1. Overview

1.1 Background

Millar Western Forest Products Ltd. has a Forest Management Agreement (FMA) that covers forest management units (FMUs) W11 and W13. It's a condition of the FMA that Millar Western completes a Detailed Forest Management Plan (DFMP) every ten years. The current plans that are in effect until replaced by the 2007-2106 DFMP, are the 1997-2006 DFMP covering FMU W13 and the 2004 Preliminary Forest Management Plan (PFMP) covering FMU W11. The 2007-2016 DFMP is the first in which both FMUs are covered by a single plan.

This chapter describes the forecasting and related timber supply analysis (TSA) that was completed for the Millar Western 2007-2016 DFMP. This planning process was completed under the Alberta Forest Management Planning Standard (Version 4.1) (ASRD, 2006) (Planning Standard). The Planning Standard requires that proponents of new DFMP's undertake forecasting to determine the environmental effects of forest management and to produce a Preferred Forest Management Scenario (PFMS) with its associated management activities and recommended annual allowable cut (AAC).

Forecasting is a large component of DFMP development and it requires a number of other sections of the DFMP to be completed prior to its completion; specifically the landbase classification and yield curve development. The landbase classification and yield curve development coincided with the beginning of the forecasting process thus permitting an understanding of the effect of landbase and yield curve decisions in terms of their effect on the forecasting.

Under direction from Millar Western and other stakeholders, The Forestry Corp., completed the development of landbase (*Appendix VI – Development of the Landbase*), the yield curves (*Appendix VII – Yield Curve Development*) and the forecasting. The landbase and yield curve stratification incorporated 12 Biodiversity Assessment Project (BAP) strata as well as 9 yield strata in W11 and 31 yield strata in W13. The effective date of the landbase was May 1st, 2004 and the forecasting model start date was May 1st, 2007.

The forecasting uses a representation of the final classified landbase, and the final yield curves to determine the PFMS. To develop a PFMS it was necessary to complete numerous sensitivity analyses to understand the dynamics of the forest. For this DFMP, two PFMSs were created, one for each FMU. This chapter reviews the inputs, assumptions and trade-offs associated with the determination of the two PFMSs.

Forecasting was a complex process that involved understanding tradeoffs associated with various DFMP objectives. Achieving targets for one objective may impact the ability to achieve targets for other objectives. A careful balance was required to best meet the objectives of the forest managers and stakeholders within the FMA area. Two different tools were used for forecasting in this DFMP. Woodstock, an aspatial planning tool, was used to explore aspatial issues and Patchworks, a spatial planning tool, was used for spatial issues and to develop the PFMSs.

Responsibility for making decisions regarding attainment of objectives and balancing trade-offs between objectives were made by one or more Impact Assessment Groups (IAGs) that were involved in the DFMP development. The IAGs were charged with defining inputs into the forecasting and setting thresholds for the indicators that they had developed. These issues spanned many different areas of forest management including sustainable harvest level determination, mountain pine beetle risk and susceptibility, water runoff, wildfire threat, biological and ecological integrity and visual quality. Each of these issues was addressed within the management planning process creating a progressive forest management plan which addresses the key issues of forest management in Millar Western's FMA.

The end results of the forecasting are two PFMSs, of which the first spatially explicit 20-year period is referred to as the Spatial Harvest Sequence (SHS). The PFMSs strike a balance between the management objectives, which range from old growth retention to maintenance of harvest opportunities. The primary objectives of the PFMSs differed by FMU. The W11 PFMS is a basic forest management scenario that includes a previously approved coniferous surge cut with significant deciduous non-sustainable reconciliation volume (or carryover). The PFMS in W13 was developed to manage the mountain pine beetle (MPB) threat following the direction of the Mountain Pine Beetle Interpretive Bulletin (ASRD (2) 2006). To address this threat, the W13 PFMS included a significant coniferous surge cut to reduce the short term mountain pine beetle risk and future susceptibility of the forest and to promote a healthy pine age class distribution while ensuring W13 can maintain a harvest level into the future.

1.2 Historic Timber Supply

Commercial harvesting activities in the Whitecourt area began in the early part of the 20th century. Millar Western began harvesting in 1922, receiving their first timber berth in 1925. Extracted timber volumes in the Whitecourt area have gradually increased with large expansions of harvest in the 1970s and 1980s associated with the construction of the Alberta Newsprint Company and Millar Western pulp mills.

Millar Western's FMA was created in 1997 and consisted only FMU W13. In 2002, FMU W11 was incorporated into the Company's FMA. W11 and W13 were historically, and continue to be, treated as separate sustained yield units for annual allowable cut determination even though they have been in the same FMA since 2002. This section provides an overview of earlier annual allowable cuts and timber supply analyses that have been completed on each unit.

Since the mid 1980's the Alberta government completed two timber supply analyses for W11, previously referred to as W3 East, prior to the incorporation of W11 into Millar Western's FMA. Subsequently Millar Western completed the 2004 Preliminary Forest Management Plan which included a new timber supply analysis to use as a basis for management until this DFMP becomes effective. Table 1 shows the previous three harvest levels (1986, 2000 and 2004) plus the current proposed harvest level for W11 (2007-2016 DFMP). The 1986 and 2000 harvest levels were based on a separate coniferous and deciduous landbases, while the 2004 and 2007 harvest levels were based on a combined landbase. It can be seen that the deciduous harvest level has fluctuated very little through time, other than the 2000 TSA, which showed a significantly higher harvest level. The coniferous harvest level has decreased through time, though the inclusion of a surge cut in the 2004 and 2007 TSAs has deferred this decrease into the future.

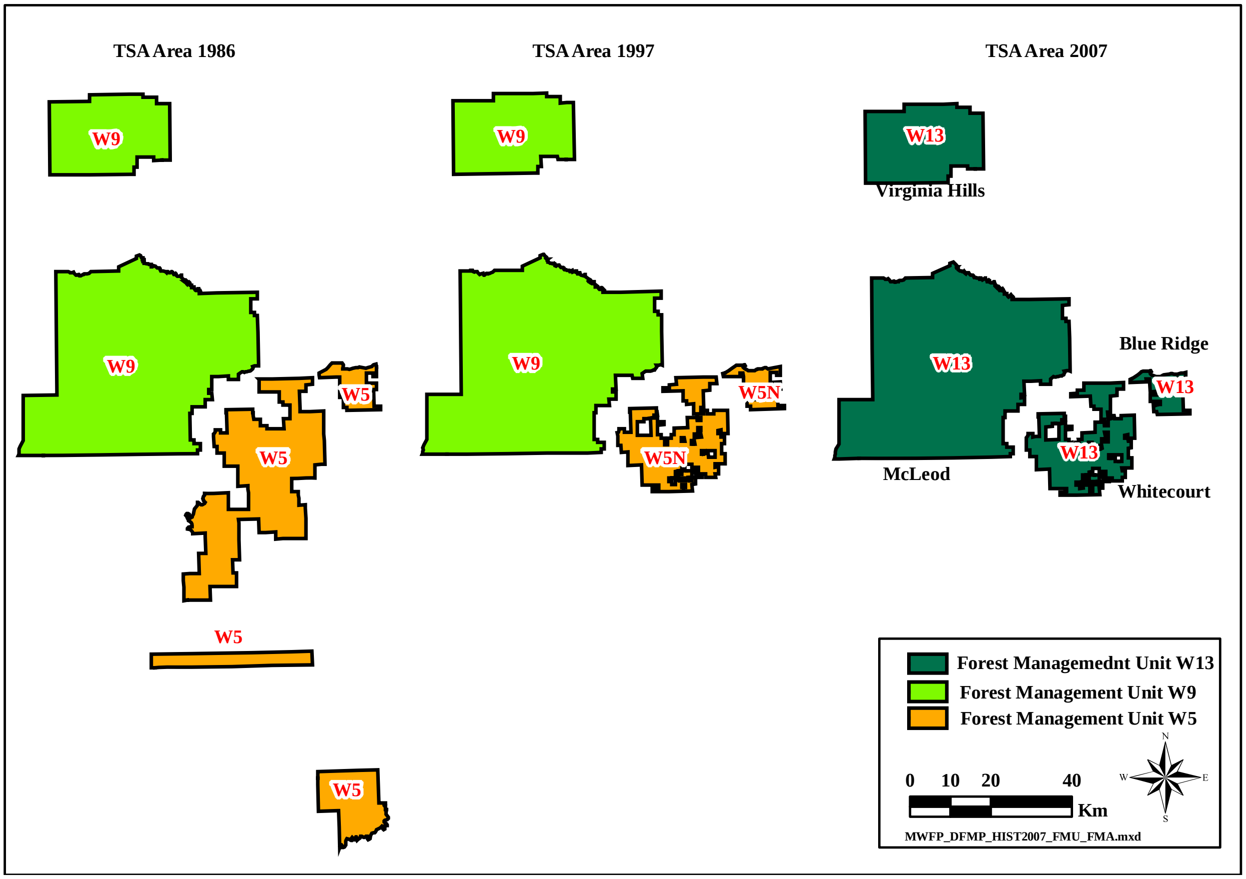
Table 1. Historical harvest levels from FMU W11, previously referred to as W3 east.

Timber Supply Analysis	Utilization	Effective Dates	Primary Harvest Volume (m^3/yr)		Incidental Harvest Volume (m^3/yr)		Combined Harvest Volume (m^3/yr)		
			Conifer	Decid	Conifer	Decid	Conifer	Decid	Total
W3 East Forest Management Plan (1986)	15/11	1986-2000	89,600	86,700	-	27,800	89,600	114,500	204,100
2000 Timber Supply Analysis	15/11	2000-2003	59,290	109,733	24,718	25,642	84,008	135,375	219,383
2004 PFMP[1&2]	15/10	2003-2016	63,721	86,532	31,279	23,332	95,000	109,863	204,863
		2017-2162	34,916	86,069	20,721	20,728	55,639	106,797	162,435
2007 DFMP[1&2]	15/10	2007-2016	65,571	66,360	29,322	39,689	94,893	106,049	200,942
		2017-2206	33,165	84,495	22,587	20,172	55,752	104,667	160,419

1 - A combined landbase and combined conifer and deciduous harvest volumes were modelled in the TSA. However, primary and incidental harvest volumes for the 2004 & 2007 AAC's are reported for comparison purposes

2 - Carryover removed from results shown here (from primary harvest levels)

Three historical harvest levels from W13 are shown in Table 2 though these harvest levels were calculated based on different FMU boundaries (Map 1). When Millar Western obtained their FMA, FMU W13 was created by combining FMU W9 and FMU W5N. FMU W9 was comprised of the McLeod and Virginia Hills areas of the current W13, and W5N was comprised of the Whitecourt Mountain and Blue Ridge areas. The 1997 Preliminary Forest Management Plan harvest levels were based on harvest levels from W5N and W9, even though W13 was the new sustained yield unit. The 2000 timber supply analysis and harvest level determination was based on the combined W13.



Map 1. W13 historical disposition map.

It can be seen that the historical W13 harvest levels (Table 2) have been fairly consistent through time, though the 2007-2016 DFMP changes the harvest flow policy. The proposed harvest level includes a surge cut above the historical levels to address the MPB and susceptibility, with a decrease post-surge from the historical levels. It should be noted that the assumptions included in these harvest calculations through time have varied. For example, the 1997 DFMP included crop plan treatments, which contained increased managed yields from intensive forest management activities; this treatment was not included the 2007-2016 DFMP. The 1986 AAC determination was based on the Phase 3 forest inventory, included direct allowances for fire losses in the annual allowable cut determination, and accounted for other values on the landscape only through area deletions.

Table 2. Historical harvest levels from FMU W13, previously known as W9 and W5N.

Timber Supply Analysis	Utilization	Effective Dates	W9 Harvest Volume (m^3/yr)		W5 Harvest Volume (m^3/yr)		Combined Harvest Volume (m^3/yr)		
			Conifer	Decid	Conifer	Decid	Conifer	Decid	Total
1986	15/11	1986-1996	337,411	89,700	66,100*	86,200*	403,511	175,900	579,411
1997 PFMP	15/11	1997-1999	336,611	89,007	7,410**	36,487**	344,021	125,494	469,515
2000 TSA	15/10	2000-2006					348,134	191,797	539,931
2007 DFMP	15/10	2007-2016					435,844	209,412	645,256
		2017-2206					295,849	145,807	441,657

* Harvest levels from the full W5

** Harvest levels from W5N, the northern portion only

1.3 Document Structure

This chapter is structured to allow easy reference to information throughout the next 10 years as the plan is implemented. This chapter is broken down into 8 sections:

- an introduction/overview;
- a discussion of the different impact assessment groups (IAGs);
- a brief landbase summary;
- a brief yield curve summary;
- a discussion of forecasting inputs and assumptions;
- a detailed description of the Preferred Forest Management Scenarios (PFMSs);
- an explanation of the forest management issues analyzed; and
- a conclusion.

The discussion of the IAGs explains the relationship between the different IAGs and their input into the forecasting process. The landbase and yield curve summary sections summarize the landbase and yield curve information that was used in the forecasting. The inputs and assumptions section presents the final inputs that were applied in the PFMSs, including minimum harvest ages, transitions, and access schedules. The PFMSs section shows the indicators, goals, and results from the PFMSs as well as implementation targets. The issues section lays out the issues that were dealt with throughout the forecasting. This section was designed to present individual stand-alone information for reference regarding the issues addressed.

2. Impact Assessment Groups and Forecasting Methods

2.1 Introduction

The development of a PFMS is a complex process that seeks to achieve a desirable balance between often competing management objectives. To enable mangers to achieve this balance, it is necessary to quantify the impacts of potential actions on all identified objectives. To quantify these impacts, computer based scenarios were created and forecast into the future. Forecasting was the primary decision support method used to predict long term impacts of potential actions. The IAGs weighed the forecasts against the full range of management objectives and made the necessary tradeoffs in developing the PFMS. This process is known as trade-off analysis.

Ideally, all objectives and their associated indicators would be built directly into the forecasting model. However, modelling constraints limit the number and complexity of indicators that can be incorporated directly into forecasting models. To include as many indicators as possible in the PFMS development process, Millar Western utilized six techniques:

- account for indicator in the landbase creation (e.g. riparian buffers);
- account for indicator in the yield curve creation (e.g. cull);
- add indicator directly into the forecasting model (e.g. old growth);
- calculate indicator during forecasting (e.g. even flow harvest level);
- undertake manual sequence or treatment modification (e.g. visual/social); or
- generate indicator through post scenario assessment (e.g. FireSmart FBP).

The first two techniques can be used for indicator reporting but require new models and datasets to be constructed to determine the impacts of different management decisions. These types of decisions tend to be yes or no decisions and determining the impacts of different potential forest management actions can be very time consuming.

Adding indicators directly into the model and/or calculating indicators within the forecasting model are the most desirable techniques. These two techniques allow the model to evaluate trade-offs, potentially providing better forest management solutions. Using this technique, ‘goals’ are set for each indicator and the model attempts to achieve these goals (i.e., goals are used within the model to drive the model towards achieving targets). For instance, if a 10% minimum old growth goal is set, the model will alter the harvest to try and achieve the 10% old growth goal. The alternative approach is to alter the model’s harvest level to try and achieve 10% old growth.

Manual sequence and treatment modifications were used to account for values that could not be modelled and this technique was used primarily in the refinement of the SHS. In using this technique, tradeoffs can only be determined by comparing the modified and unmodified scenarios.

Generating indicators through post scenario assessment was used in both the 1997 and 2007-2016 DFMP. Post scenario assessments are calculated after the forecast is completed and is used to generate indicators that are too complex to be incorporated into the forecasting model. The disadvantage of this technique is that results are available only after the forecasting is completed and the delay varies depending upon the complexity of the assessment. The entire suite of BAP habitat suitability models required months to process while Firesmart fire behaviour potential could be assessed in about a week. The technique’s advantage is that more complex indicators, such as the amount of suitable home range for a wildlife species can be determined.

Millar Western’s intent was to incorporate as many indicators as possible directly into the forecasting. This permitted the plan development team (PDT) to rapidly assess the impacts of the trade-offs and to determine the best combination of values to meet planning objectives.

In the 2007-2016 DFMP, indicator development and assessment was the responsibility of IAGs. IAGs involved in the development of PFMSs were:

- Timber Supply Analysis (TSA) IAG;
- Fire IAG;
- FORWARD IAG;
- Biodiversity Assessment Project (BAP) IAG; and
- Carbon IAG.

Each IAG was charged with:

- providing input into, selecting or clarifying the objectives for the values under consideration;
- developing indicators suitable for modelling that represented the selected objectives;
- working with the forecasting modellers to develop methods to incorporate each IAG’s indicators into the forecasting model;
- recommending or developing targets for each indicator;

- analyzing the results and providing recommendations; and
- documenting DFMP contribution.

The following sections provide an outline of each of the IAGs that were involved in the development of the PFMSs and their relationship to the forecasting process. More detail on IAGs can be found in the reports included in the appendices.

IAGs role in the PFMSs development was to ensure that the Values and objectives identified for the DFMP were addressed, however, not all Values and objectives were addressed specifically through the forecasting process. Values that were incorporated into the forecasting were:

- Landscape ecological and biological values,
- Stand-level ecological and biological values,
- Water quantity values,
- Community protection (FireSmart),
- Carbon balance,
- Timber benefits,
- Non-timber benefits (visual quality),
- Forest productivity,
- Forest protection, and
- Maintenance of forest landbase.

Individual Values, objectives, Indicators and Targets (VOITs) were addressed by different IAGs, and while some were addressed by more than one IAG, others were only addressed by a single IAG. The process whereby the VOITs were integrated into the DFMP forecasting and trade-off analysis is explained after the IAG overviews.

2.2 IAG Overview

IAGs that were involved in forecasting or the development of the PFMSs are described in this section.

2.2.1 Timber Supply Impact Assessment Group

The TSA IAG undertook more than the timber supply assessment and determination of the Annual Allowable Cut (AAC). It was the forum for operator input to the DFMP development in general, and forecasting and trade-offs in particular. Modellers that undertook forecasting were part of the TSA IAG and they received direction from the TSA IAG. Most of the trade-off decisions leading to the PFMSs were made by the TSA IAG.

The TSA IAG controlled all parts of the forecasting from the creation of the assumptions and input files, to model development, trade-off decisions, and finally interpretation of the outputs. Inputs, recommendations, and results from the other IAG were coordinated by the TSA IAG.

The TSA IAG was responsible for the timber supply products such as harvest level determination, development of the SHS, and the associated strategic and operational harvesting, renewal, and access activities.

Two subgroups were formed from the TSA IAG: the DFA Harvest Planning Committee and the DFA Silviculture Committee. These committees were initially formed to ensure that the PFMS harvesting, access, and silviculture scenarios were operationally feasible. However, as the DFMP is implemented, the committees' roles will change and will focus on facilitating the operational decisions, protocols, data collection and distribution, and reporting to meet DFMP objectives. More information on the committees can be found in *Appendix XXIII – Commitments* and in *Appendix XVI Terms of Reference – DFA Harvest Planning Committee* and in *Appendix XVII – Terms of Reference – DFA Silviculture Committee*.

2.2.2 Fire IAG

The Fire IAG was charged with addressing the FireSmart requirements in the Planning Standard and with incorporating Millar Western's wildfire initiatives into the DFMP. Millar Western believes that wildfire management is a critical component of forest management and is crucial to the company's long term survival. Millar Western is a leader in addressing landscape level fire issues as demonstrated by the 1997 DFMP which included an analysis of the regional fire regime and landscape fire effects, and explored options for the potential reduction of catastrophic fire loss through landscape design. This work formed a large part of the background to what would later become the FireSmart program.

The FireSmart process developed by the Alberta government seeks to reduce the flammability of the forest over time and to protect forest values when they do start. FireSmart's forecasting component focuses on fire behaviour potential under different fuel conditions. The model, developed by the Alberta government, uses fuel vegetation classification from AVI to produce initial fuel grid layers and then a series of updated fuel grid layers using cutblocks from the forecasts. These layers are used as input into the Fire Behaviour Potential (FBP) tool.

Millar Western recognises wildfire is a regional issue that does not respect FMA boundaries and, in 2004, initiated a regional wildfire program involving the neighbouring FMA holders and the Alberta government. The intent was to incorporate the results into the 2007-2016 DFMP. The result was partially successful in that the improved fire modelling was incorporated into the forecasting of the 2007-2016 DFMP. However, greater regional cooperation across FMA's and the integration of forest management plans to meet regional fire management objectives has not yet been achieved.

One objective of Millar Western's wildfire initiative was to develop a method to incorporate wildfire indicators directly into the forecasting models so that wildfire could be addressed as a goal and become a driver in the development of the PFMSs. Working with the Alberta government fire specialists, a set of fire fuel codes that are used to predict fire intensity were developed and integrated into the forecasting models. This permitted the creation of a fire fuel layer for the entire modelled landbase (managed and gross landbases) over the 200-year planning horizon. These fuel layers were used directly in the FireSmart FBP modeling.

Firesmart results in the form of fire behaviour potential maps for the DFA at the time steps required by the Alberta government are included in the VOIT reporting and are not elaborated upon in this chapter. With the MPB objectives in W13 and the existing surge cut in W11, fire behaviour potential was not used as driver in the development PFMSs.

2.2.3 FORWARD IAG

The FORest Watershed And Riparian Disturbance (FORWARD) group is a joint research partnership between researchers, students, forest companies, First Nations communities, and Provincial and Federal governments. The project was initiated by Millar Western and Dr. Ellie Prepas in 2001 to take advantage of the research opportunities presented by the Virginia Hills fire because of the pre-fire water monitoring data available for the area. The partnership focuses on developing models that predict how disturbance influences the movement of water and nutrients from forests to streams. Experimental work tests hypotheses relating to watershed processes that influence boreal forest soils, biodiversity, and hydrology and water quality (http://forward.lakeheadu.ca/index.htm).

Research in Millar Western's FMA includes watershed level experiments designed to determine water impacts on small watersheds under the following disturbance regimes:

- Wildfire,
- Harvesting with riparian buffers intact,
- Harvesting with riparian buffer removal, and
- Control (no disturbance).

An existing water model, the Soil and Water Assessment Tool (SWAT) was modified for forested conditions, local datasets were constructed, and the revised model was calibrated based upon the monitoring results. The result is a locally calibrated version of the SWAT model that predicts water impacts under different levels of disturbance in the Whitecourt region.

One of the aims of the FORWARD project was to develop products that would enhance the science supporting Millar Western's DFMP. To accomplish this, the FORWARD IAG was formed from selected members of the FORWARD group. In terms of the DFMP, the primary FORWARD aim was to create a process whereby water runoff could be incorporated into the forecasting model, allowing water quantity to be an active part of the trade-off analysis for PFMS development. In Millar Western's 1997 DFMP, increase in runoff was based on timber supply model outputs and could not be used directly in the control of the PFMS. In the 2007-2016 DFMP, Millar Western wanted to improve the water modeling and add water as a driver in the development of the PFMS.

In order to build the tools for the DFMP and further research, the FORWARD group developed the following products for the greater FORWARD research area which encompasses Millar Western's DFA:

- Stream network classified by Strahler order,
- Watershed delineation using the Strahler classification and based upon sub watershed polygons,
- Soil coverage for water modeling,
- Wetland classification based on water modeling requirements,
- Runoff coefficients based on hydrologic response units, and
- Process to incorporate the runoff coefficients into the forecasting process.

These components are described in detail in *Appendix XIV – FORWARD Contributions.* The forecasting component of FORWARD is described in the Inputs and Assumptions section of this Chapter.

The TSA IAG worked with the FORWARD IAG to develop the process to incorporate the water indicators into the forecasting models. Numerous methods were investigated that utilized different levels of detail and information in the process. The effort was ultimately successful in that water quantity indicators were incorporated into the forecasting models.

The FORWARD IAG's involvement with the DFMP will continue during the DFMP implementation, changing its emphasis to reporting and monitoring. Comparisons between predicted runoff coefficient values and runoff from selected harvest areas will be made using the SWAT model. The FORWARD DFMP commitments as listed in *Appendix XXIII – Commitments.*

2.2.4 Biodiversity Assessment Project IAG

The Biodiversity Assessment Project (BAP) IAG was originally established during the development of the 1997 DFMP. BAP developed a suite of tools designed for spatial landscape assessment of terrestrial biodiversity for current and forecasted lands. There were two primary components to BAP: a coarse level analysis and reporting of forested condition; and a fine filter assessment of 17 terrestrial vertebrate species. To help in determining if the assessment results were acceptable, BAP developed models to predict the Natural Range of Variation (NRV) of the forest. BAP tools were run on the NRV and comparisons were made between scenario results and confidence intervals about the mean of the NRV. Concerns were identified when indicators were outside the confidence intervals. Recommendations to operationally manage the indicators of concern were provided and implemented in the 1997 DFMP.

BAP was refined and the application in the 2007-2016 DFMP was expanded. There were two basic areas of BAP refinement related to forecasting. The first refinement was to develop biodiversity indicators that could be incorporated directly into the forecasting models thus permitting biodiversity goals to be set within the forecasting model to drive the PFMS development. The other refinement area was to tighten the linkages between BAP inputs, forecasts, and operational implementation activities on the ground. The later refinements are discussed in *Appendix XXIII – Commitments.* This section focuses on the BAP refinements to the forecasting and PFMS development.

The BAP IAG was instrumental in the development of indicators for both landscape and stand-level biodiversity objectives. BAP's stand-level indicators, called Special Habitat Elements (SHE), were used to drive some of the landscape level models but primarily as inputs into the spatial Habitat Suitability Models (HSM). BAP's HSM are too complex to be used directly in forecasting, therefore assessments were made on the forecast output. In order to develop forest management scenarios that were expected to produce good BAP assessment results, selected SHEs were incorporated as proxies into the forecasting models. Goals were set for these SHEs so that subsequent HSM assessments were appropriate. In this way BAP was used to drive PFMS development.

The BAP IAG provided ecological and biological input into compartment sequencing for harvesting and provided recommended target levels for goals, SHE, and other indicators derived in the VOIT process. This input was used in the development of the PFMSs. Refer to *Appendix XI – Biodiversity Based Compartment Prioritization* and *Appendix XII – BAP SHE Yield Curve Documentation* for more information.

The BAP IAG's final contribution to this DFMP was a Risk Assessment of the BAP results on the PFMSs (*Appendix X – Biodiversity Analysis of the PFMS*). This portion of the BAP report summarizes the results and assigns a risk to the landscape metrics, the SHEs and to each 17 HSM species. This information will be used by forest managers to modify operational treatments to maintain biodiversity. Refer to *Appendix XXIII – Commitments* for more information on the operational approach, BAP monitoring and implementation commitments.

2.2.5 Carbon IAG

The Carbon IAG prepared a carbon budget based on the PFMSs (*Appendix XI – Carbon Accounting on the DFA*). Carbon specific objectives were not used in the development of the PFMSs, only the carbon budget was reported.

2.2.6 Visual Quality

Visual Quality was addressed by Millar Western during the DMFP development however; a formal IAG was not formed. The SHS was assessed during development to determine impacts upon visual quality. The detail of Millar Western's visual quality process is discussed later in this chapter.

