The Forestry Corp.

Yield Curves for Mixedwood Management

Prepared For:

Alberta Pacific Forest Industries Inc.
Vanderwell Contractors Ltd.

August 12, 2002

Executive Summary

In Forest Management Unit (FMU) L1, Alberta Pacific Forest Industries Inc. (Al-Pac) and Vanderwell Contractors Ltd. (Vanderwell) are undertaking a unique joint forest management planning process. That process is based on three principles as follows:

1. Long and short term planning will be done on a common landbase. There will be no designation of coniferous and deciduous landbases.
2. Long range planning will have equal timber objectives of maximizing both coniferous and deciduous timber supplies.
3. Harvesting and reforestation regimes will use a range of treatments. These will include mixedwood treatments where trembling aspen and white spruce are grown together under a variety of establishment and release scenarios, as well as regeneration treatments designed to accelerate conifer establishment and growth.

In order for the desired mixedwood and enhanced forest management treatments to be incorporated into a timber supply analysis, treatment responses must be quantified in the form of yield curves for each intervention. This report documents the rationale underlying mixedwood management yield curve development, describes analyses undertaken, and presents the resultant yield curves to be used for timber supply analysis.

The common practice of generating empirical yield curves, by chrono-sequencing temporary sample plots within a stratum, is incapable of capturing the species dynamics in mixed aspen-spruce stands. Because the chrono-sequence approach groups all ages of a particular set of plots with similar species compositions, it is not surprising that the resulting yield curves do not express well the dynamics of species composition that are thought to occur in natural stand development.

The objective of the yield curve development process described here was to produce yield curves which reflect the mixedwood aspen-spruce species composition dynamics known to occur in natural stands, and to do so while reflecting consistent timber volume trends among different strata (‘C’, ‘CD’, ‘DC’ and ‘D’ in this context refer only to spruce and aspen mixtures).

To achieve these objectives, several guiding principles served as the foundation for all yield modeling as follows:

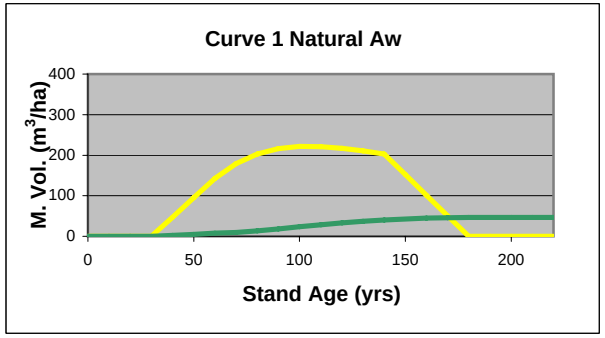
1. Based on the understanding that mixedwood sites over a range of species compositions have an inherent maximum timber producing capability, the maximum total volume (deciduous and conifer combined) is the same in aspen-dominated mixedwoods ('DC' stands) and in spruce-dominated mixedwoods ('CD' stands).
2. The maximum total volume (deciduous and conifer combined) in 'DC' and 'CD' mixedwood stands is 15% greater than the maximum total volume in pure aspen ('D') stands (MacPherson et al, 2001; Man & Leiffers, 1999).
3. The maximum conifer volume is higher in 'CD' stands than in 'DC' stands. This is based on the assumption that there is insufficient conifer stocking in stands that are characterized as 'DC' stands at 60 to 80 years to result in a fully stocked conifer stand at 120 to 160 years of total age.
4. The maximum conifer volume is the same in 'CD' and in pure conifer ('C') stands. Maximum conifer volume is attained later in 'CD' than in 'C' stands, since it takes the conifer component longer to dominate the site when it grows successionally in a mixedwood stand.

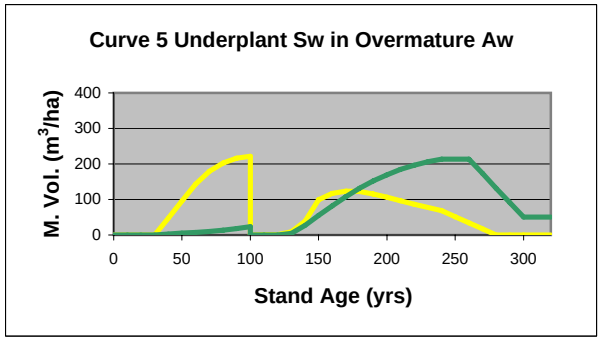
The Mixedwood Growth Model (MGM) was used to project timber yields in pure and mixed species stands of aspen and white spruce. MGM predictions for natural stands were anchored to empirically predicted natural stand timber volumes. MGM natural stand simulations were used as the starting point for developing yield predictions for various mixedwood management treatments contemplated by Al-Pac and Vanderwell.

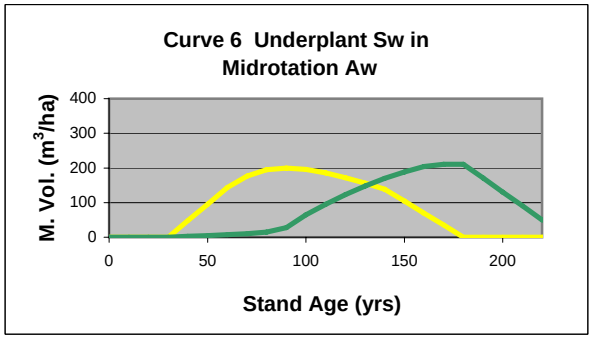
Al-Pac Detailed Forest Management Plan (DFMP) yield strata for pure and mixed species jack pine and black spruce stands were area weighted to produce aggregate jack pine and black spruce curves for the L1 DFMP.

Graphical versions of all yield curves used in the L1 DFMP timber supply analysis are found on the two pages following. Detailed stratum, treatment, and timber yield descriptions are presented in the body of the report.

Stratum AW







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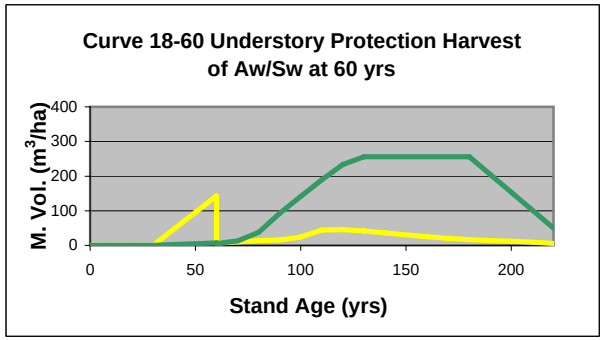

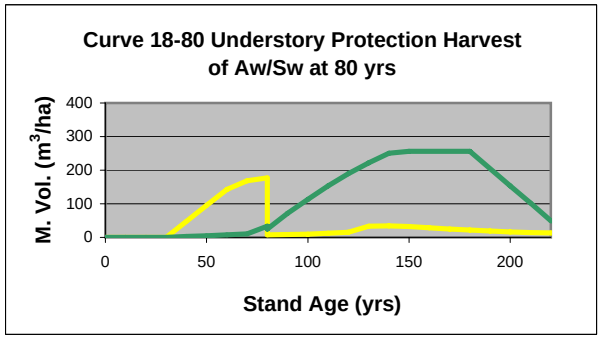

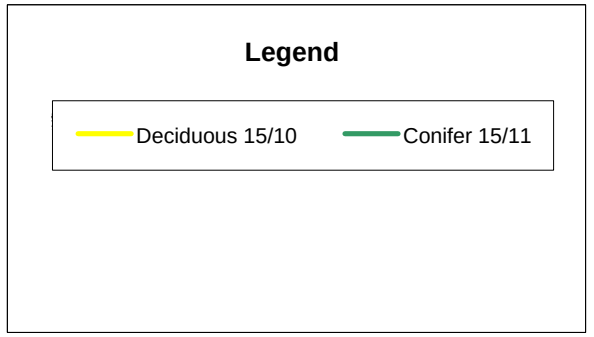

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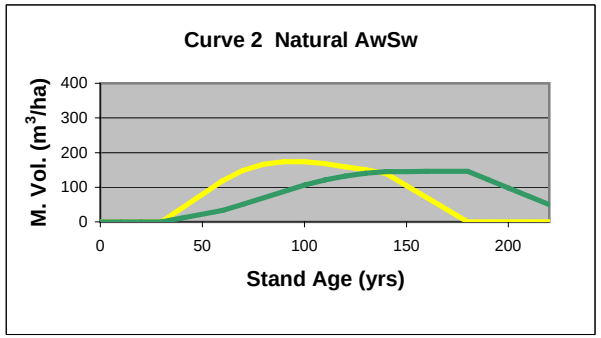

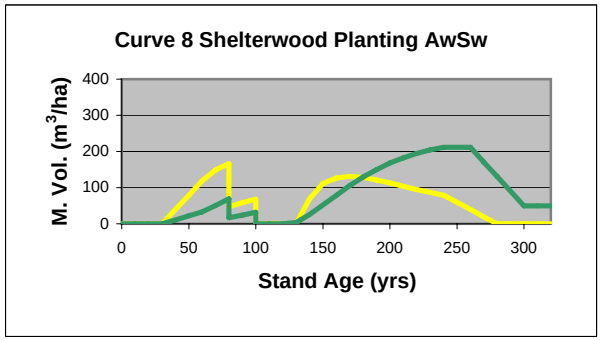

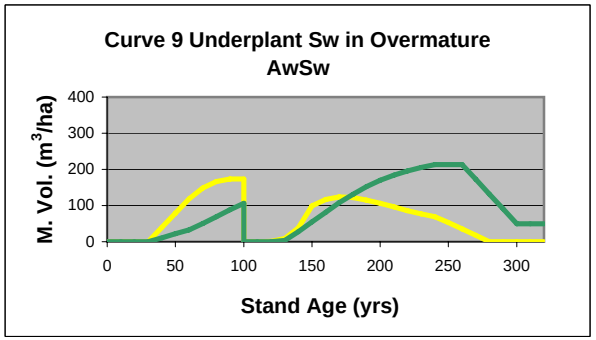

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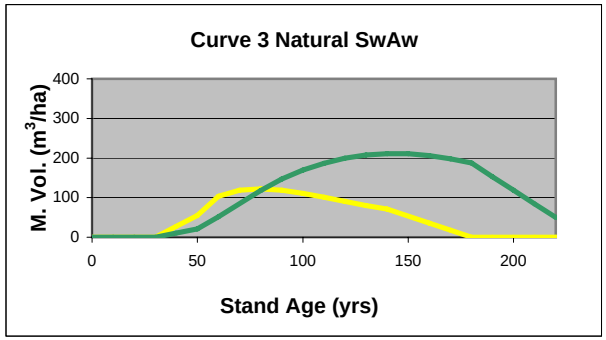

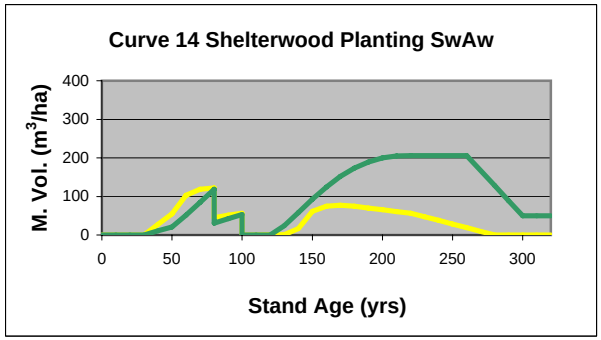

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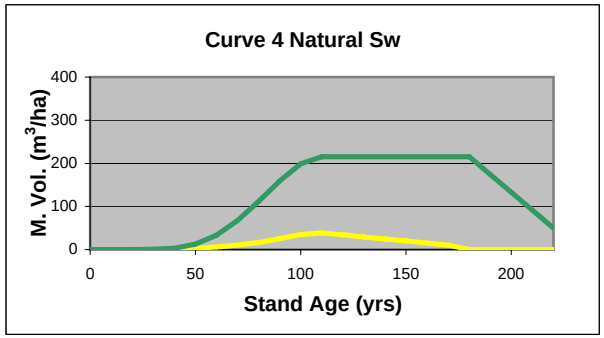

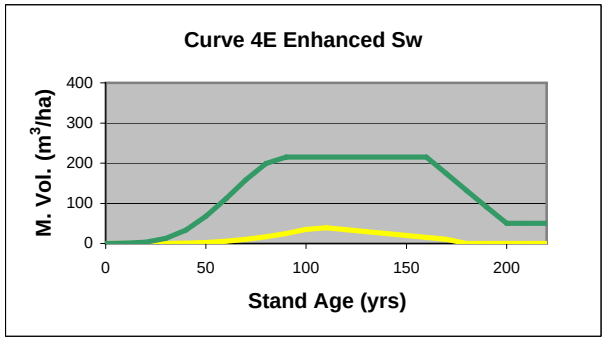

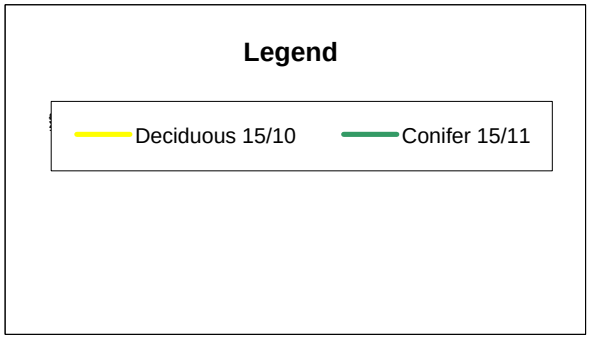

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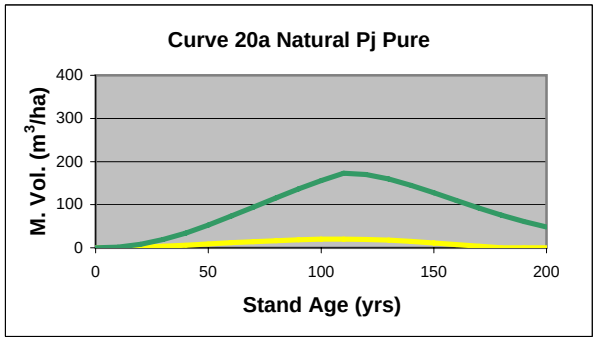
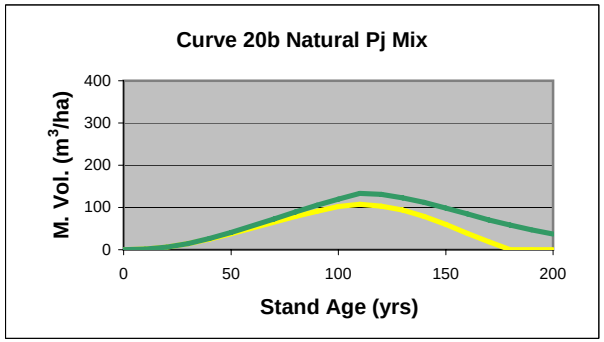
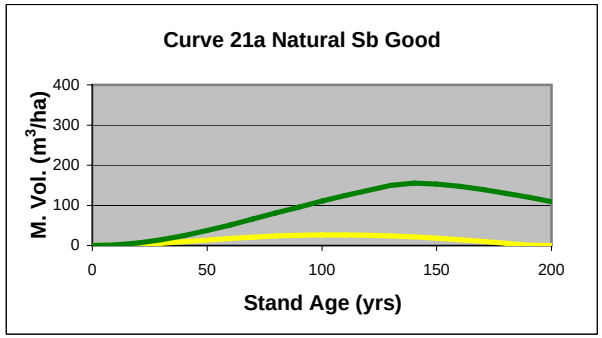
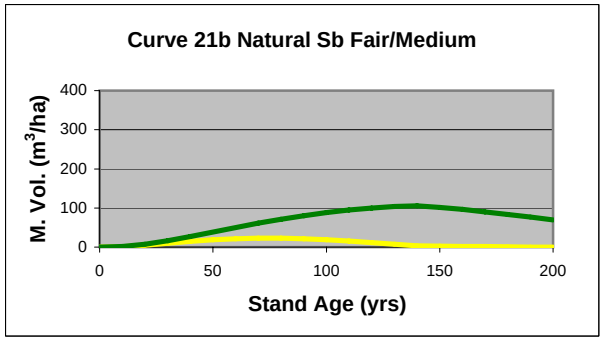
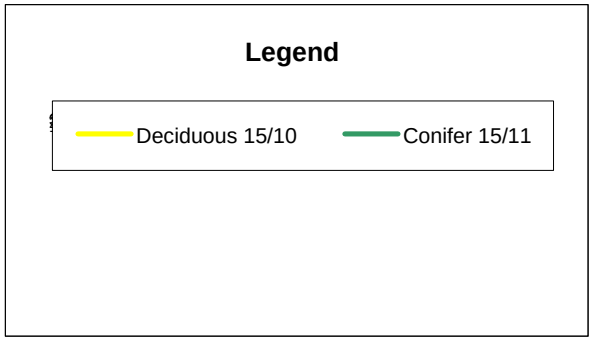




Stratum SB


Curve 21a Natural Sb Good
M. Vol. (m3/ha)
400
300
200
100
0
0
50
100
150
200
Stand Age (yrs)


Curve 21b Natural Sb Fair/Medium
M. Vol. (m3/ha)
400
300
200
100
0
0
50
100
150
200
Stand Age (yrs)


Legend
Deciduous 15/10
Conifer 15/11

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1.0 Introduction

In Forest Management Unit (FMU) L1, Alberta Pacific Forest Industries Inc. (Al-Pac) and Vanderwell Contractors Ltd. (Vanderwell) are undertaking a unique joint forest management planning process. That process is based on three principles as follows:

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In order for the desired mixedwood and enhanced forest management treatments to be incorporated into a timber supply analysis, treatment responses must be quantified in the form of yield curves for each intervention. This report documents the rationale underlying mixedwood management yield curve development, describes analyses undertaken, and presents the resultant yield curves to be used for timber supply analysis.

The objective of the process documented here was to generate yield curves which are ecologically consistent. For these yield curves, ecological consistency considered the maximum conifer, deciduous, and total volumes which were attained in various forest stand types, and the timing of maximum volume achievement in each of those types. The logic used to achieve ecological consistency among the forest stand types defined for FMU L1 is more fully described in Section 5.3.4.

In the absence of empirical treatment response data for most of the proposed treatments, a modeling approach was chosen. As a single-tree growth model, the Mixedwood Growth Model (MGM) represents the best model currently available for this type of stand development forecasting. MGM was used to simulate stand-level responses of proposed mixedwood treatments.

To establish a base line of expected natural stand yields in L1, empirical yield curves, as commonly developed with regression techniques, were produced for each of a number of yield strata. These served as the basis for comparison of subsequent MGM-based yield projections for natural stands.

Natural stand yield simulations using MGM were adjusted so as to reflect yield trends in the empirical yield curves. The final MGM simulations for natural stands were then used as the starting curves for the modeling of stand-level responses to each of the proposed mixedwood management treatments. For each proposed treatment, a unique yield curve was developed with MGM simulations.

This report documents all steps in the development of natural stand and treatment response yield curves to be used in the joint Al-Pac/Vanderwell timber supply analysis for FMU L1.

2.0 Stratification

2.1 Inventory Stratification

The Alberta Vegetation Inventory (AVI) for the Al-Pac Forest Management Agreement Area (FMA) was stratified based on the overstory and understory definition for each polygon. Table 1 provides the definitions for the stratification scheme that was chosen to reflect qualitative stand succession trends known to occur in the boreal mixedwood forest.

Stand density and site were purposely excluded from the stratification scheme because of data deficiencies and because subsequent yield modeling would not incorporate either attribute as a classification parameter.

Black spruce is an exception to this, as it was necessary to reflect the way Al-Pac and Vanderwell will manage this species in the future.

Table 1. AVI Stratification Definitions.

Yield Stratum Name	Inventory Stratum Name	Inventory Stratum Description	Inventory Stratum Overstory Definition
Aw	Aw	Pure dedicuous with no conifer understory	% Aw + Pb + Bw > 80
Aw/Sw	Aw/Sw	Pure dedicuous with conifer understory, lag in conifer height	% Aw + Pb + Bw > 80, conifer stems in understory >= 600 stems/ha
AwSw	AwSw	Deciduous leading mixedwood aspen-spruce with no conifer understory	50 <= % Aw + Pb + Bw <= 80, and 20 <= % Pl + Pj + Sw + Sb + Fb + Lt < 50, with Sw or Fb leading coniferous group
SwAw	SwAw	Conifer leading mixedwood spruce-aspen with no conifer understory	50 <= % Pl + Pj + Sw + Sb + Fb + Lt <= 70, and 20 <= % Aw + Pb + Bw < 50, with Sw or Fb leading coniferous group
Sw	Sw	Spruce leading conifer	% Pl + Pj + Sw + Sb + Fb + Lt >= 80, with Sw or Fb leading
Pj Pure	Pj	Pine leading conifer	% Pl + Pj + Sw + Sb + Fb + Lt >= 80, with Pl or Pj leading
Pj Mix	PjAw	Conifer leading mixedwood pine-aspen	50 <= % Pl + Pj + Sw + Sb + Fb + Lt <= 70, and 20 <= % Aw + Pb + Bw < 50, with Pl or Pj leading coniferous group
	AwPj	Deciduous leading mixedwood aspen-pine	50 <= % Aw + Pb + Bw <= 80, and 20 <= % Pl + Pj + Sw + Sb + Fb + Lt < 50, with Pl or Pj leading coniferous group
Sb Good	Sb	Black spruce leading conifer	% Pl + Pj + Sw + Sb + Fb + Lt >= 80, with Sb or Lt leading - TPR Good
Sb Fair/Medium	Sb	Black spruce leading conifer	% Pl + Pj + Sw + Sb + Fb + Lt >= 80, with Sb or Lt leading - TPR Fair or Medium
SwAw	SbAw	Conifer leading mixedwood black spruce-aspen	50 <= % Pl + Pj + Sw + Sb + Fb + Lt <= 70, and 20 <= % Aw + Pb + Bw < 50, with Sb or Lt leading coniferous group
AwSw	AwSb	Deciduous leading mixedwood aspen-black spruce	50 <= % Aw + Pb + Bw <= 80, and 20 <= % Pl + Pj + Sw + Sb + Fb + Lt < 50, with Sb or Lt leading coniferous group
None	NonMerch	All stands not fitting into one of the strata above	No definition

source: willi d:\projects\alpac\p269\stratum definitions.xls

3.0 Empirical Natural Stand Volume Prediction

In order to establish a base line of expected natural stand yields in L1, empirical natural stand yield curves were produced for each stratum. These served as the basis for comparison of subsequent MGM-based yield projections for natural stands.

For the Aw, AwSw, SwAw and Sw strata, empirical yield curves were produced using commonly developed regression techniques based on sample plot data.

Pj Pure, Pj Mix, Sb Fair/Medium and Sb Good natural stand curves were produced based on the approved DFMP curves for Pj and Sb yield classes as appropriate.

3.1 Strata Aw, AwSw, SwAw and Sw

3.1.1 Sample Plot Data

Al-Pac has extensive temporary and permanent sample plot databases that have been compiled as part of their Volume Sampling Program. These databases were used in the estimation of merchantable volume per hectare. Three separate databases were used: a

Deciduous Temporary Sample Plot database, a Coniferous Temporary Sample Plot database and a Permanent Sample Plot database.

Temporary sample plot data were collected under two distinct TSP programs: Deciduous Volume Sampling and Coniferous Volume Sampling. The objective of these programs was to provide a forest-wide estimate of timber in merchantable stand types. The database consisted of three separate files; one containing plot header information, one containing tree information, and one containing sample tree (height and age) information.

Permanent sample plot data were collected under a similar PSP program. The objective of this program is to provide long-term, forest-wide, unbiased estimates of forest vegetation change (growth, mortality, ingress).

In total, tree-level data for 3581 plots (FMA wide) were provided by Al-Pac for volume calculations. Table 2 provides the breakdown of plots by sampling program.

Table 2. Distribution of sample plots by data source.

Data Source	Frequency	Percent	Cumulative Frequency	Cumulative Percent
PSP	243	6.8	243	6.8
Coniferous TSP	743	20.7	986	27.5
Deciduous TSP	2595	72.5	3581	100.0

source: yanguo d:\projects\ p269\tsp compilation.doc

3.1.2 Stratum Assignment

The tree-level datasets represented all plots in the Al-Pac TSP and PSP programs. For empirical yield prediction, each plot must be assigned to a prediction stratum. Since the prediction stratum definitions are based on the AVI stand attributes, only those plots for which AVI stand attributes are known can be used.

TSP and PSP plot-level datasets, containing AVI attributes for sampled stands, were provided by Timberline Forest Inventory Consultants Ltd. The PSP dataset contained AVI information for 192 sample plots. The TSP dataset contained AVI information for 1936 sample plots.

The tree-level datasets (containing the volume/ha estimates) were combined with the plot-level datasets (containing the AVI information) based on the Township, Range, Meridian and Plot Number variables.

Only those plots that appeared in both the tree-level dataset and the plot-level dataset could be used in the analysis. Plots could not be used in the analysis if they did not have a stand origin or were identified as non-merchantable.

Eligible TSP's and PSP's were then assigned to a stratum according to their AVI inventory attributes (i.e. according to stand label). Table 3 provides the distribution of eligible plots by data source and stratum as they were used in regression analysis.

Table 3. Distribution of sample plots by source and stratum.

Data Source	Stratum				Total Eligible Plots
	Aw	AwSw	SwAw	Sw	
PSP	80	24	13	25	142
Coniferous TSP	22	10	8	103	143
Deciduous TSP	783	158	66	69	1076
Total	885	192	87	197	1361

source: yanguo d:\projects\ p269\tsp compilation.doc

3.1.3 Data Analysis

The data from the Temporary Sample Plot Programs and the Permanent Sample Plot program were combined. For each eligible sample plot, the following statistics were calculated:

- plot level volume/ha by species,
- plot level volume/ha by conifer or deciduous, and
- plot level total volume/ha.

Trees were not used in the analysis if:

- their quality codes indicated that they were missing (15), dead & standing (25), cut down (29), unknown (37), dead and down (61), in the PSP tree data.
- their quality codes indicated that they were dead potential (3), dead useless (4), live useless (6), veteran dead potential (7), immature dead potential (9), in the TSP tree data.
- their merchantable length was less than 3.66 m.

3.1.3.1 Individual Tree Height Estimation

For the PSP dataset, measured heights were available for the majority of the trees. For the TSP dataset, measured heights were only available for targeted sample trees. Individual tree heights were therefore computed for all non-measured trees using Alberta Lands and Forest Service Ht-Dbh equations with parameters based on natural subregion (Huang, 1994).

3.1.3.2 Volume Generation

Volume per hectare estimates for each plot were calculated using the iterative process presented in 'Ecologically based individual tree volume estimation for major Alberta tree species' (Huang, 1994).

The merchantable length of each tree was computed based on the Alberta-Pacific utilization standards (Timberline, 2002). Table 4 provides the utilization standards that were applied.

Table 4. Utilization standards for merchantable volume.

Species Group	Minimum Top Diameter (cm)	Stump Height (cm)	Minimum Stump Diameter (cm)	Minimum Merchantable Length (m)
Deciduous	10.0	30.0	15.0	3.66
Coniferous	11.0	30.0	15.0	3.66

source: Timberline, 2002

The merchantable length of each tree was then divided into 30 sections of equal length. Diameters were determined for the top, middle and bottom of each section using Kozak's variable exponent taper equation (eq. 1) (Kozak, 1988) and ecoregion/species specific coefficients for the province of Alberta (Huang, 1994).

$$dib = a_0 DBH^{a_1} * a_2^{DBH} * X^{b_1 Z^2 + b_2 \ln(Z+0.001) + b_3 \sqrt{Z} + b_4 e^Z + b_5 (\frac{DBH}{H})} \quad \text{eq. 1}$$

where: dib = upper stem diameter inside bark (cm) at height h (m)

DBH = diameter at breast height (cm)

H = total tree height (m)

$$X = \frac{1 - \sqrt{h/H}}{1 - \sqrt{p}}$$

Z = h/H

h = upper stem height (m)

p = relative height of inflection point from the ground

$a_0, a_1, a_2, b_1, b_2, b_3, b_4, b_5$ = coefficients

For each tree, section volumes were calculated using Newton's equation (Husch et al, 1982) - eq. 2

$$MV = \frac{ML/10}{6} * (0.00007854) * \left(d_0^2 + 4d_1^2 + d_2^2\right) \quad \text{eq.2.}$$

where: MV = merchantable volume (m^3)

ML = merchantable length (m)

d_0 = diameter at bottom of section (cm)

d_1 = diameter at middle of section (cm)

d_2 = diameter at top of section (cm)

Merchantable tree volumes were then determined by summing individual section volumes for each tree. Tree volumes were then converted to representative volumes per hectare using the appropriate plot size expansion factor.

For each plot the total coniferous gross merchantable volumes were calculated by summing the m^3/ha estimates for each live softwood tree within the plot.

For each plot the total deciduous gross merchantable volumes were calculated by summing the m^3/ha estimates for each live deciduous tree within the plot.

3.1.3.3 Regression

Regression curves were produced for the Aw, AwSw, SwAw and Sw strata based on the volume/age pairs from plots within each stratum. Volume was generated as described and age was based on the stand age as described by the inventory label (stand origin).

Both coniferous and deciduous regression curves were produced using non linear regression procedures for each of the strata. The equation used to fit the data is presented as eq. 3. Two versions of eq. 3 were attempted for each stratum; a 3 parameter model as presented and a 2 parameter model where coefficient 'a' was set equal to coefficient 'c'.

$$Volume = a * Age^{b} * e^{-c * Age} \qquad \text{eq.3}$$

where: Volume = softwood or hardwood volume per hectare (m^3/ha)

Age = stand age according to inventory (years)

a, b,c = parameters or coefficients to be estimated

e = natural logarithm (approx. 2.71828)

The software package used was SAS. The starting estimates for the parameters used were 0.001 for coefficient 'a', 2.5 for coefficient 'b' and 0.1 for coefficient 'c'. These values were chosen based on past experience with similar data. The choice between the 3 parameter model and the 2 parameter model was based on the achievement of convergence and the biological credibility of the resultant curve. The 3 parameter model was chosen over the 2 parameter in most cases. This choice was based on the belief that stands do not maintain volume growth at the older ages but begin to show a decline.

3.1.4 Yield Curves

The natural stand empirical yield curves are presented in Figures 1 through 4. No empirical yield curves were created using regression analysis for stratum Aw/Sw (aspen with white spruce understory). Appendix I provides the regression coefficients.

