Appendix III. Timber Supply Analysis Information Package

To be added by upon MoF acceptance (December 2004).

Tree Farm Licence #37

Information Package for Sustainable Forest Management Plan 9

Revised—December 19, 2004

Submitted to:

Mike Clarkson, R.P.F.
Timber Supply Forester
Ministry of Forests, Forest Analysis Branch
1-1520 Blanshard Street
Victoria, BC V8W 3J9
tel 250-387-0771 fax 250-953-3838
email: mike.clarkson@gems3.gov.bc.ca

Submitted by:

Patrick Bryant, R.P.F.
Strategic Planning Forester
Canadian Forest Products Ltd., Coastal Operations
#103-990 Cedar Street
Campbell River, BC V9W 7Z8
tel 250-850-5865 fax 250-850-5858
email: patrick.bryant@canfor.com

Prepared by:

Forest Ecosystem Solutions Ltd.
#210 – 275 Fell Avenue
North Vancouver BC V7P 3R5
tel 604-998-2222 fax 604-986-0361

Antti Makitalo M.Sc., R.P.F
email: amakitalo@forestecosystem.ca
Colin Mahony, F.I.T.
email: cmahony@forestecosystem.ca

forest ecosystem solutions ltd.

Summary of the review and changes to the information package

December 2004:

Several changes were made to the information package following MoF's and MSRM's review, including several typographical errors and inconsistencies. The following table summarizes the major changes to the methodology and documentation.

Section	Pg.	Topic	Comments from Review	Summary of changes
6.1.16	20	Area VRAF	It was unclear where the area reductions for in-block tree retention would be applied.	The area VRAF is included in the netdown as a partial reduction to the current THLB. All related tables were updated.
7.3.2	26	OAF2	The standard OAF2 of 5% does not incorporate losses associated with root rot in the CWHxm2.	A 12.5% OAF2 reduction will be applied to Fd-leading managed stands over 10 years in age within the CWHxm subzone.
7.4.6	34	Initial Volume Check	The volume check was insufficiently detailed.	The volume check was improved (used interpolated volumes from yield tables), and summarized by age class and leading species.
7.5	36	VRAF for in-block tree retention	Description of the methodology for incorporating VRAF reductions was confusing.	The text and tables describing the VRAF reduction were revised.
9.2.2	42	Visual percent denudation	Standard methods of modeling visuals are considered overly constraining for TFL37.	Canfor developed localized denudation constraints, which MoF reviewed. A series of sensitivity analyses will investigate uncertainties about impacts from visuals.
9.3.1	46	Harvest scheduling rules	No comments received.	In the base case, Canfor will apply a harvest rule called relative productivity scheduling, an innovative harvest rule recently developed by FESL.
9.3.2	48	Minimum Harvest Age	Culmination-based minimum harvest ages artificially constrain harvest.	Minimum harvest ages are based on minimum merchantable criteria and applied in conjunction with relative productivity scheduling.
Appendix B		VRI Adjustment	MSRM pointed out several areas that were inaccurate or unclear.	Several changes were made to include additional data and adjust text. Canfor clarified where it deviated from recommended MSRM standards (also see section 5.1).
Appendix D		Yield Tables	MoF requested clarification on a couple points.	The report was slightly revised with some additional information.

Table of Contents

Appendices

List of Tables

List of Figures

Table of Acronyms

AAC	Allowable Annual Cut
AU	Analysis Unit
BCTS	British Columbia Timber Sales (British Columbia Ministry of Forests)
BEC	Biogeoclimatic Ecosystem Classification
BEO	Biodiversity Emphasis Option
CAI	Current Annual Increment
CWHmm1	Coastal Western Hemlock moist maritime subzone, submontane variant
CWHvm1	Coastal Western Hemlock very wet maritime subzone, submontane variant
CWHvm2	Coastal Western Hemlock very wet maritime subzone, montane variant
CWHxm2	Coastal Western Hemlock very dry maritime subzone, western variant
DBH	Diameter at Breast Height
DFA	Nimpkish Defined Forest Area
DIB	Diameter Inside Bark
DWB	Decay, Waste, and breakage
EFZ	Enhanced Forestry Zone
EMU	Ecosystem Management Unit
FDP	Forest Development Plan
FESL	Forest Ecosystem Solutions Ltd.
FIZ	Forest Inventory Zone
FPC	Forest Practices Code
FSOS	Forest Simulation Optimization System
GIS	Geographic Information Systems
GMZ	VILUP General Management Zone
HLPO	Higher Level Plan Order
KVP	Karst Vulnerability Potential
LU	Landscape Unit
MAI	Mean Annual Increment
MHA	Minimum Harvestable Age
MHmm1	Coastal Western Hemlock moist maritime subzone, windward variant
MHmmp	Coastal Western Hemlock moist maritime subzone, parkland variant
MoF	British Columbia Ministry of Forests
MSRM	British Columbia Ministry of Sustainable Resource Management
MSYT	Managed Stand Yield Table

MWLAP	British Columbia Ministry of Water, Land and Air Protection
NSR	Not Satisfactorily Restocked
NSYT	Natural Stand Yield Table
OAF	Operational Adjustment Factor
OGMA	Old Growth Management Area
OPR	Operational Planning Regulation
PSI	Potential Site Index
PSP	Permanent Sample Plot
RMZ	Riparian Management Zone
RMZ	VILUP Resource Management Zone
RRZ	Riparian Reserve Zone
RVQC	Recommended Visual Quality Class
SFM	Sustainable Forest Management
SI_{50}	Site Index for age 50
SIA	Site Index Adjustment
SMZ	VILUP Special Management Zone
TEM	Terrestrial Ecosystem Mapping
TFL	Tree Farm License
THLB	Timber Harvesting Land Base
TIPSY	Table Interpolation Program for Stand Yields
UWR	Ungulate Winter Range
VAC	Visual Absorption Capacity
VDYP	Variable Density Yield Prediction
VEG	Visually Effective Green-up
VILUP	Vancouver Island Land Use Plan
VRAF	Variable Retention Adjustment Factor
VRI	Vegetation Resources Inventory
WHA	Wildlife Habitat Area
WTP	Wildlife Tree Patch
WTR	Wildlife Tree Retention

1 INTRODUCTION

Canadian Forest Products Ltd. (Canfor) is currently preparing a draft sustainable forest management plan (SFM plan 9) under section 2.08 of its Tree Farm Licence #37 (TFL 37) agreement and SFM certification for the Nimpkish defined forest area (DFA). Under section 2.22 of the agreement, Canfor is responsible, for preparing a timber supply analysis showing the long-term, strategic timber supply for the land base. To make timber supply analysis compatible with the SFM plan 9, the Nimpkish DFA is the land base applied for this information package. It is comprised of TFL 37 and all parks within the Upper and Lower Nimpkish LUs, but excludes other forest tenures within these LUs.

The information package fulfills section 2.04 of the agreement by documenting the procedures, assumptions, data and model to be used in the analysis. Forest Ecosystem Solutions Ltd. (FESL) is engaged to prepare the information package and conduct the timber supply analysis on Canfor's behalf. This information package follows the format of the *Provincial Guide for the Submission of Timber Supply Information Packages for Tree Farm Licences, Version 4.*

The purpose of this information package is to:

- Provide a detailed account of the factors related to timber supply that the Chief Forester must consider under the Forest Act when determining an AAC and how these factors will be applied in the timber supply analysis;
- Provide a means for communication between staff from Canfor, Ministry of Forests (MOF), Ministry of Sustainable Resource Management (MSRM) and Ministry of Water, Land, and Air Protection (MWLAP);
- Provide staff of the different ministries with the opportunity to review data and information that will be used in the timber supply analysis before it is initiated;
- Ensure that all relevant information is accounted for in the analysis to an acceptable standard;
- Reduce the risk of having analyses rejected because input assumptions and analysis methods were not agreed upon in advance.

Analysis will use FESL's Forest Simulation and Optimization System (***FSOS***), a spatial, time-step forest estate simulation and heuristic model in conjunction with FESL's data preparation and analysis approach.

Upon acceptance by the Timber Supply Branch, the assumptions used in this information package will be used to guide the development of the timber supply analysis and the twenty-year harvest plan. During the analysis, various sensitivity analyses, harvest flow alternatives, and management options will be tested to determine the influence of various factors on harvest levels. All analyses and the final proposed option will be submitted to the provincial Chief Forester for determination of the AAC.

2 PROCESS

This information package will be included as an appendix to the SFM plan 9. Its contents reflect Canfor's SFM objectives, in addition to, current legislation and policies. Where feasible, comments from public and resource agency review of the previous management plan were also considered in preparing this information package.

Forest resource and land base data come from several inventories conducted by Canfor and provincial resource ministries (see section 5.2). This information has been compiled into a Geographic Information System (GIS) database maintained by Canfor, and is the source for all summaries in the information package, unless where otherwise stated.

MoF Forest Analysis Branch will review the technical details in this information package. The North Island-Central Coast Forest District and the Vancouver Forest Region will review the analysis assumptions presented in this document.

2.1 Data Preparation and Missing Data

FESL created a master database with a complete resultant polygon list from spatial information through a series of GIS overlays. In the master database each polygon has a unique identification number.

The data described in this document is only as reliable as the databases that were used to generate it. Though the data is believed to be accurate, an exact match was not always possible between overlapping coverages. Some had to be manipulated to approximate a best fit. Although the final resultant is a close approximation of the actual landscape, caution should be used when viewing geographic data results at a large scale.

With the Canfor's consent, FESL may modify any data, netdown order or calculation in the future, if it will enhance the accuracy of this analysis. Any modifications to the dataset will be documented in subsequent versions of the information package.

3 TIMBER SUPPLY SCENARIOS AND SENSITIVITY ANALYSES

This section briefly describes the management scenarios that will be presented in the Timber Supply Analysis Report.

3.1 Base Case

The Base Case will be a non-spatial analysis using the simulation mode of ***FSOS***. The Base Case will reflect current management activities based on the following guidelines:

- Objectives set in the SFM plan 9;
- Management activity as defined by historical operations with emphasis on the last 5 years;
- Implementation of the Forest and Range Practices Act (FRPA) current to August 2004;
- Landscape Unit (LU) management to address landscape level biodiversity;
- Forest cover inventory projected and updated to December 31st, 2001;
- VDYP natural stand yields (NSYTs) for stands originating before 1961 and leading in red alder;
- TIPSY managed stand yield tables (MSYTs) for all stands originating after 1960;
- Current utilization standards;
- Potential Site Index (PSI) based on Terrestrial Ecosystem Mapping (TEM) and the Site Index Adjustment (SIA) project;
- Genetic gains from tree improvement; and
- Resource management zones (RMZ) from the Vancouver Island Land Use Plan (VILUP) Higher Level Plan Order (HLPO);

3.2 Sensitivity Analyses

Sensitivity analyses give an understanding of the contribution of specific assumptions to the timber supply dynamics of the base case. They also verify that the model is applying the harvesting constraints correctly. Sensitivity analyses on the base case scenario have been grouped into the following categories:

- Land base alternatives
- Growth and yield
- Management options
- Modeling Rules

A summary of planned sensitivity analyses is shown in Table 1.

Table 1: Sensitivity analyses

Category		Sensitivity Analysis
1 Land Base Alterations	1.1	Adjust land base by +/-10%
	1.2	Remove land base for BCTS preliminary pricing area selection within the Nimpkish DFA
	1.3	Remove conditionally operable areas
	1.4	Remove technically unconventional areas leading in hemlock or balsam
	1.5	Remove stands with marginal economic operability
	1.6	Progressively remove wildlife habitat reductions: NOGO, MAMU, and OGMAs
	1.7	Remove proposed OGMAs only
	1.8	Include uneconomic mature stands with productive regeneration attributes
2 Growth & Yield	2.1	Adjust existing stand volumes +/- 10%
	2.2	Adjust regenerated stand volumes +/- 10%
	2.3	Model 40-80 year old stands using TIPSY (calibrated to inventory volume)
	2.4	Use inventory site index for CWHvm2 stands
	2.5	Adjust regeneration delay by +1 yr
	2.6	Increase OAF1 to standard of 15%
	2.7	Adjust OAF2 by –2%
	2.8	Remove yield VRAF from future yields.
3 Management Options	3.1	Change maximum green-up area to 25% of the Land Base
	3.2	Apply Canfor's proposed visual constraints percent planimetric denudation constraints for modelling visual quality.
	3.3	Apply standard TSR approach for factoring visual resources
	3.4	Turn off visual quality constraints
	3.5	Use ecosystem-based harvesting targets as the basis for calculating VRAFs
4 Modelling Rules	4.1	Change harvest priority rule from relative productivity to relative oldest first and random harvest scheduling
	4.2	Set minimum harvest age at culmination age while applying the same merchantability criteria.
	4.3	Set minimum harvest age based on volume criteria only and remove the minimum diameter criteria.

4 MODEL

The following modeling software will be used in the timber supply analysis for the Nimpkish DFA:

4.1 Landscape Design Model - *FSOS*

Model Name: ***FSOS***
Model Developer: Dr. Guoliang Liu
Model Development: UBC, Hugh Hamilton Limited, Forest Ecosystem Solutions Ltd.
Model Type: Landscape Design Model

FSOS (Forest Simulation Optimization System) uses C++ programming language and can be run with both Windows 95 and higher operating systems. The model interfaces directly with Microsoft Access for data management. Although FSOS has both simulation and heuristic (pseudo-optimization) capabilities, the time-step simulation mode will primarily be used in this analysis. Time-step simulation grows the forest based on growth and yield inputs and harvests resultant polygons based on user-specified harvest rules and constraints that cannot be exceeded. Using "hard" constraints and harvest rules instead of targets (as would be applied in the heuristic mode of FSOS) gives results that are repeatable and more easily interpreted.

A formal comparison of FSOS and FSSIM using a benchmark dataset was performed and submitted to the MoF Timber Supply Branch in 1998 (Hugh Hamilton Limited 1998a). Acceptance notification correspondence was provided to Dave Waddell (currently Systems Forester, MoF Development & Policy Section) in September 1998, authorizing FSOS for use in Timber Supply Analysis to support AAC determinations in British Columbia.

From GIS overlay, the land base is divided into resultant polygons, each with a unique set of attributes. Constraints and harvest criteria are applied to each polygon based on these attributes. Constraints and harvest criteria can be defined by analysis unit, forest type, forest age, silvicultural treatment, user allocation, site index, non-timber resource objectives or any other parameter.

FSOS uses individual stand ages to project the current age structure of stands in the analysis area. As stands age, they move into and out of age classes established as a basis for meeting target objectives.

Generally, ***FSOS*** runs utilize 5-year periods, as the output is intended to be operationally applicable and reflect 5-year management plan objectives, but 1,10 or 20 year periods can easily be assigned. The middle of the period (year 3 for 5-year periods) is used for reporting.

The planning horizon length can vary as required. ***FSOS*** can produce spatially and temporally explicit plans over 20 years or for multiple rotations. A unique feature of ***FSOS*** is its ability to integrate strategic, tactical and operational planning phases into one process. Analysis runs include harvest timing and location for each period, as well as long-term sustainable harvest levels.

The reporting functions of ***FSOS*** are extensive. The data for each period is easily accessible for any analysis unit, zone, polygon, LU, etc. and gives an overview of the forest state at any point in time. Species compositions, age structure, patch distribution, harvest scheduling, and many other variables are tracked and reported by period. Reporting functions are highly effective for the direct comparison of differing sensitivity analysis scenarios. ***FSOS*** is linked directly to the powerful ArcMap environment for high-quality map production.

5 FOREST RESOURCE INVENTORIES

5.1 Forest Cover Inventory

All spatial information is captured and controlled to the Terrain Resource Inventory Mapping (TRIM), North American Datum (NAD) 83 base. The Nimpkish DFA forest cover inventory is based on 1:15,000 colour aerial photography flown in 1995, for an effective scale of 1:5,000. Delineation of forest cover polygons follows the MoF 1992 forest cover inventory standard, and polygon attributes are in a digital and spatial format that is compatible with the provincial inventory database. Forest cover attributes are updated for disturbance and projected to December 31, 2001.

J.S Thrower and Associates completed a Vegetation Resources Inventory (VRI) Phase II adjustment in July 2003 and updated it with new data in June 2004 (see Appendix B). This process calculates statistical adjustments for age, site index, and then volume based on comparisons of species composition, basal area, height, volume, and age between plot data and the photo-interpreted estimates. This deviated from the standard procedure of adjusting age, height and then volume, but MSRM accepted Canfor's preferred approach for use in this analysis. J.S Thrower and Associates also calculated net volume adjustment factors (NVAF) in June 2004 (see Appendix C).

5.2 Other Forest Resource Inventories

Table 2 lists the source and status of the forest resource inventories used to prepare this information package.

Table 2: Forest resource inventory status

Inventory Item	Prepared by	Status/Standard	Data Source	Completed/ Updated	Agency Acceptance
Landscape units	MSRM	Final	MSRM	Jun-04	Jun-04
Parks	MSRM	Final Goal 1, 2	MSRM	Feb-01	Feb-01
RMZs	MSRM	VILUP	MSRM	Feb-01	Feb-01
Lake, River, Stream Classification	Deal, Canfor	Controlled to TRIM Base; Stream Class. Guidebook	Field and spatial data	Aug-97 Update: Feb-04	
Road Classification	Kuzenko, Canfor		Field and spatial data	Nov-03 *(to Jan-02)*	
Terrain Classification	Lewis	RIC Standard for TSM (Level C)	1995 colour photos, 1:15,000 scale	Prelim: Jun-97 Final: Mar-99	Aug-97 Apr-02
Ecosystem Classification	Green, BA Blackwell	RIC Standards for TEM	1995 colour photos, 1:15,000 scale	Prelim: Jun- 97 Final: Mar-99	May-98 Apr-02
Forest Cover Classification	Bradshaw, Simon Reid Collins	Updated for disturbance and projected to end of 2001, MoF 1992 Standard	1995 colour photos, 1:15,000 scale	Prelim: Aug-97 Final: Jun-98 Add: Apr-04	Jan-98 Apr-02 Jun-04
Vegetation Resources Inventory—Phase 2 Adjustment	JS Thrower & Associates Ltd.	Compiled using 2004 MSRM VRI compiler	80 VRI ground sample plots established in 2001 and 2002	Prelim: Mar-02 Final: Jun-04	Jun-04
Vegetation Resources Inventory–NVAF	JS Thrower & Associates Ltd.	VRI NVAF Standard	Ground sampling in 2002 and 2003	Prelim: Mar-04 Final: June-04	Jun-04
Physical Operability	Green, BA Blackwell		Derived from spatial data and local experience	Sep-97	Jan-98
Economic Operability	Bryant, Canfor		Derived from spatial data and local experience	Nov-97	Jan-98
Silviculture History	Kuzenko, Canfor		Past Harvesting	Jun-98	
Ungulate Winter Ranges	Deal, Canfor	Designated WHA	Field and spatial data and local experience	Jul-01	Sep-01
Goshawk Conservation Areas	Deal, Canfor, Manning, Manning, Cooper & Assoc.	Draft WHA	Field and spatial data	Prelim: Jan-02 Final: Jan-03	Mar-03
Marbled Murrelet Habitat	Deal, Canfor	Designated WHA	Field and spatial data	Field: 91-04 *Aug-04*	*Feb-05*
Old Growth Management Areas	Deal, Canfor	Draft OGMA	Field and spatial data	Draft: Jul-04	Aug-04 *Dec-04*
Recreation Inventory	Matkoski; WM Resource Cnslt.	MoF Standard	Field and spatial data	May-95	Jan-98
Cave/Karst Inventory		RIC Standard for KI (Planning-Level)	Field and spatial data	Mar-04	Mar-04
Visual Landscape Inventory	Matkoski; WM Resource Cnslt.	RIC Standard for VLI	Field and spatial data	Final: Aug-92 Updated: Jan-02	Feb-02

6 DESCRIPTION OF THE LAND BASE

6.1 Definition of the Timber Harvesting Land Base

The timber harvesting land base (THLB) is determined by the netdown process, in which stands ineligible for harvest are sequentially removed from the total land base. Table 3 summarizes this procedure. The rest of this section is dedicated to a detailed description of each reduction.

The netdown is an exclusionary procedure. Once an area has been removed, it cannot be deducted further along in the process. For this reason, the total area of any given land type (e.g. protected areas) is often greater than the net area removed. Portions of the land base that are reserved from harvest may still contribute to forest cover objectives.

6.1.1 Overview

To make timber supply analysis compatible with the SFM plan the Nimpkish DFA is the land base applied for this information package. It is comprised of TFL 37 and all parks within the Upper and Lower Nimpkish LUs, but excludes other forest tenures within these LUs. The total area of the Nimpkish DFA is 196,725 ha, which is 0.02% different from the area reported in the current Management Plan 8 due to spatial data processing. The productive forest is 148,720 ha, while the current THLB is 91,340 ha.

Proposed and future road reductions are not deducted from the current THLB because the volume associated with these features will contribute to the first harvest. These future reductions are applied once the polygon has been harvested. After all future reductions are applied, the long-term THLB is 90,236 ha.

Table 3: Timber harvesting land base determination

Land Classification	Total Area (ha)[1]	Net Reduction Area (ha)	Net Reduction Volume ('000s m^3)
Nimpkish DFA		**196,725**	**67,529**
Highway 19	198	198	0
Non-forest and non-productive forest	31,713	31,523	560
Non-Productive from ecosystem mapping	36,363	13,314	4,000
Roads and railway	3,180	2,970	740
Total reductions for Non-Productive Areas		48,005	5,300
Total Productive Forest		**148,720**	**62,229**
Protected areas	18,479	11,943	4,152
Physically inoperable	45,685	15,144	6,184
Avalanche track	4,235	89	44
Riparian reductions	9,329	7,092	3,245
Class IV terrain	17,121	2,818	1,439
Karst areas	1,300	1,122	415
Campsites/recreation areas	38	20	10
Ungulate Winter Range	6,195	4,885	3,557
Goshawk WHAs (Draft)	2,778	1,611	1,089
Marbled Murrelet WHA (OIC)	322	65	65
Marbled Murrelet WHA (Draft)	9,454	2,444	1,663
Old Growth Management Areas (Draft)	16,602	1,590	990
Uneconomic forest	20,455	2,923	780
Wildlife tree retention (Area VRAF)	8,569	5,634	2,073
Total Reductions to Productive Forest		57,380	25,706
Current THLB		**91,340**	**36,523**
Future reductions			
Proposed roads	218	167	**n/a[2]**
Future roads	2,805	937	**n/a[2]**
Long-term THLB		**90,236**	**n/a[2]**

[1] Total Area of the Nimpkish DFA covered by a given land classification.

[2] Volume for proposed and future roads is not removed from the land base, since it will contribute to harvest.

6.1.2 Non-Forest and Non-Productive Forest

Areas classed as non-forest or non-productive forest are removed from the timber harvesting land base. Stands designated in the forest cover inventory non-productive descriptor as alpine forest (AF) or not satisfactorily restocked (NSR) are potentially productive, and are therefore maintained in the land base. The distribution of non-forested area removed from the THLB, by class, is given in Table 4.

Table 4: Reductions for non-forest and non-productive forest mapped in the VRI

Non-Productive Land Type		Total Area (ha)	Net Removals		% of Non-Productive Netdowns
			Area (ha)	Volume (m3)	
A	Alpine	10,295	10,295	0	21.4%
AF	Alpine Forest (not removed)	3,898	0	0	0.0%
C	Clearing	21	21	0	0.0%
CL	Clay bank	2	2	0	0.0%
G	Gravel Bar	9	9	0	0.0%
GR	Gravel Pit	89	89	0	0.2%
HY	Hydro right of way	187	0	0	0.0%
L	Lake	8,518	8,518	3,253	17.7%
MARSH	Wetland	1,271	1,271	62,640	2.6%
MUD	Mud flats and clay banks	15	15	0	0.0%
NCBR	Non-commercial brush	268	261	0	0.5%
NP	Non-Productive	4,522	4,522	452,783	9.4%
NPBR	Non-Productive Brush	1,710	1,706	0	3.6%
NSR	NSR (not removed)	294	0	0	0.0%
R	Rock	2,276	2,276	0	4.7%
RIV	River	1,221	1,221	39,665	2.5%
RW	Highway Right of way	151	0	0	0.0%
S	Swamp	529	501	0	1.0%
SAND	Sand	21	12	0	0.0%
SWAMP	Wetland	35	35	1,895	0.1%
TL	Talus	273	273	0	0.6%
U	Urban	578	497	0	1.0%
Total		**31,713**	**31,523**	**560,236**	65.7%

The TEM identifies polygons with non-productive components that are not captured by the forest cover inventory. Where the decile proportion of non-productive sites in a TEM polygon exceeds the proportion of non-productive in the forest cover inventory polygon, the difference between the two inventories is the TEM-NP proportion that is netted out of the polygon. Where the TEM polygon is entirely non-productive, a full netdown reduction is applied. This ensures that the netdown for non-productive land is consistent with the TEM.

Table 5: Reductions for non-forest and non-productive forest mapped in the TEM

BGC Variant	Total Area (ha)	Net Removals		% of Non-Productive Netdowns
		Area (ha)	Volume (m3)	
CWHxm2	24,360	190	61,042	0.4%
CWHmm1	18,886	119	42,542	0.2%
CWHvm1	53,951	1,048	426,976	2.2%
CWHvm2	45,416	2,727	1,149,440	5.7%
MHmm1	35,966	5,824	1,793,364	12.1%
MHmmp	4,377	2,678	466,853	5.6%
ATc	6,571	728	59,501	1.5%
No TEM	7,000	0	0	0.0%
Total	**196,527**	**13,314**	**3,999,717**	**27.7%**

6.1.3 Existing and Proposed Roads

Netdown reductions are applied to the degraded width of roads, defined as the distance from tree stem to tree stem on old roads and between plantable areas on new roads. Average degraded widths for each road type were compiled from Canfor's post-harvest site-degradation survey database, which includes detailed road and internal measurements on 186 cutblocks.