2.3 Forecasting Process and Scenario Development

The Canadian Standards Association Sustainable Forest Management Requirements and Guidance defines a forecast as “an explicit statement of the expected future condition of an indicator”. For this DFMP, forecasts were derived from computer models that project the forest into the future based on natural processes and management actions. The computer models used in forecasting have many names (*e.g*. forest estate models, landscape projection models) and, when used to determine timber supply, have been called timber supply models. The forecasting process is analogous to the timber supply analysis of previous plans however the term forecasting is used because of the wide range of values that are addressed.

Millar Western’s forecasting process involved the following basic steps:

- Inputs and dataset creation,
- Scenario development, forecasting and trade-off analysis, and
- Forecast based assessments.

Forecasts are created from computer based scenarios. Scenarios define a specific proposed management strategy in terms of specific policies, practices and activities which predict what would happen if a specific strategy is pursued. Forest management scenarios are typically rich in detail, and the predictions are supported by science-based estimates of how natural systems change over time and react to harvesting and silviculture. Developing scenarios are advantageous as they allow forest planners to quantitatively estimate benefits or potential impacts of management alternatives and make comparisons to facilitate decision-making.

The forecasting process also involves consultations with various stakeholders to determine which scenario provides the optimal solution for obtaining the goals and values associated with the desired future forest condition. IAGs were created to help facilitate this process.

Figure 1 demonstrates the forecasting processes showing the relationship between the IAGs, datasets created, assessments, and output.

The blue box shows the primary information input into the forecasting tools with the landbase spatial information on the left and the attribute information on the right. These datasets were loaded into the forecasting tools (Woodstock and Patchworks) and along with specific settings within the models were assembled into scenarios to generate forecasts. The Assumptions and Inputs section describes the information and model settings in greater detail.

The yellow areas in Figure 1 show the assessments that were undertaken on the forecasts developed by the forecasting model by each IAG and the outcome from those assessments are listed in the box below each IAG. All of these assessments used datasets from the forecasting model and the assessments were undertaken after the scenario was developed, the model run and the forecast generated. Acceptable outcomes from the assessments were used to help generate some of the targets for plan implementation, as listed in *Appendix XXIII – Commitments*.

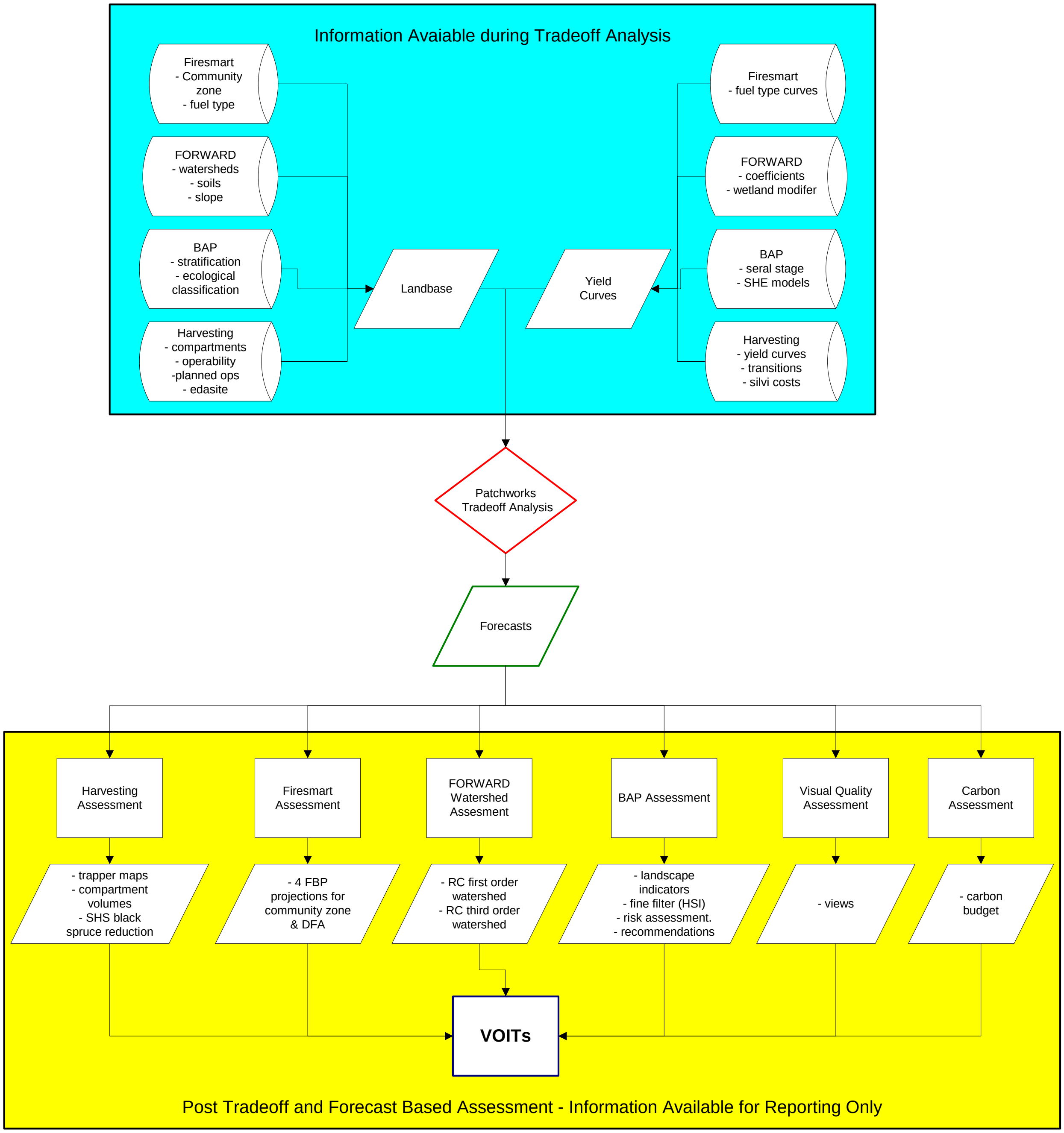


Figure 1. Forecasting information and IAG relationship flowchart

The trade-off analysis is represented by the red diamond in Figure 1. The actual trade-off process was more complex with two feedback loops. The primary trade-off process (red dashed line in Figure 2) was an iterative process using the indicators available within the forecasting model to assess acceptability of a specific scenario. Managers assessed how well the indicators met the objectives for the scenario and made changes to the model's goals to achieve a better balance between the indicators.

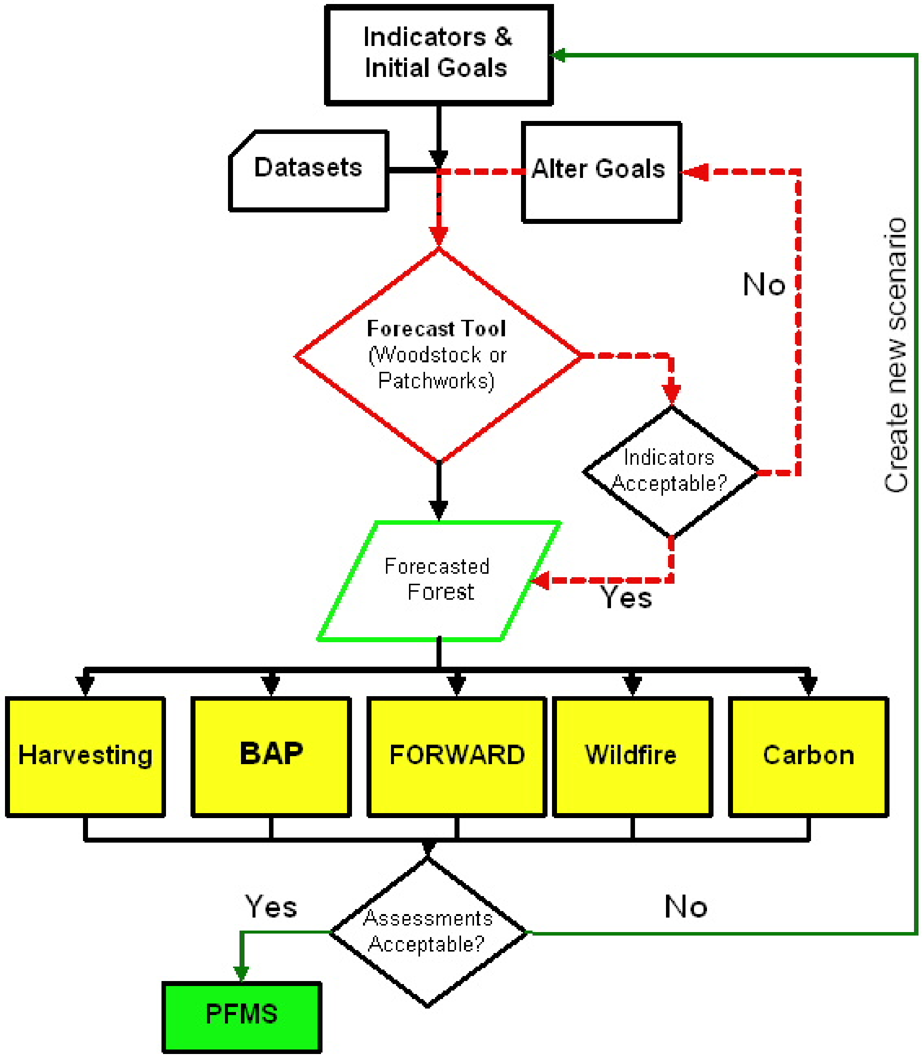


Figure 2. Forecasting trade-off and the decision process.

The advantage of including indicators in the forecasting model is evident in that only the indicators incorporated in the model can be used to evaluate the acceptability of a scenario. The response of other indicators must be inferred until post-scenario processing is completed.

When the scenario was deemed acceptable by the TSA IAG it enteres the secondary trade-off analysis feedback loop and was assessed by the IAGs (shown in yellow). The intensity of the assessment depended upon the scenario under consideration. Some scenarios received almost no assessment, while others were assessed by one or more IAG. The forecasts associated with the PFMSs was assessed by all the IAGs. Based on the outcome of the assessment(s) new scenarios were developed, potentially using new datasets and indicators (dark green loop). The entire process was repeated until the final PFMSs were developed. A complete cycle starting with a new scenario and full assessment by all the IAGs required approximately four months to complete.

3. Patchworks Landbase Summary

The process used to establish and classify the managed landbase for Millar Western's DFMP is documented in *Appendix VI – Development of the Landbase*. *Appendix VI* describes and summarizes the different landbases. The landbase classification was completed with an effective date of May 1st, 2004. The Planning Standard states that the landbase effective date must be within two years of the effective date of the forecasting. However, as per the approved Terms of Reference, exception was made to allow a three year difference in this plan due to the length of this planning process.

The Millar Western landbase process was complex, requiring creation of three distinct landbases each with numerous versions. The three different landbases included a classified landbase, a TSA landbase, and a modeling landbase. Descriptions of the spatial landbases follow:

1. Classified landbase. This landbase was developed to satisfy the requirements listed in the Forest Management Planning Standard (Alberta, 2006). The landbase includes linework for linear features (seismic, roads and utilities). The classified landbase is also used to calculate the areas and identify the locations of linear features on the landbase and to generate the attributes for the TSA landbase. This landbase carries the largest number of polygons.

2. TSA landbase. The landbase forms the start point for TSA modelling. The TSA landbase carries all information in the classified landbase but does not include spatial linework for linear features. The unique key for the TSA landbase is carried on the classified landbase.

3. Modelling landbase. This landbase was developed to make the spatial landbase more suited for both strategic and operational TSA modelling. The goal was to represent

the necessary information with appropriate attributes but to simplify the assignments wherever possible. This landbase carries the fewest number of polygons. The landbase processing maintains a link to the TSA landbase through UKEY#_TSA.

This section summarizes the work undertaken to develop the landbases as well as summarizing the modeling landbase that was used for forecasting. Landbase, yield curve and forecasting development were integrated but separate processes. For this reason, steps that were undertaken and completed during forecasting (e.g. patchworks compartments) are documented as part of the forecasting section, not the landbase section, even though patchworks compartments are assigned to the landbase.

The Alberta government granted agreement-in-principle for the landbases on July 13, 2007. Because agreement-in-principle was not granted until after the modeling was completed there were no changes to the landbase and the final model attributes were included in the agreement-in-principle landbase. This landbase was used without changes for the final PFMSs forecasting and for reporting throughout the 2007-2016 DFMP document.

3.1 Landbase Development Summary

3.1.1 Spatial Processing Summary

Forecasting requires a landbase, which accurately represents the forest and contains polygons that are reasonable decision units for strategic and operational forest planning. Decision units represent the minimum area for which a harvest/no harvest choice can be made. Ideally the decision units on the landbase would, at a minimum, represent the same area a registered forestry professional would select for harvest. Typically this is an AVI polygon, which may be divided by some boundaries, such as water buffers or pipelines. When decision units are smaller than desired, the spatial modeling tool, Patchworks in this case, must spend solution time aggregating the harvest polygons into at minimum acceptable size harvest areas. When the decision units are already operationally feasible units, the model will arrive at an acceptable solution quicker, and in some cases provide a better solution. This section reviews steps that were undertaken to create the modeling landbase and the reasons why the process was changed from the original approach and the final product ended where it did. All of the processes described, including the final results, are described in *Appendix VI – Development of the Landbase*. References to detailed processes can be found in that document.

As previously discussed the Millar Western's DFMP process spanned a long period of time. Throughout this time period there were many changes in DFMP expectations, changes in direction provided by various stakeholders including the Alberta, government and additional or revised data sets became available for the DFMP process. Whenever new spatial data was incorporated in the process, a new landbase, with a new round (representing a landbase with different linework than previous) was created. If new attribute data was included an increment of the landbase process occurred. Either of these steps takes significant time and were only undertaken when necessary. Early in this planning process the intention was to use a landbase that included all linework in the forecasting model. It was quickly realized that doing so would create a landbase, which was not suitable for use for strategic and operational planning due to the small size of the decision units. Therefore a number of processes were implemented to reduce the number of polygons and therefore increase the average polygon size.

The first step that was taken to control the number of polygons in the landbase was a sliver elimination process. This process was extensively explored and the value and results of using this process were explained to the IAGs and the Alberta government. This process was considered acceptable to all groups and included in the landbase development. It decreased the number of polygons on the landbase with very small sizes, but did not affect the remaining polygon sizes as the dissolved areas were very small.

The next step in creating appropriately sized decision units was the removal of seismic lines from the landbase which would be used for modeling. This resulted in development of a second landbase, the TSA landbase. The classified landbase still included seismic lines but the TSA landbase addressed seismic through an aspatial area reduction. For instance, in the classified landbase a 20 hectare gross area stand with one seismic line, accounting for 1.5 ha, crossing the stand would be represented by two separate polygons and the managed stand area would be 18.5 hectares. On the TSA landbase, the same stand would be represented by a single 20 hectare polygon but attributes for the managed area would be 18.5 hectares and the seismic area attribute would be 1.5 hectares even though no line work representing the seismic lines would be present. The result is that the area harvested and volume cut from harvesting either stand would be exactly the same.

Operationally, foresters do not use seismic lines to make harvest / no harvest choices. Excluding seismic from the TSA landbase reduced the number of polygons, and created more realistic decision units, while maintaining the same landbase attributes and areas as the classified landbase. As the benefits of this approach became clear, the approach was expanded to include additional linear features such as linear dispositions, minor roads, and trails.

As a final step, a dissolve was completed by selecting attributes to further improve the decision units within the landbase and reduce the number of polygons. This dissolve occurred in existing blocks, planned blocks, and the Virginia Hills surveyed areas. The intent of this step was to change the basic decision unit within these selected areas from AVI to more current information. This resulted in the creation of another landbase, referred to as the modeling landbase.

The dissolve process was similar to the seismic process except that small polygons were merged based on the same forecasting attributes. For example, if a 2 hectare managed portion of an AVI stand was left as a water buffer and it was next to a larger 24 hectare managed stand and the forecasting attributes (model themes and ages) were the same for both, the smaller stand would be dissolved into the larger one, creating a new stand with 26 hectares of managed area. The dissolve process did not change managed area as dissolves were not permitted across managed /non-managed boundaries.

These key hurdles had to be overcome to derive the final classified landbase that was used to create the PFMSs. All of these approaches were developed over time, as part of the iterative process used to develop the final classified landbase. Each of these landbases had attributes that differ subtly. The underlying AVI did not change in the process, most of the differences between landbase related to specific areas; such as harvest blocks and multi-storied stands. Though many of the results shown in the Management Issues section are based on interim landbases, the differences between sensitivities should hold true regardless of which landbase version was utilized so long as the other assumptions are held constant.

3.1.2 Attribute Processing Summary

Attribute processing was used to combine the various datasets and create the attributes required for forecasting. As was done with the spatial changes, each change in the attributes associated with a landbase caused a new numerical version of the landbase to be created. Spatial version 12 had 9 different landbase attribute sets created, mostly from changes in the years of planned blocks. Table 3 summarizes the landbase deletions and the order in which they were applied.

Table 3. Summary of landbase deletions

Code	Description	Order
XDFA	Alexis Reserve, Industrial Sites, Whitecourt Dump, Campground, Private land dispositions (LSAS), Private and non-classified lands	1
PARK	Centre of Alberta, Carson Pegasus Provincial Park, Whitecourt Mountain Natural Area, Ft Assiniboine Sandhills Provincial Park	2
XAVI	Area without AVI	3
ROAD	Roads	4
LINE	Linear Features and Utility Corridors	5
LEASE	Mineral and Surface Leases	6
SEIS	Seismic	7
GOVRES	Government Disposition Reservations and Protective Notations	8
XDFA	Recent private land dispositions in LSAS	9
REC	Recreation Leases	10
TRAIL	Recreation and Historical Trails	11
REC	Eagle River campground	12
NF	Nonforest Areas	13
FIRE	Areas burned since AVI and not in cutblocks or fire survey areas	14
U	Unproductive TPR	15
HYDROBUF	Water buffers per Ground Rules	16
LT	Larch stands	17
SB	Black spruce stands in W11	18
SB_STRUC	Complex or horizontal black spruce stands	19
SB_ADENS	A density black spruce stands	20
SB_SBLT	Sb or Sb/Lt stands with < 30% other species	21
ISL	Stands on islands in Athabasca River	22
ISO	Stands isolated by water buffers	23
NONE	Remaining polygons (managed landbase)	

3.1.3 Forecasting Themes and Additional Attributes

In order to permit the forecasting models to use the landbase, model "themes" were added to the landbase file. Themes are database fields that are summaries of information which is present on the landbase and represent information at the level required for forecasting.

Woodstock models are restricted to the information contained in themes plus an age field. Patchworks models can use other fields in the landbase file in addition to themes. The themes created for forecasting were:

- *THEME1* differentiates between FMU W11 and W13 and identifies sub areas within each FMU.
- *THEME2* identified the different land use areas within the classified landbase. Some of the areas were used to control harvesting in specific areas while others were used to schedule special treatments in some areas
- *THEME3* reflected the final BAP strata for the polygon. The black spruce stratum was split based on the moisture regime assigned in AVI to reflect biological differences.
- *THEME4* contains the assigned TPR of the stand in a numeric translation (*i.e.* 1, 2, 3).
- *THEME5* grouped the final density (F_DEN) into 2 classes.
- *THEME6* identified the stand origin process. Existing blocks from 2002 and 2003 were considered natural stands due to the roll back from the effective date to the start date of TSA modeling.
- *THEME7* identified thinned stands existing on the landbase for yield curve assignment.
- *THEME8* described operability within planned 2002 to 2006 blocks. This allowed the planned blocks to be forced in Woodstock with flexibility that was initially needed, but removed towards the end of the TSA process; once planned blocks were decided.
- *THEME9* identified AVI cutblocks, identified with *BLK_GRP* = 'MOD1' on the landbase.
- *THEME10* and *THEME11* are spare themes not required in the final model.
- *THEME12* was required to track the different slope based water indicators on the landbase. It represented a rollup of the slope measure of watersheds on the landbase.
- *THEME13* combined the soil classification and wetland class. This theme was required to track the wetland modifiers and assignment rules for FORWARD.

In addition to these themes, patchworks compartments for spatial model control and edasite assignments for silviculture reporting were added to the landbase file.

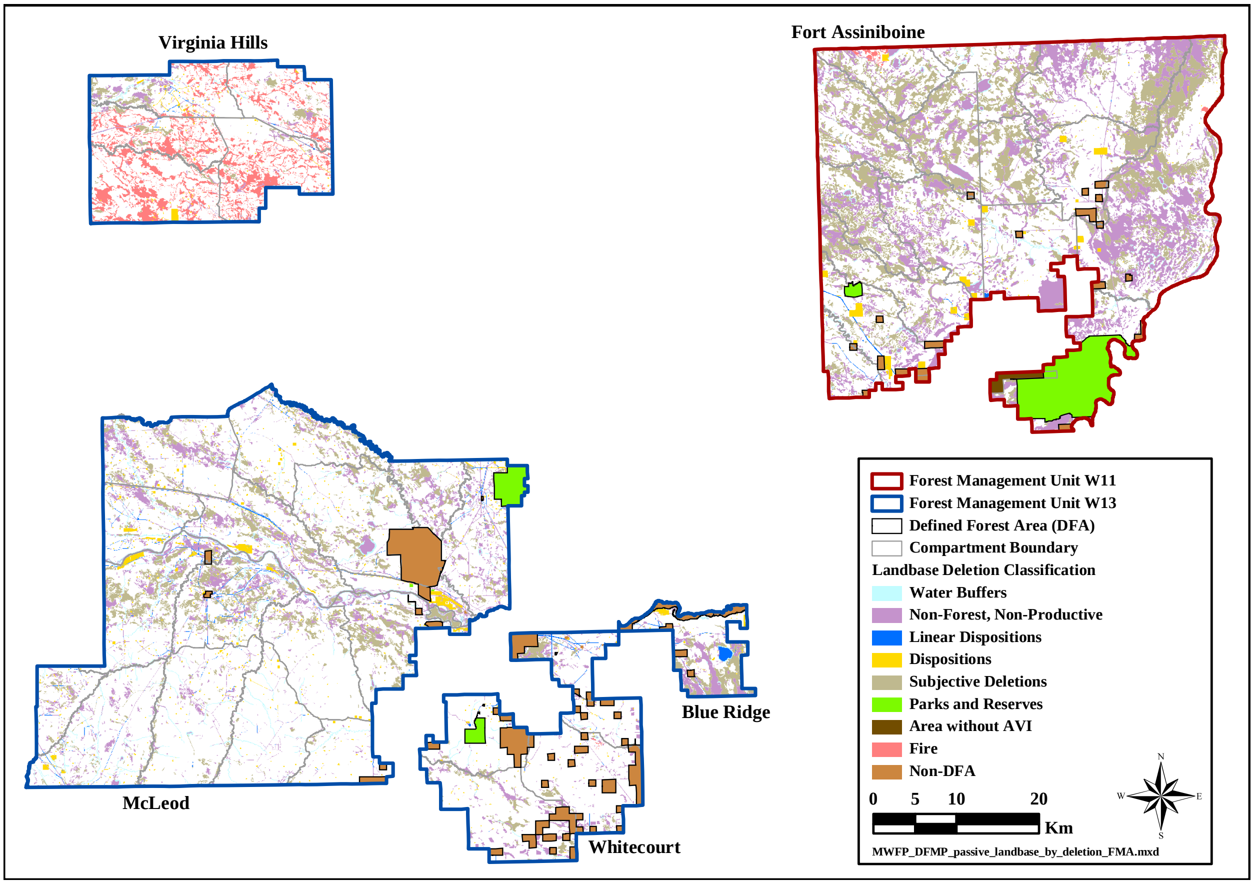
3.2 Final Landbase Summary

The final modeling landbase used for forecast modeling contained the round 12 spatial data and the attributes associated were from attribute set number 9.

The modeling landbase version includes the black spruce deletion that resulted from the review of the SHS. The unmanaged portion of the landbase, by deletion category and FMU is summarized in Table 4 and Map 2. Table 5 and Map 3 show the managed landbase by species strata from the modeling landbase. The tables contain area summaries in hectares and area percentages.

Table 4. Unmanaged modeling landbase summary (with SHS reviewed black spruce subjective deletion).

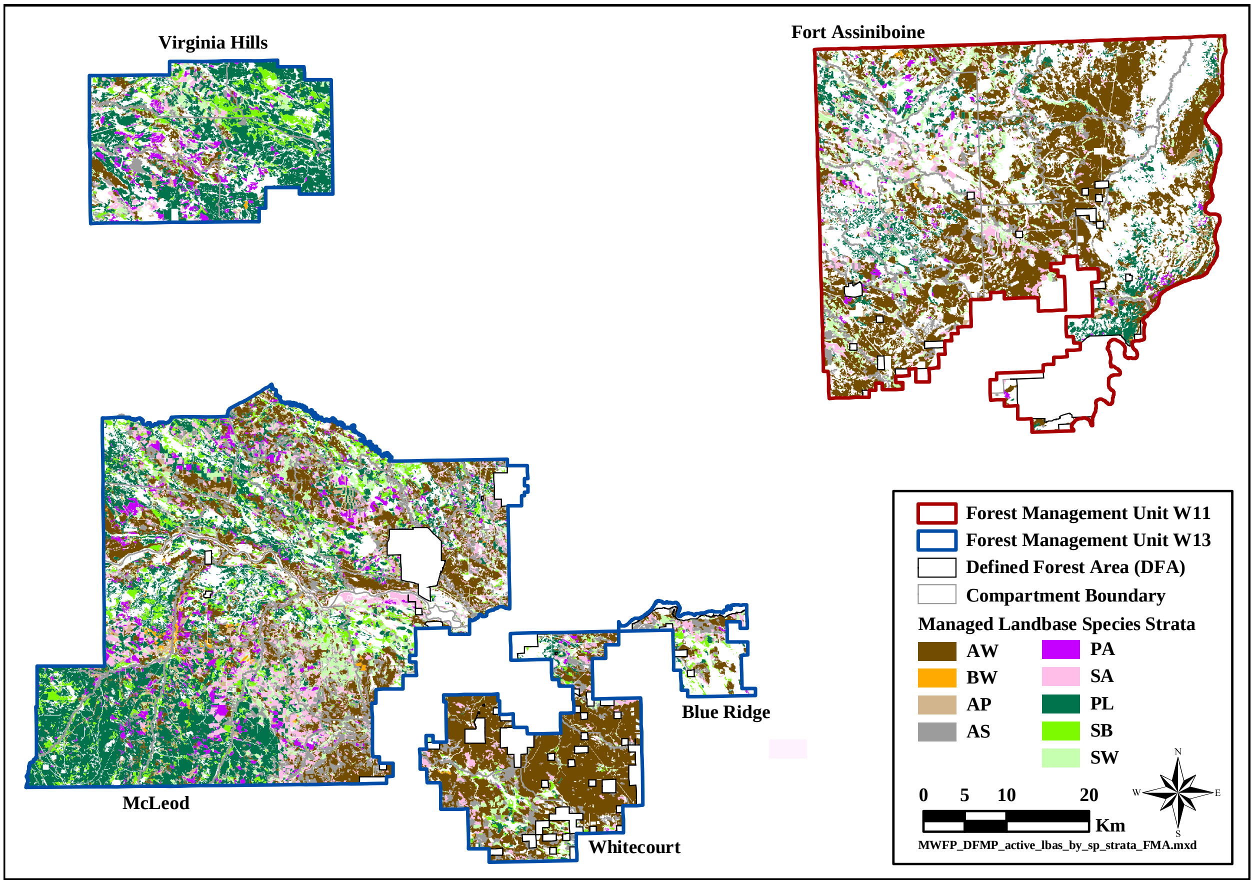
Modelling landbase Description	FMU Gross Landbase (ha)	W11 176,634	W13 301,873	ALL 478,507	% Gross Area
Area outside FMA (including parks)	**Stand area**	**11,557**	**14,491**	**26,048**	5%
or areas without AVI		7%	5%		
Seismic or linear deletion assigned	**Stand area**	**231**	**2,226**	**2,457**	1%
		0%	1%		
Non-linear landuse dispositions	**Stand area**	**1,661**	**3,678**	**5,339**	1%
		1%	1%		
Recreation	**Stand area**	**0**	**27**	**27**	0%
		0%	0%		
Nonforest, burnt or nonproductive	**Stand area**	**36,739**	**32,176**	**68,915**	14%
		21%	11%		
Water buffers	**Stand area**	**2,669**	**6,311**	**8,980**	2%
		2%	2%		
Larch and black spruce	**Stand area**	**33,605**	**20,351**	**53,956**	11%
subjective deletions		19%	7%		
Isolated stands	**Stand area**	**14**	**515**	**529**	0%
		0%	0%		
Horizontal stand deletion	**Attribute area**	**412**	**145**	**557**	0%
from managed landbase		0%	0%		
Seismic area deletion	**Attribute area**	**1,519**	**5,664**	**7,183**	2%
from managed landbase		1%	2%		
Road area deletion from	**Attribute area**	**537**	**2,279**	**2,816**	1%
managed landbase		0%	1%		
Linear feature area deletion	**Attribute area**	**309**	**1,482**	**1,792**	0%
from managed landbase		0%	0%		
Small poly area deletion	**Stand area**	**12**	**114**	**126**	0%
from managed landbase		0%	0%		
Total unmanaged landbase area		**89,265**	**89,458**	**178,724**	**37%**



Map 2. Gross landbase by deletion category.

