P14 2009-2018
Forest Management Plan

Chapter 4:
Forecasting and the PFMS

December 15, 2009

EXECUTIVE SUMMARY

The 2009-2018 Forest Management Plan (FMP) updates FMU P14's Annual Allowable Cut (AAC), allocates the AAC to the quota holders and directs the location of harvesting through a Spatial Harvest Sequence (SHS). This is the FMU's first FMP and from a timber supply perspective, includes landbase classification, yield curve development, and a timber supply analysis. The timber supply analysis is based on sustainable forest management principles as it examines the tradeoffs between the timber supply and other forest values.

The Preferred Forest Management Scenario (PFMS) represents the management strategies selected by the Plan Development Team (PDT) and is one of the primary products of the timber supply analysis. The PFMS contains numerous assumptions and inputs, which are described in this chapter. These assumptions and inputs cover a wide range of topics including minimum harvest ages, succession rules, access schedules, and seral stages. The PFMS is the result of balancing the indicators to achieve a biologically, socially, and economically viable harvest sequence.

P14 is managed as divided coniferous and deciduous landbases and is comprised of almost equal portions of deciduous and coniferous landbase area. As a result, the primary harvest levels are similar for each landbase. However, to meet existing Deciduous Timber Allocation (DTA) and Miscellaneous Timber Use (MTU) commitments on the deciduous landbase, the PFMS invokes a deciduous harvest level dropdown after the first 20 years. The harvest levels achieved in the PFMS are presented in Table 1 and the utilization standards in Table 2.

Table 1. Harvest volume from the PFMS.

	Harvest Level (m^3/yr)			
	Primary		Incidental	
Time Period	Coniferous	Deciduous	Coniferous	Deciduous
2009 - 2028	51,500	53,169	22,691	45,158
2028 - 2208	50,979	50,000	18,943	27,054

* Structural Retention is not removed from these volumes

Table 2. Utilization standards used in PFMS.

Utilization Criterion	Conifer Species	Deciduous Species
Stump height	30 cm	30 cm
Minimum log length	2.66 m	2.66 m
Minimum stump diameter outside bark	15 cm	15 cm
Minimum top diameter inside bark	11 cm	10 cm

Table 3 shows the associated timber allocations to the FMU P14 quota holders. These harvest volumes have not been reduced for structural retention, so the realized harvest volume will be 2% less than that shown below.

Table 3. Potential Timber Allocations for FMU P14.

		20 Year Harvest Level (m^3/yr)			
		Primary		Incidental	
Operator	Disposition	Coniferous	Deciduous	Coniferous	Deciduous
Boucher Bros.	CTQP140001	51,500	-	21,812	-
CBVAC	DTAP140001	-	50,470	-	40,145
CTPP		-	2,699	-	-
Total		51,500	53,169	21,812	40,145

* Structural Retention is not removed from these volumes

** Incidental volumes are based the average of the first 10 years

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1. Overview

The Plan Development Team (PDT) created the Preferred Forest Management Scenario (PFMS) with the support of computer based forecasting. Forecasting describes the management actions to be undertaken in detail for the next 20 years and with a lower level of detail for the following 180 years. Forecasting also predicts, under the proposed management actions, what the condition of the forest will be over the same 200-year planning horizon. Computer based modeling is part of the adaptive forest management process that is required for sustainable forest management and was undertaken to ensure that the proposed forest management actions did not compromise forest sustainability.

This chapter describes the forecasting process undertaken for the development of the 2009-2018 Forest Management Plan (FMP). It details the forecasting assumptions, methods and results, the knowledge gained, and the application of the results to the development of the FMP.

The Canadian Standards Association defines a forecast as: "an explicit statement of the expected future condition of an indicator". Forecasting in the context of the 2009-2018 FMP, is the process that creates the predicted future condition of FMP indicators. Indicators describe the condition of the forest, the products derived from the forest and the values present in the forest. Examples of indicators are patches of old growth forest and the amount of timber harvested. These example indicators are non-complementary in that increasing levels of old growth will decrease the amount of timber that can be harvested. This highlights the essence of forecasting within the forest management planning context; it is necessary to make tradeoffs between the desired amounts of each indictor in order to achieve a preferred scenario. Usually it is not possible to obtain everything that is desired and often undesirable outcomes are predicted for some of the indicators no matter what actions are proposed. Forecasting is a complex process and was used by the forest managers and the PDT to predict the outcomes of specific forest management activities and to assist the managers in deciding what activities and what level of activities should be proposed in a PFMS that best meet forest management objectives.

2. Forecasting Methods

2.1 Overview

Forecasting is a complex process requiring numerous inputs and assumptions. This section describes the 2009-2018 FMP forecasting process including a description of the modeling tools, inputs, assumptions, outcomes, and tradeoffs required to develop the Preferred Forest Management Scenario (PFMS).

2.2 Objective

The objective of the forecasting process is to create a reasonable forecast of the forest attributes and products using timber harvesting as the main agent of change, which will lead to the creation of a PFMS that best achieves forest management objectives.

2.3 Process

Developing a forecast involves combining data, in the form of spatial landbases and yield curves, with management assumptions into a coherent spatial model that is capable of both fine and coarse scale analysis. Following a structured progressive approach, scenarios were developed to explore the impacts of the options available, guided by the existing operability limitations and the 2006 Alberta Forest Management Planning Standard, Version 4.1 (Planning Standard) specifications to balance the social, economic and ecological forest management objectives.

The development of landbases and yield curves, the refinement of indicators and goals, and the process of evaluating scenario output to derive new scenarios are all iterative processes and are interdependent. Figure 1 outlines the process involved in developing the PFMS. Any one of the three cycles shown can be repeated as many times as necessary to ensure the best possible solution is achieved.

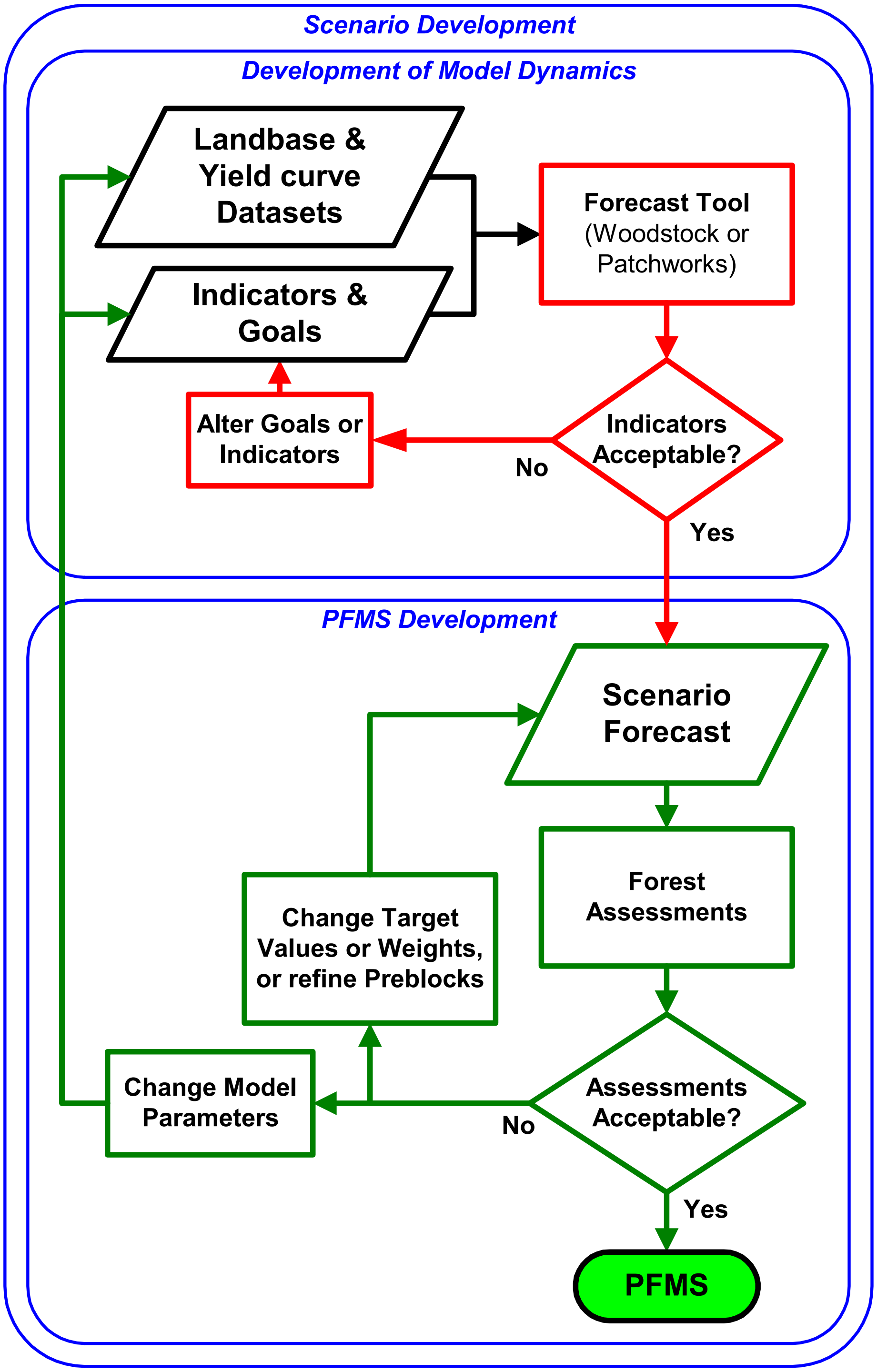


Figure 1. Forecasting planning process.

2.3.1 Development of the Model Dynamics

The forecasting process begins with the development of the model inputs; the landbase, yield curves, and initial indicators and goals. These inputs were then used to construct the model within the forecasting tools framework. Model results were analyzed to ensure the indicators correctly represent the metrics to be evaluated and that the model dynamics are realistic. If any metric or assumptions was deemed to be inaccurate or insufficient, it was re-worked and the model was rebuilt.

2.3.2 Scenario Development

Scenarios were developed to test the implications of specific management strategies. Each scenario's impact on the forest was evaluated as well as the differences between scenarios. By altering the types, locations and levels of management actions in a scenario, or by altering the desired future forest condition, the Plan Development Team (PDT) was able to determine the long term forest dynamics, desirable activities and assess the forest management tradeoffs.

Scenarios were developed within a structured process. The PDT identified forest management issues that could be addressed through forecasting. Modellers created scenarios to address identified issues and results were summarized in issue documents for the PDT to review and action. Through this process, the primary trade-off decisions such as old growth level and timber yield assumptions were resolved.

2.3.3 PFMS Development

After the management issues were resolved, a series of scenarios were generated to work towards the PFMS. These scenarios were primarily focused on changes to the Spatial Harvest Sequence (SHS) to ensure operability and the proposed harvest blocks met the social and ecological objectives.

2.4 Limitations

There are limitations in any forecasting process. The primary limitations related to the development of the PFMS are the generalization of inputs and the inability to directly address stochastic events.

2.4.1 Landbase

The landbase is built with the best information available, but it is a snapshot of the current status of roads, towns, and oil and gas activity. Future changes to landuse or other industrial infrastructure development were not incorporated into the modeling.

2.4.2 Yield curves

Timber yield curves were created by statistically fitting functions through measured localized plot volumes. The resulting yield curves represent averages across the landscape. While this approach produces reasonable results for strategic planning, the variation between individual polygons of the same strata can be large. This is especially true of the incidental volume predictions. Large variations will be observed in recovered individual block level volumes compared to volumes predicted from the yield curves. However, over large areas the harvested volumes will be close the predicted volumes.

2.4.3 Stochastic events

Stochastic events such as fire or insect outbreaks are not explicitly modeled in this process. Stochastic events by their very nature are unpredictable and less predictable when spatial location is required as it is for the development of the SHS. For these reasons, stochastic events were excluded from the forecasting. The FMP process addresses stochastic events through replanning when unplanned events cumulatively impact more than 2.5% of the net landbase.

2.5 Modeling tools

Two forecasting modeling tools were used for this analysis: Woodstock for non-spatial analysis and Patchworks for spatial analysis. The Patchworks interface allows the conversion of Woodstock models into Patchworks format, permitting common datasets to be used between scenarios and to ensure continuity and meaningful comparison of results.

Woodstock was used for strategic analysis to test and compare non-spatial management assumptions. Patchworks was used to address spatial issues. Where possible, sensitivity analyses were completed using Woodstock because Woodstock optimization provides the maximum possible solution, so there is no difference attributable to a sub optimal solution and secondly, Woodstock is much faster compared with Patchworks.

The recommended harvest level, associated SHS and the treatment regime were derived from the PFMS created in a single Patchworks scenario.

2.5.1 Woodstock

Woodstock, version 2006.12, is a strategic forest estate-modeling tool developed and serviced by Remsoft (Remsoft, 2006). It was used for strategic analysis of timber supply and comparisons of alternative strategies and formulations. This strategic analysis provided insight for the resolution of specific issues including growing stock, minimum harvest age and harvest flow.

Woodstock is completely non-spatial; every unique type is rolled up into forest classes (TSA themes by age class). The model applies treatments to all or a portion of that unique forest class. Post-treatment transitions can be one-to-many relationships defined as percentages. The optimizer selects the optimal combination of treatments throughout the entire planning horizon to solve the objective function.

Woodstock can be formulated as either:

- Basic optimization, where there was one modeling objective with rigid constraints; or
- Goal programming, where the modeling objective was to minimize deviations from a goal.

Goal programming required the identification of a weighting, which is the penalty for deviating from the goal, to allow the model to rank the goals. Typically, a high weighting results in a small deviation from the goal.

For this analysis, basic optimization was the only Woodstock formulation used. The modeling objective was to maximize primary harvest volume subject to constraints such as even flow harvest volume and minimum ending growing stock.

A structured, progressive approach was used in the development and analysis of Woodstock scenarios. Increasing levels of constraints were applied in successive scenarios to meet forest management objectives and to answer specific management questions and issues. The end result of the Woodstock stage was scenarios that met all of the non-spatial key objectives.

In this analysis, Woodstock runs and reports in 5-year periods.

Linear Programming
Woodstock uses a mathematical technique called linear programming to quickly determine the optimum answer to the management assumptions. Linear programming is a commonly used mathematical tool for forest management because of its speed and accuracy in finding the 'optimal' solution with regards to a single objective and several constraints. Davis et al. (2001) describes linear programming as: "Problems that are linear with respect to the relationships between the decision variables can be solved by a technique called linear programming. By linear, we mean the operators are restricted to plus or minus."

The linear programming solver used in this analysis is Mosek version 4.0.

2.5.2 Patchworks

Patchworks, version 1.3, is a spatially-explicit forest estate modeling tool developed and serviced by Spatial Planning Systems. It is designed to provide the user with operational-scale decision-making capacity within a strategic analytical environment. Trade-off analysis of alternative operational decisions are quickly determined and visually displayed.

Patchworks operates at the polygon level. In Patchworks terminology, polygons are the smallest element, which in this case, are the subdivided Alberta Vegetation Inventory (AVI) stands in the modeling landbase. The treatments applied to each polygon are an all or nothing decision for the model. There is only one post-treatment transition for each polygon. When Patchworks operates, one or more polygons adjacent to each other that meet specific criteria can be combined to form "patches". The modeling landbase is comprised of small polygons to allow for more options in creating patches.

The tool is fully spatial through time and the impact on an adjacent polygon 200 years into the future is considered in the first year of the simulation. Patchworks decision space can be thought of as a matrix consisting of each polygon and each potential outcome for every time slice in the planning horizon.

Patchworks is a heuristic model that attempts to achieve close to an optimal solution for the defined goals or targets (similar to the goal-programming in Woodstock). Its modeling objective is to minimize deviation from the modeling targets. To distinguish them from other types of targets, the term "goal" will be used in this document to describe the targets set in both Patchworks and Woodstock models. Patchworks uses a stochastic solving technique called simulated annealing defined in more detail below. This permits larger problems, such as spatial relationships (i.e. patch size distributions), to be solved.

In this analysis, a variety of goals were included such as harvest levels, minimum growing stock levels, minimum seral stage areas, maximum block size and range of regeneration patch sizes by period.

Goals were represented by different features or products (e.g. cubic meters or hectares) and multiplied by weighting factors, which ranked the importance and contribution of each feature or product towards the modeling objective. The weighting does not represent the relative importance of each goal but rather represents the weighting required to achieve an acceptable solution.

Patchworks solves in annual periods, however, it was set up to model and report in 20 one-year periods followed by 36 five-year periods. The model covers the entire 200 year planning horizon, beginning in 2009 until 2208. Patchworks scenarios were developed from Woodstock, to ensure identical assumptions, including landbase, yield curves, treatments and responses.

Simulated Annealing

A description of simulated annealing from Davis et al. (2001) is;

> An algorithm that simulates the cooling of materials in a heat bath – a process known as annealing. Essentially, (the) algorithm simulates the change in energy of a metal during the cooling process, and models the rate of change until it converges to a steady "frozen" state. Searching the feasible regions of a planning problem with the objective of converging on an optimal solution (a steady state) is the goal of simulated annealing. The technique moves from one "good" solution to a neighbouring solution, generally by randomly changing a single piece of the solution, perhaps the harvest prescription for a management unit.

The textbook further describes the process in which a random starting point is chosen (feasible or infeasible) and then as new choices are made, the model decides if the new treatment selection is better than the current treatment selection. If the new selection is better, then it replaces and becomes the current solution. This process is repeated many times over until no new choices provide a better solution set than what is currently being used. Furthermore, Lockwood and Moore (1993) state that "a simulated annealing procedure mimics this slow cooling process by gradually rearranging the elements of a system from a disordered state to an ordered, or nearly optimal state."

The comparison to linear programming is difficult, but at least one study has examined the differences between the different modeling techniques. Boston and Bettinger (1999) compared simulated annealing with Monte Carlo Integer programming and with Tabu search heuristics, and then compared all three with linear programming solutions to four different problems. They stated that "Simulated annealing found the highest solution value for three of the four planning problems, and was less than 1% from the highest objective function value in the fourth problem."

3. Landbase Summary

To address specific modeling and reporting requirements, landbases in three formats were created, which contain essentially the same information but at different resolutions and some additional classification:

- Classified landbase – with the highest spatial resolution;
- TSA landbase – with a lower level of spatial resolution; and
- Modeling landbase – with special modeling attributes added to the TSA landbase.

All three landbases cover the same extent and contain the same description of the forest. For instance, the information contained in the greater spatial resolution of the classified landbase (*e.g.* seismic lines) is carried as attributes in the TSA and modeling landbases. Refer to Appendix III: Landbase Development for a full description of the process used to create the landbases.

3.1 Classified Landbase

The final classified landbase consisted of 49,429 polygons with a total area of 127,331 ha. The managed landbase at 87,827 ha was 69% of the classified landbase. Table 4 and Table 5 summarize the managed and unmanaged landbase by broad groupings and Map 1 shows the managed classified landbase species strata (*F_YC*). The tables can be duplicated by grouping the landbase on the *F_YC* or *F_DEL* field and summarizing on *F_AREAHA*.

Table 4. Managed classified landbase summary (by F_YC).

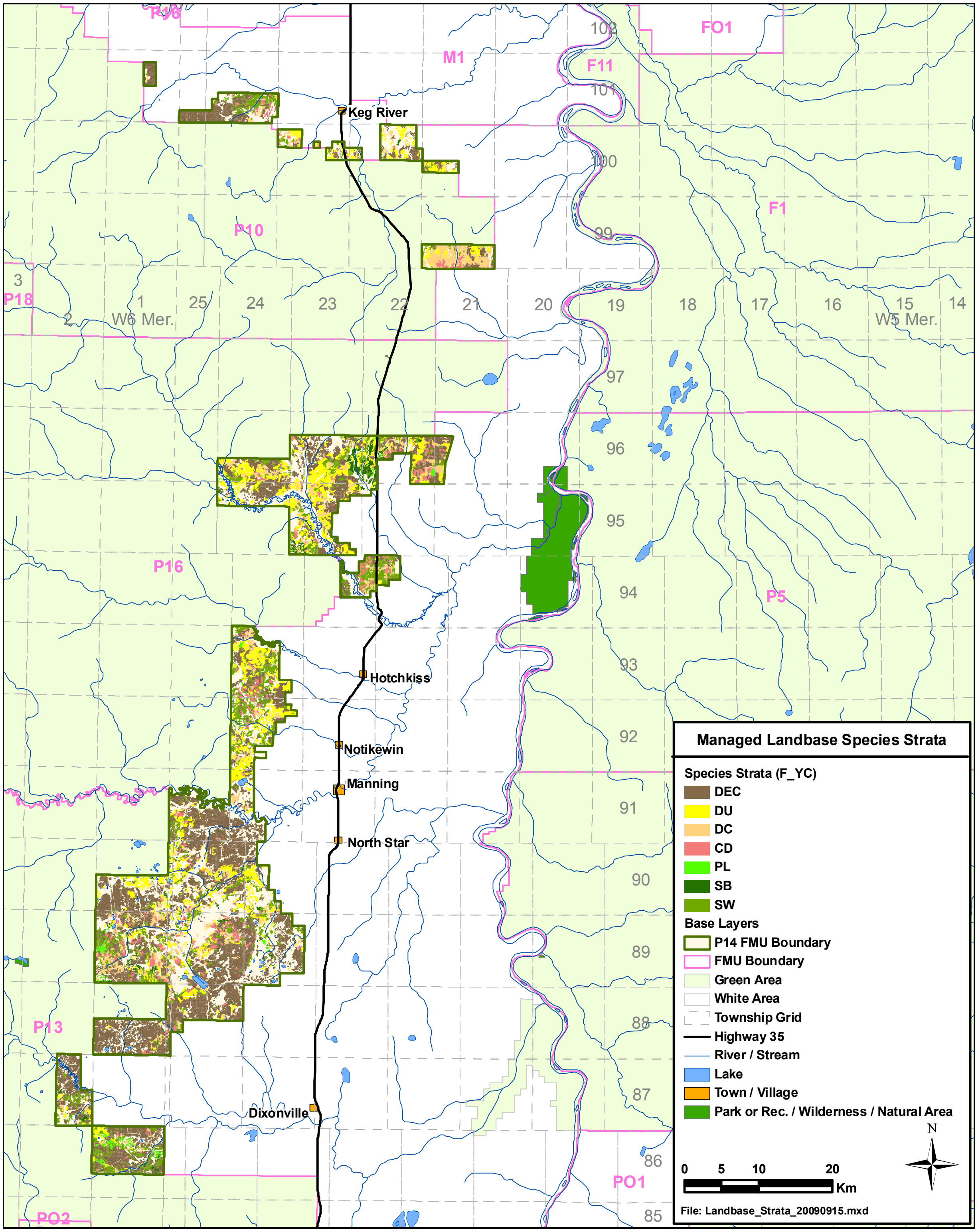
Description	F_YC	Area(ha)	% Managed Landbase	% Gross Landbase
Deciduous	DEC	43,461	49%	34%
Deciduous, conifer understory	DU	15,720	18%	12%
Deciduous mixedwood	DC	8,578	10%	7%
Conifer mixedwood	CD	4,594	5%	4%
Pine	PL	745	1%	1%
Black spruce	SB	1,985	2%	2%
White spruce	SW	12,745	15%	10%
Managed landbase	**Total**	**87,827**	**100%**	**69%**
Unmanaged Landbase		**39,505**		**31%**
Total Landbase		**127,331**		**100%**

As shown in Table 4, 68% of the managed landbase was deciduous or deciduous with a conifer understory. The deciduous species strata covered over one third of the total landbase area.

Deletions accounted for 31% or 40,119 ha of the total landbase area. Nonforest area constituted 43% of the unmanaged landbase (See Table 5).

Table 5. Unmanaged classified landbase (by F_DEL).

Description	F_DEL	Area(ha)	% Unmanaged Landbase	% Gross Landbase
Area outside FMU	XDFA	166	0%	0%
Linear features	LINEAR	469	1%	0%
Roads	ROADS	442	1%	0%
Seismic	SEIS	1,173	3%	1%
Utility corridors	UTIL	12	0%	0%
Government reservations	GOVRES	193	0%	0%
Mineral and surface leases	LEASE	222	1%	0%
Areas burnt since AVI	FIRE	453	1%	0%
Nonproductive areas	TPR	7,435	19%	6%
Nonforest area	NF	16,892	43%	13%
Water buffers	GRBUF	2,487	6%	2%
River break area	BREAK	3,089	8%	2%
Larch stands	LT	33	0%	0%
Non-commercial stands	NC	257	1%	0%
'A' density black spruce	SB_ADENS	1,674	4%	1%
Black spruce on wet sites	SB_WET	4,466	11%	4%
Nonforest harvest areas	CC_SC	41	0%	0%
Unmanaged Landbase	**Total**	**39,505**	**100%**	**31%**



Map 1. Managed landbase by species strata.

Table 6 shows a detailed summary of the classified managed landbase by stand origin and species strata. The table was created by grouping *F_ORIGIN* and *F_YC* by *F_AREAHA* for the managed landbase (*F_DEL* = 'NONE').

Table 6. Managed classified landbase summary by stand origin.

Stand origin	F_YC	Area(ha)	% Managed landbase
Natural stands			
	DEC	39,982	46%
	DU	15,720	18%
	DC	7,347	8%
	CD	3,125	4%
	PL	698	1%
	SB	1,985	2%
	SW	11,651	13%
Natural Total		80,507	92%
Regenerating stands			
	DEC	3,479	4%
	DU	0	0%
	DC	1,231	1%
	CD	1,469	2%
	PL	47	0%
	SB	0	0%
	SW	1,094	1%
Regenerating Total		7,320	8%
Managed landbase Total		**87,827**	**100%**

3.2 TSA Landbase

The final TSA landbase consisted of 18,751 polygons, 30,678 polygons less than the classified landbase which is a 62% reduction in the number of polygons. The TSA landbase areas are exactly the same as the classified landbase; total area of 127,331 ha and a managed area of 87,827 ha. Table 7 and Table 8 summarize the TSA landbase.

Table 7. TSA managed landbase summary (by F_YC).

Description	F_YC	Area(ha)	% Managed Landbase	% Gross Landbase
Deciduous	DEC	43,461	49%	34%
Deciduous, conifer understory	DU	15,720	18%	12%
Deciduous mixedwood	DC	8,578	10%	7%
Conifer mixedwood	CD	4,594	5%	4%
Pine	PL	745	1%	1%
Black spruce	SB	1,985	2%	2%
White spruce	SW	12,745	15%	10%
Managed landbase	**Total**	**87,827**	**100%**	**69%**

Table 8. TSA unmanaged landbase summary (by F_DEL).

Description	F_DEL	Area(ha)	% Unmanaged Landbase	% Gross Landbase
Area outside FMU	XDFA	166	0%	0%
Linear features	LINEAR	469	1%	0%
Roads	ROADS	491	1%	0%
Seismic	SEIS	0	0%	0%
Utility corridors	UTIL	12	0%	0%
Government reservations	GOVRES	193	0%	0%
Mineral and surface leases	LEASE	222	1%	0%
Areas burnt since AVI	FIRE	458	1%	0%
Nonforest area	NF	17,059	43%	13%
Nonproductive areas	TPR	7,510	19%	6%
Water buffers	GRBUF	2,501	6%	2%
River break area	BREAK	3,097	8%	2%
Larch stands	LT	33	0%	0%
Non-commercial stands	NC	259	1%	0%
'A' density black spruce	SB_ADENS	1,689	4%	1%
Black spruce on wet sites	SB_WET	4,514	11%	4%
Nonforest harvest areas	CC_SC	41	0%	0%
Seismic area deletion		789		
Unmanaged Landbase	**Total**	**39,505**	**100%**	**31%**

3.3 Modeling Landbase

The modeling landbase uses the same polygons as the TSA landbase with themes and other modeling fields added. The landbase deletions and managed landbase strata areas listed in Table 7 and Table 8 are also applicable to the modeling landbase. Ffinal calculations of the landbase file’s fields are listed in Appendix III: Landbase Development.

4. Timber Yield Curve Summary

Timber yield curves are a primary input of the forecasting required in the development of Forest Management Plans. This section provides a summary of the yield curve development and the changes applied to the base curves to generate the final modeling curves. Refer to Appendix IV: Yield Curve Development for the complete documentation of the process used to develop the yield curves.

4.1 Overview

Plot data were collected in 2004 under a joint SRD and Boucher Bros. program. The FMP yield strata, the strata total area, the total number of plots measured, and the number of plots eligible for curve development in each yield stratum are presented in Table 9.

Table 9. Yield strata description, total area by stratum, total and eligible plots by stratum.

	Broad	FMP Yield Stratum		Total	Percent	Total	Eligible	
Landbase	Cover Group	Code	Description	Area (ha)	Area (%)	Plots	Coniferous	Deciduous
Deciduous	D	D	Deciduous	43,461	49.5%	72	62	62
Coniferous	DC	DC	Deciduous leading mixedwood	8,578	9.8%	48	36	36
	CD	CD	Coniferous leading mixedwood	4,594	5.2%	35	35	35
	C	C-SB	Black spruce leading conifer	1,985	2.3%	47	17	39
		C-SW	White spruce leading conifer	13,490	15.4%	105	90	90
		DU	Deciduous overstory with coniferous understory	15,720	17.9%	57	55	52
		Plots Unassigned	-	-	-	8	-	-
Total				87,827	100.0%	372	295	314

4.2 Timber Yield Curves

In forecasting, almost identical timber yield curves were used for both the natural and regenerated stands. The only difference between the regenerated stand yield curves and the natural stand yield curves is the regeneration delay that was applied to the conifer component of the managed stand yield curves . The timber yield curves as used in the TSA are presented in Figure 2.

