Sundance Forest Industries Ltd.

Forest Management Plan 2007

Yield Curve Documentation

March 12, 2007

EXECUTIVE SUMMARY

Yield curves are required for use in the timber supply analysis that accompanies Forest Management Plan development. This report documents the development of yield curves for the Sundance Forest Industries Ltd. Forest Management Agreement area, for use in the 2007 Forest Management Plan.

Contained in this document are detailed methodologies for fitting volume-age yield curves, including rules for stratification, plot attribute assignment, plot deletions, volume compilation methods, and modelling techniques. Resulting yield curves, volume tables, model parameters and fit statistics are also included. Summaries indicating the distribution of both plots and landbase areas are provided for comparative purposes.

Additional growth and yield- related FMP information including methods for determining cull deductions, development of piece size curves (trees/m^3), and calculation of regeneration lag is also provided.

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1. Overview

1.1 Background

This document describes the *yield curve* development undertaken by Sundance Forest Industries Ltd. (Sundance) in order to meet the requirements of the Alberta Sustainable Resource Development (SRD) Forest Management Planning Standard (ASRD 2006).

The extent of the *gross landbase*[1] is all lands within the outer boundaries of the Forest Management Agreement (FMA) area for Sundance, also known as Forest Management Unit (FMU) R13.

Yield curves are required for use in the *timber supply analysis* that accompanies Forest Management Plan development. This report documents the development of yield curves for Sundance's *managed landbase*, for use in their 2007 Forest Management Plan.

This document describes the methods utilized for yield curve development and presents their results. Accompanying this document is a Regulated Forestry Professional (RFP) checklist derived from the Alberta Forest Management Planning Standard, Version 4.1 (ASRD 2006) relating to yield curve development and documentation deliverables.

1.2 Yield Stratification

The term *FMP yield stratum* refers specifically to *yield stratification* used in the 2007 FMP. FMP yield strata are applied to all stands in the *forested landscape* (i.e., stratum assignments are made to forested *polygons* only).

[1] Terms defined in the glossary are italicized the first time that they are used in this document.

FMP yield stratum assignment was based on layer 1 (overstory), layer 2 (understory), or composite AVI attributes for productive horizontal stands. Stratum assignment was primarily based on layer 1 AVI attributes, with the following exceptions:

- *Non-forested* overstory with a forested understory (use layer 2 AVI attributes);
- Multistory or complex stands with an A density overstory layer and B, C, or D density understory layer (use layer 2 AVI attributes);
- Horizontal stands with non-productive layer 1 (use layer 2 attributes); or
- Horizontal stands with productive layers 1 and 2 (use composite AVI attributes).

The layer used for assigning FMP yield strata is referred to as the *defining layer* (see Section 2.3).

Nine yield strata were identified for the 2007 FMP. FMP yield strata were assigned based on *broad cover group* and leading coniferous *species group* from the defining layer. A generalized description of the stratification rules is presented in Table 1-1. Full details on FMP yield stratum assignment are provided in Chapter 2.

Table 1-1. FMP yield strata for the 2007 FMP.

FMP Yield Stratum	Broad Cover Group	Leading Coniferous Species Group[1]	Leading Deciduous Species Group[1]	Crown Closure Class	Description
AP	DC	PL	n/a	ABCD	Deciduous leading pine mixedwood
AS	DC	SW, SB, FB	n/a	ABCD	Deciduous leading spruce mixedwood
DEC	D	n/a	AW, PB, BW	ABCD	Aspen or poplar or birch leading deciduous stand
PA	CD	PL	n/a	ABCD	Coniferous leading pine mixedwood
PL	C	PL	n/a	ABCD	Black spruce leading conifer stand
SA	CD	SW, SB, FB	n/a	ABCD	Coniferous leading spruce mixedwood
SB	C	SB	n/a	ABCD	Pine leading conifer stand
SW	C	SW, FB	n/a	ABCD	White spruce leading conifer stand

[1] Assignment of leading species group is described in Chapter 2.

1.3 Yield Curves

A series of yield curves[2] were fit for each yield stratum. The following is a summary of the yield curves that were developed for the 2007 FMP; detailed descriptions of yield curve development are provided in Chapters 2 to 4.

Natural Stand Yield Curves. *Natural stand yield curves* were developed for each FMP yield stratum. Deciduous and coniferous volumes were fit as a function of *stand* age. FMP yield stratum and stand age were taken from the defining layer.

[2] The term yield curve is used to represent a set of three separate curves: a volume-age curve for coniferous volume, a volume-age curve for deciduous volume, and a volume-age curve for total volume.

Managed Stand Yield Curves. *Managed stand yield curves* were developed for just three FMP yield strata – PL, DEC, and SW. Managed stand yield curves were developed using data from *natural stands* with a C or D density crown closure class as a proxy for *managed stands* (which regenerate to *fully stocked* conditions under current management practices). The same methods used for fitting base natural curves were applied to develop base managed curves.

Composite Yield Curves. Six *composite yield curves* (area-weighted yield curves) were developed for natural stands in the managed landbase: four by broad cover group (i.e., D, DC, CD, and C), one to represent the combined coniferous (C/CD/DC) landbase, and one to represent the total landbase (C/CD/DC/D).

Piece Size Curves. *Piece size* curves were developed for each FMP yield stratum except LT. The number of trees per cubic meter was fit as a function of stand age for deciduous and coniferous species separately. FMP yield stratum and stand age were taken from the defining layer.

2. Stratification

2.1 Overview

FMP yield strata are the basic units for forest management in the 2007 FMP. Strata are also the units upon which yield curves are based; as such, *plot* data must be assigned to a FMP yield stratum for empirical yield curve development.

Since yield curves are applied to *landbase polygons*, the rules for assigning attributes to plots must be consistent with the rules used to assign attributes to the landbase. In order to maintain absolute consistency between plot attribute assignment and landbase attribute assignment, plots were linked to the landbase to assign attributes, rather than using two parallel assignment processes.

Information on how plots were linked to the landbase is provided in Chapter 3; this section describes how FMP yield strata were assigned to the landbase polygons in order to obtain attribute assignments.

Note that while this section describes how the landbase is classified into FMP yield strata, it does not discuss how the landbase is classified into the managed vs. *unmanaged landbase*, or how *stand type* (natural and managed) is assigned. For more information on these aspects of landbase classification, please refer to "Forest Management Plan 2007: Development of the Landbase" (Sundance 2007).

Figure 2-1 provides an overview of the process for assigning FMP yield strata. This process is explained in detail in the sections that follow.

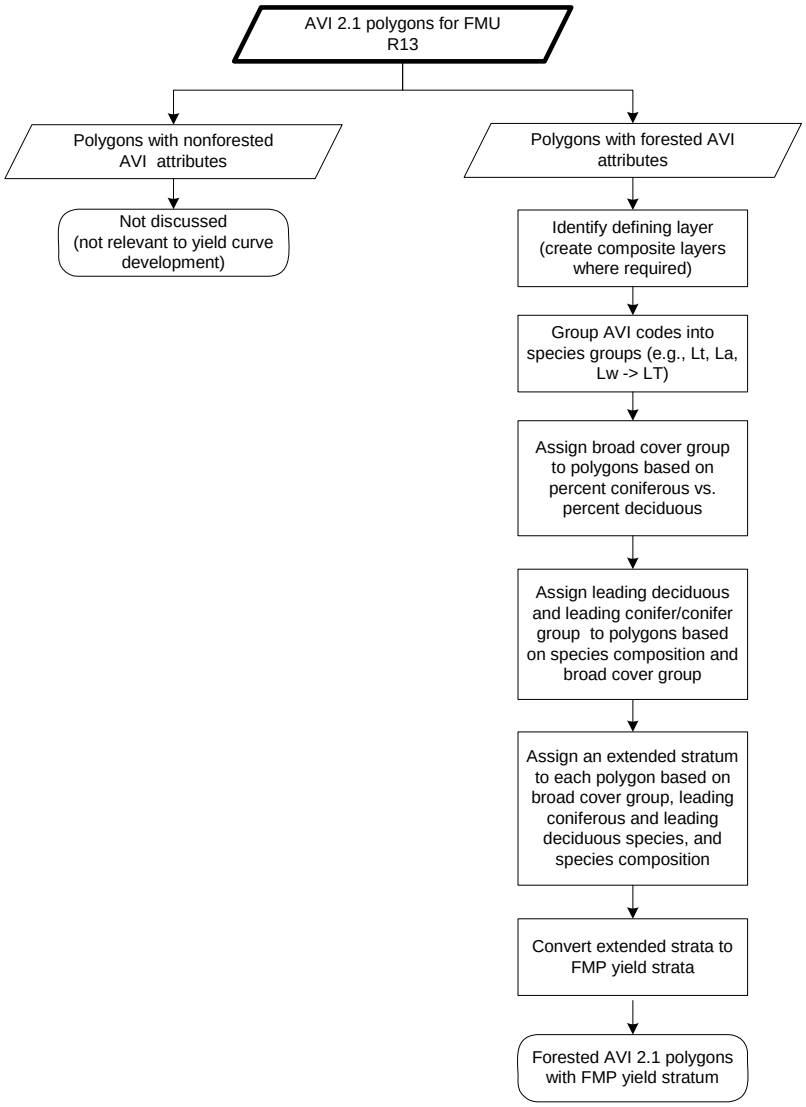

Figure 2-1. Overview of the FMP yield stratum assignment process.

2.2 Identifying Forested Polygons

Stratification was based on Alberta Vegetation Inventory (AVI) 2.1 polygon attributes (AFLW 1991). The first step in assigning FMP yield strata was to identify the polygons of interest. FMP yield strata were assigned to forested polygons only, since these are the areas that would potentially be managed for timber. Polygons with a natural or anthropogenic nonforested code in the defining layer were deemed nonforested, and were not included in the FMP yield stratum assignment process. All other polygons were deemed forested and were assigned to a FMP yield stratum as described in the following sections.

2.3 Selecting a Defining Layer

2.3.1 AVI Defining Layer

In order to classify forested polygons, a defining layer (layer used for stratification) was identified. The defining layer for a polygon could be the overstory layer (layer 1), the understory layer (layer 2), or a combination of the two (*composite layer*). The intent of selecting a defining layer based on attributes of one or more chosen layers was to best represent the forest being managed.

The defining layer was selected based on *AVI polygon* attributes. The AVI attributes used to determine the defining layer include stand structure type (single storied, complex, horizontal, or multistoried), structure value (for horizontal stands, the proportion of area in AVI layer 1 vs. AVI layer 2), height, crown closure class (density), and presence of forested species. A decision key used to assign the defining layer is presented in Figure 2-2.

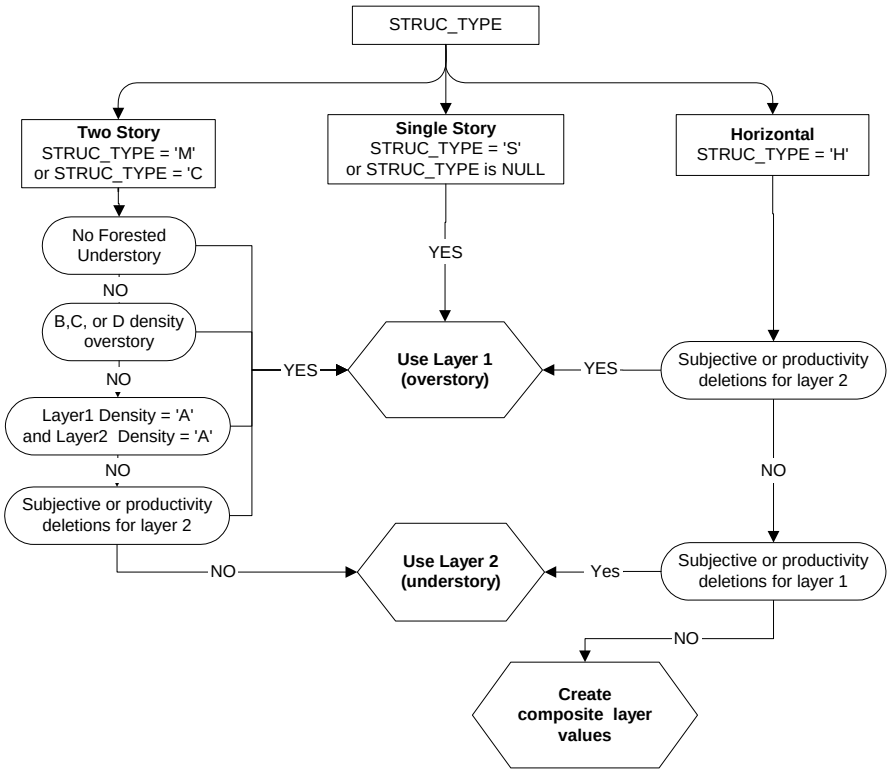

Figure 2-2. Rules for determining the defining layer.

2.3.2 Multi-story Stands with Forested Understory

Stands with a forested understory were evaluated to determine the appropriate layer to use for classification. Multi-storied stands with an overstory density of 'B','C' or 'D' were classified using layer 1. Multi-storied stands with an overstory density of 'A' and an understory with a density higher than 'A' and no subjective or productivity deletions assigned were classified by

layer 2. Figure 2-2 outlines the process to determine which information was used to assign strata.

2.3.3 Horizontal Stands

Horizontal stand structure was added as a structure type and identified as a means to aid in future timber volume sampling in the Alberta Vegetation Inventory Standards Manual (AFLW 1991). Stands assigned a structure of horizontal had numerous homogeneous stands within other distinctly different homogeneous stands where both or each individual stand is too small to delineate independently (generally, less than 2 hectares) (AFLW 1991). The stand detail is not identified spatially within the stand polygon. If a portion of the stand is not part of the managed landbase this area cannot be spatially identified. In the landbase classification this is often dealt with by tracking the area for this portion as a horizontal stand deletion area. When both portions of the horizontal stand are productive this would result in a loss of productive area. As shown in Figure 2-2 horizontal stands are represented by a combination of attributes from both layer 1 and layer 2 where both layers are productive.

A procedure to develop a set of composite attributes was developed to properly account for information from both layers in horizontal stands where both layers were forested and part of the managed landbase. Once a composite, single set of attributes was developed, the stands were processed by the same set of rules developed for single and multi-layer stands.

Productivity and subjective deletions to horizontal stands

Each layer of the horizontal stand was evaluated individually to identify the productive layers. Status codes reflecting subjective deletions and unproductive stands were assigned to each layer. Table 2-1 shows the assignment and codes for layer 1 of a horizontal stand. The process for layer 2 is the same however the selection criteria will use the fields from the "understory".

Table 2-1. Horizontal stand layer deletion assignment.

CSUBJ1	Description	Selection Criteria	Order
	Assignment for horizontal stands only	All selection for only STRUC_TYPE = 'H'	
'U'	Unproductive layer	TPR = 'U'	1
'X'	Non-productive (no forested strata)	STRATA_SRD = 'X'	2
'LT'	Larch stands	STRATA_SRD = 'C12'	3
'ASB'	A' density black spruce	STRATA_SRD = ('C9','C10','C11') and DENSITY = 'A'	4
'NCSB'	Non-commercial black spruce	STRATA_SRD = ('C9','C10','C11') and (HGT <= 6 and AGE >= 55 or HGT <= 12 and AGE >= 75 or HGT <= 18 and AGE >= 105)	5
'H'	Productive layer (no deletions)		6

STRATA_SRD is SRD extended strata (See Section 2.4.6).

The codes from each layer were combined into a single code that was used to determine how the horizontal stand would be assigned. Stands with only one productive layer were assigned attributes of the productive layer and the area updated based on the *STRUC_PCT* or portion of the stand that is productive. Table 2-2 shows examples. As shown in Example 'B' in the table a horizontal stand with a noncommercial black spruce layer 1 and a productive layer 2 would be

classed based on layer 2 and the area reduced by the structure percent to reflect only the productive horizontal stand area.

Table 2-2. Horizontal stand defining layer assignment.

Example	STRUC_PCT	USTRUC_PCT	Polygon Area (ha)	CSUBJ1	CSUBJ2	CSUBJ	Defining Layer	Landbase Area (ha)
A	7	3	100	LT	U	H_LT_U	1	100
B	7	3	100	NCSB	H	H1_NCSB	2	30
C	7	3	100	H	ASB	H2_ASB	1	70
D	7	3	100	H	H	HCOMP	3	100

Where both layers of a horizontal stand are productive the stand was processed as a composite stand and attributes reflect a combination of the attributes for each layer.

A composite layer was created for all horizontal stands with two forested layers where the second layer had no productivity or subjective deletions. A set of composite layer attributes was generated by combining both layer attributes for crown closure class, height class, species composition, stand origin and *timber productivity rating*. As shown in Figure 2-2 composite layer values will be calculated only for stands that meet all of the following conditions:

- STRUC_TYPE = 'H'
- Both "overstory" and "understory" layers in inventory are forested and productive, CSUBJ1 = 'H' and CSUBJ2 = 'H'.

Stands that meet these criteria will be assigned stand and species composition values that combine attributes from both the "overstory" and "understory" AVI layers. Composite values of the following AVI fields will be created and used to characterize the stand:

- DENSITY
- HEIGHT
- ORIGIN
- TPR
- SP1 to SP6
- SP1P to SP6P

Midpoint density values

Each horizontal layer is weighted by the portion of the stand area it represents. Composite values also need to reflect the relative density of each portion of the stand. This is done with a numeric representation of the crown closure class. The fields for *MIDPT* and *UMIDPT* are additional numeric fields that represent the midpoint of the crown closure class as outlined in Table 2-3. These numbers are used to apportion attributes from the two layers of a horizontal stand to create composite stand values as shown in the following sections.

Table 2-3. Midpoint values of crown closure class.

Crown Closure Class	Range of Crown Closure	Midpoint of Class
A	6 - 30 %	18
B	31 - 50 %	40
C	51 - 70 %	60
D	71 - 100 %	85

The *CMIDPT* field is the single value that combines the crown closure values for overstory and understory by proportion as based on *STRUC_PCT*. It is calculated as:

$$CMIDPT = ((STRUC\_PCT / 10) * MIDPT) + ((USTRUC\_PCT / 10) * UMIDPT)$$

2.3.4 Creating Composite Layers

Composite attributes had to be created for polygons with a composite defining layer. Composite layers were developed by combining AVI 2.1 overstory and understory attributes, generally involving some form of weighting. The following sections describe how composite attributes were developed for the polygons requiring a composite defining layer.

Crown Closure Class

Composite crown closure class is assigned based on overstory and understory crown closure class, stored in the DENSITY and UDENSITY fields. Density (represented by the midpoint value) for each layer is assigned based on the proportion of the stand it occupies. The calculated value for *CMIDPT* is assigned a crown closure class according to the range it falls within (see Table 2-3).

Height

Composite height for the defining layer is developed by weighting both the understory and overstory heights by their respective crown closure classes and percent of stand area. The midpoint value for each crown closure class (Table 2-3) is used to proportion stand values. The composite height is calculated as follows:

$$CHEIGHT = \frac{(HEIGHT * MIDPT * (STRUC\_PCT / 10)) + (UHEIGHT * UMIDPT * (USTRUC\_PCT / 10))}{(MIDPT * (STRUC\_PCT / 10) + UMIDPT * (USTRUC\_PCT / 10))}$$

Where:
CHEIGHT = composite layer height in m
HEIGHT = height of the AVI layer 1
UHEIGHT = height of the AVI layer 2
MIDPT = midpoint of the layer 1 crown closure class
UMIDPT = midpoint of the layer 2 crown closure class
STRUC_PCT = percent of area for horizontal stand (10-percent class)

Composite height is then rounded to the nearest meter.

Origin

Composite origin is assigned by weighting the year of origin for both layers by the percent of the stand they represent. The composite origin is calculated as follows:

$$CORIGIN = \left((STRUC\_PCT / 10) * ORIGIN\right) + \left((USTRUC\_PCT / 10) * UORIGIN\right)$$

A composite age (*CAGE)* is calculated for the FMP from a base year of 2005 where age is calculated as 2005 minus the origin year.

$$CAGE = \left((STRUC\_PCT / 10) * AGE\right) + \left((USTRUC\_PCT / 10) * UAGE\right)$$

Timber Productivity Rating

Within the AVI, timber productivity rating (TPR) was originally assigned to each layer based on the height and age of the leading species (species 1). TPR reflects the potential of the site to grow timber, therefore the most productive TPR was assigned to the composite layer.

Species Composition

Some species codes are grouped together as shown in Table 2-4.

Table 2-4. Assignment of species group.

Species Type	Species Group	Description	AVI Species Codes
Deciduous	AW	Aspen	A, Aw
	BW	Birch	Bw
	PB	Poplar	Pb
Conifer	FB	True fir	Fb, Fa
	FD	Douglas-fir	Fd
	LT	Larch	Lt, La, Lw
	PL	Pine	P, Pl, Pj, Pa, Pf
	SB	Black spruce	Sb
	SW	White spruce	Sw, Se

The species group percents for the composite layer are calculated based on the combined species percentages in the overstory and understory. The percent by species is calculated separately for each species in the overstory and understory.

After calculating individual species percents for each layer a composite percent for each species is calculated which is weighted by the midpoint of the crown closure class and both layers are combined to provide the overall percentages for each species; e.g., for white spruce:

$$CSW\_PCT = \frac{\left(SW\_PCT * MIDPT * (STRUC\_PCT / 10)\right) + \left(USW\_PCT * UMIDPT * (USTRUC\_PCT / 10)\right)}{\left(MIDPT * (STRUC\_PCT / 10) + UMIDPT * (USTRUC\_PCT / 10)\right)}$$

Where: *CSW_PCT* = composite percent SW (10-percent AVI class, no rounding)
SW_PCT = percent SW, AVI layer1 (10-percent AVI class)
USW_PCT = percent SW, AVI layer 2 (10-percent AVI class)
MIDPT = midpoint of the layer 1 crown closure class

UMIDPT = midpoint of the layer 2 crown closure class
STRUC_PCT = percent of area for horizontal stand (10-percent class)

The composite species group percents are then ranked in order of descending percent from species 1 to species 6 (if needed). If two species have the same composite percent, species present in layer 1 takes priority over those in layer 2, and the original species order takes precedence where both species were present in the same layer. Species percents are not rounded.

Composite values for species percents, species orders, softwood and hardwood percents, age, leading species and broad cover group were assigned to FMP yield strata with the same process outlined in Section 2.4.

2.4 Assigning an FMP Yield Stratum to the Defining Layer

This section describes the process by which the attributes from the defining layer were used to assign FMP yield strata. In order to assign FMP yield strata, a series of steps were involved. First, AVI species were grouped into species groups, and broad cover group was assigned. Using this information, *extended strata* were assigned; these were combined to form species strata, which were then either combined, split or directly assigned to FMP yield strata.

2.4.1 Species Group

For the purposes of amalgamating similar species, individual species (AVI species codes) were combined into species groups within *species type* (deciduous and coniferous) (Table 2-4)

The species percents from AVI where AVI species codes matched the species group were summed to generate the species distribution. Percent values were the same as AVI classes (*SP1P* to *SP5P*) where classes 1 to 10 represented values 1 to 100 where each class represents 10 percent.

2.4.2 Species Order

The stratification rules in the following section consider the order of species as one of the decision criteria. To simplify coding the appropriate species order value was updated for each of the species in *SP1* to *SP5* fields. When a species was not present it was assigned an order value of 9.

2.4.3 Species Type Percent

Deciduous species types (See Table 2-4) were summed to generate the deciduous (*HARDPCT*) species percents, and coniferous (*SOFTPCT*) species percents were subtracted *HARDPCT* from 100.

2.4.4 Leading Species by Species Type

The first listed deciduous species was stored as *LEAD_DEC* and can be identified as the minimum species order among *AW_PCT*, *BW_PCT* and *PB_PCT*. Where *HARDPCT* was 0, 'NO' was listed as the leading deciduous species. The first listed conifer species was stored as *LEAD_CON* and calculated as the minimum order among conifer species. Where *SOFTPCT* was 0, 'NO' was listed as the leading conifer species.

2.4.5 Broad Cover Group

The species group and the species distribution (as calculated from the AVI species percent classes) were used to calculate the broad cover group for a forested layer (Table 2-5).

Table 2-5. Broad cover group assignment using deciduous and coniferous species percent.

Broad Cover Group	Percent Deciduous	Percent Coniferous	Description
D	? 80	< 20	Deciduous
DC[1]	50-79	21-50	Deciduous-leading mixedwood
CD[1]	21-50	50-79	Coniferous-leading mixedwood
C	< 20	? 80	Coniferous

[1] A 50/50 split is assigned to CD if SP1 is coniferous and DC if SP1 is deciduous.

2.4.6 Extended Strata

Extended strata are defined in the Alberta Forest Management Planning Standard (SRD 2006). In order to assign extended strata, an intermediary step was required. This step identified leading deciduous species (DRULE) and the leading coniferous species or combination of coniferous species (CRULE) as a function of broad cover group and species composition.

The first listed deciduous species was deemed the leading deciduous species. The assignment of leading coniferous species was more complex, and was based on relative percent composition by species.

The rules for assignment are presented in Table 2-6 and Table 2-7.

Table 2-6. Rules for assigning DRULE based on BCG and species composition.

DRULE	Description	Selection Criteria
'AW_LEAD'	Aspen leading deciduous	*HARDPCT* > 0 and *AW_ORD* < *BW_ORD* and *AW_ORD* < *PB_ORD*
'BW_LEAD'	Birch leading deciduous	*HARDPCT* > 0 and *BW_ORD* < *AW_ORD* and *BW_ORD* < *PB_ORD*
'PB_LEAD'	Poplar leading deciduous	*HARDPCT* > 0 and *PB_ORD* < *AW_ORD* and *PB_ORD* < *BW_ORD*
'NO_D'	No deciduous present	*HARDPCT* = 0

Table 2-7. Rules for assigning CRULE based on BCG and species composition.