Table 5. Managed landbase summary (with SHS reviewed black spruce deletion) for the modeling landbase.

Modelling landbase Description	Code	Gross Landbase Area (ha)	176,634 W11	301,873 W13	478,507 ALL	% Gross Area
Aspen	AW		53,186	57,846	111,032	23%
Birch	BW		130	1,105	1,235	0%
Aspen-pine mixedwood	AP		1,505	6,042	7,547	2%
Aspen-spruce mixedwood	AS		4,875	19,115	23,989	5%
Pine-aspen mixedwood	PA		1,555	10,354	11,909	2%
Spruce-aspen mixedwood	SA		5,066	17,700	22,766	5%
Pine	PL		11,588	66,640	78,229	16%
Black spruce	SB			10,805	10,805	2%
White spruce	SW		9,463	16,808	26,271	5%
	Total managed area		**87,369**	**206,415**	**293,784**	61%



Map 3. Managed landbase by species strata.

4. Timber Yield Curve Summary

The Millar Western timber yield curve creation process resulted in numerous different sets of yield curves. This section summarizes the yield curves that were used in the forecasting, and provides a very brief description of the process used to create the curves. The process used to create the yield curves for the Millar Western 2007-2016 DFMP is more thoroughly documented in *Appendix VII – Yield Curve Development*. *Appendix VII* describes the yield curves created and the process including equations used to develop these curves.

2007-2016 DFMP timber yield curves were submitted for agreement-in-principle at the end of February 2007. Changes to these curves were required for application in the forecasting models and to address issues such as stand break-up and succession that are better addressed during forecasting development. This section summarises the timber yield curve development, as documented in Appendix II, and summaizes the changes required for forecasting. Modifications to timber yield curves after the timber yield curve document was completed are described in the Forecasting Inputs and Assumptions section.

4.1 Timber Yield Stratification

Stratification is a complex but critical issue for forecasting and reporting. The complexity of the stratification increases as the number of uses for the stratification increases. Building on the experiences in the 1997 DFMP, the planning team decided early on to develop a consistent but flexible stratification for forecasting that would serve all the Impact Assessment Groups. The stratification was built on the Alberta government's detailed yield stratification and rolled up to BAP strata then species strata and yield strata and finally broad cover group. The stratification process is described in detail in *Appendix VI – Development of the Landbase* and summarized in *Appendix VII – Yield Curve Development*.

Table 6 and Table 7 show the different stratification used for W11 and W13. Further definitions of the yield strata are provided in Section 5.4, while cull and utilization are addressed in Sections 4.3.1 and 4.2.1 respectively.

Table 6. W11 yield strata relationship to species strata and broad cover group.

BROAD COVER GROUP	SPECIES STRATA	YIELD STRATA DENSITY AB	CD
D	AW	AW_AB	AW_CD
	BW	BW	
DC	AP	APAS_ABCD	
	AS		
CD	PA	PASA_ABCD	
	SA		
C	LT	LT	
	PL	PL_AB	PL_CD
	SB	SB	
	SW	SW_AB	SW_CD

Table 7. W13 yield strata relationship to species strata and broad cover group.

BROAD COVER GROUP	SPECIES STRATA	YIELD STRATA TPR G	M	F
D	AW	AW_G	AW_M	AW_F
	BW	BW		
DC	AP	AP_G	AP_M	AP_F
	AS	AS_G	AS_M	AS_F
CD	PA	PA_G	PA_M	PA_F
	SA	SA_G	SA_M	SA_F
C	LT	LT		
	PL	PL_G	PL_M	PL_F
	SB	SB_G	SB_M	SB_F
	SW	SW_G	SW_M	SW_F

4.2 Timber Yield Curves

4.2.1 Utilization Standard

All volumes are reported based on 15/10 cm utilization. This is defined as a minimum stump diameter of 15 cm and minimum top diameter of 10 cm and a minimum merchantable log length of 4.88 meters. In W13, the operators elected to follow a 30 cm stump height for white spruce and 20 cm for all other species. This reduced stump height was applied to better reflect operations in W13. The W11 operators elected to retain the 30 cm stump height. The full utilization parameters are provided in Table 8.

Table 8. Utilization parameters used in yield curve creation.

Utilization Characteristic	FMU W11	FMU W13
Minimum top diameter inside bark	10 cm	10 cm
Minimum stump diameter outside bark	15 cm	15 cm
Stump height	30 cm	30 cm - SW
		20 cm - all other spp.
Minimum log length	4.88 m	4.88 m
Species	all	all

4.2.2 Timber Yield Curve Sets

The six timber yield curve sets developed to address timber condition and management intervention are described here.

Base Natural Stand Yield Curves. Base natural stand yield curves were developed for each DFMP yield stratum. In FMU W11, volume as a function of age was empirically fit using TSP and PSP data. In FMU W13, volume as a function of AVI-based site index and age was empirically fit using TSP and PSP data. Average AVI-based site index for leading conifer and deciduous species were inserted into these equations to develop site-specific yield curves for fair, medium and good site types.

Base Managed Stand Yield Curves. Base managed stand yield curves were developed for each DFMP yield stratum in each FMU. Base managed stand yield curves were developed using data from natural stands with a C or D density crown closure class as a proxy for fully stocked natural stands. The same methods used for fitting base natural curves were applied to develop base managed curves.

Site Index Increase Yield Curves. Site index increase yield curves were developed for the FMU W13 PL DFMP yield stratum, to reflect the effect of management on pine volume yield. Average site index inputs used to create site-specific natural stand PL yield curves were increased using results from a Foothills Growth and Yield Association study (Dempster 2004). These increased site indices were used as inputs to the PL natural stand yield curve equation, to create site-specific site index increase yield curves.

Thinning Yield Curves. Thinning yield curves were developed for the PL and SB yield strata in FMU W13. Natural stand yield curves were modified to reflect volume removal and subsequent recovery. Commercial thinning yield curves were developed based on a scenario of 35% volume removal at 45 years, with a recovery to 90% of natural stand volume, 15 years after thinning. Salvage thinning yield curves were developed based on a scenario of 33% volume removal at 90 years, with no recovery assumption (67% of natural stand volume at final harvest).

Athabasca Flats Selective Logging Yield Curves. Yield curves were developed for stands in the Athabasca Flats area (W13) that have been harvested using selective logging methods. Because this area was comprised of a number of different DFMP yield strata, a composite natural stand yield curve was developed using area-weighting of the component natural stand yield curves. This composite curve was then localized using plot data to create a pre-treatment Athabasca Flats natural stand yield curve. Plot data were then used to calculate the percent volume removed by selective logging, which was applied to the localized natural stand yield curve to create a post-treatment Athabasca Flats yield curve. No post-treatment recovery assumptions were applied to this curve.

Subunit-Specific Aspen Yield Curves. Maintaining the strategy requested by Weyerhaeuser and applied in the 1997-2006 DFMP, separate subunit-specific aspen yield curves for natural stands were developed to reflect subunit-specific differences in productivity for the Whitecourt/Blue Ridge (W/BR) and McLeod/Virginia Hills (MC/VH) subunits of FMU W13, which were referred to as the old W5N and W9 FMUs respectively in the 1997-2006 DFMP. Data were split by subunit. The same methods used to develop natural stand yield curves were used to develop site-specific yield curves for each subunit. In the following figures these curves are coded as “W13 AW W/BR” and “W13 AW MC/VH” respectively, which relates to the old W5N and W9 FMUs.

4.2.3 Timber Yield Curves before Forecasting Changes

Timber yield curves before the changes required for input into the forecasting models are shown on the following pages. These curves required modifications for cull, regeneration lag and breakup before application in the models.

Figure 3 shows the W11 base natural stand yield curves and Figure 4 the W11 base managed stand yield curves. Note the white birch curve (BW) was common to both FMUs and is shown with the W13 yield curves.

W13 base natural and base managed stand yield curves are shown in Figure 5 thru Figure 8 and Figure 9 thru Figure 12 respectively. W13 pine site index increase curves are presented in Figure 13 and the Athabasca Flats post treatment yield curves is in Figure 14. W13 commercial and salvage thinning yield curves are shown in Figure 15 and Figure 16 respectively.

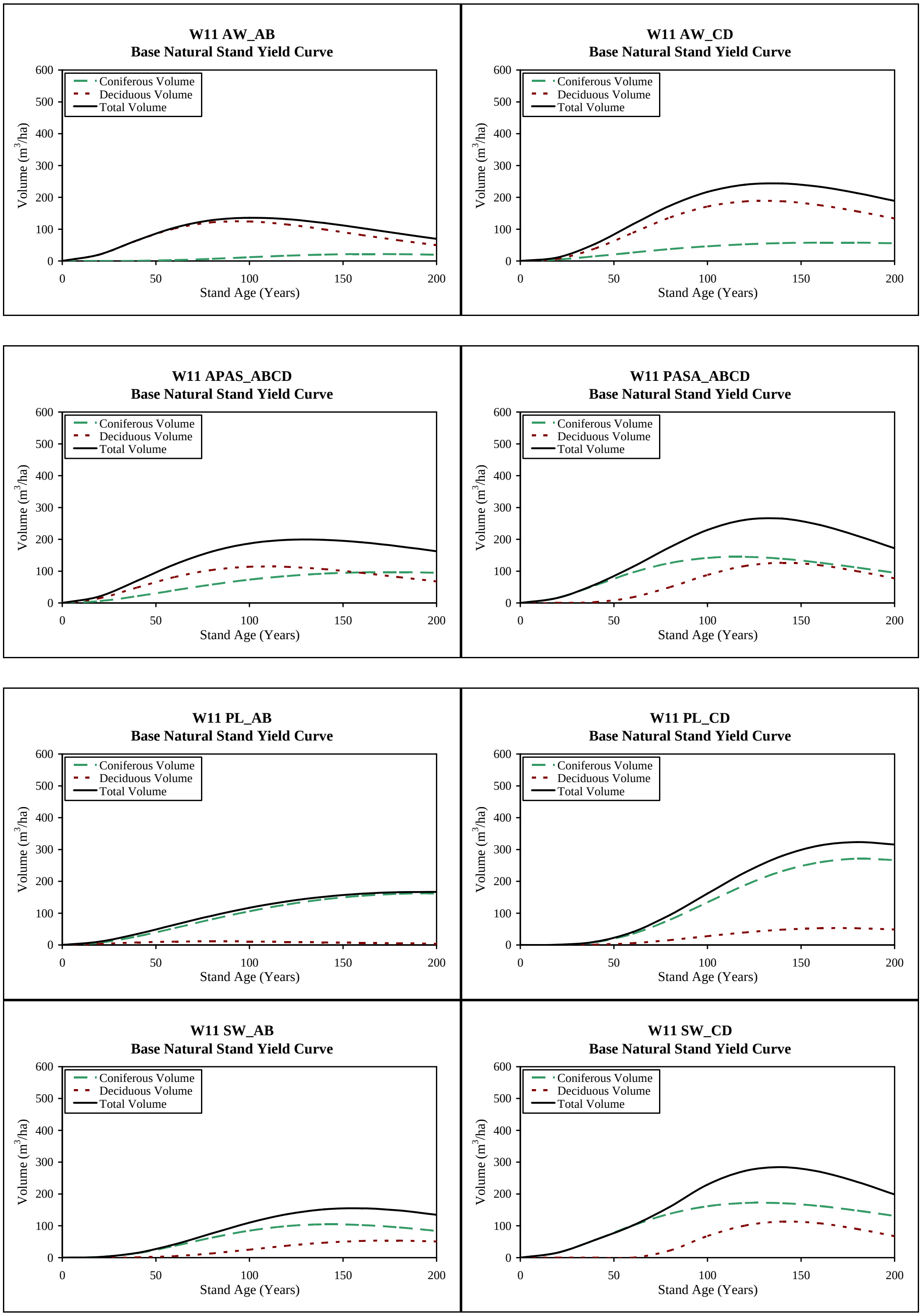


Figure 3. W11 base natural stand yield curves.

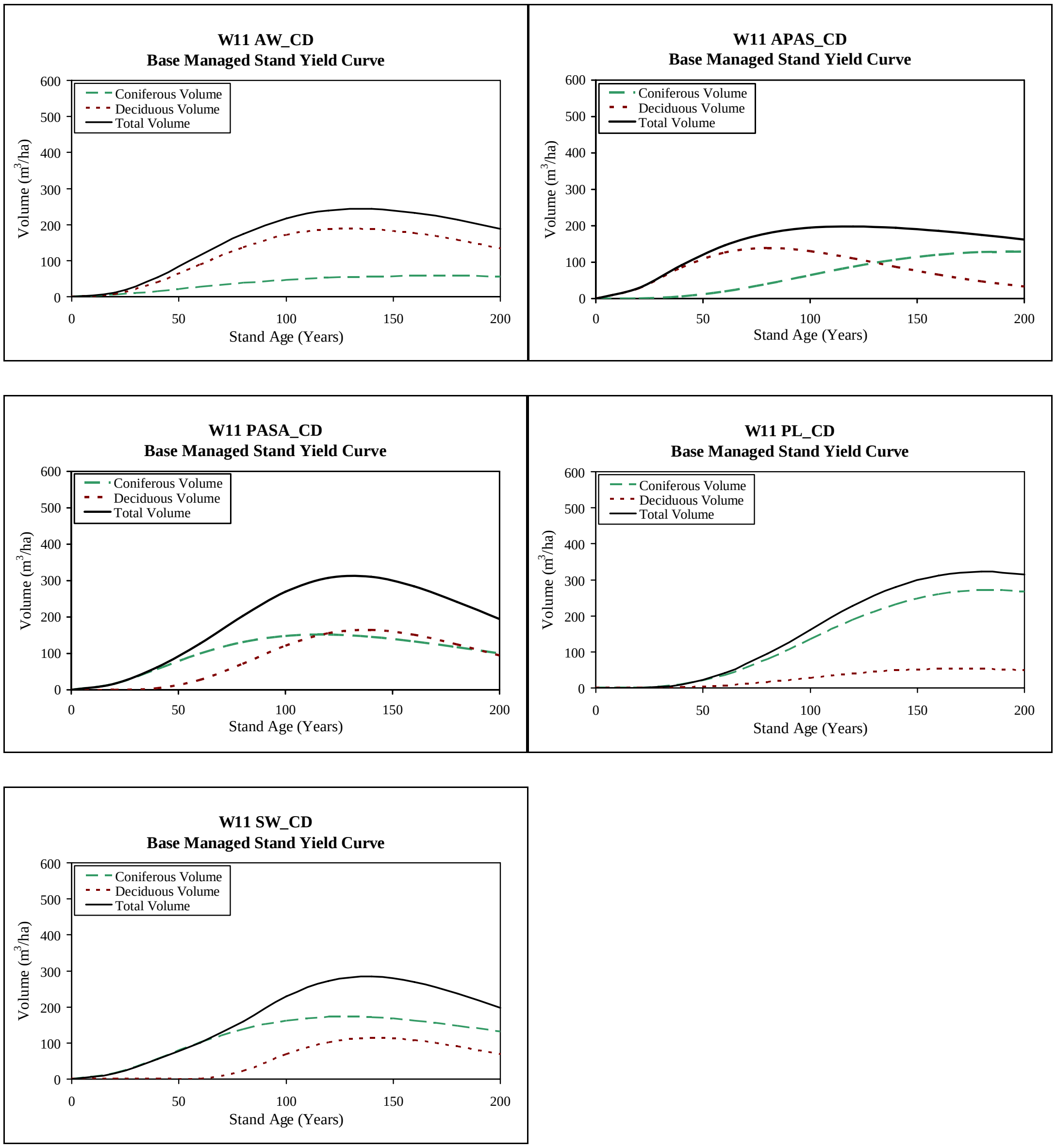


Figure 4. W11 base managed stand yield curves.

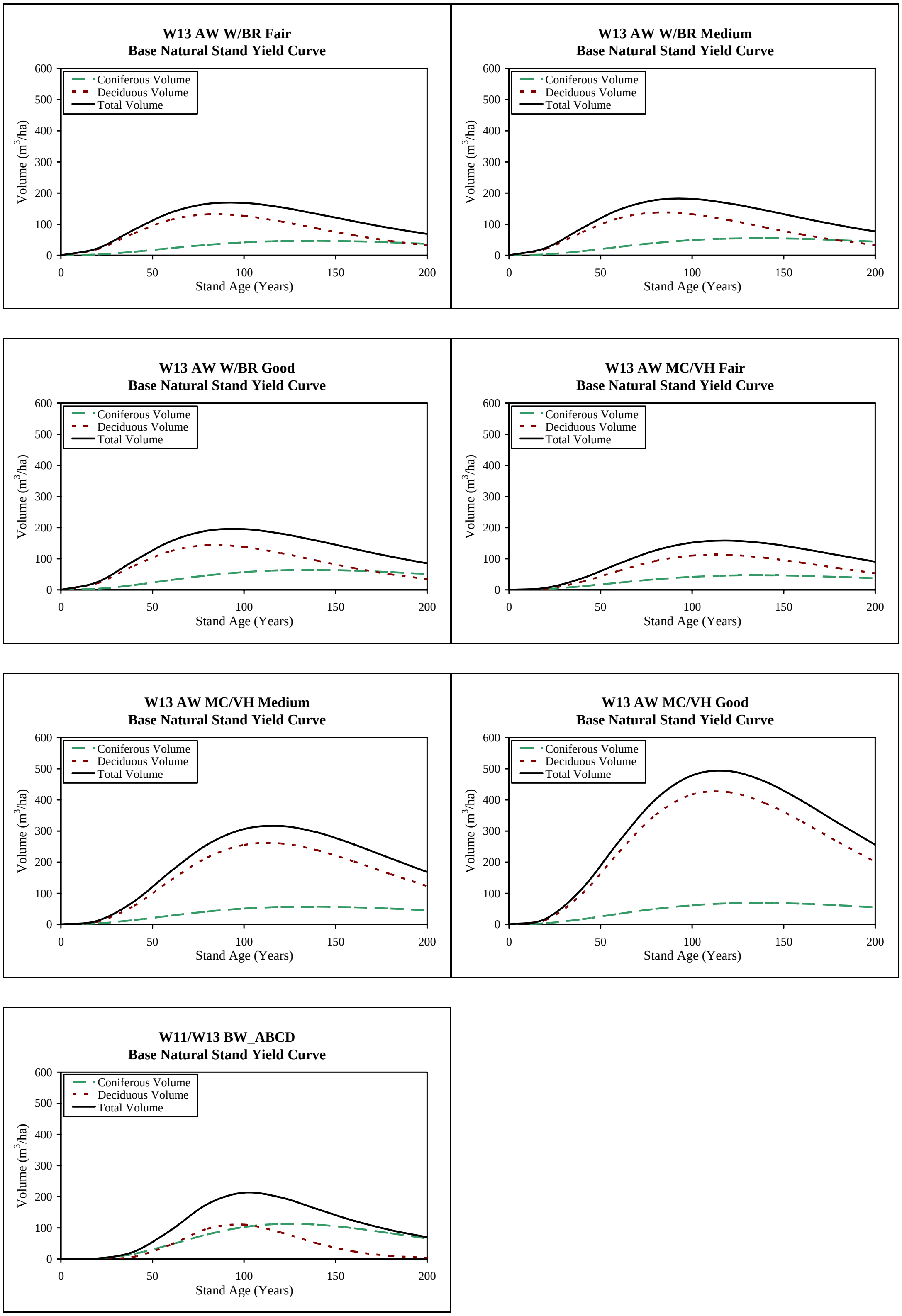


Figure 5. W13 base natural stand yield curves (1 of 4).

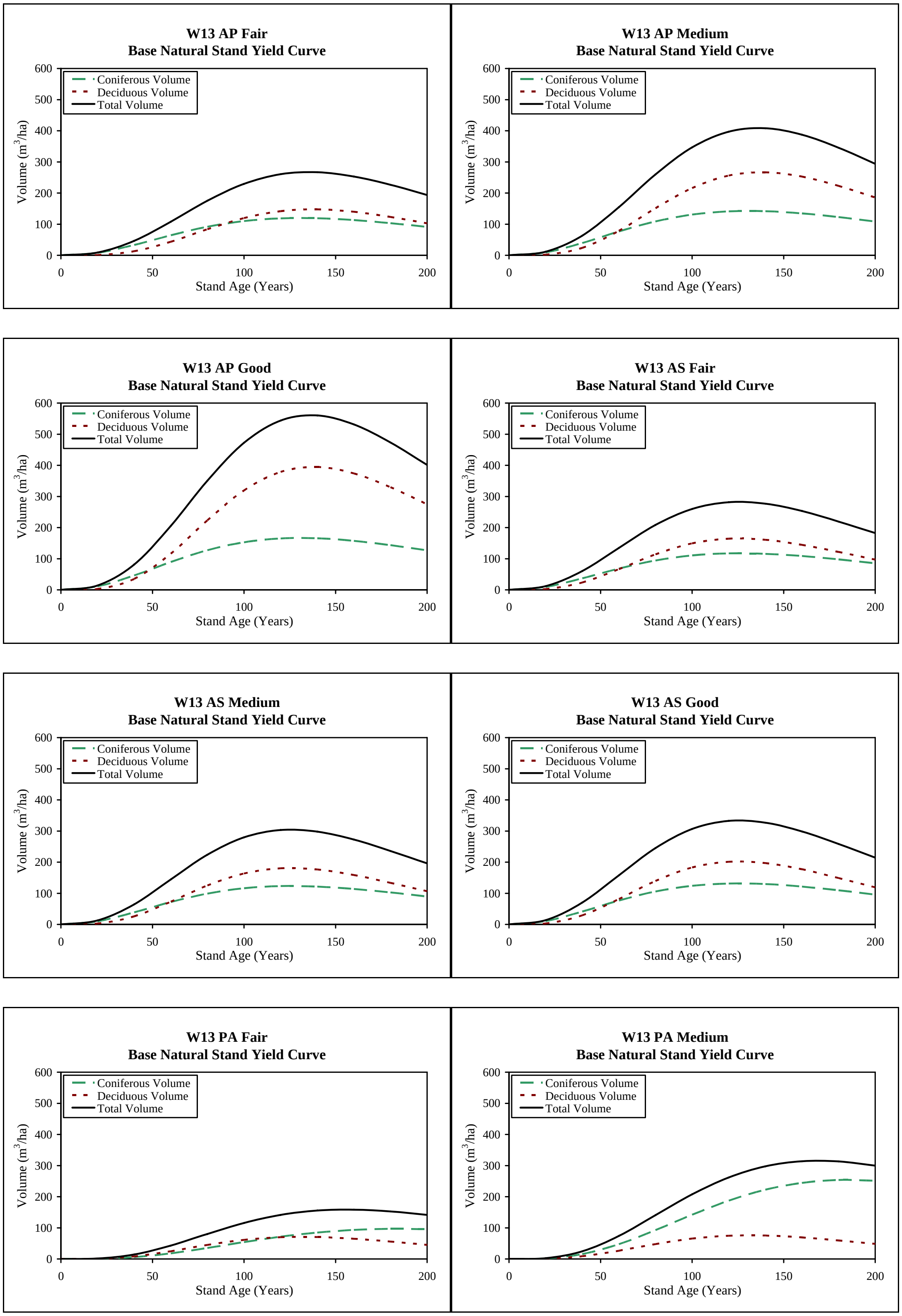


Figure 6. W13 base natural stand yield curves (2 of 4).

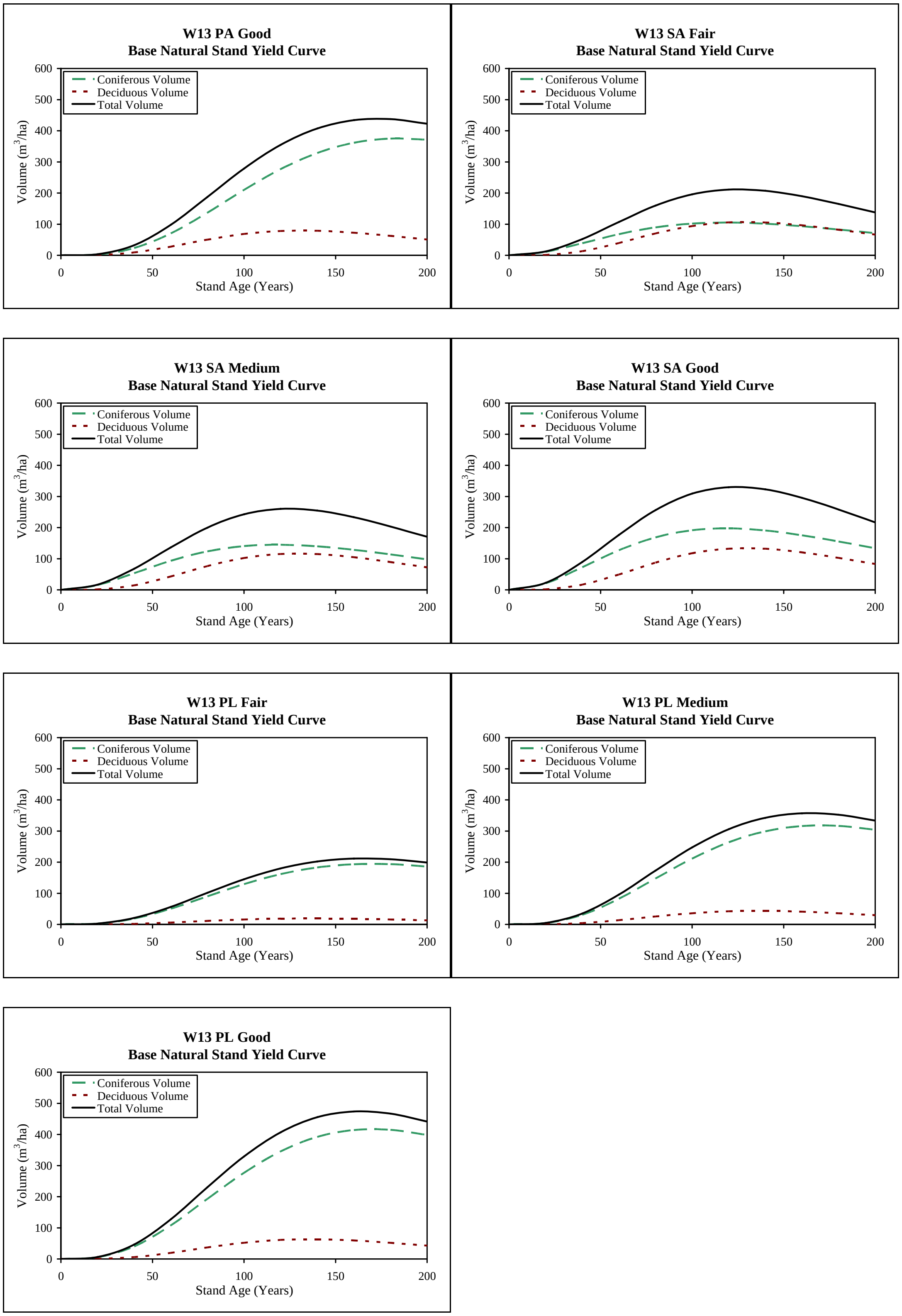


Figure 7. W13 base natural stand yield curves (3 of 4).