Road-related disturbances such as landings and gravel pits are captured in the forest cover inventory and are removed as non-productive areas. Existing road surfaces, however, are not accounted for in the forest cover inventory. Similarly, proposed road surfaces are mapped and planned for development but are not part of the forest cover inventory. In GIS, a buffer was applied to the road linework to account for the width of road surfaces but because this buffer was dissolved, detailed area reductions for each road class and status are unavailable. The criteria for this exercise are given in Table 6.

Table 6: Summary of length and GIS buffer widths for existing and proposed roads

Existing/ Proposed	Road Class	Status	Length (km)	Buffer Width (m)	netdown reduction
Existing	Paved Highway	Maintained	94	0	n/a
	Primary Main	Maintained	235	13	Current
		Planted	10	0	Current
	Secondary Main	Deactivated	160	10	Current
		Maintained	560	11	Current
		Planted	6	0	n/a
	Spur	Deactivated	1,642	9	Current
		Maintained	454	10	Current
		Planted	87	0	n/a
	Railway	Maintained	112	11	Current
Proposed	Primary Main	Maintained	1	13	Future
	Secondary Main	Deactivated	3	10	Current
		Maintained	12	10	Future
	Spur	Deactivated	104	10	Current
		Maintained	207	10	Future
		Planted	12	10	Current
Total			**3,697**		

6.1.4 Parks

The Nimpkish DFA includes several provincial and regional parks. Although these protected areas contribute to some forest cover objectives for the Nimpkish DFA, they are not available for timber harvesting and are excluded from the THLB. Table 7 provides a summary of these parks by area and timber volume.

Table 7: Reductions for protected areas

Park Name	Total Area (ha)	Productive Area (ha)	Net Removals		% of Productive Netdowns
			Area (ha)	Volume (m^3)	
Claude Elliot Creek	110	101	101	0	0.2%
Claude Elliot Lake	203	105	105	67,257	0.2%
Lower Nimpkish River	280	156	156	88,015	0.3%
Mt. Cain	497	141	141	63,085	0.2%
Nimpkish Island	15	0	0	0	0.0%
Nimpkish Lake	3,929	2,738	2,738	1,628,307	4.8%
River side	9	6	6	4,213	0.0%
Schoen Lake	7,490	5,722	5,722	431,795	10.0%
Woss Lake	5,946	2,974	2,974	1,869,650	5.2%
Total	**18,480**	**11,943**	**11,943**	**4,152,321**	**20.8%**

6.1.5 Physically Inoperable

Canfor has conducted an internal review of physically inoperable areas, based on safety considerations, operational performance, environmental sensitivity, and local knowledge. Harvesting in physically inoperable areas is unrealistic for reasons of accessibility, soil sensitivity, or worker safety. Table 8 summarizes the netdown for physically inoperable area. The removals include 5,043 hectares of class V (unstable) terrain.

Difficult regeneration

Blocky talus sites represent colluvial slopes featuring very high surface coarse fragment contents. These sites are extremely difficult to regenerate following harvesting, and are thus considered inoperable. These sites were identified in the ecology database using the "talus" site modifier, which was used to recognize these sites. All polygons, which featured a talus modifier in site modifiers 1, 2 or 3 for the first site series component, were classified as physically inoperable.

Table 8: Summary of the physical operability determination

Physical Operability Rating	Total Area (ha)	Productive Area (ha)	Net Removals		% of Productive Netdowns
			Area (ha)	Volume (m^3)	
O Operable	129,072	123,047	0	0	0.0%
C Conditional	5,607	4,156	0	0	0.0%
I Inoperable	45,673	16,283	15,144	6,184,337	26.4%
W Water	9,145	0	0	0	0.0%
Unrated (parks and other)	7,030	5,234	0	0	0.0%
Total	**196,527**	**148,720**	**15,144**	**6,184,337**	**26.4%**

6.1.6 Avalanche Tracks

Harvesting timber within avalanche tracks can create risk for areas further down slope. According to current practices, areas of forest considered important for mitigating the impacts of avalanches are reserved from harvest. All polygons identified in the TEM as site group "AV" (avalanche track) are removed from the THLB (4,235 gross hectares and 89 net hectares).

6.1.7 Riparian Reserves and Management Zones

A GIS buffer function was used to determine the spatial distribution of riparian reserve zones (RRZs) and riparian management zones (RMZs). The netdown for riparian zones is a polygon-specific percent reduction based on the proportion of each polygon that lies within the buffer for streams, lakes, or wetlands. This method allows forest cover attributes within riparian zones to be maintained without increasing the number of polygons in the database.

The RRZ buffer width is consistent with the FPC *Riparian Management Area Guidebook*. The RMZ retention levels reflect current practice. The total riparian buffer to be excluded from harvest is a combination of the RRZ and the RMZ buffer. Where buffers of different riparian classes overlap, the larger buffer takes precedence. Table 9 shows the total riparian management area buffer width by stream class. Riparian reserve and management zones occupy 9,329 ha of the TFL. Excluding previous removals, 7,091 ha are removed as RRZ or RMZ.

Table 9: Netdown reductions for riparian management areas

	Riparian Management Zones			Riparian Reserve Zones			
Riparian Class	**RMZ Width (m)**	**RMZ area retention %**	**net RMZ removals (ha)**	**RRZ Width (m)**	**net RRZ removals (ha)**	**Net RMA removals (ha)**	**% of Productive Netdowns**
Streams							
S1(<100m)	20	30%	333	50	1,158	1,492	2.6%
S2	20	25%	672	30	1,431	2,104	3.7%
S3	20	25%	592	20	732	1,324	2.3%
S4	30	25%	171	0		171	0.3%
S5	30	25%	467	0		467	0.8%
S6	20	5%	1,057	0		1,057	1.8%
Total Streams			3,292		3,321	6,614	11.5%
Lakes							
L1	40	15%	196	10	62	258	0.4%
L2	20	20%	12	10	5	17	0.0%
L3	30	5%	5	0		5	0.0%
L4	30	5%	4	0		4	0.0%
Total Lakes			3,509		67	283	0.5%
Wetlands							
W1	40	15%	53	10	15	68	0.1%
W2	20	20%	57	10	27	84	0.1%
W3	30	5%	20	0		20	0.0%
W4	30	5%	23	0		23	0.0%
W5	40	20%		10		0	0.0%
Total Wetlands			153		42	195	0.3%
Total Riparian			**6,954**		**3,430**	**7,091**	12.4%

6.1.8 Unstable Terrain

Terrain stability mapping was completed for the Nimpkish DFA at a scale of 1:15,000. It identified areas of potential (class IV) and active (class V) instability. Percent reductions for these classes are based on recent operational experience. Class V terrain is a criterion in the inoperability determination, and has already been removed as inoperable. Cutblocks on class IV terrain typically require 10% area reductions. The class IV reduction factor in the Kilpala area is 26%, which reflects the greater sensitivity of this area to logging-related slope failures. Netdown removals of unstable terrain are shown in Table 10.

Table 10: Reductions for unstable terrain

Terrain Stability Class	Special Areas	Partial Reduction	Total Area (ha)	Productive Area (ha)	Net Removals		% of Productive Netdowns
					Area (ha)	Volume (m^3)	
Not Classified (Parks, etc.)			16,339	5,194	0	0	0.0%
I		0%	21,286	17,880	0	0	0.0%
II		0%	41,205	36,607	0	0	0.0%
III		0%	60,576	53,024	0	0	0.0%
IV		10%	40,056	27,671	2,179	1,115,099	3.8%
IV	Kilpala	26%	4,487	3,048	634	319,305	1.1%
V[1]		95%	12,578	5,296	5	4,960	0.0%
Total			**196,527**	**148,720**	**2,818**	**1,439,363**	**4.9%**

[1] Note that most Terrain Stability Class V areas were previously considered in physically inoperable (section 6.1.5).

6.1.9 Karst Landscapes

Karst landscapes are sensitive to logging impacts due to safety concerns, the intrinsic value of cave systems, and the presence of karst-associated flora and fauna. In 2004, Canfor completed a planning-level karst inventory that identified, among other things, the karst vulnerability potential (KVP) of areas within the Nimpkish DFA. Based on KVP, the features that are likely to exist and best management practices, netdown reductions were estimated for each karst polygon. These reductions for potential karst are summarized in Table 11.

Table 11: Reductions for forest cover over potential karst

Karst Vulnerability Rating	Average Partial Reduction	Total Area (ha)	Productive Area (ha)	Net Removals		% of Productive Netdowns
				Area (ha)	Volume (m^3)	
Low	11%	3,529	3,278	313	148,497	0.5%
Medium	17%	4,353	4,085	657	198,600	1.1%
High	23%	523	491	106	47,760	0.2%
Very High	29%	214	199	47	20,319	0.1%
Total		**8,618**	**8,054**	**1,122**	**415,176**	**2.0%**

6.1.10 Campsites/Recreation Areas

Canfor manages several campsites and recreation areas in the Nimpkish DFA are reserved from harvest. The net removals for campsites and recreation areas are shown in Table 12.

Table 12: Netdown removals for campsites and recreation areas

CAMPSITE	Total Area (ha)	Productive Area (ha)	Net Removals		% of Productive Netdowns
			Area (ha)	Volume (m^3)	
Atluck Lake	3	2	1	587	0.0%
Anutz Lake	2	0	0	0	0.0%
Kinman	15	14	12	6,912	0.0%
Nimpkish Lake	5	2	2	392	0.0%
Woss Lake	4	2	2	908	0.0%
Hoomak Rest Area	1	0	0	0	0.0%
Lower Klaklakama (N)	1	1	0	99	0.0%
Lower Klaklakama (S)	2	2	2	705	0.0%
Vernon Lake	5	2	1	342	0.0%
Total	**38**	**25**	**20**	**9,945**	**0.0%**

6.1.11 Wildlife Habitat Reductions

Ungulate Winter Range

An ungulate winter range plan for the Nimpkish DFA was first established in 1983. The most recent revisions to the ungulate winter range plan were completed in July 2001 and approved by government under Operational Planning Regulation (OPR) Section 69 on September 13, 2001. This plan designates specific areas of forest where harvesting is reserved to provide cover attributes necessary for deer and elk survival. Table 13 summarizes the reduction for ungulate winter and summer range.

Table 13: Reductions for ungulate winter range

SPECIES	Total Area (ha)	Productive Area (ha)	Net Removals		% of Productive Netdowns
			Area (ha)	Volume (m^3)	
Deer	5,199	4,957	4,270	2,998,996	7.4%
Elk	997	852	615	558,414	1.1%
Total	**6,195**	**5,809**	**4,885**	**3,557,410**	**8.5%**

Queen Charlotte Goshawk

To date, inventories conducted on the Nimpkish DFA have identified 45 Queen Charlotte goshawk nests. As part of Canfor's alternate management strategy for Queen Charlotte goshawk, eleven conservation areas ranging from 135 ha to 538 ha were established throughout the Nimpkish DFA. Most of these areas are given full harvest exclusion although single-tree selection is permitted in three of the areas (Claude Elliot, Klaklakama, and Loon). For the purposes of timber supply analysis, all goshawk territories were modeled using 100% harvest exclusion. Table 14 shows the area removals associated with each goshawk conservation area.

Table 14: Area reserved for Queen Charlotte goshawk territory

Harvest Strategy	Location	Percent Netdown Reduction	Total Area (ha)	Productive Area (ha)	Net Removals		% of Productive Netdowns
					Area (ha)	Volume (m^3)	
100% Retention	Claude Elliot	100%	97	97	45	38,610	0.1%
	Hoomak	100%	182	174	79	47,992	0.1%
	John	100%	133	125	45	45,766	0.1%
	Kaipit	100%	142	142	138	77,786	0.2%
	Klaklakama	100%	228	228	74	59,737	0.1%
	Loon	100%	104	104	79	60,689	0.1%
	Loon_2	100%	56	55	47	31,180	0.1%
	Lukwa	100%	227	204	158	133,505	0.3%
	Rona	100%	302	250	219	113,952	0.4%
	Toad	100%	313	293	115	91,273	0.2%
	Toad_2	100%	4	4	4	2,432	0.0%
	Vernon	100%	222	222	94	61,677	0.2%
Reserve	Nimpkish Island	100%	49	27	0	2	0.0%
Single Tree	Claude Elliot	100%	215	161	129	110,341	0.2%
	Klaklakama	100%	310	285	242	139,339	0.4%
	Loon	100%	194	188	145	74,945	0.3%
Total			**2,778**	**2,559**	**1,611**	**1,089,226**	**2.8%**

Marbled Murrelet

Field verification of marbled murrelet nesting habitat was completed between 2001 and 2004 using a combination of habitat modelling, air-photo interpretation, habitat plots and transects, audio-visual surveys, low-level aerial surveys, and terrestrial radar surveys. Using this information, Canfor has to develop the framework for an adaptive management strategy to conserve suitable marbled murrelet nesting habitat. This strategy will be submitted to MWLAP by December 2004. Proposed WHAs are currently in place and are not expected to change. They should be formally designated by February 2005. To account for this strategy, harvesting is currently excluded from the proposed WHAs. Currently, one 322 ha WHA is established and a 64-hectare net land base reduction is allocated (see Table 15). Table 16 summarizes the reductions applied for the proposed marbled murrelet WHAs.

Table 15: Netdown reduction for the established marbled murrelet WHA

Wildlife Habitat Area Code	Total Area (ha)	Productive Area (ha)	Net Removals		% of Productive Netdowns
			Area (ha)	Volume (m^3)	
MAMU-UN-KH-01	322	306	65	64,852	0.1%
Total	**322**	**306**	**65**	**64,852**	**0.1%**

Table 16: Netdown reductions for proposed marbled murrelet WHAs.

MAMU Priority	Total Area (ha)	Productive Area (ha)	Net Removals Area (ha)	Net Removals Volume (m^3)	% of Productive Netdowns
1	2,889	2,212	1,259	870,683	2.2%
2	6,347	5,344	1,142	760,506	2.0%
3	218	194	43	31,630	0.1%
Total	**9,454**	**7,750**	**2,444**	**1,662,820**	**4.3%**

6.1.12 Old-Growth Management Areas

Field verification of draft OGMAs was completed between 1999 and 2004 using a combination of spatial analysis, air-photo interpretation, and low-level aerial surveys. Canfor teamed with MSRM to identify draft OGMAs that address LU planning initiatives. The LU plan for Upper and Lower Nimpkish LUs is currently under review and is scheduled to be in place by December 2004. The proposed OGMAs are not expected to change. Accordingly, harvesting is currently excluded from the proposed OGMAs. Table 17 summarizes the reductions applied for the proposed OGMAs.

Table 17: Netdown reductions for OGMAs

LU	BGC_UNIT	Total Area (ha)	Productive Area (ha)	Net Removals Area (ha)	Net Removals Volume (m^3)	% of Productive Netdowns
Lower Nimpkish	CWHxm2	1,228	1,181	429	284,568	0.7%
	CWHvm1	2,528	2,351	232	194,390	0.4%
	CWHvm2	1,617	1,329	192	99,142	0.3%
	MHmm1	1,288	972	213	75,292	0.4%
Upper Nimpkish	CWHxm2	647	587	21	12,686	0.0%
	CWHmm1	1,074	987	176	117,839	0.3%
	CWHvm1	2,498	2,291	41	37,418	0.1%
	CWHvm2	2,964	2,565	96	57,049	0.2%
	MHmm1	2,592	1,755	190	111,358	0.3%
	Total	**16,435**	**14,017**	**1,590**	**989,742**	**2.8%**

Keen's Long-Eared Myotis

Canfor has identified several caves that may be hibernacula for Keen's long-eared myotis. Two OGMAs are established to protect the entrances of these cave systems (Table 18). Consequently, a netdown reduction associated with this cave system is incorporated into the OGMA designation (see section 6.1.12).

Table 18: OGMAs established to protect hibernacula for Keen's long-eared myotis.

OGMA Label	Total Area (ha)	Productive Area (ha)	Net Removals Area (ha)	Net Removals Volume (m^3)	% of Productive Netdowns
LN-048	250	209	100	25,329	0.2%
LN-149	21	21	16	14,099	0.0%
Total	**271**	**230**	**117**	**39,428**	**0.2%**

6.1.13 Cultural Heritage Resource Reductions

An archaeological overview assessment for the NICC Forest District identifies culturally sensitive areas within the Nimpkish DFA. Representatives from the Namgis Band conduct site-specific assessments of Canfor's operational plans. To date, modifications to harvesting plans for protecting cultural heritage resources are typically considered with other resource values such as WTPs, or RMAs. Consequently, there are no associated area reductions to the THLB.

6.1.14 Not-Satisfactorily Restocked Conditions

There is no backlog NSR within the Nimpkish DFA. Canfor is committed to prompt regeneration of all current NSR. As a result, harvested NSR lands are not excluded from the land base.

6.1.15 Uneconomic and Low Productivity Forest

Economic Operability

Canfor stratifies productive natural stands based on stand attributes. The resulting 286 forest cover strata have been divided into three economic operability types according to the stand's economic availability at the middle of the most current market cycle:

- Economic—available for harvest;
- Marginally economic—available for harvest under favourable market conditions, particularly where adjacent to economically operable stands; and
- Uneconomic—stand value is not expected to offset harvesting costs.

The economic operability classification was primarily a database and GIS exercise using the following attributes as criteria: site series, maximum mean annual increment, local knowledge, previous performance, stand volume, stand value, stand height, crown closure, and leading species. Stands removed from the THLB as uneconomic are summarized in Table 19. A sensitivity analysis will test the impact of removing marginally economic stands from harvest. The area of marginally economic stands is shown in Table 20.

Additional areas of natural stands are not projected to meet the minimum merchantable volume of $250m^3$/ha within 350 years. These stands have been amalgamated with stands labelled Uneconomic in the economic operability determination.

Table 19: Reductions for uneconomic stands by BEC variant

Reason for Exclusion	BGC_UNIT	Total Area (ha)	Productive Area (ha)	Net Removals		% of Productive Netdowns
				Area (ha)	Volume (m^3)	
Economically Inoperable	CWHmm1	58	46	21	10,000	0.0%
	CWHvm1	1,160	904	356	127,925	0.6%
	CWHvm2	2,440	1,591	748	201,685	1.3%
	CWHxm2	711	686	359	140,329	0.6%
	MHmm1	6,875	4,077	621	176,589	1.1%
	MHmmp	2,142	0	0	0	0.0%
	ATc	547	0	0	0	0.0%
Projected Yield <250 m^3/ha	CWHmm1	253	232	96	11,408	0.2%
	CWHvm1	435	390	199	27,539	0.3%
	CWHvm2	730	478	256	42,231	0.4%
	CWHxm2	198	183	97	11,638	0.2%
	MHmm1	3,902	2,030	168	30,309	0.3%
	MHmmp	752	0	0	0	0.0%
	ATc	253	0	0	0	0.0%
Total	**Total**	**20,455**	**10,617**	**2,923**	**779,653**	**5.1%**

A sensitivity analysis will test the impact of marginally economic stands from the THLB. Table 20 shows the net area and volume that would be removed in this sensitivity analysis.

Table 20: Marginally economic stands to be netted out as a sensitivity analysis

Sensitivity Analysis	BGC_UNIT	Total Area (ha)	Productive Area (ha)	Net Removals	
				Area (ha)	Volume (m^3)
Marginal Economic Operability	CWHmm1	216	201	68	24,764
	CWHvm1	1,411	1,289	608	256,624
	CWHvm2	5,891	5,016	3,029	1,466,144
	CWHxm2	265	255	102	43,205
	MHmm1	12,719	9,510	3,169	1,588,230
	MHmmp	904	0	0	0
	ATc	257	0	0	0
Total	**Total**	**21,663**	**16,272**	**6,976**	**3,378,967**

6.1.16 Wildlife Tree Retention

Wildlife Tree Retention (WTR) is the primary means for managing stand structure. Since 1991, Canfor has progressively applied an ecosystem-based harvest strategy (see section 7.5) that incorporates targets associated with stand-level management. Subsequently, FPC requirements required wildlife tree patches (WTP) in all cutblocks. Following a landscape level analysis in 1998, Canfor received MoF approval to apply variable percentages from Table 20(b) of the Biodiversity Guidebook to all new cutblocks.

Canfor's ecosystem-based harvest strategy incorporates targets for internal (within-block) retention of patches and single trees. For the purposes of this timber supply analysis, demonstrated rates of internal retention on TFL37 are incorporated into the Variable Retention Adjustment Factor (VRAF) included in TIPSY Beta Version 3.2 (MoF, May 2004). The total effect of internal retention is divided into an area reduction (Area VRAF) and a yield reduction (Yield VRAF). The derivation of VRAF reductions is described extensively in section 7.5. The Area VRAF is incorporated into the netdown and applies to all THLB polygons in TFL37. Partial reductions for riparian management areas, Class IV terrain, and karst reserves contributed to area VRAF requirements. Net of previous reductions, 5,634 ha of THLB are removed for internal retention (Table 21).

Table 21: Area reductions for internal retention associated with ecosystem-based harvesting.

Partial Retention Regime	Total Area (ha)	Productive Area (ha)	Area VRAF	Equivalent reduction (1-VRAF)	Net Removals (Area VRAF)	
					Area (ha)	Volume (m^3)
EFZ/GMZ_Fire	34,724	24,786	89.8%	10.2%	1,061	282,329
EFZ/GMZ_Gap	106,113	88,423	91.0%	9.0%	3,344	1,333,315
SMZ_Fire	7,615	6,674	82.5%	17.5%	629	189,048
SMZ_gap	20,740	17,040	90.4%	9.6%	600	267,931
Protected Areas/Other RMZs	27,534	11,797	n/a	0%	0	0
Total/Average	**196,725**	**148,720**	**89.8%**	**10.2%**	**5,634**	**2,072,623**

6.1.17 Future Roads

To estimate future access requirements (beyond proposed roads), road density in the accessible land base is extrapolated to the currently undeveloped THLB. This procedure follows the steps described below, and is summarized in Table 22. The netdown for future roads is 3.9%.

Table 22: Procedure for determining the reduction for future roads

Step	Description	Value
1	Gross THLB area accessible by existing roads	81,048 ha
	Gross THLB area not accessible by existing roads	28,414 ha
2	Length of existing roads	3,393 km
	Ratio of road length to accessed gross THLB area (km/ha)	4.19%
3	Future road requirements	1190 km
4	Average degraded road width	9.3 m
5	Future road reduction to gross THLB	1,108 ha
	Future road reduction to currently non-accessed gross THLB	3.90%
6	Future road reduction applied to net THLB	937 ha

Step 1
To estimate the areas that are currently accessible with current and proposed roads, a 175 meter buffer was applied to the current and proposed road network. This buffer approximates the average yarding distance observed on the existing road network of the Nimpkish DFA. All logging roads were buffered because even though mainlines do not contribute to the future reductions they contribute to development.

Step 2
The total length of existing roads (mainline, branches, and spurs) was compared to the accessible gross THLB. The gross THLB is the sum of the total area of polygons that are wholly or partially available for harvest. It excludes all polygons that have been completely netted down (e.g. inoperable) but includes the total area of any polygons that have been partially netted down (e.g. class IV terrain, potential karst). The gross THLB is used instead of the net THLB because the length of road required to access a polygon is assumed to be independent of any partial reductions that apply to that polygon.

Step 3
The length of future road requirements was found by multiplying the inaccessible gross THLB area by the ratio of existing road length to accessible gross THLB area.

Step 4
The average degraded width for future roads is the length-weighted average degraded width of existing branches and spurs. The procedure for determining this average is shown in Table 23. Mainline roads are not included in this calculation under the assumption that all mainline roads are in place for accessing the Nimpkish DFA and future road development will involve only branches and spurs. For the purposes of this calculation, it is assumed that current levels of deactivation and rehabilitation will persist into the future

Table 23: Procedure for determining the average degraded width for future roads.

Road class	Existing length (km)	Proportion	Degraded width (m)	Proportional degraded width (m)
Secondary (Branch)--Maintained	560	19%	11	2.1
Spur—Maintained	454	16%	10	1.6
Secondary (Branch)—Deactivated	160	5%	10	0.5
Spur—Deactivated	1642	56%	9	5.1
Secondary (Branch)—Debuilt & Planted	6	0%	0	0.0
Spur—Planted	87	3%	0	0.0
Total degraded width	**2908**	**100%**		**9.3**

Step 5
The area of future roads is the length of future road requirements multiplied by the average degraded width. The percent reduction is the area of future roads divided by the gross THLB.

Step 6
This 3.9% reduction will be applied uniformly to the inaccessible net THLB after one rotation. When applied, the reduction will reduce the net THLB by 937 ha, or 1.0%.

6.2 DESCRIPTION OF THE THLB

This section describes the attributes of the THLB.

The Age distributions by area and volume for the net productive land base and the current THLB are given in Table 24, and shown graphically in Figure 1. Ages and volumes from the Phase II adjusted VRI are projected to December 31, 2001.

