WOOD SUPPLY REPORT
FOR
FOREST MANAGEMENT LICENCE AREA #1

FORESTRY BRANCH

MANITOBA CONSERVATION

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PREFACE

This report contains a wood supply analysis for Forest Management Licence Area #1 (FMLA). The purpose of this analysis is to examine the short and long term effects of current forest policy, management and harvesting practices on the availability and sustainability of timber for harvesting in the FMLA under licence to Tembec Inc.

To determine annual allowable harvest levels, the Director of Forestry must have an up-to-date assessment of the wood supply based on best available information and current management and harvesting practices. The report that follows provides this assessment, however, it should not be considered as a recommendation on permissible harvest levels.

This report focuses on a single forest management scenario that reflects current policy and practices in forest management and harvesting operations. Current management practices are defined by the specifications in the Forest Management Licence, management plans, guidelines for the protection of forest resources, forest act and regulations and land use decisions of the Manitoba Government. Consultation with industry and regional resource managers assisted in formulating the forest management scenario.

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1. INTRODUCTION

Wood supply is the quantity of timber available for harvest over time. Wood supply is dynamic, not only because trees naturally grow and die, but also because of the conditions that effect tree growth, and the environmental, social and economic factors that affect the availability of trees for harvest, change through time.

Wood supply analysis is the process of assessing and predicting the current and future timber supply for a geographic area. In this case, the area is the Tembec Forest Management Licence area (FMLA). This report documents the wood supply analysis undertaken by Manitoba Conservation for the Tembec FMLA. The analysis follows the completion of a new forest resource inventory (FRI), undertaken in 1997 and subsequent volume sampling completed in 2002. New technology and methodologies have been employed in this determination of new harvest levels employing a more consultative approach with the forest industry. The aerial photography, photo interpretation work and map digitizing was undertaken by the Province. The volume sampling was carried out under contract to Timberline Forestry Consultants. The information gathered in these efforts serves as the basis for this analysis and forms part of the information used by the Director of Forestry in determining an Annual Allowable Cut (AAC).

The wood supply projections presented in this analysis look far into the future. However, because of uncertainty surrounding the information and because forest management objectives change through time, these projections should not be viewed as static prescriptions that remain in place for that length of time. They remain relevant only as long as the information upon which they are based remains relevant. Thus it is important that re-analysis occurs regularly, using new information and knowledge to update the wood supply picture. This allows close monitoring of the timber supply and of the implications stemming from changes in management practices and objectives.

2. PROVINCIAL POLICY AND MANDATE

The Forestry Branch of is responsible for determining the sustained yield capacity of Manitoba's forests and the assignment of annual harvest levels on the harvestable land base. Any allocations made to the forest industry either through Forest Management Licence (FML) or timber quota assignment or special allocation are only undertaken to the extent allowed by the long term sustainability of the forest resource. This level governs the development capacity of the forest. The Forestry Branch has adopted a more open and consultative approach to determine wood supply. Working closely with industry and the Integrated Regional Resource Management Team (IRMT), key inputs into the determination of wood supply are discussed prior to inclusion into the analysis model. The approach allows for more input from other user groups and forestry managers from the operations side.

3. WOOD SUPPLY ISSUES

The FMLA is the primary source of forest products for the forest industry located within the Lake Winnipeg East Forest Section. Rising demand of the forest resources in this area and increased pressure on the land base for other uses gave importance to re-inventorying the forests to determine the sustainable harvest level which could be supported on this land base. Since the last inventory, several new resource management issues have been identified, including woodland caribou, protected areas initiative, parklands re-configuration and rezoning, treaty land entitlement selections and expanded watercourse reserves as well as changing operating standards and practices to name a few. These changes and the pressure they bring to bear on the land base are significant and require careful consideration in determining the forest's ability to supply the forest industry with the required forest products on a sustainable and environmentally sensitive basis.

4. NEW FOREST LANDS INVENTORY

The Forest Lands Inventory (FRI) was completed 1999 for FMU 31 and 35 using 1997 aerial photography. Manitoba Conservation undertook the photo interpretation, mapping and volume sampling of the land base. Forest stands were delineated from the aerial photographs and each stand was given forest cover and site attributes based on photo interpretation protocols. Volume sampling was undertaken using methodologies and procedures detailed in the Forestry Branch volume sampling manual.

5. WOOD SUPPLY PROCESS

This analysis undertakes to determine the theoretical maximum sustainable softwood harvest level that can be sustained on the land base in Tembec's Forest Management Licence Area (FMLA). The determination of sustainable wood supply is undertaken in two parts. First, the strategic level wood supply is determined in accordance with the primary objective of this analysis; determine maximum softwood harvest that can be sustained over the planning horizon. The sustainable harvest is calculated in consideration of forest management policies such as uninterrupted fibre supply from the land base (even flow) and operational constraints that included, for example, defined timber utilization standards, riparian zone protection, minimum harvest age and forest regeneration delay. Secondly, the tactical level wood supply is determined, whereby the harvest blocks and harvest schedules derived from the strategic level optimization analysis are further constrained with spatial considerations, such as flow fluctuation, harvest-block adjacency & proximal distance, green up, and cut-block size.

The strategic and tactical level analysis were formulated to best reflect forest policy, operating guidelines and harvesting practices presently followed by the industry and is considered to be current forest practices as the Provincial “Base Case” wood supply analysis.

The “Woodstock” and “Stanley” forest resource planning software, developed by Remsoft Inc. was used in the analysis to determine the optimal, sustainable harvest level in accordance to stated objectives and actions and constraints. “Stanley” is a simulation model that was used to spatially locate the areas scheduled for harvest in the “Woodstock” harvest sequence file. The following sections document the wood supply process, detailing model inputs and outputs, structure and data preparation. All GIS processing was undertaken using ESRI ArcInfo and ArcGIS software.

6. DATA PREPARATION FOR GIS PROCESSING

The wood supply analysis was undertaken for that portion of the land base encompassed by the FMLA boundary. This includes all of Forest Management Unit (FMU) 31 and a south west portion of FMU 35.

6.1 Map Layers

The information for the two FMU areas was collected and prepared as digital map layers using ESRI ArcInfo Geographic Information System (GIS) software.

The map layers are listed in the table below with a brief description and then described in detail after the table.

6.1.1 Forest Resource Inventory

The FLI polygon attributes were combined with four layers of resource management information to obtain the final FRI layer. The four layers include Forest Management Licence (FML) boundary, land ownership, land status and Forest Management Unit boundary. Combining the layers added additional attributes to the final FRI layer, which facilitated the analysis for open and closed crown land. The status and ownership codes within the FRI database describe legal land designations and accompanying land use restrictions, providing the ability to filter out specific lands. Combinations of status and ownership are used to identify, for example, closed and open zones within parks, protected area proposals, private lands or lands designated TLE.

The original FRI layer is stored in map tiles with each tile representing an area of about 10 km by 10km. For the wood supply analysis the FRI map tiles were appended together to make one FRI map for the FMLA.

6.1.2 FMLA Boundary

A FMLA boundary was needed in order to set the geographic limits for the wood supply analysis (illustrated in Appendix I).

6.1.3 Permanent Sample Plots (PSP)

A number of long term or permanent sample plots are maintained on the FMLA. These plots are measured periodically to obtain information on forest stand dynamics (growth, mortality, succession, etc.) which will be used in developing forest growth models. Each PSP plot has been assigned a 100m buffer.

Table 1. Map layers prepared for Analysis

No	Layer name	Description
1	Forest Resource Inventory	Forest Resource Inventory (FRI) polygons with land status and ownership information.
2	FML Boundary	Boundary of Forest Management Licence.
3	Permanent Sample Plots (PSP)	Buffers delineating no-cut areas around provincial PSP plots
4	Heritage Sites	Sites identified as being important to provincial heritage values (e.g. archaeological discovery)
5	Riparian Buffers	Buffers delineating riparian areas around lakes and rivers.
6	Road Buffers	Buffers delineating areas around provincial roads.
7	Depletion updates	Areas harvested and/or burnt after the photography forest inventory was completed (i.e. 1997-2003)
8	Protected Areas	Areas protected from development through the Protected Area Initiative (PAI) program.
9	Treaty Land Entitlement (TLE)	Selection of lands by First Nations to fulfill outstanding Treaty Land Entitlement claims.
10	Woodland Caribou Management Zone	Area for woodland caribou management for maintaining wildlife habitat.

6.1.4 Heritage Sites

The heritage site map layer consists of geographically located points that identify where a heritage value has been discovered, e.g. archaeological sites. Heritage sites are protected from forest management operations by establishing a 50-meter buffer around each site. The site and buffer area were subsequently excluded from harvest consideration. The archaeological and other heritage sites were obtained from Manitoba Culture, Heritage and Tourism.

The heritage sites buffer areas were assessed and found that their sites were covered in either riparian area or non productive forested land, therefore the heritage sites buffer areas were excluded from the area file.

6.1.5 Riparian zones

The area immediately surrounding streams, lakes and other water features as known as a riparian zone. This area provides certain values to wildlife and also provides protection to streams, rivers and lakes. Riparian areas may undergo site specific management review and approved by the IRMT (maintenance harvesting). Timber volumes within the riparian areas are not accounted for in the model and this wood supply analysis.

There are provincial guidelines on buffer widths around water features that are generally interpreted and applied at the regional level. In order to facilitate the net down process for riparian buffers the Regional Integrated Resource Management Team (IRMT) was consulted and a map was prepared illustrating the buffer widths that are likely to be employed on the land base. In some cases the rationale for buffers and the width of the buffer included line of site issues and aesthetics. The results of this work were hard coded into the spatial database.

Many lakes and rivers received special consideration in establishing riparian buffer widths. The Eastern Region reviewed the recreational land use category lands in Nopiming Provincial Park. Based on this review, a 250 m no-cut buffer was established on all Rivers and Lakes in the Happy Lake area. Additional no-cut zones were established in Beresford Lake and Bird Lake areas. Details are provided in Appendix II.

Single-line streams or rivers were extracted from the “Line” coverage for each FRI tile in the wood supply area. These stream tiles were then merged into one cover for the wood supply area. This line cover received a 50 meter riparian buffer.

All lakes and **double-lined** rivers that were not identified by the IRMT were put into a separate cover. An attribute was created in this cover to indicate whether the polygon was a small lake, large lake or double-lined river. Lake polygons greater than 20 hectares were considered large lakes and received a riparian buffer of 100 meters, lakes 20 hectares and less were considered small lakes and received a riparian buffer of 50 meters, and double-lined rivers were given a 100 meter riparian buffer. Islands within lakes and rivers are considered to be inside the buffer and consequently removed from the harvestable land base.

Buffer widths employed for this analysis offer various degrees of protection, depending on the regional assessment of protection needed. It is also recognized that these riparian protection zones may require maintenance from time to time to ensure their health and function. Maintenance may include selective harvesting.

6.1.6 Road Buffers

Harvesting operations are precluded from consideration on land within 100 meters of a provincial road (i.e. a numbered highway). For each FMU, the provincial roads were identified and a map layer was created with a 'line of site' buffer of 100 meters established along either side of these roads.

It is recognized road buffers may require maintenance from time to time to ensure their health and function. Road side buffer management requests are evaluated on a site by site basis by the IRMT.

6.1.7 Forest Inventory Update

The Forest Resource Inventory (FRI) for the FMLA was completed using 1997 aerial photography. The inventory was then updated to reflect depletion activities that occurred between 1998 and 2003, establishing the base year for this wood supply analysis at 2004. The depletion updates include both harvesting and fire. Forest renewal activities were also incorporated into the update process, modifying polygon attributes on depleted areas where required.

6.1.8 Protected Areas

The Protected Area Initiative (PAI) identified areas within the FMLA that were designated for special protection. In addition to the closed zones within parks a separate polygon map layer was created identifying proposed protected areas. The proposed protected areas identified are listed below.

- Happy Lake protected Area
- Observation Point protected Area

At the time of this analysis a 750m Park Reserve was established along the Manigotagon River from Lake Winnipeg to Nopiming Provincial Park. The reserve is now designated as a closed zone under the Park's Act.

Along with the closed zones in provincial parks, these protected areas were excluded from harvest consideration. They are presented in Appendix I.

6.1.9 Treaty Land Entitlement Area

The map layer of the Treaty Land Entitlement (TLE) area was received from the Crown Land Registry of Manitoba Conservation. The polygons in this map layer represent the selection of lands by First Nations that have outstanding Treaty Land Entitlement Claims (Crown Lands Act 5(1) (d)). A map showing the location of the selections is presented in Appendix I.

6.1.10 Woodland Caribou Management Zone

This is a single cover polygon identifying the woodland caribou management zone within the FMLA. This zone is important caribou habitat and receives special attention in the wood supply analysis.

7. LAND BASE NET DOWN PROCESS

The map layers described in Section 6 (Data Preparation for GIS Processing) were prepared as ArcInfo GIS coverage's. These coverages were overlaid on the FMLA FMU to facilitate the net down of the land base in preparation for wood supply analysis.

Overlaying the coverages involved combining 10 coverages for the FMLA into one coverage. The final combined coverages are termed net down coverages. Net down is the process by which areas and associated volumes are identified for inclusion or exclusion in the wood supply analysis.

These net down coverages are a combination of all the polygons from the combined map layers and are illustrated on maps in Appendix I. Attributes for the net down coverages are listed in Appendix II with information on which map layer they originated. The final net down coverage contains attributes from all contributing layers. Only attributes from the FRI, necessary for this analysis, were included in the database.

7.1 Strata label assignment

A separate FRI attribute database was developed and used to assign a yield strata label to each forest stand. The yield strata label is used to assign growth or productivity estimates for that stand (polygon). This yield strata label was brought into the database using the FRI polygon unique identifier as a link. New attributes for crown closure and year of origin were also joined to the database using the unique identifier link. Yield strata label assignment requires a polygon to have a valid forest cover type to be eligible.

Missing crown closure or height information in polygons with a valid forest cover type is an indication that they once were productive hectares. These hectares were further examined to determine whether or not they were treated for forest renewal or underwent surveys indicating the areas were regenerating satisfactorily. Regenerating hectares were assigned appropriate yield strata; all others are considered to be **Potentially Productive** forest for this analysis. Potentially productive hectares include fires, plantations and harvested areas which do not exhibit any interpretable forest cover and, as yet, have no forest renewal data that would assist in assigning a yield strata label. It is anticipated that the fire depleted stands will regenerate but it is unclear as to what it will regenerate into.

During the land base net down process, all map layers are processed into one final shape file by GIS geocoding.

Combinations of status and ownership codes assist in determining availability of lands for harvest. The list of status and ownership combinations is extensive but only those pertinent to this analysis are used in the land base net down work. To expedite the wood supply analysis, some attributes in the net down process were redefined by new status and ownership code combinations. Details are provided within the landscape section of the model formulation (theme 6 and 7) outlined in Appendix IV.

Numerous (150,000) small polygons (<0.005 ha.) were created during the net down process and development of the single shape file. These small polygons account for less than 100 ha in total area. In order to reduce the database size and Woodstock process time, these small polygons were eliminated from the Woodstock area file but not in the total area report.

7.2 Net Down Hierarchy

There is a number of no-harvest or restricted harvest areas that have been identified on this land base and in many instances these situations overlap. For example, a polygon that is within a riparian buffer may also be within a road buffer or a protected area. The land base net down for wood supply was, therefore, done in a specified order and in a way that ensured that each polygon was accounted for only once.

8. GROWTH AND YIELD

8.1 Data Acquisition

The FRI for FMU 31 was completed in 1998 and a volume sampling program was under-taken in 2001-2002 by Timberline Forestry Consultants and Manitoba Conservation. To facilitate the volume sampling program the FRI was stratified into 42 separate forest development types that were similar in species composition, height and density. Using an area weighted randomized design a total of 2,033 plots were established within 678 polygons across 200,000 hectares of stratified forest land. The following information, recorded at each plot, was used in the development of yield curves.

- Tree species
- Diameter of all trees within the plot > 7.0cm at breast height
- Height (measured to nearest 0.1m)
- Tree condition code
- FRI crown closure
- FRI moisture class
- FRI age
- Yield strata

Details of the sampling methodology are available under separate cover.

Managed stands were not sampled in the volume sampling program.

The sampling data underwent rigorous quality control measures through a field auditing program and double data entry incorporating automated error checking routines.

8.2 Eligible tree/specie

Dead trees, trees with a broken stem or top and without a height were not included in the development of yield curves. Eligible Trees with missing heights were provided a height estimate using a localized species height diameter model. The eligible softwood species used in the development of softwood yield curves includes JP, WS, BS and BF. The hardwood species used in the development of hardwood yield curves only includes TA, BA, WB and ASH.

8.3 Volume Compilations

All field volume sampling data was converted to digital format database suitable for use in computer analysis. All subsequent volume calculations and summaries were undertaken using Statistical Analysis Systems (SAS).

8.3.1 Utilization standards

Yield curves were developed for six levels of utilization from log length to whole tree. The level of utilization used for this "Base Case" analysis is Manitoba Conservation's, log-length standard.

Log-length:

Minimum top diameter inside bark
Softwood = 7.62cm
Hardwood = 10.16cm

Minimum diameter at breast height = 11.0cm

Merchantable length = the portion of tree length between stump height and minimum top diameter, that is divisible (without remainder) by 2.54 meters

Stump height = 0.15m.

Tree-length:

Minimum top diameter inside bark
Softwood = 7.62cm
Hardwood = 10.16cm

Minimum diameter at breast height = 11.0cm

Merchantable length = the portion of tree length between stump height and minimum top diameter. Merchantable length must be >= 2.54m

Stump height = 0.15m.

8.3.2 Merchantable Tree Volume

The merchantable volume of each eligible tree within a plot was determined using Kozak's variable exponent taper equation and the methodology and formulation outlined in an Alberta Environmental Protection Report (Huang 1994) the Kozak model [equation 1] is an allometric function with the general form $y= kx^c$, where y and x are dependent and independent variables, respectively, k is a constant and c is an exponent that changes along the stem to describe stem form (Huang 1994).

[1] $$d = a_0 D^{a_1} a_2^D X^{b_1 z^2 + b_2 \ln(z+0.001) + b_3 \sqrt{z} + b_4 e^z + b_5 (D/H)}$$

where

[2] $$X = (1 - \sqrt{h/H})/(1 - \sqrt{p})$$

and

d = top diameter inside bark (cm) at h
h = height above ground (m) to d, $0 \le h \le H$
H = Total tree height (m)
D = diameter at breast height outside bark (cm)
Z = h/H
P = location of inflection point (22.5% of total height)
e = base of natural logarithm (≈ 2.71829)
$a_0, a_1, a_2, b_1, b_2, b_3, b_4, b_5 =$ parameters to be estimated

Taper data from the Provincial stem analysis program was used in the determination of taper equation parameters for Aspen, White Spruce, Black Spruce and Jack Pine. Parameters used for Balsam Poplar, Fir, Larch and White Birch were taken from similar studies carried out in Saskatchewan. The parameters of Kozak's taper equation are listed by species in Table 2.

Table 2. Taper equation parameters for eco-region 90

Param	Balsam poplar	aspen	White spruce	Black spruce	Pine	Fir	Larch	White Birch
a0	0.76702	0.88643	0.8863	0.9327	1.0327	0.8510	0.9327	0.7909
a1	1.0170	0.9964	1.0250	0.9984	0.9388	1.0374	0.9984	1.0624
a2	0.9977	0.9986	0.9955	0.9961	1.0004	0.9966	0.9961	0.9952
b1	-0.368	0.1623	0.2639	0.4897	0.3309	1.7263	0.4897	-0.195
b2	0.0564	-0.067	-0.073	-0.106	-0.068	-0.374	-0.106	0.0242
b3	-2.018	0.1815	0.4979	0.9350	0.4476	2.8798	0.9350	-1.854
b4	1.2385	0.2632	-0.115	-0.407	-0.126	-1.535	-0.407	1.1538
b5	-0.038	-0.196	0.1614	0.2544	0.1535	0.2057	0.2544	-0.040
p	0.19	0.225	0.225	0.225	0.225	0.15	0.225	0.15

The utilization standards described above were incorporated into the calculation of merchantable volume of each tree. This volume was then reduced for cull using the estimations listed in Table 3.

All programming and calculation subroutines were carried out using S.A.S. programming language and statistical subroutines.

8.3.3 Merchantable Plot Volume
Individual net merchantable tree volumes within each plot were aggregated and converted to volumes per hectare on a species level, which in turn were individually summed to provide estimates of total merchantable softwood volume per hectare, total merchantable hardwood volume per hectare and total merchantable volume per hectare.

Table 3. Provincial Cull Reduction Percent (%) Based on Age Classes by Species

AGE CLASS	WS	BS	JP	BF	TL	BA	TA	WB
20			0.16					
30			0.87			0.94	1.94	
40	0.5		1.74	5.7		1.67	2.67	
50	0.5		2.64	6		2.86	3.86	0.4
60	1.3	0.5	3.59	6.5	0.5	4.50	5.50	1.1
70	1.3	0.9	4.58	8	0.9	6.60	7.60	1.7
80	3.3	1	5.61	10	1	9.16	10.16	2.4
90	3.5	1.6	6.68	14	1.6	12.18	13.18	3.4
100	3.6	2	7.78	18	2	15.65	16.65	4.8
110	3.7	2.3	11.9	20	2.3	15.65	16.65	6.7
120	4	2.7	14.4	25	2.7	15.65	16.65	9.1
130	4	3.3	17.1	28	3.3	15.65	16.65	11.7
140	5	3.7	19.6	35	3.7	15.65	16.65	14.5
150	5	4.2	22.2	43	4.2	15.65	16.65	17.4
160	7.2	5	24.8	50	5	15.65	16.65	20.2

8.3.4 Mean Merchantable Stand Volume
The net merchantable volumes (softwood, hardwood and total) of each plot within a stand were summed and averaged to arrive at the mean net merchantable volume of the stand for softwood, hardwood and total.

8.3.5 Stand Age Assignment
For yield curve development purposes the stand age is based on the FRI year of origin and survey year.

8.4. Yield Curve Development

8.4.1 Yield Stratification
Sampling data from the 42 volume sampling development types was aggregated into 12 main strata types comprised of forested stands, similar in productivity and growth.

The level of grouping ensured that the number of observations and their distribution across age classes were adequate for the development of empirical yield curves.

The process also considered the silvicultural characteristics of species and species associations. SAS programming was undertaken to populate the FRI polygon attribute table with the appropriate yield strata label. The yield strata are presented in Table 4. For assignment purposes, the stratum order in the table is also the decision hierarchy for the yield curve stratum assignment in the FRI.

Table 4. Yield Strata

Stratum code	Species Comp. Definitions	Comments
JP	JP 8,9,10	at least 80% Jack pine
BS	BS 8,9,10	At least 80% black spruce
BF	BF 8,9,10	at least 80% fir or 80% white spruce
STL	(BS + TL), 8, 9, 10 and 5≤BS<8	at least 80% BS/TL species, BS leading
TLS	(TL + BS), 8, 9, 10 and TL≥5	at least 80% TL/BS species, TL leading
MSPF	(S+JP+BF) 5,6,7	50-70% softwood; leading softwood BS, WS, JP, BF, RP, WP, or SP
NSPF	(S+JP+BF) 3,4	50 - 70% hardwood; leading hardwood TA, BA, WB
SMIX	(S+P+F) 8,9,10	at least 80% softwood species
ASH	AS≥5	Leading deciduous Ash
HWD	HWD 8,9,10	≥ 80% hardwood species and (TA+BA+WB)≥5, leading deciduous TA, BA or WB
OTHSW	OSW all	Other softwood, softwood>=5
OTHHW	OHW all	other hardwood, hardwood>5

The strata were further refined during the analysis process. Further refinements were based on crown closure class and moisture class. Crown closure class was grouped into density class as defined in Table 5. The moisture classes were used for black spruce strata (see Appendix III for detail). The moisture class aggregation is defined in Table 6 for partitioning black spruce strata into lowland black spruce (LBS) and upland black spruce (UBS).

The final yield curve assignment strata are presented in Table 7.

Table 5. Density Class Definition

Label	Density class definition
1	Crown closure $\leq$ 50% includes crown closure classes 11 – 50%.
2	Crown closure > 50% includes crown closure classes 51 – 100%
100	Crown closure $\leq$ 100%

Table 6. Moisture Class Definition

Moisture Class	Moisture Class Definition
1	FRI moisture code < 4
2	FRI moisture code = 4

8.4.2 Yield Curve Fitting

8.4.2.1 *Yield curve model*

The forest stand is considered to be the ecological unit of interest whose characteristics form the basis for the individual strata definitions. Sampling methodology facilitates the calculation of mean merchantable volume estimates of a stand by locating 3 plots in each randomly selected stand. The aggregation of these stands under a strata label, allows for the development of strata level yield curves that best reflect the productivity of the forest stands that define them.

The net mean volume per hectare of each forest stand falling within the stratum is the observed values plotted over their interpreted stand age. To describe the mean stand volume/age relationship, the following two parameter non-linear model [equation 1] was used to construct yield curves based on stand level merchantable volume and age of origin from the FRI. The SAS - PROC NLIN least squares procedure was used for this analysis work.

[Equation 1] $\textbf{Volume} = \mathbf{a * age^{b} * e^{-a*age}}$

Where:
Volume = Merchantable volume per hectare (m^3/ha)
Age = interpreted FRI stand age
a, b = coefficients
e = natural log base

8.4.2.2 *Curve adjustments*

For each stratum, merchantable softwood volume, merchantable hardwood volume and total merchantable volume were modeled separately. In some cases, yield curves underwent minor modification to ensure that the sum of predicted softwood volume and hardwood volume equalled the predicted total volume. In many cases these adjustments were minor and only made to the subordinate volume curve. The adjustment factor and the adjusted softwood and hardwood volume are calculated as follows:

Adjustment Factor = ((MSV + MHV) – TMV) / (MSV + MHV)
Where:
MSV = Merchantable Softwood Volume
MHV = Merchantable Hardwood Volume
TMV = Total Merchantable Volume

Calibrated MSV = MSV * (1- Adjustment Factor).
Calibrated MHV = MHV * (1- Adjustment Factor.
All three relationships were plotted.

The use of mean stand volume as the observed values in the development of yield curves assists in mitigating the effects of outlier plots and minimizes the removal of data. In this relatively small data set, it was generally felt that outliers legitimately represent the naturally high degree of variability in unit volumes exhibited by the strata and the removal of outliers should be avoided when possible. However, for some strata, there were outlying stands that made it difficult to achieve convergence during regression analysis work. In such cases the outlier was examined to determine whether or not its removal would permit convergence in the regression analysis.

In this analysis three outliers were removed affecting three strata. The outlying observation was excluded from hardwood, softwood and total volume component modeling. Table 7 documents the strata from which the outlier was removed.

For some strata, the frequent number of observations found around rotation age and/or the low number of observations at older age classes resulted in yield curves with an unreasonable growth trajectory that continued to increase volume at ages well beyond the limits of the data and well past the theoretical stand break-up age. To improve the unreasonable growth trajectories a dummy observation for total merchantable volume was inserted into the data set at age 200 years. The magnitude and placement of these observations achieved the effect of drawing down the total merchantable volume curve through the older age classes without significantly effecting the position and slope of the original curve within the range of existing data. The hardwood and softwood curves were then balanced to the total volume curve.

In this analysis four dummy observations were employed, affecting three strata. Table 7 documents the strata which received a dummy observation. Details are provided in Appendix III.

8.4.2.3 *Final Yield Curve Assignments*

The final yield curve stratum, presented in Table 7, reflects the refinements for moisture class and density class. Graphic and tabular displays of Manitoba Conservation Log-Length yield curves are presented in Appendix III along with supporting rationale regarding yield curve refinements.

Table 7. Yield Curve Assignment Strata.

Stratum No.	Yield Curve Label	Density Class	# of plots	# of stands (observation)	Outlier observations removed	dummy observations added	Final observations Used
1	JP	100	90	30	1		29
2	UBS[1]	100	45	15			15
3	LBS[1]	100	110	37		1	38
4	BF[2]	1					
5	BF[2]	2					
6	STL	100	81	27			27
7	TLS	100	180	60			60
8	MSPF(1)	1	66	22	1	1	22
9	MSPF(2)	2	165	55		1	56
10	NSPF	100	249	83			83
11	NSPF1[3]	100	177	59			59
12	NSPF2[3]	100	72	24			24
13	SMIX(1)	1	213	71	1		70
14	SMIX(2)	2	426	142			142
15	ASH	100	153	51		1	52
16	HWD(1)	1	42	14			14
17	HWD(2)	2	213	71			71
18	OTHSW[4]	100					
19	OTHHW[4]	100					
TOTAL			2033	678	3	4	679

[1] LBS and UBS are subsets of BS and defined by moisture class 4 and moisture class 1,2,3 respectively

[2] BF strata was removed and area re-assigned to SMIX

[3] NSPF1 and NSPF2 are subsets of NSPF and the totals do not reflect the re-assignment of observations from NSPF to these strata.

[4] OTHSW strata was removed and area re-assigned to MSPF density class 1
OTHHW strata was removed and area re-assigned to HWD density class 1

8.5 Modeling Considerations

8.5.1 <u>The Minimum harvest age</u>

Constraining the model, in selecting stands for harvest, is the minimum allowable harvest age. In establishing minimum harvest age, the mean annual increment (MAI) and periodic annual increment (PAI) derived from the strata yield curves were closely examined along with the associated age/diameter distributions and cull percentages. The data for mixed-wood strata, such as MSPF and NSPF, was carefully examined to avoid compromising the combined potential productive capacity of softwood and hardwood species within the stratum. In the case of softwood leading mixed-wood, the minimum harvest age and operating range for softwood took precedence over the optimum for hardwood. However, the final choice reflects the overriding objective to minimize volume loss and waste. The minimum harvest age for each stratum is presented in Table 8.

8.5.2 Death age

Death age represents that point in time when the current forest stand structure collapses either due to fire or senescence. For this analysis the forest stand age is reset to zero at death and the growth cycle repeats. The chosen death age is a reflection of age class presence (or lack of) as found within the FRI and volume sampling program as well as the fire history throughout the forest management unit. The death age for each stratum is presented in Table 8.

Table 8. Minimum Harvest Age and Death Age

Stratum	Minimum Harvest Age (years)	Optimum Range of Operability (years)	Death Age (years)
JP	60	60 – 110	130
LBS	80	80 – 180	180
UBS	70	60 – 180	180
MSPF(1)	70	70 – 130	140
MSPF(2)	70	70 – 120	140
SMIX(1)	70	70 – 130	150
SMIX(2)	60	60 – 130	150
BF(1)	60	60 – 100	140
BF(2)	65	60 – 100	140
STL	65	65 – 120	180
TLS	65	65 – 130	180
NSPF	60	60 – 95	140
NSPF(1)	60	60 – 120	140
NSPF(2)	60	60 – 100	140
HWD(1)	65	60 – 100	140
HWD(2)	65	65 – 130	140
ASH	70	70 – 100	180
OTHSW	60	60 – 130	150
OTHHW	60	60 – 100	180

9. WOOD SUPPLY MODEL AND STRUCTURE

The forest modeling structure was created within the Spatial Woodstock and Stanley (Remsoft 2003) forest-modeling environment. The system is flexible and can produce models using both simulation and optimization formulations.

In Spatial Woodstock all the activities and interventions, including, for example, harvesting, planting, and any combination of treatments can be portrayed spatially on maps. Spatial Woodstock can also show the change in these activities over time.

Stanley is a harvest block scheduling tool that goes beyond the strategic level of forest estate planning to application on the ground. Stanley assists in the process of developing a spatial harvest plan. Stanley includes an integrated set of tools for generating stand (polygon) description lists, identifying stands eligible for harvest, finding best fit solutions. Stanley accounts for any regulation or constraint that may have to be addressed at the spatial level. It deals with, for example, green-up delays, limitations on opening size and other forest operations implementation guidelines.

Current forest policy guided the structure the Woodstock optimization model for the current forest harvest scenario. The model's input files, rationale and coding are presented in Appendix IV.

9.1 Wood Supply Land base

The land base, upon which this analysis was undertaken, is comprised of FMU 31 and FMU 35. The FMLA includes the whole of FMU 31 and a portion of FMU 35. The linkage to the FMUs is retained for future analysis work.

The FMLA land base statistics were generated from the FRI following the land base net down process described in previous sections. The net down process identified coverages outlined in Table 1. The model takes into account the entire forested land base within the FMLA boundaries. The productive forests (total growing stock) are grown in accordance with the yield strata to which they belong. The net down process identifies areas which will be precluded from harvest consideration. For example, riparian zones, protected areas, provincial road buffers, and areas within provincial parks closed to harvesting are such areas precluded from harvest consideration. The productive forested hectares within these areas will, be summarized and reported by the model to assist in meeting the requirements of other resource values. The balance of the area (net growing stock) or area upon which harvesting can take place is termed the "harvestable land base". The harvest eligibility of forest stands on the harvestable land base is defined by imposed operability and management constraints (minimum harvest age and volume/ha.). Forest stands on the harvestable land base that satisfy the operability constraints constitute the "net operable land base". It is the net operable land base where harvesting activities are likely to occur. The hectares contributing to net operable land base and the associated operable volume are not static. They change through time, as stands age and grow and move in and out of the operability range.

9.2 Model Control

The base year for this analysis is 2002 and the land base has been updated with all outstanding spatial information (forest management activities) from year of photography to 2001. The updates, for example include depletion due to harvesting, fires, plantations and land withdrawals.

The objective of the model is to maximize total merchantable softwood volume under an even- flow constraint (consistent periodic harvest level policy). The model utilizes a linear program solver (Mosek solver, MOSEK Aps) to optimize the objective over a 200 year planning horizon. The optimization was constrained by a forest management policy that does not permit net operable softwood growing stock to decline in the last 50 years of the planning horizon. A five year planning interval was chosen as one that was best suited to operational planning objectives and tracking change in the forest profile overtime.

9.2.1 Planning Horizon

The 200 year planning horizon was chosen as a period of time that would best measure the effects of present day harvest strategies, objectives and constraints on the future forest. It is also a suitable period to allow a reasonable risk assessment to be undertaken on many model assumptions, operational/planning constraints and productivity projections. The longer the planning horizon, the greater the impact on volume maximization under an even flow policy.

9.2.2 Even Flow

The softwood even flow policy, which ensures an even flow of wood to the processing facility, was used in this analysis to ensure that the long-term supply of the resource will continue with some assurance. Even flow minimizes harvest fluctuations by being sensitive to the age class structure of the forest and the variable productivity rates across the land base. This sensitivity ensures that the demand and supply of wood resources from the land base today can be maintained over a long period of time. Such policy provides for stability and reliability in long term wood supply.

9.2.3 Non-declining Yield

To assist in the assurance of sustainability, a non-declining, net operable softwood growing stock constraint was introduced in the last 50 years of the planning period. The model objective, to maximize volume over the planning horizon, will attempt to liquidate the forest down to this maximum production level at the end of the planning period. Such a scenario ignores any catastrophic events to supply such as fire or insect and disease outbreaks. It also undertakes this maximization based on some assumptions, which may or may not change. Such considerations need to be factored into the model to provide some insurance that the supply risks they pose are managed against the even flow policy. Non-declining operable growing stock is one constraint imposed in this “Base Case” that addresses these risks.