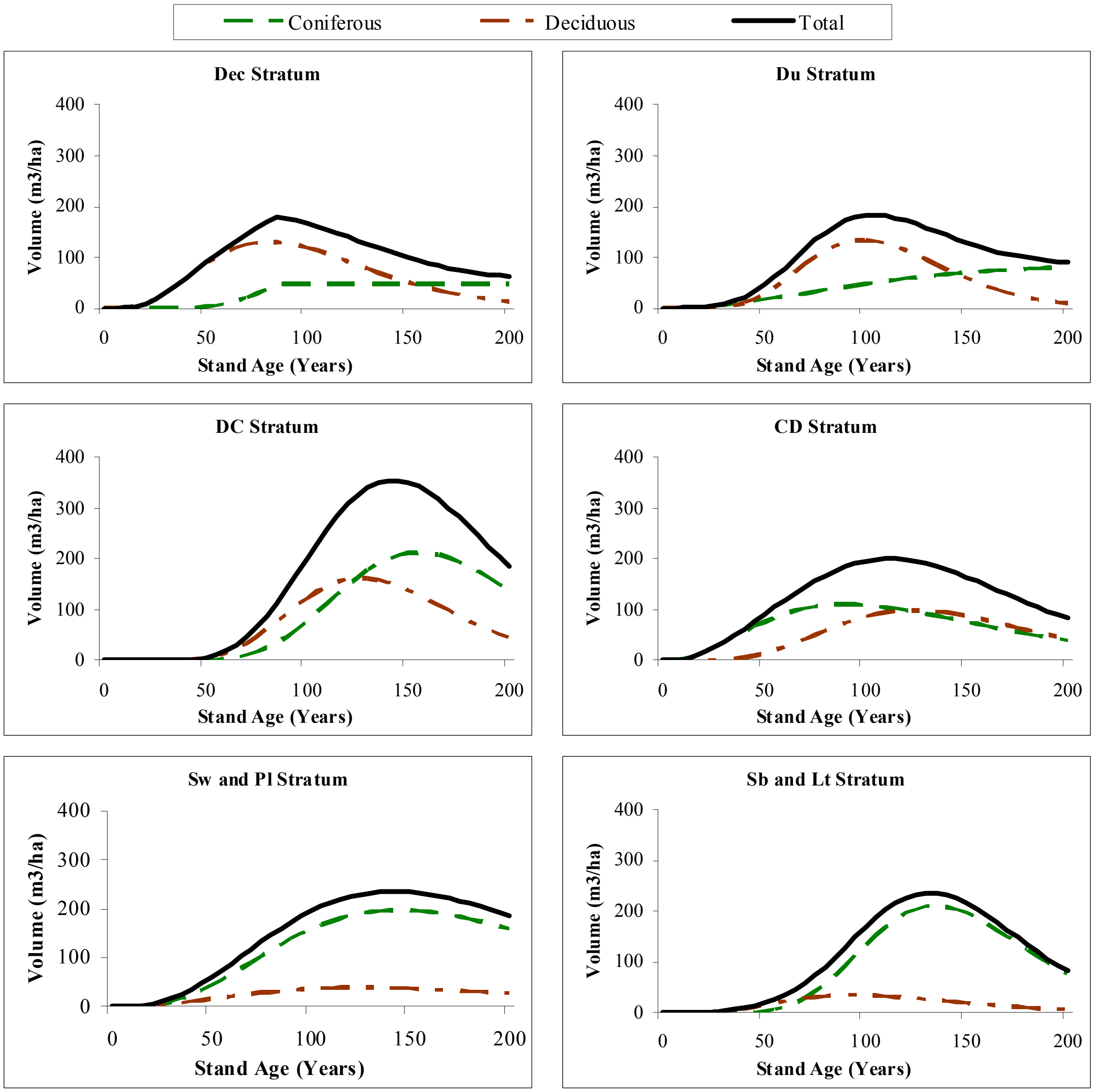


Figure 2. Natural and regenerated timber yield curves as used in forecasting.

4.2.1 D and Du Strata

P14 is operated under a divided landbase approach where the coniferous operators and deciduous operators harvest, regenerate and manage separate and distinct stands according to landbase assignment. To ensure that the modeling reflected the management approach, separate strata were created for the pure deciduous (D) and pure deciduous with coniferous understory (Du) stratum. When the initial yield curves were reviewed, the coniferous volume in the Dec stratum was unrealistically high. Boucher Bros recommended that, based on field observations and historical harvest volumes recovered in Dec stands, that an arbitrarily cap of

50m^3/ha be placed on the coniferous volume component of the Dec stratum. A sensitivity analysis was undertaken to determine the impacts of this decision (refer to section 7.1).

4.2.2 Utilization

Empirical volume over age timber yield curves for conifer and deciduous volume components were fit using widely accepted methods for each of the six strata to 15/11 and 15/10 utilization standards respectively (Table 10).

Table 10. Utilization standards by species group.

Utilization Criterion	Conifer Species	Deciduous Species
Stump height	30 cm	30 cm
Minimum log length	2.66 m	2.66 m
Minimum stump diameter outside bark	15 cm	15 cm
Minimum top diameter inside bark	11 cm	10 cm

4.2.3 Volume caps

Due to plot limitations and the resulting curve form, the volume relationship in the conifer component for the pure deciduous stratum (Dec) was unrealistic and was capped for use in timber supply.

4.2.4 Cull

For forecasting, cull was applied to the yield curves as a percent reduction. The cull reduction was 3.26% for coniferous components and was derived from scale data. A cull reduction of 9% for deciduous components of each stratum was the same factor applied by Daishowa-Marubeni International Ltd. (DMI) in their current FMP.

4.2.5 Regeneration Lag

A two year regeneration lag was applied to the conifer component of all curves by shifting the curves to the right 2 years. No regeneration lag was applied to the deciduous components.

4.2.6 Green tree retention

A green tree retention factor was not applied to the yield curves for forecasting. Retention is included in the harvest level and will be left in the harvested areas and charged to the AAC drain.

5. Forecasting Inputs and Assumptions

5.1 Overview

This section describes the final inputs and assumptions used in forecasting the final scenarios. In some cases, sensitivity analyses required different inputs than those described here to compare assumptions. Different inputs are only described if required to clarify the analysis.

The term “goal” is used in the document to distinguish what was to be achieved in the forecasting models from the “targets” associated with VOIT’s.

5.2 Inputs

5.2.1 Data sets

Six versions of the modeling landbase file were created for forecasting. The final version was Round6\Data\P14_LB4_BUILD1_SHS.shp.

Different yield curve sets were forecasted during the analysis. The final set is contained in Round6\Tracks\Woodstock\p_v6.yld.

5.2.2 Seral Stages

Seral stages that classified stands by ecological development phase were developed for the FMU (Table 11). Age ranges were based on the ecology of the primary tree species in each stratum. Forecasting used the regeneration seral stage as the age range of the young patch indicator and the mature and old seral stages as the age range of the interior old forest indicator.

Table 11. Seral stage age ranges for each stratum.

	Seral Stage			
	Regeneration	Young	Mature	Old
Strata	Age Range (years)	Age Range (years)	Age Range (years)	Age Range (years)
DEC	0-14	15-59	60-99	100+
Du	0-14	15-59	60-99	100+
DC	0-14	15-69	70-109	110+
CD	0-14	15-69	70-109	110+
Pl	0-14	15-69	70-119	120+
Sb	0-14	15-104	105-159	160+
Sw	0-14	15-104	105-149	150+

5.3 Assumptions

5.3.1 Harvest Treatments

The only treatment available in the analysis was clearcut harvesting of mature stands regardless of understory condition. As the deciduous with conifer understory (Du) strata is part of the coniferous landbase, it was managed for the coniferous component and was harvested when the coniferous understory was merchantable.

5.3.2 Growing Stock

There are two main types of growing stock in the model, managed and operable.

- Managed growing stock represents the volume at the appropriate utilization standard in forested stands within the managed stands, regardless of stand age.
- Operable growing stock is a sub-set of the managed growing stock that only includes the volume from stands at, or above, the minimum operable age.

Each of these is further broken down into coniferous and deciduous and into primary and incidental for a total of eight indicators:

1. Coniferous primary managed growing stock,
2. Coniferous incidental managed growing stock,
3. Coniferous primary operable growing stock,
4. Coniferous incidental operable growing stock,
5. Deciduous primary managed growing stock,
6. Deciduous incidental managed growing stock,
7. Deciduous primary operable growing stock, and
8. Deciduous incidental operable growing stock.

Only the primary operable growing stocks for coniferous and deciduous volumes are controlled and reported.

5.3.3 Minimum Harvest age

The minimum harvest age for the DEC stratum was 70 years and the minimum harvest age for all other strata was 90 years. Managed stand minimum harvest age was the same as the natural stand minimums.

5.3.4 Regeneration Lag

A regeneration lag was built into the yield curves for forecasting. The applicable curves were shifted to the right. The regeneration lag was 2 years for coniferous components of all strata and zero years for deciduous components of all strata. These were applied by shifting the components to the right

5.3.5 Strata Transitions

In this analysis, all strata following harvesting transition back to themselves with one exception, deciduous with conifer understory (Du) strata transitions to the CD strata after harvest.

Stand breakup was conservative and assumed to be very slow. All yield curves dropped to low volumes and the death age was set to 300 years. Stands that were not harvested dropped to low volumes and remained so to near the end of the planning horizon while providing old growth values.

5.3.6 Interior Old Forest

In this model, the old forest interior core patches were comprised of Mature and Old seral stages in patches of 150 ha or more using a 50 m topology distance. This means that stands up to 50 m apart were considered within the same patch.

5.3.7 Carryover Volume

There was no carryover volume assigned to the P14 FMU and therefore was not modeled in the analysis.

5.3.8 Operational Considerations

The development of a 20 year Spatial Harvest Sequence (SHS) as part of the forecasting supports forest sustainability by tightening the relationship between strategic planning and field operations. It ensures that the long term consequences of the field operations are incorporated into the forecasting and that harvesting activity reflects the strategically determined allowable cut. For this to be effective, the SHS must be operationally feasible. Operators requested that annual harvesting operations be somewhat grouped and that merchantable patches left behind for future harvest be large enough to harvest at a later date. Operational considerations were addressed in the forecasting process by the following five techniques.

Annual Harvest Patches
Annual harvesting was controlled by creating patch goals comprised of only recently harvested stands with an age of zero or one year. By setting the topology distance to 200 m and constraining the 100+ ha and 250+ ha patch goals to minimum levels, the model was

encouraged to create several clusters of stands each year. This technique removed the requirement to restrict harvesting to annually identify operating unit boundaries.

Operational Leave Patches
One concern when developing operational plans is the amount of standing merchantable timber left behind after harvesting. Leave patches that are eligible for harvest in the future should be large enough to make it economical to return to harvest them. A patch goal was created comprised of merchantable timber in the managed landbase and of a size class of 0-40 ha based on 15 m topology distance. This patch goal was set to a maximum of 2% of the leave patches to be less than 40 ha. This was to encourage the model to minimize the merchantable patches less than 40 ha in size.

Operating Units
Boucher Bros. does not utilize compartments in their strategic or operational planning as P14 is relatively small and there is access to all parts of the unit. However, in the model only, operating units were created to help the model combine harvest activities into operationally feasible groups for the remainder of the planning horizon after the SHS period (which covers the first 20 years of the planning horizon). The number of operating units that harvesting activities occur in any one period was lightly controlled to help the annual harvest patch goals perform more effectively. This goal supports sustainability by maintaining the effects of the operational harvesting patterns over the entire planning horizon.

Greenup Patches
For the first 20 years of the planning horizon, a greenup patch goal was used to discourage large continuous harvest groupings. A greenup goal using a topology distance of 15 m and a size of 1,000+ ha was set to a maximum of zero for the first 20 years. The main purpose of this goal was to partially offset the success of the other grouping mechanisms.

Opening Patch Sizes
Opening patch size refers to the size distributions of the regeneration seral stage. The size groupings were: 0-2 ha, 2-200 ha, 200-500 ha and 500+ ha. The patch size goals used a topology distance of 5 m.

The model was constrained to have at least 90% of the regeneration patches in the 2-200 ha patch size and up to 10% of the patches in the 200-500 ha patch size class.

5.3.9 Access Control

The access control functionality within Patchworks was used to control access to areas identified by Boucher Bros. in the first 20 years as being preblocks, good candidates for current harvest or stands that should be deferred. In the context of this plan, preblocks are desired stands that the company has identified to be harvested in the SHS. This control feature was utilized in the final versions of the model after an almost satisfactory scenario (P14_P5006) was generated. From this almost satisfactory scenario, Boucher Bros. and SRD area representatives field checked the potential SHS from ground and helicopter. From this field checking, Boucher Bros. made adjustments to the SHS and the model was then re-run to create the PFMS. Table 12 shows the categories, descriptions and the control placed on each category in the PFMS.

Table 12. Patchworks access control settings.

Category	Description	Year of Planning Horizon 1-5	6-10	11-15	16-20	21+
AFTER10	Only available after the first 10 years	Closed	Closed	Open	Open	Open
AFTER20	Only available after the first 20 years	Closed	Closed	Closed	Closed	Open
OPTION1	Area open to harvest if required - 1st priority	Open	Open	Open	Open	Open
OPTION2	Area open to harvest if required - 2nd priority	Closed	Open	Open	Open	Open
SHS	Stands to keep from Scenario P14_P5006	Keep	Keep	Keep	Keep	Open
SHS_11_20	Stands desired to be harvested in the second 10 years	Closed	Closed	Open	Open	Open
SHS_1_10	Stands desired to be harvested in the first 10 years	Open	Open	Closed	Closed	Open

Legend:
- Open for harvest
- Model must keep existing harvest treatments
- Closed for harvest

5.3.10 Mountain Pine Beetle

The 2009-2018 FMP was not developed to address potential losses associated with mountain pine beetle (MPB). Until the beetle flight in the summer of 2009 when MPB spread across much of central Alberta, P14 was outside the MPB management zone and there was no observed MPB activity in the FMU. However, a MPB stand susceptibility index (SSI) rating was completed for the P14 area (refer to The Landscape Assessment in Chapter 2) and very little area was identified as susceptible to MPB infestations. For these reasons, neither a MPB compartment ranking nor a MPB risk assessment has been competed for P14. SRD will continue to monitor the MPB situation in and around P14 and will review MPB action priorities in response to changes in MPB population development and spread.

Despite the low probability of MPB infestation and the low potential for loss, the PDT decided to reduce the potential impact from MPB where practical. Therefore, stands with pine content were identified as pine stands in theme7 and given a higher priority in the sequencing. These steps will reduce any potential impact from MPB even if the beetle becomes established in the area.

Theme7 is calculated from the inventory information and was grouped into two types. The DEC_PINE type represents those stands on the deciduous landbase where the percentage of pine is >= 20%. The PINE type, those stands on the coniferous landbase where Pl is either the first or second species listed in the overstory.

In the model, each type was constrained to be reduced as much as reasonably possible over the first 20 years without adversely affecting the other modeling constraints. Due to the small amount of pine on the landbase and the low susceptibility, the goals were not weighted heavily.

5.3.11 FireSmart

Early in the planning process, the PDT met with Alberta fire specialists to develop a FireSmart strategy for the plan. A review of the available information identified black spruce stands in the non-managed or passive landbase as the greatest risk for fire. Harvesting activities cannot alter fuel on the non-managed landbase so other techniques such as prescribed burns would be required to reduce fire risk. Currently, there are no plans for prescribed burns in P14. The managed landbase is largely comprised of deciduous dominated stands with few large patches of highly flammable conifer stands. Normal harvesting operations was deemed to be sufficient to address fire risk.

The forecasting didn't incorporate FireSmart directly into the analysis. Due to the broken nature of FMU and the lack of community zones within the FMU, the PDT determined that a FireSmart analysis would not likely modify the behaviour of the operations in P14. FireSmart analysis was completed by SRD on the PFMS and supports the PDT's decision (refer to the Landscape Assessment in Chapter 2). Additional FireSmart work may be undertaken at a later date.

5.4 Target Weighting

The weighting of individual targets impacts the models ability to achieve the target values desired by the management team. However, the weighting of the targets is not a mathematical process of determining the actual weights but a process of ensuring desired outcome of the target values. Some targets are desired to be even flow, some are required to meet a minimum or maximum, with fluctuations allowed above or below the minimum or maximum, and still others can have significant deviation from the target value and still be within accepted values. Once the desired effect is agreed upon, the weights are adjusted to achieve the targets.

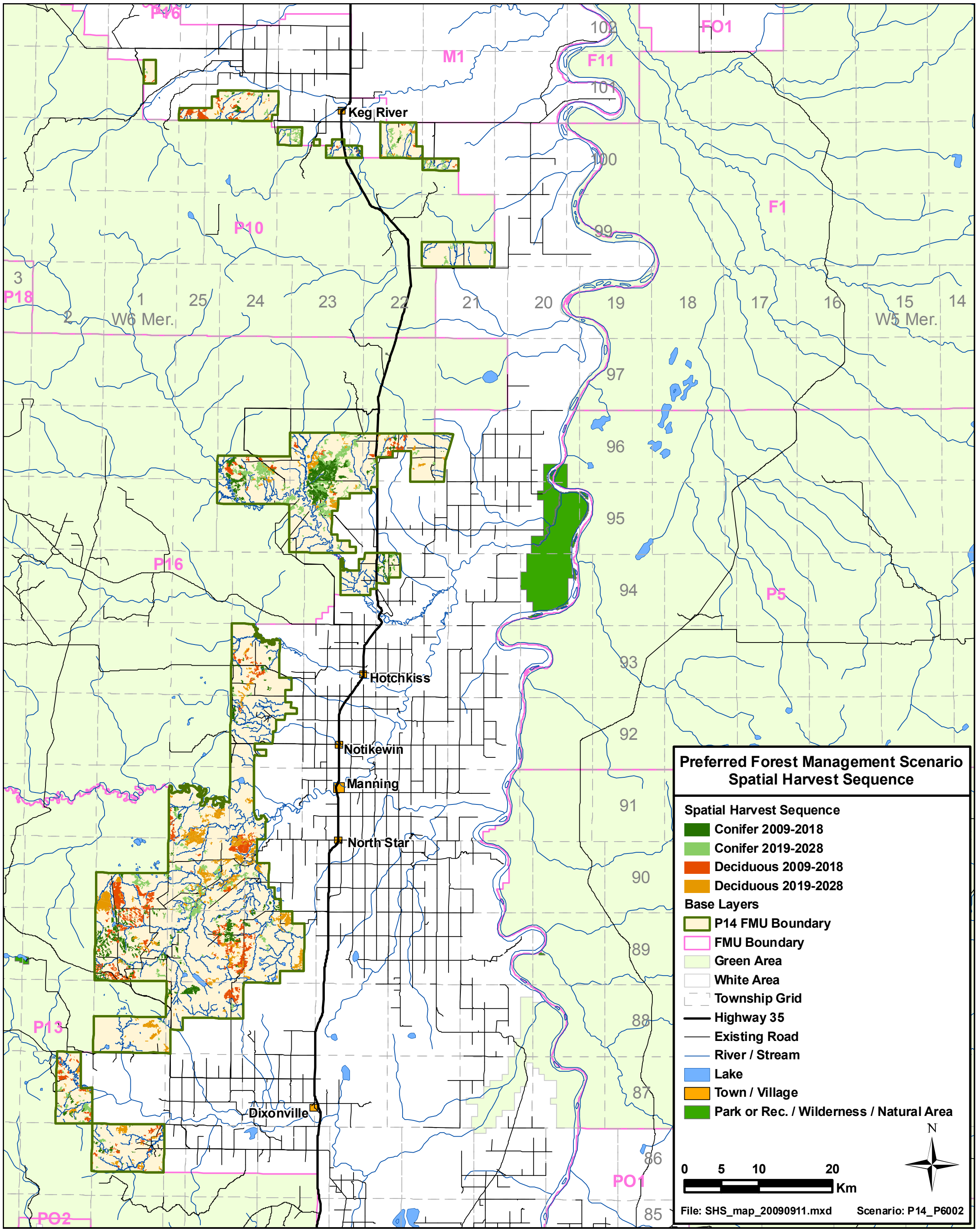
Some targets are difficult to achieve and the weighting will be higher than other targets. Other targets will achieve their values with very little encouragement, so very little weighting is required. The relative weighting between targets does not reflect their relative importance, but simply reflects the required weighting to achieve the desired outcome.

6. Preferred Forest Management Scenario

The Preferred Forest Management Scenario (PFMS) is the result of combining the decisions from earlier analysis, the targets for values of interest, and the biological and anthropogenic assumptions with operational considerations. A PFMS is not the result of a computer analysis but rather the analysis was used to provide information to the PDT who combined this information with their knowledge of the forest and forest management to refine each successive scenario unitil the overall results were satisfactory. The result is a biologically, socially and economically reasonable forest management scenario to direct forest management harvesting, regeneration and access for the next 10 to 20 years.

This section presents the PFMS in detail including both strategic and operational targets and their associated results. The section is organized by indicator with the action based indicators presented first, followed by the inventory indicators and the patch targets. The PFMS is run P14_P6002.

An integral part of the PFMS is the Spatial Harvest Sequence (SHS) which is the first 20 years of harvest beginning in the 2009/10 timber year and is divided into years 1-10 and 11-20 (Map 2).



Map 2. Map of the SHS by decade and landbase for the PFMS.

6.1 Harvest Volume

P14 is a new FMU and the harvest allocations were recently updated to reflect the creation of the P14. Thus, one forest management objective was to achieve the recent allocated harvest levels (DTA and CTQ) provided there was no undo impact on other values. While the harvest volumes determined in the PFMS were close to the allocated amounts, it was not possible to achieve the deciduous allocations under an even flow policy. A slight surge cut for 20 years was implemented in the PFMS to achieve the current deciduous allocations. Refer to section 7.4 for more information on the impacts of the surge cut.

The conifer primary harvest volume achieved very close to an even flow through the whole planning horizon while the deciduous primary harvest volume had a 6% dropdown after the 20 year SHS. The unconstrained incidental volumes fluctuated over time and are presented as average volumes for the appropriate periods. Gross harvest volumes for the 20 year SHS and the remainder of the planning horizon are shown in Table 13 but are not reduced 2% to account for structural retention. Structural retention volume is AAC chargeable.

Table 13. Gross harvest volume from the PFMS.

	Harvest Level (m^3/yr)			
	Primary		Incidental	
Time Period	Coniferous	Deciduous	Coniferous	Deciduous
2009 - 2028	51,500	53,169	22,691	45,158
2028 - 2208	50,979	50,000	18,943	27,054

* Structural Retention is not removed from these volumes

6.1.1 Coniferous Harvest

The coniferous harvest level is very close to even flow for the full planning horizon (droping 503 m^3/yr, or less than 1% after 20 years). There is a slight increase in the first 20 years due to the combination of complex operability constraints and polygon sizes that exist on the landbase that impede the model's ability to create a strict even flow. The coniferous harvest target is shown in Figure 3 and the harvest volume by strata is shown in Figure 4.

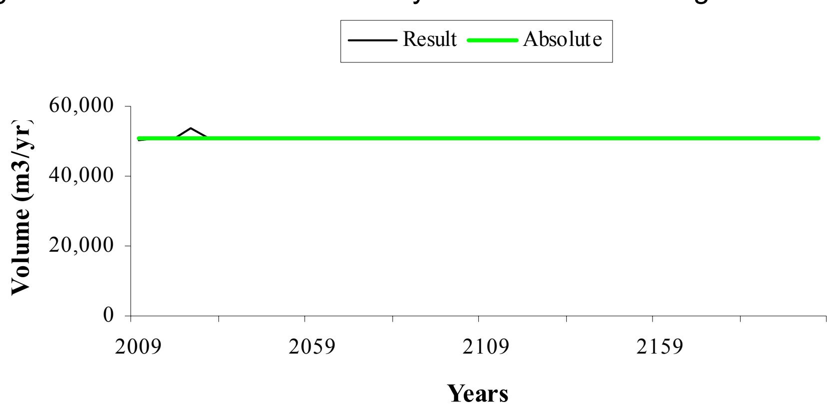


Figure 3. Coniferous harvest target.

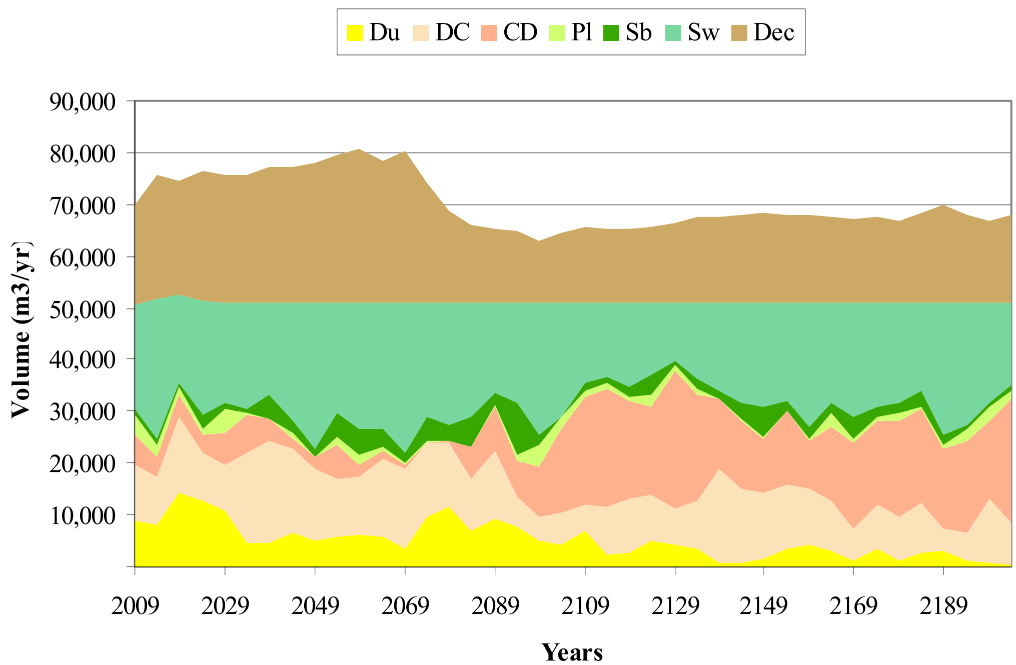


Figure 4. Coniferous harvest volume by strata.

6.1.2 Deciduous Harvest

The deciduous harvest level is even flow for the first 20 years and then drops down 6% to a new even flow level for the remainder of the planning horizon. The deciduous harvest target is shown in Figure 5 and the harvest volume by strata is shown in Figure 6.

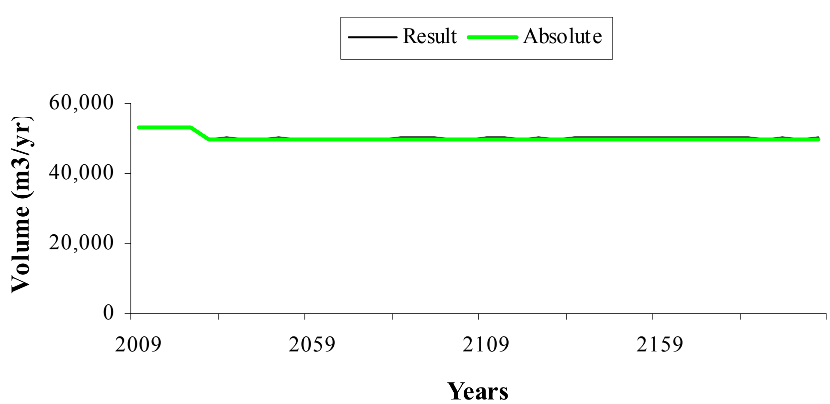


Figure 5. Deciduous harvest target.

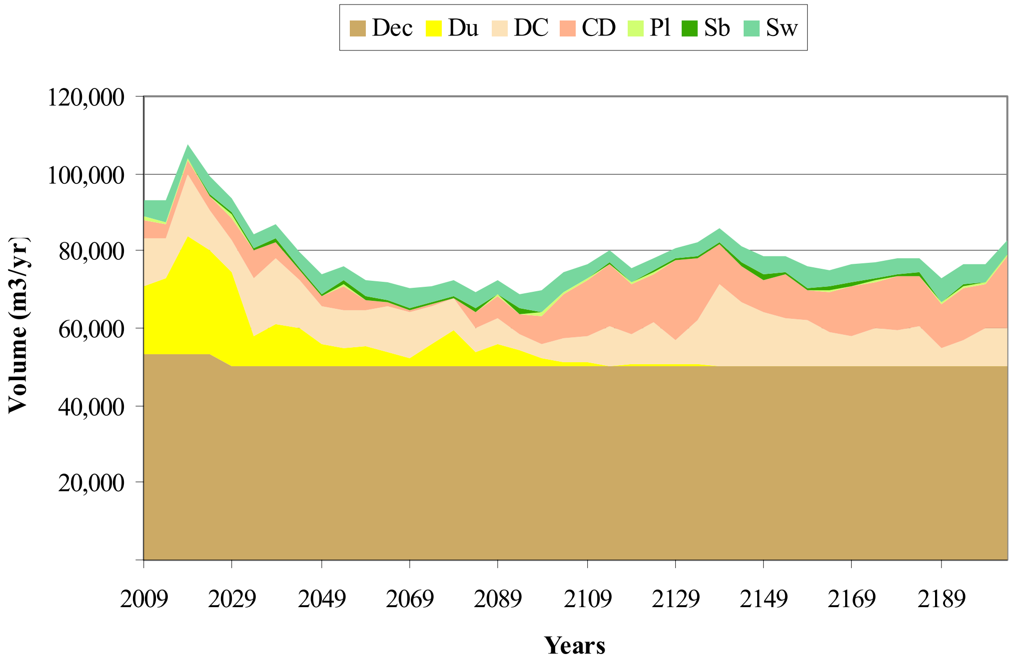


Figure 6. **Deciduous harvest volume by strata.**

6.2 Area Harvested

The area harvested varies throughout the planning horizon. This section shows the area harvested by strata and age class.