Table 24: Age distribution by area and volume

MoF Age Class (years)	Productive Area (ha)	Productive Volume (000's m³)	Current THLB [1] Area (ha)	Current THLB [1] Volume (000's m³)	% Productive in THLB Area (ha)	% Productive in THLB Volume (000's m³)
0	2,512	0	1,711	0	68%	n/a
1-20	29,380	33	20,812	25	71%	76%
21-40	25,767	3,777	21,069	3,065	82%	81%
41-60	10,167	4,125	7,721	3,195	76%	77%
61-80	6,178	3,366	4,393	2,524	71%	75%
81-100	1,685	1,138	1,247	844	74%	74%
101-120	944	549	291	195	31%	35%
121-140	766	379	172	134	22%	35%
141-250	2,826	1,346	1,269	701	45%	52%
>250	68,495	47,514	32,656	25,839	48%	54%
total	**148,720**	**62,228**	**91,340**	**36,522**	**61%**	**59%**

1. Current THLB is a subset of the productive land base.

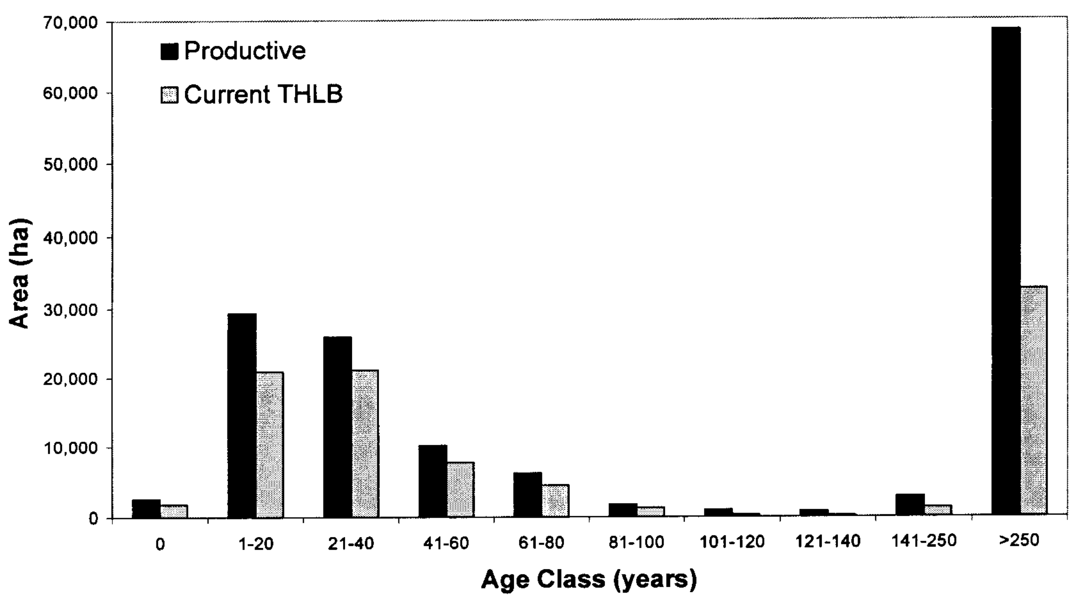


Figure 1: Age distribution by area

7 GROWTH AND YIELD

J.S. Thrower and Associates Ltd. developed yield tables for natural and managed stands for this analysis. The procedures and assumptions used to develop the yield tables are detailed in a report attached as Appendix D: *Natural and Managed Stand Yield Tables for Management Plan 9 on TFL 37.* This section summarizes the report and provides additional information as required.

7.1 Utilization Levels

Canfor's utilization specifications are designated in schedule C of the TFL 37 agreement. Table 25 identifies the utilization levels used in the development of the yield tables. Indicated values reflect current operational practices, except the top diameter-inside bark for natural stands. Although Canfor harvests a minimum top DIB of 15 cm for natural stands, VDYP does not model this utilization level, so 10.0 cm is used as a default top DIB.

Table 25: Utilization levels

	Min DBH (cm)	Stump Height (cm)	Top DIB (cm)
Managed stands (TIPSY)	12.5	30	10
Natural stands (VDYP)	17.5	30	10

7.2 Yields for Natural (Unmanaged) Stands

The following section describes the methods used to develop the natural stand yield tables (NSYT) that will be used in the timber supply analysis for the Nimpkish DFA. Natural stands are defined as all polygons that were established 1960 or earlier, or leading in red alder.

7.2.1 Site Index Estimates for Natural Stands

Site index estimates for Natural Stands are based on VRI Phase II adjusted site index (JS Thrower & associates 2004; Appendix C). Table 26 describes the source of the site index equations utilized in VDYP, Version 6.6d to generate yield information for the TFL.

Table 26: Source of site index equations

Species	Site Index Reference
Amabilis fir	Kurucz (1982)
Western redcedar	Kurucz (1982)
Yellow cedar	Kurucz (1982)
Red alder	Harrington & Curtis (1986)
Coastal Douglas-fir	Bruce (1981)
Western Hemlock	Wiley (1978)
Lodgepole pine	Goudie (1984)
Western white pine	Curtis, Diaz, & Clendenen (1990)
Sitka spruce	Goudie (1987)

7.2.2 Decay, Waste and Breakage (DWB)

Yield table volumes generated using VDYP are net DWB using forest inventory zone (FIZ) B and loss factors for special cruise 347.

7.2.3 Existing Natural Timber Volumes

Mature and unmanaged immature stand volumes reported in this information package are derived from the VRI completed June 2004. VRI volumes incorporate decay through cruiser-called net factor call grading followed by NVAF ground sampling and analysis. NVAF analysis is a required component of the provincial VRI program and uses destructive sampling to derive the true net volume of sample trees and adjusts the inventory for bias.

7.2.4 Calibrating the NSYTs to the Inventory

NSYT were generated based on a VRI Phase II adjusted site index. However, the raw VDYP volumes do not reflect Phase II volume adjustments (NVAF), and are not consistent with inventory volumes. Generally, the raw VDYP curves underestimate volume relative to the NVAF-adjusted inventory. As a result, the VDYP curves must be adjusted so that they intersect the inventory volume.

The simplest way of fitting the yield curves to the inventory volume is to proportionally adjust the curves by a uniform multiplier. However, a proportional adjustment is considered unsuitable because it may overestimate future volumes (Personal communication, May 29, 2003, Albert Nussbaum, Senior Analysis Forester, MoF Analysis Section). A more desirable approach is to use the unadjusted VDYP curve as a guide curve that the adjusted curve converges to, on either side of the inventory adjustment. This approach reduces the risk of overestimating future volumes in younger stands.

The adjustment equation is adopted from Pienaar and Rheney (1995), based on a methodology suggested by Ian Moss of ForesTree Dynamics Ltd. The equation used to fit the yield curve to the inventory volume requires the following components:

- A measure of the difference between the inventory volume and the volume predicted by VDYP (V_{DIFF});
- An expression that makes the adjusted curve diverge from the VDYP curve as it approaches the inventory volume (A_1).
- An expression that makes the adjusted curve converge with the VDYP curve once it passes through the inventory volume (A_2).

The following equation structure meets these criteria:

$$V_{ADJi} = V_{VDYPi} + V_{DIFF} * A_1 * A_2$$

$$A_1 = Age_i / Age_{inv}$$

$$A_2 = e / e^\wedge(Age_i / Age_{inv})$$

Where:

V_{ADJi} is the adjusted volume at any age i on the yield curve;

V_{VDYPi} is the unadjusted volume from the VDYP yield curve at any age i;

V_{DIFF} is the difference between the inventory volume and the VDYP yield curve at inventory age, Age_{inv};

Age_{inv} is the inventory age of the polygon, and the age at which V_{DIFF} is measured;

Age_i is the x-axis of the yield curve; and

e is the base of the natural logarithm, with a numerical value of 2.71828.

Figure 2 shows a generic yield curve adjustment using these parameters.

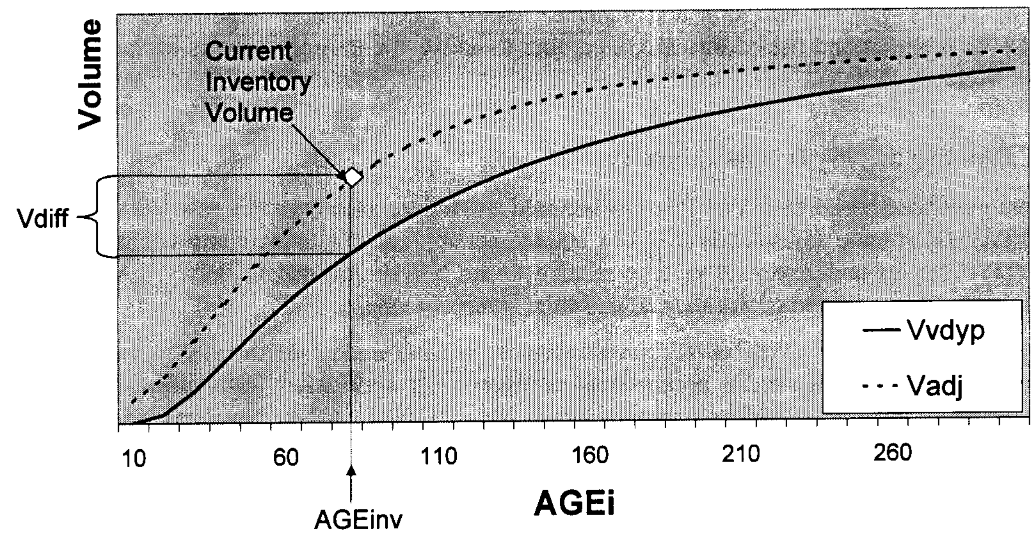


Figure 2: Generic graph showing the calibration of an unadjusted NSYT to the Phase II adjusted inventory volume [1]

The maximum age modelled in the VDYP curves (maximum Age_i) is 350 years. During timber supply modeling, ***FSOS*** will assign the corresponding maximum VDYP volume to all stands older than 350 years. As a result, the adjustment for stands that have an inventory age (Age_{inv}) older than 350 years would be underestimated because Age_i/Age_{inv} would never reach a value of 1. To prevent this downward bias, the maximum Age_{inv} is set at 350 years.

The calibration equation increases VDYP volumes to fit the inventory, but makes the adjusted curve converge on the unadjusted VDYP curve in the future. This approach is conservative with respect to future volumes of young natural stands, in response to uncertainty about how these stands will develop. It should be noted that younger stands (≤140 years) make up only 24% of the area modeled by VDYP, as shown in Figure 2. The risk associated with the uncertainty around projecting young VDYP stands is relatively small as a result.

Culmination age would be conserved by ratio adjustment, because the entire yield curve is multiplied by a single ratio and therefore retains its shape. In contrast, our approach changes the shape of the yield curve, with a corresponding change to the culmination age. Where the adjustment increases volume, the culmination age of the curve is reduced. The net effect of these shifts is that the volume at culmination age is approximately the same for the adjusted and unadjusted VDYP curves.

[1] The dashed line shows the final (calibrated) NSYT.

7.3 YIELDS FOR MANAGED STANDS

The following section describes the source and methods used to develop the managed stand yield tables that will be used in the timber supply analysis for the Nimpkish DFA.

7.3.1 Site Index Estimates for Existing and Future Managed Stands

J.S. Thrower & Associates Ltd. developed improved estimates of PSI for the main commercial species of the Nimpkish DFA (see Appendix A). The yield tables for existing and future managed stands incorporate these PSI estimates, except in the MHmm1 where inventory site index was used and in the CWHvm2 where an empirical elevation model was used.

The elevation model was originally developed as part of the SIA project and updated in 2000 (Appendix A). With this model, each site series in the CWHvm2 was matched with a corresponding site series of similar productivity in the CWHvm1 and the MHmm1. For each site series in the CWHvm2, site index was assumed to decrease linearly with elevation from the adjusted PSI estimate for the CWHvm1 site series (based on a reference elevation of 450 m) to the net-area-weighted average inventory site index for the MHmm1 site series (based on a reference elevation of 1,000 m). CWHvm2 polygons below 450 m (about 1% of the CWHvm2 area) were assigned the adjusted PSI estimate for the CWHvm1 site series and CWHvm2 polygons above 1,000 m were assigned the inventory site index from the MHmm1 site series. Albert Nussbaum (Senior Analysis Forester, MoF Analysis Section) approved this approach for the base case in June 2003, on the condition that a sensitivity analysis is run to test the timber supply effects of using inventory site index in the CWHvm2.

7.3.2 Operational Adjustment Factors

The TIPSY program allows the use of operational adjustment factors (OAFs) to reduce the gross volumes of regenerated stands. There are two OAFs applied in TIPSY: OAF1 and OAF 2. In the construction of the MSYTs, OAFs were applied as follows:

- OAF1: 10% for all species.
- OAF2: 12.5% Fd leading managed stands over 10 years in age within the CWHxm subzone otherwise 5% for all species.

OAF1

OAF 1 allows for yield reductions associated with non-productive areas in the stand, uneven spacing of crop trees (clumping), and endemic and random loss. The standard OAF1 of 15 % is considered a province-wide approximation of the difference between PSPs and actual yields, and is composed of the following estimates:

- Espacement 4%
- Non-productive 4%
- Random risk 3%
- Endemic losses 4%

By identifying non-productive deciles, terrestrial ecosystem mapping (TEM) provides semi-spatial resolution of non-productive areas within forested polygons.Table 27 shows the distribution of non-productive TEM deciles in the forested land base. The forested land base as a whole has 10.7% NP in its polygons. Most of this non-productive is concentrated in the forested non-THLB, which has 32.4% NP. The THLB has only 1.3% non-productive TEM deciles.

Table 27: Distribution of non-productive TEM deciles in the forested land base

Land Base	Area (ha)		% NP
	Total	NP	
THLB	113,828.0	1,457.0	1.3%
Forested Non-THLB	49,292.0	15,976.0	32.4%
All forested	**163,119.0**	**17,433.0**	**10.7%**

The TEM provides spatial resolution of NP inclusions within forested polygons and provides an opportunity to account for in-stand non-productive areas through semi-spatial area netdowns, rather than blanket OAF1 yield adjustments. By replacing the non-productive component of OAF1 with a netdown reduction (TEM-NP), OAF1 in this analysis is composed of only espacement, endemic losses, and risk. Endemic losses and risk are consider lower on the Nimpkish DFA than in the province as a whole, and consequently the non-NP OAF is reduced slightly to 10% (instead of 11%). Albert Nussbaum (Senior Analysis Forester, MoF Analysis Section) approved this approach for the base case (pers. comm. May 29, 2003), on the condition that a sensitivity analysis is run to test the timber supply effects of applying standard OAF1 to the MSYTs.

OAF2

OAF2 allows for increasing volume losses towards maturity, attributable to DWB, disease and pest factors. The standard OAF2 of 5 % is also a province-wide approximation of the difference between PSPs and actual yields that accelerate with age.

During the review of the proposed data package, Stephan Zeglen (Forest Pathologist, MoF Stewardship, Coast Forest Region) was concerned of an inconsistency between TSA and TFL managed stand assumptions regarding volume losses associated with root rot in the CWHxm subzone. Based on Jeff Beale's 1992 masters thesis, OAF2 was increased in recent timber supply analyses for the Sunshine Coast, Arrowsmith, and Strathcona TSAs. Mr. Zeglen felt this 7.5% increase in addition to the standard 5% OAF2 adjustment is a more appropriate assumption to apply to the Nimpkish DFA.

Canfor was unable to validate Mr. Beale's 1992 results from the Sunshine Coast with stands from the Nimpkish DFA and will consider investigating the issue further. For this analysis though, a 12.5% OAF2 reduction will be applied to 2,408 hectares of Fd-leading managed stands over 10 years in age within the CWHxm subzone. This represents 2.7% of the THLB and imposes a relatively insignificant downward impact on the medium term harvest forecast of approximately 0.2%.

7.3.3 Existing Managed Timber Volumes

Volumes for immature managed stands, established between 1961 and 1995 inclusively, were derived from the aggregated yield tables for managed stands, described in section 7.3 and Appendix D. Polygons for the development of MSYTs are based on the overlay of the TEM and the forest cover inventory. Yield tables were generated for each resultant polygon using *BatchTIPSY version 3.0a*, and then aggregated based on curve similarities (see section 7.4).

7.3.4 Silviculture Management Regimes

Silviculture regimes in current era stands reflect typical operational practices based on site series and are given in Appendix D.

7.3.5 Regeneration Assumptions

The species composition of future managed stands is based on site series rather than the attributes of the harvested stand. These regeneration assumptions are provided in Appendix D.

7.3.6 Site index of Secondary Species

Site index of secondary species is the appropriate PSI for that species. MoF site index conversion equations are not used.

7.3.7 Regeneration Delay

Cutblocks are planted following harvest within 2 years in the CWH zone, and within 3 years in the MH zone. Canfor plants one-year-old seedling stock, making the effective regeneration delay 1 year in the CWH and 2 years in the MH.

7.3.8 Genetic Gain Allowances

As a result of an on-going tree improvement program, a rational volume increase is expected for stands regenerating from genetically improved stock. Table 28 shows the volume adjustments applied to the future MSYTs. These are based on the future managed species distributions presented in Table 15 of Appendix D. Canfor's tree improvement program will be in transition for the next 20 years, and the gains used in this analysis are pro-rated estimates for the transition period only.

Table 28: Genetic gain forecasts for class A seed stock

Elevation	Spp	% Availability	% Planting Program	% Gain	Seed Source and Timing of Gain
>700 m	Fd	1.00	0.10	0.03	Orchard#116 = 3% first 5 years Orchard#116 rogued= 8% next 15 years
	Hw	1.00	0.25	0.05	Orchard#130 = 2% first 5 years Orchard#130 rogued= 10% next 19 years
	Yc	0.90	0.28	0.07	5% first 3 yrs as usage of A stock increases from 53% in 2002 to 90% in 2004 12% from 2005-2010 with 100% usage 18% from 2011 to 2022
<700 m	Cw	0.95	0.33	0.04	Orchard#186 = 3% first 3 years Orchard#186 rogued= 7% next 7 years Orchard#186 replaced = 10% remaining 10 years
	Fd	1.00	0.27	0.07	Orchard#149 & US Sources = 8% first 5 years Orchard#162 & US Sources = 12% next 5 years Orchard#177 = 16% last 10 years
	Hw	1.00	0.20	0.09	Orchard#133 = 17% first 10 years Orchard#179 = 20% next 10 years
	Yc	1.00	0.01	0.07	As for Yc > 700m

Source: J.S. Thrower and Associates Ltd. 2003. *Yield Tables for Natural and Managed Stands: Management Plan 9 on TFL 37.*

7.4 Yield Table Aggregation

Reducing the number of yield curves leads to efficient database management, faster run times, and easier interpretation. It also facilitates sensitivity analyses and changes to specific yield curves. However, aggregation reduces the spatial variation in yield attributes because it involves averaging the data. Also, aggregation can mask attributes that are important to interpretation. The ideal aggregation would have the following attributes:

- small number of groups
- based on operationally relevant criteria
- low variation within groups
- no overlap between groups
- preserves the variation of the original population

Many of these attributes are mutually exclusive. For example, to achieve a small number of groups, we must accept large variance within the groups, and a dampening in the overall variation of the population. Aggregating based on operationally relevant criteria will likely create groups that have a high degree of overlap in some important yield curve inputs such as site index. Aggregation therefore involves trade-offs between the aggregation criteria, the degree of aggregation, and preservation of spatial variation.

The approach for aggregating the yield curves described below, is intended to achieve a substantial reduction in the number yield curves while still preserving important variations in productivity, curve shape, species composition, and ecology.

7.4.1 Populations for aggregation

Clustering populations define which yield tables can be clustered together. Yield tables that are in different populations will never be clustered, no matter how similar they are. The basic populations for the TFL37 yield tables are Natural, Existing Managed, and Future Managed. For several reasons, it was necessary to subdivide these basic populations into smaller groups:

- The sensitivity analyses for CWHvm2 site index and transitional (41-80 year old) stands require replacing one set of yield curves with another. It will be much easier to perform this replacement if the curves of interest are totally independent of their larger population, so the VDYP curves for transitional stands and the TIPSY curves for CWHvm2 stands were treated as separate populations in the clustering.
- Clustering for future curves was partially based on ecology, and it was desirable to treat the MHmm1 as a separate population from the lower elevation stands. This will facilitate future scenarios testing different forms of ecosystem-based management (EBM).
- Natural stands whose yield curves are less than 250 m^3/ha at 350 years are explicitly excluded from the THLB. To ensure that these stands do not bias cluster volumes applied to the THLB, they were separated from the rest of the VDYP old population.

Figure 3 shows the breakdown of the TFL37 yield tables into the eight clustering populations.

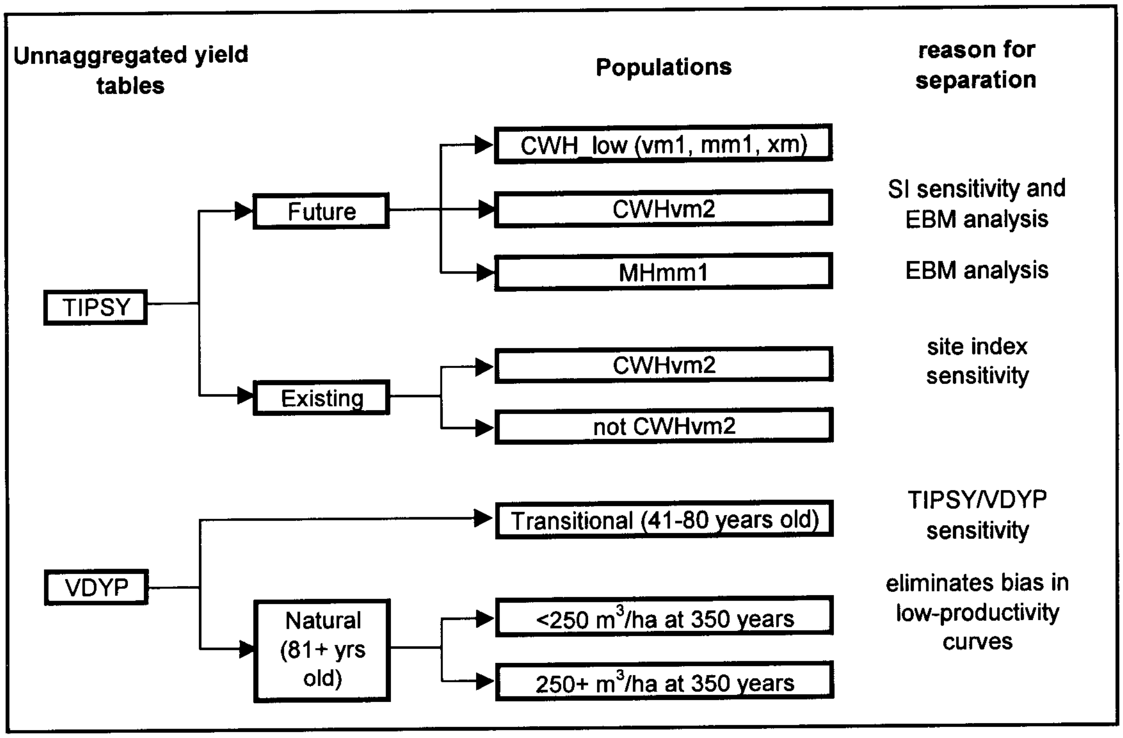


Figure 3: Subdivision of the yield curves into exclusive clustering populations.

7.4.2 Species-based vs. Ecosystem-Based Clustering

The methodology for aggregating future curves is substantially different from that used for existing managed and natural stands. Clustering of existing managed and natural curves followed a species-based approach, while future curves were clustered using an ecosystem-based approach. The species approach divides the population of yield curves into subpopulations that are relatively uniform in species composition, and then clusters the yield curves within these subpopulations. The ecosystem-based approach averages the yield curves based on unique combinations of site series to create several hundred EcoGroups, each with only one yield curve. The EcoGroups are then clustered based on similarities in yield. The important difference between these two types of clustering is that the curves are averaged once in the species approach and twice in the ecosystem approach. The two approaches are discussed further below.

7.4.3 Species-Based Clustering (Natural and Existing Managed Stands)

Tree species is an important variable to monitor in timber supply analysis. Therefore it is desirable to stratify the yield tables into species groups before clustering them based on volume yield attributes. The object of stratifying each population into species groups is to ensure that the final yield curves are relatively uniform in terms of species composition.

Traditionally, timber supply analyses have used a "leading species" approach, which groups stands purely on the basis of their leading species. A better alternative would account for all species in each polygon. For this reason, a multi-variate statistical technique (k-means clustering) was used to aggregate yield curves based on the overall similarity in their species composition.

Populations for Species Clustering

Not all of the eight yield populations were divided into species groups. The Old_<250m^3 population was excluded from species clustering because differences in species composition within this population were assumed to be insignificant for timber supply analysis.

Species composition

Species composition was simplified to six species codes: HwBa (Hw, Hm, Ba, and Bg), Fd (Fd and Pw), Cw, Yc, Dr (all deciduous), Pl, and Ss. The yield tables within each of the four yield populations were clustered separately based on their similarities in these six variables.

Species composition for VDYP yield tables can be taken directly from the inventory. TIPSY curves were based on dynamic species composition, meaning that the species composition at harvest is not the same as inventory species composition. To ensure that the species groups for existing managed stands reflect the approximate species composition at harvest, TIPSY tables were clustered on species composition at 80 years.

Choosing the number of species groups

An advantage of the k-means technique is that it allows the user to select the desired number of groups. To determine the number of clusters that gives the best result, the final cluster centres of successive k-means runs were arranged into a branching tree that shows the emergence of new groups and the change in pre-existing groups. One of these trees is shown in the spreadsheet 00-546_TFL37 MP9 Cluster Curves.xls, included with this information package (MoF Forest Analysis Branch only). The goal was to find the number of clusters that most effectively portrayed distinct groups that are significant to our analysis. The yield populations were divided as follows: Natural old (8 groups), natural transitional (7 groups), existing managed not vm2 (7 groups), and existing managed vm2 (4 groups). Some of these groups are minor, for example leading in Ss or Pl. Such groups can be given one curve each.