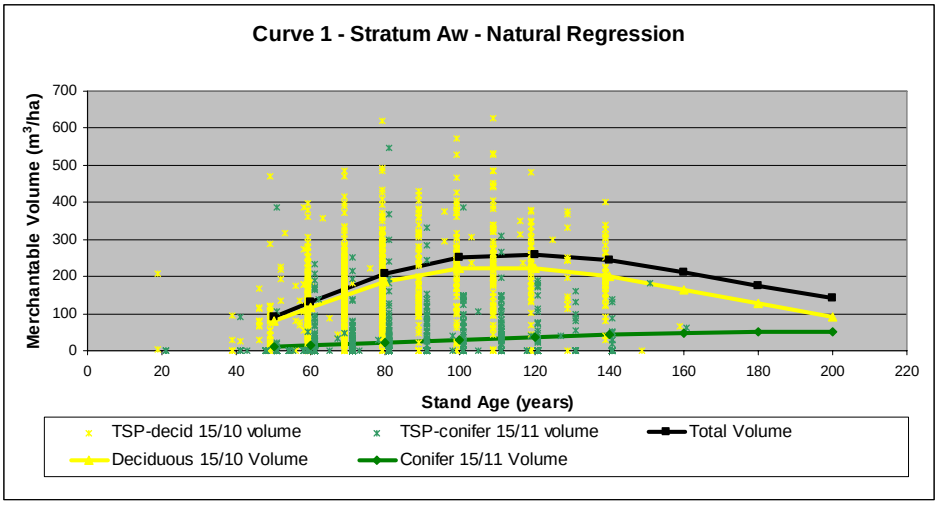


Figure 1. Natural Stand Regression Yield Curves for Stratum Aw.

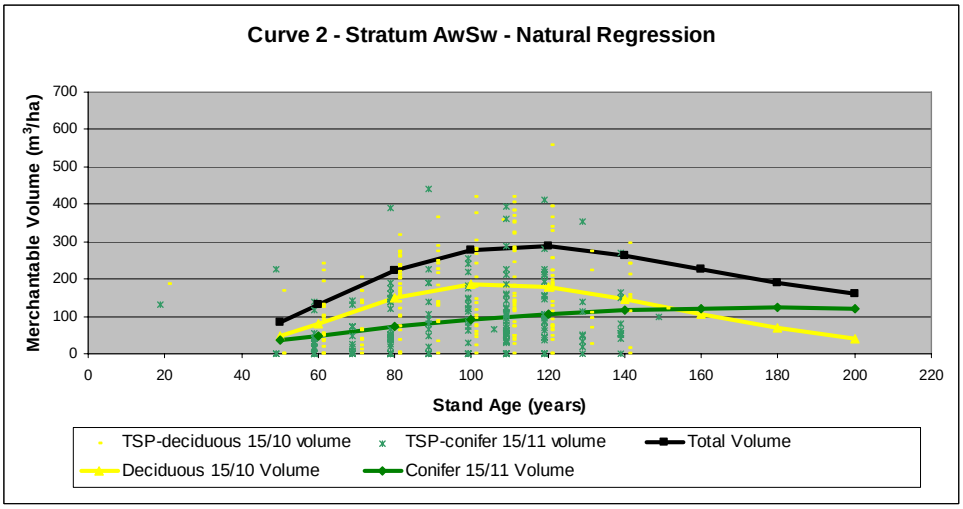


Figure 2. Natural Stand Regression Yield Curves for Stratum AwSw.

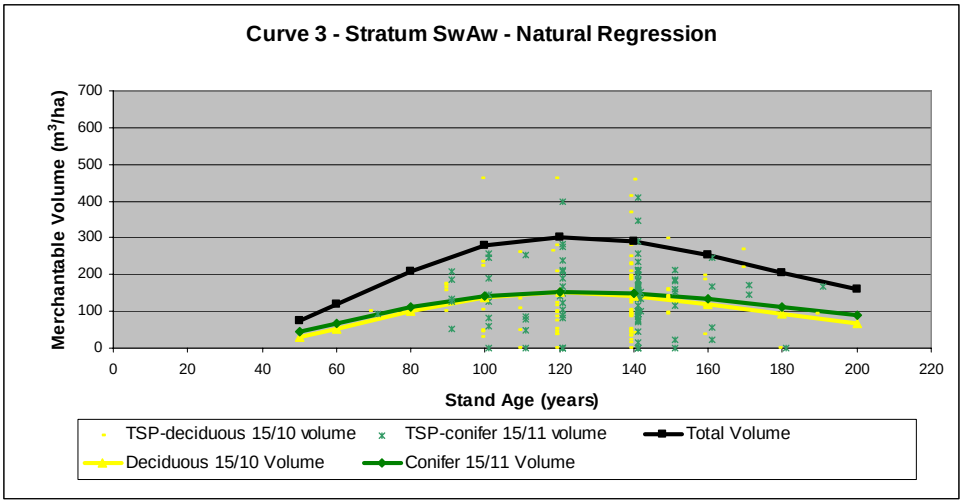


Figure 3. Natural Stand Regression Yield Curves for Stratum SwAw.

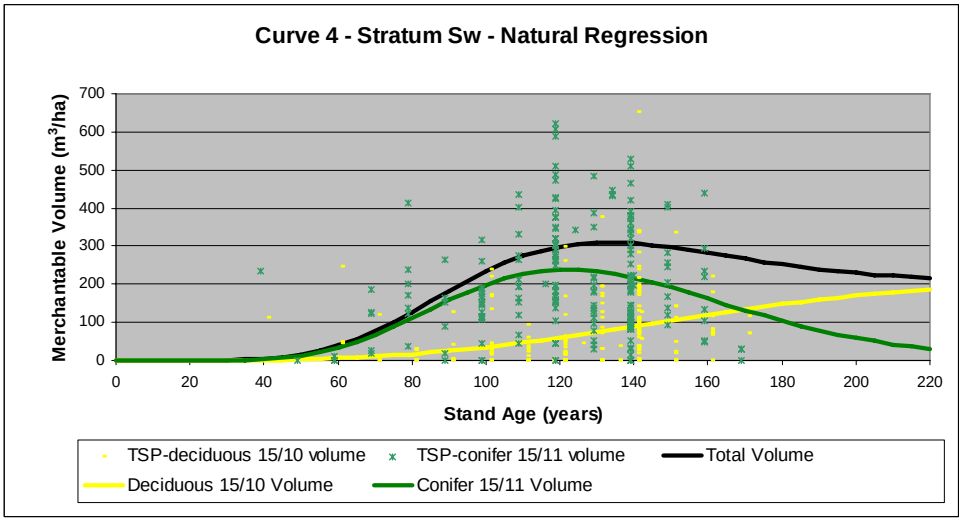


Figure 4. Natural Stand Regression Yield Curves for Stratum Sw.

3.2 Strata Pj and Sb

3.2.1 Stratum Assignment

As no mixedwood management treatments are contemplated for yield strata dominated by Jack Pine and Black Spruce, no new yield curves were required. Had the existing DFMP yield strata aligned well with the Jack Pine and Black Spruce stratum definitions for this project, the DFMP yield curves could have been used directly.

However, this project defined Jack Pine and Black Spruce strata differently than previously defined DFMP yield strata. Therefore, existing yield curves approved in the Al-Pac DFMP process for Jack Pine and Black Spruce were combined in appropriate ways for application to the Jack Pine and Black Spruce strata as defined for this project.

Yield curves for each of the Jack Pine and Black Spruce dominated yield strata in this project are area-weighted combinations of one or more DFMP yield curves. Table 5 defines which DFMP yield curves were used to construct each Jack Pine and Black Spruce curve for this project.

Table 5. DFMP yield class descriptions for area-weighted mixedwood strata.

Mixedwood Stratum	DFMP Yield Class Descriptions					
	Yield Class Number	Yield Class Label	Broad Cover Group	Lead Conifer	Crown Closure	TPR
Pj Mixed	10	PjAw/AwPj	CD/DC	Pj	BCD	FMG
Pj Pure	19	Pj-O	C	Pj	AB	FMG
	20	Pj-C-FM	C	Pj	CD	FM
	21	Pj-C-G	C	Pj	CD	G
Sb Fair/Med	16	Sb-O	C	Sb	AB	FMG
	17	Sb-C-FM	C	Sb	CD	FM
Sb Good	18	Sb-C-G	C	Sb	CD	G

source: Table 10, Timberline 2001

The following definitions apply (Timberline 2001):

Broad Cover Group

- CD = 30-50% deciduous and 50-70% conifer crown closure
- DC = 60-70% deciduous and 30-40% conifer crown closure
- C = 0-20% deciduous and 80-100% conifer crown closure

Crown Closure

- Open = A & B density
- Closed = C & D density

Timber Productivity Rating (TPR)

- F = Fair
- M = Moderate
- G = Good

3.2.2 Area-Weighting

Table 6 details the area of the Al-Pac FMA assigned to each DFMP Jack Pine and Black Spruce stratum. It also shows the proportional contribution of DFMP yield curves to each Jack Pine and Black Spruce yield curve for this project.

Table 6. DFMP yield class areas for area-weighted mixedwood strata - June 2002.

Mixedwood Stratum	DFMP Yield Class			Area (ha)	% Area Wt
	No.	Label	Description		
Pj Mixed	10	MxPj	Aw/Pj mixedwood	67,146	100
Pj Pure	19/20	Pj-O-C-FM	pure jack pine, open, close, fair & moderate	362,174	77
	21	Pj-C-G	pure jack pine, close, good	110,099	23
Sb Fair/Med	16	Sb-O	pure black spruce, open	80,908	42
	17	Sb-C-FM	pure black spruce, close, fair & moderate	110,569	58
Sb Good	18	Sb-C-G	pure black spruce, close, good	94,933	100

source: TFIC June 21, 2002

3.2.3 Yield Curves

The natural stand empirical yield curves are presented in Figures 5 through 8.

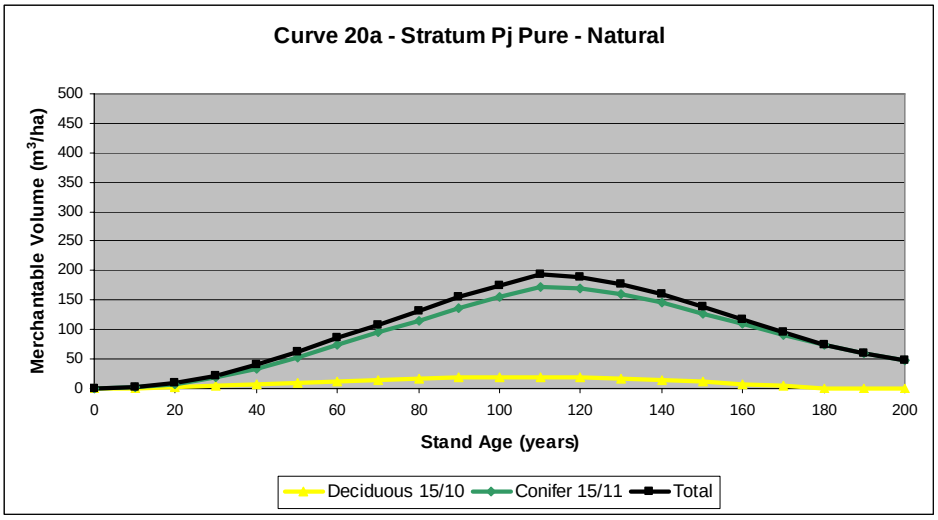


Figure 5. Natural Stand Area-weighted Yield Curves for Stratum Pj Pure.

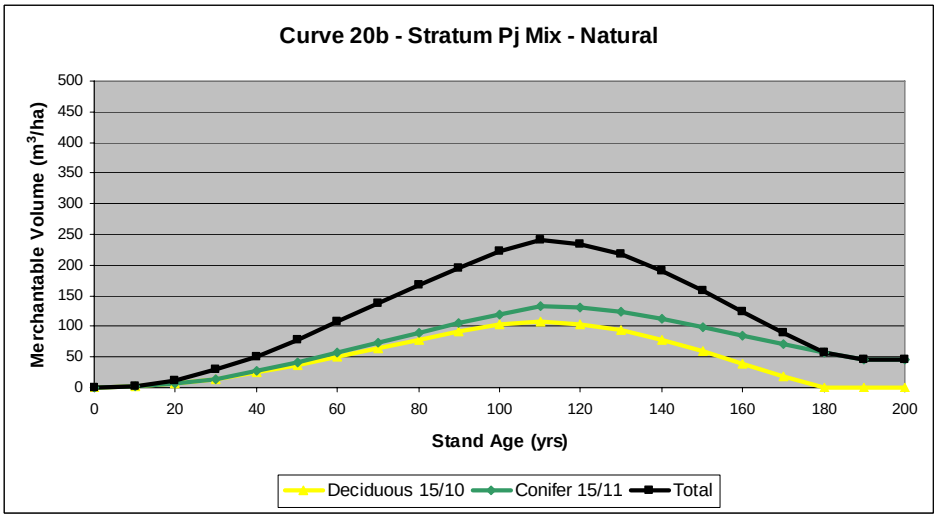


Figure 6. Natural Stand Yield Curves for Stratum Pj Mix.

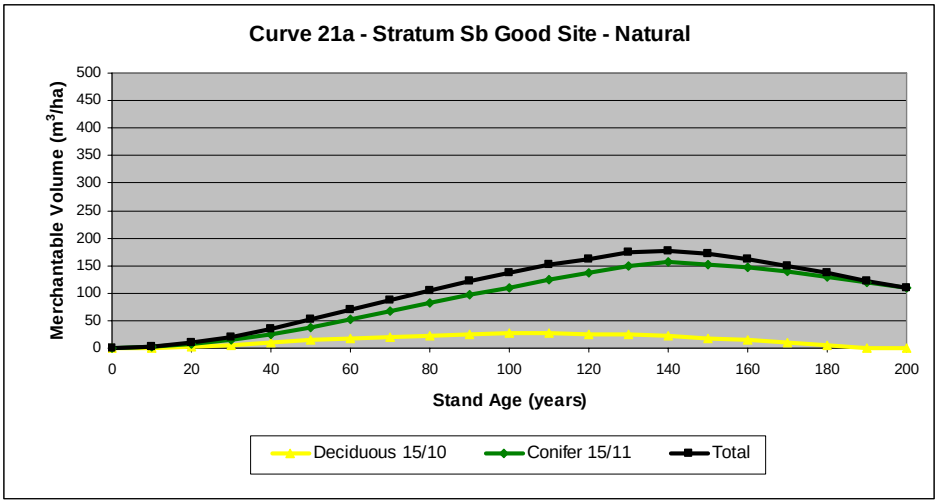


Figure 7. Natural Stand Yield Curves for Stratum Sb Good.

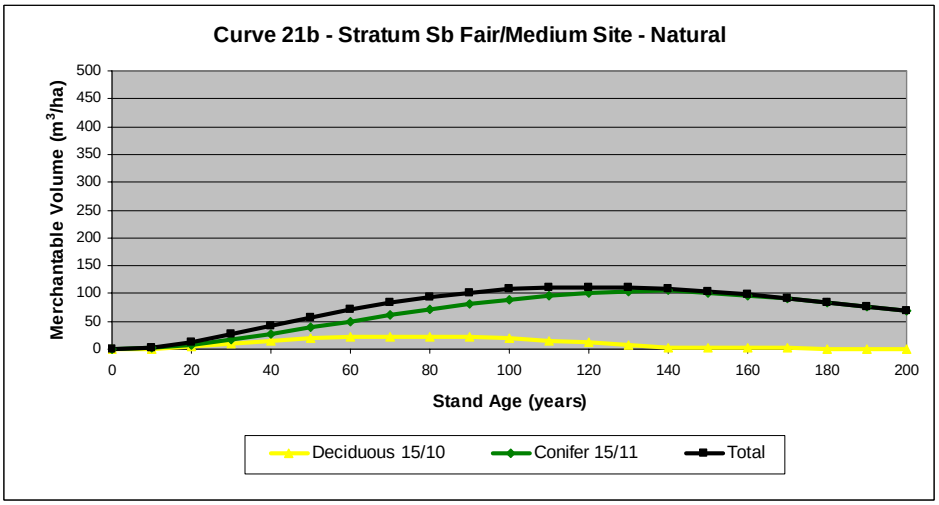


Figure 8. Natural Stand Area-weighted Yield Curves for Stratum Sb Fair/Medium.

4.0 Mixedwood Management Treatment Descriptions

4.1 Introduction

Al-Pac has defined mixedwood management treatments that are appropriate for each of the Aw, Aw/Sw, AwSw, SwAw, and Sw strata. The following sections describe the treatments for each of these strata. It is for these treatments that yield curve responses were modeled.

4.2 Stratum Aw

Two alternative mixedwood management treatments were considered for stratum Aw.

1. Underplant of Sw in Overmature Aw - white spruce underplanted in B and C density aspen stands greater than 60 years of age; 20 years later an understory protection harvest to remove aspen canopy and release understory spruce.
2. Successful Underplant of Sw in Midrotation Aw - white spruce underplanted in B and C density aspen stands between 30 and 40 years old; planted white spruce develops into a viable understory.

4.3 Stratum Aw/Sw

One alternative mixedwood management treatment applied at two different ages was considered for the Aw/Sw stratum.

1. Understory Protection Harvest - aspen canopy removed after 60 or 80 years of age releasing the white spruce understory.

4.4 Stratum AwSw

Two alternative mixedwood management treatments were considered for the AwSw stratum.

1. Shelterwood - removal of 50% of the canopy in C and D density aspen-white spruce stands on TPR="Good" sites of any age accompanied by a planting of white spruce; residual canopy removed 20 years later to release underplanted white spruce.
2. Underplant of Sw in Overmature AwSw - white spruce underplanted in B and C density aspen-white spruce stands greater than 60 years of age; 20 years later an understory protection harvest to remove aspen canopy and release understory spruce.

4.5 Stratum SwAw

Only one alternative mixedwood management treatment was considered for the SwAw stratum.

1. Shelterwood - removal of 50% of the canopy in C and D density white spruce-aspen stands on TPR="Good" sites of any age accompanied by a planting of white spruce; residual canopy removed 20 years later to release underplanted white spruce.

4.6 Stratum Sw

For the Sw stratum an enhanced response to white spruce planting was considered.

5.0 Simulated Natural Stand Volume Prediction

5.1 Mixedwood Growth Model

The Mixedwood Growth Model (MGM) is a deterministic, distance-independent, individual tree-based stand growth model (Titus, 1997). It was originally developed to model white spruce and aspen growing in varying degrees of mixture. Stand development is controlled using a 'Crop Plan'. The crop plan is a sequence of 'Events' that determine the source and characteristics of the stand, the growth schedule, and the timing and method of other activities like thinning, harvesting and regeneration (Titus, 1997).

Initially, MGM was used to simulate natural stand development for each stratum. Natural stand development curves from MGM were compared to the empirical curves. MGM inputs were modified to yield natural stand development curves which resembled the empirical curves. Those inputs were then used as the basis for modeling treatment responses with MGM.

For this analysis, version MGM99F—GF.xls (provided by Dr. S. Titus at the University of Alberta) was used.

For each stratum, a 'basic' crop plan representing natural stand development was developed using either an average tree list or a cohort list. Treatment 'Events' were then added to the 'basic' crop plan to produce Treatment Yield Crop Plans.

Simulated natural stand volumes were created using MGM for strata Aw, Aw/Sw, AwSw and SwAw.

5.2 Simulating Natural Stand Establishment in MGM

In MGM, input data for stand establishment can take on various forms. One form is an actual tree list by species, with corresponding diameter at breast height, total height, total or breast height age and density of stems. This tree list may be an actual tree list from a sample plot or an average tree list based on several sample plots.

Input may also be in the form of a cohort list. This list describes cohorts of trees by species, with corresponding breast height age, density of stems, average diameter at breast height (with associated standard deviation) and average height (with associated standard deviation) for each cohort.

It was important that the input data for each stratum begin at an age prior to the introduction of treatments. Therefore, starting stand ages of 50 years or 60 years were used.

For strata Aw and AwSw, an average tree list was generated based on all plots within each stratum with an AVI label indicating an inventory age of 60 years.

For stratum SwAw, an average tree list could not be developed as there were not enough plots at the early stand ages. Therefore, a cohort list was created based on the average tree list for a stand at 50 years of age.

5.2.1 Average Tree List

The following outlines the procedure used to generate the 'average' tree list based on the TSP and PSP data.

For each plot within the Aw or AwSw strata, with an age of 60 years, the following individual tree information (Stump diameter outside >= 15.0 cm) was retained:

- species,
- measured DBH,
- height (or predicted height if measured height was not available; the heights were estimated using Alberta Land and Forest Service height-DBH equations by Natural Region (Huang, 1994b)), and
- expansion factor (to per hectare based on plot size).

The tree tallies for plots within the same stratum were then combined.

Table 7 presents the number of plots available within the Aw and the AwSw strata by data source.

Table 7. Number of plots eligible for inclusion in tree lists as the input for MGM (by data source and stratum-age class combination)

Stratum Group	Age Class	Data Source	Number of Plots
Aw	60	PSP	16
		Coniferous TSP	5
		Deciduous TSP	134
AwSw	60	PSP	3
		Deciduous TSP	18

source: yanguo d:\projects\ p269\tsp compilation.doc

Within each stratum:

- the DBH and height were averaged in the each DBH-class (2 cm) by species.
- the expansion factors were summed to get the total expansion factor for each average tree in the each DBH-class (2 cm) by species.
- the number of plots (including zero-volume plots) within the stratum was determined.
- the total expansion factor was then divided by the number of plots to obtain a weighted expansion factor (new tree expansion factor) for each averaged tree (i.e., each species-DBH-Class combination).
- using the sample tree ages, the average tree age in each DBH-class (2 cm) by species was computed where possible.

This created the average tree list representing an average 'theoretical' hectare based on all plots within each stratum.

5.2.1.1 Stratum Aw

The average tree list generated for the Aw stratum consisted of trembling aspen, balsam poplar, and white birch for the deciduous component and white spruce, black spruce, balsam fir and jack pine for the coniferous component. MGM only allows for treatment 'Events' to be applied to white spruce, lodgepole pine, trembling aspen and black spruce. Therefore, all deciduous species were labeled as trembling aspen. Originally, the balsam fir was labeled as white spruce and jack pine was labeled as lodgepole pine. However, initial MGM runs depicted high conifer volumes compared to the empirical volumes predicted using non-linear regression. By removing the balsam fir, jack pine and black spruce from the tree list (representing approximately 30 stems/ha) conifer volumes more closely mimicked the empirical regression curves.

Site index was set at 22 m for trembling aspen and 16 m for white spruce based on the average tree ages and heights found in the tree list. For those DBH-classes with no representative tree age, an age was estimated based on the ages available . Table 8 provides the average tree list used as the starting point to simulate the Aw stratum stand development within MGM. The deciduous density at stand age 60 years is 837 stems/ha and the conifer density is 47 stems/ha resulting in a total density of 884 stems/ha.

Table 8. Average tree list for stratum Aw with stand age 60 years.

SPECIES	DBH	Density	HT	Total Age	SPECIES	DBH	Density	HT	Total Age
AW	14.32	196.29	17.71	49	SW	14.07	12.47	11.82	39
AW	15.90	226.16	18.53	51	SW	15.89	11.38	12.58	43
AW	17.90	141.88	19.44	53	SW	17.65	4.36	13.02	48
AW	19.79	88.31	20.29	53	SW	20.03	5.24	16.38	43
AW	21.80	32.17	20.62	62	SW	21.58	2.39	15.94	39
AW	23.81	22.59	21.73	65	SW	26.10	1.39	21.05	
AW	25.69	9.24	22.22		SW	27.55	0.49	20.05	
AW	28.00	8.27	22.63	74	SW	31.62	1.20	23.65	
AW	29.65	2.02	22.20	42	SW	33.97	0.58	24.05	
AW	31.88	1.10	23.82		SW	36.20	0.06	20.00	
AW	34.18	0.61	22.83		SW	38.00	0.06	21.00	
AW	36.40	0.19	24.52		SW	42.60	0.14	27.36	
AW	37.72	0.98	25.24	139	SW	46.35	0.23	28.07	
AW	40.10	0.15	24.94		SW	49.00	0.10	28.49	
AW	42.07	0.42	25.12		SW	51.90	0.12	28.88	
AW	43.75	0.23	24.50		SW	54.00	0.11	27.20	157
AW	45.30	0.12	26.50	144	SW	55.90	0.08	28.80	97
AW	47.60	0.11	25.48		SW	66.00	0.15	30.98	93
AW	52.10	0.15	25.68						
BW	14.06	8.51	13.98	41					
BW	16.05	7.87	15.41	44					
BW	18.20	1.05	14.87	44					
BW	20.15	1.62	16.83						
BW	21.77	1.43	17.55						
BW	23.90	1.15	18.43						
BW	27.30	0.44	19.70						
PB	14.14	23.04	15.66	85					
PB	15.87	20.96	16.05	51					
PB	17.60	12.79	17.29	87					
PB	19.77	7.03	18.03						
PB	21.52	5.12	18.36						
PB	24.10	3.07	19.19	57					
PB	25.97	5.48	18.89	117					
PB	27.87	2.73	19.89	59					
PB	29.75	2.45	20.74	66					
PB	31.75	0.73	21.85						
PB	33.10	0.13	20.52						
PB	35.93	0.58	22.77						
PB	38.00	0.30	22.82						
PB	40.20	0.20	23.53						
PB	41.10	0.06	21.90						
PB	43.10	0.18	23.95						
PB	46.10	0.21	24.33						

source: sarah c:\projects\ p269\yield curves\round4-13\Aw_curves4.doc

5.2.1.2 Stratum Aw/Sw

As there was insufficient data for the generation of a tree list for the Aw/Sw stratum, the tree list generated for the Aw stratum was used. The understory was simulated by introducing a white spruce understory component into the stand prior to treatment application.

5.2.1.3 Stratum AwSw

The average tree list generated for the AwSw stratum consisted of trembling aspen, balsam poplar, and white birch for the deciduous component and white spruce, black spruce, balsam fir and jack pine for the coniferous component. MGM only allows for treatment 'Events' to be applied to white spruce, lodgepole pine, trembling aspen and black spruce. Therefore, all deciduous species were labeled as trembling aspen and all coniferous species were labeled as white spruce.

Initial MGM runs depicted high deciduous volumes compared to the empirical volumes predicted using non-linear regression. By decreasing the trembling aspen density by 10% across all diameters, the volumes more closely mimicked the empirical regression curves.

Site index was set at 22 m for trembling aspen and 16 m for white spruce based roughly on the average tree ages and heights found in the tree list. For those DBH-classes with no representative tree age, an age was estimated based on the ages available. Table 9 provides the average tree list (with trembling aspen density decreased by 10%) that was used as the starting point to simulate the AwSw stratum stand development within MGM. The deciduous density at stand age 60 years is 663 stems/ha and the conifer density is 191 stems/ha resulting in a total density of 854 stems/ha.

Table 9. Average tree list for stratum AwSw with stand age 60 years.

SPECIES	DBH	Density	HT	Total Age	SPECIES	DBH	Density	HT	Total Age
Aw	14.2	216.6	16.6	46	Fb	14.5	11.5	12.8	
Aw	16.0	118.3	17.8	47	Fb	17.2	0.5	14.8	
Aw	18.0	82.9	18.4	50	Fb	19.9	0.5	15.4	
Aw	19.8	39.9	19.3		Fb	24.3	4.1	19.1	
Aw	21.9	27.8	19.4	66	Pj	15.1	8.0	12.5	43
Aw	23.7	13.5	21.1		Sw	14.2	42.4	12.9	
Aw	26.1	16.6	20.6	35	Sw	15.8	53.6	14.0	
Aw	28.0	9.4	22.6		Sw	17.9	21.9	14.1	40
Aw	29.8	10.1	23.5	99	Sw	19.5	10.7	15.1	
Aw	31.7	3.2	23.8		Sw	22.4	7.0	17.5	
Aw	33.9	3.5	24.9	98	Sw	23.9	6.5	17.7	
Aw	44.1	0.5	24.2		Sw	25.8	7.3	17.8	45
Aw	59.6	0.5	25.9		Sw	29.5	5.6	23.4	
Bw	14.0	22.0	13.8		Sw	33.6	4.9	24.8	61
Bw	15.3	26.2	14.6		Sw	43.7	1.6	27.6	
Bw	19.6	0.5	15.3		Sw	47.9	1.1	28.3	
Bw	21.3	7.4	18.0		Sw	50.1	1.0	28.6	
Pb	14.3	5.2	14.9						
Pb	15.8	10.1	16.2						
Pb	18.2	12.8	16.8						
Pb	19.9	2.1	18.3						
Pb	21.4	7.0	18.5	72					
Pb	23.8	6.1	18.9						
Pb	26.3	1.0	21.0						
Pb	27.8	7.4	20.5						
Pb	29.0	3.2	21.1						
Pb	31.3	2.7	21.7						
Pb	37.9	3.7	23.1						
Pb	39.0	1.8	23.3						

source: sarah c:\projects\ p269\yield curves\round4-13\AwSw_curves4.doc

5.2.2 Cohort List

5.2.2.1 Stratum SwAw

For stratum SwAw, plot data were only available for the older stand ages. Therefore, a cohort list was used to simulate the starting conditions of a 50 year old stand. A cohort list consists of the following information:

- species,
- breast height age (yrs),
- site index,
- density (stems/ha),
- average dbh (cm),
- standard deviation around average dbh (cm),
- average height (cm), and
- standard deviation around average height (cm).

Two cohort entries were used, white spruce and aspen. Several scenarios were run using a variety of starting ages, densities and site indices. The final cohort list described a 50 year old mixedwood stand, with the white spruce given a breast height age of 35 years and the aspen a breast height age of 40 years. The site index was set at 20 m. The average dbh and height along with their corresponding standard deviations were taken from the lookup table within MGM based on natural subregion, species, site index and breast height age. Table 10 provides the resultant cohort list that was used as input for stratum SwAw.

Table 10. Cohort list for stratum SwAw used as input into MGM.

Species	Breast Height Age (yrs)	Site Index (m)	Density (stems/ha)	Average Dbh (cm)	Std. Dev. (cm)	Average Height (m)	Std. Dev. (m)
Sw	35	20	450	13.6	2.7	10.9	2.2
Aw	40	20	1000	13.8	1.4	15.1	1.5

source: sarah c:\mgm98\round4_13cmdbh\mgmswaw3.xls

5.3 Simulating Natural Stand Development in MGM

A 'basic' MGM crop plan was created for strata Aw, AwSw and SwAw in order to simulate natural stand development. Each crop plan was established using the 'ESTABLISH TREES' event in MGM. The 'STANDS DB' option was used to establish a stand based on an average tree list (Aw, AwSw). The 'SIMULATE TREES' option was used to establish a stand based on a cohort list (SwAw). The 'GROW' event was then used to grow the established stands by 20-year intervals for 200 years without intervention. MGM Crop plans for natural stand development can be found in Appendix II.

5.3.1 Merchantability Inputs

Growth was based on Alberta Site Index Curves (within the model) for the Central Mixedwood Ecoregion. Ingrowth was allowed to occur, but trees smaller than 1.3 m in height were not accounted for. No percentage volume loss was included.

While merchantability standards are normally set based on minimum stump diameter, MGM only allows for minimum dbh. In order to reflect the 15 cm minimum stump diameter that was applied to the volume estimates used in regression analysis, an equivalent minimum dbh had to be determined.

Using the provincial stump-dbh equation (Huang, 1994) and the coefficients for the Central Mixedwood Ecoregion, the corresponding diameters at breast height for white spruce and aspen were calculated based on a 15.0 cm stump diameter. The average value was computed (13.6 cm) and used as input into MGM.

