 1.3) depicts the same values as Table 1.2. The total sums between the chart and table differs slightly due to rounding errors.

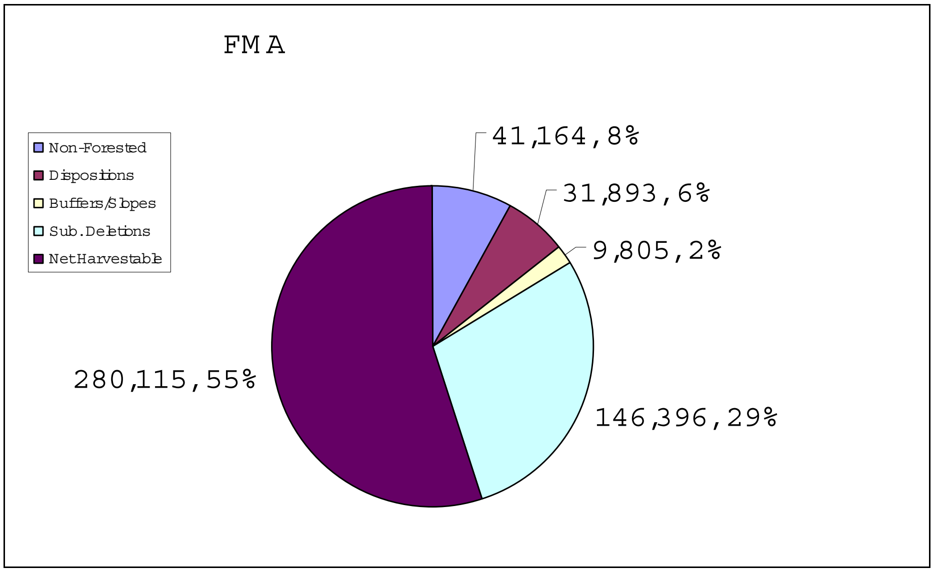


Figure 1.3 FMA Area Overview

Table 1.3 Summary of Land Base Netdown by FMU

	FMU E1		FMU E2		FMU W5		FMU W6		FMA	
Category	Total (ha)	% Total	Total (ha)	% Total	Total (ha)	% Total	Total (ha)	% Total	Total (ha)	% Total
Non-Forested	5,495	5.1%	9,091	8.0%	5,660	9.6%	20,918	9.1%	41,164	8.1%
Dispositions	4,834	4.5%	9,890	8.7%	3,708	6.3%	13,461	5.9%	31,893	6.3%
Buffers/Slopes	3,006	2.8%	2,344	2.1%	937	1.6%	3,518	1.5%	9,805	1.9%
Sub. Deletions	39,835	37.1%	24,780	21.9%	16,280	27.5%	65,501	28.5%	146,396	28.7%
Net Harvestable	54,169	50.5%	67,193	59.3%	32,678	55.1%	126,075	54.9%	280,115	55.0%
Total	107,339	100.0%	113,298	100.0%	59,263	100.0%	229,473	100.0%	509,373	100.0%

1.3.4 Comparison to the 1986 Timber Supply Analysis

The differences in forest land base between the 1986 TSA and the current timber supply analysis (2006) can be summarized as follows:

- There have been dramatic changes in the FMU boundaries between management plans;
- 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 2.1 (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; and

- 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.

1.3.5 Age Class Distribution Area

Figure 1.4 and Figure 1.5 shows the current age composition of the forested land base in the FMA 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.

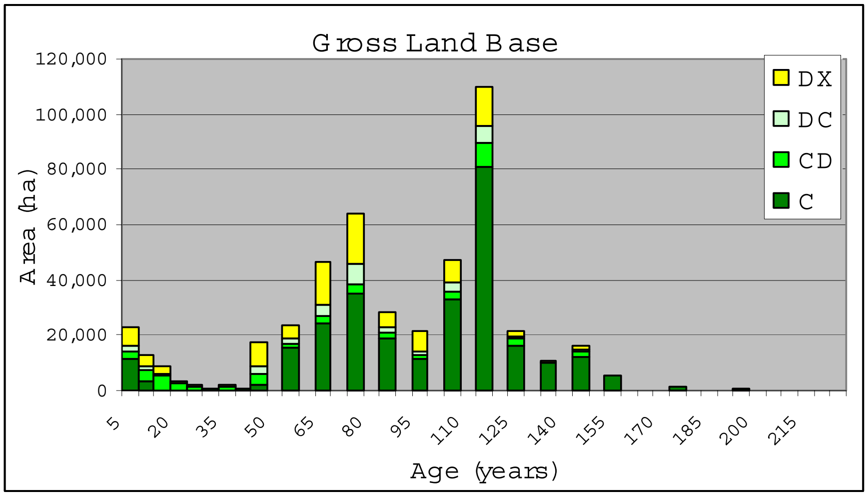


Figure 1.4 Initial Age Class Distribution of Gross Forested Land Base

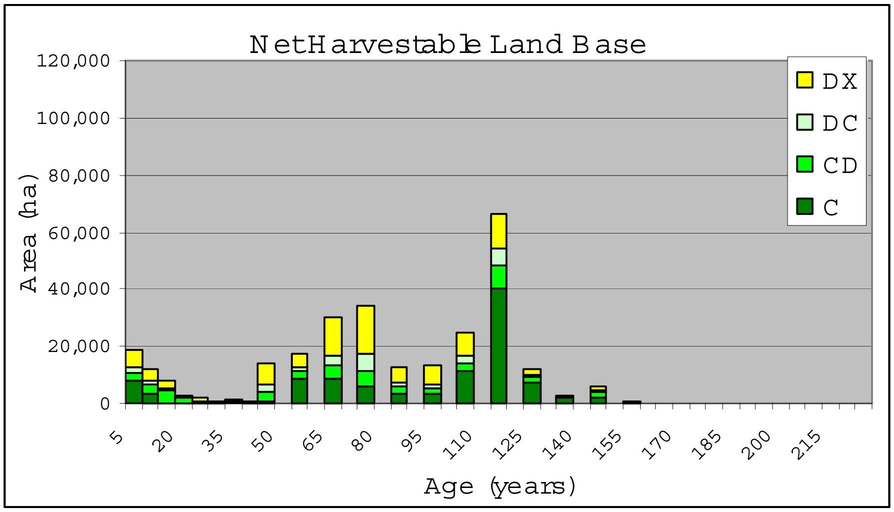


Figure 1.5 Initial Age Class Distribution of Net Harvestable Land Base

1.4 Yield Curves

1.4.1 Yield Curve Development

Yield curves were developed by estimating volume as a function of age, site, crown closure, natural sub region, 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 1.4 summarizes the 30 yield strata within which the full set of yield curves was developed.

Area-weighted projections for 111 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 coniferous utilization and 15/10/15 deciduous utilization. (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)) Four area-weighted yield curves are presented next as Figure 1.6 and Figure 1.7.

Table 1.4 The 30 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	Poor	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	Poor	All
19*	Coniferous	Lower/Upper Foothills	Good	All
20*	Coniferous	Lower/Upper Foothills	Medium	All
21*	Coniferous	Lower/Upper Foothills	Poor	All
22	Deciduous	Lower Foothills	Good	"A"
23	Deciduous	Lower Foothills	Good	"B"
24	Deciduous	Lower Foothills	Good	"C"
25	Deciduous	Lower Foothills	Good	"D"
26	Deciduous	Upper Foothills	Good	"A"
27	Deciduous	Upper Foothills	Good	"B"
28	Deciduous	Upper Foothills	Good	"C"
29	Deciduous	Upper Foothills	Good	"D"
30**	Deciduous	Lower/Upper Foothills	Poor	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 161 yield curves were applied to the land base (108 for coniferous dominated stands, 50 for deciduous dominated stands, and 3 for coniferous dominated switch stands).

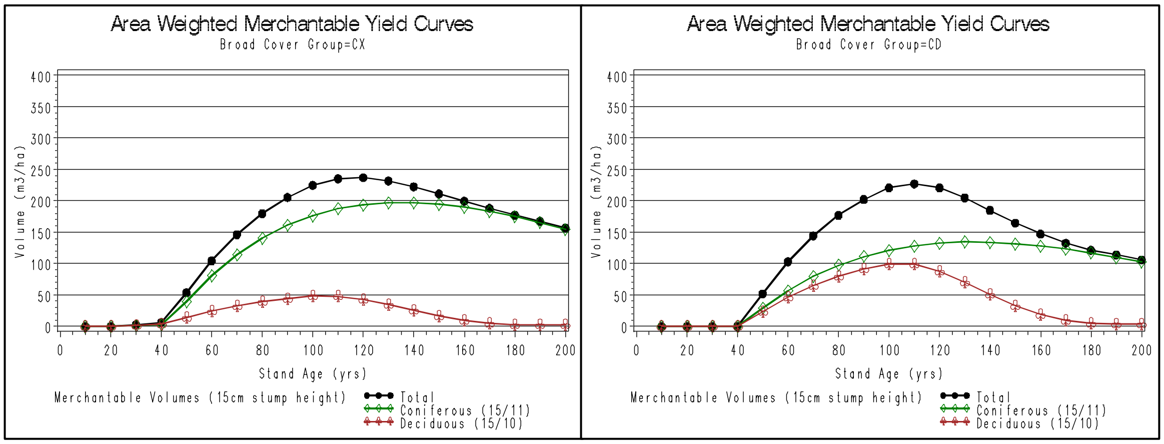


Figure 1.6 Area Weighted Yield Curves for the 'C' and 'CD' Broad Cover Groups

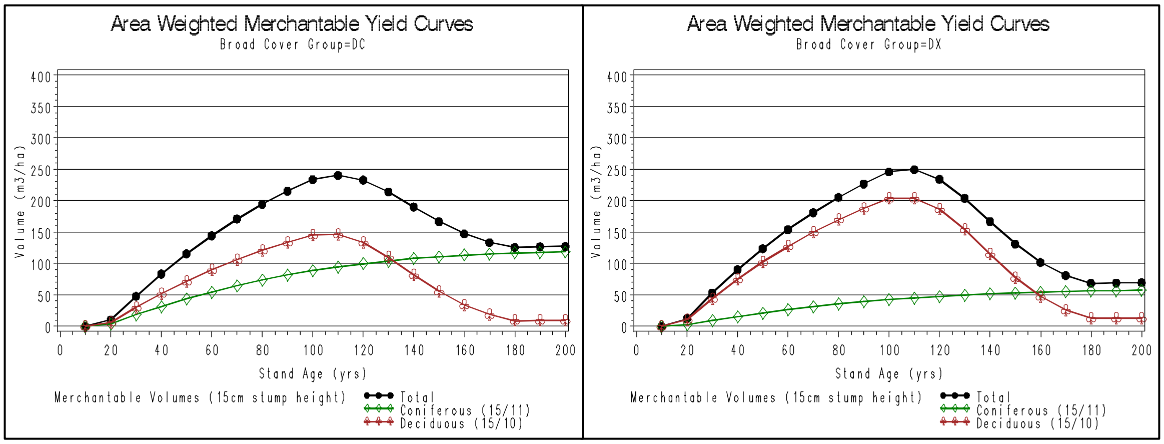


Figure 1.7 Area Weighted Yield Curves for the 'DC' and 'DX' Broad Cover Groups

1.4.2 Alternate Utilization Standards

It was determined that some of the conifer operators with quotas in the FMA preferred to harvest at an alternate utilization standard. Rather than operating at a 15/11, some quota holders operate at a 15/10 utilization standard. This means they harvest stems down to a 10 cm minimum top diameter rather than 11 cm. An adjustment factor was calculated to convert the yield estimates from 15/11 to 15/10. Details regarding the adjustment factor for the alternate 15/10 coniferous utilization factor is located in Appendix 6.11 of Volume II.

1.5 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 the overstorey or understorey 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 (Table 1.5). 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.

Table 1.5 Yield Stratum Stratification

Total Yield Stratum Number*	Yield Group Description	NSR	Site	Mean SI	CC	Net Area (ha)	Number of Plots
C1	Coniferous Switch Stands Not included	LF	G	16.2	A	13,289	109
C2					B	10,410	113
C3					C	37,846	277
C4					D	5,615	38
C5			M	14.7	A	4,502	44
C6					B	8,500	92
C7					C	31,937	242
C8					D	8,642	85
C9			P	12.1	A to D	11,556	97
C10		UF	G	16.2	A	914	24
C11					B	2,000	50
C12					C	8,805	199
C13					D	2,409	47
C14			M	14.5	A	606	18
C15					B	118	3
C16					C	608	10
C17					D	86	2
C18			P	11.1	A to D	13,289	3
Coniferous Non-Switch Stand Totals						147,997	1,453
C19	Coniferous Switch Stands	LF/UF	G	NA	A to D	9,607	130
C20			M	NA	A to D	196	0
C21			P	NA	A to D	81	0
Coniferous Totals						9,884	130
D1	Deciduous Good Site Switch and Non-switch stands	LF	G	17.7	A	7,631	109
D2					B	19,276	259
D3					C	75,217	828
D4					D	14,089	167
D5		UF	G	17.1	A	422	12
D6					B	1,010	28
D7					C	3,361	101
D8					D	374	3
Deciduous Good Site Non-Switch and Switch Stand Totals						123,381	1,507
D9	Deciduous Poor Site Switch and Non-switch stands	LF/UF	P	NA	A to D	852	10
Deciduous Totals						852	10

1.5.1 Marginal Stands

The Edson FMA has a number of timber operators with diverse operation standards. These operators agree upon the definition of what constitutes a truly merchantable stand. However, there is a relatively small range of forest types (hereafter referred to as marginal) where there was some disagreement as to merchantability and inclusion into the productive land base. Some Edson FMA timber harvesters expressed a concern that the subjective deletion rules were too coarse and removed some merchantable stands. To identify the most likely operationally viable area, the previously subjectively deleted stands with the most favorable AVI stand attributes were identified and assigned to marginally operable status. The following points summarize the steps to identify and incorporate marginal stands:

- Identify marginal stands – In the process of defining the net land base, two subjective deletion rules were used: 1) Stands with 10% or more Larch composition or 2) Stands with 80% or more Black spruce composition. All stands that met either of the above criteria were removed from the net land base. The following rules identify potential marginal stands eligible for harvesting activities
    - The stand must have been classified as a subjective deletion in the November 24, 2004 land base allocation process and have no more than 20% larch composition and or 80 % black spruce composition.
    - The stand must be greater than and equal to 14m tall
    - The stand must have greater than an "A" crown closure

- Estimate volume from marginal stands – Initially yield curve plots located within marginal areas were removed and did not contribute to the final yield curve projections for the net land base. To estimate volumes for these types plot volumes sampled on marginal area were compiled separately. A conservative rotation age of 140 years was assumed for marginal stands. Mean Annual Increment (MAI) was then calculated by dividing mean volume (m^3/ha) by 140 years.

- Estimate marginal stand potential harvest volumes – Potential harvest levels from marginal stands were calculated by multiplying MAI by marginal stand area for each FMU (Table 1.6).

- Locate marginal stands on Spatial Harvest Sequence map - After the Spatial Harvest Sequence had been derived (marginal stands not included) marginal stands neighboring sequenced stands were identified and flagged for possible inclusion.

- Allocation – The marginal stands identified were allocated to participating operators in proportion to their quota allocation.

Table 1.6 Estimated Annual Gross* Marginal Stand Volume by FMU

FMU	Marginal Stand Area (ha)	Coniferous MAI (m^3/ha/yr)	Coniferous Volume (m^3/yr)
E1	2,331	0.87	2,028
E2	2,564	0.87	2,231
W5	730	0.87	635
W6	3,178	0.87	2,765
FMA	8,803		7,659

*does not take into account cull, retention, or spatial reduction percentage

1.6 Forecasting Model

1.6.1 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 1.8). 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 each Forest Management Unit, the RSPS (without the Allocation Optimizer) was used to forecast sustainable harvest volumes.

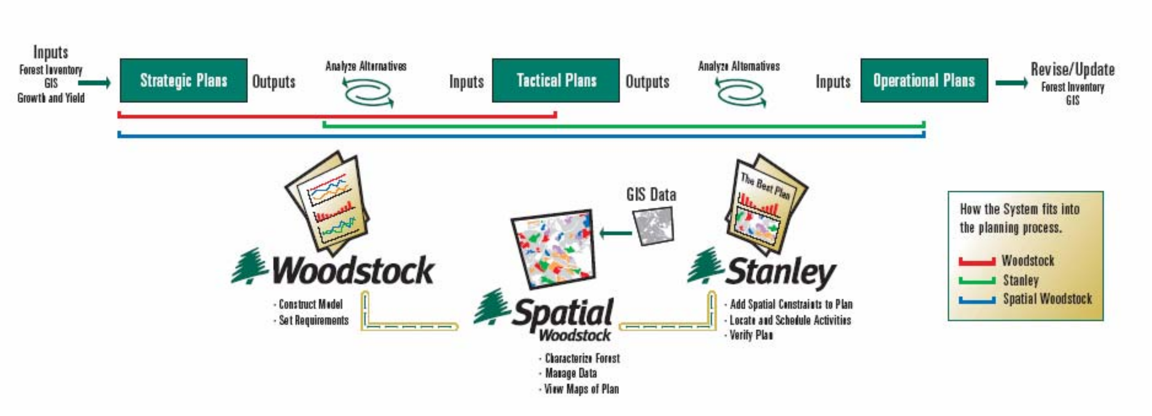


Figure 1.8 Overview of Remsoft Spatial Planning System (Remsoft 2005)

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.

1.6.2 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 1.7 Versions of the Various Models used in Forecasting

Model	Version
Woodstock	3.28.2
Spatial Woodstock	3.28.2
Stanley	3.28.2
MOSEK	3.0

1.7 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 1.9 and is outlined in this section.