Yield curve aggregation within species groups

Species groups are subpopulations that can contain anywhere from a dozen to several thousand yield curves. The yield curves within each species group typically show a wide range of productivity and curve shapes. The purpose of volume clustering is to assign yield curves for various productivity levels that follow patterns within this variation.

Given the large range of productivity within each species group, five curves were necessary to achieve aggregated yield curves that are sufficiently uniform. Some species groups were not subdivided into volume groups: the Pine-leading and Spruce-leading species groups in all populations were given one curve each (the curves are the average of all curves in these species groups). With these exceptions, assigning 5 curves to each species group resulted in 43 curves for the Existing Managed population, 31 curves for the Transitional (41-80 years old) population, and 32 curves for the Old (81+ years old) population. One curve was assigned to the Old_<250m^3 population.

Variables for clustering

Old stands were not clustered based on their curve shape because these curve shapes will not affect future yields and should not be allowed to affect the clustering. Consequently, clustering the natural old population was done on only one variable (volume at 350 years). Conversely, curve shape is an important factor in younger stands, while the volume at the end of the curve is relatively unimportant. Clustering of the existing managed and transitional stands was performed on the middle of the curve (volume at ages 40, 80, 120, 160, and 200). Excluding volumes at ages greater than 200 years increases the relative importance of the volumes at ages when harvesting is more likely to occur.

7.4.4 Ecosystem-Based Clustering (Future Stands)

The species compositions of future yield curves are equivalent to the average expected species composition in that site series across the Nimpkish DFA. In addition, each site series has a large array of species. Once they are combined in complex polygons (polygons with more than one site series), there are no truly distinct groups of curves based on species. Therefore, because there is no real spatial precision about which species will be in which polygons, future groups are not clustered based on species composition. Alternatively, future groups are grouped into units called EcoGroups, according to an ecology-based stratification.

EcoGroups

Site series are logical units for the ecosystem-based clustering approach, since they are the basis for both species composition and productivity assumptions in future stands. Also, they will likely control any attribute assumptions for unanticipated scenarios. The challenge is that complex polygons have up to three site series.. To simplify the situation, the TEM data was generalized in two ways:

1. Only the first two deciles were considered. Only 10% of the TFL has 3 site series, and this third decile usually has a value of 1 (10 % of the polygon). For the purposes of the analysis, the third site series can be treated as redundant information.
2. The decile proportion of each site series was not taken into account. This is based on an analysis that showed that almost all leading site series have a decile of 6 to 8.

These generalizations resulted in 332 unique combinations of leading and secondary site series, called EcoGroups. The CWHmm1/08(07) EcoGroup is shown as an example in Table 29.

Table 29: A sample EcoGroup [1]

EcoGroup Name	BGC_UNIT	Leading SS	Leading Decile	Secondary SS	Secondary decile	Minor SS	Minor decile
CWHmm1/08(07)	CWHmm1	08	6	07	2	12	2
CWHmm1/08(07)	CWHmm1	08	6	07	3	12	1
CWHmm1/08(07)	CWHmm1	08	6	07	4		
CWHmm1/08(07)	CWHmm1	08	7	07	3		
CWHmm1/08(07)	CWHmm1	08	8	07	2		

1. The CWHmm1/08(07), and some combinations of TEM data that fall into this EcoGroup. The EcoGroup approach simplifies TEM data by treating the third ("minor") site series and the decile proportions as noise.

Yield Curve Aggregation

Volume clustering for future managed stands was similar to clustering in existing managed stands. The difference is that clustering was performed on the average curve for each EcoGroup (280 curves for CWH_low, 80 for CWHvm2, and 44 curves for MHmm1). Figure 4 shows the component yield curves for the EcoGroup presented in Table 29. The five input (Original) yield curves are shown as thin lines, and the EcoGroup (average) curve has black data points. Differences in the input yield curves are primarily due to the influence of the CWHmm1/12 site series in the third decile. Different decile proportions of the 08 and 07 site series have no effect on the yield curve in this case.

Clustering was performed on the volume at ages 40, 80, 120, 160, and 200. The EcoGroup curves were condensed into 7 curves for CWH_low, 4 for CWHvm2, and 3 curves for MHmm1. The majority of the area of each curve is usually held by one or two EcoGroups, meaning that the future curves can be typified based on their leading site series. This result is advantageous for any analysis that requires ecological interpretations.

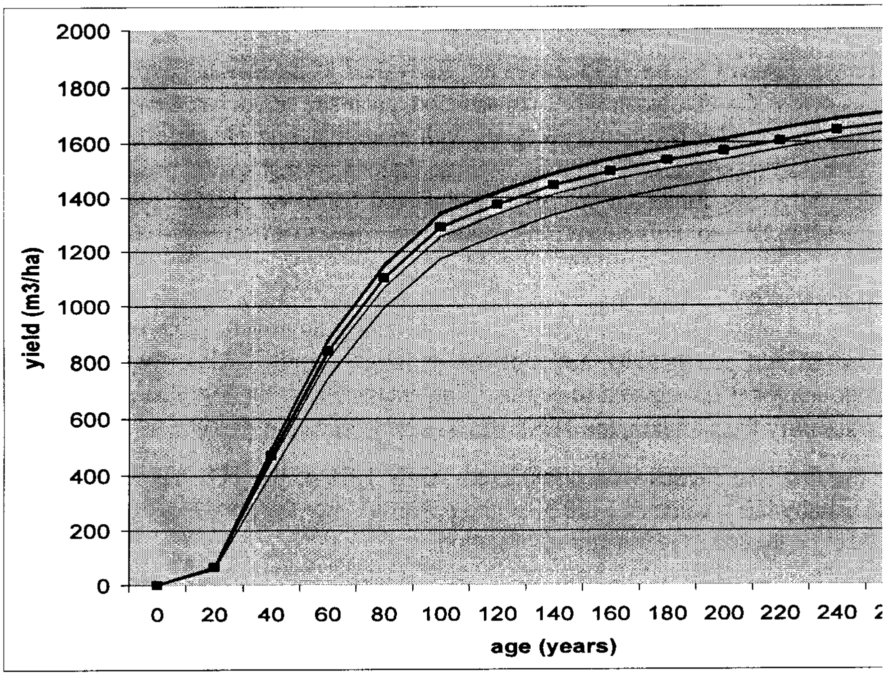


Figure 4: Yield curves for the CWHmm1/08(07) EcoGroup

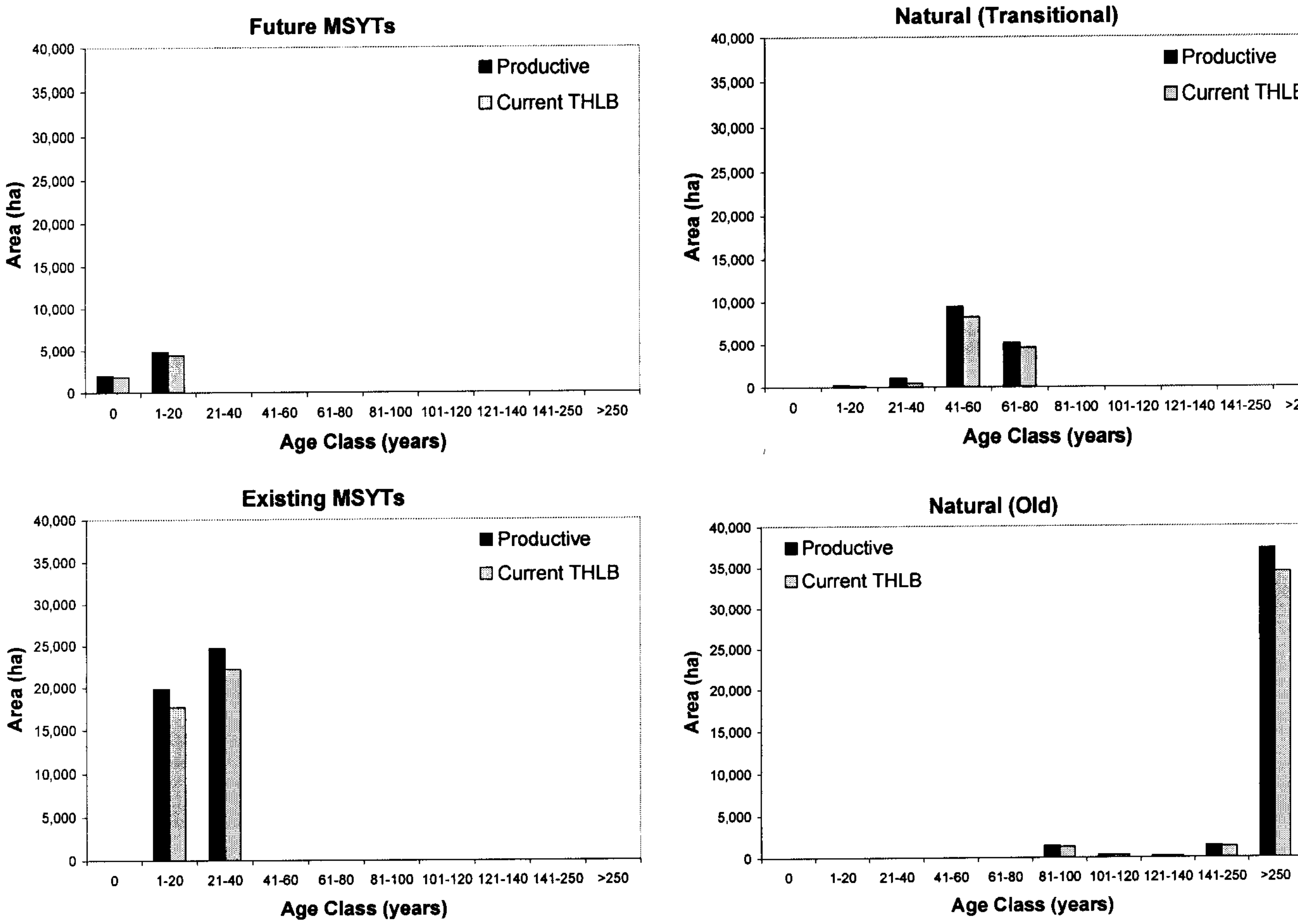
7.4.5 Aggregation Results

A summary of the aggregation is provided in Table 30. Full results are provided in the spreadsheet 00-546_TFL37 MP9 Cluster Curves.xls (Appendix 5). The current age structure of these populations is shown in Figure 5.

Table 30: Summary of results of yield curve aggregation

Population		Area (ha)	Number of tables	
			Original	Clusters
Future	CWH low elevation	87,332	41,428	7
	CWHvm2	42,521	23,040	4
	MHmm1	29,646	18,202	3
Total Future		**159,499**	**82,670**	**14**
Existing	Not CWHvm2	37,376	11,783	27
	CWHvm2	9,393	5,568	16
Total Existing Managed		**46,769**	**17,351**	**43**
Natural	Old <250 m3/ha	14,182	8,855	1
	Old 250+ m3/ha	77,425	46,723	32
	Transitional	17,485	7,464	31
Total Natural		**109,092**	**63,042**	**64**
Sensitivity analyses	Future CWHvm2 SI	42,521	23,040	4
	Existing CWHvm2 SI	9,393	5,568	16
	Transitional TIPSY	17,485	7,464	31
Total Sensitivity Curves		**69,399**	**36,072**	**51**
Grand Total			**199,135**	**172**

Figure 5: Current age structure of the Future, Existing, Natural (Transitional), and Natural (Old) yield populations[1]



7.4.6 Existing Timber Volume Check

The purpose of the volume check is to compare inventory volumes with the volumes that will be read from the yield curves at year zero of the planning horizon. This provides confidence that the process of aggregation into analysis units did not introduce major errors or biases into the initial growing stock modeled in timber supply analysis.

The basic initial volume check by yield populations is shown in Table 31. Volume checks by MoF age class and leading species are given in Table 32 and Table 33, respectively. Inventory volumes are the NVAF-adjusted VRI volumes. Yield volumes were interpolated from the analysis unit yield curves based on the Phase 2 adjusted VRI age of each resultant polygon. Interpolation assumed linear volume growth between 5-year points on the yield curves.

As described above, the NSYTs were adjusted so that they intersect the area-weighted inventory volumes. This adjustment ensures that there is no difference between inventory volume and the current volume predicted by the NSYTs. However, the existing timber volume check is used in this case to verify that no

1 The transitional population includes some deciduous stands less than 41 years old.

substantial biases were introduced by the aggregation of yield tables into the NSYT analysis units. The volumes for managed stands predicted by TIPSY were not adjusted to the inventory volume. Consequently, there is a volume difference between the inventory and the managed stand yield tables.

Table 31: Initial volume check by yield population

Yield Population	Net Area (ha)	Yield Volume (m^3)	Inventory Volume (m^3)	Difference (m^3)	% Difference
Future MSYTs	5,770	0	0	0	0%
Existing MSYTs	37,324	3,530,743	3,029,599	501,144	16.5%
Transitional NSYTs	12,115	5,811,103	5,718,848	92,256	1.6%
Mature NSYTs	36,132	27,814,168	27,773,231	40,937	0.1%
Total	91,340	37,156,015	36,521,677	634,337	**1.7%**
Natural stands	48,247	33,625,272	33,492,079	133,193	**0.4%**

Table 32: Initial volume check by MoF age class

MoF Age Class		Net Area (ha)	Yield Volume (m^3)	Inventory Volume (m^3)	Difference (m^3)	% Difference
0	0 years	1,711	0	0	0	0%
1	1-20 years	20,812	131,185	25,221	105,964	420%
2	21-40 years	21,069	3,459,052	3,065,401	393,650	13%
3	41-60 years	7,721	3,197,920	3,195,304	2,616	0.1%
4	61-80 years	4,393	2,613,184	2,523,544	89,640	4%
5	81-100 years	1,247	667,641	843,804	-176,164	-21%
6	101-120 years	291	160,967	194,561	-33,594	-17%
7	121-140 years	172	118,010	133,826	-15,815	-12%
8	141-250 years	1,269	698,521	701,275	-2,755	-0.4%
9	>250 years	32,656	26,109,537	25,838,741	270,795	1.0%
Total		91,340	37,156,015	36,521,677	634,337	**1.7%**

Table 33: Initial volume check by generalized groups of leading species[1]

Species Group		Net Area (ha)	Yield Volume (m^3)	Inventory Volume (m^3)	Difference (m^3)	% Difference
B	Balsam	6,055	2,951,929	2,982,206	-30,277	-1%
C	Cedar	3,834	2,415,191	2,383,890	31,301	1%
D	Deciduous	983	236,675	227,058	9,618	4%
F	Douglas-Fir	24,238	5,212,606	4,726,515	486,091	10%
H	Hemlock	45,996	23,829,692	23,685,397	144,295	1%
P	Pine	27	4,732	3,500	1,233	35%
S	Spruce	83	43,219	45,475	-2,256	-5%
Yc	Cypress	4,346	2,453,470	2,467,638	-14,168	-1%
Total		**85,562**	**37,147,513**	**36,521,677**	**625,836**	**1.7%**

[1] *Existing species composition is available only for stands greater than 5 years old.*

7.5 Yield Adjustments for Ecosystem-Based Harvesting

Since 2001, Canfor has practiced varying levels of internal retention, consistent with its Forestry Principles Implementation Plan (2002). Retention targets, established as ecosystem-based harvesting, are defined for ecosystem management units (EMU) that combine the natural disturbance type and the VILUP RMZs.

Retention silviculture systems affect timber supply primarily by: (1) foregoing timber volume in leave trees and patches, and (2) reducing regeneration yields due to partial shading by retained trees. These effects will be incorporated into SFM plan 9 timber supply analysis using variable retention adjustment Factors (VRAF) provided in TIPSY v.3.2. This section describes the retention regimes differentiated in the analysis and the methods used to apply the VRAFs to the yield tables. This method is innovative and will likely be modified during the SFM plan 9 information package review process.

7.5.1 Ecosystem Management Units

EMUs are derived from combinations of existing management zones, specifically VILUP RMZs and BEC variants. Variants are aggregated into natural disturbance types to differentiate ecosystems dominated by fire from those dominated by gap dynamics. Table 34 shows the criteria and distribution of EMUs.

Table 34: Summary of ecosystem management units

EMU	Natural disturbance type	BEC variants	Area (ha)		
			Total DFA	Productive	THLB
EFZ - Fire			17,620	11,708	8,170
GMZ - Fire	NDT 2	CWHxm2, CWHmm1	17,103	13,078	9,778
SMZ - Fire			7,615	6,674	4,421
EFZ - Gap		CWHvm1,	44,688	39,345	25,790
GMZ - Gap	NDT 1	CWHvm2,	61,426	49,078	32,671
SMZ - Gap		MHmm1	20,740	17,040	10,509

7.5.2 Retention Targets

Operational retention targets for cutblocks are defined using three variables: number of stems for single-tree retention, proportion of the wildlife tree patch target as retention within the opening, and % forest influence. Targets for these variables depend on the EMU, as shown in Table 35. Single-tree and internal patch retention targets are minima that are often exceeded in order to meet forest influence targets and to provide insurance for windthrow losses. Canfor's demonstrated performance relative to these retention targets is discussed in section 7.5.3.

Table 35: Retention targets for EMUs

EMU	Required Stems/ha	Proportion of WTP target as Internal Retention Patch	% Forest Influence
EFZ - FIRE	2-5	>/= 15%	>/= 50%
EFZ - GAP	0	>/= 25%	>/= 50%
GMZ - FIRE	6-10	>/= 25%	>/= 50%
GMZ - GAP	0	>/= 35%	>/= 50%
SMZ - FIRE	12-18	>/= 40%	>/= 50%
SMZ - GAP	0	>/= 50%	>/= 50%

7.5.3 Performance

In preparation for this information package, Canfor provided data showing retention performance in all cutblocks with SPs approved in 2003 and 2004. Sixty three cutblocks are represented in the data set, with a total area of 1,762 hectares. These data were condensed to characterize actual retention regimes for input into VRAF:

- Average % interior retention—the sum of single-tree and group retention, divided by the total $_{cutblock}$ area. Assuming a crown area of 30m^2/tree, each single tree represents 0.3% retention in this calculation;
- % Group vs. single-tree retention—the relative proportions of each retention type and always add up to 100%;
- Average group size; and
- Average residual stand height.

Retention regimes applied in the VRAFs are shown in Table 36. VILUP EFZs and general management zones (GMZ) were combined in the VRAF input regimes because, despite differences in the retention targets, the performance data show no significant difference between actual retention practices in these RMZs.

Table 36: Demonstrated performance in retention cutblocks approved in 2003 and 2004

Ecosystem-based harvesting Regime	Number of Sample Cutblocks	Total Area of Sample Cutblocks (ha)	Average % interior retention	% Group Retention	% single tree retention	Average Group Size (ha)	Average Residual Stand Height (m)
EFZ/GMZ_Fire	10	283	10.2%	92%	8%	1.04	36
EFZ/GMZ_Gap	35	1,048	9.0%	97%	3%	1.29	34
SMZ_Fire	3	67	17.5%	71%	29%	0.94	32
SMZ_gap	15	363	9.6%	99%	1%	0.65	39
Total/Average	**63**	**1,762**	**9.6%**	**96%**	**4%**	**1.11**	

The average interior retention is greater than the targets for Canfor's ecosystem-based harvesting regimes, which range from 2% to 11%. As mentioned above, targets are frequently exceeded at harvest to buffer against windthrow losses. A sensitivity analysis will test the effects of using the targets as the basis for calculating VRAFs.

7.5.4 Applying VRAF to timber supply

Yield tables for the analysis were developed before release of the VRAF model. Consequently, VRAF will be applied retroactively to the aggregated future yield tables.

A series of TIPSY runs tested the sensitivity of VRAF to various yield inputs such as species, site index, initial density, slope, and BGC zone. Species (Fd vs. Hw/Cw/Ba) and site index were the only factors that significantly impacted VRAF. Table 37 shows the variation of VRAF within each partial harvesting regime at various site indices and species.

Table 37: Relationship of species and site index on total VRAF within each of the ecosystem-based harvesting regimes.

Partial harvesting Regime	Species	Site Index 20	25	30	35	40
EFZ/GMZ_Fire	Fd	89%	89%	89%	87%	86%
	Hw/Cw/Ba	88%	87%	86%	85%	n/a
EFZ/GMZ_Gap	Fd	89%	89%	89%	88%	86%
	Hw/Cw/Ba	88%	87%	86%	85%	n/a
SMZ_Fire	Fd	76%	75%	73%	71%	69%
	Hw/Cw/Ba	72%	71%	70%	69%	n/a
SMZ_Gap	Fd	89%	89%	89%	88%	86%
	Hw/Cw/Ba	89%	88%	87%	86%	n/a

Variation of VRAF within the EFZ/GMZ and SMZ_Gap regimes is similar, and these three regimes can justifiably be combined for the purposes of applying VRAF to the yield tables. Table 38 shows the VRAFs that apply to the Future MSYTs, based on average site index and leading species within each analysis unit.

Table 38: Total VRAF for future managed stands.

Future MSYT aggregate	Leading Species	Net Area (ha)	Average Site Index (m)	Total VRAF SMZ_fire	Total VRAF Other
Future_CWHlow_vpoor	Cw	16	21.7	72%	88%
Future_CWHlow_poor	Fd	2,069	26.5	75%	89%
Future_CWHlow_med	Fd	5,945	29.8	73%	89%
Future_CWHlow_good	Fd	32,629	36.1	71%	88%
Future_CWHlow_vgood (early)	Fd	11,684	33.0	72%	88%
Future_CWHlow_vgood (late)	Hw	3,276	29.7	70%	86%
Future_CWHvm2_vpoor	Cw	323	15.1	n/a	89%
Future_CWHvm2_poor	Cw	6,408	15.5		89%
Future_CWHvm2_med	Hw	18,241	20.4		88%
Future_CWHvm2_good	Hw	669	23.7		87%
Future_MHmm1_poor	Hw	404	12.4	n/a	89%
Future_MHmm1_med	Hw	8,286	15.1		89%
Future_MHmm1_good	Hw	200	16.9		89%

VRAF is composed of two adjustments:

1. Area adjustment ($VRAF_{area}$): an adjustment for the land area occupied by reserved trees;
2. Yield adjustment ($VRAF_{yield}$): an adjustment for the effect of retention on regenerating trees.

$$VRAF_{total} = VRAF_{area} * VRAF_{yield}$$

$VRAF_{area}$ must be applied to the harvested stand (NSYT or existing MSYT) to account for portions of the existing stand that is excluded from harvest as internal retention patches. $VRAF_{yield}$ is only applied to the regenerating stand (future MSYT). Consequently, the area and yield adjustments must be applied separately. The area component of the VRAF will be applied as a partial reduction to current THLB area of applicable polygons, while the yield adjustment will be applied to only to the Future MSYTs. The area and yield adjustments are shown in Table 39. A sensitivity analysis will be done to test the timber supply impact of setting the yield VRAF to zero.

Table 39: Separate area and yield adjustments associated with VRAF.

	SMZ_fire	Other	SMZ_Fire	SMZ_gap	EFZ/GMZ Fire	EFZ/GMZ Gap
Area adjustment for internal retention (Area VRAF)			**82.5%**	**90.4%**	**89.8%**	**91.0%**
Future MSYT aggregate	**Total VRAF [1]**		**Yield adjustment at 100 years net of area adjustment (Yield VRAF)**			
Future_CWHlow_vpoor	72%	88%	87.3%	97.4%	97.9%	96.7%
Future_CWHlow_poor	75%	89%	90.9%	98.5%	99.1%	97.8%
Future_CWHlow_med	73%	89%	88.5%	98.5%	99.1%	97.8%
Future_CWHlow_good	71%	88%	86.1%	97.4%	97.9%	96.7%
Future_CWHlow_vgood (early)	72%	88%	87.3%	97.4%	97.9%	96.7%
Future_CWHlow_vgood (late)	70%	86%	84.9%	95.2%	95.7%	94.5%
Future_CWHvm2_vpoor		89%		98.5%		97.8%
Future_CWHvm2_poor	n/a	89%	n/a	98.5%	n/a	97.8%
Future_CWHvm2_med		88%		97.4%		96.7%
Future_CWHvm2_good		87%		96.3%		95.6%
Future_MHmm1_poor		89%		98.5%		97.8%
Future_MHmm1_med	n/a	89%	n/a	98.5%	n/a	97.8%
Future_MHmm1_good		89%		98.5%		97.8%

1 *The area VRAF has already been removed from the THLB in the netdown process. Total VRAF is given for context only.*

8 PROTECTION

8.1 Unsalvaged Losses

Unsalvaged losses result from natural events that are epidemic in origin. Table 40 shows unsalvaged losses on the TFL, which total 9,874 m^3/year. Net available volume (the allowable annual cut) will be determined by removing unsalvaged losses from modeled harvest levels.

The primary epidemic losses in the Nimpkish DFA are windthrow and anthropogenic fire. Windthrow generally occurs in standing timber at the edge of cutblocks, and consequently there is a high salvage rate for windthrow. In addition, the extensive road system in the Nimpkish DFA allows for considerable salvage of fire-affected stands. Occasionally, snow press damages large volumes of standing timber.

Table 40: Unsalvaged losses

Event	Origin	Period of records	Volume loss (m3/year)		
			Gross	Salvage	Net loss
Fire	Anthropogenic	1961-1996, 1998-2001	10,083	8,190	1,893
	Natural	1961-1996, 1998-2001	36	0	36
Insects	Natural	1998-2001	0	0	0
Flood	Natural	1998-2001	0	0	0
Wind	Block-related	1992-1996, 1998-2001	19,567	17,774	1,793
	Natural	1992-1996, 1998-2001	0	0	0
Snow	Press	1998-2001	8,138	6,510	1,628
	Slide	1998-2001	4,525	0	4,525
Total			**42,348**	**32,474**	**9,874**

9 INTEGRATED RESOURCE MANAGEMENT

This section provides details on how non-timber resource values with timber objectives are integrated with the modeling methodology.