6.2.1 Strata

The area harvested by strata shows the combination of the coniferous and deciduous harvests. After the first rotation, there is a decrease in the total area harvested due to the regulation of the forest. Figure 7 shows the area harvested by strata and Map 3 and Map 4 show the strata harvested in the first and second decades of the SHS. The deciduous landbase harvest area actually decreases in the second rotation as more of the area is harvested closer to the maximum volumes obtained than at the younger ages.

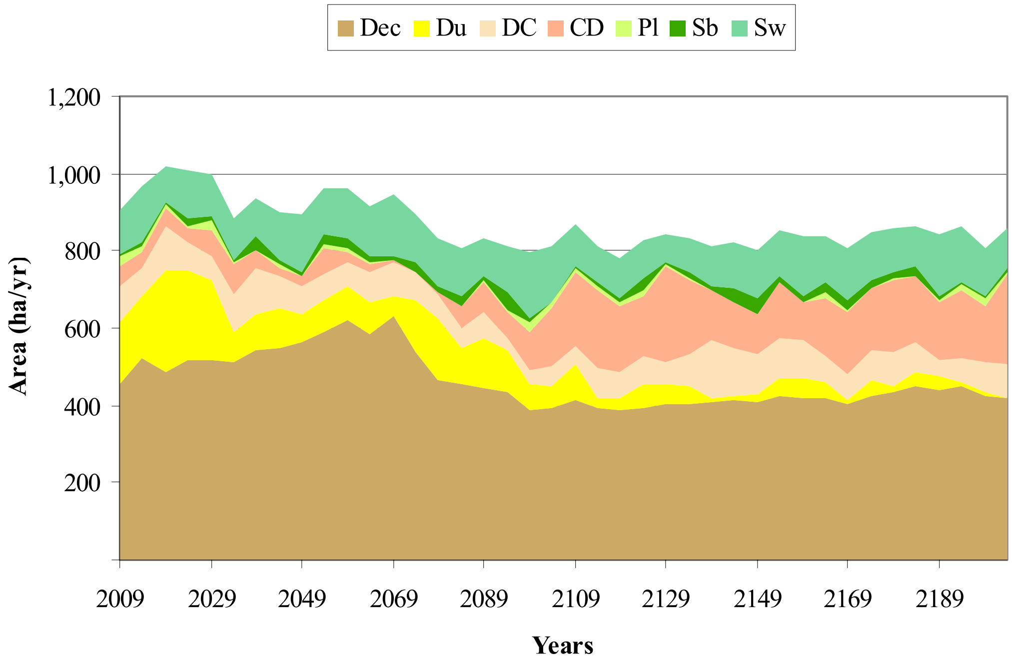
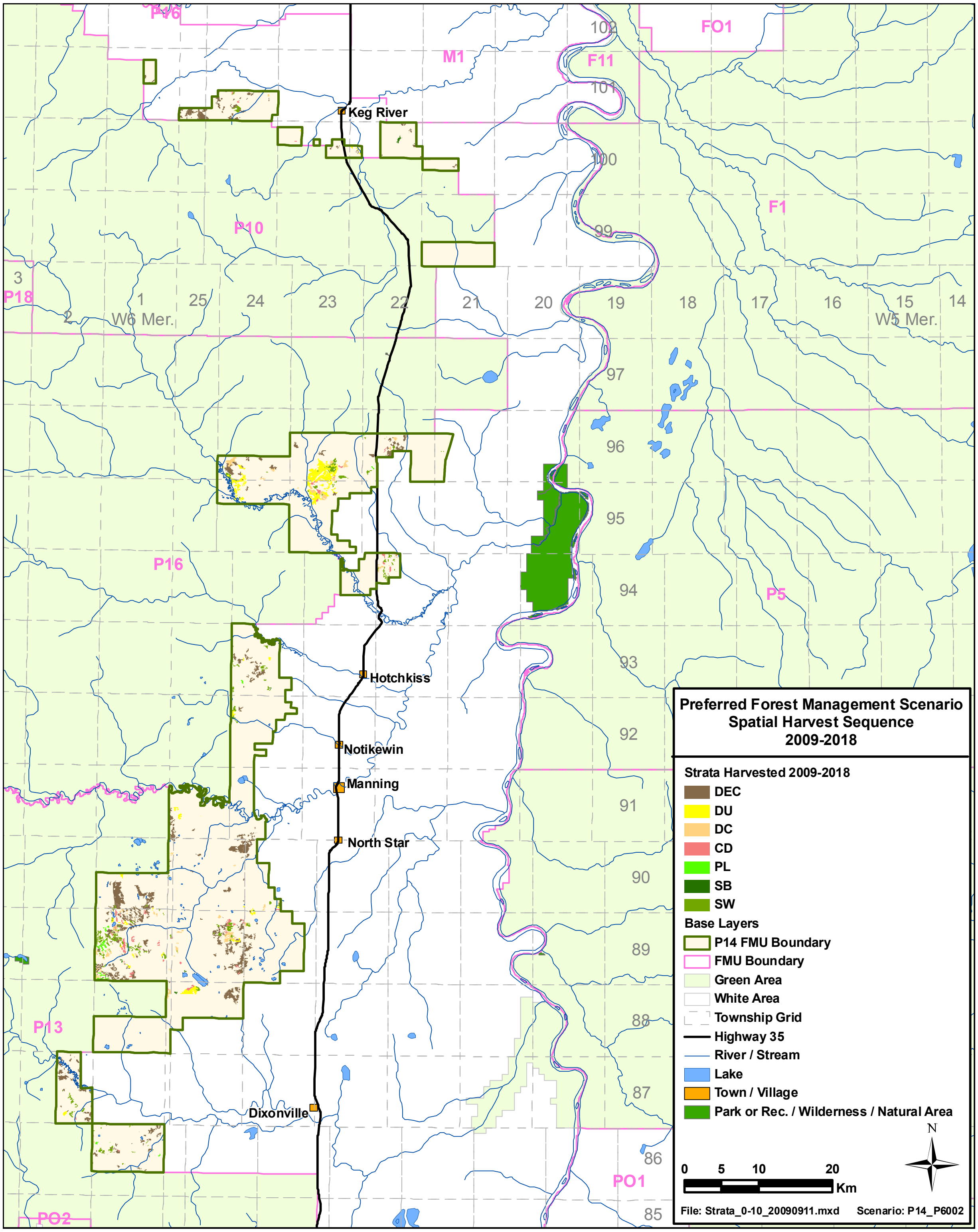
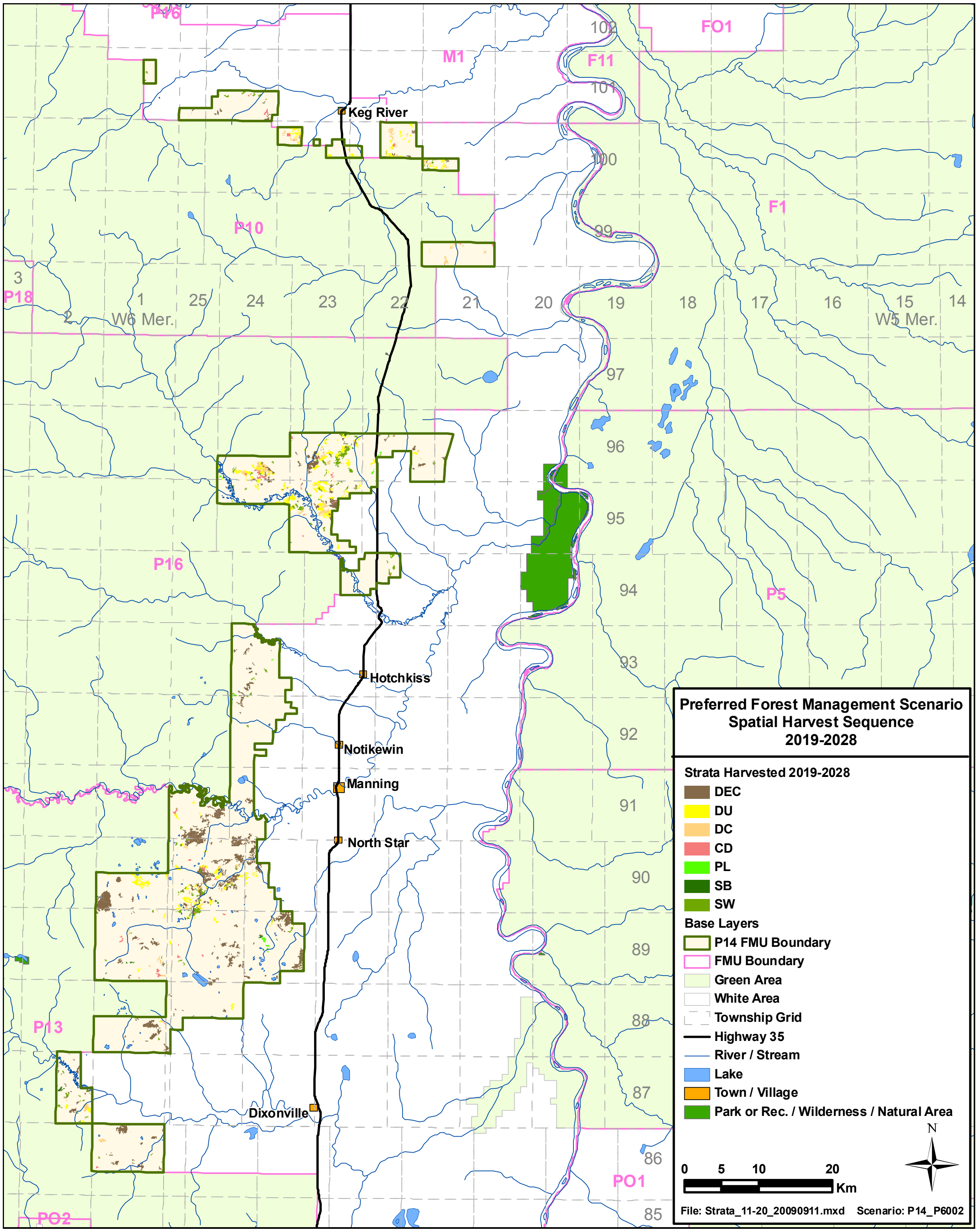


Figure 7. Area harvested by strata.



Map 3. 2009-2018 SHS by strata.



Map 4. 2019-2028 SHS by strata.

6.2.2 Age Class

The age class distribution of the area harvested changes through the planning horizon (Figure 8). For the first 60 years, increasing area in older age classes are harvested to a point where 80% of the stands being harvested are greater than 120 years old. Then, over the next 40 years as the forest transitions closer to a regulated state, younger age classes are harvested to a point where 80% of the stands harvested are less than 100 years old. In the second half of the planning horizon, the forest is close to a regulated state and the age class distribution remains fairly stable.

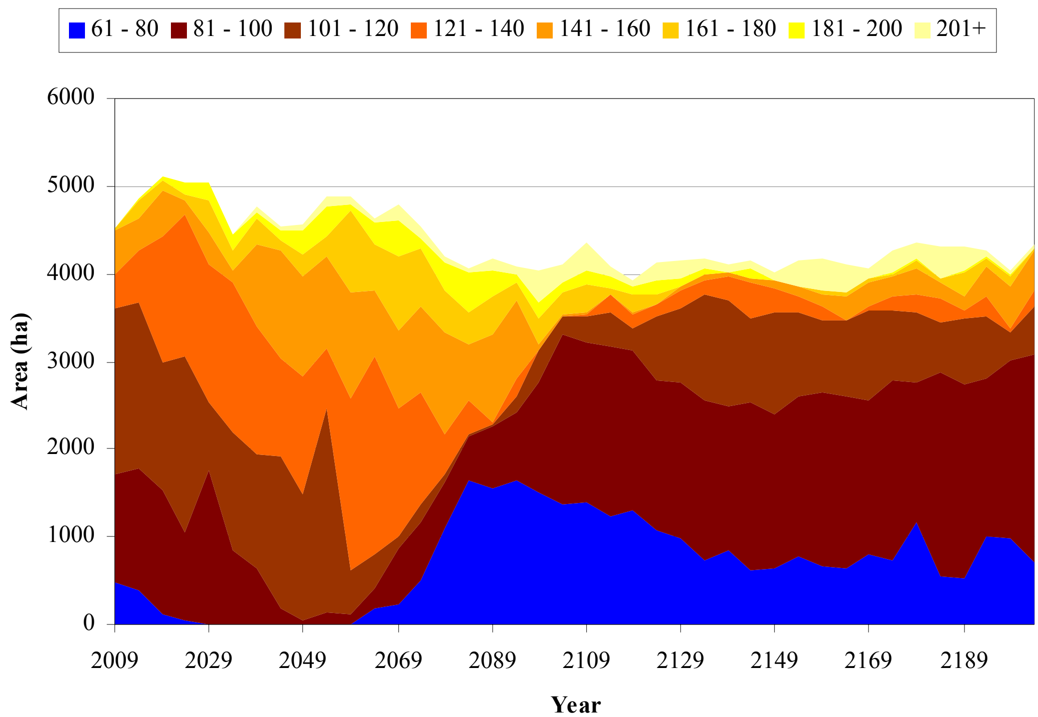


Figure 8. Area harvested by age classes.

Table 14 and Table 15 show the area harvested in each strata by age class for the first and second decades of the PFMS. The tables also show the managed landbase area and percentages to show that the SHS is harvesting close to the existing landbase strata profile.

Table 14. Area harvested by age class and strata in the first decade.

	Harvested Age Class								Managed Landbase	
	70-80	81-100	101-120	121-140	141-160	161+	Total			
Harvest Strata	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(ha)	(%)	(ha)	(%)
Dec	905	1,398	1,800	432	280	80	4,896	52%	43,461	49%
Du	0	629	536	325	106	0	1,596	17%	15,720	18%
DC	0	269	387	19	156	0	832	9%	8,578	10%
CD	0	92	327	8	36	16	479	5%	4,594	5%
Pl	0	67	106	16	0	0	189	2%	745	1%
Sb	0	19	14	26	1	0	60	1%	1,985	2%
Sw	0	220	539	223	197	136	1,315	14%	12,745	15%
	905	2,695	3,711	1,049	776	232	9,368		87,827	

Table 15. Area harvested by age class and strata in the second decade.

Harvest Strata	Harvested Age Class 70-80 (ha)	81-100 (ha)	101-120 (ha)	121-140 (ha)	141-160 (ha)	161+ (ha)	Total (ha)	Total (%)	Managed Landbase (ha)	Managed Landbase (%)
Dec	188	1,342	1,831	1,556	94	0	5,011	53%	43,461	49%
Du	0	667	952	604	262	0	2,485	27%	15,720	18%
DC	0	245	279	263	148	5	939	10%	8,578	10%
CD	0	66	75	163	92	4	401	4%	4,594	5%
Pl	0	67	8	13	0	0	88	1%	745	1%
Sb	0	98	27	6	0	0	131	1%	1,985	2%
Sw	0	156	209	311	92	321	1,088	12%	12,745	15%
	188	2,641	3,380	2,915	688	330	10,142		87,827	

6.2.3 Action/Intensity/Reforestation

The primary silviculture system employed in P14 is clearcut followed by either natural or artificial regeneration, with understory protection where appropriate. In the modeling, all strata are regenerated back to the original strata with the exception of the deciduous with understory (Du) strata, which is regenerated to coniferous leading mixedwood (CD). Table 16 and Table 17 show the area by strata that is harvested and regenerated for the first and second decade of the PFMS.

Table 16. Area harvested and regenerated in the first decade of the PFMS.

Harvest Strata	Regenerating Strata Dec	Du	DC	CD	Pl	Sb	Sw
Dec	4,896	-	-	-	-	-	-
Du	-	-	-	1,596	-	-	-
DC	-	-	832	-	-	-	-
CD	-	-	-	479	-	-	-
Pl	-	-	-	-	189	-	-
Sb	-	-	-	-	-	60	-
Sw	-	-	-	-	-	-	1,315
Total	4,896	0	832	2,076	189	60	1,315

Table 17. Area harvested and regenerated in the second decade of the PFMS.

Harvest Strata	Regenerating Strata Dec	Du	DC	CD	Pl	Sb	Sw
Dec	5,011	-	-	-	-	-	-
Du	-	-	-	2,484	-	-	-
DC	-	-	939	-	-	-	-
CD	-	-	-	401	-	-	-
Pl	-	-	-	-	88	-	-
Sb	-	-	-	-	-	131	-
Sw	-	-	-	-	-	-	1,088
Total	5,011	0	939	2,885	88	131	1,088

6.3 Trees per Meter

Trees per meter is an indicator of piece size and is an important metric to consider when evaluating the economic feasibility of the PFMS. Figure 9 shows the coniferous and deciduous trees per meter for the planning horizon. Both the coniferous and deciduous trees per meter metrics are largely determined by the harvested age class, with older age classes having fewer trees per cubic meter of harvested volume. As the forest moves towards a regulated state, the trees per meter increases (smaller trees) and stabilizes. For the first 40 years of the planning horizon, coniferous trees per meter will decrease (the trees will increase in size).

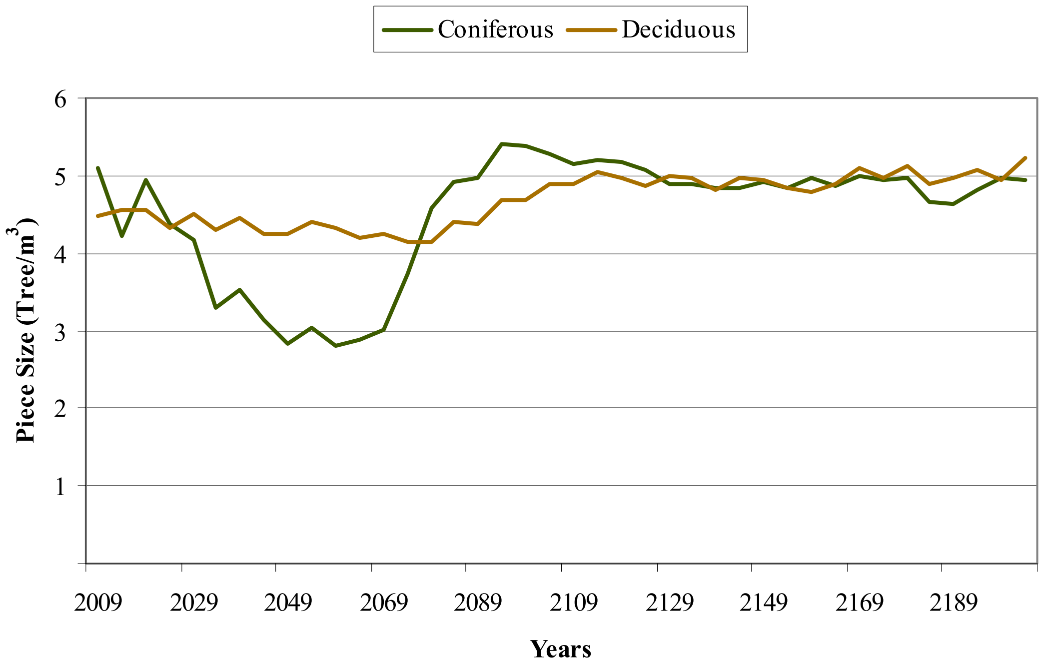


Figure 9. Coniferous and deciduous piece size.

6.4 Growing Stock

Growing stock represents the total volume of all the trees on the landbase. In this document, only the primary growing stock (excludes the incidental volume) is considered as primary volumes are the controlling volume for timber supply. Two different representations of growing stock are reported, managed growing stock and operable growing stock. Managed growing stock represents the volume at the appropriate utilization standard in forested stands within the managed stands, regardless of stand age. Operable growing stock is a sub-set of the managed growing stock that only includes the volume from stands at, or above, the minimum operable age.

The managed conifer and deciduous growing stock levels in the PFMS are not significantly impacted by the harvest activities.

The operable coniferous growing stock decreases to about 33% of the original level and then stabilizes for the second rotation. The operable deciduous growing stock decreases to about

15% of the original level but then increases back up to 35% of the original level for the second rotation (Figure 10).

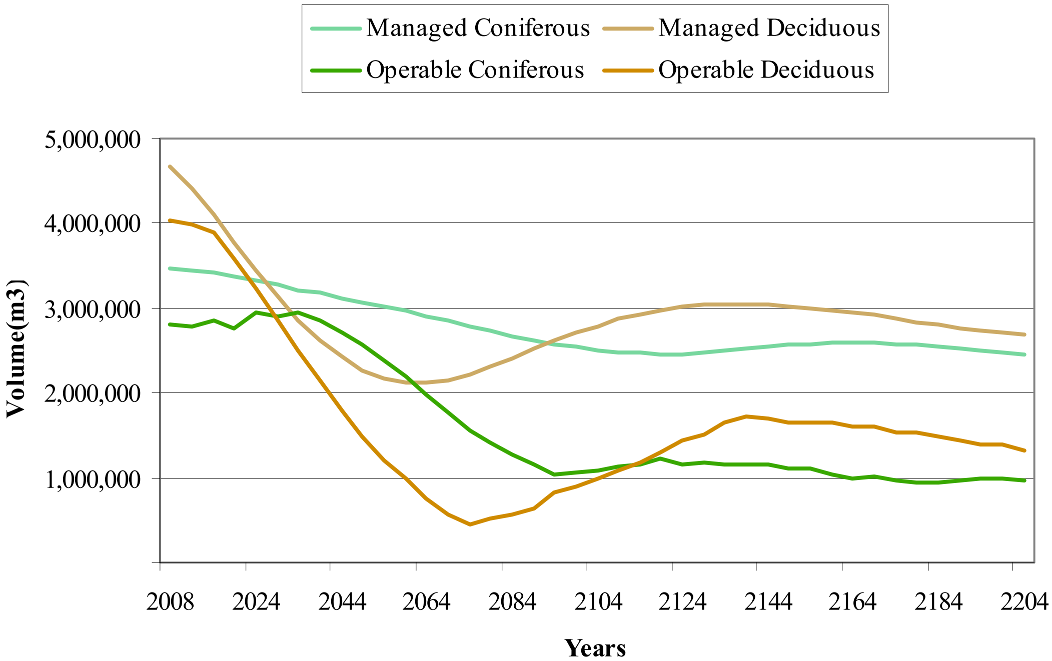


Figure 10. Growing stock by type on the managed landbase.

6.4.1 Growing Stock Constraints

The operable growing stock for both the coniferous and deciduous volume is controlled by a target in the model. The planning standard specifies that the growing stock must be stable, or non-declining over the final 50 years of the planning horizon. Patchworks is not the optimal tool for creating such a constraint, so a similar level from Woodstock was applied as a minimum growing stock goal for the length of the planning horizon. The model met this target in the coniferous landbase (Figure 11) at all time points. The operable deciduous growing stock met its goal (Figure 12) in the final 50 years of the planning horizon but was below for several years prior. This is primarily due to the currently older age classes of the deciduous landbase that decreases in volume due to decreasing volume on the yield curves after 90 years of age. Once the forest is in a regulated state with a larger amount of younger deciduous stands, the growing stock increases and stabilizes.

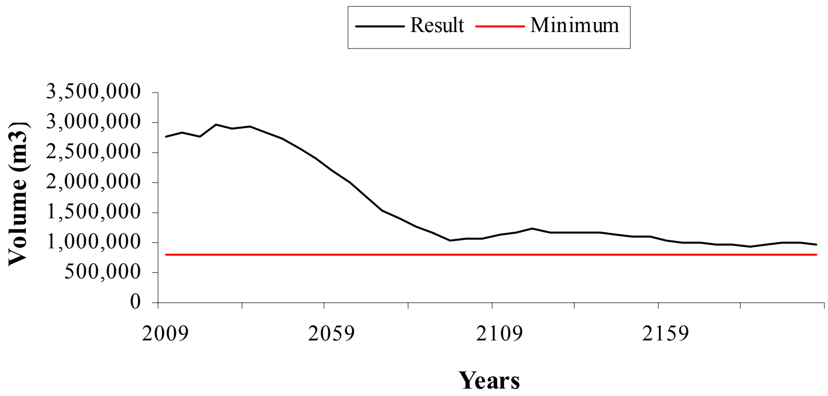


Figure 11. Target of operable coniferous growing stock.

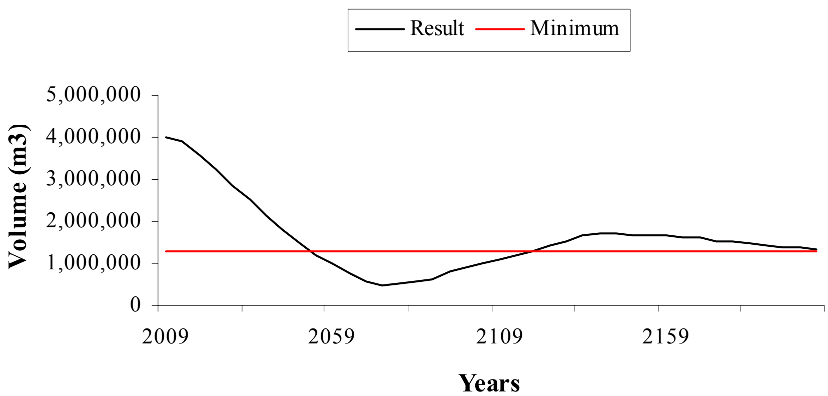


Figure 12. Target of operable deciduous growing stock.

6.5 Area

This section describes the status of the landbase through the planning horizon.

6.5.1 Strata

The total forested landbase area by strata stays constant through time. Approximately half of the landbase is pure deciduous with the second largest category being mixedwood stands, including deciduous with coniferous understories (Figure 13). The conversion of the Du to CD is clearly visible.

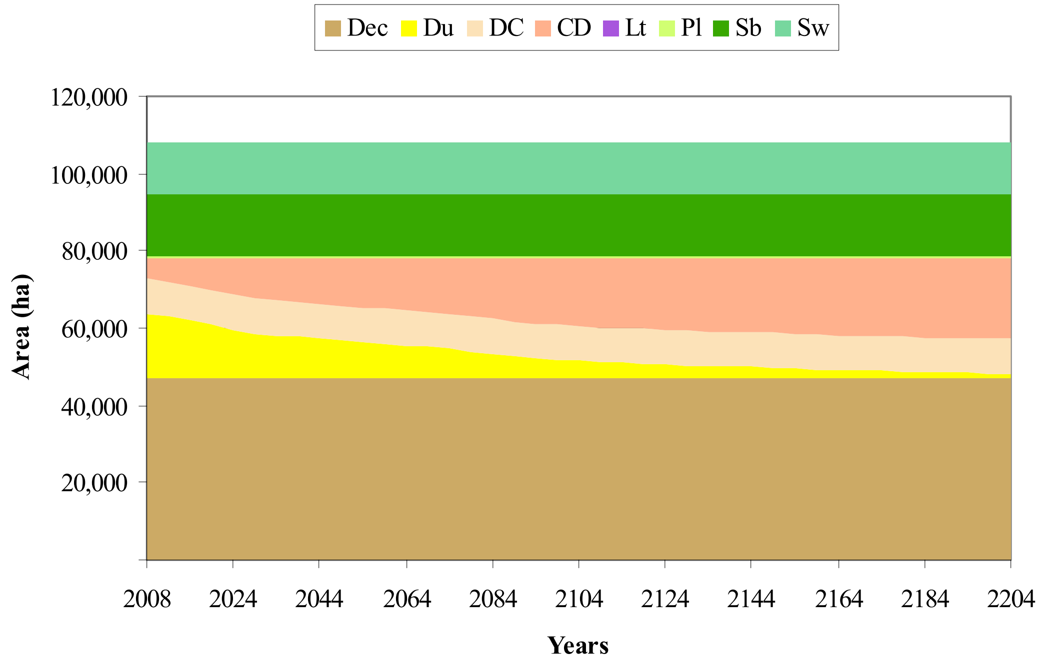


Figure 13. **Area by strata on the gross landbase.**

The managed landbase is similar to the forested landbase but there is a lower proportion of black spruce (Figure 14).