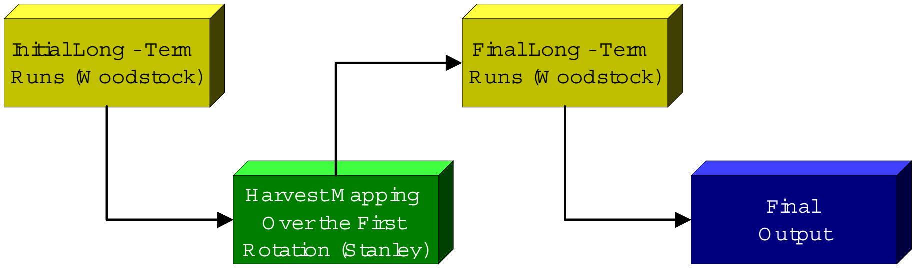


Figure 1.9 Overview of the Modeling Approach

1.7.1 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 1.11.1 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 1.8.

Table 1.8 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

1.7.2 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 May 1, 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. The majority of these were allocated into periods 1 and 2 however, a smaller number were scheduled into periods 3 and 4.
- 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 1.11.2 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 20 year Spatial Harvest Sequence were generated with Stanley. The map of expectations was repeatedly assessed and refined by the operations planning staff of Weyerhaeuser and the other timber operators to create a harvest design to be used operationally for the first 10 years and somewhat less for the following ten years (years 11 to 20). A map of the SHS is located in Appendix 6.6 of Volume II.

1.7.3 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 32 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 FMUs.

1.8 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).

1.8.1 Successional Dynamics

As the planning horizon for the Woodstock™ model exceeds the lifespan of most tree species in FMA area, 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.

1.8.2 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. In the event of a large scale impact (>= 2.5% of the harvestable land base) a re-calculation of the AAC is anticipated to 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.

1.9 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 1.9. The table shows the volumes summarized from the four individual FMUs. Since W5 has a different lower operability limit for C & CD BCGs, the MAIs and MAI age are shown as averages across the FMUs. Detailed LRSY calculations are located in Appendix 6.9: Supporting Tables of Volume II.

Table 1.9 Long Run Sustainable Yield

Timber Harvesting Landbase		FMA		Average MAI (m^3/ha/yr)			Volume (m^3/yr)		
	Broad Cover Group	Area (ha)	@ Age	Conifer	Decid	Total	Conifer	Decid	Total
Deciduous	Deciduous	90,830	80.00	0.45	2.13	2.56	40,874	193,014	233,887
	Deciduous / Coniferous	16,329	80.00	0.93	1.51	2.44	15,104	24,698	39,802
	Coniferous / Deciduous	11,796	92.50	1.23	1.01	2.24	14,546	11,925	26,471
	Coniferous	702	92.50	1.78	0.49	2.27	1,255	343	1,597
	Sub-total	119,657					71,778	229,979	301,757
Coniferous	Coniferous	112,466	92.50	1.78	0.49	2.27	201,055	54,920	255,975
	Coniferous / Deciduous	32,918	92.50	1.23	1.01	2.24	40,487	33,183	73,670
	Deciduous / Coniferous	15,074	80.00	0.93	1.51	2.44	13,943	22,799	36,743
	Deciduous	0	80.00	0.45	2.13	2.56	0	0	0
	Sub-total	160,458					255,485	110,902	366,387
	Grand Total	280,115					327,263	340,881	668,144

1.10 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 1.10.

Table 1.10 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]
	Eligibility	Operability Windows	[ACTIONS] [LIFESPANS]
	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}

1.11 Summary of Model Variables

1.11.1 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.

1.11.1.1 Start Date

May 1st, 2004 was selected as the start date. May 1st is the beginning of the timber operating and production tracking year. 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 May 1st, 2004.

1.11.1.2 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.

1.11.1.3 Objective and Strategic Level Sustainability Criteria

The primary objective of the forecasting model was to maximize the total primary volume harvested over planning horizon. The timber supply objective is to maximize the sum of coniferous and deciduous primary harvest volumes (conifer volume from the conifer land base and deciduous volume from the deciduous land base) 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. The goal for primary volumes for each FMU was even flow volume over the entire planning horizon of 160 years with an allowable fluctuation of +/-5%. Similarly, the goal for incidental volumes (deciduous volume from the coniferous land base and coniferous volume from the deciduous land base) for each FMU was even flow volume over the entire planning horizon of 160 years with an allowable fluctuation of +/-10%.

Other sustainability constraints incorporated into the model included:

- Total harvestable growing stock on both the coniferous land base and deciduous land base will not decrease over the last 40 years (8 periods) of the planning horizon;
- In FMU E1, at least 400,000 m^3 of coniferous volume from pure C and CD stands will be obtained from the Erith and Rodney Creek HDAs;

- LMUs will be utilized for controlling conifer primary harvest volume flows to facilitate embedded quota holders and their historic operating areas. In W6, the primary conifer harvest volumes will be constrained as follows:
  - Carrot River >= 19%; Carrot River LMU (includes HDAs: Tower, Nine Mile, North Rat Creek, and North Minnow (note: Minnow North is open in period three));
    - Operators: Blue Ridge, Millar Western
  - Cynthia >= 36%; Cynthia LMU (includes HDAs: Granada, Nojack South, Chip Lake, Bigoray, Sinkhole, Eta Lake, and Paddy Creek)
    - Operators: CCTL, MTU, Weyerhaeuser
  - Wolf Lake >= 42%; Wolf Lake LMU (includes HDAs: Big Rock, Coyote Creek, North Pembina, Zeta Lake, South Rat Creek, and South Minnow (note: South Minnow is open in period 3))
    - Operators: ANC

- Various Harvest Design Areas aggregated for preferred timing during sequence.

1.11.1.4 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 Sectiond 3.1.9.4 and 8.2.3 of the DFMP. 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:

Table 1.11 Seral Stage Constraints

FMU	Natural Sub-region	Old Growth Broad Cover Group Category	Minimum Area that Must Be Late Seral Stage or Older	Minimum Area that Must Be Very Late Seral Stage or Older	Minimum Area that Must Be Over-mature Seral Stage or Older
E1	LF	CD	559	112	0
		Other Pure CX	2,398	480	0
		DC	282	56	0
		DX	351	70	0
		Pure CX Pine Leading	1,105	221	0
		Pure CX Pine/White Spruce Mix	188	38	0
		Pure CX White Spruce Leading	301	60	0
	UF	CD	3	1	0
		Other Pure CX	10	5	3
		DC	3	1	0
		DX	4	2	0
		Pure CX Pine Leading	2	1	1
		Pure CX Pine/White Spruce Mix	3	1	1
		Pure CX White Spruce Leading	1	0	0
E2	LF	CD	460	92	0
		Other Pure CX	1,583	317	0
		DC	387	77	0
		DX	1,594	319	0
		Pure CX Pine Leading	291	58	0
		Pure CX Pine/White Spruce Mix	117	23	0
		Pure CX White Spruce Leading	231	46	0

FMU	Natural Sub-region	Old Growth Broad Cover Group Category	Minimum Area that Must Be Late Seral Stage or Older	Minimum Area that Must Be Very Late Seral Stage or Older	Minimum Area that Must Be Over-mature Seral Stage or Older
	UF	CD	98	39	0
		Other Pure CX	165	83	41
		DC	103	41	0
		DX	124	50	0
		Pure CX Pine Leading	76	38	19
		Pure CX Pine/White Spruce Mix	62	31	16
		Pure CX White Spruce Leading	74	25	12
W5	LF	CD	273	55	0
		Other Pure CX	959	192	0
		DC	220	44	0
		DX	922	184	0
		Pure CX Pine Leading	188	38	0
		Pure CX Pine/White Spruce Mix	35	7	0
		Pure CX White Spruce Leading	167	33	0
W6	LF	CD	1,020	204	0
		Other Pure CX	3,810	762	0
		DC	725	145	0
		DX	2,007	401	0
		Pure CX Pine Leading	1,234	247	0
		Pure CX Pine/White Spruce Mix	217	43	0
		Pure CX White Spruce Leading	1,259	252	0
	UF	CD	49	20	0
		Other Pure CX	908	454	227
		DC	17	7	0
		DX	31	13	0
		Pure CX Pine Leading	87	43	22
		Pure CX Pine/White Spruce Mix	12	6	3
		Pure CX White Spruce Leading	31	10	5

1.11.1.5 Profile Constraints

To promote sustainability, constraints were used in the model to ensure that there were no significant unforeseen modeling biases toward any strata types. Prior to the inclusion of these controls, operational problems were observed relating to disproportionately high amounts of low density (CC='A') stand areas being scheduled for harvest. When unconstrained, the model was attempting to take maximum benefit from moving understocked stands to fully-stocked status as soon as possible.

To avoid this problem, crown closure and site class were identified as the two selection factors which most strongly influence the volume obtained from a stand. In the TSA each FMU is identified as a sustained yield unit and the area by crown closure class and site class were estimated for each unit. The goal was to identify a range of areas for each class that allowed for flexibility in the model yet ensured that most harvest strata types are harvested in some proportion to its distribution within the operable land base. Therefore, the goal harvest range for each site and crown closure class was to harvest between +50% or -50% of the proportional harvest area based on the rotation age (Table 1.12, and Table 1.13). For easier implementation into the model, the ranges were reported for each five-year period.

Table 1.12 Proportional Five-Year Operational Harvest Area Target by Site Class

FMU	Land Base	Site	Lower 50% Harvest Range (ha)	Upper 50% Harvest Range (ha)
E1	CON	G	517	1,550
		M	552	1,657
		P	91	272
	DEC	G	501	1,504
		M	27	80
		P	5	16
E2	CON	G	450	1,351
		M	171	512
		P	32	96
	DEC	G	1,396	4,189
		M	43	128
		P	8	24
W5	CON	G	244	733
		M	96	288
		P	43	128
	DEC	G	540	1,621
		P	2	6
W6	CON	G	1,711	5,132
		M	812	2,437
		P	200	599
	DEC	G	1,213	3,638
		P	4	13

Table 1.13 Proportional Five-Year Operational Harvest Area Target by Crown Closure Class

FMU	Land base	AVI Crown Closure	Lower 50% Harvest Range (ha)	Upper 50% Harvest Range (ha)
E1	CON	A	172	515
		B	192	577
		C	523	1,570
		D	272	817
	DEC	A	44	131
		B	96	288
		C	318	954
		D	75	226
E2	CON	A	119	357
		B	148	444
		C	293	879
		D	93	279
	DEC	A	94	282
		B	280	839
		C	909	2,728
		D	164	493
W5	CON	A	139	418
		B	50	150
		C	169	508
		D	24	73
	DEC	A	45	136
		B	93	280
		C	285	854
		D	119	356
W6	CON	A	398	1,193
		B	541	1,624
		C	1,659	4,976
		D	125	376
	DEC	A	37	112
		B	163	490
		C	891	2,673
		D	125	376

1.11.1.6 Periodic and Quadrant Reconciliation Volumes

With May 1st, 2004 being used as the start date for the TSA process, some reconciliation of pre-May 1st, 2004 production levels occurred. This allowed the model to approximate the impact of these additional (or reduced) volumes on the long-term sustainability to the timber supply. Table 1.14 provides the estimated volumes for each timber operator within individual FMUs. Actual audited numbers for over/underproduction will occur post-DFMP, and will likely deviate somewhat from the estimates provided in the tables below.

Table 1.14 Net Quadrant Reconciliation Volume Applied to Period 1

		Net Volume (m^3)			
Vol	Operator	E1	E2	W5	W6
Coniferous	Weyerhaeuser	404	8,388		-28,698
	MTU	-7,932	-702	7,138	25,872
	EDFOR		-26,426		
	CCTL				14,175
	ANC				219,520
	Blue Ridge				23,111
	Millar Western				5,978
	Total	-7,528	-18,740	7,138	259,958
Deciduous	Weyerhaeuser	66,956	59,610	-7,259	234,569
	MTU				17,274
	EDFOR				
	CCTL				12,732
	ANC				
	Blue Ridge				
	Millar Western				
	Total	66,956	59,610	-7,259	264,575

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 with the remainder of the second period blocks.

1.11.1.7 Treatment Types

The stand-level treatments are described in Table 1.15. 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 land base was defined as 180 years; senescence for coniferous the coniferous land base is 300 years. Table 1.16 outlines the lifespans used in this plan.

Table 1.15 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 1.16 Lifespan for Broad Cover Groups

BCG	Lifespan (years)
Deciduous	180
DC Mixedwood	180
CD Mixedwood	300
Coniferous	300

1.11.1.8 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 are specific to FMUs as follows:

Coniferous dominated stands (C and CD)

- E1 and E2: 80 years for entire planning horizon
  - Rationale: most stands approaching max MAI (most coniferous dominated yield curves reach max MAI around 90)
- W5: 100 years 1st Rotation, 80 years 2nd Rotation
  - Rationale: in negotiation with the MTU group 100 years was selected to ensure the oldest of the coniferous dominated stands were harvested first.
- W6: 80 years 1st Rotation, 70 years 2nd Rotation
  - Rationale: 70 was selected based upon the direction provided from Alberta SRD.

Deciduous (D and DC stands)

- Entire FMA: 1st Rot 80 years, 2nd Rot - 60 years
  - Rationale: there were concerns that the older deciduous stands must be sequenced first therefore 80 years was selected for the first rotation (most deciduous dominated yield curves reach max MAI around 70). A second rotation of 60 was selected because most stands are approaching max MAI.

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; and
- 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.

1.11.1.9 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.

1.11.1.10 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). Additional detail regarding the determination of regeneration lags is located in Appendix 6.10 of Volume II. Table 1.17 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 42% (2.1 yrs / 5 yr period) of the area (ha) delayed one five-year period and 58% of blocks regenerate with no delay. This is represented in the transition rules.

Table 1.17 Regeneration Lag for Broad Cover Groups

BCG	Lag (years)
Deciduous	0.4
DC Mixedwood	2.1
CD Mixedwood	3.1
Coniferous	1.7

1.11.2 Stanley

1.11.2.1 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 1.18.

Table 1.18 Summary of Input Parameters and Assumptions Required for Stanley

Parameter/Criteria	Value
Spatial Planning Horizon	60 years (12 periods)
Green-up Delays	First 20 years (4 periods) C 20 years (3 periods) CD, DC, DX 15 years (2 periods) Last 40 years (periods 5 to 12) C 15 years (2 periods) CD, DC, DX 10 years (1 period)
Minimum Block Size	2 ha
Maximum Block Size	None
Target Block Size	100 ha
Adjacency Distance	55 m
Proximity Distance	21 m
Timing Deviations	4 periods (20 years)
Spatial Flow Tolerance	Primary Flows +/- 5%, Incidental Flows +/- 10%
Objectives and Weights	Primary Volumes: fmuCON5YR: Primary Coniferous Volume – Weight = 3 fmuDEC5YR: Primary Deciduous Volume – Weight = 3 Incidental Volumes: fmuCONIN5YR: Primary Coniferous Volume – Weight = 1 fmuDECIN5YR: Primary Deciduous Volume – Weight = 1
Allow multi-period openings	Yes

For E1 no green up constraints were used, instead the stand structure retention was increased to 8%.

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.

1.11.2.2 General

The planning horizon was twelve five-year periods, or 60 years from the model start date. Separate runs were made for each FMU. 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.

1.11.2.3 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.

1.11.2.4 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.

No maximum block size was used.

1.11.2.5 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 100 ha. This meant the model would attempt to aggregate polygons until the patch was close to 100 ha in size.

1.11.2.6 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 60 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.

1.11.2.7 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 three 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.

1.11.3 Aspatial Post-Modeling Harvest Level Reductions

1.11.3.1 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 3% in FMUs E2, W5 and W6 and 8% in E1 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 1.19 for the quantitative reduction factors.

1.11.3.2 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 1.19 for the quantitative reduction factors.

Table 1.19 Aspatial Post-Modeling Harvest Level Reductions

FMU	Cull Reduction %		Stand Structure Retention %		Total Reduction %	
	Coniferous	Deciduous	Coniferous	Deciduous	Coniferous	Deciduous
E1	3	7	8	8	11	15
E2	3	7	3	3	6	10
W5	3	7	3	3	6	10
W6	3	7	3	3	6	10

1.12 Exploring Trade-offs and Sensitivities

As part of any timber supply analysis it is important to understand how sensitive certain parameters are and the impacts they bear. A number of sensitivity runs were carried out to understand the impacts of certain aspects (1.12.1) as well as the quantification of grazing areas on the FMA (1.12.2). Additional details regarding both of these additional analysis are located in Appendix 6.7 of Volume II.

1.12.1 Sensitivity Analysis

Additional timber supply analysis was conducted to assess the sensitivity of the AAC to the following scenarios:

1) Spatial harvest sequence removed
2) First period carry over volume removed
3) Old forest constraints removed
4) Profile constraints removed
5) Harvest Design Area (HDA) access constraints removed
6) Surge cut removed (W6 only)

For this sensitivity analysis, the aspatial Woodstock model developed to generate the spatial harvest sequence and the PFMS was used as the base model. Scenarios one to five were assessed for all four FMUs. Scenario 6 was assessed for W6 only.

An additional series of sensitivity runs was conducted to assess the impact of changing the timing of harvesting blocks in periods one to four of the SHS. For this portion of the sensitivity analysis, the preferred forest management scenario that includes the LP schedule generated by Stanley was used as the base case.

The Edson FMA AAC is most sensitive to the introduction of spatial constraints, as seen in the scenario examining the impact of the spatial harvest sequence. The AAC is relatively insensitive to all the scenarios examined. Removing the HDA access constraints made the greatest impact on AAC; it resulted in a 1.3% increase for deciduous AAC.