9.1 MANAGEMENT ZONES AND MULTI-LEVEL OBJECTIVES

Management zones are geographically specific areas that require unique management considerations. Areas requiring the same management regime or the same forest cover requirements are grouped into management zones. Table 41 lists the management zones for the Nimpkish DFA and the rationale used to define these zones.

Multiple resource issues may be present on the same forest area. For example, goshawk critical habitat may also have areas that are visually sensitive and require a mature-plus-old growth objective. ***FSOS*** can accommodate multiple overlapping resource layers by establishing target levels for each layer. The model then schedules harvest units which best meet the target levels for all resource layers together.

Table 41: Management zones

Management Zone	Total Area (ha)	THLB Area (ha)	Criteria used to Delineate Zone	Rationale/Comment
BEC Variants:			Based on the climatically determined potential climax vegetation on zonal sites, and differentiated by moisture and temperature regimes.	Landscape-level biodiversity management requires representation of seral stages at the BEC variant level, as consistent with the Landscape Unit Planning Guide.
ATc	7,265	0		
CWHmm1	18,886	10,629		
CWHvm1	56,355	33,780		
CWHvm2	47,348	26,064		
CWHxm2	24,358	11,741		
MHmm1	37,800	9,126		
MHmmp	4,377	0		
Landscape Units:			Legally established as an objective set by Government under the FRPA in the Order Establishing Provincial Non-Spatial Old Growth Objectives (effective June 30, 2004), pursuant to section 4(1) of the FPC.	
Lower Nimpkish	78,081	38,133		
Upper Nimpkish	118,446	53,207		
VILUP HLPO RMZs			Legally established in the VILUP HLPO Section I, pursuant to section 3(1) of the FPC.	(RMZs are used to define the applicable area for specific land use objectives, such as cutblock green-up.
Protected Areas[1]	17,974	0		
Special Mgmt. Zones (SMZ)	29,582	14,930		
General Mgmt. Zones (GMZ)	84,640	42,450		
Enhanced Forestry Zones (EFZ)	64,332	33,960		
Visual Quality			Scenic areas declared known by the Port McNeill Forest District on January 14, 1999, VILUP HLPO, section II (C)(6) and a Visual Landscape Inventory updated in 2002.	
Ecosystem-based harvesting	13,600	7,516		
Modification	7,980	4,612		
Maximum Modification	209	79		

[1]Mt. Cain Regional Park and Riverside Park are not VILUP protected areas and are zoned in GMZs.

9.2 Forest Cover Requirements

Timber supply analysis will account for forest cover objectives at the landscape level. Forest cover requirements aim to consider biodiversity, identified wildlife habitat, and visual quality values by specifying target height and age distributions. The primary sources of direction for forest cover requirements in the Nimpkish DFA are the VILUP HLPO and the draft SFM Plan 9 for the Nimpkish DFA. Table 42 summarizes the forest cover targets to be applied in the base case.

Table 42: Forest cover objectives – Base Case scenario

Resource	Criteria	Cover requirement	Applied to:	
			Zone	Cover type
Landscape green-up	Green-up height	No more than 33% of stands can be less than 3 meters in height in SMZs and GMZs, and 1.3 m in the EFZ	SMZ, GMZ, and EFZ	THLB
Visual quality	% denudation and visually effective green-up	No more than a specified percentage of each visual quality polygon can be less than the visually effective green-up height.	Visual quality polygons	crown forested land base
Landscape Level Biodiversity	Mature + old seral cover	A specified percentage of each variant must be greater than the designated mature seral age.	BEC variants in SMZs	Productive forest land base

9.2.1 Landscape Green-up

As directed previously in Section 68(5) of the OPR and upheld in the FRPA, the green-up height in SMZs and GMZs is 3 metres. As specified in the VILUP HLPO and pursuant to Section 68(4) of the OPR, the green-up requirement for EFZs is 1.3 m. Like FSSIM, the simulation mode of FSOS is unable to model spatial adjacency in time-step simulation mode. As a surrogate for spatial adjacency constraints, a landscape green-up constraint will be applied in the base case, specifying that no more than 33% of the THLB area of each type of VILUP RMZ may be below green-up height at any given time.

9.2.2 Visual Resources

Canfor's visual landscape inventory produced visual absorption capacity (VAC) and recommended visual quality classes (RVQC) for 62 visual quality polygons in the Nimpkish DFA. Recently, Canfor further stratified each visual quality polygon into low and steep gradient slopes, as well as, areas that are potentially screened from predominant viewpoints.

Visual quality objectives are managed on 11,586 ha (13%) of the THLB. Consequently, the assumptions used to model visual quality constraints are a major consideration for the Nimpkish DFA's timber supply analysis. Reflecting demonstrated practices, Canfor developed an alternative to the standard TSR modelling approach, which Lloyd Davies (Visual Landscape Forester, Coast Forest Region, MoF) reviewed for use in the base case of this analysis. Initially, Mr. Davies recommended using more conservative assumptions but at the time this information package was finalized, he found it difficult to accept these figures in isolation of all other constraints being applied. Still, Canfor will apply the MoF-modified figures in the base case, while incorporating sensitivity analyses, discussed later, to explore the effects on timber supply.

Forest cover requirements for visual quality objectives are composed of two values:

1. Visually Effective Greenup (VEG)—the stand height at which regeneration is perceived as a newly established forest, above which the stand is considered to have no visual impact; and
2. Percent Planimetric Denudation—the maximum proportion of the productive area of a visual polygon that can be below the VEG height.

Visually Effective Greenup (VEG)
VEG is calculated according to the *Procedures for Factoring Visual Resources into Timber Supply Analyses*. To account for the effect of slope on visual impact, the procedures specify VEG tree heights for seven slope classes. This timber supply analysis will use the area-weighted average of these slope classes to calculate VEG height for each visual quality polygon. Table 43 shows the calculation of the overall area-weighted average VEG tree height for the combined visual quality polygons.

Table 43: Sample calculation of VEG tree height for visual quality polygons [1]

	Area (ha) by slope class (%) and associated VEG height (m)							Average VEG tree height
Slope Class	0-10%	11-20%	21-30%	31-40%	41-50%	51-60%	>61%	
Associated VEG height	**3m**	**4m**	**5m**	**6m**	**7m**	**8m**	**8.5m**	**6.34 m**
Crown Forested Area (ha)	1,235	2,168	2,550	2,816	2,462	2,071	3,960	

[1] This table shows the calculation of the average VEG tree height for all visual quality polygons. Timber Supply analysis will use the same method to calculate VEG height separately for each visual polygon.

Traditionally, timber supply analyses have assumed that a cutblock has 100% visual impact until it reaches VEG height. This assumption does not reflect the visual contribution of cutblocks during their green-up period. Canfor asserts that, similar to the equivalent clearcut area (ECA) concept, stands progressively recover towards a VEG condition after harvest. To model this effect in timber supply analysis, a logistic curve will be used in the base case to progressively reduce the visual impact of cutblocks to during their green-up period (Figure 6). The VEG curve is used to weight the contribution of cutblocks of different heights to the current percent denudation of a visual polygon.

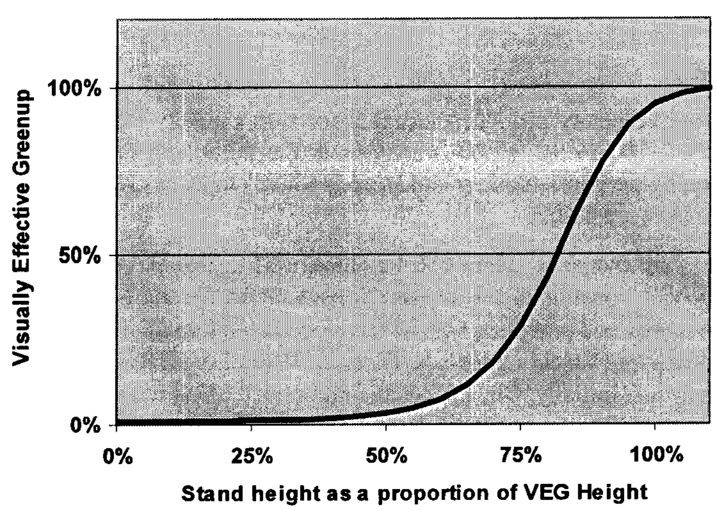


Figure 6: Relationship between stand height and visually effective green-up (VEG).

Percent Planimetric Denudation

Canfor considers standard TSR assumptions of percent denudation to be overly constraining for timber supply analysis for the Nimpkish DFA. In consideration of demonstrated performance with visual design and ecosystem-based harvesting practices, Canfor will apply percent planimetric denudation values shown in Table 44, which are prorated according to the relative area of each low gradient and steep gradient slopes in each visual quality polygon.

Table 44: Localized percent planimetric denudation constraints.

Recommended Visual Quality Class (RVQC)	Productive Area (ha)	Net Area (ha)	Maximum Planimetric Denudation Low Gradient (<30% slope)	Steep Gradient (>30% slope)
Partial Retention	10,929	7,016	33%	15%
Modification	6,175	4,492	50%	25%
Maximum Modification	158	79	75%	40%
Total	**17,262**	**11,586**		

Sensitivity analyses for visual quality constraints

Although the assumptions described above provide a reasonable estimate for how visual quality objectives constrain harvesting practices, there is considerable uncertainty on the issue. Consequently, three sensitivity analyses will be used to assess the risk associated with these assumptions:

1. Standard TSR approach – The *Procedures for Factoring Visual Resources into Timber Supply Analyses* (BC Ministry of Forests *et al.* 1998) specifies area-based percent denudation ranges for each visual quality class, assuming clearcutting is the silvicultural system applied. For the Nimpkish DFA, the VAC rating was used to specify the percent denudation for each recommended visual quality class (Table 45). In addition, the traditional interpretation of VEG is applied (100% visual impact below VEG height).

Table 45: Percent denudation for each combination of RVQC and VAC.

RVQC[1]	VAC[2]	Productive Forest Area (ha)	Percent denudation[3]
MM	M	158	32.5
M	L	533	15
M	M	5,453	20
M	H	189	25
PR	L	5,468	5
PR	M	5,462	10

[1]Recommended Visual Quality Class: PR = partial retention; M = modification; MM=maximum modification.
[2]Visual Absorption Capacity: H=high; M = medium; L = low.
[3]VAC-specific percent denudation figures are taken from Table 4 in the *Procedures for Factoring Visual Resources into Timber Supply Analyses.*

2. Relaxed percent planimetric denudation constraints – Initially, Canfor proposed a set of localized percent planimetric denudation constraints, which MoF felt were too optimistic. The base case approach described above is considered a compromise, while this sensitivity analysis reduces visual constraints by increasing percent denudation to Canfor's original estimates (Table 46).

Table 46: Relaxed percent planimetric denudation constraints.

Recommended Visual Quality Class (RVQC)	Maximum Planimetric Denudation	
	Low Gradient (<30% slope)	**Steep Gradient (>30% slope)**
Partial Retention	50%	20%
Modification	60%	33%
Maximum Modification	80%	50%

3. Disable visual quality constraints – This sensitivity analysis removes all forest cover constraints applied in the analysis. It is not intended to suggest that visual quality is not required, but rather to identify the overall magnitude that visual quality constraints have on timber supply within the Nimpkish DFA.

9.2.3 Biodiversity

The Landscape Unit Planning Guide establishes old seral cover and wildlife tree habitat as the current priorities for LU biodiversity management in BC. As stated in the *Provincial Guide For the Submission of Timber Supply Analysis Information Packages for Tree Farm Licences* (B.C. MoF 2001), objectives for coarse woody debris and patch size distribution should not constrain timber supply in the base case. Consequently, these attributes will not be modelled in this timber supply analysis. Wildlife tree patches and old seral forest cover requirements are addressed through Canfor's OGMA strategy as discussed in section 6.1.12.

Landscape Units

The Nimpkish DFA covers two LUs, shown in Table 47. The boundaries and biodiversity emphasis of these LUs were legally established became legally established through the Provincial Non-Spatial Old Growth Objectives (effective June 30, 2004) as part of the Regional Landscape Unit Planning Strategy (Ian McDougall, Senior Planning Biologist, MSRM, Aug. 10, 2004).

Table 47: Area and biodiversity emphasis of the LUs

Landscape Unit	BEO	Total Area (ha)	Productive Area (ha)	Net Area (ha)
Lower Nimpkish	Low	78,081	60,986	38,133
Upper Nimpkish	Intermediate	118,446	87,734	53,206

Mature and Old Seral Cover Requirements

Mature+old seral cover requirements are the minimum percent area of productive forest older than a specified age for each BEC variant within each LU. VILUP HLPO Section 2(1)(a) specifies mature-plus-old forest cover objectives for all special management zones in the Nimpkish DFA. Cover requirements for productive forest in mature and old seral stages are shown in Table 48. A sensitivity analysis will test the impact of removing mature+old seral cover requirements.

Table 48: Mature+Old seral forest cover targets in SMZs

LU	RMZ #	RMZ Name	BGC Variant	Area (ha) Productive	THLB	Mature	Old	M+O	M+O Target	M+O Current
Lower Nimpkish	6	Woss-Zeballos	CWHvm2	828	507	0	826	826	>18%	100%
			MHmm1	192	36	1	189	190	>19%	99%
	10	Pinder-Atluck	CWHvm1	3,758	2,372	259	1,694	1,953	>18%	52%
			CWHvm2	1,486	896	27	1,392	1,419	>18%	96%
			CWHxm2	383	263	11	7	18	>17%	5%
			MHmm1	392	99	6	375	381	>19%	97%
Upper Nimpkish	6	Woss-Zeballos	CWHmm1	141	101		8	8	>34%	6%
			CWHvm1	244	172	0	174	174	>36%	71%
			CWHvm2	671	416	14	657	671	>36%	100%
			MHmm1	512	211	11	501	512	>36%	100%
	9	Tsitika-Woss	CWHmm1	1,969	1,298	35	250	285	>34%	14%
			CWHvm1	4,544	3,310	14	1,253	1,267	>36%	28%
			CWHvm2	2,258	1,387	3	1,609	1,612	>36%	71%
			CWHxm2	4,107	2,712	152	482	634	>34%	15%
			MHmm1	539	217	1	526	527	>36%	98%
	11	Schoen-Strathcona	CWHvm1	188	136	1	140	142	>36%	76%
			CWHvm2	806	591	14	721	735	>36%	91%
			MHmm1	622	159	3	592	595	>36%	96%

9.2.4 Recreation Resources

Recreation resources in the Nimpkish DFA primarily involve campsites. These are accounted for in the netdown and no additional forest cover requirements for recreation resources are applied.

9.2.5 Wildlife

Wildlife habitat areas for ungulate range, Queen Charlotte goshawk territories, and marbled murrelet nesting habitat are reserved from harvest and accounted for in the netdown. For the purposes of timber supply analysis, no additional forest cover requirements are specified for wildlife habitat.

9.3 Timber Harvesting

9.3.1 Harvest Scheduling

Simulation models are rule-driven, and require harvest scheduling rules to control the order in which stands are harvested. In order to understand the impacts of the timber supply assumptions and constraints, it is important that these rules are able to organize harvest in a way that realizes the productive potential of the land base. Poorly designed harvest scheduling rules contain inherent constraints to harvest, which can either reduce or exacerbate the effect of intended constraints. Harvest scheduling is therefore fundamental to effective timber supply modeling.

Relative productivity scheduling, an innovative harvest rule that has recently been developed by FESL, will be used for the base case in this analysis. The relative productivity scheduling provides a more systematic and flexible approach to harvesting than other scheduling rules. Because this scheduling rule is recently developed, a sensitivity analysis will show base case harvest levels using the more commonly used relative oldest first rule. The two rules are discussed in more detail below.

"Relative oldest first" scheduling

The relative oldest first rule is a commonly used rule that will be used as a sensitivity analysis against relative productivity scheduling. In this rule, the age of a stand is related to its minimum harvestable age. Stands that have the greatest proportional difference between their actual age and their minimum harvest age are given priority for harvest, subject to forest cover requirements.

One of the main drawbacks of the relative oldest first rule is its dependence on high minimum harvest ages. Minimum harvest age has two roles in relative oldest first simulations: (1) Establish a minimum merchantable age below which harvest is not allowed; and (2) Provide a target age for harvest scheduling. These are conflicting roles. Setting minimum harvestable age at minimum merchantability can negatively impact growing stock in the long term because it allows persistent harvest below culmination age. On the other hand, setting MHA close to culmination age can constrain the medium term because it exacerbates the shortage of available volume at pinch points. Harvest flows are artificially constrained by the necessity to compromise between the two roles of MHA, which limits the ability of relative oldest first scheduling to realize the productive potential of the land base.

"Relative productivity" scheduling

Relative productivity scheduling is intended to address the problems associated with relative oldest first scheduling. Specifically, it schedules harvests strategically to maximize yields from each polygon and is independent of minimum harvest age. Relative productivity scheduling provides a more rational approach to harvest scheduling that better reflects the opportunities available to forest planners.

The premise of relative productivity scheduling is that the productivity of the future stand is the best indicator of when to harvest the existing stand on any given polygon. Culmination age is often thought of as the optimal time to harvest a stand if you're trying to maximize volume flows over the planning horizon. However, harvesting the current stand at culmination age is optimal only if the existing stand is on the same curve that it will regenerate to after harvest. This is not the case in TFL37: yields for natural and existing managed stands are usually quite different from future managed stand yields. In this situation, the culmination age of the existing stand is irrelevant to decisions of when to harvest that stand. What matters is the growth rate of the existing stand relative to the maximum growth rate of the future stand that it will regenerate to. A stand that is currently growing faster than the culmination growth rate of the future stand should be deferred from harvest until its growth rate has dropped to the level of the future stand. Conversely, a slow-growing stand that will be replaced by a fast-growing future stand should be harvested as soon as possible. Scheduling harvests according to the culmination volume of the regenerated stand instead of the existing stand should increase timber supply because it attempts to maximize volume production on each polygon over the course of the planning horizon.

The central concept is relative productivity: measuring the current growth of a stand based on the growth of the stand that will follow it. At any period *i* in the planning horizon, relative productivity (RP_i) can be expressed in terms of the current annual increment (CAI) of the existing stand and the culmination MAI of the future stand:

$$RP_i = CAI_i - culmMAI_{future}$$

Where:

CAI_i *is Current Annual Increment of the existing stand at cutting period* i
$CAI_i = (MAI_i - MAI_{i-1})/DeltaX$
DeltaX *is the length of the periods (e.g. 5 years)*
MAIi is the mean annual increment of the existing stand at period i
$culmMAI_{future}$ *is the culmination MAI of the future PHR stand*

When RP_i is >0, the existing stand is growing faster than the average growth rate of the future stands, and harvest should be deferred. When RP_i is <0, the existing stand is growing slower than the future stands, and this stand should be made eligible for harvest to realize the potential of the site. The relative productivity concept is illustrated in Figure 7.

The relative productivity concept is a rational basis for harvest scheduling. Harvesting stands with large negative RP_i values before stands with small-negative or positive RP_i values will realize more volume during the planning horizon. This scheduling strategy is called relative productivity because it prioritizes stands that are growing slowest relative to their future stand.

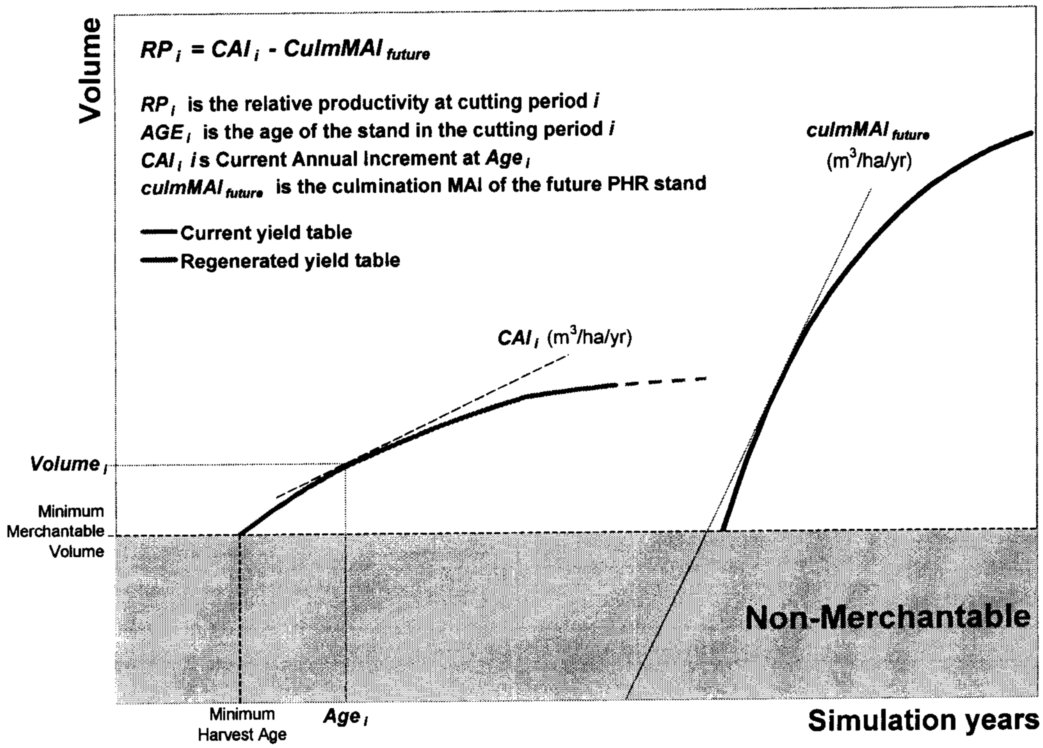


Figure 7: Illustration of the relative productivity scheduling rule[1].

9.3.2 Minimum Harvest Age

Minimum harvest age is the earliest age at which stands become eligible for harvest within the timber supply model. Minimum harvest ages can have a profound effect on harvest levels by creating acute timber supply shortages, or "pinch points", that constrain the rest of the planning horizon.

For this analysis, minimum harvest age is estimated as the earliest possible age that a forest stand meets the minimum merchantability criteria described in Table 49. In practice, most forest stands are harvested beyond the minimum harvest age due to economic considerations and constraints on harvesting which arise from managing for other forest values. The analysis will report on these criteria throughout the planning horizon.

[1] *In this example,* RP_i *is always negative, so the stand would be a priority for harvest as soon as it reaches minimum harvest age.*

Table 49: Minimum merchantability criteria used to determine minimum harvest ages[1].

Harvesting System	Net Volume (m^3/ha)	Average stem diameter (qDBH) (cm)
Ground	250	24
Cable	350	30

Minimum harvest age can also impact the harvest flow through the application of harvest schedule. As discussed in section 9.3.1, an advantage of relative productivity scheduling is that it is independent of minimum harvest age. Minimum harvest age under this rule can be considered the "bare minimum" that Canfor would harvest. Stands are targeted for harvest based on culmination age of future stands, but the model will be able to occasionally harvest stands below culmination age in order to meet volume targets during minor timber supply shortages. Using minimum merchantability criteria for determining minimum harvest age better reflects the flexibilities available to forest planners in real harvest scheduling situations. Accordingly, minimum harvest ages for each analysis unit are shown in Table 50 (natural stands), Table 51 (existing managed stands) and Table 52 (future managed stands). Culmination age is shown only as a reference.

Table 50: Minimum harvest age for natural stand yield tables.

Yield Table (names specify species composition and productivity)	Current THLB Area (ha)	Culm. MAI (m^3/ha/yr)	Culm. Age (yrs)	Ground Harvesting		Cable Harvesting	
				Minimum Harvest Age (MHA)	Volume at MHA (m^3/ha)	Minimum Harvest Age (MHA)	Volume at MHA (m^3/ha)
Old Natural Stand Yield Tables (>80 years old)							
2HS	60	6.9	65	40	263	50	373
3FH_vpoor	305	1.9	120	115	252	215	351
4FH_poor	513	3.2	105	75	265	100	373
5FH_med	513	4.3	90	55	264	80	441
6FH_good	257	5.4	85	45	281	70	524
7FH_vgood	252	8.3	75	35	253	55	538
8H_vpoor	223	1.2	175	165	252	250	351
9H_poor	1,491	1.6	155	105	258	150	381
10H_med	3,881	2.4	135	75	254	120	452
11H_good	5,707	3.5	110	60	264	100	518
12H_vgood	5,669	5.0	90	45	262	75	552
13CH_vpoor	3,141	1.2	150	160	256	250	350
14CH_poor	536	1.8	135	100	266	130	355
15CH_med	585	2.6	125	75	268	105	410
16CH_good	796	3.2	110	60	254	90	442
17CH_vgood	866	4.1	110	50	252	80	494
18D_vpoor	234	4.6	40	60	253	n/a	n/a
19D_poor	144	5.2	40	55	265	135	351
20D_med	135	5.8	50	45	260	65	358
21D_good	88	6.8	50	40	256	55	362
22D_vgood	92	8.1	45	35	265	45	360

[1] *Both criteria must be met for the stand to be merchantable.*

Yield Table (names specify species composition and productivity)	Current THLB Area (ha)	Culm. MAI (m^3/ha/yr)	Culm. Age (yrs)	Ground Harvesting		Cable Harvesting	
				Minimum Harvest Age (MHA)	Volume at MHA (m^3/ha)	Minimum Harvest Age (MHA)	Volume at MHA (m^3/ha)
23YH_vpoor	35	1.1	155	195	252	n/a	n/a
24YH_poor	477	1.3	155	125	255	180	353
25YH_med	2,123	1.7	145	100	261	135	365
26YH_good	1,796	2.4	130	75	255	110	416
27YH_vgood	1,761	3.2	115	60	266	95	486
28HFC_vpoor	548	1.4	155	155	255	235	351
29HFC_poor	680	2.2	135	100	260	130	355
30HFC_med	1,331	2.9	125	75	269	105	416
31HFC_good	1,231	3.8	110	60	277	90	480
32HFC_vgood	947	6.6	85	45	306	60	474
33PH	209	2.3	130	125	259	255	351
Transitional Natural Stand Yield Tables (40-80 yrs old)							
34PH	11	3.3	120	75	255	125	442
35CH_vpoor	0	0.6	165	110	265	150	358
36CH_poor	145	2.5	130	70	250	90	353
37CH_med	212	4.2	110	60	274	75	376
38CH_good	370	6.0	90	50	267	60	357
39CH_vgood	135	8.1	80	40	268	50	383
40HF_vpoor	124	1.9	145	130	258	190	355
41HF_poor	128	4.0	105	70	257	90	360
42HF_med	608	6.1	85	50	258	65	386
43HF_good	1,262	8.6	75	40	277	50	402
44HF_vgood	1,460	10.7	65	35	309	45	464
45FH_vpoor	45	2.1	120	100	255	145	354
46FH_poor	120	5.0	80	55	284	70	391
47FH_med	621	7.3	75	45	289	60	442
48FH_good	1,434	9.2	70	40	306	55	499
49FH_vgood	851	11.2	65	35	304	50	543
50D_vpoor	100	4.3		60	251	n/a	n/a
51D_poor	159	6.4	35	40	262	70	351
52D_med	84	6.9	40		276	45	
53D_good	102	8.2	40	35	286	45	383
54D_vgood	29	8.6	45	30	253	45	428
55YH_vpoor	0	0.4	250	170	252	280	351
56YH_poor	0	1.2	150	115	259	160	354
57YH_med	8	3.0	115	80	258	105	361
58YH_good	6	4.4	110	60	267	75	369
59YH_vgood	4	6.6	85	50	296	60	388
60H_vpoor	30	1.4	155	125	250	180	351
61H_poor	86	3.6	110	75	272	95	368
62H_med	649		80	50	276	65	403
63H_good	1,435	8.7	70	40	298	50	421
64H_vgood	1,897	10.9	60	35	329	45	481

Table 51: Minimum harvest age for existing managed stands.