9.3 Strategic Level, Non-Spatial Constraints

The current forest operating scenario is a softwood only harvest operation. The main objective in the Woodstock model formulation maximizes the sustainable softwood harvest level within a softwood even flow constraint. The harvest level is contingent upon adherence to the accompanying harvest schedule and to all imposed constraints as identified within the model’s formulation. In this analysis this harvest level is termed the theoretical maximum sustained yield (TMSY). This analysis is a softwood only harvest operation and there is no even flow constraint imposed on hardwood volumes that become available for harvest as a result of a softwood only harvest operation.

9.3.1 Regeneration Lag

Depleted hectares in the softwood and softwood leading strata types undergo softwood renewal strategies and are, therefore, not added back into the productive land base for a period of time (regeneration lag) to reflect an adequate establishment period for the softwood. As result of the study on free to grow data, the regeneration lag is 10 years for black spruce(UBS & LBS) and tamarack strata(TLS and STL), while other softwood strata and softwood leading mixed-wood strata is for 5 years. There is no regeneration lag constraint imposed on hardwood stands. This reflects the findings that adequate hardwood regeneration is immediate while softwood requires certain years to establish.

9.3.2 Minimum Allowable Harvest Age

Table 6 of this report presents the operability range for strata. The minimum age in this range is the earliest a stand can be harvested within the strata. As stated earlier the minimum operability age reflects the combined hardwood and softwood productivity.

9.3.3 Minimum Merchantable Volume per Hectare

This operability requirement reflects current operating practices. Softwood-dominated strata must have at least 50 m^3 per hectare of softwood volume before becoming eligible for harvest.

9.3.4 Woodland Caribou Habitat Constraints

In the Owl Lake area of the FMLA, woodland caribou management zone were developed by Eastern Manitoba Woodland Caribou Advisory Committee (EMWCAC), (Manitoba Model

Forest, 2005). Based on the local data and available information from other provinces, EMWCAC suggested that the Owl Lake caribou were using approximately 1/3 of the current available high quality range that was delineated in the woodland caribou management zone (Map 6, Appendix I).

It was therefore recommended as: “at least 2/3(67%) of the overall winter range needs to be maintained at the current level of high habitat units through time in order to sustain the herd.” This was referred as the “2/3 Rule” and provided a basis for forest planning. In the Woodstock, a minimum of 2/3 (67%) of overall winter zone is maintained as high quality winter habitat over the whole planning horizon (200 years). Since the high value winter habitats were mainly from old conifer/softwood stands, the constraints will be sensitive to the age class distribution and harvest scenario.

9.3.5 Treatment and Response

Table 9 illustrates the post harvest transition pathways defined by the FML holder and used in this wood supply analysis. For this analysis, post-harvest hectares are assigned age and strata type based on treatment and response projections outlined in the silviculture renewal strategy provided by the FML holder (Tembec). The strategy must ensure that the softwood productivity of the forest is maintained. Periodic assessments and analysis will be carried out to monitor whether or not the projected responses have been achieved and more importantly, the softwood productivity on the operable land base is maintained.

Regeneration survey data, free to grow data, permanent sample plot data and Temporary plot data were further examined to determine whether or not trends in forest succession could be established for un-harvested aging natural stands. The results of this examination were inconclusive and therefore, for this analysis a death age has been assigned and aging strata hectares revert back to their original forest strata type upon death.

Table 9. Treatment and Response Pathways under Softwood Operation

STRATA HARVESTED	PERCENT CHANGE	NEW STRATA
JP	75%	JP
	15%	SMIX
	10%	MSPF
SMIX	70%	SMIX
	25%	MSPF
	5%	JP
UBS	50%	UBS
	30%	SMIX
	20%	MSPF
LBS	80%	LBS
	20%	STL
BF	50%	SMIX
	30%	MSPF
	20%	BF
STL	85%	STL
	15%	TLS
TLS	95%	TLS
	5%	STL
MSPF	50%	MSPF
	30%	SMIX
	20%	NSPF2
NSPF1	50%	MSPF
	30%	SMIX
	20%	NSPF1
NSPF2	100%	NSPF2
HWD	100%	HWD
OTHSW	100%	OTHSW
OTHHW	100%	OTHHW

9.3.6 Stand Break-up or Death

Death defines the natural break-up of a stratum. Death ages range from 130 to 180 years. For reasons presented in earlier sections, death, not succession, occurs on forested stands left to grow beyond their operability range. If left un-harvested a stand will age towards stand break-up or senescence at which time the age will reset to 0. Death age for each stratum is presented in Table 8.

9.4 Tactical Level, Spatial Constraints

In addition to the non-spatial constraints at the strategic level there are spatial constraints imposed at the tactical level for this analysis. The strategic level optimization, undertaken by Woodstock, focuses on long-term planning objectives and provides an even flow softwood TMSY that could be achieved from this land base. The strategic level analysis, however, does not account for "on-the-ground" harvest planning logistics.

The spatial constraints in this analysis include maximum block size, harvest block distribution and green-up delay. It is import to evaluate the impact of these spatial constraints on the non-spatial strategic harvest level.

The "Stanley" spatial planning system was used to analyze the annual harvest at tactical level. Stanley attempts to implement the Woodstock schedule as closely as possible, subject to declared spatial rules or constraints. It is unique in that it employs both a block building and a block scheduling phase. Furthermore, it offers two forms of spatial allocation: spatial simulation and spatially constrained allocation. Stanley automates the process of mapping these complex models – integrating and sequencing the myriad of activities and showing how they will be manifested on the landscape in certain time frames. Stanley generates a spatial harvest schedule based on the strategic Woodstock harvest plan and overlays the harvest blocks (polygon groupings) on the wood supply area. The maps generated also show where harvest blocks may be located and how much area will be harvested. Stanley greatly assists in formulating strategic management plans that are operationally feasible.

The forest management and harvest scenario evaluated in this "Base Case" analysis is one that incorporates non-continuous harvest openings (cut-blocks), maximum cut-block size and green-up delays. Stanley's goal is to find the best fit or configuration of polygon groupings (cut-blocks) to meet the Woodstock harvest schedule for the first 25 years. In doing so Stanley must take into consideration the set spatial constraints for maximum block size, adjacency and proximity rules.

9.4.1 <u>Harvest Blocking Period</u>

The first 25 years (5 periods) of the 200 year harvest sequence produced by Woodstock are scheduled by Stanley.

9.4.2 <u>Greenup/adjacency/proximal distance</u>

The green-up delay represents the amount of time which must pass before the harvest of adjacent or proximal blocks can occur. This delay for harvested stands addresses wildlife food and cover requirements as outlined in the "Timber Harvesting Practices for Forest Operations in Manitoba" and accompanying guidelines documents.

Adjacency is the distance within which a stand is considered to be adjacent to another stand. During the allocation phase, Stanley groups eligible, adjacent polygons into harvest units based on harvest timings specified in the harvest sequence file.

Proximal distance is the distance within which a polygon is considered proximate but not adjacent to another polygon. During the scheduling phase, Stanley checks proximate polygons for compliance with green-up delay. Both adjacent and proximal distances are expressed in linear units within the spatial data set.

9.4.3 Cut-block Size

Provincial policy and harvesting guidelines stipulate the maximum cut-block size is to be 100 hectares. Cut-blocks in excess of this size require recommendation for approval from the IRMT to the Director of Forestry. Based on the results of Ecosystem-based Management Pilot Project it was determined that the disturbance regime could provide a regional-scale template for harvesting in this Ecoregion. The mid-range fires, where fire suppression is most effective would be the size most relevant to forest management and would be where managers would attempt to emulate the natural disturbance. The 250 ha size is the lower end of the mid-range fires and so was adopted by the regional IRMT as an appropriate threshold for cut-block design. Therefore, the model formulation of Stanley in this analysis restricts cut-block size to a maximum of 250 hectares. However, Stanley is not constrained by this and may seek out more optimal sizes and configurations as it explores alternative block patterns. It should be noted that this goal is worked toward in consideration of green-up requirements which may significantly impact the optimum harvest schedule generated by Woodstock. Stanley reports the number of occurrences the target was violated.

9.4.4 Volume Reduction for Wildlife Trees

A global reduction of annual harvest level is used to reflect tree retention for wildlife. According to Tembec’s harvest practice, the reduction is 2% and 5% for softwood and hardwood respectively. The percentage reflects current operating practices followed by the industry operating on this land base.

10. AREA REPORT

The total area of the land base in FML1 is 889,471 hectares in size (see Table 10). A total of 116,777 hectares or 13.1% of the FML1 area is non-forested and

182,158 hectares or 20.5% of the total area is non-productive forest. The non-productive forest land includes forest stands with less than 5% of crown closure. Areas previously burned or harvested which have not been treated and do not support any interpretable forest cover have been classed as potentially productive forest land. Potentially productive forest land accounts for 5.8% of the FMLA area.

Table 10. FMLA Area Summary

Classification	Area (ha)	Percent of total
Non-forested		
water	45,883	5.2%
Barren-Bare Rock	578	0.1%
Fields	76	0.0%
Meadow	1,306	0.1%
Marsh Muskeg	18,844	2.1%
Unclassified	50,091	5.6%
Subtotal	**116,777**	**13.1%**
Non-productive Forest		
Treed Muskeg	139,216	15.7%
Treed Rock	18,059	2.0%
Willow/Alder	24,384	2.7%
Protection Forests	498	0.1%
Subtotal	**182,158**	**20.5%**
Potential Productive forest	**51,233**	**5.8%**
Productive Forest	**539,303**	**60.6%**
Total	**889,471**	**100.0%**

Of the 539,303 hectares of productive forest land, Table 11 shows that 11.9% is closed to harvesting primarily due to park land use codes. A series of deductions are applied to the remaining productive forest land base as part of the process used to define the operable harvesting land base in the wood supply analysis. These deductions account for the factors that effectively reduce the availability or suitability of the productive forest area to account for environmental, ecological, economical or social reasons.

The net down work on the FMLA results in a 20.2% reduction of the productive forest land base area. This reduction results in a total harvestable land base of 430,364 hectares. This is 48.4% of the total FMLA or 79.8% of the total productive forest land within the FMLA.

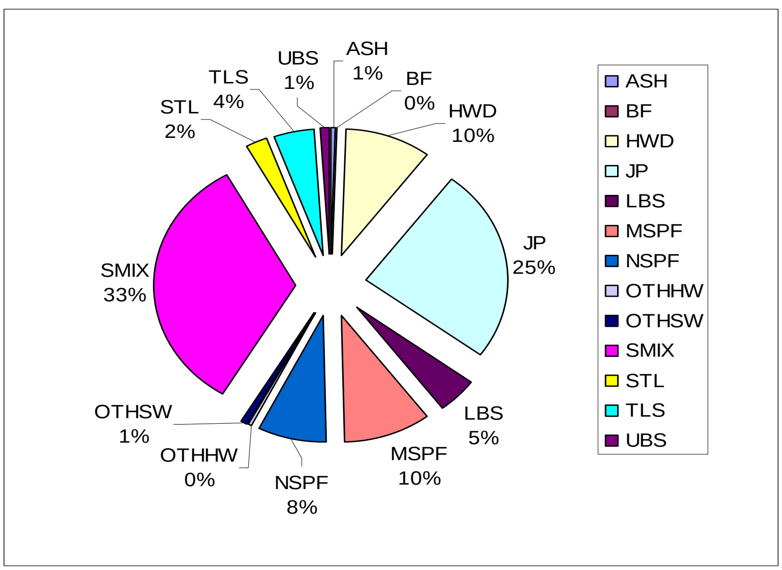
Table 11. FMLA Netdown Summary

Productive Forest	Deduction (HA)	Balance	Percent of total area	Percent of productive area
		539,303	**60.6%**	**100%**
Private Land	2,200			0.41%
Closed	64,190			11.90%
Proposed Protected Areas (PAI)	5,271			0.98%
TLE	1,221			0.23%
Special Buffers				
Happy Lake	1,238			0.23%
Beresford Lake	72			0.01%
Bird Lake	1,173			0.22%
Winnipeg River	1,375			0.25%
Manigotagan River[1]	2,977			0.55%
PSP	74			0.01%
River Zones	5,642			1.05%
Lake Zones	20,757			3.85%
Road Buffers	2,749			0.51%
SUBTOTAL	**108,939**		**12.2%**	**20.2%**
Harvestable Forest Land Base		**430,364**	**48.4%**	**79.8%**

[1] At the time of GIS net down, it was slightly different from the final legal version as protected area in Dec, 2005

Chart 1 illustrates the distribution of forest strata on the harvestable forest land base within the FMLA.

Chart 1. Forest Strata Percent Distribution in FMLA



11. RESULTS AND DISCUSSION

This section presents the results of the wood supply analysis for the FMLA. The "Base Case" harvest forecast uses the most current information on land base ownership and status, timber harvest, yield curves, tree utilization standards, regeneration survey reports, and forest management/practices. The model formulation and accompanying management policies and constraints were developed to best represent current harvesting practices and policies for the Licence area. The results of this current forest harvesting scenario is considered the benchmark and subject to sensitivity analysis that will examine more closely the capability of the land base to meet the softwood Theoretical Maximum Sustained Yield (TMSY) and forest management goals, under changing operating practices, policies and constraints. These analyses work will assist the Director of Forestry in determining the approved level of AAC on the FMLA. It is important to note that in this analysis, piece size and any expectation of volumes by specific softwood species are not considered. This analysis has directed its efforts to determine the maximum sustainable harvest level of softwood fibre on the FMLA. Further analysis and exploration of forest management/operational strategies could be done within the mandate and forest management planning process of forest management Licence holders and quota holders.

11.1 Strategic Level Results

The strategic level harvest forecasts, for the FMLA, represent current management policies and constraints as described in previous sections of this report. The model results presented in Table 12 shows the non-spatial theoretical maximum sustainable wood supply. This TMSY is achieved under Manitoba Conservation's "Log-Length" utilization standard and even-flow policy over the 200 year planning horizon. The theoretical maximum softwood sustained yield of 351,583 m^3/yr was determined to be available for harvest under the current softwood only harvest operation. Hardwood volumes reported as available for harvest were not subject to the even flow constraint and therefore fluctuate from period to period with a low of 4,131 m^3/yr to a high of 147,551 m^3/yr.

Over the 200 year planning horizon, the sum of the minimum or maximum softwood and hardwood growing stock will not equal the corresponding total because softwood and hardwood total growing stock does not occur at the same time. This phenomenon also exists in the other indicators' minimum or maximum value over the time.

Long Run Sustained Yield Average (LRSYA) is the theoretical average harvest level that the forest (on the harvestable land base) can support over the long term and it is an important indicator of sustainability in the evaluation of harvest levels. It is calculated by multiplying the mean annual increment of a yield stratum at minimum harvest age by the operable area of that stratum. The accumulated results of this calculation, from each strata type contributing to the softwood harvest level, define softwood LRSYA. A graphical illustration of the sustainable harvest levels in the FMLA is presented in Appendix V, Figures 1.

The graph shows that softwood LRSY on the operable land base declines across the planning horizon, falling below the even flow, TMSY for softwood near the end of the planning horizon. The hardwood LRSYA increases through time indicating that the softwood productivity of the land base is transitioning to hardwood resulting in an increase in hardwood productivity. The main causes for the drop in softwood LRSY on the operable land base are the treatment and response pathways assigned to harvested hectares. The response pathways change the profile of the softwood land base over time by transitioning a significant number of hectares from a softwood stand type to a mixed wood stand type; effectively increasing the hardwood productivity on the operable land base at the expense of softwood productivity. As a result the softwood LRSYA on the operable land base drops significantly through time.

Table 12. Summary of Strategic Wood Supply Results for the FMLA

	Theoretical Wood Supply				
	Over 200 years			year 1-100	year 101-200
	Minimum	Maximum	Average	Average	Average
Harvest Softwood(m^3/yr)	351,583	351,583	351,583	351,583	351,583
Harvest Hardwood(m^3/yr)	4,131	147,551	59,315	45,294	72,336
Total Harvest volume(m^3/yr)	355,715	499,135	410,898	396,878	424,919
Softwood LRSYA (m^3/yr)	340,175	401,089	373,491	389,411	357,571
SW merchantable growing stock(000's m^3)	16,666	24,330	20,271	22,380	18, 161
HW merchantable growing stock(000's m^3)	8,754	15,091	12,324	12,675	11,972
Total merchantable growing stock(000's m^3)	25,410	38,145	32,594	35,055	30,133
SW merchantable operable stock(000's m^3)	2,189	12,589	5,799	8,257	3,342
HW merchantable operable stock(000's m^3)	331	2,030	1,064	1,384	734
Total merchantable operable stock(000's m^3)	2,520	13,670	6,863	9,641	4,085

11.1.1 <u>Post Harvest Transitional Trends</u>

Figure 2 in Appendix V illustrate transitional trends, on the harvestable land base, resulting from softwood harvest operations and accompanying silviculture programs. The trends illustrate the timing of transition from existing natural stands to second growth stands (previously depleted and regenerating). Harvesting at maximum sustainable levels will result in harvesting operations moving into second growth stands in approximately 80 years, completing the transition into the new forest at 100 years.

Woodstock begins growing the new forest immediately after the predetermined lag period which accounts for the time needed to establish a new forest. An increase in the period required to establish a new forest would have an impact on the timing of the transition and delay forest growth. This in turn would compromise the calculated TMSY. Also, failure to achieve the forest renewal objectives and/or development type targets used in the analysis will significantly impact TMSY, and the model's ability to meet established constraints. For example, less optimistic treatment and response pathways, which were assessed as part of this analysis, have resulted in failure to satisfy the caribou constraint within the model and will reduce softwood AAC.

It is imperative that measures be in place to monitor the establishment and growth of the new forest to ensure that reforestation efforts are successful. A program that follows forest development, from harvest to free-to-grow, would greatly assist in the assignment of forest development pathways for future analysis work.

Figure 2 also illustrates that the move from existing forest to new forest coincides with the average age (rotation age) of harvest for softwood strata. Within 100 years all harvesting will be in second growth forest. This transition timing indicates that average piece size of future harvest operations may decline as harvesting begins to target stands nearer and nearer to minimum harvest age. It would be reasonable then to expect that by period 19 (95 years) the majority of harvesting will be in stands with an average diameter breast height (DBH) of 15cm (based on an analysis of height/age and height/dbh curves) and by the end of the second rotation the average DBH may drop even further.

11.1.2 Harvest Volume by Strata

Figure 3 in Appendix V illustrates volume harvested by forest strata type. The strata contribution to harvested volumes varies over time and is a dynamic process that takes into account forest age class distribution, strata size and productivity, minimum harvest age, death and the effects of transition pathways for depleted hectares. In the FMLA the JP and SMIX strata make up the greatest proportion of the total harvested softwood volume. The dominant harvest cycle pattern of these two main yield strata can be clearly seen across the planning horizon. Figure 3 shows that within the first period of the planning horizon the JP yield strata accounts for 87% of harvested volume. The Contribution from the JP strata diminishes in the following periods where the volume is made up by the SMIX yield strata. The MSPF stratum begins to significantly contribute to wood supply following period 15. The appearance of this stratum is largely due to the post harvest transitions provided by Tembec. It is the forest renewal program that defines forest strata distribution in the second and third rotation and ultimately the species mix available for the mill. If there is a requirement for a specific species mix the periodic dominance of the JP strata may be compromised. It is therefore, important to take a close look at the species mixtures of the strata types to ensure that they sufficiently satisfy the species mix requirements of the mill.

11.1.3 <u>Total Growing Stock</u>

Figure 4 in Appendix V shows a projection of total growing stock in cubic meters on all forested lands within the FMLA. This graph reflects the inventory of forested development types across the FMLA and the collective impact of growth and mortality across the planning horizon. The graph also reflects the impact to growing stock due to harvest operations and the impact these depletions have on the age class structure of the forest and forest productivity in general. These activities, as well as other forest attributes and growth dynamics cause fluctuations in the total volume of the forested land base over time. The graph shows that the present level of total growing stock on the FMLA is approximately 32 million cubic meters of which 23 million are softwoods and 8 million are hardwoods. The level of total growing stock increases to 38 million in period 9 and then gradually declines to 23 million by period 19, only to increase to 32 million by the end of the planning horizon. The gradual decline in growing stock between period 9 and 23 is largely due to changing age class structure reflecting the associated changes in forest productivity.

Although across the planning horizon there is a net gain to total growing stock, there is a decline of 13% in the softwood component. The increase in the hardwood growing stock, results in an overall area weighted increase of 13% in total growing stock. The decline in softwood growing stock is largely a reflection of the models treatment and response pathways in the softwood working groups. There is an apparent trend toward increasing the hardwood land base through time at the expense of softwood.

11.1.4 <u>Net Growing Stock</u>

Figure 5 in Appendix V shows a projection of the net growing stock or growing stock on the harvestable land base. The harvestable land base is the land base resulting from all land base net down activities which remove lands (buffers, Protected areas, TLEs, etc) from harvest consideration. The harvestable land base produces operable growing stock through time.

11.1.5 <u>Operable Growing Stock</u>

Figure 6 in Appendix V depicts the softwood net operable growing stock. The operable growing stock (OGS) is that portion of the net growing stock that satisfies all harvesting and operability constraints such as minimum harvest age and minimum softwood volume per hectare. The OGS provides the best indication of available volume and the overall ability of the land base to meet annual volume commitments under the current forest harvesting scenario. The OGS graph only accounts for softwood volumes available under a softwood operation; where operations are restricted to softwood and softwood leading strata. It does not include incidental softwood volume that may become available in the event of a hardwood operation.

The even flow constraint across the planning horizon has resulted in significant amounts of operable growing stock or growing stock that is eligible for harvest over and above the softwood TMSY. While this may appear to be excessive, little of this volume is lost to mortality and it serves as an adequate buffer at three times the TMSY over the 100 year burn cycle; characteristic in this area of the province.

The occurrence of unplanned events is a random chance and the magnitude of loss cannot be predicted. However such events are sure to take place and minimizing this risk to wood supply is important. In order to assist in minimizing the risk to wood supply, a non declining yield constraint for the last 50 years of the planning horizon was instituted, preventing the model from reducing the OGS to zero. Sufficient operable growing stock exists for the first 150 years of the 200 year planning horizon to absorb loses due to unplanned events. A substantial loss to fire or disease will, however, require recalculation of the wood supply.

The increases and declines in OGS coincide with softwood strata rotation or harvest cycles on the harvestable land base and effects on softwood productivity due to the treatment and response pathways on harvested land. The slight increase in operable growing stock in period 9 reflects the mass maturing of areas burned in the1980's.

The total softwood OGS at the beginning of the planning horizon is approximately 12.3 million cubic meters which declines to 2.1 million by year 150 and maintained at that level until the end of the planning horizon.

It is important to understand that this forest harvest scenario is a softwood operation, targeting softwood leading strata. Illustrating the hardwood OGS would only reflect that portion of the hardwood within operable softwood stands. However, a total harvest operation, that utilizes both hardwood and softwood species would reflect much increased volumes of hardwood and softwood. The softwood gain would be from incidental softwood acquired from hardwood leading strata and hardwood operations would include hardwood leading strata types, bypassed in a softwood only harvest scenario.

11.1.6 Area Harvested by strata type

Figures 7 and 8 in Appendix V shows the total area harvested from the operable forest land base. The total harvest area remains relatively stable across the planning horizon. However individual strata types see peaks and valleys and periods when harvesting is very low or does not take place at all. This variability in harvest strata reflects transition pathways after harvest, individual strata productivity and age class distribution. This variability in harvest area among strata types must certainly be taken into account when planning harvesting and silviculture programs.

11.1.7 Mean Annual Volume Harvested

Figure 9 in Appendix V illustrates the mean volume per hectare harvested over time. The mean volume per hectare is the total harvest volume divided by total harvest area at each planning period and is one of the important indicators in evaluating feasibility of operations.

There are significant changes in mean volume per hectare between some periods throughout the planning horizon. One notable change in mean volume per hectare occurs between period 15 and 17. The increase in average harvest from 65 years in period 15 to 120 years in period 16 (see average harvest age graph in figure 16) reflects the effects of increased harvest level in the BS strata types (UBS, LBS). These types have higher death age than most strata. Consequently the model chooses to delay the harvest of these strata until the latter part of their operating window. While this logic makes sense to the model it may present forest planning and operational challenges. Smaller fluctuations in mean volume per hectare may be more desirable.

11.1.8 Average Harvest Age

Figure 10 in Appendix V illustrates the strata-area weighted average softwood harvest age by period over the 200 year planning period. The graph illustrates that the strata are harvested within an acceptable range in age. The significant jumps in average harvest age in period 15 and 28 follows the completion of harvesting in the JP strata and subsequent moves into the aging BS, SMIX and MSPF strata where the majority of harvesting occurs at an age well above the average harvest age of the JP strata.

If the steady drop in average harvest age between period 15 and 27 is an indication of piece size then the trends in second and third rotation cycle beyond period 27 will see a gradual decline in piece size across the harvestable area on the FMLA.

11.1.9 Age Class Distribution

Figure 11 in Appendix V presents the area weighted age class distribution of all strata across the FMLA. The Graphs illustrate the current and future age class distribution on the total productive forest area and on the harvestable (after net down) land base.

Under the current management scenario and in the absence of natural disturbances (fires), the age class distribution on the harvestable forest land base becomes more evenly distributed through time, reflecting the impact dynamics of harvesting (assumes available hardwood on the operable land base is harvested), management policies and constraints such as even-flow and wildlife habitat maintenance. A percentage of area in older age classes is maintained, in part, to satisfy the caribou constraint within the model.

The influence of large fires is clearly illustrated within the age class structure overtime. There have been two major fire events one in the early 1980's and another in 1930's. The influences of these events on wood supply are illustrated in the harvest area and harvest volume summaries.

11.1.10 Mortality

Figure 12 in Appendix V tracks mortality occurring through time on the harvestable forest land base in FMLA. The vast majority of mortality occurs in hardwood and hardwood leading stand types. Under this forest harvest scenario only strata attaining the softwood operability levels are harvested. Hardwood and hardwood leading strata are left un-harvested and they eventually age to death. The majority of softwood mortality occurs in areas that are closed to harvesting (buffers and closed zones). The level of softwood mortality in the open zone is very small.

All areas within buffers have been excluded from harvest and left to age to a natural death.

Buffers of advanced age are also subject to wind-throw and breakage which may compromise intended functions such as providing soil stability, stream side shade and wildlife corridors. Buffers have long been criticized as presenting an opportunity for fire and insects to spread quickly by acting as a wick. Therefore, in the interest of buffer management and maintenance, site specific timber harvesting may be allowed. The volumes gained through specific buffer management actions may be small but would be incremental to the AAC.

11.1.11 Habitat Suitability Indices

Figure 13 in Appendix V illustrates the caribou, moose and other selected wildlife species habitat suitability indices that result from this "Base Case" scenario.

The habitat suitability indices (HSI) were used in this analysis to evaluate food and cover habitat on all available land area, including closed and restricted areas, buffer areas, and protected areas that were removed from harvest consideration. This graphic demonstrates the trend in habitat availability under the current forest management regime. Note that the caribou HSI is separated between high value habitat zone (1B) and the FML area at large. All levels of habitat are maintained within reasonable levels with only minor fluctuations across the planning horizon.

11.2 Tactical Level Results

As stated previously in the report the spatial constraints are applied to the Woodstock harvest sequence file to produce a 25-year tactical harvest schedule that is achievable under the current forest harvest scenario. The spatial simulation tests the feasibility of implementation of the long term, non-spatial strategic level schedule to short term, spatially constrained tactical level.

To arrive at the 'best fit', Stanley, through a series of iterative passes, assembles polygons into cut-blocks and schedules them into a particular planning period. The rules for green-up, adjacency, proximity and size all factor into the equation to arrive at a harvest block configuration that best satisfies the Woodstock harvest schedule for the first 5 periods of the planning horizon. A high tolerance setting of 10 years either side of the "Woodstock" harvest schedule allows "Stanley" greater flexibility in the allocation process, but at the expense of a greater divergence from the goals and objectives reconciled in the strategic schedule. The Stanley simulation runs are also allowed multiple period openings for a cut-block. This setting provides "Stanley" with greater flexibility in aggregating polygons into cut-blocks.

In the simulation, the tactical output also includes a map showing the location and timing of hectares (cut-blocks) to be harvested. The spatially allocated cut-blocks provide insight into the nature and probable pattern of the harvest layout and a strong indication of the extent of operational infrastructure that will be needed to facilitate the layout pattern.

- <u>Green-up delay</u>
  A global green-up delay of 15 years is incorporated in the tactical analysis. The green-up delay accounts for the regeneration lag introduced in the strategic analysis. It also accounts for the period of time necessary for all species regenerating on the site to

achieve a height suitable for wildlife cover and reforestation targets.

- Adjacency rule
  In this analysis Stanley was programmed with a zero meter adjacency rule. The rule is the highest constraint level, ensuring only polygons that touch are considered to be adjacent and eligible for grouping into cut-blocks. Linear features such as roads and transmission lines would prevent grouping polygons from either side into a cut-block.

- Proximal distance
  In this analysis Stanley was programmed to include a proximal distance of 0 meters. Previously harvested Blocks within 0 meters (touching) are considered to be proximate. A proximate block (still in green-up delay) would prevent harvest eligibility of a neighbouring polygon. Proximate constraint reflects the green-up delay, ensuring that cut-blocks are not in proximity of previously harvested blocks still in green-up period. A 0 proximity constraint is the least constraining, meaning only blocks that touch are of a concern. Blocks across a road from each other or separated by a stream buffer would not be proximate.

- Cut block size
  In this analysis Stanley was programmed to limit polygon groupings (cut blocks) to a maximum opening size of 250 hectares. No minimum opening size was enforced and cut block area could be aggregated over 2 periods.

The tactical level analysis also applied a global reduction for wildlife tree retention. Areas, within operable stands are left standing to serve as cover for wildlife and to provide movement corridors. The Company estimates that 2% of operable forest land is left as residual cover for this purpose. With an approximate, average annual depletion of 3,800 hectares, on the operable land base, over the first 25 years this 2% residual equates to 7,735 cubic meters annually of un-harvested operable volume.

Preliminary analysis work was necessary to account for the NSPF1 stratum. This stratum was developed to account for the softwood area and volume harvested within the hardwood leading NSPF stratum (see Appendix III). It is a proportional subset of NSPF and has no spatial attributes, consequently “Stanley” cannot schedule NSPF1 strata because NSPF1 does not physically exist within the FRI. Analysis has shown that the NSPF1 stratum accounts for 2% of the softwood TMSY and the impact on the “Stanley” simulation exercise would be approximately equivalent. Prior to running the “Stanley” simulation the NSPF1 stratum was removed.

The optimal solution achieved 99.7% of the TMSY produced by the "Woodstock" harvest schedule in the first 25 years. A total of 500 iterations were undertaken with an average score of 98.9%. Table 13 presents the numerical results of the simulation exercise and the impact of global spatial reductions and gains on the "Woodstock" TMSY.

Table 13. Stanley Simulation Scenario (0-25 years)

Source	Softwood volume reductions (m^3/yr)	Softwood volume gains (m^3/yr)	Softwood volume balance (m^3/yr)
Woodstock TMSY (less NSPF1)			344,470
1.1% reduction due to simulation exercise	3,867		340,603
2% wildlife tree reduction	7,031		333,572
NSPF1 strata (351,583 – 344,470)		7,113	340,685
Totals	11,602	7,113	340,685

Table 14. Harvest Block Size Statistics (0-25 years)

Block Size Category (hectares)	Number of blocks (% of total)	Total area (% of total)
<= 10	12,376 (84.3%)	29,155 (29.6%)
10.1 – 20	1,160 (7.9%)	16,244 (16.5%)
20.1 – 30	462 (3.1%)	11,226 (11.4%)
30.1 – 50	361 (2.5%)	13,752 (13.9%)
50.1 – 100	246 (1.7%)	17,061 (17.3%)
100.1 – 150	63 (0.4%)	7,556 (7.7%)
150.1 – 200	11 (0.1%)	1,875 (1.9%)
200.1 – 250	8 (0.1%)	1,714 (1.7%)
Total	14,687	98,593

Based on the long term strategic level (200 years) and subsequent short term tactical level (25 years) analysis, the 'net' softwood TMSY for the next 25 years is 340,685 m^3/yr. This level is achieved by Stanley by dispersing the harvesting in eligible strata types throughout the FMLA. The cut-block statistics in Table 14 show that almost 30% of the area scheduled for harvest in the first 25 years are from blocks less than or equal to 10 hectares in size; indicating that the harvest operation is highly fragmented.

Under the current forest practice, the 'net' hardwood TMSY (non-even flow), harvested from softwood leading stands, varies between 1,336 m^3/yr to maximum of 26,664 m^3/yr over the first 25 years. After the deductions are applied for spatial constraints (1.5%) and wildlife tree retention (5%), the 'net' hardwood TMSY for the first 25 years under the softwood operation is 18,550 m^3/yr. Hardwood volumes from un-harvested hardwood stands (softwood operation) are not considered in this TMSY. The net hardwood TMSY will be addressed the detail in the total harvest volume scenario in addendum.

Presently, Tembec harvest operations are more consolidated than the spatially fragmented blocks of the Stanley simulation. There are sound reasons for consolidating harvest operations from both an economic perspective and a wildlife perspective. However, there is a cost for these benefits and that cost is volume. Unless timber harvesting operations can confine harvesting into strata types and age classes that very closely follow the strata types and ages scheduled for harvest by “Woodstock” there must be an adjustment to harvest levels.

12. SENSITIVITY ANALYSIS

An important part of these analyses is risk analysis and an assessment of how results might be affected by uncertainty and change in scenario parameters. The wood supply analysis assessment and the findings of sensitivity analysis work provide a basis for deliberation and discussion towards the determination of approved annual harvest levels.

Minimum operability constraint of 50 m^3/ha

The yield curves are developed from empirical data gathered at volume plots that were randomly located, among strata types, throughout the FMLA. The volume plots within a stratum, often varied considerably in productivity. The yield curves developed from this variable data estimate a stratum’s productivity over time. The resulting yield curve produces a productivity estimate for all hectares within a stratum. If that estimate rises to greater than 50 m^3/ha through time then the model assumes that all harvestable hectares within that stratum are able to contribute to the overall wood supply. If the operability requirement of 50m^3/ha limits the number of hectares within a stratum deemed operable, then all harvestable hectares may not, in fact, be harvested and the volume projected by the curve must be made up by those hectares within the stratum that are greater than 50m^3/ha . The assumption is that the greater yields balance off the volume loss on hectares that are not operable. There is a risk associated with this assumption and work will need to be undertaken to improve and refine yield data across the FMLA to minimize this risk.

Unaccounted incidental gains in softwood volume

To some extent the Company’s harvest operations migrate across forest stand boundaries into forest stands that have not been included in the wood supply analysis due to low yielding merchantable softwood (i.e. treed muskeg). The Company estimates that this opportunistic harvesting accounts for approximately 5% of the area harvested annually. Analysis has shown that this gain is usually offset by unproductive treed muskeg reaching into the strata along the boundary. This give and take occurs largely along the interpreted stand boundaries of strata types. Because the volume sampling plots used in the construction of yield curves were located well away from polygon boundaries, this variability is not accounted for in the yield curve estimates of a stratum. Small areas of low productivity

(treed muskeg) that fall within productive strata types (polygon) may not reflect in the average yield for the polygon. Therefore these stand types (treed muskeg) do not contribute directly to the TMSY. Further spatial analysis of both harvested and un-harvested areas and tightening of forest polygon delineation may help to evaluate potential volume gains.