Table 1.20 Summary of FMA Level Impacts on AAC of Sensitivity Analysis Runs

Scenario	Primary Conifer (m3)	% Change	Primary Deciduous (m3)	% Change	Total AAC (m3)	% Change
Base	308,890	0.0%	263,423	0.0%	572,313	0.0%
Impact of spatial sequence	304,755	-1.3%	255,594	-3.0%	560,349	-2.1%
Remove carry over volume	310,072	0.4%	263,775	0.1%	573,847	0.3%
Remove profile constraints	309,888	0.3%	263,897	0.2%	573,785	0.3%
Remove old growth constraints	308,970	0.0%	263,972	0.2%	572,942	0.1%
Remove HDA access constraints	309,038	0.0%	266,827	1.3%	575,864	0.6%
Remove surge cut[1]	310,239	0.4%	263,423	0.0%	573,662	0.2%

1.12.2 Grazing

The final, aspatial Woodstock models that were used to develop the spatial harvest sequence and the PFMS, were used to determine the grazing disposition AAC levels. New outputs were created to report on grazing area deciduous and coniferous harvest levels, and total deciduous and total conifer AAC for each FMU. No other changes were made to the FMU models.

Harvest levels within grazing areas fluctuate considerably from period to period. In order to accurately calculate harvest in grazing areas as a percentage of the AAC, the average harvest in grazing areas for the 32 period planning horizon calculated to represent grazing area AAC.

Table 1.21 Gross Harvest Levels within Grazing Areas for the FMUs

	E1		E2		W5		W6	
	Conifer	Deciduous	Conifer	Deciduous	Conifer	Deciduous	Conifer	Deciduous
Mean Gross AAC Grazing	76	97	7,959	16,108	6,538	18,309	1,868	4,738
Gross AAC*	94,852	43,863	83,082	104,997	33,589	56,801	186,617	164,746
% AAC on grazing areas	0.1%	0.2%	9.6%	15.3%	19.5%	32.2%	1.0%	2.9%

With the exception of W6, the Gross AAC for each FMU was calculated as the sustainable, even-flow harvest levels starting in period two. Period one was excluded because it includes carryover volume.

W6 has a coniferous surge cut for the first five periods and a carry over volume for deciduous and conifer in the first period. A large portion of the harvest within grazing areas occurs in the first period, and using the sustainable harvest level after the surge as the AAC for the entire FMU would give too much weighting to the grazing area harvest during that time. Instead, for W6 the AAC was calculated as the average annual harvest level for 32 periods.

At the FMA level, the grazing disposition AAC is 4.1% of the total for coniferous and 10.6% for deciduous.

1.13 Preferred Management Strategy

1.13.1 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 FMA. This scenario was constructed to observe non-declining yields on the operable growing stock 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;
- Minimum block size of 2 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 FMA. A portion of the blocks in the 20 year spatial harvest sequence were manually planned by the Weyerhaeuser planning team in Edson and some of the other timber operators (mainly BRL and ANC) within the FMA. This increases the expected congruency between the Spatial Harvest Sequence and the operational harvesting activities.

1.13.2 Harvest Levels and Resulting Forest Conditions

The volumes that the company has calculated as the proposed net sustainable harvest levels are provided in Table 1.22. Figure 1.10 through Figure 1.13 show the pattern of harvest flows in each of the FMUs over the planning horizon.

Table 1.22 Proposed Harvest Levels

	Coniferous Landbase			
	(Periods 1 and 2)		(Periods 3 and 4)	
FMU	Primary Conifer Vol (m^3/yr)	Incidental Decid Vol (m^3/yr)	Primary Conifer Vol (m^3/yr)	Incidental Decid Vol (m^3/yr)
E1	65,749	12,357	65,749	12,431
E2	39,685	6,842	39,685	9,086
W5	22,351	11,441	22,351	10,970
W6	164,392	61,682	164,392	54,447
FMA	292,177	92,322	292,177	86,934

* Cull: 3% for coniferous; 7% for deciduous Stand retention: 3% for E2, W5, W6; 8% for E1

† Period 1 includes carry-over/overcut volumes. For W6 only the coniferous landbase volumes for periods 1 to 4 represent an additional 10% surge cut.

	Deciduous Landbase			
	(Periods 1 and 2)		(Periods 3 and 4)	
FMU	Primary Decid Vol (m^3/yr)	Incidental Conifer Vol (m^3/yr)	Primary Decid Vol (m^3/yr)	Incidental Conifer Vol (m^3/yr)
E1	23,520	21,853	23,520	17,655
E2	79,791	36,967	79,791	35,669
W5	38,066	7,895	38,066	8,206
W6	82,634	25,602	82,634	19,939
FMA	224,012	92,317	224,012	81,468

* Cull: 3% for coniferous; 7% for deciduous Stand retention: 3% for E2, W5, W6; 8% for E1

† Period 1 includes carry-over/overcut volumes. For W6 only the coniferous landbase volumes for periods 1 to 4 represent an additional 10% surge cut.

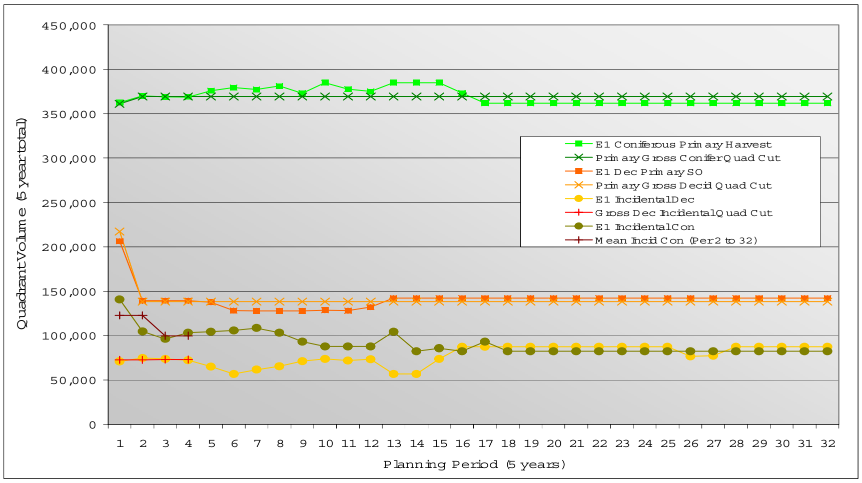


Figure 1.10 E1 Harvest Flows

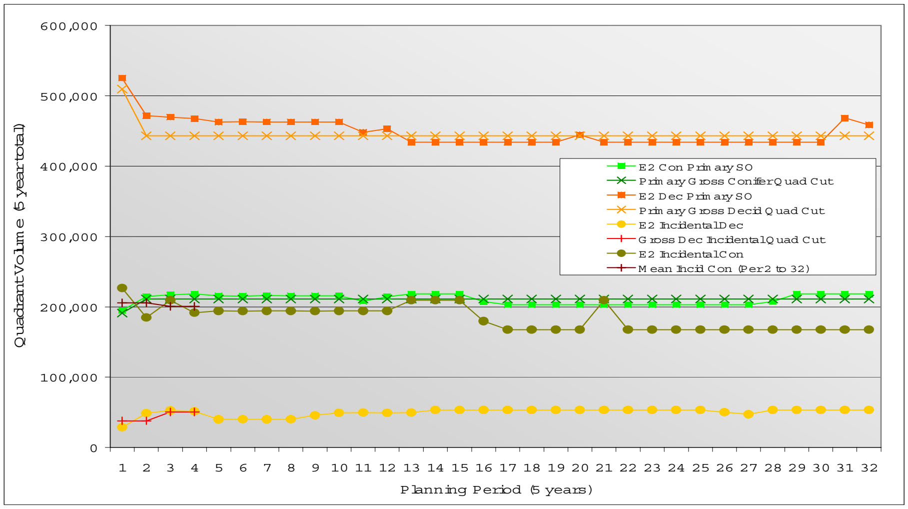


Figure 1.11 E2 Harvest Flows

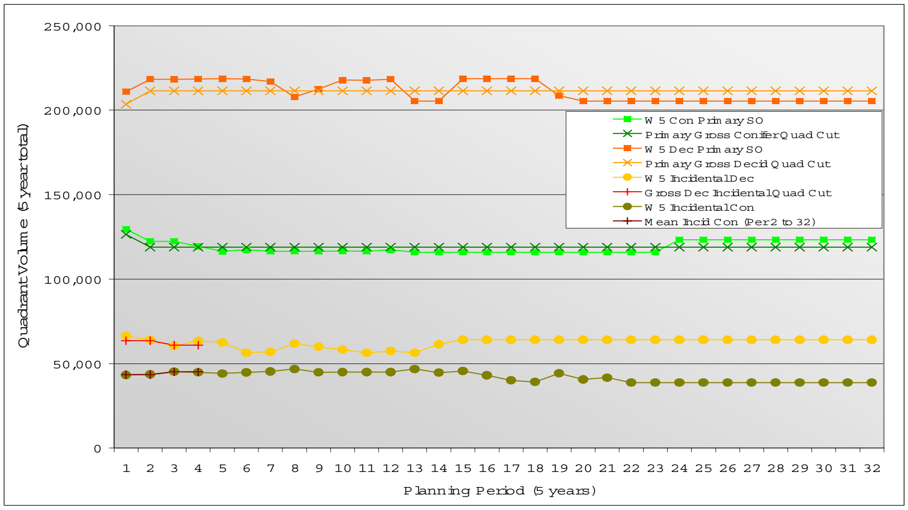


Figure 1.12 W5 Harvest Flows

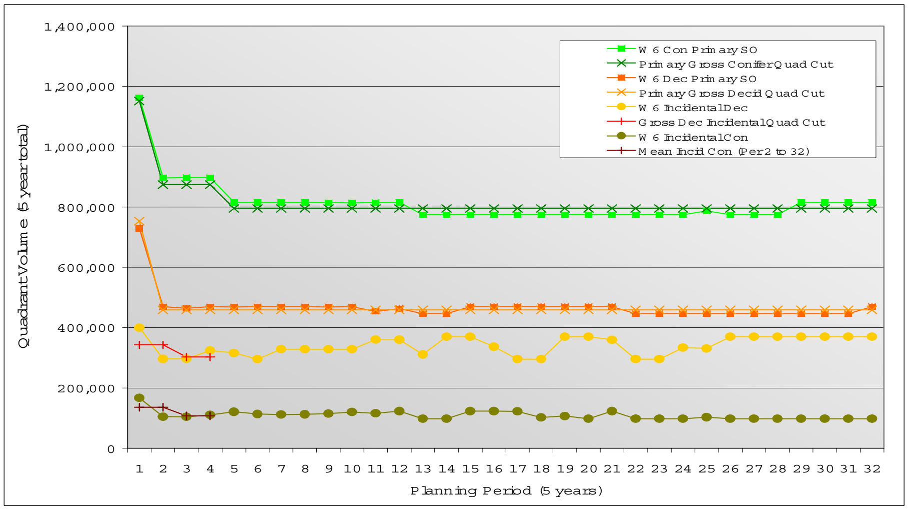


Figure 1.13 W6 Harvest Flows

1.13.2.1 Changes in Recommended Harvest Levels as Compared to Previous Management Plan Harvest Levels

Significant changes have occurred in both the area of timber harvesting land base and the associated primary harvest levels from past management plans. This is not surprising, since there have been many significant changes in both the state of the forest (such as the quantity of growing stock), and the information available used to conduct timber supply analyses. As noted previously, the timber harvesting land base has declined across the FMA area for a variety of reasons, however, primary harvest levels, as ratios to land base, have remained relatively the same, with some exceptions, most notably with deciduous types. Again, this is not surprising since there have been significant improvements in both inventory and growth and yield information for deciduous species, in keeping with their significance as a commercially valuable crop in Alberta since the early 1980s when previous management plans were being prepared.

Table 1.23 Comparison of Primary Harvest Levels and Net Land Base to the 1986 Management Plan

Management Plan		Net Conifer Land Base (ha)	Primary Conifer Vol (m^3/yr)	Incid Conifer Vol (m^3/yr)	Net Decid Land Base (ha)	Primary Decid Vol (m^3/yr)	Incid Decid Vol (m^3/yr)
1986	E1	54,748	118,300		26,325	24,111	
	E2	24,623	47,300		36,741	64,800	
	W5	35,006	66,100		44,935	86,200	
	W6	106,892	214,987		43,269	74,805	
	sub-total	221,269	446,687	0	151,270	249,916	0
2006	E1	37,106	65,749	21,853	17,063	23,520	12,357
	E2	20,890	39,685	36,967	46,303	79,791	6,842
	W5	15,328	22,351	7,895	17,350	38,066	11,441
	W6	87,134	164,392	25,602	38,941	82,634	61,682
	sub-total	160,458	292,177	92,317	119,657	224,012	92,322

- Information regarding incidental volumes in 1986 was not determined

1.13.3 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, objectives, 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.

A spike occurs in many of the deciduous land base graphs at period 22 (year 2114). For each of the FMUs there is a single period uplift in average volume per hectare (Figure 1.14), piece size (Figure 1.18), and average harvest age (Figure 1.16). This is indicative of a spike in the deciduous age class. What is interesting about this spike is that, in each case, it is made up of pure deciduous strata types (D13 (0% con), D14 (10% con), and D15 (20% con)) that are all 100 years of age. Each of these stands are on good sites in the Lower Foothills Natural Subregion with a fully stocked crown closure. The model initially harvested these stands in the first period. Not all of them originally were fully stocked. After the initial harvest they are assumed to be reforested to a fully stocked status. The model then allows these stands to mature to the maximum predicted volume at 100 years and then harvests them .

In letting the highly productive cohort reach it's maximum volume, the model temporarily strayed from the oldest first harvest paradigm , selecting younger stands in the periods leading up to year 110. This created a pocket/island of pure deciduous stands separated from the remainder of the age classes (Figure 1.33). The age class clump was harvested and that resulted in the spikes that appear in the graphs.

1.13.3.1 Average Volume per Hectare

Average harvest volumes lies between 106 to 213 m^3/ha for the deciduous and 86 to 204 m^3/ha for the coniferous dominant cover types. The volumes were generally stable over time although there is a slight decline after period 12 (Figure 1.14 and Figure 1.15).

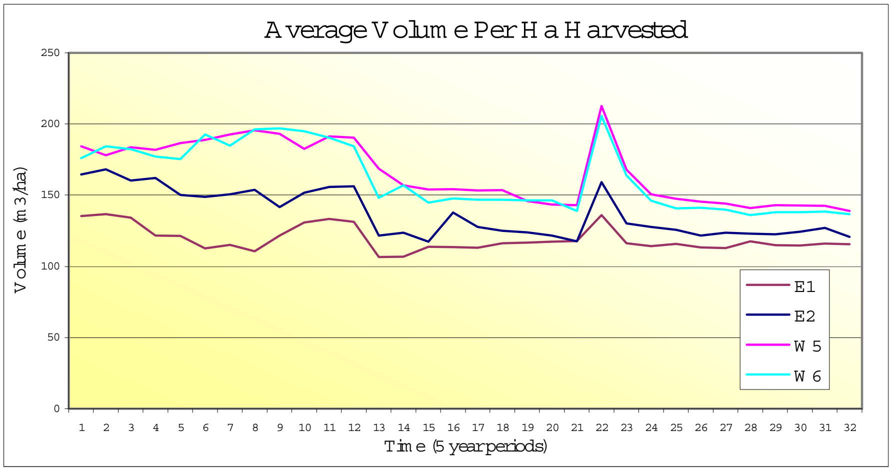


Figure 1.14 Average Volume per Hectare of Harvest from the Deciduous Land Base

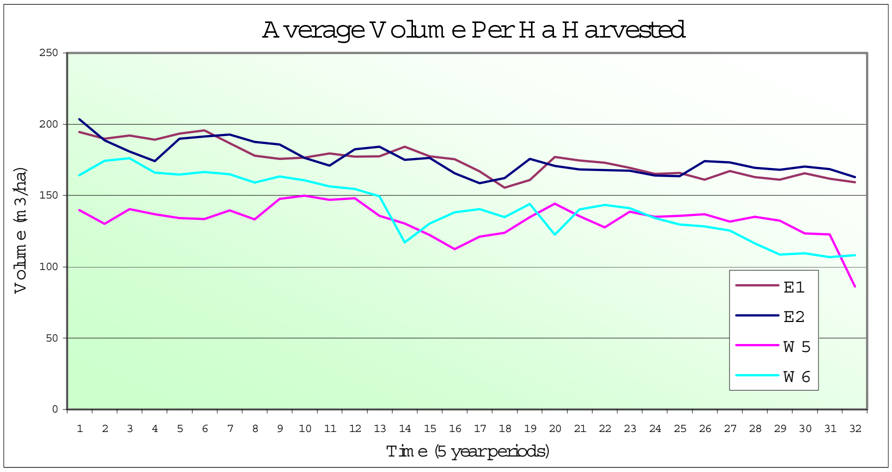


Figure 1.15 Average Volume per Hectare of Harvest from the Coniferous Land Base

1.13.3.2 Average Harvest Age

The average harvest age on the deciduous land base varies from 95 to 128 over the first 12 periods, with E1 and E2 generally being older. Average harvest age declines at that point and generally stabilizes between 61 (lowest point) and 73 for the remainder of the planning horizon. Average harvest age initially increases in the conifer land base for the first 12 periods, varying between 110 (E2, period 4) and 138 (E1, period 6). At period 13, average harvest age begins to fluctuate before stabilizing at period 20 to an average of 84 (Figure 1.16 and Figure 1.17).