MGM does not allow for the setting of a minimum merchantable length. As the empirical regression yields were based on this utilization standard, it was important to determine the affect of not applying it in the MGM simulations. Tree lists for each of the four strata (Aw, AwSw, SwAw, Sw) were generated at 20 year intervals using the MGM 'basic' crop plans. Merchantable volumes were then calculated as described in section 3.1.3, both with and without a minimum merchantable length requirement. Conifer volumes at stand age 60 years in the Aw stratum were found to vary by 0.5 m^3/ha. All other strata/age combinations showed no difference in the merchantable volumes reported.

Merchantability standards were therefore set as follows:

- minimum dbh = 13.6 cm
- minimum top diameter = 10.0 cm for deciduous
- minimum top diameter = 11.0 cm for conifer
- stump height = 0.3 m
- no minimum merchanable length

5.3.2 Simulated Volume Prediction vs Empirical Plot Data

Simulated volume prediction (yield curves) produced using the merchantable volumes generated with the 'basic' MGM crop plans for natural stands were compared to the

empirical plot data and are shown in Figures 9 through 11. Simulated volumes for all strata fell within the observed variation of empirical volumes.

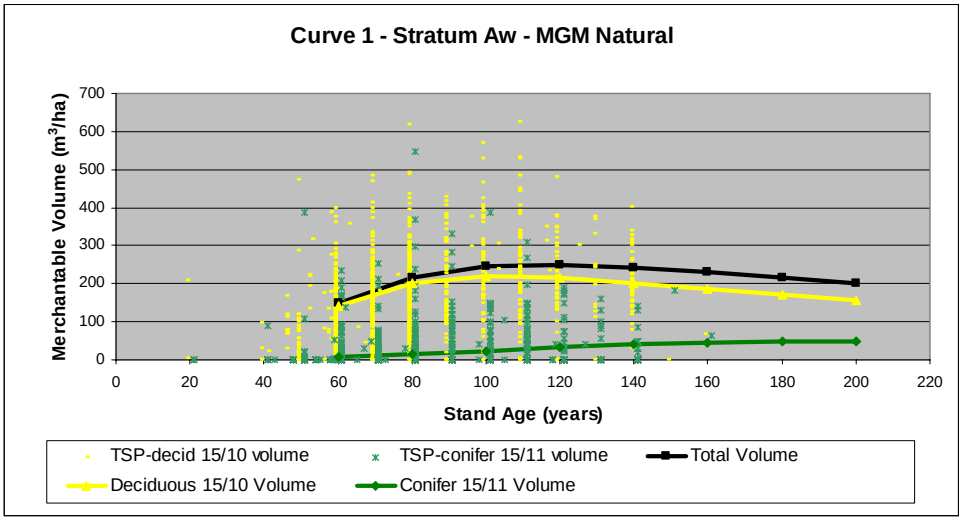


Figure 9. Simulated volume prediction and empirical plot data for stratum Aw.

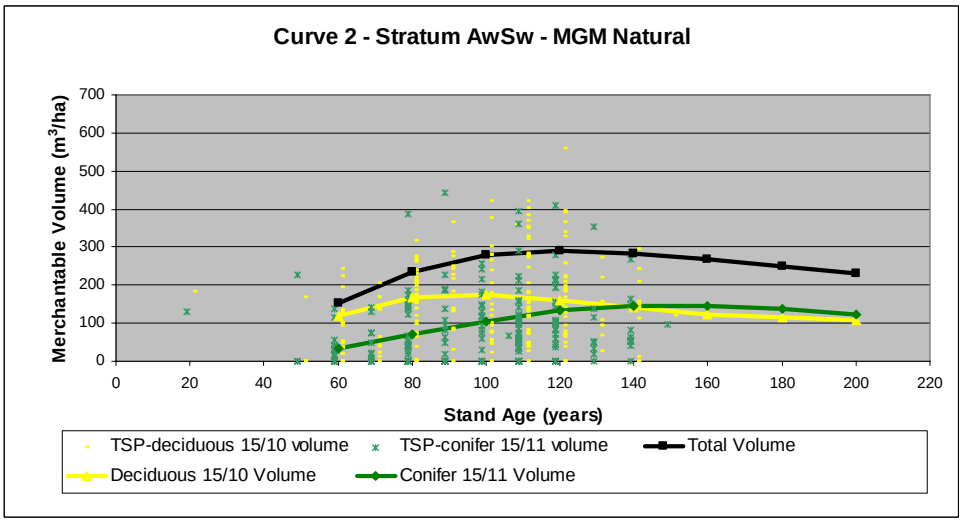


Figure 10. Simulated volume prediction and empirical plot data for stratum AwSw.

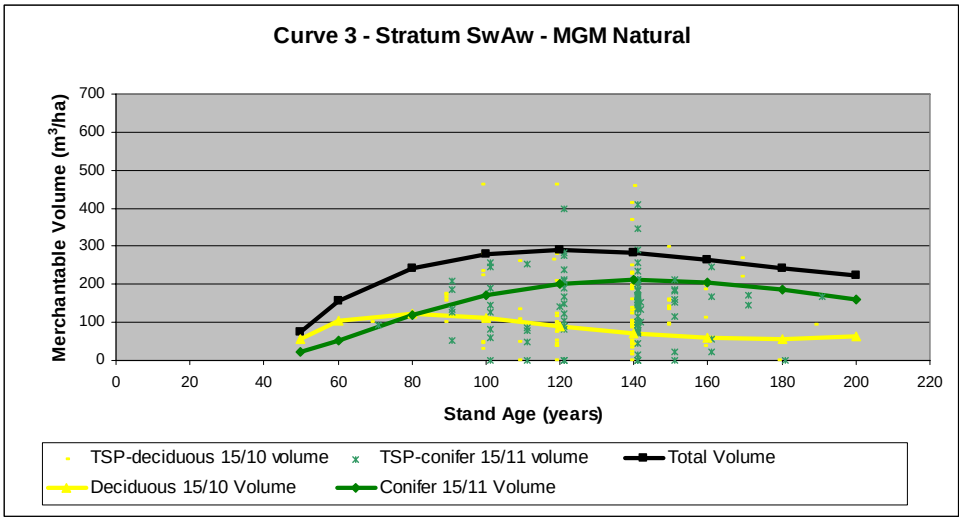


Figure 11. Simulated volume prediction and empirical plot data for stratum SwAw.

5.3.3 Simulated Volume Prediction vs Empirical Volume Prediction

The yield curves produced using the merchantable volumes generated with the 'basic' MGM crop plans for natural stands were compared to the empirical natural stand volume predictions (regression) and are shown in Figures 12 through 14.

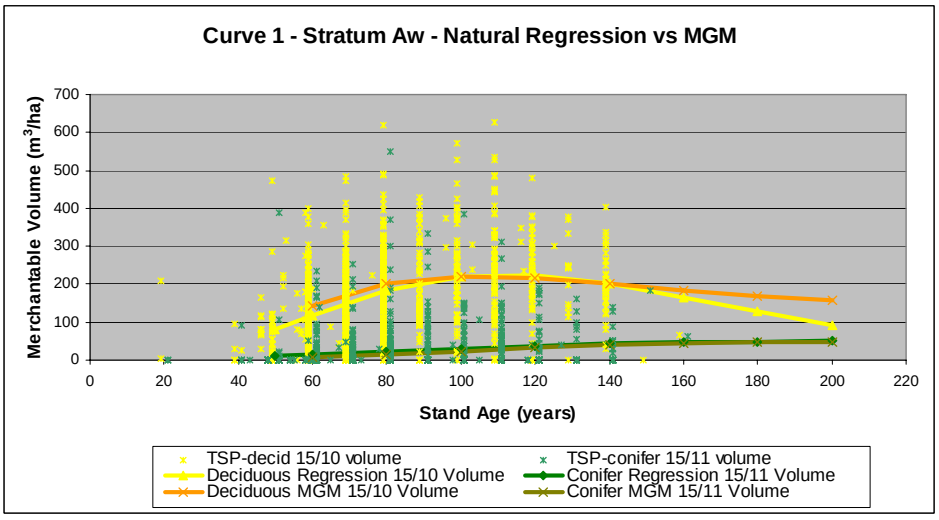


Figure 12. Simulated volume prediction vs empirical volume prediction for Aw.

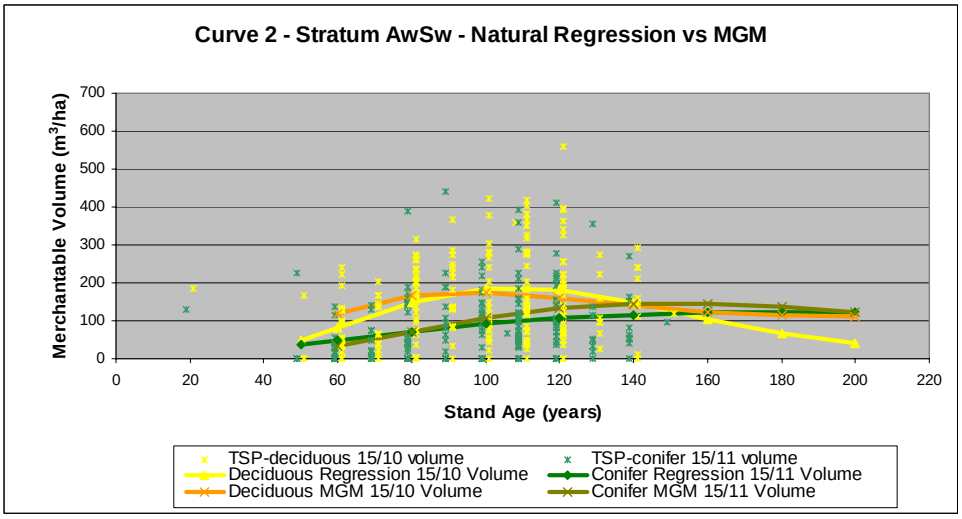


Figure 13. Simulated volume prediction vs empirical volume prediction for AwSw.

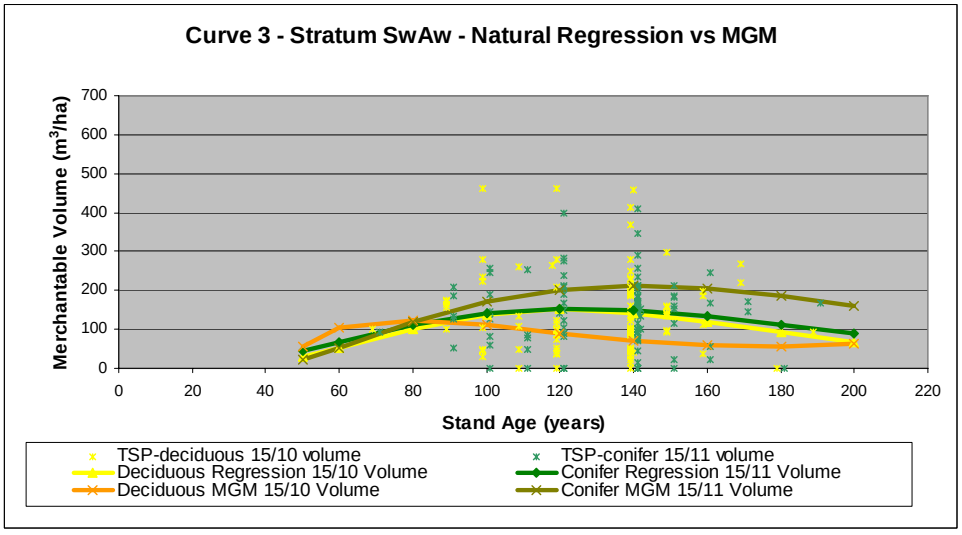


Figure 14. Simulated volume prediction vs empirical volume prediction for SwAw.

5.3.4 Discussion - 'Basic' Crop Plan Choices

The process of choosing the appropriate 'basic' crop plan for each of the three strata (Aw, AwSw and SwAw) involved the comparison of many MGM runs. The use of average tree lists based on TSP and PSP data was always the first choice for stand establishment.

In the case of strata Aw and AwSw, it was possible to create average tree lists for an age young enough to simulate realistic stand development (age 60 years). This is confirmed by the comparative graphs. For both strata, the simulated volume prediction curves fall well within the observed variation of the sample plot data and closely mimic the empirical volume prediction curves.

For the SwAw stratum, the youngest age group with enough plot data to generate an average tree list was 100 years, well beyond the age at which mixedwood management treatments were to be applied. Therefore, in this case, the use of the cohort list for stand establishment was required. Many different cohort lists were attempted (varying species, density, starting age and site index) and compared to the empirical volume prediction curves. It became apparent that while it was possible to mimic the empirical volume prediction curves below 100 years, after 100 years MGM would always allow the white spruce to dominate stand development. The empirical volume prediction curves show white spruce and trembling aspen being equal throughout the life of the stand.

The choice was made to use a cohort list for natural stand establishment that closely mimicked the empirical volume prediction within the treatment age range (under 100 years of age). In this way, the application of mixedwood management treatments could be simulated with some degree of confidence. The choice of cohort was also dependent on the comparison with spruce and aspen volumes for the AwSw and Sw strata. It was felt that consistency across strata was important in order to reflect realistic treatment results.

The comparative graphs for the SwAw strata show that the simulated volume prediction curves fall within the observed variation of the sample plot data and closely mimic the first 100 years of the empirical volume prediction curves.

5.3.5 Ecological Consistency Between Yield Strata

In most timber supply analyses, existing forest stands are assigned to yield strata based on their current species composition. These strata assignments are static through time, and imply that once a stand has been assigned to a given stratum, it stays in that stratum until it breaks up in old age. Under these assumptions, a young aspen stand remains a pure aspen stand forever.

It is well understood that for mesic boreal forest spruce-aspen sites, forest stand development trajectories may pass through multiple species composition strata from the time of stand initiation to the time of stand break-up. With the availability of a spruce seed source, a young aspen stand could move through a series of strata. Hypothetically, it could develop from a pure deciduous stand, to a deciduous dominated mixedwood, to a conifer dominated mixedwood, to ultimately end up as a pure conifer stand.

The common practice of generating empirical yield curves, by chrono-sequencing temporary sample plots within a stratum, is incapable of capturing the species dynamics described above. Because the chrono-sequence approach groups all ages of a particular set of plots with similar species compositions, it is not surprising that the resulting yield curves do not express well the dynamics of species composition that are thought to occur in natural stand development.

The objective of the process described here was to produce yield curves which reflected the mixedwood aspen-spruce species composition dynamics known to occur in natural stands, and to do so while reflecting consistent timber volume trends among different strata ('C', 'CD', 'DC' and 'D' in this context refer only to the spruce and aspen mixtures).

To achieve these objectives, several guiding principles served as the foundation for all MGM modeling as follows:

1. Based on the understanding that mixedwood sites over a range of species compositions have an inherent maximum timber producing capability, the maximum total volume (deciduous and conifer combined) is the same in aspen-dominated mixedwoods ('DC' stands) and in spruce-dominated mixedwoods ('CD' stands).
2. The maximum total volume (deciduous and conifer combined) in 'DC' and 'CD' mixedwood stands is 15% greater than the maximum total volume in pure aspen ('D') stands (MacPherson et al, 2001; Man & Leiffers, 1999).
3. The maximum conifer volume is higher in 'CD' stands than in 'DC' stands. This is based on the assumption that there is insufficient conifer stocking in stands that are characterized as 'DC' stands at 60 to 80 years to result in a fully stocked conifer stand at 120 to 160 years of total age.
4. The maximum conifer volume is the same in 'CD' and in pure conifer ('C') stands. Maximum conifer volume is attained later in 'CD' than in 'C' stands, since it takes the conifer component longer to dominate the site when it grows successionally in a mixedwood stand.

6.0 Simulated Treated Stand Volume Prediction

6.1 Mixedwood Growth Model

The Mixedwood Growth Model (MGM, Titus 1997) was used to simulate treatment responses for the various treatments described in Section 4.0.

Simulated treatment volumes were created using MGM for strata Aw, Aw/Sw, AwSw and SwAw.

6.2 Treatment Yield Crop Plans

The natural ('basic') crop plans created in the previous section using MGM were used as starting crop plans for the treatment crop plans for strata Aw, Aw/Sw, AwSw and SwAw.

6.2.1 Crop Plan Events

Crop plan events or treatments added to the natural crop plans included:

1. Planting White Spruce:

   The planting of white spruce was simulated by inserting a 'REGEN' event into the crop plan at the appropriate stand age. With the 'REGEN' event new trees were simulated using the 'SIMULATE TREES' option in MGM and creating a cohort list.

As MGM simulates trees based on breast height age the years to breast height for white spruce was estimated to be 15. Therefore, the 'REGEN' event was inserted into a crop plan at least 15 years after the time of planting. For example, the planting of 2 year old seedlings was simulated 20 years after the actual planting with trees having a breast height age of 7 years.

Breast Height Age (20 yrs later) = Total Tree Age – Years to Breast Height

= 22 years – 15 years

= 7 years

The density of the planted white spruce was chosen to reflect the expected conifer volume with respect to the natural conifer curve.

The average dbh and height along with their corresponding standard deviations were taken from the lookup table within MGM based on natural subregion, species, site index and breast height age.

2. Thinning of the Canopy:

   The thinning of the canopy was simulated by inserting a 'HARVEST' event into the crop plan at the appropriate age. One 'HARVEST' event was required for each species removed. A specific percentage of the density was removed, with the largest diameter trees being removed first.

3. Harvesting of the Canopy:

   The harvesting of the canopy was simulated by inserting one 'HARVEST' event into the crop plan at the appropriate age. A specific percentage of the density was removed, with the largest diameter trees being removed first.

4. Damage to Canopy as a Result of Thinning:

   Damage to the canopy was simulated by inserting one 'HARVEST' event into the crop plan at the appropriate age. A specific percentage of the density was removed proportionally across all diameters.

5. Aspen Suckering:

   Aspen suckering was added to the crop plan after each thinning or harvest of aspen. The suckers were simulated by inserting a 'REGEN' event into the crop plan at the appropriate stand age. With the 'REGEN' event new trees were simulated using the 'SIMULATE TREES' option in MGM and creating a cohort list.

   As MGM simulates trees based on breast height age the years to breast height for aspen was estimated to be 3. Therefore, the 'REGEN' event was inserted into a crop plan at least 3 years after the time of harvesting or thinning.

   The density of the suckers was chosen to reflect the expected deciduous volume with respect to the natural deciduous curve.

   The average dbh and height along with their corresponding standard deviations were taken from the lookup table within MGM based on natural subregion, species, site index and breast height age.

6.2.2 Stratum Aw

6.2.2.1 Underplant Sw in Overmature Aw

The following notes describe the changes made to the Aw 'basic' crop plan in order to produce merchantable volumes for this mixedwood management alternative.

- Sw planted at 80 years - input as 7 year old (bh) trees at 100 years, 500 trees/ha with site index of 22 and MGM corresponding diameter and height estimates.
- 100% canopy harvested at 100 years – 99% of Aw density harvested, selecting the largest diameter trees first; 12% of the Sw density harvested, selecting the largest diameter trees first.
- Aw suckering following harvest – input as 8 year old trees at 110 years, 1000 trees/ha with site index 22 and MGM corresponding diameter and height estimates.

6.2.2.2 Successful Underplant of Sw in Midrotation Aw

The following notes describe the changes made to the Aw 'basic' crop plan in order to produce merchantable volumes for this mixedwood management alternative.

- Sw planted at 30 years - input as 17 year old (bh) trees at 60 years, 700 trees/ha with site index of 16 and MGM corresponding diameter and height estimates.

6.2.3 Stratum Aw/Sw

6.2.3.1 Understory Protection Harvest of Aw/Sw

The following notes describe the changes made to the Aw 'basic' crop plan in order to produce merchantable volumes for this mixedwood management alternative. Crop plans and yield curves were produced for the application of this treatment at two different ages in order to reflect different responses based on stand age.

- create white spruce understory - input as 27 year old (bh) trees at 60 years, 1200 trees/ha with site index of 22 and MGM corresponding diameter and height estimates.
- Aw harvested at 60 years or 80 years – 90% of Aw density harvested at 60 years or 80 years, selecting the largest diameter trees first.
- Sw harvest damage - 25% of the Sw density harvested at 60 years or 80 years, selecting proportionally across diameter classes.
- Aw suckering following harvest – input as 8 year old trees at 70 years or 90 years, 1000 trees/ha with site index 22 and MGM corresponding diameter and height estimates.

6.2.4 Stratum AwSw

6.2.4.1 Shelterwood Planting in AwSw

The following notes describe the changes made to the AwSw 'basic' crop plan in order to produce merchantable volumes for this mixedwood management alternative.

- 50% of canopy harvested at 80 years – 50% harvest of Aw component by selecting the largest diameter trees first; 50% harvest of Sw component by selecting the largest diameter trees first.
- Aw suckering following harvest – input as 3 year old trees at 85 years, 800 trees/ha with MGM corresponding diameter and height estimates.
- Sw planted at 80 years - input as 7 year old (bh) trees at 100 years, 500 trees/ha with site index of 22 and MGM corresponding diameter and height estimates.
- Harvest shelterwood canopy at 100 years - 25% of Aw density harvested, selecting the largest diameter trees first; 16% of the Sw density harvested, selecting the largest diameter trees first.
- Aw suckering following harvest – input as 17 year old trees at 120 years, 400 trees/ha with MGM corresponding diameter and height estimates.

6.2.4.2 Underplant Sw in Overmature AwSw

The following notes describe the changes made to the AwSw 'basic' crop plan in order to produce merchantable volumes for this mixedwood management alternative.

- Sw planted at 80 years - input as 7 year old (bh) trees at 100 years, 500 trees/ha with MGM corresponding diameter and height estimates.
- 100% canopy harvested at 100 years – 99% of Aw density harvested, selecting the largest diameter trees first; 25% of the Sw density harvested, selecting the largest diameter trees first.
- Aw suckering following harvest – input as 8 year old trees at 110 years, 800 trees/ha with MGM corresponding diameter and height estimates.

6.2.5 Stratum SwAw

6.2.5.1 Shelterwood Planting in SwAw

The following notes describe the changes made to the SwAw 'basic' crop plan in order to produce merchantable volumes for this mixedwood management alternative.

- 50% of canopy harvested at 80 years – 50% harvest of Aw component by selecting the largest diameter trees first; 50% harvest of Sw component by selecting the largest diameter trees first.
- Aw suckering following harvest – input as 3 year old trees at 85 years, 800 trees/ha with site index of 22 and MGM corresponding diameter and height estimates.
- Sw planted at 80 years - input as 7 year old (bh) trees at 100 years, 500 trees/ha with site index of 22 and MGM corresponding diameter and height estimates.

- Harvest shelterwood canopy at 100 years - 30% of Aw density harvested, selecting the largest diameter trees first; 26% of the Sw density harvested, selecting the largest diameter trees first.
- Aw suckering following harvest – input as 17 year old trees at 120 years, 400 trees/ha with site index of 22 and MGM corresponding diameter and height estimates.

7.0 Stand Visualization System

The **Stand Visualization System (SVS)** generates graphic images depicting stand conditions represented by a list of individual stand components, e.g., trees, shrubs, and down material using detailed geometric models. The images produced by SVS, while abstract, provide a readily understood representation of stand conditions and help communicate silvicultural treatments and forest management alternatives to a variety of audiences (McGaughey R. J. 1999).

To assist in the analysis of silvicultural treatment responses, SVS tree lists were generated based on MGM outputs at various stages in stand development. A conversion program was written to modify MGM tree lists specifically.

The following additions to the MGM treelist outputs were generated:

1. Extra trees were created in order to ensure that all the plots had the appropriate number of trees for 0.1 ha. These trees were located randomly over the display area , and
2. Crown radii equal to 8% of total tree height were assigned to all trees, and
3. All trees were assigned a crown ratio in order according to the following rules:
    - if species is coniferous, then crown ratio = 0.7;
    - if species is deciduous, then crown ratio = 0.3.

Rangepoles were placed on the corners of the plots. These rangepoles are 30m tall, alternating orange and gray at 10 meter intervals.

Each SVS diagram randomly allocates trees across the sample plot. For this reason, consecutive diagrams do not illustrate the development of individual trees but rather the sample plot as a whole.

8.0 Results

8.1 Stratum Aw Yield Curves

8.1.1 Natural Stand Aw

Figure 15 provides the resultant natural Aw yield curve, with tables showing merchantable 15/10 and 15/11 utilization stand attributes and volumes.

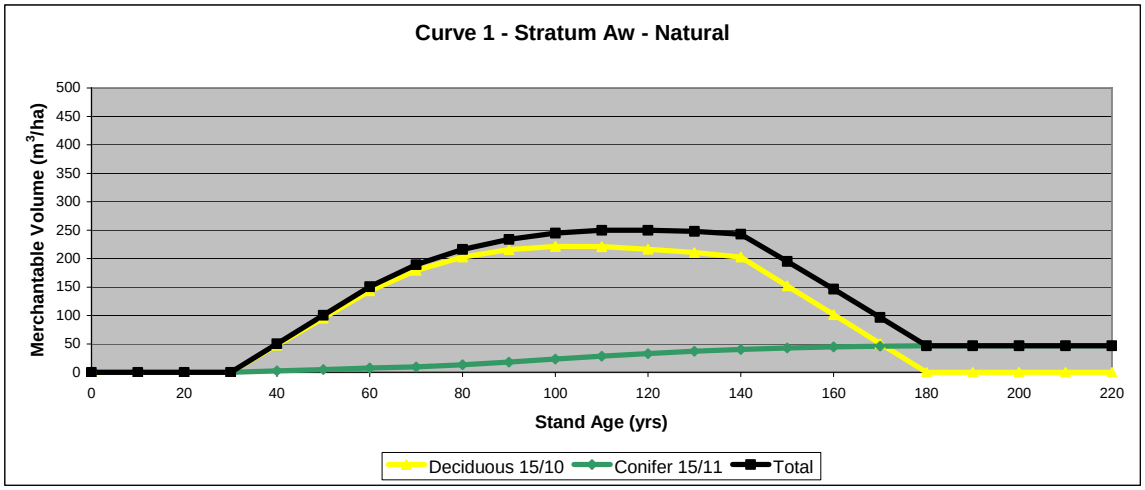
Merchantable volumes were assumed to occur sometime after 30 years of age. Straight-line interpolation was used to generate volumes between 30 years of age (0 m^3/ha) and the MGM starting age (60 yrs).

In order to model stand breakup and decline, deciduous volumes were forced to 0 m^3/ha 180 years after aspen initiation. Straight-line interpolation was used to decrease deciduous volumes over a 40 year period.

Coniferous volumes were assumed to stabilize 180 years after species initiation at 46.9 m^3/ha.

All non MGM generated volumes are shown in blue type.

Figure 16 provides the SVS diagrams illustrating the development of the Aw natural stand over time.

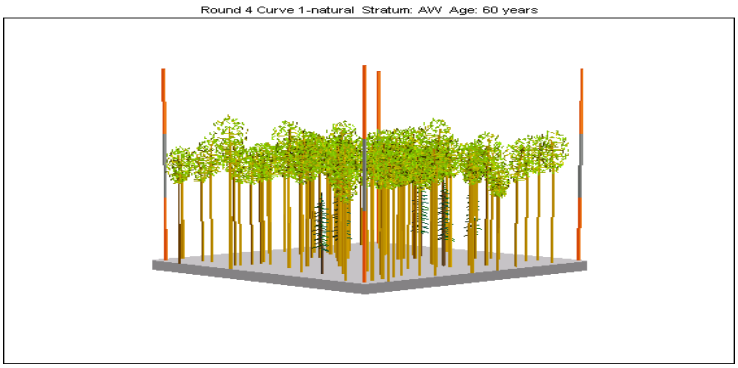


Stand Age	Merchantable Volume				
	Conifer 15/11	Deciduous 15/10	Total	% Conifer	% Deciduous
0	0.0	0.0	0.0	0	0
10	0.0	0.0	0.0	0	0
20	0.0	0.0	0.0	0	0
30	0.0	0.0	0.0	0	0
40	2.5	47.7	50.2	5	95
50	5.0	95.5	100.5	5	95
60	7.5	143.2	150.7	5	95
70	9.7	179.4	189.1	5	95
80	13.6	202.7	216.3	6	94
90	18.1	215.8	233.9	8	92
100	23.5	221.5	245.0	10	90
110	28.4	221.2	249.6	11	89
120	33.1	216.6	249.7	13	87
130	37.1	210.8	247.9	15	85
140	40.2	202.8	243.0	17	83
150	42.8	152.1	194.9	22	78
160	45.0	101.4	146.4	31	69
170	45.9	50.7	96.6	48	52
180	46.9	0.0	46.9	100	0
190	46.9	0.0	46.9	100	0
200	46.9	0.0	46.9	100	0
210	46.9	0.0	46.9	100	0
220	46.9	0.0	46.9	100	0

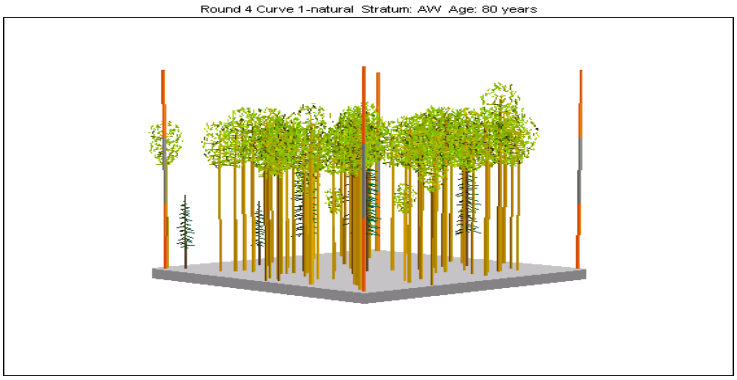
Stand Age	MGM Merchantable Utilization Stand Attributes					
	Conifer Density	Decid Density	Conifer Ave Dbh	Decid Ave Dbh	Conifer Ave Ht	Decid Ave Ht
60	41	838	18.5	17.4	14.3	18.7
80	38	646	23.9	21.0	19.1	22.6
100	56	515	23.6	23.2	20.4	25.0
120	64	407	24.9	24.9	22.2	26.8
140	62	338	26.8	25.8	24.3	27.9
160	70		26.1		24.3	
180	70		26.4		25.0	
200	72		26.2		25.2	

blue values - denote straight line interpolation.

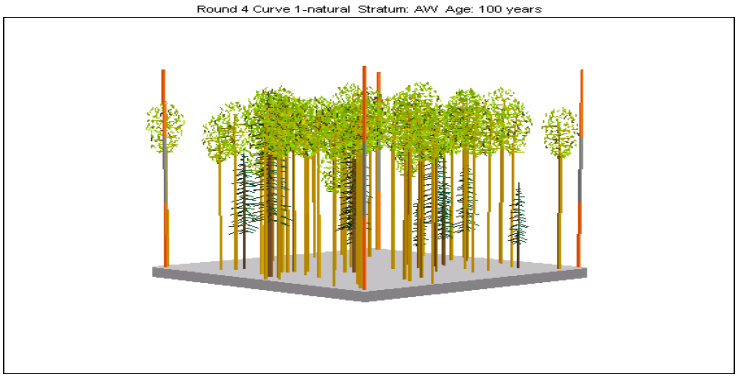
Figure 15. Stratum Aw – Natural Stand – yield curve and stand attribute summaries.