In the interim, the director of Forestry will authorize a volume harvested in treed muskeg stands as follows; 5 year average harvest area (1437.8 ha) x 5% x 50 m^3 /ha = 3,595 m^3 /yr. This annual volume will be in effect until July 2011 and will be applied as a global adjustment at the tactical level. The company will be required to annually track volume harvested from treed muskeg stands and to submit a detailed spatial analysis report of harvested polygons examining productive and unproductive areas within these areas for the five year period, 2006-2011. The Branch will audit this report and if necessary re-calculate the treed muskeg harvest volume figure.

Mill Requirements

This wood supply analysis is carried out without consideration given to piece size beyond minimum merchantable DBH. If the mill requires a specific log size profile then additional analysis will be required to determine the impact on this forest harvest scenario's theoretical maximum sustained yield. However, given that over the planning period the average harvest age can vary greatly, any piece size constraint would negatively affect wood supply.

In addition, if the mill requirements include an optimum species mix then additional analysis work will be required. It is again likely, based on the area harvested by strata type over time, that a species mixture constraint would negatively affect this forest harvest scenario's theoretical maximum sustained yield as well.

Harvesting Pattern

The identified forest harvest scenario and associated analysis, maximizes harvest volume based on forest policy, minimum harvest age, productivity and a host of other inputs. The outcome of this strategic level analysis is a harvest sequence file which explicitly identifies periodic harvest area by strata type and age. No consideration is given to the spatial distribution of the hectares scheduled for harvest.

The tactical level analysis introduces spatial constraints such as maximum block size and green-up delays. The spatial constraints are meant to account for operational policy and guidelines. Stanley attempts to find a spatial harvest solution that best satisfies the spatial constraints but bound to the Woodstock harvest sequence. The result is a further reduction in sustainable yield. While deviations from this sequence are expected at the operational level there must be some effort made to limit the degree to which the harvest sequence is violated. Stanley assists in finding the harvest areas that will best satisfy the Woodstock harvest sequence.

Manitoba Conservation's preferred management strategy, for the area within FML1, is to conduct harvesting, reforestation and road decommissioning as quickly as possible. The Company, with the support of the Manitoba Conservation Regional IRMT, presently employs a harvest strategy that progressively harvests an area within a relatively short period of time (approximately 2-5 years). This harvest strategy results in extensively harvested areas, broken by landscape features or strips or patches of residual forest cover. The purpose of this strategy is to confine and minimize road access across the FMLA. Wildlife considerations are the primary reasons for this strategy. This harvest strategy implements the preferred management strategy, also mimics natural disturbance patterns within the FMLA since the tactical level analysis restricts cut block size to a maximum of 250 hectares which represents the lower end of the mid-range fires size. Under such a harvest scenario it will be a challenge for the Company to follow the Woodstock harvest schedule and thereby avoid compromising the TMSY.

The Forest Management Plan and subsequent Annual Operating Plans will be closely examined to ensure that a reasonable harvest strategy is in place to follow as closely as possible the Woodstock harvest schedule.

Managed vs. unmanaged stand yield curves

There is an expectation of managed stands yield curves to produce greater yield estimates than un-managed stand yield curves. Studies in some areas have shown that it is possible for gains in forest productivity on managed plantations. Studies have also shown that exceptional gains could be had using genetically superior seedlings in the planting programs. However, in Manitoba, the bulk of managed stands (plantations) are only now approaching an age and frequency that will facilitate the development of early yield estimates that could be compared to un-managed or natural stands. Research studies are presently in place to provide data on genetic gain, un-managed stand yield curves will continue to be used for both managed stands and stands planted with genetically improved stock. As a result, gains in productivity due to plantations, genetically improved seed and/or post harvest treatments go unaccounted for in this wood supply analysis.

Potentially productive hectares

The Woodstock model cannot, assign potentially productive hectares to a specific development type with an associated yield curve and therefore does not consider these hectares in determining the theoretical maximum sustained yield. A sensitivity analysis was undertaken to measure this impact on AAC. This analysis suggests that potentially productive hectares should be closely monitored for emerging development types and periodically assigned strata. Wood supply analysis should be re-run as warranted.

Treatment and response

The response of hectares after harvesting reflects the silviculture program in place to insure successful forest renewal and an operable forest for future operations. The response pathways in this analysis reflect in part the Company's historical forest renewal information and the Company's intention to undertake the necessary post harvest treatment to insure the response pathways incorporated into this analysis are achieved.

Sensitivity analysis has shown that the maximum theoretical sustained yield is highly sensitive to deviations in these pathways. Analysis has shown that the slightest failure to achieve the softwood renewal targets result in an infeasible solution whereby the model cannot satisfy the harvesting constraints (i.e. caribou habitat maintenance) over the planning horizon (200 years). Tests have also shown that significant changes occur in the theoretical maximum sustained yield. It can be concluded that development types that arise from post harvest treatment significantly influence forest productivity in the latter part of the 200 year planning horizon. This, in turn, has a great effect on even-flow harvest levels and thus, current harvesting levels. It is concluded that any failures from the planned treatment and response pathway targets would have a significant influence on sustainable harvest levels across the planning horizon and if not corrected would result in a significant fall down in harvest levels for the second rotation. Under a softwood harvesting scenario, Harvesting transitioned stands would begin in period 15 (75 years) and by period 20 (100 years) all harvesting would be in the new forest.

It was also noted that the treatment and response pathways used in this analysis result in declining softwood productivity on harvestable land in the FMLA. This is a concern, under the current harvest scenario, and it suggests that more needs to be done to maintain and measure softwood productivity.

Death age vs. succession

Succession pathways reflect change in forest species composition over time. Species composition, in part, defines forest development types. Each development type has a corresponding yield curve that reflects its productivity over time. Defined succession pathways within a model provide the ability for forested hectares to move from one development type yield curve to another in response to changing species composition.

While succession is known to occur there is very little data available to identify these pathways for use within this wood supply analysis. Consequently identified strata types remain constant throughout their growth period until it is reset by either harvest or death. Additional research, including the establishment of new PSP's is required to fully understand forest succession dynamics in the FMLA.

The dynamics of the land base age class configuration, harvesting constraints and the model's objective results in very little softwood death. The model captures almost all available softwood from softwood leading development types before the type reaches its death age and the age is reset to 0. The mortality graph in Appendix V illustrates this. Average harvest age, the annual mean area harvested by development type, mortality and particularly average harvest age and minimum operability limits suggest that succession would likely have a small impact on softwood harvest levels under a softwood harvest scenario. Stands are harvested at or very near to rotation age, allowing stands little time to change in species composition (and development type). There may be some softwood gain in hardwood and hardwood leading strata over the planning horizon but this gain would be marginal.

Extending the age of death only resulted in marginal changes to wood supply resulting in insignificant impacts.

Even flow hardwood

Under the current forest harvest scenario an even flow constraint is imposed in determining the softwood TMSY. The volume of hardwood available for harvest under this scenario fluctuates from period to period because it was not constrained by even-flow. Imposing an even-flow constraint on hardwood resulted in a **7% reduction** in the softwood TMSY. This reduction is primarily due to the low and highly variable volumes of hardwood amongst the different softwood leading strata which contribute to the softwood TMSY.

At the strategic level the hardwood non-even flow volumes available for harvest (illustrated in Appendix V, figure 1) in the first 25 years of the planning horizon varies from a low of 12,124 m^3/yr in period 1 to a high of 28,518 m^3/yr in period 2 with an overall average of 19,839m^3/yr across the 25 year harvest window. The overall average hardwood harvest across the planning horizon under a non-even flow constraint is 59,315 m^3/yr compared to 47,965 m^3/yr of hardwood available under an even flow constraint.

Utilization Level

The Manitoba Conservation Log-Length utilization level is used in this "Base Case" analysis. The "Base Case" forest management scenario is a softwood only harvest operation where stands must contain a minimum 50 m^3/ha of softwood volume. This harvest scenario is reflected in the "Base Case" model formulation.

The theoretical maximum sustainable wood supply in this "Base Case" reflects the MC Log-Length utilization standard at the tree level and softwood only utilization at the stand level. In a softwood only operation the hardwood harvested would only be in conjunction with a softwood operation. Hardwood stands that do not meet the minimum merchantable softwood volume per hectare would not contribute to hardwood volume harvested. Should the company wish to either change its utilization practices at the tree level or move to a total volume operation (hardwood and softwood species) at the stand level there would be an increase in operable volumes.

A sensitivity analysis was carried out whereby various tree utilization levels were examined to evaluate probable gain in wood supply. In addition to the Manitoba Log-Length and Tree-Length utilization standards, three other levels, proposed by Tembec, were examined. A description of the Tembec tree utilization levels is as follows:

Tembec Short-Wood utilization standard 1

Minimum diameter breast height…...................	11.0cm.
Minimum top diameter black spruce …………	6.35cm
Minimum Top Diameter (other softwoods)…..	7.62cm.

Minimum stump height …………………….. 23.0cm.
Minimum hardwood top diameter………..… 10.16cm

Merchantable length of first log = 2.54m. minimum merchantable length of subsequent logs (up to minimum top diameter) = 1.27m.

Tembec Full-Tree utilization standard 2

Minimum diameter breast height…................... 11.0cm.
Minimum top diameter black spruce ………… 6.35cm
Minimum Top Diameter (other softwoods)…... 7.62cm.
Minimum stump height …………………….. 23.0cm.
Minimum hardwood top diameter………..… 10.16cm

Merchantable length is the portion of tree length between stump height and minimum top diameter. Merchantable length must be >= 2.54m.

Tembec Full-Tree utilization standard 3

Minimum diameter breast height…................... 11.0cm.
Minimum top diameter black spruce ………… 5.08cm
Minimum Top Diameter (other softwoods)…... 7.62cm.
Minimum stump height …………………….. 23.0cm.
Minimum hardwood top diameter………..… 10.16cm

Merchantable length is the portion of tree length between stump height and minimum top diameter. Merchantable length must be >= 2.54m.

Table 15. Impacts of Changes in Tree Utilization Levels at Strategic Level

	Manitoba Conservation Utilization Standards			
	Softwood only Operation even-flow softwood non-even-flow hardwood (TMSY)		**Total Volume Operation (TMSY)**	
Utilization level	**Softwood (m^3/yr)**	**Hardwood average (m^3/yr)**	**Softwood (m^3)**	**Hardwood (m^3)**
MC Log-Length	**351,583**[1]	**59,315**[1]	368,539	134,706
MC Tree-Length	372,236	61,979	391,132	142,533
Tembec (1)	363,611	60,023	380,797	135,738
Tembec (2)	371,626	61,331	390,234	140,433
Tembec (3)	374,526	61,338	393,200	140,423

[1] TMSY for the “Base Case” in this report

In addition to changing utilization standards at the tree level the utilization at the stand level was examined. A “total volume operation” was introduced whereby both softwood and hardwood species are utilized. Under a total volume operation the minimum operable volume for hardwood is 75 m^3/ha while the softwood operability limit remains the same. Under a total volume operation the even-flow constraint was applied to both hardwood and softwood. More utilization levels were used to produce TMSYs from Woodstock runs under softwood only and total volume operations. Table 15 presents the results of this exercise.

Changing the utilization level (in the softwood only harvest scenario) from MC log-length utilization standard to a total tree length standard results in a **6%** increase in softwood wood supply. Introducing a **total volume harvest operation** that utilizes both hardwood and softwood species, increases softwood volumes by an additional **5%** at the tree length utilization level for an overall increase of **11%** over the “Base Case” level. This potential increase in the harvest level of softwood is primarily due to capturing all softwood trees within the newly eligible hardwood working groups. However this increased softwood volume under a total harvest operation has significant silvicultural implications. Although the hardwood development type has been assigned a treatment and response pathway that cycles back to 100% hardwood and the same yield curve; It is not likely that predominantly hardwood stands, once harvested would yield similar softwood volumes at the second rotation. Harvesting mixed-wood strata would also present considerable softwood renewal challenges. These silvicultural facts were not a consideration in the determination of TMSY levels under a total volume operation scenario.

It is worth considering that under a total (softwood + hardwood) harvest scenario, the softwood component of the hardwood strata (>80% hardwood species composition) will likely be reduced by hardwood volume at the second rotation. The rationale being that successful softwood renewal would be unlikely in hardwood development types and natural ingress of softwood species would take much longer than one hardwood rotation to become merchantable, provided under-story protection is in place. Under this rationale the hardwood volumes would likely increase at the expense of softwood. The volume of softwood reported as available under a total volume operation in Table 15 may, therefore, be overstated and further analysis under a total harvest scenario is necessary. A more thorough analysis of a total volume harvest scenario is detailed in an addendum to this report.

<u>Isolated Stands</u>

No deduction was made for operable stands that remain un-harvested due to their location. A typical isolated stand would be a small black spruce stand surrounded by swamp and a considerable distance from nearest operable stand. Many variables go into defining an isolated stand such as the size of the stand, the merchantable volume and the piece size as well as the stands proximity to a road. Combinations of these factors would define an isolated stand. In addition some stands may become isolated as a result of neighbouring harvest and renewal activities. For this analysis a spatial exercise was carried out and outputs examined in order to estimate the significance of occurrence. The results of this exercise indicate that a 1-2% reduction to AAC maybe appropriate to account for isolated stands.

<u>Average harvest volume per hectare</u>

The average harvested softwood volume per hectare varies considerably from period to period, most notably period 14 -15 and 27-28. Extreme fluctuations may cause operational and planning difficulties. To address this issue a sensitivity analysis was carried out to measure the impacts on analysis results when a constraint is imposed to limit fluctuations in mean volume/ha harvested from period to period.

Sensitivity analysis resulted in a less than 1% reduction to TMSY when harvest volume per hectare fluctuation was limited to a 5% range between any two consecutive periods. This analysis demonstrates that the fluctuation in harvested volume per hectare in the "Base Case" can be minimized without significant risk to TMSY.

13. SUMMARY

In undertaking this wood supply analysis the Forestry Branch completed approximately 200 different wood supply model runs. In the course of developing model inputs and formulation, a technical advisory committee undertook consultations with industry, regional Integrated Resource Management Teams and other branches within Manitoba Conservation. The technical advisory committee assisted in defining objectives, developing strategies, forecasting future forest conditions for analysis and in evaluating outcomes. This was done to ensure that operating practices and environmental safeguards (such as utilization standards, stream buffers, woodland caribou management zone and other wildlife HSI), were addressed by the model formulation at both the strategic and tactical levels.

A strategic level analysis has been completed in the Tembec FMLA and it has been determined that historic harvest levels are below the theoretical sustainable capacity of the forested land base. Current harvesting levels are approximately 250,000 m^3/yr the TMSY on the FMLA is 351,583 m^3/yr. The theoretical maximum sustained yield or TMSY is the optimum solution resulting from this wood supply analysis. There are, however, many challenges associated with achieving the TMSY. This risk is in the model inputs such as yield curves and treatment and response pathways as well as the FRI itself. Other considerations in assessing risk include unplanned losses to fire, insect and disease, adherence to minimum operability (volume/ha) levels and the ability to harvest the land base in accordance with the optimized harvest schedule.

A tactical level spatial analysis has also been undertaken to assess the feasibility of the harvest schedule under a set of spatial constraints that reflect provincial policy and harvesting guidelines. This analysis resulted in a 1-2% reduction to the TMSY. The 'net' softwood TMSY is 340,685 m^3/yr, and the 'net' hardwood TMSY (non-even flow) is 18,550 m^3/yr under the softwood operation. However, the spatial distribution of the harvest that is needed to achieve 98% of the TMSY is in contrast to the harvesting strategy presently being followed on the FMLA. Adjustments to either harvesting patterns or harvest level or both will be required in order to achieve the TMSY across the planning horizon.

The results demonstrate that the available operable growing stock is 23 times greater in volume than the strategic level TMSY during first 100 years, and on average 16 times greater over 200 years. This level of OGS is required to provide long term even flow of softwood volume. It also provides for a more than sufficient store of volume to absorb unplanned losses due to, for example, fire and thereby minimize the impacts of the loss on wood supply levels in the short term.

The forest renewal strategy along with an intensive silvicultural management program will result in a successfully regenerating forest of managed stands. There may be gains in productivity due to the use of genetically improved seed for planting stock and/or increased levels of post harvest treatments. This strategy will produce AAC effects that the current TMSY does not account for.

At the strategic level the wildlife habitat is considered an important component of ecosystem-based management. For woodland caribou, its requirement for high value habitat has been maintained in the Owl Lake areas, and its habitat exists in abundance throughout the whole FMLA over the planning horizon. In addition, other wildlife habitats are tracked and monitored. At the TMSY harvest all levels of six wildlife habitats studied in this analysis are maintained within reasonable ranges with only minor fluctuations throughout the FMLA over 200 years.

A series of sensitivity analyses were conducted to evaluate uncertainties in data or management practices that can effect the timber supply projections to varying degrees.

Analysis has showed that uncertainties with two issues, current harvesting strategy and operability limits associated with yield strata productivity could have a dramatic effect on short term harvest levels.

The current harvesting strategy calls for concentrated harvesting in relatively small areas (working circles). The rationale supporting this approach cites wildlife management concerns and ecological goals. However, this approach to harvesting may not be compatible with the harvest schedule supporting the TMSY. The WSA harvest schedule spreads the harvest across the entire FMLA as it seeks to achieve the maximum sustainable yield. Failure to harvest in accordance with this schedule results in a significant reduction to the TMSY. Harvesting strategies must be addressed in the Forest Management Plan and determinations made regarding the adjustment to harvesting levels based on management goals outlined in the forest management plan.

The variability of data supporting strata yield curves suggests that not all hectares within a stratum may be operable. The model assumes this to be so when the softwood yield curve achieves at least $50m^3$/ha. The greater volume per hectare achieved on operable areas within a strata is assumed to offset the volume loss on hectares that are not operable. If this assumption is incorrect the short term wood supply could be reduced by as much as 10%. However while there is some uncertainty about volumes in existing stands, related to the operability question, there is no solid evidence to indicate that stand volumes may be overestimated by 10%. This issue was examined to primarily inform decision-makers about which factors are most important in defining wood supply.

One important factor, treatment and response pathways, does not have an immediate effect on harvest levels but does have a significant influence on even flow softwood harvest levels in the mid to long term. The treatment and response pathways define the future forest. Harvesting at TMSY will result in the complete migration of harvesting operations into the new forest in approximately 100 years. Various levels of renewal responses to harvesting were tested and it was concluded that the treatment and response pathways incorporated into this model reflect the minimum level of renewal effort required to meet the harvesting and management constraints within the model. Failure to achieve this minimum level of renewal results in the models inability to meet constraints or management objectives (i.e. maintenance of caribou habitat). Failure will also result in a step-down in the sustainable harvest level.

Also examined were the impacts of various utilization levels. It was demonstrated that significant gains can be made in the TMSY simply by moving from a log length standard utilization level to a full tree (tree length) utilization level. Even greater increases are available by moving to a total harvest (softwood and hardwood) operation. The changes would certainly assist in mitigating losses in TMSY due to harvest scheduling problems as an example. Further analysis is required to determine the wood supply for the FMLA under a total volume scenario.

The sensitivity analysis work has also demonstrated a need for further work in the area of managed stand yield curves, piece size analysis, treatment and response pathways as well as forest succession. Growth models developed from comprehensive permanent sample plot data must take on greater importance in future modeling and forest management programs.

This report provides the necessary information for the Director of Forestry to establish new AAC's for the FMLA.

14. REFERENCE

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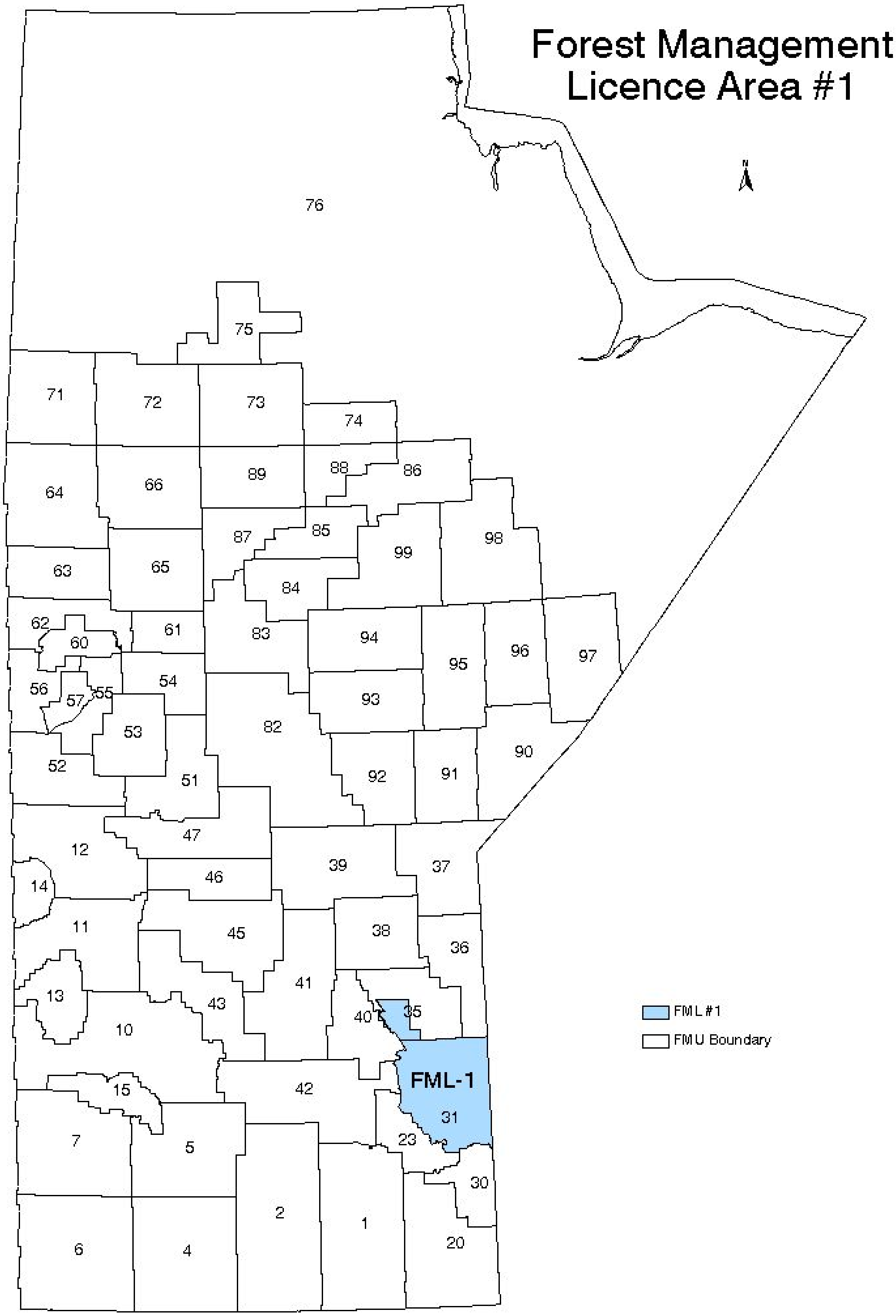
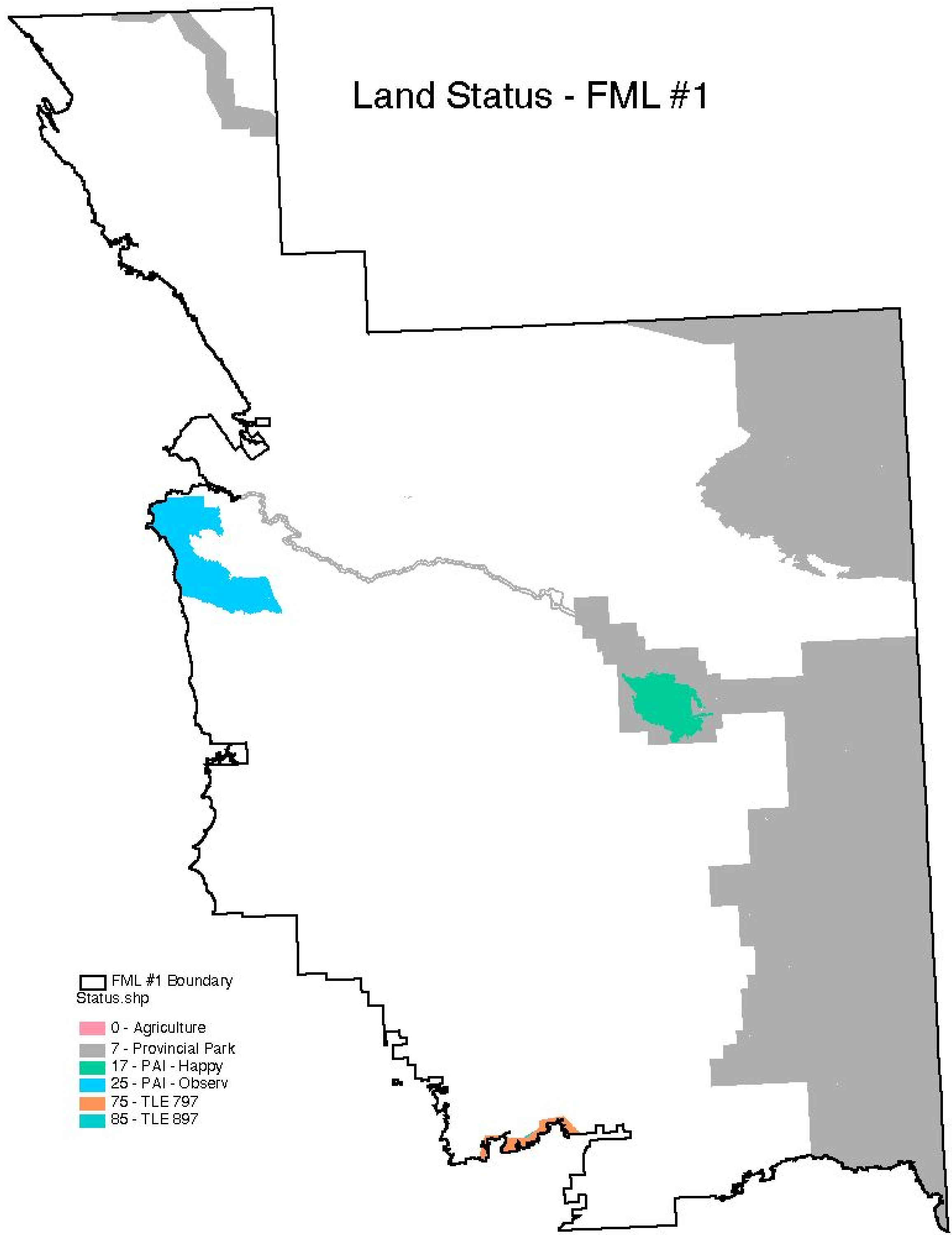
15. APPENDICES

Appendix I Maps

Map 1

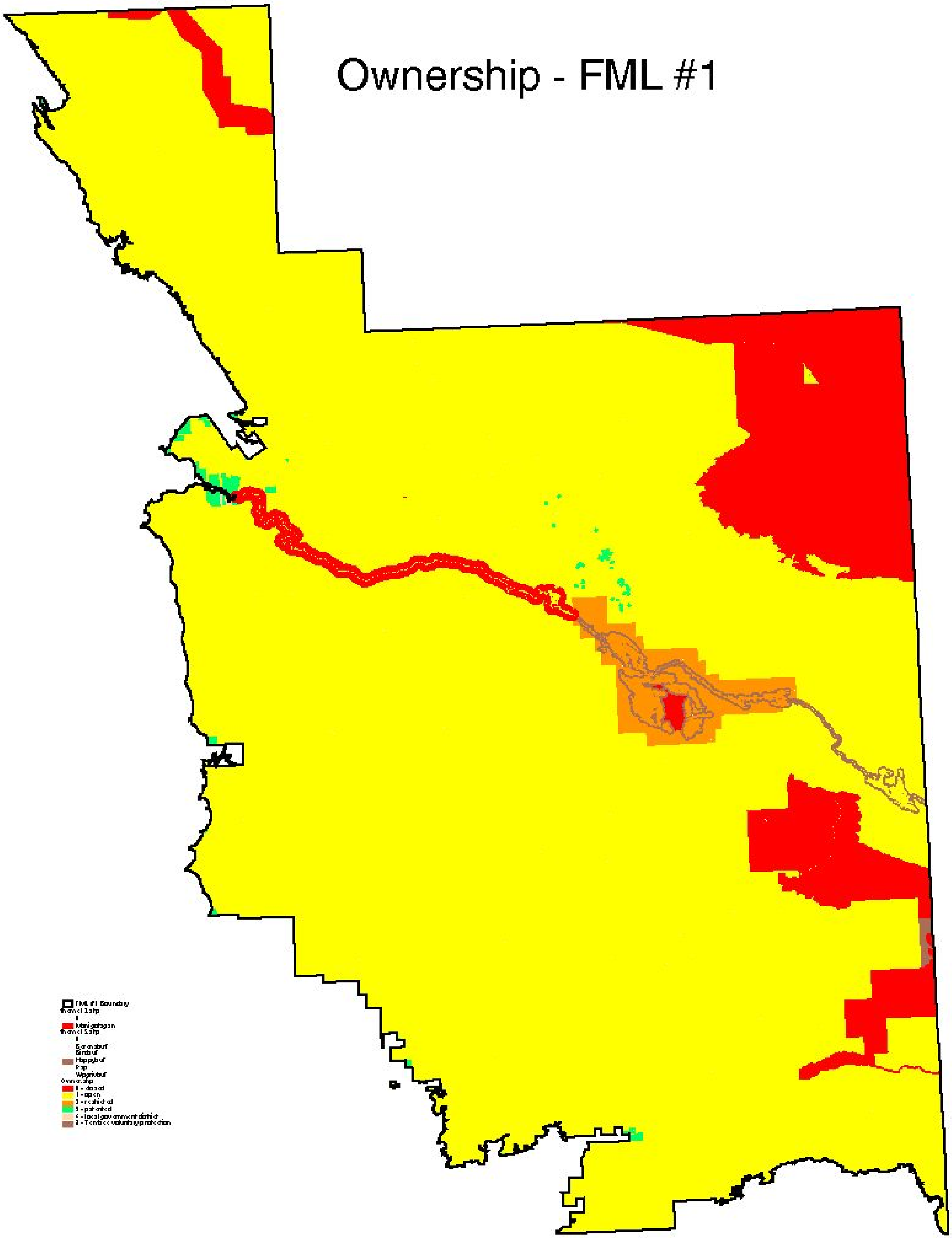


Map 2

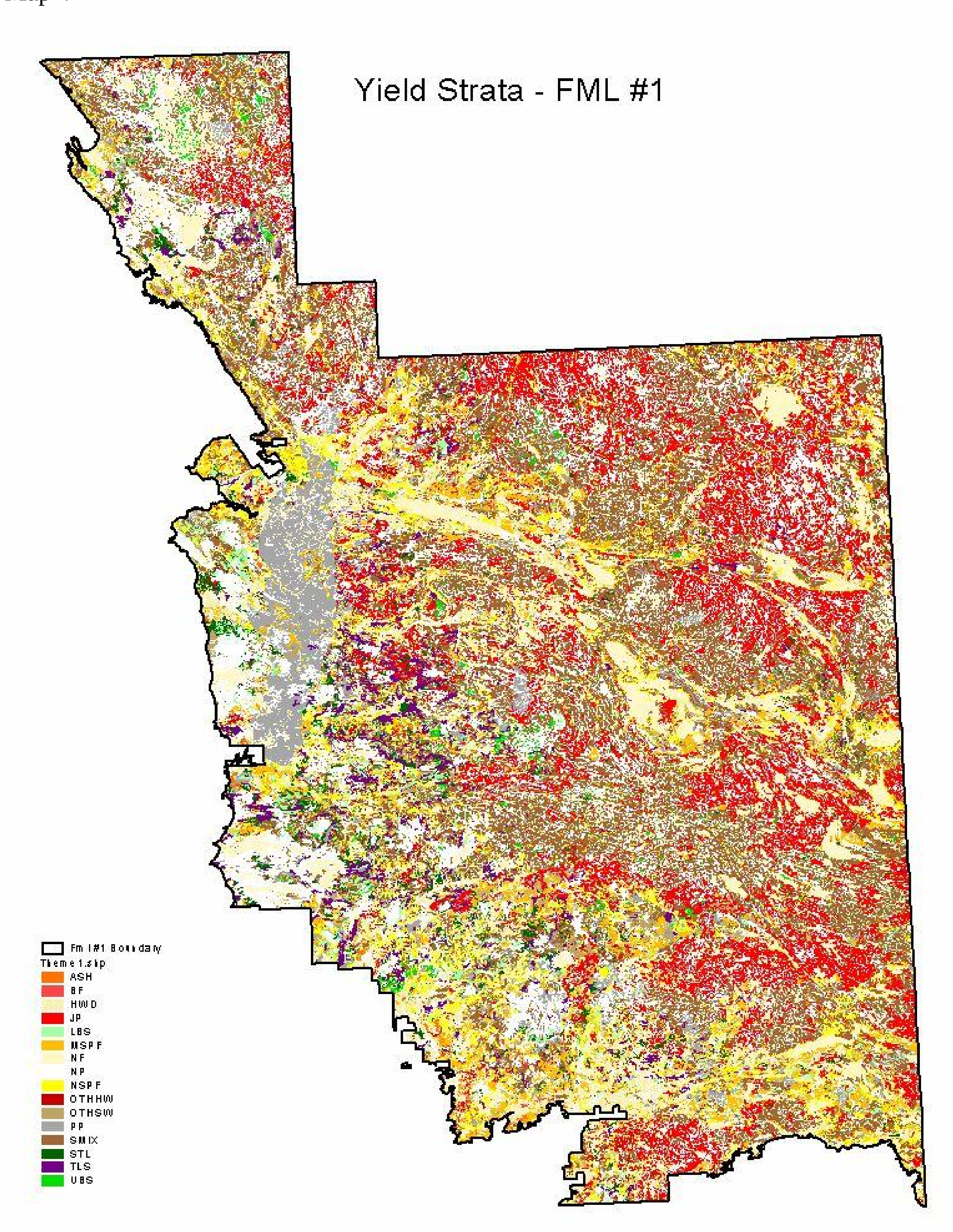


Land Status - FML #1
FML #1 Boundary
Status.shp
0 - Agriculture
7 - Provincial Park
17 - PAI - Happy
25 - PAI - Observ
75 - TLE 797
85 - TLE 897