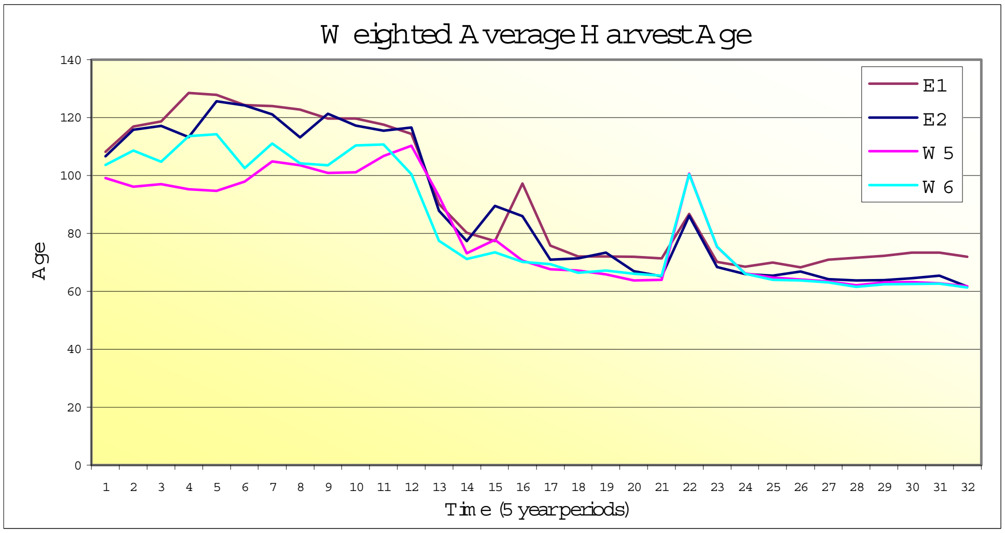


Figure 1.16 Average Age of Harvest over Time from the Deciduous Land Base

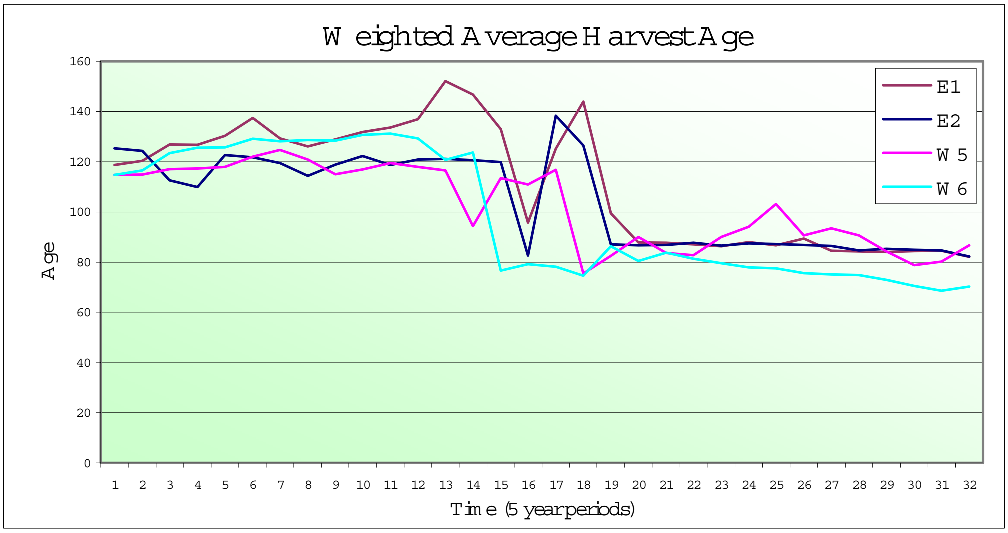


Figure 1.17 Average Age of Harvest over Time from the Coniferous Land Base

1.13.3.3 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. Average piece size shows strong consistency between FMUs across the planning horizon. Deciduous DBHq ranges between 26 and 28 for the first 12 periods before declining to an average of 24 by the end of the planning horizon. The coniferous DBHq exhibits a similar trend, averaging 24 for the first 12 periods before declining to 21 by the end of the planning horizon. Figure 1.18 and Figure 1.19 show the piece size (DBHq) trends by FMU over the planning horizon.

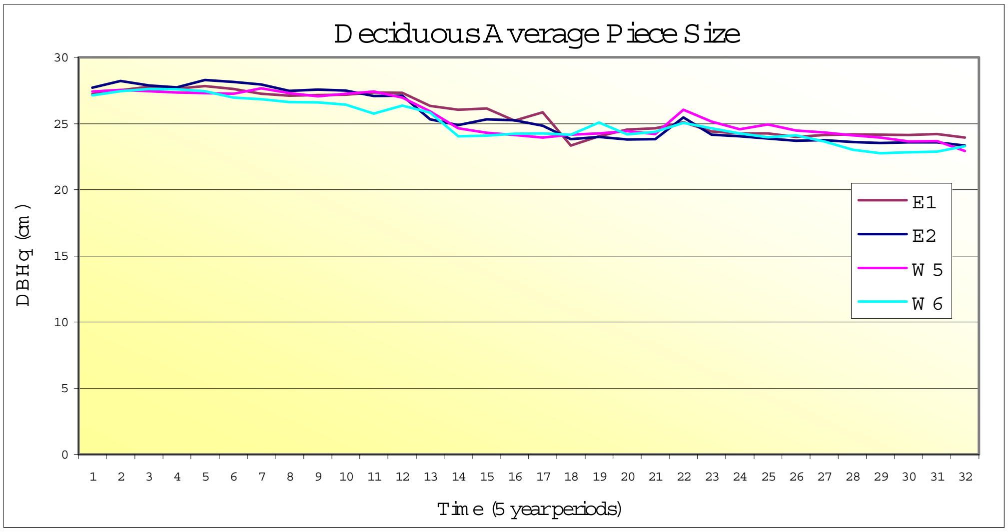


Figure 1.18 Deciduous Piece Size throughout the Planning Horizon

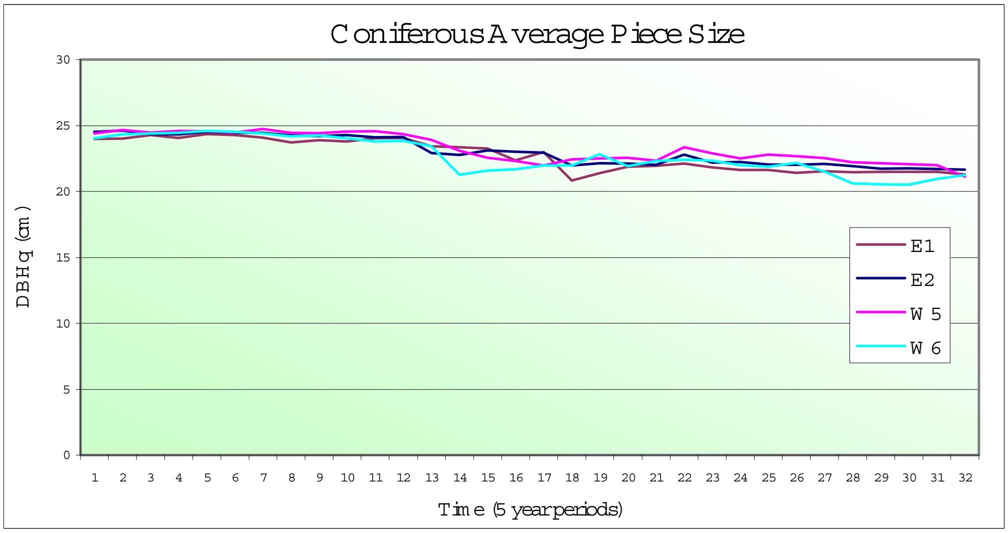


Figure 1.19 Coniferous Piece Size throughout the Planning Horizon

1.13.3.4 Growing Stock

Both softwood and hardwood growing stocks (GS) exhibit a declining trend over the majority of the planning horizon (Figure 1.20 and Figure 1.21). These patterns are typical of mature forest with plenty of standing merchantable volume at the beginning of the modeling start date. The rate of change in the deciduous operable growing stock (OGS) decreases from period 12 to the end of the planning horizon. The conifer operable growing stock follows a similar trend, with the rate of change decreasing after period 16.

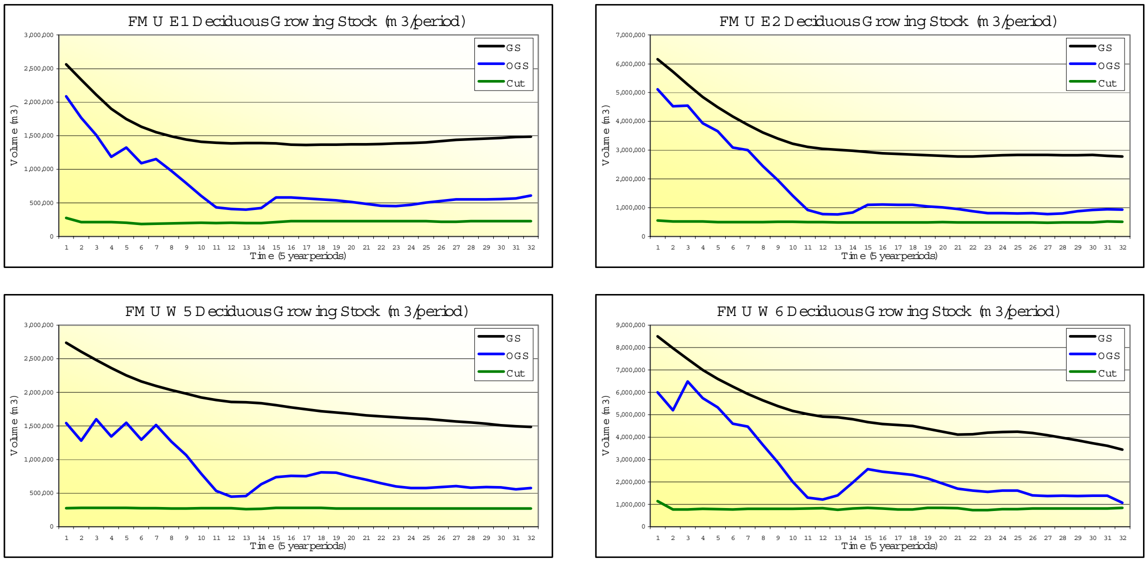


Figure 1.20 Deciduous Growing Stock Projections

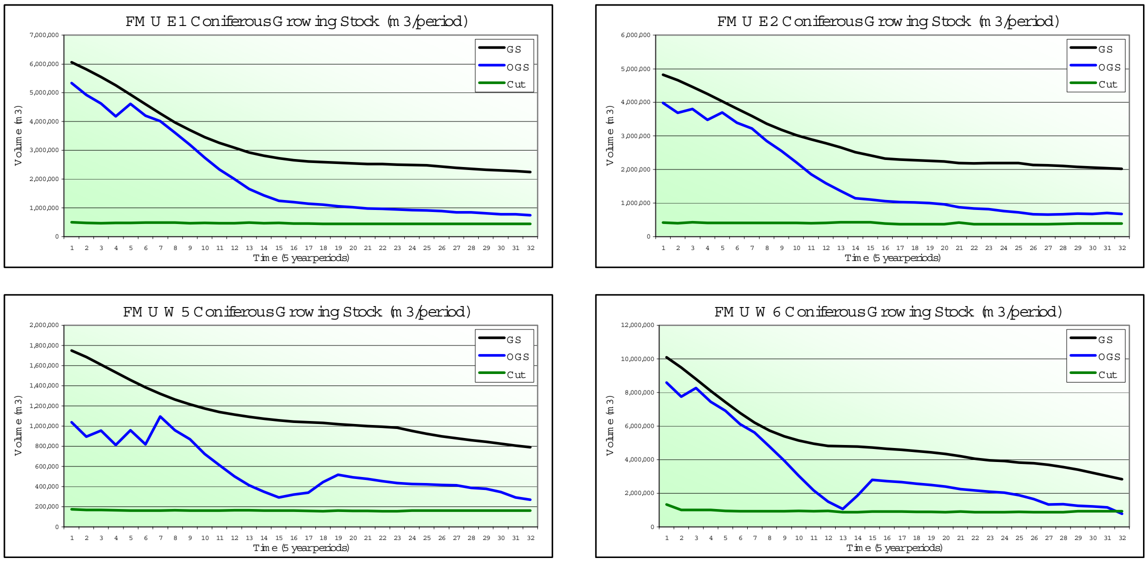


Figure 1.21 Coniferous Growing Stock Projections

1.13.3.5 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 Figure 1.22 through Figure 1.28, and Table 1.24 through Table 1.30. Overall, the seral constraints were easily met with the exception of the very late and extremely late conifer in the Upper Foothills region 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 matured enough to contribute to those specific constraints.

Table 1.24 FMU E1 Area of Older Seral Stages in the Lower Foothills Natural Subregion

E1 Lower Foothills	Target Minimum Area		Time from Start Date (years)				
Seral Stage	(%)	(ha)	0	10	50	100	160
Late Decid	5.0	351	4,215	3,568	1,509	998	351
Very Late Decid	1.0	70	2,418	2,122	712	319	98
Late DC	5.0	282	3,159	2,550	1,427	485	282
Very Late DC	1.0	56	1,963	1,725	440	245	67
Late CD	5.0	559	4,267	3,445	2,748	1,236	2,902
Very Late CD	1.0	112	418	2,993	1,471	887	927
Late PL	5.0	1,105	15,902	13,699	10,283	2,600	1,676
Very Late PL	1.0	221	405	10,823	5,656	1,672	1,676
Late PS	5.0	188	3,730	3,101	1,105	576	450
Very Late PS	1.0	38	590	2,769	1,099	451	450
Late SW	10.0	301	2,875	2,501	1,463	868	605
Very Late SW	2.0	60	1,689	2,362	1,456	626	604
Late 'other' Con	5.0	2,398	30,153	33,952	43,878	42,734	41,313
Very Late 'other' Con	1.0	480	6,165	21,353	38,768	42,311	41,313

* PL = Pine, PS = Pine/White Spruce, SW = White Spruce

Table 1.25 FMU E1 Area of Older Seral Stages in the Upper Foothills Natural Subregion

E1 Upper Foothills	Target Minimum Area		Time from Start Date (years)				
Seral Stage	(%)	(ha)	0	10	50	100	160
Late Decid	5.0	4	84	76	6	16	4
Very Late Decid	2.0	2	31	22	6	3	1
Late DC	5.0	3	55	28	9	6	5
Very Late DC	2.0	1	49	21	9	3	0
Late CD	5.0	3	63	63	58	21	14
Very Late CD	2.0	1	0	43	58	21	5
Late PL	2.0	2	121	113	76	16	4
Very Late PL	1.0	1	1	106	76	4	4
Extremely Late PL	0.5	1	0	0	1	4	4
Late PS	10.0	3	26	26	7	1	1
Very Late PS	5.0	1	0	26	7	1	1
Extremely Late PS	2.5	1	0	0	0	1	1
Late SW	10.0	1	10	10	10	1	1
Very Late SW	5.0	0	0	10	10	1	1
Extremely Late SW	2.5	0	0	0	0	1	1
Late 'other' Con	10.0	10	80	94	88	94	88
Very Late 'other' Con	5.0	5	7	69	86	88	88
Extremely Late 'other' Con	2.5	3	0	0	1	86	88

* PL = Pine, PS = Pine/White Spruce, SW = White Spruce

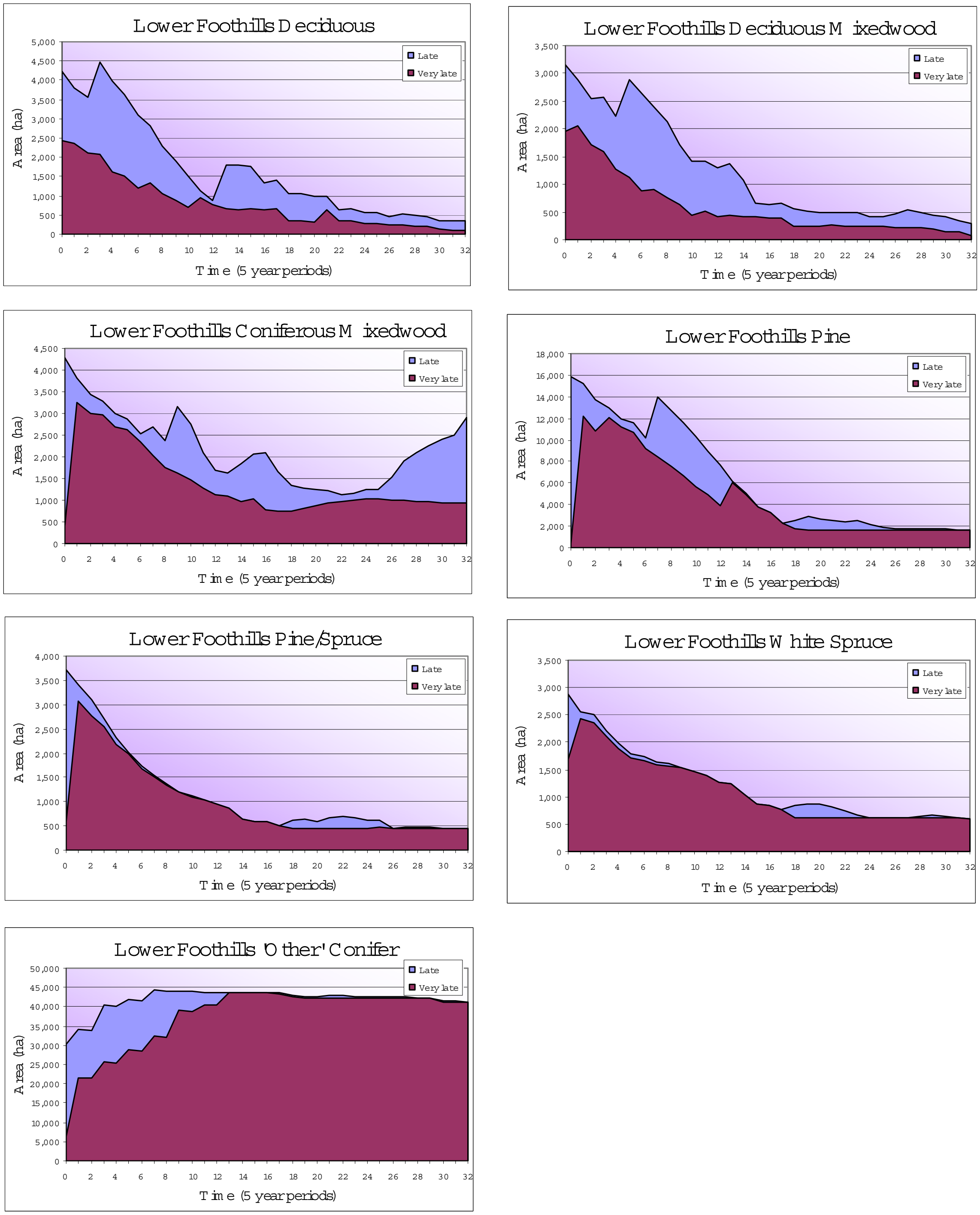


Figure 1.22 FMU E1 Area of Seral Stages within the Lower Foothills Natural Subregion