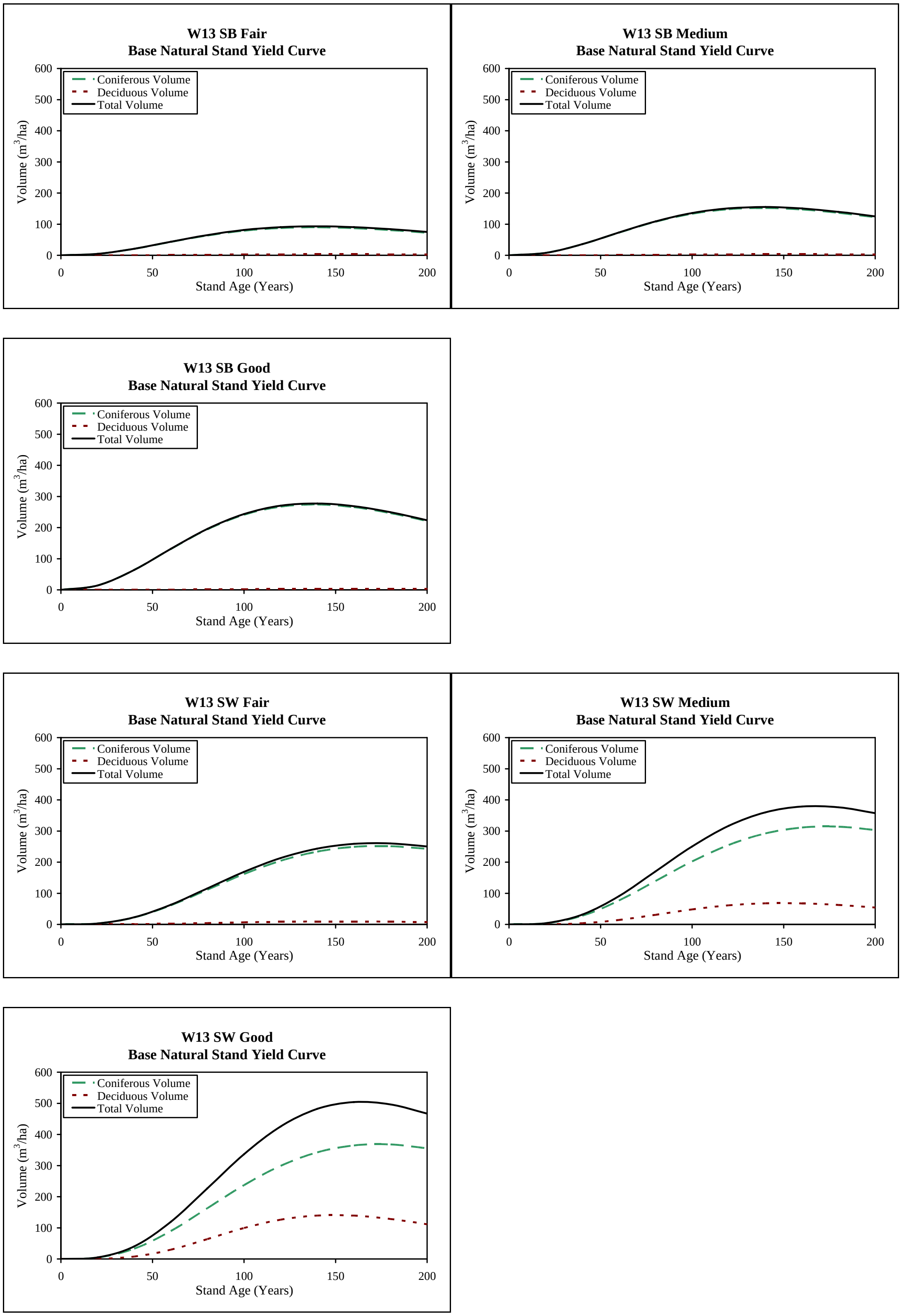


Figure 8. W13 base natural stand yield curves (4 of 4).

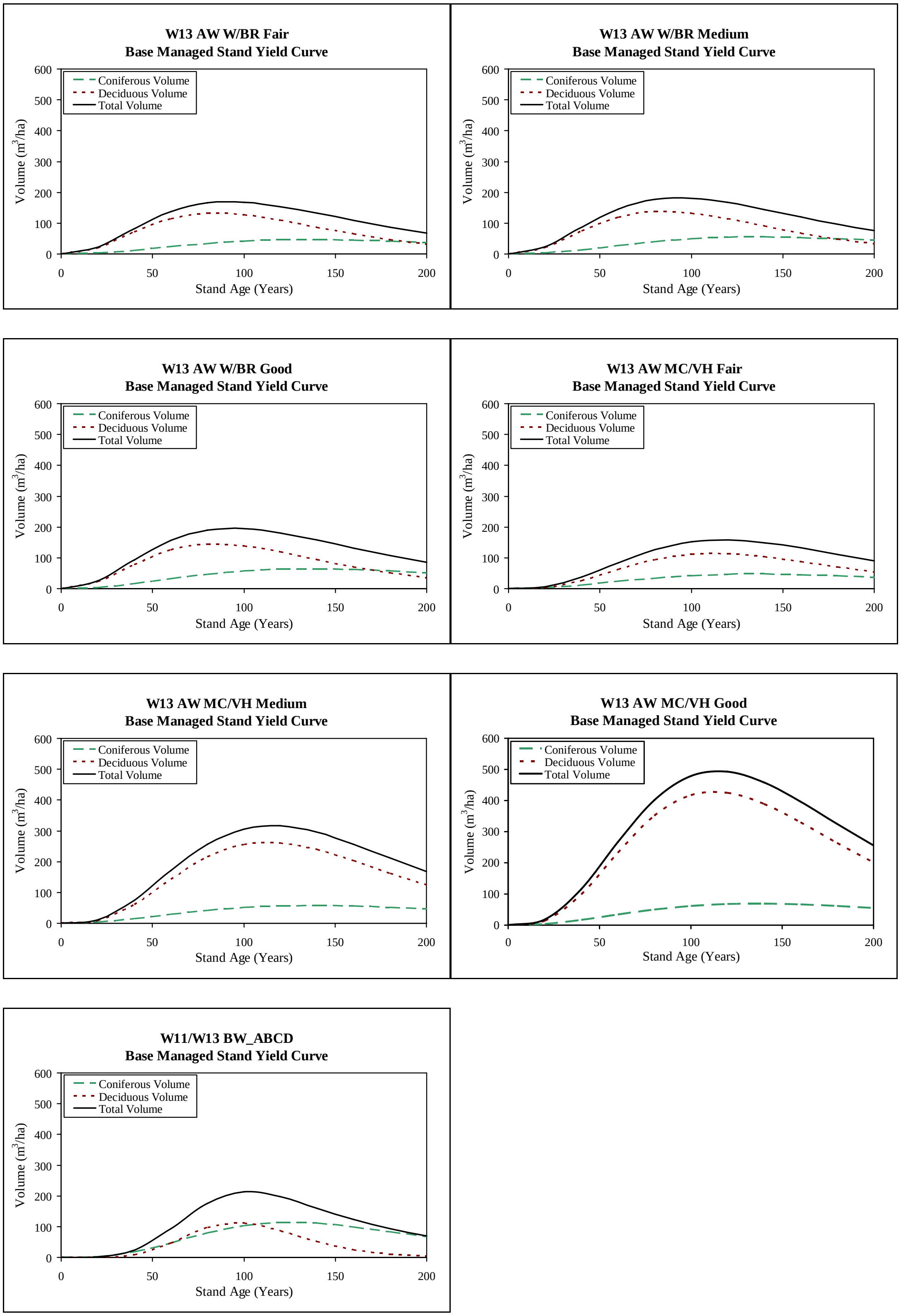


Figure 9. W13 base managed stand yield curves (1 of 4).

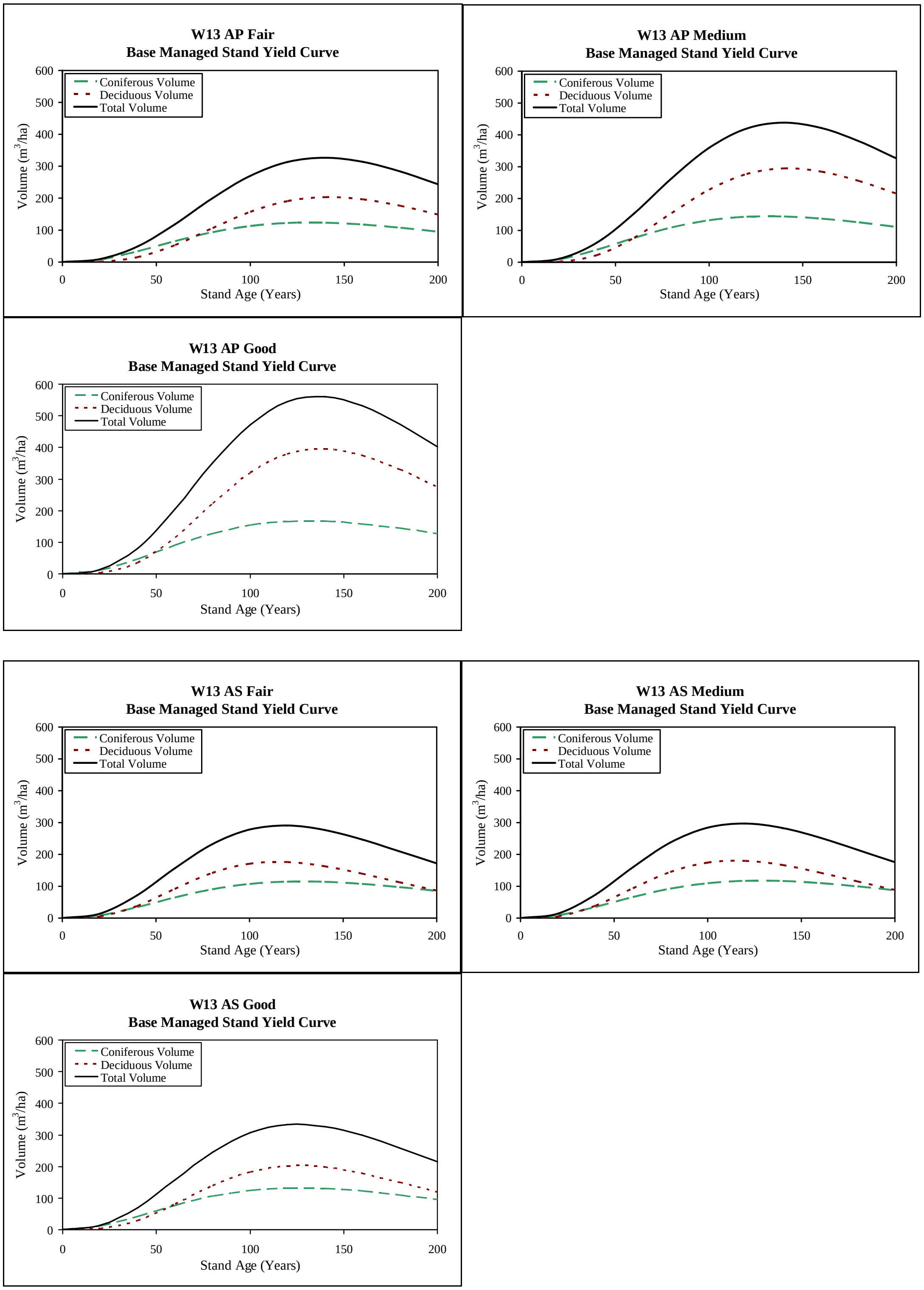


Figure 10. W13 base managed stand yield curves (2 of 4).

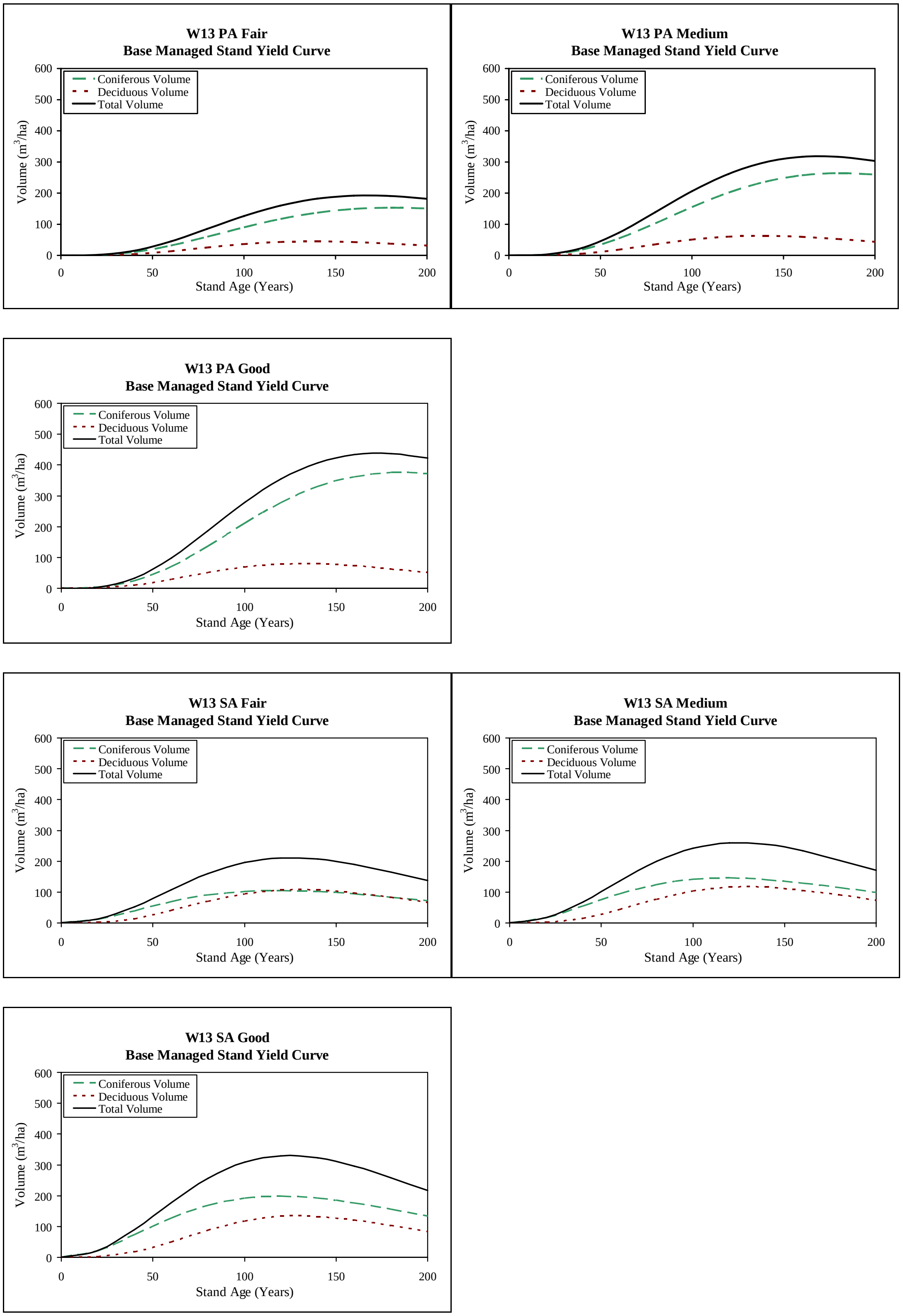


Figure 11. W13 base managed stand yield curves (3 of 4).

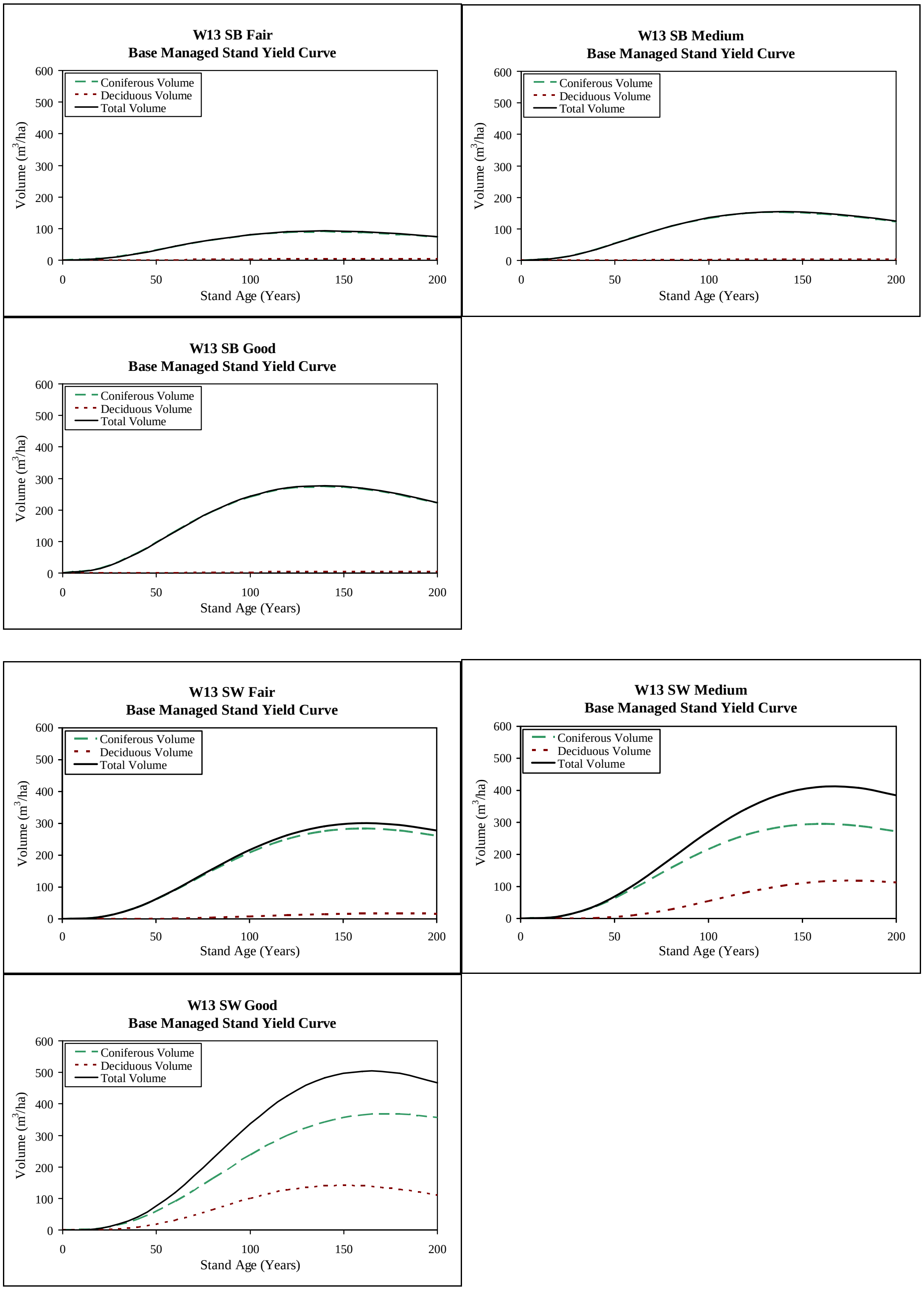


Figure 12. W13 base managed stand yield curves (4 of 4).

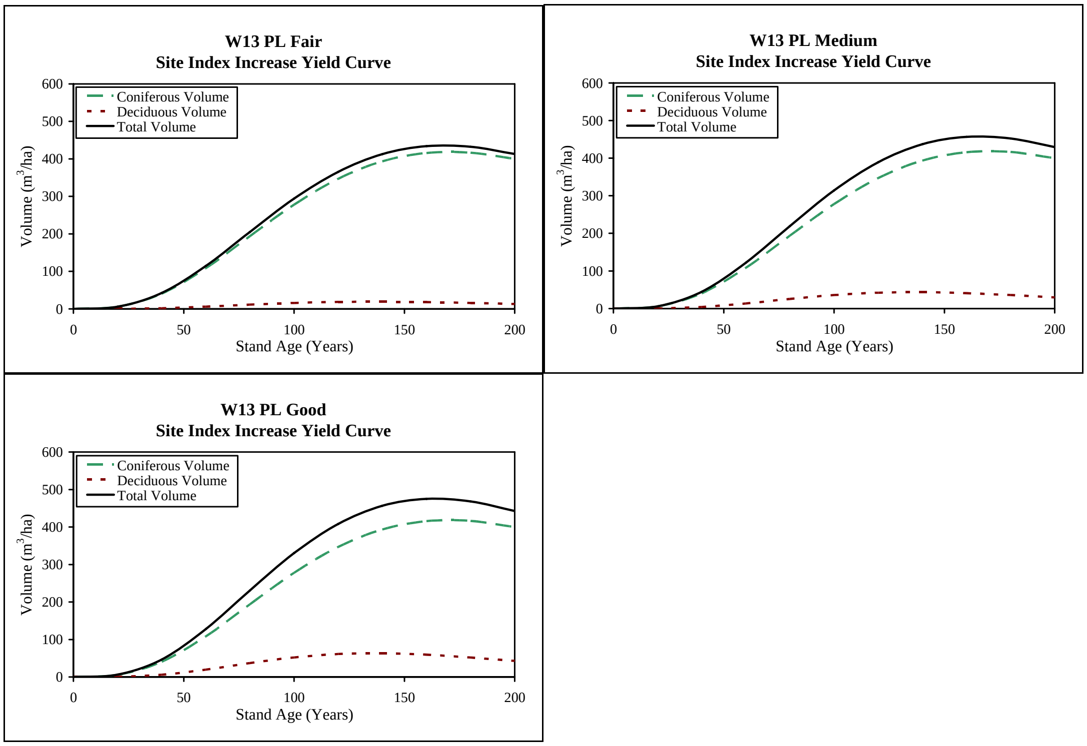


Figure 13. W13 pine site index increase managed stand yield curves.

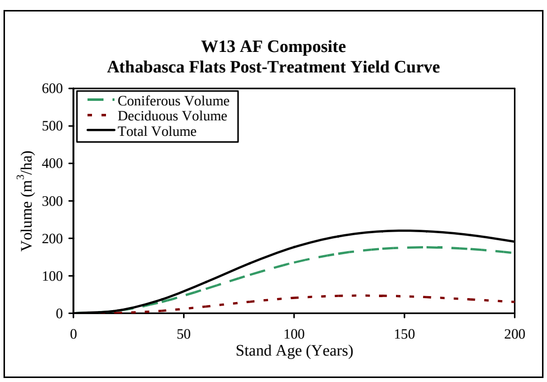


Figure 14. W13 composite Athabasca Flats post-treatment yield curve.

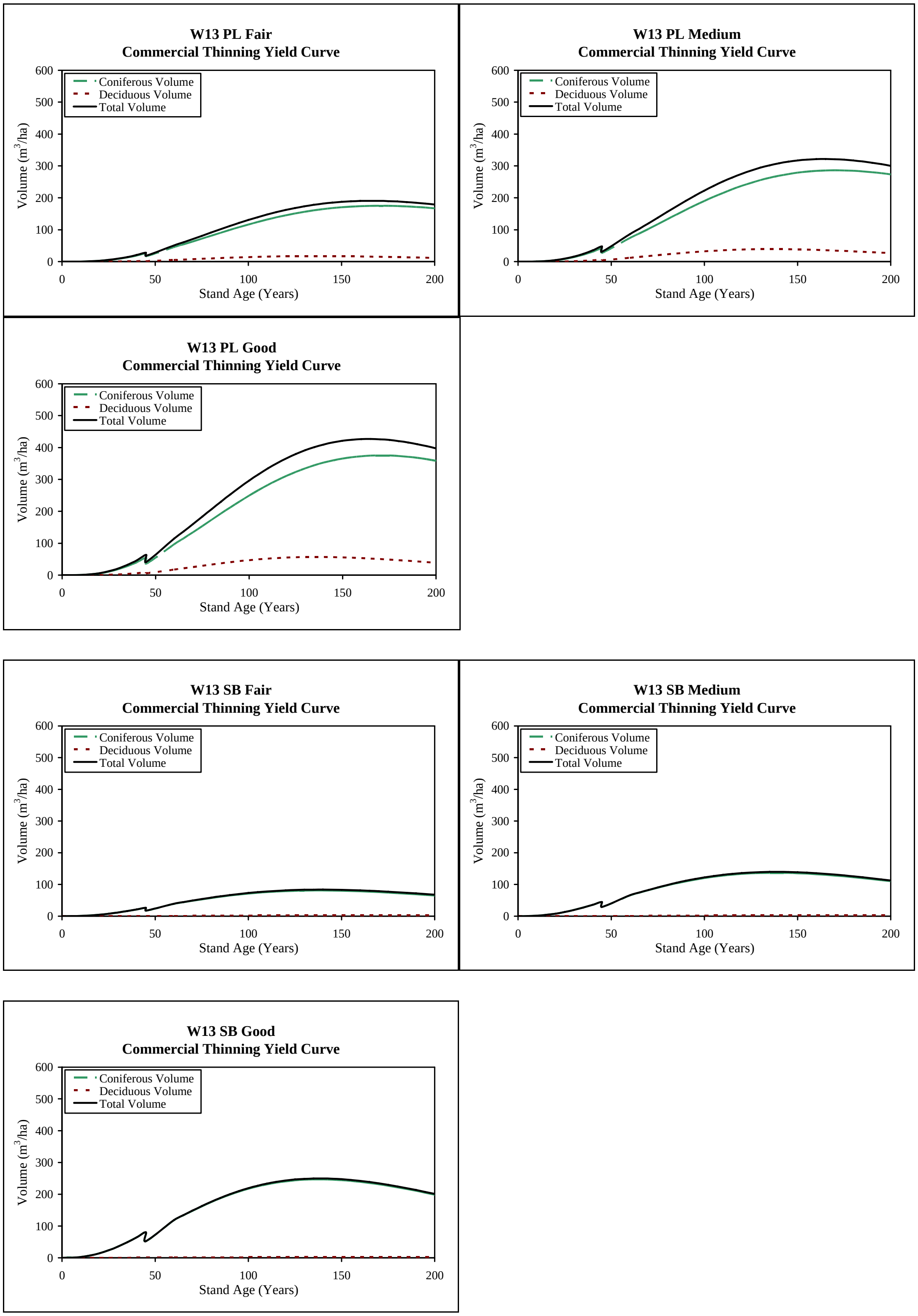


Figure 15. W13 commercial thinning yield curves.