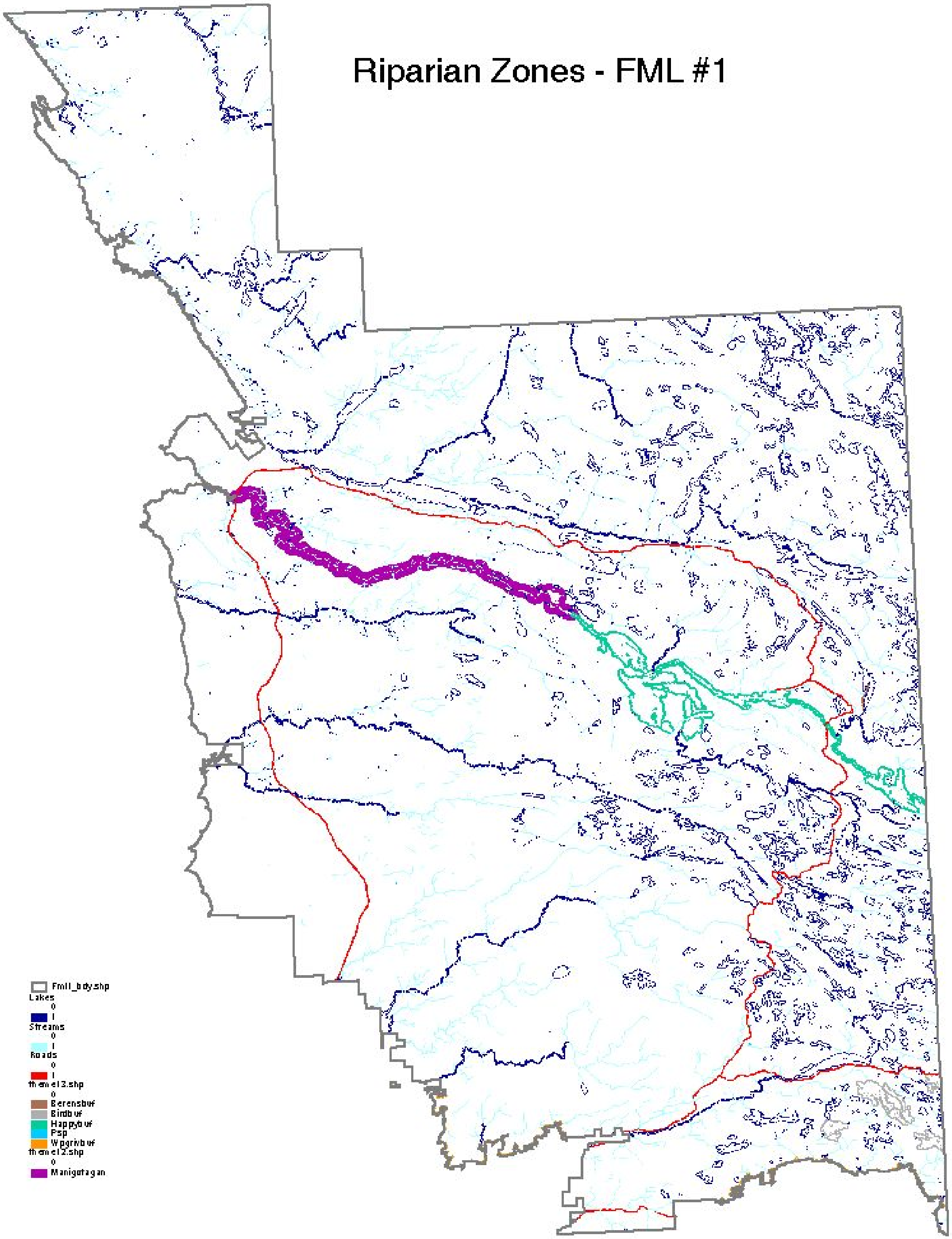
Map 3



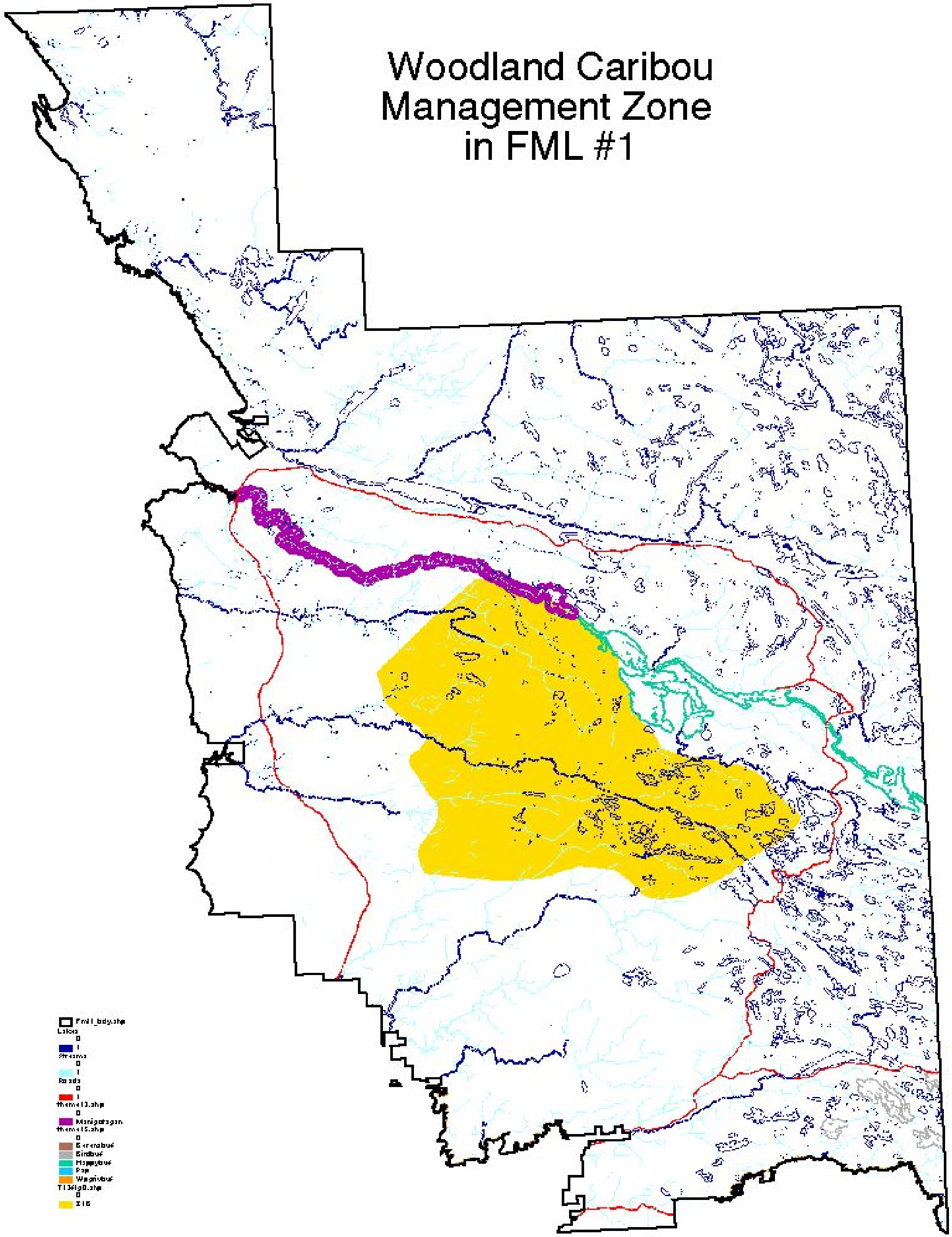
Map 4


Yield Strata - FML #1
Fml #1 Boundary
Theme1.shp
ASH
BF
HWD
JP
LBS
MSPF
NF
NP
NSPF
OTHHW
OTHSW
PP
SMIX
STL
TLS
UBS

Map 5


Riparian Zones - FML #1
Fml1_bdy.shp
Lakes
0
1
Streams
0
1
Roads
0
1
theme13.shp
0
Berensbuf
Birdbuf
Happybuf
Psp
Wpgrivbuf
theme12.shp
0
Manigotagan

Map 6


Woodland Caribou
Management Zone
in FML #1
Lakes
Roads
Manigotagan

Appendix II Map Layers

Each of the GIS data layers were used in the Wood Supply Analysis are listed and described below. The Wood Supply area includes all of FMU 31 and the part of FMU 35 that is within the FMLA.

1. Wood Supply Boundary
Cover name: WS_BDY

This is the boundary of the wood supply area. It covers all of FMU 31 and the part of FMU 35 where the new inventory was completed. The new inventory only included a small part of the Atikaki Park in FMU 35, so most of the Atikaki Park in FMU 35 is not included in the wood supply area. This cover was used to clip the other wood supply covers to a common area.

Attribute Name	Value	Description
Bdy	"in"	Inside of the wood supply area.

2. Treaty Land Entitlement Selection Areas
Cover name: TLE_WS

This is a cover showing the selection of lands by First Nations that are validated Treaty Land Entitlement Claims. This cover has been clipped to the Wood Supply area.   These TLE areas are to be netted out of the land base.

Attribute Name	Value	Description
Site_id	e.g. 797	Site identification for TLE site selection. Can be linked back to original coverage to get other attributes.

3. Protected Area Initiative Areas
Cover name: PAI_WS

This cover shows the proposed protected areas identified by the Manitoba Conservation Parks and Protected Areas Branch. These protected area boundaries have been adjusted from the original ASI and are used in this WSA. There are two protected areas inside of the wood supply area. The Observation protected area was buffered out into Lake Winnipeg by 1000 meters. However, it was clipped at the shore of the lake for this analysis.   The Happy Lake proposal is found partially within a park reserve

Attribute Name	Value	Description
Pai	"Happy" "Observation"	Protected area around Happy Lake. Protected area near Observation Point.

4. Caribou Winter Zone
Cover name: CRB_WZONE

This cover is a single polygon showing the Caribou winter zone within the wood supply area.   Some constraints to the wood supply may be applied to this area.

Attribute Name	Value	Description
Caribou_zn	"Z1B"	Caribou Winter Zone 1 B.

5. Tembec Operating Areas
Cover name: OP_AREAS

This is a polygon cover of the operating areas that Tembec will be operating in for the next two 5-year periods. The coverage was provided by Tembec and has been cut into the net down coverage to accommodate future analysis work.

Attribute Name	Value	Description
Op_area	e.g. "Rainy Lake"	Name of operating area.

Op_area_no	Numbers 1 to 19	Operating areas and supporting data have been provided by Tembec.

6. Cover Showing Changes in Ownership
Cover Name: OWNER_CHANGE

Two areas in the restricted parks were to be changed to closed as per the instruction of the IRMT: the area south and east of the highway in the Black River area is closed and the area north of the highway in the Bird River area is also closed. The highway lines from the roads coverage was used to split these restricted areas and create polygons of these new closed areas identified by the IRMT. There was also an exclusion area proposed by Tembec to join the two closed areas of the Nopiming Park at the Ontario Border. This exclusion area was also added to this cover. The coverage contains just these three polygons and in all other cases the own_id attribute from the FRI will be used to indicate areas closed to logging.

Attribute Name	Value	Description
Own_change	"closed" "extension"	- Two areas changed from "restricted" to "closed" by IRMT. - Tembec voluntary protection.

7. Buffers on Heritage sites
Cover Name: HSITES_BUFF

Archaeological and other heritage sites were received from the Department of Culture, Heritage and Tourism as a point shape file. These points were converted to an ArcInfo coverage and the points were buffered with a 50 meter buffer to get this polygon coverage.

Attribute Name	Value	Description
Arch1buff	e.g. 6521	Archaeological site identification number.
Arch2buff	e.g. 6522	In a few cases the Archaeological sites were close enough together that the buffers merged together so we needed a second attribute to identify the second site within the buffer polygon in these few cases.

8. Buffers on Provincial Roads
Cover Name: RDS_BUFF

A coverage of roads was received from the Department of Transportation and the provincial roads inside of the wood supply area were extracted from this coverage. These roads line up well with the orthophotos. The provincial roads line coverage was buffered at 100 meters to get this polygon coverage.

Attribute Name	Value	Description
Rdbuff	"inside" " "	- Inside of the road buffer. - Not inside of the road buffer.

9. Buffer Around the Beresford Lake Subdivision
Cover Name: BERES_BUFF

For the Beresford Lake subdivision the road was used and buffered out 200 meters from the road. The boundary of the lake was used to define the portions of the buffer that landed in the lake.

Attribute Name	Value	Description
Beres_sub	"inside" " "	- Inside 200 meter Beresford subdivision buffer. - Not inside of subdivision buffer.

10. Buffer on Permanent Sample Plots
Cover name: PSP_BUFF

The permanent sample plot (PSP) point coverage was used to place 100 meter buffers around PSPs.

Attribute Name	Value	Description
Psp_buff	"inside" " "	- Inside 100 meter buffer around permanent sample plot - Not inside of PSP buffer.

11. 50 Meter Buffers on Single-Line Streams
Cover Name: STR_BUFF

Single-line streams or rivers were extracted from the “Line” coverage for each FRI tile in the wood supply area. These stream tiles were then merged into one cover for the wood supply area. This line cover was buffered with 50 meter buffers to get the resulting polygon buffer cover. This buffer size was suggested by the IRMT.

Attribute Name	Value	Description
Strbuff	“inside” “ ”	- Inside 50 meter stream buffer. - Not inside of stream buffer.

12. 30 Meter Buffers on Single-Line Streams
Cover Name: STR_BUFF30

Single-line streams or rivers were extracted from the “Line” coverage for each FRI tile in the wood supply area. These stream tiles were then merged into one cover for the wood supply area. This line cover was buffered with 30 meter buffers to get the resulting polygon buffer cover. This coverage is an option to the 50 meter buffers that were suggested by the IRMT.

Attribute Name	Value	Description
Strbuff30	“inside” “ ”	- Inside 30 meter stream buffer. - Not inside of stream buffer.

13. 100 Meter Buffers on Single-Line Streams
Cover Name: STR_BUFF100

Single-line streams or rivers were extracted from the “Line” coverage for each FRI tile in the wood supply area. These stream tiles were then merged into one cover for the wood supply area. This line cover was buffered with 100 meter buffers to get the resulting polygon buffer cover. This coverage is an option to the 50 meter buffers that were suggested by the IRMT.

Attribute Name	Value	Description
Strbuff100	“inside” “ ”	- Inside 100 meter stream buffer. - Not inside of stream buffer.

14. Buffers on Selected Lakes in Bird River Area
Cover Name: BIRD_BUFF

Some lakes in the Bird River area were selected by the IRMT to have 200 meter buffers: Booster, Flanders, Davidson, Summerhill, Birse and Ryerson. A cover of the lakes and double-line rivers in the wood supply area was extracted from the FRI from which cover the IRMT selected lakes were extracted into a cover for the Bird River area. The lake boundaries were erased from this cover and the islands were added back in. The islands are considered to be inside of the buffer.

Attribute Name	Value	Description
Birdbuff	“inside” “ ”	- Inside 200 meter buffer on Bird River lakes. - Not inside of Bird River lakes buffer.

15. Buffer on Winnipeg River
Cover Name: WRIV_BUFF

This cover is a buffer of 200 meters on the Winnipeg River.

Attribute Name	Value	Description
Wpgrivbuff	“inside” “ ”	- Inside 200 meter buffer on Winnipeg River. - Not inside of Winnipeg River buffer.

16. Buffer on Lakes and Rivers in Happy Lake Area
Cover Name: HAP_BUFF

A 250 meter buffer was placed around the lakes that are connected to the Manigotagan River system. The buffer begins on the Manigotagan River at the western edge of the large restricted park area in Nopiming Provincial Park (just south of Big Clearwater Lake). The buffer extends east along the Manigotagan and includes the lakes that are connected to the river, which are: Quesnel Lake, Manigotagan Lake, Happy Lake, Long Lake and Gem Lake. The buffer follows along this lake and river system to the Ontario border. The islands are considered to be inside of the buffer.

Attribute Name	**Value**	**Description**
Happybuff	"inside" " "	- Inside 250 meter buffer on lakes and rivers in Happy Lake area. - Not inside of Happy Lake area buffer.

17. Buffer on Manigotagan River
Cover Name: MAN250_BUFF

There are two buffer covers made for the section of the Manigotagan River beginning from Lake Winnipeg in the west extending east to the Nopiming Provincial Park. This first option is a 250 meter buffer on that section of the river.

Attribute Name	**Value**	**Description**
Manbuff250	"inside" " "	- Inside 250 meter buffer on Manigotagan River. - Not inside of Manigotagan River buffer.

18. Buffer on Manigotagan River
Cover Name: MAN750_BUFF

Manigotagan River received a 750 meter buffer on the section of river from Lake Winnipeg to Nopiming Provincial Park at the time of the GIS netdown. It's closed in ownership now as finalized in December 2005.

Attribute Name	**Value**	**Description**
Manbuff750	"inside" " "	- Inside 750 meter buffer on Manigotagan River. - Not inside of Manigotagan River buffer.

19. 30 Meter Buffer option on Lakes and Double-Lined Rivers
Cover Name: REG_BUFF30

The lakes and double-lined rivers that were not identified by the IRMT were put into a separate cover. A 30 meter buffer was created for these lakes and rivers in a separated coverage. Islands within the lakes were considered to be inside the buffer, so they will be netted out of the land base. The buffer coverage has the following attribute.

Attribute Name	**Value**	**Description**
Lakbuff30	"inside" " "	- Inside 30 m buffer on non-IRMT lakes and double-lined rivers. - Not inside of lakes and rivers buffer.

20. 100 Meter Buffer option on Double-Lined Lakes and Rivers
Cover Name: REG_BUFF100

The lakes and double-lined rivers, not identified by the IRMT, were placed into a separate cover. A 100 meter buffer option was created for these lakes and rivers in a separated buffer coverage. Islands within the lakes were considered to be inside the buffer, so they will be netted out of the land base. The buffer coverage has the following attribute.

Attribute Name	**Value**	**Description**
Lakbuff100	"inside" " "	- Inside 100 m buffer on non-IRMT lakes and double-lined rivers. - Not inside of lakes and rivers buffer.

21. Buffers on Double-Lined Lakes and Rivers

Cover Name: REG_BUFF

The lakes and double-lined rivers that were not identified by the IRMT were placed into a separate cover. An attribute was created in this cover to indicate whether the polygon was a small lake, large lake or double-lined river. Lake polygons greater than 20 hectares were considered large lakes and received a buffer of 100 meters, lakes 20 hectares and less were considered small lakes and received a buffer of 50 meters, and double-lined rivers were given a 100 meter buffer. Islands within the lakes were considered to be inside the buffer, so they will be netted out of the land base. These buffer sizes were recommended by the IRMT.

Attribute Name	Value	Description
Lakbuff	"inside" " "	- Inside 50 m or 100 m buffer on non-IRMT lakes and double-lined rivers. - Not inside of lakes and rivers buffer.

Appendix III Yield Curves Development

Presented in this appendix are graphical illustrations of the yield curves used in this analysis. Supporting data is provided in table form. Observations removed from consideration in the least squares solution are circled. Dummy variables are represented by an X.

Yield curves have been developed for commercially important forest stands. The stand mean merchantable volume per hectare was regressed over FRI age using a 2-parameter model.

Tree level merchantable volume is aggregated into plot level merchantable volume. The three plots per polygon (forest stand) are then averaged to produce mean merchantable volume of the stand. All stands underwent stratification into groups, similar in species composition, density and productivity. Yield curves were developed, estimating total merchantable softwood and hardwood volume over stand age for tree length utilization standards and log length utilization standards.

The maximum age class present in the FMLA varies with strata, The volume sampling plots, with the exception of those plots falling within LBS, STL, TLS and UBS, rarely encountered softwood stands older than 110 years and hardwood stands older than 90 years.

Dummy Observations

For some strata the frequent number of plots found around rotation age and/or low number of plots at older age classes caused the trajectory of the growth model to increase in merchantable volume, well beyond the limits of the data and well past the theoretical stand break-up age. This continuous increment in volume over time is an unreasonable expectation. To address this issue a dummy observation was inserted into the data set at age 200 years. The magnitude and placement of these observations achieved the effect of drawing down the total merchantable volume curve through the older age classes without significantly effecting the position and slope of the original curve within the range of existing data. In total, 4 dummy observations were used. The affected strata include LBS, MSPF (density 1 and 2) and HWD(density 1). The process used to assign the value to the dummy observation was primarily trial and error using the following guidelines.

- Cause little change to the curves original slope through valid sampling data.
- Cause a negative slope to begin on the curve near or beyond the break-up age or near/beyond the extent of the data

Outliers and influential observations

Variability in a stratum's merchantable volumes is expected. Never the less it is important that some natural growth pattern can be reflected in the data assigned to a stratum. Since yield curves are applied to an aggregation of stand types (forming the stratum) the stand is considered the ecological unit. The three plots located within the stand type are averaged to provide the mean volume/ha of the stand (observation). The aggregation of sampled stands into a stratum label, provide the volume/ha data for the development of strata yield curves. The stand averaging process assists in mitigating the effects of outliers, minimizing the removal of data. In this relatively small data set, it was generally felt that outliers legitimately represent the high degree of variability in unit volumes exhibited by the strata. However, for some strata, outliers made it difficult to achieve convergence in the regression analysis. In such cases the outlier was examined to see if removal of the observation permitted convergence in the regression analysis.

Outliers (outside 3 standard deviations) were considered for removal when:

a) convergence could not be achieved using SAS PROC NonLIN procedure
b) the curve was significantly influenced by the outlier(s) largely due to a lack of observations.

In total, 3 observations were removed affecting 3 strata (MSPF(1), JP, SMIX(1).

STRATA RATIONALE

NSPF STRATA
The stratum occupies approximately 40,400 hectares of harvestable land base. This stratum is hardwood leading mixed-wood. The softwood component often occurs in small dense patches where the softwood volume per hectare significantly exceeds the mean estimate from the stratum's softwood yield curve. For a harvest scenario (total volume harvest) that fully utilizes the softwood and hardwood an NSPF yield curve was developed for use within the wood supply model. However, the current harvest scenario is softwood only.

Under a "softwood only" harvest scenario, the NSPF strata required "special consideration". Due to the Companies softwood operating practices a minimum operable softwood volume constraint of 50 m^3/ha is applied. As a result the model will not schedule any hectares of this stratum for softwood harvest because the softwood yield on the NSPF curve does not achieve the minimum operable volume of 50 m^3/ha. The softwood volume is only recoverable when the model objective is to maximize "Total volume" in an operation utilizing both hardwood and softwood species.

Under the present operating scenario, records show that the company harvests the small patches of softwood on approximately 20% of the area of this strata type. To address this issue the observations within the strata type were partitioned into subsets that identify those observations with softwood volume greater than 50 m^3/ha and those observations with less than 50 m^3/ha of softwood volume. Approximately 30% of all randomly located observations in the NSPF strata contained softwood volumes that were greater than 50 m^3/ha. The NSPF strata area was then divided into the two separate strata; NSPF1 and NSPF2.

NSPF1 STRATA
This strata (comprised of NSPF observations with >50m^3/ha softwood) was assigned an area of 8,000 hectares (20%) from the NSPF strata. The assignment was carried out by redefining hectares within the wood stock area file. It was a non-spatial exercise and assumes that every NSPF polygon has 20 % of its area defined as NSPF1. The distribution of the data among age classes allowed for the development of yield curves for both softwood and hardwood. The softwood yield curve exceeds the 50 m^3 minimum operable volume per hectare allowing the 8,000 hectare to be available for harvest. The hardwood does not achieve the minimum operable level of 75 m^3/ha. However, it will be

harvested as incidental hardwood during the softwood operation and will, therefore, contribute towards the hardwood AAC. Statistical analysis showed that there were insignificant differences in volume estimates between low density and high density classes so further partitioning into density classes was not done.

NSPF2 STRATA

This strata (comprised of NSPF observations with <50m^3/ha softwood) was assigned an area of 32,000 hectares from the NSPF strata. The assignment was carried out by redefining hectares within the Woodstock area file. The exercise was non-spatial and assumes that every NSPF polygon has 80% of its area defined as NSPF2. The distribution of the data among age classes allowed for the development of yield curves for both softwood and hardwood. This stratum meets the minimum hardwood volume requirements of 75 m^3/ha but would not contribute toward the hardwood AAC because softwood operations would not take place in this stratum and the hardwood, therefore, would not be recovered. Statistical analysis showed that there were insignificant differences in volume estimates between low density and high density classes so further partitioning into density classes was not done.

JP STRATA

The stratum occupies approximately 132,700 hectares. Although the sampling design strived to achieve a balance of samples across all age classes there were few ages encountered above 100 years in the JP stratum. In addition the stratum's sample plots varied greatly in volume at all age classes and despite additional sampling, the volume variability and age range remains unchanged. Attempts to divide this stratum into density classes proved to be too difficult due to the low number of samples in density class 1 and the questionable MAI /CAI relationships that resulted from this division. It was determined that while there appeared to be a significant difference in productivity there needed to be more volume plots established in the lower density classes of this stratum to further strengthen the yield information necessary for partitioning. As a result, a composite density curve is used for this stratum in this analysis.

BS STRATA

The Black Spruce stratum occupies approximately 33,651 hectares of harvestable forest land base. Plot volume was found to differ significantly along the soil moisture gradient. Although the upland area only accounts for approximately 11,000 hectares or 30% of the overall BS strata, the difference in productivity warranted partitioning by moisture class. The strata was therefore, partitioned into lowland black spruce (LBS) and upland black spruce (UBS) totalling 22,751 ha and 10,946 ha respectively. The partitioning was based on the FRI moisture class. For LBS, 30 volume sampling plots of a total 111 plots were located in low density stands which occupy approximately 20% of the total area of this stratum. For UBS, 18 plots of a total 45 plots were located in low density stands which occupy approximately 50% of the strata area. However it was determined that while sample plot location is reflective of the area contribution made by low density and high density stands and differences in productivity appeared significant, more samples would be needed in the low density stands in order to develop reliable yield estimates for this density class. Consequently the strata partitioning was confined to moisture class and disregarded any further partitioning (density) for yield curve development.

STL STRATA

This stratum occupies approximately 14,700 hectares of the harvestable land base. Low density stands occupy approximately 32% with the balance of hectares in high density stands. The total number of sample plots in this stratum is 81. There are 30 plots in the low density and 51 plots in the high density which is similar to the area ratio. However the 30 plots in low density stands are insufficient in number and distribution among age classes for the development of a reliable yield curve. Consequently this stratum was not partitioned into density classes for yield curve development. Additional data is required in density class1 stands in order to develop density class yield curves.

TLS STRATA

This stratum occupies approximately 23,000 hectares of harvestable land base. The sampling area and plot ratios between density classes are similar to the STL stratum, giving rise to similar yield curve development strategy. Additional data is required to develop yield curves based on density class for this stratum.

MSPF STRATA

The stratum occupies approximately 59,000 hectares of harvestable land base. The low density stands account for 11,500 or roughly 19% of this area with high density stands accounting for the balance. A total of 234 plots were established in this stratum.
This is a softwood dominated mixed wood strata with extreme variability between plot and stand volume calculations. However, statistical analysis showed significant difference in plot (stand) volumes between density classes. Further analysis demonstrated that sample plot frequency and distribution among age classes was sufficient to allow the partitioning of the strata into two density classes prior to the construction of yield curves. Approximately 29% of the sampling plots were established in low density stands and 71% were established in high density stands.

SMIX STRATA

This stratum occupies approximately 180,500 hectares of harvestable land base. The strata represents those stands which are predominantly softwood in composition but with no single species occupying greater than 80% of the species composition. It is similar to MSPF except for a noted deficiency in hardwood presence. The distinction between MSPF and SMIX strata reflects less the differences in the softwood volume component and more the site capability and total volume production. Approximately 51,000 hectares or 28% of the total area of the strata are in low density stands. Statistical analysis found a significant difference in plot volumes between the two density classes and the sample plot frequency and distribution among age in both density classes allowed partitioning the strata into two density classes prior to the construction of yield curves.

HARDWOOD STRATA

The strata is a composite of commercial hardwood species TA, BA and WB (excludes ash) and occupies approximately 51,500 hectares of harvestable land base. Plot volumes were highly variable across age classes and statistical analysis showed a significant difference in plot volume between density classes. Although the low density class only occupies approximately 6,500 hectares (15%) of the total area, the great difference in productivity warranted partitioning the strata into density classes. The sample plot frequency and distribution among age classes also supported partitioning.

ASH STRATA
In the pre sampling stratification work on the land base, non-commercial hardwoods were aggregated into OTHWD for sampling purposes. After sampling was completed the random nature of the sample design found most plots in this strata were actually established in ASH stands. As a result the OTHWD was redefined to partition out the Ash even though ash stands only occupy approximately 2,600 hectares. This was done because a significant number of plots were established in Ash stands which would allow for the development of a yield curve specific to ash. However, the size of the strata negated any partitioning into density class.

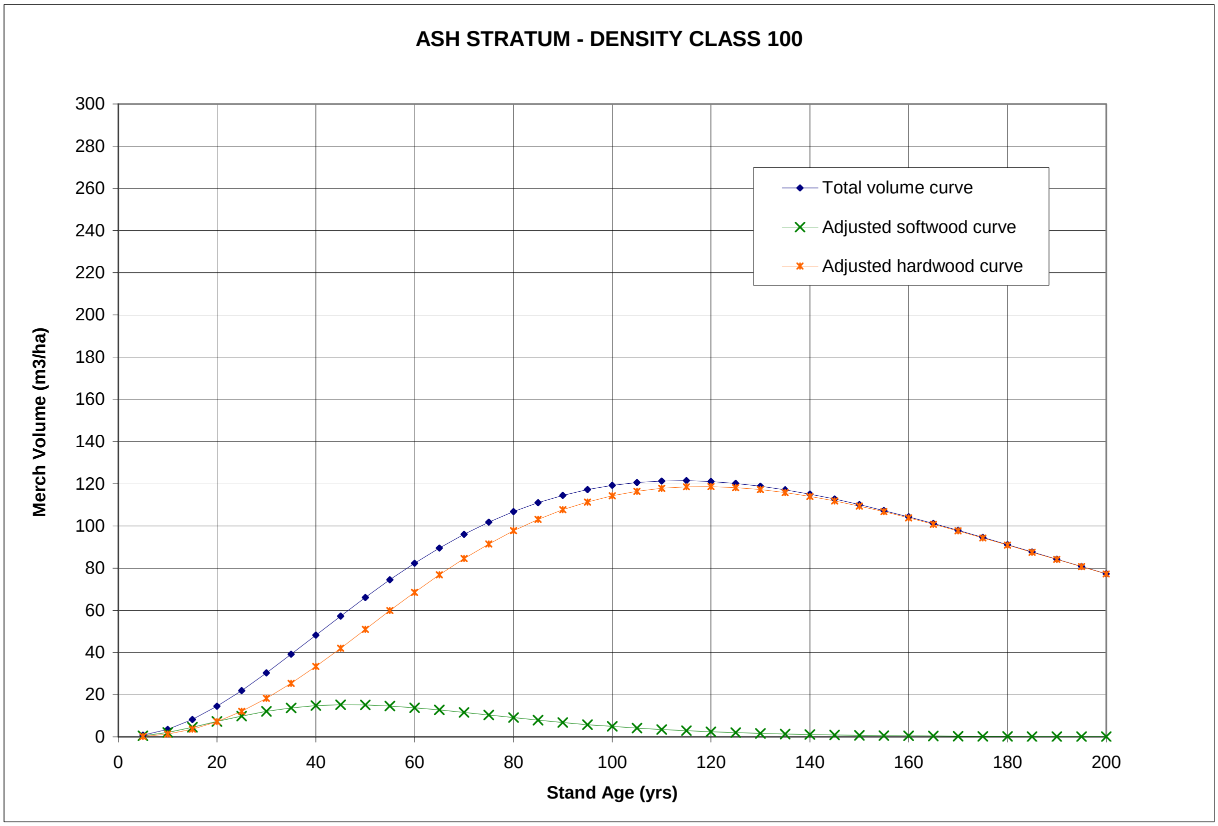
OTHWD STRATA
The stratum only occupies approximately 2,000 hectares of harvestable land base and due to the small area and sample size a yield curve was not developed for this stratum. The HDWD density 1 yield curve is used to estimate productivity over time.

OTHSWD STRATA
The stratum is comprised of stands with a softwood component that did not meet any of the other softwood strata definitions. It occupies approximately 7,500 hectares of harvestable land base and has a significant softwood component (cedar, tamarack, spruce, pine) as well as some hardwood species; often resulting in complex species compositions. Yield curves were not developed for this stratum. The MSPF density 1 yield curve is used to estimate productivity over time.

BF STRATA
The stratum occupies approximately 500 hectares of harvestable land base and did not receive any sampling. By definition the strata is at least 80% balsam fir. Volume estimates over time for this strata are provided by the MSPF yield curves.

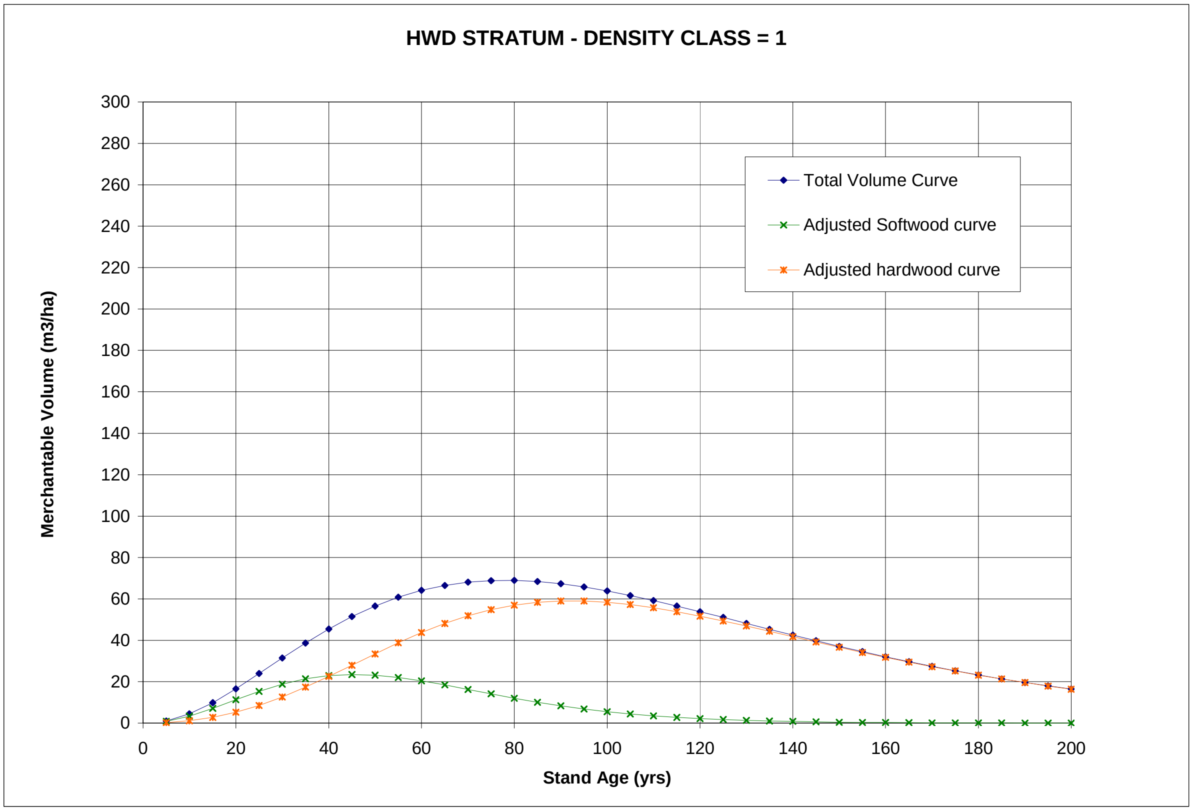
Yield Curve graphs and supporting data

The Manitoba LOG-LENGTH yield curves are presented along with a values table for easy reference.