Yield Table (names specify species composition and productivity)	Current THLB Area (ha)	Culm. MAI (m^3/ha/yr)	Culm. Age (yrs)	Ground Harvesting		Cable Harvesting	
				Minimum Harvest Age (MHA)	Volume at MHA (m^3/ha)	Minimum Harvest Age (MHA)	Volume at MHA (m^3/ha)
Existing Managed Stand Yield Tables (not CWHvm2)							
65SH	8	15.6	60	35	394	45	612
66HF_vpoor	397	2.2	120	95	293	190	524
67HF_poor	1,102	7.0	100	55	316	85	592
68HF_med	2,052	8.9	90	45	297	70	603
69HF_good	2,530	11.1	80	40	319	60	636
70	0	12.5	70	40	372	55	640
71HC_vpoor	317	2.7	140	85	307	145	555
72HC_poor	284	7	110	55	293	85	578
73HC_med	335	8.9	100	50	337	70	587
74HC_good	251	11.1	90	40	298	60	618
75HC_vgood	172	12.2	90	40	340	55	603
76YH_vpoor	50	2.3	150	125	277	260	520
77YH_poor	12	2.8	150	115	296	205	549
78YH_med	4	7.1	110	60	333	85	571
79YH_good	41	8.7	110	50	314	75	619
80YH_vgood	10	11.4	90	40	289	60	617
81PH	563	4.4	60	45	278	100	520
82H_vpoor	206	3.1	160	105	289	190	
83H_poor	1,261	6.1	110	65	338	100	620
84H_med	1,546	8.3		50	299	80	639
85H_good	2,716	10.9	90	45	363	65	669
86H_vgood	4	12.2	80	40	335	60	685
87FH_vpoor	1,018	2.4	120	95	291	180	517
88FH_poor	2,793	7.1	90	50	288	80	567
89FH_med	6,388	9.2	80	45	333	65	586
90FH_good	5,491	11.6		40	356	55	603
91FH_vgood	178	12.9	70	35	313	50	596
Existing Managed Stand Yield Tables (CWHvm2)							
92FH_vpoor	619	2.8	120	105	295	210	527
93FH_poor	686	3.7	110	85	304	150	541
94FH_med	367	4.7	110	70	295		558
95FH_good	2	5.7	100	60	286	100	567
96FH_vgood	340		90	55	315	85	590
97PH	1,041	2.5	100	50	287	90	497
98H_vpoor	1,416	3.3	160	95	290	170	583
99H_poor	844	4.7	140	80	318	130	608
100H_med	241	6.3	120	65	330	100	623
101H_good	178	7.9	100	55	330	80	607
102H_vgood	380	10.2	90	45	313	70	671
103HY_vpoor	735	3.5	150	95	300	160	574
104HY_poor	267	4.6	140	80	314	125	578

Yield Table (names specify species composition and productivity)	Current THLB Area (ha)	Culm. MAI (m^3/ha/yr)	Culm. Age (yrs)	Ground Harvesting		Cable Harvesting	
				Minimum Harvest Age (MHA)	Volume at MHA (m^3/ha)	Minimum Harvest Age (MHA)	Volume at MHA (m^3/ha)
105HY_med	5	6.3	120	65	324	100	619
106HY_good	55	7.9	110	55	324	80	603
107HY_vgood	16	10.6	100	45	309	65	602

Table 52: Minimum harvest age for future managed stands.

Yield Table (names specify climate and productivity)	Future THLB Area (ha)	Culm. MAI (m^3/ha/yr)	Culm. Age (yrs)	Ground Harvesting		Cable Harvesting	
				Minimum Harvest Age (MHA)	Volume at MHA (m^3/ha)	Minimum Harvest Age (MHA)	Volume at MHA (m^3/ha)
Future Managed Stand Yield Tables							
108CWH_marginal	55	1.4	60	60	256	n/a	n/a
109CWH_vpoor	47	4.1	100	55	255	75	356
110CWH_poor	2,069	6.6	90	55	334	80	546
111CWH_med	5,945	8.5	80	50	364	70	589
112CWH_good	32,629	12.9	70	40	412	55	680
113CWH_vgood	11,684	10.6	80	45	394	60	617
114CWH_great	3,276	13.6	80	40	416	55	
115CWHvm2_vpoor	323	2.1	120	90	255	165	469
116CWHvm2_poor	6,408	4.1	120	85	332	145	596
117CWHvm2_med	18,241	6.5	110	65	353	100	646
118CWHvm2_good	669	8.7	100	55	372	80	665
119MHmm1_poor	404	1.7	180	140	260	230	435
120MHmm1_med	8,286	3.0	155	115	319	205	588
121MHmm1_good	200	3.7	130	100	346	175	624

9.3.3 Initial Harvest Rate

The initial harvest rate for the Base Case will be the current AAC for the Nimpkish DFA, as shown in Table 53. This harvest rate is net of unsalvaged losses (section 8.1).

Table 53: Initial annual harvest rate

Volume Allocation [1]	Volume (m^3/year)	Percent
Canfor	942,763	88.3%
BCTS	79,585	7.5%
Other	45,652	4.3%
Current AAC	**1,068,000**	

[1] *Revised volumes expected following reallocation for forest revitalization act (Bill 28)*

9.3.4 Fixed Cutblocks

The simulation start year is January 1, 2002. Canfor has provided spatial data delineating depletions current to July 1, 2004. Depletions will be fixed for harvest in the base case to ensure that harvesting in the first period is consistent with depletions that occurred during 2002-2003. In addition, any planned cutblocks with an A, CP, or PA approval status will be fixed in the first and second simulation periods.

9.3.5 Harvest Flow Objectives

Several harvest flow objectives will be incorporated into the Base Case.

- Sustain the current harvest level until reductions are necessary for long-term sustainability;
- Where decreases in the harvest rate are necessary, volume harvested will decrease by no more than 10% per ten-year period; and
- Maintain even flow in the long term with a non-declining growing stock.

10 REFERENCES

B.C. Ministry of Forests 2001. *Vancouver Island Higher Level Plan Order, effective December 2000.* Victoria, Province of British Columbia.

B.C. Ministry of Forests, Forest Practices Branch. 1998. *Procedures for factoring visual resources in timber supply analyses.* Victoria, B.C. REC-029.

BC Ministry of Forests and Ministry of Environment, Lands and Parks 1995a. *Biodiversity Guidebook.* Forest Practices Code of British Columbia. Victoria: Province of British Columbia.

BC Ministry of Forests and Ministry of Environment, Lands and Parks 1995b. *Riparian Management Area Guidebook.* Forest Practices Code of British Columbia. Victoria: Province of British Columbia.

BC Ministry of Forests and Ministry of Environment, Lands and Parks 1999. *Landscape Unit Planning Guide.* Forest Practices Code of British Columbia. Victoria: Province of British Columbia.

Canadian Forest Products Ltd., 2001. *Sustainable Forest Management Plan: Canadian Forest Products Ltd. Coastal Operations—Nimpkish DFA.* Revised September 2002.

Canadian Forest Products Ltd., 2002. *Forestry Principles Implementation Plan: Coastal Region.*

J.S. Thrower & Associates Ltd. 2000. *Potential site index estimates for the major commercial tree species on TFL 37.* Contract report for Canadian Forest Products Ltd. March 31, 2000.

J.S. Thrower & Associates Ltd. 2003. *Yield Tables for Natural and Managed Stands: Management Plan 9 on TFL 37.* Contract report for Canadian Forest Products Ltd. September 26, 2003.

J.S. Thrower & Associates Ltd. 2004. *Tree Farm Licence 37 Vegetation Resources Inventory Statistical Adjustment-Version 3.0.* Contract report for Canadian Forest Products Ltd. June 3, 2004.

J.S. Thrower & Associates Ltd. 2004. *Tree Farm Licence 37 Net Volume Adjustment Factor Analysis-Version 2.0.* Contract report for Canadian Forest Products Ltd. June 3, 2004.

Pienaar, L.V. and J.W. Rheney.1995. Modeling stand level growth and yield response to silvicultural treatments. For. Sci. 41(3):629-638.

APPENDIX A: SITE INDEX ADJUSTMENT REPORT

J.S. Thrower & Associates Ltd. 2000. *Potential site index estimates for the major commercial tree species on TFL 37.* Contract report for Canadian Forest Products Ltd., March 31, 2000.

Potential Site Index Estimates for the Main Commercial Species on TFL 37

Final Report

Prepared for

Pat Bryant, RPF
Canadian Forest Products Ltd.
Englewood Division
Woss, BC

Project: CFW-011-007

31 March 2000

J.S. Thrower & Associates Ltd. *Consulting Foresters*
Vancouver – Kamloops – Victoria BC

Executive Summary

Potential site index (PSI) estimates were developed for Pacific silver fir (Ba), western red cedar (Cw), coastal Douglas-fir (Fdc), western hemlock (Hw), mountain hemlock (Hm), and yellow cedar (Yc) for the forested ecosystems on TFL 37. These PSI estimates will be used to generate managed stand yield tables for the next timber supply analysis for Management Plan 9.

PSI estimates were developed using four different methods:

1. statistical adjustment of ecologically-based preliminary site index estimates (in the CWHxm, CWHmm1, and CWHvm1),
2. elevation model (CWHvm2),
3. unadjusted preliminary PSI (MHmm1), and
4. localized site index conversion equations (for Ba and Cw throughout the TFL).

The main contribution of this project is that new PSI estimates are available at the eco-polygon level. This provides a spatial distribution of estimates across the TFL that will improve yield table data used in the timber supply analysis.

Adjustment Formula	Ba	Cw	Fdc	Hw
Inventory Avg Site Index (m)	21.1	17.7	30.5	20.3
Avg PSI (m)	21.8	21.7	32.0	23.1
Difference (m)	0.7	4.0	1.5	2.8
Difference (%)	3.2	22.6	4.9	13.8

The adjusted PSI estimates for the four main species (Fdc, Hw, Ba, and Cw) are between 5% and 20% higher than the current forest cover inventory site index estimates. The new PSI estimates should better reflect growth in PHR stands on TFL 37. These estimates should be monitored and updated as new information becomes available.

Table of Contents

List of Tables

List of Figures

1. INTRODUCTION

1.1 BACKGROUND

Site index is a function of height and age and is the most important variable used in models to develop yield tables. Traditionally, site index has been determined using photo-interpretation. However, photo-interpretation under-estimates site index in old-growth stands because tree damage is not visible on a photo and suppression is not accounted for. As well, photo-interpretation does not provide accurate height estimates for young stands (age class 1 and 2). On Canadian Forest Products Ltd. (Canfor) Tree Farm Licence (TFL) 37, more than 50% of the productive forested landbase (PFLB) is in age-class 8 and 9 and another 35% is too young to provide accurate site index estimates (Appendix I).

A site index project was completed on TFL 37 in 1997 to provide reliable potential site index (PSI) estimates for post-harvest regenerated (PHR) stands. After field sampling, the average PSI was estimated by species for three different productivity groups (low, medium, and high). The average PSI estimates can now be updated, and localized PSI estimates generated at the eco-polygon level. Accurate site index estimates are important to provide a realistic forecast of predicted yield for the upcoming timber supply analysis.

1.2 OBJECTIVE

The objective of this project was to:

> *Develop reliable PSI estimates for the main tree species on TFL 37 using relationships between height growth and biogeoclimatic site series on the PFLB.*

The main tree species are coastal Douglas-fir (Fdc), western hemlock (Hw), Pacific silver fir (Ba), western red cedar (Cw), mountain hemlock (Hm), and yellow cedar (Yc). Site index estimates will be applied at the site series level to develop reliable yield estimates for the timber supply analysis for Management Plan 9.

1.3 TERMS OF REFERENCE

This project was completed for Pat Bryant, *RPF,* of Canfor. The project was completed by Guillaume Thérien, *PhD,* Christie Staudhammer, *MSc,* and Céline Boisvenue, *MSc, RPF,* of J.S. Thrower and Associates Ltd. Funding for the project was provided through Forest Renewal BC.

2. METHODS

2.1 Overview

The final PSI estimates were developed in three phases:

Phase 1: **Preliminary PSI estimates** were developed for the major tree crop species and ecosystems on TFL 37 using the knowledge and experience of experts in coastal forest productivity and ecosystem classification.

Phase 2: **Field sampling** was completed to estimate actual site index in random plots throughout the TFL.

Phase 3: **Final PSI estimates** for the different species were developed using four different methods (Table 1):

1. Statistical adjustment of preliminary PSI estimates (AdjPSI) from field sampling,
2. Elevation model (Elev),
3. Unadjusted preliminary PSI (PPSI), and
4. MOF site index conversion equations (ConvEqn).

Table 1. Final PSI estimation method.

	Site	Adjustment Method					
Subzone	Series	Ba	Cw	Fdc	Hm	Hw	Yc
CWHxm, CWHmm1 & CWHvm1	All	ConvEqn	ConvEqn	AdjPSI		AdjPSI	
CWHvm2	02/10	ConvEqn	ConvEqn	AdjPSI		AdjPSI	
	Others	Elev	Elev	Elev		Elev	
MHmm1	All	PPSI			PPSI	PPSI	PPSI

2.2 Phase 1 – Preliminary PSI Estimates

Preliminary site index estimates were developed by Karel Klinka, *PhD, RPF,* Bob Green, *MSc, RPF,* Jim Thrower, *PhD, RPF,* and Pat Bryant, *RPF,* in 1997 for all site series in the PFLB (Appendix II). These experts used their collective knowledge of ecosystem classification and forest productivity attributes of the TFL as well as the SIBEC database to produce these estimates.

Table 2. Preliminary PSI estimates by species.

Spp	Area (ha)	Avg (m)	Min (m)	Max (m)
Ba	138,801	24.8	8.0	40.0
Cw	123,096	24.6	8.0	30.0
Fdc	122,355	31.3	18.0	43.0
Hm	21,079	12.4	8.0	18.0
Hw	144,174	24.7	8.0	32.0
Yc	21,079	12.4	8.0	19.0

The CWHmm1 subzone was established following the completion of the 1997 project. Site indices from the CWHxm were used to develop PSI estimates in the CWHmm1 because both subzones have similar productivity characteristics. Weighted average preliminary PSI estimates by species are provided in Table 2.

2.3 PHASE 2 – FIELD SAMPLING

2.3.1 Objective

The objective was to measure height and age of site trees to determine site index from a random sample of stands and ecological conditions in the TFL. The field site index estimates were then compared to the preliminary PSI estimates and a ratio developed to adjust the PSI estimates.

2.3.2 Target and Sample Populations

The target population was the PFLB (144,174 ha), and is where PSI estimates will be applied. The sample population consisted of all Fdc and Hw leading stands in age classes 2 to 6 in the CWHmm1, CWHvm1, and CWHxm subzone/variants (33,798 ha, 23% of PFLB) where reliable site index estimates could be obtained (Figure 1).[1] The MHmm1 variant was not included in the sample population as very few sampling opportunities existed in age class 2 to 6 in this subzone.

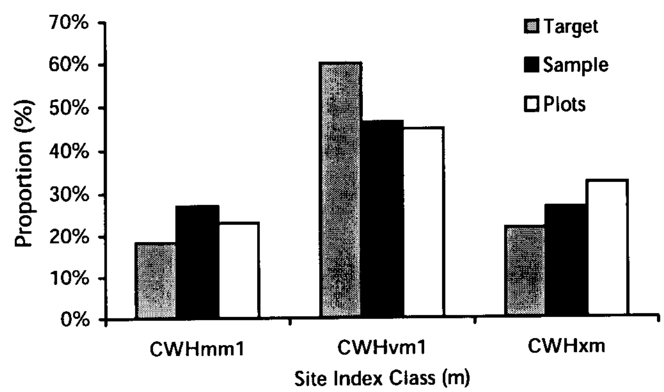


Figure 1. Area proportion (%) by BEC subzone in the target and sample populations, and the sample.

2.3.3 Sample Size and Allocation

Field sampling produced data from 87 400-m^2 (11.28-m radius) plots located throughout the CWHxm, CWHmm1, and CWHvm1 subzones/variants. Sample polygons were selected with probability proportional to area and a sample point was then randomly selected within each polygon. Universal Transverse Mercator (UTM) coordinates for the random points were estimated from field maps.

Ecological classification of the TFL has changed since field sampling and four additional plots are now located in the CWHvm2 variant. These four plots were removed from analysis since an elevation model was used to develop PSI estimates in the CWHvm2 variant. The remaining 83 plots were used in the adjustment process.

Site index estimates were also collected for Ba and Cw to construct localized site index conversion equations with Hw. Site index measurements were taken on 42 paired Ba and Hw site trees and 48 Cw and Hw pairs.

[1] J.S. Thrower & Associates Ltd. 1997. Canadian Forest Products TFL 37 Site Index BEC Map Unit Correlations Work Plan – Version 3.2. Unpublished Report, Contract No. CFW-011-002. 22 p.

2.3.4 Site Index

Site index was estimated from height and age measurements for the target species in each plot. Both target species were present in 17 of the 83 plots, for a total of 100 observations (53 Fdc and 47 Hw observations). Breast-height ages were adjusted to account for sampling during the growing season. Height growth was assumed to have started May 10 and ceased July 17. The average site index for the TFL was 35.6 m for Fdc and 28.5 for Hw (Table 3).

Table 3. Field site index statistics.

Spp	Subzone	N	Avg (m)	Min (m)	Max (m)	Std Dev
Fdc	CWHmm1	25	35.3	19.5	43.8	6.1
	CWHvm1	11	39.6	35.8	44.0	2.3
	CWHxm	19	33.7	24.8	40.0	4.4
	Total	*55*	*35.6*	*19.5*	*44.0*	*5.3*
Hw	CWHmm1	8	27.4	20.9	32.5	4.1
	CWHvm1	28	28.6	17.6	37.9	4.7
	CWHxm	14	29.0	19.9	33.9	5.0
	Total	*50*	*28.5*	*17.6*	*37.9*	*4.6*

Note: N is greater than 100 because five plots split across two subzones/variants.

2.4 PHASE 3 – FINAL PSI ESTIMATES

2.4.1 Statistical Adjustment

Adjusted PSI estimates were developed for Fdc and Hw in all site series in the CWHxm, CWHmm1, CWHvm1 subzones/variants. The preliminary PSI estimate for each eco-polygon in the sample population was adjusted using a ratio reflecting the relationship between preliminary PSI and field site index estimates. Two ratios were required for Hw since the direction of the observed bias in the preliminary PSI estimates was not consistent between the subzones. A single Fdc adjustment ratio was estimated because the adjustment ratios were similar in each subzone. The coefficients of the model were estimated using the least-squares method where each observation was weighted by the portion of the sample cluster area inside the eco-polygon[2].

2.4.2 Elevation Model

Experts in ecological classification and forest productivity recognize that forest productivity within a site series in the CWHvm2 variant generally decreases as elevation increases. For most site series in this variant, site indices were assumed to decrease linearly as elevations increased from 450 m (the limit between the CWHvm1 and CWHvm2 variants) to 1,000 m (the limit between the CWHvm2 and MHmm1 variants).

A maximum and minimum site index was required for each site series to develop the rate of decrease. A table was constructed of equivalent site associations between the CWHvm2, CWHvm1 (ending at 450 m), and MHmm1 (starting at 1,000 m, Appendix III). For a given site series in the CWHvm2, a rate of decrease was calculated between:

1. the adjusted PSI estimate in the corresponding CWHvm1 site association (max PSI), and
2. the unadjusted PSI estimate from the corresponding MHmm1 site association (min PSI).

[2] Weights were required because some clusters crossed eco-polygon boundaries.

However, there were exceptions in the use of the elevation method:

1. oooThe rates of decrease were developed for Ba and Hw only. The minimum site indices were not available because Fdc and Cw do not grow in the MHmm1 variant. Therefore, the rates developed for Hw were used to decrease the adjusted PSI estimate from the CWHvm1 variant for Fdc and Hw.
2. In site series CWHvm2/02 and CWHvm2/10, forest productivity is very low and likely will not be affected by changes in elevation. Therefore, the rate of decrease was assumed to be zero for all species within these two site series.
3. As the CWHvm2/09 does not have an equivalent site association in the CWHvm1 variant, the preliminary PSI estimate for CWHvm2/09 was used as the maximum site index for calculating the rate of decrease for Ba and Hw.

2.4.3 Unadjusted Preliminary PSI Estimates

Very few sampling opportunities existed in age class 2 to 6 in the MHmm1 variant (21,079 ha, 15% of the PFLB). Forest productivity in this variant was assumed not to be correlated to elevation since the range of productivity in the MHmm1 variant is already narrow and other climatic factors also influence productivity. For this variant, it was considered reasonable to use the unadjusted preliminary site index estimates.

2.4.4 Site Index Conversion Equations

A localized site index conversion equation was developed for Ba and Cw using Hw site index as the independent variable. The equation was applied to the CWHxm, CWHmm1, and CWHvm1 subzones/variants where the conversion field data was collected.

3. RESULTS

3.1 ADJUSTMENT STATISTICS

3.1.1 Fdc

The average adjusted Fdc PSI estimate for the CWHxm, CWHmm1, and CWHvm1 subzone/ variants was 34.4 m with a sampling error of ±1.2 m (Table 4). This represents a 6.6% increase from the preliminary PSI estimates (Figure 2). The final adjusted Fdc PSI estimates have shifted slightly upward compared to the preliminary estimates (Figure 3).

Adjusted Fdc SI = 1.066 * prelim Fdc SI

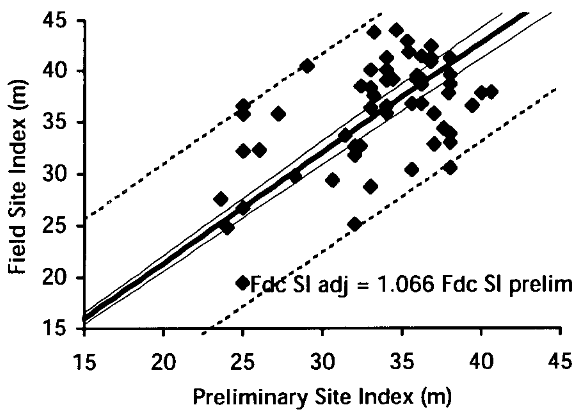


Figure 2. Field and preliminary site indices for Fdc (dashed line is 95% confidence interval of observations; thin solid line is 95% confidence interval of the ratio; weight is not represented).

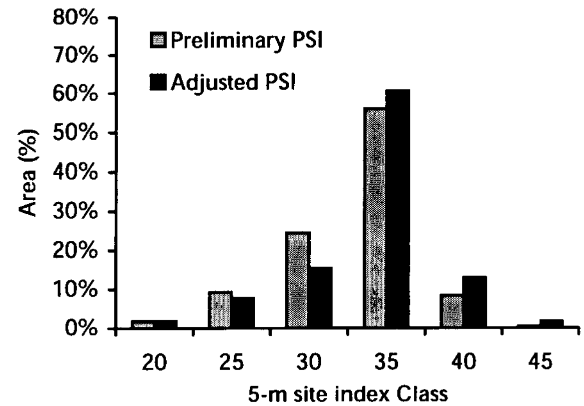


Figure 3. Fdc PSI distribution, before and after statistical adjustment.

Table 4. Statistical adjustment statistics.