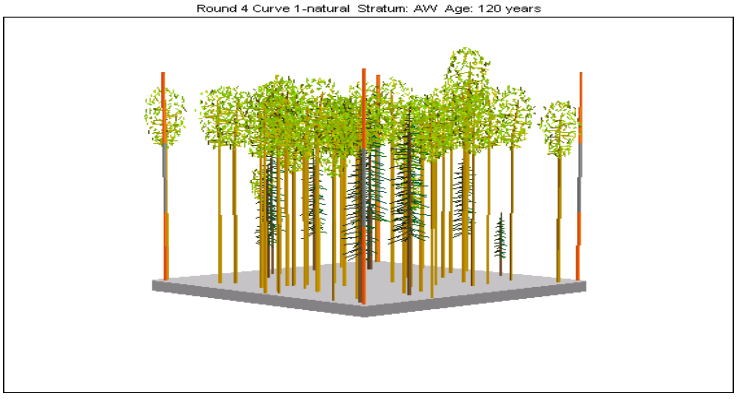
Stratum Aw (Curve 1) Natural stand at age 60 years



Stratum Aw (Curve 1) Natural stand at age 80 years



Stratum Aw (Curve 1) Natural stand at age 100 years



Stratum Aw (Curve 1) Natural stand at age 120 years

Figure 16. SVS diagrams for Stratum Aw – Natural Stand.

8.1.2 Underplant Sw in Overmature Aw

Figure 17 provides the resultant Aw yield curve when white spruce is underplanted late in the life of the stand and harvested at age 100 years. Tables showing merchantable 15/10 and 15/11 utilization stand attributes and volumes have been included.

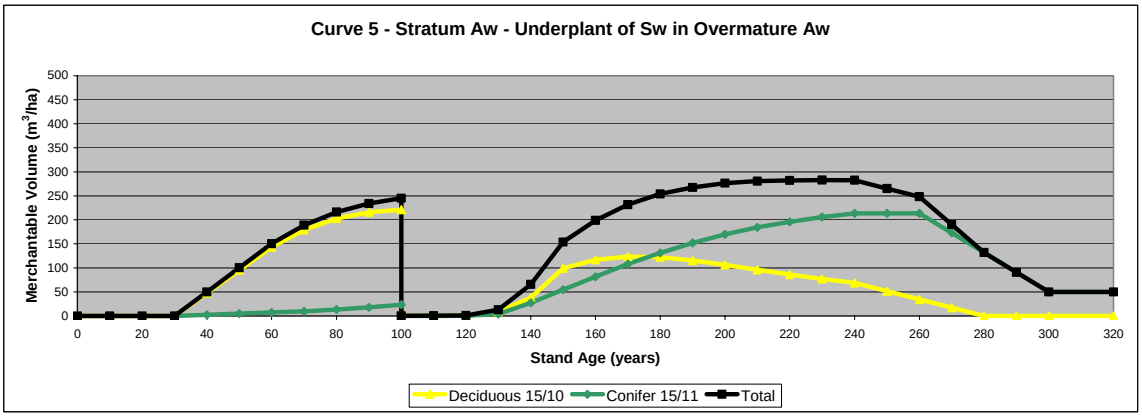
Merchantable volumes were assumed to occur sometime after 30 years of age. Straight-line interpolation was used to generate volumes between 30 years of age (0 m^3/ha) and the MGM starting age (60yrs).

In order to model stand breakup and decline, deciduous volumes were forced to 0 m^3/ha 180 years after aspen initiation. In this case, the stand age of 280 years represents 180 years after Aw initiation since harvest occurred at 100 years. Straight-line interpolation was used to decrease deciduous volumes over a 40 year period.

Coniferous volumes were capped at 213.7 m^3/ha so as to match the maximum conifer volume estimated for the natural SwAw curve (Curve 3). This volume was maintained until stand break up and decline. Conifer volumes were assumed to decline 180 years after spruce initiation. In this case, the stand age of 260 years represents 180 years after Sw initiation since planting occurred at 80 years. Straight-line interpolation was used to decrease coniferous volumes to 50 m^3/ha over a 40 year period.

All non MGM generated volumes are shown in blue type.

Figure 18 provides the SVS diagrams illustrating the development of the Aw stand over time.

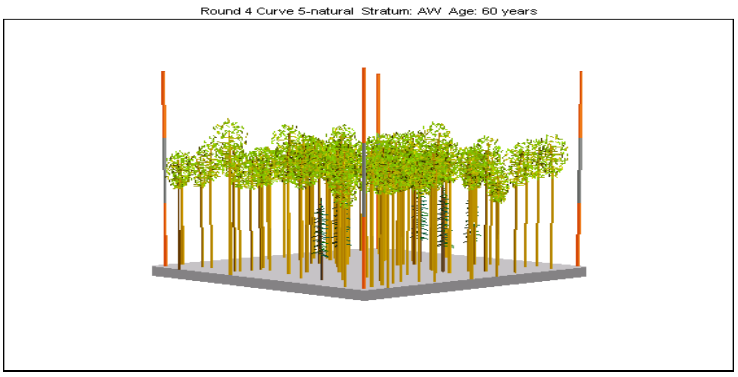


Stand Age	Merchantable Volume				
	Conifer 15/11	Deciduous 15/10	Total	% Conifer	% Deciduous
0	0.0	0.0	0.0	0	0
10	0.0	0.0	0.0	0	0
20	0.0	0.0	0.0	0	0
30	0.0	0.0	0.0	0	0
40	2.5	47.7	50.2	5	95
50	5.0	95.5	100.5	5	95
60	7.5	143.2	150.7	5	95
70	9.7	179.4	189.1	5	95
80	13.6	202.7	216.3	6	94
90	18.1	215.8	233.9	8	92
100	23.5	221.5	245.0	10	90
100	0.0	0.2	0.2	0	100
110	0.1	0.6	0.7	15	85
120	0.2	0.9	1.1	20	80
130	4.1	9.0	13.1	31	69
140	27.3	38.4	65.7	42	58
150	54.6	99.4	154.0	35	65
160	81.7	117.2	198.9	41	59
170	108.0	123.7	231.7	47	53
180	131.4	122.5	253.9	52	48
190	152.2	115.4	267.6	57	43
200	169.8	106.4	276.2	61	39
210	184.3	96.3	280.6	66	34
220	196.0	86.1	282.1	69	31
230	205.9	77.1	283.0	73	27
240	213.7	68.9	282.6	76	24
250	213.7	51.7	265.4	81	19
260	213.7	34.4	248.1	86	14
270	172.8	17.2	190.0	91	9
280	131.9	0.0	131.9	100	0
290	90.9	0.0	90.9	100	0
300	50.0	0.0	50.0	100	0
320	50.0	0.0	50.0	100	0

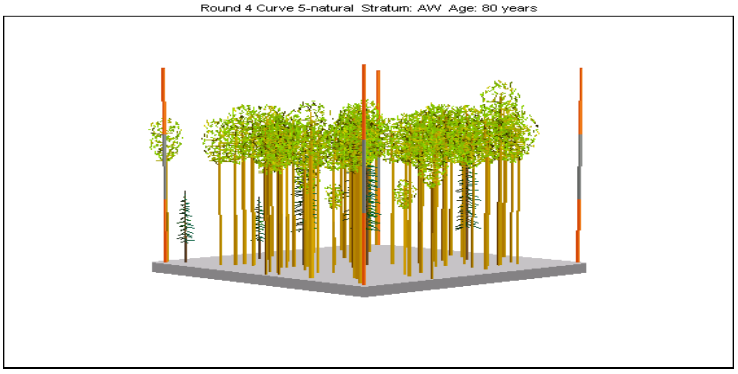
Stand Age	Breast Height Age		MGM Merchantable Utilization Stand Attributes					
	Planted Spruce	Aspen Suckers	Conifer Density	Decid Density	Conifer Ave Dbh	Decid Ave Dbh	Conifer Ave Ht	Decid Ave Ht
60			41	838	18.5	17.4	14.3	18.7
80	0		38	646	23.9	21.0	19.1	22.6
100	7	0	56	515	23.6	23.2	20.4	25.0
100	7	3		2		14.2		19.3
110	17	8	2	5	13.6	14.8	14.0	21.2
120	27	18	2	5	16.3	16.2	16.8	23.3
140	47	38	353	373	15.7	14.7	13.7	18.8
160	67	58	398	603	20.0	17.4	17.9	22.3
180	87	78	362	429	23.7	19.4	21.3	25.0
200	107	98	331	293	26.3	20.9	23.8	26.9
220	127	118	300	204	28.4	21.8	25.7	28.2
240	147	138	277	143	29.8	22.9	27.1	29.1

blue values - denote straight line interpolation.

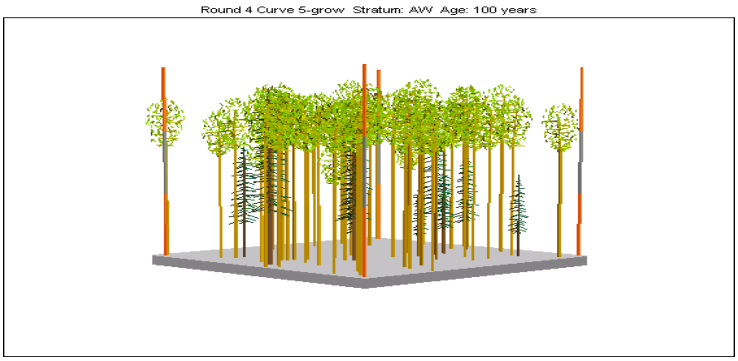
Figure 17. Stratum Aw – Underplant Sw in Overmature Aw – yield curve and stand attribute summaries.



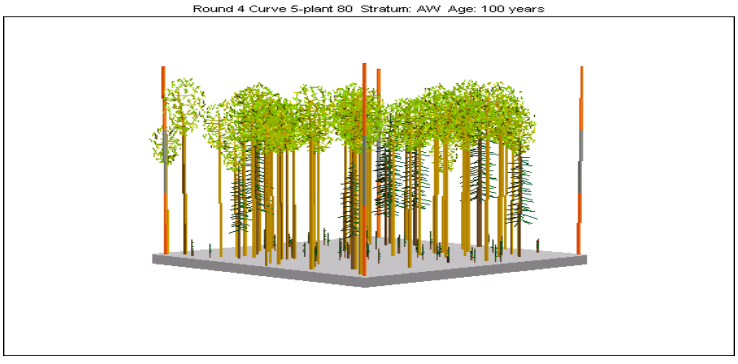
Stratum Aw (Curve 5)
Natural stand at age 60 years



Stratum Aw (Curve 5)
Natural stand at age 80 years

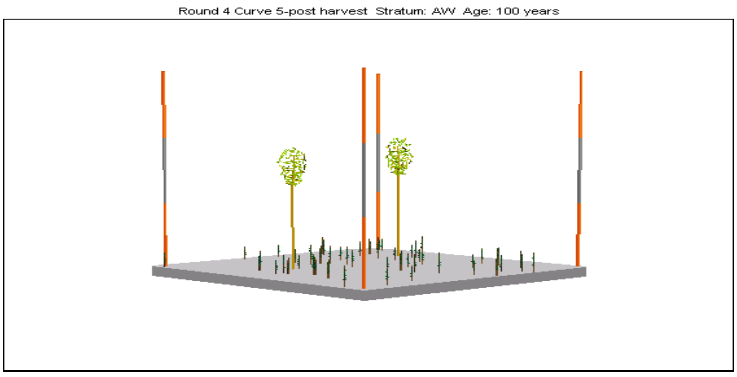


Stratum Aw (Curve 5)
Natural stand at age100 years

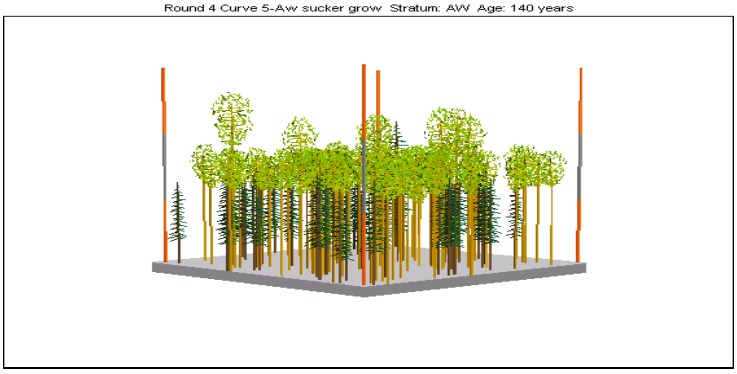


Stratum Aw (Curve 5)
Underplant Sw at 80 years and grown to age 100 years

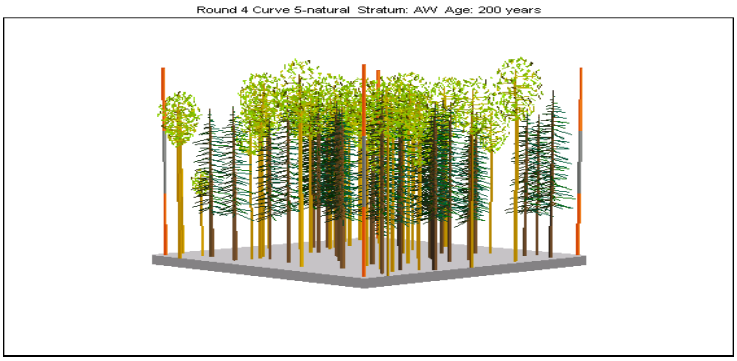
Figure 18. SVS diagrams for Underplanting Sw in Overmature Aw.



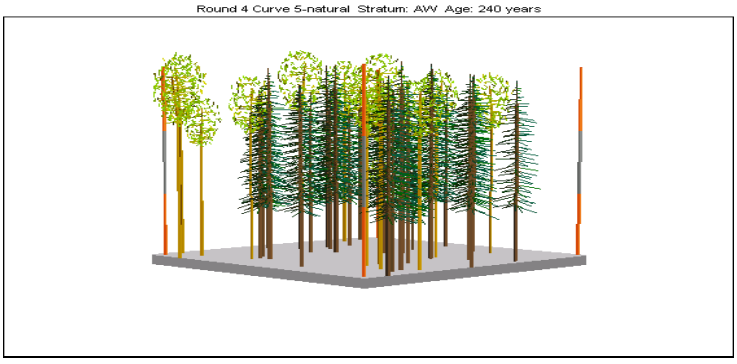
Stratum Aw (Curve 5)
Harvest of canopy at age 100 years



Stratum Aw (Curve 5)
Grown to age 140 years



Stratum Aw (Curve 5)
Grown to age 200 years



Stratum Aw (Curve 5)
Grown to age 240 years

Figure 18 continued. SVS diagrams for Underplant Sw in Overmature Aw.

8.1.3 Successful Underplant of Sw in Midrotation Aw

Figure 19 provides the resultant Aw yield curve when white spruce is successfully underplanted near midrotation. Tables showing merchantable 15/10 and 15/11 utilization stand attributes and volumes have been included.

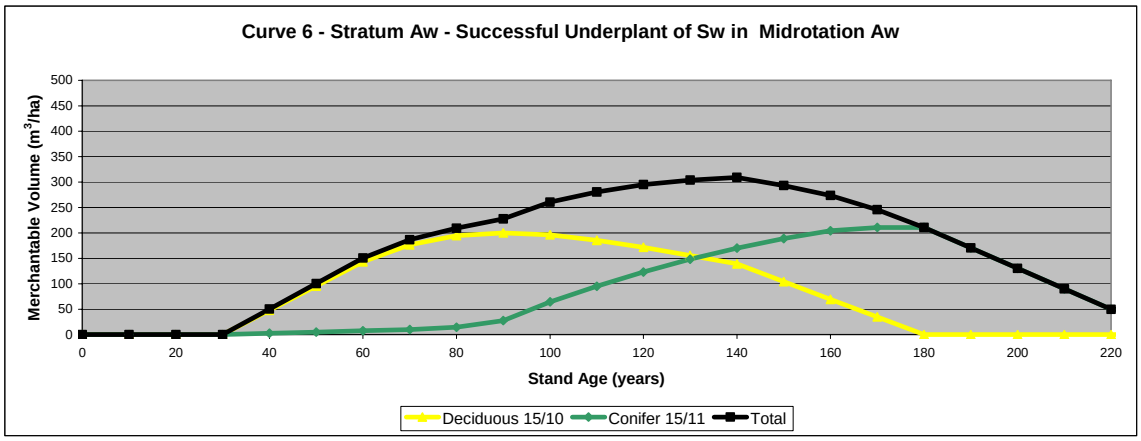
Merchantable volumes were assumed to occur sometime after 30 years of age. Straight-line interpolation was used to generate volumes between 30 years of age (0 m^3/ha) and the MGM starting age (60yrs).

In order to model stand breakup and decline, deciduous volumes were forced to 0 m^3/ha 180 years after aspen initiation. Straight-line interpolation was used to decrease deciduous volumes over a 40 year period.

Coniferous volumes were capped at 210.7 m^3/ha so as to match the maximum conifer volume estimated for the natural SwAw curve (Curve 3). This volume was maintained until stand break up and decline. Coniferous volumes were assumed to decline 180 years after spruce initiation. The stand age of 180 years was used to represent the years since Sw initiation, as it was believed that planting at midrotation would simulate a natural understory stand. Straight-line interpolation was used to decrease coniferous volumes to 50 m^3/ha over a 40 year period.

All non MGM generated volumes are shown in blue type.

Figure 20 provides the SVS diagrams illustrating the development of the Aw stand over time.

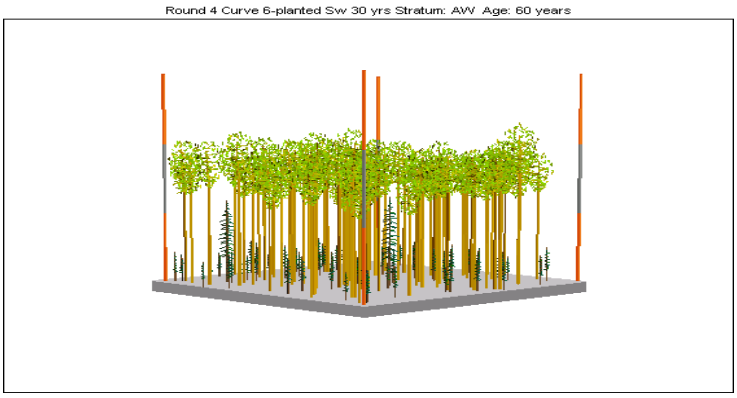


Stand Age	Merchantable Volume				
	Conifer 15/11	Deciduous 15/10	Total	% Conifer	% Deciduous
0	0.0	0.0	0.0	0	0
10	0.0	0.0	0.0	0	0
20	0.0	0.0	0.0	0	0
30	0.0	0.0	0.0	0	0
40	2.5	47.7	50.2	5	95
50	5.0	95.5	100.5	5	95
60	7.5	143.2	150.7	5	95
70	10.1	176.6	186.7	5	95
80	14.4	194.7	209.1	7	93
90	27.7	199.9	227.6	12	88
100	64.4	196.0	260.4	25	75
110	94.9	185.4	280.3	34	66
120	123.1	171.7	294.8	42	58
130	148.2	155.7	303.9	49	51
140	170.3	139.0	309.3	55	45
150	188.9	104.2	293.1	64	36
160	204.2	69.5	273.7	75	25
170	210.7	34.7	245.4	86	14
180	210.7	0.0	210.7	100	0
190	170.5	0.0	170.5	100	0
200	130.3	0.0	130.3	100	0
210	90.2	0.0	90.2	100	0
220	50.0	0.0	50.0	100	0
230	50.0	0.0	50.0	100	0
240	50.0	0.0	50.0	100	0
250	50.0	0.0	50.0	100	0

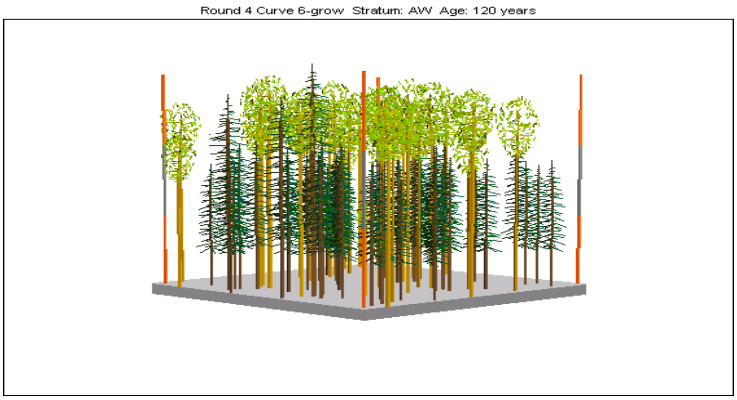
Stand Age	Breast Height Age		MGM Merchantable Utilization Stand Attributes					
	Planted Spruce	Aspen Suckers	Conifer Density	Decid Density	Conifer Ave Dbh	Decid Ave Dbh	Conifer Ave Ht	Decid Ave Ht
60	17		41	838	18.5	17.4	14.3	18.7
80	37		35	619	25.2	21.0	20.0	22.6
100	57		532	451	16.6	23.3	15.2	25.0
120	77		491	328	20.5	24.6	19.0	26.6
140	97		442	231	23.5	25.7	21.9	27.8
160	117		395		25.8		24.1	
180	137							
200	157							

blue values - denote straight line interpolation.

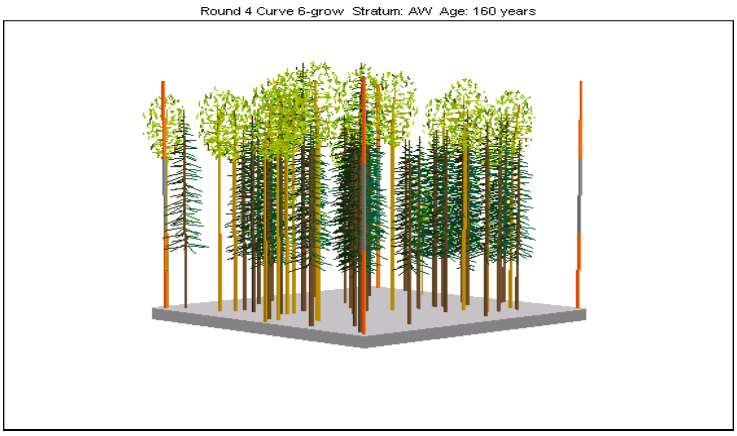
Figure 19. Stratum Aw – Successful Underplant of Sw in Midrotation Aw – yield curve and stand attribute summaries.



Stratum Aw (Curve 6)
Successful Underplant of Sw at age 30 years and grown to age 60 years



Stratum Aw (Curve 6)
Grown to age 120 years



Stratum Aw (Curve 6)
Grown to age 160 years

Figure 20. SVS diagrams for Successful Underplant of Sw in Midrotation Aw.

8.2 Stratum Aw/Sw Yield Curves

8.2.1 60 year Understory Protection Harvest of Aw/Sw

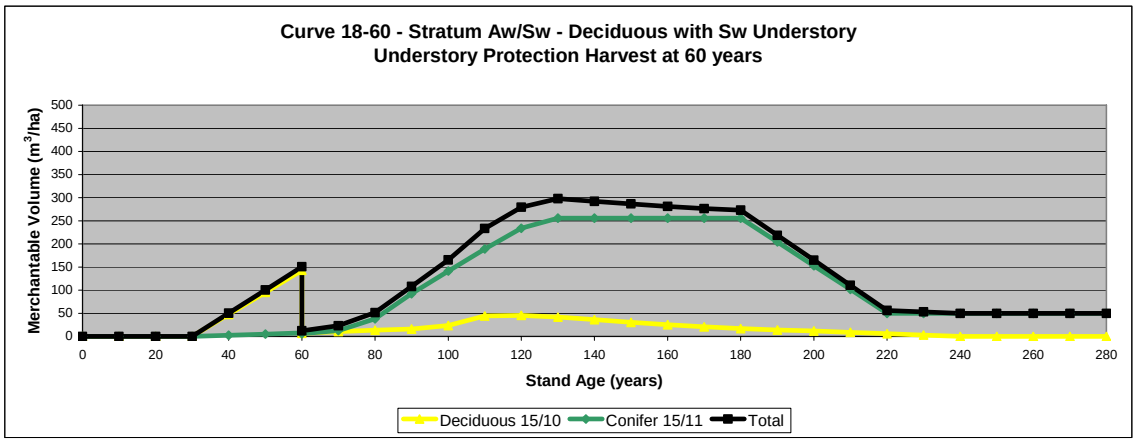
Figure 21 provides the resultant Aw/Sw yield curve when aspen is successfully harvested at age 60 years protecting the white spruce understory. Tables showing merchantable 15/10 and 15/11 utilization stand attributes and volumes have been included.

Merchantable volumes were assumed to occur sometime after 30 years of age. Straight-line interpolation was used to generate volumes between 30 years of age (0 m^3/ha) and the MGM starting age (60yrs).

In order to model stand breakup and decline, deciduous volumes were forced to 0 m^3/ha 180 years after aspen initiation. In this case, the stand age of 240 years represents 180 years after Aw initiation since harvest occurred at 60 years. Straight-line interpolation was used to decrease deciduous volumes over a 40 year period.

Coniferous volumes were capped at 255.9 m^3/ha so that maximum total volume was approximately the same as those in the natural SwAw stratum. This volume was maintained until stand break up and decline. Coniferous volumes were assumed to decline 180 years after spruce initiation. Straight-line interpolation was used to decrease coniferous volumes to 50 m^3/ha over a 40 year period.

All non MGM generated volumes are shown in blue type.



Stand Age	Merchantable Volume				
	Conifer 15/11	Deciduous 15/10	Total	% Conifer	% Deciduous
0	0.0	0.0	0.0	0	0
10	0.0	0.0	0.0	0	0
20	0.0	0.0	0.0	0	0
30	0.0	0.0	0.0	0	0
40	2.5	47.7	50.2	5	95
50	5.0	95.5	100.5	5	95
60	7.5	143.2	150.7	5	95
60	5.7	6.7	12.4	46	54
70	12.6	10.6	23.2	54	46
80	37.9	13.5	51.4	74	26
90	92.2	16.0	108.2	85	15
100	141.5	23.8	165.3	86	14
110	189.0	44.4	233.4	81	19
120	233.6	45.6	279.2	84	16
130	255.9	41.9	297.8	86	14
140	255.9	36.1	292.0	88	12
150	255.9	30.4	286.3	89	11
160	255.9	25.2	281.1	91	9
170	255.9	20.6	276.5	93	7
180	255.9	17.0	272.9	94	6
190	204.4	14.0	218.4	94	6
200	152.9	12.0	164.9	93	7
210	101.5	9.0	110.5	92	8
220	50.0	6.0	56.0	89	11
230	50.0	3.0	53.0	94	6
240	50.0	0.0	50.0	100	0
250	50.0	0.0	50.0	100	0
260	50.0	0.0	50.0	100	0
270	50.0	0.0	50.0	100	0
280	50.0	0.0	50.0	100	0

Stand Age	Breast Height Age		MGM Merchantable Utilization Stand Attributes					
	Planted Spruce	Aspen Suckers	Conifer Density	Decid Density	Conifer Ave Dbh	Decid Ave Dbh	Conifer Ave Ht	Decid Ave Ht
60			41	838	18.5	17.4	14.3	18.7
60	27		31	84	18.6	14.2	14.4	16.8
70	37	8	197	80	15.0	16.1	11.6	18.9
80	47	18	420	77	16.2	17.3	13.3	20.6
100	67	38	762	171	19.5	15.7	16.7	19.3
120	87	58	688	235	23.4	17.4	20.1	21.8
140	107	78		126		19.6		24.5
160	127	98		73		20.7		26.0
180	147	118		45		21.1		26.6
200				31		21.1		26.3

blue values - denote straight line interpolation.

Figure 21. Stratum Aw/Sw – Understory Protection Harvest of Aw/Sw at age 60 years – yield curve and stand attribute summaries.

8.2.2 80 year Understory Protection Harvest of Aw/Sw

Figure 22 provides the resultant Aw/Sw yield curve when aspen is successfully harvested at age 80 years protecting the white spruce understory. Tables showing merchantable 15/10 and 15/11 utilization stand attributes and volumes have been included.

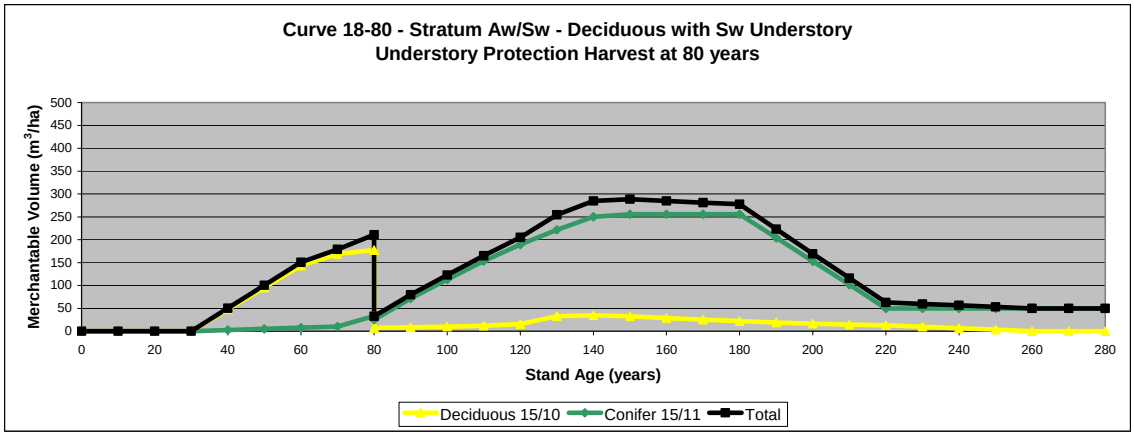
Merchantable volumes were assumed to occur sometime after 30 years of age. Straight-line interpolation was used to generate volumes between 30 years of age (0 m^3/ha) and the MGM starting age (60yrs).

In order to model stand breakup and decline, deciduous volumes were forced to 0 m^3/ha 180 years after aspen initiation. In this case, the stand age of 260 years represents 180 years after Aw initiation since harvest occurred at 80 years. Straight-line interpolation was used to decrease deciduous volumes over a 40 year period.

Coniferous volumes were capped at 255.9 m^3/ha to be consistent with the understory protection harvest at 60 years, and so that the maximum total volumes were approximately the same as those in the natural SwAw stratum. This volume was maintained until stand break up and decline. Coniferous volumes were assumed to decline 180 years after spruce initiation. Straight-line interpolation was used to decrease coniferous volumes to 50 m^3/ha over a 40 year period.

All non MGM generated volumes are shown in blue type.

Figure 23 provides the SVS diagrams illustrating the development of the Aw/Sw stand over time.