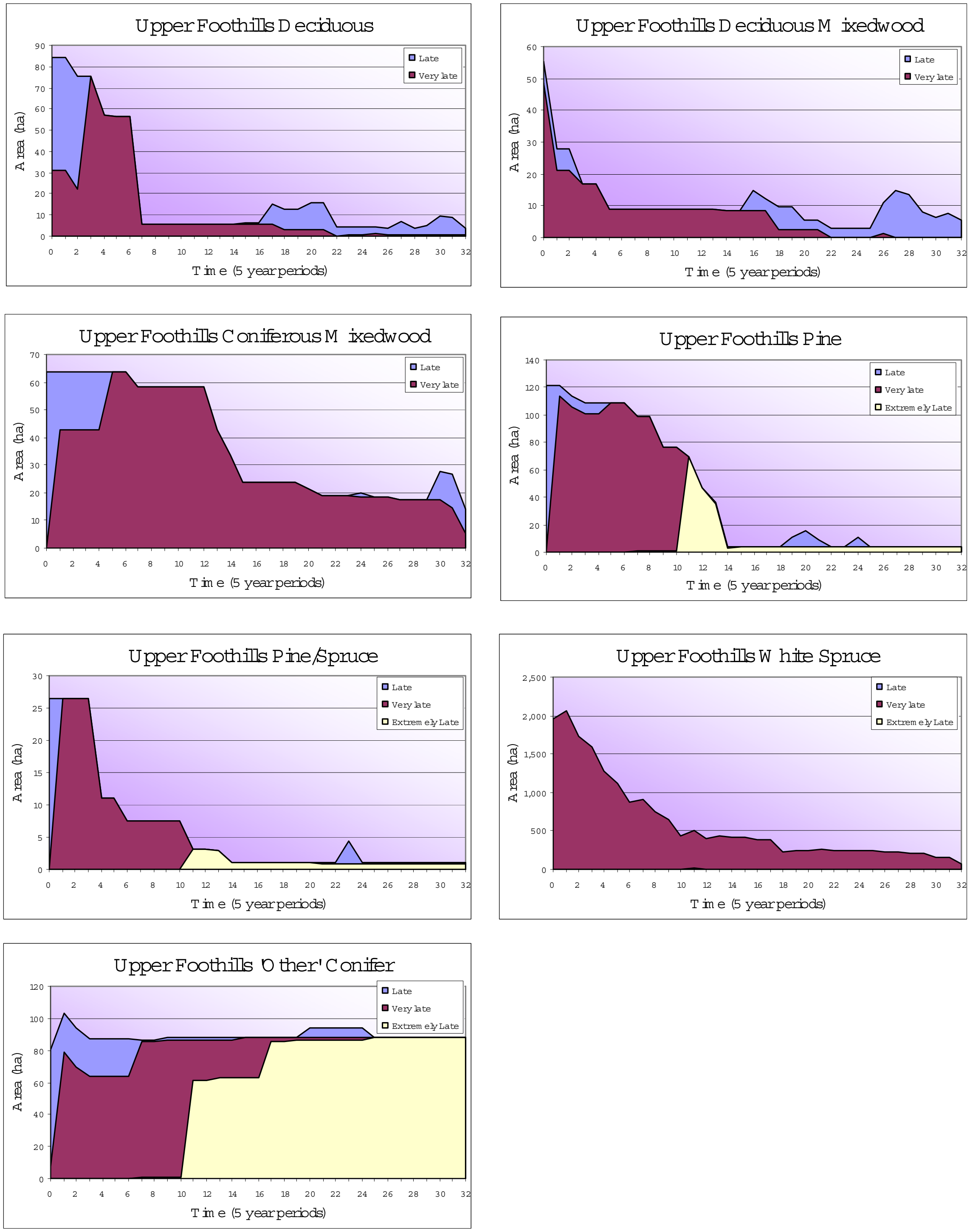


Figure 1.23 FMU E1 Area of Seral Stages within the Upper Foothills Natural Subregion

Table 1.26 FMU E2 Area of Older Seral Stages in the Lower Foothills Natural Subregion

E2 Lower Foothills	Target Minimum Area		Time from Start Date (years)				
Seral Stage	(%)	(ha)	0	10	50	100	160
Late Decid	5.0	1,594	20,752	19,682	7,930	3,298	1,594
Very Late Decid	1.0	319	6,607	7,737	4,889	2,446	362
Late DC	5.0	387	6,163	6,278	2,342	1,189	387
Very Late DC	1.0	77	2,334	2,806	1,961	773	124
Late CD	5.0	460	2,961	2,560	2,803	2,527	2,068
Very Late CD	1.0	92	538	1,117	1,799	1,039	1,147
Late PL	5.0	291	2,488	2,172	1,870	922	847
Very Late PL	1.0	58	12	700	1,269	847	847
Late PS	5.0	117	1,644	1,425	614	396	374
Very Late PS	1.0	23	419	570	570	378	374
Late SW	10.0	231	1,716	1,420	889	433	362
Very Late SW	2.0	46	1,057	976	788	401	362
Late 'other' Con	5.0	1,583	16,484	18,462	29,216	28,790	24,457
Very Late 'other' Con	1.0	317	7,188	10,507	24,289	28,531	24,457

* PL = Pine, PS = Pine/White Spruce, SW = White Spruce

Table 1.27 FMU E2 Area of Older Seral Stages in the Upper Foothills Natural Subregion

E2 Upper Foothills	Target Minimum Area		Time from Start Date (years)				
Seral Stage	(%)	(ha)	0	10	50	100	160
Late Decid	5.0	124	1,867	1,927	879	484	459
Very Late Decid	2.0	50	483	1,159	690	236	151
Late DC	5.0	103	1,574	1,599	1,138	485	572
Very Late DC	2.0	41	578	920	916	317	254
Late CD	5.0	98	1,243	981	1,336	193	98
Very Late CD	2.0	39	234	510	1,036	166	92
Late PL	2.0	76	1,247	1,024	2,503	204	146
Very Late PL	1.0	38	359	602	396	160	146
Extremely Late PL	0.5	19	0	0	132	60	146
Late PS	10.0	62	458	356	222	62	62
Very Late PS	5.0	31	216	269	169	27	18
Extremely Late PS	2.5	16	0	0	119	23	18
Late SW	10.0	74	382	331	182	74	74
Very Late SW	5.0	25	83	128	97	25	37
Extremely Late SW	2.5	12	0	0	35	21	22
Late 'other' Con	10.0	165	787	697	693	553	437
Very Late 'other' Con	5.0	83	226	315	474	525	437
Extremely Late 'other' Con	2.5	41	0	0	159	408	425

* PL = Pine, PS = Pine/White Spruce, SW = White Spruce

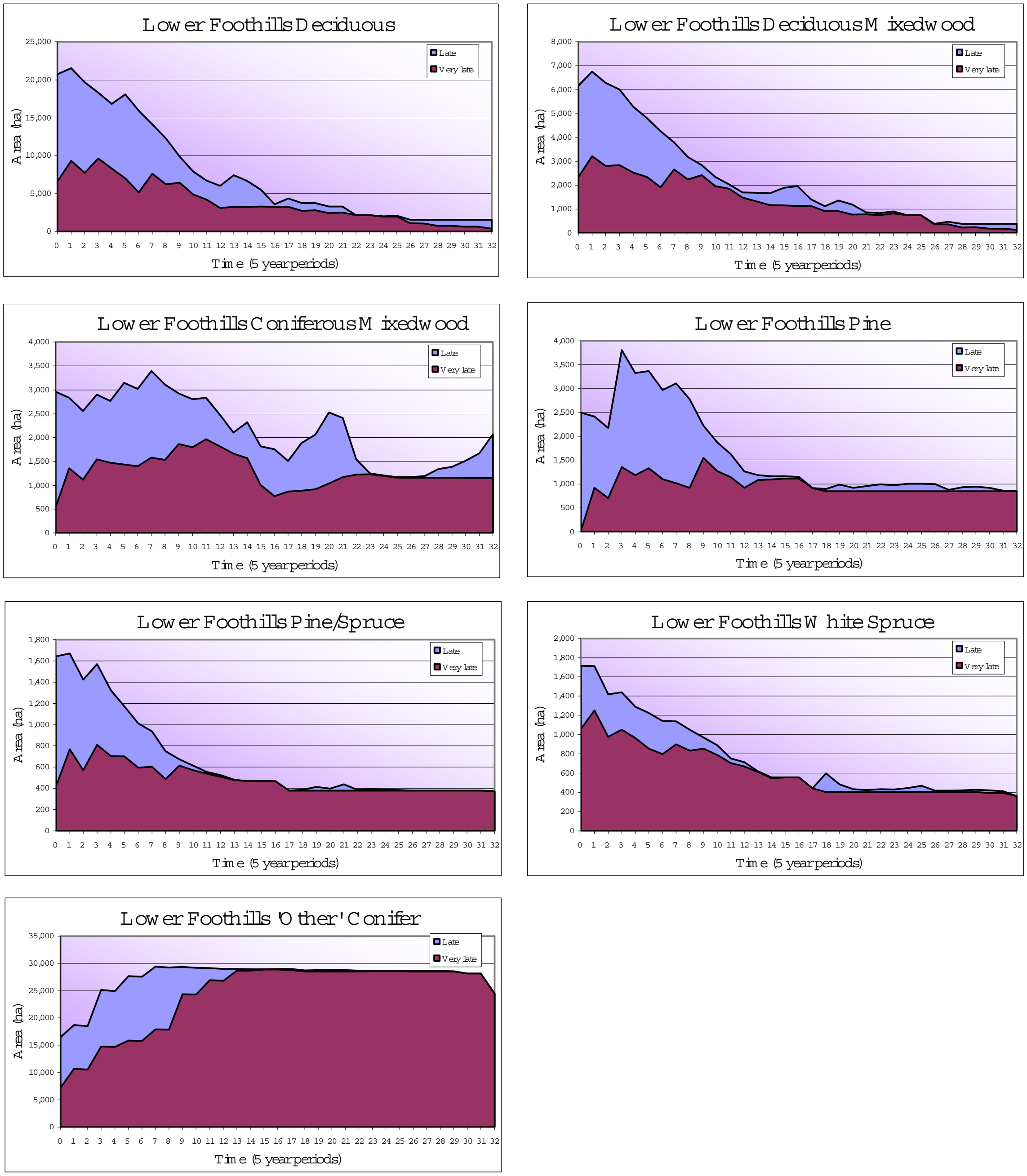


Figure 1.24 FMU E2 Area of Seral Stages within the Lower Foothills Natural Subregion

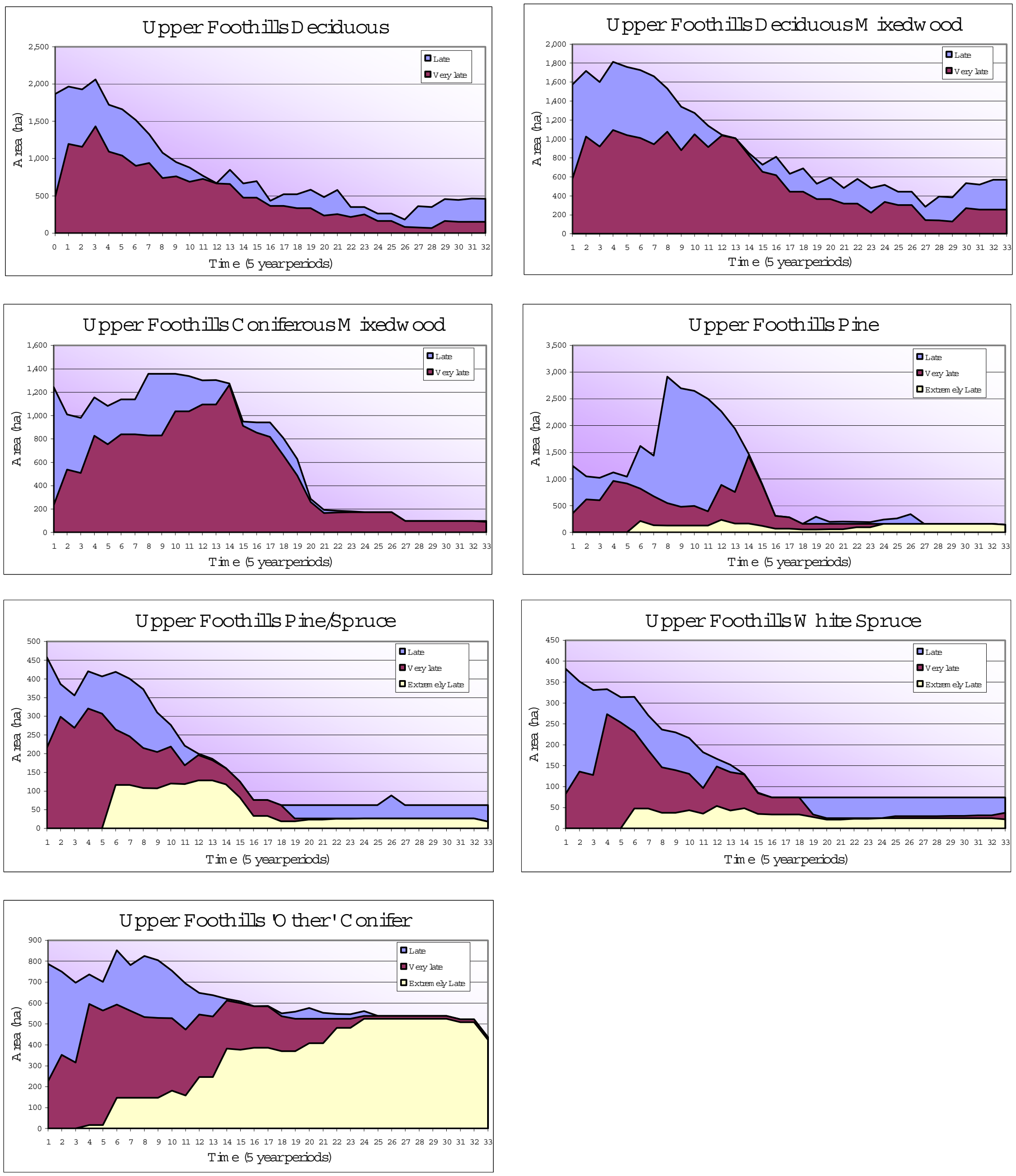


Figure 1.25 FMU E2 Area of Seral Stages within the Upper Foothills Natural Subregion

Table 1.28 FMU W5 Area of Older Seral Stages in the Lower Foothills Natural Subregion

W5 Lower Foothills	Target Minimum Area		Time from Start Date (years)				
Seral Stage	(%)	(ha)	0	10	50	100	160
Late Decid	5.0	922	8,114	9,081	4,745	3,048	922
Very Late Decid	1.0	184	1,064	1,213	1,995	1,573	186
Late DC	5.0	220	2,560	2,454	1,225	422	1,096
Very Late DC	1.0	44	273	398	574	301	54
Late CD	5.0	273	1,493	1,441	983	1,746	557
Very Late CD	1.0	55	317	772	447	565	547
Late PL	5.0	188	1,549	1,164	2,148	442	301
Very Late PL	1.0	38	456	509	708	302	301
Late PS	5.0	35	542	477	172	154	77
Very Late PS	1.0	7	184	287	108	77	77
Late SW	10.0	167	1,020	1,091	599	401	269
Very Late SW	2.0	33	161	503	462	272	269
Late 'other' Con	5.0	959	8,495	10,115	18,063	17,672	16,536
Very Late 'other' Con	1.0	192	2,003	4,470	11,939	17,452	16,535