Spp	Subzone/Variant CWH_	N[a]	Ratio	SE of ratio	CI of ratio (95%)	Avg Prelim PSI	Avg Adj PSI	SE of Adj PSI	CI of Adj PSI (95%)
Fdc	xm, mm1, & vm1	65	1.066	0.019	[1.030, 1.105]	32.3	34.4	0.6	[33.2, 35.7]
Hw	xm	17	1.159	0.056	[1.040, 1.278]	24.7	28.6	1.4	[25.6, 31.5]
	mm1 & vm1	47	0.970	0.023	[0.924, 1.016]	28.2	27.3	0.7	[26.0, 28.6]

a: N is greater than the number of sample plots because some plots crossed more than one eco-polygon.

3.1.2 Hw

The average adjusted Hw PSI estimate was 28.6 m (± 2.9 m) for the CWHxm and 27.3 m (± 1.3 m) for the CWHmm1 and CWHvm1 variants (Table 4). This is a 15.9% increase in the CWHxm and a 3.0% decrease in the CWHmm1 and CWHvm1 from the preliminary PSI estimates (Figure 4). The distribution of the final adjusted Hw PSI estimates shifted towards the 30-m class in the CWHxm subzone (Figure 5) and changed mainly in the 20 m and 25 m class in the CWHmm1 and CWHvm1 variants.

CWHxm:	Adjusted Hw SI	= 1.159 * prelim Hw SI
CWHmm1 and CWHvm1:	Adjusted Hw SI	= 0.970 * prelim Hw SI

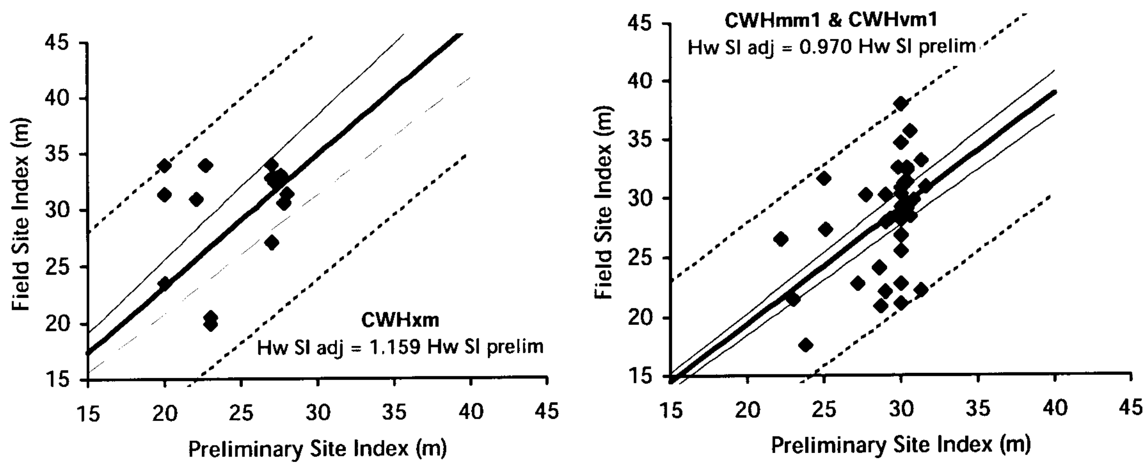


Figure 4. Field and preliminary site indices for Hw (dashed line is 95% confidence interval of observations; thin solid line is 95% confidence interval of the ratio; weight is not represented).

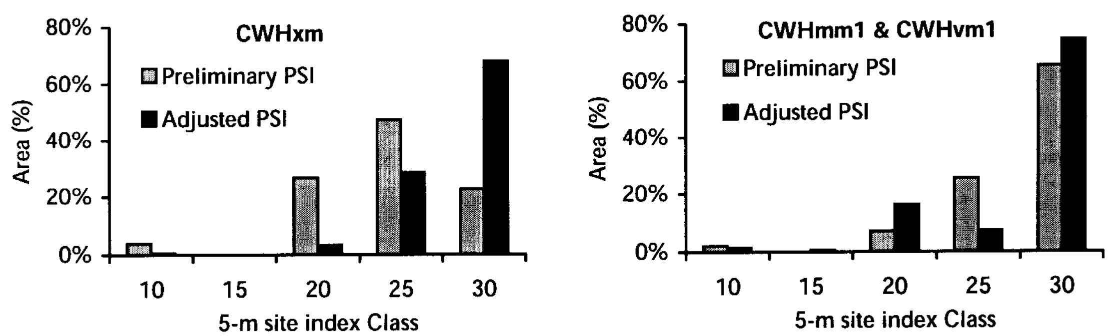


Figure 5. Hw PSI distribution, before and after statistical adjustment.

3.2 Elevation Model

The rate of decrease in forest productivity ranged from 2.0 m to 3.0 m per 100 m gain in elevation for Cw, Fdc, and Hw, and 1.3 to 2.5 m per 100 m gain in elevation for Ba (Table 5). The average site index for the site series where the elevation model was used was 18.8 m, 16.4 m, 26.8 m, and 19.5 m for Ba, Cw, Fdc, and Hw, respectively.

Table 5. Rate of decrease in productivity (m/100 m elevation gain).

Site Series	Ba	Hw, Fdc, Cw
CWHvm2/01	-2.0	-2.6
CWHvm2/01-poor	-1.3	-2.1
CWHvm2/01s	-1.3	-2.1
CWHvm2/03	-2.1	-2.6
CWHvm2/04	-2.5	-3.0
CWHvm2/05	-2.0	-2.6
CWHvm2/06	-2.2	-2.7
CWHvm2/06-poor	-2.2	-2.7
CWHvm2/06s	-2.2	-2.7
CWHvm2/07	-1.9	-2.4
CWHvm2/09	-2.0	-2.0
CWHvm2/11	-2.1	-2.6

3.3 Unadjusted Preliminary PSI Estimates

The unadjusted preliminary PSI estimates were used in the MHmm1 variant. The average site indices in this subzone were 12.9 m, 12.3 m, 12.3 m, and 12.4 m for Ba, Hw, Hm, and Yc, respectively. The MHmm1 variant was the only variant where Hm and Yc are crop species.

3.4 Site Index Conversion Equations

Site index conversion equations for Ba and Cw were built using site pair information collected during field sampling. These equations are:

$$\text{Adj PSI Ba} = -4.6 + 1.09 * \text{Adj PSI Hw}$$
$$\text{Adj PSI Cw} = 13.4 + 0.39 * \text{Adj PSI Hw}$$

These equations were used to calculate the final PSI estimates for Ba and Cw in the CWHmm1, CWHvm1, CWHxm subzone/variants. Using site index conversion equations, the average adjusted PSI estimates were 25.4 m for Ba and 24.1 m for Cw.

4. DISCUSSION

4.1 Target and Sample Populations

Normally, in a sampling design, the sample population is identical to the target population. However, in cases where the variable of interest (site index) cannot be measured throughout the target population, sampling is limited to a subset of the target population. The relationship between preliminary and field site index must be identical on a given ecological unit in the target and sample population to infer results from the sample population. This is considered a safe assumption as site series is independent of age and leading species, the criteria used to define the sample population (Figure 1).

4.2 Adjustment Ratio

There are many unbiased estimators of the relationship between preliminary and field site index estimates that can be used. The weighted least-squares method without intercept was considered the most appropriate estimator because the variation in field site index appeared constant across the range of preliminary PSI estimates.

The adjustment ratio for Hw in the CWHxm subzone appears to be high because the preliminary PSI estimates were based on the dry CWHxm subzone usually encountered on southern Vancouver Island. On northern Vancouver Island, the annual precipitation in the CWHxm subzone is higher, closer to what is typically observed in the CWHvm1 variant. Given the lower elevation of the CWHxm subzone, it is expected that the final PSI estimates are slightly higher in the CWHxm subzone than in the CWHvm1 variant after adjustment.

4.3 Variation Between Preliminary and Field Estimates

The adjustment ratios showed a high degree of variability, especially for Hw in the CWHxm subzone. This is expected since there are many sources of variation that cannot be controlled by the sampling design. There are four main sources of variation:

1. Within-site series variation.
2. Within-polygon variation.
3. Mapping error.
4. Different bias trends in the relationship between preliminary and field estimates.

4.3.1 Within-Site Series Variation

Forest productivity variation within a site series is the major source of variation in the relationship between PSI and field site index estimates. Site index on any individual site series can deviate by 2 to 3 m from the average site index due to local variation in environmental and climatic factors.

4.3.2 Within-Polygon Variation

There are approximately 185,523 ha (79% of the PFLB) of complex site series in the eco-polygons database. The preliminary PSI estimate for these eco-polygons is a weighted average of the preliminary PSI estimates for each site series within the polygon. If a sample cluster is established in an ecologically complex eco-polygon, the site series proportions within the cluster may differ from the site series proportions for the entire eco-polygon. This difference introduces variation in the relationship between preliminary PSI and field site index estimates.

4.3.3 Mapping Error

The ecological map was developed using photo-interpretation with ground truthing. Mapping from an aerial photo can be imprecise and some polygon lines or labels may not reflect the actual site series on the ground. Therefore, for plots established close to eco-polygon boundaries, the map polygon may be different from the ground polygon. This variation increases as mapping resolution increases and smaller polygons are delineated.

4.3.4 Different Bias Trends in the Relationship Between Preliminary and Field Estimates

Ideally, each species and site series combination has a unique adjustment ratio. However, this would make sampling too costly as each combination would require an independent sample. To reduce sampling costs, it is safe to assume that the same adjustment ratio applies to a group of site series. This assumption introduces a source of variation but is a reasonable compromise between sampling costs and precision.

4.4 Application in Timber Supply Analysis

The new PSI estimates should be slightly higher than the site index estimates in the current inventory database. For polygons where inventory site index estimates are reliable (age class 3 to 6), PSI estimates are the same for Hw-leading polygons, and about 10% higher for Fdc polygons (Table 6). There is not enough area in other leading species to be conclusive. The productivity increase is more pronounced when all polygons in the PFLB are considered (Table 7).

Table 6. Comparing current inventory to potential site index estimates (age class 3 to 6).

Spp	Area (ha)	Site Index Current	Site Index Potential	Difference (m)	Difference (%)
Fdc	3,197	31.7	35.2	3.6	11.2%
Hw	11,773	28.1	28.3	0.2	0.8%

Table 7. Comparing current inventory to potential site index estimates (entire PFLB).

Spp	Site Index Current	Site Index Potential	Difference (m)	Difference (%)
Ba	21.1	21.8	0.7	3.2%
Cw	17.7	21.7	4.0	22.6%
Fdc	30.5	32.0	1.5	4.9%
Hw	20.3	23.1	2.8	13.8%

Note: Hm and Yc only occur in the MHmm1.

The main contribution of this project is the spatial resolution of site index estimates for PHR stands for use in timber supply analysis. Previously, site index was assigned to an entire forest cover polygon. The new PSI estimates, developed at the eco-polygon level, create a more realistic estimate of spatial timber supply and should contribute to better planning and forest management.

5. CONCLUSIONS

1. **Use the new PSI estimates in the MP 9 timber supply analysis.**
   The final PSI estimates represent the best forest productivity estimates available for TFL 37. They should provide a more accurate estimate of the long-run sustained yield in future timber supply analysis. Thus, we recommend these estimates be used to generate the managed stand yield tables for existing and future PHR stands on the TFL for the timber supply analysis for MP 9.

2. **Update these PSI estimates frequently.**
   The PSI estimates reflect the best information currently available on TFL 37. However, these estimates should be updated regularly as old-growth stands are harvested and replaced with PHR stands. Silviculture surveys, monitoring plots, and special surveys and projects are potential sources of information.

3. **Improve site index estimates for higher elevation subzones.**
   PSI estimates at higher elevations were not based on field data because there are few areas to measure PSI accurately. The elevation model and unadjusted PSI should provide better information than is currently available in the inventory. However, we recommend that special studies be conducted to quantify forest productivity at higher elevations.

4. **Monitor the growth of PHR stands.**
   There is some uncertainty in the new PSI estimates resulting from the sampling and site index prediction methods. We recommend that PHR stands on the TFL be periodically monitored to ensure the PSI estimates and the associated growth and yield continue to adequately represent the actual conditions of the TFL.

APPENDIX I – TFL 37 LANDBASE

Location

Canfor's TFL 37 is located in the north central portion of Vancouver Island around the Nimpkish valley, northwest of Campbell River (Figure 6). The total landbase of the TFL is 190,668 ha of which 144,174 ha (76%) is the PFLB (Table 8). The allowable annual cut for the TFL is 1,068,000 m^3.

Figure 6. Location of TFL 37.

Table 8. Landbase description of TFL 37.

Description	Area (ha)
Entire TFL	190,665
Non-Forested	33,163
Forested	157,502
Non-Productive Forest	13,328
Productive Forest (PFLB)	144,174
NSR	531
Stocked	143,644

Forest Cover

The most important species on TFL 37 are Hw and Fdc, which occupy almost 75% of the productive landbase (Table 9). Yc, Ba, Cw), and Hm cover approximately 23%. Other species present include cottonwood (Ac), grand fir (Bg), alder (Dr), broadleaf maple (Mb), lodgepole pine (Pl), white pine (Pw), and Sitka spruce (Ss).

Almost half the productive landbase is in age class 9 (251 years or older), while approximately a third has been regenerated in the last 40 years. Only 13% of the productive landbase is between 41 and 140 years old. About 1,500 ha are regenerated every year.

Table 9. Species and age class distribution.

	Age Class									Total	
Spp	1	2	3	4	5	6	7	8	9	(ha)	(%)
Hw	12,481	6,211	5,927	4,615	747	484	1,520	3,290	39,006	74,281	51.7
Fdc	10,673	15,319	2,061	1,024	45	81	456	745	2,711	33,114	23.1
Yc	384	122	15	3	10		3	176	10,920	11,633	8.1
Ba	3,885	150	52	56	80	20	57	327	4,676	9,303	6.5
Cw	484	180	280	190	14	8	209	184	6,427	7,975	5.6
Hm	3	42	14	29	1		6	42	4,253	4,390	3.1
Dr	618	1,088	496	261	25	5	11	6		2,509	1.7
Pl	12	29	14	22		2	95	27	3	205	0.1
Ss	71	4		8		3		10	84	180	0.1
Pw	11	7								18	0.0

Bg	18									18	0.0
Ac			1	4				10		16	0.0
Mb		2								2	0.0
Total (ha)	*28,638*	*23,153*	*8,861*	*6,213*	*922*	*603*	*2,356*	*4,817*	*68,081*	*143,644*	
(%)	*19.9*	*16.1*	*6.2*	*4.3*	*0.6*	*0.4*	*1.6*	*3.4*	*47.4*		

Note: An extra 531 ha is considered NSR for a total PFLB area of 144,174 ha. The shaded area highlights age classes with reliable site estimates.

Ecological Classification

More than 85% of the PFLB (123,00 ha) is in the CWH biogeoclimatic zone, and the rest is in the MH zone (Figure 7). Within the CWH, the CWHvm1 and CWHvm2 variants occupy almost 75% of the area, the rest being split evenly between the CWHmm1 variant and the CWHxm subzone. The most common subzone/variants on the TFL are also the subzone/variants for which we have the most forest productivity information.

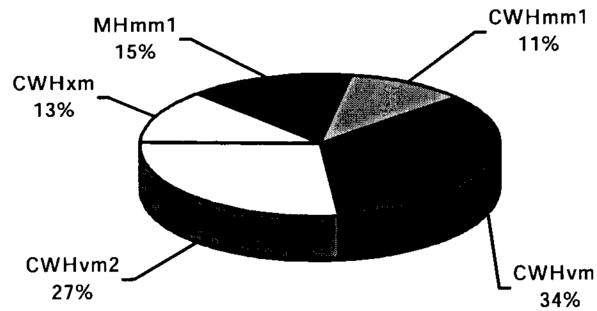


Figure 7. Area by subzone/variant.

APPENDIX II – PRELIMINARY SITE INDEX ESTIMATES

Table 10. Preliminary PSI estimates in the CWHmm1 and CWHxm.

	CWHmm1				CWHxm			
Site Series	Ba	Cw	Fdc	Hw	Ba	Cw	Fdc	Hw
01	28	27	32	29	30	25	33	27
01-poor	25	22	26	24	25	22	26	24
01s					25	22	26	24
02	10	11	18	10		12	20	12
03	21	22	25	22		20	25	20
04	23	23	28	22	26	22	28	22
05	30	28	35	30	36	26	37	28
06	31	28	33	31	30	28	34	28
06-poor	25	22	26	23	25	22	26	23
06s					25	22	26	23
07	35	30	38	31	40	28	40	28
08	35	30	38	31	40	28	43	28
09	40	28	43	28	40	28	43	28
11		10		10		8		8
12	18	22		20		22	24	23

Table 11. Preliminary PSI estimates in the CWHvm1 and CWHvm2.

	CWHvm1				CWHvm2			
Site Series	Ba	Cw	Fdc	Hw	Ba	Cw	Fdc	Hw
01	29	27	34	30	27	25	31	28
01-poor	25	23	26	25	23	21	24	23
01s	25	23	26	25	23	21	24	23
02	12	12	20	12	10	10	18	10
03	21	21	29	23	21	19	26	21
04	24	23	29	25	22	21	26	23
05	29	28	37	31	27	26	35	29
06	30	30	34	31	28	26	31	30
06-poor	23	22	26	23	21	20	24	21
06s	23	22	26	23	21	20	24	21
07	31	30	38	32	29	28	36	30
09	31	30	38	32	21	20	21	21
10	31	30	38	32	8	8		8
11					21	20	22	21
12	23	22		23				
13	8	8		8				
14	23	22	24	23				

Table 12. Preliminary PSI estimates in the MHmm1.

	MHmm1			
Site Series	Ba	Hm	Hw	Yc
01	16	15	15	15
01-poor	15	14	14	14
02	8	8	8	8
03	17	16	16	17
04	16	15	15	15
05	19	18	18	19
06	10	10	10	10
07	11	11	11	11
08	8	8	8	8
09	8	8	8	8
20	8	8	8	8
21	8	8	8	8
27	14	13	13	13

APPENDIX III – SITE SERIES EQUIVALENT AMONG CWHVM1, CWHMM2, AND MHMM1

Table 13. Site Series equivalent in the CWHvm1, CWHvm2, and MHmm1.

CWHvm1	CWHvm2	MHmm1
01	01	01
01-poor	01-poor	01
01s	01s	01
02	02	02
03	03	02
04	04	02
05	05	03
06	06	04
06-poor	06-poor	06
06s	06s	06
07	07	05
08	08	07
N/A	09	06
13	10	08
14	11	09

APPENDIX IV – ADJUSTED PRELIMINARY SITE INDEX ESTIMATES

Table 14. Adjusted PSI estimates.

	CWHmm1		CWHvm1		CWHxm	
Site Series	Fdc	Hw	Fdc	Hw	Fdc	Hw
01	34.2	28.1	36.3	29.1	35.2	31.3
01-poor			27.8	24.3	27.8	27.8
01s			27.8	24.3	27.8	27.8
02	19.2	9.7	21.4	11.6	21.4	13.9
03	26.7	21.3	31.0	22.3	26.7	23.2
04	29.9	21.3	31.0	24.3	29.9	25.5
05	37.4	29.1	39.5	30.1	39.5	32.5
06	35.2	30.1	36.3	30.1	36.3	32.5
06-poor			27.8	22.3	27.8	26.7
06s			27.8	22.3	27.8	26.7
07	40.6	30.1	40.6	31.0	42.7	32.5
08	40.6	30.1			45.9	32.5
09			40.6	31.0		
11		9.7				9.3
12		19.4		22.3	25.6	26.7
13				7.8		
14			25.6	22.3		

APPENDIX B: VRI STATISTICAL ADJUSTMENT REPORT

J.S. Thrower & Associates Ltd. 2004. *Tree Farm Licence 37 Vegetation Resources Inventory Statistical Adjustment-Version 3.0.* Contract report for Canadian Forest Products Ltd. June 3, 2004 (revised December 6, 2004).

Tree Farm Licence 37
Vegetation Resources Inventory
Statistical Adjustment

Version 3.1

Prepared for

Pat Bryant, RPF
Inventory Forester
Canadian Forest Products Ltd.
Englewood Division
Woss, BC

Project: CFW-019

June 3, 2004
(Revised December 6, 2004)

CANFOR

J.S. Thrower & Associates Ltd. *Consulting Foresters*
Vancouver – Kamloops, BC

Executive Summary

Canadian Forest Products Ltd. (Canfor) completed a Vegetation Resources Inventory (VRI) on Tree Farm Licence (TFL) 37. Eighty (80) VRI timber emphasis ground sample plots were randomly selected and installed in polygons considered economical or marginally economical for harvesting in the vegetated treed (VT) land base (128,590 ha, 67% of the TFL). However, only polygons 41 years and older were adjusted (93,498 ha, 49% of the TFL). Young (<41 years), non-vegetated, vegetated non-treed (VN) and VT polygons considered uneconomical for harvesting were left unadjusted. The adjusted volumes reported do not include the net volume adjustment factor (NVAF). NVAF volumes are reported in a separate document.

Following VRI adjustment, the overall average merchantable volume less decay, waste, and breakage was 345 m^3/ha for the entire TFL. The average volume was 662 m^3/ha in mature (polygons 61 years or older), economic and marginally economic polygons.

		2001 Volume (m^3/ha)	
Population	Maturity	Pre-Adjustment	Post-Adjustment
Adjusted	Mature	601	662
	All	575	629
Entire TFL	All	318	345

We recommend that Canfor use these adjusted site index, height, age, and volume estimates for the upcoming Sustainable Forest Management Plan 9 for TFL 37.

Table of Contents

List of Tables

List of Figures

1. INTRODUCTION

1.1 BACKGROUND

Canadian Forest Products Ltd. (Canfor) began implementing a Vegetation Resources Inventory (VRI) program on Tree Farm Licence (TFL) 37 in 1996. The TFL 37 VRI program was a four-phase process (Figure 1):

1. Phase I (unadjusted inventory data) - Attributes of all polygons are estimated using photo-interpretation;
2. Phase II (ground plot data) - Measurements are taken from randomly located ground samples;
3. Adjustment Phase - Phase I estimates are adjusted using the Phase II ground samples to give the preliminary adjusted VRI database; and
4. Net Volume Adjustment Factor (NVAF) Sampling - Random trees are selected for stem-analysis studies to develop adjustment ratios that correct taper and decay estimation bias. These ratios are then applied to the VRI database to obtain the final adjusted VRI database.

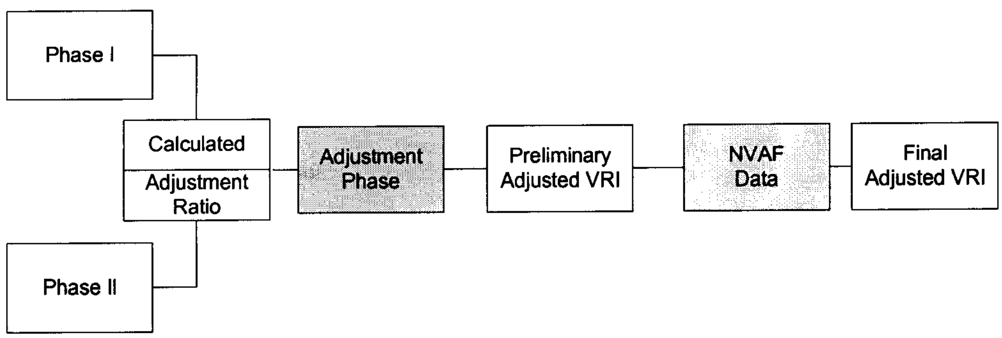


Figure 1. VRI program.

The VRI program used on TFL 37 deviated from a regular VRI program because the NVAF phase was completed after the preliminary VRI adjustment (completed using unadjusted Phase II data). Therefore, the NVAF adjustment was applied after the preliminary VRI adjustment. It should be noted that both methods yield exactly the same results.

Olympic Resource Management Ltd. (ORM) completed Phase I in 1997,[1] Phase II occurred during the 2000 and 2001 field seasons, and the preliminary statistical adjustment was completed in March 2002.[2] In this updated version of the preliminary statistical adjustment, ground volumes were re-compiled using the most recent Ministry of Sustainable Resource Management (MSRM) VRI compiler and regular VRI and VRI enhanced plots. The NVAF Sampling Phase was completed in December 2003 and the NVAF analysis was completed in May 2004. The NVAF analysis is not included in this report, and is discussed under separate cover.[3]

[1] Phase I was a retro-fit of a recent inventory to VRI standards.

[2] J.S. Thrower & Associates Ltd. 2002. Statistical adjustment of Tree Farm Licence 37 Vegetation Resources Inventory. Unpublished Report, Contract No. CFW-014, March 31, 2002. 6 pp.

[3] J.S. Thrower & Associates Ltd. 2004. Tree Farm Licence 37 Net Volume Adjustment Factor Analysis. Unpublished Report, Contract No. CFW-021, June 3, 2004. 13 pp.

1.2 Project Objectives

The objectives of this project were:

1. *To develop unbiased average inventory estimates of height, age, and net merchantable volume for the economic and marginally economic vegetated treed polygons, 41 years and older on TFL 37.*
2. *To develop polygon-level estimates of height, age, site index, and net merchantable volume.*

1.3 Terms of Reference

Pat Bryant, *RPF* of Canfor was the project leader. Guillaume Thérien, *PhD* of J.S. Thrower & Associates Ltd. (JST) completed the statistical adjustment and prepared this report.

2. METHODS

2.1 Study Area

TFL 37 is located on northern Vancouver Island, approximately 100 km north of Campbell River. The TFL covers 190,669 ha (Table 1), of which about 142,000 ha (75%) is Vegetated Treed (VT). The area sampled in Phase II was the economic and marginally economic area of the VT land base (128,590 ha, 67% of the TFL). The adjusted land base was the area where stand age was 41 years or older (93,498 ha, 49% of the TFL).

Table 1. TFL 37 land base net down statistics.