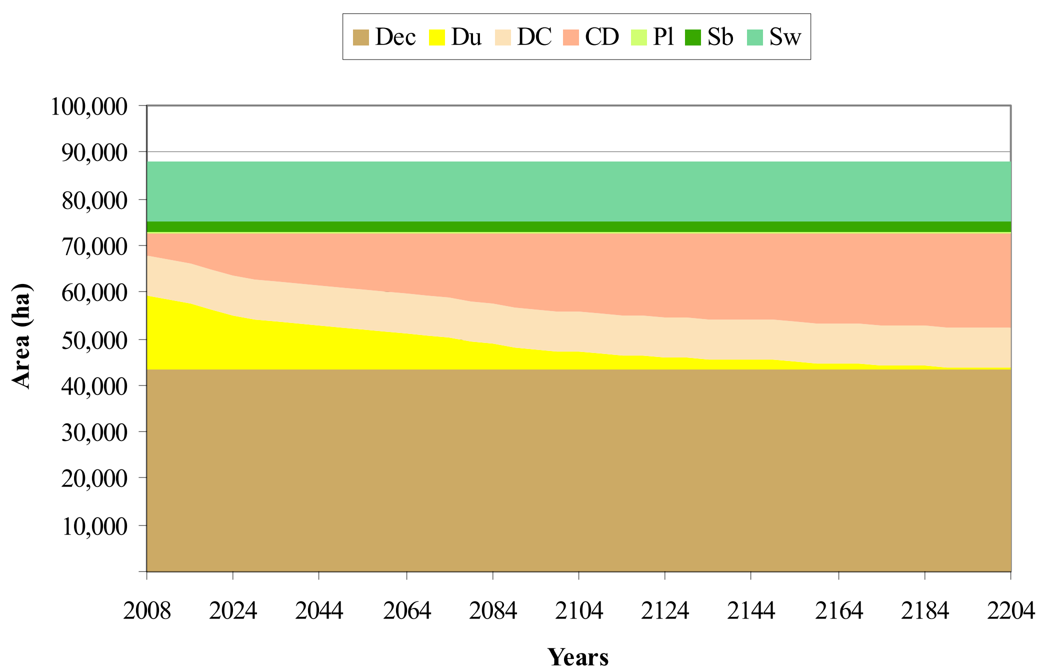


Figure 14. **Area by strata on the managed landbase.**

6.5.2 Stand Origin

At the beginning of the planning horizon, stands in the P14 FMU are predominantly natural, or fire origin. As harvest activity progresses, the managed landbase is converted to a managed state while the remainder of the gross landbase remains as natural origin (Figure 15 and Figure 16).

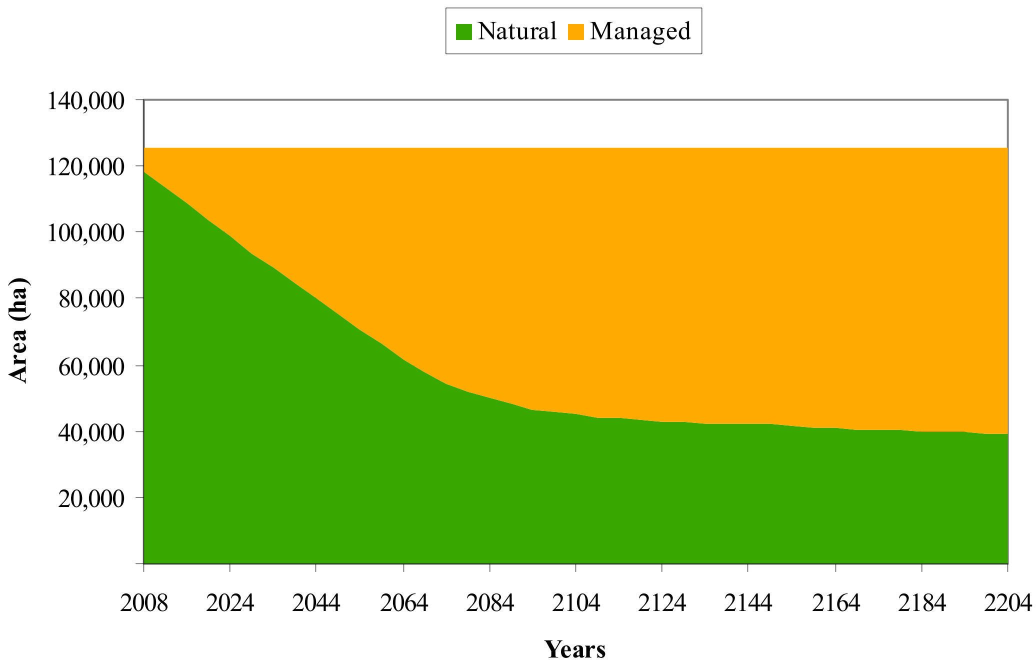


Figure 15. Area by origin on the gross landbase.

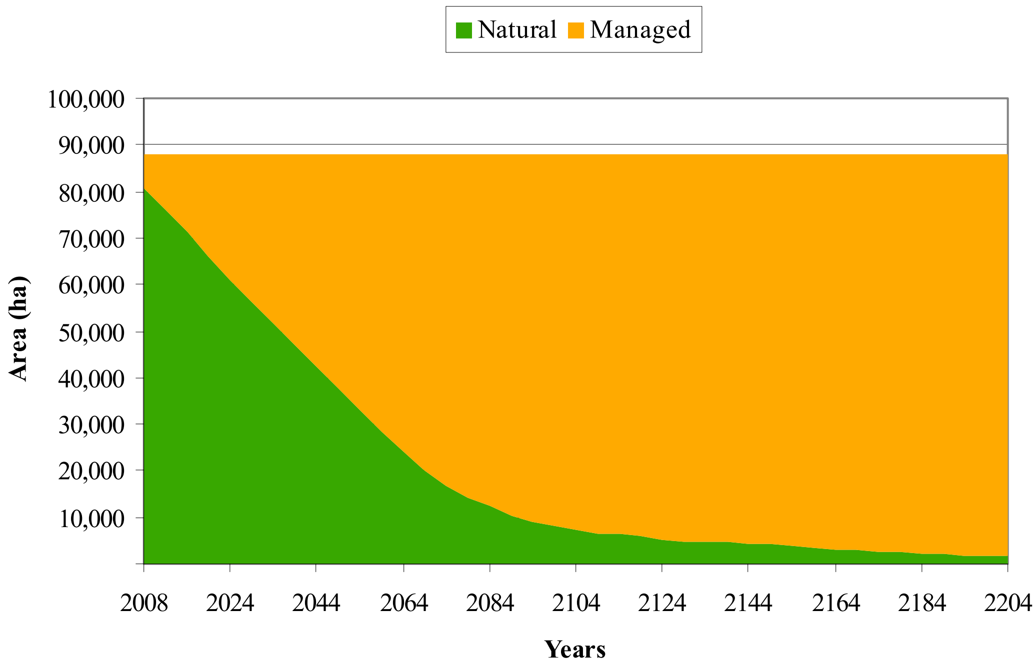


Figure 16. Area by origin on the managed landbase.

6.5.3 Age Class

As the forest moves from a natural state to a regulated state, the age class distribution of both the gross landbase and the managed landbase becomes younger. Figure 17 shows the gross landbase age class distribution over time and Figure 18 shows the managed landbase age class distribution.

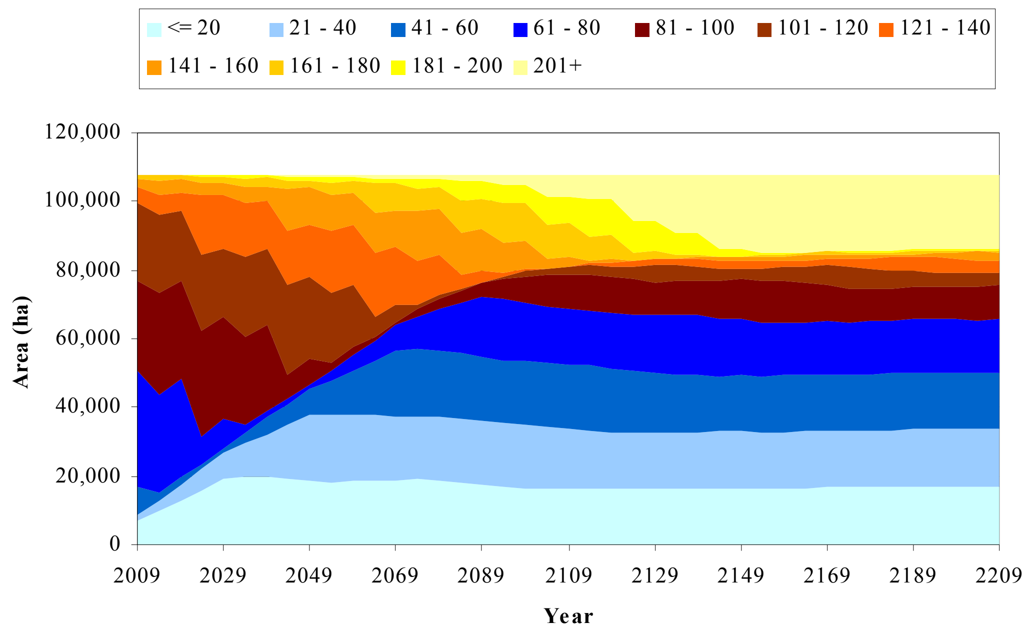


Figure 17. Area by age class on the gross landbase.

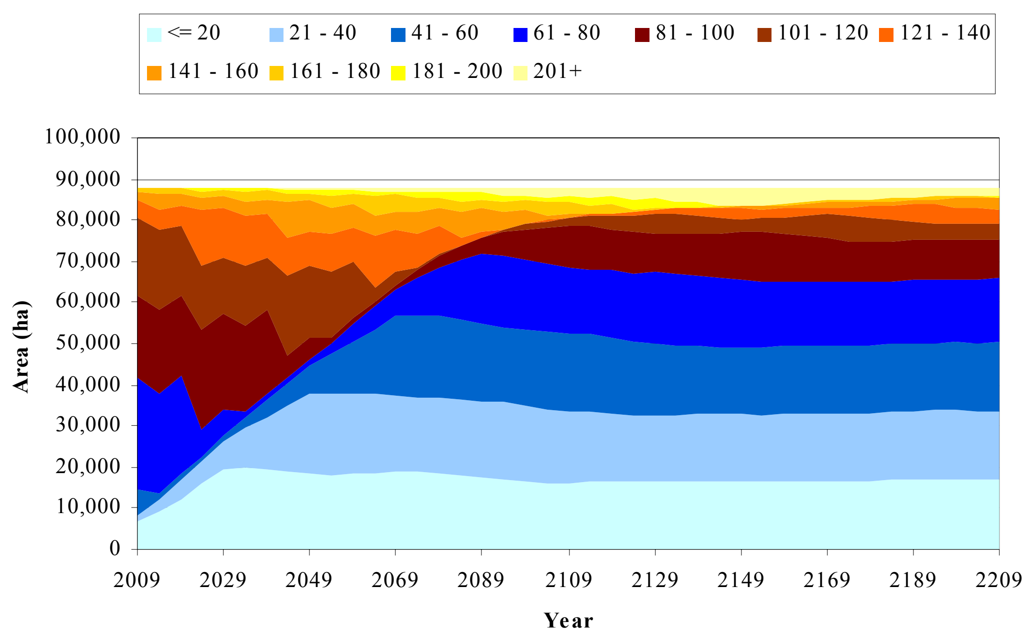


Figure 18. Area by age class on the managed landbase.

6.5.4 Seral Stage

The old seral stage was controlled in the model to maintain at least 10% of the managed landbase in the old seral stage (Figure 19).

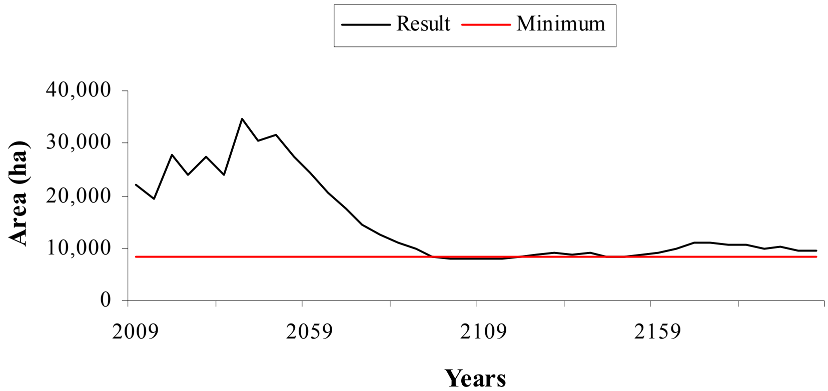


Figure 19. Managed landbase old seral stage target.

Figure 20 and Figure 21 show the seral stages of the gross and managed landbases. As the seral stages mimic the age class graphs, the trend of shifting towards a younger forest is also seen in the seral stages.

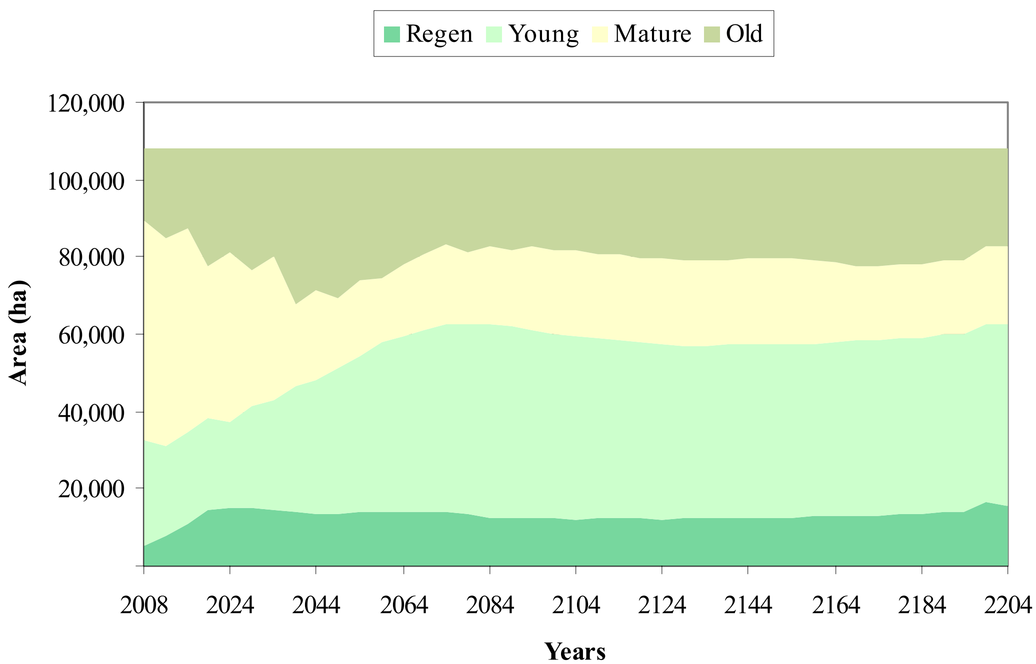


Figure 20. Area by old and mature seral stages on the gross landbase.

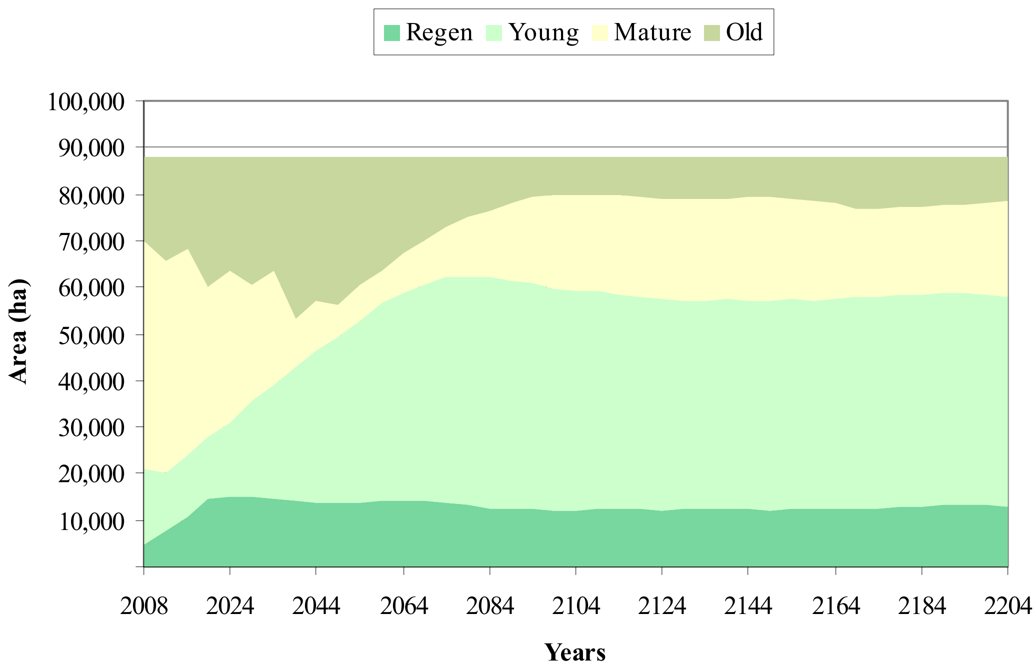


Figure 21. Area by old and mature seral stages on the managed landbase.

The old seral stage is further broken down by strata in both the gross and managed landbases as shown in Figure 22 and Figure 23. These show that the old seral stage has representation from all strata, and that the Du strata is harvested at older ages. This is due to the management strategy of harvesting the Du strata for the conifer component, which is inherently older at max MAI than the other strata.

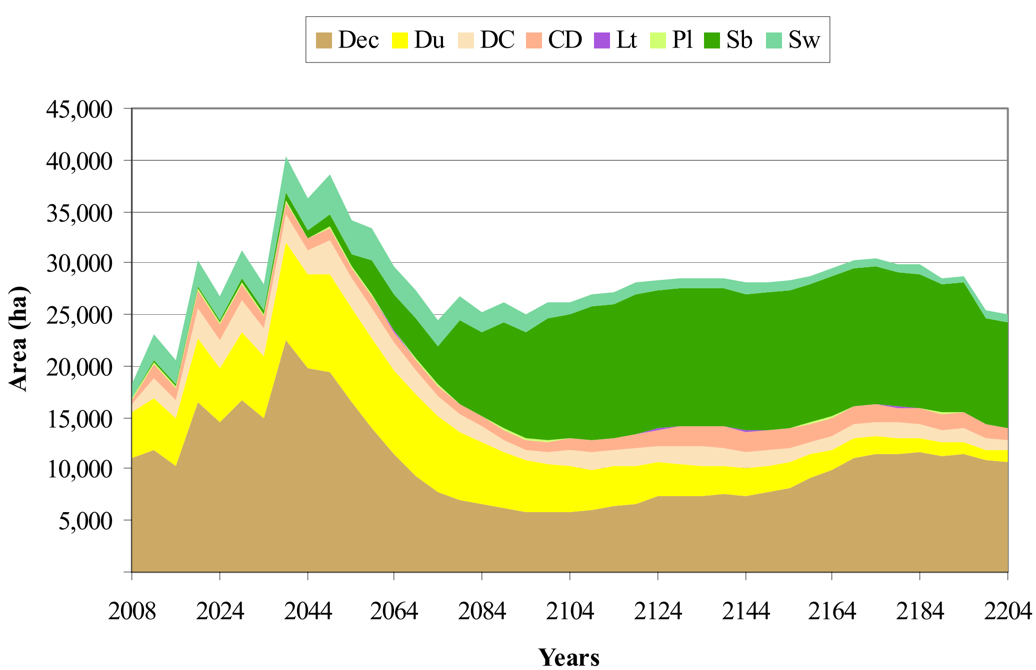


Figure 22. Area of strata in the old seral stage on the gross landbase.

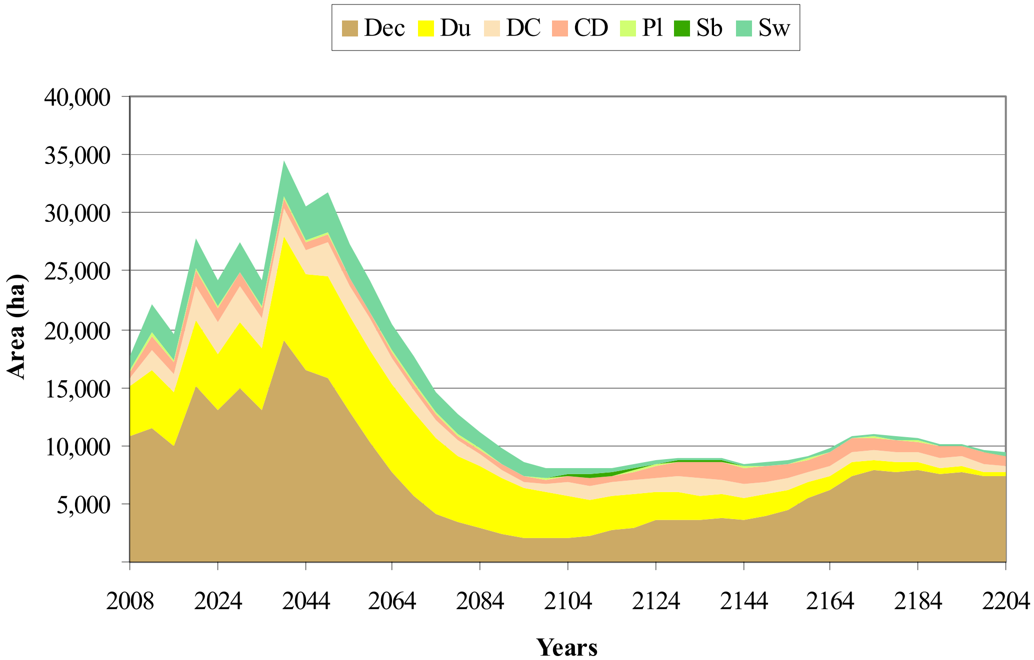


Figure 23. Area of strata in the old seral stage on the managed landbase.

6.5.5 Mountain Pine Beetle

Until the summer of 2009, mountain pine beetle was not considered a serious threat in P14 due to its northern location outside of the infestation area and the little amount of pine in the unit. For these reasons, a mountain pine beetle plan was not considered for this FMP. None the less, steps were taken to reduce the amount of mature pine by focusing harvesting on pine where possible. This strategy remains valid even with the arrival of mountain pine beetle in the area from the flight of 2009. The potential impact from mountain pine beetle on the unit remains small.

As discussed in section 5.3.10, the P14 FMP used two categories to determine the pine stands susceptible to mountain pine beetle infestations. Since the area of pine stands on the landbase is small, there was little priority placed on sequencing them first. However, two targets were lightly weighted to allow the model to choose the pine stands first if all other objectives were met. Figure 24 and Figure 25 show the pine targets for the 'PINE' and DEC_PINE' stands. The two dips in the maximum value show the 10 year and 20 year targets of reducing the standing area on the landbase. A reduction from 3,734 ha to 2,428 ha (35% reduction) in the PINE type and a reduction from 97 ha to 23 ha (76% reduction) in the DEC_PINE types was achieved.

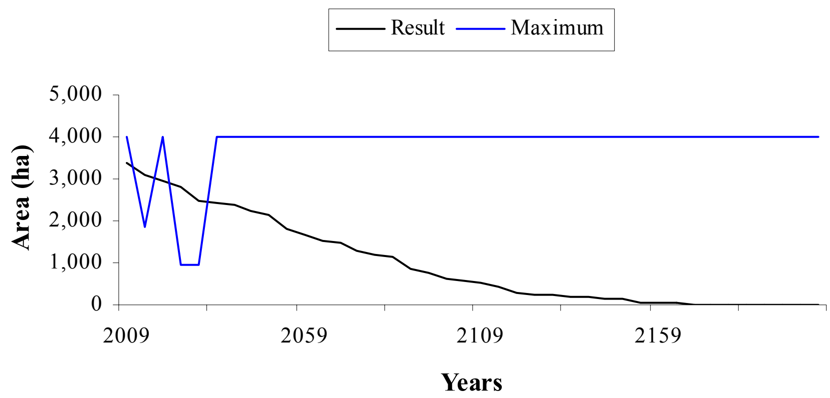


Figure 24. Target for existing 'PINE' stands.

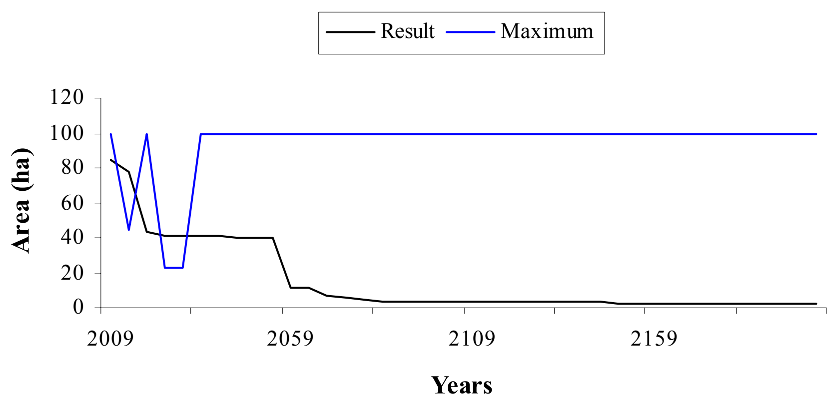


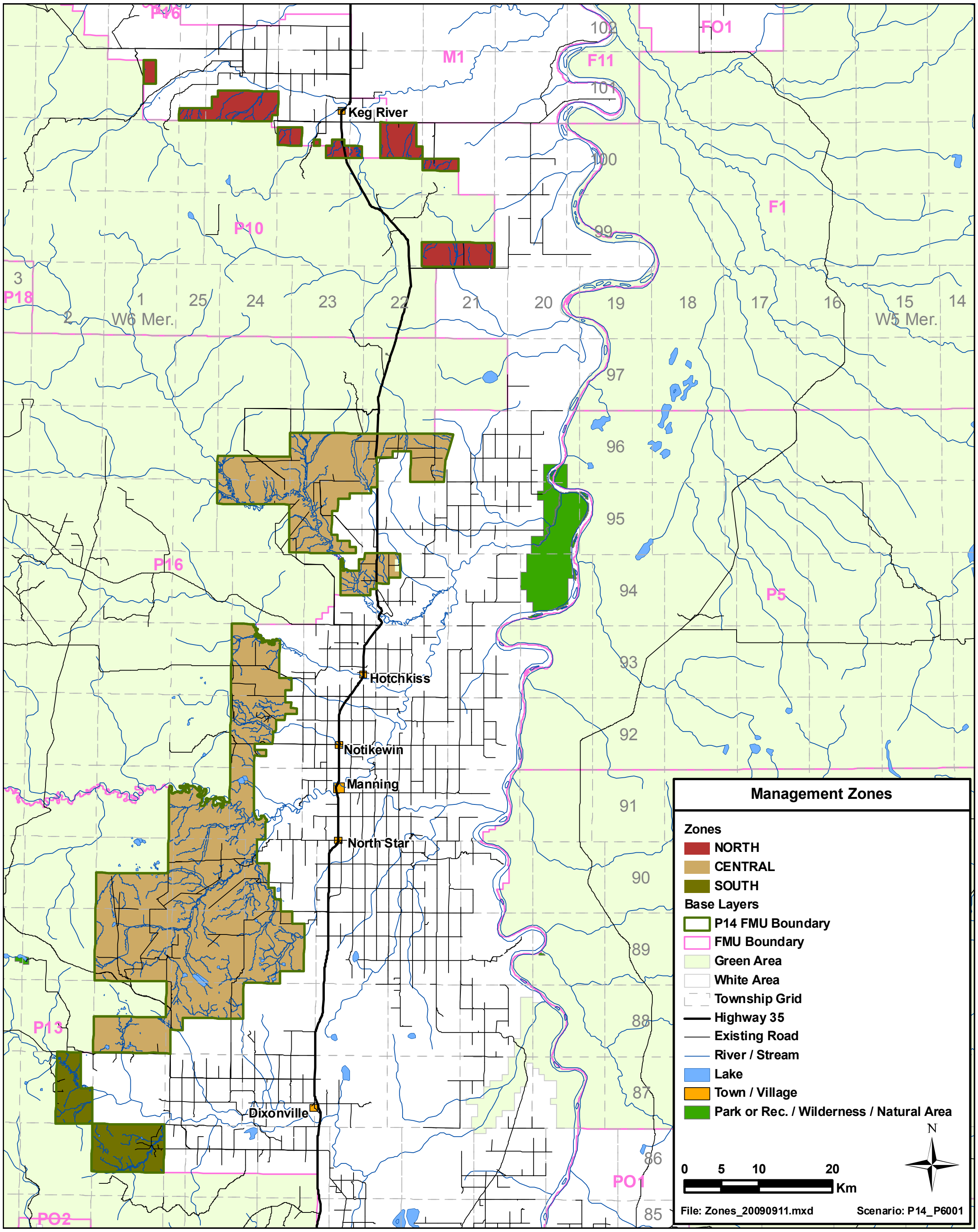
Figure 25. Target for existing 'DEC_PINE' stands.

6.6 Operational Constraints

The operational constraints used in the model were added strictly to control model behaviour so that the outcome was more operational or realistic. The only constraints that apply to operations are specifically stated in the FMP and in other documents such as the operating ground rules. Operational constraints were designed to create an operationally acceptable harvest pattern on the landscape by balancing several competing objectives. Many of the targets are constrained lightly and are designed to move the SHS towards an operationally feasible solution while still meeting other objectives.

6.6.1 Zone Control

Many of the spatial constraints are split into three zones to facilitate different desired block patterns in each zone. The central zone is the bulk of the area and is primarily focused in the grouping of operations. Based on consultations, the north and south zones are more sensitive to the local populations and their desire to slow down the harvest and to restrict large groupings of harvest blocks. These zones are shown in Map 5.



Map 5. Zones used in spatial constraints.

To control the amount of volume harvested in the north and south zones during the 20 year SHS, targets were set to control the amount of merchantable volume remaining in each zone at year 10 and year 20.

The level of merchantable growing stock was set to be approximately the same as the initial merchantable growing stock for each zone. These are shown as the pinch points between the minimum and maximum target lines in Figure 26 for the north zone and Figure 27 for the south zone.