* PL = Pine, PS = Pine/White Spruce, SW = White Spruce

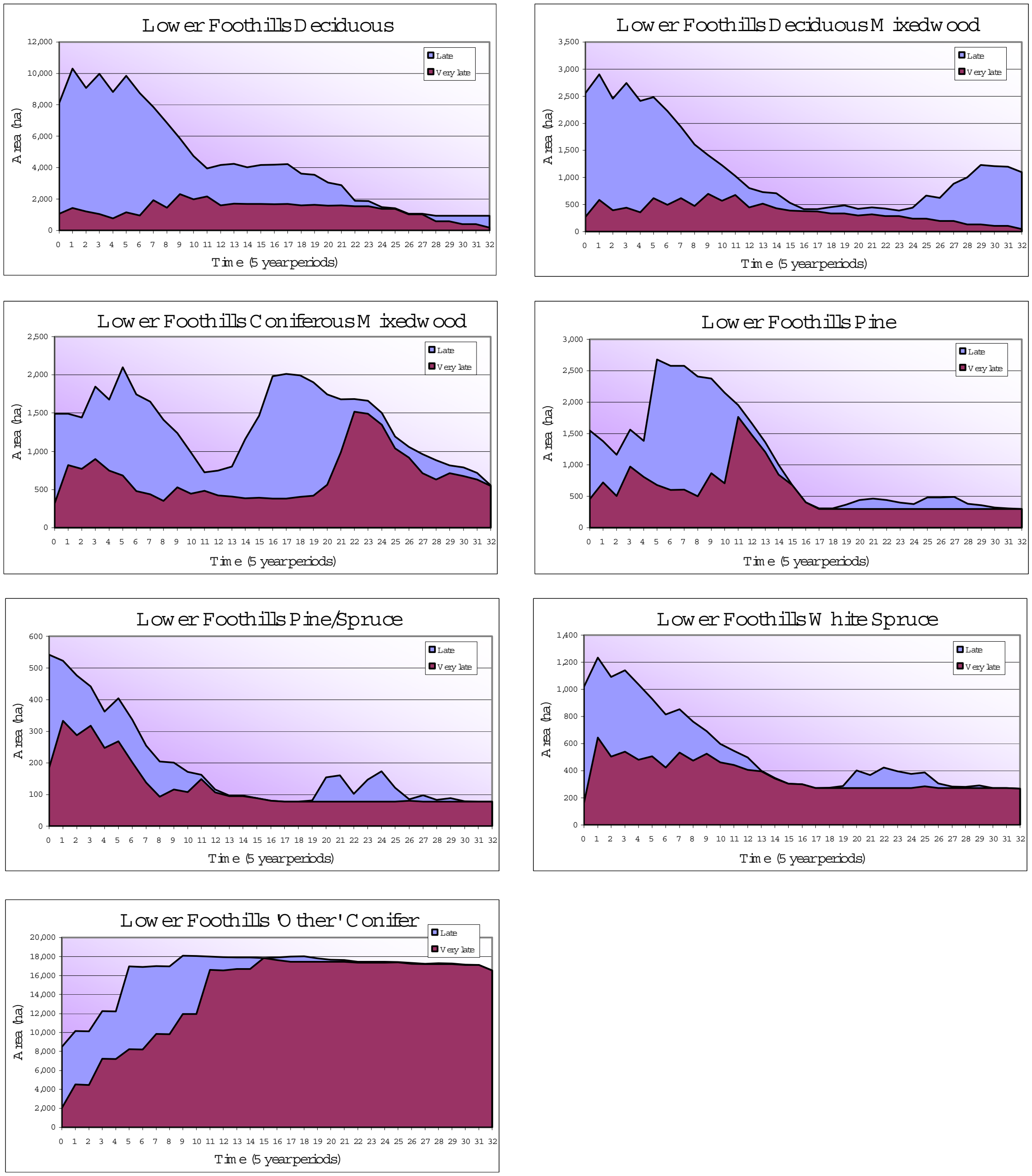


Figure 1.26 FMU W5 Area of Seral Stages within the Lower Foothills Natural Subregion

Table 1.29 FMU W6 Area of Older Seral Stages 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		21,362	24,097	8,770	6,475	2,007
Very Late Decid	1.0		6,617	4,652	4,879	2,927	465
Late DC	5.0		8,458	9,039	5,524	1,154	2,184
Very Late DC	1.0		3,073	2,893	4,154	958	139
Late CD	5.0		7,174	6,687	3,559	2,292	1,627
Very Late CD	1.0		2,968	4,596	1,808	1,272	1,627
Late PL	5.0		17,786	14,192	8,337	2,258	2,064
Very Late PL	1.0		1,682	10,822	4,342	2,024	2,064
Late PS	5.0		2,667	2,445	1,093	503	488
Very Late PS	1.0		1,073	1,447	718	496	488
Late SW	10.0		4,805	5,400	3,371	1,439	1,315
Very Late SW	2.0		2,246	2,573	2,291	1,345	1,315
Late 'other' Con	5.0		46,445	52,386	64,317	65,304	55,155
Very Late 'other' Con	1.0		17,728	35,032	60,202	61,883	55,155

* PL = Pine, PS = Pine/White Spruce, SW = White Spruce

Table 1.30 FMU W6 Area of Older Seral Stages in the Upper Foothills Natural Subregion

W6 Upper Foothills	Target Minimum Area		Time from Start Date (years)				
Seral Stage	(%)	(ha)	0	10	50	100	160
Late Decid	5.0	31	477	169	73	215	31
Very Late Decid	2.0	13	144	140	73	16	7
Late DC	5.0	17	258	239	152	29	17
Very Late DC	2.0	7	109	214	152	4	5
Late CD	5.0	49	224	209	184	57	56
Very Late CD	2.0	20	4	147	63	32	56
Late PL	2.0	87	4,266	3,294	694	303	303
Very Late PL	1.0	43	164	2,285	682	303	303
Extremely Late PL	0.5	22	0	0	11	302	303
Late PS	10.0	12	115	101	27	18	18
Very Late PS	5.0	6	37	76	27	18	18
Extremely Late PS	2.5	3	0	0	2	18	18
Late SW	10.0	31	165	149	86	60	60
Very Late SW	5.0	10	15	130	80	60	60
Extremely Late SW	2.5	5	0	0	2	60	60
Late 'other' Con	10.0	908	5,937	5,809	6,240	6,297	5,334
Very Late 'other' Con	5.0	454	2,486	4,382	6,159	6,215	5,334
Extremely Late 'other' Con	2.5	227	164	164	2,396	6,144	5,294

* PL = Pine, PS = Pine/White Spruce, SW = White Spruce

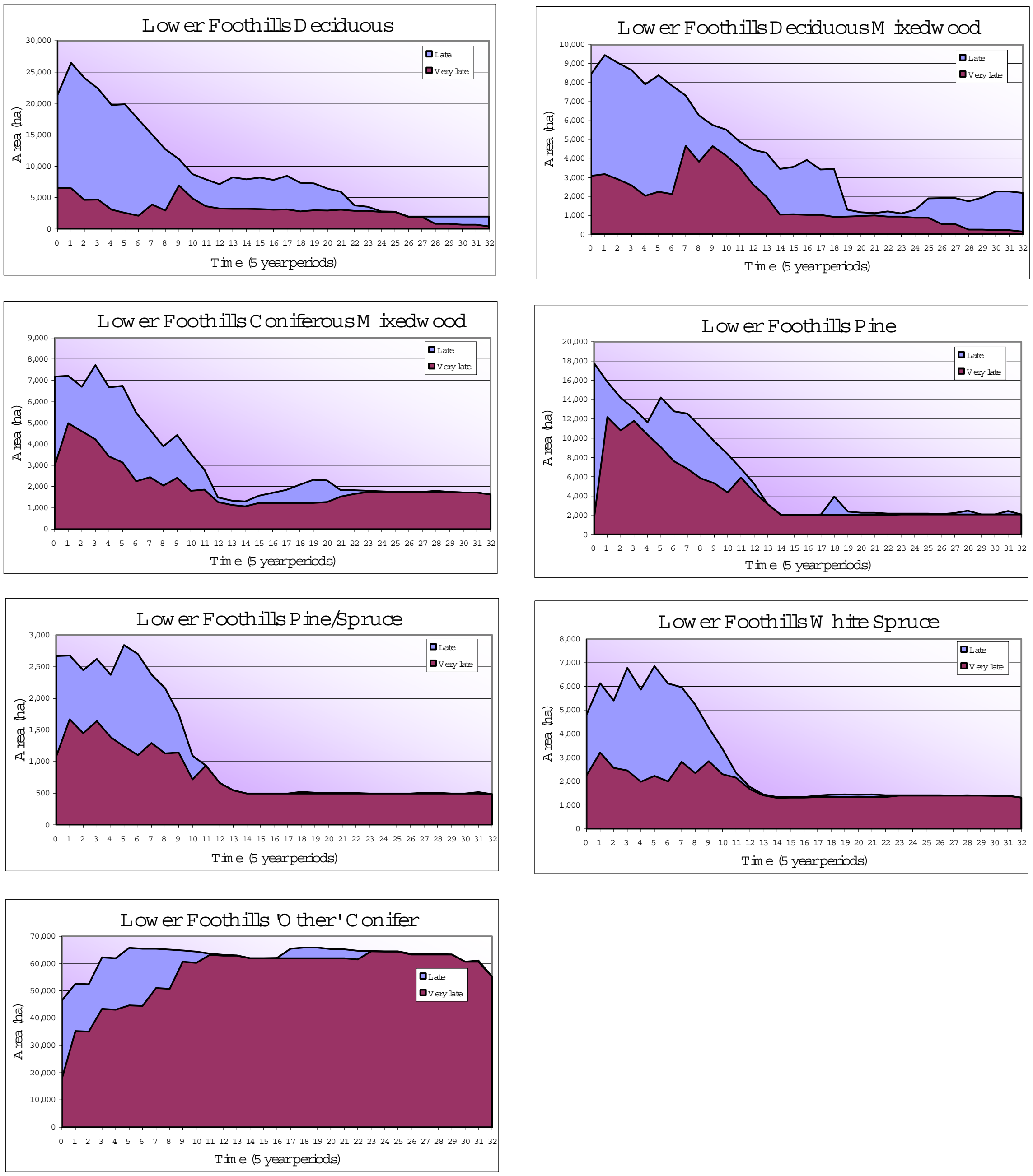


Figure 1.27 FMU W6 Area of Seral Stages within the Lower Foothills Natural Subregion

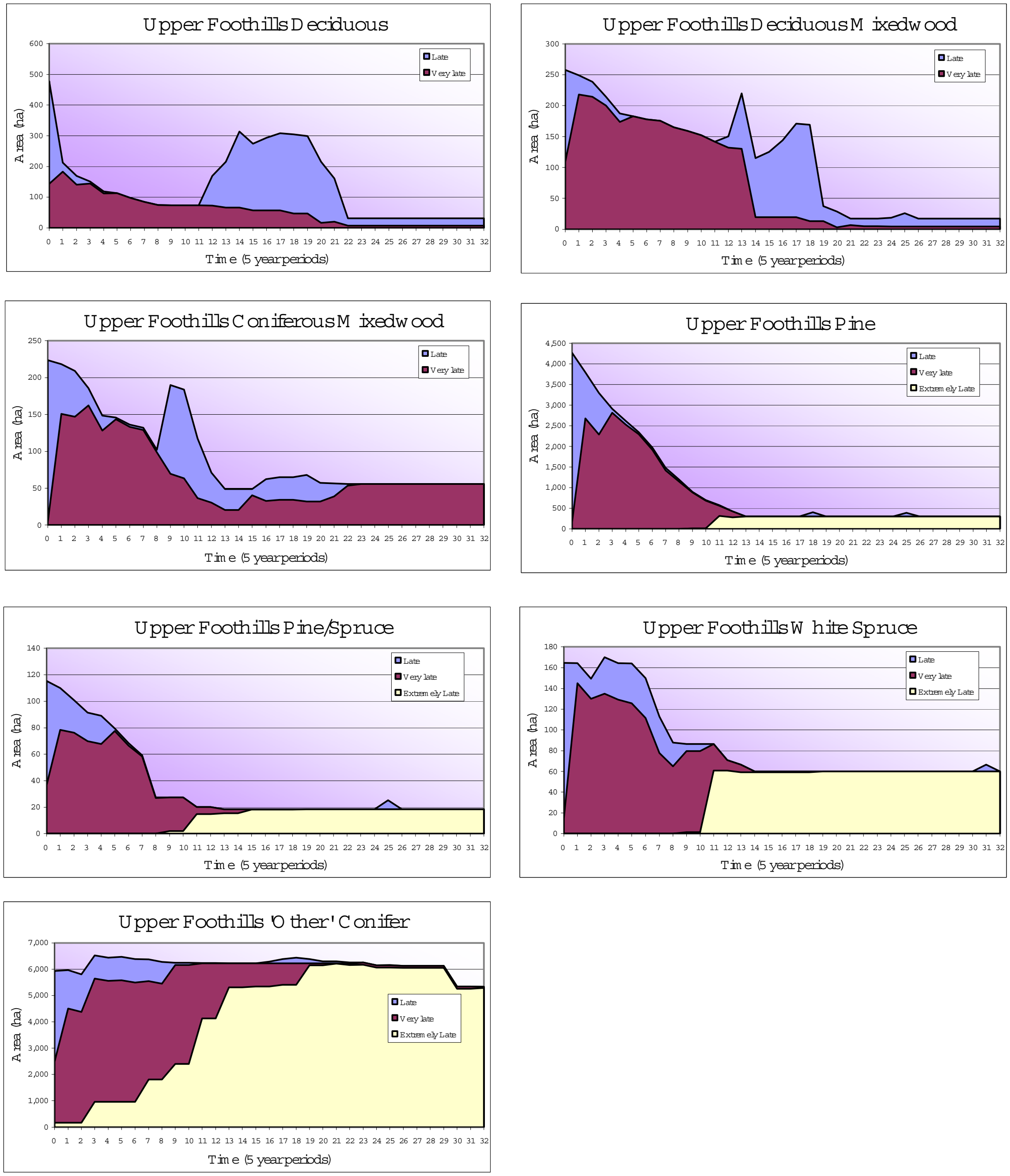


Figure 1.28 FMU W6 Area of Seral Stages within the Upper Foothills Natural Subregion

1.13.3.6 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 FMA varied. The average patch size, depending on FMU, planning period and seral stage, (Table 1.31) ranged from approximately 1.0 to 11.1 ha. The range of average patch sizes decreases over the spatial harvest planning horizon (i.e. the minimum increases and the maximum decreases). By period 10, patch size ranges from 1.0 to 4.1 ha. Similar tables showing individual BCGs are shown in Appendix 6.9 of Volume II.

Table 1.31 Patch Size Distribution

Time from now (yrs)	Seral Stage	Average Patch Area (ha)				
		FMU E1	FMU E2	FMU W5	FMU W6	All
0	Early	3.1	2.2	1.3	4.3	2.9
	Immature	1.3	1.0	1.1	1.1	1.1
	Mature	8.6	5.3	4.7	6.5	6.1
	Late	7.9	5.6	4.6	6.0	6.1
	Very Late	5.3	6.0	3.1	5.0	5.1
	Over Mature	11.1	4.7	9.7	6.8	6.8
	Total	6.1	4.3	3.5	5.0	4.8
	Avg of Stages	6.2	4.1	4.1	4.9	4.7
10	Early	1.6	1.7	1.5	2.4	2.0
	Immature	1.6	1.3	1.2	1.8	1.5
	Mature	8.7	5.3	4.7	6.2	6.0
	Late	6.3	4.7	3.9	4.4	4.8
	Very Late	3.6	4.7	1.7	3.6	3.6
	Over Mature	11.1	3.1	9.7	6.3	6.2
	Total	4.7	3.7	3.0	3.9	3.9
	Avg of Stages	5.5	3.5	3.8	4.1	4.0
50	Early	2.2	2.0	1.9	1.8	1.9
	Immature	2.6	2.2	2.2	2.0	2.2
	Mature	1.8	1.9	1.8	2.3	2.1
	Late	3.6	2.0	2.0	2.7	2.5
	Very Late	1.9	1.2	1.0	1.4	1.4
	Over Mature	2.1	3.2	2.3	4.1	3.4
	Total	2.2	1.8	1.7	2.0	1.9
	Avg of Stages	2.4	2.1	1.9	2.4	2.2

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 (DC & CD BCGs combined) - 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 1.32 looks at the amount of IOF at 0, 10, and 50 years both ignoring and incorporating seismic lines as hard edges. Both the total area of IOF and the average IOF patch size increase over time where seismics are ignored. Supporting tables are shown in Appendix 6.9 of Volume II. Maps of the IOF are located in Appendix 6.12.

Table 1.32 Area of Interior Older Forest

		Ignoring Seismics					Incorporating Seismics				
Time from now (yrs)	Cover Type	FMU E1	FMU E2	FMU W5	FMU W6	All	FMU E1	FMU E2	FMU W5	FMU W6	All
0	Decid		179.8		114.4	173.2		146.1			146.1
	MX		122.7			122.7					
	Pine	180	123.2		181.3	167.8					
	SB		127.8			127.8					
	SW										
	Total	180	553.4	0.0	295.7	591.5	0	146.1	0.0	0.0	146.1
	Average	180	138.4	0.0	147.9	147.9	0	146.1	0.0	0.0	146.1
10	Decid		162.8			162.8		146.1			146.1
	MX		126.1			126.1					
	Pine	180			128.6	147.7					
	SB		127.8		281.1	250.4					
	SW										
	Total	180	416.7	0.0	409.7	687.1	0	146.1	0.0	0.0	146.1
	Average	180	138.9	0.0	204.8	171.8	0	146.1	0.0	0.0	146.1
50	Decid		139.8			150.7					
	MX		257.1			257.1					
	Pine	113	200.9			162.4					
	SB	165	139.3	189.9	219.2	184.8					
	SW										
	Total	279	737.1	189.9	219.2	755.1	0	0.0	0.0	0.0	0.0
	Average	139	184.3	189.9	219.2	188.8	0	0.0	0.0	0.0	0.0

1.13.3.7 Area Harvested

The area harvested over time is fairly consistent, with FMU W6 exhibiting the greatest variability. The area of deciduous harvested ranges from 962 ha (FMU E1, period 11) up to 4,145 ha (FMU W6, period 1). The area of conifer harvested ranges from 778 ha (FMU W5, period 11) up to 7,635 ha (FMU W6, period 31) (Figure 1.29).