CRULE	Description	Selection Criteria
'FBFD_LEAD_MW'	True fir or Douglas-fir leading conifer in mixedwood	*C_CODE* = ('DC', 'CD') and (((*FB_PCT* + *FD_PCT*) > *PL_PCT* and (*FB_PCT* + *FD_PCT*) > (*SB_PCT* + *LT_PCT*) and (*FB_PCT* + *FD_PCT*) > *SW_PCT*) or (*LEAD_CON* = ('FB','FD') and (*FB_PCT* + *FD_PCT*) >= *PL_PCT* and (*FB_PCT* + *FD_PCT*) >= (*SB_PCT* + *LT_PCT*) and (*FB_PCT* + *FD_PCT*) >=
'PL_LEAD_MW'	Pine leading conifer in mixedwood	*C_CODE* = ('DC', 'CD') and ((*PL_PCT* > (*FB_PCT* + *FD_PCT*) and *PL_PCT* > (*SB_PCT* + *LT_PCT*) and *PL_PCT* > *SW_PCT*) or (LEAD_CON = 'PL' and *PL_PCT* >= (*FB_PCT* + *FD_PCT*) and *PL_PCT* >= (*SB_PCT* + *LT_PCT*) and *PL_PCT* >= *SW_PCT*))
'SBLT_LEAD_MW'	Black spruce or larch leading conifer in mixedwood	*C_CODE* = ('DC', 'CD') and (((*SB_PCT* + *LT_PCT*) > (*FB_PCT* + *FD_PCT*) and (*SB_PCT* + *LT_PCT*) > *PL_PCT* and (*SB_PCT* + *LT_PCT*) > *SW_PCT*) or (*LEAD_CON* = ('SB', 'LT') and (*SB_PCT* + *LT_PCT*) >= (*FB_PCT* + *FD_PCT*) and (*SB_PCT* + *LT_PCT*) >= *PL_PCT* and (*SB_PCT* + *LT_PCT*)
'SW_LEAD_MW'	White spruce leading conifer in mixedwood	*C_CODE* = ('DC', 'CD') and ((*SW_PCT* > (*FB_PCT*+*FD_PCT*) and *SW_PCT* > *PL_PCT* and *SW_PCT* > (*SB_PCT* + *LT_PCT*)) or (*LEAD_CON* = 'SW' and *SW_PCT* >= (*FB_PCT*+*FD_PCT*) and *SW_PCT* >= *PL_PCT* and *SW_PCT* >= (*SB_PCT* + *LT_PCT*)))
'FB_LEAD'	True fir leading conifer in pure stand	*C_CODE* = ('C', 'D') and ((*FB_PCT* > *FD_PCT* and *FB_PCT* > *LT_PCT* and *FB_PCT* > *PL_PCT* and *FB_PCT* > *SB_PCT* and *FB_PCT* > *SW_PCT*) or (*LEAD_CON* = 'FB' and *FB_PCT* >= *FD_PCT* and *FB_PCT* >= *LT_PCT* and *FB_PCT* >= *PL_PCT* and *FB_PCT* >= *SB_PCT* and *FB_PCT* >= *SW_PCT*))
'FD_LEAD'	Douglas-fir leading conifer in pure stand	*C_CODE* = ('C', 'D') and ((*FD_PCT* > *FB_PCT* and *FD_PCT* > *LT_PCT* and *FD_PCT* > *PL_PCT* and *FD_PCT* > *SB_PCT* and *FD_PCT* > *SW_PCT*) or (*LEAD_CON* = 'FD' and *FD_PCT* >= *FB_PCT* and *FD_PCT* >= *LT_PCT* and *FD_PCT* >= *PL_PCT* and *FD_PCT* >= *SB_PCT* and *FD_PCT* >= *SW_PCT*))
'LT_LEAD'	Larch leading conifer in pure stand	*C_CODE* = ('C', 'D') and ((*LT_PCT* > *FB_PCT* and *LT_PCT* > *FD_PCT* and *LT_PCT* > *PL_PCT* and *LT_PCT* > *SB_PCT* and *LT_PCT* > *SW_PCT*) or (*LEAD_CON* = 'LT' and *LT_PCT* >= *FB_PCT* and *LT_PCT* >= *FD_PCT* and *LT_PCT* >= *PL_PCT* and *LT_PCT* >= *SB_PCT* and *LT_PCT* >= *SW_PCT*))
'PL_LEAD'	Pine leading conifer in pure stand	*C_CODE* = ('C', 'D') and ((*PL_PCT* > *FB_PCT* and *PL_PCT* > *FD_PCT* and *PL_PCT* > *LT_PCT* and *PL_PCT* > *SB_PCT* and *PL_PCT* > *SW_PCT*) or (*LEAD_CON* = 'PL' and *PL_PCT* >= *FB_PCT* and *PL_PCT* >= *FD_PCT* and *PL_PCT* >= *LT_PCT* and *PL_PCT* >= *SB_PCT* and *PL_PCT* >= *SW_PCT*))
'SB_LEAD'	Black spruce leading conifer in pure stand	*C_CODE* = ('C', 'D') and ((*SB_PCT* > *FB_PCT* and *SB_PCT* > *FD_PCT* and *SB_PCT* > *LT_PCT* and *SB_PCT* > *PL_PCT* and *SB_PCT* > *SW_PCT*) or (*LEAD_CON* = 'SB' and *SB_PCT* >= *FB_PCT* and *SB_PCT* >= *FD_PCT* and *SB_PCT* >= *LT_PCT* and *SB_PCT* >= PL_*PCT* and *SB_PCT* >= *SW_PCT*))
'SW_LEAD'	White spruce leading conifer in pure stand	*C_CODE* = ('C', 'D') and ((*SW_PCT* > *FB_PCT* and *SW_PCT* > *FD_PCT* and *SW_PCT* > *LT_PCT* and *SW_PCT* > *PL_PCT* and *SW_PCT* > *SB_PCT*) or (*LEAD_CON* = 'SW' and *SW_PCT* >= *FB_PCT* and *SW_PCT* >= *FD_PCT* and *SW_PCT* >= *LT_PCT* and *SW_PCT* >= PL_*PCT* and *SW_PCT* >= *SB_PCT*))
'NO_C'	No coniferous present	*SOFTPCT* = 0

Based on CRULE, DRULE, broad cover group and species composition, forested polygons were then assigned to an extended stratum (Table 2-8).

Table 2-8. Assigning extended strata based DRULE, CRULE, BCG and species composition.

STRATA_SRD	Description	Selection Criteria
'D1'	Pure aspen	*C_CODE* = 'D' and *AW_PCT* >= 9
'D2'	Aspen leading with poplar	*C_CODE* = 'D' and *DRULE* = 'AW_LEAD' and *AW_PCT* < 9 and
'D3'	Aspen leading without	*C_CODE* = 'D' and *DRULE* = 'AW_LEAD' and *AW_PCT* < 9 and
'D4'	Poplar leading	*C_CODE* = 'D' and *DRULE* = 'PB_LEAD'
'D5'	Birch leading	*C_CODE* = 'D' and *DRULE* = 'BW_LEAD'
'DC1'	Aspen/white spruce	*C_CODE* = 'DC' and *DRULE* = 'AW_LEAD' and *CRULE* =
'DC2'	Aspen/pine	*C_CODE* = 'DC' and *DRULE* = 'AW_LEAD' and *CRULE* =
'DC3'	Aspen/black spruce	*C_CODE* = 'DC' and *DRULE* = 'AW_LEAD' and *CRULE* =
'DC4'	Aspen/fir	*C_CODE* = 'DC' and *DRULE* = 'AW_LEAD' and *CRULE* =
'DC5'	Poplar/white spruce	*C_CODE* = 'DC' and *DRULE* = 'PB_LEAD' and *CRULE* =
'DC6'	Poplar/pine	*C_CODE* = 'DC' and *DRULE* = 'PB_LEAD' and *CRULE* =
'DC7'	Poplar/black spruce	*C_CODE* = 'DC' and *DRULE* = 'PB_LEAD' and *CRULE* =
'DC8'	Poplar/fir	*C_CODE* = 'DC' and *DRULE* = 'PB_LEAD' and *CRULE* =
'DC9'	Birch/white spruce	*C_CODE* = 'DC' and *DRULE* = 'BW_LEAD' and *CRULE* =
'DC10'	Birch/pine	*C_CODE* = 'DC' and *DRULE* = 'BW_LEAD' and *CRULE* =
'DC11'	Birch/black spruce	*C_CODE* = 'DC' and *DRULE* = 'BW_LEAD' and *CRULE* =
'DC12'	Birch/fir	*C_CODE* = 'DC' and *DRULE* = 'BW_LEAD' and *CRULE* =
'CD1'	White spruce/aspen	*C_CODE* = 'CD' and *CRULE* = 'SW_LEAD_MW' and *DRULE* =
'CD2'	White spruce/poplar	*C_CODE* = 'CD' and *CRULE* = 'SW_LEAD_MW' and *DRULE* =
'CD3'	White spruce/birch	*C_CODE* = 'CD' and *CRULE* = 'SW_LEAD_MW' and *DRULE* =
'CD4'	Pine/aspen	*C_CODE* = 'CD' and *CRULE* = 'PL_LEAD_MW' and *DRULE* =
'CD5'	Pine/poplar	*C_CODE* = 'CD' and *CRULE* = 'PL_LEAD_MW' and *DRULE* =
'CD6'	Pine/birch	*C_CODE* = 'CD' and *CRULE* = 'PL_LEAD_MW' and *DRULE* =
'CD7'	Black spruce/aspen	*C_CODE* = 'CD' and *CRULE* = 'SBLT_LEAD_MW' and *DRULE* =
'CD8'	Black spruce/poplar	*C_CODE* = 'CD' and *CRULE* = 'SBLT_LEAD_MW' and *DRULE* =
'CD9'	Black spruce/birch	*C_CODE* = 'CD' and *CRULE* = 'SBLT_LEAD_MW' and *DRULE* =
'CD10'	Fir/aspen	*C_CODE* = 'CD' and *CRULE* = 'FBFD_LEAD_MW' and *DRULE* =
'CD11'	Fir/poplar	*C_CODE* = 'CD' and *CRULE* = 'FBFD_LEAD_MW' and *DRULE* =
'CD12'	Fir/birch	*C_CODE* = 'CD' and *CRULE* = 'FBFD_LEAD_MW' and *DRULE* =
'C1'	Pure white spruce	*C_CODE* = 'C' and *SW_PCT* >= 9
'C2'	White spruce leading with	*C_CODE* = 'C' and *CRULE* = 'SW_LEAD' and *SW_PCT* < 9 and *PL_PCT*
'C3'	White spruce leading without pine	*C_CODE* = 'C' and *CRULE* = 'SW_LEAD' and *SW_PCT* < 9 and *PL_PCT* <= 1
'C4'	Pure pine	*C_CODE* = 'C' and *PL_PCT* >= 9
'C5'	Pine leading with white spruce	*C_CODE* = 'C' and *CRULE* = 'PL_LEAD' and *PL_PCT* < 9 and *SW_PCT* > 1 and *SW_ORD* < *FB_ORD* and *SW_ORD* < *SB_ORD*
'C6'	Pine leading with black spruce	*C_CODE* = 'C' and *CRULE* = 'PL_LEAD' and *PL_PCT* < 9 and *SB_PCT* > 1 and *SB_ORD* < *FB_ORD* and *SB_ORD* < *SW_ORD*
'C7'	Pine leading with fir	*C_CODE* = 'C' and *CRULE* = 'PL_LEAD' and *PL_PCT* < 9 and *FB_PCT* > 1 and *FB_ORD* < *SB_ORD* and *FB_ORD* < *SW_ORD*
'C8'	Pine leading without spruce and fir	*C_CODE* = 'C' and *CRULE* = 'PL_LEAD' and *PL_PCT* < 9 and *FB_PCT* <= 1 and *SB_PCT* <=1 and *SW_PCT* <= 1
'C9'	Pure black spruce	*C_CODE* = 'C' and *SB_PCT* >= 9
'C10'	Black spruce leading with	*C_CODE* = 'C' and *CRULE* = 'SB_LEAD' and *SB_PCT* < 9 and *PL_PCT*
'C11'	Black spruce leading without pine	*C_CODE* = 'C' and *CRULE* = 'SB_LEAD' and *SB_PCT* < 9 and *PL_PCT* <= 1
'C12'	Larch leading	*C_CODE* = 'C' and *CRULE* = 'LT_LEAD'
'C13'	Pure Douglas-fir	*C_CODE* = 'C' and *FD_PCT* >= 9
'C14'	Douglas-fir leading	*C_CODE* = 'C' and *CRULE* = 'FD_LEAD' and *FD_PCT* < 9
'C15'	Pure balsam fir	*C_CODE* = 'C' and *FB_PCT* >= 9
'C16'	Balsam fir leading with pine	*C_CODE* = 'C' and *CRULE* = 'FB_LEAD' and *FB_PCT* < 9 and *PL_PCT*
'C17'	Balsam fir leading without	*C_CODE* = 'C' and *CRULE* = 'FB_LEAD' and *FB_PCT* < 9 and *PL_PCT*
'XX0'	Non-forested	*C_CODE* = NULL

2.4.7 FMP Yield Strata

Extended strata were converted to FMP yield strata as shown in Table 2-9.

Table 2-9. Conversion of extended strata to FMP yield strata.

Broad Cover Group	FMP Yield Stratum	Extended Stratum	Description
D	DEC	D1, D2, D3, D4, D5	Aspen or poplar or birch leading deciduous stand
DC	AP	DC2, DC10	Deciduous leading pine mixedwood
	AS	DC1, DC3, DC4, DC5, DC6, DC7, DC8, DC9, DC11,	Deciduous leading spruce mixedwood
CD	PA	CD4, CD5, CD6	Coniferous leading pine mixedwood
	SA	CD1, CD2, CD3, CD7, CD8, CD9, CD10, CD11, CD12	Coniferous leading spruce mixedwood
C	LT	C4, C5, C6, C7, C8	Larch leading conifer stand
	PL	C9, C10, C11	Black spruce leading conifer stand
	SB	C1, C2, C3, C13, C14, C15, C16, C17	Pine leading conifer stand
	SW	C12	White spruce leading conifer stand

3. Plot Attribute Assignment and Volume Compilation

3.1 Overview

This section describes how plot data were prepared for use in yield curve development. Data sources and the initial number of plots are described. The method of assigning landbase attributes to plots is then described, along with dataset deletions. The number of eligible plots is then tabulated relative to landbase areas for comparative purposes. Finally, the methods for compiling gross *merchantable stand volum*e (m^3/ha) for each eligible plot are described.

3.2 Data Sources

Plot data were available from a variety of data sources. Both permanent sample plot and temporary sample plot data were used.

The majority of data were collected within the Sundance FMA area. TSP data from a grid-based sampling program were collected in 1999. In 2005, additional TSP data were collected on a stratified basis in order to increase sample size at the extremes of ages (old and young stands), since the majority of data collected under the 1999 program were in mature ages.

A PSP program was also initiated by Sundance in their FMA area in 1998, with data collected using Permanent Growth Sample (PGS) plot protocols developed by Hinton Wood Products. Only the most-recent measurement was used from each plot.

After assessing the initial number of plots by FMP yield stratum, certain strata were identified as having an insufficient sample size for yield curve development. Supplemental data were

obtained from the Hinton Wood Products (HWP) Permanent Growth Sample (PGS) dataset for these FMP yield strata.

The total number of plots by data source, type of data and sampling program is provided in Table 3-1.

Table 3-1. Data sources used in yield curve development.

Data Source	Data Type	Sampling Program	Ownership	Collection Year(s)	Number of Plots	
					Natural Stand	Managed Stand
Sundance	PSP	New PSP	Sundance	2004	98	98
	TSP	Existing TSP	Sundance	1999	1,272	1,272
		New TSP	Sundance	2005	112	112
	Total				1,482	1,482
HWP	PSP	PGS[1, 2]	HWP	1956-2004	95	205
Total					1,577	1,687

[1] Only the number of eligible PGS plots is listed.

[2] Natural stand includes 32, 31 and 15 plots for AP, AS, and SB, respecitvely. Managed stand includes and additional 64 plots for SW.

The following sections provide a summary of the data collection protocols as they relate to use for yield curve development. Not all plot data collection activities are summarized here.

3.2.1 Sundance 1999 TSP Data

A temporary sample plot program was initiated by Sundance in 1999. Sampling intensity was targeted to sample approximately 1,700 TSPs across the FMA area. A systematic grid survey approach was utilized for sampling, based on the Alberta Township System grid. Points for sampling were pre-selected at grid intersections 1, 3, 5, 7, and 9. From each grid point a triangular transect was utilized.

The triangles were equilateral with the first leg of the triangle parallel to a section grid. The dimensions of the triangles were 800 meters per side with plots spaced every 200 m. This provided a total of 12 potential plots per transect. If additional transects were required in a given township, other grid points were chosen in a pre-determined order as replacements.

Plots were not established if they fell on private land, aboriginal land reserves, non-vegetated land, forb meadows, shrubby meadows, and flooded shrubby meadows ("excluded plots". Plots were sampled less frequently in non-productive cover types such as poor black spruce, old black spruce, and larch leading stands ("undesirable plots", a maximum two plots per transect). Some of the triangles were flipped or rotated to avoid non-productive cover types or non-forested areas. For more information on rules regarding transect location, see TFIC (1999). Plots were offset to avoid creeks, leases, seismic lines, roads and rights-of-way. Naturally nonforested openings were considered part of the sampling frame.

Circular, fixed radius TSP plots were established at each plot location. Initially a 400 m^2 (11.28 m radius) plot size was established, which was divided into 4 quadrants, each 100 m^2 in size. After sampling 23 plots, it was decided that plot size was too large, and the base plot size was reduced to 200 m^2 (7.98 m radius) with 50 m^2 quadrants.

In each plot, a "stopping" rule was put in place to determine the number of quadrants sampled. Quadrants were progressively sampled in a clockwise direction until at least 10 trees ≥ 7.01 cm were measured. For example, the first quadrant is sampled; if the rule is not met the second quadrant is sampled. If there are still insufficient trees the next quadrant is sampled and if the rule is still not met, then the final quadrant is sampled. Therefore at each plot, either 1, 2, 3 or 4 quadrants could be sampled depending on density. Because of the stopping rules and the change in base plot size, sampled plot area varies from 50 m^2 to 400 m^2.

All live trees > 7.0 cm DBH were sampled. Species, DBH and crown class codes were recorded for each tree. Three heights and heights to live crown per species by tree layer were sampled. Height trees were to include the largest diameter tree for each species. Breast height age was measured for all height trees, corrected for years to breast height (as per field manual rules), and recorded as total age.

A total of 1,272 TSPs were sampled under the 1999 Sundance program.

For more details of the sampling design, please refer to "Sundance Forest Industries Limited Temporary Sample Plot Procedures Manual" (TFIC 1999).

3.2.2 Sundance 2005 TSP Data

The intent of the 1999 TSP program was to have an unbiased sampling design that would provide statistically valid estimates of volume and piece size regardless of stratification or inventory, in order to allow for flexibility in future use of the TSP data. The sampling intensity was set to ensure that the range of variation was covered.

However, the age class distribution on the Sundance FMA area led to little or no sampling of young and old age classes, since the majority of stand origin dates were between 1890 and 1910. In particular, there was little data from older stands, which was necessary to anchor yield curves.

The purpose of the 2005 TSP program was to supplement the data collected in 1999 with information from older and younger stands. The goal was to sample across all strata where suitable stands existed.

For this program, a stratified sampling scheme was used to identify candidate stands. Fire origin stands greater than 2 hectares in size were eligible if origin dates were less than 1890 with no stand modifier (CC, IK, etc.) or the stand age was less than 40 years old and the stand was confirmed to be fire origin.

To limit sample bias, no more than 20 plots could be located within one township, and no more than 5 plots could be located in a given polygon. Where more than one polygon per township was sampled, an attempt was made to ensure that stand types represented different yield strata. This was limited due to access constraints and the limited amount of older age classes available for sampling.

Within each selected stand, a random starting point was selected. This was the location for plot 1. Additional plots were established at cardinal directions, 200 m from plot 1. Plots were offset

from oil lease areas, seismic lines, roads, rights-of-way and creeks. Naturally nonforested openings were sampled.

Each plot was 100 m² in size (5.64 m fixed radius). All live trees > 7.0 cm DBH were sampled. Species, DBH and crown class codes were recorded for each tree. Three heights per species per tree layer were sampled. Height trees were to include the largest diameter tree for each species. Breast height age was also recorded for all height trees, without correction for years to breast height.

3.2.3 Sundance 2004 PSP Data

Permanent sample plots were established in the Sundance FMA area in 1998 to 2001. The most-recent measurements of 98 PSPs were used in this analysis. Sundance used the HWP Permanent Growth Sample Program manual to collect their PSP data. For a description of field protocols, please see the following section.

3.2.4 HWP PGS Data

HWP has been collecting growth and yield data from their FMA area since 1956 as part of their PGS program. Plots have been remeasured up to six times and provide a valuable source of information about changes in stand characteristics over time.

Data are stored in a Microsoft Access database called the "One Database". The One Database includes data collected under a variety of research programs; each dataset is identified using an installation number to identify the different data collection protocols. PGS plots are identified as installations 1-8. Installation 1 represents the original PGS grid (established between 1956 and 1961). Installation 2 represents a supplemental "expansion" grid, established in 1988, to include areas added to the HWP FMA area. The remaining installations represent PGS plots established on a stratified (non-grid) basis, each with a specific research focus (e.g., mixedwoods, caribou lichen, young pine, etc.).

Current data collection protocols for PGS plots are identified in Weldwood of Canada Limited, Hinton Division, Permanent Growth Sample Manual (MCH Forestry Ltd. 2004).

Grid-based PGS plots were established in clusters of four, with cluster centers established every two miles at the intersection of the Alberta Legal Survey grid section lines. Four PGS plots were established 100.6 m from the cluster center at bearings of 45, 135, 225 and 315 degrees. Plots were offset in order to ensure that the entire plot was located in a single stand (cover) type.

Main plot sizes are either 405 or 810 m². Generally, the 810 m^2 plot size is used for sampling fire origin stands. PGS plots were established in both fire origin and regenerated stands, with some regenerated plots reestablished in the same location as fire origin plots after harvesting. Subplots are used to capture sapling and regeneration data.

Tagging limits for sampling have changed over the years; the current protocol is that all trees (live and dead) ≥ 7.1 cm DBH are tagged and measured within the main tree plot. The tree data

collection includes species, DBH, height, height to live crown, crown size, tree status and damage codes.

3.3 Plot Attribute Assignment and Deletions

3.3.1 Sundance TSP and PSP Data

Attribute Assignment

Precise spatial locations were not available for the Sundance TSP or PSP data. Plot data were therefore linked aspatially to the landbase using AVI polygon number. FMP yield stratum and age were then taken from the associated defining layer. Where the AVI polygon was split into more than one landbase polygon, the FMP yield stratum and age were taken from the polygon portion that was fire origin (F_ORIGIN="NAT") with no associated deletions (F_DEL="NONE") (where possible).

Plot Deletions

Plots were eligible for natural (standing timber) empirical yield curve development if they were:

1. Within the managed landbase; and

2. Established in natural (non-regenerating) stands that had not been burned since sampling, and had not been harvested either before or after sampling.

Plots were eligible for managed stand empirical yield curve development if they were:

1. Within the managed landbase; and

2. Established in natural (non-regenerating) stands.

The distinction is that natural stand yield curves represent standing timber, and therefore only plots that were representative of timber currently standing on the landbase could be used. Managed stand yield curves represent potential growth conditions on the landbase, and could also include plots that no longer remain on the landbase, as long as an appropriate FMP yield stratum and age assignment could be obtained.

Plots were linked aspatially to AVI polygons. However, many AVI polygons were split during the landbase netdown process, resulting in dissimilar FMP yield stratum assignments and netdown status (into the managed vs. unmanaged landbase, or as natural vs. managed stands).

In order to consistently apply deletion rules to plots, the following criteria were applied:

1. Plots in polygons with partial AVI polygon deletions (e.g. half the polygon was burned) are still considered representative of the residual portions of the stand.

2. Plots should be eligible for managed stand yield curves regardless of whether they have been burned or harvested since sampling, since they represent potential stand conditions in the managed landbase (assuming a FMP yield stratum and age can be assigned to the pre-disturbance condition under which the plot was sampled).

3. Plots outside of the managed landbase should be deleted unless part of the polygon is within the managed landbase. In that case, plots from the same polygon outside of the managed landbase are representative of areas within the managed landbase.

These criteria were converted to an objective rule set as shown in Table 3-2.

Note that these rules are based on a proportion of area falling under any one deletion rule. The intent of these rules was to limit the number of circumstances under which actual plot location would need to be spatially examined using field maps. That is, if 50% or less of a polygon was burned, the plot was assumed to be representative of the remaining 50%+ of standing timber, regardless of where the plot was originally located. However, in cases where plots "failed" the deletion rules, the plot could still be used if it could be proven that the plot was located in the appropriate stand type.

As an example, if more than 50% of the polygon was burned, the plot failed the deletion rules (e.g., most of the AVI polygon was burned). In these cases the plot location on field maps could be examined to determine whether it was in the remaining (standing) portion of the AVI polygon or not. Since this could result in a significant workload, generally only plots from underrepresented FMP yield strata were examined (e.g., mixedwood FMP yield strata).

In addition to deletions under these rules, there were four other plots deleted from the Sundance dataset. One 1999 TSP plot could not be linked to the landbase data, and three PSP plots did not have measurement records. They were excluded from the dataset.

Table 3-2. Deletion rules for plots used in yield curve development.