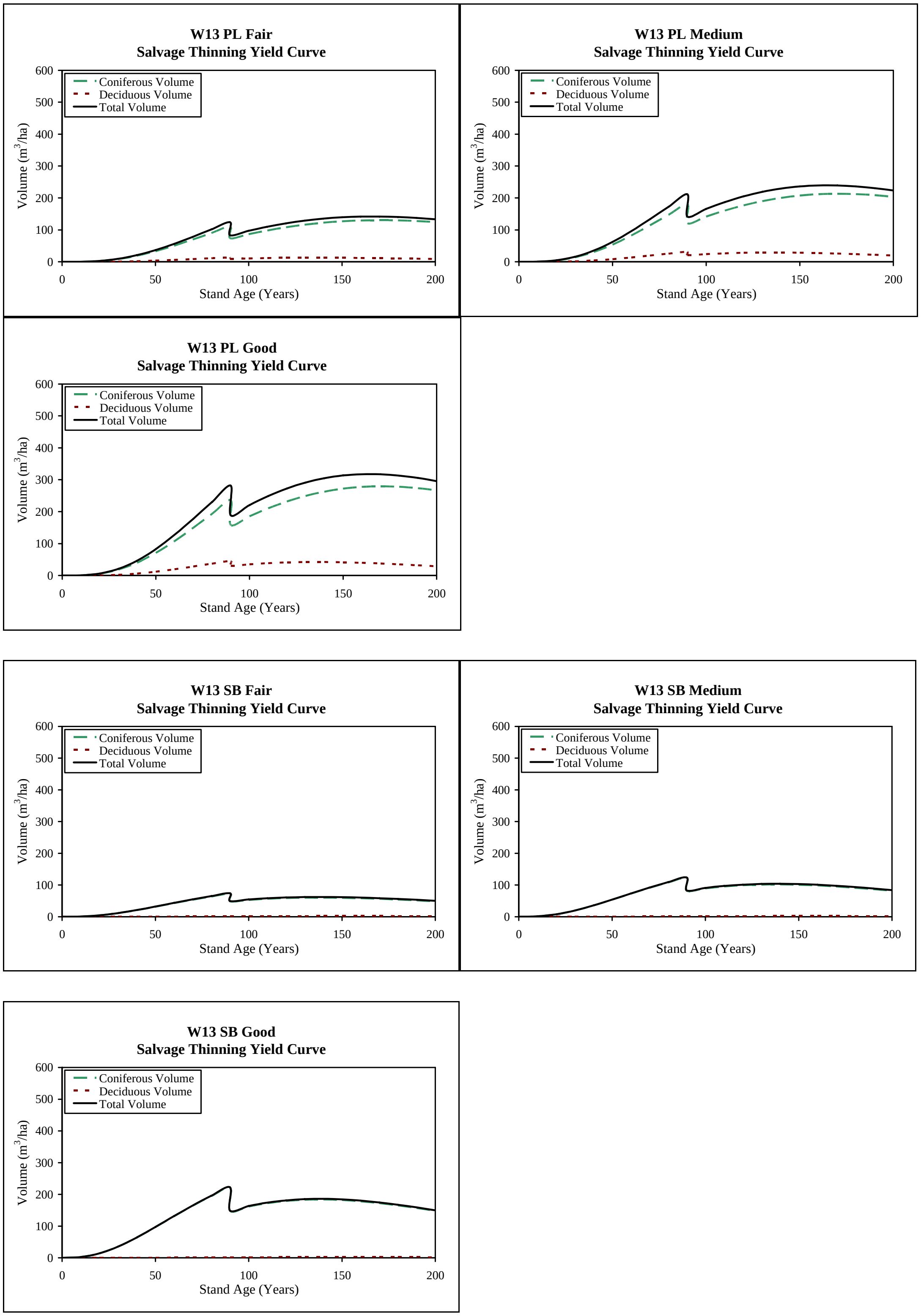


Figure 16. W13 salvage thinning yield curves.

4.3 Changes to Timber Yield Curves for Forecasting

In order to apply the timber yield curves to forecasting, slight modifications from their original form were required. The modifications were:

- Cull deductions were applied to all yield curves based on values in Table 9;
- Regeneration lag was applied by shifting the curves to the right;
- Yield curves were truncated to the lifespan of the stands (see Table 13 in section 5.5); and
- Only select commercially thinned curves were developed. The remainder were created by assigning a proportional reduction to the natural curves, with no volume recovery occurring.

4.3.1 Cull

Cull was calculated based on Millar Western scale data and can be seen in Table 9. All timber volume yield curves were reduced to account for cull. Cull reductions percentages were applied by scaling using the Woodstock *P function.

Table 9. Percent cull by volume type and FMU.

Volume Type	Cull %
FMU W11	
Coniferous	2.2
Deciduous	5.2
FMU W13	
Coniferous	2.2
Deciduous	5.2

4.3.2 Regeneration Lag

The regeneration lags were calculated in the yield curve development process (Table 10). The final regeneration lags were 3 years for deciduous broad cover group blocks in both FMUs. The other broad cover groups had a 4 year regeneration lag in W13 and 6 years in W11. In this forecasting process, the regeneration lag was incorporated by shifting the managed yield curves right by the length of the regeneration lag. Detailed calculations are described in *Appendix VII – Yield Curve Development*.

Table 10. Regeneration lags by FMU and broad cover group.

FMU	Broad Cover Group	Rounded Regen Lag
W 11	C, CD, DC	6
	D	3
W 13	C, CD, DC	4
	D	3

4.3.3 Full Timber Yield Curve Set

The full set of timber yield curves required for forecasting are shown in Table 11.

Yield strata represent the division of strata for timber volume curves to be created and assigned. These splits occurred where there are differences in volumes that could be related into yield curves. In W11, species strata were divided by density in pure stands to create 11 yield stratum. Mixedwood stands were grouped into DC and CD cover groups due to the small amount of data available. The BW strata was created for an FMA wide area, and not broken down by density or TPR. LT curves were not created for either FMU due to their non-merchantability.

In W13, the species strata were broken down by TPR to create the yield strata. There were 26 yield strata in W13 that can be seen in Table 7. As previously stated a white birch curve was calculated at the FMA level, and no curves were created for Lt due to its non-merchantability.

Table 11. Volume yield curves included in the Millar Western DFMP.

DFMP Yield Stratum	Natural					Managed	
	FMU			Athabasca Flats	Thinned	Base	Site Index Increase
	Wide	W5	W9				
W11							
AW_AB	Y						
AW_CD	Y					Y	
BW	Y					Y	
APAS_ABCD	Y					Y	
PASA_ABCD	Y					Y	
LT							
PL_AB	Y						
PL_CD	Y					Y	
SB							
SW_AB	Y						
SW_CD	Y					Y	
W13							
AW_G		Y	Y		Y	Y	
AW_M		Y	Y		Y	Y	
AW_F		Y	Y		Y	Y	
BW	Y						
AP_G	Y				Y	Y	
AP_M	Y				Y	Y	
AP_F	Y				Y	Y	
AS_G	Y				Y	Y	
AS_M	Y				Y	Y	
AS_F	Y				Y	Y	
PA_G	Y				Y	Y	
PA_M	Y				Y	Y	
PA_F	Y				Y	Y	
SA_G	Y			Y	Y	Y	
SA_M	Y			Y	Y	Y	
SA_F	Y			Y	Y	Y	
PL_G	Y				Y		Y
PL_M	Y				Y		Y
PL_F	Y				Y		Y
SB_G	Y				Y	Y	
SB_M	Y				Y	Y	
SB_F	Y				Y	Y	
SW_G	Y				Y	Y	
SW_M	Y				Y	Y	
SW_F	Y				Y	Y	

Y required for modeling, created by scaling with no volume increase (see note)

5. Forecasting Inputs and Assumptions

5.1 Overview

Forecasting is a complex process that requires numerous inputs and assumptions. The inputs relate to natural systems such as growth, succession, management actions, and post harvest transitions. The assumptions relate to how processes such as natural disturbance are incorporated into the forecasting model.

The purpose of this section is to explicitly show the final inputs and assumptions used in the forecasting for Millar Western's DFMP, which was used to create the two PFMSs[1]. In many cases sensitivity analyses were completed to test the impact of different sets of inputs and/or assumptions. The results of these analyses allowed managers and stakeholders to decide which set of inputs or assumptions to use in the PFMSs. This section shows only the final sets used to create the PFMSs. The different assumptions and sets analyzed and the results of the analysis can be seen in Section 7 Management Issues and Decisions.

5.2 Modeling Tools

Two forecasting tools were used for this DFMP, Woodstock and Patchworks. Woodstock models were converted into Patchworks format using the Patchworks interface which permitted

[1] Note the distinction between Preferred Forest Management Scenario (PFMS) and Preferred Forest Management Scenarios (PFMSs) used in this document.

common datasets to be utilized between the modeling tools to ensure continuity and meaningful comparison of results.

Woodstock was used for strategic, non-spatial analysis to test and compare different management assumptions. Patchworks dealt with the spatial issues involved with creating the PFMSs. Where possible, sensitivity analysis was completed using Woodstock for two reasons. Firstly, Woodstock uses linear optimization which, when feasible, provides the maximum possible solution. Whereas Patchworks uses a heuristic approach, that does not provide the maximum possible solution i.e. it does not necessarily find the optimal solution. Therefore the difference between two Patchworks runs could be the difference between the runs, the difference between the solutions, or both. Secondly, Woodstock quickly provides solutions when compared with Patchworks. For these reasons whenever there were no spatial requirements for sensitivity analysis, Woodstock was used. Patchworks was used to develop the two PFMSs , one for each FMU, and their related products such as the recommended harvest levels and the SHS.

The term goal is used in this document to define the modeling ‘targets’ used in both Patchworks and Woodstock models, to distinguish them from targets that are defined as part of the VOITs. In the analysis a variety of goals were defined such as harvest levels, minimum growing stock levels, minimum seral stage areas, maximum block size and range of regeneration patch sizes by period, using appropriate measures (*e.g.* cubic meters or hectares) and weighting factors.

A structured, progressive approach was used in the development and analysis of 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 results of the analysis were scenarios that met all of the achievable objectives as measured by the managers and stakeholders.

5.2.1 Woodstock

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

Woodstock is non-spatial. Every unique development type is rolled up into forest classes (TSA themes by age class). The model can then apply treatments to all or a portion of each unique forest class. Post-treatment transitions can be one to many relationships defined as percentages. Woodstock uses a mathematical technique called linear programming to quickly determine the absolute answer to a set of management assumptions. Linear programming is a commonly used mathematical tool in forest management because of its speed and accuracy in finding the ‘optimal’ solution with regards to a single objective and several constraints. The optimizer (a program that analyses variables and determines the optimal result) selects the optimal combination of treatments throughout the entire planning horizon to solve the objective function.

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

5.2.2 Patchworks

Patchworks is a spatially-explicit landscape forecasting modeling tool developed and serviced by Spatial Planning Systems[2]. Patchworks is designed to provide the user with operational-scale decision-making capacity within a strategic analytical environment. Patchworks allows planners to explore the interactions between attributes such as physical wood supply, harvesting economics and other values. Trade-off analysis of alternative operational decisions are quickly determined and visually and quantitatively displayed.

Patchworks operates at the polygon level. In Patchworks, polygons are the smallest element, which in this case are the subdivided Alberta Vegetation Inventory stands in the classified landbase. The treatments applied to each polygon are an *all or nothing* decision for the model. When Patchworks operates, one or more polygons adjacent to each other that meet specific criteria can be combined to form patches that allows spatial metrics to be considered in the selection of a PFMS. The landbase is comprised of many small polygons allowing Patchworks options in creating patches.

Patchworks 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 period in the planning horizon.

Patchworks is a heuristic model that attempts to achieve close to an optimal solution for the defined goals (similar to the goal-programming in Woodstock). Its modeling objective is to minimize deviation from the modeling goals. Patchworks uses a heuristic solving technique called simulated annealing that permits large problems to solved. Unlike Woodstock, spatial relationships (*i.e.* patch size distributions) can be applied in the objective function.

Patchworks solves in annual periods, however, it was set up to model and report in 41 five year increments to match Woodstock for the purpose of this analysis. The initial period represented the 2002 to 2006 harvest years. This allowed blocks that were being operated during the plan development period to be included without requiring updates to the landbase. The DFMP planning of the model begins in 2007 and continues to 2206.

5.3 Planning Horizon

The DFMP planning horizon was 205 years, although only 200 years of the planning horizon were within the DFMP period. The first 5 years of the planning horizon were used to bring the landbase up from 2002 to the start date of the DFMP, 2007. In reporting, the results show the final 200 years of the planning horizon, from 2007 to 2206.

[2] Spatial Planning Systems. 134 Frontenac Cres., Box 908, Deep River, ON K0J 1P0

5.4 Forecasting Strata Definitions

There were a number of strata groupings forecasted in the Millar Western DFMP. The simplest of the groupings was broad cover group (BCG) (Table 12). Species strata were the most commonly reported on and represents the breakdown of forested stands into 10 species strata that are the basic timber harvesting volume types. BAP strata were assigned so that the BAP SHE curves could be properly related to the landbase. Though Millar Western's operations do not recognize the difference between some of these BAP types in terms of harvest species, they represent biological trends required by BAP.

Table 12. Broad cover group, species strata and BAP strata relationships.

Broad Cover Group	Species Strata	BAP Strata	Description
D	AW	AW	Apen
		PB	Poplar
	BW	BW	Birch
DC	AP	AW_PL	Aspen leading pine mixedwood
	AS	AS_SWSB	Aspen leading spruce mixedwood
		PB_CON	Poplar leading mixedwood
CD	PA	PL_DEC	Pine leading mixedwood
	SA	SWSB_DEC	Spruce leading mixedwood
C	LT	LT	Larch
	PL	PL	Pine
	SB	SB_UP	Upland black spruce
		SB_LOW	Lowland black spruce
	SW	SW	White Spruce

5.5 Lifespan and Succession

Lifespan and succession rule sets were determined with the assistance of a biologist, field staff and timber supply analysts (Table 13). These rules represent a set of biological realistic assumptions that could be included in the forecasting model.

Three succession mechanisms were used in the forecasting model. 'Stand breakup' was a mechanism were the stand returned to a young state as the mature trees on the stand all died in the same period. 'Succession' involved a transition of dominant types in a stand. The age of the stand decreased but there was still a mature forest layer associated with the stand. The final succession type modeled was a 'gap phase' succession pattern, where death and ingress were assumed to equal each other, holding a stand at a steady age.

Table 13. Succession rules used in the PFMSs.

MWFP Succession Matrix Apr 11th, 2006								
	Pre-succession Strata			Succession		Post-succession Strata		
Broad Cover Group	Species Strata	BAP Strata	FMU	Age (yrs)	Mechanism	BAP Strata	Density	Age (yrs)
D	AW	AW	W9/W11	150	Stand Breakup	AW	CD	0
			W5	150	Stand Breakup	AW*	CD	0
		PB	all	150	Stand Breakup	PB	CD	0
	BW	BW	all	110	Stand Breakup	BW	CD	0
DC	AP	AW_PL	all	160	Succession	PL_DEC	AB	140
	AS	AW_SWSB	all	180	Succession	SWSB_DEC	AB	160
		PB_CON	all	180	Succession	SWSB_DEC	AB	160
CD	PA	PL_DEC	all	200	Stand Breakup	SWSB_DEC	CD	0
	SA	SWSB_DEC	all	180	Gap Phase	SWSB_DEC	n/c	n/c
C	LT	LT	all	210	Gap Phase	LT	n/c	n/c
	PL	PL	all	220	Stand Breakup	SW	CD	0
	SB	SB_UP	all	180	Succession	SW	AB	160
		SB_LOW	all	250	Gap Phase	SB_LOW	n/c	n/c
	SW	SW	all	210	Gap Phase	SW	n/c	n/c

* W5N Aspen stands (AW W/BR) regenerate back to the W9 Aspen curve (AW MC/VH)
n/c = no change

5.6 Minimum Harvest Ages

The minimum harvest ages used in W11 are provided in Table 14. The difference in minimum harvest ages between the W11 managed and natural stands was the regeneration delay that was applied (refer to *Appendix VII – Yield Curve Development* for more information).

Minimum harvest ages in W13 (Table 15) varied by timber productivity rating (TPR). There was an increased minimum harvest age in medium and fair pine in natural stands. This increased minimum harvest age was implemented because many of these stands regenerated at high densities post-fire and may show suppressed growth. As with W11, the difference between the natural and managed stand minimum harvest ages in W13 is attributable to the regeneration lag.

The application of minimum harvest ages in the modeling was more complex than shown in the tables, although the outcome was the same. In the modeling, natural and managed minimum harvest ages are the same, but the timber volume components of the yields curves were shifted to the right by the number of years of the regeneration delay. In this way, tree age was the same between the natural and managed stands. Other non-timber attributes such as BAP SHE curves, were not shifted to the right by regeneration delay as BAP required years since disturbance. In all forecasts, managed stand harvest ages are reported as time since disturbance for all attributes timber or otherwise. Therefore, a reported 84 year old AW managed stand will produce less volume than an 84 year old natural stand, because the trees are actually 3 years younger than in the natural stand.

Table 14. W11 minimum harvest ages by origin.

Broad Cover Group	Yield Strata	Stand Origin Natural	Stand Origin Managed
D	AW	61	64
	BW	61	64
DC	AP	81	87
	AS	81	87
CD	PA	81	87
	SA	81	87
C	PL	81	87
	SB	101	107
	SW	81	87

Table 15. W13 minimum harvest ages by origin and TPR.

Broad Cover Group	Yield Strata	TPR Min Age (yrs) Good	Medium	Fair
Natural Stands				
D	AW	76	81	86
	BW	76	81	86
DC	AP	61	66	71
	AS	81	86	91
CD	PA	61	66	71
	SA	81	86	91
C	PL	61	76	76
	SB	86	91	-
	SW	81	86	91
Managed stands				
D	AW	79	84	89
	BW	79	84	89
DC	AP	65	70	75
	AS	85	90	95
CD	PA	65	70	75
	SA	85	90	95
C	PL	65	70	75
	SB	90	95	-
	SW	85	90	95

Note that minimum harvest ages were not provided for SB fair sites in W13 as they are non-merchantable.

5.7 Stand Transitions

Stand transitions within the forecast models vary with stand treatment. Table 16 shows the pre-treatment stand information, the treatment regimes available for selection, and the resulting post-treatment stand information. The difference between the clearcut and conversion action was the regeneration strategy. Under the clearcut regime stands regenerate to their pre-harvest strata while under the conversion regime the post-harvest strata changes from the pre-harvest strata. The structural retention strategies are discussed in section 5.23. The different vegetation management regimes refer to whether manual or chemical tending would occur based on the silviculture regime.

Table 16. Response to treatment matrix used in the PFMSs.

Pre-treatment Strata						Treatment Regime				Post-treatment Strata[2]			
Broad Cover Group	**MW Species Strata**	**BAP Specific Strata**	**Crown Closure Class**	**TPR**	**Disturbance Origin[3]**	**Harvest Type**	**Structure Retention Level**	**Regeneration Intensity**	**Vegetation Management Strategy**	**BAP Specific Strata**	**Crown Closure Class**	**Disturbance Origin**	**Age**
D	AW	AW	AB,CD	G,M,F	Nat,Ext	Clearcut	Lret	Managed	NoVegC	AW	CD	Ext	0
		AW	AB,CD	G,M	Nat,Ext	Conversion	NRet	Managed	VegC	SW	CD	LowInt	0
		PB	AB,CD	G,M,F	Nat,Ext	Clearcut	Lret	Managed	NoVegC	PB	CD	Ext	0
		PB	AB,CD	G,M	Nat,Ext	Conversion	NRet	Managed	VegC	SW	CD	LowInt	0
	BW	BW	AB,CD	G,M,F	Nat,Ext	Clearcut	Lret	Managed	NoVegC	AW	n/c	Ext	0
DC	AP	AW_PL	AB,CD	G,M,F	Nat,LowInt	Clearcut	Lret	Managed	VegC	AW_PL	CD	LowInt	0
		AW_PL	AB,CD	G,M	Nat,LowInt	Conversion	Nret	Managed	VegC	PL	CD	LowInt	0
	AS	AW_SWSB	AB,CD	G,M,F	Nat,LowInt	Clearcut	Lret	Managed	VegC	AW_SWSB	CD	LowInt	0
		AW_SWSB	AB,CD	G,M	Nat,LowInt	Conversion	Nret	Managed	VegC	SW	CD	LowInt	0
		PB_CON	AB,CD	G,M,F	Nat,LowInt	Clearcut	Lret	Managed	VegC	PB_CON	CD	LowInt	0
		PB_CON	AB,CD	G,M	Nat,LowInt	Conversion	Nret	Managed	VegC	SW	CD	LowInt	0
CD	PA	PL_DEC	AB,CD	G,M,F	Nat,LowInt	Clearcut	Lret	Managed	VegC	PL_DEC	CD	LowInt	0
		PL_DEC	AB,CD	G,M	Nat,LowInt	Conversion	Nret	Managed	VegC	PL	CD	LowInt	0
	SA	SWSB_DEC	AB,CD	G,M,F	Nat,LowInt	Clearcut	Lret	Managed	VegC	SWSB_DEC	CD	LowInt	0
		SWSB_DEC	AB,CD	G,M	Nat,LowInt	Conversion	Nret	Managed	VegC	SW	CD	LowInt	0
C	PL	PL	AB,CD	G,M,F	Nat,LowInt	Clearcut	Lret	Managed	VegC	PL	CD	LowInt	0
	SB	SB	AB,CD	G,M	Nat,LowInt	Clearcut	Lret	Managed	VegC	SB	CD	LowInt	0
	SW	SW	AB,CD	G,M,F	Nat,LowInt	Clearcut	Lret	Managed	VegC	SW	CD	LowInt	0

[2] TPR is not altered by any treatment.

[3] Nat = Natural (fire-origin)

Ext = Extensive (same timber volumes as natural)

LowInt = Low Intensity Regeneration (managed)

n/c = no change (e.g. AB to AB, CD to CD)

5.8 Silviculture Regimes

There were numerous silvicultural regimes developed by members of the DFA Silviculture committee and other experts for this DFMP. Refer to *Appendix IX – Silviculture Generic Establishment Regimes (GER)* for details on the process and outcomes. The available treatments are based on the Edatopic Grid characteristics of the stand (*i.e.*, moisture and nutrient regime). These regimes describe all possible silvicultural treatments that could be applied to each site based on its edasite (see section 5.7 for edasite definitions). The treatment information assigned also included treatment costs, used for internal Millar Western reporting only.

5.9 Understory Management

The management of multi-story stands and stands with understories will be addressed at the operational level. Unique treatments for understory management were not included in the DFMP forecasting process. Understory treatments will be applied on the ground as required by Operating Ground Rules.

5.10 Natural Disturbance

Prior to human activity natural disturbance caused the majority of changes to the forest structure and age. Natural disturbance includes all natural factors that affect a forest ecosystem such as fire, storms and insect outbreaks. Historically in Alberta, fire has had the largest effect on forest dynamics. It has been suggested that through time, fire suppression activities have increased the age class structure of the forest, by reducing the area burned on the landbase (Cumming, S.G., 2005). There have also been different insect populations that have affected the forest dynamics in Alberta. These insect populations include forest tent caterpillar (*Malacosoma disstria),* spruce budworm (*Choristoneura funiferana*) and recently MPB (mountain pine beetle *Dendroctonus ponderosae*).

Alberta's forest companies operate primarily within the Green Area, which was established by the Alberta government for the purpose of timber production. Though other industries, such as oil and gas and ranchers, operate on the same landbase they generally do not rely on the mature timber and may view it as a hindrance to their operations. Since large scale natural disturbances typically affect mature timber, they primarily impact forest companies. It is important however, to mitigate the effects of natural disturbance, not only from a timber supply perspective, but also for maintaining an increasing large number of values on the landbase. One way of mitigating the effects of natural disturbance elements, specifically forest fire, is by salvaging timber from burnt fires. This permits timber volume to be harvested from fires while postponing the harvest of green timber.

As the proportion of mature and over mature forest on the landbase is reduced, the impact of natural disturbance on forest industry may increase in the future. Conversely, there could also be a decrease in the area affected by natural disturbance, especially by pests such as mountain pine beetle, when the mature and over-mature forest area is reduced, since these forests tend to be more susceptible to natural disturbance.

5.11 Landbase Losses Accounted

There are two mechanisms to account for losses on the productive landbase included in the forecasting. The first is the AAC recalculation trigger that occurs when the harvest level or managed landbase is reduced by more than 2.5% from the approved harvest level or managed landbase area. Millar Western would then recalculate their harvest level based on the new reduced landbase. The second is a result of the historical method of dealing with fire in TSAs. When a fire burned on the landbase it was typically removed from the managed landbase in the next TSA until the area was inventoried or surveyed to show regeneration. It may be assumed that as areas burn and are removed from the landbase area, other older burned area will be returned back to the landbase. Therefore, fire has inherently been accounted for in the harvest level calculations through both a recalculation trigger and post-fire area removal.

5.12 Mountain Pine Beetle

There were two MPB ranking systems used in forecasting. The first was the static Alberta Sustainable Resource Development (ASRD) MPB ranking system (Version 2.6, September 2006). The second ranking was the Millar Western MPB ranking, which used components of the December 2005 ASRD stand susceptibility index (SSI) calculation to create a dynamic rating system. SSI represents the ability of the beetles to reproduce within a stand after it's infested. These ranking systems are described below, along with how they were used in the Millar Western forecasting.

The Millar Western MPB ranking was incorporated into the forecasting model, while the ASRD ranking was used to assess scenarios but not to actively used to control the forecasting model. The ASRD ranking was calculated for the 2007 landbase and stands with high rankings were assigned a low rank post harvest, but no stands were able to increase in rank during the forecasting. The ASRD ranking was forecasted into the future but as no stands could increase in ranking and the stand's ranking decreased due to harvesting, the overall ranking could only decline. The Millar Western approach recognized that young pine stands were likely to become increasingly at risk to MPB over time. This was deemed important as Millar Western has relatively large areas that are currently classified as having a low ranking based on young stand ages (for example the Windfall Burn area) that will become more susceptible in the near future.

The ASRD MPB rankings of stands changed during the development of the plan to reflect the changing situation. The use of the Millar Western rankings provided some stability to the forecasting and prevented the need to constantly rebuild the forecasting model to incorporate the revised ASRD ranking systems.