Age	Volume Estimates (m^3/ha)[1]					Mean Annual Increment (m^3/yr)		
	Softwood		Hardwood		Total	softwood	hardwood	total
	predicted	adjusted	predicted	adjusted				
10	4.61	2.17	2.91	1.37	3.54	0.22	0.14	0.35
20	11.94	7.27	11.85	7.21	14.47	0.36	0.36	0.72
30	16.58	12.08	25.01	18.22	30.31	0.40	0.61	1.01
40	17.86	14.8	40.35	33.44	48.24	0.37	0.84	1.21
50	16.72	15.16	56.16	50.92	66.08	0.30	1.02	1.32
60	14.34	13.8	71.2	68.52	82.32	0.23	1.14	1.37
70	11.57	11.55	84.64	84.49	96.04	0.17	1.21	1.37
80	8.92	9.09	95.98	97.71	106.79	0.11	1.22	1.33
90	6.66	6.82	104.98	107.66	114.48	0.08	1.20	1.27
100	4.83	4.95	111.62	114.28	119.23	0.05	1.14	1.19
110	3.43	3.49	115.97	117.81	121.3	0.03	1.07	1.10
120	2.39	2.4	118.23	118.64	121.04	0.02	0.99	1.01
130	1.65	1.63	118.64	117.22	118.85	0.01	0.90	0.91
140	1.12	1.08	117.43	114.01	115.09	0.01	0.81	0.82
150	0.75	0.71	114.89	109.42	110.14	0.00	0.73	0.73
160	0.5	0.46	111.26	103.84	104.31	0.00	0.65	0.65
170	0.33	0.3	106.79	97.59	97.89	0.00	0.57	0.58
180	0.21	0.19	101.69	90.94	91.13	0.00	0.51	0.51
190	0.14	0.12	96.15	84.11	84.23	0.00	0.44	0.44
200	0.09	0.08	90.34	77.27	77.35	0.00	0.39	0.39

[1] **Based on 8 foot (2.54m) utilization**

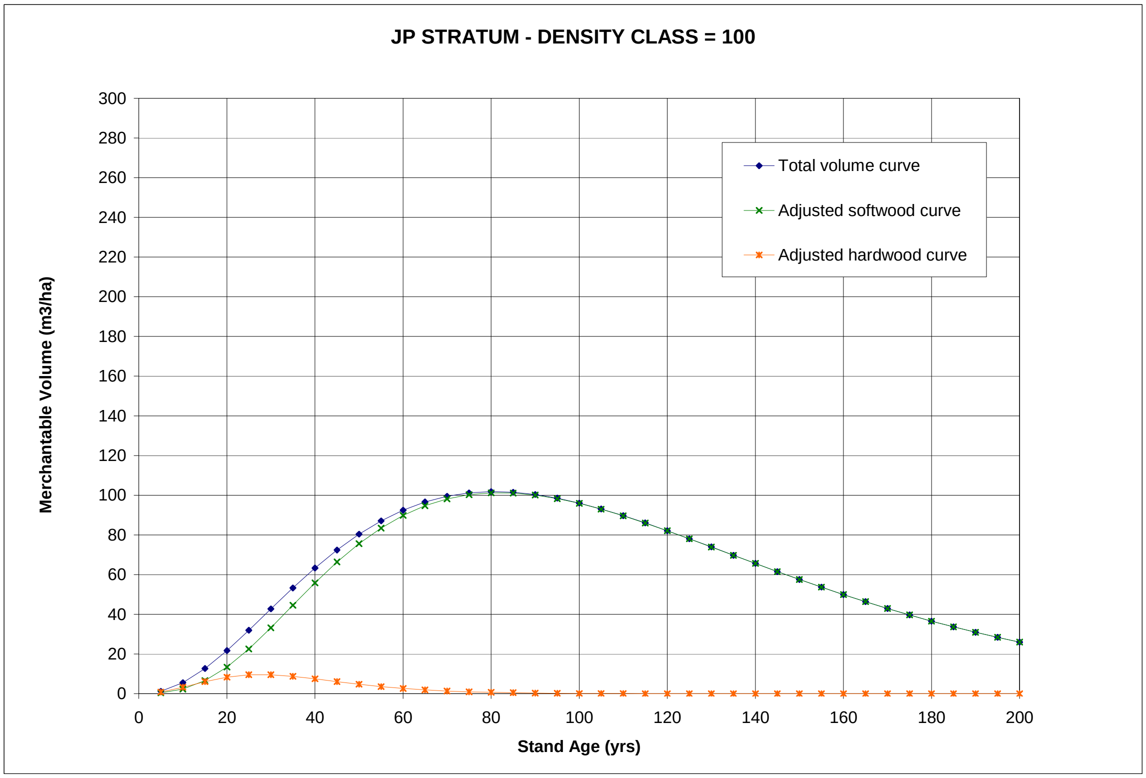


Age	Volume Estimates (m³/ha)[1]					Mean Annual Increment(m³/yr)		
	Softwood		Hardwood		Total	softwood	hardwood	total
	predicted	adjusted	predicted	adjusted				
10	6.44	3.36	2.18	1.13	4.49	0.34	0.11	0.45
20	17.36	11.29	8.11	5.27	16.56	0.56	0.26	0.83
30	24.18	18.8	16.24	12.63	31.43	0.63	0.42	1.05
40	25.72	22.93	25.23	22.5	45.43	0.57	0.56	1.14
50	23.59	23.13	34.1	33.44	56.57	0.46	0.67	1.13
60	19.7	20.41	42.19	43.7	64.11	0.34	0.73	1.07
70	15.43	16.27	49.12	51.81	68.08	0.23	0.74	0.97
80	11.52	11.99	54.7	56.93	68.93	0.15	0.71	0.86
90	8.3	8.32	58.88	58.98	67.29	0.09	0.66	0.75
100	5.81	5.5	61.69	58.34	63.84	0.06	0.58	0.64
110	3.98	3.5	63.26	55.68	59.18	0.03	0.51	0.54
120	2.67	2.16	63.71	51.65	53.81	0.02	0.43	0.45
130	1.76	1.31	63.21	46.84	48.15	0.01	0.36	0.37
140	1.15	0.77	61.92	41.72	42.5	0.01	0.30	0.30
150	0.74	0.45	59.98	36.62	37.07	0.00	0.24	0.25
160	0.47	0.26	57.55	31.74	32	0.00	0.20	0.20
170	0.3	0.15	54.75	27.23	27.38	0.00	0.16	0.16
180	0.19	0.08	51.7	23.16	23.24	0.00	0.13	0.13
190	0.12	0.05	48.5	19.54	19.58	0.00	0.10	0.10
200	0.07	0.03	45.22	16.37	16.4	0.00	0.08	0.08

[1] **Based on 8 foot (2.54m) utilization**

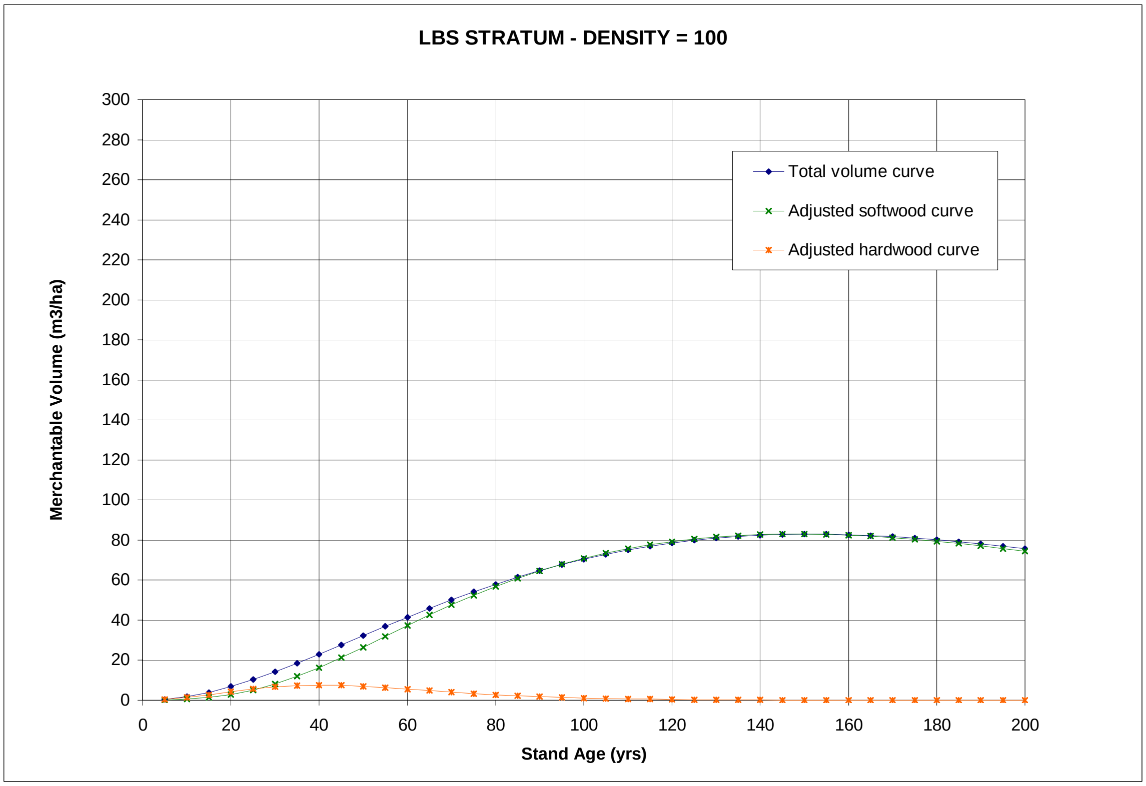
Age	Volume Estimates (m³/ha)[1]					Mean Annual Increment (m³/yr)		
	Softwood		Hardwood		Total	softwood	hardwood	total
	predicted	adjusted	predicted	adjusted				
10	1.86	1.59	5.2	4.43	6.02	0.16	0.44	0.60
20	5.98	5.55	22.14	20.56	26.12	0.28	1.03	1.31
30	10.76	10.39	46.72	45.1	55.49	0.35	1.50	1.85
40	15.29	15.07	73.99	72.91	87.97	0.38	1.82	2.20
50	19.07	19.01	100.11	99.79	118.81	0.38	2.00	2.38
60	21.92	21.99	122.63	122.99	144.98	0.37	2.05	2.42
70	23.8	23.93	140.24	141.01	164.95	0.34	2.01	2.36
80	24.8	24.94	152.53	153.36	178.3	0.31	1.92	2.23
90	25.03	25.12	159.63	160.21	185.34	0.28	1.78	2.06
100	24.64	24.65	162.09	162.14	186.79	0.25	1.62	1.87
110	23.77	23.67	160.6	159.95	183.62	0.22	1.45	1.67
120	22.55	22.34	155.93	154.47	176.81	0.19	1.29	1.47
130	21.1	20.77	148.85	146.57	167.34	0.16	1.13	1.29
140	19.5	19.07	140.05	136.98	156.05	0.14	0.98	1.11
150	17.84	17.33	130.14	126.37	143.69	0.12	0.84	0.96
160	16.18	15.59	119.63	115.26	130.85	0.10	0.72	0.82
170	14.56	13.91	108.91	104.09	118.01	0.08	0.61	0.69
180	13.01	12.33	98.33	93.18	105.51	0.07	0.52	0.59
190	11.55	10.85	88.1	82.77	93.61	0.06	0.44	0.49
200	10.2	9.49	78.41	73	82.49	0.05	0.37	0.41

[1] **Based on 8 foot (2.54m) utilization**



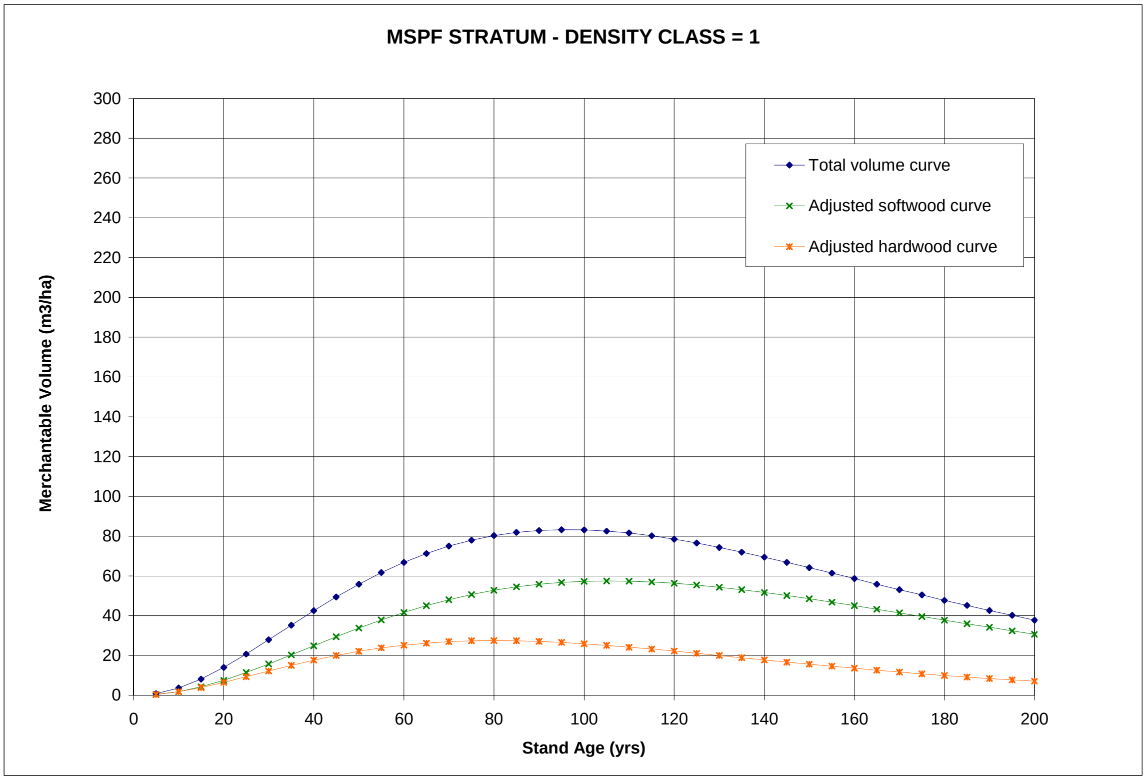
Age	Volume Estimates (m^3/ha)[1]					Mean Annual Increment (m^3/yr)		
	Softwood		Hardwood		Total	softwood	hardwood	total
	predicted	adjusted	predicted	adjusted				
10	4.99	2.32	6.94	3.22	5.54	0.23	0.32	0.55
20	19.64	13.39	12.23	8.34	21.73	0.67	0.42	1.09
30	39.05	33.2	11.2	9.52	42.72	1.11	0.32	1.42
40	58.67	55.84	7.84	7.46	63.31	1.40	0.19	1.58
50	75.63	75.61	4.74	4.74	80.36	1.51	0.09	1.61
60	88.47	89.82	2.61	2.65	92.48	1.50	0.04	1.54
70	96.8	98.1	1.35	1.37	99.47	1.40	0.02	1.42
80	100.84	101.16	0.67	0.67	101.83	1.26	0.01	1.27
90	101.19	100.06	0.32	0.31	100.37	1.11	0.00	1.12
100	98.59	95.89	0.15	0.14	96.03	0.96	0.00	0.96
110	93.79	89.63	0.07	0.06	89.69	0.81	0.00	0.82
120	87.49	82.09	0.03	0.03	82.12	0.68	0.00	0.68
130	80.26	73.93	0.01	0.01	73.94	0.57	0.00	0.57
140	72.6	65.62	0.01	0.01	65.63	0.47	0.00	0.47
150	64.88	57.54	0	0	57.54	0.38	0.00	0.38
160	57.37	49.92	0	0	49.92	0.31	0.00	0.31
170	50.26	42.9	0	0	42.9	0.25	0.00	0.25
180	43.67	36.56	0	0	36.56	0.20	0.00	0.20
190	37.66	30.93	0	0	30.93	0.16	0.00	0.16
200	32.27	25.99	0	0	25.99	0.13	0.00	0.13

[1] **Based on 8 foot (2.54m) utilization**



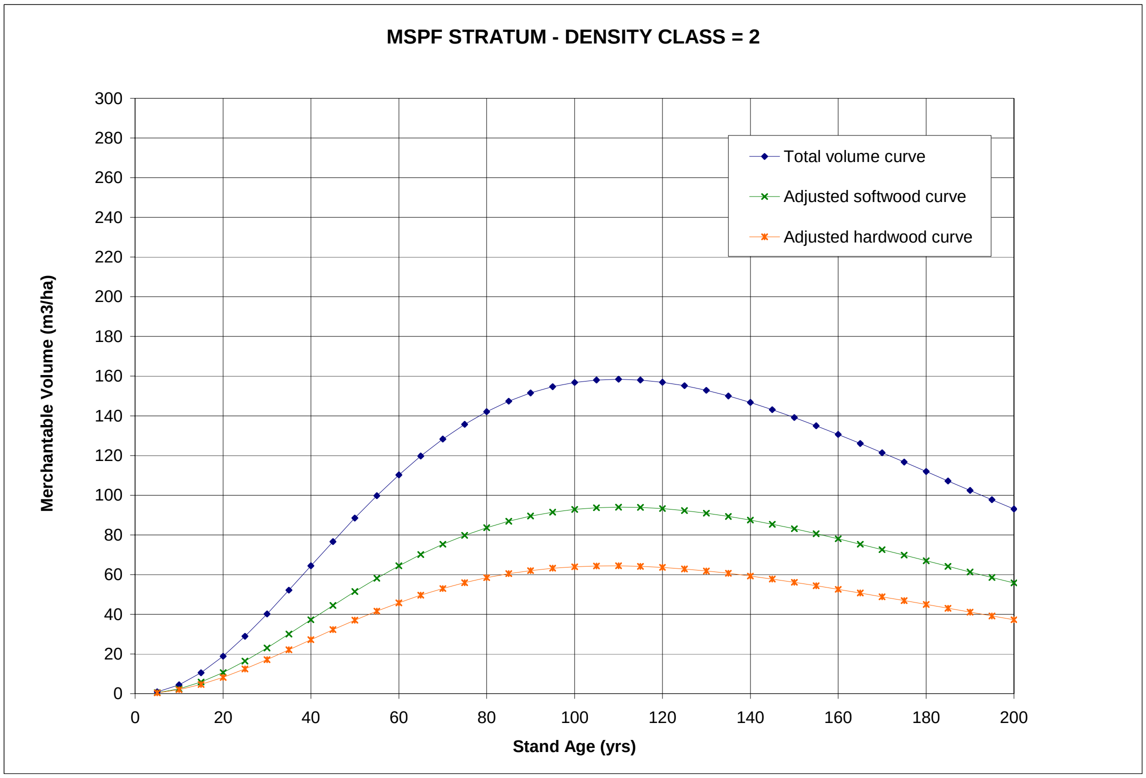
Age	Volume Estimates (m³/ha)[1]					Mean Annual Increment (m³/yr)		
	Softwood		Hardwood		Total	softwood	hardwood	total
	predicted	adjusted	predicted	adjusted				
10	1.77	0.51	4.66	1.34	1.85	0.05	0.13	0.19
20	6.85	2.9	10.04	4.25	7.15	0.15	0.21	0.36
30	14.23	8.14	11.74	6.71	14.84	0.27	0.22	0.49
40	22.96	16.3	10.68	7.58	23.89	0.41	0.19	0.60
50	32.22	26.47	8.47	6.96	33.44	0.53	0.14	0.67
60	41.41	37.29	6.16	5.55	42.84	0.62	0.09	0.71
70	50.07	47.63	4.22	4.02	51.65	0.68	0.06	0.74
80	57.92	56.83	2.77	2.72	59.54	0.71	0.03	0.74
90	64.77	64.6	1.76	1.75	66.35	0.72	0.02	0.74
100	70.5	70.88	1.08	1.09	71.97	0.71	0.01	0.72
110	75.1	75.73	0.66	0.66	76.39	0.69	0.01	0.69
120	78.58	79.25	0.39	0.39	79.64	0.66	0.00	0.66
130	81	81.55	0.23	0.23	81.78	0.63	0.00	0.63
140	82.42	82.78	0.13	0.13	82.91	0.59	0.00	0.59
150	82.96	83.06	0.08	0.08	83.13	0.55	0.00	0.55
160	82.7	82.51	0.04	0.04	82.55	0.52	0.00	0.52
170	81.74	81.26	0.02	0.02	81.29	0.48	0.00	0.48
180	80.2	79.43	0.01	0.01	79.44	0.44	0.00	0.44
190	78.16	77.11	0.01	0.01	77.12	0.41	0.00	0.41
200	75.72	74.42	0	0	74.42	0.37	0.00	0.37

[1] **Based on 8 foot (2.54m) utilization**



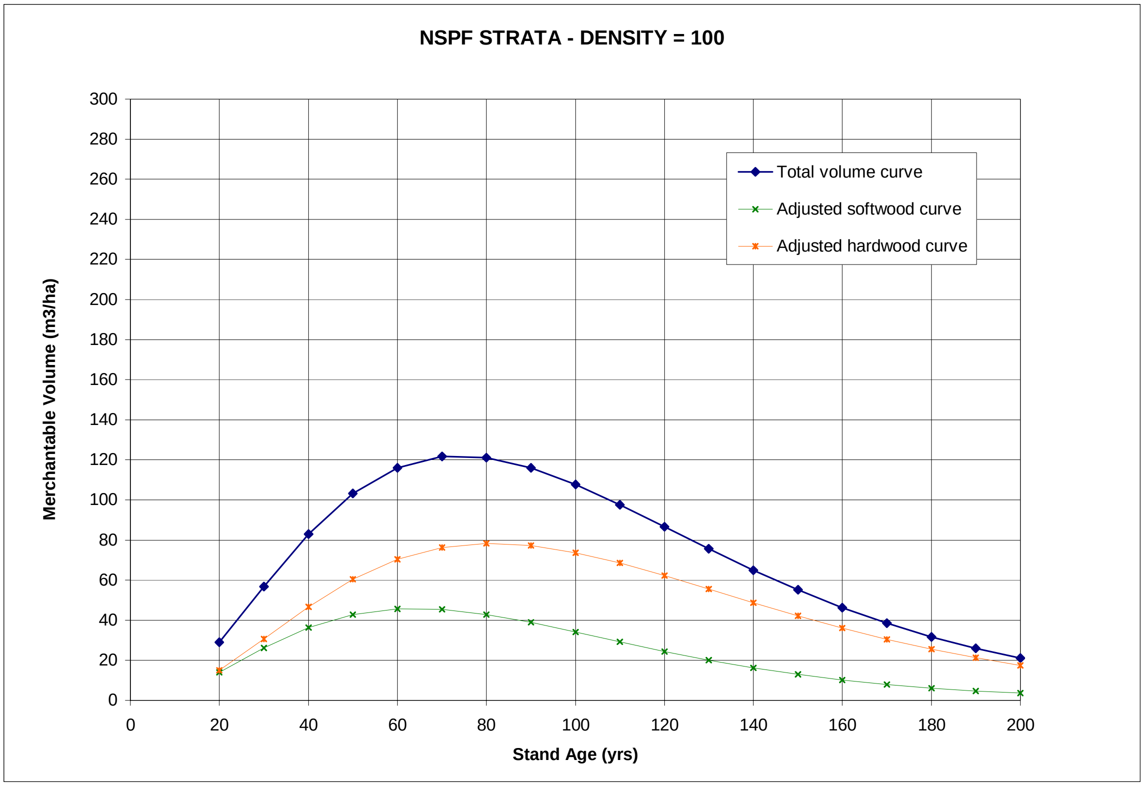
Age	Volume Estimates (m^3/ha)[1]					Mean Annual Increment (m^3/yr)		
	Softwood		Hardwood		Total	softwood	hardwood	total
	predicted	adjusted	predicted	adjusted				
10	2.42	1.84	2.35	1.79	3.63	0.18	0.18	0.36
20	8.82	7.54	7.55	6.46	13.99	0.38	0.32	0.70
30	17.26	15.71	13.39	12.19	27.9	0.52	0.41	0.93
40	26.2	24.85	18.6	17.64	42.49	0.62	0.44	1.06
50	34.59	33.75	22.63	22.08	55.83	0.68	0.44	1.12
60	41.81	41.63	25.3	25.19	66.82	0.69	0.42	1.11
70	47.56	48.03	26.69	26.95	74.98	0.69	0.39	1.07
80	51.73	52.75	26.98	27.51	80.25	0.66	0.34	1.00
90	54.39	55.78	26.4	27.08	82.86	0.62	0.30	0.92
100	55.67	57.26	25.18	25.9	83.16	0.57	0.26	0.83
110	55.76	57.36	23.52	24.2	81.55	0.52	0.22	0.74
120	54.85	56.3	21.6	22.18	78.48	0.47	0.18	0.65
130	53.15	54.33	19.56	19.99	74.33	0.42	0.15	0.57
140	50.85	51.67	17.49	17.77	69.44	0.37	0.13	0.50
150	48.11	48.52	15.47	15.61	64.13	0.32	0.10	0.43
160	45.08	45.06	13.57	13.56	58.62	0.28	0.08	0.37
170	41.89	41.43	11.8	11.67	53.1	0.24	0.07	0.31
180	38.63	37.77	10.19	9.96	47.73	0.21	0.06	0.27
190	35.39	34.16	8.74	8.44	42.59	0.18	0.04	0.22
200	32.23	30.68	7.46	7.1	37.77	0.15	0.04	0.19

[1] **Based on 8 foot (2.54m) utilization**



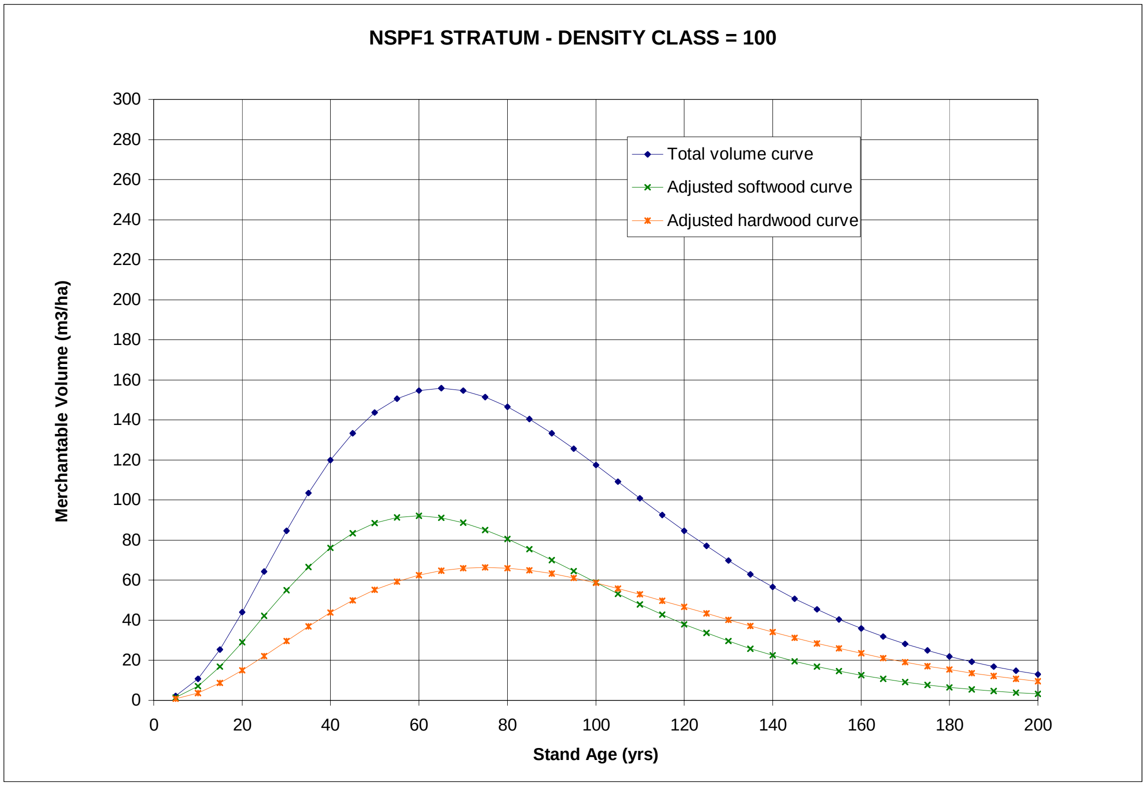
Age	Volume Estimates (m^3/ha)[1]					Mean Annual Increment (m^3/yr)		
	Softwood		Hardwood		Total	softwood	hardwood	total
	predicted	adjusted	predicted	adjusted				
10	3.04	2.45	2.47	1.99	4.44	0.25	0.20	0.44
20	11.95	10.65	9.22	8.22	18.87	0.53	0.41	0.94
30	24.5	22.99	18.31	17.19	40.17	0.77	0.57	1.34
40	38.46	37.21	28.15	27.23	64.44	0.93	0.68	1.61
50	52.16	51.45	37.57	37.06	88.51	1.03	0.74	1.77
60	64.5	64.41	45.88	45.82	110.22	1.07	0.76	1.84
70	74.82	75.27	52.69	53	128.27	1.08	0.76	1.83
80	82.84	83.66	57.84	58.41	142.07	1.05	0.73	1.78
90	88.49	89.47	61.35	62.03	151.5	0.99	0.69	1.68
100	91.91	92.84	63.33	63.97	156.81	0.93	0.64	1.57
110	93.3	94	63.96	64.44	158.43	0.85	0.59	1.44
120	92.96	93.27	63.44	63.65	156.91	0.78	0.53	1.31
130	91.16	90.98	61.97	61.84	152.83	0.70	0.48	1.18
140	88.21	87.48	59.75	59.26	146.74	0.62	0.42	1.05
150	84.36	83.07	56.97	56.1	139.18	0.55	0.37	0.93
160	79.88	78.03	53.8	52.56	130.59	0.49	0.33	0.82
170	74.96	72.61	50.37	48.79	121.4	0.43	0.29	0.71
180	69.8	66.99	46.81	44.92	111.91	0.37	0.25	0.62
190	64.53	61.34	43.2	41.06	102.4	0.32	0.22	0.54
200	59.29	55.79	39.63	37.29	93.08	0.28	0.19	0.47

[1] **Based on 8 foot (2.54m) utilization**



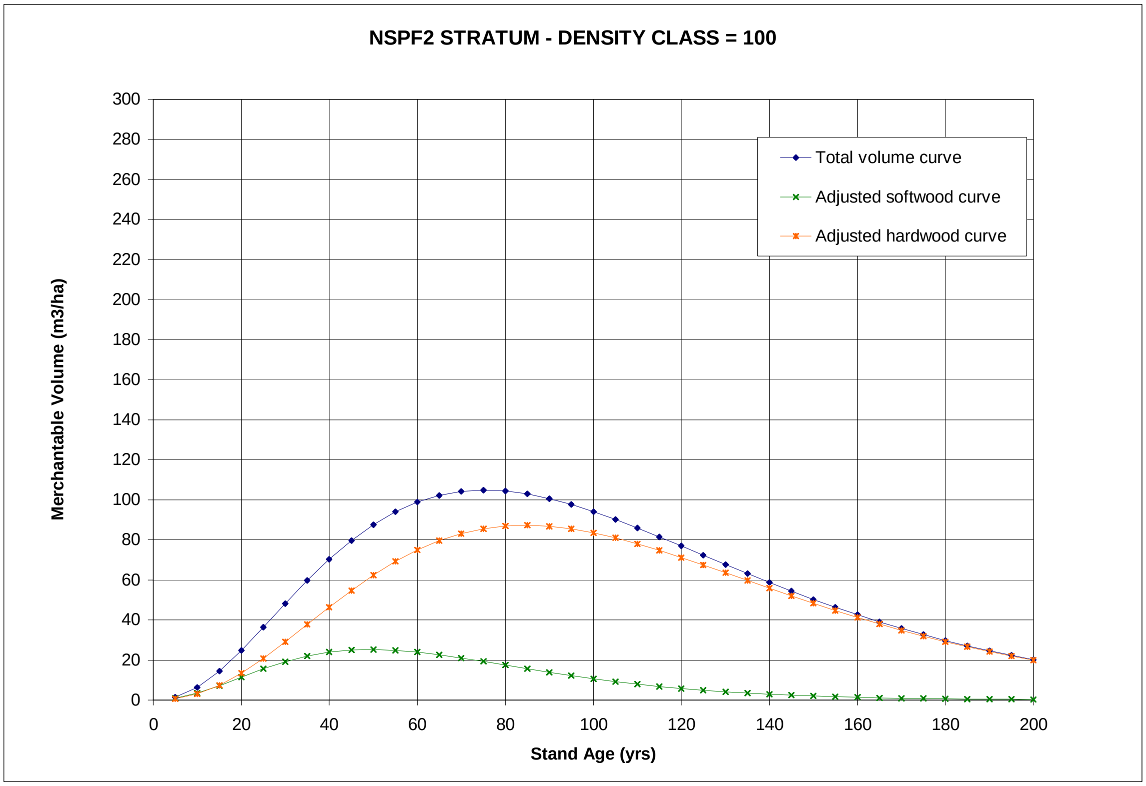
Age	Volume Estimates (m^3/ha)[1]					Mean Annual Increment (m^3/yr)		
	Softwood		Hardwood		Total	softwood	hardwood	total
	predicted	adjusted	predicted	adjusted				
10	4.63	3.73	4.39	3.54	7.27	0.37	0.35	0.73
20	15.61	14.07	16.61	14.97	29.04	0.70	0.75	1.45
30	27.42	26.12	32.21	30.69	56.81	0.87	1.02	1.89
40	36.88	36.24	47.55	46.72	82.96	0.91	1.17	2.07
50	42.85	42.83	60.42	60.38	103.21	0.86	1.21	2.06
60	45.39	45.71	69.84	70.33	116.04	0.76	1.17	1.93
70	45.09	45.44	75.63	76.21	121.65	0.65	1.09	1.74
80	42.76	42.88	78.07	78.29	121.17	0.54	0.98	1.51
90	39.12	38.87	77.70	77.20	116.07	0.43	0.86	1.29
100	34.79	34.12	75.13	73.68	107.81	0.34	0.74	1.08
110	30.25	29.19	70.98	68.48	97.66	0.27	0.62	0.89
120	25.81	24.43	65.77	62.25	86.67	0.20	0.52	0.72
130	21.68	20.07	59.97	55.53	75.60	0.15	0.43	0.58
140	17.96	16.23	53.94	48.74	64.98	0.12	0.35	0.46
150	14.71	12.95	47.94	42.19	55.14	0.09	0.28	0.37
160	11.93	10.20	42.16	36.08	46.28	0.06	0.23	0.29
170	9.58	7.96	36.75	30.51	38.47	0.05	0.18	0.23
180	7.64	6.15	31.78	25.56	31.70	0.03	0.14	0.18
190	6.05	4.71	27.28	21.22	25.93	0.02	0.11	0.14
200	4.76	3.58	23.27	17.48	21.06	0.02	0.09	0.11