F_Del	Definition	Comments	Deletion Rule
NONE	No deletion	Eligible for yield curve development	N/A
LT	Larch	Entire polygon should be a deletion	Delete all plots if any portion of polygon[1] has F_DEL=LT
NCSB	Non-commercial black spruce	Entire polygon should be a deletion	Delete all plots if any portion of polygon[1] has F_DEL=NCSB
NF	Nonforested	Entire polygon should be a deletion	Delete all plots if any portion of polygon[1] has F_DEL=NF
SB_ADENS	A density black spruce	Entire polygon should be a deletion	Delete all plots if any portion of polygon[1] has F_DEL=SB_ADENS
TPR	Unproductive TPR	Entire polygon should be a deletion	Delete all plots if any portion of polygon[1] has F_DEL=TPR
FIRE	Recent burn (1998)	Valid plot deletion for natural curves[2, 3]	Delete if plot falls within RECBURN and F_DEL=NONE is <50% of polygon area
GOVRES	Government reserve	Valid plot deletion for all curves[4]	Delete if plot falls within GOVERES and F_DEL=NONE is <50% of polygon area and plot <> PSP[5]
GRBUF	Ground rules buffer	Valid plot deletion for all curves[4]	Delete if plot falls within GRBUF and F_DEL=NONE is <50% of polygon area
LEASE	Grazing lease	Valid plot deletion for all curves[4]	Delete if plot falls within LEASE and F_DEL=NONE is <50% of polygon area
LINEAR	Linear	Not a valid plot deletion[6]	N/A
XDFA	Private lands/nonclassified areas	Valid plot deletion for all curves[4]	Delete if plot falls within XDFA and F_DEL=NONE is <50% of polygon area

F_Origin	Definition	Comments	Deletion Rule
MGD	Managed stand	Valid plot deletion for natural curves[2, 3]	Delete if plot falls within managed portion and F_ORIGIN=NAT is <50% of polygon area
NAT	Natural stand	Eligible for yield curve development	N/A
RECBURN	Recent burn	Same as F_DEL="FIRE"	Deletions covered under FIRE deletion rule
X	Nonforested	Valid plot deletion for all curves[4]	Delete if plot falls within F_ORIGIN=X and F_ORIGIN=X is >50% of polygon area

[1] This deletion is applied to the **AVI polygon**, therefore all plots located within the polygon will be deleted.

[2] Natural stand yield curves must represent the existing standing timber at the reference year. Therefore, plots from stands that are harvested or burned since sampling (and prior to the reference year) no longer represent the standing timber. However, where only portions of stands have been harvested or burned, the plots may still be used to represent the standing timber that remains. To create an objective cutoff, the remaining natural fire origin portion of the stand must be 50% or greater in order to allow the plot to be reused.

[3] Although plots in areas that have been burned or harvested since sampling no longer represent the standing timber, these plots do represent potential stand conditions in regenerating stands. Therefore these plots can be used for the development of managed stand yield curves (or, for that matter, natural stand yield curves for regenerating stands - just not for standing timber).

[4] Outside the managed landbase - plot does not represent operable timber BUT if >=50% of the polygon is in the managed landbase, it is a reasonable assumption that the plot is representative of managed portions of the polygon.

[5] In these cases, reserves only exist to protect PSPs; plot data should never be thrown away for this reason.

[6] Linear features make up small percentages of the polygon area; whether or not the linear feature destroyed the sampled plot, the plot is still representative of the remaining portion of the stand.

3.3.2 HWP PSP Data

For yield curve development, the following FMP yield strata required additional data:

- AP Natural Stands (only 32 eligible Sundance plots, could not obtain good model form)
- AS Natural Stands (only 27 eligible Sundance plots, deciduous volume would not *converge*)
- SB Natural Stands (only 15 eligible Sundance plots)
- SW Managed Stands (only 60 eligible Sundance plots; lack of plots resulted in unreasonably high volumes at older ages)

Attribute Assignment

In order to provide as consistent a method as possible for FMP yield stratum assignment, the SRD yield stratum assignment rules prepared for the Sundance landbase were applied to the HWP AVI. The only change to the code was photo date (changed to 2001). Code for deletions based on AVI polygon attributes (nonproductive black spruce, TPR U, A density black spruce, larch etc.) was also applied based on the AVI.

The resulting shapefile contained stratification and deletions consistent with the Sundance landbase. The difference from the Sundance landbase is that the HWP AVI was not updated for *cutblocks* or other deletions (dispositions, leases, buffers, etc.).

Spatial locations were available for all HWP plots. The HWP plot shapefile was spatially intersected with the modified HWP AVI in order to obtain FMP yield stratum and age assignments for each plot. Where there was more than one *observation* per plot, plot attributes were attached to each observation by recalculating age based on measurement year.

Eligible plots to be used as supplemental data were identified as follows:

- Only grid PGS plots (Installation 1 and 2)
- No *clearcut* modifier (MOD 1 <> CC)
- Establishment status of "F" (fire origin) in database
- Establishment number = 1 (original establishment; meaning no disturbance since establishment)
- Most recent measurement only
- Within 10 years of photo date (insufficient data when restricted to +/- 5 years of photo date)

Using this process, the following number of plots was extracted for supplementing the Sundance dataset:

- AP Natural Stands: 28 PGS plots available; all were used (approximately 1:1 ratio)
- AS Natural Stands: 31 PGS plots available; all were used (approximately 1:1 ratio)
- SB Natural Stands: 36 PGS plots available; all were used (approximately 2:1 ratio)
- SW Managed Stands: 110 PGS plots; only C or D density were used (65 plots) (approximately 1:1 ratio)

Plot Deletions

No additional plot deletions were required since plots in stands with deletions were excluded during the plot selection process.

3.3.3 Plot Summaries

Number of Eligible Plots

The total number of plots by yield stratum and sampling program is presented in Table 3-3.

Table 3-3. Number of plots by yield stratum and sampling program.

FMP Yield Stratum	Number of Plots					
	Sundance				HWP	
	TSP1999	TSP2005	PSP	Total	PGS	Total
Natural Stand Dataset						
AP	40	3	1	44	28	72
AS	33	2	2	37	31	68
DEC	85	6	3	94	-	94
PA	57	6	11	74	-	74
PL	798	70	62	930	-	930
SA	23	10	-	33	-	33
SB	114	3	15	132	36	168
SW	107	12	-	119	-	119
LT	11	-	2	13	-	13
X	3	-	2	5	-	5
Unassigned	1	-	-	1	-	1
Total	1,272	112	98	1,482	95	1,577
Managed Stand Dataset						
AP	40	3	1	44	28	72
AS	33	2	2	37	31	68
DEC	85	6	3	94	-	94
PA	57	6	11	74	-	74
PL	798	70	62	930	-	930
SA	23	10	-	33	-	33
SB	114	3	15	132	36	168
SW	107	12	-	119	110	229
LT	11	-	2	13	-	13
X	3	-	2	5	-	5
Unassigned	1	-	-	1	-	1
Total	1,272	112	98	1,482	205	1,687

Additional Deletions: Influential Points

Fourteen plots with conifer volume ≥ 800 m^3/ha were excluded in the yield curve development (this deletion rule was used in Sundance yield curve development for the last FMP). During the fitting of empirical yield curves, eighteen additional outliers were identified and were entirely removed from the dataset.

A list of *influential points*, *plot volumes* and ages, dataset deleted from and reason for deletion is provided in Table 3-4.

Table 3-4. Influential points, deletion type and reason for deletion.

FMA_ID	Plot_ID	Plot Number	FMP Yield Stratum	Age	Volume (m^3/ha) Coniferous	Deciduous	Total	Deletion	Reason for Deletion
5120450574	45125804	804	AS	109	192	757	949	Both	Outlier
5130460221	46135210	210	AP	58	540	78	617	Both	Outlier
5140450207	45145301	301	AS	109	0	1,439	1,439	Both	Outlier
5170480283	48175712	712	DEC	159	323	0	323	Both	Outlier
5170480418	48175711	711	DEC	159	431	0	431	Both	Outlier
5180520156	52185501	501	DEC	119	0	1,136	1,136	Both	Outlier
5180529122	52185111	111	AS	119	65	512	577	Both	Outlier
5190520105	52195101	101	AS	109	0	619	619	Both	Outlier
5190520105	52195106	106	AS	109	0	534	534	Both	Outlier
5190520105	52195112	112	AS	109	252	1,613	1,865	Both	Outlier
5160450472		1	PA	145	6	525	531	Both	Outlier
5160450472		2	PA	145	0	589	589	Both	Outlier
5160450472		3	PA	145	179	304	483	Both	Outlier
5170480283		1	DEC	165	299	394	694	Both	Outlier
5170480283		2	DEC	165	265	0	265	Both	Outlier
5170480283		3	DEC	165	434	0	434	Both	Outlier
5170480418		1	DEC	165	667	0	667	Both	Outlier
5170520198		2	PA	135	98	532	630	Both	Outlier
5120460271	46125412	412	PL	109	879	0	879	Both	Con. volume >= 800 m^3/ha
5140460051	46145104	104	PL	99	1,543	0	1,543	Both	Con. volume >= 800 m^3/ha
5140480532	48145507	507	SW	109	1,082	0	1,082	Both	Con. volume >= 800 m^3/ha
5150450538	45155412	412	PL	99	801	0	801	Both	Con. volume >= 800 m^3/ha
5150450608	45155502	502	SA	99	891	0	891	Both	Con. volume >= 800 m^3/ha
5150460246	46155307	307	PL	99	1,049	0	1,049	Both	Con. volume >= 800 m^3/ha
5150460981	46155702	702	PA	109	854	0	854	Both	Con. volume >= 800 m^3/ha
5150480491	48155501	501	PL	109	1,002	0	1,002	Both	Con. volume >= 800 m^3/ha
5160440172	44165305	305	PL	109	1,163	0	1,163	Both	Con. volume >= 800 m^3/ha
5160470345	47165504	504	PL	109	1,005	0	1,005	Both	Con. volume >= 800 m^3/ha
5160489022	48165311	311	SW	109	1,030	0	1,030	Both	Con. volume >= 800 m^3/ha
5170430096	43175304	304	PL	139	813	0	813	Both	Con. volume >= 800 m^3/ha
5170460354	46175507	507	PL	109	977	0	977	Both	Con. volume >= 800 m^3/ha
5180520152	52185509	509	AP	119	801	0	801	Both	Con. volume >= 800 m^3/ha

Final Number of Plots

The number of plots used in empirical yield curve development is presented in Table 3-5. Eligible plots are those used for curve fitting.

For natural stand yield curves, the number of plots for the DEC, PA, PL, SA, and SW strata includes Sundance data only, while the number of plots for the AP, AS, and SB strata includes both Sundance and HWP data. For managed stand yield curves, the number of plots for the SW

stratum includes both Sundance and HWP data, while number of plots for remaining strata includes Sundance data only.

Table 3-5. Number of eligible and ineligible plots, and influential points by yield stratum.

FMP Yield Stratum	Number of Plots							
	Natural Stand				Managed Stand			
	Eligible	Ineligible	Outliers	Total	Eligible	Ineligible	Outliers	Total
AP	60	12	2	72	-	-	-	-
AS	58	10	6	68	-	-	-	-
DEC	85	9	7	94	81	8	5	94
PA	66	8	5	74	-	-	-	-
PL	865	65	9	930	752	170	8	930
SA	31	2	1	33	-	-	-	-
SB	51	117	2	168	-	-	-	-
SW	110	9	-	119	125	103	1	229
LT	-	13	-	13	-	-	-	-
X	-	5	-	5	-	-	-	-
Unassigned	-	1	-	1	-	-	-	-
Total	1,326	251	32	1,577	958	281	14	1,253

Note that for managed stand curves, only the plots with C or D density were used. However, since some plots from burned or harvested stands were added back to the dataset where possible, the number of eligible plots is higher than might be expected based on the number of plots used for natural stand yield curve development.

The final number of eligible plots by FMP yield stratum assignment is presented in Table 3-6.

Table 3-6. Number of eligible plots for empirical yield curve development by FMP yield stratum.

FMP Yield Stratum	Number of Plots					
	Natural Stand			Managed Stand		
	Sundance	HWP	Total	Sundance	HWP	Total
AP	32	28	60	-	-	-
AS	27	31	58	-	-	-
DEC	85	-	85	81	-	81
PA	66	-	66	-	-	-
PL	865	-	865	752	-	752
SA	31	-	31	-	-	-
SB	15	36	51	-	-	-
SW	110	-	110	60	65	125
Total	1,231	95	1,326	893	65	958

3.4 Age Assignment

Stand age for the defining layer at the reference year (2005) was also already appended to plot data from linking plot locations with landbase attributes (field F_AGE).

Stand age for each plot at the year of measurement was calculated as stand age in 2005 (the reference year) minus the number of years between 2005 and the measurement year:

$$Age_{Obs} = Age_{2005} - (2005 - MmtYear)$$

Where : Age_{Obs} = stand age at year of measurement

Age_{2005} = stand age in 2005 (F_AGE)

MmtYear = measurement year (establishment year for PSPs)

3.5 Data Distribution

Both number and percent of plots by FMP yield stratum and defining layer, with landbase areas (landbase file LB2_TSA_DESC), are presented in Table 3-7. Plots show a reasonable distribution relative to the distribution of landbase areas for all strata. The exception is stratum SA, which has slightly higher representation of plots with composite assignment relative to total landbase area.

Table 3-7. Number of plots and managed landbase areas by yield stratum and AVI layer.

FMP Yield Stratum	Defining Layer	Observations		Landbase Area (ha)			Percent Landbase Area		
		Total	%	Natural	Managed	Total	Natural	Managed	Total
AP	Overstory	52	87%	3,863	961	4,824	76%	85%	77%
	Understory	1	2%	27	95	122	1%	8%	2%
	Composite	7	12%	1,221	68	1,290	24%	6%	21%
	Total	60	100%	5,112	1,124	6,236	100%	100%	100%
AS	Overstory	46	79%	1,663	398	2,061	67%	76%	69%
	Understory	8	14%	7	77	84	0%	15%	3%
	Composite	4	7%	805	49	855	33%	9%	28%
	Total	58	100%	2,475	524	3,000	100%	100%	100%
DEC	Overstory	56	66%	6,012	1,465	7,477	75%	76%	75%
	Understory	-	0%	19	119	138	0%	6%	1%
	Composite	29	34%	1,946	342	2,289	24%	18%	23%
	Total	85	100%	7,977	1,926	9,904	100%	100%	100%
PA	Overstory	47	71%	4,310	1,438	5,748	68%	84%	72%
	Understory	1	2%	13	177	189	0%	10%	2%
	Composite	18	27%	2,003	92	2,095	32%	5%	26%
	Total	66	100%	6,326	1,706	8,032	100%	100%	100%
PL	Overstory	815	94%	106,275	13,906	120,181	96%	96%	96%
	Understory	18	2%	1,601	291	1,892	1%	2%	2%
	Composite	32	4%	3,117	328	3,445	3%	2%	3%
	Total	865	100%	110,993	14,525	125,518	100%	100%	100%
SA	Overstory	9	29%	1,114	48	1,162	61%	31%	58%
	Understory	1	3%	76	91	167	4%	58%	8%
	Composite	21	68%	643	18	661	35%	12%	33%
	Total	31	100%	1,832	157	1,989	100%	100%	100%
SB	Overstory	31	61%	1,279	33	1,312	52%	75%	53%
	Understory	19	37%	1,052	11	1,064	43%	25%	43%
	Composite	1	2%	114	0	114	5%	0%	5%
	Total	51	100%	2,445	45	2,489	100%	100%	100%
SW	Overstory	80	73%	13,184	541	13,725	79%	85%	79%
	Understory	19	17%	3,156	82	3,239	19%	13%	19%
	Composite	11	10%	402	12	414	2%	2%	2%
	Total	110	100%	16,742	636	17,377	100%	100%	100%
Grand Total		1,326		153,902	20,644	174,546			

The number and percent of observations by FMP yield stratum and height class are shown in Table 3-8. The table also presents the landbase area and percent area by FMP yield stratum, stand type (natural vs. managed) and height class. Plots are generally in proportion to the distribution of natural stands, with the exception of the AP, AS, and SB strata. In these cases, lower height classes are overrepresented, which means that if there is a bias in yield predictions, it is likely a conservative bias (predicted yields lower than actual).

Table 3-8. Number of plots and managed landbase areas by yield stratum and height class.

FMP Yield	Height	Observations		Landbase Area (ha)			Percent Landbase Area		
Stratum	Class (m)	Total	%	Natural	Managed	Total	Natural	Managed	Total
AP	0-10	28	47%	185	1,070	1,255	4%	95%	20%
	11-20	3	5%	1,681	40	1,721	33%	4%	28%
	21+	29	48%	3,246	14	3,260	63%	1%	52%
	Total	60	100%	5,112	1,124	6,236	100%	100%	100%
AS	0-10	34	59%	119	513	631	5%	98%	21%
	11-20	4	7%	785	12	797	32%	2%	27%
	21+	20	34%	1,572	0	1,572	63%	0%	52%
	Total	58	100%	2,475	524	3,000	100%	100%	100%
DEC	0-10	7	8%	465	1,552	2,017	6%	81%	20%
	11-20	34	40%	2,600	160	2,760	33%	8%	28%
	21+	44	52%	4,913	215	5,128	62%	11%	52%
	Total	85	100%	7,977	1,926	9,904	100%	100%	100%
PA	0-10	17	26%	1,100	1,676	2,776	17%	98%	35%
	11-20	22	33%	2,596	30	2,627	41%	2%	33%
	21+	27	41%	2,630	0	2,630	42%	0%	33%
	Total	66	100%	6,326	1,706	8,032	100%	100%	100%
PL	0-10	32	4%	2,330	14,447	16,777	2%	99%	13%
	11-20	679	78%	88,175	7	88,183	79%	0%	70%
	21+	154	18%	20,487	71	20,558	18%	0%	16%
	Total	865	100%	110,993	14,525	125,518	100%	100%	100%
SA	0-10	1	3%	135	157	292	7%	100%	15%
	11-20	24	77%	863	0	863	47%	0%	43%
	21+	6	19%	834	0	834	46%	0%	42%
	Total	31	100%	1,832	157	1,989	100%	100%	100%
SB	0-10	46	90%	1,335	45	1,380	55%	100%	55%
	11-20	5	10%	1,088	0	1,088	44%	0%	44%
	21+	-	0%	22	0	22	1%	0%	1%
	Total	51	100%	2,445	45	2,489	100%	100%	100%
SW	0-10	9	8%	1,391	633	2,024	8%	100%	12%
	11-20	75	68%	10,609	3	10,612	63%	0%	61%
	21+	26	24%	4,742	0	4,742	28%	0%	27%
	Total	110	100%	16,742	636	17,377	100%	100%	100%
Grand Total		1,326		153,902	20,644	174,546			

The number and percent of observations by FMP yield stratum and age class are shown in Table 3-9. The table also presents the landbase area and percent area by FMP yield stratum, stand type and age class.

Table 3-9. Number of plots and managed landbase areas by yield stratum and age class.

FMP Yield	Age	Observations		Landbase Area (ha)			Percent Landbase Area		
Stratum	Class (y)	Total	%	Natural	Managed	Total	Natural	Managed	Total
AP	0-39	-	0%	30	1,059	1,088	1%	94%	17%
	40-79	4	7%	540	65	605	11%	6%	10%
	80-119	49	82%	3,704	0	3,704	72%	0%	59%
	120+	7	12%	839	0	839	16%	0%	13%
	Total	60	100%	5,112	1,124	6,236	100%	100%	100%
AS	0-39	-	0%	4	419	423	0%	80%	14%
	40-79	14	24%	220	105	325	9%	20%	11%
	80-119	41	71%	1,777	0	1,777	72%	0%	59%
	120+	3	5%	474	0	474	19%	0%	16%
	Total	58	100%	2,475	524	3,000	100%	100%	100%
DEC	0-39	6	7%	335	1,699	2,034	4%	88%	21%
	40-79	11	13%	1,095	227	1,322	14%	12%	13%
	80-119	59	69%	5,445	0	5,445	68%	0%	55%
	120+	9	11%	1,102	0	1,102	14%	0%	11%
	Total	85	100%	7,977	1,926	9,904	100%	100%	100%
PA	0-39	-	0%	8	1,513	1,522	0%	89%	19%
	40-79	25	38%	1,587	193	1,780	25%	11%	22%
	80-119	40	61%	4,211	0	4,211	67%	0%	52%
	120+	1	2%	520	0	520	8%	0%	6%
	Total	66	100%	6,326	1,706	8,032	100%	100%	100%
PL	0-39	2	0%	266	14,239	14,504	0%	98%	12%
	40-79	82	9%	6,778	287	7,065	6%	2%	6%
	80-119	637	74%	94,557	0	94,557	85%	0%	75%
	120+	144	17%	9,392	0	9,392	8%	0%	7%
	Total	865	100%	110,993	14,525	125,518	100%	100%	100%
SA	0-39	-	0%	0	129	129	0%	82%	6%
	40-79	4	13%	215	28	244	12%	18%	12%
	80-119	23	74%	1,093	0	1,093	60%	0%	55%
	120+	4	13%	524	0	524	29%	0%	26%
	Total	31	100%	1,832	157	1,989	100%	100%	100%
SB	0-39	1	2%	15	45	59	1%	100%	2%
	40-79	38	75%	1,663	0	1,663	68%	0%	67%
	80-119	5	10%	614	0	614	25%	0%	25%
	120+	7	14%	153	0	153	6%	0%	6%
	Total	51	100%	2,445	45	2,489	100%	100%	100%
SW	0-39	-	0%	17	602	619	0%	95%	4%
	40-79	14	13%	3,483	34	3,517	21%	5%	20%
	80-119	73	66%	8,930	0	8,930	53%	0%	51%
	120+	23	21%	4,311	0	4,311	26%	0%	25%
	Total	110	100%	16,742	636	17,377	100%	100%	100%
Grand Total		1,326		153,902	20,644	174,546			

3.6 Volume Compilation

Each eligible plot from the combined TSP/PSP dataset was used to compile gross merchantable stand volume estimates. Use of the term *gross* indicates that there has been no deduction for *cull*.

For each sample plot, the merchantable length of each live tree with a minimum stump diameter of 15.0 cm was calculated. This calculation was based on the height of the tree, a 15.0 cm stump height and minimum stump diameter, with top diameter (by species type) and log length as defined in Table 3-10.

Table 3-10. Minimum utilization standards by species type.

Utilization Characteristic	Conifer Species	Deciduous Species
Stump height	15 cm	15 cm
Minimum log length	3.84 m	2.49 m
Minimum stump diameter outside bark	15 cm	15 cm
Minimum top diameter inside bark	11 cm	10 cm

Dead trees in the Sundance and HWP PSP datasets were excluded for tree volume calculation. Trees in the Sundance TSP datasets with condition codes for dead, physical damage, disease, and mistletoe were also excluded for tree volume calculation.

Calculations involved the iterative process presented in "Ecologically Based Individual Tree Volume Estimation For Major Alberta Tree Species" (Huang 1994b). Trees not meeting utilization limits were deleted from the dataset.

The merchantable length of each tree was 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 (Kozak 1988) and ecoregion/tree species-specific coefficients for the province of Alberta (Huang 1994a). The equation was:

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

Where: *dib* = stem diameter inside bark (cm) at height h (m)

DBH = diameter at breast height outside bark (cm)

H = total tree height[3] (m)

[3] Recorded total height was used for volume calculations. Where heights were missing, equations from Huang (1994a) were used to estimate total height.

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

$Z = h/H$

h = 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, volumes for each section were calculated using Newton's equation (Husch *et al.* 1982):

$$MV = \frac{ML/10}{6} * (0.00007854) * (d_0^2 + 4d_1^2 + d_2^2)$$

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)

Gross *merchantable tree volumes* were then determined by summing individual section volumes for each tree. Tree volumes were converted to gross merchantable stand volume (volume per hectare) using the appropriate plot size expansion factor. Plots with no merchantable trees were assigned zero gross merchantable volume (0 m^3/ha) and retained within the dataset.

For each plot, the total coniferous gross merchantable stand volume was calculated by summing the m^3/ha estimates for each live coniferous tree within the plot. The total deciduous gross merchantable stand volume was calculated by summing the m^3/ha estimates for each live deciduous tree within the plot.

4. Base Yield Curves

4.1 Overview

For each of the eight FMP yield strata, one natural stand empirical yield curve was fit. Volume was fit as a function of stand age using *nonlinear regression* techniques. These are the base natural stand yield curves for Sundance.

There is an assumption that harvested stands will return as fully stocked under standard management practices, since current reforestation standards enforce strict stocking limits. Plots from natural stands with a C or D crown closure class (based on the defining layer) were used as a proxy to represent managed stands (referred to as the *fully stocked method*). Managed stand yield curves were created for the DEC, PL and SW strata only. No managed stand yield curves were required for the SB stratum, and regenerating mixedwood stands (AP, AS, PA, SA) are represented by natural stand yield curves.

Area-weighted *composite yield curves* were also developed for natural stands. Six area-weighted curves were developed for natural stands: four to represent each broad cover group (D, DC, CD, and C), one overall composite for the coniferous landbase (DC, CD and C combined), and one overall composite for the whole landbase (D, DC, CD and C combined). Curves were based on natural stand yield curves, weighted by the proportion of area of natural stands that each FMP yield stratum currently represents within the managed landbase.

A full list of *base yield curves* is provided in Table 4-1.

Table 4-1. Base FMP yield curves.

FMP Yield Stratum	Natural Stand Yield Curve Code	Managed Stand Yield Curve Code
AP	AP_N	
AS	AS_N	
DEC	DEC_N	DEC_M
PA	PA_N	
SA	SA_N	
PL	PL_N	PL_M
SB	SB_N	
SW	SW_N	SW_M
COMPOSITE	ALL_N	

4.2 Natural Stand Yield Curves

4.2.1 Yield Curve Development

Data from the base TSP/PSP dataset were used to fit natural stand yield curves (see Section 3 for information on data preparation). Base natural stand yield curves were fit using one of two models:

2-parameter model (2P):

$$Volume = a(Age)^{b} e^{(-a*Age)}$$

2-parameter model with constant (2P+k):

$$Volume = a(Age)^{b} e^{\left(-Age/k\right)}$$

Where: *Volume* = gross merchantable stand volume (m^3/ha)

Age = stand age at year of measurement

a, b, k = coefficients

Conifer and deciduous volume were modelled using one of the two equations. A 3-parameter equation was examined but did not result in improved curve fit. Where the constant k was required to achieve biologically reasonable curve form, values between 10 and 100 were tested to achieve the most biologically reasonable fit that also fit to the data. Total volume was calculated by summing conifer and deciduous volume.