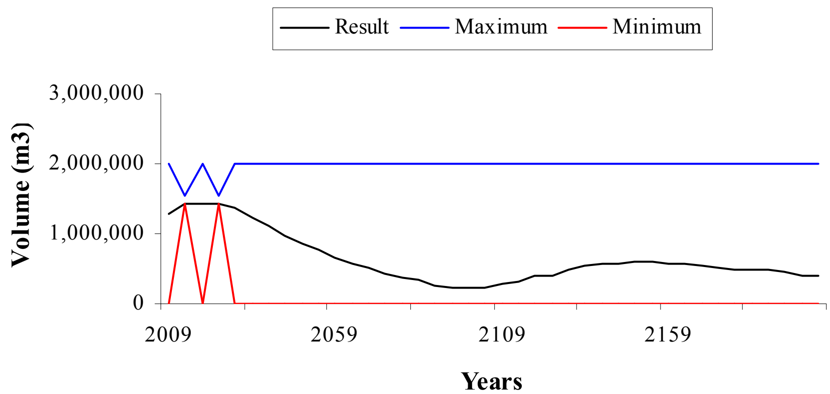


Figure 26. North zone growing stock target.

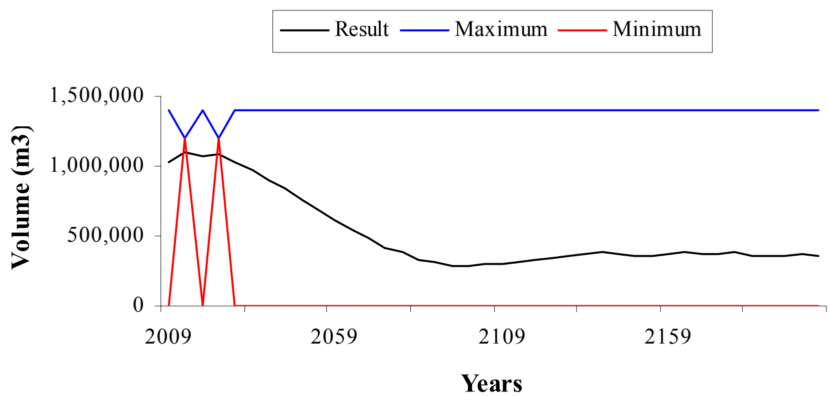


Figure 27. South zone growing stock target.

To control the harvest level after the first 20 years, maximum harvest area targets were implemented for the north and south zones. These allowed control over the rate of harvest in these zones after the SHS, but without the complexity of growing stock control.

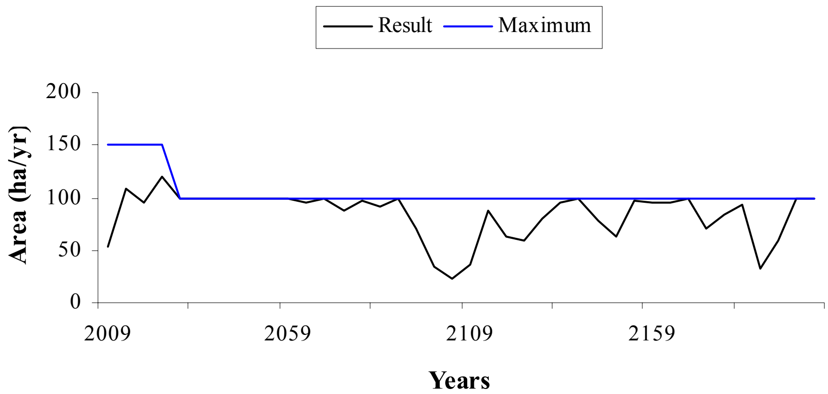


Figure 28. North zone harvest area target.

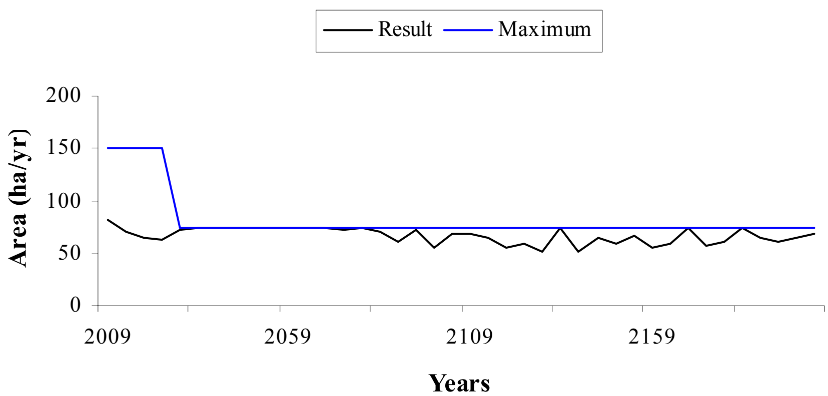


Figure 29. South zone harvest area target.

6.6.2 Annual Harvest Patches

Annual harvest patches were implemented to encourage the model to cluster the stands of each years harvest in an effort to simulate the harvest patterns of annual camps that are not limited to hard-coded operating unit boundaries. The values that the targets are set at are not weighted heavily, and are meant to push the model towards having grouped patches, but not be an overriding factor. The topology distance was set to 200 m

In the central zone, two patch targets were implemented, 100+ ha (Figure 30) and 250+ ha (Figure 31), and were constrained to minimum levels, with a heavier weighting in the first 20 years of the planning horizon.

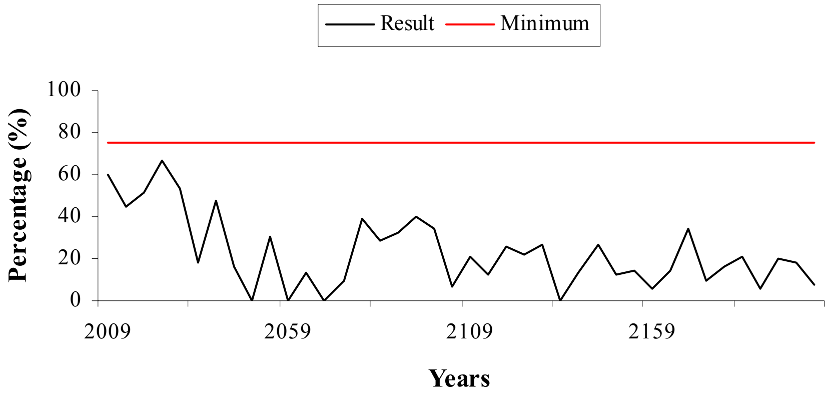


Figure 30. Annual patches in central zone > 100 ha

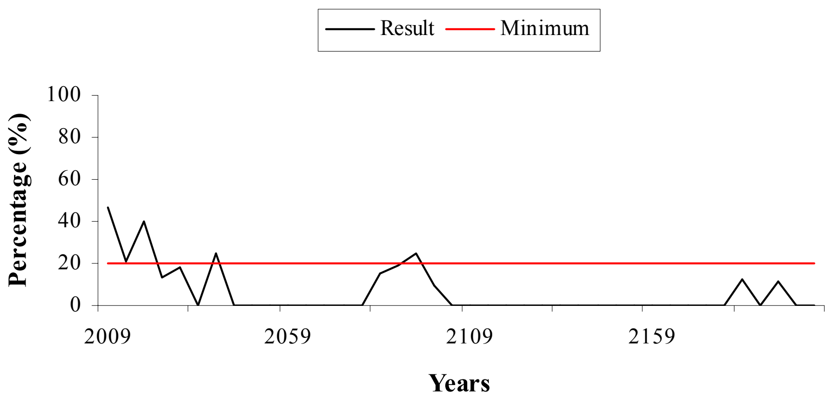


Figure 31. Annual patches in central zone > 250 ha

In the north and south zones, a single patch target of 40+ ha was utilized to create smaller clusters of blocks (Figure 32) but was weighted much less to allow the spreading out of blocks.

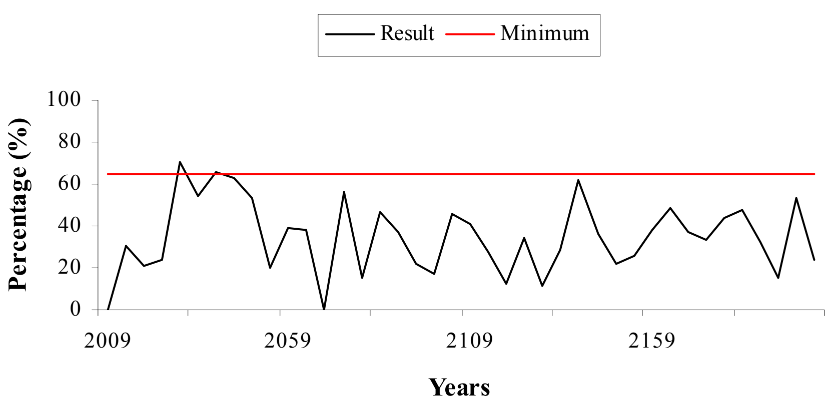


Figure 32. Annual patches in north and south zones > 40 ha

6.6.3 Operational Leave Patches

Operational leave patches are implemented to ensure that the forested stands remaining after each year of harvest are large enough to be worth returning for. All stands in the managed landbase that are not in the regen seral stage contribute to this patch target. The maximum value is set at 2% and is weighted heavily to reduce the number of operable patches that are less than 40 ha in size (Figure 33).

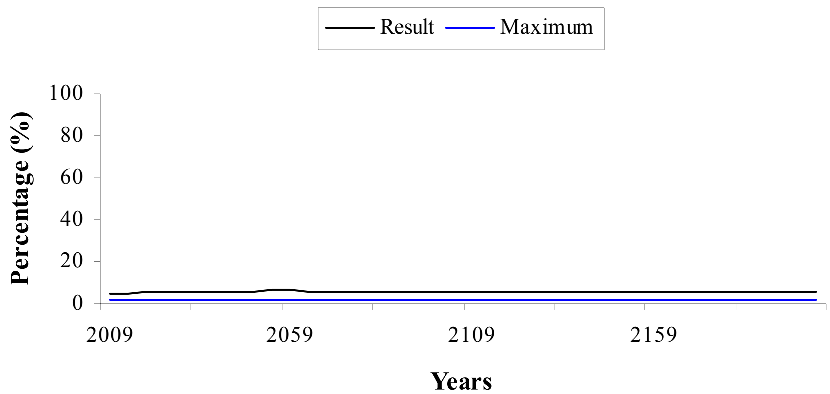


Figure 33. Leave patches less than 40 ha which are older than the regen seral stage.

6.6.4 Operating Units

Operating units were developed for the P14 FMU for modeling purposes. None of the operators use operating units for actual planning purposes, but they are in the forecasting model to add realism to the harvest sequence after the 20 year SHS period and to retain operational patterns into the future to avoid overstating future harvest levels. These units are not used for reporting purposes nor have they been scrutinized by the companies operating in P14.

This methodology is computationally simpler than the annual patches described in section 6.6.1 and therefore is used for the post SHS analysis to reduce the model size. Figure 34 shows the area of operating units that are open in each year of the scenario and clearly shows that it was not heavily constrained in the first 20 years, but was used in the last 20 years to mimic operational constraints.

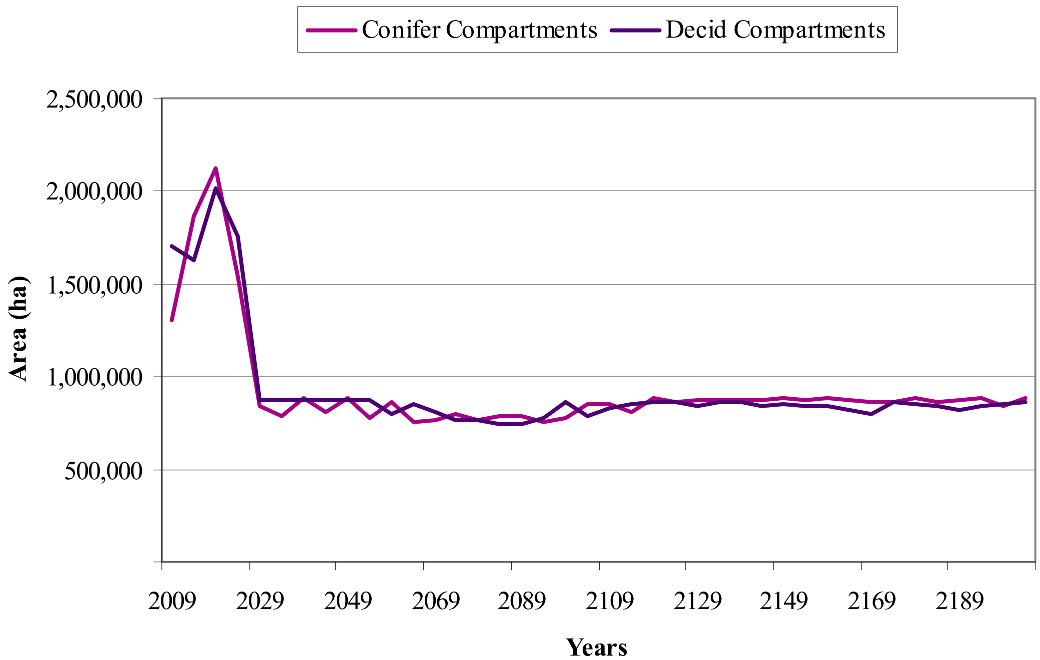


Figure 34. Operating unit area that is open in each year.

6.6.5 Greenup Patches

The greenup target was only used in the first 20 years to partially offset the success of the grouping mechanisms in certain areas within the SHS. The target constraint shown in Figure 35 shows that this target effectively eliminated all greenup patches greater than 1,000 ha.

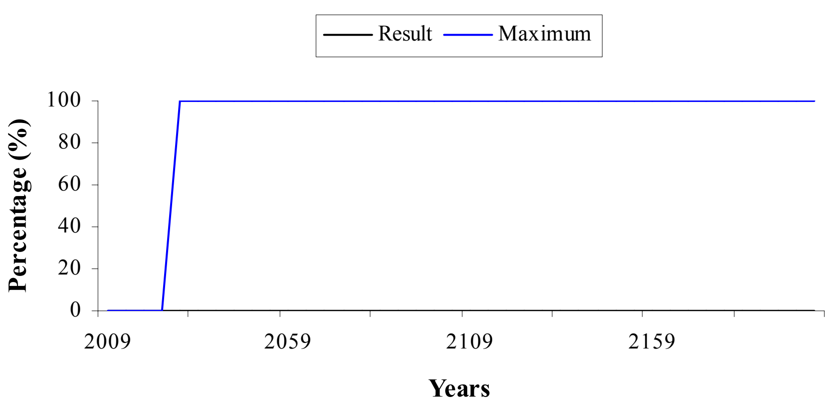


Figure 35. Patch target for greenup stands greater than 1,000 ha.

6.6.6 Opening Patch Size

The opening patch sizes were constrained so that at least 90% of the blocks would be in opening patches of 2 to 200 ha. The 0-2 ha size class was constrained to zero, but due to spatial arrangement of managed landbase polygons, a very small percentage of the area is in this size class. The resulting opening size classes are shown in Figure 36.

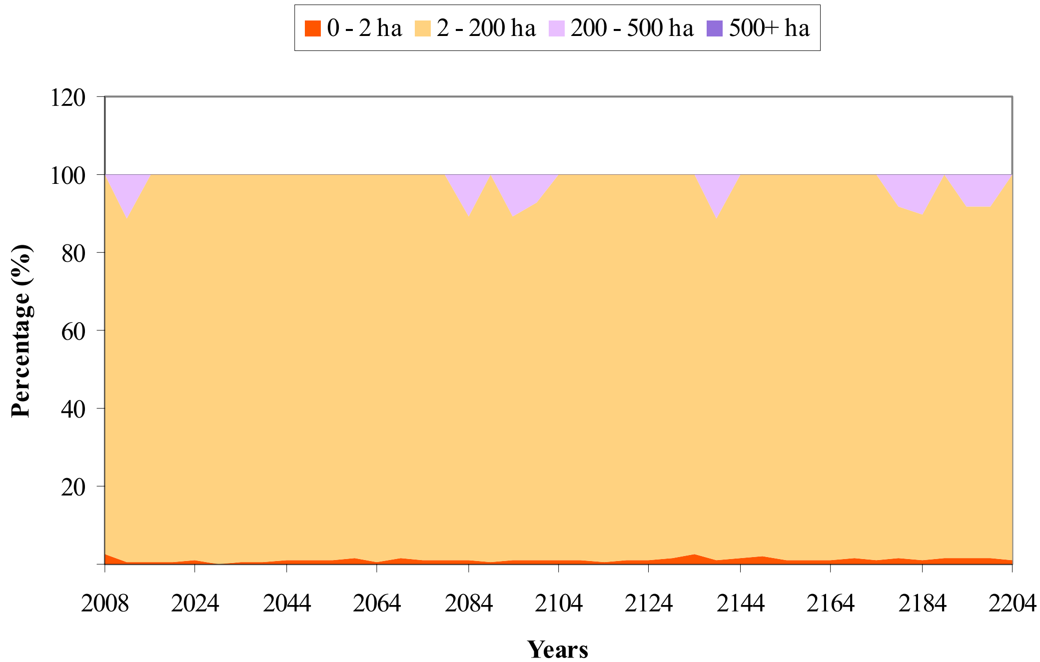


Figure 36. Opening patch sizes.

6.7 Interior Core Patches

The true interior core patch target required in the SRD planning standard is more complex than what can be included in the modeling framework. A proxy that created patches larger than what is required is used instead. In the model, core patches are made up of mature and old seral stages on the gross landbase, and a target that 75% of the old and mature forest must be in patches greater than 150 ha (Figure 37).

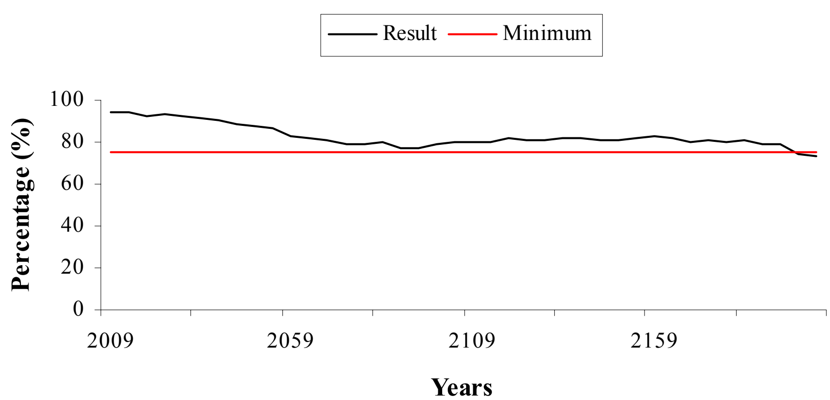


Figure 37. Old forest core patches greater than 150 ha.

7. Management Issues

There were only four management issues that arose during the development of the plan that were addressed by forecasting. Two were yield curve based and two were model based. The management issues addressed through forecasting were:

- Inconsistencies in volume between strata;
- Impact of old growth and growing stock;
- Final yield curve impact; and
- Deciduous drop down scenario.

7.1 Yield Curve Inconsistencies

7.1.1 Question

What is the effect on harvest level of modifying the Round 1 yield curves to address the three inconsistencies identified with the yield curves? Inconsistencies were addressed by creating the following modified curves:

1. Combining the two mixedwood yield curves (CD and DC) into a single mixedwood curve;

2. Capping conifer and deciduous volume within the DC stratum at 150 m3/ha; and

3. Capping the incidental conifer volume in the pure deciduous stratum (DEC) at 50 m3/ha.

Action Undertaken

Modify the existing Round 1 yield curves and undertake Woodstock-based sensitivity analysis and compare the results of the initial and modified yield curve sets.

7.1.2 Background

The P14 FMU volume sampling plot distribution did not generate empirical yield curves with the expected differences in volume between coniferous and deciduous components and for some strata, the trajectories were not biologically realistic. The primary cause is the limited distribution of plot ages within a stratum, which in some cases spans only a 40 year period. The resulting yield curve formulations are atypical for several of the strata. Without additional plot data, the choices were to modify the existing curves using professional judgement, combine strata or use yield growth models to create or modify the curves. To provide direction to the PDT on the most reasonable approach, a sensitivity analyses was undertaken to examine the impact on harvest levels when the DC, CD and DEC curves are either amalgamated or modified to better reflect forest growth. If impacts from the yield curve assumptions are small than there is little risk to forest sustainability.

7.1.3 Methodology

Four timber supply scenarios were created using an interim landbase (landbase#2), the modified yield curves and the non-spatial Woodstock modeling environment. A summary of area by strata is shown in Table 18.

Table 18. Landbase#2 area by stratum.

Strata	Managed Landbase Area (ha)
Dec	42,985
Du	15,677
DC	7,403
CD	3,194
Pl	753
Sb	1,993
Sw	11,842
Total	83,846

The yield curves and the modifications for the four scenarios are described below.

Baseline scenario

The full set of Round 1 yield curves were used in the baseline scenario but only the yield curves under investigation in this sensitivity analysis are shown in this section. The three yield curves which were later replaced are shown in Figure 38, Figure 39 and Figure 40.

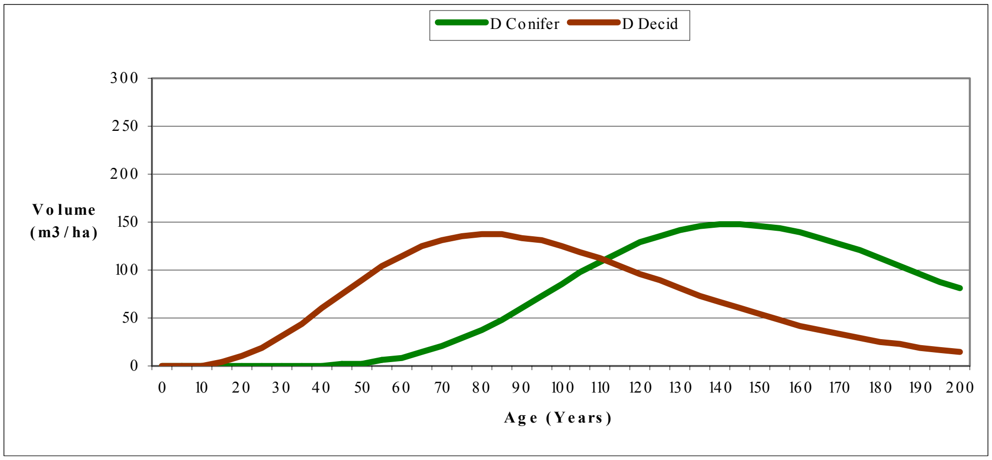


Figure 38. Pure deciduous (DEC) stratum baseline curves.

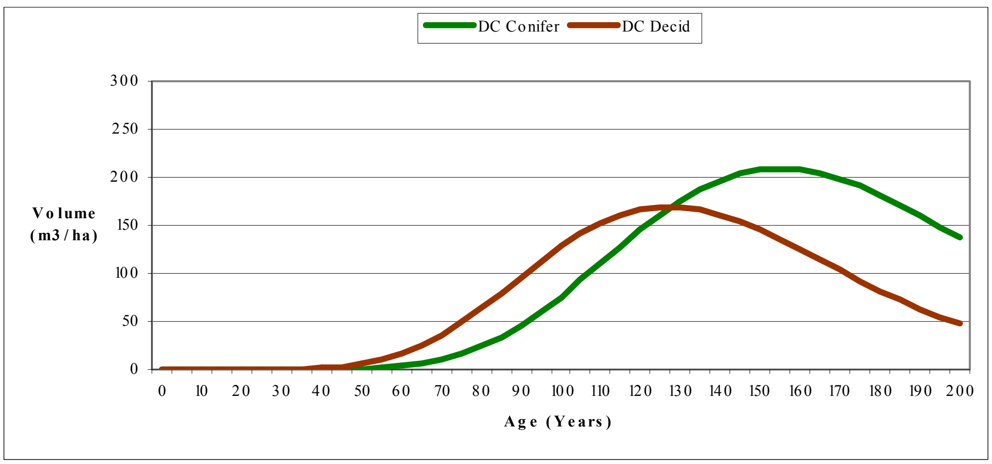


Figure 39. Deciduous leading mixedwood (DC) stratum baseline curves.

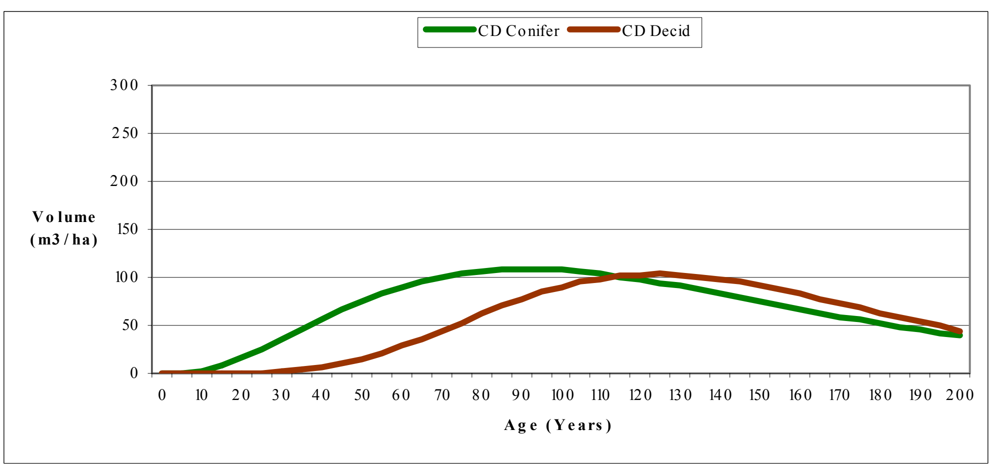


Figure 40. Coniferous leading mixedwood CD stratum baseline curves.

Combined mixedwood scenario

The Mixedwood scenario was created to address the higher conifer yields predicted in the DC stratum compared to the CD stratum. This scenario employed a single mixedwood yield prediction derived by combining the plots of both the DC and CD strata to create a single mixedwood yield curve which replaced both the DC and CD yield curves (Figure 41). All other curves and assumptions remained the same as the baseline scenario.

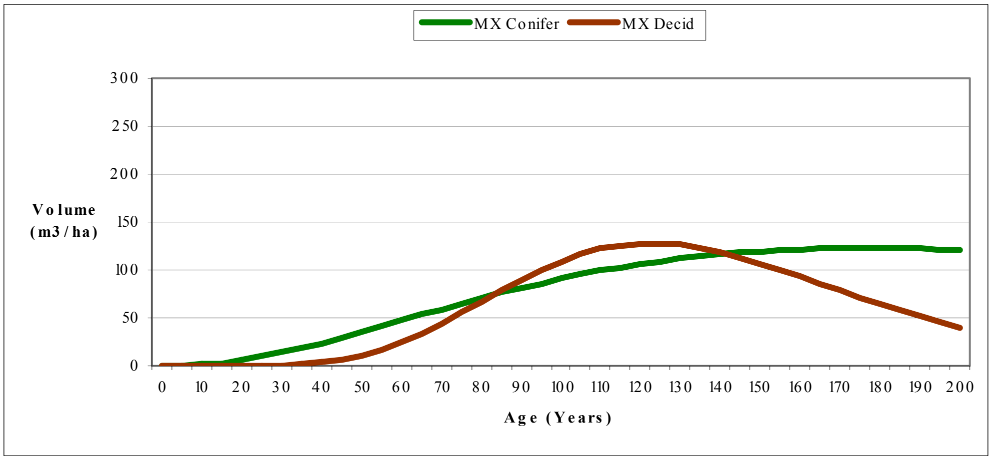


Figure 41. Combined mixedwood (MX) stratum curve.

DC strata cap scenario

The DC strata cap scenario was created to address the conifer yield which was much higher in the DC stratum than the CD stratum. This scenario replaced the Round 1 DC yield curves with the same yield curves but which were capped at 150 m^3/ha (Figure 42). All other curves and assumptions remained the same as the baseline scenario.

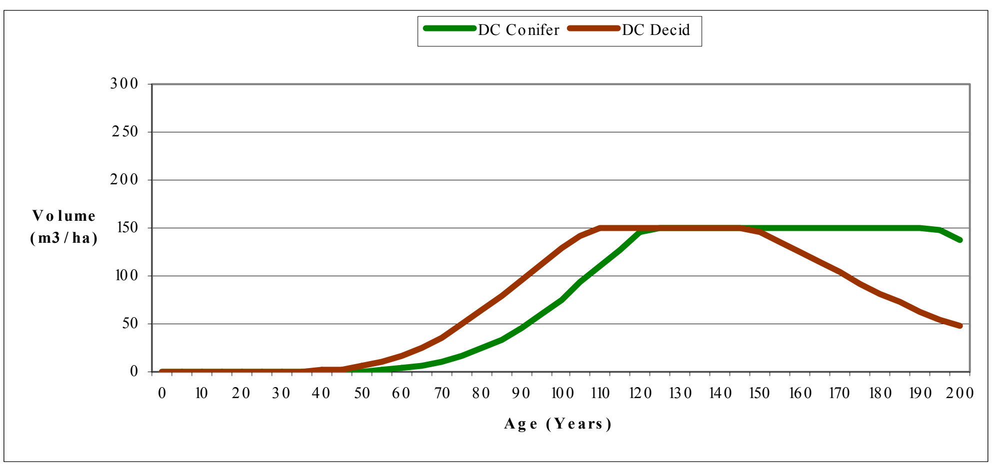


Figure 42. DC strata with 150 m^3/ha cap.

DEC strata cap scenario

The DEC cap scenario was created to better represent the species volumes produced from regenerating pure deciduous stands under the current regeneration standards. This scenario replaced the DEC strata yield curve with a new curve where the conifer component was capped at 50 m^3/ha (Figure 43). The deciduous component remained the same as the baseline scenario as did all the other yield curves and assumptions. The revised curve was applied to both the natural landbase and to the regenerating landbase.