5.12.1 ASRD MPB Ranking

The September 2006 ASRD ranking (version 2.6) was comprised of three components and applied on a polygon level:

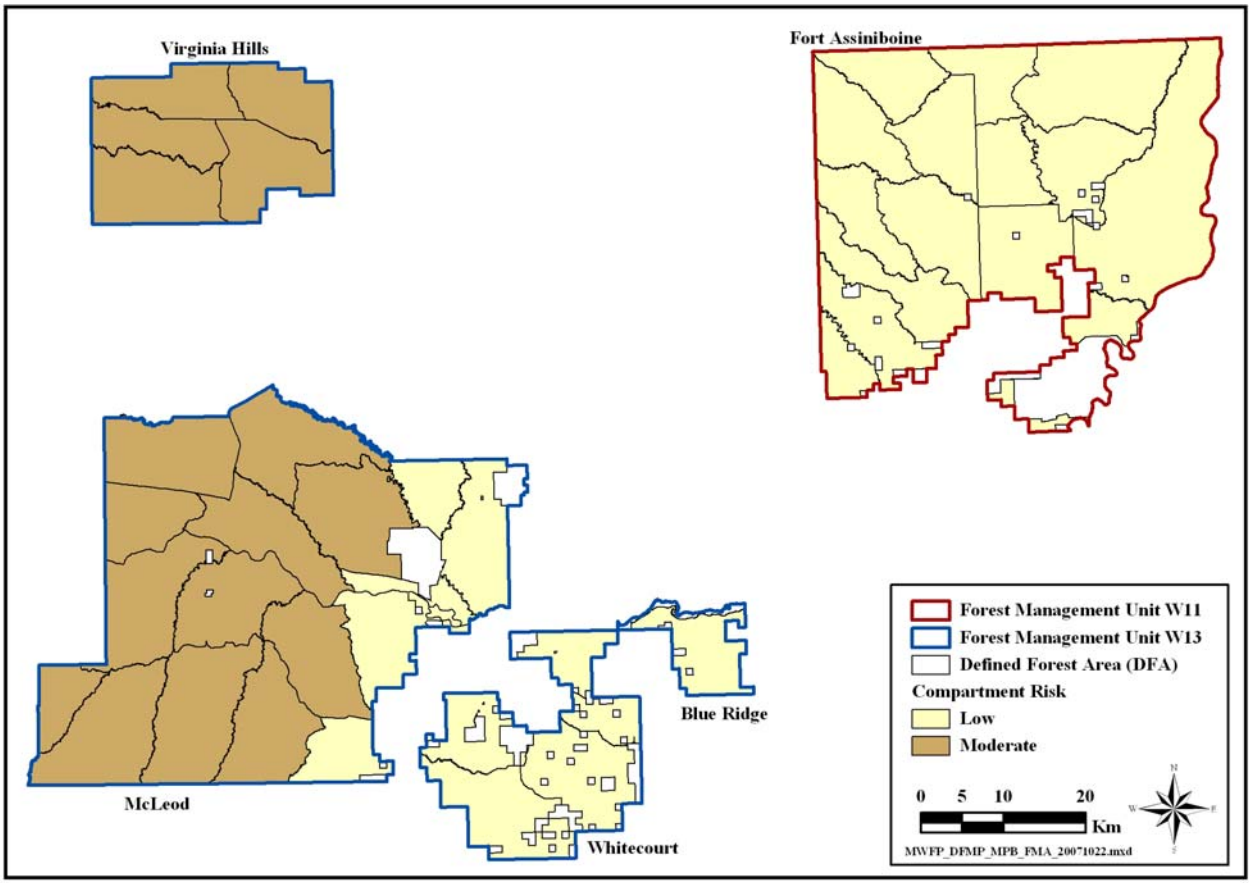
- Stand Susceptibly Index (SSI);
- Compartment Risk; and
- Climate Factor.

The SSI of the polygon was calculated using the ASRD Pine Rating model. The planning team used all of the default input parameters with the effective date of 2007.

The Compartment Risk was completed by the Alberta government for Millar Western's DFMP. The following compartments were ranked as moderate:

- North Goose
- Meekwap
- West Goose
- Pass Creek
- Kaybob
- Sakwatamau
- Chickadee Creek
- Bessie Creek
- Tom Hill
- Goose
- Headless Valley
- Two Creeks
- Athabasca
- West Windfall
- Baseline Lake
- Windfall
- Ocelot

The remaining compartments were ranked as low risk, including all compartments in W11 (Map 4).



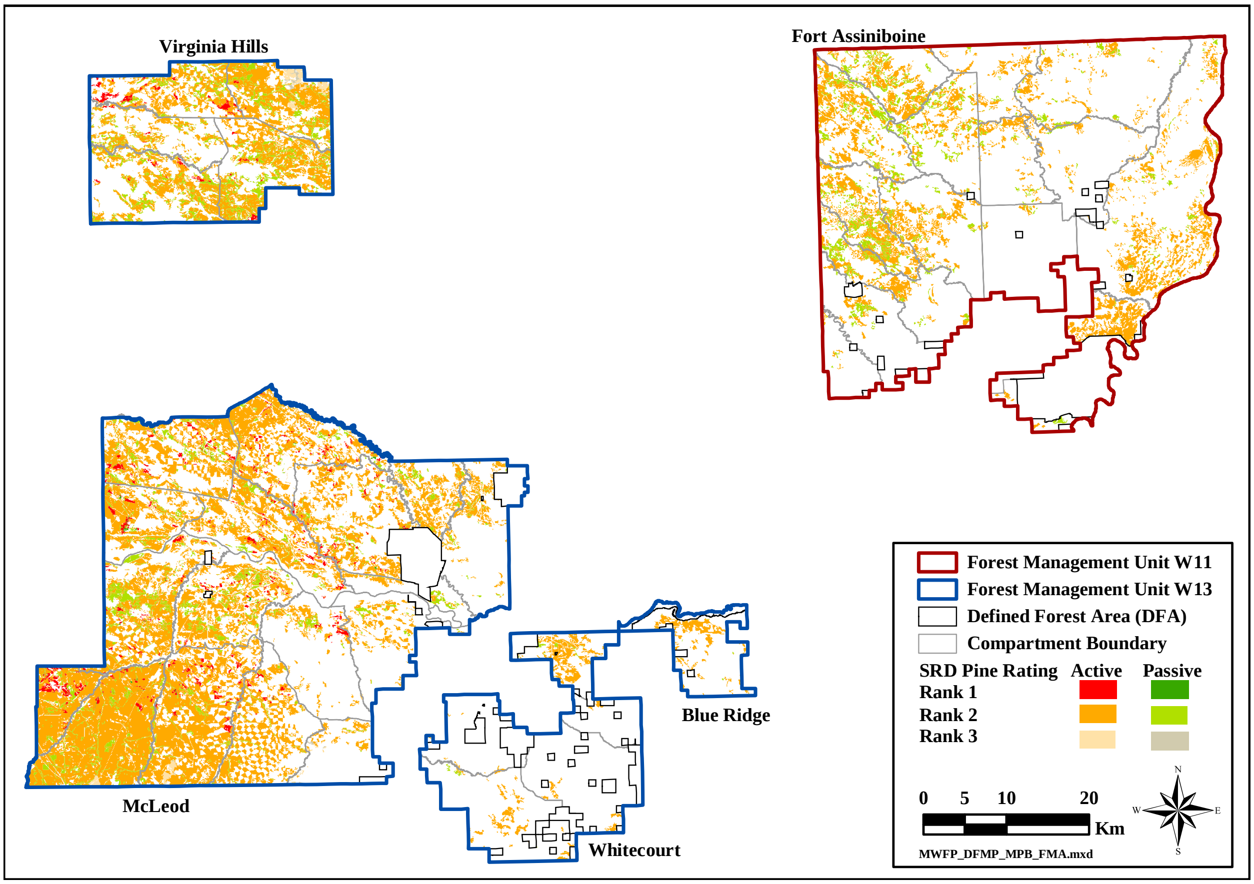
Map 4. ASRD MPB compartment risk assignments

The final component of the MPB ranking was Climate Factor. Climate Factor is a measure of the effect that climate would have on beetle development, or the probability that the beetles will undergo one year lifecycles (ASRD (2), 2006).

These three components were combined (see Table 17) to calculate the ASRD MPB ranking. The ASRD ranking for the managed (active) and unmanaged (passive) landbase is shown in Map 5. The majority of W13 polygons are Rank 2 . The Climate Factor and Compartment Risk comprise the main components of this ASRD ranking; a Climate Factor of >= 0.8 and a High Compartment Risk would result in a Rank 1 stand, even if there were only 10% pine in the stand. Alternatively, if the Compartment Risk were Low and the Climate Factor were <= 0.5, the highest the rank would be is 2 even if the SSI were 100 (highest SSI possible).

Table 17. ASRD MPB ranking.

Climate Factor (per stand)	Compartment Risk	SRD Ranking			
Very Suitable 1.0	High	1	1	1	1
	Moderate	2	1	1	1
	Low	2	2	1	1
Highly Suitable 0.8	High	1	1	1	1
	Moderate	2	2	1	1
	Low	2	2	2	1
Moderately Suitable 0.5	High	2	1	1	1
	Moderate	2	2	2	1
	Low	3	2	2	2
Low Suitability 0.2	High	2	1	1	1
	Moderate	3	2	2	2
	Low	3	2	2	2
Very Low Suitability 0.1	High	3	2	2	2
	Moderate	3	3	2	2
	Low	3	3	3	3
SSI		0 to 30	31 to 50	51 to 80	81 to 100



Map 5. ASRD MPB Rankings on the DFA in 2007.

5.12.2 Millar Western MPB Ranking

The Millar Western MPB ranking was created by utilizing the inputs from the December 2005 ASRD SSI system which were used to create a set of dynamic SSI yield curves to show stand susceptibility through the planning horizon. The intent of this dynamic ranking was to account for stand growth and decay and to be able to incorporate a MPB ranking directly into the Forecasting tools as an indicator and goal. The equation to calculate SSI was as follows:

SSI = P * A * D * L

Where:

P = basal area factor (percentage of susceptible pine basal area)
A = age factor
D = density factor
L = location/climate factor

Each of these variables were based on look up tables. Although not all of these variables were related to stand age (i.e., some were related to height), they were converted into age based lookup tables to create SSI curves by species strata based on stand age. These curves became the Millar Western ranking system and were applied during forecasting as one of the parameters to select stands for harvesting.

5.13 Patches (Opening and Old)

Patches are an important consideration in forestry, given current concerns regarding fragmentation of the forest. For many biological reasons there has been a recent effort to mimic natural disturbance patterns, including minimizing fragmentation. Mimicking historic disturbance patterns requires a mix of many, small disturbance patches along with fewer, larger disturbance patches. Anthropogenic disturbances often create small openings, however, creation of larger, contiguous patches requires careful planning.

There are two mechanisms available to Millar Western to allow a reduction in forest fragmentation. First, larger Opening Patch sizes can be targeted, directly reducing fragmentation. The second mechanism involves aggregating the Old forest on the landbase. The historical disturbance patterns show that there would be both large disturbed areas and undisturbed areas on the landscape. To mimic the historical disturbance patterns it is important to aggregate the managed and unmanaged Oldgrowthness patches on the landbase in the spatial model.

Patches were only dealt with within Patchworks, as Woodstock is not capable of spatial analysis. Patches were created by determining which adjacent stands met certain criteria and the summing the area of these adjacent stands. Neighbouring stands within 15 meters were considered adjacent.

Linear disturbances in forested landscape are caused by roads, trails, pipelines, transmission corridors and seismic activity. Forest harvesting requires roads while the other types of linear disturbances described are created by other industrial activity, which also creates roads. Alberta Vegetation Inventory specifications capture larger *(i.e.*, greater than 15 m) road allowances, transmission corridors and most and pipelines as polygon features. The other features (generally less than 15 meters wide) are captured as single lines and are not present as polygons in the forest inventory and were ignored in all forecasting patch analysis.

5.13.1 Opening Patch

It was important to Millar Western to maintain a patch size distribution that would mimic the natural range of variability of historic disturbances for this DFMP. The distribution selected was based on Dr. Dave Andison's research in the foothills of Alberta (Andison DW, 2003(a), Andison DW, 2003(b)). The research stressed the need for large patches on the landbase, while still maintaining a smaller average patch size. This was meant to create a negative exponential distribution of patch sizes on the landbase. An Opening Patch refers to any polygons that are in the Clearing or Regenerating seral stages, and within 15 m of any other polygons in the Clearing or Regenerating seral stages (Table 18).

Opening Patches are assessed on the gross landbase since, biologically, an opening on either landbase, managed or unmanaged, contributes to biological diversity. Additionally, the patch size distributions used in the forecasting were based on gross landbase calculations therefore implementing it on the managed landbase would not be appropriate.

5.13.2 Old Patch

Increasing the size of Opening Patches will only lead to a reduction in fragmentation if these patches are maintained through time. To ensure maintenance of large patches over time, the forecasting model included a goal to aggregate the amount of large Old Patches on the forest. Old Patches are arguably more important than young patches as they are more difficult to create. Old Patches used the same 15 m adjacency distance as the Opening Patches, and were also measured on the gross landbase. A 120ha contiguous patch was used as a proxy for the 100 ha interior old patch as defined in the Planning Standard.

5.14 Seral Stages

Seral stages were developed for use in the forecasting (Table 18). The six seral stages varied by BAP strata and age. The BAP IAG defined these seral stages based on stand structures and trends observed in Millar Western's sample plot data.

Table 18. Seral stages used in the forecasting for the 2007-2016 DFMP

	Age (years)					
BAP Strata	**Clearing**	**Regenerated**	**Young**	**Immature**	**Mature**	**Old**
AW	< 2	2-11	12-35	36-70	71-130	131-150
PB	< 2	2-11	12-35	36-70	71-140	141-150
BW	< 3	3-11	12-30	31-70	71-100	101-110
AW_PL	< 2	2-13	14-35	36-65	66-130	131-160
AW_SWSB	< 4	4-14	15-45	46-70	71-140	141-180
PB_CON	< 4	4-14	15-40	41-70	71-150	151-180
PL_DEC	< 2	2-11	12-40	41-75	76-160	161-200
SWSB_DEC	< 5	5-19	20-45	46-80	81-150	151-180
PL	< 2	2-11	12-40	41-80	81-140	141-220
LT	< 2	2-19	20-50	51-90	91-130	131-210
SW	< 5	5-19	20-55	56-85	86-170	171-210
SB_LOW	< 7	7-19	20-80	81-120	121-180	181-250
SB_UP	< 7	7-19	20-70	71-100	101-160	161-180

An aggregation of the Clearing and Regenerated seral stages was used to define the age range for Opening Patches for forecasting.

Old forest was addressed differently in forecasting; the Old forest seral stage was not used for the purpose of model control. The BAP IAG developed a method that accounted for the development of Old forest attributes through a HSI based process. This indicator was named Oldgrowthness. It was used as a goal in forecasting and is described below.

Oldgrowthness was used to constrain the amount of Old growth characteristics on the landbase, within the forecasting model. It is a biological measure assigned by Dr. Frédérik Doyon from the Institut Québécois d'Aménagement de la Forêt Feuillue (IQAFF). This measure is not the integer approach to Old growth that is typically taken when defining Old growth. It's based upon the premise that Old growth transitions through time. Stands may show portions of Old growth characteristics depending upon their development stage and this portion will increase up to 100% through time. It is based on a habitat suitability index (HSI) process of creating curves (Dr. Doyon, personal communication).

> *"Oldgrowthness is a continuous measure of Old growth. The assignment of Oldgrowthness used the approach of fuzzy logic where a state is not considered fixed but as probability of being in that state. In the case of Oldgrowthness, a stand starts to obtain a probability of being Oldgrowthness at the mid-point of the Mature seral stage period with a value of 0.5 and it increases it Oldgrowthness value up to 0.75 when the stage switches from mature to Oldgrowthness. It then keeps increasing at the same rate as it ages as an Old growth stand until it gets to 1. At this moment, the stand is fully an Old growth stand. If the stand is naturally initiated after a natural catastrophic disturbance, it maintains many biological legacies that come from the Old growth stage it was before disturbance and retains a non-zero value of Oldgrowthness. However, the Oldgrowthness rapidly declines as the biological legacies are lost as the stand ages. After clearcutting, if no efforts are made to retain any biological legacies, the Oldgrowthness is zero after clearcut."*

Different Oldgrowthness curves were developed for each BAP strata based on the stand origin (see Figure 17 for Natural Curves, Figure 18 for Natural Origin Thinned Curves and Figure 19 for Managed Curves). There is an initial level of Oldgrowthness in young natural stands which represents the Oldgrowthness values associated with snags, down woody debris and other Old growth characteristics present in young natural stands. This Oldgrowthness value is not present after a stand is harvested.

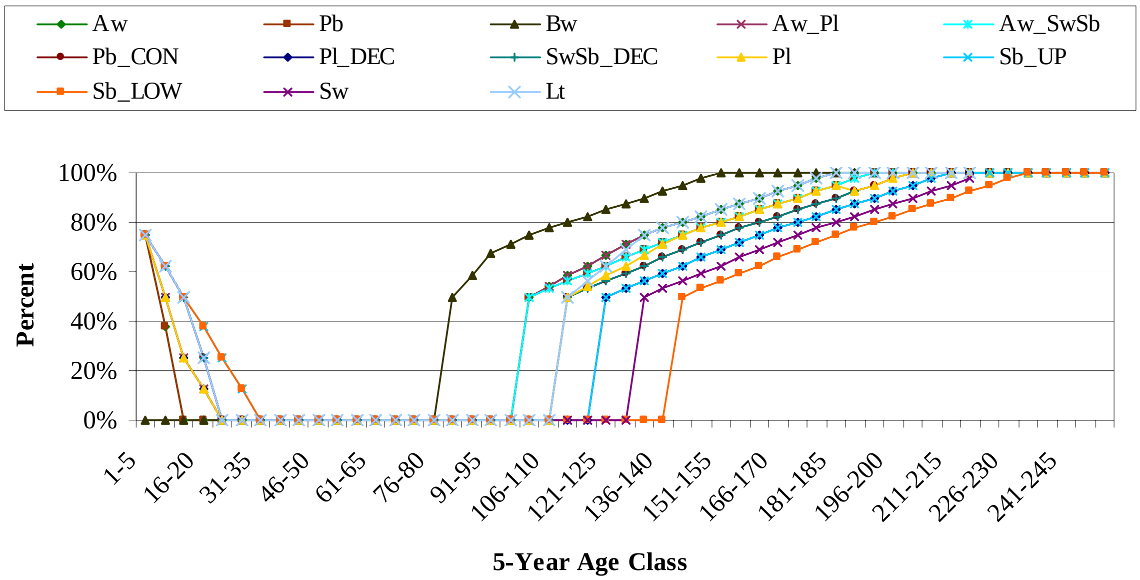


Figure 17. Natural Oldgrowthness curves by BAP strata.

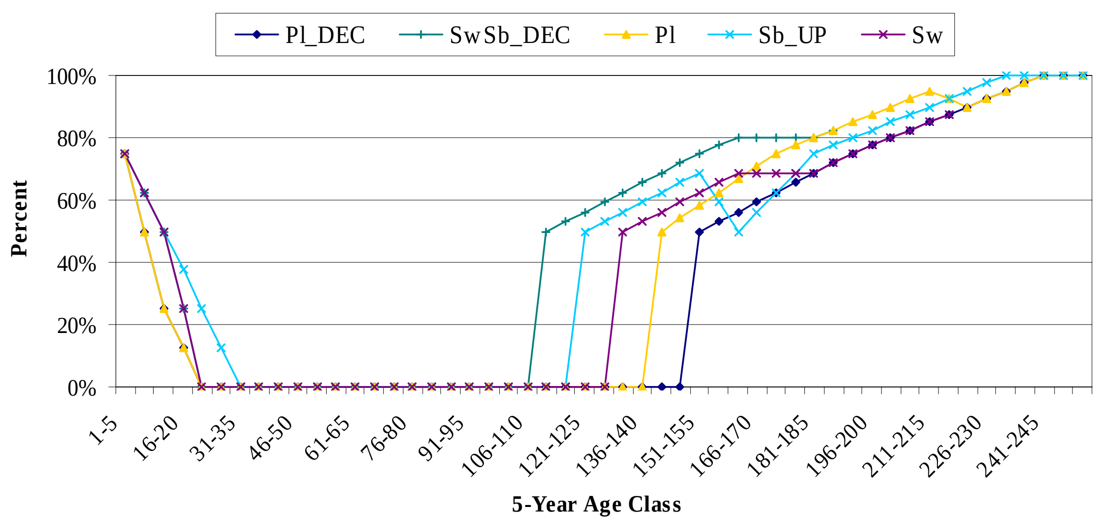


Figure 18. Natural origin thinned Oldgrowthness curves by BAP strata.

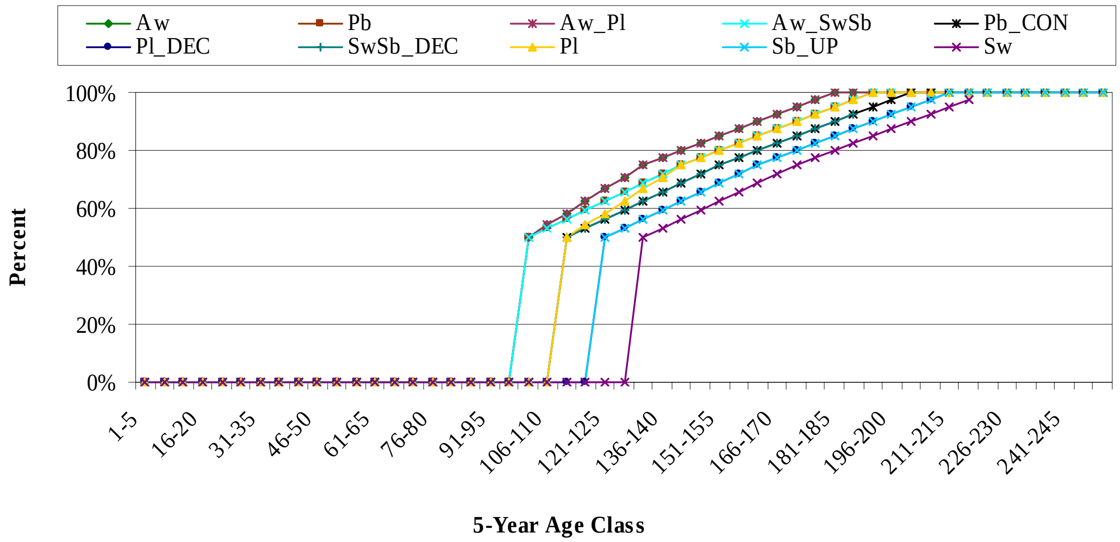


Figure 19. Managed Oldgrowthness curves by BAP strata.

5.15 Biodiversity Assessment Program (BAP)

BAP was used by Millar Western to track different indicators on the forested, non-forested, managed (active) and unmanaged (passive) landbase. Through the previous DFMP planning process a number of key indicators were identified as important to include in the planning process. Upon recommendation from the BAP IAG, a list of the appropriate indicators for tracking with the forecasting model was developed. Incorporating BAP indicators allowed monitoring and control of the selected indicators as listed:

- Density of dead coniferous trees > 20 cm DBH;
- Density of dead coniferous trees > 40 cm DBH;
- Density of dead deciduous trees > 20 cm DBH;
- Density of dead deciduous tress > 40 cm DBH;
- Density of live coniferous saplings < 7.1 cm;
- Density of live deciduous saplings < 7.1 cm;
- Volume of down woody debris;
- Average DBH;
- Proportion of Oldgrowthness;
- Total basal area;
- Free-to-maneuver flying space (Clear);
- Free-to-maneuver flying space (Entangled);
- Free-to-maneuver flying space (Porous/Obstructed);
- Percent ground cover of herbs (All: large-leaved and graminoids);
- Percent ground cover of shrubs (Tall shrubs); and
- BAP species percent.

The functions for the BAP coarse filter indicators are presented in *Appendix XII – BAP SHE Yield Curve Documentation.*

There were many other BAP indicators that were analyzed on a draft PFMSs using the BAP toolbox. These are discussed in *Appendix X – Biodiversity Analysis of the PFMS*.

5.16 Fire Fuel Types

The Planning Standard requires that FireSmart planning occur in the DFMP development process. Millar Western is concerned about wildfire loss and beginning with the 1997-2006 DFMP invested considerable effort in long term reduction of fire risk. In order to incorporate fire risk into the forecasting, the planning team worked with the Alberta government to develop dynamic fuel type tracking within the forecasting model. The intent was to incorporate wildfire into the scenario development process (see section 2.2.2).

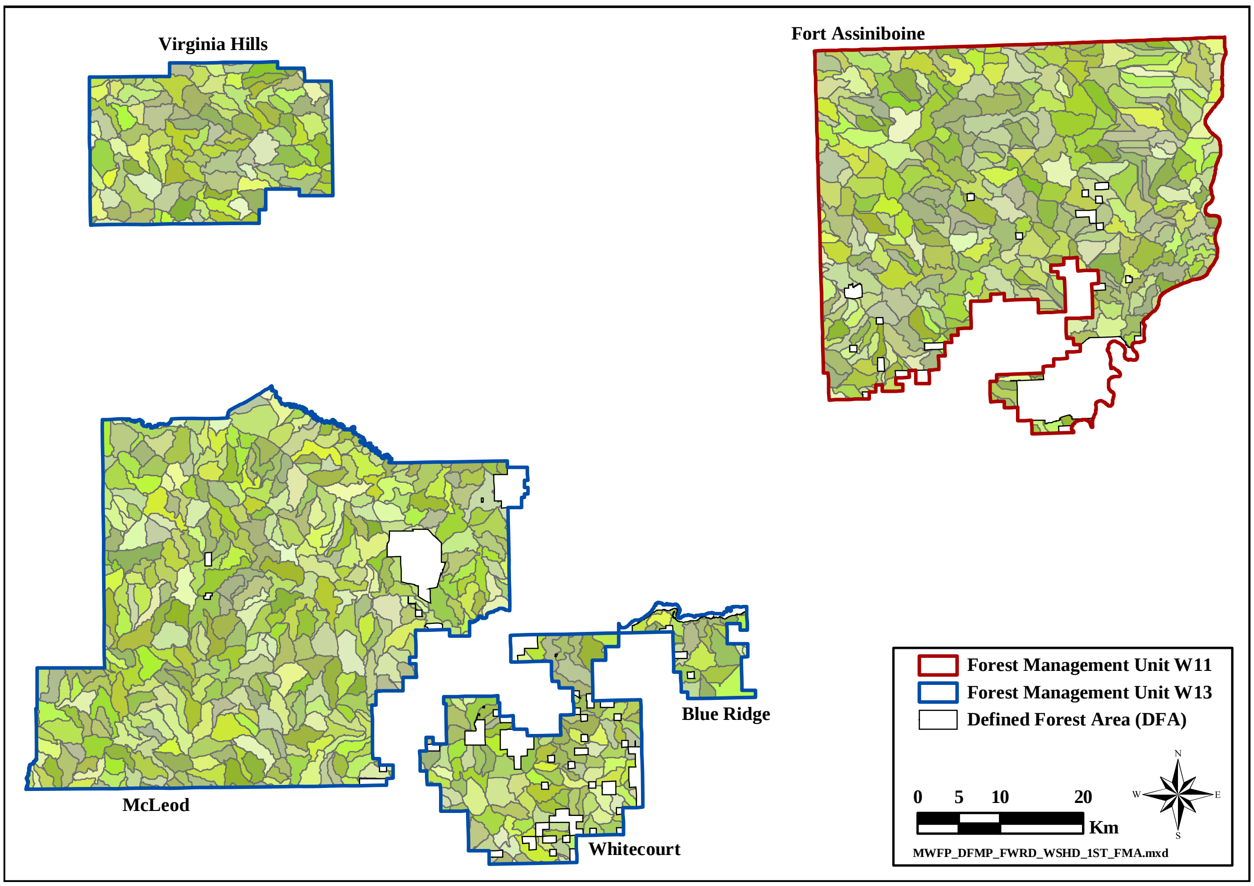
To accomplish this, the Canadian Forest Service fuel type codes were assigned to BAP strata as described in Table 19.