An exception to this process was the SW stratum. Because the regression to fit deciduous volume would not converge, total volume was fit instead, and deciduous volume was calculated by subtracting coniferous volume from total volume. Where predicted coniferous volume was greater than predicted total volume, total volume was set equal to coniferous volume.

Model selection was qualitatively based on goodness-of-fit. Sample size, model form, coefficients and fit statistics (R^2) by yield curve are presented in Table 4.2. Yield curves are presented in Appendix III.

Table 4-2. Model form and model coefficients, base natural stand yield curves.

FMP Yield Stratum	Number of Observations	Species Type	Model Form	Model Coefficients a	b	k	R^2
AP	60	Coniferous	2P	2.438991E-02	2.4577544		0.00
		Deciduous	2P+k	1.454934E-07	5.6373318	20	0.01
AS	58	Coniferous	2P	1.877100E-02	2.3778287		0.04
		Deciduous	2P+k	1.467549E-08	6.0666632	20	-0.01
DEC	85	Coniferous	2P+k	3.018424E-08	5.4010858	30	0.04
		Deciduous	2P+k	4.722775E-17	11.5043792	10	0.11
PA	66	Coniferous	2P+k	1.814084E-05	4.2924303	30	0.24
		Deciduous	2P+k	6.054249E-15	10.2628654	10	0.09
PL	865	Coniferous	2P	2.059453E-02	2.4755876		0.04
		Deciduous	2P	3.690870E-02	1.9933631		0.00
SA	31	Coniferous	2P	1.537301E-02	2.3797634		0.06
		Deciduous	2P	2.307376E-02	2.4035304		0.01
SB	51	Coniferous	2P	1.111928E-02	2.2131561		0.28
		Deciduous	2P	1.638573E-02	1.7093732		0.01
SW	110	Coniferous	2P	2.274996E-02	2.5019363		0.04
		Total[1]	2P	2.434822E-02	2.5340156		0.03
Total	1,326						

[1] Regression to fit deciduous volume would not converge; instead, total volume was fit and predicted deciduc volume was calculated using predicted total volume minus predicted coniferous volume (or zero, whichever was greater).

4.3 Managed Stand Yield Curves

4.3.1 Yield Curve Development

Base managed stand yield curves were developed using data from fully stocked natural stands as a proxy for managed stands. A subset of the TSP/PSP data used to fit base natural stand yield curves was selected. Only those plots with a defining layer crown closure class of C or D were used to fit managed stand yield curves. Plots which had previously been excluded from model development because they were in burned or harvested stands were included in managed stand yield curve development where possible (see Section 3.3 for more information). Base managed stand yield curves were fit using one of two models:

2-parameter model (2P):

$$Volume = a(age)^b e^{(-a*age)}$$

2-parameter model with constant (2P+k):

$$Volume = a(age)^b e^{\left(-age/k\right)}$$

Where: *Volume* = gross merchantable stand volume (m^3/ha)

Age = stand age at year of measurement

a, b, k = coefficients

Model selection was qualitatively based on goodness-of-fit. Sample size, model form, coefficients and fit statistics (R^2) by yield curve are presented in Table 4-3. Yield curves are presented in Appendix IV.

Table 4-3. Model form and model coefficients, base managed stand yield curves.

FMP Yield Stratum	Number of Observations	Species Type	Model Form	Model Coefficients a	b	k	R^2
DEC	81	Coniferous	2P	1.399434E-02	2.16690225		0.02
		Deciduous	2P+k	9.245186E-08	5.75856829	20	0.12
PL	752	Coniferous	2P	1.959888E-02	2.48064870		0.04
		Deciduous	2P	4.069816E-02	2.11105981		0.00
SW	125	Coniferous	2P	1.686090E-02	2.44930918		0.18
		Deciduous	2P	5.499481E-02	2.41480358		0.08
Total	958						

4.4 Composite Yield Curves

4.4.1 Yield Curve Development

Composite yield curves provide an area-weighted estimate of volume over time across all natural stands within the Sundance managed landbase. These curves are useful to provide comparisons from one FMP to the next.

Composite yield curves were created for natural stands within the Sundance managed landbase. Six area-weighted curves were developed for natural stands: four to represent each broad cover group (D, DC, CD, and C), one overall composite for the coniferous landbase (DC, CD and C combined), and one overall composite for the whole landbase (D, DC, CD and C combined).

Each natural stand yield curve was weighted by the proportion of the total area of natural stands within the managed landbase. The total area of natural stands by FMP yield stratum used for area-weighting was obtained from the landbase (landbase file LB2_TSA_DESC) and is provided in Table 4-4. Composite yield curves were developed by summing all area-weighted natural stand yield curves at each age. The composite yield curves are presented in Appendix V.

Table 4-4. Total area of natural stands by FMP yield stratum.

Landbase	Broad Cover Group	FMP Yield Stratum	Area (ha)	Percent
Coniferous	DC	AP	5,112	3.3
		AS	2,475	1.6
Deciduous	D	DEC	7,977	5.2
Coniferous	CD	PA	6,326	4.1
	C	SA	1,832	1.2
		PL	110,993	72.1
		SB	2,445	1.6
		SW	16,742	10.9
Total			153,902	100.0

5. Yield Curves for Timber Supply Analysis

This document has outlined the development of a number of yield curves. Table 5-1 lists the curves used to represent natural and managed stands timber supply analysis. Managed stand yield curves were only developed for the DEC, PL and SW FMP yield strata. The base natural yield curves for AP, AS, PA and SA strata will be used to represent managed stands. Managed stand yield curves for SB are not required since all SB stands are transitioned to PL after harvest. Sundance yield curves developed for the 2007 FMP are graphically presented by FMP yield stratum in Appendix VI, for ease of comparison.

Table 5-1. Yield curves used in timber supply analysis by stand type and FMP yield stratum.

Stand Type	FMP Yield Stratum	Yield Curve Code	Curve Type
Natural	AP	AP_N	Base natural
	AS	AS_N	Base natural
	DEC	DEC_N	Base natural
	PA	PA_N	Base natural
	SA	SA_N	Base natural
	PL	PL_N	Base natural
	SB	SB_N	Base natural
	SW	SW_N	Base natural
Managed	AP	AP_N	Base natural
	AS	AS_N	Base natural
	DEC	DEC_M	Base managed, fully stocked
	PA	PA_N	Base natural
	SA	SA_N	Base natural
	PL	PL_M	Base managed, fully stocked
	SW	SW_M	Base managed, fully stocked

6. Additional Growth and Yield Issues

Although this document's primary purpose is to describe the development of volume-age yield curves for the 2007 FMP, there are a number of related growth and yield issues that are also included herein. These are: cull, piece size curves, and *regeneration lag* calculations.

6.1 Cull Deductions

Cull deductions are applied to yield curves to reflect losses to cull (trees or portions thereof that are merchantable but are removed because of defect). The new Alberta Forest Management Planning Standard (SRD 2006) requires that cull be applied as a percent reduction to yield curves, rather than as a reduction to the harvest level in timber supply analysis. This section describes the methods by which cull was derived.

6.1.1 Methods

Scaling data (number of logs, gross scaled volume, cull volume, and *net* volume) were used to determine coniferous cull. Sundance cull data for the 2005/2006 and 2006/2007 timber years (65 records) were used to determine coniferous cull.

Cull was determined by calculating percent cull for each record. Each record was then weighted by gross scaled volume, so that records representing more scaled volume had a higher influence on the cull calculation. All records were then summed to obtain percent cull. The equation was:

$$PctCull = \sum_{i=1}^{n} \left(\left(\frac{CullVol_i}{GrossVol_i} \right) * \left(\frac{GrossVol_i}{GrossVol_{tot}} \right) \right) * 100$$

which reduces to $PctCull = \frac{\sum_{i=1}^{n} CullVol_i}{GrossVol_{tot}} * 100$

Where: *PctCull* = percent cull

CullVol = cull volume (m^3)

GrossVol = gross scaled volume (m^3)

6.1.2 Results

A 0.84% coniferous cull was obtained from the results of calculations. A 7% deciduous cull that Weyerhaeuser used in their last FMP, will be used for deciduous cull in Sundance 2007 FMP.

A 7% reduction was applied to the deciduous component of each yield curve, and a 0.84% reduction was applied to the coniferous component of each yield curve. However, cull was applied to yield curves during timber supply modelling and therefore net merchantable volume yield curves are not presented here.

6.2 Piece Size Curves

Piece size curves were required to provide an estimate of how piece size (number of trees per cubic meter of gross merchantable tree volume) changes over time.

6.2.1 Methods

The base TSP/PSP dataset used in yield curve development was used for piece size curve development. The plots that were eligible for empirical yield curve development were used in piece size development. Plot attributes were the same as previously defined, and volumes compiled for yield curve development were retained for use in this analysis.

For each plot, trees per m^3 was calculated, by dividing total number of merchantable trees in the plot by the gross merchantable plot volume. An equation to predict trees per m^3 as a function of age was then fit directly using plot data:

$$PieceSize = a_0 + \frac{a_1}{Age}$$

Where: *PieceSize* = number of trees per m^3 of gross merchantable tree volume

Age = age at year of measurement

a_0, a_1 = coefficients

Plots with no volume were excluded, since piece size could not be calculated (dividing by zero). Several influential points were also removed. These were extreme values that affected curve fit. The final number of plots by FMP yield stratum was different for coniferous and deciduous curves, since there could be coniferous volume with no deciduous volume, or vice versa. The number of plots used to develop piece size curves is summarized in Table 6-1.

Table 6-1. Number of plots used for fitting coniferous and deciduous piece size curves.

		Coniferous Curves			Deciduous Curves		
FMP Yield Stratum	Number of Eligible Plots[1]	Outliers	Plots With Zero Volumes	Final Number of Eligible Plots	Outliers	Plots With Zero Volumes	Final Number of Eligible Plots
AP	60	-	7	53	-	14	46
AS	58	2	11	45	2	12	44
DEC	85	-	53	32	-	25	60
PA	66	-	17	49	-	40	26
PL	865	-	69	796	-	819	46
SA	31	-	7	24	-	13	18
SB	51	1	8	42	1	38	12
SW	110	-	11	99	-	98	12
Total	1,326	3	183	1,140	3	1,059	264

[1] Number of eligible plots for empirical yield curve development in Table 3-6.

6.2.2 Results

Model coefficients are presented in Table 6.2. Piece size curves are provided in Appendix VII.

Table 6-2. Model coefficients for piece size curves.

FMP Yield Stratum	Species Type	Model Coefficients	
		a_0	a_1
AP	Coniferous	0.47468	333.19538
	Deciduous	-0.93222	338.67009
AS	Coniferous	2.18470	6.48415
	Deciduous	1.88350	89.79342
DEC	Coniferous	3.65941	152.57514
	Deciduous	-1.84024	547.11336
PA	Coniferous	-4.60029	764.98033
	Deciduous	-1.74971	507.20673
PL	Coniferous	3.77193	181.05738
	Deciduous	0.00078	392.93855
SA	Coniferous	-4.09401	843.90056
	Deciduous	-4.36177	674.93581
SB	Coniferous	3.41203	337.45922
	Deciduous	-2.37931	786.42762
SW	Coniferous	4.18831	111.27946
	Deciduous	-0.48371	350.89412

6.3 Regeneration Lag

Regeneration lag (regen lag) is the time in years following harvesting that is required for the harvested area to become stocked with desirable tree species. Regeneration lag calculations employ historic data to project anticipated regeneration lag in forecasting.

Regeneration lag calculations were required for Sundance's FMA area for the 2007 FMP. They have been completed in accordance with the Alberta Forest Management Planning Standard Version 3 – June 2005 and additional instructions provided by SRD (Regeneration Lag Assessment Version 8.0 (ASRD 2005), received from Stephen Wills, April 28, 2006).

Regeneration lag was calculated separately according to one of two broad cover group classes (pure conifer and mixedwoods grouped together, and pure deciduous). Regeneration lag was applied as a shift to all yield curves representing managed stands used in the Sundance 2007 FMP during timber supply modelling (see Chapter 5).

6.3.1 Methods

Regeneration lag was determined in two stages: first, a regeneration lag was assigned to each existing cutblock post 1990 using the rules provided by SRD, and then an area-weighted regeneration lag was calculated for each broad cover group class. Two area-weighted regeneration lags were calculated for the 2007 FMP:

- D broad cover groups;
- C, CD and DC broad cover groups;

Sundance's cutblock dataset used for the landbase classification contained all the information required for the regeneration lag calculations. The development of the cutblock dataset is described in Sundance (2007). The relevant information for the regeneration lag calculations from this dataset included:

- Post-harvest broad cover group declaration;
- Status of regeneration surveys (completed or not completed);
- Result of the survey;
- Year of harvest (calculated using timber year (defined in the Alberta Forest Management Planning Standard as May 1 to April 30) of skid clearance date);
- Harvest type (clearcut);
- Silviculture activities (calculated as the dominant treatment occurring within 2 years of skid clearance date that was applied to at least 60% of the cutblock area; treatments in order of decreasing dominance were: planting, seeding – including drag scarification for pine, site preparation, and lastly leave-for-natural);
- Last treatment date (calculated as the year, from July 1 to June 30, of the most recent silvicultural activity that was applied to at least 20% of the cutblock area; tending was not considered a silvicultural activity for this analysis);

- Planting stock; and
- Cutblock area.

Assigning Regeneration Lag to Cutblocks

First, the cutblocks that were used in the regeneration lag calculations were selected from the cutblock dataset. The selected cutblocks met the following criteria:

- Clearcut harvest;
- Harvested on or after March 1, 1991;
- Harvested before May 1, 1997 for C, CD and DC broad cover groups; and
- Harvested before May 1, 2000 for D broad cover groups.

Based on SRD's rules, cutblocks harvested before May 1, 1997 (C, CD and DC broad cover groups) and May 1, 2000 (D broad cover groups) were to be included in the regeneration lag calculation. Additional years could also be included if all blocks within that year had been declared SR or NSR; Sundance did not include any additional years for these calculations.

Status and management strategy were then assigned to all cutblocks using the hierarchy in Table 6-3.

Table 6-3. Hierarchy and criteria for assigning regeneration status and management strategy.

Status	Management Strategy	Assignment Criteria
SR	Plant or Seed	Regeneration survey completed, result was SR, planting or seeding activities[1] occurred within 2 years of harvest
SR	Site Preparation	Regeneration survey completed, result was SR, site preparation activities occurred within 2 years of harvest
SR	LFN	Regeneration survey completed, result was SR, and LFN strategy was identified
CSR	-	Regeneration survey completed, result was CSR
NSR	-	Regeneration survey completed, result was NSR
Overdue	-	No regeneration survey completed

[1]Activities must cover 60% or more of the cutblock area.

Once status and management strategy was assigned, the regeneration lag was calculated for each cutblock using the rules provided in Table 6-4.

Table 6-4. Rules for assigning regeneration lag to cutblocks.

Broad Cover Group	Management Strategy				
	SR Plant or Seed	SR Site Preparation	SR LFN	CSR	Overdue or NSR[1]
C	If planting stock was 2+0, then last treatment date minus year of harvest minus 1 year, otherwise last treatment date minus year of harvest	Last treatment date minus year of harvest plus 2 years	Maximum of: 5 years or last treatment date minus year of harvest		Maximum of: 10 years or 2005 minus year of harvest
CD			Maximum of: 4 years or last treatment date minus year of harvest		Maximum of: 10 years or 2005 minus year of harvest
DC			Maximum of: 2 years or last treatment date minus year of harvest		Maximum of: 10 years or 2005 minus year of harvest
D			Maximum of: 1 year or last treatment date minus year of harvest	3 years	Maximum of: 7 years or 2005 minus year of harvest

[1] The regeneration lag assessment year was the same as the effective date of the landbase classification (2005).

Calculating an Area-Weighted Regeneration Lag

The regeneration lag assigned to each cutblock was averaged for broad cover group class using cutblock areas.

6.3.2 Results

The area-weighted regeneration lag was calculated, and then rounded up to the nearest year, which was used in timber supply modelling (Table 6-5).

Table 6-5. Calculated regeneration lag by broad cover group.

Broad Cover Group	Non-rounded Regeneration Lag (years)	Rounded Regeneration Lag (years)
C, CD, DC	2.95	3
D	1.76	2

The regen lag calculation was applied to all managed stand yield curves used in the Sundance 2007 FMP. Regeneration lag was applied during timber supply analysis, therefore lagged curves are not presented here.

7. References

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Appendix I Glossary

Glossary Term	Definition
AVI polygon	A polygon delineated based on aerial photography using Alberta Vegetation Inventory rules (AFLW 1991, Nesby 1996). For vegetated areas, areas must be sufficiently similar in terms of structure, moisture regime, crown closure, height, species composition, and origin year to be considered a single unit, or polygon. For nonvegetated areas, areas must have a similar nonvegetated classification.
Base yield curve	The "standard" set of yield curves developed for the FMP yield strata, representing the main stand types within the FMA area. Base yield curves may or may not be used to represent these stand types in the final timber supply analysis.
Broad cover group	A classification of forest types based on coniferous and deciduous components of the AVI species composition. The broad cover groups are coniferous (C), coniferous-leading mixedwood (CD), deciduous-leading mixedwood (DC) and deciduous (D).
Clearcut	A regeneration system where all or most of the merchantable trees in a defined area are harvested in one cutting with reproduction obtained through artificial or natural means. [SRD 2006]
Composite layer	A single AVI attribute string created by merging attributes from both the overstory and understory.
Composite yield curve	Area-weighted composite yield curves developed from empirically-fit natural stand yield curves.
Convergence	Nonlinear regression involves an iterative process in SAS™. An initial set of parameters is provided for the model, and the program attempts to improve the fit of the model to the data by modifying these values. Once the model can no longer be improved by changing these values, the model is said to have achieved convergence. Occasionally, convergence cannot be achieved, often due to the presence of influential points.
Cull	Trees or portions thereof that are merchantable but are removed because of defect.
Cutblock	A specified area that is either designated for harvest or has already been harvested.
Defining layer	The inventory layer used to assign strata. The defining layer may be the overstory, the understory or a composite of the two (composite layer).
Extended strata	One of the three levels of yield stratification rules outlined in the Alberta Forest Management Planning Standard, intended to provide a standardized stratification scheme acceptable to Alberta. Extended stratification is a detailed level used to address specific local issues. Rolls up into Recommended stratification (moderate level of detail) and then to the Minimum stratification (basic level of detail). For the Sundance 2007 FMP, extended strata are converted to FMP yield strata.
FMP yield strata	A stratification applied to the forested landscape. Assignment is based upon species strata and/or crown closure class. FMP Yield strata form the basis for the development of yield curves; each FMP yield stratum has one or more associated yield curves.
Forested landscape	Areas within the gross landbase currently supporting, or being regenerated to, forested tree species.
Fully stocked	All potential growing space is effectively occupied by merchantable tree species.
Fully stocked method	A method for developing managed stand yield curves. Yield curves are empirically fit using plots from natural stands with a C or D density crown closure class; these curves are used as a proxy to represent fully stocked managed stands.
Gross landbase	Entire area in ha within the boundaries of the Sundance FMA area. Includes areas within the outer boundaries of the FMA area that are normally excluded from the FMU area, such as parks.
Gross volume	Indicates that no defect/cull deduction has been applied; this term can be applied to tree-level, plot-level or stand-level volumes (e.g., gross total tree volume, gross merchantable tree volume, gross total plot volume, gross merchantable plot volume, gross total stand volume, gross merchantable stand volume).

Glossary Term	Definition
Influential point	An extreme data point that negatively influences model performance, resulting in failure to converge or an unacceptable curve shape.
Landbase polygon	A polygon within the (classified, TSA, or modelling) landbase derived during spatial processing to incorporate various spatial layers and attributes of interest.
Managed landbase	Areas that are available for forest management activities. Comprised of the combined coniferous and deciduous landbases. Also referred to as the timber harvesting landbase, net landbase, contributing landbase, active landbase.
Managed stand	Stand initiation is caused by anthropogenic disturbance such as harvesting.
Managed stand yield curve	Empirical yield curves fit using C and D crown closure class data from natural stands as a proxy for managed stands within the managed landbase.
Mean annual increment	The average annual increase in volume of individual trees or stands up to the specified point in time. The MAI changes with different growth phases in a tree's life, being highest in the middle years and then slowly decreasing with age. The point at which the MAI peaks is commonly used to identify the biological maturity of the stand and its readiness for harvesting. [SRD 2006]
Merchantable stand volume	Merchantable tree volume summed to represent volume on a per hectare basis.
Merchantable tree volume	A tree-level term; the volume of those portions of a tree bole that meet utilization requirements (stump height, top and bottom diameter limits, log length).
Natural stand	Natural stands developed under natural (non-anthropogenic) disturbance regimes. Stand initiation was due to natural disturbances such as fire, pest or pathogen outbreak, etc.
Natural stand yield curve	Empirical yield curves fit using data from all sampled natural stands within the managed landbase.
Net	Indicates that a defect/cull deduction has been applied; this term can be applied to tree-level, plot-level or stand-level volumes (e.g., net total tree volume, net merchantable tree volume, net total plot volume, net merchantable plot volume, net total stand volume, net merchantable stand volume).
Non-forested landscape	Areas within the gross landbase currently not supporting or being regenerated to forested tree species.
Nonlinear regression/nonlinear models	The practice of fitting a model where the dependant variable is a nonlinear function of one or more independent variables. Nonlinear regression is differentiated from curvilinear regression by the fact that derivatives of a nonlinear regression equation with respect to a given parameter depend on more than one parameter. One benefit of nonlinear models is that they are often derived on the basis of physical and/or biological considerations.
Observation	One plot measurement at a specific point in time. All temporary sample plots have only one associated observation. Permanent sample plots may have one or more observations (remeasured data) for a single plot.
Piece size	The number of trees required to obtain one cubic meter of gross merchantable tree volume.
Plot	Unit of measurement, within which variables of interest are assessed. May be variable or fixed radius.
Plot volume	Gross merchantable tree volume within a plot, converted to a per hectare basis (m^3/ha).
Polygon	A closed geometric entity used to spatially represent area features with associated attributes.
Regeneration lag	The period of time between harvest and establishment of the regenerated stand.
Species group	A single species code used to represent one or more AVI species. For example, the LT species group is comprised of La, Lt, and Lw.
Stand	A community of trees sufficiently uniform in species, age, arrangement or condition as to be distinguishable as a group in the forest or other growth in the area. A stand may also be that polygon as defined in the AVI or Phase III inventory. [SRD 2006]
Stand type	Stand type is not equivalent to stand origin. Stand type reflects stand origin and any silvicultural modifiers applied to that stand. For example, a natural stand that has been thinned is considered a thinned stand type.
Stand volume	Gross merchantable volume within a stand on a per hectare basis (m^3/ha); aka gross merchantable stand volume.

Glossary Term	Definition
Strata/Stratification	A classification scheme for defining polygons within the gross landbase. There are two types of strata referenced in the Sundance 2007 FMP: extended strata and FMP yield strata.
Timber productivity rating	The potential timber productivity of a stand based on the height and age of the first listed species in the AVI overstory string. TPR reflects factors affecting tree growth including soil, topography, climate, elevation, moisture, etc. [AFLW 1991]. TPR is assigned by 1) calculating the site index for the first listed species based on stand-level SI equations and 2) using species and SI to assign a TPR class.
Timber supply analysis	Calculations/computer models with built-in assumptions regarding forest growth patterns, used to determine the annual allowable cut. (Also calculates the spatial harvest sequence and other non-timber values.) [SRD 2006]
Total stand volume	Total tree volume summed to represent volume on a per ha basis.
Total tree volume	A tree-level term; the volume of the entire bole (excluding branches, roots, leaves) of a tree.
Unmanaged landbase	Areas that are unavailable for forest management activities. Also referred to as the passive or non-contributing landbase.
Yield curve	A graphical representation of a predictive yield equation. One yield curve is in fact comprised of three curves: a conifer curve, a deciduous curve and a total curve.
Yield equation	Mathematically describes the relationship between predictor variables (e.g., age, site index) and the response variable (e.g., yield in terms of volume or piece size).
Yield table	A summary table showing yield (e.g., volume, piece size) as a function of varying levels of predictor variables (e.g., age) and classification criteria (e.g., FMP yield stratum).
Yield strata	A set of strata with associated yield projections (yield curves and/or yield tables). See FMP yield strata.