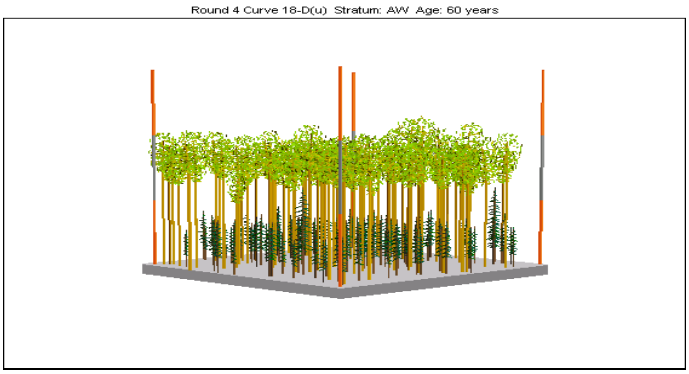


Stand Age	Merchantable Volume				
	Conifer 15/11	Deciduous 15/10	Total	% Conifer	% Deciduous
0	0.0	0.0	0.0	0	0
10	0.0	0.0	0.0	0	0
20	0.0	0.0	0.0	0	0
30	0.0	0.0	0.0	0	0
40	2.5	47.7	50.2	5	95
50	5.0	95.5	100.5	5	95
60	7.5	143.2	150.7	5	95
70	10.2	168.9	179.1	6	94
80	33.5	177.4	210.9	16	84
80	25.1	7.2	32.3	78	22
90	71.4	8.5	79.9	89	11
100	113.2	9.5	122.7	92	8
110	153.2	12.0	165.2	93	7
120	189.4	15.7	205.1	92	8
130	221.7	32.9	254.6	87	13
140	250.3	34.4	284.7	88	12
150	255.9	32.5	288.4	89	11
160	255.9	28.8	284.7	90	10
170	255.9	25.2	281.1	91	9
180	255.9	21.8	277.7	92	8
190	204.4	18.9	223.3	92	8
200	152.9	16.5	169.4	90	10
210	101.5	14.5	116.0	88	13
220	50.0	12.9	62.9	79	21
230	50.0	9.7	59.7	84	16
240	50.0	6.5	56.5	89	11
250	50.0	3.2	53.2	94	6
260	50.0	0.0	50.0	100	0
270	50.0	0.0	50.0	100	0
280	50.0	0.0	50.0	100	0

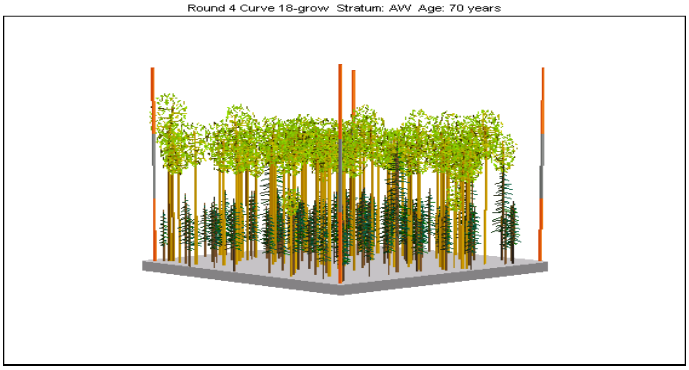
Stand Age	Breast Height Age		MGM Merchantable Utilization Stand Attributes					
	Planted Spruce	Aspen Suckers	Conifer Density	Decid Density	Conifer Ave Dbh	Decid Ave Dbh	Conifer Ave Ht	Decid Ave Ht
60	27		41	838	18.5	17.4	14.3	18.7
80	47		334	560	16.1	21.1	14.2	22.6
80	47		251	42	16.1	17.2	14.2	20.5
90	57	8	739	44	16.0	17.6	14.6	21.4
100	67	18	709	46	18.3	17.8	16.7	22.1
120	87	38	647	101	21.8	16.1	20.0	20.1
140	107	58	582	183	24.6	17.2	22.7	21.7

blue values - denote straight line interpolation.

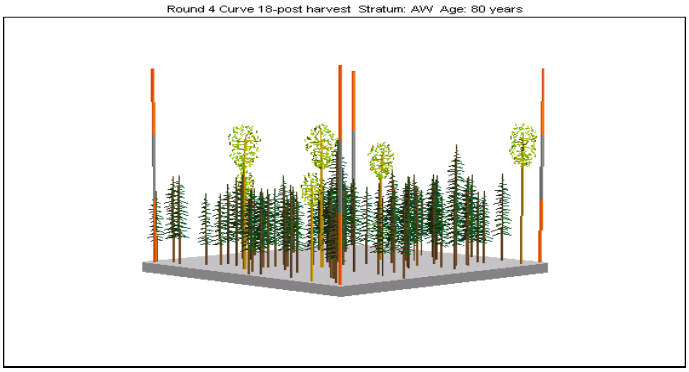
Figure 22. Stratum Aw/Sw – Understory Protection Harvest of Aw/Sw at age 80 years – yield curve and stand attribute summaries.



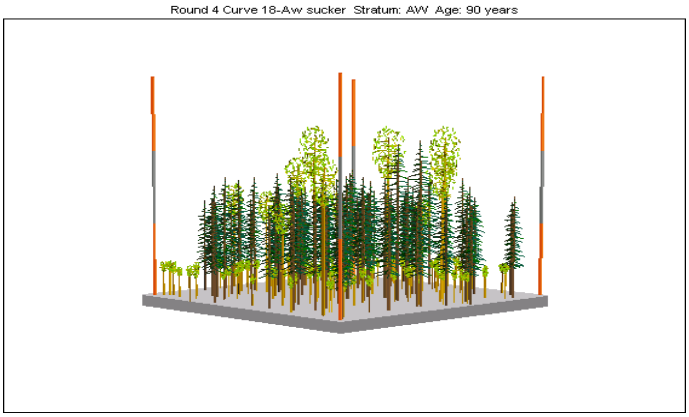
Stratum Aw/Sw (Curve 18)
Aspen stand with white spruce understory at age 60 years



Stratum Aw/Sw (Curve 18)
Aspen stand with white spruce understory at age 70 years

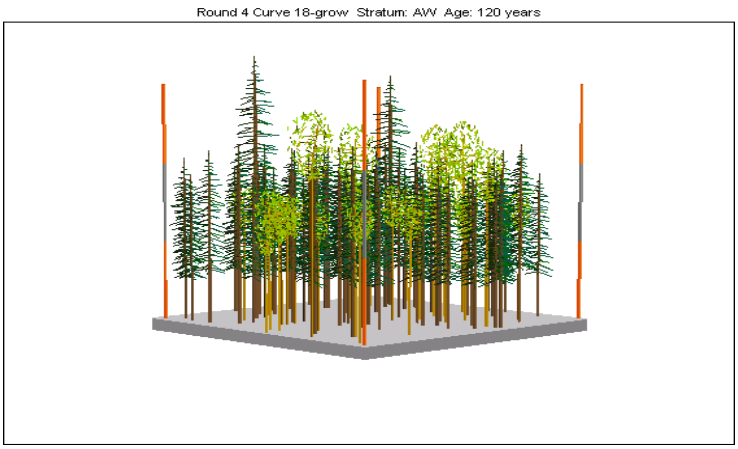


Stratum Aw/Sw (Curve 18)
Understory protection harvest of aspen canopy at age 80 years

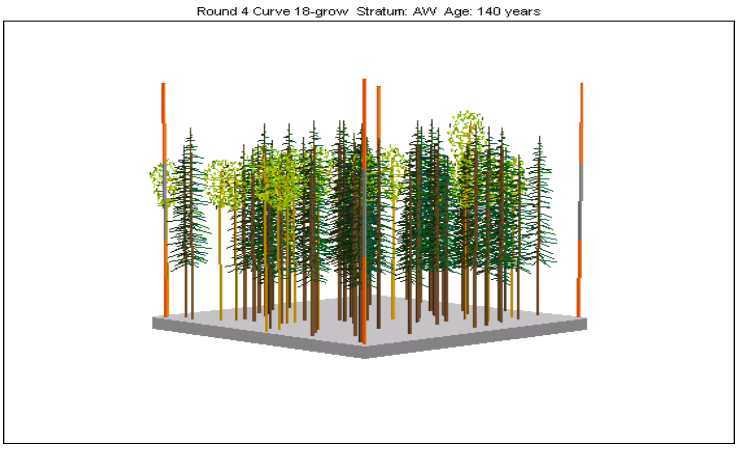


Stratum Aw/Sw (Curve 18)
Aspen suckering and white spruce response at age 90 years

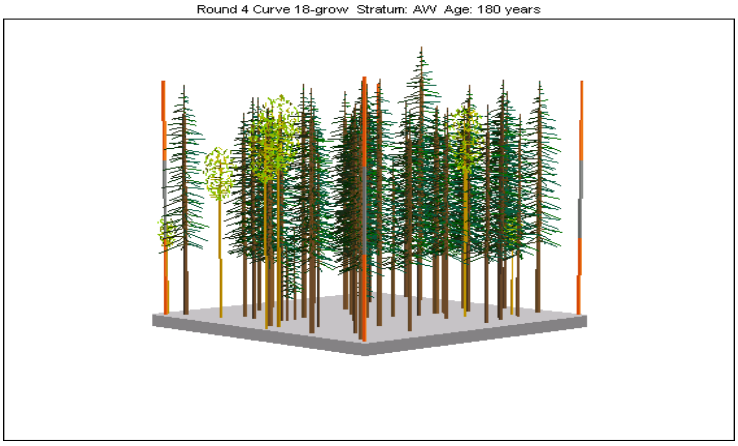
Figure 23. SVS diagrams for 80 year Protection Harvest of Aw/Sw.



Stratum Aw/Sw (Curve 18)
Grown to age 120 years



Stratum Aw/Sw (Curve 18)
Grown to age 140 years



Stratum Aw/Sw (Curve 18)
Grown to age 180 years

Figure 23 continued. SVS diagrams for 80 year Protection Harvest of Aw/Sw.

8.3 Stratum AwSw Yield Curves

8.3.1 Natural Stand AwSw

Figure 24 provides the resultant natural AwSw yield curve, with tables showing merchantable 15/10 and 15/11 utilization stand attributes and volumes.

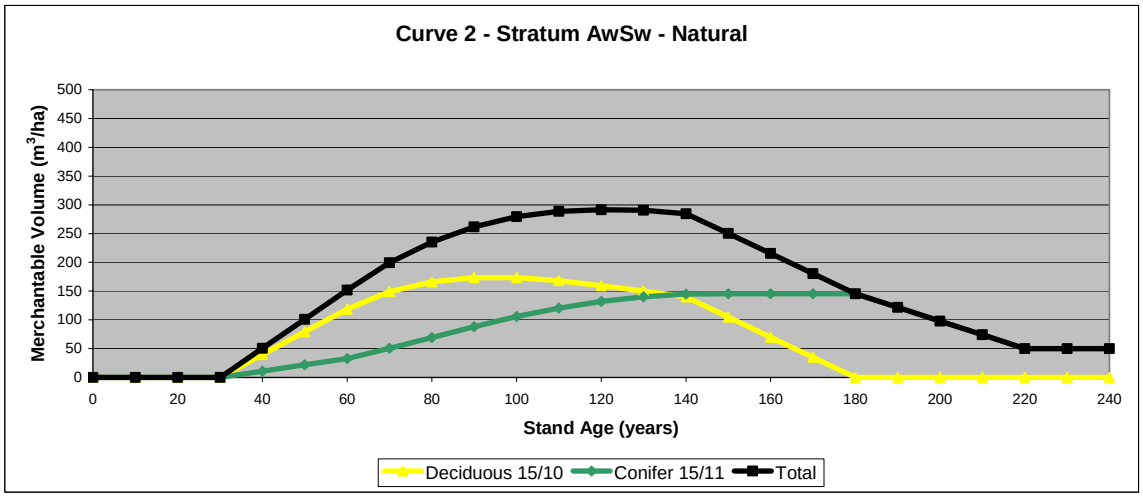
Merchantable volumes were assumed to occur sometime after 30 years of age. Straight-line interpolation was used to generate volumes between 30 years of age (0 m^3/ha) and the MGM starting age (60 yrs).

In order to model stand breakup and decline, deciduous volumes were forced to 0 m^3/ha 180 years after aspen initiation. Straight-line interpolation was used to decrease deciduous volumes over a 40 year period.

Coniferous volumes maximized at 145.6 m^3/ha. This volume was maintained until stand break up and decline. Coniferous volumes were assumed to decline 180 years after spruce initiation. Straight-line interpolation was used to decrease coniferous volumes to 50 m^3/ha over a 40 year period.

All non MGM generated volumes are shown in blue type.

Figure 25 provides the SVS diagrams illustrating the development of the AwSw natural stand over time.

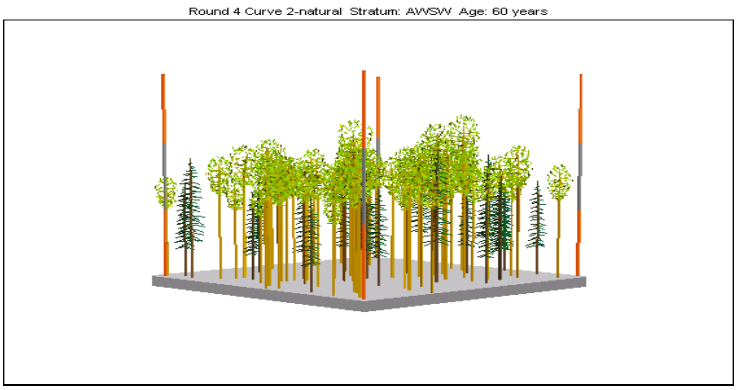


Stand Age	Merchantable Volume				
	Conifer 15/11	Deciduous 15/10	Total	% Conifer	% Deciduous
0	0.0	0.0	0.0	0	0
10	0.0	0.0	0.0	0	0
20	0.0	0.0	0.0	0	0
30	0.0	0.0	0.0	0	0
40	10.9	39.6	50.5	22	78
50	21.8	79.1	100.9	22	78
60	32.8	118.7	151.5	22	78
70	50.4	148.9	199.3	25	75
80	69.3	166.1	235.4	29	71
90	88.2	173.4	261.6	34	66
100	105.8	173.6	279.4	38	62
110	120.6	168.1	288.7	42	58
120	132.2	159.4	291.6	45	55
130	140.3	150.3	290.6	48	52
140	144.8	139.7	284.5	51	49
150	145.4	104.8	250.2	58	42
160	145.6	69.8	215.4	68	32
170	145.6	34.9	180.5	81	19
180	145.6	0.0	145.6	100	0
190	121.7	0.0	121.7	100	0
200	97.8	0.0	97.8	100	0
210	74.1	0.0	74.1	100	0
220	50.0	0.0	50.0	100	0
230	50.0	0.0	50.0	100	0
240	50.0	0.0	50.0	100	0

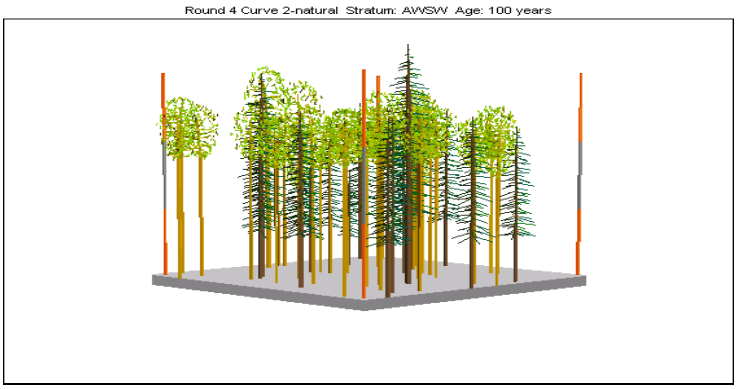
Stand Age	MGM Merchantable Utilization Stand Attributes					
	Conifer Density	Decid Density	Conifer Ave Dbh	Decid Ave Dbh	Conifer Ave Ht	Decid Ave Ht
60	188	657	18.4	17.8	15.0	17.8
80	167	476	24.6	22.0	20.3	22.0
100	160	356	28.5	24.5	23.9	24.6
120	147	261	31.4	26.5	26.6	26.5
140	132	204	33.4	27.4	28.7	27.5
160	125		33.3		29.1	

blue values - denote straight line interpolation.

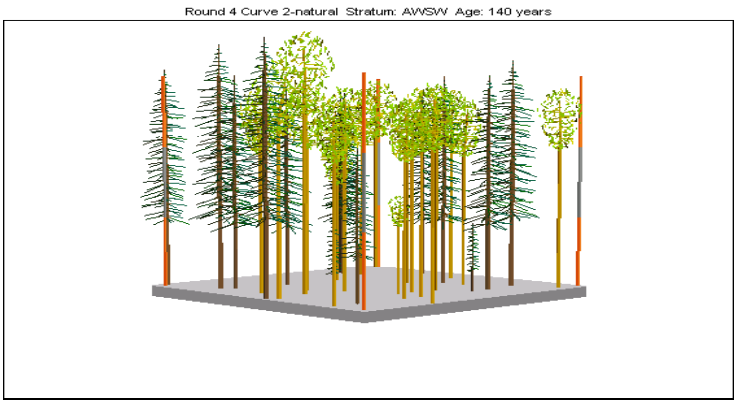
Figure 24. Stratum AwSw – Natural Stand – yield curve and stand attribute summaries.



Stratum AwSw (Curve 2) Natural Stand at 60 years



Stratum AwSw (Curve 2) Natural Stand at 100 years



Stratum AwSw (Curve 2) Natural Stand at 140 years

Figure 25. SVS diagrams for Natural Stand AwSw.

8.3.2 Shelterwood Planting in AwSw

Figure 26 provides the resultant AwSw yield curve when planted white spruce is grown under a shelterwood harvest system. Tables showing merchantable 15/10 and 15/11 utilization stand attributes and volumes have been included.

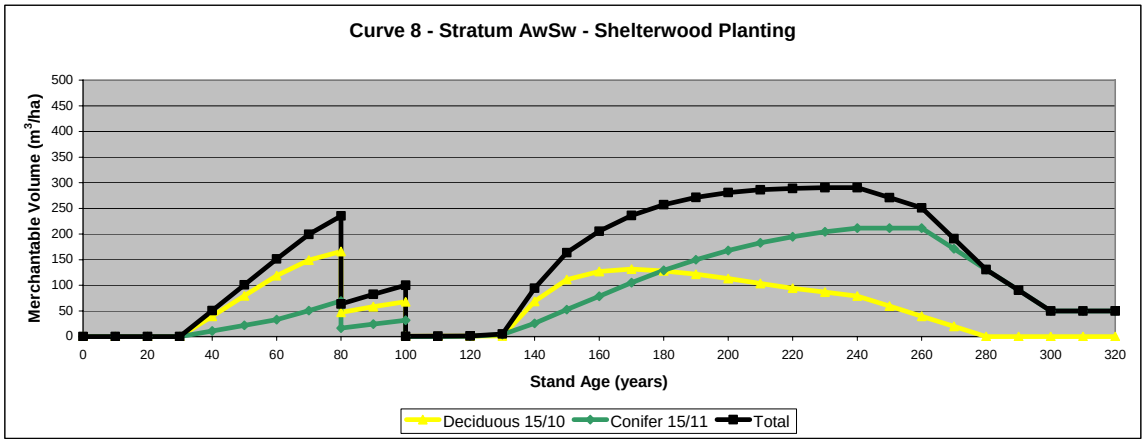
Merchantable volumes were assumed to occur sometime after 30 years of age. Straight-line interpolation was used to generate volumes between 30 years of age (0 m^3/ha) and the MGM starting age (60yrs).

In order to model stand breakup and decline, deciduous volumes were forced to 0 m^3/ha 180 years after aspen initiation. In this case, the stand age of 280 years represents 180 years after Aw initiation since final harvest occurred at 100 years. Straight-line interpolation was used to decrease deciduous volumes over a 40 year period.

Coniferous volumes were capped at 211.5 m^3/ha so as to match the maximum conifer volume estimated for the natural SwAw curve (Curve 3). This volume was maintained until stand break up and decline. Conifer volumes were assumed to decline 180 years after spruce initiation. In this case, the stand age of 260 years represents 180 years after Sw initiation since planting occurred at 80 years. Straight-line interpolation was used to decrease coniferous volumes to 50 m^3/ha over a 40 year period.

All non MGM generated volumes are shown in blue type.

Figure 27 provides the SVS diagrams illustrating the development of the AwSw stand over time.

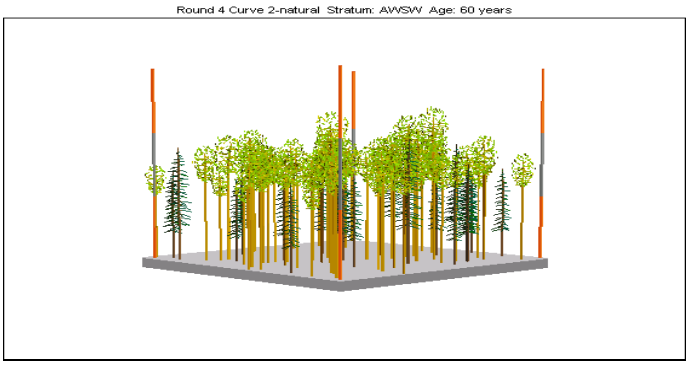


Stand Age	Merchantable Volume				
	Conifer 15/11	Deciduous 15/10	Total	% Conifer	% Deciduous
0	0.0	0.0	0.0	0	0
10	0.0	0.0	0.0	0	0
20	0.0	0.0	0.0	0	0
30	0.0	0.0	0.0	0	0
40	10.9	39.6	50.5	22	78
50	21.8	79.1	100.9	22	78
60	32.8	118.7	151.5	22	78
70	50.4	148.9	199.3	25	75
80	69.3	166.1	235.4	29	71
80	16.4	47.2	63.6	26	74
90	24.0	58.4	82.4	29	71
100	31.9	68.0	99.9	32	68
100	0.0	0.4	0.4	0	100
110	0.0	0.7	0.7	0	100
120	0.3	1.0	1.3	25	75
130	3.8	1.1	4.9	77	23
140	25.7	68.7	94.4	27	73
150	52.4	111.1	163.5	32	68
160	78.7	126.7	205.4	38	62
170	104.9	131.3	236.2	44	56
180	129.0	127.9	256.9	50	50
190	150.0	121.3	271.3	55	45
200	167.9	112.9	280.8	60	40
210	182.7	103.6	286.3	64	36
220	194.6	94.3	288.9	67.4	32.6
230	204.1	86.4	290.5	70.3	29.7
240	211.5	79.0	290.5	72.8	27.2
250	211.5	59.3	270.8	78.1	21.9
260	211.5	39.5	251.0	84.3	15.7
270	171.1	19.8	190.9	89.7	10.3
280	130.8	0.0	130.8	100.0	0.0
290	90.4	0.0	90.4	100.0	0.0
300	50.0	0.0	50.0	100.0	0.0
310	50.0	0.0	50.0	100.0	0.0
320	50.0	0.0	50.0	100.0	0.0

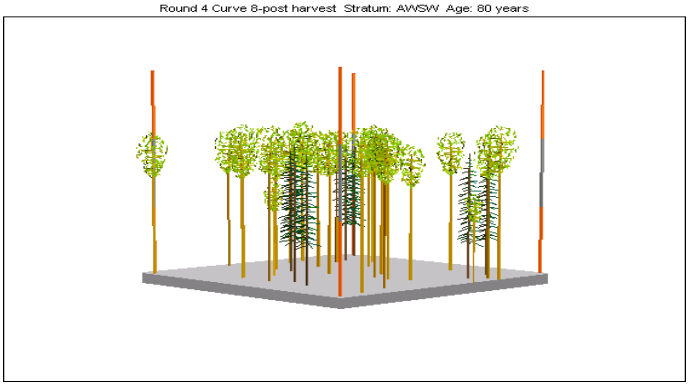
Stand Age	Breast Height Age		MGM Merchantable Utilization Stand Attributes					
	Planted Spruce	Aspen Suckers	Conifer Density	Decid Density	Conifer Ave Dbh	Decid Ave Dbh	Conifer Ave Ht	Decid Ave Ht
60			188	657	18.4	17.8	15.0	17.8
80			167	476	24.6	22.0	20.3	22.0
80			76	228	20.4	18.4	18.2	20.9
85		3	79	224	21.4	19.1	19.2	21.8
100		18	84	227	23.7	20.4	21.6	23.5
100	7	18		5		13.8		18.7
120	27	38	3	5	15.4	17.3	15.9	23.4
140	47	58	350	660	15.5	14.5	13.7	20.2
160	67	78	396	621	19.7	17.3	17.9	23.7
180	87	98	380	418	23.0	19.7	21.1	26.2
200	107	118	342	286	25.8	21.4	23.7	27.8
220	127	138	310	200	27.9	22.8	25.7	28.8
240	147	158	282	142	29.4	24.3	27.2	29.6

blue values - denote straight line interpolation.

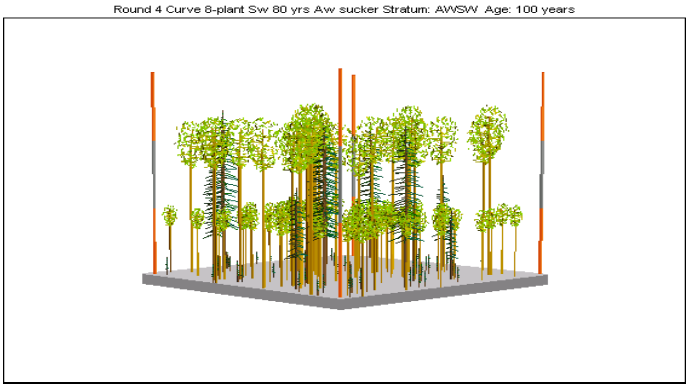
Figure 26. Stratum AwSw – Shelterwood Planting – yield curve and stand attribute summaries.



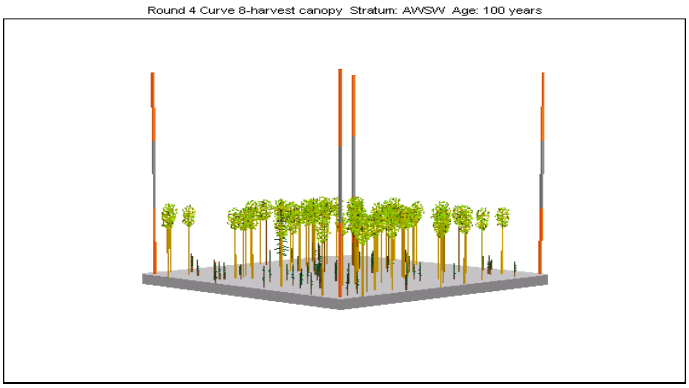
Stratum AwSw (Curve 8) Natural Stand at 60 years



Stratum AwSw (Curve 8) Harvest 50% of the density at age 80 years

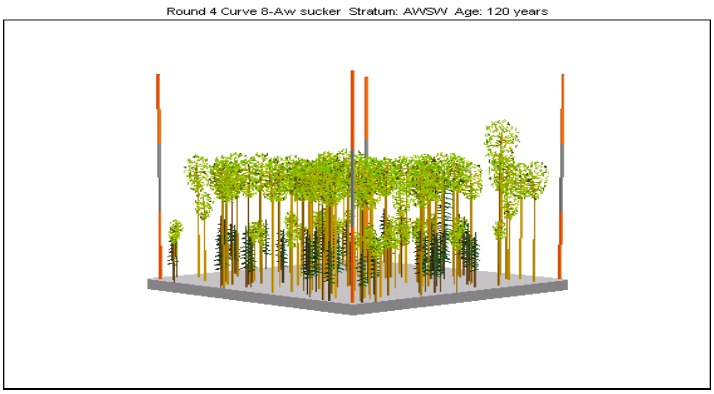


Stratum AwSw (Curve 8) Plant Sw at age 80 years following harvest and grown to age 100 years

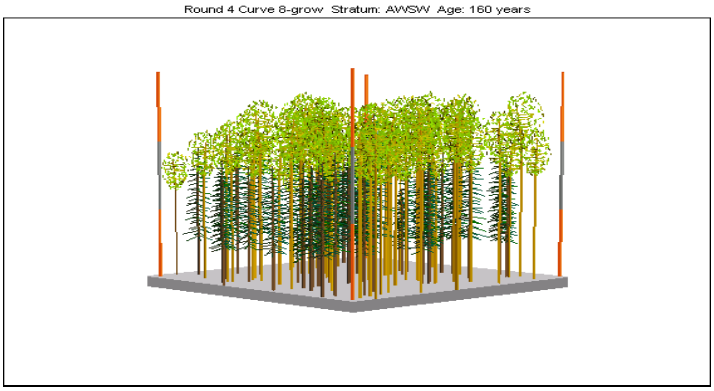


Stratum AwSw (Curve 8) Harvest remaining canopy at age 100 years

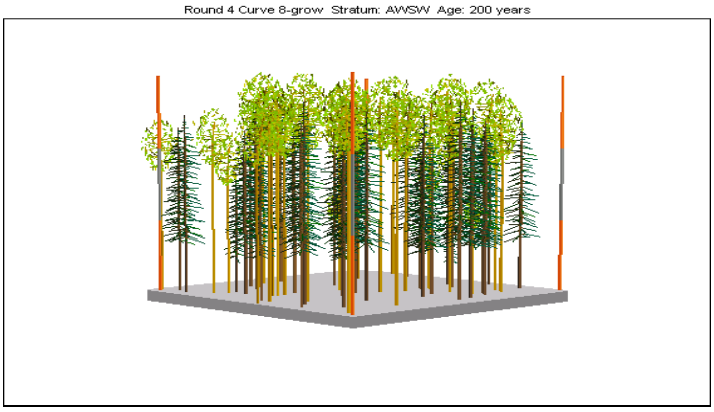
Figure 27. SVS diagrams for Shelterwood Planting of AwSw.



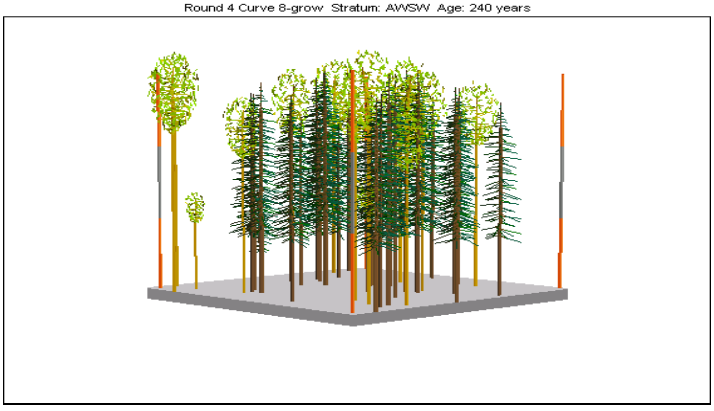
Stratum AwSw (Curve 8) Grown to age 100 years



Stratum AwSw (Curve 8) Grown to age 160 years



Stratum AwSw (Curve 8) Grown to age 200 years



Stratum AwSw (Curve 8) Grown to age 240 years

Figure 27 continued. SVS diagrams for Shelterwood Planting of AwSw.

8.3.3 Underplant of Sw in Overmature AwSw

Figure 28 provides the resultant AwSw yield curve when white spruce is underplanted in an overmature AwSw stand. Tables showing merchantable 15/10 and 15/11 utilization stand attributes and volumes have been included.