Table 19. CFS Fuel type codes by BAP strata and age group.

SRD Strata	BAP Strata	Density	Description	Age Range	Fuel Types Code	Fuel Types Value
D1-D5	AW, BW, AP	AB	Deciduous Open	0-20	O1b	31
				>20	D1	13
		CD	Deciduous Closed	0-10	O1b	31
				>10	D1	13
DC1-DC12	AW_PL, AW_SWSB, PB_CON	AB	Deciduous Mixedwood Open	0-20	O1b	31
				>20	M1	60
		CD	Deciduous Mixedwood Closed	0-10	O1b	31
				>10	M1	60
CD1-CD12	PL_DEC,SWSB_DEC	AB	Conifer Mixedwood Open	<2	S2	22
				3-20	O1b	31
				>20	M1	60
		CD	Conifer Mixedwood Closed	<2	S2	22
				3-20	O1b	31
				>20	M1	60
C1-C3,C13-C17	SW	AB	Conifer White Spruce Open	<2	S2	22
				3-60	O1b	31
				>60	C2	2
		CD	Conifer White Spruce Closed	<2	S2	22
				3-20	O1b	31
				21-30	C6	6
				31-60	C2	2
				>60	C3	3
C4-C8	PL	AB	Conifer Pine Open	<2	S1	21
				3-60	O1b	31
				>60	C3	3
		CD	Conifer Pine Closed	<2	S1	21
				3-10	O1b	31
				11-50	C4	4
				>50	C3	3
C9-C12	SB,LT	AB	Conifer Black Spruce Open	<2	S2	22
				3-60	O1b	31
				>60	C1	1
		CD	Conifer Black Spruce Closed	<2	S2	22
				3-20	O1b	31
				21-40	C1	1
				>40	C2	2
	103, 1111, 105 107		Non Forest	-	NF	101
	206, 106, 203, 207, 204		Grasslands	-	O1b	31
	64		Water	-	WA	102

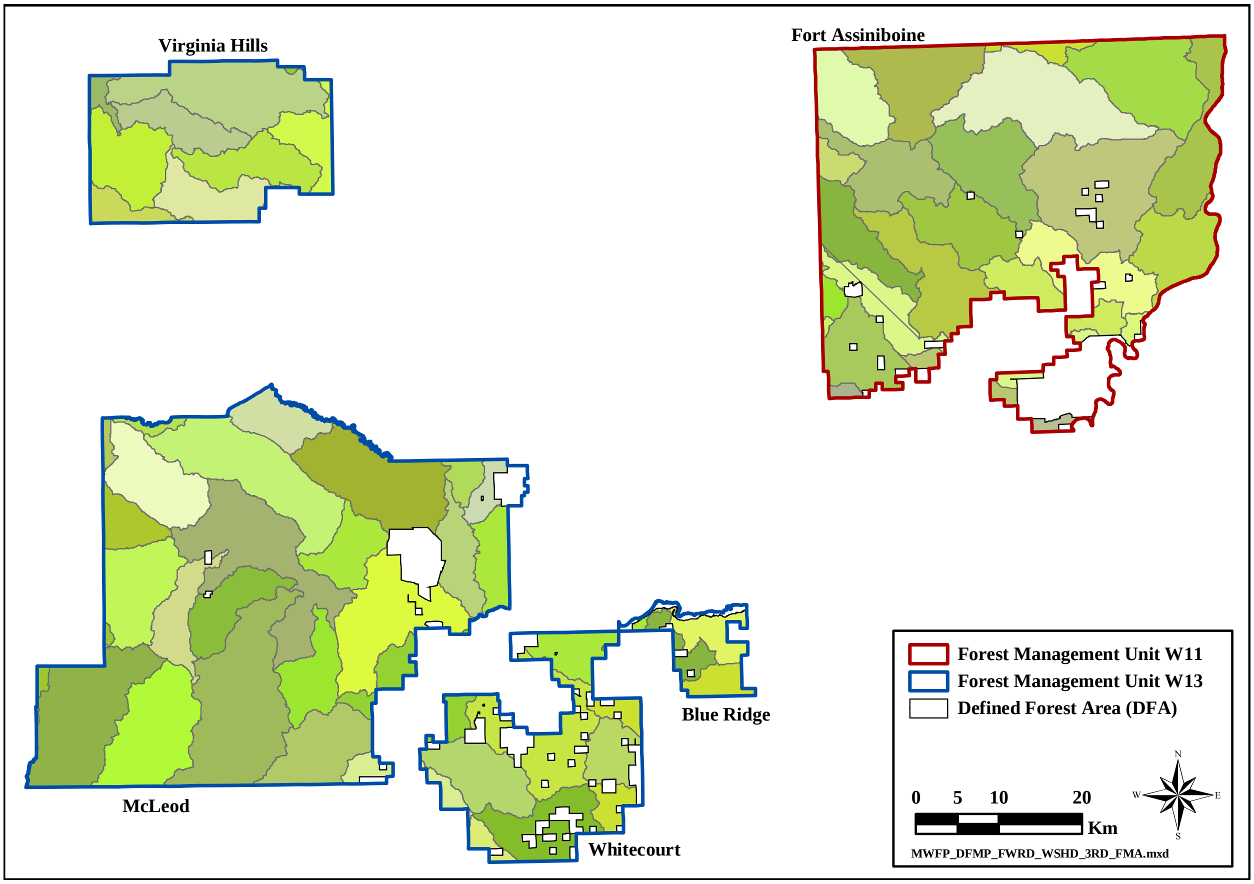
5.17 Hydrology

The FORWARD IAG investigated hydrological issues, including the effect of forest harvesting on streamflow, based on observations within disturbed and non-disturbed watersheds. The two working landscape units used were: functional first order watersheds (Map 6), defined as small watershed units nominally 6 km^2 in area, and functional third order watersheds (Map 7) that are intermediate watershed units, nominally 128 km^2 in area. For these working landscape units, it was first necessary to develop spatial datasets for the watershed, stream, and soils layers. A detailed description of this process and products are presented in *Appendix XIV – FORWARD Contributions*. Using these datasets, as well as streamflow and precipitation data from FORWARD research watersheds, the FORWARD IAG used models to derive runoff coefficients (RCs) to represent the hydrological condition of a given area. RCs are unitless values, defined as the ratio of watershed stream outflow (depth per unit area in mm) to watershed precipitation input (depth per unit area in mm).



Map 6. Functional 1st order watersheds.

The colours on these 2 maps do not represent any attributes, but are included to make identify the watershed boundaries and patterns clearer.



Map 7. Functional 3rd order watersheds.

The forested RCs used for various soil types in the model are presented in Figure 20. The non-forested RCs (Table 20) are age independent as the assumption was that these land types and vegetation types do not grow or change over the planning horizon. Forested complexes do change over time, with most of the change, from a hydrologic perspective, coming immediately after harvest until the stand becomes fully established.

Using measured precipitation and streamflow data for verification, FORWARD developed a model that used soils, vegetation, and slope data to predict RCs and developed a lookup table for spatially defined polygons as follows:

$$RC_{soil/slope/veg/\Delta t} = RC_{norm} * C_{soil} * C_{slope} * C_{veg} * C_{\Delta t}$$

Where $RC_{soil/slope/veg/\Delta t}$ is the value entered into the lookup table, RC_{norm} is the normal RC, and C_{soil}, C_{slope}, C_{veg} and $C_{\Delta t}$ are correction factors representing a percentage change from norm calculated from the normalized linear equations developed for each landscape parameter (*i.e.* watershed modifier). Δt represents year after disturbance.

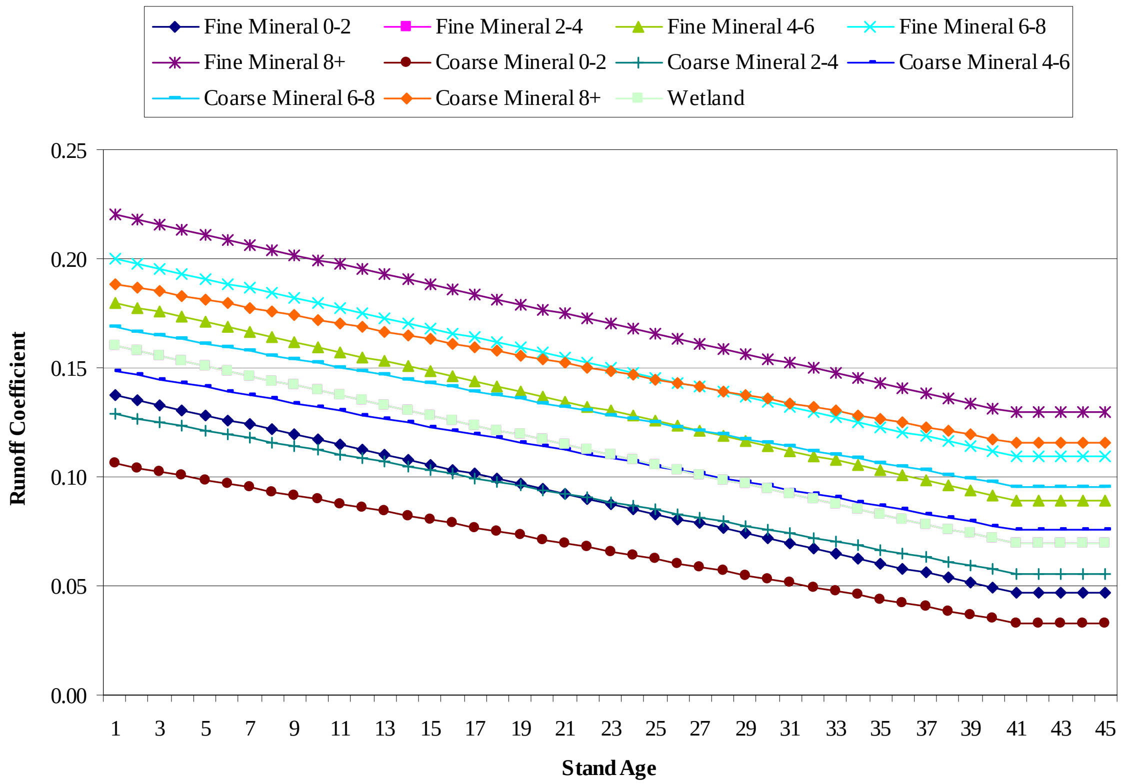


Figure 20. Forested RCs by age, slope and substrate used in the forecasting model for the 2007-2016 Millar Western DFMP.

These RCs were then area weighted across functional first order watersheds as follows:

$$RC_{Wf(i)} = \frac{\sum_{j=1}^{n} RC_{P(j)} * A_{P(j)}}{A_{Wf(i)}}$$

where $RC_{Wf(i)}$ is the aggregate RC of first order watershed "i" calculated as the sum of "*n*" polygons, each with an individual RC ($RC_{P(j)}$) times the area of the polygon ($A_{P(j)}$) divided by the area of the watershed ($A_{Wf(i)}$).

FORWARD identified wetlands as a significant contributing factor in runoff modeling. Wetlands as defined by FORWARD, are not the typical ecological definition of a wetland, but rather areas that store water. In FORWARD's wetland definition, wetlands include forested peat-filled depressions because they store water. These are generally black spruce stands, often supporting dense merchantable timber and would not normally be considered wetlands because of the full forest cover. Refer to *Appendix XIV – FORWARD Contributions* for more information on wetlands.

Table 20. Non-Forested RCs used in the forecasting model.

Vegetation Type	Slopes				
	0-2.5	**2.5-4.5**	**4.5-6.5**	**6.5-8.5**	**>8.5**
Other Mineral and Riparian					
Anthropogenic non-vegetated.	0.200	0.220	0.240	0.240	0.240
Anthropogenic vegetated- agriculture	0.150	0.170	0.190	0.190	0.190
Natural non-vegetated	0.200	0.220	0.240	0.240	0.240
Bryophyte	0.150	0.170	0.190	0.190	0.190
Bare ground, burned, non-vegetated	0.200	0.220	0.240	0.240	0.240
Herbaceous grassland	0.100	0.120	0.140	0.140	0.140
Herbaceous forbs	0.100	0.120	0.140	0.140	0.140
Shrub open	0.070	0.090	0.110	0.110	0.110
Shrub closed	0.047	0.069	0.089	0.109	0.129
Course Mineral					
Anthropogenic non-vegetated.	0.172	0.189	0.206	0.206	0.206
Anthropogenic vegetated- agriculture	0.129	0.146	0.163	0.163	0.163
Natural non-vegetated	0.172	0.189	0.206	0.206	0.206
Bryophyte	0.129	0.146	0.163	0.163	0.163
Bare ground, burned, non-vegetated	0.172	0.189	0.206	0.206	0.206
Herbaceous grassland	0.086	0.103	0.120	0.120	0.120
Herbaceous forbs	0.086	0.103	0.120	0.120	0.120
Shrub open	0.060	0.077	0.095	0.095	0.095
Shrub closed	0.033	0.056	0.076	0.096	0.116
Wetland					
Non-Forested	0.069				

After calculating the first order watershed scale RC, it was also necessary to add an adjustment factor relating to the percent of wetlands in a given watershed. Wetland cover was part of the soils dataset, as described in *Appendix XIV – FORWARD Contributions*. To integrate this relationship into the landscape level forecasting, the wetland adjustment calculation was carried out external to the Patchworks model code. The aggregate first order watershed RC value was adjusted using the percent wetland in the functional first order watershed as a modifying factor. This adjustment was based on an empirical relationship documented in first order watersheds with up to 30% wetland cover *(%Wetland* below). The formula used to calculate the wetland adjustment factor was:

$$Wetland\ adjustment = 0.0138 * \%Wetland * 100$$

It is important to note that this relationship was held constant beyond 30% wetland cover. Two factors influenced this decision: (1) lack of data on watersheds with more than 30% wetlands in the watershed, and (2) most watersheds in the FMA and connecting watersheds surrounding the FMA had less than 30% wetland cover.

The RC for each functional third order watershed were then calculated as:

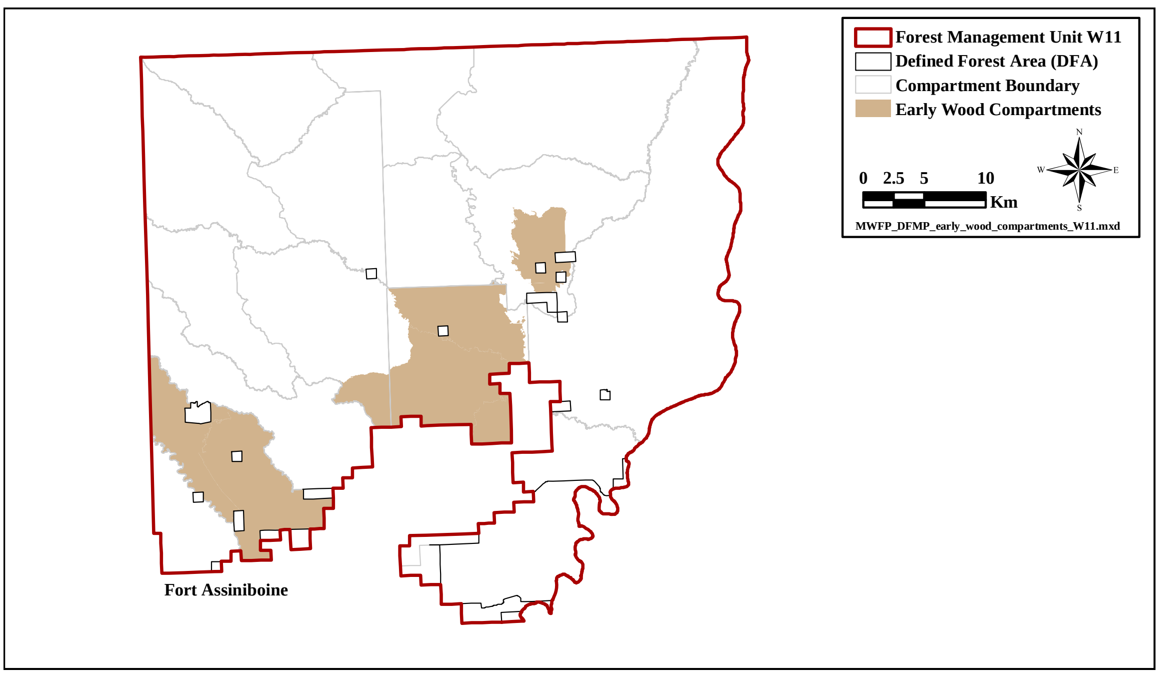
$$RC_{Wt(k)} = \frac{\sum_{i=1}^{m} RC_{Wf(i)} * A_{Wf(i)}}{A_{Wt(k)}}$$

where $RC_{Wt(k)}$ is the aggregate RC of the third order watershed "k" calculated as the sum of "m" first order watersheds, each with an individual area weighted RC ($RC_{Wf(i)}$) times the area of the first order watershed ($A_{Wf(i)}$) divided by the area of the third order watershed ($A_{Wt(k)}$).

The final measure for assessing the effect of forest harvesting was the area weighted aggregate RC for a watershed plus the adjustment factor. The maximum RC value observed over the planning horizon minus the minimum RC value observed over the planning (baseline watershed condition) represented the maximum change for a given watershed in the planning horizon. If the maximum increase in first order watershed RC was greater than 150%, the increase was considered above the threshold identified by the FORWARD IAG.

5.18 Early Wood

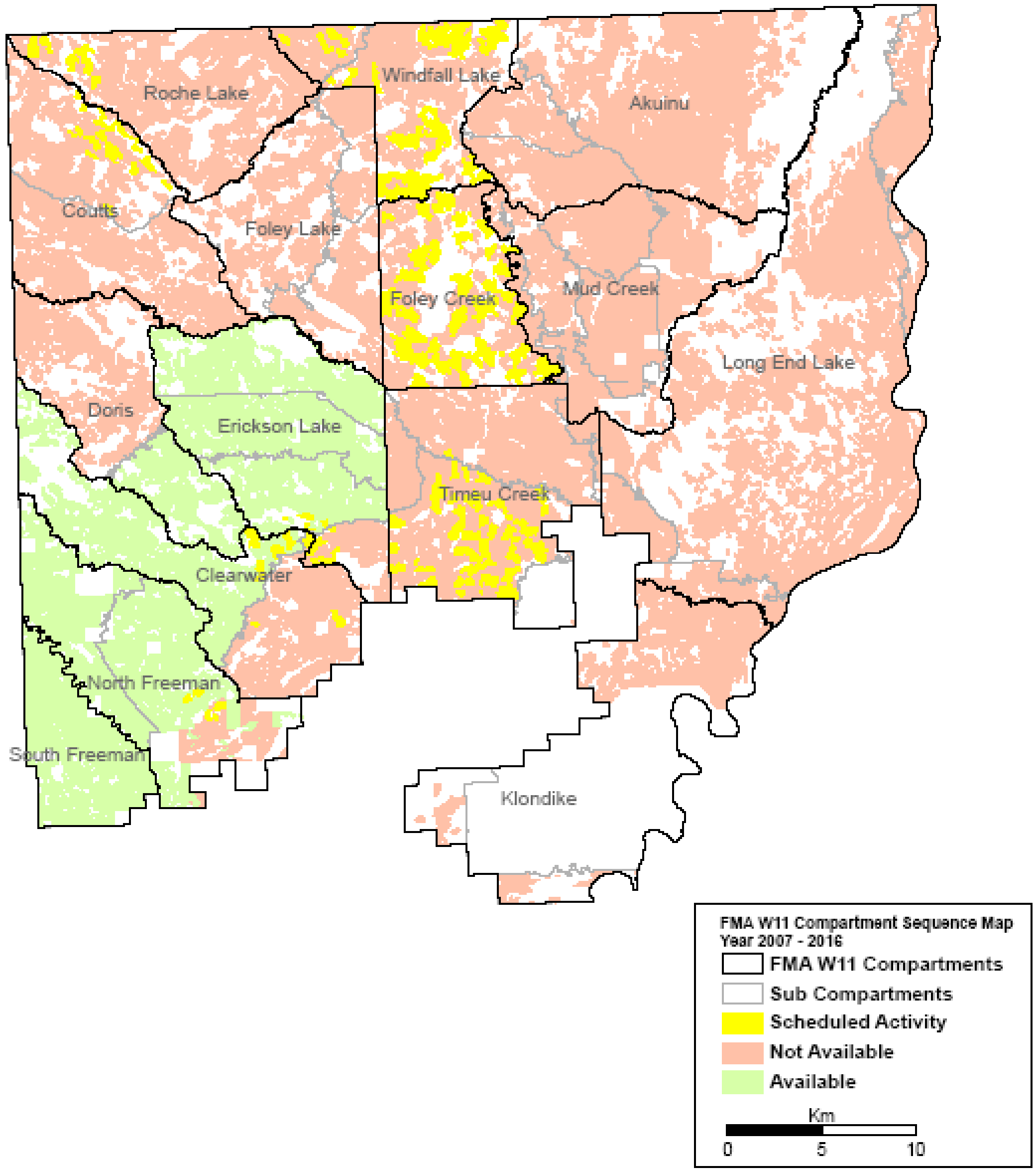
Early wood refers to volume that is can be harvested relatively early in the winter because of favorable ground conditions. Early wood harvest is important in W11 as a large amount of the volume is only accessible in the winter after the construction of winter roads. Millar Western has an agreement with the Fort Assiniboine Deciduous Loggers Committee (FADLC) to provide 30 % of the annual deciduous harvest from early wood areas. The early wood areas are shown in Map 8.



Map 8. Early wood sub compartments in W11.

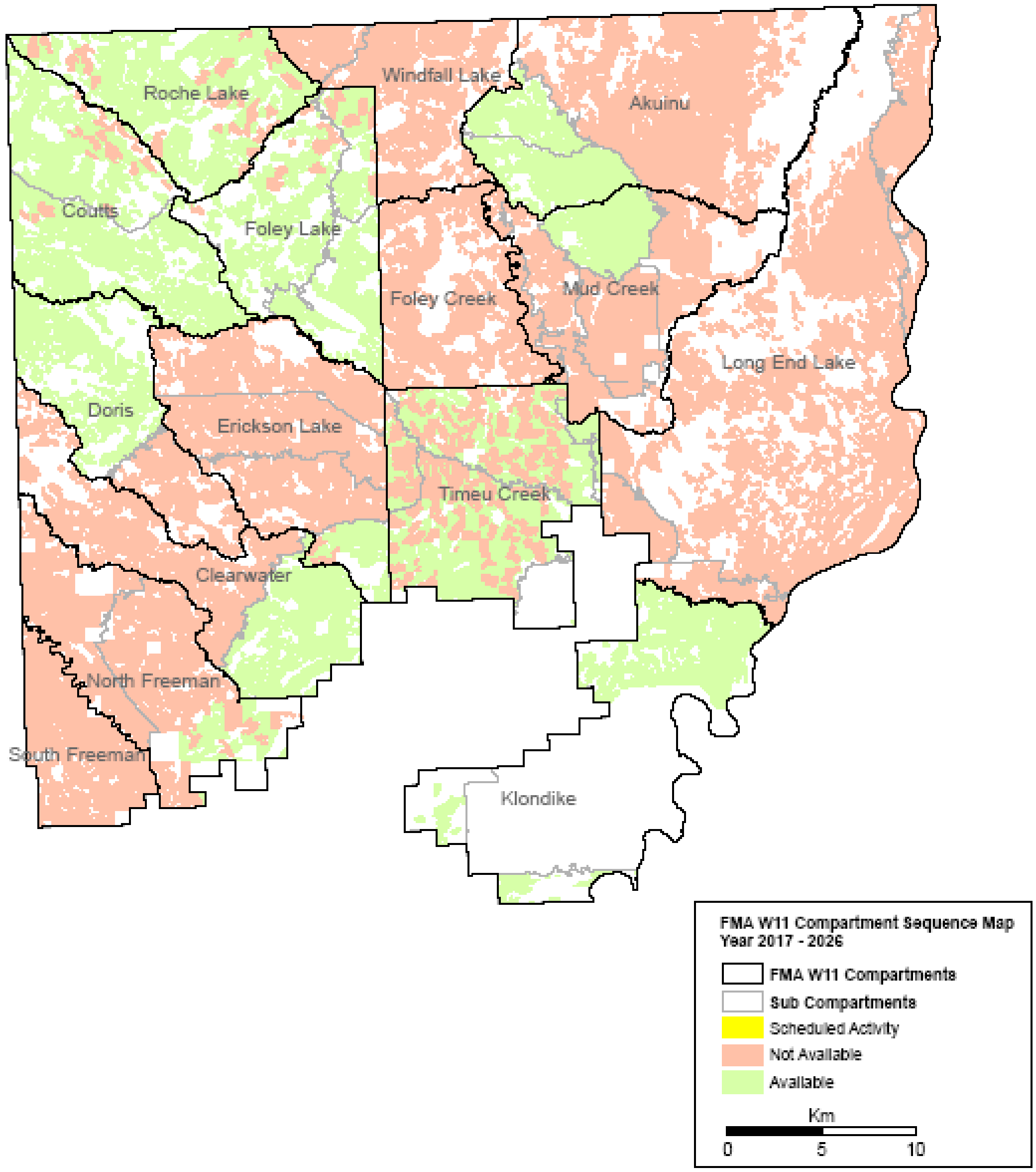
5.19 Access Schedule

Patchworks uses access control units to control the spatial distribution of harvest during periods of interest. Patchworks access control units were subsets of the Millar Western operational compartments as identified on the following maps. In both FMUs it was decided to control the compartment sequence for the first 20 years, after which time the model was able to select harvest from any eligible areas of the FMUs. Only twenty years of the SHS was restricted due to a lack of knowledge about factors that will change the desired harvest patterns in the future. The only exception is the Chickadee fire area which was deferred for 30 years. The W11 0 to 10 and 10 to 20 year access control schedules can be seen in Map 9 and Map 10 respectively. The W13 0 to10 year compartment sequence can be seen in Map 11, and the 10 to 20 year compartment sequence can be seen in Map 12. These compartment sequences were created by combining numerous sets of information listed below. The maps shown represent the compartment sequences that were used for the SHSs which were field reviewed. There were numerous manual changes to the sequence made which might conflict with the access schedule shown in the Figures.