Appendix II Glossary Terminology Structure

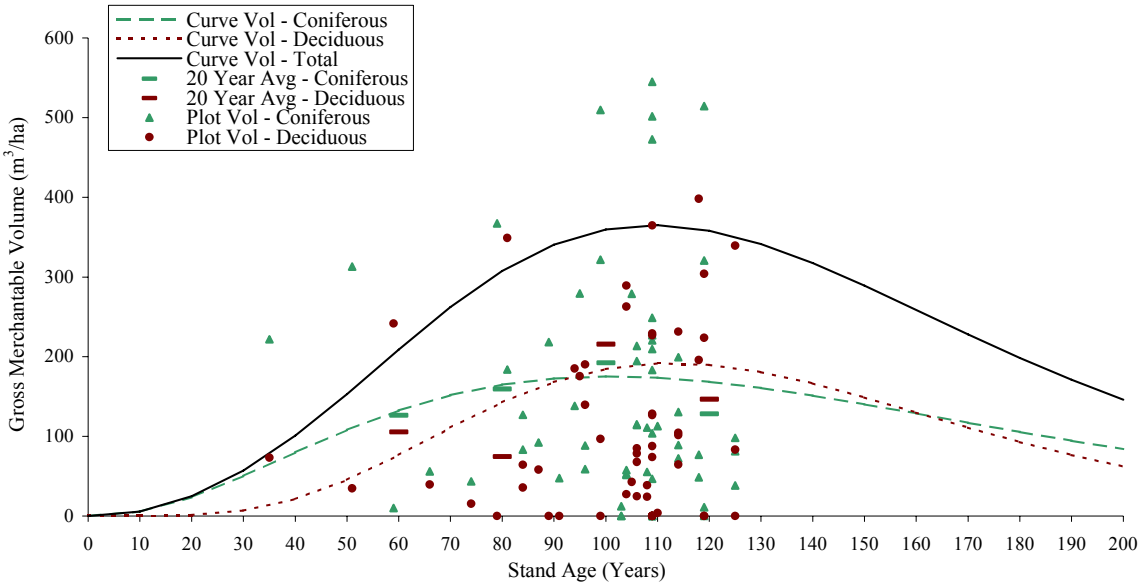
Volumes
- Tree Volume
  - Total Tree Volume
    - Gross Total Tree Volume
    - Net Total Tree Volume
  - Merchantable Tree Volume
    - Gross Merchantable Tree Volume
    - Net Merchantable Tree Volume
- Stand Volume
  - Total Stand Volume
    - Gross Total Stand Volume
    - Net Total Stand Volume
  - Merchantable Stand Volume
    - Gross Merchantable Stand Volume
    - Net Merchantable Stand Volume

Areas
- Gross Landbase
  - Managed Landbase
    - Forested Landscape
      - Stand Types
        - Managed Stands
        - Natural Stands
  - Unmanaged Landbase
    - Forested Landscape
      - Stand Types
        - Managed Stands
        - Natural Stands
    - Non-forested Landscape

Strata and Yield Curves
- Yield Strata
  - Extended Strata
  - FMP Yield Strata
    - Yield Curves
      - Base
        - Natural Stand
        - Managed Stand
        - Composite

Appendix III Yield Curves: Natural Stand

AP STRATUM / Base Natural Stand Yield Curve



2-PARAMETER EQUATION (2P): volume = $a(age)^b e^{(-a*age)}$

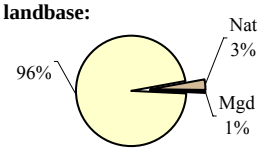
2-PARAMETER EQUATION WITH CONSTANT (2P+k): volume = $a(age)^b e^{(-age/k)}$

Parameter Estimates:		
Coniferous	a	2.439E-02
Eqn: 2P	b	2.4577544
	k	n/a
Deciduous	a	1.455E-07
Eqn: 2P+K	b	5.6373318
	k	20

Utilization Standards:	
Con. Top Diameter (cm):	11.0
Dec. Top Diameter (cm):	10.0
Con. Min. Log Length (m):	3.84
Dec. Min. Log Length (m):	2.49
Stump Diameter (cm):	15.0
Stump Height (cm):	15.0

Stratum Summary:	
Total Number of Plots:	60
Nat. Stand Area (ha):	5,112
Mgd. Stand Area (ha):	1,124

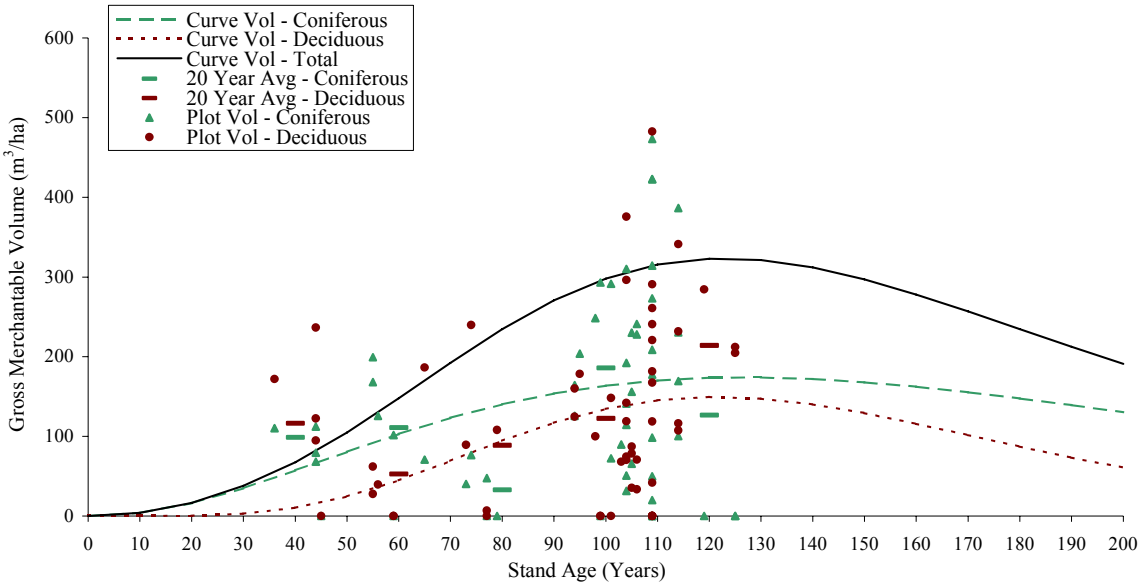
Stratum as a % of the managed landbase:



Stand Age	Number of Plots	Predicted Gross Merchantable Volume[1] (m^3/ha)			Mean Annual Increment (m^3/ha/year)[2]		
		Conifer	Deciduous	Total	Conifer	Deciduous	Total
0	0	0.0	0.0	0.0	0.000	0.000	0.000
10	0	5.5	0.0	5.5	0.548	0.004	0.552
20	0	23.6	1.2	24.8	1.180	0.058	1.238
30	0	50.1	6.9	57.0	1.670	0.230	1.900
40	0	79.6	21.2	100.8	1.990	0.529	2.519
50	1	108.0	45.2	153.1	2.159	0.903	3.062
60	1	132.4	76.6	209.0	2.207	1.276	3.483
70	2	151.5	110.7	262.3	2.165	1.582	3.747
80	4	164.9	142.6	307.4	2.061	1.782	3.843
90	4	172.6	168.0	340.5	1.917	1.866	3.784
100	11	175.2	184.5	359.7	1.752	1.845	3.597
110	28	173.5	191.5	365.0	1.577	1.741	3.318
120	6	168.4	189.7	358.1	1.403	1.581	2.984
130	3	160.6	180.7	341.3	1.235	1.390	2.625
140	0	151.0	166.4	317.4	1.078	1.189	2.267
150	0	140.2	148.9	289.1	0.934	0.993	1.927
160	0	128.7	130.0	258.7	0.804	0.812	1.617
170	0	117.1	110.9	228.0	0.689	0.653	1.341
180	0	105.6	92.9	198.4	0.586	0.516	1.102
190	0	94.5	76.4	170.9	0.497	0.402	0.899
200	0	84.0	61.9	145.8	0.420	0.309	0.729

[1] Gross volume is calculated at the utilization standards specified on this page with no deductions for cull.
[2] Maximum MAI highlighted in light yellow.

AS STRATUM / Base Natural Stand Yield Curve



2-PARAMETER EQUATION (2P): volume = $a(age)^b e^{(-a*age)}$

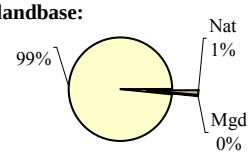
2-PARAMETER EQUATION WITH CONSTANT (2P+k): volume = $a(age)^b e^{(-age/k)}$

Parameter Estimates:		
Coniferous	a	1.877E-02
Eqn: 2P	b	2.3778287
	k	n/a
Deciduous	a	1.468E-08
Eqn: 2P+K	b	6.0666632
	k	20

Utilization Standards:	
Con. Top Diameter (cm):	11.0
Dec. Top Diameter (cm):	10.0
Con. Min. Log Length (m):	3.84
Dec. Min. Log Length (m):	2.49
Stump Diameter (cm):	15.0
Stump Height (cm):	15.0

Stratum Summary:	
Total Number of Plots:	58
Nat. Stand Area (ha):	2,475
Mgd. Stand Area (ha):	524

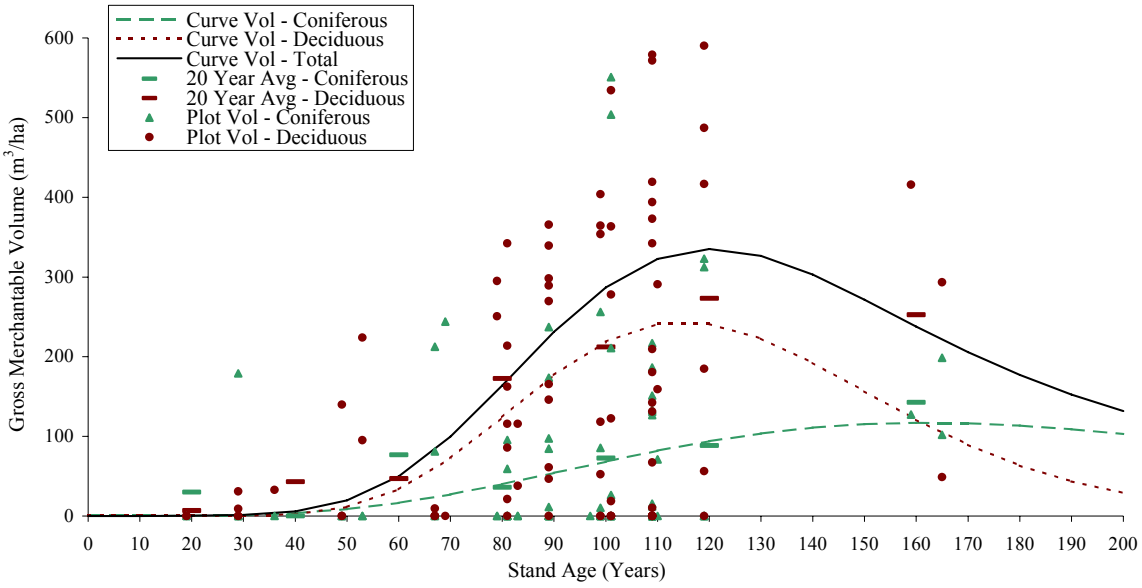
Stratum as a % of the managed landbase:



Stand Age	Number of Plots	Predicted Gross Merchantable Volume[1] (m^3/ha)			Mean Annual Increment (m^3/ha/year)[2]		
		Conifer	Deciduous	Total	Conifer	Deciduous	Total
0	0	0.0	0.0	0.0	0.000	0.000	0.000
10	0	3.7	0.0	3.7	0.371	0.001	0.372
20	0	16.0	0.4	16.4	0.800	0.021	0.821
30	0	34.8	3.0	37.8	1.159	0.100	1.259
40	5	57.1	10.4	67.5	1.428	0.260	1.688
50	1	80.5	24.4	104.9	1.610	0.489	2.098
60	5	102.9	44.8	147.7	1.715	0.746	2.462
70	3	123.1	69.2	192.3	1.758	0.989	2.747
80	3	140.1	94.4	234.5	1.752	1.180	2.931
90	2	153.7	116.9	270.6	1.708	1.299	3.007
100	13	163.7	134.4	298.1	1.637	1.344	2.981
110	23	170.2	145.3	315.5	1.547	1.321	2.868
120	1	173.4	149.5	322.9	1.445	1.245	2.691
130	2	173.9	147.3	321.2	1.338	1.133	2.471
140	0	171.9	140.1	312.0	1.228	1.001	2.229
150	0	167.9	129.1	297.0	1.119	0.861	1.980
160	0	162.2	115.8	278.1	1.014	0.724	1.738
170	0	155.3	101.5	256.8	0.914	0.597	1.511
180	0	147.5	87.1	234.6	0.819	0.484	1.303
190	0	139.0	73.3	212.3	0.732	0.386	1.118
200	0	130.2	60.7	190.9	0.651	0.304	0.954

[1] Gross volume is calculated at the utilization standards specified on this page with no deductions for cull.
[2] Maximum MAI highlighted in light yellow.

DEC STRATUM / Base Natural Stand Yield Curve



2-PARAMETER EQUATION (2P): volume = $a(age)^b e^{(-a*age)}$

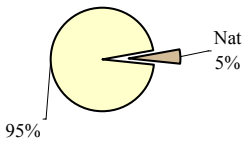
2-PARAMETER EQUATION WITH CONSTANT (2P+k): volume = $a(age)^b e^{(-age/k)}$

Parameter Estimates:		
Coniferous	a	3.018E-08
Eqn: 2P+K	b	5.4010858
	k	30
Deciduous	a	4.723E-17
Eqn: 2P+K	b	11.5043792
	k	10

Utilization Standards:	
Con. Top Diameter (cm):	11.0
Dec. Top Diameter (cm):	10.0
Con. Min. Log Length (m):	3.84
Dec. Min. Log Length (m):	2.49
Stump Diameter (cm):	15.0
Stump Height (cm):	15.0

Stratum Summary:	
Total Number of Plots:	85
Nat. Stand Area (ha):	7,977
Mgd. Stand Area (ha):	n/a

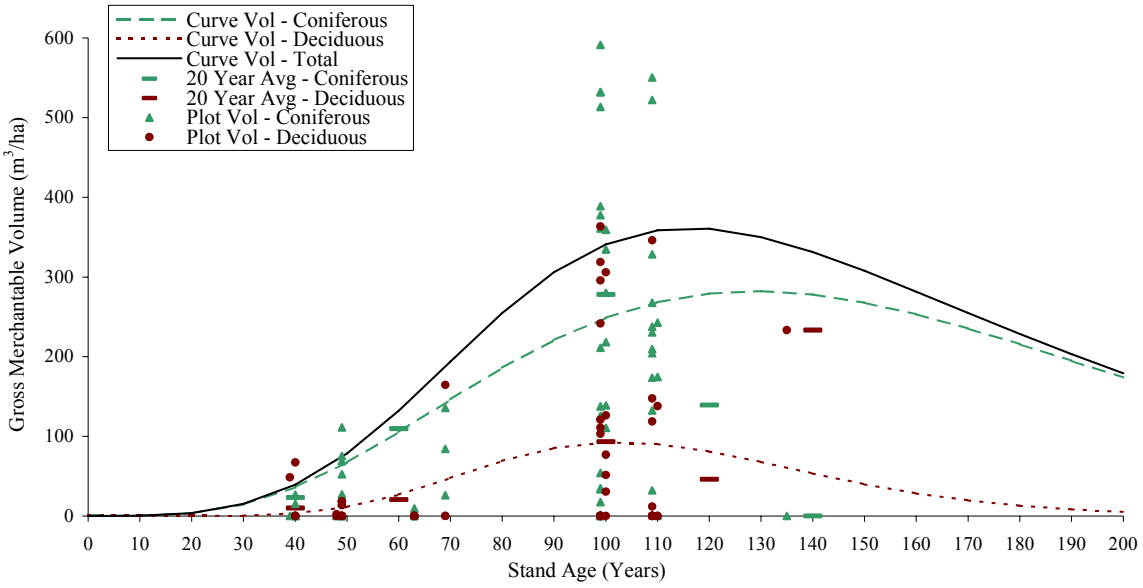
Stratum as a % of the managed landbase:



Stand Age	Number of Plots	Predicted Gross Merchantable Volume[1] (m^3/ha)			Mean Annual Increment (m^3/ha/year)[2]		
		Conifer	Deciduous	Total	Conifer	Deciduous	Total
0	0	0.0	0.0	0.0	0.000	0.000	0.000
10	0	0.0	0.0	0.0	0.001	0.000	0.001
20	2	0.2	0.0	0.2	0.008	0.000	0.009
30	4	1.1	0.2	1.3	0.035	0.008	0.043
40	1	3.6	2.3	5.9	0.089	0.058	0.148
50	5	8.6	11.2	19.7	0.171	0.224	0.395
60	0	16.4	33.5	49.9	0.274	0.558	0.832
70	5	27.0	72.6	99.6	0.386	1.037	1.423
80	11	39.8	124.1	163.9	0.498	1.551	2.049
90	10	53.9	177.0	230.9	0.599	1.966	2.566
100	17	68.3	218.8	287.1	0.683	2.188	2.871
110	21	81.9	240.9	322.8	0.744	2.190	2.935
120	6	93.9	241.2	335.0	0.782	2.010	2.792
130	0	103.6	222.8	326.4	0.797	1.714	2.511
140	0	110.8	192.3	303.1	0.791	1.373	2.165
150	0	115.2	156.4	271.7	0.768	1.043	1.811
160	1	117.0	120.9	237.9	0.731	0.756	1.487
170	2	116.3	89.4	205.7	0.684	0.526	1.210
180	0	113.5	63.4	176.9	0.630	0.352	0.983
190	0	108.9	43.5	152.4	0.573	0.229	0.802
200	0	102.9	28.9	131.8	0.515	0.144	0.659

[1] Gross volume is calculated at the utilization standards specified on this page with no deductions for cull.
[2] Maximum MAI highlighted in light yellow.

PA STRATUM / Base Natural Stand Yield Curve



2-PARAMETER EQUATION (2P): volume = $a(age)^b e^{(-a*age)}$

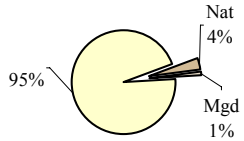
2-PARAMETER EQUATION WITH CONSTANT (2P+k): volume = $a(age)^b e^{(-age/k)}$

Parameter Estimates:		
Coniferous	a	1.814E-05
Eqn: 2P+K	b	4.2924303
	k	30
Deciduous	a	6.054E-15
Eqn: 2P+K	b	10.2628654
	k	10

Utilization Standards:	
Con. Top Diameter (cm):	11.0
Dec. Top Diameter (cm):	10.0
Con. Min. Log Length (m):	3.84
Dec. Min. Log Length (m):	2.49
Stump Diameter (cm):	15.0
Stump Height (cm):	15.0

Stratum Summary:	
Total Number of Plots:	66
Nat. Stand Area (ha):	6,326
Mgd. Stand Area (ha):	1,706

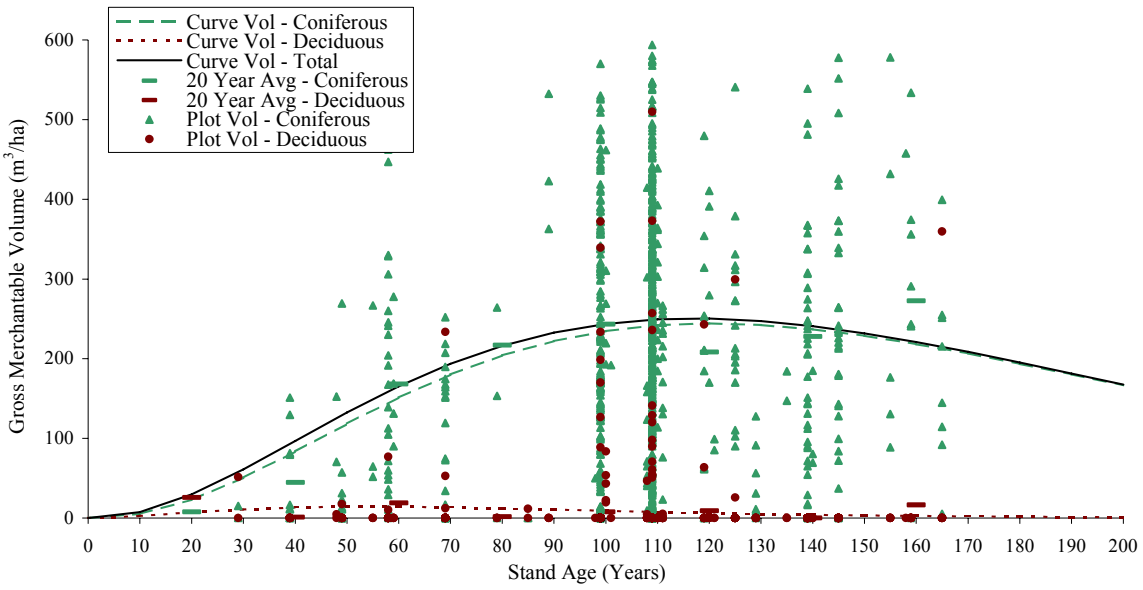
Stratum as a % of the managed landbase:



Stand Age	Number of Plots	Predicted Gross Merchantable Volume[1] (m^3/ha)			Mean Annual Increment (m^3/ha/year)[2]		
		Conifer	Deciduous	Total	Conifer	Deciduous	Total
0	0	0.0	0.0	0.0	0.000	0.000	0.000
10	0	0.3	0.0	0.3	0.025	0.000	0.025
20	0	3.6	0.0	3.6	0.179	0.001	0.180
30	0	14.6	0.4	15.1	0.487	0.015	0.502
40	6	36.0	3.1	39.1	0.900	0.077	0.977
50	11	67.2	11.1	78.4	1.345	0.223	1.567
60	5	105.4	26.6	132.0	1.756	0.444	2.200
70	3	146.3	47.6	193.9	2.090	0.681	2.771
80	0	186.0	69.0	255.0	2.325	0.863	3.187
90	0	220.9	85.0	305.9	2.455	0.945	3.399
100	25	248.8	92.2	341.0	2.488	0.922	3.410
110	15	268.4	90.2	358.6	2.440	0.820	3.260
120	0	279.4	81.1	360.5	2.328	0.676	3.004
130	0	282.3	67.8	350.1	2.171	0.522	2.693
140	1	278.0	53.4	331.4	1.986	0.381	2.367
150	0	267.9	39.9	307.7	1.786	0.266	2.051
160	0	253.2	28.4	281.6	1.582	0.178	1.760
170	0	235.3	19.5	254.8	1.384	0.115	1.499
180	0	215.5	12.9	228.4	1.197	0.072	1.269
190	0	194.8	8.3	203.0	1.025	0.043	1.069
200	0	173.9	5.1	179.1	0.870	0.026	0.895

[1] Gross volume is calculated at the utilization standards specified on this page with no deductions for cull.
[2] Maximum MAI highlighted in light yellow.

PL STRATUM / Base Natural Stand Yield Curve



2-PARAMETER EQUATION (2P): volume = $a(age)^b e^{(-a*age)}$

2-PARAMETER EQUATION WITH CONSTANT (2P+k): volume = $a(age)^b e^{(-age/k)}$

Parameter Estimates:		
Coniferous	a	2.059E-02
Eqn: 2P	b	2.4755876
	k	n/a
Deciduous	a	3.691E-02
Eqn: 2P	b	1.9933631
	k	n/a

Utilization Standards:	
Con. Top Diameter (cm):	11.0
Dec. Top Diameter (cm):	10.0
Con. Min. Log Length (m):	3.84
Dec. Min. Log Length (m):	2.49
Stump Diameter (cm):	15.0
Stump Height (cm):	15.0

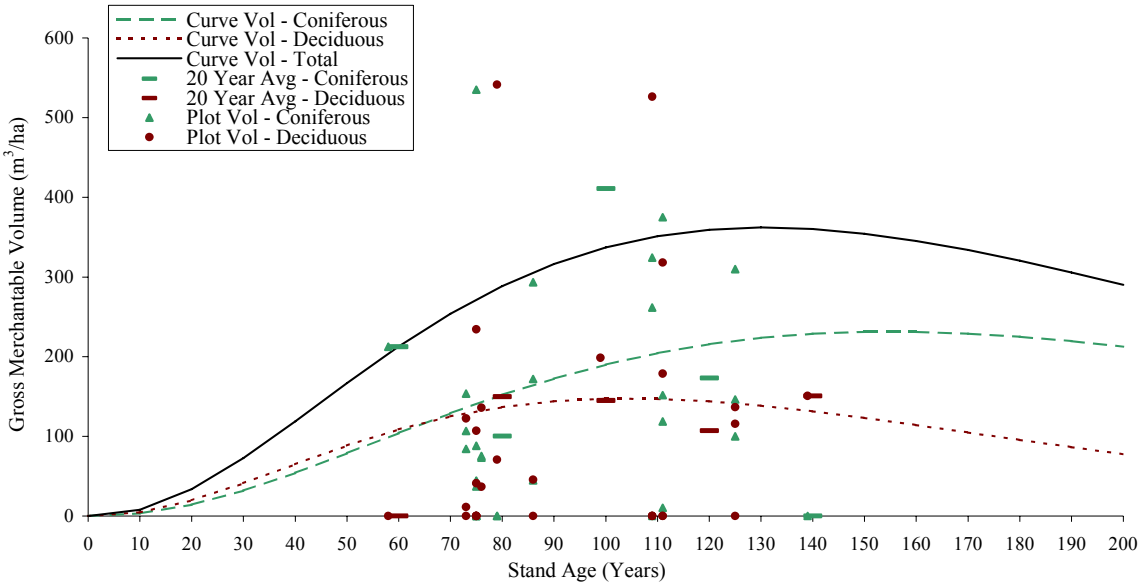
Stratum Summary:	
Total Number of Plots:	865
Nat. Stand Area (ha):	110,993
Mgd. Stand Area (ha):	n/a

Stratum as a % of the managed landbase:

Stand Age	Number of Plots	Predicted Gross Merchantable Volume[1] (m^3/ha)			Mean Annual Increment (m^3/ha/year)[2]		
		Conifer	Deciduous	Total	Conifer	Deciduous	Total
0	2	0.0	0.0	0.0	0.000	0.000	0.000
10	10	5.0	2.5	7.5	0.501	0.251	0.752
20	15	22.7	6.9	29.6	1.134	0.346	1.480
30	33	50.4	10.7	61.1	1.679	0.358	2.037
40	24	83.6	13.2	96.7	2.089	0.329	2.418
50	3	118.2	14.2	132.4	2.363	0.284	2.647
60	5	151.0	14.1	165.2	2.517	0.235	2.753
70	166	180.0	13.3	193.3	2.572	0.190	2.762
80	463	203.9	12.0	215.9	2.549	0.150	2.699
90	19	222.2	10.5	232.6	2.469	0.116	2.585
100	26	234.7	8.9	243.6	2.347	0.089	2.436
110	47	241.9	7.5	249.3	2.199	0.068	2.267
120	30	244.1	6.1	250.3	2.035	0.051	2.086
130	14	242.3	5.0	247.2	1.863	0.038	1.902
140	8	236.9	4.0	240.9	1.692	0.029	1.720
150	0	228.7	3.2	231.9	1.525	0.021	1.546
160	0	218.4	2.5	220.9	1.365	0.016	1.380
170	0	206.5	1.9	208.4	1.215	0.011	1.226
180	0	193.6	1.5	195.1	1.076	0.008	1.084
190	0	180.1	1.2	181.3	0.948	0.006	0.954
200	0	166.5	0.9	167.4	0.832	0.004	0.837

[1] Gross volume is calculated at the utilization standards specified on this page with no deductions for cull.
[2] Maximum MAI highlighted in light yellow.