[1] **Based on 8 foot (2.54m) utilization**



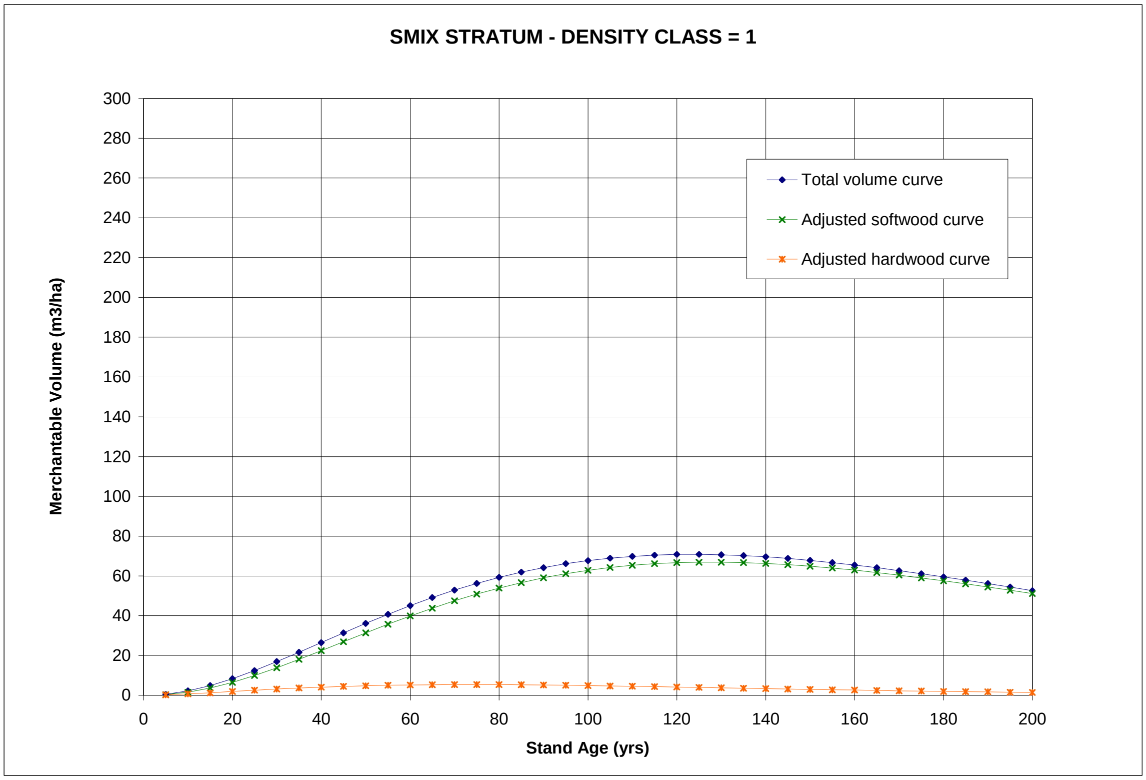
Age	Volume Estimates(m³/ha)[1]					Mean Annual Increment(m³/yr)		
	Softwood		Hardwood		adjusted	Softwood	Hardwood predicted	Adjusted
	predicted	adjusted	predicted	adjusted				
10	8.71	7.1	4.55	3.71	10.81	0.71	0.37	1.08
20	32.15	29.01	16.61	14.99	44.01	1.45	0.75	2.20
30	57.87	55.01	31.23	29.69	84.7	1.83	0.99	2.82
40	77.65	76.1	44.76	43.86	119.96	1.90	1.10	3.00
50	88.67	88.47	55.26	55.14	143.61	1.77	1.10	2.87
60	91.46	92.06	62.1	62.51	154.58	1.53	1.04	2.58
70	87.92	88.67	65.39	65.95	154.61	1.27	0.94	2.21
80	80.28	80.62	65.66	65.94	146.56	1.01	0.82	1.83
90	70.48	70.11	63.58	63.24	133.35	0.78	0.70	1.48
100	59.98	58.81	59.82	58.65	117.46	0.59	0.59	1.17
110	49.79	47.89	55	52.91	100.8	0.44	0.48	0.92
120	40.47	38.03	49.6	46.61	84.65	0.32	0.39	0.71
130	32.34	29.56	44.03	40.24	69.8	0.23	0.31	0.54
140	25.46	22.55	38.54	34.14	56.68	0.16	0.24	0.40
150	19.79	16.91	33.35	28.5	45.42	0.11	0.19	0.30
160	15.21	12.5	28.56	23.47	35.97	0.08	0.15	0.22
170	11.58	9.12	24.23	19.09	28.2	0.05	0.11	0.17
180	8.73	6.57	20.4	15.34	21.91	0.04	0.09	0.12
190	6.54	4.68	17.06	12.21	16.89	0.02	0.06	0.09
200	4.86	3.3	14.17	9.62	12.92	0.02	0.05	0.06

[1] **Based on 8 foot (2.54m) utilization**



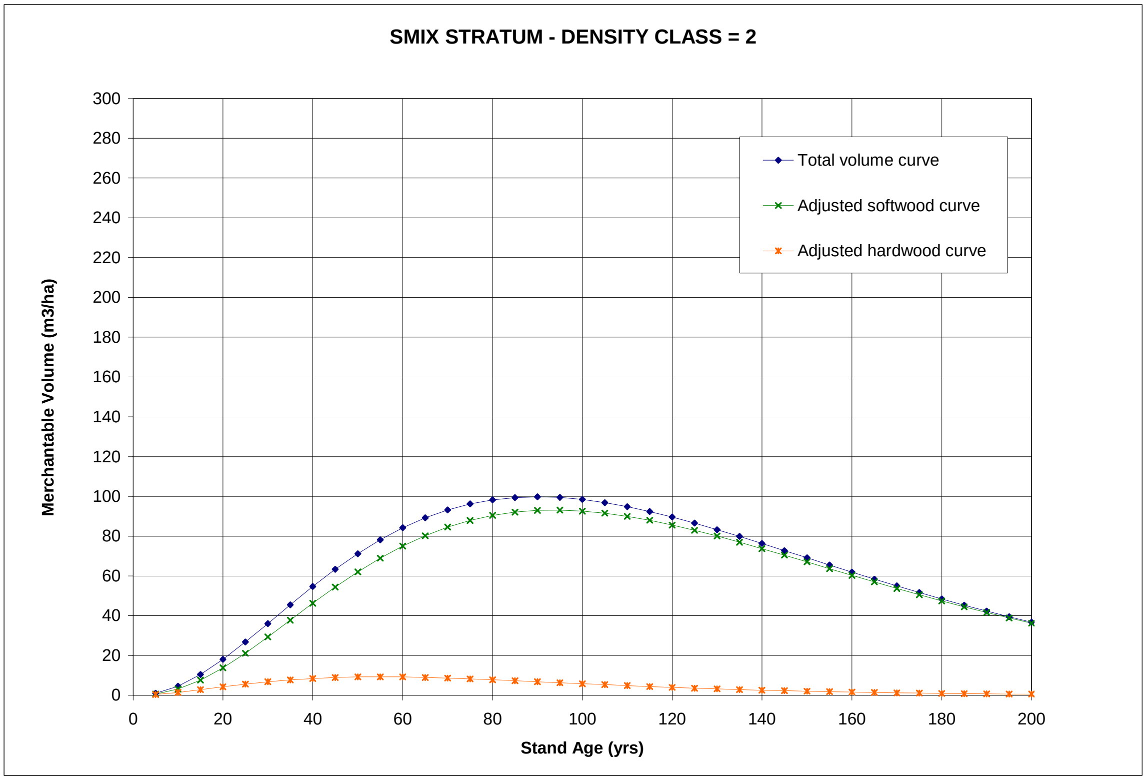
Age	Volume Estimates(m^3/ha)[1]					Mean Annual Increment(m^3/yr)		
	Softwood		Hardwood				Hardwood	
	predicted	adjusted	predicted	adjusted	adjusted	Softwood	predicted	adjusted
10	4.69	3.4	4.07	2.95	6.34	0.34	0.30	0.63
20	13.54	11.46	15.79	13.36	24.82	0.57	0.67	1.24
30	20.75	19.16	31.45	29.04	48.2	0.64	0.97	1.61
40	24.52	23.87	47.68	46.41	70.28	0.60	1.16	1.76
50	25.14	25.2	62.23	62.38	87.58	0.50	1.25	1.75
60	23.55	23.89	73.89	74.94	98.82	0.40	1.25	1.65
70	20.74	20.98	82.18	83.14	104.12	0.30	1.19	1.49
80	17.45	17.4	87.14	86.93	104.33	0.22	1.09	1.30
90	14.18	13.81	89.08	86.8	100.62	0.15	0.96	1.12
100	11.21	10.58	88.49	83.56	94.14	0.11	0.84	0.94
110	8.67	7.88	85.87	78.07	85.95	0.07	0.71	0.78
120	6.58	5.73	81.74	71.18	76.91	0.05	0.59	0.64
130	4.92	4.09	76.56	63.57	67.66	0.03	0.49	0.52
140	3.63	2.87	70.73	55.81	58.67	0.02	0.40	0.42
150	2.65	1.98	64.57	48.26	50.25	0.01	0.32	0.34
160	1.92	1.35	58.35	41.21	42.57	0.01	0.26	0.27
170	1.37	0.91	52.25	34.81	35.72	0.01	0.20	0.21
180	0.98	0.61	46.41	29.11	29.72	0.00	0.16	0.17
190	0.69	0.41	40.93	24.14	24.55	0.00	0.13	0.13
200	0.48	0.27	35.86	19.87	20.13	0.00	0.10	0.10

[1] **Based on 8 foot (2.54m) utilization**



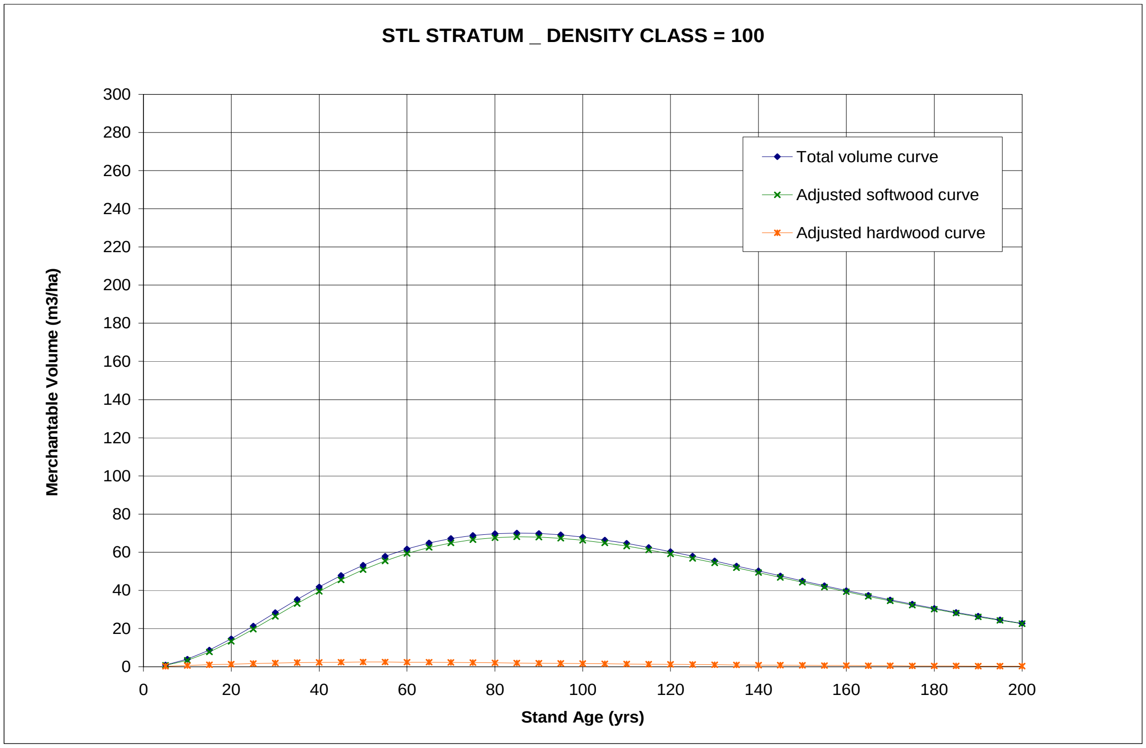
Age	Volume Estimates (m³/ha)[1]					Mean Annual Increment (m³/yr)		
	Softwood		Hardwood		Total	softwood	hardwood	total
	predicted	adjusted	predicted	adjusted				
10	1.92	1.54	0.84	0.67	2.21	0.15	0.07	0.22
20	7.23	6.47	2.11	1.89	8.35	0.32	0.09	0.42
30	14.68	13.82	3.29	3.1	16.92	0.46	0.10	0.56
40	23.15	22.44	4.22	4.09	26.52	0.56	0.10	0.66
50	31.78	31.35	4.86	4.79	36.14	0.63	0.10	0.72
60	39.97	39.85	5.22	5.21	45.06	0.66	0.09	0.75
70	47.33	47.46	5.36	5.38	52.84	0.68	0.08	0.75
80	53.61	53.89	5.32	5.35	59.24	0.67	0.07	0.74
90	58.71	59.02	5.14	5.17	64.19	0.66	0.06	0.71
100	62.6	62.81	4.87	4.88	67.7	0.63	0.05	0.68
110	65.33	65.32	4.53	4.53	69.85	0.59	0.04	0.64
120	66.98	66.64	4.16	4.14	70.79	0.56	0.03	0.59
130	67.64	66.92	3.78	3.74	70.65	0.51	0.03	0.54
140	67.45	66.28	3.4	3.34	69.62	0.47	0.02	0.50
150	66.53	64.89	3.03	2.95	67.84	0.43	0.02	0.45
160	64.99	62.88	2.68	2.59	65.47	0.39	0.02	0.41
170	62.96	60.39	2.35	2.26	62.64	0.36	0.01	0.37
180	60.54	57.54	2.06	1.95	59.49	0.32	0.01	0.33
190	57.83	54.43	1.79	1.68	56.12	0.29	0.01	0.30
200	54.92	51.18	1.55	1.44	52.62	0.26	0.01	0.26

[1] **Based on 8 foot (2.54m) utilization**



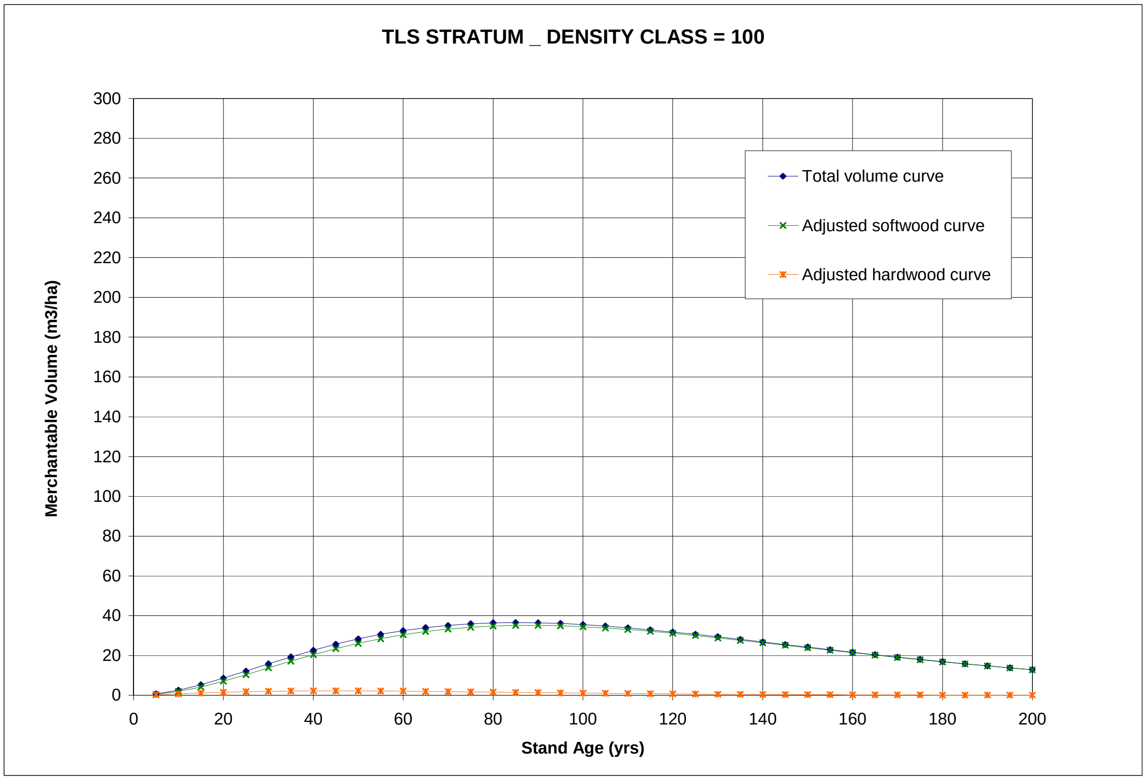
Age	Volume Estimates (m³/ha)[1]					Mean Annual Increment (m³/yr)		
	Softwood		Hardwood		Total	softwood	hardwood	total
	predicted	adjusted	predicted	adjusted				
10	3.98	3.11	1.87	1.46	4.58	0.31	0.15	0.46
20	15.57	13.77	4.82	4.26	18.03	0.69	0.21	0.90
30	31.24	29.29	7.24	6.78	36.07	0.98	0.23	1.20
40	47.72	46.23	8.72	8.45	54.68	1.16	0.21	1.37
50	62.76	62	9.3	9.19	71.19	1.24	0.18	1.42
60	75.08	75.01	9.2	9.19	84.2	1.25	0.15	1.40
70	84.14	84.51	8.62	8.66	93.18	1.21	0.12	1.33
80	89.89	90.4	7.78	7.82	98.22	1.13	0.10	1.23
90	92.58	92.94	6.81	6.84	99.78	1.03	0.08	1.11
100	92.65	92.6	5.83	5.83	98.43	0.93	0.06	0.98
110	90.59	89.96	4.9	4.86	94.82	0.82	0.04	0.86
120	86.88	85.6	4.05	3.99	89.58	0.71	0.03	0.75
130	81.99	80.03	3.3	3.22	83.26	0.62	0.02	0.64
140	76.31	73.73	2.66	2.57	76.3	0.53	0.02	0.55
150	70.19	67.05	2.13	2.03	69.09	0.45	0.01	0.46
160	63.9	60.31	1.69	1.59	61.91	0.38	0.01	0.39
170	57.65	53.72	1.33	1.24	54.96	0.32	0.01	0.32
180	51.59	47.44	1.04	0.95	48.4	0.26	0.01	0.27
190	45.84	41.58	0.81	0.73	42.31	0.22	0.00	0.22
200	40.47	36.19	0.62	0.56	36.74	0.18	0.00	0.18

[1] **Based on 8 foot (2.54m) utilization**



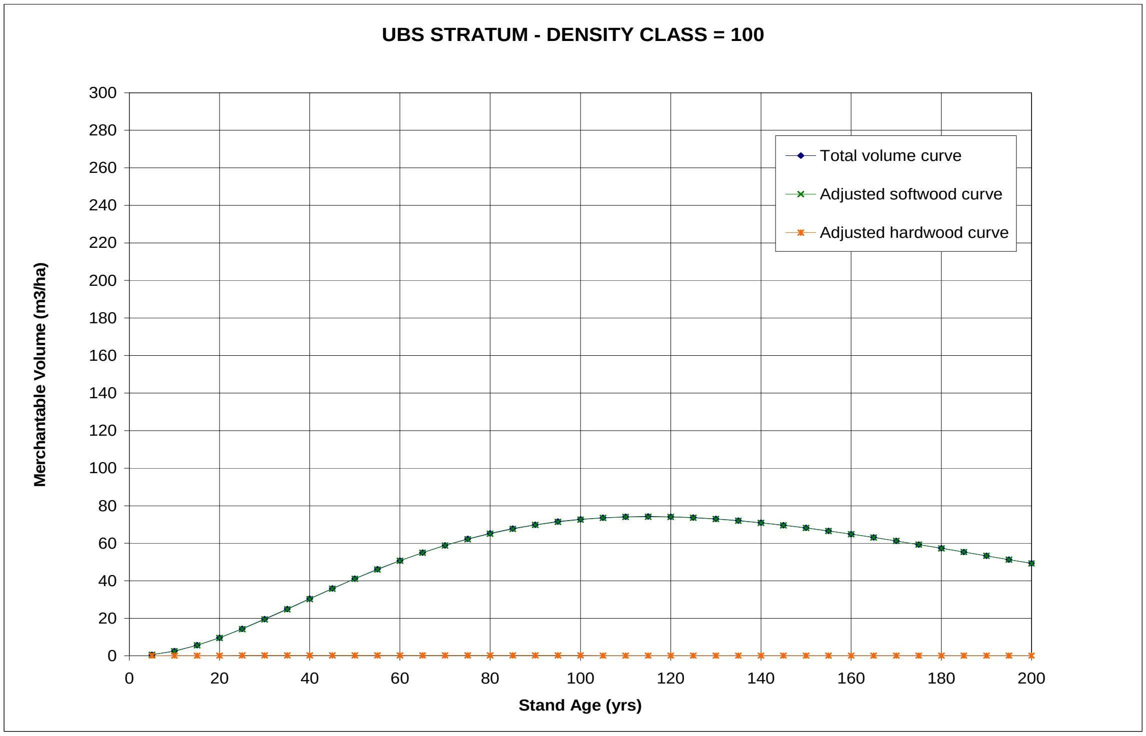
Age	Volume Estimates (m^3/ha)[1]					Mean Annual Increment (m^3/yr)		
	Softwood		Hardwood		Total	softwood	hardwood	total
	predicted	adjusted	predicted	adjusted				
10	3.69	3.34	0.66	0.6	3.93	0.33	0.06	0.39
20	13.69	13.3	1.4	1.36	14.66	0.67	0.07	0.73
30	26.49	26.38	1.93	1.92	28.3	0.88	0.06	0.94
40	39.25	39.51	2.24	2.26	41.77	0.99	0.06	1.04
40	50.25	50.81	2.37	2.39	53.2	1.27	0.06	1.33
50	58.64	59.35	2.35	2.38	61.73	1.19	0.05	1.23
60	64.21	64.9	2.23	2.26	67.16	1.08	0.04	1.12
70	67.09	67.63	2.06	2.08	69.7	0.97	0.03	1.00
80	67.64	67.93	1.86	1.86	69.79	0.85	0.02	0.87
90	66.31	66.29	1.64	1.64	67.93	0.74	0.02	0.75
100	63.54	63.19	1.43	1.42	64.61	0.63	0.01	0.65
110	59.75	59.09	1.23	1.22	60.3	0.54	0.01	0.55
120	55.3	54.36	1.05	1.03	55.39	0.45	0.01	0.46
130	50.51	49.34	0.88	0.86	50.2	0.38	0.01	0.39
140	45.59	44.25	0.74	0.72	44.96	0.32	0.01	0.32
150	40.74	39.27	0.62	0.59	39.87	0.26	0.00	0.27
160	36.09	34.55	0.51	0.49	35.03	0.22	0.00	0.22
170	31.72	30.14	0.42	0.4	30.54	0.18	0.00	0.18
180	27.68	26.12	0.34	0.32	26.44	0.15	0.00	0.15
190	24.01	22.48	0.28	0.26	22.75	0.12	0.00	0.12
200	25.99	32.27	0	25.99	0	0.13	0.00	0.13

[1] **Based on 8 foot (2.54m) utilization**



Age	Volume Estimates (m^3/ha)[1]					Mean Annual Increment (m^3/yr)		
	Softwood		Hardwood		Total	softwood	hardwood	total
	predicted	adjusted	predicted	adjusted				
10	2.32	1.88	0.82	0.66	2.54	0.19	0.07	0.25
20	7.81	7.1	1.63	1.48	8.58	0.36	0.07	0.43
30	14.41	13.77	2.11	2.02	15.79	0.46	0.07	0.53
40	20.79	20.4	2.29	2.25	22.65	0.51	0.06	0.57
50	26.2	26.1	2.25	2.24	28.34	0.52	0.04	0.57
60	30.31	30.44	2.08	2.09	32.52	0.51	0.03	0.54
70	33.05	33.31	1.84	1.85	35.16	0.48	0.03	0.50
80	34.52	34.81	1.58	1.59	36.4	0.44	0.02	0.46
90	34.89	35.11	1.32	1.33	36.43	0.39	0.01	0.40
100	34.35	34.44	1.08	1.09	35.53	0.34	0.01	0.36
110	33.12	33.04	0.88	0.88	33.91	0.30	0.01	0.31
120	31.38	31.11	0.7	0.7	31.81	0.26	0.01	0.27
130	29.31	28.85	0.55	0.55	29.4	0.22	0.00	0.23
140	27.03	26.4	0.43	0.42	26.83	0.19	0.00	0.19
150	24.66	23.89	0.34	0.33	24.22	0.16	0.00	0.16
160	22.29	21.41	0.26	0.25	21.66	0.13	0.00	0.14
170	19.99	19.02	0.2	0.19	19.22	0.11	0.00	0.11
180	17.79	16.77	0.15	0.14	16.92	0.09	0.00	0.09
190	15.73	14.69	0.12	0.11	14.8	0.08	0.00	0.08
200	13.83	12.79	0.09	0.08	12.87	0.06	0.00	0.06

[1] **Based on 8 foot (2.54m) utilization**



Age	Volume Estimates (m³/ha)[1]					Mean Annual Increment (m³/yr)		
	Softwood		Hardwood		Total	softwood	hardwood	total
	predicted	adjusted	predicted	adjusted				
10	2.53	2.46	0.09	0.09	2.55	0.25	0.01	0.26
20	9.63	9.55	0.14	0.14	9.69	0.48	0.01	0.48
30	19.44	19.4	0.17	0.17	19.57	0.65	0.01	0.65
40	30.29	30.29	0.19	0.19	30.48	0.76	0.00	0.76
50	40.92	40.96	0.19	0.19	41.15	0.82	0.00	0.82
60	50.53	50.6	0.19	0.19	50.79	0.84	0.00	0.85
70	58.64	58.72	0.19	0.19	58.9	0.84	0.00	0.84
80	65.03	65.1	0.18	0.18	65.28	0.81	0.00	0.82
90	69.65	69.7	0.17	0.17	69.87	0.77	0.00	0.78
100	72.59	72.6	0.16	0.16	72.76	0.73	0.00	0.73
110	73.99	73.96	0.15	0.15	74.11	0.67	0.00	0.67
120	74.05	73.98	0.13	0.13	74.12	0.62	0.00	0.62
130	72.98	72.87	0.12	0.12	72.99	0.56	0.00	0.56
140	70.99	70.84	0.11	0.11	70.95	0.51	0.00	0.51
150	68.28	68.09	0.1	0.1	68.19	0.45	0.00	0.45
160	65.04	64.81	0.09	0.09	64.9	0.41	0.00	0.41
170	61.41	61.15	0.08	0.08	61.24	0.36	0.00	0.36
180	57.55	57.27	0.07	0.07	57.34	0.32	0.00	0.32
190	53.56	53.26	0.07	0.07	53.32	0.28	0.00	0.28
200	49.54	49.23	0.06	0.06	49.29	0.25	0.00	0.25

[1] **Based on 8 foot (2.54m) utilization**

Appendix IV Forest Model Coding

Overview of Forest Modeling Structure

Description	**Woodstock Input Files**
Model Control	Control File (objectives, planning horizon, period length)
Land base Themes themes	Landscape File (aggregation of polygon attribute into
Area Net down	Areas File (aggregation of areas in accordance with defined themes)
Lifespan Section	Describes death age of yield strata
Yields Section	Yields File (merchantable volume yield equations)
Transition Section	Forest response to harvest and death.
Action Section	Actions File (harvest, death and associated constraints)
Output Section	Output Reports and Graphics (model results)
Optimize Section	Describes model objective and constraints
Schedule Section	Optimal solution provided by LP solver
Reports Section	Provides specifically requested output reports

Woodstock Model Formulation[1]

Control Section:

The control section is where the parameters used to execute the Woodstock model are specified. Beyond establishing the planning horizon for the model the control section keywords allow image file activation and warning message controls. In this model, OPTIMIZE is set to on, generating a linear programming matrix in the format specified in the OPTIMIZE section (MOSEK). The linear programming matrix is then passed to the linear programming solver software to find an optimal solution. The solver generates a file that details which of the decision variables were selected in the optimal solution. A utility program to convert a solution file to a management schedule file is included in Woodstock. This file uses the format for the SCHEDULE section, and is processed by the Woodstock interpreter. If reports and graphics are defined, the interpreter will create report files and display graphics as the schedule file is processed.

Model formulation example:

; Control

```
*LENGTH       40  (5 yr  periods)
*REPORTS      ON
*GRAPHICS     ON
*QUEUE        OFF
*OPTIMIZE     ON
*SCHEDULE  ON
*WARNINGS  ON
*IMAGE        ON
*BUILD        ON
*DEBUG       ON
*LPSCHEDULE  OFF
```

[1] the informational text in this appendix has been paraphrased from “Woodstock and the Woodstock User’s Guide, Copyright Remsoft Inc. 1998

Landscape Section:

Landscape themes describe a variety of Characteristics about the forest. They are analogous to different map layers in a GIS system or stand attributes in a database. Themes are numbered sequentially and denoted with a descriptive label indicating its purpose or nature. For a given landscape theme, there can be many attributes attached that describe the various conditions or site attributes found throughout the forest. The database upon which the themes are constructed rely heavily on GIS to encode polygons with spatial attributes (buffers, protected areas) developed through layering and the database net down process.

For example, the polygons within the FRI database contain species composition. Using this data and an algorithm that aggregates species composition into strata types, a new field is defined, and each polygon is populated with the resulting strata type code. This code is then listed under a landscape theme. There are 19 different strata (see detail in section 8.4.2.4). You may also describe a forest condition that is based on an aggregate of theme attributes. For example, by combining forest strata codes MSPF, and NSPF into an aggregate coded mixed stands.

To refer to polygons or areas of interest within the forest, you do so by specifying a landscape theme "mask" which is simply a line of code representing the sequence of themes (theme 1, theme 2, theme 3, …). The attribute code appropriately placed on the theme mask will identify (filter) the desired information from the data set. When you use a question mark (?) as a thematic attribute code, all attribute codes within that theme are represented. In this analysis there are 15 themes as follows:

```
; Landscape

*THEME 1  YIELD STRATA
NA       ; NOT APPLICABLE
NF       ; non forested
NP       ; non productivity
PP       ; potentially productive
HWD      ; 80%+  aspen, Poplar, Birch
NSPF2    ; deciduous dominated mixed wood
MSPF     ; coniferous dominated mixed wood
SMIX     ; 80% Spruce/Pine/Fir mixtures
JP       ; 80%+  Jack Pine
UBS      ; 80%+  upland Black Spruce (moisture code >3)
LBS      ; 80%+  lowland Black Spruce (moisture code <=3
STL      ; Spruce over Tamarack
TLS      ; Tamarack over Spruce
ASH      ; 80%+ Ash
BF       ; 80%+ White Spruce/Balsam fir mixture (defaults to SMIX)
OTHSW    ; Other softwoods
OTHHW    ; Other hardwoods
NSPF1    ; 20% of original NSPF in hectare.

*AGGREGATE swstands
   JP BF SMIX UBS LBS STL TLS OTHSW
*AGGREGATE hwstands
   HWD ASH OTHHW
*AGGREGATE mixstands
```

NSPF1 NSPF2 MSPF

*AGGREGATE treatment
JP BF SMIX UBS LBS STL TLS NSPF2 OTHSW NSPF1

*THEME 2 crown closure percent
0 ;0-10% crown closure
1 ;11-20% crown closure
2 ;21-30% crown closure
3 ;31-40% crown closure
4 ;41-50% crown closure
5 ;51-60% crown closure
6 ;61-70% crown closure
7 ;71-80% crown closure
8 ;81-90% crown closure
9 ;91-100% crown closure

*AGGREGATE 11 ;open
0 1 2 3 4
*AGGREGATE 12 ; closed
5 6 7 8 9

*THEME 3 SUBTYPE
4
6
10
11
13
14
15
16
20
21
30
31
44
46
50
51
53
54
55
……………
*AGGREGATE NOTSubt6   ;CARIBOU HIGH VALUE SUBTYPES
4
10
11
13
14
15
16
…..
*THEME 4 MOISTURE ; FRI manual
0

```
1
2
3
4

*AGGREGATE DRY  ;for woodland caribou habitat
0 1 2
*AGGREGATE WET ;for woodland caribou habitat

3 4

*THEME 5  FML Area
   FML-1  ;Tembec Forest Management Licence
   IWSA-1 ;Integrated Wood Supply Area 1
    NA


*THEME 6  Land Status  ; legal designation or status of a particular parcel of land
   0    ;Agriculture
   1    ;Provincial Forest
   2    ;Permanent Forest
   3    ;National Park
   4    ;Wildlife Management Area
   5    ;Forest Management Licence
   6    ;Specified Area
   7    ;Provincial Park
   8    ;INCO Land
   9    ;Other Land

   17   ;Portion of Happy Lake PAI within Provincial Park area (status 7)

   25   ; Observation point PAI within the Forest Management Licence Area (status 5)
   75   ;TLE 797 within Forest Management Licence area (status 5)

   85   ;TLE 897 within  Forest Management Licence area (status 5)

*AGGREGATE openland   ;represents forested Provincial crown land
   1 2 4 5 6 7
*AGGREGATE closedland
   0 3 8 9  17 25   75 85
*THEME 7 Land Ownership  ;owner (with implied use restrictions) of a particular parcel of land
   0    ;Provincial Crown Land - Closed
   1    ;Provincial Crown Land - Open
   2    ;Provincial Crown Land - Restricted
   3    ;Federal Crown Land
   4    ;Municipal Land
   5    ;Patented Land
   6    ;Local Government District
   7    ;Indian Reserve
   9    ; Other (include Community Pasture)
   8    ; Tembec Voluntary Protection
*AGGREGATE Ok2cut
     1   2  ; based on the review of IRMT
*AGGREGATE not2cut
```

```
   0  3 4 5 6 7 8 9

*THEME 8 Road Buffer
   1 ;inside  ; within a 100m road allowance buffer
   0     ; not in a road allowance buffer

*THEME 9    caribou winter range
  Z1B      ; inside caribou winter range zone 1B
   0       ; outside a caribou winter range

*THEME 10   IRMT stream Buffer
   1 ;inside     ;inside (50m-single line stream/100m-double line stream) water buffer
   0        ;outside IRMT buffer

*THEME 11    IRMT lake buffer
   1 ;inside   ;inside (50m on lake<5ha/100m on lake>5ha) buffer
   0      ; outside an IRMT lake buffer

*THEME 12  Manigotagon750
   1 ;inside     ;inside 750 meter  park reserve and ownership changed as closed
   0     ;outside 750 meter park reserve  buffer

*THEME 13  Special Reserves
   Berensbuf   ;Berensford buffer
   Wpgrivbuf  ;Winnipeg river buffer
   Birdbuf         ;Bird Lake Buffer
   Bloodbuf       ;Bloodvein Lake buffer
   Happybuf      ;Happy Lake buffer
   PSP               ;PSP plots
   0            ;outside special reserve areas
*AGGREGATE 1 insideSpecialReserves
   Berensbuf     Wpgrivbuf    Birdbuf       Bloodbuf      Happybuf  psp
*THEME 14 Management Status
   cut  ;harvested but not regenerated stands
   rgn  ;regenerating stands
   std  ;standing timber

*AGGREGATE growing
   rgn std
*THEME 15 TemecOpArea
 0 ;       Not      OP  area
 1 ;      Anson    Lake
 2 ;      Beaver   Creek     /    Okimaw Lake
 3 ;      Beresford    Lake
 4 ;      Bernic    Lake
 5 ;       Black   River North   5 ;       Black   River  West
 6 ;       Black   River South
 7 ;       Duncan   Creek
 8 ;       Fredericks    Lake
 9 ;       Kaneeshoot    Lake
10 ;       Hooker    Lake  West  10 ;Loon Straits / Bloodvein 10 ; Shallow    Lake
11 ;       Manigotogan   River
12 ;       Maskwa       / Rocky     Ridge  ;   Round    Lake
13 ;       O'Hanley    East 13 ;    O'Hanley    West13 ;    Traverse     Bay
```

14 ; Owl Lake
15 ; Rabbit River
16 ; Rainy Lake
17 ; Sandy River East
18 ; Sandy River West
19 ; Shoe Lake

Areas Section:

The areas section defines the development types that populate your forest. A development type is simply a portion of your forest database that is defined or redefined by a particular set of landscape theme attributes: each unique combination of thematic attributes represents a different development type. The areas section input file (area file) is a product of the attribute layering and GIS netdown work on the forest land base. The area database and attributes of interest are organized into associated age classes and restructured to match the fields of the thematic mask presented in the themes section. The main purpose of this file is to:

a) describe the existing forest in terms of landscape themes and attribute codes,
b) provide an age-class structure of the existing forest,
c) detail the distribution of area associated with development types across the forest, and to
d) provide a means of recognizing discrete portions of the forest within a stratum based forest model.

```
*A Jp 0 4 1 Fml-1 5 1 0 0 0 0 0 0 Std 0 1 5.66     ; for this combination there area 5.66ha
;in period 1(5 year) age class

*A Jp 0 4 1 Fml-1 5 1 0 Z1b 0 0 0 0 Std 0 13 2.38
*A Jp 0 4 1 Fml-1 7 1 0 0 0 0 0 0 Std 0 3 13.40
*A Jp 0 4 1 Fml-1 7 1 0 0 0 1 0 0 Std 0 3 12.86
*A Jp 0 4 1 Fml-1 7 1 1 0 0 0 0 0 Std 0 3 5.570
*A Jp 0 4 1 Fml-1 7 1 1 0 0 1 0 0 Std 0 3 1.78
*A Jp 0 4 3 Fml-1 5 1 0 0 0 0 0 0 Std 0 16 3.00
*A Jp 1 4 1 Fml-1 35 1 0 0 0 0 0 0 Std 0 9 4.09
*A Jp 1 4 1 Fml-1 35 1 0 0 0 0 0 0 Std 0 17 1.79
…………………………
```

Lifespan Section:
The lifespan specification indicates the maximum age a yield stratum may reach before it is assumed to die or be replaced by another development type through succession. In this analysis a lifespan is specified for every yield strata present in the forest as per the following development masks.