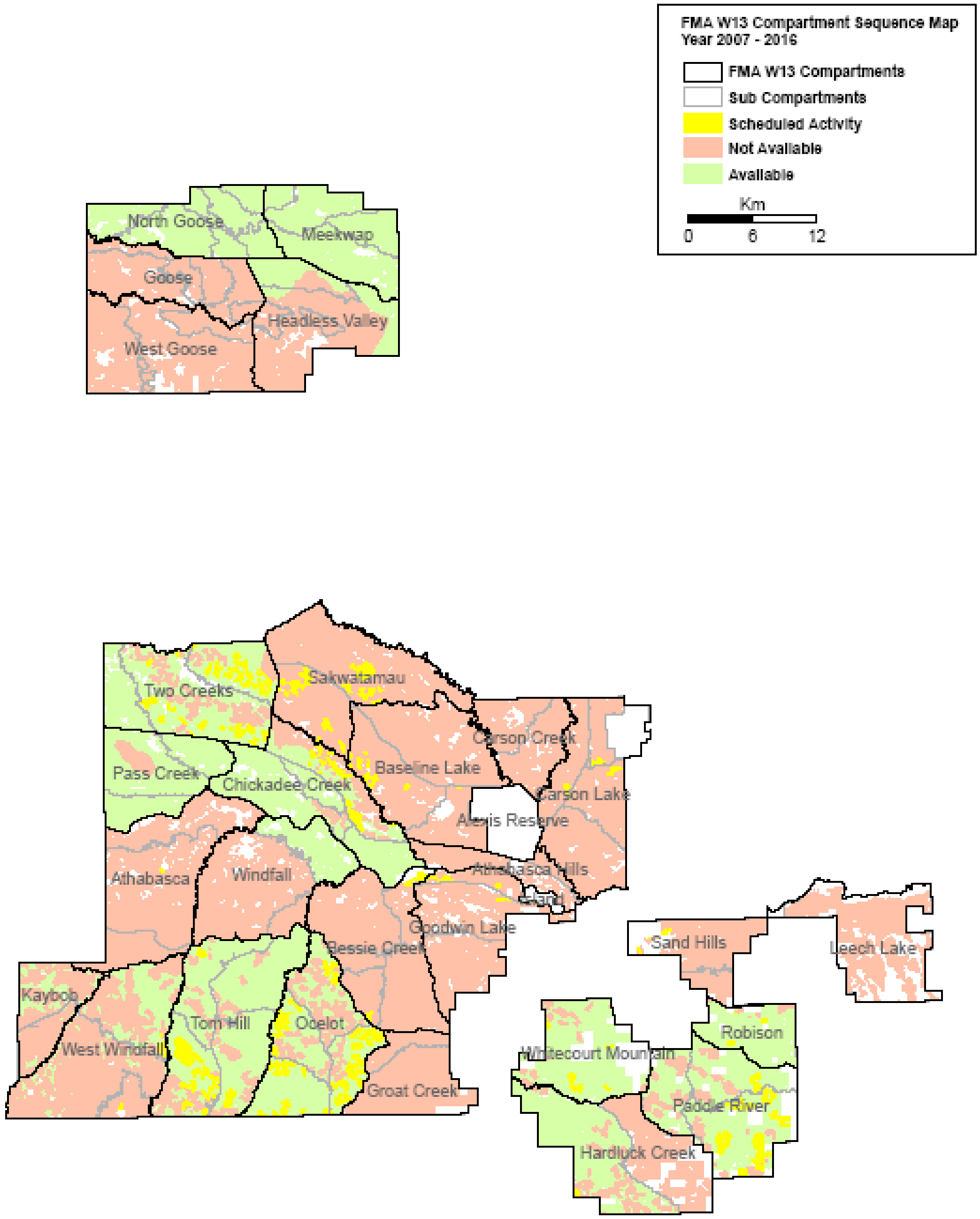


Map 9. W11 compartment sequence for 2007-2016.

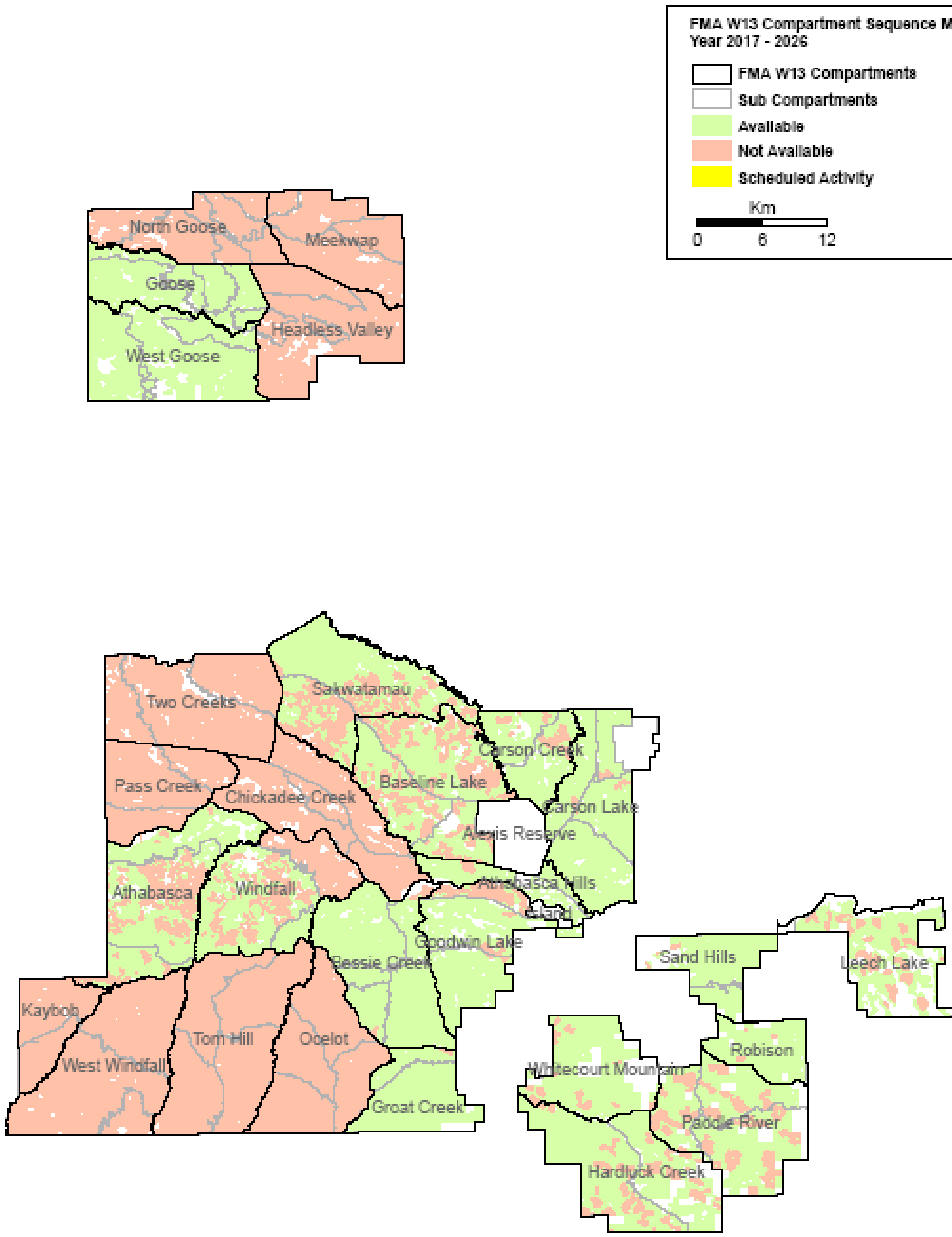
The scheduled activity, coloured yellow on the maps, represents existing planned blocks that were forced into the model. All planned blocks were harvested in the first 10 years of the SHS.



Map 10. W11 compartment sequence for 2017-2026.



Map 11. W13 Compartment sequence for 2007 – 2016



Map 12. W13 Compartment sequence for 2017 – 2026

Chickadee Fire

In May 2006, there was a fire in the Chickadee Creek area, which was after the effective date of the landbase and therefore landbase was not updated to include this fire. Some of the fire area was salvaged within the TSA effective period, and therefore is shown in the model as regenerating timber post harvest. The unsalvaged portion of the fire maintained its pre-fire characteristics and this area was deferred from the harvest sequence for 30 years to ensure it was not scheduled in the SHS. During the next management plan development, the regeneration in this area will be assessed to determine its contribution to the landbase.

FORWARD

There were a number of FORWARD research watersheds that were excluded in the compartment sequence. These watersheds were burned by wildfire, logged, or are retained for reference with no disturbance. Therefore all of the FORWARD research watersheds were locked out for 20 years to prevent any treatment assignment in the SHS.

Planned Blocks

Significant effort was involved on Millar Western's part in establishing planned blocks across the landbase. Therefore all planned blocks were set as to not allow the model to modify the treatment.

Windfall Burn

The Windfall area was burnt in 1956 and naturally regenerated at very high densities. Currently many of these stands are not yet operable although meet minimum harvest age criteria. It is the belief of Millar Western that this area may require a longer time period to become operable than other sites. Due to local variability, and uncertainty, the pine stands in this area were deferred from harvest for the length of the SHS.

Grazing Leases

At the onset of the DFMP planning process there was uncertainty around integration of forestry and grazing operations. Millar Western decided to defer their harvest in grazing leases, licenses, and permits for the first 10 years of the planning horizon, after which time the forecasting allows Millar Western to harvest in these areas. The other operators in the FMA may be scheduled to harvest within the leases, licenses, and permits at any time during the planning horizon.

Athabasca Flats

The Athabasca Flats area is a special management area where Millar Western conducted partial harvests using horse logging to extract timber from the area. Due to the time and effort put into this program there will be no harvest, other than the planned partial harvesting in the SHS.

Huestis Demonstration Forest

The Huestis Demonstration Forest is a special management zone within Millar Western's FMA. This area was previously protected under a Government DRS reservation and was not part of the DFA. More recently the Alberta government has agreed to remove the reservation and allow the area to be actively managed. In the 2007-2016 DFMP, this area contributed to the managed landbase and was eligible for harvesting, but was not scheduled as part of the SHS because, subsequent to the approval of the 2007-20016 DFMP, Millar Western, in collaboration with the Alberta government, will develop a stand level plan for the Huestis Demonstration Forest. This stand level plan may include harvesting activity that was not scheduled in the 2007-2016 DFMP.

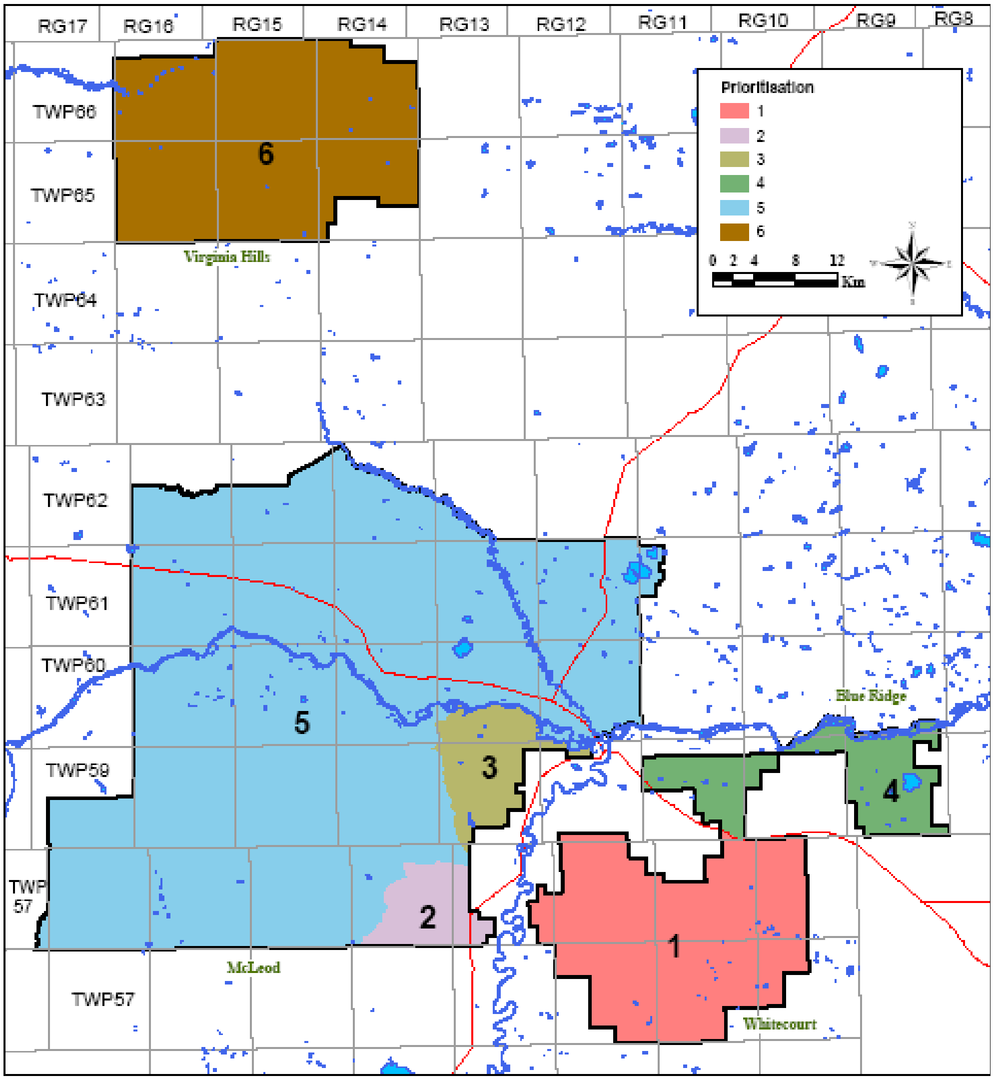
Previously Thinned

Areas that were previously thinned were deferred from harvest for the length of the SHS.

5.20 Operator Zones of Interest

In W13, Weyerhaeuser has rights to harvest 45,000m^3/yr of deciduous volume prioritized in B, C, and D density pure deciduous stands. They have prioritized the areas of interest (beginning with zone 1) for harvest, which can be seen in Map 13.

W11 does not have operator prioritization zones. It was decided in the planning process that the coniferous harvest from this unit would not be restricted to the quota spheres as this was found to have a negative effect on other indicators.



Map 13. **Weyerhaeuser harvest prioritization zones.**

5.21 Economics

Economic curves, based on a previous analysis completed by Millar Western, were included in the forecasting model but were used for internal Millar Western reporting only. Piece size curves were used as a long term economic indicator.

5.21.1 Piece Size

The piece size curves were slightly modified from those described in the yield curve documentation before they were used in the forecasting model. The initial version of the piece size curves created with the raw data available produced curves in which the tree size values dropped to a very low numbers (*i.e.* very big trees) and in some cases 0 trees/m^3. To address this deficiency, analysis of the curve data suggested that curves should be limited to above the 10^{th} percentile. Plots that were within the lower 10^{th} percentile were deleted and the curves refit, which produced reasonable maximum piece sizes for each strata grouping.

The W11 curves, by species strata, are shown in Figure 21 and the W13 curves are presented in Figure 22. CON and DEC labels refer to whether the curves related to the coniferous or deciduous piece size curves for each stratum. For the W11 curves the AB, CD, or ABCD, refer to the density of the stands.

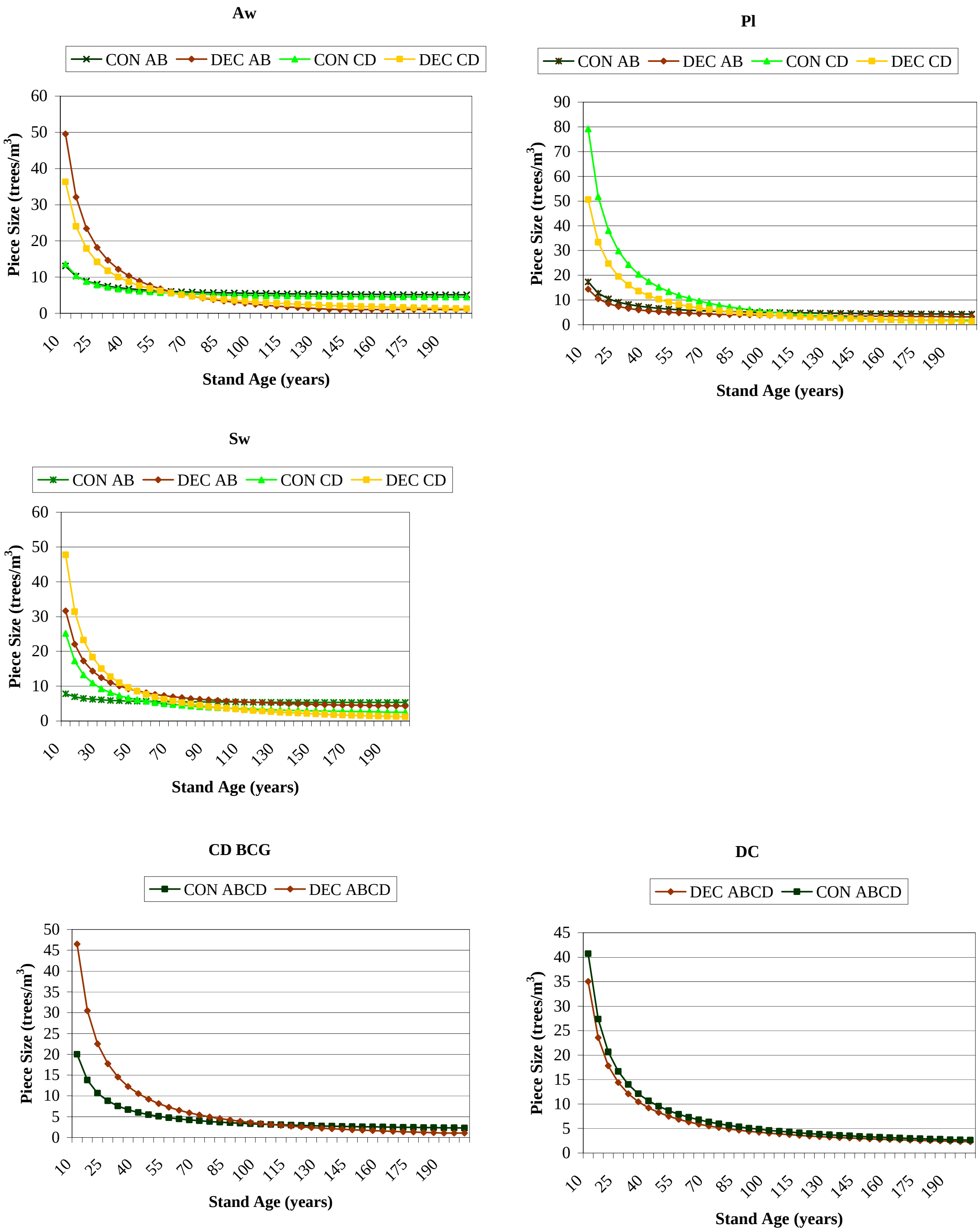


Figure 21. W11 Piece Size curves used in forecasting.

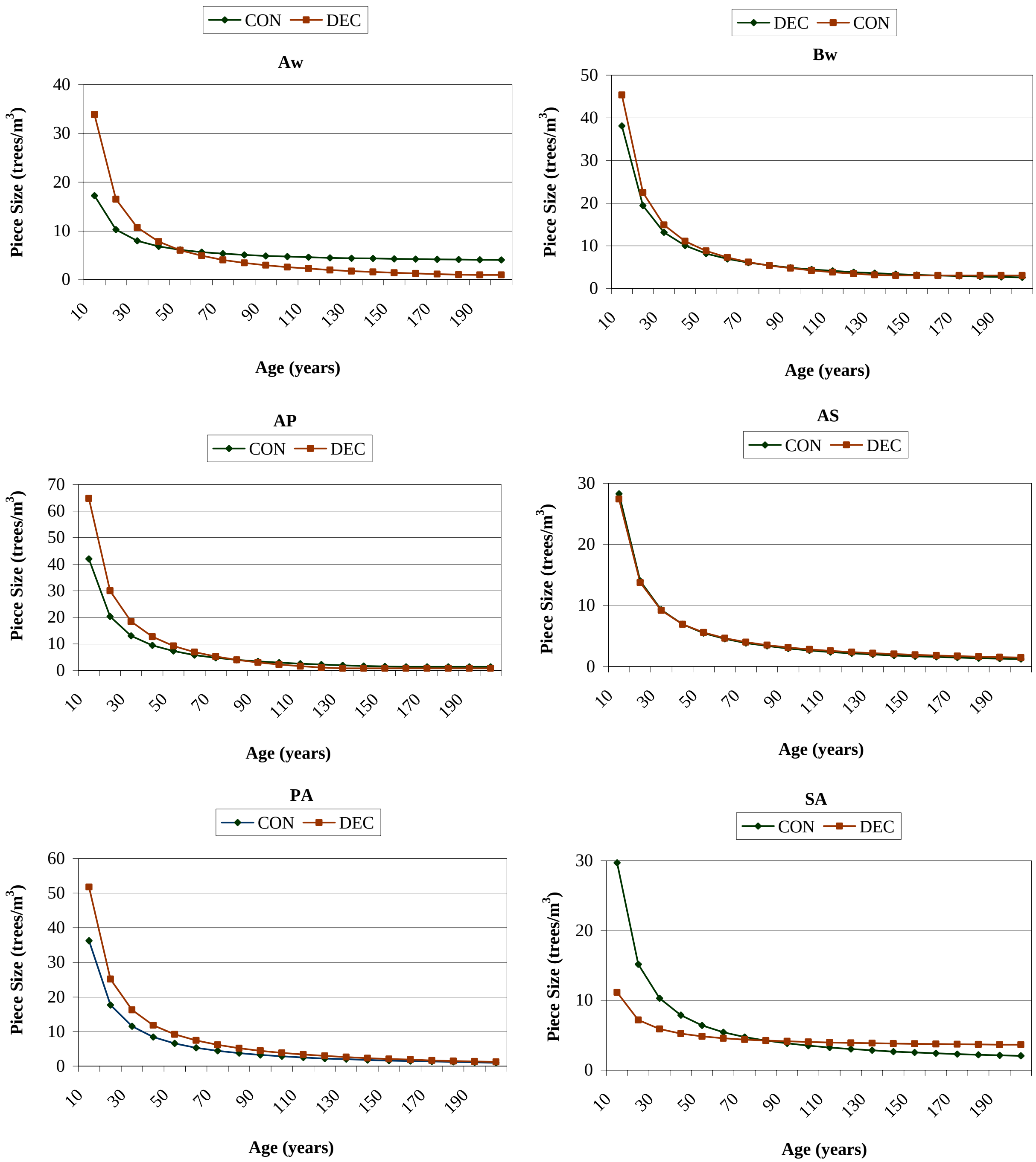


Figure 22. W13 Piece size curves used in forecasting (1 of 2).

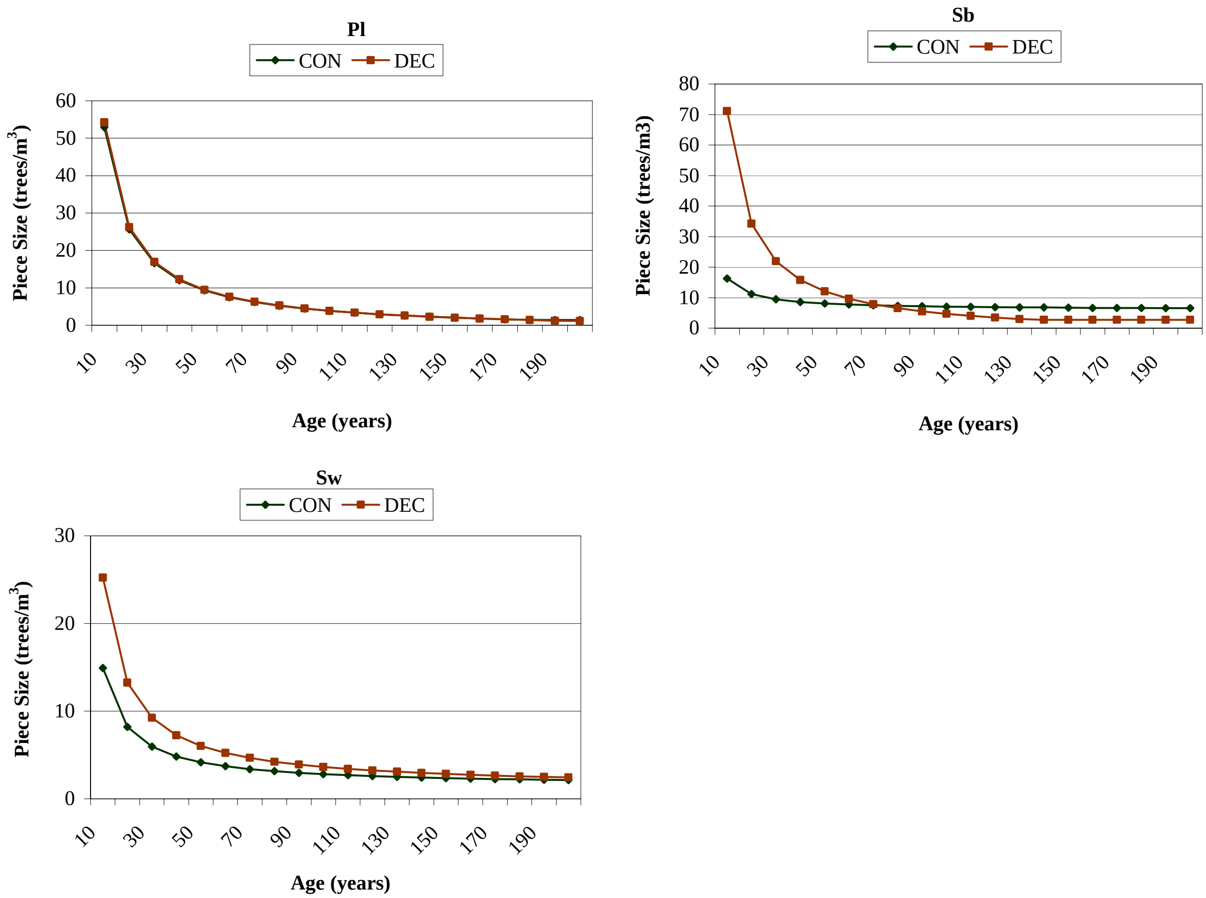


Figure 23. W13 Piece size curves used in forecasting (2 of 2).

5.22 Visual Quality

Visual quality was only implemented in the forecasting model in the area surrounding the town of Whitecourt, including Whitecourt Mountain. Visual quality in this area was addressed in two manners within the PFMSs. Firstly, through a smaller blocks size goal for the area around the town of Whitecourt and Whitecourt Mountain and secondly, the block shapes in this area were manually assessed for shape and size issues and updated where needed. There was additional visual quality work completed during SHS review to address visual quality in identified sensitive areas. Millar Western has committed to developing a visual quality inventory of the DFA during the DFMP.

5.23 Structure Retention

The Planning Standard requires that companies include structure retention in their harvesting activities. Millar Western has commited to retaining 1% residual structure. The structural retention volume will be planned for on a block by block basis and tracked and reported at the appropriate level. There was no AAC reduction included in the forecasting related to structural retention as the volume will be addressed through the process described in **VOIT 11 - Percent of FMU AAC residual structure (living and dead), within a harvest area, representative of the status (living/dead), size and species distribution of the overstorey trees by operating compartment (1.1.2.1A)**.