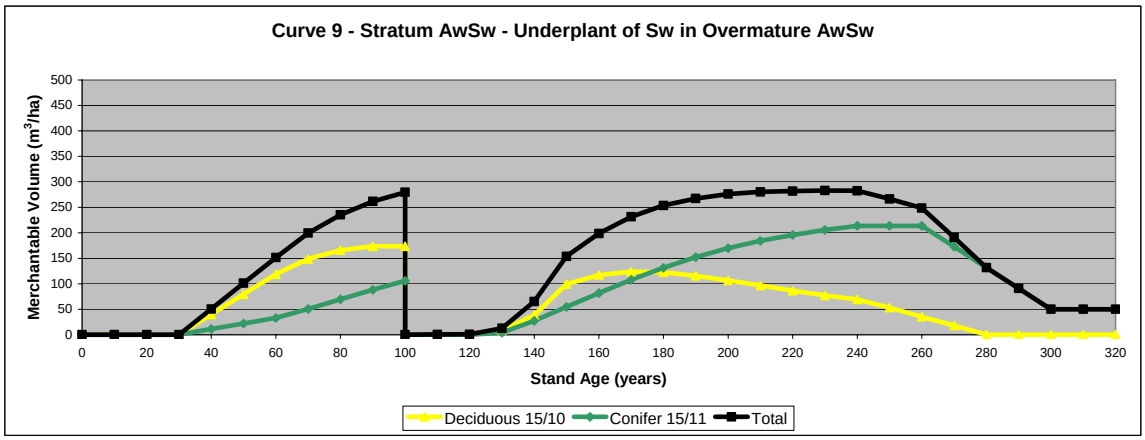
Merchantable volumes were assumed to occur sometime after 30 years of age. Straight-line interpolation was used to generate volumes between 30 years of age (0 m^3/ha) and the MGM starting age (60yrs).

In order to model stand breakup and decline, deciduous volumes were forced to 0 m^3/ha 180 years after aspen initiation. In this case, the stand age of 280 years represents 180 years after Aw initiation since final harvest occurred at 100 years. Straight-line interpolation was used to decrease deciduous volumes over a 40 year period.

Coniferous volumes were capped at 213.5 m^3/ha so as to match the maximum conifer volume estimated for the natural SwAw curve (Curve 3). This volume was maintained until stand break up and decline. Conifer volumes were assumed to decline 180 years after spruce initiation. In this case, the stand age of 260 years represents 180 years after Sw initiation since planting occurred at 80 years. Straight-line interpolation was used to decrease coniferous volumes to 50 m^3/ha over a 40 year period.

All non MGM generated volumes are shown in blue type.

Figure 29 provides the SVS diagrams illustrating the development of the AwSw stand over time.

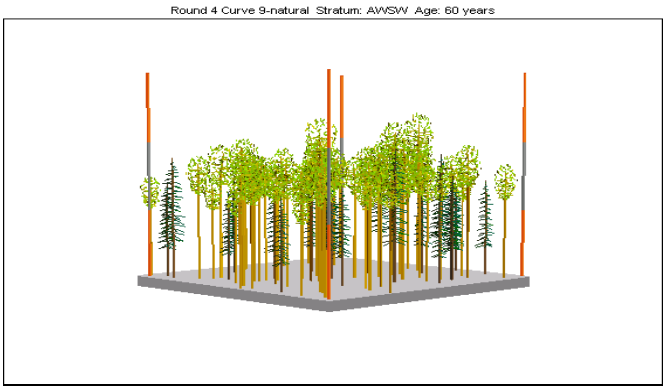


Stand Age	Merchantable Volume				
	Conifer 15/11	Deciduous 15/10	Total	% Conifer	% Deciduous
0	0.0	0.0	0.0	0	0
10	0.0	0.0	0.0	0	0
20	0.0	0.0	0.0	0	0
30	0.0	0.0	0.0	0	0
40	10.9	39.6	50.5	22	78
50	21.8	79.1	100.9	22	78
60	32.8	118.7	151.5	22	78
70	50.4	148.9	199.3	25	75
80	69.3	166.1	235.4	29	71
90	88.2	173.4	261.6	34	66
100	105.8	173.6	279.4	38	62
100	0.0	0.1	0.1	0	100
110	0.0	0.4	0.4	0	100
120	0.1	0.6	0.7	14	86
130	3.9	8.6	12.5	31	69
140	27.2	38.0	65.2	42	58
150	54.5	99.1	153.6	35	65
160	81.6	117.0	198.6	41	59
170	107.8	123.7	231.5	47	53
180	131.3	122.5	253.8	52	48
190	152.0	115.4	267.4	57	43
200	169.6	106.4	276.0	61	39
210	184.1	96.4	280.5	66	34
220	195.8	86.2	282.0	69	31
230	205.7	77.2	282.9	73	27
240	213.5	69.0	282.5	76	24
250	213.5	53.0	266.5	80	20
260	213.5	35.0	248.5	86	14
270	172.6	18.0	190.6	91	9
280	131.7	0.0	131.7	100	0
290	90.9	0.0	90.9	100	0
300	50.0	0.0	50.0	100	0
310	50.0	0.0	50.0	100	0
320	50.0	0.0	50.0	100	0

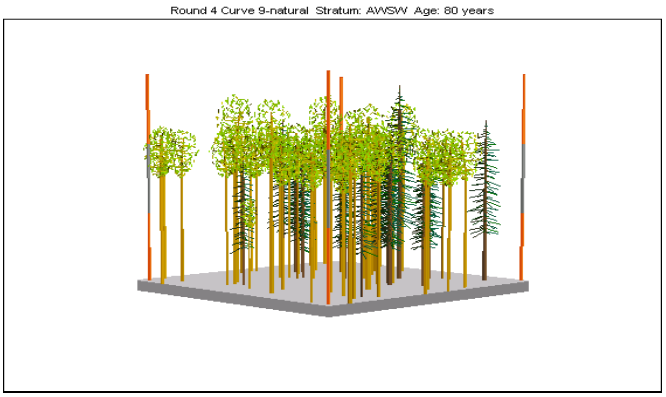
Stand Age	Breast Height Age		MGM Merchantable Utilization Stand Attributes					
	Planted Spruce	Aspen Suckers	Conifer Density	Decid Density	Conifer Ave Dbh	Decid Ave Dbh	Conifer Ave Ht	Decid Ave Ht
60			188	657	18.4	17.8	15.0	17.8
80			167	476	24.6	22.0	20.3	22.0
100			160	356	28.5	24.5	23.9	24.6
100	7			1		14.2		19.3
110	17	8	1	4	13.6	14.6	14.0	21.2
120	27	18	1	4	16.3	16.0	16.8	23.3
140	47	38	352	373	15.7	14.6	13.7	18.8
160	67	58	398	603	20.0	17.4	17.9	22.3
180	87	78	361	430	23.7	19.4	21.3	25.0
200	107	98	330	293	26.3	20.9	23.8	26.9
220	127	118	300	205	28.4	21.8	25.7	28.2
240	147	138	276	143	29.8	22.9	27.1	29.1

blue values - denote straight line interpolation.

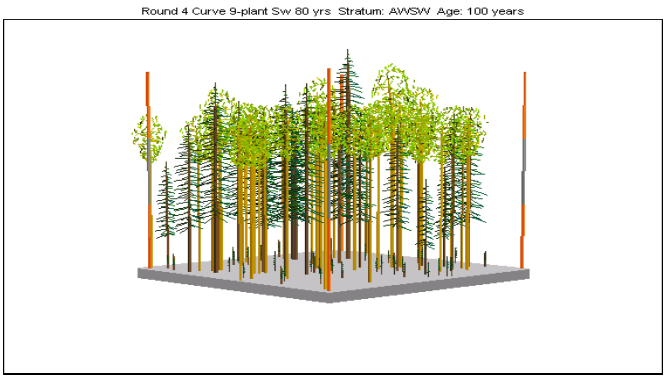
Figure 28. Stratum AwSw – Underplant Sw in Overmature AwSw – yield curve and stand attribute summaries.



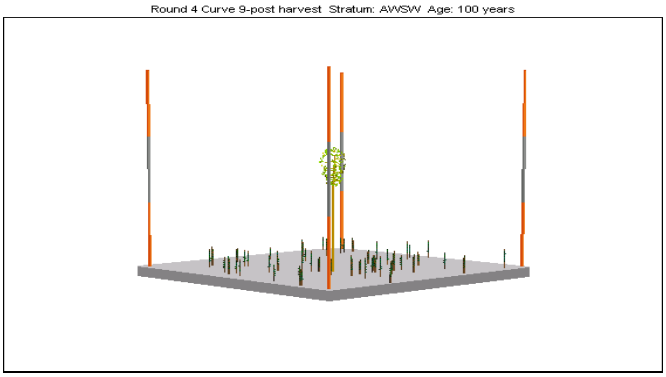
Stratum AwSw (Curve 9) Natural Stand at 60 years



Stratum AwSw (Curve 9) Natural Stand at 80 years

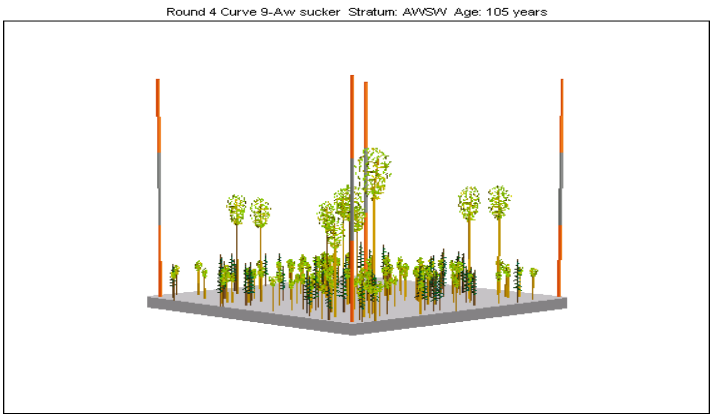


Stratum AwSw (Curve 9) Underplant Sw at 80 years and grown to age 100 years

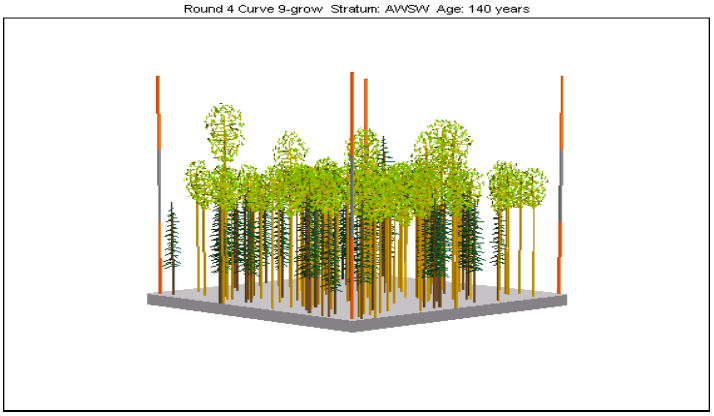


Stratum AwSw (Curve 9) Harvest of canopy at age 100 years

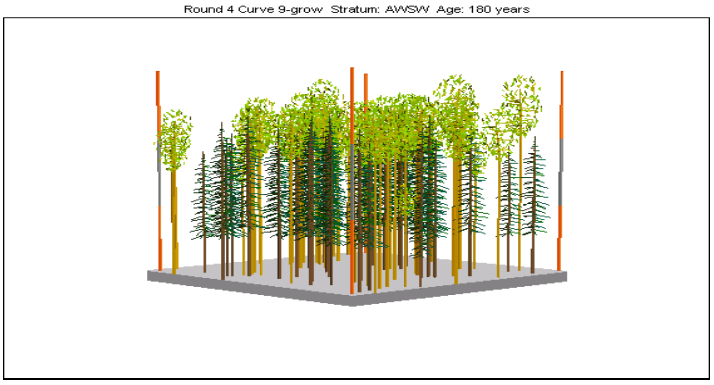
Figure 29. SVS diagrams for Underplant of Sw in Overmature of AwSw.



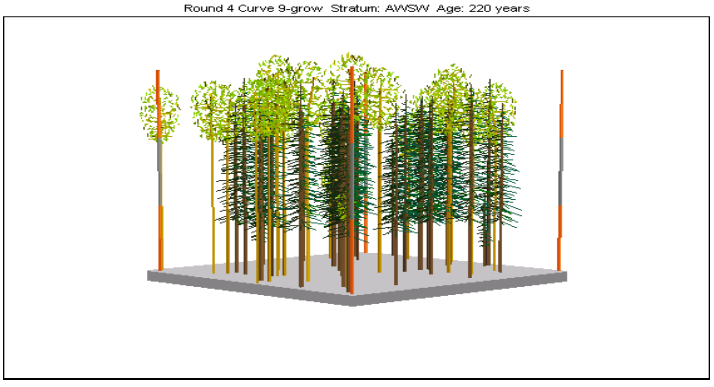
Stratum AwSw (Curve 9) Aw suckers after harvest at age 105 years



Stratum AwSw (Curve 9) Grown to age 140 years



Stratum AwSw (Curve 9) Grown to age 180 years



Stratum AwSw (Curve 9) Grown to age 220 years

Figure 29 continued. SVS diagrams for Underplant of Sw in Overmature of AwSw.

8.4 Stratum SwAw Yield Curves

8.4.1 Natural Stand SwAw

Figure 30 provides the resultant natural SwAw yield curve, with tables showing merchantable 15/10 and 15/11 utilization stand attributes and volumes.

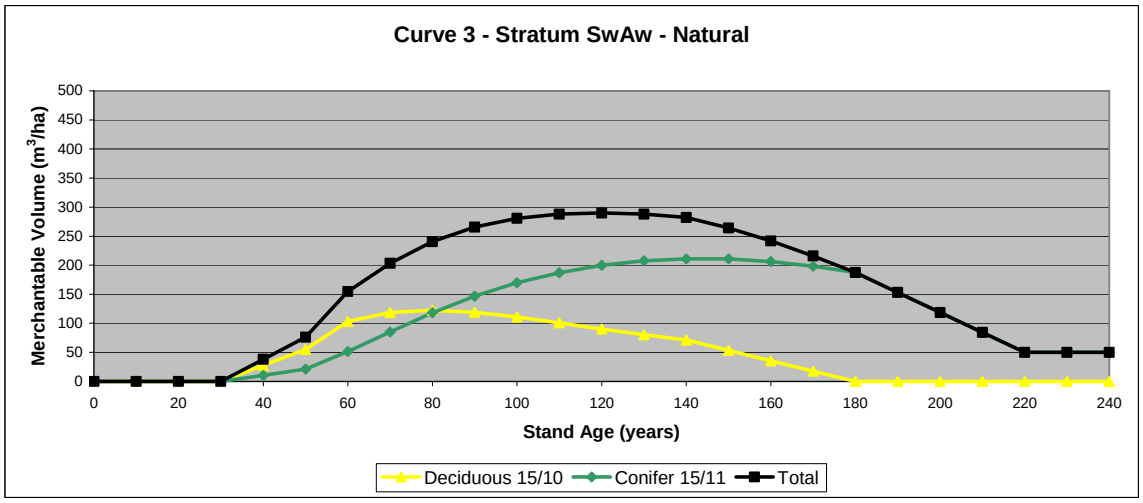
Merchantable volumes were assumed to occur sometime after 30 years of age. Straight-line interpolation was used to generate volumes between 30 years of age (0 m^3/ha) and the MGM starting age (50 yrs).

In order to model stand breakup and decline, deciduous volumes were forced to 0 m^3/ha 180 years after aspen initiation. Straight-line interpolation was used to decrease deciduous volumes over a 40 year period.

Coniferous volumes were assumed to decrease 180 years after spruce initiation. Straight-line interpolation was used to decrease coniferous volumes to 50 m^3/ha over a 40 year period.

All non MGM generated volumes are shown in blue type.

Figure 31 provides the SVS diagrams illustrating the development of the SwAw natural stand over time.

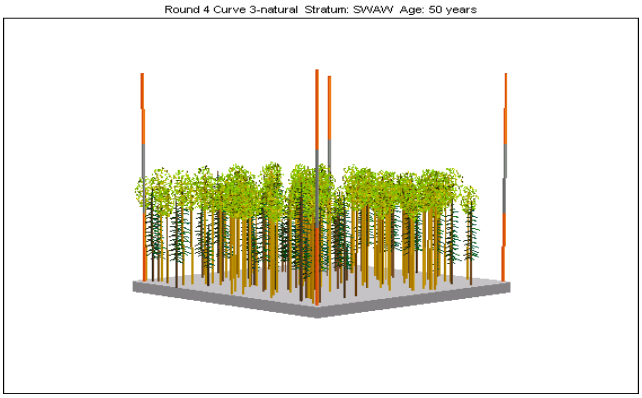


Stand Age	Merchantable Volume				
	Conifer 15/11	Deciduous 15/10	Total	% Conifer	% Deciduous
0	0.0	0.0	0.0	0	0
10	0.0	0.0	0.0	0	0
20	0.0	0.0	0.0	0	0
30	0.0	0.0	0.0	0	0
40	10.5	27.6	38.1	28	72
50	21.0	55.2	76.2	28	72
60	51.4	103.2	154.6	33	67
70	84.9	118.5	203.4	42	58
80	118.3	122.3	240.6	49	51
90	146.8	118.9	265.7	55	45
100	169.7	111.0	280.7	60	40
110	187.0	101.0	288.0	65	35
120	199.6	90.2	289.8	69	31
130	207.5	80.3	287.8	72	28
140	211.1	71.2	282.3	75	25
150	210.8	53.4	264.2	80	20
160	206.3	35.6	241.9	85	15
170	198.3	17.8	216.1	92	8
180	187.4	0.0	187.4	100	0
190	153.1	0.0	153.1	100	0
200	118.7	0.0	118.7	100	0
210	84.4	0.0	84.4	100	0
220	50.0	0.0	50.0	100	0
230	50.0	0.0	50.0	100	0
240	50.0	0.0	50.0	100	0

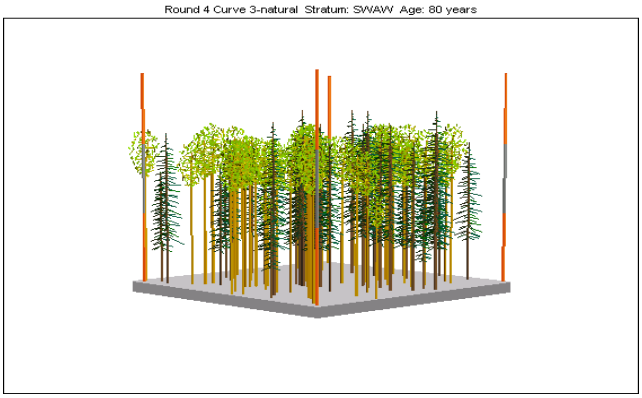
Stand Age	MGM Merchantable Utilization Stand Attributes					
	Conifer Density	Decid Density	Conifer Ave Dbh	Decid Ave Dbh	Conifer Ave Ht	Decid Ave Ht
50	270	700	16.0	14.6	13.0	15.2
60	327	800	19.0	16.4	15.6	17.4
80	361	511	23.0	19.6	19.4	20.9
100	304	336	27.4	21.5	23.1	23.1
120	261	221	30.3	23.0	25.7	24.7
140	221	155	32.5	23.8	27.8	25.6
160	189	112	33.7	25.1	29.0	26.1
180	154	80	34.9	28.6	30.4	27.0
200	132	70	34.2	32.4	30.0	26.0

blue values - denote straight line interpolation.

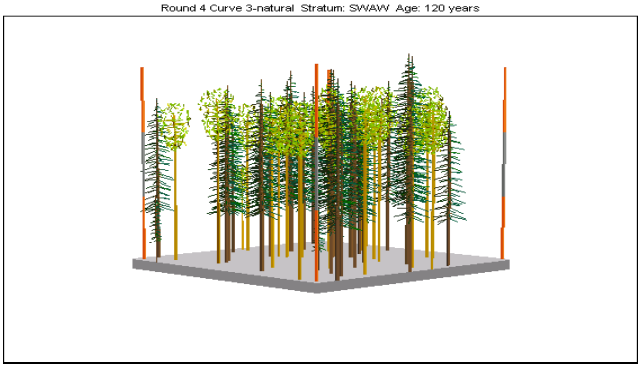
Figure 30. Stratum SwAw – Natural Stand – yield curve and stand attribute summaries.



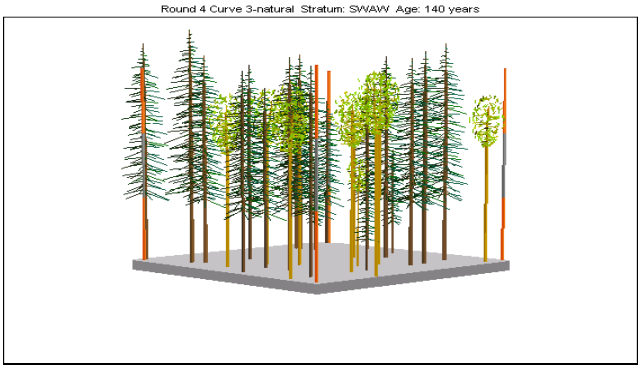
Stratum SwAw (Curve 3) Natural stand at age 60 years



Stratum SwAw (Curve 3) Natural stand grown to age 80 years



Stratum SwAw (Curve 3) Natural stand grown to age 120 years



Stratum SwAw (Curve 3) Natural stand grown to age 140 years

Figure 31. SVS diagrams for Natural Stand SwAw

8.4.2 Shelterwood Planting in SwAw

Figure 32 provides the resultant SwAw yield curve when planted white spruce is grown under a shelterwood harvest system. Tables showing merchantable 15/10 and 15/11 utilization stand attributes and volumes have been included.

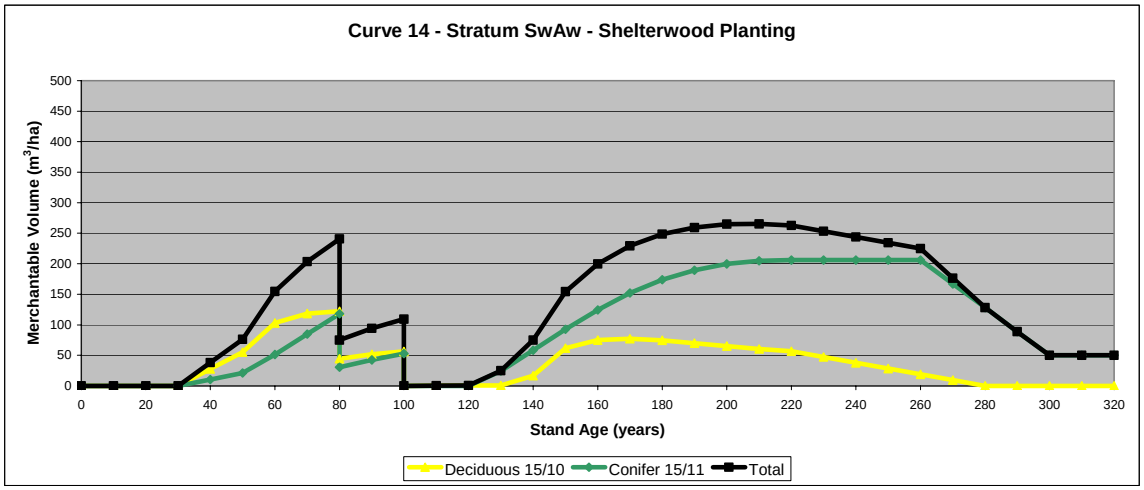
Merchantable volumes were assumed to occur sometime after 30 years of age. Straight-line interpolation was used to generate volumes between 30 years of age (0 m^3/ha) and the MGM starting age (50yrs).

In order to model stand breakup and decline, deciduous volumes were forced to 0 m^3/ha 180 years after aspen initiation. In this case, the stand age of 280 years represents 180 years after Aw initiation since final harvest occurred at 100 years. Straight-line interpolation was used to decrease deciduous volumes over a 40 year period.

Coniferous volumes maximized at 206.1 m^3/ha. This volume was maintained until stand break up and decline to be consistent with the shelterwood harvest in the AwSw stratum, and with the maximum coniferous volume in the natural SwAw stratum. Conifer volumes were assumed to decline 180 years after spruce initiation. In this case, the stand age of 260 years represents 180 years after Sw initiation since planting occurred at 80 years. Straight-line interpolation was used to decrease coniferous volumes to 50 m^3/ha over a 40 year period.

All non MGM generated volumes are shown in blue type.

Figure 33 provides the SVS diagrams illustrating the development of the SwAw stand over time.

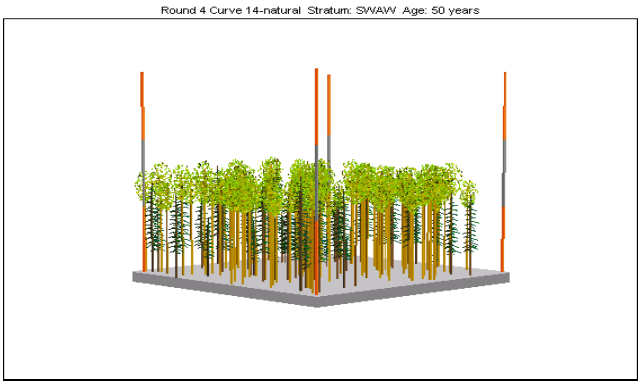


Stand Age	Merchantable Volume				
	Conifer 15/11	Deciduous 15/10	Total	% Conifer	% Deciduous
0	0.0	0.0	0.0	0	0
10	0.0	0.0	0.0	0	0
20	0.0	0.0	0.0	0	0
30	0.0	0.0	0.0	0	0
40	10.5	27.6	38.1	28	72
50	21.0	55.2	76.2	28	72
60	51.4	103.2	154.6	33	67
70	84.9	118.5	203.4	42	58
80	118.3	122.3	240.6	49	51
80	30.6	44.5	75.1	41	59
90	42.4	51.7	94.1	45	55
100	52.9	56.3	109.2	48	52
100	0.0	0.0	0.0	0	0
110	0.0	0.3	0.3	0	100
120	0.0	0.5	0.5	0	100
130	24.2	0.6	24.8	97	3
140	58.2	16.8	75.0	78	22
150	92.7	61.7	154.4	60	40
160	124.6	75.1	199.7	62	38
170	152.1	77.2	229.3	66	34
180	173.8	74.8	248.6	70	30
190	189.4	69.9	259.3	73	27
200	199.6	65.3	264.9	75	25
210	204.9	60.5	265.4	77	23
220	206.1	56.8	262.9	78	22
230	206.1	47.3	253.4	81	19
240	206.1	37.9	244.0	84	16
250	206.1	28.4	234.5	88	12
260	206.1	18.9	225.0	92	8
270	167.1	9.5	176.6	95	5
280	128.1	0.0	128.1	100	0
290	89.0	0.0	89.0	100	0
300	50.0	0.0	50.0	100	0
310	50.0	0.0	50.0	100	0
320	50.0	0.0	50.0	100	0

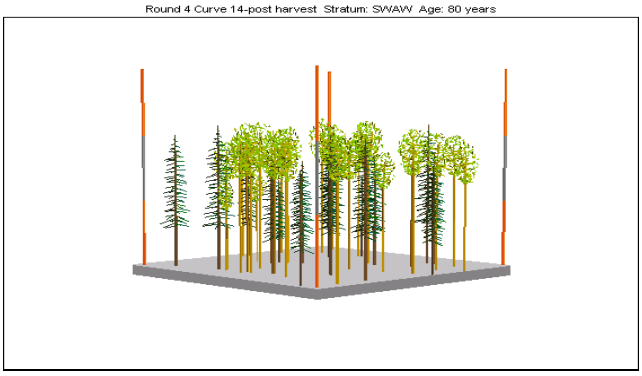
Stand Age	Breast Height Age		MGM Merchantable Utilization Stand Attributes					
	Planted Spruce	Aspen Suckers	Conifer Density	Decid Density	Conifer Ave Dbh	Decid Ave Dbh	Conifer Ave Ht	Decid Ave Ht
50			270	700	16.0	14.6	13.0	15.2
60			327	800	19.0	16.4	15.6	17.4
80			361	511	23.0	19.6	19.4	20.9
80			175	236	18.9	17.8	16.9	20.5
85		3	173	238	20.0	18.2	18.0	21.0
100		18	161	221	22.8	19.4	20.6	22.5
100	7	18						
120	27	38		4		15.9		21.7
140	27	58	383	204	18.4	14.5	16.5	16.0
160	57	78	352	450	23.5	16.6	21.2	21.9
180	67	98	306	290	27.2	18.9	24.6	24.1
200	87	118	266	189	29.6	20.9	26.9	25.7
220	107	138	226	130	31.5	22.8	28.7	26.7
240	127	158	189	99	33.0	25.2	30.2	27.0

blue values - denote straight line interpolation.

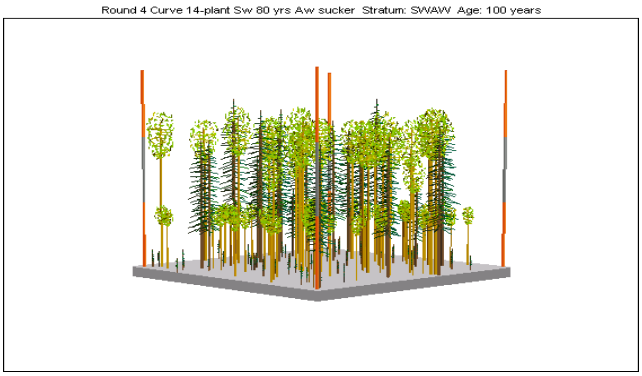
Figure 32. Stratum SwAw – Shelterwood Planting – yield curve and stand attribute summaries.