SA STRATUM / Base Natural Stand Yield Curve



2-PARAMETER EQUATION (2P): volume = $a(age)^b e^{(-a*age)}$

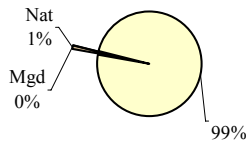
2-PARAMETER EQUATION WITH CONSTANT (2P+k): volume = $a(age)^b e^{(-age/k)}$

Parameter Estimates:		
Coniferous	a	1.537E-02
Eqn: 2P	b	2.3797634
	k	n/a
Deciduous	a	2.307E-02
Eqn: 2P	b	2.4035304
	k	n/a

Utilization Standards:	
Con. Top Diameter (cm):	11.0
Dec. Top Diameter (cm):	10.0
Con. Min. Log Length (m):	3.84
Dec. Min. Log Length (m):	2.49
Stump Diameter (cm):	15.0
Stump Height (cm):	15.0

Stratum Summary:	
Total Number of Plots:	31
Nat. Stand Area (ha):	1,832
Mgd. Stand Area (ha):	157

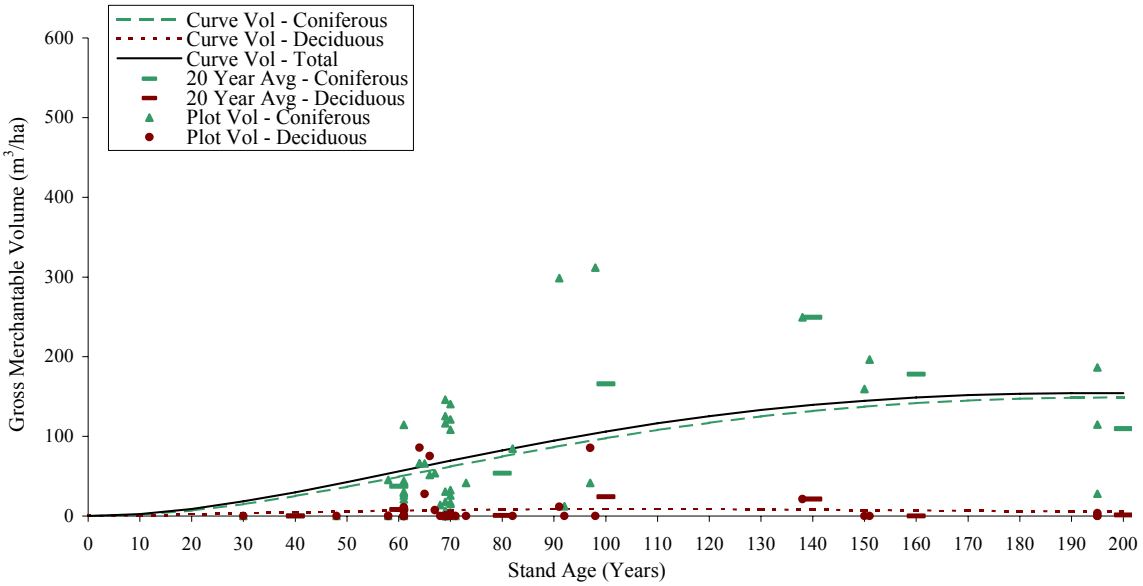
Stratum as a % of the managed landbase:



Stand Age	Number of Plots	Predicted Gross Merchantable Volume[1] (m^3/ha)			Mean Annual Increment (m^3/ha/year)[2]		
		Conifer	Deciduous	Total	Conifer	Deciduous	Total
0	0	0.0	0.0	0.0	0.000	0.000	0.000
10	0	3.2	4.6	7.8	0.316	0.464	0.780
20	0	14.1	19.5	33.6	0.705	0.974	1.680
30	0	31.7	41.0	72.7	1.058	1.367	2.425
40	0	54.0	65.0	119.0	1.349	1.625	2.974
50	0	78.7	88.2	166.9	1.574	1.765	3.339
60	1	104.2	108.6	212.7	1.736	1.810	3.546
70	3	128.9	124.9	253.8	1.842	1.784	3.625
80	11	151.9	136.6	288.5	1.899	1.708	3.607
90	3	172.4	144.0	316.4	1.915	1.600	3.515
100	1	190.0	147.3	337.2	1.900	1.473	3.372
110	8	204.4	147.0	351.4	1.858	1.337	3.194
120	0	215.6	143.9	359.4	1.796	1.199	2.995
130	3	223.6	138.5	362.1	1.720	1.065	2.785
140	1	228.7	131.4	360.1	1.634	0.938	2.572
150	0	231.1	123.1	354.3	1.541	0.821	2.362
160	0	231.1	114.1	345.3	1.444	0.713	2.158
170	0	228.9	104.8	333.8	1.347	0.617	1.963
180	0	224.9	95.5	320.4	1.250	0.531	1.780
190	0	219.3	86.3	305.7	1.154	0.454	1.609
200	0	212.5	77.5	290.1	1.063	0.388	1.450

[1] Gross volume is calculated at the utilization standards specified on this page with no deductions for cull.
[2] Maximum MAI highlighted in light yellow.

SB STRATUM / Base Natural Stand Yield Curve



2-PARAMETER EQUATION (2P): volume = $a(age)^b e^{(-a*age)}$

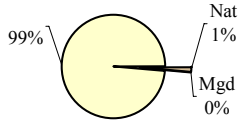
2-PARAMETER EQUATION WITH CONSTANT (2P+k): volume = $a(age)^b e^{(-age/k)}$

Parameter Estimates:		
Coniferous	a	1.112E-02
Eqn: 2P	b	2.2131561
	k	n/a
Deciduous	a	1.639E-02
Eqn: 2P	b	1.7093732
	k	n/a

Utilization Standards:	
Con. Top Diameter (cm):	11.0
Dec. Top Diameter (cm):	10.0
Con. Min. Log Length (m):	3.84
Dec. Min. Log Length (m):	2.49
Stump Diameter (cm):	15.0
Stump Height (cm):	15.0

Stratum Summary:	
Total Number of Plots:	51
Nat. Stand Area (ha):	2,445
Mgd. Stand Area (ha):	45

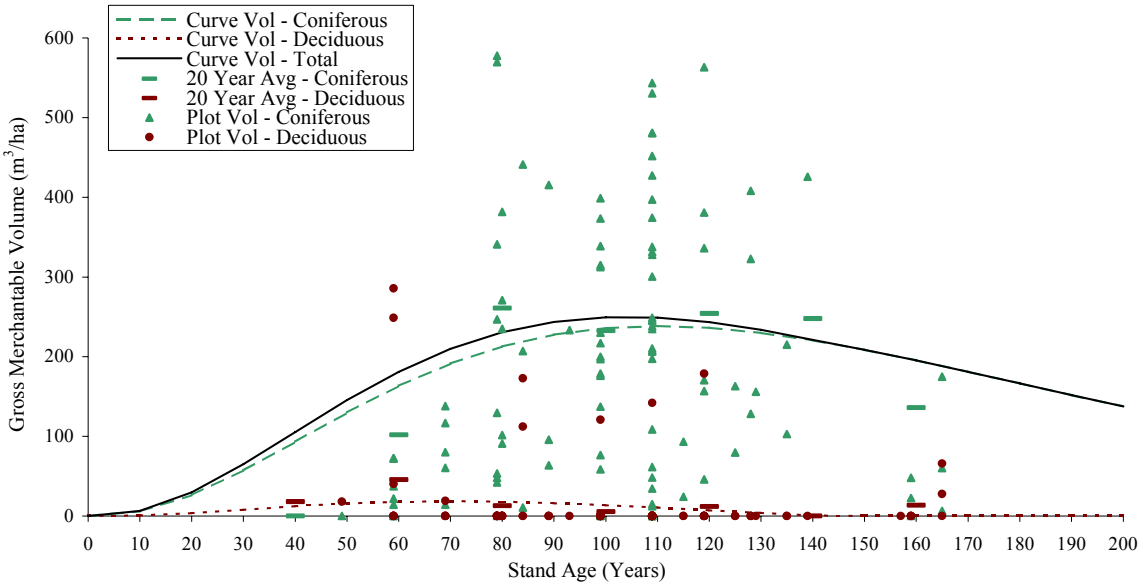
Stratum as a % of the managed landbase:



Stand Age	Number of Plots	Predicted Gross Merchantable Volume[1] (m^3/ha)			Mean Annual Increment (m^3/ha/year)[2]		
		Conifer	Deciduous	Total	Conifer	Deciduous	Total
0	0	0.0	0.0	0.0	0.000	0.000	0.000
10	0	1.6	0.7	2.3	0.163	0.071	0.234
20	0	6.7	2.0	8.7	0.337	0.099	0.436
30	1	14.8	3.4	18.2	0.493	0.112	0.605
40	0	25.0	4.7	29.7	0.626	0.116	0.742
50	1	36.7	5.8	42.5	0.734	0.116	0.850
60	13	49.2	6.7	55.9	0.819	0.112	0.931
70	24	61.9	7.4	69.3	0.884	0.106	0.990
80	1	74.4	7.9	82.3	0.930	0.099	1.029
90	2	86.4	8.2	94.6	0.960	0.091	1.051
100	2	97.6	8.3	106.0	0.976	0.083	1.060
110	0	107.8	8.3	116.2	0.980	0.076	1.056
120	0	117.0	8.2	125.2	0.975	0.068	1.043
130	0	125.0	8.0	133.0	0.961	0.062	1.023
140	1	131.7	7.7	139.4	0.941	0.055	0.996
150	2	137.3	7.4	144.7	0.916	0.049	0.965
160	0	141.7	7.0	148.7	0.886	0.044	0.929
170	0	145.0	6.6	151.6	0.853	0.039	0.892
180	0	147.3	6.1	153.4	0.818	0.034	0.852
190	0	148.5	5.7	154.2	0.782	0.030	0.812
200	4	148.9	5.3	154.2	0.744	0.027	0.771

[1] Gross volume is calculated at the utilization standards specified on this page with no deductions for cull.
[2] Maximum MAI highlighted in light yellow.

SW STRATUM / Base Natural Stand Yield Curve



2-PARAMETER EQUATION (2P): volume = $a(age)^b e^{(-a*age)}$

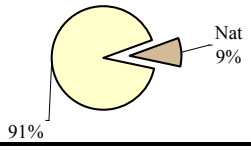
2-PARAMETER EQUATION WITH CONSTANT (2P+k): volume = $a(age)^b e^{(-age/k)}$

Parameter Estimates:		
Coniferous	a	2.275E-02
Eqn: 2P	b	2.5019363
	k	n/a
Total	a	2.435E-02
Eqn: 2P	b	2.5340156
	k	n/a

Utilization Standards:	
Con. Top Diameter (cm):	11.0
Dec. Top Diameter (cm):	10.0
Con. Min. Log Length (m):	3.84
Dec. Min. Log Length (m):	2.49
Stump Diameter (cm):	15.0
Stump Height (cm):	15.0

Stratum Summary:	
Total Number of Plots:	110
Nat. Stand Area (ha):	16,742
Mgd. Stand Area (ha):	n/a

Stratum as a % of the managed landbase:

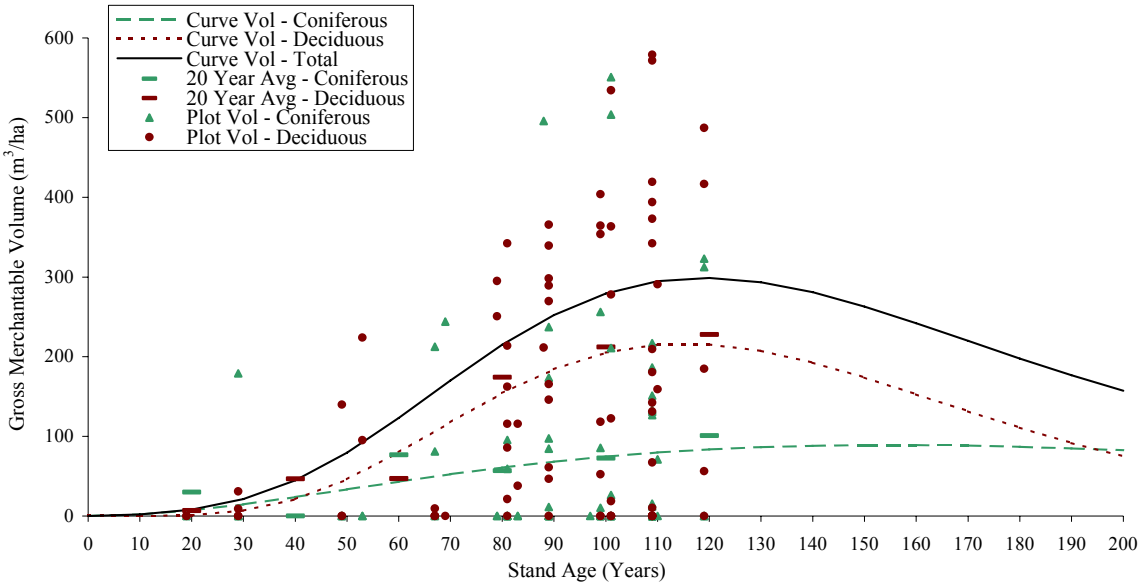


Stand Age	Number of Plots	Predicted Gross Merchantable Volume[1] (m^3/ha)			Mean Annual Increment (m^3/ha/year)[2]		
		Conifer	Deciduous	Total	Conifer	Deciduous	Total
0	0	0.0	0.0	0.0	0.000	0.000	0.000
10	0	5.8	0.8	6.5	0.576	0.077	0.653
20	0	26.0	3.7	29.6	1.298	0.183	1.482
30	0	57.0	7.9	64.9	1.902	0.262	2.164
40	0	93.3	12.1	105.5	2.333	0.304	2.637
50	1	129.9	15.6	145.5	2.598	0.312	2.911
60	8	163.3	17.8	181.1	2.722	0.296	3.018
70	5	191.3	18.5	209.8	2.733	0.264	2.997
80	19	212.8	17.9	230.7	2.660	0.223	2.883
90	4	227.6	16.1	243.7	2.529	0.179	2.708
100	16	236.0	13.5	249.5	2.360	0.135	2.495
110	32	238.6	10.5	249.0	2.169	0.095	2.264
120	9	236.2	7.1	243.3	1.969	0.059	2.028
130	6	229.9	3.8	233.7	1.768	0.029	1.797
140	3	220.4	0.6	221.0	1.574	0.004	1.579
150	0	208.6	0.0	208.6	1.391	0.000	1.391
160	4	195.3	0.0	195.3	1.221	0.000	1.221
170	3	181.0	0.0	181.0	1.065	0.000	1.065
180	0	166.4	0.0	166.4	0.924	0.000	0.924
190	0	151.7	0.0	151.7	0.799	0.000	0.799
200	0	137.4	0.0	137.4	0.687	0.000	0.687

[1] Gross volume is calculated at the utilization standards specified on this page with no deductions for cull.
[2] Maximum MAI highlighted in light yellow.

Appendix IV Yield Curves: Managed Stand

DEC STRATUM / Base Managed Stand Yield Curve



2-PARAMETER EQUATION (2P): volume = $a(age)^b e^{(-a*age)}$

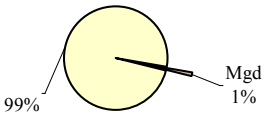
2-PARAMETER EQUATION WITH CONSTANT (2P+k): volume = $a(age)^b e^{(-age/k)}$

Parameter Estimates:		
Coniferous	a	1.399E-02
Eqn: 2P	b	2.1669022
	k	n/a
Deciduous	a	9.245E-08
Eqn: 2P+K	b	5.7585683
	k	20

Utilization Standards:	
Con. Top Diameter (cm):	11.0
Dec. Top Diameter (cm):	10.0
Con. Min. Log Length (m):	3.84
Dec. Min. Log Length (m):	2.49
Stump Diameter (cm):	15.0
Stump Height (cm):	15.0

Stratum Summary:	
Total Number of Plots:	81
Nat. Stand Area (ha):	n/a
Mgd. Stand Area (ha):	1,926

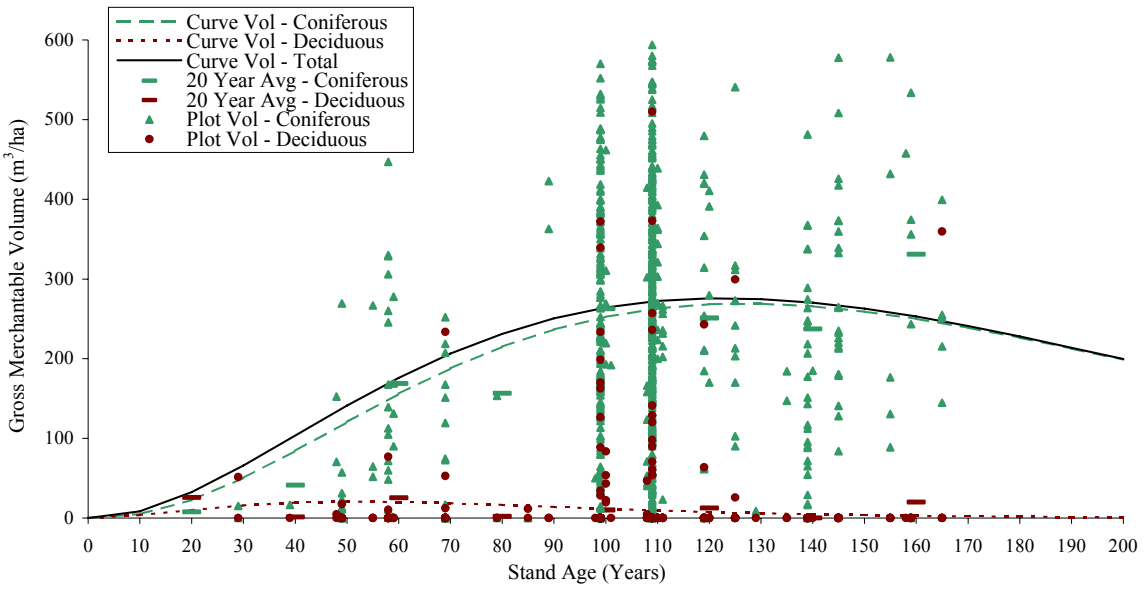
Stratum as a % of the managed landbase:



Stand Age	Number of Plots	Predicted Gross Merchantable Volume[1] (m^3/ha)			Mean Annual Increment (m^3/ha/year)[2]		
		Conifer	Deciduous	Total	Conifer	Deciduous	Total
0	0	0.0	0.0	0.0	0.000	0.000	0.000
10	0	1.8	0.0	1.8	0.179	0.003	0.182
20	2	7.0	1.1	8.0	0.349	0.053	0.402
30	4	14.6	6.6	21.2	0.487	0.221	0.707
40	0	23.7	21.0	44.7	0.592	0.526	1.118
50	5	33.4	46.1	79.5	0.668	0.922	1.590
60	0	43.1	79.9	123.0	0.718	1.332	2.050
70	5	52.3	117.8	170.1	0.747	1.682	2.430
80	11	60.8	154.1	214.9	0.759	1.926	2.686
90	11	68.2	184.2	252.3	0.757	2.046	2.804
100	17	74.5	204.9	279.4	0.745	2.049	2.794
110	21	79.6	215.2	294.8	0.724	1.956	2.680
120	5	83.6	215.4	299.0	0.696	1.795	2.491
130	0	86.4	207.2	293.6	0.665	1.593	2.258
140	0	88.2	192.5	280.7	0.630	1.375	2.005
150	0	89.1	173.7	262.8	0.594	1.158	1.752
160	0	89.1	152.8	241.9	0.557	0.955	1.512
170	0	88.3	131.4	219.7	0.519	0.773	1.292
180	0	86.9	110.8	197.6	0.483	0.615	1.098
190	0	84.9	91.7	176.6	0.447	0.483	0.930
200	0	82.5	74.7	157.3	0.413	0.374	0.786

[1] Gross volume is calculated at the utilization standards specified on this page with no deductions for cull.
[2] Maximum MAI highlighted in light yellow.

PL STRATUM / Base Managed Stand Yield Curve



2-PARAMETER EQUATION (2P): volume = $a(age)^b e^{(-a*age)}$

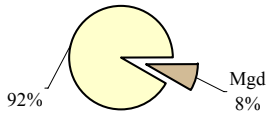
2-PARAMETER EQUATION WITH CONSTANT (2P+k): volume = $a(age)^b e^{(-age/k)}$

Parameter Estimates:		
Coniferous	a	1.960E-02
Eqn: 2P	b	2.4806487
	k	n/a
Deciduous	a	4.070E-02
Eqn: 2P	b	2.1110598
	k	n/a

Utilization Standards:	
Con. Top Diameter (cm):	11.0
Dec. Top Diameter (cm):	10.0
Con. Min. Log Length (m):	3.84
Dec. Min. Log Length (m):	2.49
Stump Diameter (cm):	15.0
Stump Height (cm):	15.0

Stratum Summary:	
Total Number of Plots:	752
Nat. Stand Area (ha):	n/a
Mgd. Stand Area (ha):	14,525

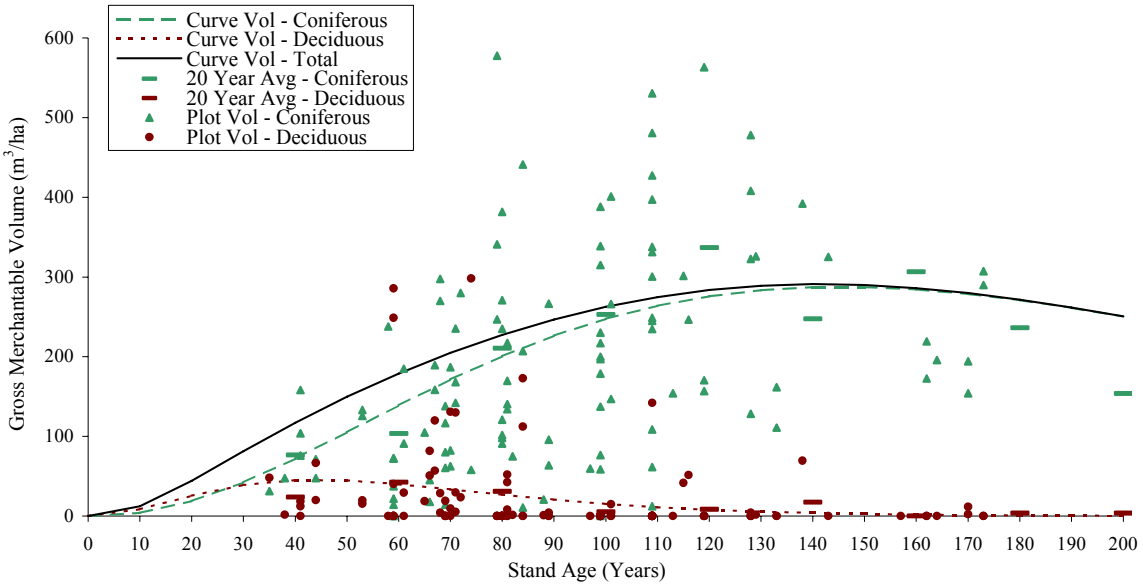
Stratum as a % of the managed landbase:



Stand Age	Number of Plots	Predicted Gross Merchantable Volume[1] (m^3/ha)			Mean Annual Increment (m^3/ha/year)[2]		
		Conifer	Deciduous	Total	Conifer	Deciduous	Total
0	0	0.0	0.0	0.0	0.000	0.000	0.000
10	0	4.9	3.5	8.4	0.487	0.350	0.837
20	0	22.4	10.1	32.4	1.118	0.503	1.621
30	2	50.2	15.8	66.0	1.675	0.525	2.200
40	1	84.3	19.3	103.6	2.108	0.481	2.589
50	15	120.6	20.5	141.1	2.411	0.411	2.822
60	25	155.8	20.1	175.9	2.596	0.335	2.931
70	18	187.7	18.5	206.2	2.681	0.264	2.946
80	2	214.9	16.3	231.2	2.686	0.204	2.890
90	4	236.6	13.9	250.5	2.629	0.155	2.784
100	171	252.6	11.6	264.2	2.526	0.116	2.642
110	408	263.0	9.4	272.4	2.391	0.086	2.477
120	20	268.3	7.5	275.8	2.235	0.063	2.298
130	12	268.9	5.9	274.9	2.069	0.046	2.115
140	34	265.7	4.6	270.3	1.898	0.033	1.931
150	22	259.2	3.6	262.7	1.728	0.024	1.752
160	13	250.0	2.7	252.8	1.563	0.017	1.580
170	5	238.9	2.1	241.0	1.405	0.012	1.417
180	0	226.3	1.5	227.8	1.257	0.009	1.266
190	0	212.7	1.2	213.9	1.120	0.006	1.126
200	0	198.6	0.9	199.4	0.993	0.004	0.997

[1] Gross volume is calculated at the utilization standards specified on this page with no deductions for cull.
[2] Maximum MAI highlighted in light yellow.