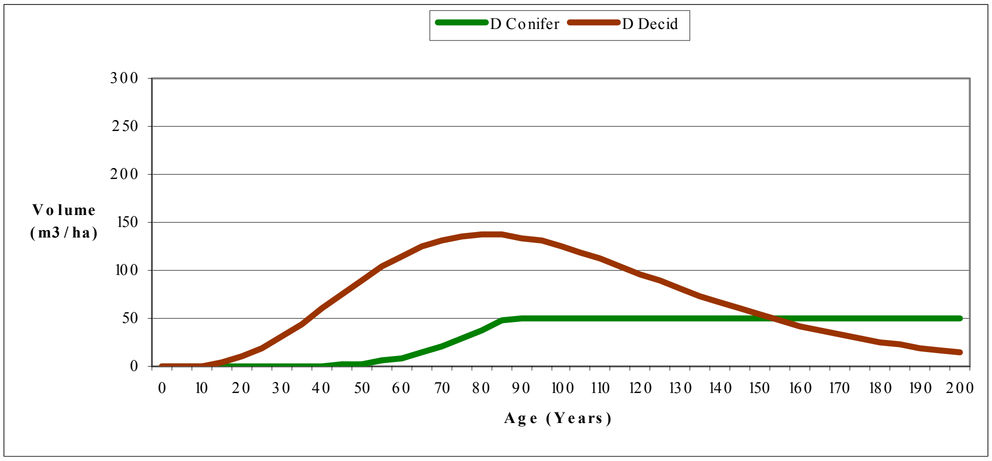


Figure 43. DEC strata with 50 m^3/ha cap on conifer component.

7.1.4 Model Assumptions

The primary assumptions used in all scenarios were:

- 200-year planning horizon;
- Round2 landbase, with less managed area than the final landbase as ARIS information for old blocks was not yet incorporated;
- Round1 yield curves with cull and stand retention applied;
- Evenflow both primary coniferous harvest volume and primary deciduous harvest volume;
- Maximize total primary harvest volume;
- Non-declining yield of coniferous and deciduous growing stock for the final 50 years; and
- Non-spatial model, no other constraints applied.

7.1.5 Results

All of the assumptions in the sensitivity analysis are conservative, result in lower harvest levels and are applicable to either the conifer landbase or the incidental conifer volume. No assumptions were made that impacted primary deciduous volumes. For the four scenarios described above, even flow primary harvest levels and the average secondary harvest volume over the first 20 years of the planning horizon are shown in Table 19.

Table 19. Comparison of harvest levels using different yield curves.

		Harvest Level - From 2009 To 2028			
		Primary		Secondary	
		Conifer	Deciduous	Conifer	Deciduous
Name	Scenario Description	m3/yr	m3/yr	m3/yr	m3/yr
Base	Base run for testing yield curves	56,669	63,911	83,182	65,266
Mixedwood	Combined CD and DC curves into one mixedwood curve	49,379	63,911	83,182	94,058
DC Cap	Cap on both components in DC strata of 150 m3/yr	54,535	63,911	83,182	66,042
DEC Cap	Cap on conifer component in DEC strata to 50 m3/yr	56,669	63,911	33,002	65,266

In the mixedwood scenario, the conifer primary volume decreases by 13.4% while the deciduous incidental volume increases by 45% from the baseline scenario. This is due to the conifer MX curve rising slower and is generally lower than both the CD or DC conifer curves. The deciduous MX curve is higher than the CD deciduous curve but is lower than the DC deciduous curve. The increase in incidental volume is somewhat misleading as this volume component is not constrained in any of these scenarios and can change over the 200 years of the planning horizon.

In the 'DC Cap' scenario, the effect on harvest level is slight, probably due to the model's ability to harvest the majority of these stands before the cap takes effect.

In the 'DEC Cap' scenario, the only impact is that the coniferous incidental volume drops 60%. The drop in conifer volume is attributed to the significant reduction in the conifer component of the DEC curve.

7.1.6 Discussion

The underlying problem addressed by this analysis is that the plot data does not generate the expected relationships due to the low number of plots in each stratum and the narrow age range of the plots. This analysis demonstrates that changes to the yield curves can have large impacts on the incidental harvest volumes in the first 20 years and less impact on the primary harvest volumes.

The main discomfort with the Round 1 CD and DC curves generated directly from the plot data is that the DC stratum is nearly double the CD stratum volumes, although the volume comes later and is lower than the CD curves at the minimum harvest age of 90 years. As the forest moves to a younger and more regulated age class structure, the CD stratum will produce more volume than the DC stratum, thus the model will prefer to harvest DC stands early in the planning horizon but prefer CD stands after one rotation.

In a typical timber supply, the DC and CD curves are usually very similar in shape and volume. The combined mixedwood scenario combines the plot data for the DC and CD strata producing one single mixedwood curve. However, this curve provides less conifer volume near minimum harvest age than the CD curve and less overall volume than the DC curve. The net result is a lower conifer primary harvest volume, but a large increase in the deciduous incidental harvest volume. The DC cap scenario simply caps the DC volume at 150 m^3/yr, and the result is a similar trend but not as large as the mixedwood curve scenario.

The plot age range for the CD strata spans ages between 55 and 125 years old which is more realistic than the DC strata where the plot ages span between 55 and 105 years, with the majority of the plots being 105 years old. As a result, the tail of the DC curve after 105 years old is completely dependant on the formula used. The CD curve appears to be more realistic, so a prudent decision was to cap the DC curve and keep the existing CD curve, which reduces the primary conifer but not as much as the mixed curve does and the deciduous incidental is less variable. The decision was to apply the capped DC curves and retain the CD curve and not to use the mixedwood curve.

The case of the DEC stratum is straight forward. Without some capping or reduction in the conifer curve component, incidental volume is likely to be overestimated. Furthermore, the impact of regeneration liability will force the achievement of a level of spruce stocking in the pure deciduous regenerated blocks that does not meet regeneration standards or the stand composition of pure deciduous stands. The outcome would be higher regeneration costs, a shift to conifer landbase and a shift in biodiversity. Applying a curve that better meets the biological and regeneration standards for the conifer component will reduce the modelled secondary conifer but may more realistically represent the actual volumes that will be recovered from pure deciduous stands.

The decision was to apply capped DEC curves with the incidental conifer volume component capped at 50 m^3/ha.

7.2 Old Growth and Growing Stock Impacts

7.2.1 Question

What is the effect on harvest level of increasing the level of deciduous operable growing stock and old forest on the managed landbase? Can current DTA levels be maintained with higher levels of deciduous growing stock and old growth in the future?

Action Undertaken

Examine a set of scenarios with and without targets on old growth and deciduous growing stock.

7.2.2 Background

Deciduous harvest levels will be lower under ecological management protocols, new forest inventory and yield projections. Deciduous harvest levels are constrained by the current unbalanced age class structure of the forest which has limited amounts of young forest present. This translates into growing stock limitations approximately 60 years in the future.

To achieve the harvest levels of the current DTA commitment, old growth and deciduous operable growing stock levels are low in 60 years. The choice was to either reduce the deciduous harvest level or accept the low primary deciduous growing stock and deciduous old growth levels. This sensitivity analysis investigates the impacts on harvest levels of greater amounts of deciduous growing stock and old growth. Conifer growing stock does not suffer from the same low growing stock and old growth levels as deciduous growing stock and was not investigated.

7.2.3 Methodology

Three timber supply scenarios were created as described below.

Baseline scenario – P14_P2003
The goal of this scenario is to achieve the current DTA commitment of roughly 50,000 m^3/yr deciduous harvest level. The growing stock and old growth targets are slightly constrained, but the harvest level is the over-riding target.

Growing stock scenario – P14_P2004
The growing stock scenario forced the deciduous growing stock to be above 1 million m^3, for the entire planning horizon, which is roughly 25% of the initial growing stock of 4 million m^3. A drop down in deciduous harvest volume after the first 20 years was required to achieve the DTA commitment and the growing stock level.

Old growth scenario – P14_P2005

The old growth scenario forced the total managed landbase to maintain at least 10% of the managed landbase as old seral stage forest. This scenario required a drop down in deciduous harvest volume after the first 20 years to achieve DTA commitments.

7.2.4 Model Assumptions

The primary assumptions used in all scenarios were:

- 200-year planning horizon;
- round3 final landbase;
- round2 yield curves with cull and stand retention applied;
- even flow both primary coniferous harvest volume and primary deciduous harvest volume;
- maximize total primary volume harvest;
- non-declining yield of coniferous and deciduous growing stock for the final 50 years; and
- spatial model with harvest and core forest patch targets.

7.2.5 Results

The Patchworks model for P14 contains one year periods for the first 20 years and five year periods for the remainder of the planning horizon. To highlight this, the output graphs show a grey vertical break line dividing the greater detail of the first 20 years from the rest of the years.

Figure 44 compares deciduous growing stock over the planning horizon for the three scenarios. In all three scenarios, growing stock is most limited between the years 2069 and 2089. This limitation is the result of the small amount of area present in the younger age classes today, which translates into limited area for old growth and growing stock 60-80 years into the future.

The minimum level of deciduous growing stock is only slightly higher under the old growth scenario (P2005) compared with the baseline scenario level (P2003). However, the growing stock scenario doubles the minimum amount of deciduous growing stock.

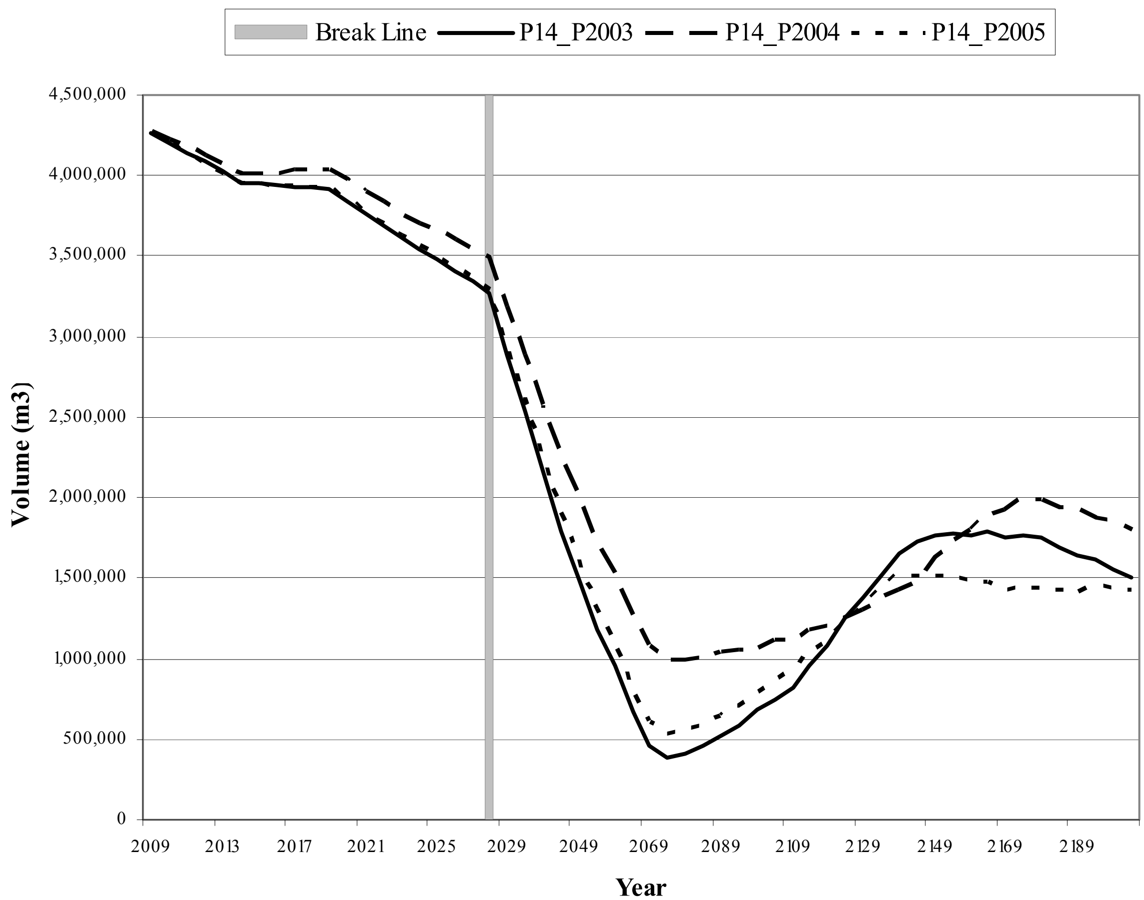


Figure 44. Comparison of deciduous growing stock.

If the managed landbase old seral stage is unconstrained, it falls to less than 2% of the total managed landbase area (P14_P2003 in Figure 45). However, if either the old growth or the deciduous growing stock targets are included, then 10% of the managed landbase can be maintained in the old seral stage.

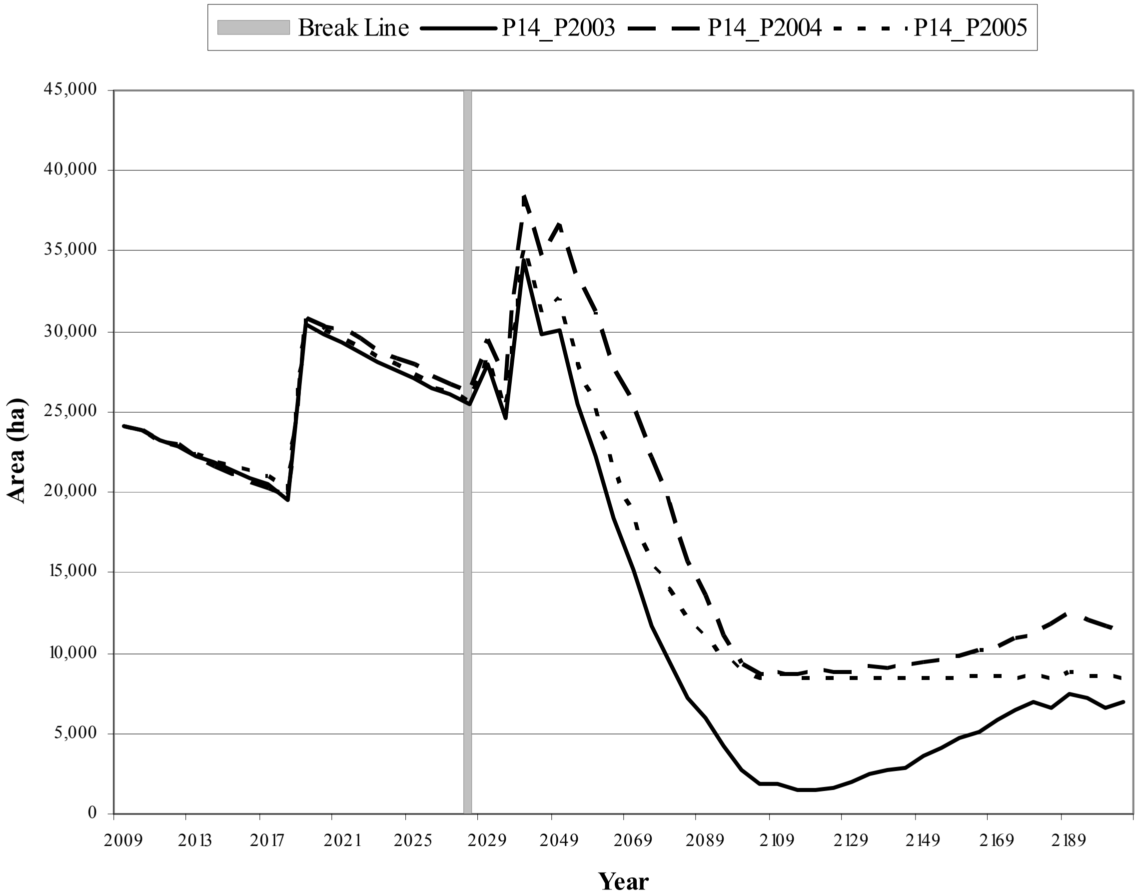


Figure 45. Comparison of managed landbase old seral stage.

Figure 46 shows the effect on deciduous harvest level as a result of the three scenarios. An even-flow harvest level that meets the current DTA allocation is only achieved in the baseline scenario (P14_P2003). The growing stock scenario (P14_P2004) shows that volumes close to the current commitment are not obtainable in any period (39,800 m^3/yr average over the first 20 years). A longer run would reduced the differences between years harvest volume over the first 20 years and would be even lower if an even-flow objective is forced. The old growth scenario (P14_P2005) maintains the 49,500 m^3/yr for the first 20 years, but then drops to 45,000 m^3/yr for the remainder of the planning horizon. The old growth scenario provides a compromise between harvest level and deciduous growing stock while being able to achieve the old growth target.

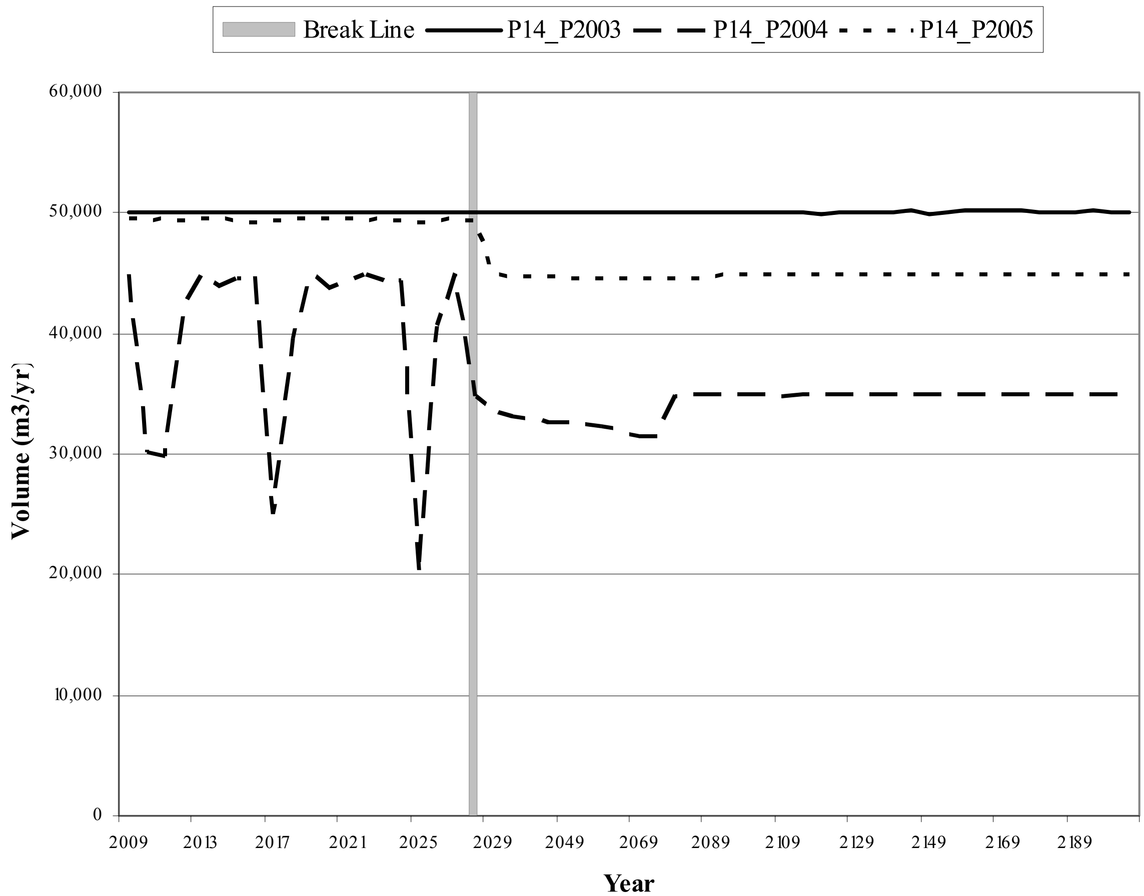


Figure 46. Comparison of deciduous primary harvest volume.

7.2.6 Discussion

Increasing the minimum levels of deciduous growing stock and old growth reduces deciduous harvest after 20 years. DTA harvest levels cannot be maintained when deciduous growing stock minimums are enforced.

7.2.7 Decision

The initial decision was to use a refined version of the old growth scenario and accept lower deciduous harvest levels. In later versions of the yield curves created by deleting plots in harvested stands, this issue was reduced when the revised deciduous yield curve was able to sustain a deciduous even flow harvest of 49,800 m^3/yr that met the current DTA target. However, a deciduous surge cut was required to meet all the current deciduous commitments (refer to the PFMS).

7.3 Final Yield Curve Impact

7.3.1 Question

What is the effect on harvest levels between three sets of yield curves created by changes to the area in the managed landbase.

Action Undertaken

Examine a set of scenarios with three different yield curve sets.

7.3.2 Background

As the landbase undergoes edits and landbase is added or removed from the non-harvested managed landbase, the number of plots associated with the managed landbase also changes. In the final landbase, a large amount of area was added back in due to ARIS information, but area was removed from the non-harvested managed landbase as block data was updated. This section examines the timber supply results from using three sets of curves.

7.3.3 Methodology

The three timber supply scenarios were created as described below.

Baseline scenario – P14_P2003
Using round 2 yield curves from landbase 2 valid stands.

scenario – P14_P3001
Curves with plots removed for recent harvest blocks. CD strata curve has changed significantly, while other curves have slight changes.

scenario – P14_P4001
Curves created with all valid pre-harvest plots put back in to generate potential regeneration curves.

7.3.4 Model Assumptions

The primary assumptions used in all scenarios were:

- 200-year planning horizon;
- Round 3 final landbase;
- Even flow both primary coniferous harvest volume and primary deciduous harvest volume;
- Maximize total primary volume harvest;
- Non-declining yield of coniferous and deciduous growing stock for the final 50 years; and

- Spatial model.

7.3.5 Results

The Patchworks model for P14 has one year periods for the first 20 years and five year periods for the remainder of the planning horizon. To highlight this, the output graphs show a grey vertical break line dividing the greater detail of the first 20 years from the rest of the years.

The three scenarios have very similar outputs for both conifer and deciduous volume and for managed landbase in old seral stages. However, the coniferous growing stock is significantly lower for the two scenarios with revised yield curves while the deciduous growing stock is a bit higher than the baseline scenario.

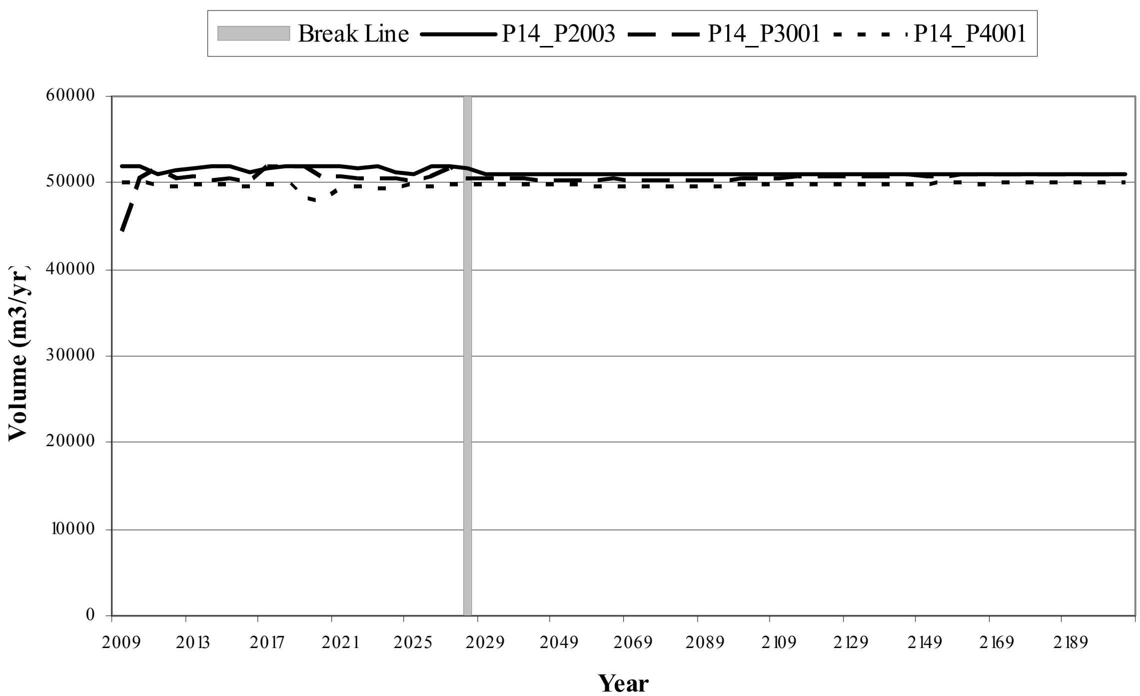


Figure 47. Comparison of coniferous harvest levels.

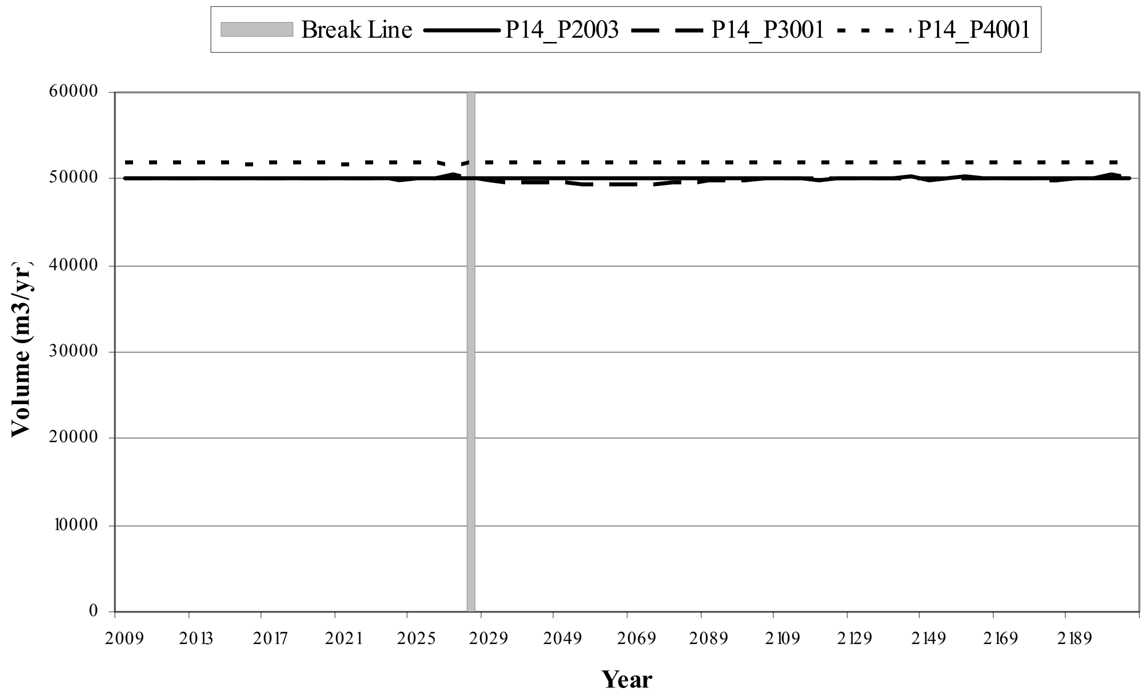


Figure 48. Comparison of deciduous harvest levels.

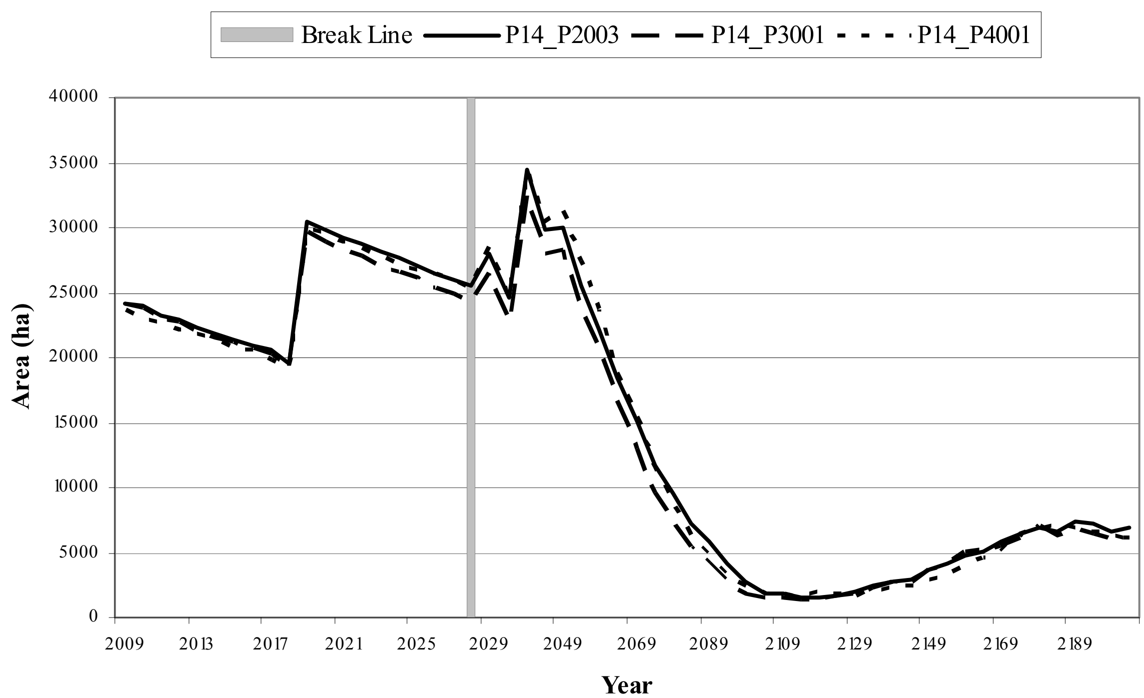


Figure 49. Comparison of old seral stage area.