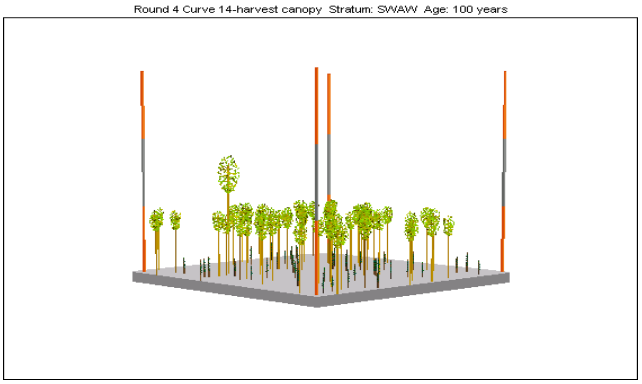
Stratum SwAw (Curve 14)
Natural stand at age 60 years



Stratum SwAw (Curve 14)
Harvest 50% of the density at age 80 years

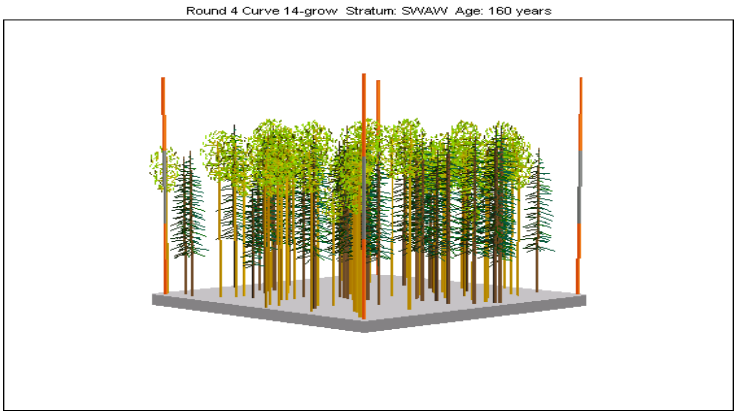


Stratum SwAw (Curve 14)
Plant Sw at age 80 years following harvest and grown to age 100 years

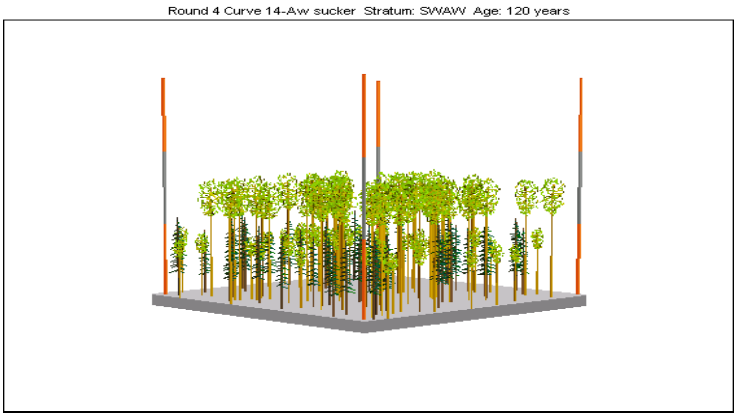


Stratum SwAw (Curve 14)
Harvest remaining canopy at age 100 years

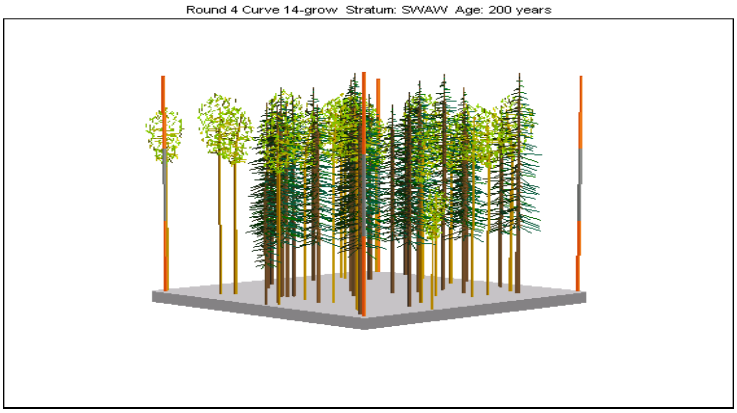
Figure 33. SVS diagrams for Shelterwood Planting in SwAw.



Stratum AwSw (Curve 14)
Grown to age 120 years



Stratum AwSw (Curve 14)
Grown to age 160 years



Stratum AwSw (Curve 14)
Grown to age 200 years

Figure 33 continued. SVS diagrams for Shelterwood Planting in SwAw.

8.5 Stratum Sw Yield Curves

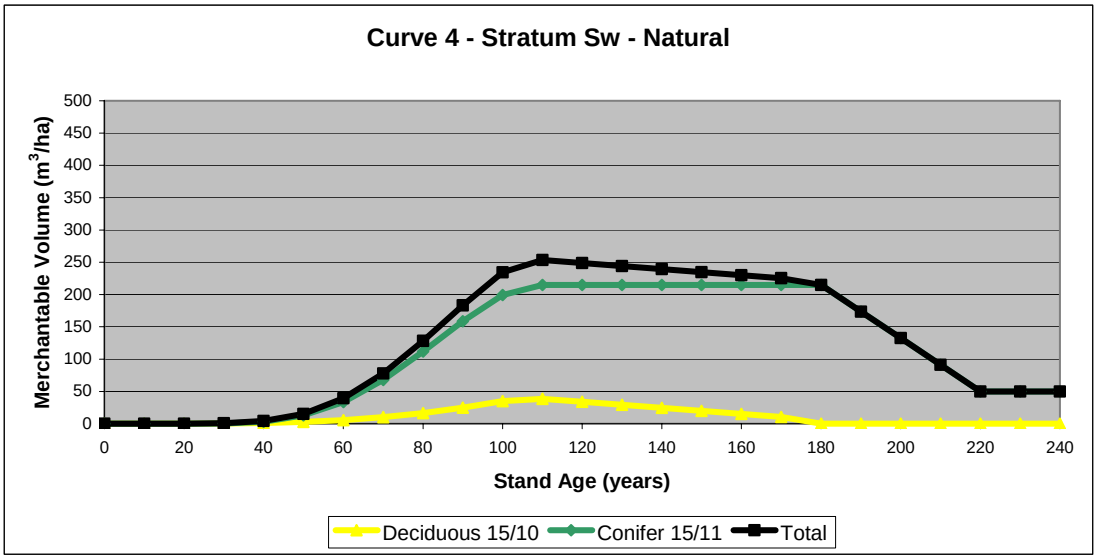
8.5.1 Natural Stand Sw

Figure 34 provides the resultant natural Sw yield curve produced through regression analysis, with tables showing merchantable 15/10 and 15/11 utilization stand attributes. The regression curve was used because there were no mixedwood management treatments for this stratum. In addition, the majority of the inventory ages associated with the plot data for this stratum were well over 100 years of age. Therefore, the work involved in developing an appropriate cohort list could not be justified.

Coniferous volumes were capped at 214.9 m^3/ha at 105 years and are consistent with the maximum conifer volume estimated for the natural SwAw curve (Curve 3). This volume was maintained until stand break up and decline.

In order to model stand breakup and decline, conifer volumes were assumed to decline 180 years after spruce initiation. Straight-line interpolation was used to decrease coniferous volumes to 50 m^3/ha over a 40 year period. Deciduous volumes were forced to 0 m^3/ha 180 years after aspen initiation. Straight-line interpolation was used to decrease deciduous volumes from 105 years.

No SVS diagrams accompany this yield curve as there are no associated tree lists from which to generate diagrams.



Stand Age	Merchantable Volume				
	Conifer 15/11	Deciduous 15/10	Total	% Conifer	% Deciduous
0	0.0	0.0	0.0	0	0
10	0.0	0.0	0.0	0	0
20	0.0	0.0	0.0	0	0
30	0.4	0.3	0.7	57	43
40	3.2	1.0	4.2	76	24
50	12.7	2.6	15.3	83	17
60	33.6	5.6	39.2	86	14
70	67.8	10.1	77.9	87	13
80	111.9	16.5	128.4	87	13
90	158.6	24.9	183.5	86	14
100	199.2	35.2	234.4	85	15
110	214.9	38.7	253.6	85	15
120	214.9	34.0	248.9	86	14
130	214.9	29.3	244.2	88	12
140	214.9	24.6	239.5	90	10
150	214.9	19.9	234.8	92	8
160	214.9	15.2	230.1	93	7
170	214.9	10.5	225.4	95	5
180	214.9	0.0	214.9	100	0
190	173.7	0.0	173.7	100	0
200	132.5	0.0	132.5	100	0
210	91.2	0.0	91.2	100	0
220	50.0	0.0	50.0	100	0
230	50.0	0.0	50.0	100	0
240	50.0	0.0	50.0	100	0

Regression Coefficients	
conifer	deciduous
2.23E-14	1.056E-08
9.6996	5.2022
0.0794	0.0203

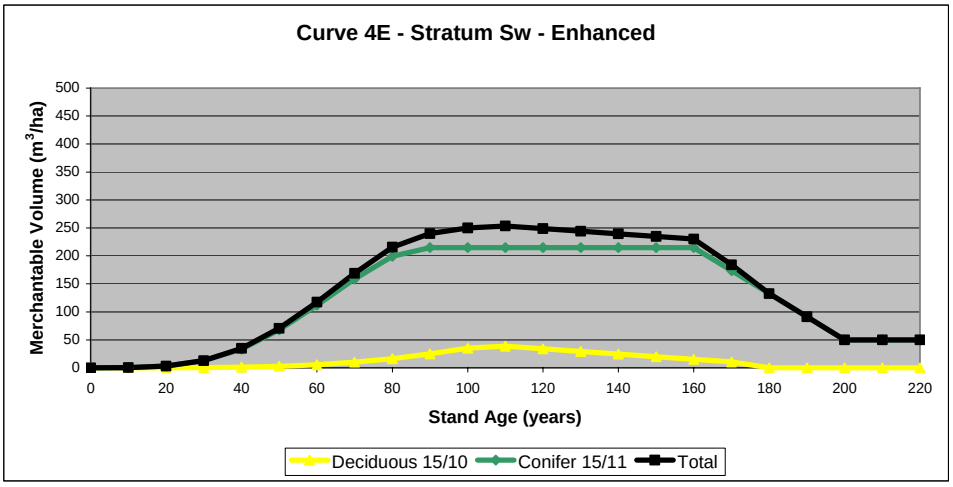
blue values - denote straight line interpolation.

Figure 34. Stratum Sw – Natural Stand – empirical yield curve and volume summaries.

8.5.2 Enhanced Sw

Figure 35 provides the resultant enhanced Sw yield curve, with tables showing merchantable 15/10 and 15/11 utilization stand attributes. The enhanced curve assumes that the conifer volumes would be realized 20 years earlier than the natural curve. This curve is solely for intensive conifer management including herbicide.

No SVS diagrams accompany this yield curve as there are no associated tree lists from which to generate diagrams.



Stand Age	Merchantable Volume				
	Conifer 15/11	Deciduous 15/10	Total	% Conifer	% Deciduous
0	0.0	0.0	0.0	0	0
10	0.4	0.0	0.4	100	0
20	3.2	0.0	3.2	100	0
30	12.7	0.3	13.0	98	2
40	33.6	1.0	34.6	97	3
50	67.8	2.6	70.4	96	4
60	111.9	5.6	117.5	95	5
70	158.6	10.1	168.7	94	6
80	199.2	16.5	215.7	92	8
90	214.9	24.9	239.8	90	10
100	214.9	35.2	250.1	86	14
110	214.9	38.7	253.6	85	15
120	214.9	34.0	248.9	86	14
130	214.9	29.3	244.2	88	12
140	214.9	24.6	239.5	90	10
150	214.9	19.9	234.8	92	8
160	214.9	15.2	230.1	93	7
170	173.7	10.5	184.2	94	6
180	132.5	0.0	132.5	100	0
190	91.2	0.0	91.2	100	0
200	50.0	0.0	50.0	100	0
210	50.0	0.0	50.0	100	0
220	50.0	0.0	50.0	100	0

blue values - denote straight line interpolation.

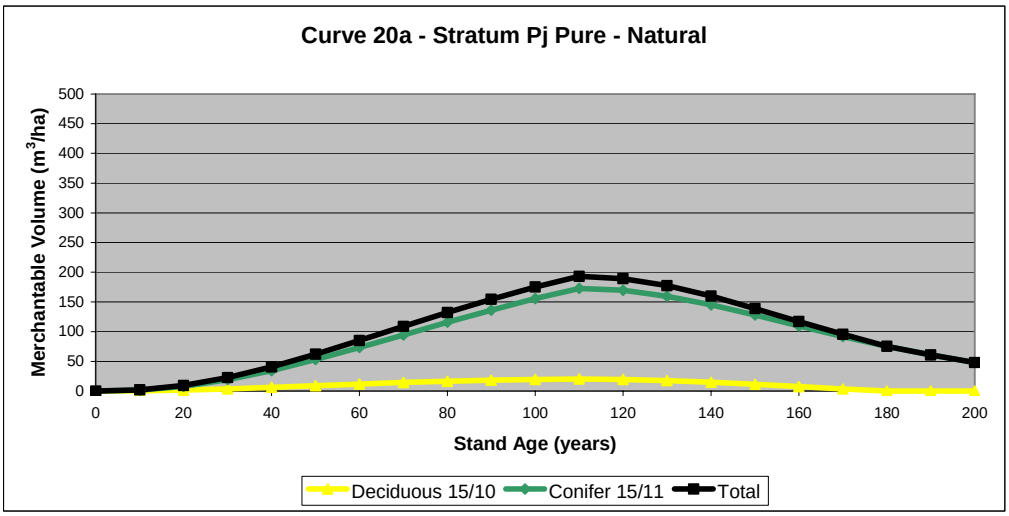
Figure 35. Stratum Sw – Enhanced Stand – empirical yield curve and volume summaries.

8.6 Stratum Pj Yield Curves

8.6.1 Natural Stand Pj Pure

Figure 36 provides the resultant natural Pj Pure yield curve produced by area-weighting the two approved DFMP jack pine yield classes (Section 3.2).

No SVS diagrams accompany this yield curve as there are no associated tree lists from which to generate diagrams.



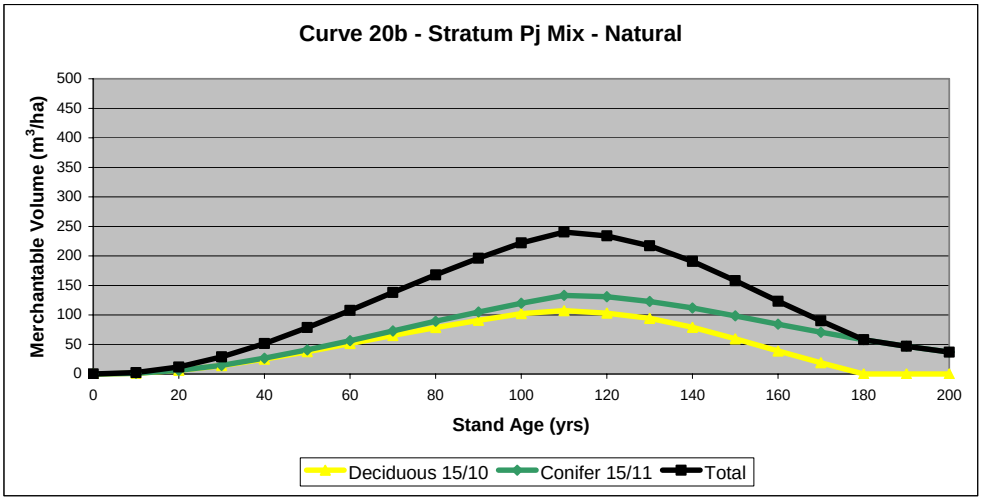
Stand Age	Merchantable Volume				
	Conifer 15/11	Deciduous 15/10	Total	% Conifer	% Deciduous
0	0.0	0.0	0.0	0	0
10	1.6	0.4	1.9	81	19
20	7.8	1.6	9.5	83	17
30	19.0	3.7	22.7	84	16
40	34.4	6.2	40.7	85	15
50	52.9	9.0	61.9	85	15
60	73.3	11.7	85.0	86	14
70	94.6	14.3	108.9	87	13
80	115.8	16.5	132.3	88	12
90	136.3	18.3	154.6	88	12
100	155.5	19.7	175.2	89	11
110	172.9	20.2	193.0	90	10
120	169.7	19.4	189.0	90	10
130	159.7	17.7	177.4	90	10
140	145.0	14.8	159.9	91	9
150	127.8	11.2	139.0	92	8
160	109.6	7.3	116.9	94	6
170	91.8	3.6	95.4	96	4
180	75.4	0.0	75.4	100	0
190	60.7	0.0	60.7	100	0
200	48.1	0.0	48.1	100	0

Figure 36. Stratum Pj Pure – Area weighted DFMP yield curve and volume summaries.

8.6.2 Natural Stand Pj Mix

Figure 37 provides the resultant natural Pj Mix yield curve based on the approved DFMP yield class (Section 3.2).

No SVS diagrams accompany this yield curve as there are no associated tree lists from which to generate diagrams.



Stand Age	Merchantable Volume				
	Conifer 15/11	Deciduous 15/10	Total	% Conifer	% Deciduous
0	0.0	0.0	0.0	0	0
10	1.2	1.2	2.4	49	51
20	6.0	6.0	12.0	50	50
30	14.7	14.1	28.8	51	49
40	26.5	25.0	51.6	51	49
50	40.8	37.7	78.5	52	48
60	56.5	51.3	107.8	52	48
70	72.9	65.2	138.0	53	47
80	89.3	78.5	167.8	53	47
90	105.1	91.0	196.1	54	46
100	119.8	102.3	222.1	54	46
110	133.3	107.2	240.5	55	45
120	130.8	103.1	233.9	56	44
130	123.1	94.2	217.3	57	43
140	111.8	79.0	190.8	59	41
150	98.5	59.7	158.1	62	38
160	84.5	38.9	123.3	68	32
170	70.8	19.2	90.0	79	21
180	58.1	0.0	58.1	100	0
190	46.8	0.0	46.8	100	0
200	37.1	0.0	37.1	100	0

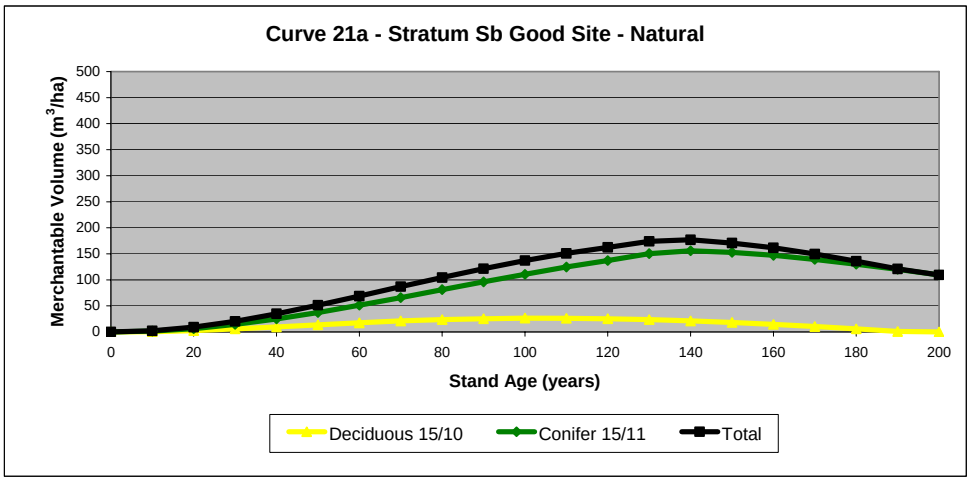
Figure 37. Stratum Pj Mix – DFMP yield curve and volume summaries.

8.7 Stratum Sb Yield Curves

8.7.1 Natural Stand Sb Good

Figure 38 provides the resultant natural Sb Good yield curve based on the DFMP black spruce yield class (Section 3.2).

No SVS diagrams accompany this yield curve as there are no associated tree lists from which to generate diagrams.



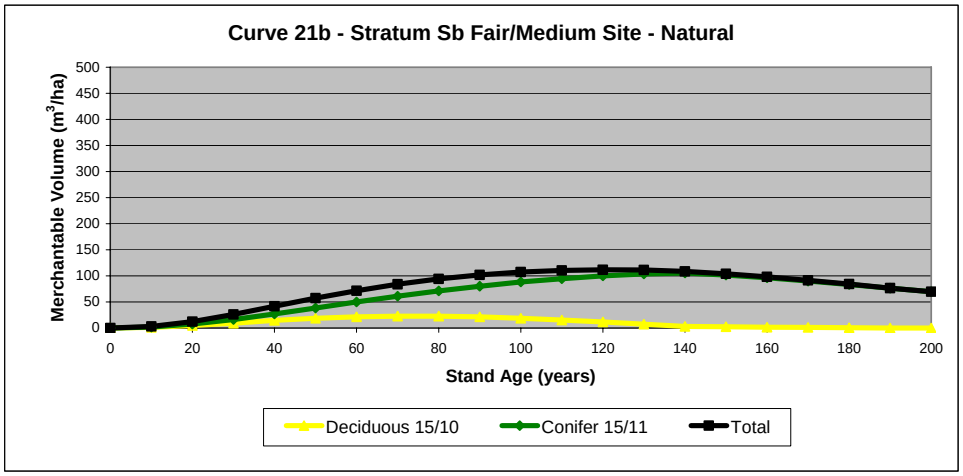
Stand Age	Merchantable Volume				
	Conifer 15/11	Deciduous 15/10	Total	% Conifer	% Deciduous
0	0.0	0.0	0.0	0	0
10	1.5	0.6	2.1	71	29
20	6.4	2.7	9.0	71	29
30	14.4	5.8	20.3	71	29
40	25.0	9.7	34.7	72	28
50	37.5	13.7	51.2	73	27
60	51.3	17.6	68.9	74	26
70	66.0	21.0	86.9	76	24
80	81.0	23.6	104.6	77	23
90	96.0	25.4	121.4	79	21
100	110.6	26.3	136.9	81	19
110	124.7	26.3	151.0	83	17
120	137.0	25.4	162.4	84	16
130	150.2	23.7	173.8	86	14
140	155.6	21.2	176.8	88	12
150	152.7	18.0	170.7	89	11
160	147.0	14.3	161.4	91	9
170	139.3	10.2	149.5	93	7
180	130.2	5.7	135.9	96	4
190	120.1	1.0	121.0	99	1
200	109.5	0.0	109.5	100	0

Figure 38. Stratum Sb Good – DFMP yield curve and volume summaries.

8.7.2 Natural Stand Sb Fair/Medium

Figure 39 provides the resultant natural Sb Fair/Medium yield curve produced by area-weighting the two approved DFMP black spruce yield classes (Section 3.2).

No SVS diagrams accompany this yield curve as there are no associated tree lists from which to generate diagrams.



Stand Age	Merchantable Volume				
	Conifer 15/11	Deciduous 15/10	Total	% Conifer	% Deciduous
0	0.0	0.0	0.0	0	0
10	1.9	1.2	3.1	63	37
20	7.8	4.7	12.5	62	38
30	16.5	9.6	26.1	63	37
40	27.0	14.6	41.6	65	35
50	38.5	18.7	57.2	67	33
60	50.0	21.6	71.6	70	30
70	61.1	23.0	84.1	73	27
80	71.4	22.9	94.3	76	24
90	80.5	21.5	102.1	79	21
100	88.4	19.1	107.4	82	18
110	94.9	15.7	110.6	86	14
120	100.0	11.8	111.8	89	11
130	103.8	7.5	111.3	93	7
140	105.7	3.1	108.8	97	3
150	101.8	2.3	104.1	98	2
160	96.4	1.8	98.2	98	2
170	90.3	1.3	91.5	99	1
180	83.6	0.7	84.3	99	1
190	76.7	0.1	76.8	100	0
200	69.7	0.0	69.7	100	0

Figure 39. Stratum Sb Fair/Medium – Area weighted DFMP yield curve and volume summaries.

9.0 Literature Cited

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10.0 Appendix I - Regression Coefficients

Regression Coefficients for Empirical Volume Prediction by Stratum.

Stratum	Coniferous Coefficients			Deciduous Coefficients		
	a	b	c	a	b	c
Aw	0.00837	1.9623	0.00837	0.000036	4.2197	0.038
AwSw	1.25E-02	2.2038	0.0125	2.756E-08	6.1717	0.0579
SwAw	5.80E-05	3.8692	0.0312	0.000000162	5.4345	0.04469
Sw	2.23E-14	9.6996	0.0794	1.056E-08	5.2022	0.0203

11.0 Appendix II - Crop Plans

The following crop plans show the 15/11 utilization standard. The reported conifer volumes and stand attributes were taken from these MGM runs. The same crop plans were run with the 15/10 utilization standard. The reported deciduous volumes and stand attributes were taken from these MGM runs.

Curve 1 - Stratum Aw - Natural

Crop Plan		**aspen-4-13**		9/6/06 10:38 AM	**Normal stop. (Multiple blank events)**			C:\mgm98\				
	Stand Age	**Year**	**Event**	**Settings**								
			Crop Plan									
	0	1997	Record	Sheet := Clear								
	0	2000	Initialize	DistrbYear := 2000	CropPlanID := aspen-4-13							
	0	2000	Options	ERSwitch := 1	ERIndex := 1	_MinDbh := 13.6	_topdib := 11	_StumpHt := 0.3	SiteCurvesIndex := 2	AllowIngrowth := True	_VolumeLoss := 0	UsePLM := False
	60	2060	Establish	stOrigin := 3	StandAge := 60	TreeSource := aw60b	ExtSourceIndex := 1					
	60	2060	Record	Sheet := Crop Plan								
	60	2060	Record	Sheet := Stand								
	60	2060	Grow	Schedule := 5								
	65	2065	Grow	Schedule := 5								
	70	2070	Grow	Schedule := 5								
	75	2075	Grow	Schedule := 5								
	80	2080	Record	Sheet := Stand								
	80	2080	Grow	Schedule := 5								
	85	2085	Grow	Schedule := 5								
	90	2090	Grow	Schedule := 5								
	95	2095	Grow	Schedule := 5								
	100	2100	Record	Sheet := Stand								
	100	2100	Grow	Schedule := 5								
	105	2105	Grow	Schedule := 5								
	110	2110	Grow	Schedule := 5								
	115	2115	Grow	Schedule := 5								
	120	2120	Record	Sheet := Stand								
	120	2120	Grow	Schedule := 5								
	125	2125	Grow	Schedule := 5								
	130	2130	Grow	Schedule := 5								
	135	2135	Grow	Schedule := 5								
	140	2140	Record	Sheet := Stand								
	140	2140	Grow	Schedule := 5								
	145	2145	Grow	Schedule := 5								
	150	2150	Grow	Schedule := 5								
	155	2155	Grow	Schedule := 5								
	160	2160	Record	Sheet := Stand								
	160	2160	Grow	Schedule := 5								
	165	2165	Grow	Schedule := 5								
	170	2170	Grow	Schedule := 5								
	175	2175	Grow	Schedule := 5								
	180	2180	Record	Sheet := Stand								
	180	2180	Grow	Schedule := 5								
	185	2185	Grow	Schedule := 5								
	190	2190	Grow	Schedule := 5								
	195	2195	Grow	Schedule := 5								
	200	2200	Record	Sheet := Stand								
	200	2200	Record	Sheet := Yields								
	200	2200	MultiGraph	PlotColumn := 4	PlotHeader := D_Den							
	200	2200	Record	Sheet := Multigraph								
	200	2200	End									

Curve 6 - Stratum Aw - Underplant of Sw in Midrotation Aw

Crop Plan	49	aspen6-4-13				3/25/2002	10:17:02 AM					
Crop Plan		**aspen6-4-13**		3/25/02 10:17 AM	**Running**			C:\mgm98\				
	Stand Age	**Year**	**Event**	**Settings**								
			Crop Plan									
	0	1997	Record	Sheet := Clear								
	0	2000	Initialize	DistrbYear := 2000	CropPlanID := aspen6-4-13							
	0	2000	Options	ERSwitch := 1	ERIndex := 1	_MinDbh := 13.6	_topdib := 11	_StumpHt := 0.3	SiteCurvesIndex := 2	AllowIngrowth := True	_VolumeLoss := 0	UsePLM := False
	60	2060	Establish	stOrigin := 3	StandAge := 60	TreeSource := aw60b	ExtSourceIndex := 1					
	60	2060	Regen	stOrigin := 2	StandAge := 60	Seed := 0.7607	StandParsList := [Sw 17 16 700 5.1 1.0 4.1 0.8 0.8 *]					
	60	2060	Record	Sheet := Crop Plan								
	60	2060	Record	Sheet := Stand								
	60	2060	Grow	Schedule := 5								
	65	2065	Grow	Schedule := 5								
	70	2070	Grow	Schedule := 5								
	75	2075	Grow	Schedule := 5								
	80	2080	Record	Sheet := Stand								
	80	2080	Grow	Schedule := 5								
	85	2085	Grow	Schedule := 5								
	90	2090	Grow	Schedule := 5								
	95	2095	Grow	Schedule := 5								
	100	2100	Record	Sheet := Stand								
	100	2100	Grow	Schedule := 5								
	105	2105	Grow	Schedule := 5								
	110	2110	Grow	Schedule := 5								
	115	2115	Grow	Schedule := 5								
	120	2120	Record	Sheet := Stand								
	120	2120	Grow	Schedule := 5								
	125	2125	Grow	Schedule := 5								
	130	2130	Grow	Schedule := 5								
	135	2135	Grow	Schedule := 5								
	140	2140	Record	Sheet := Stand								
	140	2140	Grow	Schedule := 5								
	145	2145	Grow	Schedule := 5								
	150	2150	Grow	Schedule := 5								
	155	2155	Grow	Schedule := 5								
	160	2160	Record	Sheet := Stand								
	160	2160	Grow	Schedule := 5								
	165	2165	Grow	Schedule := 5								
	170	2170	Grow	Schedule := 5								
	175	2175	Grow	Schedule := 5								
	180	2180	Record	Sheet := Stand								
	180	2180	Grow	Schedule := 5								
	185	2185	Grow	Schedule := 5								
	190	2190	Grow	Schedule := 5								
	195	2195	Grow	Schedule := 5								
	200	2200	Record	Sheet := Stand								
	200	2200	Record	Sheet := Yields								
	200	2200	MultiGraph	PlotColumn := 4	PlotHeader := D_Den							
	200	2200	Record	Sheet := Crop Plan								
	200	2200	End									