SW STRATUM / Base Managed Stand Yield Curve



2-PARAMETER EQUATION (2P): volume = $a(age)^b e^{(-a*age)}$

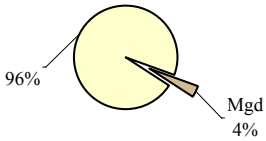
2-PARAMETER EQUATION WITH CONSTANT (2P+k): volume = $a(age)^b e^{(-age/k)}$

Parameter Estimates:		
Coniferous	a	1.686E-02
Eqn: 2P	b	2.4493092
	k	n/a
Deciduous	a	5.499E-02
Eqn: 2P	b	2.4148036
	k	n/a

Utilization Standards:	
Con. Top Diameter (cm):	11.0
Dec. Top Diameter (cm):	10.0
Con. Min. Log Length (m):	3.84
Dec. Min. Log Length (m):	2.49
Stump Diameter (cm):	15.0
Stump Height (cm):	15.0

Stratum Summary:	
Total Number of Plots:	125
Nat. Stand Area (ha):	n/a
Mgd. Stand Area (ha):	636

Stratum as a % of the managed landbase:

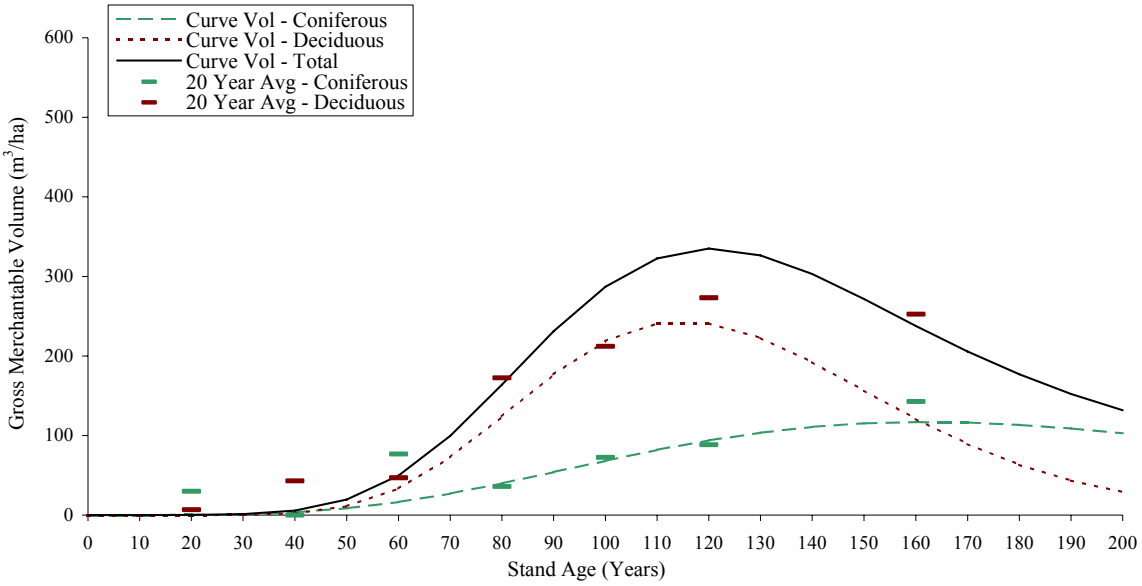


Stand Age	Number of Plots	Predicted Gross Merchantable Volume[1] (m^3/ha)			Mean Annual Increment (m^3/ha/year)[2]		
		Conifer	Deciduous	Total	Conifer	Deciduous	Total
0	0	0.0	0.0	0.0	0.000	0.000	0.000
10	0	4.0	8.2	12.3	0.401	0.825	1.226
20	0	18.5	25.4	43.9	0.925	1.269	2.193
30	0	42.2	39.0	81.2	1.406	1.299	2.705
40	7	72.1	45.0	117.1	1.802	1.126	2.928
50	2	105.2	44.5	149.8	2.104	0.891	2.995
60	10	138.9	39.9	178.8	2.315	0.665	2.981
70	20	171.2	33.4	204.6	2.446	0.477	2.923
80	21	200.6	26.6	227.2	2.507	0.333	2.840
90	4	226.1	20.4	246.6	2.513	0.227	2.740
100	16	247.3	15.2	262.5	2.473	0.152	2.625
110	15	263.9	11.0	274.9	2.399	0.100	2.499
120	6	275.9	7.9	283.7	2.299	0.065	2.364
130	7	283.6	5.5	289.1	2.181	0.042	2.224
140	2	287.2	3.8	291.0	2.052	0.027	2.079
150	0	287.4	2.6	289.9	1.916	0.017	1.933
160	4	284.3	1.7	286.1	1.777	0.011	1.788
170	4	278.7	1.2	279.8	1.639	0.007	1.646
180	0	270.8	0.8	271.6	1.505	0.004	1.509
190	0	261.2	0.5	261.7	1.375	0.003	1.377
200	7	250.2	0.3	250.5	1.251	0.002	1.253

[1] Gross volume is calculated at the utilization standards specified on this page with no deductions for cull.
[2] Maximum MAI highlighted in light yellow.

Appendix V Yield Curves: Composite

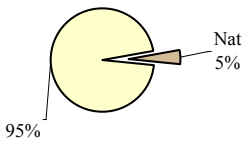
Base Composite Yield Curve for Natural Stands, D Broad Cover Group



Utilization Standards:	
Con. Top Diameter (cm):	11.0
Dec. Top Diameter (cm):	10.0
Con. Min. Log Length (m):	3.84
Dec. Min. Log Length (m):	2.49
Stump Diameter (cm):	15.0
Stump Height (cm):	15.0

Stratum Summary:	
Nat. Stand Area (ha):	7,977
Mgd. Stand Area (ha):	n/a

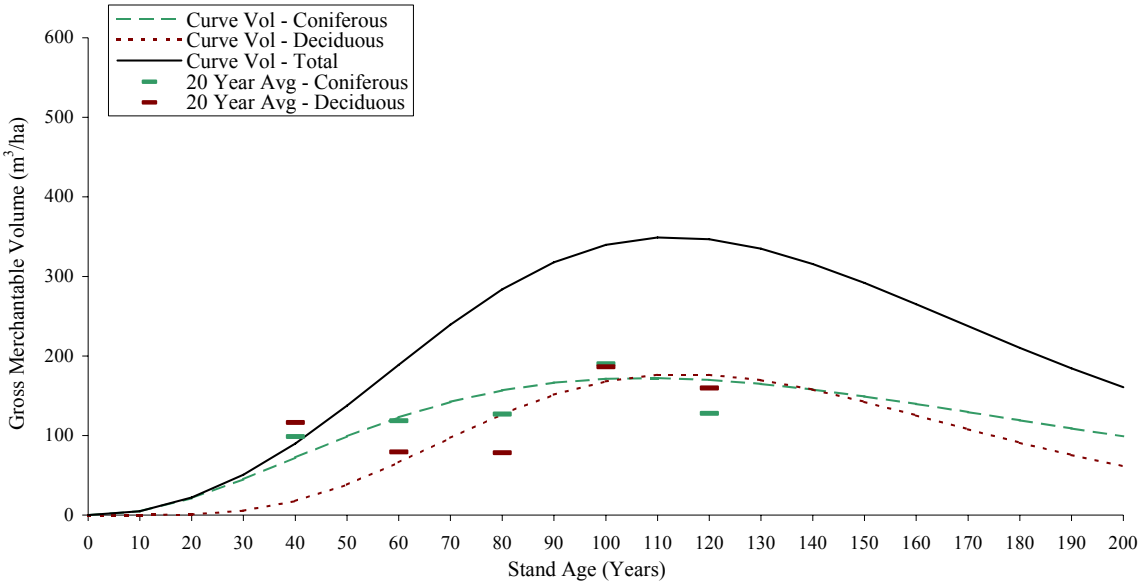
Stratum as a % of the managed landbase:



Stand Age	Predicted Gross Merchantable Volume[1] (m³/ha)			Mean Annual Increment (m³/ha/year)[2]		
	Conifer	Deciduous	Total	Conifer	Deciduous	Total
0	0.0	0.0	0.0	0.000	0.000	0.000
10	0.0	0.0	0.0	0.001	0.000	0.001
20	0.2	0.0	0.2	0.008	0.000	0.009
30	1.1	0.2	1.3	0.035	0.008	0.043
40	3.6	2.3	5.9	0.089	0.058	0.148
50	8.6	11.2	19.7	0.171	0.224	0.395
60	16.4	33.5	49.9	0.274	0.558	0.832
70	27.0	72.6	99.6	0.386	1.037	1.423
80	39.8	124.1	163.9	0.498	1.551	2.049
90	53.9	177.0	230.9	0.599	1.966	2.566
100	68.3	218.8	287.1	0.683	2.188	2.871
110	81.9	240.9	322.8	0.744	2.190	2.935
120	93.9	241.2	335.0	0.782	2.010	2.792
130	103.6	222.8	326.4	0.797	1.714	2.511
140	110.8	192.3	303.1	0.791	1.373	2.165
150	115.2	156.4	271.7	0.768	1.043	1.811
160	117.0	120.9	237.9	0.731	0.756	1.487
170	116.3	89.4	205.7	0.684	0.526	1.210
180	113.5	63.4	176.9	0.630	0.352	0.983
190	108.9	43.5	152.4	0.573	0.229	0.802
200	102.9	28.9	131.8	0.515	0.144	0.659

[1] Gross volume is calculated at the utilization standards specified on this page with no deductions for cull.
[2] Maximum MAI highlighted in light yellow.

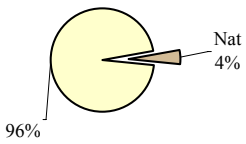
Base Composite Yield Curve for Natural Stands, DC Broad Cover Group



Utilization Standards:	
Con. Top Diameter (cm):	11.0
Dec. Top Diameter (cm):	10.0
Con. Min. Log Length (m):	3.84
Dec. Min. Log Length (m):	2.49
Stump Diameter (cm):	15.0
Stump Height (cm):	15.0

Stratum Summary:	
Nat. Stand Area (ha):	7,587
Mgd. Stand Area (ha):	n/a

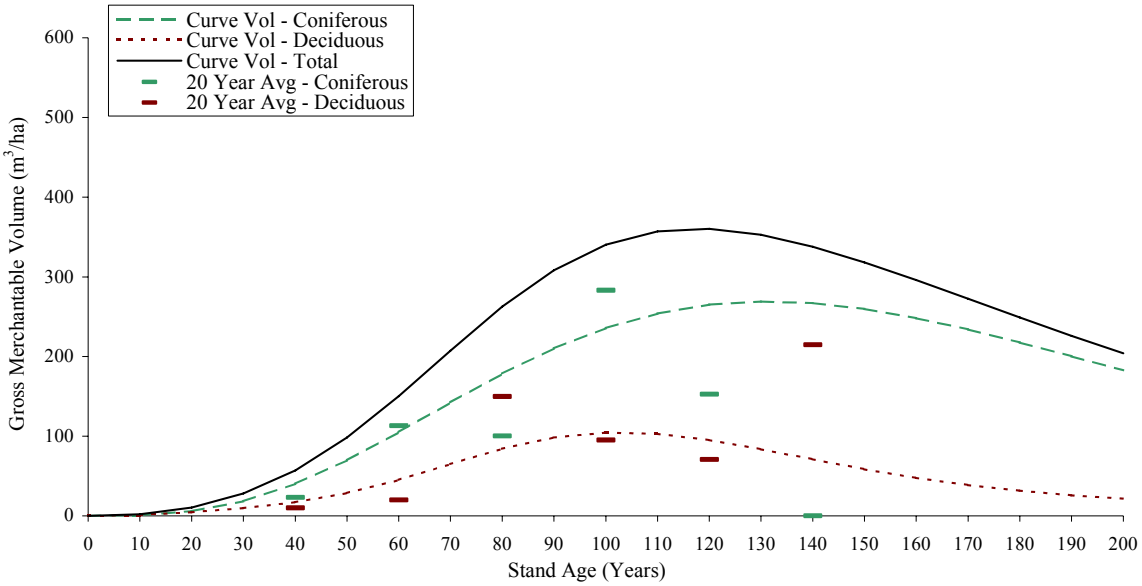
Stratum as a % of the managed landbase:



Stand Age	Predicted Gross Merchantable Volume[1] (m³/ha)			Mean Annual Increment (m³/ha/year)[2]		
	Conifer	Deciduous	Total	Conifer	Deciduous	Total
0	0.0	0.0	0.0	0.000	0.000	0.000
10	4.9	0.0	4.9	0.491	0.003	0.494
20	21.1	0.9	22.0	1.056	0.046	1.102
30	45.1	5.6	50.7	1.503	0.187	1.691
40	72.3	17.7	89.9	1.807	0.441	2.248
50	99.0	38.4	137.4	1.980	0.768	2.748
60	122.8	66.2	189.0	2.046	1.103	3.150
70	142.3	97.2	239.4	2.032	1.388	3.421
80	156.8	126.8	283.6	1.960	1.586	3.546
90	166.4	151.3	317.7	1.849	1.681	3.530
100	171.4	168.2	339.6	1.714	1.682	3.396
110	172.4	176.5	348.9	1.567	1.604	3.172
120	170.0	176.6	346.6	1.417	1.472	2.888
130	164.9	169.8	334.7	1.269	1.306	2.575
140	157.8	157.8	315.6	1.127	1.127	2.255
150	149.2	142.5	291.7	0.995	0.950	1.945
160	139.6	125.4	265.0	0.873	0.784	1.656
170	129.5	107.9	237.4	0.762	0.635	1.397
180	119.2	91.0	210.2	0.662	0.505	1.168
190	109.0	75.4	184.4	0.574	0.397	0.971
200	99.0	61.5	160.5	0.495	0.307	0.803

[1] Gross volume is calculated at the utilization standards specified on this page with no deductions for cull.
[2] Maximum MAI highlighted in light yellow.

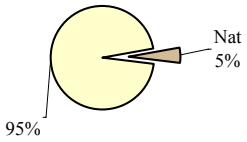
Base Composite Yield Curve for Natural Stands, CD Broad Cover Group



Utilization Standards:	
Con. Top Diameter (cm):	11.0
Dec. Top Diameter (cm):	10.0
Con. Min. Log Length (m):	3.84
Dec. Min. Log Length (m):	2.49
Stump Diameter (cm):	15.0
Stump Height (cm):	15.0

Stratum Summary:	
Nat. Stand Area (ha):	8,158
Mgd. Stand Area (ha):	n/a

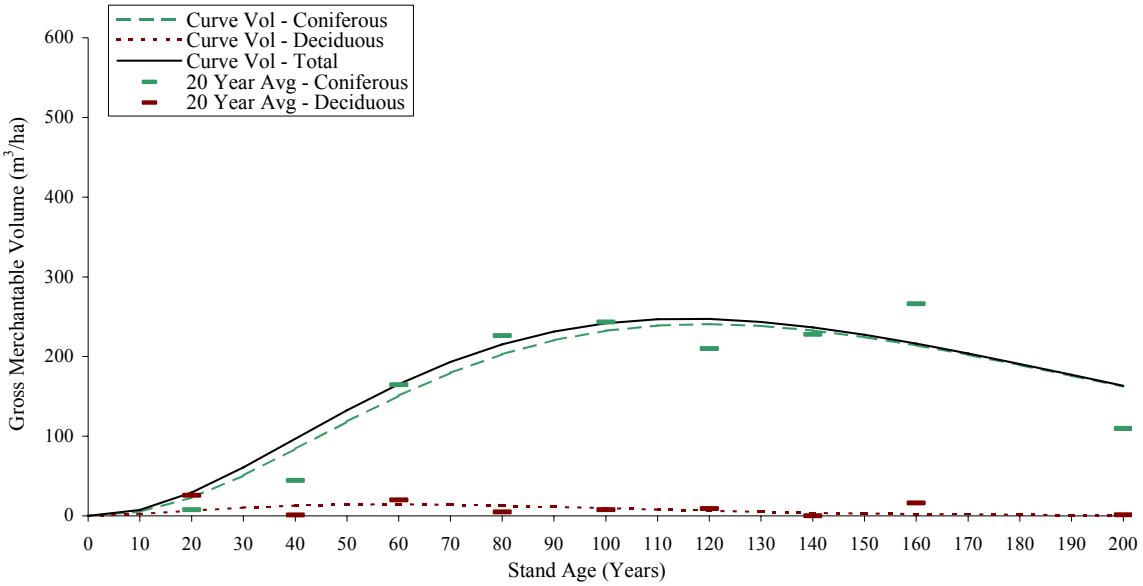
Stratum as a % of the managed landbase:



Stand Age	Predicted Gross Merchantable Volume[1] (m³/ha)			Mean Annual Increment (m³/ha/year)[2]		
	Conifer	Deciduous	Total	Conifer	Deciduous	Total
0	0.0	0.0	0.0	0.000	0.000	0.000
10	0.9	1.0	1.9	0.091	0.104	0.195
20	5.9	4.4	10.3	0.297	0.220	0.517
30	18.5	9.5	28.0	0.615	0.318	0.934
40	40.0	17.0	57.0	1.001	0.424	1.425
50	69.8	28.5	98.3	1.396	0.569	1.965
60	105.1	45.0	150.1	1.752	0.750	2.502
70	142.4	65.0	207.4	2.034	0.928	2.963
80	178.3	84.2	262.5	2.229	1.052	3.281
90	210.0	98.3	308.3	2.334	1.092	3.425
100	235.6	104.6	340.2	2.356	1.046	3.402
110	254.0	103.0	357.0	2.309	0.936	3.245
120	265.1	95.2	360.2	2.209	0.793	3.002
130	269.1	83.7	352.8	2.070	0.644	2.714
140	266.9	70.9	337.8	1.907	0.506	2.413
150	259.6	58.6	318.2	1.731	0.390	2.121
160	248.2	47.7	295.9	1.551	0.298	1.850
170	233.9	38.7	272.6	1.376	0.227	1.603
180	217.6	31.4	249.1	1.209	0.175	1.384
190	200.3	25.8	226.1	1.054	0.136	1.190
200	182.6	21.4	204.0	0.913	0.107	1.020

[1] Gross volume is calculated at the utilization standards specified on this page with no deductions for cull.
[2] Maximum MAI highlighted in light yellow.

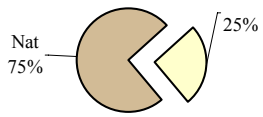
Base Composite Yield Curve for Natural Stands, C Broad Cover Group



Utilization Standards:	
Con. Top Diameter (cm):	11.0
Dec. Top Diameter (cm):	10.0
Con. Min. Log Length (m):	3.84
Dec. Min. Log Length (m):	2.49
Stump Diameter (cm):	15.0
Stump Height (cm):	15.0

Stratum Summary:	
Nat. Stand Area (ha):	130,179
Mgd. Stand Area (ha):	n/a

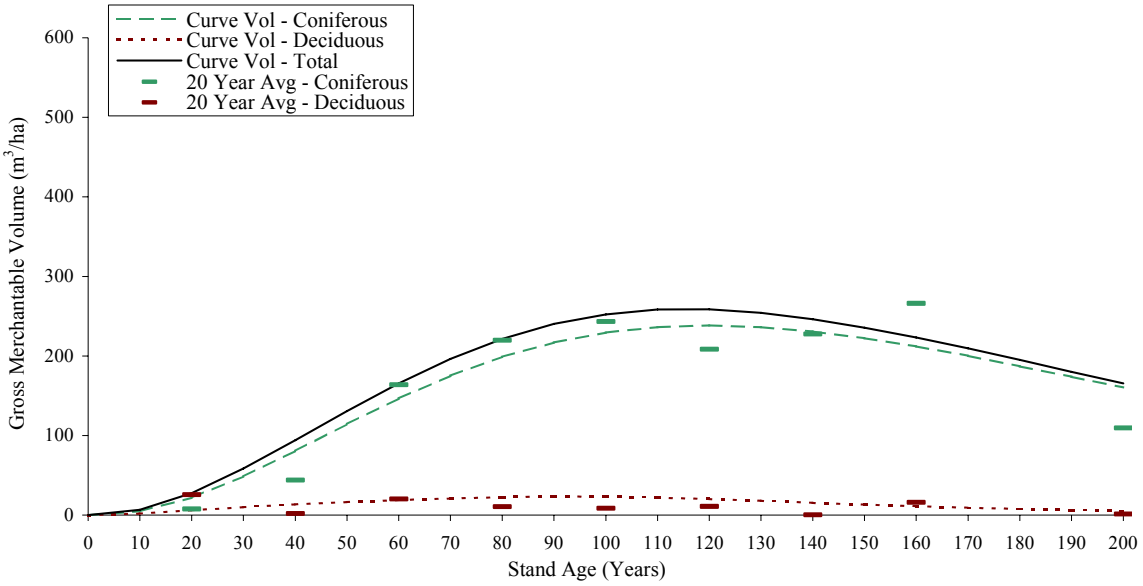
Stratum as a % of the managed landbase:



Stand Age	Predicted Gross Merchantable Volume[1] (m³/ha)			Mean Annual Increment (m³/ha/year)[2]		
	Conifer	Deciduous	Total	Conifer	Deciduous	Total
0	0.0	0.0	0.0	0.000	0.000	0.000
10	5.0	2.3	7.3	0.504	0.226	0.730
20	22.8	6.4	29.2	1.140	0.320	1.461
30	50.6	10.2	60.8	1.685	0.341	2.026
40	83.7	12.9	96.6	2.093	0.322	2.415
50	118.1	14.2	132.4	2.363	0.284	2.647
60	150.7	14.5	165.2	2.512	0.241	2.753
70	179.3	13.8	193.1	2.561	0.198	2.759
80	202.6	12.7	215.3	2.533	0.158	2.691
90	220.3	11.2	231.5	2.448	0.124	2.572
100	232.3	9.5	241.8	2.323	0.095	2.418
110	238.9	7.9	246.8	2.172	0.072	2.243
120	240.7	6.3	247.0	2.006	0.053	2.059
130	238.5	4.9	243.3	1.834	0.038	1.872
140	232.8	3.6	236.4	1.663	0.026	1.689
150	224.4	2.8	227.2	1.496	0.019	1.515
160	214.0	2.3	216.2	1.337	0.014	1.351
170	202.1	1.8	203.9	1.189	0.010	1.199
180	189.2	1.4	190.6	1.051	0.008	1.059
190	175.9	1.1	177.0	0.926	0.006	0.932
200	162.4	0.9	163.3	0.812	0.004	0.816

[1] Gross volume is calculated at the utilization standards specified on this page with no deductions for cull.
[2] Maximum MAI highlighted in light yellow.

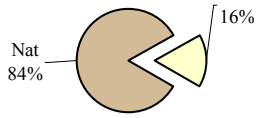
Base Composite Yield Curve for Natural Stands, C/CD/DC Broad Cover Groups



Utilization Standards:	
Con. Top Diameter (cm):	11.0
Dec. Top Diameter (cm):	10.0
Con. Min. Log Length (m):	3.84
Dec. Min. Log Length (m):	2.49
Stump Diameter (cm):	15.0
Stump Height (cm):	15.0

Stratum Summary:	
Nat. Stand Area (ha):	145,925
Mgd. Stand Area (ha):	n/a

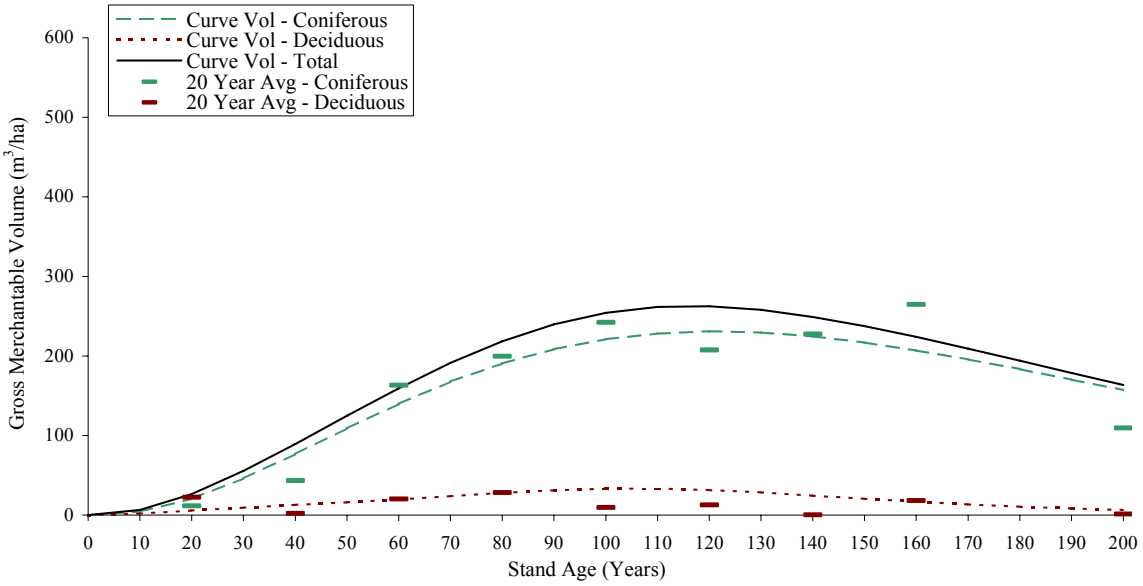
Stratum as a % of the managed landbase:



Stand Age	Predicted Gross Merchantable Volume[1] (m³/ha)			Mean Annual Increment (m³/ha/year)[2]		
	Conifer	Deciduous	Total	Conifer	Deciduous	Total
0	0.0	0.0	0.0	0.000	0.000	0.000
10	4.8	2.1	6.9	0.480	0.207	0.688
20	21.8	6.0	27.8	1.089	0.300	1.389
30	48.5	9.9	58.4	1.616	0.332	1.948
40	80.7	13.4	94.0	2.017	0.334	2.351
50	114.5	16.3	130.7	2.289	0.326	2.615
60	146.7	18.9	165.5	2.445	0.314	2.759
70	175.3	21.0	196.3	2.504	0.300	2.804
80	198.9	22.6	221.5	2.486	0.282	2.769
90	216.9	23.3	240.2	2.410	0.259	2.669
100	229.3	23.1	252.4	2.293	0.231	2.524
110	236.3	22.0	258.2	2.148	0.200	2.348
120	238.4	20.1	258.6	1.987	0.168	2.155
130	236.4	17.9	254.2	1.818	0.137	1.955
140	230.8	15.4	246.2	1.648	0.110	1.759
150	222.5	13.2	235.7	1.483	0.088	1.571
160	212.0	11.2	223.2	1.325	0.070	1.395
170	200.1	9.4	209.4	1.177	0.055	1.232
180	187.2	7.7	194.9	1.040	0.043	1.083
190	173.8	6.3	180.1	0.915	0.033	0.948
200	160.2	5.2	165.4	0.801	0.026	0.827

[1] Gross volume is calculated at the utilization standards specified on this page with no deductions for cull.
[2] Maximum MAI highlighted in light yellow.