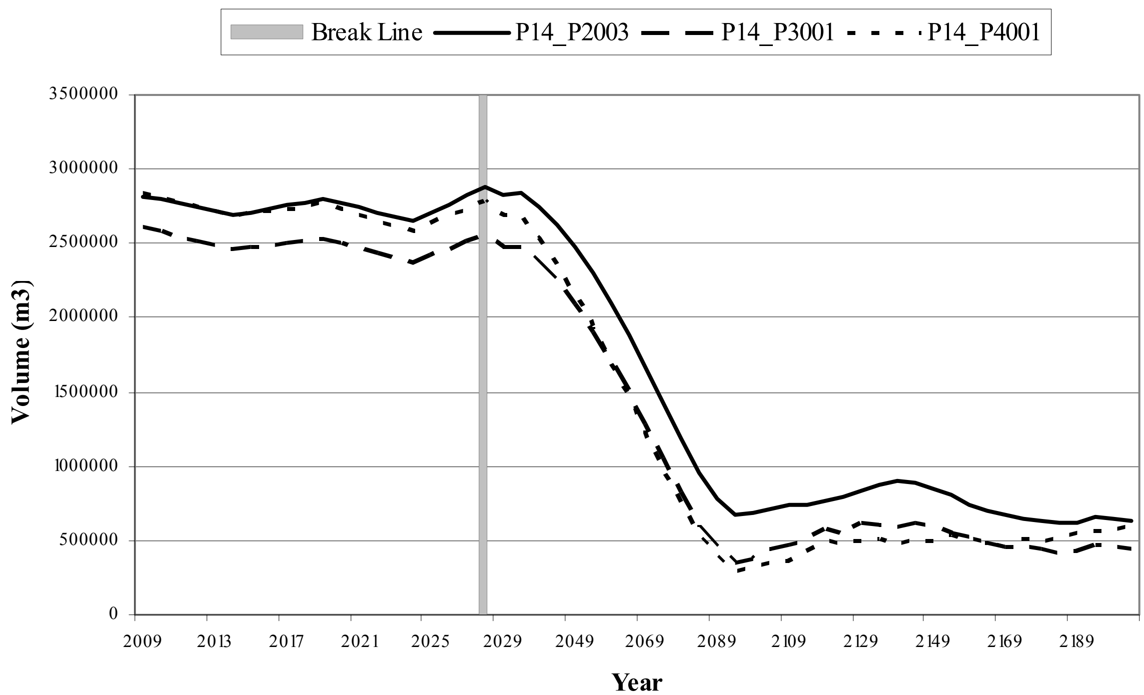


Figure 50. Comparison of coniferous growing stock.

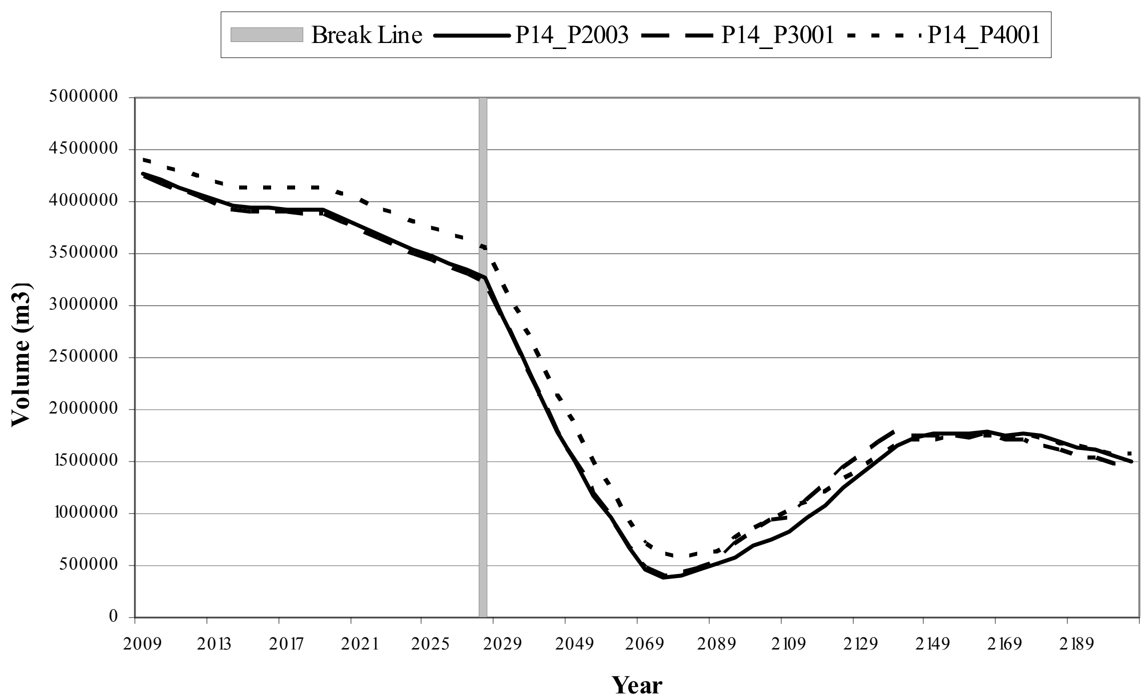


Figure 51. Comparison of deciduous growing stock.

7.3.6 Discussion

There was little concern in using the revised landbase 3 curves. They different in shape, but do not have much impact on the model's ability to achieve similar results.

7.3.7 Decision

Apply the yield curves created by following yield curve standards which do not use plots from existing harvested areas (Scenario P14_P3001).

7.4 Deciduous Dropdown Scenario

7.4.1 Question

What is the effect on the deciduous harvest level if the existing deciduous volume commitments are met for the first 20 years of the planning horizon?

Action Undertaken

Examine two scenarios: one with deciduous even flow and the other with the first 20 years set at 52,000 m^3/yr and even flow after that.

7.4.2 Background

Near the end of the planning process, it was realized that the current commitment for the P14 FMU primary deciduous volume was not 49,360 m^3/yr as previously assumed, but an additional 2,640 m^3/yr is also committed to CTPP operators for a total of 52,000 m^3/yr. This commitment was allocated through the CTPP and not by a DTA. A conifer surge cut was not investigated as even flow scenarios met current conifer allocations.

In a pure even flow environment, the model is unable to achieve the harvest level of 52,000 m^3/yr. Two very similar scenarios were created to explore the feasibility of having a dropdown in deciduous volume after the first 20 years.

7.4.3 Methodology

Two timber supply scenarios were created as described below.

Deciduous even flow scenario – P14_P6001
This is the maximum even flow harvest level that can be achieved in the final model with operational and spatial constraints and the final yield curves and landbase. This is the second choice for PFMS if the dropdown is unacceptable.

Deciduous dropdown Scenario – P14_P6002
This scenario forces a harvest level of 52,000 m^3/yr for the first 20 years. A drop down in deciduous harvest volume after the first 20 years was required.

7.4.4 Model Assumptions

The primary assumptions used in all scenarios were:

- 200-year planning horizon;
- Round3 final landbase;
- Round2 yield curves with cull and stand retention applied;
- Even flow primary coniferous harvest volume;
- Maximize total primary volume harvest;

- Non-declining yield of coniferous and deciduous growing stock for the final 50 years; and
- Spatial model with harvest and core forest patch targets.

7.4.5 Results

Table 20 and Figure 52 show the effect on deciduous harvest level as a result of the two scenarios. An even flow harvest level was achieved in the even flow scenario (P14_P6001). The deciduous dropdown scenario (P14_P6002) shows volumes that meet the current commitment are achievable for the first 20 years with a drop down of 1.5% below the even flow scenario for the remainder of the planning horizon.

Table 20. Harvest volumes for even flow and dropdown scenarios.

Analysis	Deciduous Harvest Volume (m^3/yr)	
	First 20 Years	After 20 Years
Even flow scenario (P14_P6001)	50,772	50,772
Dropdown Scenario (P14_P6002)	53,169	50,000
Difference	2,397	(772)

* Structural Retention is not removed from these volumes

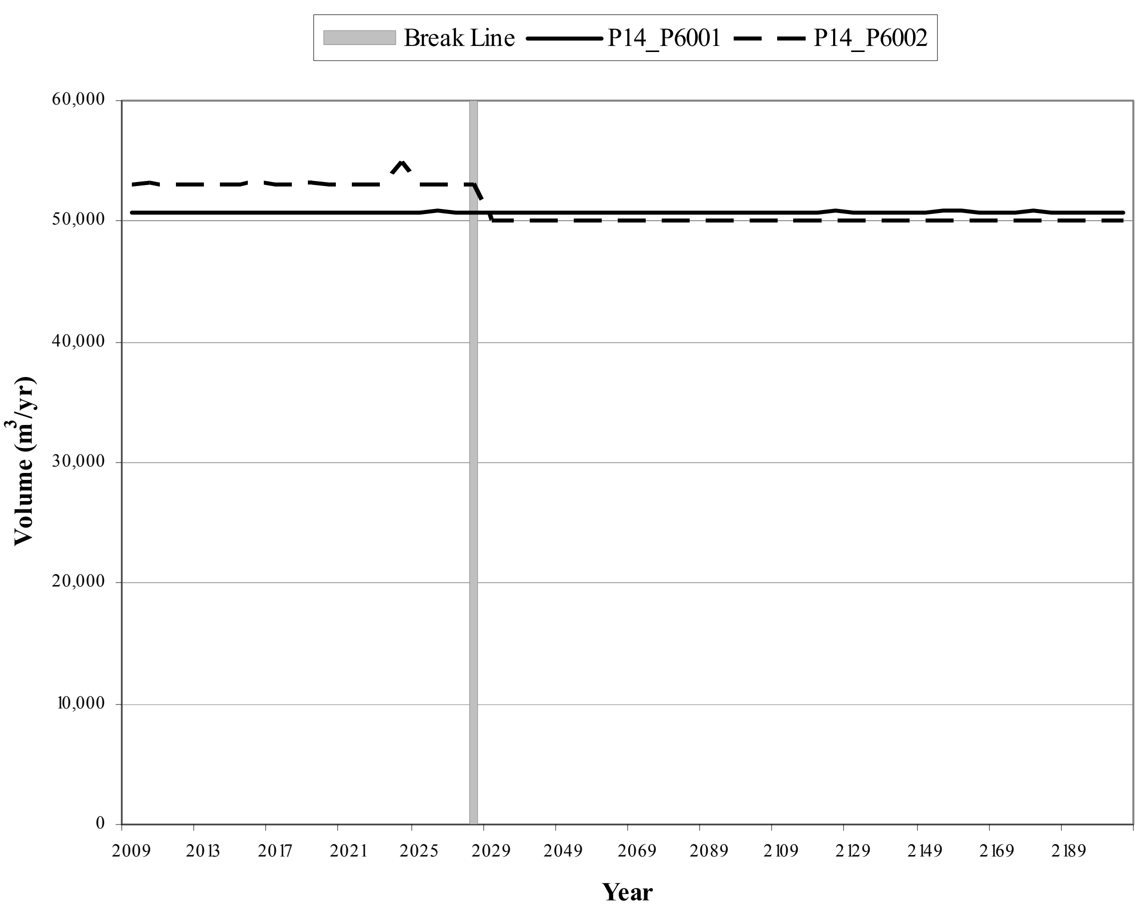


Figure 52. Comparison of deciduous primary harvest volume.

Figure 53 compares deciduous growing stock over the planning horizon for the two scenarios. This shows that the growing stock levels are nearly identical between the two scenarios, with a slightly faster recovery in the dropdown scenario.

The Patchworks model for P14 has one year periods for the first 20 years and five year periods for the remainder of the planning horizon. To highlight this, the two output graphs above show a grey vertical break line dividing the greater detail of the first 20 years from the rest of the years.

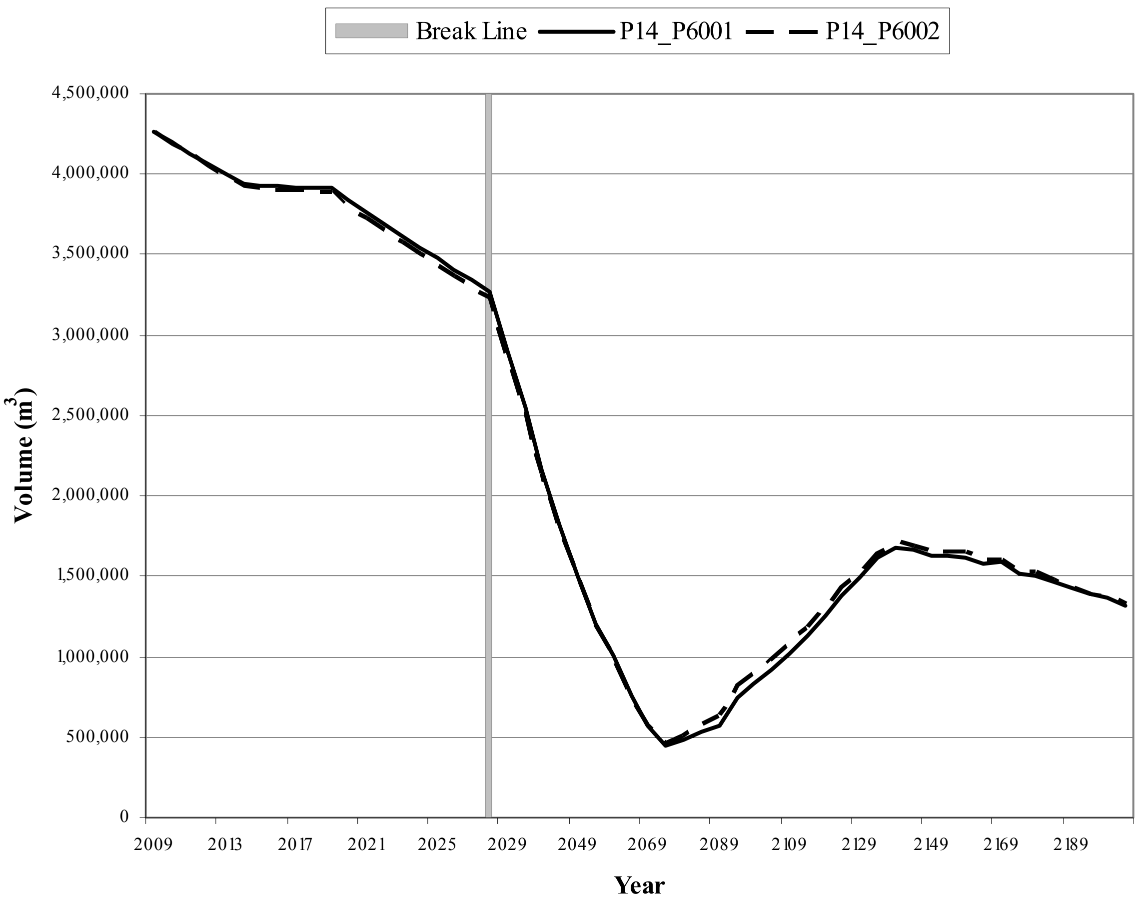


Figure 53. Comparison of deciduous growing stock.

Figure 54 is a series of TSA metrics that compare the two scenarios side by side. These clearly show that there is minimal difference in the two scenarios.

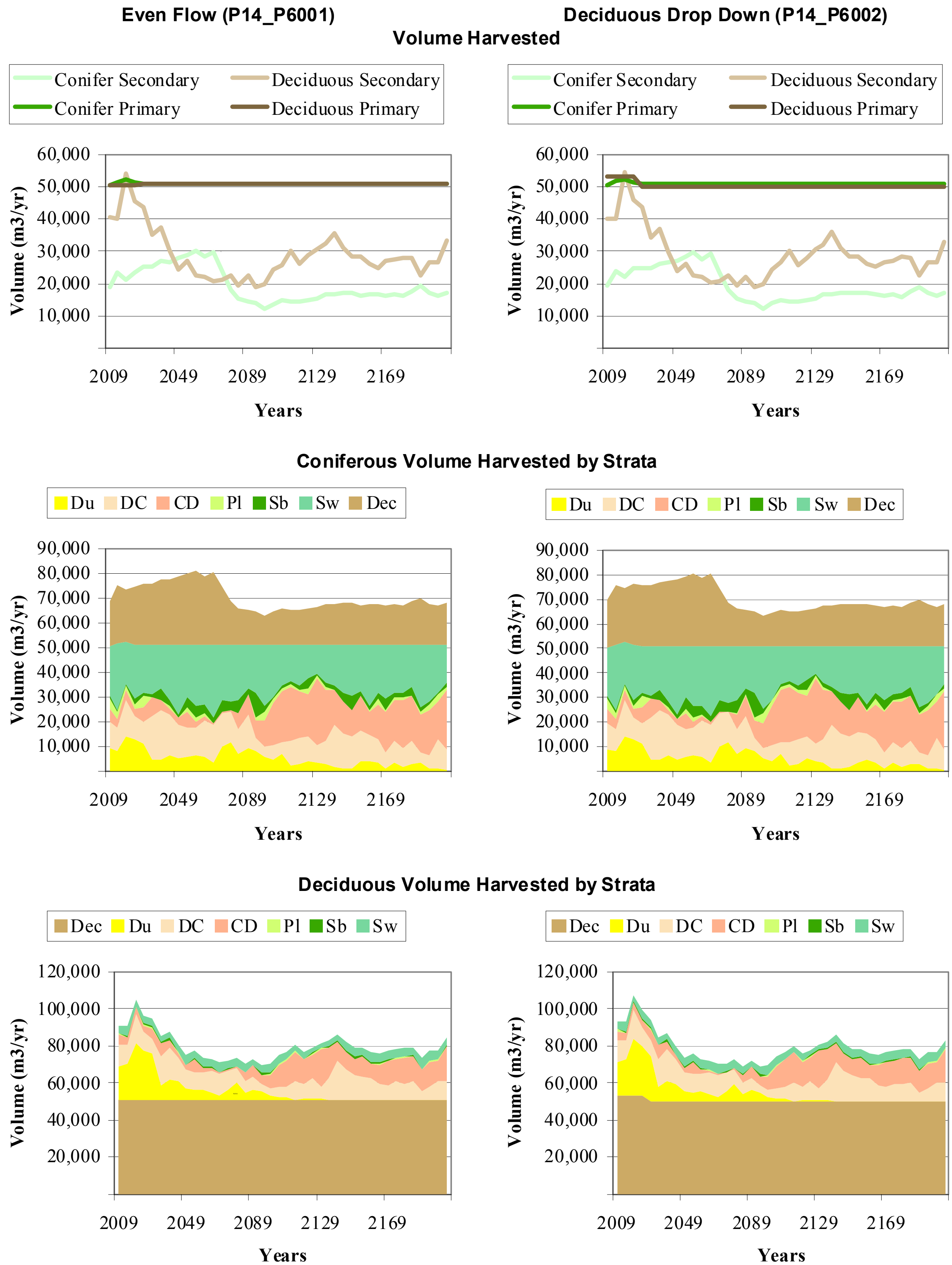


Figure 54. Comparison of TSA Metrics (1 of 6).

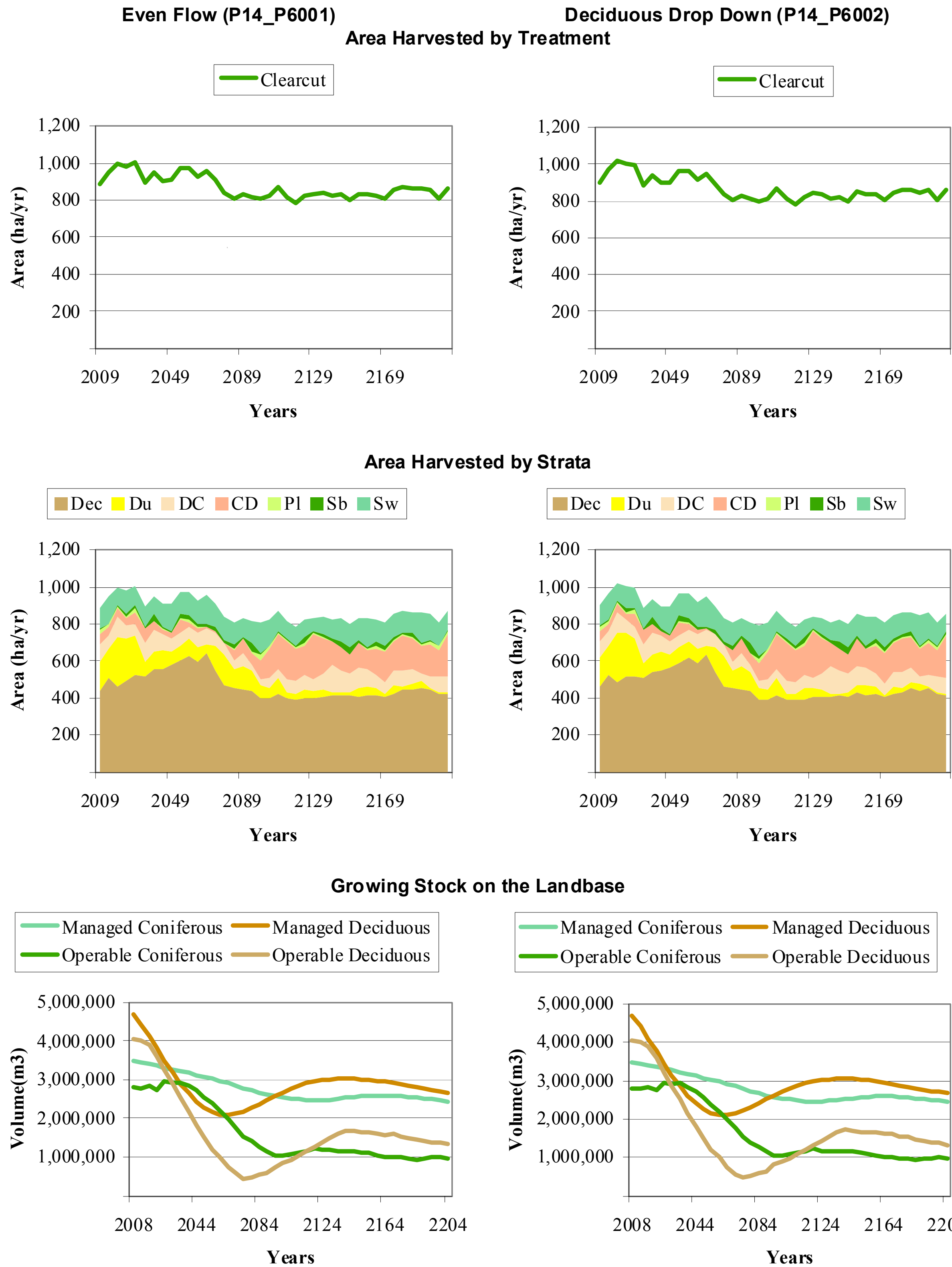


Figure 54. Comparison of TSA Metrics (2 of 6).

Figure 54. Comparison of TSA Metrics (3 of 6).

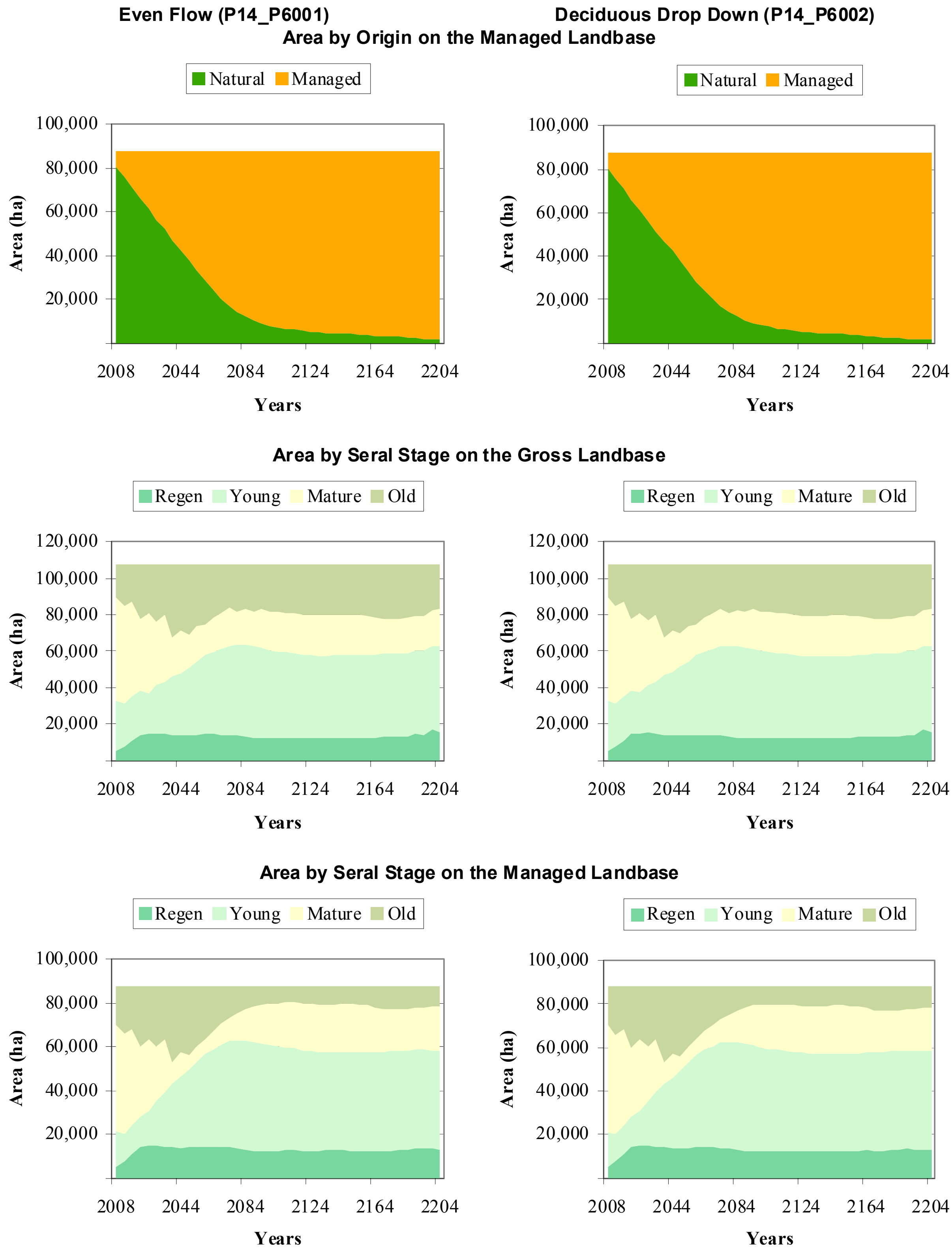
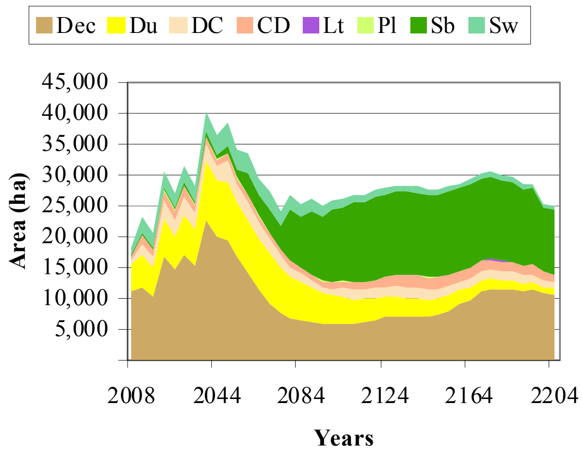
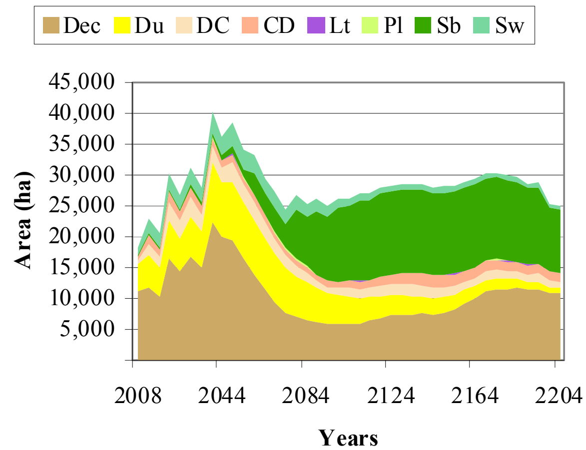


Figure 54. Comparison of TSA Metrics (4 of 6).