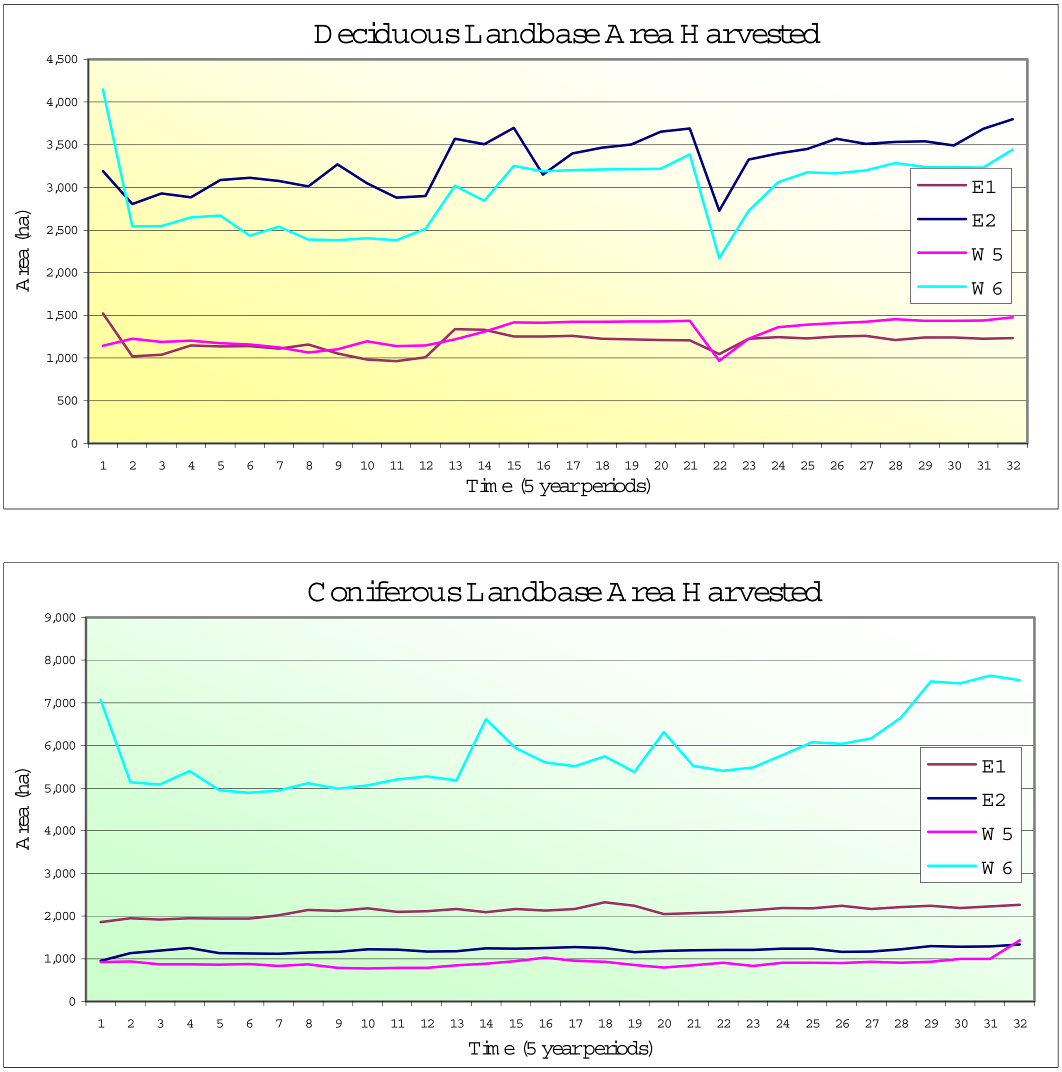


Figure 1.29 Projected Harvest Area (ha)

1.13.3.8 Age Class Distribution

The initial age class structure of the net harvestable land base is skewed towards the late seral stages. There is a large concentration of merchantable timber between 65 and 115 years of age and a relative shortage of younger (> 65 years) stands (Figure 1.30). This large spike (age 115) 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 1.31 thru Figure 1.34 for snapshots of the age class distribution over time.

The initial age class distribution for all forested stands is presented in Figure 1.35. The pattern looks almost exactly the same as the net land base but has much more area. The pattern of development over time (Figure 1.36 thru Figure 1.39) 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.

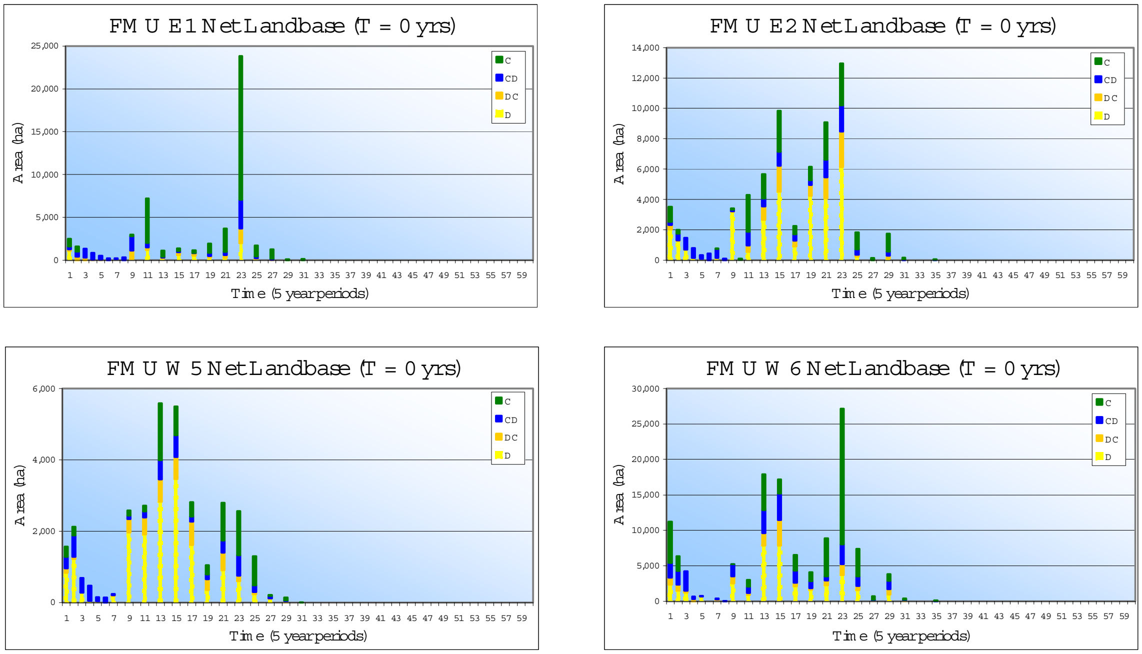


Figure 1.30 Age Class Distribution of the Net Harvestable Land Base at T = 0 years

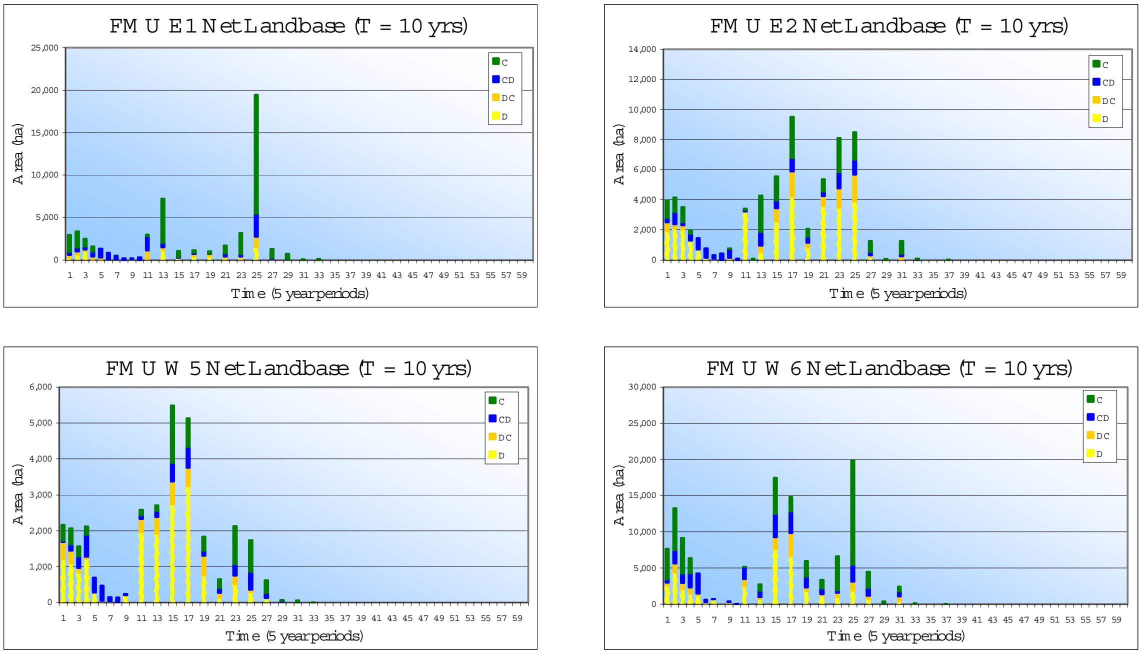


Figure 1.31 Age Class Distribution of the Net Harvestable Land Base at T = 10 years

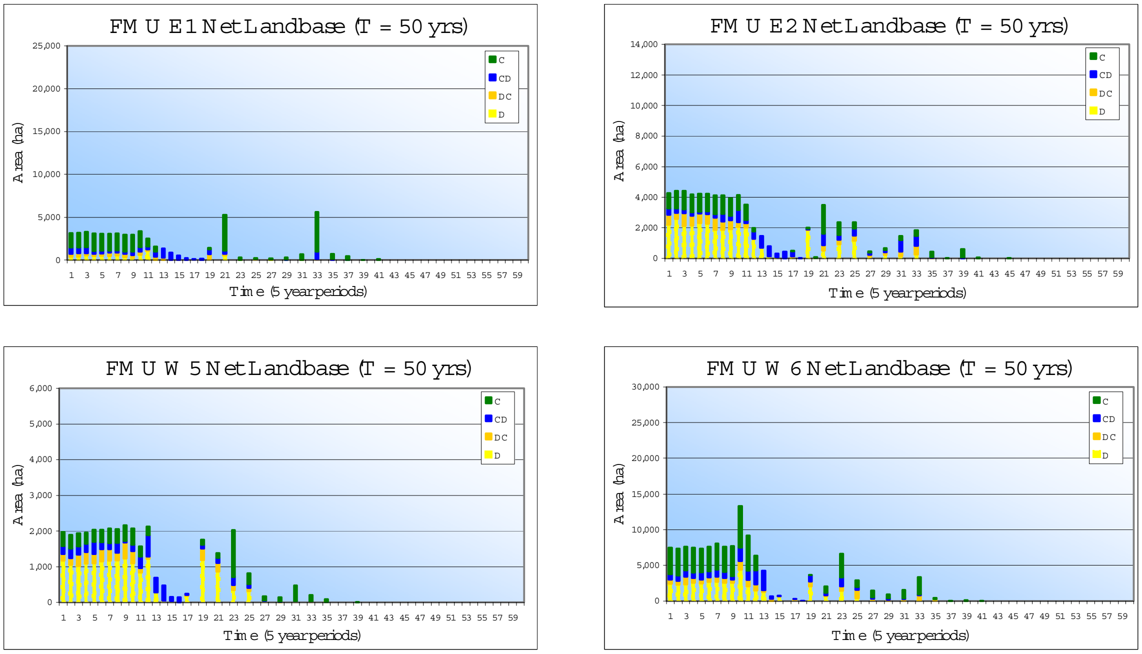


Figure 1.32 Age Class Distribution of the Net Harvestable Land Base at T = 50 years

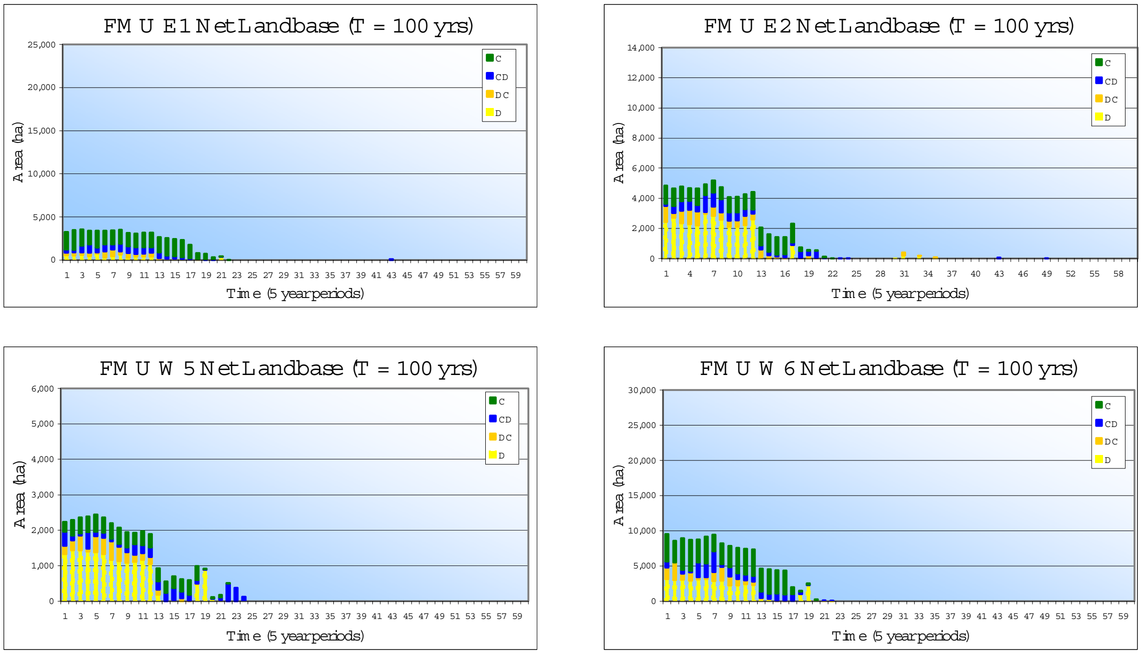


Figure 1.33 Age Class Distribution of the Net Harvestable Land Base at T = 100 years

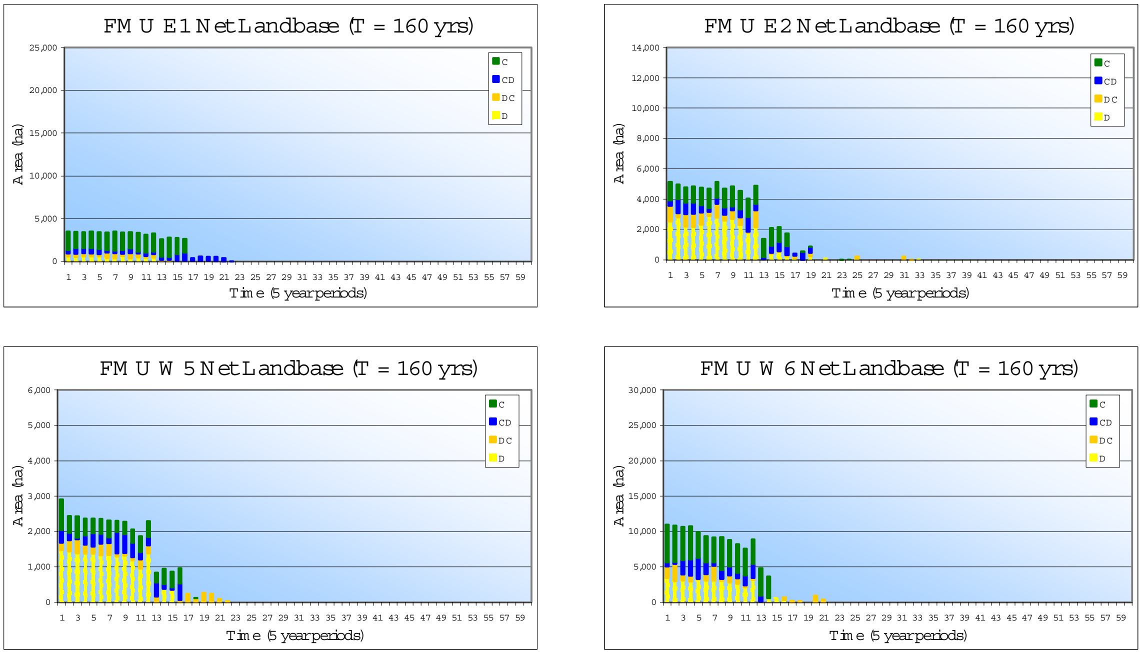


Figure 1.34 Age Class Distribution of the Net Harvestable Land Base at T = 160 years