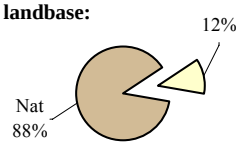
Base Composite Yield Curve for Natural Stands, All Broad Cover Groups (C/CD/DC/D)



Utilization Standards:	
Con. Top Diameter (cm):	11.0
Dec. Top Diameter (cm):	10.0
Con. Min. Log Length (m):	3.84
Dec. Min. Log Length (m):	2.49
Stump Diameter (cm):	15.0
Stump Height (cm):	15.0

Stratum Summary:	
Nat. Stand Area (ha):	153,902
Mgd. Stand Area (ha):	n/a

Stratum as a % of the managed landbase:



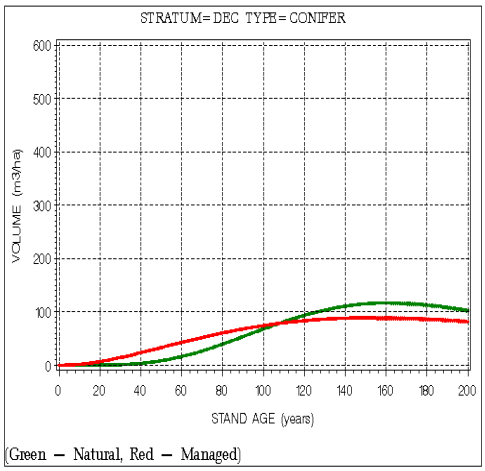
Stand Age	Predicted Gross Merchantable Volume[1] (m³/ha)			Mean Annual Increment (m³/ha/year)[2]		
	Conifer	Deciduous	Total	Conifer	Deciduous	Total
0	0.0	0.0	0.0	0.000	0.000	0.000
10	4.6	2.0	6.5	0.456	0.196	0.652
20	20.7	5.7	26.4	1.033	0.285	1.318
30	46.0	9.4	55.5	1.534	0.315	1.849
40	76.7	12.8	89.5	1.917	0.320	2.237
50	109.0	16.0	125.0	2.179	0.320	2.499
60	139.9	19.6	159.6	2.332	0.327	2.659
70	167.6	23.7	191.3	2.394	0.339	2.733
80	190.7	27.9	218.5	2.383	0.348	2.731
90	208.5	31.3	239.8	2.317	0.348	2.664
100	221.0	33.2	254.2	2.210	0.332	2.542
110	228.3	33.3	261.6	2.075	0.303	2.378
120	230.9	31.6	262.5	1.924	0.263	2.188
130	229.5	28.5	258.0	1.765	0.219	1.984
140	224.6	24.6	249.1	1.604	0.176	1.780
150	216.9	20.6	237.5	1.446	0.138	1.584
160	207.1	16.9	224.0	1.294	0.106	1.400
170	195.7	13.5	209.2	1.151	0.079	1.231
180	183.4	10.6	194.0	1.019	0.059	1.078
190	170.4	8.3	178.7	0.897	0.043	0.940
200	157.3	6.4	163.7	0.786	0.032	0.818

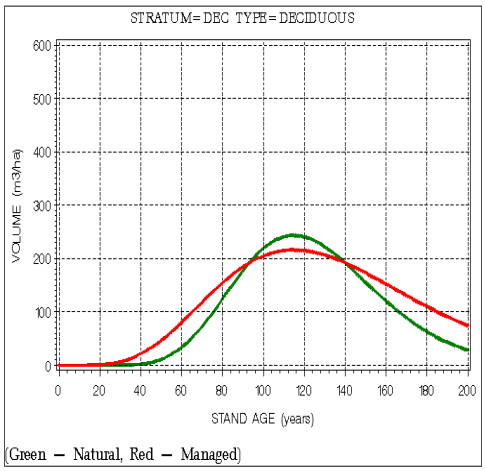
[1] Gross volume is calculated at the utilization standards specified on this page with no deductions for cull.
[2] Maximum MAI highlighted in light yellow.

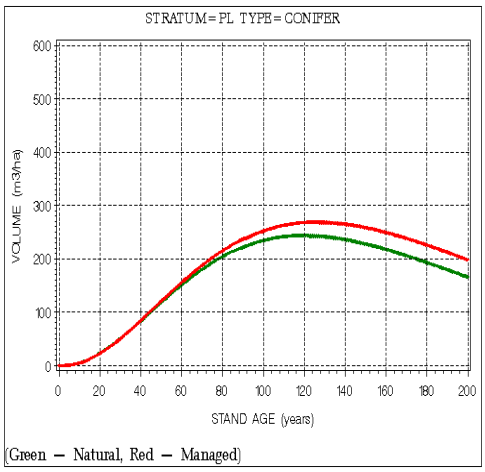
Appendix VI Yield Curves: Comparisons

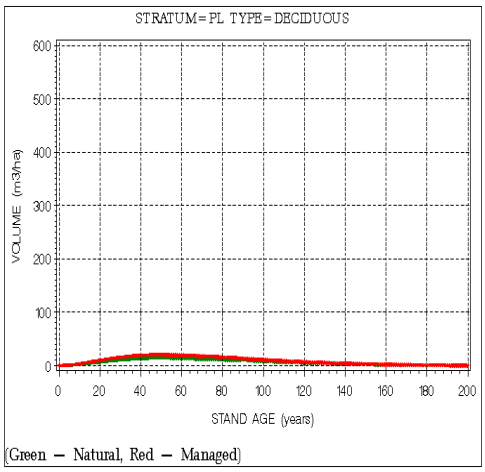
Yield curve comparisons show the yield curves from Appendices III to V graphed together by FMP yield stratum for comparison purposes. Note that curves only show total gross merchantable stand volume. Only the DEC, PL and SW yield strata have more than one type of yield curve, therefore these are the only FMP yield strata presented.

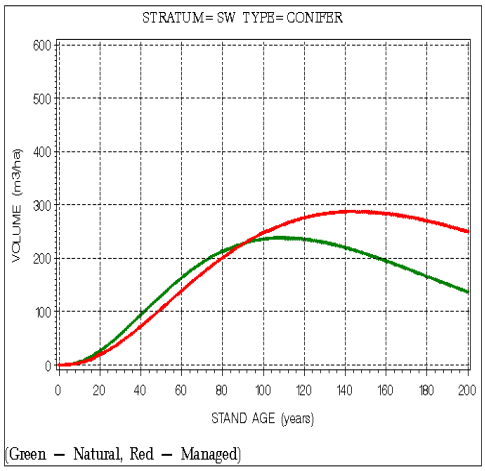
Composite natural stand yield curves (C, CD, DC, D, C/CD/DC, and C/CD/DC/D) are also presented side-by-side for comparative purposes.

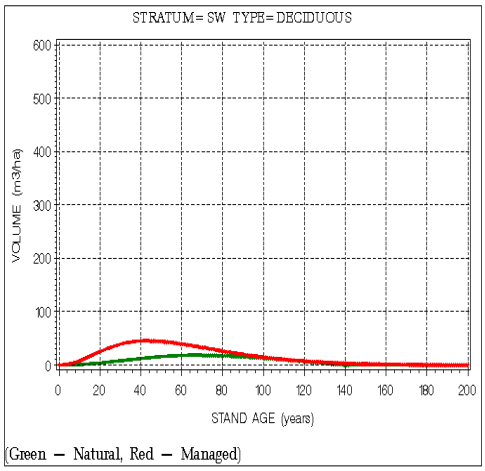

STRATUM= DEC TYPE= CONIFER
VOLUME (m3/ha)
STAND AGE (years)
(Green – Natural, Red – Managed)

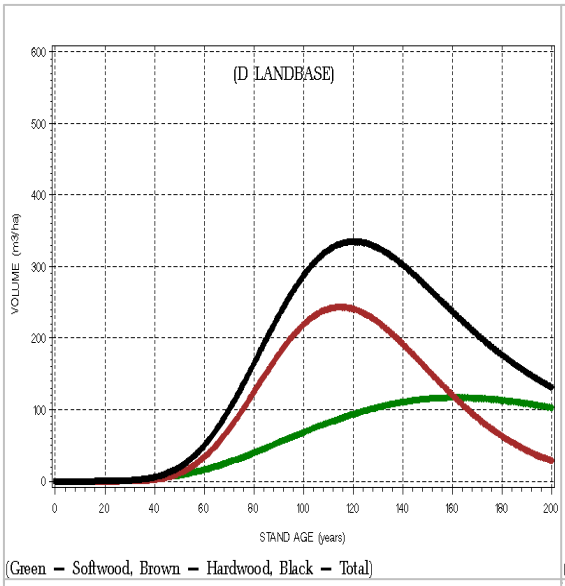

STRATUM= DEC TYPE= DECIDUOUS
VOLUME (m3/ha)
STAND AGE (years)
(Green – Natural, Red – Managed)


STRATUM= PL TYPE= CONIFER
VOLUME (m3/ha)
STAND AGE (years)
(Green – Natural, Red – Managed)

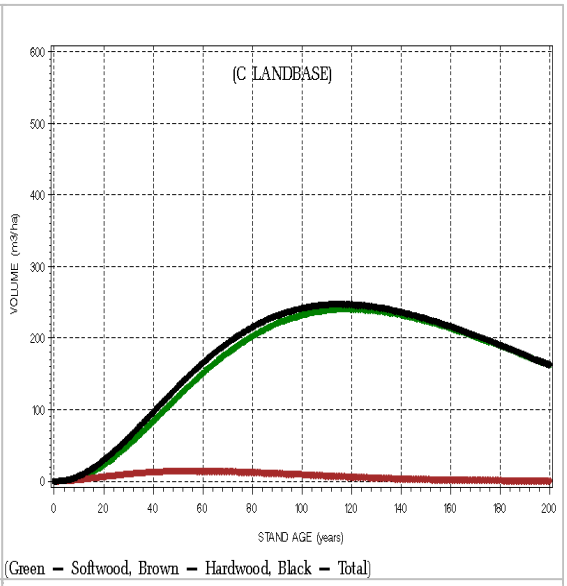

STRATUM= PL TYPE= DECIDUOUS
VOLUME (m3/ha)
STAND AGE (years)
(Green – Natural, Red – Managed)


STRATUM= SW TYPE= CONIFER
VOLUME (m3/ha)
STAND AGE (years)
(Green – Natural, Red – Managed)

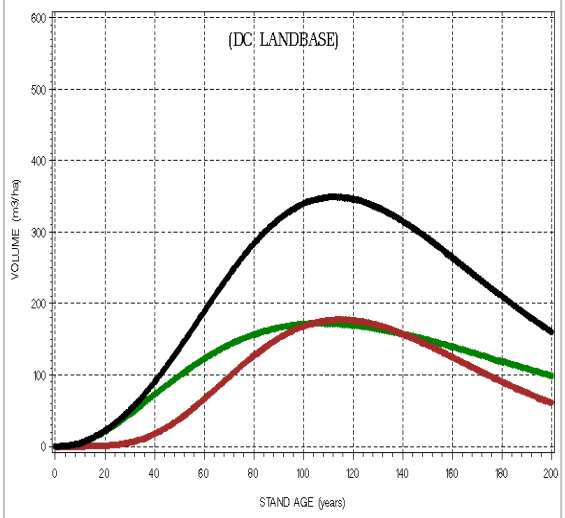

STRATUM= SW TYPE= DECIDUOUS
VOLUME (m3/ha)
STAND AGE (years)
(Green – Natural, Red – Managed)



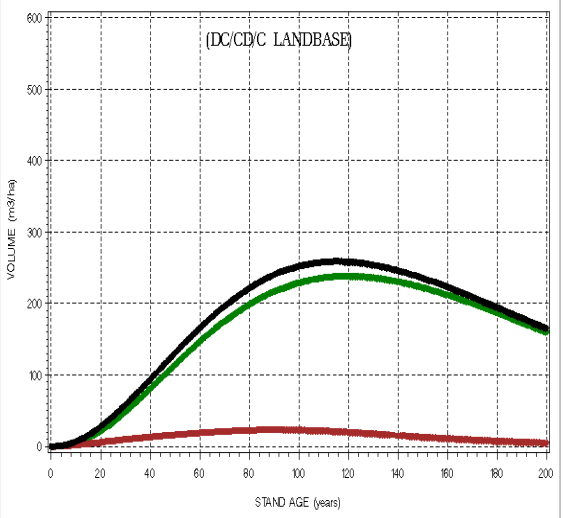
(Green – Softwood, Brown – Hardwood, Black – Total)



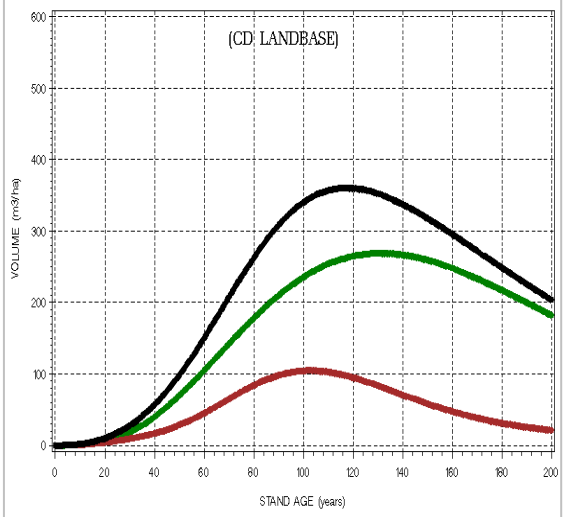
(Green – Softwood, Brown – Hardwood, Black – Total)



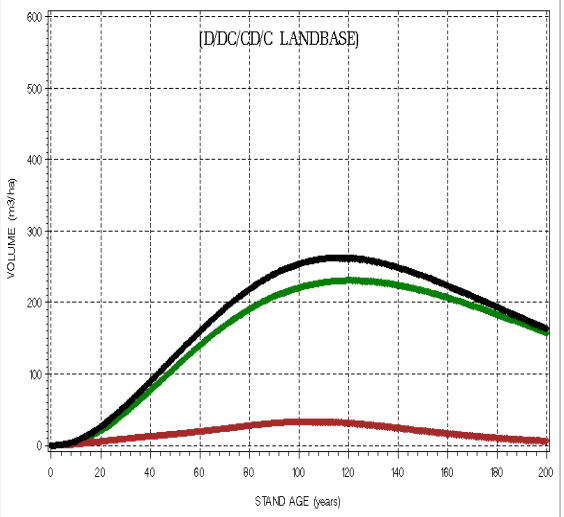
(Green – Softwood, Brown – Hardwood, Black – Total)



(Green – Softwood, Brown – Hardwood, Black – Total)

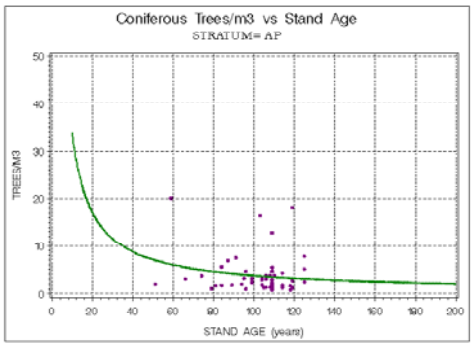


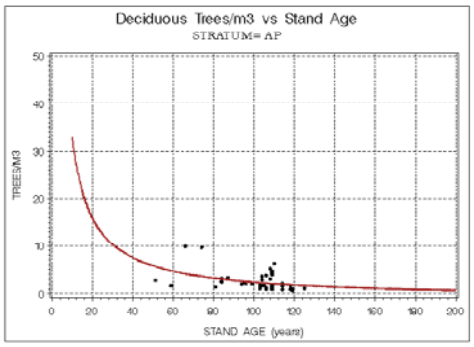
(Green – Softwood, Brown – Hardwood, Black – Total)

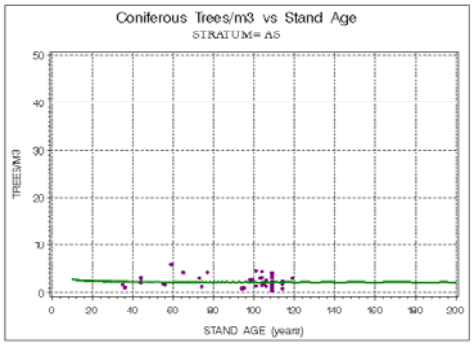


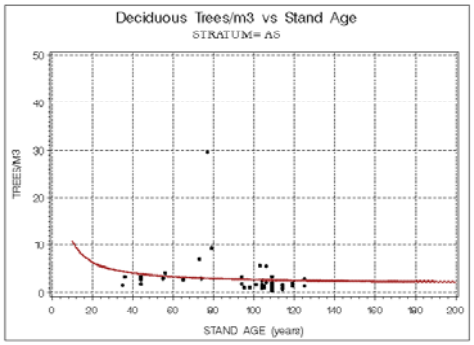
(Green – Softwood, Brown – Hardwood, Black – Total)

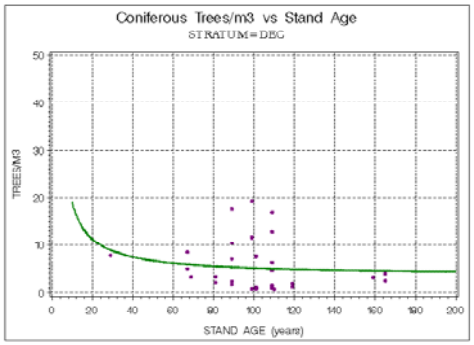
Appendix VII Yield Curves: Piece Size

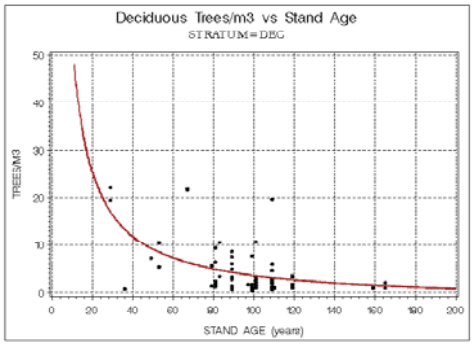

Coniferous Trees/m3 vs Stand Age
STRATUM= AP
TREES/M3
STAND AGE (years)

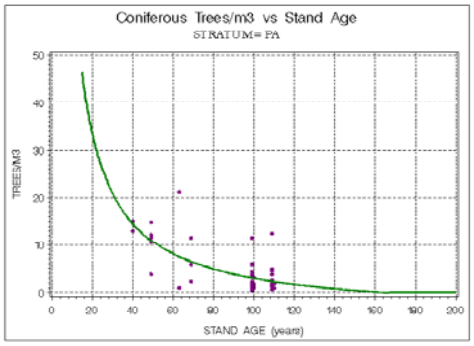

Deciduous Trees/m3 vs Stand Age
STRATUM= AP
TREES/M3
STAND AGE (years)

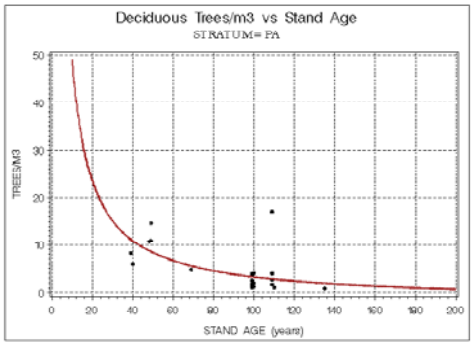

Coniferous Trees/m3 vs Stand Age
STRATUM= AS
TREES/M3
STAND AGE (years)

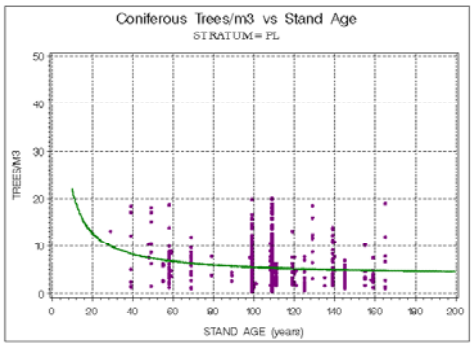

Deciduous Trees/m3 vs Stand Age
STRATUM= AS
TREES/M3
STAND AGE (years)

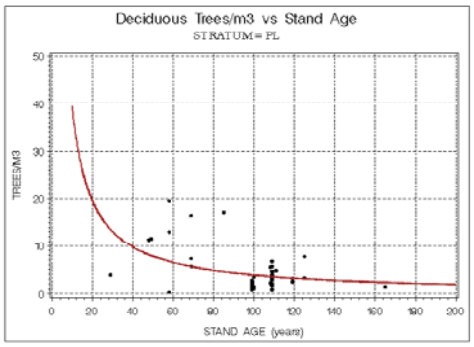

Coniferous Trees/m3 vs Stand Age
STRATUM= DEG
TREES/M3
STAND AGE (years)

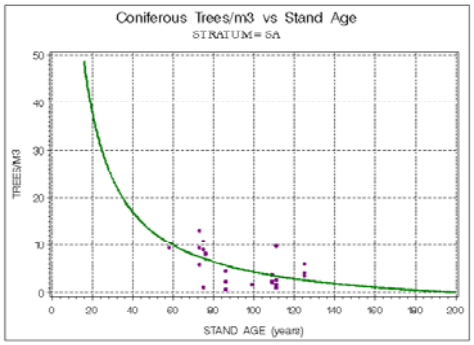

Deciduous Trees/m3 vs Stand Age
STRATUM= DEG
TREES/M3
STAND AGE (years)

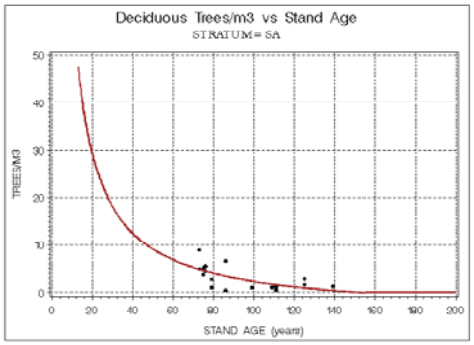

Coniferous Trees/m3 vs Stand Age
STRATUM= PA
TREES/M3
STAND AGE (years)

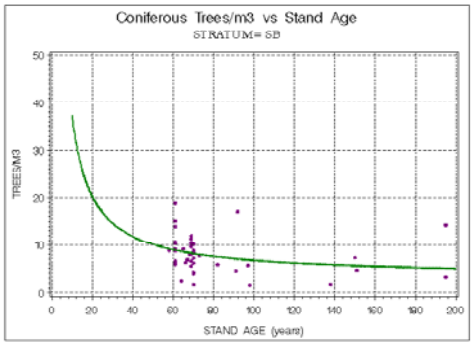

Deciduous Trees/m3 vs Stand Age
STRATUM= PA
TREES/M3
STAND AGE (years)

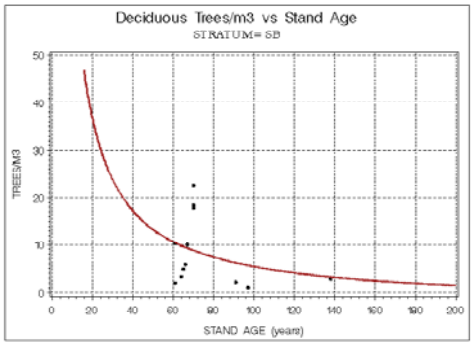

Coniferous Trees/m3 vs Stand Age
STRATUM= PL
TREES/M3
STAND AGE (years)

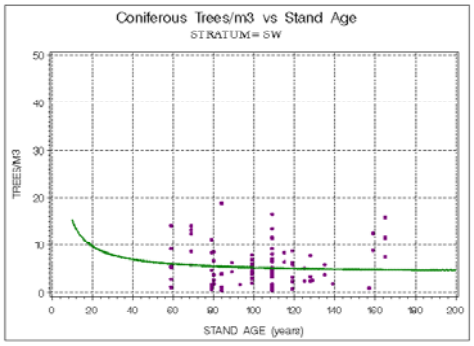

Deciduous Trees/m3 vs Stand Age
STRATUM= PL
TREES/M3
STAND AGE (years)

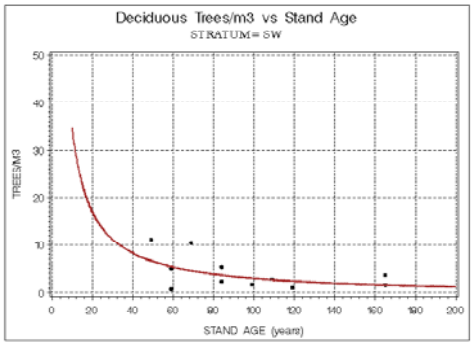

Coniferous Trees/m3 vs Stand Age
STRATUM= SA
TREES/M3
STAND AGE (years)


Deciduous Trees/m3 vs Stand Age
STRATUM= SA
TREES/M3
STAND AGE (years)


Coniferous Trees/m3 vs Stand Age
STRATUM= SB
TREES/M3
STAND AGE (years)


Deciduous Trees/m3 vs Stand Age
STRATUM= SB
TREES/M3
STAND AGE (years)


Coniferous Trees/m3 vs Stand Age
STRATUM= SW
TREES/M3
STAND AGE (years)


Deciduous Trees/m3 vs Stand Age
STRATUM= SW
TREES/M3
STAND AGE (years)

The Forestry Corp. Project Number: P539
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