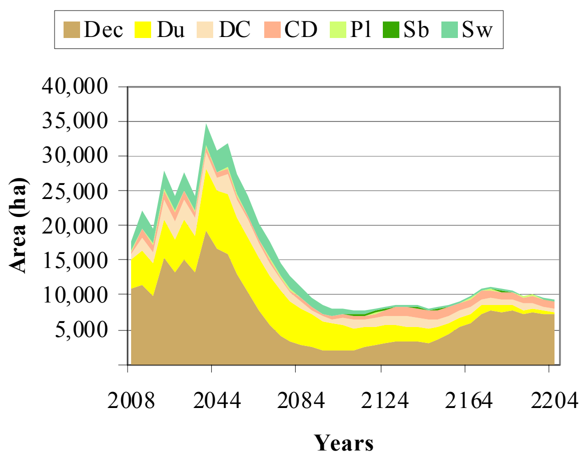
Even Flow (P14_P6001) **Deciduous Drop Down (P14_P6002)**

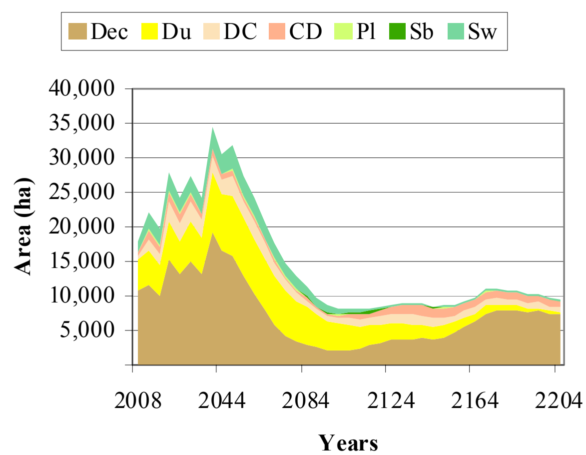
Area by Strata in Old Seral Stage on the Gross Landbase



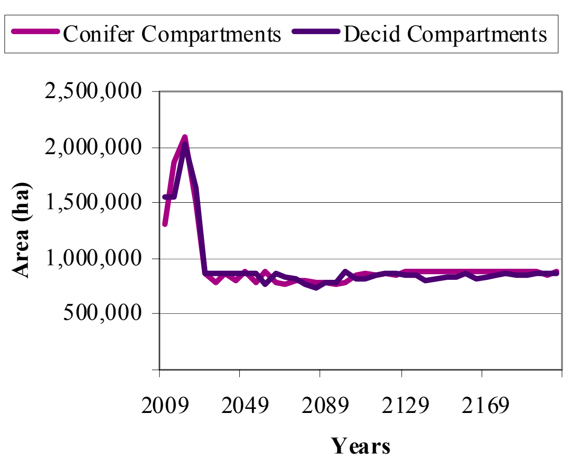


Area by Strata in Old Seral Stage on the Managed Landbase





Area of Compartments Open



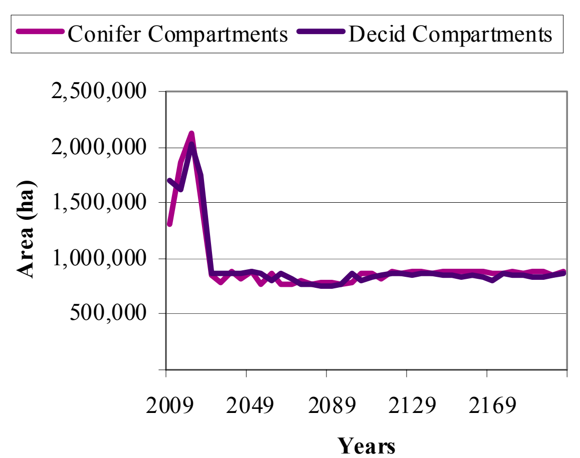


Figure 54. Comparison of TSA Metrics (5 of 6).

Figure 54. Comparison of TSA Metrics (6 of 6).

7.4.6 Discussion

The impact on the growing stock and the harvest level after 20 years is slight when a dropdown harvest strategy is implemented.

7.4.7 Decision

The PDT recommended that the dropdown scenario be the PFMS.

8. Scenario Summary and LRSYA

8.1 Scenarios Forecasted

The scenarios that were forecasted and saved are summarized in Table 21.

Table 21. List of Scenarios Forecasted

Scenario	Model Type	Round	Description
W1001_base	Woodstock	1	Set up a base run for first issue document testing yield curves
W1002_MX	Woodstock	1	Test combined CD and DC curves into one MX curve
W1003_CDDC	Woodstock	1	Testing a cap of 150 m3 on DC strata
W1005_D_CAP	Woodstock	1	Test capping of conifer component in DEC strata to 50 m3/yr
P14_P2001	Patchworks	2	First scenario with final landbase
P14_P2003	Patchworks	2	Second scenario with final landbase
P14_P2004	Patchworks	2	Force minimum Decid growing stock
P14_P2005	Patchworks	2	Force minimum Managed old growth
P14_P3001	Patchworks	3	First scenario with revised Yield curves
P14_P4001	Patchworks	4	First scenario with revised Yield curves using all plots
P14_P5001	Patchworks	5	First scenario with corrected aris information on landbase
P14_P5002	Patchworks	5	Second scenario with corrected aris information on landbase
P14_P5003	Patchworks	5	Revised from Phil's comments July 17 2008
P14_P5004	Patchworks	5	Better grouping of blocks than P5003
P14_P5005	Patchworks	5	Incorporate current AOP planned blocks
P14_P5006	Patchworks	5	SHS to be field checked
P14_P5010	Patchworks	5	1st run after field check changes
P14_P5011	Patchworks	5	2nd run after field check changes
P14_P6001	Patchworks	6	Boucher Bros. Final SHS
P14_P6002	Patchworks	6	Boucher Bros. Final SHS with Deciduous stepdown

8.2 LRSYA Calculation

The Long Run Sustained Yield Average (LRSYA) calculation is derived by the area in each stratum multiplied with the maximum mean annual increment (MAI) for that stratum. It represents the theoretical maximum volume that can be harvested from the landbase indefinitely. LRSYA ignores age class differences and assumes the forest is fully regulated at rotation age and that no other values impact the harvest level. It is a useful check on harvest levels as a harvest above LRSYA must reduce growing stock and cannot be sustained indefinitely. Table 22 shows the LRSYA for primary volumes calculated for the coniferous and deciduous landbases using the current strata areas (standing timber). Table 23 contains the same information for the managed landbase area following 100% transition to managed strata (DU transitions to CD). Table 24 shows the LRSYA calculated volume as compared with the 2009 PFMS harvest volume. Incidental volumes are not present in either table.

Table 22. Primary volume LRSYA calculations for standing timber.

		Age at Max MAI		LRSYA Calculated Volume (m^3/yr)		
Strata	Area (ha)	Coniferous	Deciduous	Coniferous	Deciduous	Total
D	43,461	-	75	-	74,997	74,997
DU	15,720	115	-	7,631	-	7,631
DC	8,578	140	-	12,281	-	12,281
CD	4,594	90	-	5,648	-	5,648
PL	745	105	-	1,188	-	1,188
SW	12,745	105	-	20,324	-	20,324
SB	1,985	125	-	3,246	-	3,246
Total/Average	87,828	120	75	50,320	74,997	125,316

Table 23. Primary volume LRSYA calculations for managed stands.

		Age at Max MAI		LRSYA Calculated Volume (m^3/yr)		
Strata	Area (ha)	Coniferous	Deciduous	Coniferous	Deciduous	Total
D	43,461	-	75	-	74,997	74,997
DU	-	115	-	0	-	0
DC	8,578	140	-	12,281	-	12,281
CD	20,314	90	-	24,976	-	24,976
PL	745	105	-	1,188	-	1,188
SW	12,745	105	-	20,324	-	20,324
SB	1,985	125	-	3,246	-	3,246
Total/Average	87,828	120	75	62,015	74,997	137,012

Table 24. Natural LRSYA volume compared with PFMS harvest volume.

	Harvest Volume (m^3/ha)		
Analysis	Coniferous	Deciduous	Total
LRSYA (standing timber)	50,320	74,997	125,316
2009 Analysis*	50,470	52,106	102,575
Difference	150	(22,891)	-22,741

* 2009 analysis is Net AAC (reduced 2% for structural retention) for comparison purposes

For the coniferous landbase, Figure 55 shows that the existing age class distribution is mostly younger than the average age of maximum MAI (about 110 years of age) and that conifer yields do not decline with age. This means that in the first rotation there is plenty of time to capture the volume at maximum MAI and therefore the PFMS harvest volumes are close to the LRSYA volumes.

For the deciduous landbase, however, the majority of the area is at or older than the age at maximum MAI (75 years) and about 22% of the area is at the maximum volume per hectare (Figure 56). Unlike the conifer curve, deciduous yields decrease after 110 years of age. The impact of this is a lower harvest volume in the PFMS compared to the LRSYA, due to the inability to harvest all stands before stand volume decreases. Stands harvested after the peak MAI will produce lower volume and MAI, pushing harvest levels below LRSYA.

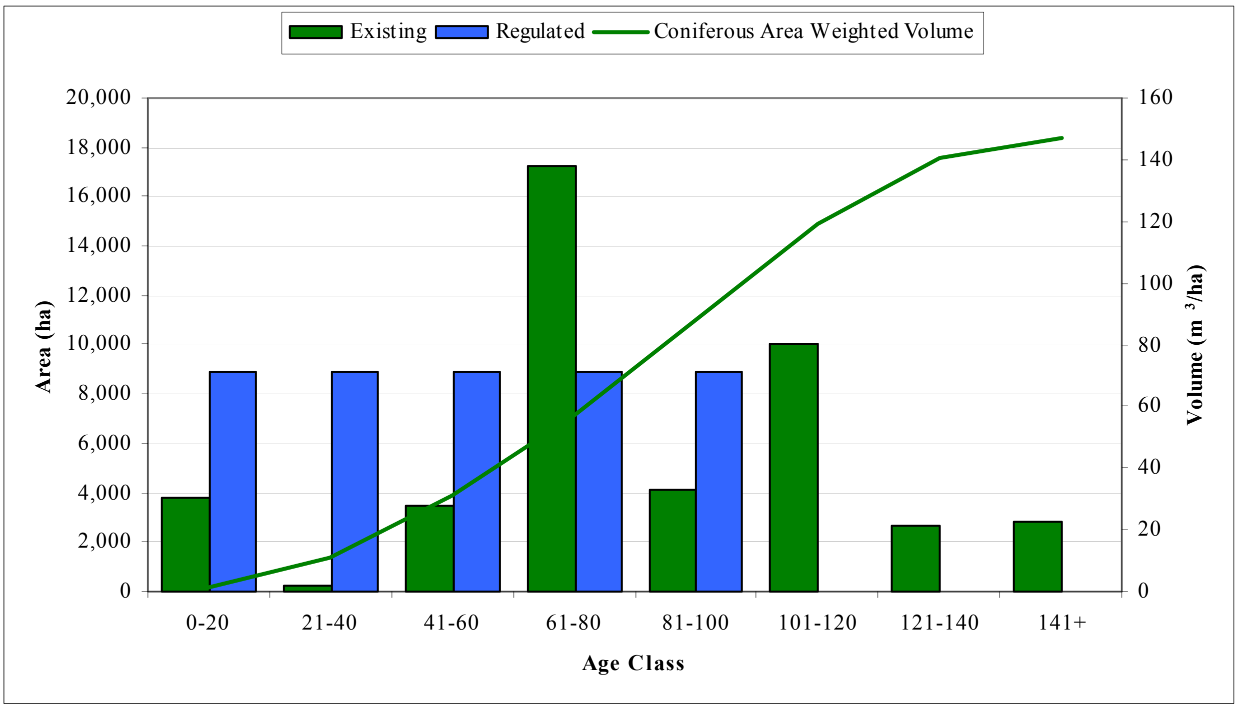


Figure 55. Comparison of existing and regulated age class for coniferous landbase.

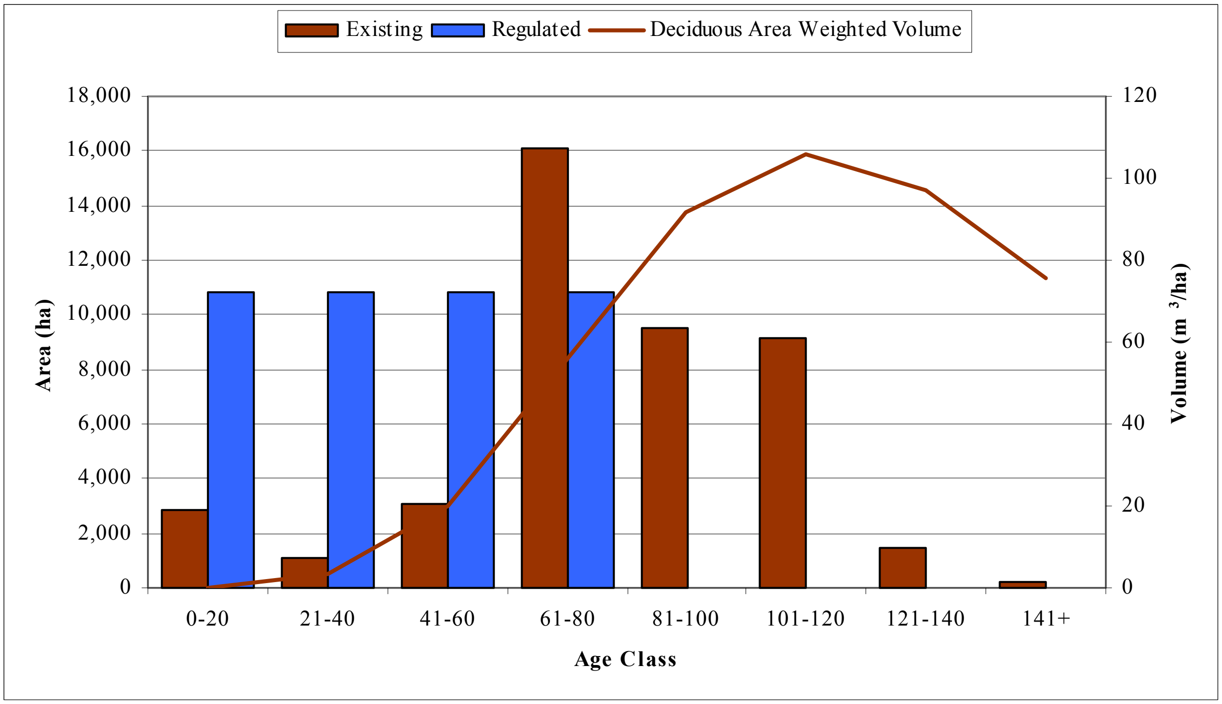


Figure 56. Comparison of existing and regulated age class for deciduous landbase.

9. Previous TSA Comparison

This section compares the current 2009 forecasting with the previous TSA and explains the differences in harvest levels that were achieved. Most of the detail contained in Chapter 4 discussing the historical timber supply analysis completed in 1996 is not repeated here. Instead, this section compares the modeling inputs of the landbase and yield curves and describes the differences in modeling technique.

Compared to the 1996 analysis, the current PFMS primary conifer harvest level increased 10,910 m^3/yr or 28% while the deciduous decreased 180 m^3/yr or 0.3% and overall primary harvest level increased 10,729 m^3/yr or 12% from 1996 (Table 25). Note that a deciduous surge cut was required in the PFMS or the deciduous reduction from 1996 would have been even greater at 2,530 m^3/yr or 4.8% from the 1996 levels.

Table 25. Comparison of net harvest levels with 1996 analysis.

Analysis	Harvest Volume (m^3/ha)		
	Coniferous	Deciduous	Total
1996 Analysis	39,560	52,286	91,846
2009 Analysis*	50,470	52,106	102,575
Difference	10,910	(180)	10,729

* 2009 analysis is Net AAC (reduced 2% for structural retention) for comparison purposes

9.1 Landbase

The 1996 analysis was completed with a net landbase derived from a Phase III forest inventory. A new inventory derived from AVI protocols was approved in 2007 and was used to develop the net landbase for the current analysis. In the current net landbase, there is a landbase shift from deciduous landbase to coniferous landbase, due to an increase in the amount of deciduous stands with coniferous understories (Table 26). The coniferous understories in the deciduous stands were likely present but not visible when the photos for the Phase III inventory were taken approximately 30 years ago. There is very little change in the total net landbase (0.3% increase) considering the differences in inventory, the amount of disturbance and landbase netdown protocols between the two analyses.

Table 26. Comparison of net landbase with 1996 analysis.

		Net Landbase Area (ha)		
Analysis	**Inventory**	**Coniferous**	**Deciduous**	**Total**
1996 Analysis	Phase III	39,539	48,018	87,557
2009 Analysis	AVI (2007)	44,366	43,461	87,827
Difference		4,827	(4,557)	270

9.2 Area Weighted Yield Curves

Figure 57 shows the area weighted yield curves for the coniferous and deciduous landbases from the 1996 and current analysis. On the coniferous landbase, the 2009 conifer component has less volume over the operable range than the 1996 curve, while the deciduous component has more volume in the middle age range of the curve than the 1996 curve. On the deciduous landbase, the maximum MAI of the primary deciduous volume component has shifted to younger ages and the older age classes have much lower volumes in the 2009 analysis. The curves used in the 1996 analysis were regional curves while the 2009 curves were developed from plot data exclusively from the P14 FMU and some of the 2009 curves were capped.

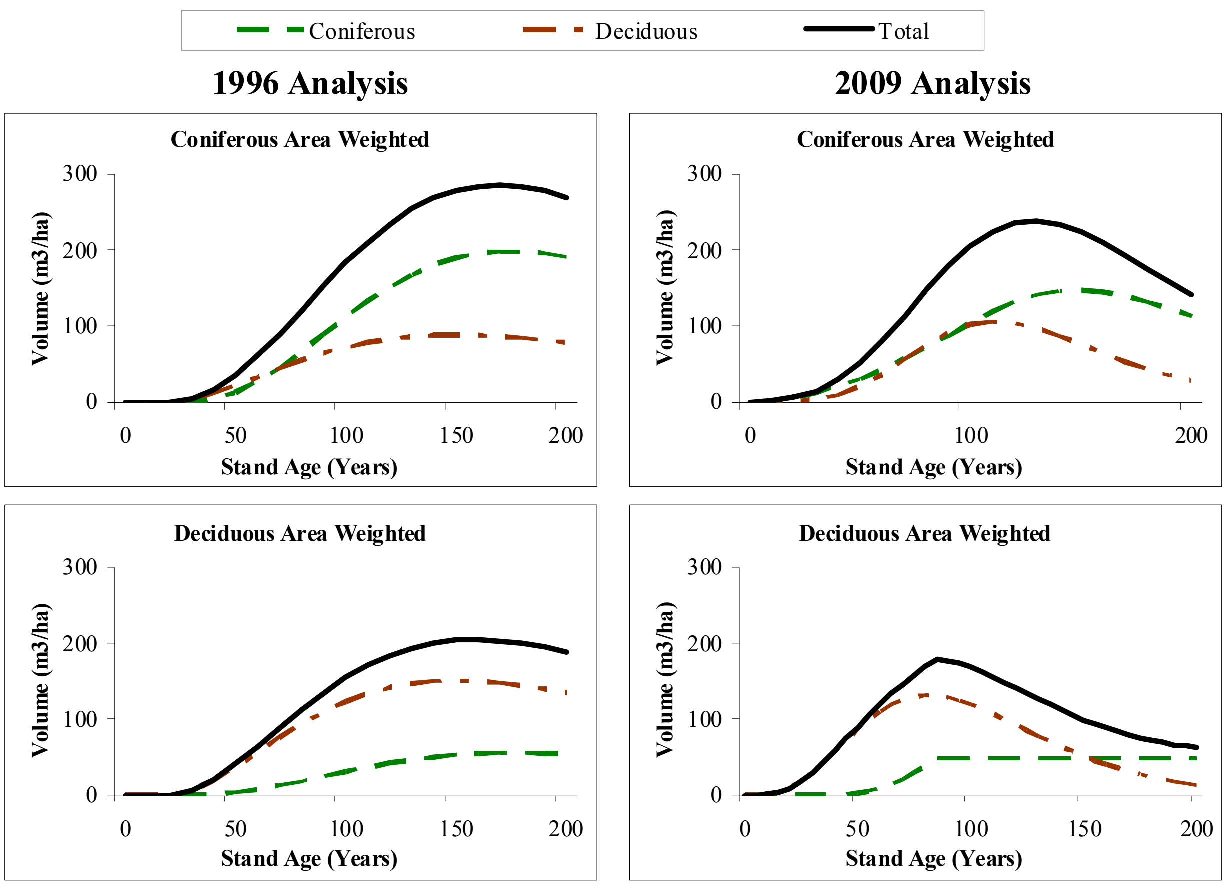


Figure 57. Comparison of area weighted yield curves from 1996 and 2009.

9.3 Modeling Technique

The modeling techniques used in the two analyses are drastically different from a technical perspective but both are conservative in nature. The 1996 analysis used LRSYA calculations, which is a simple method to determine sustainable harvest levels. The 2009 analysis used complex computer based spatial modeling and included non-timber values as well as operational constraints. This modeling approach was necessary to achieve the current planning standards for sustainable forest management .

The harvest level change from 1996 was not very large considering that the new level was based on a new forest inventory derived from new standards, new yield curves derived from local, not regional, plot data, new modeling techniques that included operational values and a switch from sustained yield to sustainable forest management.

10. Conclusions

The TSA required the development of a large number of inputs and assumptions. Many of these had sensitivity analyses run on them to test the sensitivity of the timber supply model to changes to the inputs and assumptions. There were additional sensitivities completed to test the effect of constraints on the timber supply model. These above discussed sensitivities allowed the stakeholders in the FMP process to make informed decisions regarding the direction of the TSA. These decisions, inputs, and constraints were assembled along with operational considerations in a Patchworks scenario to create the PFMS.

The PFMS balances forest values and timber extraction given Alberta's sustainable forest management requirements, local forest management issues and the goals of the forest managers and the stakeholders involved in the planning process. The PFMS includes a 20 year SHS to direct the layout and location of harvesting operations. A small deciduous surge cut is included in the PFMS which allows the existing DTA and MTU commitments to be achieved. The coniferous cut is even flow over the 200 year planning horizon (Table 27 and Table 28).

Table 27. PFMS harvest volume.

	Harvest Level (m^3/yr)			
	Primary		Incidental	
Time Period	Coniferous	Deciduous	Coniferous	Deciduous
2009 - 2028	51,500	53,169	22,691	45,158
2028 - 2208	50,979	50,000	18,943	27,054

* Structural Retention is not removed from these volumes

Table 28. PFMS utilization standards.

Utilization Criterion	Conifer Species	Deciduous Species
Stump height	30 cm	30 cm
Minimum log length	2.66 m	2.66 m
Minimum stump diameter outside bark	15 cm	15 cm
Minimum top diameter inside bark	11 cm	10 cm

11. References

(SRD) Sustainable Resources Development. 2006. Alberta Forest Management Planning Standard, Version 4.1. Edmonton, Alberta.

(SRD (2)) Sustainable Resources Development. 2006 Interpretive Bulletin Planning Mountain Pine Beetle Response Operations, Version 2.6. Edmonton, Alberta.

Boston, K. and Bettinger, P. 1999. An Analysis of Monte Carlo Integer Programming, Simulated Annealing , and Tabu Search Heuristics for Solving Spatial Harvest Scheduling Problems. For. Sci. 45(2): 292-301.

Davis, Johnson, Howard and Bettinger. 2001. Forest Management to Sustain Ecological, Economic and Social Values, Fourth Edition. McGraw-Hill Companies Inc. New York, NY.

Lockwood, C. and Moore, T. 1993. Harvest scheduling with spatial constraints: a simulated annealing approach. Can J. For. Res. 23: 468-478.

Remsoft, 2006. Woodstock 2006.8 User's Guide. Remsoft Inc., Fredericton, Canada. 280 pages.

Appendix I Planning Standard Section 5.12

Table 29. Section 5.12 Historical Allocation

Company Name	Disposition Number	FMU	Landbase Management Type	Effective Date of AAC	Deciduous AAC (%)	Deciduous AAC (m3/yr)	Incidental Deciduous (%)	Incidental Deciduous (m3/yr)	Coniferous AAC (%)	Coniferous AAC (m3/yr)	Incidental Coniferous (%)	Incidental Coniferous (m3/yr)
Boucher Bros.	CTQP140001	P14	Quota	6-Oct-2003	0%	-	0%	-	100%	39,560	100%	-
CBVAC	DTAP140001	P14	DTA	3-Nov-2006	94.9%	49,360	100%	-	0%	-	0%	-
CTPP	-	P14	CTPP	Annual	5.1%	2,640	0%	-	0%	-	0%	-

Table 30. Section 5.12 Proposed Allocation

Company Name	Disposition Number	FMU	Landbase Management Type	Effective Date of AAC	Deciduous AAC (%)	Deciduous AAC (m3/yr)	Incidental Deciduous (%)	Incidental Deciduous (m3/yr)	Coniferous AAC (%)	Coniferous AAC (m3/yr)	Incidental Coniferous (%)	Incidental Coniferous (m3/yr)
Boucher Bros.	CTQP140001	P14	Quota		0%	-	0%	-	100%	51,500	100%	21,812
CBVAC	DTAP140001	P14	DTA		94.9%	50,470	100%	40,145	0%	-	0%	-
CTPP	-	P14	CTPP		5.1%	2,699	0%	-	0%	-	0%	-

* 2% Structural Retention is not removed from these volumes
** Incidental volumes are based the average of the first 10 years

Table 31. Section 5.12 Utilization

Disposition Number	Utilization used to determine Harvest Level in PFMS				Operational Utilization						Marginal Dues Utilization			
	Top Diameter (cm)	Butt Diameter (cm)	Minimum Length (m)	Stump Height (cm)	Top Diameter (cm)	Butt Diameter (cm)	Minimum Length (m)	Stump Height (cm)	Deciduous AAC (m3/yr) based on operational utilization	Coniferous AAC (m3/yr) based on operational utilization	Top Diameter (cm)	Butt Diameter (cm)	Minimum Length (m)	Stump Height (cm)
CTQP140001	11	15	2.66	30	11	15	2.66	30	-	51,500	-	-	-	-
DTAP140001	10	15	2.66	30	10	15	2.66	30	50,470	-	-	-	-	-

* Structural Retention is not removed from these volumes

Table 32. Section 5.12 Production

Disposition Number	Cut Control Period	Periodic Cut Control AAC (m3/yr)	Quadrant Date	Previous Quadrant Production (m3)	Quadrant Coniferous Under-production (m3)	Quadrant Deciduous Under-production (m3)	Quadrant AAC (m3/yr)
CTQP140001			May 1, 2008 to April 30, 2013				
DTAP140001			May 1, 2006 to April 30, 2011				

Table 33. Section 5.12 Chargeability

Disposition Number	Deciduous Species used in AAC	Coniferous Species used in AAC	Species NOT chargeable to AAC	Rights to Species NOT chargeable to AAC	Structure Retention (%)	Structure Retention (%) Accounted for in AAC	Net Landbase Variations (net landbase not included in AAC, by covertype or by species)	Net Landbase Variation: Rights to Timber	Industrial Salvage Accounted for in AAC
CTQP140001		Fb, Fd, Pl, Sb, Sw	Lt		2%	0%	N/A	N/A	0
DTAP140001	Aw, Pb		Bw		2%	0%	N/A	N/A	0

Table 34. Section 5.12 Fiber Assignment Agreements

Assignment Type	Directed to (Company Name)	Disposition Number	Species (coniferous or deciduous)	Volume (m3)
	None			

Appendix II SHS Maps

Appendix III PFMS Goal Weightings

Table 35 lists the weightings and values applied to the goal in the PFMS. The weightings are dependant on the value of the goal and are set based on the model reaction as opposed to the relative importance of each. As a result, the weights cannot be construed to imply the relative importance of each goal.

Table 35. Patchworks PFMS goal weightings and values

	Minimum Goals			Maximum Goals		
	Value		Weighting	Value		Weighting
Target Name	SHS	Post SHS	All	SHS	Post SHS	All
Access.UnitsOpen.Conif	-	-	-	1,100,000	1,100,000	1.E+10
Access.UnitsOpen.Decid	-	-	-	1,000,000	1,000,000	1.E+10
feature.Area.managed.Future.Conif	-	-	-	4,500	3,500	1.E+30
feature.Area.managed.Future.Decid	-	-	-	1,905	0	1.E+30
feature.Area.managed.SS.Rollup.Old	8,500	8,500	1.E+20	-	-	-
feature.Pine.managed.DEC_PINE	-	-	-	94	98	1.E+17
feature.Pine.managed.PINE	-	-	-	3,752	3,915	1.E+18
feature.Volume.managed.Merch.Rollup.Primary.ConVol	800,000	800,000	1.E+03	-	-	-
feature.Volume.managed.Merch.Rollup.Primary.DecVol	1,300,000	1,300,000	1.E+05	-	-	-
feature.Volume.managed.Merch.Zone.North	135,238	0	1.E+30	1,957,143	2,000,000	1.E+20
feature.Volume.managed.Merch.Zone.South	114,286	0	1.E+30	1,380,952	1,400,000	1.E+20
patch.AnnualHarvest.Central.100plus.size	75	75	1.E+14	-	-	-
patch.AnnualHarvest.Central.250plus.size	20	20	1.E+02	-	-	-
patch.AnnualHarvest.NthSth.40plus.size	65	65	1.E+08	-	-	-
patch.BlockSize.0_2.size	-	-	-	0	0	1.E+16
patch.BlockSize.200_500.size	-	-	-	10	10	1.E+16
patch.BlockSize.500plus.size	-	-	-	0	0	1.E+30
patch.Core.150plus.size	75	75	1.E+00	-	-	-
patch.Green_up.1000plus.size	-	-	-	0	100	1.E+20
patch.NotRegen.0_40.size	-	-	-	2	2	1.E+10
product.Species.managed.DU	-	-	-	400	400	1.E+20
product.Volume.managed.Rollup.Primary.ConVol	51,000	255,000	1.E+19	51,000	51,000	1.E+21
product.Volume.managed.Rollup.Primary.DecVol	52,933	250,000	1.E+21	52,933	50,000	1.E+20
product.Zone.managed.NORTH	-	-	-	148	100	1.E+30
product.Zone.managed.SOUTH	-	-	-	148	75	1.E+30

Appendix IV Digital Data

For the digital version of the Patchworks files and supporting information, refer to DVD titled: P14 TSA Patchworks Models PFMS, dated December 23, 2009 created by The Forestry Corp.

The Forestry Corp. Project Number: P631
For additional information, please contact:
The Forestry Corp.
101-11710 Kingsway Avenue
Edmonton, AB
T5G 0X5
(780) 452-5878
www.forcorp.com

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