Curve 5 - Stratum Aw - Underplant of Sw in Overmature Aw

Crop Plan	72	aspen5-4-13				3/25/2002	9:43:44 AM						
Crop Plan		**aspen5-4-13**		3/25/02 9:43 AM	**Running**			C:\mgm98\					
	Stand Age	**Year**	**Event**	**Settings**									
			Crop Plan										
	0	1997	Record	Sheet := Clear									
	0	2000	Initialize	DistrbYear := 2000	CropPlanID := aspen5-4-13								
	0	2000	Options	ERSwitch := 1	ERIndex := 1	_MinDbh := 13.6	_topdib := 11	_StumpHt := 0.3	SiteCurvesIndex := 2	AllowIngrowth := True	_VolumeLoss := 0	UsePLM := False	
	60	2060	Establish	stOrigin := 3	StandAge := 60	TreeSource := aw60b	ExtSourceIndex := 1						
	60	2060	Record	Sheet := Crop Plan									
	60	2060	Record	Sheet := Stand									
	60	2060	Grow	Schedule := 5									
	65	2065	Grow	Schedule := 5									
	70	2070	Grow	Schedule := 5									
	75	2075	Grow	Schedule := 5									
	80	2080	Record	Sheet := Stand									
	80	2080	Grow	Schedule := 5									
	85	2085	Grow	Schedule := 5									
	90	2090	Grow	Schedule := 5									
	95	2095	Grow	Schedule := 5									
	100	2100	Regen	stOrigin := 2	StandAge := 100	Seed := 0.7607	StandParsList := [Sw 7 22 500 3.1 0.6 2.5 0.5 0.8 *]						
	100	2100	Record	Sheet := Stand									
	100	2100	Harvest	RemRuleIndex := 3	RemAmtIndex := 3	SpeciesIndex := 2	HtDbhRatio := False	LowerLimit := 1.3	UpperLimit := 1.75	RemovalAmt := 99			
	100	2100	Harvest	RemRuleIndex := 3	RemAmtIndex := 3	SpeciesIndex := 1	HtDbhRatio := False	LowerLimit := 1.3	UpperLimit := 1.75	RemovalAmt := 12			
	100	2100	Record	Sheet := Stand									
	100	2100	Grow	Schedule := 5									
	105	2105	Grow	Schedule := 5									
	110	2110	Regen	stOrigin := 2	StandAge := 110	Seed := 0.7607	StandParsList := [Aw 8 22 1000 3.9 0.4 4.3 0.4 0.8 *]						
	110	2110	Grow	Schedule := 5									
	115	2115	Grow	Schedule := 5									
	120	2120	Record	Sheet := Stand									
	120	2120	Grow	Schedule := 5									
	125	2125	Grow	Schedule := 5									
	130	2130	Grow	Schedule := 5									
	135	2135	Grow	Schedule := 5									
	140	2140	Record	Sheet := Stand									
	140	2140	Grow	Schedule := 5									
	145	2145	Grow	Schedule := 5									
	150	2150	Grow	Schedule := 5									
	155	2155	Grow	Schedule := 5									
	160	2160	Record	Sheet := Stand									
	160	2160	Grow	Schedule := 5									
	165	2165	Grow	Schedule := 5									
	170	2170	Grow	Schedule := 5									
	175	2175	Grow	Schedule := 5									
	180	2180	Record	Sheet := Stand									
	180	2180	Grow	Schedule := 5									
	185	2185	Grow	Schedule := 5									
	190	2190	Grow	Schedule := 5									
	195	2195	Grow	Schedule := 5									
	200	2200	Grow	Schedule := 5									
	205	2205	Grow	Schedule := 5									
	210	2210	Grow	Schedule := 5									
	215	2215	Grow	Schedule := 5									
	220	2220	Grow	Schedule := 5									
	225	2225	Grow	Schedule := 5									
	230	2230	Grow	Schedule := 5									
	235	2235	Grow	Schedule := 5									
	240	2240	Grow	Schedule := 5									
	245	2245	Grow	Schedule := 5									
	250	2250	Grow	Schedule := 5									
	255	2255	Grow	Schedule := 5									
	260	2260	Grow	Schedule := 5									
	265	2265	Grow	Schedule := 5									
	270	2270	Grow	Schedule := 5									
	275	2275	Grow	Schedule := 5									
	280	2280	Grow	Schedule := 5									
	285	2285	Grow	Schedule := 5									
	290	2290	Grow	Schedule := 5									
	295	2295	Grow	Schedule := 5									
	300	2300	Record	Sheet := Yields									
	300	2300	MultiGraph	PlotColumn := 4	PlotHeader := D_Den								
	300	2300	Record	Sheet := Multigraph									
	300	2300	End										

Curve 18-60 - Stratum Aw/Sw - Understory Protection Harvest

Crop Plan	52	aspen18-4-13-60				3/25/2002	11:02:51 AM					
Crop Plan		**aspen18-4-13-60**		3/25/02 11:02 AM	**Running**			C:\mgm98\				
	Stand Age	**Year**	**Event**	**Settings**								
			Crop Plan									
	0	1997	Record	Sheet := Clear								
	0	2000	Initialize	DistrbYear := 2000	CropPlanID := aspen18-4-13-60							
	0	2000	Options	ERSwitch := 1	ERIndex := 1	_MinDbh := 13.6	_topdib := 11	_StumpHt := 0.3	SiteCurvesIndex := 2	AllowIngrowth := True	_VolumeLoss := 0	UsePLM := False
	60	2060	Establish	stOrigin := 3	StandAge := 60	TreeSource := aw60b	ExtSourceIndex := 1					
	60	2060	Regen	stOrigin := 2	StandAge := 60	Seed := 0.7607	StandParsList := [Sw 27 16 1200 8.2 1.6 6.6 1.3 0.8 *]					
	60	2060	Record	Sheet := Crop Plan								
	60	2060	Record	Sheet := Stand								
	60	2060	Harvest	RemRuleIndex := 3	RemAmtIndex := 3	SpeciesIndex := 2	HtDbhRatio := False	LowerLimit := 1.3	UpperLimit := 1.75	RemovalAmt := 90		
	60	2060	Harvest	RemRuleIndex := 6	RemAmtIndex := 3	SpeciesIndex := 1	HtDbhRatio := False	LowerLimit := 1.3	UpperLimit := 1.75	RemovalAmt := 25		
	60	2060	Record	Sheet := Stand								
	60	2060	Grow	Schedule := 5								
	65	2065	Grow	Schedule := 5								
	70	2070	Regen	stOrigin := 2	StandAge := 70	Seed := 0.7607	StandParsList := [Aw 8 22 1000 3.9 0.4 4.3 0.4 0.8 *]					
	70	2070	Grow	Schedule := 5								
	75	2075	Grow	Schedule := 5								
	80	2080	Record	Sheet := Stand								
	80	2080	Grow	Schedule := 5								
	85	2085	Grow	Schedule := 5								
	90	2090	Grow	Schedule := 5								
	95	2095	Grow	Schedule := 5								
	100	2100	Record	Sheet := Stand								
	100	2100	Grow	Schedule := 5								
	105	2105	Grow	Schedule := 5								
	110	2110	Grow	Schedule := 5								
	115	2115	Grow	Schedule := 5								
	120	2120	Record	Sheet := Stand								
	120	2120	Grow	Schedule := 5								
	125	2125	Grow	Schedule := 5								
	130	2130	Grow	Schedule := 5								
	135	2135	Grow	Schedule := 5								
	140	2140	Record	Sheet := Stand								
	140	2140	Grow	Schedule := 5								
	145	2145	Grow	Schedule := 5								
	150	2150	Grow	Schedule := 5								
	155	2155	Grow	Schedule := 5								
	160	2160	Record	Sheet := Stand								
	160	2160	Grow	Schedule := 5								
	165	2165	Grow	Schedule := 5								
	170	2170	Grow	Schedule := 5								
	175	2175	Grow	Schedule := 5								
	180	2180	Record	Sheet := Stand								
	180	2180	Grow	Schedule := 5								
	185	2185	Grow	Schedule := 5								
	190	2190	Grow	Schedule := 5								
	195	2195	Grow	Schedule := 5								
	200	2200	Record	Sheet := Stand								
	200	2200	Record	Sheet := Yields								
	200	2200	MultiGraph	PlotColumn := 4	PlotHeader := D_Den							
	200	2200	End									

Curve 18-80 - Stratum Aw/Sw - Understory Protection Harvest

Crop Plan	52	aspen18-4-13-80				3/25/2002	10:49:49 AM					
Crop Plan		**aspen18-4-13-80**		3/25/02 10:49 AM	**Running**			C:\mgm98\				
	Stand Age	**Year**	**Event**	**Settings**								
			Crop Plan									
	0	1997	Record	Sheet := Clear								
	0	2000	Initialize	DistrbYear := 2000	CropPlanID := aspen18-4-13-80							
	0	2000	Options	ERSwitch := 1	ERIndex := 1	_MinDbh := 13.6	_topdib := 11	_StumpHt := 0.3	SiteCurvesIndex := 2	AllowIngrowth := True	_VolumeLoss := 0	UsePLM := False
	60	2060	Establish	stOrigin := 3	StandAge := 60	TreeSource := aw60b	ExtSourceIndex := 1					
	60	2060	Regen	stOrigin := 2	StandAge := 60	Seed := 0.7607	StandParsList := [Sw 27 16 1200 8.2 1.6 6.6 1.3 0.8 *]					
	60	2060	Record	Sheet := Crop Plan								
	60	2060	Record	Sheet := Stand								
	60	2060	Grow	Schedule := 5								
	65	2065	Grow	Schedule := 5								
	70	2070	Grow	Schedule := 5								
	75	2075	Grow	Schedule := 5								
	80	2080	Record	Sheet := Stand								
	80	2080	Harvest	RemRuleIndex := 3	RemAmtIndex := 3	SpeciesIndex := 2	HtDbhRatio := False	LowerLimit := 1.3	UpperLimit := 1.75	RemovalAmt := 90		
	80	2080	Harvest	RemRuleIndex := 6	RemAmtIndex := 3	SpeciesIndex := 1	HtDbhRatio := False	LowerLimit := 1.3	UpperLimit := 1.75	RemovalAmt := 25		
	80	2080	Record	Sheet := Stand								
	80	2080	Grow	Schedule := 5								
	85	2085	Grow	Schedule := 5								
	90	2090	Regen	stOrigin := 2	StandAge := 90	Seed := 0.7607	StandParsList := [Aw 8 22 1000 3.9 0.4 4.3 0.4 0.8 *]					
	90	2090	Grow	Schedule := 5								
	95	2095	Grow	Schedule := 5								
	100	2100	Record	Sheet := Stand								
	100	2100	Grow	Schedule := 5								
	105	2105	Grow	Schedule := 5								
	110	2110	Grow	Schedule := 5								
	115	2115	Grow	Schedule := 5								
	120	2120	Record	Sheet := Stand								
	120	2120	Grow	Schedule := 5								
	125	2125	Grow	Schedule := 5								
	130	2130	Grow	Schedule := 5								
	135	2135	Grow	Schedule := 5								
	140	2140	Record	Sheet := Stand								
	140	2140	Grow	Schedule := 5								
	145	2145	Grow	Schedule := 5								
	150	2150	Grow	Schedule := 5								
	155	2155	Grow	Schedule := 5								
	160	2160	Record	Sheet := Stand								
	160	2160	Grow	Schedule := 5								
	165	2165	Grow	Schedule := 5								
	170	2170	Grow	Schedule := 5								
	175	2175	Grow	Schedule := 5								
	180	2180	Record	Sheet := Stand								
	180	2180	Grow	Schedule := 5								
	185	2185	Grow	Schedule := 5								
	190	2190	Grow	Schedule := 5								
	195	2195	Grow	Schedule := 5								
	200	2200	Record	Sheet := Yields								
	200	2200	MultiGraph	PlotColumn := 4	PlotHeader := D_Den							
	200	2200	Record	Sheet := Stand								
	200	2200	End									

Curve 2 - Stratum AwSw - Natural

Crop Plan	47	aspenspruce-4-13				3/25/2002	11:19:12 AM						
Crop Plan		**aspenspruce-4-13**		3/25/02 11:19 AM	**Running**			C:\mgm98\					
	Stand Age	**Year**	**Event**	**Settings**									
			Crop Plan										
	0	1997	Record	Sheet := Clear									
	0	2000	Initialize	DistrbYear := 2000	CropPlanID := aspenspruce-4-13								
	0	2000	Options	ERSwitch := 1	ERIndex := 1	_MinDbh := 13.6	_topdib := 11	_StumpHt := 0.3	SiteCurvesIndex := 2	AllowIngrowth := True	_VolumeLoss := 0	UsePLM := False	
	60	2060	Establish	stOrigin := 3	StandAge := 60	TreeSource := awsw60	ExtSourceIndex := 1						
	60	2060	Record	Sheet := Crop Plan									
	60	2060	Record	Sheet := Stand									
	60	2060	Grow	Schedule := 5									
	65	2065	Grow	Schedule := 5									
	70	2070	Grow	Schedule := 5									
	75	2075	Grow	Schedule := 5									
	80	2080	Record	Sheet := Stand									
	80	2080	Grow	Schedule := 5									
	85	2085	Grow	Schedule := 5									
	90	2090	Grow	Schedule := 5									
	95	2095	Grow	Schedule := 5									
	100	2100	Record	Sheet := Stand									
	100	2100	Grow	Schedule := 5									
	105	2105	Grow	Schedule := 5									
	110	2110	Grow	Schedule := 5									
	115	2115	Grow	Schedule := 5									
	120	2120	Record	Sheet := Stand									
	120	2120	Grow	Schedule := 5									
	125	2125	Grow	Schedule := 5									
	130	2130	Grow	Schedule := 5									
	135	2135	Grow	Schedule := 5									
	140	2140	Record	Sheet := Stand									
	140	2140	Grow	Schedule := 5									
	145	2145	Grow	Schedule := 5									
	150	2150	Grow	Schedule := 5									
	155	2155	Grow	Schedule := 5									
	160	2160	Record	Sheet := Stand									
	160	2160	Grow	Schedule := 5									
	165	2165	Grow	Schedule := 5									
	170	2170	Grow	Schedule := 5									
	175	2175	Grow	Schedule := 5									
	180	2180	Record	Sheet := Stand									
	180	2180	Grow	Schedule := 5									
	185	2185	Grow	Schedule := 5									
	190	2190	Grow	Schedule := 5									
	195	2195	Grow	Schedule := 5									
	200	2200	Record	Sheet := Stand									
	200	2200	Record	Sheet := Yields									
	200	2200	MultiGraph	PlotColumn := 4	PlotHeader := D_Den								
	200	2200	End										

Curve 8 - Stratum AwSw - Shelterwood Planting

Crop Plan	81	awsw8-4-13				3/25/2002	11:32:13 AM						
Crop Plan		**awsw8-4-13**	3/25/02 11:32 AM	**Running**			C:\mgm98\						
	Stand Age	**Year**	**Event**	**Settings**									
			Crop Plan										
	0	1997	Record	Sheet := Clear									
	0	2000	Initialize	DistrbYear := 2000	CropPlanID := awsw8-4-13								
	0	2000	Options	ERSwitch := 1	ERIndex := 1	_MinDbh := 13.6	_topdib := 11	_StumpHt := 0.3	SiteCurvesIndex := 2	AllowIngrowth := True	_VolumeLoss := 0	UsePLM := False	
	60	2060	Establish	stOrigin := 3	StandAge := 60	TreeSource := awsw60	ExtSourceIndex := 1						
	60	2060	Record	Sheet := Crop Plan									
	60	2060	Record	Sheet := Stand									
	60	2060	Grow	Schedule := 5									
	65	2065	Grow	Schedule := 5									
	70	2070	Grow	Schedule := 5									
	75	2075	Grow	Schedule := 5									
	80	2080	Record	Sheet := Stand									
	80	2080	Harvest	RemRuleIndex := 3	RemAmtIndex := 3	SpeciesIndex := 2	HtDbhRatio := False	LowerLimit := 1.3	UpperLimit := 1.75	RemovalAmt := 50			
	80	2080	Harvest	RemRuleIndex := 3	RemAmtIndex := 3	SpeciesIndex := 1	HtDbhRatio := False	LowerLimit := 1.3	UpperLimit := 1.75	RemovalAmt := 50			
	80	2080	Record	Sheet := Stand									
	80	2080	Grow	Schedule := 5									
	85	2085	Regen	stOrigin := 2	StandAge := 85	Seed := 0.7607	StandParsList := [Aw 3 22 800 1.0 0.1 2.1 0.2 0.8 *]						
	85	2085	Grow	Schedule := 5									
	90	2090	Grow	Schedule := 5									
	95	2095	Grow	Schedule := 5									
	100	2100	Record	Sheet := Stand									
	100	2100	Regen	stOrigin := 2	StandAge := 100	Seed := 0.7607	StandParsList := [Sw 7 22 500 3.1 0.6 2.5 0.5 0.8 *]						
	100	2100	Harvest	RemRuleIndex := 3	RemAmtIndex := 3	SpeciesIndex := 2	HtDbhRatio := False	LowerLimit := 1.3	UpperLimit := 1.75	RemovalAmt := 25			
	100	2100	Harvest	RemRuleIndex := 3	RemAmtIndex := 3	SpeciesIndex := 1	HtDbhRatio := False	LowerLimit := 1.3	UpperLimit := 1.75	RemovalAmt := 16			
	100	2100	Record	Sheet := Stand									
	100	2100	Grow	Schedule := 5									
	105	2105	Grow	Schedule := 5									
	110	2110	Grow	Schedule := 5									
	115	2115	Grow	Schedule := 5									
	120	2120	Regen	stOrigin := 2	StandAge := 120	Seed := 0.7607	StandParsList := [Aw 17 22 400 7.7 0.8 8.5 0.8 0.8 *]						
	120	2120	Record	Sheet := Stand									
	120	2120	Grow	Schedule := 5									
	125	2125	Grow	Schedule := 5									
	130	2130	Grow	Schedule := 5									
	135	2135	Grow	Schedule := 5									
	140	2140	Record	Sheet := Stand									
	140	2140	Grow	Schedule := 5									
	145	2145	Grow	Schedule := 5									
	150	2150	Grow	Schedule := 5									
	155	2155	Grow	Schedule := 5									
	160	2160	Record	Sheet := Stand									
	160	2160	Grow	Schedule := 5									
	165	2165	Grow	Schedule := 5									
	170	2170	Grow	Schedule := 5									
	175	2175	Grow	Schedule := 5									
	180	2180	Record	Sheet := Stand									
	180	2180	Grow	Schedule := 5									
	185	2185	Grow	Schedule := 5									
	190	2190	Grow	Schedule := 5									
	195	2195	Grow	Schedule := 5									
	200	2200	Record	Sheet := Stand									
	200	2200	Grow	Schedule := 5									
	205	2205	Grow	Schedule := 5									
	210	2210	Grow	Schedule := 5									
	215	2215	Grow	Schedule := 5									
	220	2220	Record	Sheet := Stand									
	220	2220	Grow	Schedule := 5									
	225	2225	Grow	Schedule := 5									
	230	2230	Grow	Schedule := 5									
	235	2235	Grow	Schedule := 5									
	240	2240	Record	Sheet := Stand									
	240	2240	Grow	Schedule := 5									
	245	2245	Grow	Schedule := 5									
	250	2250	Grow	Schedule := 5									
	255	2255	Grow	Schedule := 5									
	260	2260	Record	Sheet := Stand									
	260	2260	Grow	Schedule := 5									
	265	2265	Grow	Schedule := 5									
	270	2270	Grow	Schedule := 5									
	275	2275	Grow	Schedule := 5									
	280	2280	Record	Sheet := Stand									
	280	2280	Grow	Schedule := 5									
	285	2285	Grow	Schedule := 5									
	290	2290	Grow	Schedule := 5									
	295	2295	Grow	Schedule := 5									
	300	2300	Record	Sheet := Stand									
	300	2300	Record	Sheet := Yields									
	300	2300	MultiGraph	PlotColumn := 4	PlotHeader := D_Den								
	300	2300	End										

Curve 9 - Stratum AwSw - Underplant of Sw in Overmature AwSw

Crop Plan	77	aspenspruce9-4-13				3/25/2002	11:45:15 AM					
Crop Plan		**aspenspruce9-4-13**	3/25/02 11:45 AM	**Running**				C:\mgm98\				
	Stand Age	**Year**	**Event**	**Settings**								
			Crop Plan									
	0	1997	Record	Sheet := Clear								
	0	2000	Initialize	DistrbYear := 2000	CropPlanID := aspenspruce9-4-13							
	0	2000	Options	ERSwitch := 1	ERIndex := 1	_MinDbh := 13.6	_topdib := 11	_StumpHt := 0.3	SiteCurvesIndex := 2	AllowIngrowth := True	_VolumeLoss := 0	UsePLM := False
	60	2060	Establish	stOrigin := 3	StandAge := 60	TreeSource := awsw60	ExtSourceIndex := 1					
	60	2060	Record	Sheet := Crop Plan								
	60	2060	Record	Sheet := Stand								
	60	2060	Grow	Schedule := 5								
	65	2065	Grow	Schedule := 5								
	70	2070	Grow	Schedule := 5								
	75	2075	Grow	Schedule := 5								
	80	2080	Record	Sheet := Stand								
	80	2080	Grow	Schedule := 5								
	85	2085	Grow	Schedule := 5								
	90	2090	Grow	Schedule := 5								
	95	2095	Grow	Schedule := 5								
	100	2100	Record	Sheet := Stand								
	100	2100	Regen	stOrigin := 2	StandAge := 100	Seed := 0.7607	StandParsList := [Sw 7 22 500 3.1 0.6 2.5 0.5 0.8 *]					
	100	2100	Harvest	RemRuleIndex := 3	RemAmtIndex := 3	SpeciesIndex := 2	HtDbhRatio := False	LowerLimit := 1.3	UpperLimit := 1.75	RemovalAmt := 99		
	100	2100	Harvest	RemRuleIndex := 3	RemAmtIndex := 3	SpeciesIndex := 1	HtDbhRatio := False	LowerLimit := 1.3	UpperLimit := 1.75	RemovalAmt := 25		
	100	2100	Record	Sheet := Stand								
	100	2100	Grow	Schedule := 5								
	105	2105	Grow	Schedule := 5								
	110	2110	Regen	stOrigin := 2	StandAge := 110	Seed := 0.7607	StandParsList := [Aw 8 22 1000 3.9 0.4 4.3 0.4 0.8 *]					
	110	2110	Grow	Schedule := 5								
	115	2115	Grow	Schedule := 5								
	120	2120	Record	Sheet := Stand								
	120	2120	Grow	Schedule := 5								
	125	2125	Grow	Schedule := 5								
	130	2130	Grow	Schedule := 5								
	135	2135	Grow	Schedule := 5								
	140	2140	Record	Sheet := Stand								
	140	2140	Grow	Schedule := 5								
	145	2145	Grow	Schedule := 5								
	150	2150	Grow	Schedule := 5								
	155	2155	Grow	Schedule := 5								
	160	2160	Record	Sheet := Stand								
	160	2160	Grow	Schedule := 5								
	165	2165	Grow	Schedule := 5								
	170	2170	Grow	Schedule := 5								
	175	2175	Grow	Schedule := 5								
	180	2180	Record	Sheet := Stand								
	180	2180	Grow	Schedule := 5								
	185	2185	Grow	Schedule := 5								
	190	2190	Grow	Schedule := 5								
	195	2195	Grow	Schedule := 5								
	200	2200	Record	Sheet := Stand								
	200	2200	Grow	Schedule := 5								
	205	2205	Grow	Schedule := 5								
	210	2210	Grow	Schedule := 5								
	215	2215	Grow	Schedule := 5								
	220	2220	Record	Sheet := Stand								
	220	2220	Grow	Schedule := 5								
	225	2225	Grow	Schedule := 5								
	230	2230	Grow	Schedule := 5								
	235	2235	Grow	Schedule := 5								
	240	2240	Record	Sheet := Stand								
	240	2240	Grow	Schedule := 5								
	245	2245	Grow	Schedule := 5								
	250	2250	Grow	Schedule := 5								
	255	2255	Grow	Schedule := 5								
	260	2260	Record	Sheet := Stand								
	260	2260	Grow	Schedule := 5								
	265	2265	Grow	Schedule := 5								
	270	2270	Grow	Schedule := 5								
	275	2275	Grow	Schedule := 5								
	280	2280	Record	Sheet := Stand								
	280	2280	Grow	Schedule := 5								
	285	2285	Grow	Schedule := 5								
	290	2290	Grow	Schedule := 5								
	295	2295	Grow	Schedule := 5								
	300	2300	Record	Sheet := Stand								
	300	2300	Record	Sheet := Yields								
	300	2300	MultiGraph	PlotColumn := 4	PlotHeader := D_Den							
	300	2300	End									

Curve 3 - Stratum SwAw - Natural

Crop Plan	50	swaw3-13				3/25/2002	12:16:28 PM				
Crop Plan		**swaw3-13**		3/25/02 12:16 PM	**Running**				C:\mgm98\		
	Stand Age	**Year**	**Event**	**Settings**							
			Crop Plan								
	0	1997	Record	Sheet := Clear							
	0	2000	Initialize	DistrbYear := 2000	CropPlanID := swaw3-13						
	0	2000	Options	ERSwitch := 1	ERIndex := 1	_MinDbh := 13.6	_topdib := 11	_StumpHt := 0.3	SiteCurvesIndex := 2	AllowIngrowth := True	_VolumeLoss := 0	UsePLM := False
	50	2050	Establish	stOrigin := 2	StandAge := 50	Seed := 0.7607	StandParsList := [Sw 35 20 450 13.6 2.7 10.9 2.2 0.8 *,Aw 40 20 1000 13.8 1.4 15.1 1.5 0.8 *]					
	50	2050	Record	Sheet := Crop Plan								
	50	2050	Record	Sheet := Stand								
	50	2050	Grow	Schedule := 5								
	55	2055	Grow	Schedule := 5								
	60	2060	Record	Sheet := Stand								
	60	2060	Grow	Schedule := 5								
	65	2065	Grow	Schedule := 5								
	70	2070	Grow	Schedule := 5								
	75	2075	Grow	Schedule := 5								
	80	2080	Record	Sheet := Stand								
	80	2080	Grow	Schedule := 5								
	85	2085	Grow	Schedule := 5								
	90	2090	Grow	Schedule := 5								
	95	2095	Grow	Schedule := 5								
	100	2100	Record	Sheet := Stand								
	100	2100	Grow	Schedule := 5								
	105	2105	Grow	Schedule := 5								
	110	2110	Grow	Schedule := 5								
	115	2115	Grow	Schedule := 5								
	120	2120	Record	Sheet := Stand								
	120	2120	Grow	Schedule := 5								
	125	2125	Grow	Schedule := 5								
	130	2130	Grow	Schedule := 5								
	135	2135	Grow	Schedule := 5								
	140	2140	Record	Sheet := Stand								
	140	2140	Grow	Schedule := 5								
	145	2145	Grow	Schedule := 5								
	150	2150	Grow	Schedule := 5								
	155	2155	Grow	Schedule := 5								
	160	2160	Record	Sheet := Stand								
	160	2160	Grow	Schedule := 5								
	165	2165	Grow	Schedule := 5								
	170	2170	Grow	Schedule := 5								
	175	2175	Grow	Schedule := 5								
	180	2180	Record	Sheet := Stand								
	180	2180	Grow	Schedule := 5								
	185	2185	Grow	Schedule := 5								
	190	2190	Grow	Schedule := 5								
	195	2195	Grow	Schedule := 5								
	200	2200	Record	Sheet := Stand								
	200	2200	Record	Sheet := Yields								
	200	2200	MultiGraph	PlotColumn := 4	PlotHeader := D_Den							
	200	2200	End									

Curve 14 - Stratum SwAw - Shelterwood Planting

Crop Plan	84	swaw14co-4-13				3/25/2002	12:29:02 PM						
Crop Plan		**swaw14co-4-13**		3/25/02 12:29 PM	**Running**			C:\mgm98\					
Stand Age		**Year**	**Event**	**Settings**									
			Crop Plan										
0		1997	Record	Sheet := Clear									
0		2000	Initialize	DistrbYear := 2000	CropPlanID := swaw14co-4-13								
0		2000	Options	ERSwitch := 1	ERIndex := 1	_MinDbh := 13.6	_topdib := 11	_StumpHt := 0.3	SiteCurvesIndex := 2	AllowIngrowth := True	_VolumeLoss := 0	UsePLM := False	
50		2050	Establish	stOrigin := 2	StandAge := 50	Seed := 0.7607	StandParsList := [Sw 35 20 450 13.6 2.7 10.9 2.2 0.8 *,Aw 40 20 1000 13.8 1.4 15.1 1.5 0.8 *]						
50		2050	Record	Sheet := Crop Plan									
50		2050	Record	Sheet := Stand									
50		2050	Grow	Schedule := 5									
55		2055	Grow	Schedule := 5									
60		2060	Record	Sheet := Stand									
60		2060	Grow	Schedule := 5									
65		2065	Grow	Schedule := 5									
70		2070	Grow	Schedule := 5									
75		2075	Grow	Schedule := 5									
80		2080	Record	Sheet := Stand									
80		2080	Harvest	RemRuleIndex := 3	RemAmtIndex := 3	SpeciesIndex := 2	HtDbhRatio := False	LowerLimit := 1.3	UpperLimit := 1.75	RemovalAmt := 50			
80		2080	Harvest	RemRuleIndex := 3	RemAmtIndex := 3	SpeciesIndex := 1	HtDbhRatio := False	LowerLimit := 1.3	UpperLimit := 1.75	RemovalAmt := 50			
80		2080	Record	Sheet := Stand									
80		2080	Grow	Schedule := 5									
85		2085	Regen	stOrigin := 2	StandAge := 85	Seed := 0.7607	StandParsList := [Aw 3 22 800 1.0 0.1 2.1 0.2 0.8 *]						
85		2085	Grow	Schedule := 5									
90		2090	Grow	Schedule := 5									
95		2095	Grow	Schedule := 5									
100		2100	Regen	stOrigin := 2	StandAge := 100	Seed := 0.7607	StandParsList := [Sw 7 22 500 3.1 0.6 2.5 0.5 0.8 *]						
100		2100	Record	Sheet := Stand									
100		2100	Harvest	RemRuleIndex := 3	RemAmtIndex := 3	SpeciesIndex := 2	HtDbhRatio := False	LowerLimit := 1.3	UpperLimit := 1.75	RemovalAmt := 30			
100		2100	Harvest	RemRuleIndex := 3	RemAmtIndex := 3	SpeciesIndex := 1	HtDbhRatio := False	LowerLimit := 1.3	UpperLimit := 1.75	RemovalAmt := 26			
100		2100	Record	Sheet := Stand									
100		2100	Grow	Schedule := 5									
105		2105	Grow	Schedule := 5									
110		2110	Grow	Schedule := 5									
115		2115	Grow	Schedule := 5									
120		2120	Regen	stOrigin := 2	StandAge := 120	Seed := 0.7607	StandParsList := [Aw 17 22 400 7.7 0.8 8.5 0.8 0.8 *]						
120		2120	Record	Sheet := Stand									
120		2120	Grow	Schedule := 5									
125		2125	Grow	Schedule := 5									
130		2130	Grow	Schedule := 5									
135		2135	Grow	Schedule := 5									
140		2140	Record	Sheet := Stand									
140		2140	Grow	Schedule := 5									
145		2145	Grow	Schedule := 5									
150		2150	Grow	Schedule := 5									
155		2155	Grow	Schedule := 5									
160		2160	Record	Sheet := Stand									
160		2160	Grow	Schedule := 5									
165		2165	Grow	Schedule := 5									
170		2170	Grow	Schedule := 5									
175		2175	Grow	Schedule := 5									
180		2180	Record	Sheet := Stand									
180		2180	Grow	Schedule := 5									
185		2185	Grow	Schedule := 5									
190		2190	Grow	Schedule := 5									
195		2195	Grow	Schedule := 5									
200		2200	Record	Sheet := Stand									
200		2200	Grow	Schedule := 5									
205		2205	Grow	Schedule := 5									
210		2210	Grow	Schedule := 5									
215		2215	Grow	Schedule := 5									
220		2220	Record	Sheet := Stand									
220		2220	Grow	Schedule := 5									
225		2225	Grow	Schedule := 5									
230		2230	Grow	Schedule := 5									
235		2235	Grow	Schedule := 5									
240		2240	Record	Sheet := Stand									
240		2240	Grow	Schedule := 5									
245		2245	Grow	Schedule := 5									
250		2250	Grow	Schedule := 5									
255		2255	Grow	Schedule := 5									
260		2260	Record	Sheet := Stand									
260		2260	Grow	Schedule := 5									
265		2265	Grow	Schedule := 5									
270		2270	Grow	Schedule := 5									
275		2275	Grow	Schedule := 5									
280		2280	Record	Sheet := Stand									
280		2280	Grow	Schedule := 5									
285		2285	Grow	Schedule := 5									
290		2290	Grow	Schedule := 5									
295		2295	Grow	Schedule := 5									
300		2300	Record	Sheet := Stand									
300		2300	Record	Sheet := Yields									
300		2300	MultiGraph	PlotColumn := 4	PlotHeader := D_Den								
300		2300	End										