The _DEATH function in the TRANSITIONS section determines the outcome of the development type in the case of death.

;lifespan
LBS ? ? ? ? ? ? ? ? ? ? ? ? ? cut ? 2 ; 2 x 5 = 10 years regen lag
UBS ? ? ? ? ? ? ? ? ? ? ? ? ? cut ? 2 ; 2 x 5 = 10 years regen lag
STL ? ? ? ? ? ? ? ? ? ? ? ? ? cut ? 2 ; 2 x 5 = 10 years regen lag
TLS ? ? ? ? ? ? ? ? ? ? ? ? ? cut ? 2 ; 2 x 5 = 10 years regen lag
? ? ? ? ? ? ? ? ? ? ? ? ? ? cut ? 1 ; 1 x 5 = 5 years regen lag

;Death
JP ? ? ? ? ? ? ? ? ? ? ? ? ? ? 26
HWD ? ? ? ? ? ? ? ? ? ? ? ? ? ? 28
NSPF2 ? ? ? ? ? ? ? ? ? ? ? ? ? ? 28
NSPF1 ? ? ? ? ? ? ? ? ? ? ? ? ? ? 28
MSPF ? ? ? ? ? ? ? ? ? ? ? ? ? ? 28
SMIX ? ? ? ? ? ? ? ? ? ? ? ? ? ? 30
UBS ? ? ? ? ? ? ? ? ? ? ? ? ? ? 36
LBS ? ? ? ? ? ? ? ? ? ? ? ? ? ? 36
STL ? ? ? ? ? ? ? ? ? ? ? ? ? ? 36
TLS ? ? ? ? ? ? ? ? ? ? ? ? ? ? 36

ASH ? ? ? ? ? ? ? ? ? ? ? ? ? ? 36
BF ? ? ? ? ? ? ? ? ? ? ? ? ? ? 28
OTHSW ? ? ? ? ? ? ? ? ? ? ? ? ? ? 30
OTHHW ? ? ? ? ? ? ? ? ? ? ? ? ? ? 36
? ? ? ? ? ? ? ? ? ? ? ? ? ? ? 40 ;all others die at 40 periods

Yields Section:

The yields section is the part of a Woodstock model that associates stand volumes with the development types in the model. Whereas landscape themes describe the land base in static terms (attributes that remain the same over time), the yield tables provide dynamic information about the forest. The yields section contains the growth information needed to move the model forward in time.

In this model, the yield components represent two characteristics of interest: volume and habitat indices. Both are age dependent, with the value of the component varying with the age of the development type.

The yield tables used in the model are based on periods rather than years. Yield table entries represent 5-year intervals.

The thematic attribute masks are used to locate sets of yield tables associated with the development types as follows:

```
*Y JP   ?  ? ?  ? ? ? ? ? ? ? ? ? ? ? ?
SOFTYLD 1 0.39 2.32 6.57 13.39 22.51 33.2 44.59 55.84 66.33 75.61 83.47 89.82 94.67 98.1
100.22 101.16 101.06 100.06 98.29
95.89 92.97 89.63 85.98 82.09 78.05 73.93 69.77 65.62 61.54 57.54 53.66 49.92 46.33 42.9 39.64
36.56 33.66 30.93 28.38 25.99
HARDYLD 1 0.83 3.22 6.07 8.34 9.49 9.52 8.72 7.46 6.07 4.74 3.59 2.65 1.92 1.37 0.96 0.67
0.46 0.31 0.21
0.14 0.1 0.06 0.04 0.03 0.02 0.01 0.01 0.01 0 0 0 0 0 0 0 0 0 0 0 0
SwHwYLD SOFTYLD + HARDYLD


………………
;Wildlife HSI for 15 themes
;Caribou HSI, for example
        *Y      JP    11      ?   ?      ?   ?   ?   ?   ?   ?   ?   ?   ?   ?   ?   ;?
 CARIHSI   0      0.1    0.1 0.1      0.2 0.2 0.5 0.5 0.5 0.5 0.7 0.7 0.8 0.8 0.8 0.8 0.8 0.8 0.8 0.7 0.7
0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7
        *Y      JP    12      ?   ?      ?   ?   ?   ?   ?   ?   ?   ?   ?   ?   ?   ;?
 CARIHSI   0      0.1    0.1 0.1      0.2 0.2 0.3 0.4 0.5 0.8 0.8 0.8 0.9 0.9 0.9 0.9 0.9 0.9 0.9 0.8 0.8
0.8 0.8 0.8 0.8 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7 0.7
```

Transitions Section:

The transition section is key to forest dynamics in a Woodstock model. Transition specifications describe how the forest will respond to actions or events in terms of forest development represented using landscape themes. Transitions are specific in terms of source and target so it is possible to model complex management prescriptions or outcomes of actions.

The transition section also provides a means for restricting access to development types following an action or prevents any actions from occurring on a target development type for a specified number of periods following the action.

The transitions section allows the user to:

a) document the changes that areas of the forest undergo following an action,
b) represent forest dynamics in the form of a transition matrix,
c) provide a mechanism for restricting access to development types following treatment and
d) provide a mechanism for changing the default age of development types arising out of an action.

The Transitions used in this model are coded as follows:

```
;Transitions
*CASE _DEATH
 ;when harvested(cut)development types
 ;stay a regen lag.
 *SOURCE ? ? ? ? ?  ? ? ? ? ?  ? ? ? cut ?
 *TARGET ? ? ? ? ?  ? ? ? ? ?  ? ? ? rgn ? 100

;rgn back to std
 *SOURCE ? ? ? ? ?  ? ? ? ? ?  ? ? ? rgn ?
 *TARGET ? ? ? ? ?  ? ? ? ? ?  ? ? ? std ?  100

;standing stands to original development type.
 *SOURCE ? ? ? ? ?  ? ? ? ? ?  ? ? ? std ?
 *TARGET ? ? ? ? ?  ? ? ? ? ?  ? ? ? std ? 100

*CASE harvest
;Softwood operation

  *SOURCE JP   ? ? ? ?  ? ? ? ? ?  ? ? ? ?   ?
  *TARGET JP   ? ? ? ?  ? ? ? ? ?  ? ? ? cut ? 75   ; regen lag
  *TARGET SMIX ? ? ? ?  ? ? ? ? ?  ? ? ? cut ? 15
  *TARGET MSPF ? ? ? ?  ? ? ? ? ?  ? ? ? cut ? 10

  *SOURCE BF   ? ? ? ?  ? ? ? ? ?  ? ? ? ?   ?
  *TARGET SMIX ? ? ? ?  ? ? ? ? ?  ? ? ? cut ? 50
  *TARGET MSPF ? ? ? ?  ? ? ? ? ?  ? ? ? cut ? 30
  *TARGET BF   ? ? ? ?  ? ? ? ? ?  ? ? ? cut ? 20


  *SOURCE LBS  ? ? ? ?  ? ? ? ? ?  ? ? ? ?   ?
  *TARGET LBS  ? ? ? ?  ? ? ? ? ?  ? ? ? cut ? 80
  *TARGET STL  ? ? ? ?  ? ? ? ? ?  ? ? ? cut ? 20
```

*SOURCE UBS ? ? ? ? ? ? ? ? ? ? ? ? ? ?
*TARGET UBS ? ? ? ? ? ? ? ? ? ? ? ? cut ? 50
*TARGET MSPF ? ? ? ? ? ? ? ? ? ? ? ? cut ? 20
*TARGET SMIX ? ? ? ? ? ? ? ? ? ? ? ? cut ? 30

*SOURCE TLS ? ? ? ? ? ? ? ? ? ? ? ? ? ?
*TARGET TLS ? ? ? ? ? ? ? ? ? ? ? ? cut ? 95
*TARGET STL ? ? ? ? ? ? ? ? ? ? ? ? cut ? 5

*SOURCE STL ? ? ? ? ? ? ? ? ? ? ? ? ? ?
*TARGET STL ? ? ? ? ? ? ? ? ? ? ? ? cut ? 85
*TARGET TLS ? ? ? ? ? ? ? ? ? ? ? ? cut ? 15

*SOURCE SMIX ? ? ? ? ? ? ? ? ? ? ? ? ? ?
*TARGET SMIX ? ? ? ? ? ? ? ? ? ? ? ? cut ? 70
*TARGET MSPF ? ? ? ? ? ? ? ? ? ? ? ? cut ? 25
*TARGET JP ? ? ? ? ? ? ? ? ? ? ? ? cut ? 5

*SOURCE MSPF ? ? ? ? ? ? ? ? ? ? ? ? ? ?
*TARGET MSPF ? ? ? ? ? ? ? ? ? ? ? ? cut ? 50
*TARGET SMIX ? ? ? ? ? ? ? ? ? ? ? ? cut ? 30
*TARGET NSPF2 ? ? ? ? ? ? ? ? ? ? ? ? rgn ? 20

*SOURCE NSPF2 ? ? ? ? ? ? ? ? ? ? ? ? ? ?
*TARGET NSPF2 ? ? ? ? ? ? ? ? ? ? ? ? rgn ? 100

*SOURCE HWD ? ? ? ? ? ? ? ? ? ? ? ? ? ?
*TARGET HWD ? ? ? ? ? ? ? ? ? ? ? ? rgn ? 100

*SOURCE NSPF1 ? ? ? ? ? ? ? ? ? ? ? ? ? ?
*TARGET NSPF1 ? ? ? ? ? ? ? ? ? ? ? ? cut ? 20
*TARGET MSPF ? ? ? ? ? ? ? ? ? ? ? ? cut ? 50
*TARGET SMIX ? ? ? ? ? ? ? ? ? ? ? ? cut ? 30

*SOURCE OTHSW ? ? ? ? ? ? ? ? ? ? ? ? ? ? ?
*TARGET OTHSW ? ? ? ? ? ? ? ? ? ? ? ? cut ? 100

*SOURCE OTHHW ? ? ? ? ? ? ? ? ? ? ? ? ? ? ?
*TARGET OTHHW ? ? ? ? ? ? ? ? ? ? ? ? rgn ? 100

*SOURCE ASH ? ? ? ? ? ? ? ? ? ? ? ? ? ?
*TARGET ASH ? ? ? ? ? ? ? ? ? ? ? ? rgn ? 100

Actions Section

This section provides the mechanism for effecting changes in the model. Without defining actions, development types within the model would just grow older and eventually die. Woodstock models need interventions defined by the user such as silvicultural treatment or harvesting. The only inherent activities Woodstock can perform are death and inventory - the user must define all others.

The outcomes of actions are not part of the ACTIONS section, but are specified in another section (TRANSITIONS). In a Woodstock model, actions are defined by three parameters:

a) whether the development type arising from the action is assumed to have an age different from the pre-treatment development type from which it originated.
b) the circumstances in which the action may be applied (eligibility or operability windows),
c) whether outputs arising from the action should be a direct function of yield components and area treated, or as a function of area treated and the difference between pre-treatment and post-treatment yield components (complete harvest or partial harvest).

This model's action file is as follows:

```
*ACTION          harvest   y            ; harvest  with age reset to 0
*OPERABLE  harvest

jp   ? ? ? FML-1 OPENLAND OK2CUT 0  ? 0 0 0 0 ? ? SOFTYLD >= 50 AND _AGE >= 12
tls  ? ? ? FML-1 OPENLAND OK2CUT 0  ? 0 0 0 0 ? ? SOFTYLD >= 50 AND _AGE >= 13
stl  ? ? ? FML-1 OPENLAND OK2CUT 0  ? 0 0 0 0 ? ? SOFTYLD >= 50 AND _AGE >= 13
smix 11 ? ? FML-1 OPENLAND OK2CUT 0  ? 0 0 0 0 ? ? SOFTYLD >= 50 AND _AGE >= 14
smix 12 ? ? FML-1 OPENLAND OK2CUT 0  ? 0 0 0 0 ? ? SOFTYLD >= 50 AND _AGE >= 12
ubs  ? ? ? FML-1 OPENLAND OK2CUT 0  ? 0 0 0 0 ? ? SOFTYLD >= 50 AND _AGE >= 14
lbs  ? ? ? FML-1 OPENLAND OK2CUT 0  ? 0 0 0 0 ? ? SOFTYLD >= 50 AND _AGE >= 16
bf    11 ? ? FML-1 OPENLAND OK2CUT 0 ? 0 0 0 0 ? ? SOFTYLD >= 50 AND _AGE >= 12
bf    12 ? ? FML-1 OPENLAND OK2CUT 0 ? 0 0 0 0 ? ? SOFTYLD >= 50 AND _AGE >= 13
othsw ? ? ? FML-1 OPENLAND OK2CUT 0 ? 0 0 0 0 ? ? SOFTYLD >= 50 AND _AGE >= 12

 ;MIXSTANDS
MSPF 11 ? ? FML-1 OPENLAND OK2CUT 0 ? 0 0 0 0 ? ? SOFTYLD >= 50 AND _AGE >= 14
MSPF 12 ? ? FML-1 OPENLAND OK2CUT 0 ? 0 0 0 0 ? ? SOFTYLD >= 50 AND _AGE >= 14

NSPF2  ? ? ? FML-1 OPENLAND OK2CUT 0 ? 0 0 0 0 ? ? HARDYLD >= 975 AND _AGE >=
12 ; the high soft volume constraint  is to prevent harvesting LBS stratum
NSPF1  ? ? ? FML-1 OPENLAND OK2CUT 0 ? 0 0 0 0 ? ? SOFTYLD >= 50 AND  _AGE >=
12

  hwd  ? ? ? FML-1 OPENLAND OK2CUT 0  ? 0 0 0 0 ? ? hardyld >= 975 AND _AGE >= 13
```

Outputs Section

The output section calculates the various measures of interest such as total softwood harvest or area harvested. All outputs are triggered by actions and a function of a per unit area estimate in a yield table multiplied by the area effected by the triggering action. Outputs are the basis for evaluating a management regime, and the levels of output produced are used to control activities across the forest and across the planning periods.

The objective function (maximize volume) can be composed of one or more outputs (total softwood harvest + total hardwood harvest). Constraints such as minimum age or minimum volume/ha can be established on various outputs as well. Almost any output defined can be part of an objective function or constraint.

The output section provides:

a) a means of reporting on benefits and/or costs arising from actions as well as areas affected by them.
b) provides a mechanism for controlling actions by limiting production of one or more outputs.
c) provides a basis for comparison among different management strategies.

Examples of outputs for this model are as follows:

```
*OUTPUT  totswvolhar   Clear Cut Softwood Volume Harvested
 *SOURCE harvest  softyld

*OUTPUT tothwvolhar   harvested hardwood volume
 *SOURCE harvest  hardyld

*OUTPUT totalharvest   Totalharvestvolume
 *SOURCE totswvolhar + tothwvolhar

;Growing stock volume
*OUTPUT softgs        Total Softwood Growing Stock
 *SOURCE ? ? ? ? fml-1 ? ? ? ? ? ? ? ? ? ? ? _INVENT() softyld
*OUTPUT hardgs        Total hardwood Growing Stock
 *SOURCE ? ? ? ? fml-1 ? ? ? ? ? ? ? ? ? ? ? _INVENT() hardyld
*OUTPUT totgs        Total Growing Stock
 *SOURCE ? ? ? ? fml-1 ? ? ? ? ? ? ? ? ? ? ? _INVENT() swhwyld


*OUTPUT softogs       Operable Softwood Volume
 *SOURCE _INVENT(harvest) softyld
*OUTPUT HARDogs       Operable HARDwood Volume
 *SOURCE _INVENT(harvest) hardyld
*OUTPUT totogs       total Operable Volume
 *SOURCE _INVENT(harvest) swhwyld
……
```

Optimize Section:

This section is used to formulate the model as a linear program, which requires a different viewpoint than, is required with simulation models. In a simulation model, the user decides what prescriptions to implement, determine what order to implement them in and review the outcome as the simulator executes the model. In a linear programming model, the user decides the kind of outcome desired and the model determines the best means of accomplishing that objective.

Objective Functions

In this section the objective function is presented. In this model the objective function maximizes the amount of wood harvested from the forest by summing the outputs of interest. The Woodstock interpreter uses the output definitions to formulate the objective function as the sum of all decision variables that generate harvest volume multiplied by the appropriate yield entries. In defining an objective function not only do you specify the outputs you want but also the time interval when the specified outputs will contribute to the objective function. In this model the maximization occurs over the 200 year planning horizon.

Constraints

Harvest flow constraints are typically used to control the flow of outputs on a period by period basis. For example, non-declining yield would allow the harvest level to increase or remain at the previous period level over the planning horizon, but the harvest level could not decrease. Strict even-flow would force the harvest to remain constant throughout the planning horizon and a sequential flow would allow the harvest to fluctuate by a fixed or proportional amount each period.

The model is optimized under the following objective and constraint formulation:

```
; Optimize

*OBJECTIVE
_MAX totswvolhar 1.._LENGTH ;determine max softwood volume harvest for 200 years

*CONSTRAINTS
 _EVEN(totswvolhar) 1.._LENGTH; Zero fluctuation in volume from period 1 - 40
HVhabitatarea - 34127 >= 0  1.._LENGTH; ;The high value habitat for caribou must occupy at
least 2/3rds of the total area of these

 _NDY(SOFTOGS) 30.._LENGTH; Softwood operable growing stock can not decline between
periods 30 and 40.

*FORMAT MOSEK; LP Solver
```

Schedule Section:

This section is created by the linear program solver (MOSEK), which provides the optimal solution to a Woodstock through a solution file. Woodstock processes that solution file and creates a management schedule file. The management schedule file is then included with the other sections of the Woodstock model. The Woodstock model carries out the actions selected in the optimal solution, allowing the creation of reports and graphics.

The SCHEDULE section is simply a listing of actions performed on specific **hectares** associated with specific **age classes** within development types in **each planning period**. Each line is the SCHEDULE section represents one decision variable and so a development type mask, age, area, action code and planning period will be listed.

The first few lines of the model schedule is presented as follows:

```
-development mask--                    age  hectares   action   period
JP 1 4 1 FML-1 5 1 0 Z1B 0 0 0 0 STD 0 18 7.150000 HARVEST 1 _Existing ;A3381 100.0% of class
JP 1 4 1 FML-1 5 1 0 Z1B 0 0 0 0 STD 0 19 31.520000 HARVEST 1 _Existing ;A3380 100.0% of class
JP 1 4 1 FML-1 5 1 0 Z1B 0 0 0 0 STD 0 21 10.340000 HARVEST 1 _Existing ;A3379 100.0% of class
JP 1 4 2 FML-1 5 1 0 Z1B 0 0 0 0 STD 0 18 1.890000 HARVEST 1 _Existing ;A3364 100.0% of class
JP 1 4 2 FML-1 5 1 0 Z1B 0 0 0 0 STD 0 19 16.240000 HARVEST 1 _Existing ;A3363 100.0% of class
JP 2 4 1 FML-1 5 1 0 Z1B 0 0 0 0 STD 0 18 4.580000 HARVEST 1 _Existing ;A3344 100.0% of class
JP 2 4 1 FML-1 5 1 0 Z1B 0 0 0 0 STD 0 19 7.370000 HARVEST 1 _Existing ;A3343 100.0% of class
JP 2 4 1 FML-1 5 1 0 Z1B 0 0 0 0 STD 0 21 3.800000 HARVEST 1 _Existing ;A3342 100.0% of class
JP 2 4 2 FML-1 5 1 0 Z1B 0 0 0 0 STD 0 18 4.420000 HARVEST 1 _Existing ;A3323 100.0% of class
JP 2 4 2 FML-1 5 1 0 Z1B 0 0 0 0 STD 0 19 7.290000 HARVEST 1 _Existing ;A3322 100.0% of class
……
```

Reports Section:

The report section specifies the outputs that are to be reported numerically, in several formats and is completely customizable. This model generates reports of all outputs on a period to period basis.

The reports provide:

a) a mechanism for evaluating management strategies by reporting outputs generated by a Woodstock model run,
b) custom reports that are helpful in testing and debugging models
c) user-definable reports in ASCII text format that can be read directly and/or imported into other software for additional analysis and generation of high quality graphs.

An example of the formulation of the reports section is as follows:

```
;  Reports

; all outputs in spreadsheet format

*TARGET  all.wk1   _FORM2
_ALL    0.. _LENGTH

*TARGET  operable1.wk1
_OPERABLE (_DEATH,harvest)  1.. _LENGTH

*TARGET    WoodstockReport.WK1
swgstock          1.. _LENGTH
hwgstock          1.. _LENGTH
gstock            1.. _LENGTH
swopstock         1.. _LENGTH
hwopstock         1.. _LENGTH
opstock           1.. _LENGTH
totswvolhar       1.. _LENGTH
tothwvolhar       1.. _LENGTH
totalharvest      1.. _LENGTH
ccarea             1.. _LENGTH
HVhabitatarea    1.._LENGTH
.
.
.
.
```

Graphics Section:

In order to visualize changes in the forest overtime, optional graphics of outputs are plotted over time; providing a mechanism for graphically displaying output levels in real time.

The formulation in this section is as follows.

; Graphics
***SCREENSIZE** MAXIMIZED
***FONT1** "SYSTEM" 8 0 1000
***FONT2** "SYSTEM" 8 0 1000

***WINDOW** (0, 163, 480, 350) "Fig. 1.2 Harvest Volume (000's) over 200 years
_LEGEND (488, 130)
_YAXIS (*,*,*)

*LINES
lrsy 1 1000 _RED _NONE _DOTTED "LRSY"
totswvolhar 1 5000 _GREEN _CIRCLE _SOLID "SW Harvest Volume/yr"
tothwvolhar 1 5000 _BLUE _SQUARE _SOLID "HW Harvest Volume/yr"
.
.
.
.