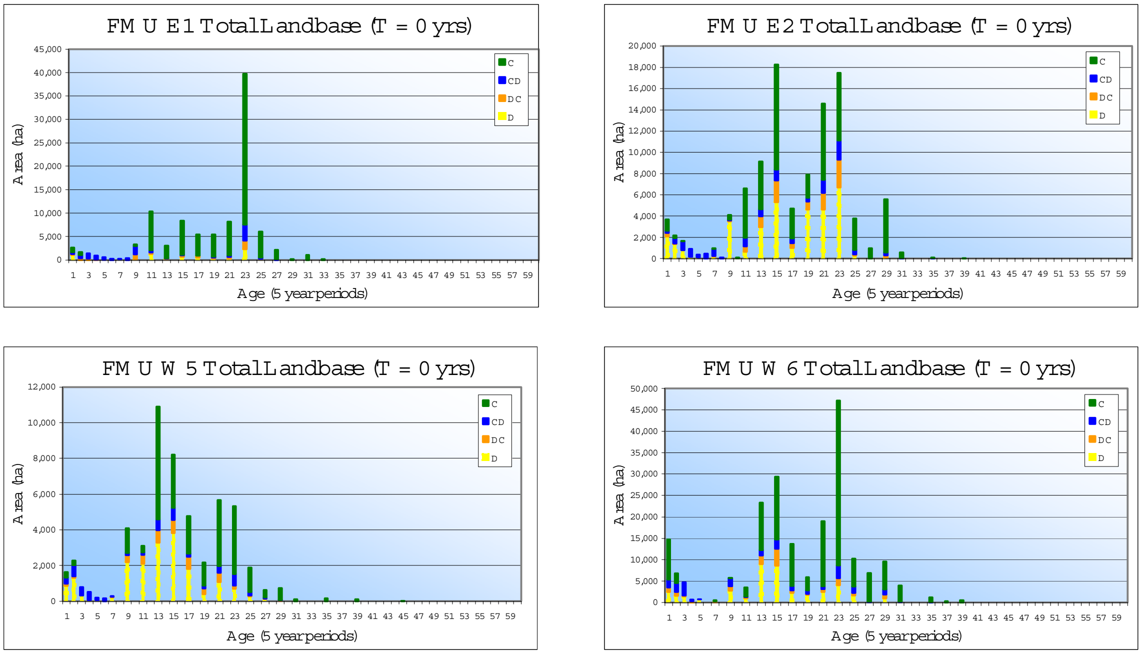
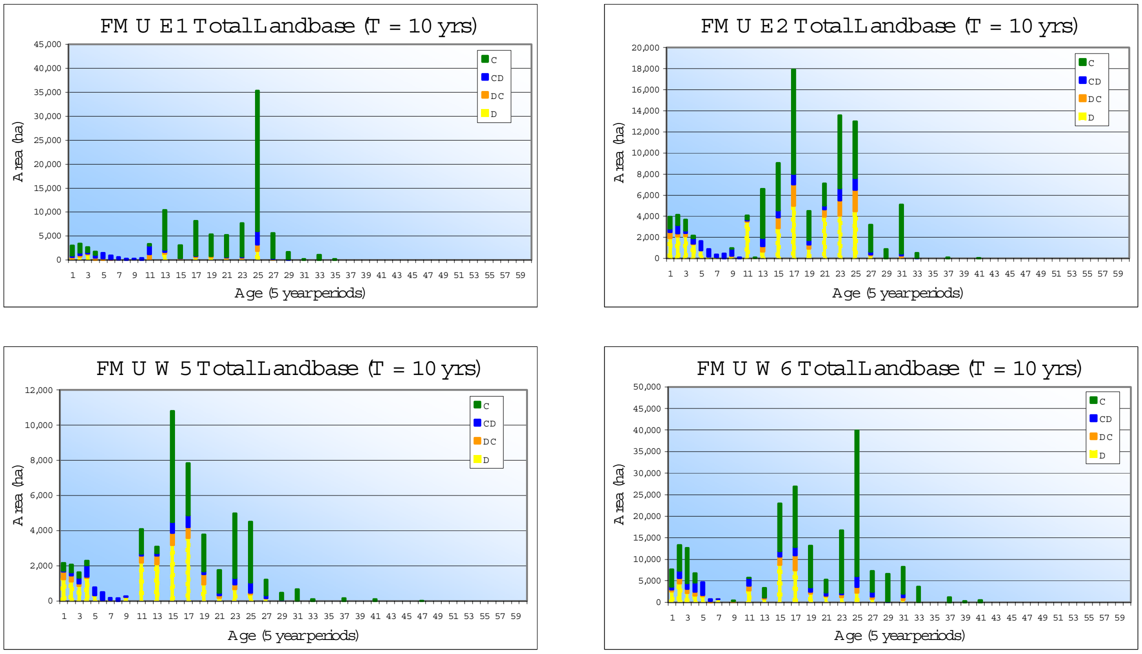


Figure 1.35 Age Class Distribution of the Gross Land Base at T = 0 years



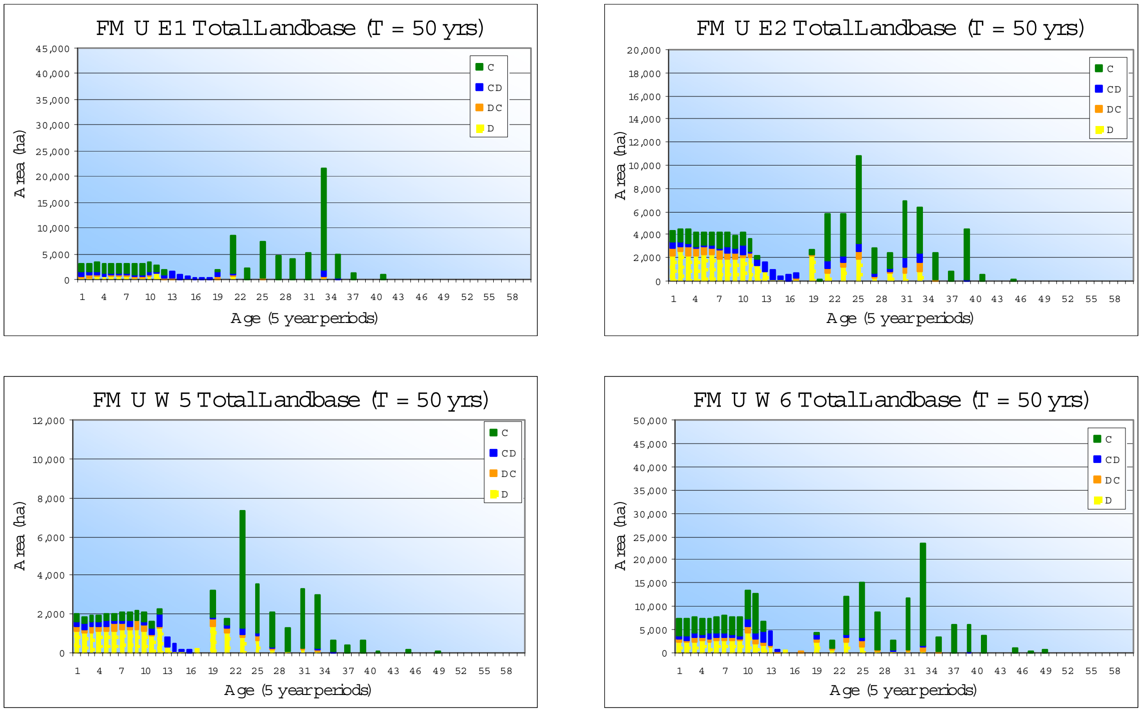
FMU E1 Total Landbase (T = 10 yrs)

FMU E2 Total Landbase (T = 10 yrs)

FMU W5 Total Landbase (T = 10 yrs)

FMU W6 Total Landbase (T = 10 yrs)

Figure 1.36 Age Class Distribution of the Gross Land Base at T = 10 years



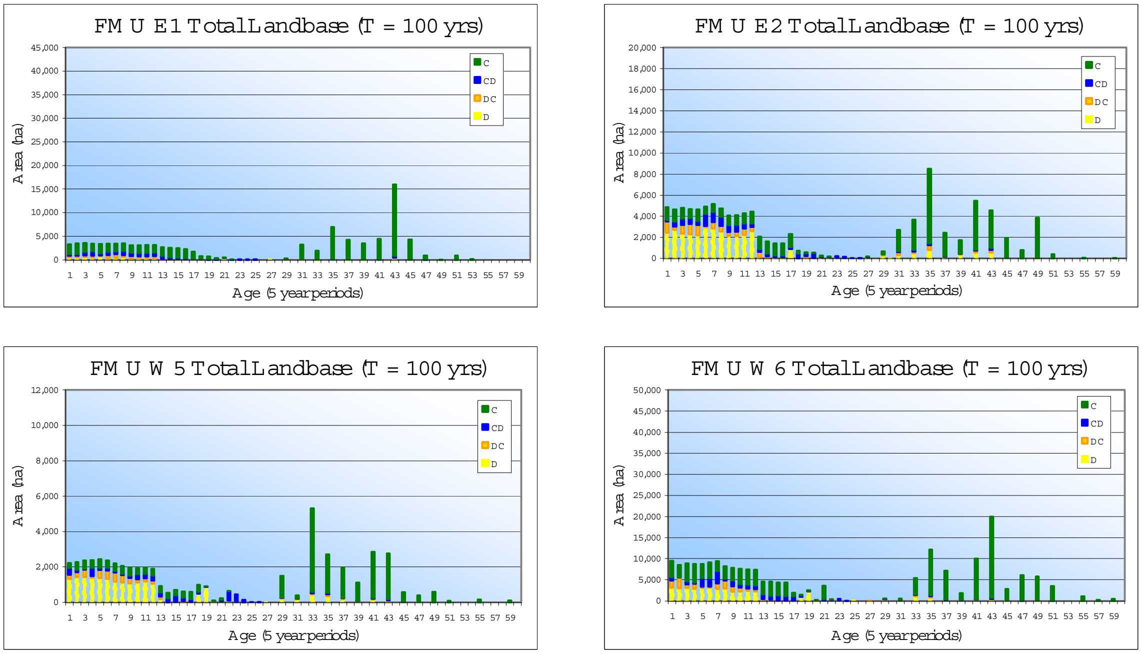
FMU E1 Total Landbase (T = 50 yrs)

FMU E2 Total Landbase (T = 50 yrs)

FMU W5 Total Landbase (T = 50 yrs)

FMU W6 Total Landbase (T = 50 yrs)

Figure 1.37 Age Class Distribution of the Gross Land Base at T = 50 years



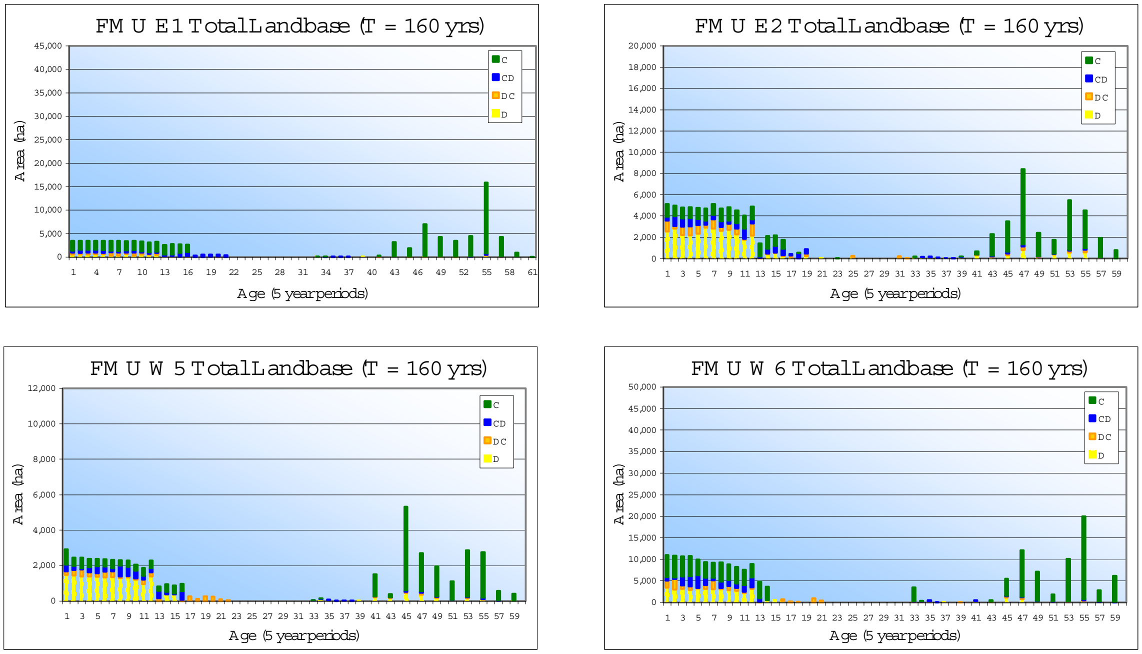
FMU E1 Total Landbase (T = 100 yrs)

FMU E2 Total Landbase (T = 100 yrs)

FMU W5 Total Landbase (T = 100 yrs)

FMU W6 Total Landbase (T = 100 yrs)

Figure 1.38 Age Class Distribution of the Gross Land Base at T = 100 years



FMU E1 Total Landbase (T = 160 yrs)

FMU E2 Total Landbase (T = 160 yrs)

FMU W5 Total Landbase (T = 160 yrs)

FMU W6 Total Landbase (T = 160 yrs)

Figure 1.39 Age Class Distribution of the Gross Land Base at T = 160 years

Data shown graphically in Figure 1.14 through Figure 1.39 are shown in tabular form in Appendix 6.9 of Volume II. Maps of the spatial harvest sequence can be found in Appendix 6.6. A statement and subsequent tables from Weyerhaeuser with respect to quota production chargeability can be found in Appendix 6.8. A patch size database for periods 0, 2, and 10 can be found on the accompanying DVD.

Table 1.33 through Table 1.36 shows the area harvested by both Forest Management Unit, Land Management Unit and Harvest Design Area (H.D.A.) for the duration of the SHS. The LMU will be the base unit to gauge the 20% allowable variance of sequenced harvest area.

Table 1.33 FMU E1 SHS Harvest Area by LMU and H.D.A.

E1	Harvest Design Areas Volumes (m3)							
Moose Creek LMU	Period 1		Period 2		Period 3		Period 4	
H.D.A.	Con	Dec	Con	Dec	Con	Dec	Con	Dec
Broken Cabin	25	10	0	0	110,896	43,740	46,328	4,358
Coyote Creek	84	4	15	0	97	0	110	2
Erith	10,793	37,801	146,971	37,853	44,873	21,025	0	18,810
Fickle Lake	22,079	53,447	0	0	18,670	21,128	13,256	26,606
Rodney Creek	26,381	21,212	208,593	100,312	105,766	38,371	179,446	71,071
Sang Lake	267,869	87,621	0	0	0	0	0	0
Svedberg	35,376	6,256	14,661	1,048	88,841	15,028	129,624	18,423

Table 1.34 FMU E2 SHS Harvest Area by LMU and H.D.A.

E2	Harvest Design Areas Volumes (m3)							
Edson LMU	Period 1		Period 2		Period 3		Period 4	
H.D.A.	Con	Dec	Con	Dec	Con	Dec	Con	Dec
Cricks Creek	9,609	245,701	26,542	111,597	12,574	101,072	9,336	24,732
Deer Hill	47,662	121,254	33,521	95	14,884	56,207	25,593	41,046
Grande Prairie Trail	4,423	201	14,868	22,376	4,070	3,336	11,126	9,821
Grand Trunk	0	0	0	0	2	6	0	0
Medicine Lodge	4,703	4,210	14,982	18,526	34,943	47,205	45,767	8,556
Obed Lake	0	308	10,753	0	14,522	1,791	22,078	16,451
Oldman Creek	90,102	9,063	38,248	28,946	24,714	317	15,931	1,780
Pioneer	0	0	7,010	45,502	3,345	13,422	0	0
Shining Bank East	5,273	109,545	302	0	2,117	0	5,425	102,514
Sundance Creek	224	0	0	10,491	52,786	105,354	30,554	146,308
Surprise Lake	0	0	0	0	1,772	0	3,424	4,055
Swanson	0	0	0	0	15,281	3,196	13,891	72,339
Tom Hill	27,901	17,815	36,192	136,169	24,662	84,934	25,482	33,313
Trout Creek	5,101	17,072	32,262	97,928	11,145	52,736	9,554	6,656

Table 1.35 FMU W5 SHS Harvest Area by LMU and H.D.A.

W5	Harvest Design Areas Volumes (m3)							
Beaver Meadows LMU	Period 1		Period 2		Period 3		Period 4	
H.D.A.	Con	Dec	Con	Dec	Con	Dec	Con	Dec
East Bank	1,764	0	1,935	0	38,970	4,199	34,665	16,399
Easyford	31,284	122,883	9,918	0	11,815	31,099	17,370	46,166
Hattonford	11,526	0	19,557	128,492	21,386	60,148	12,947	17,471
Keyhole	1,049	13,840	1,526	0	4,101	2,291	3,434	9,261
Lobstick	15,145	22,936	18,264	25,677	9,111	11,170	12,959	22,450
Lodgepole	7,644	43,467	2,331	0	7,270	20,719	1,546	14,777
Lost Elk Ridge	10,332	7,795	3,469	0	4,572	63,414	11,860	52,510
Mackay Lake	5,073	0	15,212	64,139	2,977	2,021	2,984	9,116
McLeod	45,729	0	50,127	0	22,127	23,197	21,647	30,386

Table 1.36 FMU W6 SHS Harvest Area by LMU and HDA.

FMU W6	Harvest Design Areas Volumes (m3)							
	Period 1		Period 2		Period 3		Period 4	
LMU/HDA.	Con	Dec	Con	Dec	Con	Dec	Con	Dec
Carrot Creek								
Nine Mile	39,230	101,266	144,404	0	37,379	2,047	29,358	5,587
North Rat Creek	55,646	0	17,137	164,138	0	2,611	17,315	3,440
Tower	17,307	6,492	4,438	0	3,101	10,854	33,945	14,430
Cynthia								
Bigoray	27,945	50,948	27,559	10,808	18,545	19,597	16,642	15,103
Chip Lake	7,182	0	356	0	148,716	92,391	79,040	24,565
Eta Lak	215,603	145,935	1,738	0	68,620	151,883	85,263	98,857
Granada	121,003	121,578	0	0	0	0	0	374
No Jack South	11,308	0	125,015	89,489	7,128	25,937	5,751	23,756
Paddy Creek	3,291	40,522	61,768	104,164	2,743	2,666	151,808	155,953
Sinkhole Lake	40,177	42,100	0	0	36,058	26,936	50,876	30,064
Wolf Lake								
Big Rock	52,332	27,214	117,223	9,825	6,061	0	41,920	0
Coyote Creek	5,384	14,780	90,954	5,948	1,063	657	70,329	4,923
Minnow Lake (N&S)	0	0	0	0	232,638	88,207	91,663	29,871
North Pembina	140,764	71,335	69,558	980	205,595	6,119	71,641	10,429
South Rat Creek	11,546	54,618	166,695	79,597	95,514	34,176	77,839	40,931
Zeta Lake	412,474	52,854	69,619	4,130	34,233	150	73,836	11,059

1.14 Conclusion

This timber supply analysis has focused on defining expected harvest levels that can reasonably 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 important to make forest management decisions today that will not unduly affect choices and opportunities of future generations.

1.15 References

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

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