Appendix V Figures

FIGURE 1

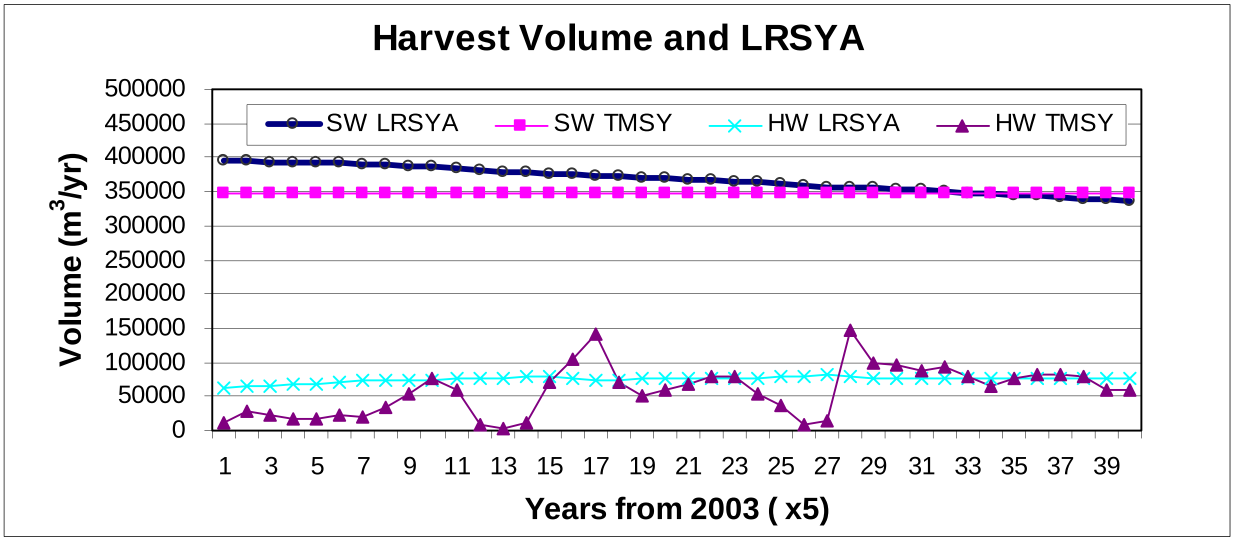


FIGURE 2

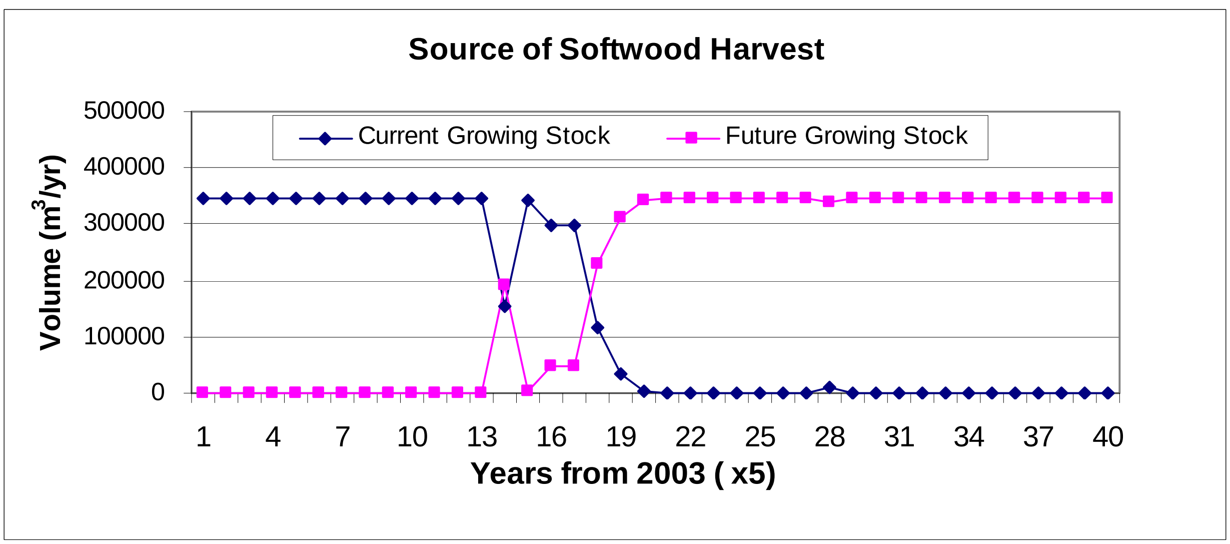


FIGURE 3

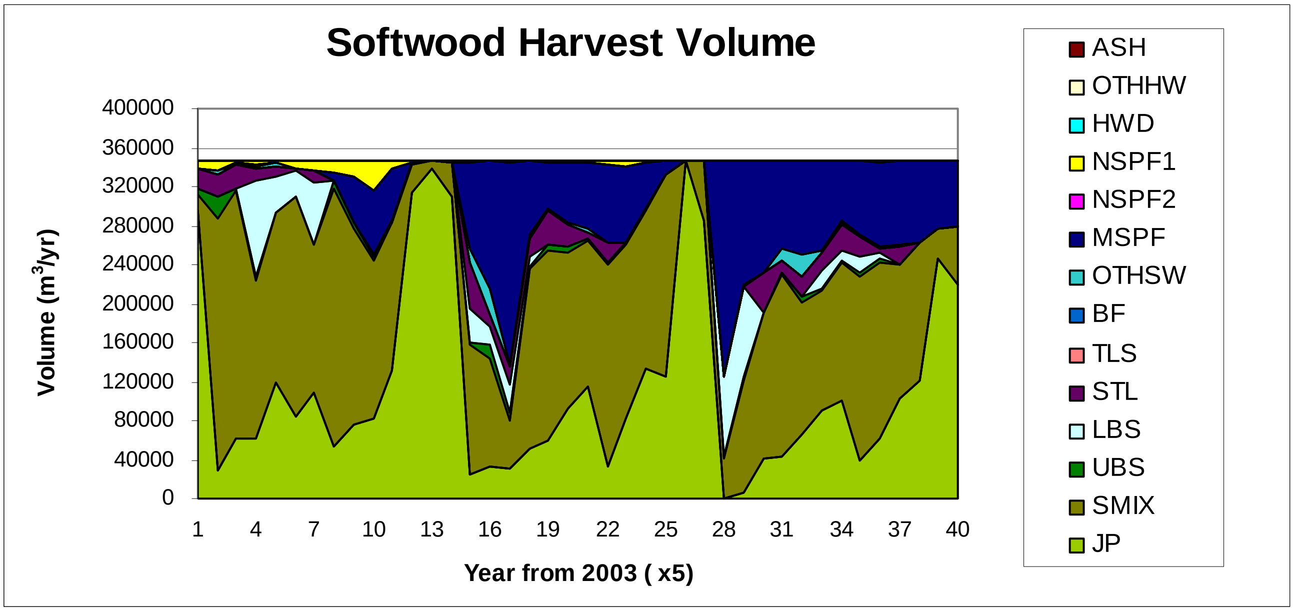


FIGURE 4

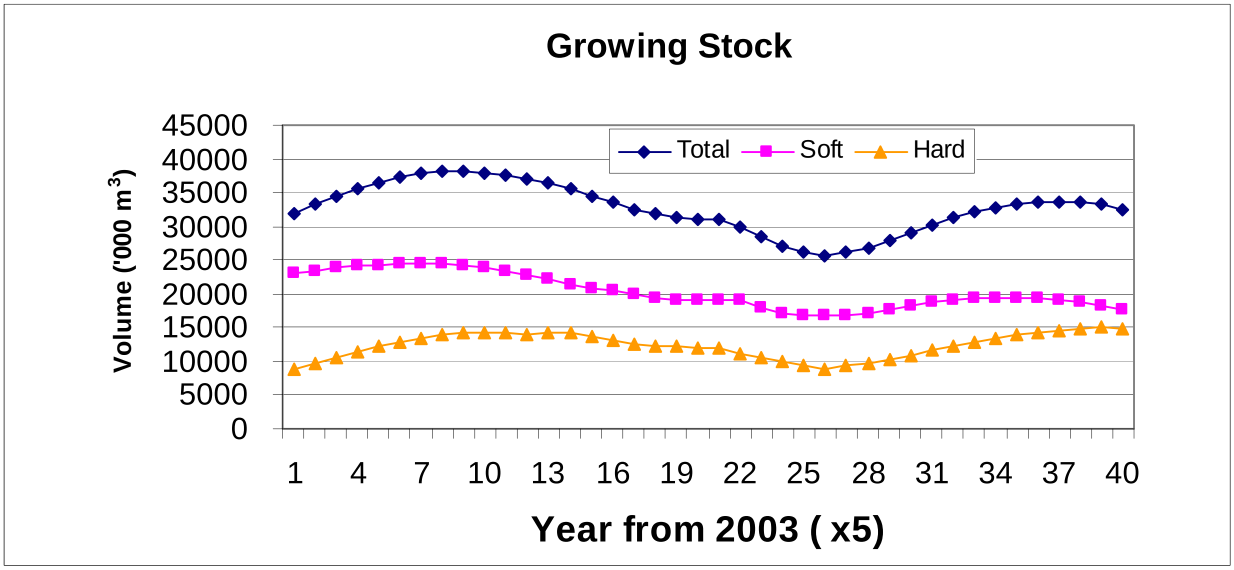


FIGURE 5

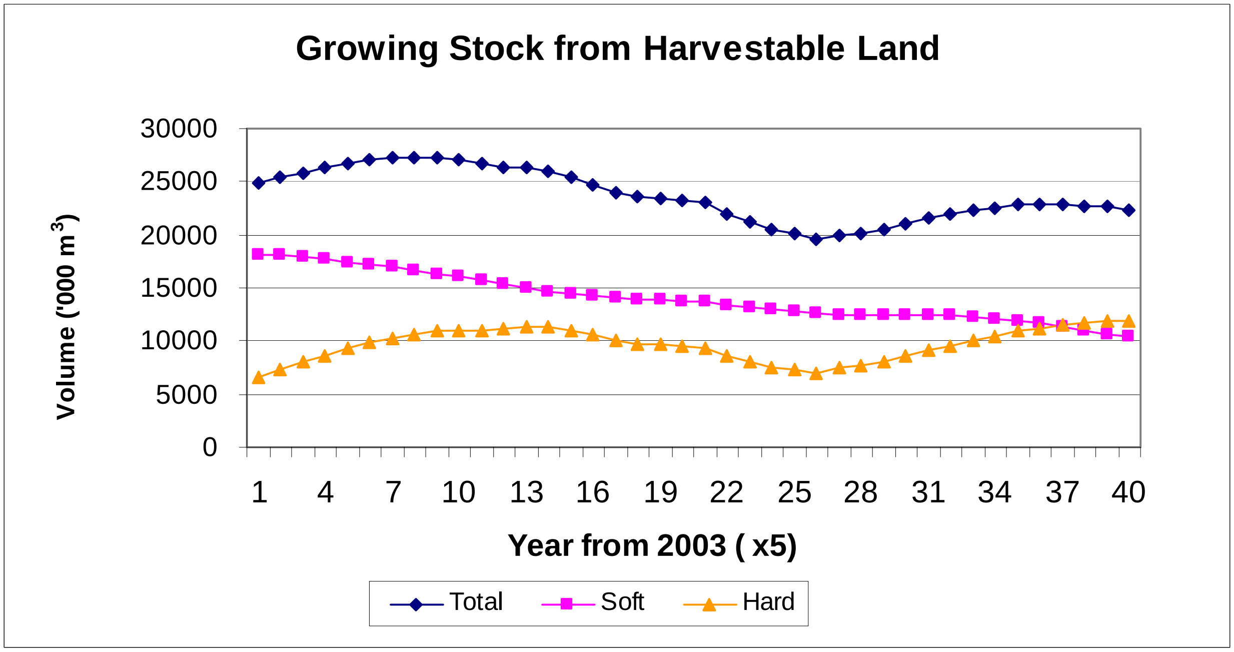


FIGURE 6

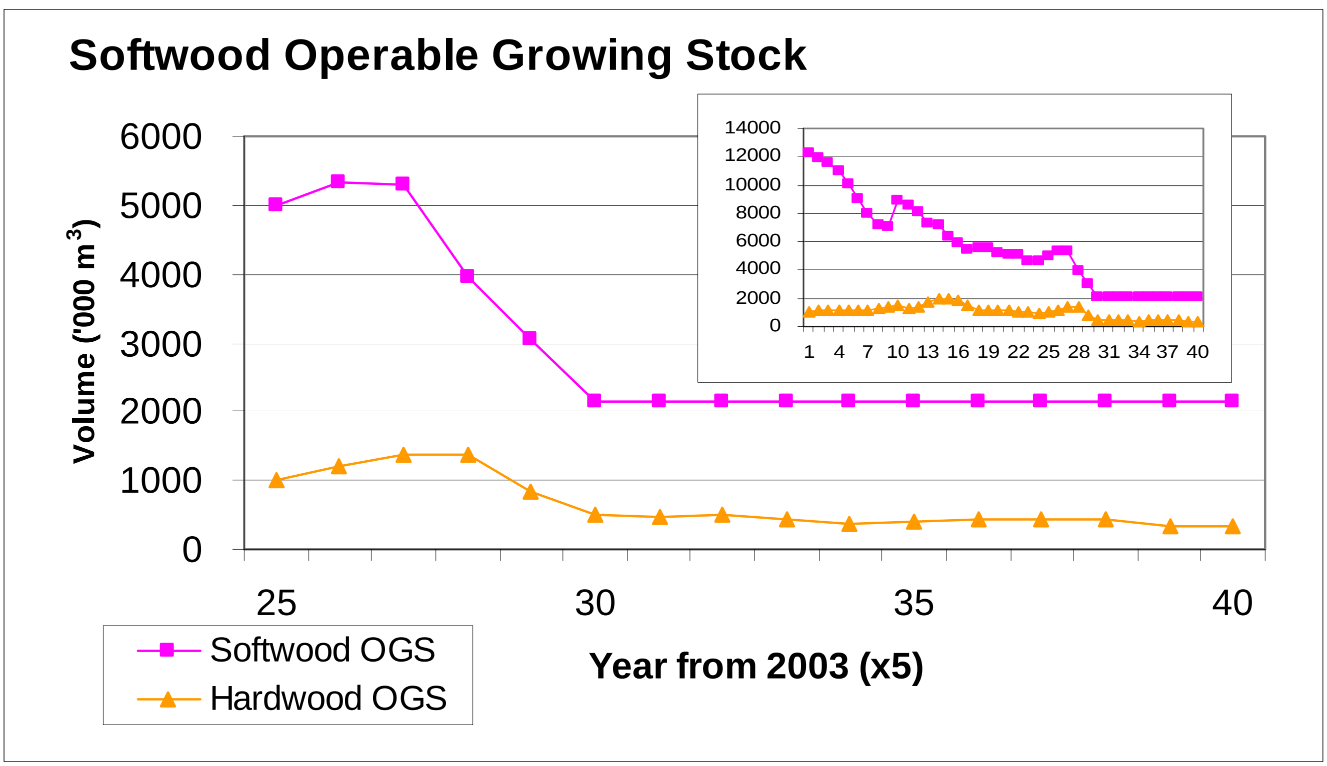


FIGURE 7

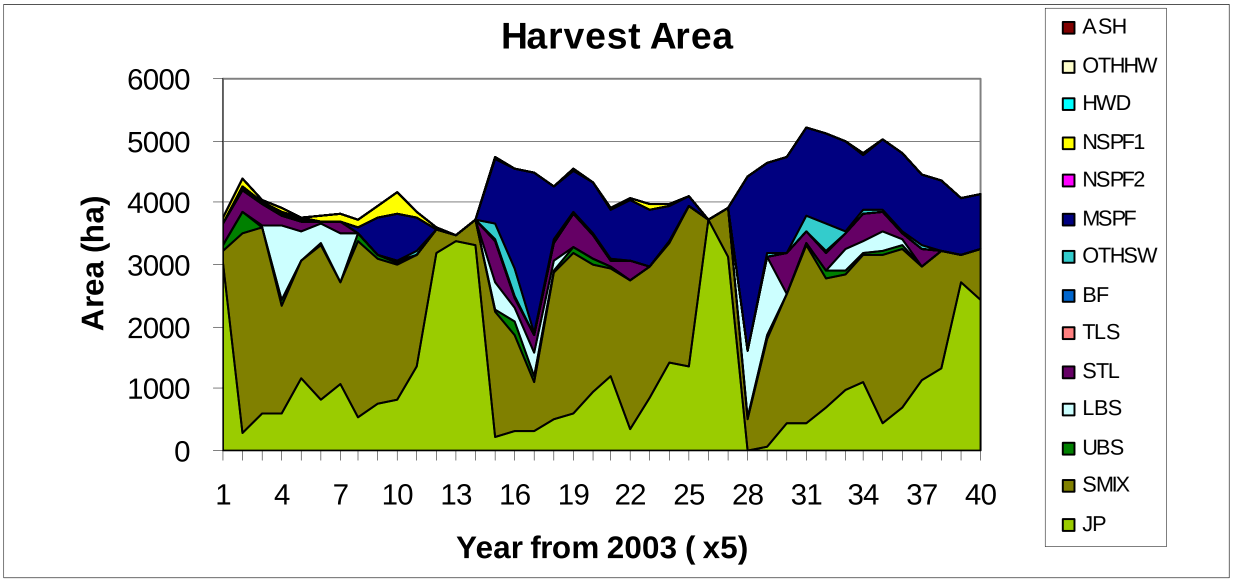


FIGURE 8

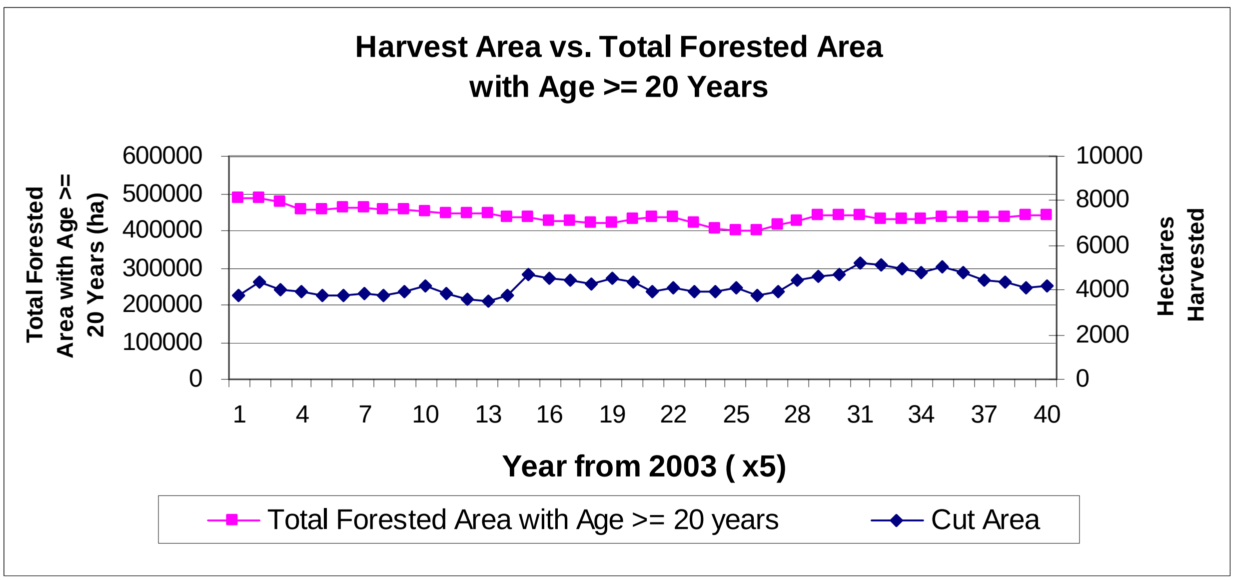


FIGURE 9

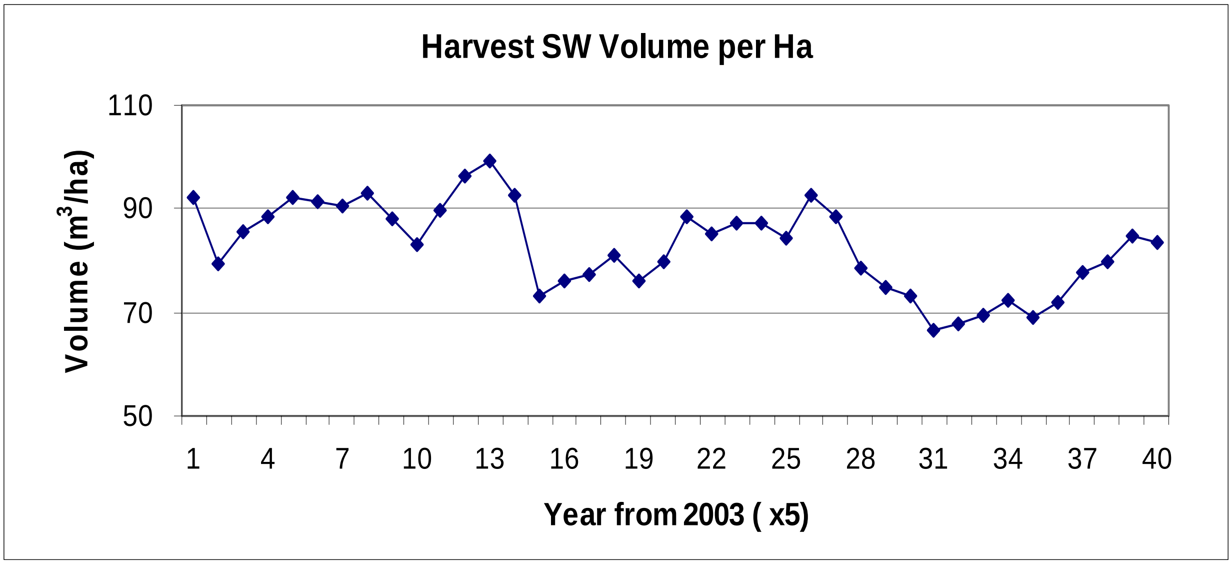


FIGURE 10

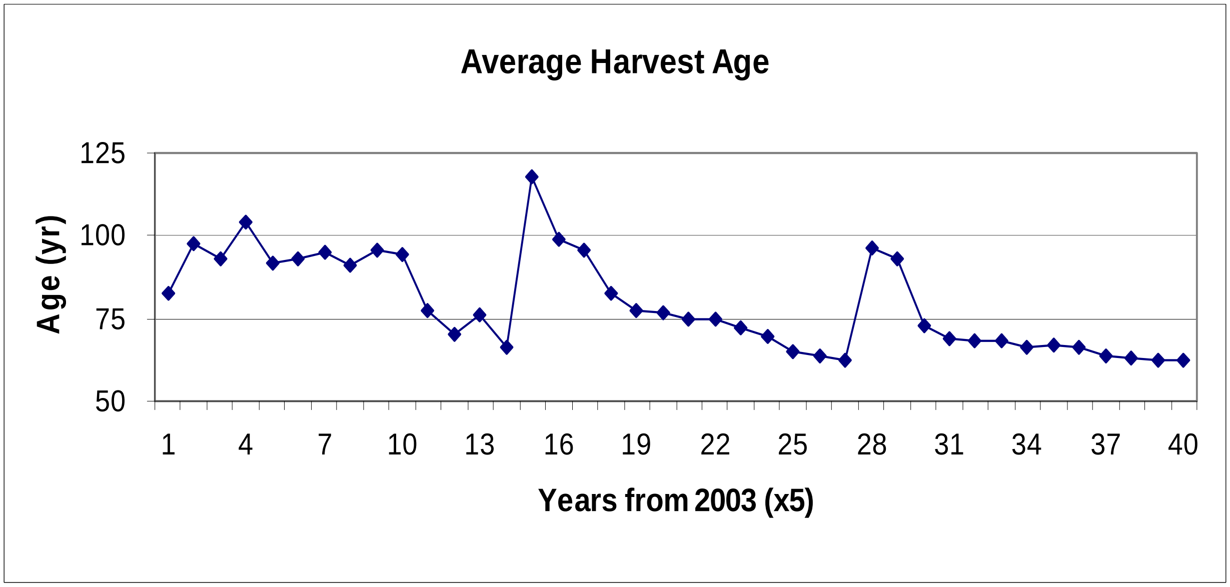
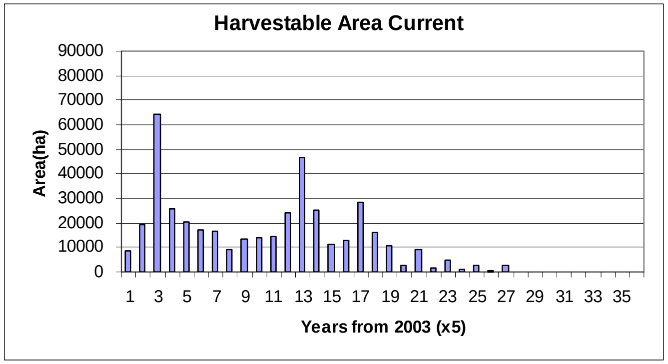
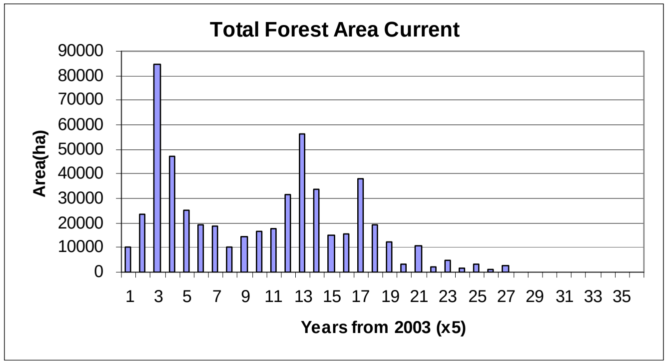
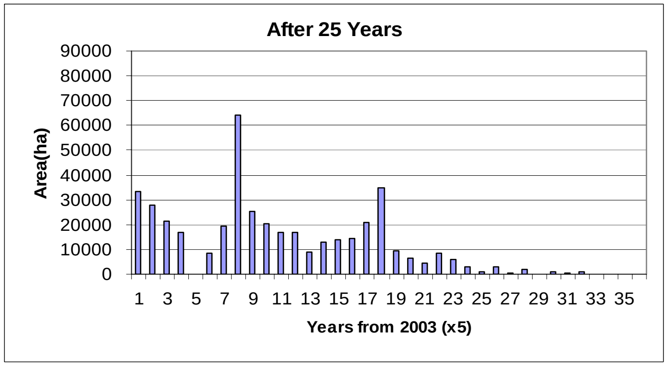
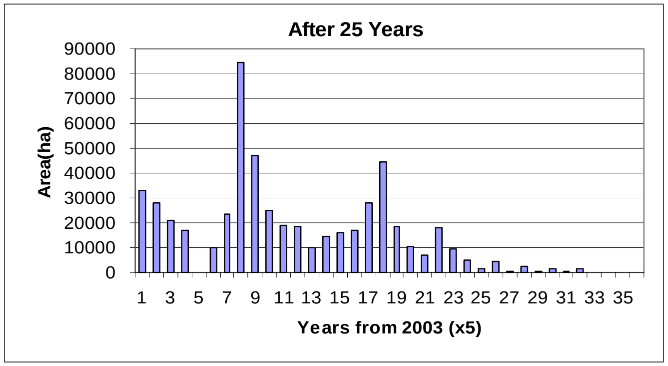


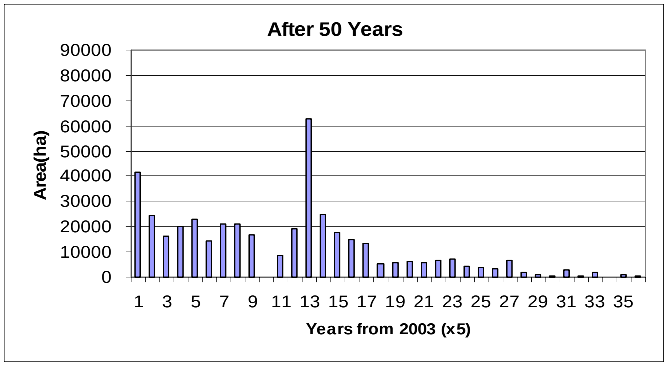
FIGURE 11


Harvestable Area Current
Area(ha)
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35
Years from 2003 (x5)


Total Forest Area Current
Area(ha)
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35
Years from 2003 (x5)


After 25 Years
Area(ha)
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35
Years from 2003 (x5)


After 25 Years
Area(ha)
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35
Years from 2003 (x5)


After 50 Years
Area(ha)
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35
Years from 2003 (x5)

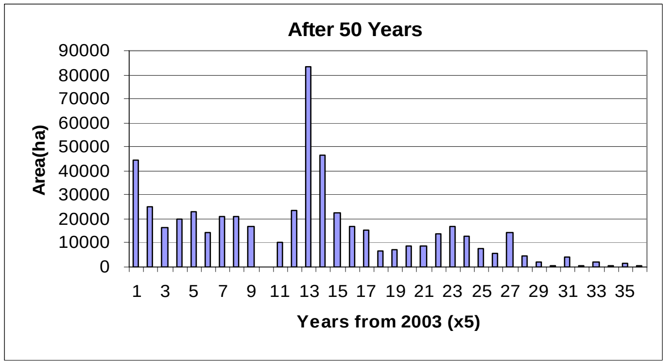
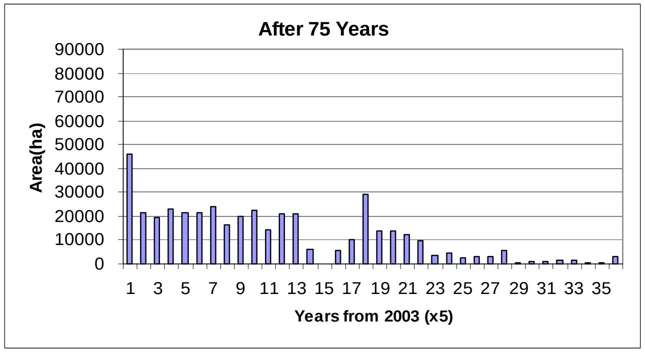
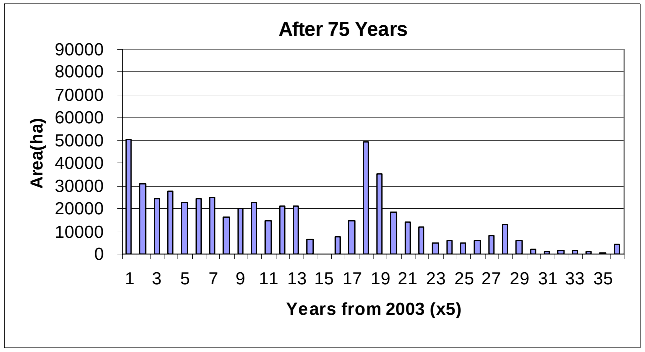
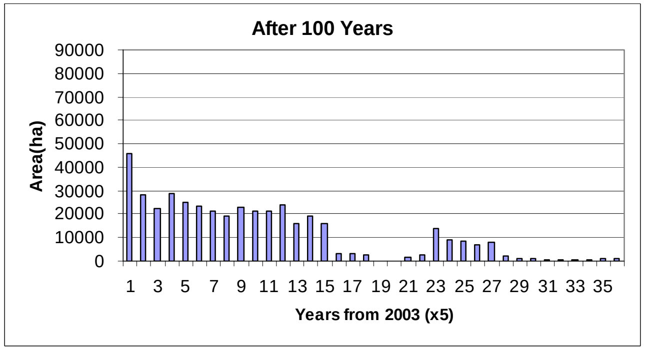
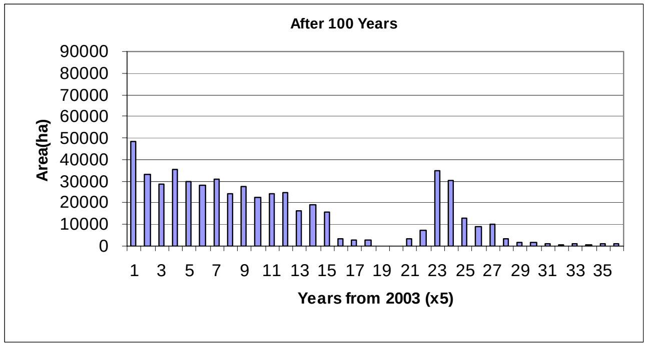

After 50 Years
Area(ha)
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35
Years from 2003 (x5)

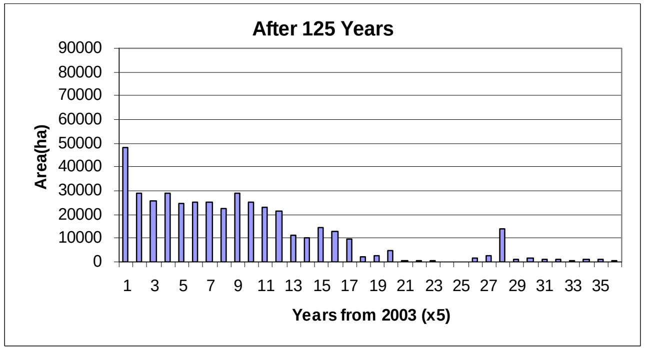
FIGURE 11 Cont.











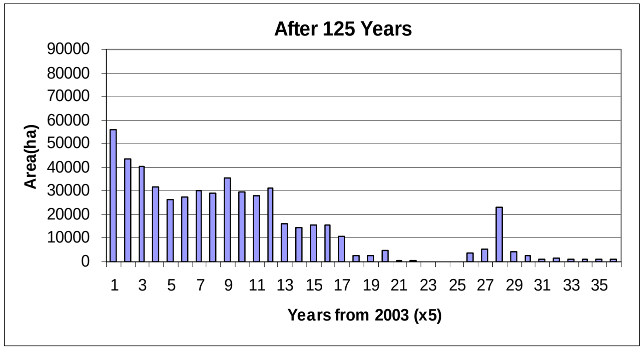
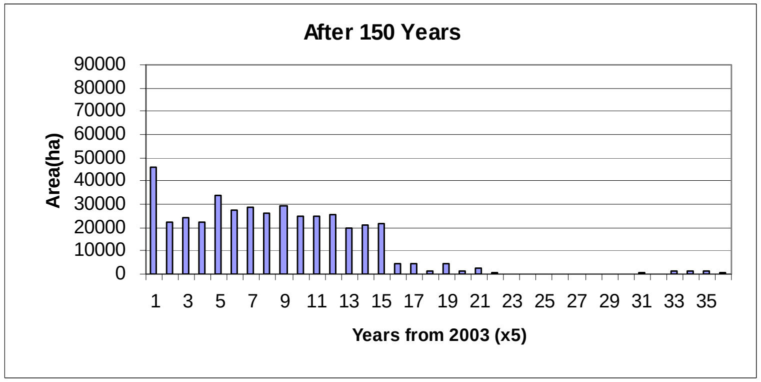
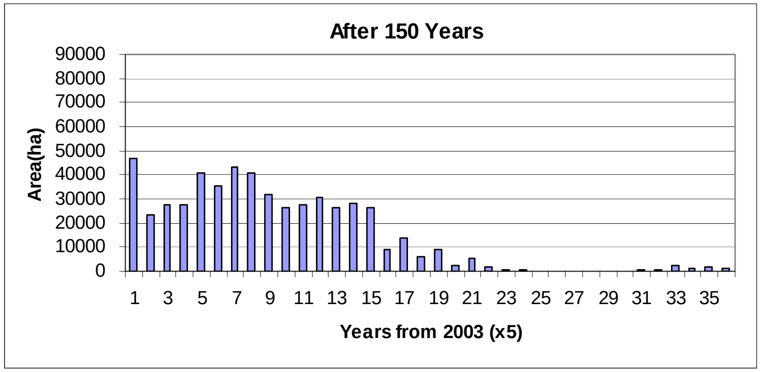
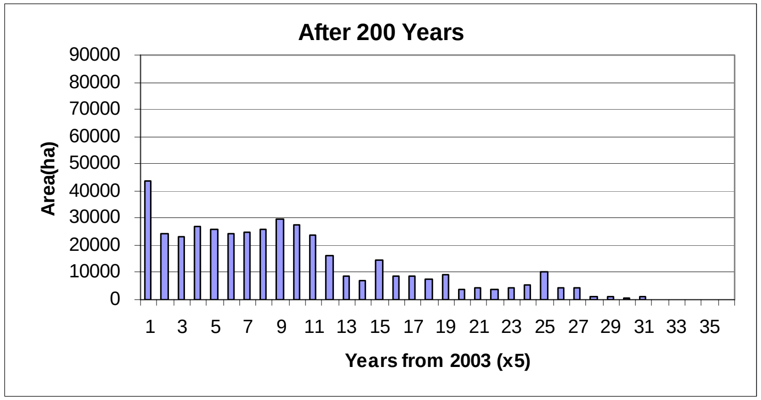


FIGURE 11 Cont.







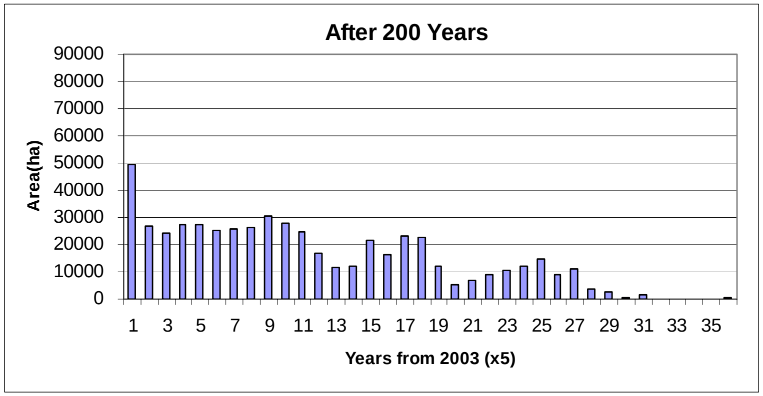


FIGURE 12

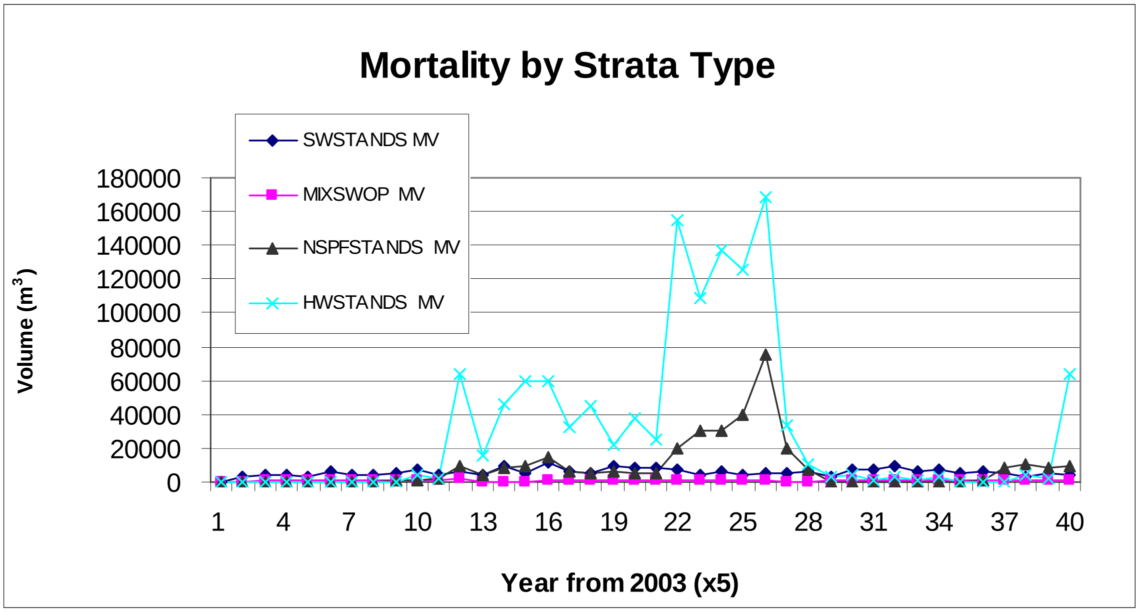
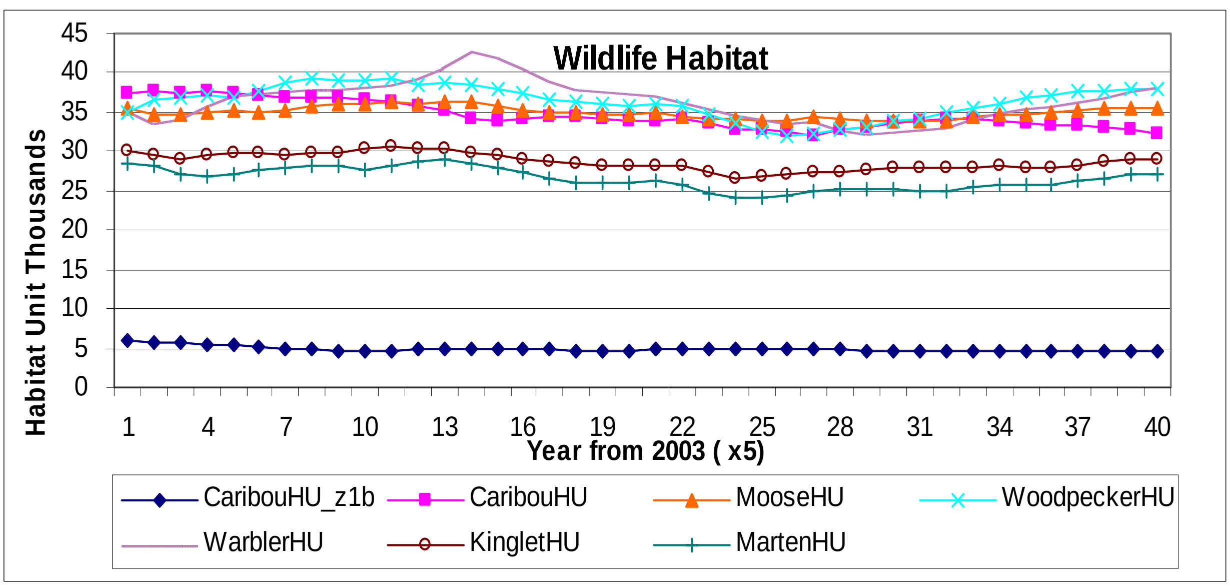


FIGURE 13



Appendix VI Definition of Terms

Adjacent distance	The distance within which a polygon is considered adjacent to another polygon.
Age class	One of the intervals into which the age range of forest stands is divided for classification and use.
Annual allowable cut (AAC)	The volume of wood which may be harvested, under management, on an annual basis.
ArcGIS	A GIS software developed by Environmental Systems Research Institute (ESRI).
ArcInfo	A GIS software developed by ESRI
“Base Case”	The wood supply forecast which illustrates the effect of current forest management practices on the wood supply using best available information, and which forms the reference point for further analysis.
Buffer	A land area that is in place to mitigate any effects that development may have on the target area, feature or species requiring protection.
Crown closure	The percentage of ground area covered by the vertically projected tree crown areas.
Current Annual Increment (CAI)	Growth increment for a given year.
Cut-block	A singularly unique harvest area, identified by distinct boundaries and readily identifiable on forest cover type maps.
Even flow	In harvest scheduling, the requirement that the harvest level in each period be equal to the harvest level in the preceding period.
Flow fluctuation	The acceptable variation of harvest level under harvest flow policy.
Forest Management Licence (FML)	Forest companies that have agreements with the Province of Manitoba in regards to the management of their licenced areas.
Forest Management Unit (FMU)	An area of forest land managed as a unit for fiber production and other renewable resources.
Forest practices	Activities that are conducted in the forest during all stages of forest management operations (e.g. surveys, harvesting, road construction, silviculture).
Forest development type	All forest stands that were aggregated by species composition, crown closure and height.
Forest type	A group of forested areas or stands of similar composition, which differentiates it from others.
Geographic Information System (GIS)	An information system which uses a spatial database to provide answers to queries of a geographical nature through a variety of manipulations such as sorting, selective retrieval, calculation, spatial analysis and modeling.

Greenup delay	The greenup delay represents the amount of time which must pass between the harvest of adjacent blocks.
Growing stock	The volume estimate for all standing timber at a particular time.
Harvestable land base	Productive forest land after GIS netdown within the wood supply area.
Harvest flow policy	The rules governing the pattern of future timber harvest levels.
Indicator	A systematically measured and assessed quantitative or qualitative variable, which when observed periodically, demonstrates trends.
Integrated Resource Management (IRM)	The management of two or more resources in the same general area and period of time (e.g. water, soil, timber, grazing, wildlife, and forests.)
IRMT	Integrated Resource Management Teams, consisting of Manitoba government regional resource staff.
Long Run Sustained Yield Average (LRSYA)	The hypothetical harvest level that can be sustained indefinitely from a management area sum (strata area x MAI at rotation).
Mean Annual Increment (MAI)	Stand volume divided by stand age. The age at which mean volume is at peak productivity is called maximum MAI.
Map layer	A spatial dataset containing a specific spatial information on a mapable feature. Layers are also referred to as coverages.
Merchantable	A tree or stand that has attained sufficient size, quality, and/or volume to make it suitable for harvesting.
Net operable land base	Areas further removed due to some imposed management and/or operating constraint, such as minimum age or volume per hectare requirement.
Netdown	A GIS process by which areas and associated volumes are identified for inclusion or exclusion.
Operable land base	The available harvest area in accordance with the operability constraints.
Optimization	A forecasting method in which a description of current conditions, constraints, rules for change and objectives are captured in order to identify a set of tactics which will provide an ideal balance of objectives.
Period of harvest	A time interval composed of one or more years.
Planning horizon	Planning period or years over which forest management activities, and other impacts on forest values are projected.
Polygon	A stream of digitized points approximating the delineation (perimeter) of an area (forest type) on a map. Polygons often are comprised of line segments or arcs which join at nodes to

	produce a polygon.
Productive forest land	Forest land that is capable of producing a merchantable stand within a reasonable length of time.
Protected Area	A land, freshwater or marine area which is protected by legislation or regulation to limit industrial extraction and development. In Manitoba these areas are protected from logging, mining, hydro electric development, oils and gas exploration and development, and any other activity that would have an adverse impact.
Proximal distance	The distance within which a polygon is considered proximate, but not adjacent, to another polygon.
Regeneration	The renewal of a forest, either through natural or human intervention. This term may also be used to describe the young forest itself.
Regeneration lag	The time in years or periods of delay, required for forest stand establishment.
Rotation	The period of years required to establish and grow timber crops to a specified condition of maturity.
Silviculture	The theory and practice of controlling the establishment, composition, structure and growth of forests in order to achieve specified management objectives.
Stand	A community of trees possessing sufficient uniformity in composition, age, arrangement or condition to be distinguishable from the forest of other growth on adjoining area, thus forming a silvicultural or management entity.
Succession	Changes in species composition over time, often in a predictable order.
Sustainable harvest volume	The level of harvest that can be sustained continuously over time.
Timber quota	The right to harvest a share (as a percentage) of the coniferous and/or deciduous AAC within an FMU.
Theoretical maximum sustained yield (TMSY)	The theoretical maximum sustained yield or TMSY is the model's optimum solution in consideration of the model formulation of objectives, inputs, actions and constraints.
Treatment response	The transition process after forest stands are harvested.
Utilization standard	Standards establishing the minimum merchantable stand and merchantable tree.
Wood supply	The timber harvesting opportunities associated with a specific forest condition, management strategy and wood flow policy.
Wood supply analysis	An assessment of future timber supplies over long planning horizons (200 years) by using wood supply models.

Wood supply model	An analytical model that simulates the harvest and growth of a collection of forest stands over time in accordance with stated objects, actions and constraints.
Volume	The amount of wood in a tree, forest stand, or other specified area, recorded by a unit of measure.