Description	Area (ha)	Area (%)
TFL land base	190,669	100
Non-Vegetated	34,655	18
Vegetated Non-Treed	13,721	7
Vegetated Treed (VT)	142,293	75
Uneconomic VT	13,703	8
Economic/Marginally Economic	128,590	67
Age <= 40 yrs	35,091	18
Age >= 41 yrs	93,498	49

2.2 Estimation Phase Data

ORM completed Phase I using 1996 aerial photography. The inventory was updated for depleted areas to December 2001. Age and height were projected to 2001. Crown closure and stocking class were not projected. Approximately 27% of the sampled land base (35,091 ha) was 40 years or younger. Attributes in these stands were assumed known without error and were left unadjusted. Inventory (1996) age was not photo-interpreted past 300 years, thus all stands older than this limit were labeled 300 years old. This is similar to labeling these stands as old-growth without estimating age. Hence, the adjusted land base was divided into two strata based on age: less than 300 years in 1996 (Young stratum, 67,545 ha) and 300 years in 1996 (Old stratum, 25,953 ha).

Phase I showed an average volume[4] of 575 m^3/ha for the adjusted land base (41 yrs and older), while the mature portion of the sampled land base (61 years and older) was 601 m^3/ha (82,044 ha). The average volume for the entire TFL was 318 m^3/ha.

[4] For the purpose of this project, Estimation Phase volume was defined as whole-stem volume minus stump (30 cm height), top (the section above a diameter inside bark of 10 cm), decay, waste, and breakage at a utilization level of 17.5 cm+. Volume was estimated using *VDYP version 6.6d*.

2.3 Ground Sampling Phase Data

Eighty (80) VRI ground sample plots were established in the 2000 and 2001 field seasons. Nine of the originally selected plots were replaced because they were located in previously harvested cut-blocks (therefore, vegetated non-treed). One original plot location was relocated for safety reasons; a second plot was dropped for safety and replaced with another plot as a similar plot location could not be found in the selected polygon. The remaining 69 plots were established at their original locations.

Forty (40) plots were sampled in each of the two sampling seasons; however, we assumed that all plots were sampled in 2001 for this study. One plot was rejected because it was now in a non-vegetated polygon and 19 plots were in stands between 0 and 40 years. This left 60 plots for analysis: 21 in the Young stratum and 39 in the Old stratum.

The sample was distributed evenly across the target population. Therefore each plot represented the same area/plot and had the same sampling weight.

2.4 Statistical Adjustment

The MSRM standards and procedures for attribute adjustment were modified for this statistical adjustment.[5] Site index, not height, was adjusted in both strata. Canfor considered the adjustment of site index more important than height. Adjusted height was derived from adjusted age and adjusted site index. Age in the Old stratum was not available; the average ground age was therefore used as the adjusted age for all stands in that stratum. For stands in the Young stratum, a confidence index (CI) was computed based on age:

$$CI = 9 - 6 \times \frac{(age - 40)}{(305 - 40)}$$

and used in the statistical adjustment. The CI decreased linearly from 9 at age 40 to 3 at age 305 and is a measure of the reliability of the Phase I attributes (with 9 meaning known without error). Phase I attributes in the Old stratum were all assumed to have the same reliability and therefore did not require a CI estimate.

The NVAF ratio estimation and application were completed in May 2004, under a separate cover.[3] Therefore, volumes presented in this report do no include the NVAF adjustment.

[5] Ministry of Sustainable Resources Management. 2001. Vegetation Resources Inventory Attribute Adjustment Procedures. Draft Version 4.4, April 2002. 36 pp.

3. RESULTS AND DISCUSSION

3.1 OVERVIEW

The MSRM assumes that the Estimation Phase inventory volume is biased due to two sources of error: an attribute bias associated with the photo-interpreted height and age, and a model bias inherent to the growth and yield model used to estimate volume (*VDYP version 6.6d*).

The attribute adjustment procedure was a two-step process. In the first step, the Estimation Phase site index and age bias were corrected using the adjustment ratio estimated from the ground and the Estimation Phase site index and age and the confidence index. Adjusted height was then derived using adjusted site index and adjusted age. An attribute-adjusted volume was then estimated using VDYP. In the second step, the model bias in the attribute-adjusted volume was corrected using the adjustment ratio estimated from the ground and the attribute-adjusted volume. All adjustment ratios were estimated using the ratio of means (ROM) method following MSRM standards.

3.2 SITE INDEX AND AGE

Fifty-eight (58) plots had data for a species that matched the leading species in the Estimation Phase using the MSRM criteria.[6] One Old stratum plot was dropped from the analysis because the Estimation Phase and ground data did not come from the same layer in the two-layered stand. No age (and no site index) was measured on one plot in the Young stratum and on two plots in the Old stratum and no height (and no site index) was estimated on seven plots in the Old stratum.

Phase I site index tended to be over-estimated while Phase I age was under-estimated (Table 2). The relationship between ground and Estimation Phase site index was slightly better than the age relationship (Figure 2 to Figure 3). The sampling error was about 14-15% for site index, and 16-18% for age.

Table 2. Site index and age adjustment statistics for economic and marginally economic polygons, 41 years and older, in the TFL 37 VT area.

		Population		Sample					Adj. Pop.	
Attribute	Stratum	Area (ha)	Avg	Size	Ground Avg	Est Avg	ROM	R^2	Avg	E[a]
Site Index (m)	Young	25,953	26.4	20	22.7	23.5	0.966	56%	24.6	14%
	Old	67,545	12.4	29	11.8	14.7	0.802	59%	11.7	15%
Age (yrs)	Young	25,953	92.9	20	138.6	112.1	1.236	76%	110.2	18%
	Old	67,545	N/A	36	436.8	N/A	N/A	N/A	436.8	16%

[a] E is sampling error.

[6] First, a match was attempted at the species level (case 1); second at the genus level (case 3); and third at the conifer/deciduous level (case 5). No height/age for the second species was available in the inventory.

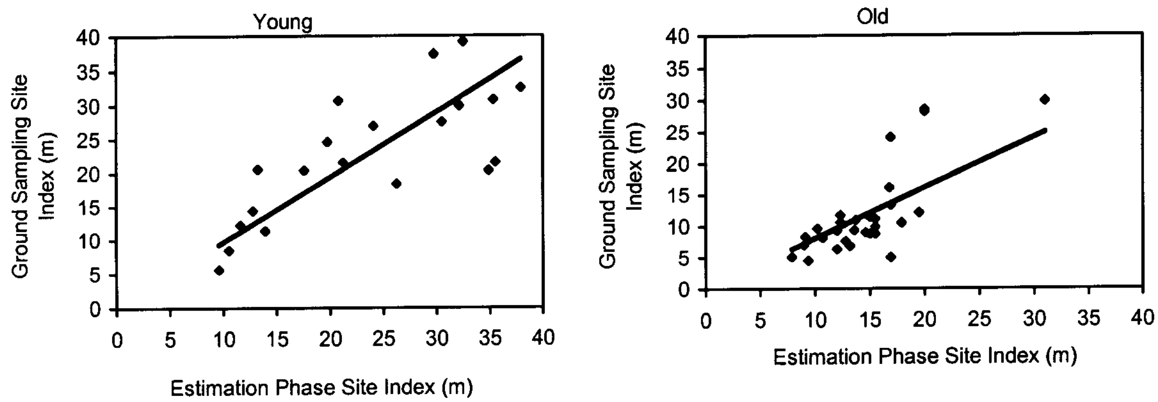


Figure 2. Ground sampling vs. Estimation Phase site index by stratum.

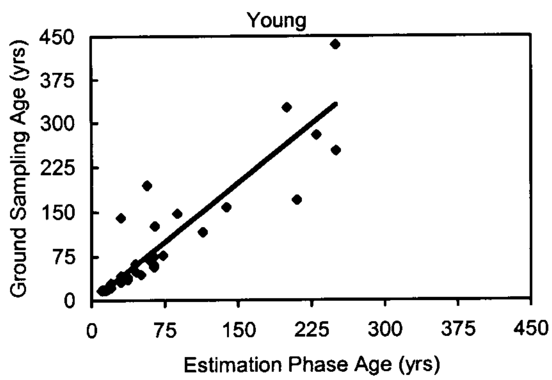


Figure 4. Ground sampling vs. Estimation Phase age (Young stratum).

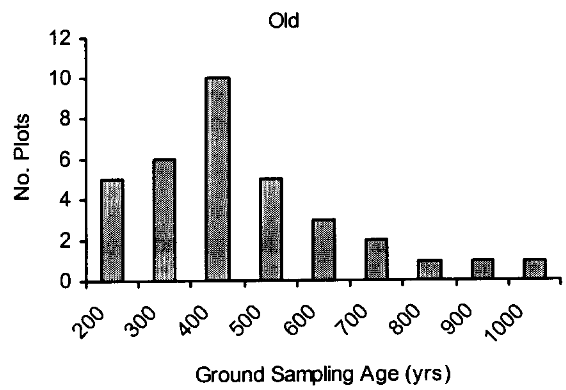


Figure 3. Distribution of ground sampling age (Old stratum).

3.3 Volume

An attribute-adjusted volume was generated with VDYP using the Phase I attributes and the adjusted site index and age. The average attribute-adjusted volume for the adjusted land base was 483 m^3/ha (Table 3). Before adjusting height and age, the Phase I volume was 575 m^3/ha. Therefore, the height and age correction resulted in a 16% decrease to Phase I volume (from 575 to 483 m^3/ha). The attribute-adjusted volume tended to over-estimate ground volume in the Young stratum but largely under-estimated volume in the Old stratum (Figure 5). On average, the attribute-adjusted volume under-estimated ground volume by approximately 29% (total sample ground average [604.8 m^3/ha] / overall sample map average [467.4 m^3/ha]). The adjusted volume for the land base was approximately 9% higher than the original Phase I volume (from 575 to 629 m^3/ha).

Table 3. Volume adjustment statistics for economic and marginally economic polygons, 41 years and older, in the TFL 37 VT area.

Stratum	Population Area (ha)	Population Avg (m^3/ha)	Sample Size	Sample Ground Avg (m^3/ha)	Sample Map[a] Avg (m^3/ha)	Sample ROM	Sample R^2	Adj. Pop. Avg (m^3/ha)	Adj. Pop. E (m^3/ha)
Young	25,953	486.8	21	461.2	498.1	0.926	22%	450.8	24%
Old	67,545	481.6	39	659.9	455.6	1.449	51%	697.7	13%
Total	*93,498*	*483.0*	*60*	*604.8*	*467.4*	*1.294*		*629.2*	*12%*

[a] Map average is the attribute-adjusted volume.

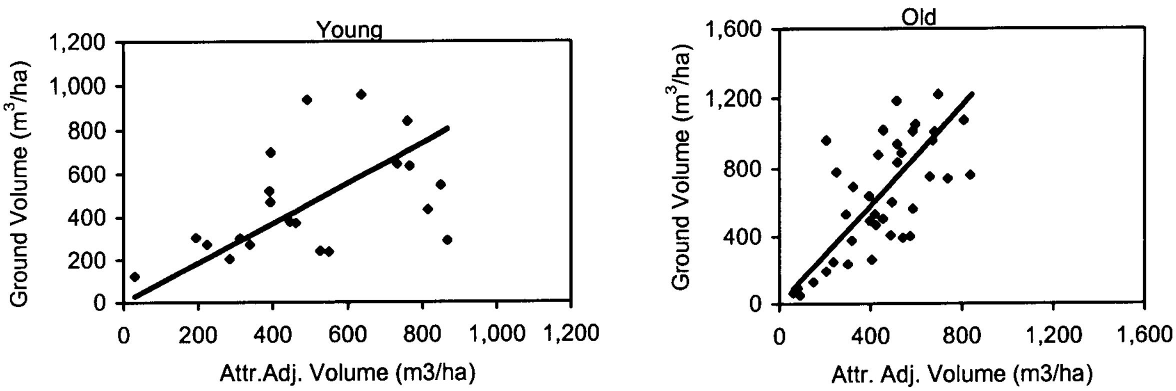


Figure 5. Ground vs. attribute-adjusted volume for the economic and marginally economic polygons, 41 years and older, in the TFL 37 VT area.

When only the mature adjusted land base was considered, the average adjusted volume was 662 m^3/ha, an increase of 10% compared to the corresponding Phase I volume (Table 4). The overall average adjusted volume was 345 m^3/ha for the entire TFL land base.

Table 4. Phase I and adjusted volumes.

Population	Maturity	Est. Phase Area (ha)	Est. Phase Volume (m^3/ha)	Adjusted Pop. Area (ha)	Adjusted Pop. Volume (m^3/ha)	Diff %
Adjusted	Mature	82,044	601	82,601	662	10
	All	93,498	575	93,498	629	9
Entire TFL	All	190,669	318	190,669	345	8

The sample was originally selected across four strata, defined based on age and operability. These four areas were

- A: economic areas less than 100 years old;
- B: economic or marginally economic areas between 100 and 249 years old;
- C: economic areas 250 years and older, and
- D: marginally economic areas 250 years and older.

Table 5. Unadjusted and adjusted volumes by the original strata used for sample selection.

Adjusted	Strata	Area (ha)	Volume (m^3/ha) Est. Phase	Volume (m^3/ha) Adjusted	% Difference
Yes	A	19,909	454	453	0%
	B	4,913	597	475	-20%
	C	48,509	716	823	15%
	D	20,168	348	374	7%
	Total	93,498	575	629	9%
No	A	35,091	114	114	0%
Total	*Total*	*128,590*	*449*	*488*	*9%*

Since most of the volume gain took place in the old-growth polygons, volume in strata C and D increased by 7 and 9%, respectively (Table 5). The volume in stratum A remained the same while the volume in stratum B, the smallest stratum, decreased by 20%.

4. CONCLUSION

In this project, we adjusted the TFL 37 VT economic and marginally economic polygons using random ground observations. We recommend that:

> Canfor use the adjusted age, site index, height, and volume for the upcoming Sustainable Forest Management Plan 9 for TFL 37.

APPENDIX C: NVAF FINAL REPORT

J.S. Thrower & Associates Ltd. 2004. Tree Farm Licence 37 Net Volume Adjustment Factor Analysis--Version 2.0. Contract report for Canadian Forest Products Ltd. June 3, 2004.

Tree Farm Licence 37
Net Volume Adjustment Factor Analysis

Version 2.0

Prepared for

Pat Bryant, RPF
Canadian Forest Products Ltd.
Englewood Division
Woss, BC

Project: CFW-021

June 3, 2004

J.S. Thrower & Associates Ltd. *Consulting Foresters*
Vancouver – Kamloops, BC

Executive Summary

Canadian Forest Products Ltd. (Canfor) completed Net Volume Adjustment Factor (NVAF) ground sampling in 2002 and 2003 on Tree Farm Licence (TFL) 37. The NVAF sampling and analysis is a required component of the provincial Vegetation Resources Inventory (VRI) program. The NVAF uses destructive sampling to derive the true volume of the sample trees. This information is then used to adjust the bias in VRI volume due to taper equations and decay estimation methods.

Seventy-nine (79) trees were sampled. An NVAF adjustment ratio was computed for three species groups:

1. Dead trees;
2. Live, Douglas-fir (F) mature trees, and
3. All other live trees (non F-mature).

The adjustment ratios varied significantly across these three groups:

Species Group	Sample Size	NVAF Ratio
Dead	10	0.90
Live F-mature	9	1.19
Live Others (non F-mature)	60	1.01
Live Total	*69*	*1.03*

This means that there is approximately 3% more live net merchantable volume (whole-stem volume less top, stump, decay, and waste) on TFL 37 than indicated in the preliminary VRI adjusted database. This corresponds to a volume increase of 18 m^3/ha.

The 95% sampling error of the overall NVAF adjustment ratio for live volume was 5.5%. Therefore, we are 95% confident that the true NVAF ratio is between 0.97 and 1.09.

We recommend that the TFL 37 VRI database be corrected to reflect the information provided by the NVAF analysis.

This page is intentionally left blank.

Table of Contents

List of Tables

List of Figures

1. INTRODUCTION

1.1 BACKGROUND

Canadian Forest Products Ltd. (Canfor) began implementing a Vegetation Resources Inventory (VRI) on Tree Farm Licence (TFL) 37 in 1996 to comply with the Ministry of Sustainable Resource Management's (MSRM) provincial inventory standard. The VRI program is a four-step process:

1. Phase I (unadjusted inventory data) - Attributes of all polygons are estimated using photo-interpretation;
2. Phase II (ground plot data) - Measurements are taken from randomly located ground samples;
3. Adjustment Phase - Phase I estimates are adjusted using the Phase II ground samples to give the preliminary adjusted VRI database; and
4. Net Volume Adjustment Factor (NVAF) Sampling - Random trees are selected for stem-analysis studies to develop adjustment ratios that correct taper and decay estimation bias. These ratios are then applied to the VRI database to obtain the final adjusted VRI database.

Olympic Resource Management (ORM) completed Phases I and II for Canfor in 1997 and 2001, respectively. A preliminary NVAF sample was collected in 2002 by R.G. Mecredy Cruising & Forest Consulting and analyzed by J.S. Thrower & Associates Ltd. (JST) in March 2003.[1] In August 2003, Canfor decided to sample additional NVAF trees to increase the confidence in the NVAF. The NVAF adjustment ratios developed in this report will be used to finalize the adjusted VRI database.

1.2 OBJECTIVES

The objectives of this project were to:

1. *Determine the NVAF ratios for the different species groups on TFL 37.*
2. *Estimate the impact of the NVAF adjustment on the preliminary VRI adjusted inventory.*

1.3 TERMS OF REFERENCE

JST completed this project for Pat Bryant, *RPF* of Canfor. Guillaume Thérien, *PhD* was the JST analyst. Funding was provided through Canfor's Forest Investment Account allocation. The original version of this report was submitted to Canfor in March 2004; however, data problems were identified and have been corrected in this updated version (2.0).

[1] J.S. Thrower & Associates Ltd. 2003. Tree Farm Licence 37 Net Volume Adjustment Factor Analysis. March 31, 2003. Unpublished Report. Project No. CFW-018. 11 pp.

2. METHODS

2.1 Study Area

TFL 37 is located on northern Vancouver Island, approximately 100 kilometres north of Campbell River. The TFL covers 190,669 ha (Table 1), of which about 142,000 ha (75%) is Vegetated Treed (VT). The sampled land base was the economic and marginally economic area of the VT land base (128,590 ha, 67% of the TFL). The adjusted land base was stands 41 years and older (93,498 ha, 49% of the TFL).

Table 1. TFL 37 land base net down statistics.

Description	Area (ha)	Area (%)
TFL land base	190,669	100
Non-Vegetated	34,655	18
Vegetated Non-Treed	13,721	7
Vegetated Treed (VT)	142,293	75
Uneconomic VT	13,703	8
Economic/Marginally Economic	128,590	67
Age <= 40 yrs	35,091	18
Age >= 41 yrs	93,498	49

An accurate description of the volume composition on TFL 37 was determined from the 80 VRI ground samples (Phase II data) completed in 2000/2001. The immature component of the TFL (<100 years at sampling time) represents approximately 20% of the TFL volume (Figure 1). Most of the immature volume is either hemlock (H) or Douglas-fir (F). The mature component (80% of the total estimated net merchantable volume) is a mixture of mainly H, F, balsam (B), and yellow cedar (Y). Cedar (C) and minor species are also present.

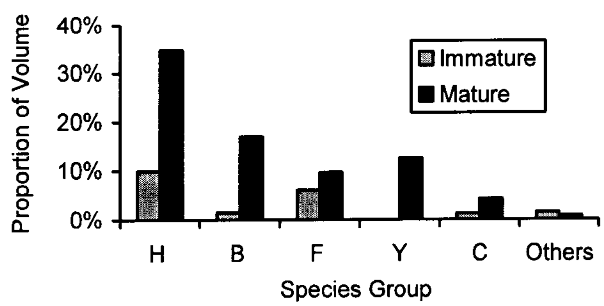


Figure 1. Distribution of ground volume by species group and maturity class.

Approximately two thirds of the volume on the TFL is from trees 25 to 75 cm in diameter at breast height (DBH), while about 15% comes from trees 95 cm or larger (Figure 2).

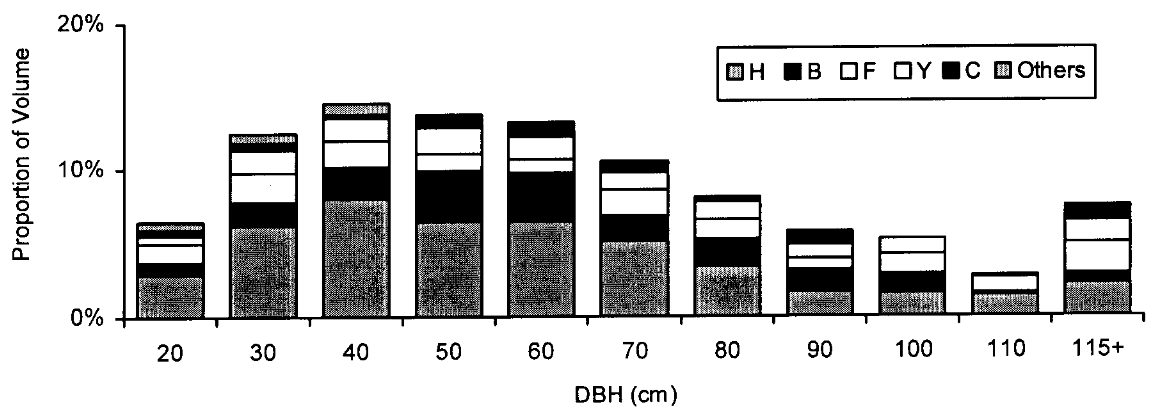


Figure 2. Distribution of ground volume by species group and tree size.

2.2 Sample Distribution

Canfor's initial objective was to distribute the NVAF sample of live trees proportionally to each species' volume in the population. However, following discussion with the MSRM, it was decided to disproportionately sample F trees (28% in the sample versus only 16% in the population) to address a concern that the NVAF ratio adjustment for F trees might not be constant across all ages.[2] The B and C species groups were under-sampled to address this initiative (Table 2). The sample size for dead trees was arbitrarily set at 10 trees.

Table 2. Distribution of live trees in the TFL 37 population and sample by species.

Species	Population	Sample
H	44%	43%
B	19%	12%
F	16%	28%
Y	13%	12%
C	6%	3%
Others	3%	3%

2.3 Sample Selection

The NVAF sample of live trees for this project was selected in two batches. The MSRM selected the first batch and JST selected the second. Seventy-nine trees (69 live and 10 dead) were selected in total (Table 3).

Table 3. Distribution of TFL 37 NVAF sample trees by maturity class and species group.

Status	Maturity	H	B	F	Y	C	Others	Total
Live	Immature	8	0	10	0	0	2	20
	Mature	22	8	9	8	2	0	49
	Total	*30*	*8*	*19*	*8*	*2*	*2*	*69*
Dead	Immature	2	0	0	0	0	1	3
	Mature	2	0	0	3	0	2	7
	Total	*4*	*0*	*0*	*3*	*0*	*3*	*10*
All	*Immature*	*10*	*0*	*10*	*0*	*0*	*3*	*23*
	Mature	*24*	*8*	*9*	*11*	*2*	*2*	*56*
	Total	*34*	*8*	*19*	*11*	*2*	*5*	*79*

Will Smith, *RPF* (MSRM – Terrestrial Information Branch) selected all dead trees and the first batch of 50 live trees. The sample selection followed a stratified sampling approach. Live trees were stratified by economic status[3] and species group, and trees within each stratum were systematically selected with a random start from a list sorted by DBH. Dead trees were randomly selected within each economic status.[4]

JST selected the second batch of 19 live trees also following a stratified sampling approach. Trees were stratified by species group, elevation class, and DBH class and selected randomly within each stratum (Appendix I, Table 12).

Five selected F trees from batch 2, all in cluster 85, were rejected for safety reasons and needed replacement; however, only one potential F replacement tree was available in the original NVAF tree list. Hence, four new F trees were selected from all trees located in auxiliary plots that had not been NVAF-enhanced during initial ground sampling. There were 20 clusters with 84 F trees available for further sampling. After consultation with Will Smith, two clusters (cluster 23 and 96) were randomly selected. The four trees were randomly selected from a list of 17 F trees in these two clusters, resulting in three trees from cluster 96 and one tree from cluster 23.

---

[2] J.S. Thrower & Associates Ltd. 2003. Tree Farm Licence 37 Net Volume Adjustment Factor Sampling Second Phase – Sample Plan. Unpublished Report, Contract No. CFW-021, August 13 2003. 9 pp.

[3] Economic status is a Canfor internal polygon-level attribute used to describe the economic potential of a stand.

[4] Will Smith, personal communication, July 29, 2003.

In addition, due to harvesting, four of the selected trees were no longer available for NVAF sampling when the crew returned to the field (Table 4). Therefore, these four trees were replaced by trees of the same species and similar size in the vicinity of the plot. These trees were considered as replacements for a non-response (similar to replacing a VRI plot location for safety reasons). Sampling weights for these four replacement trees were assumed to remain identical to those computed for the original trees.

Table 4. Tree data for original and replacement trees.

Cluster	Plot	Tree	Spp	Original DBH (cm)	Original Height (m)	Replacement DBH (cm)	Replacement Height (m)
35	E	1	F	78.3	57.3	75.0	59.4
35	E	7	F	139.1	60.9	143.2	69.1
35	E	8	F	113.3	61.3	119.9	66.0
43	N	2	B	76.0	39.8	69.7	36.0

2.4 Analysis

2.4.1 Overview

JST computed the sampling weight and the actual and predicted net merchantable tree volumes[5] for all trees (Appendix I). JST computed the actual volumes using the NVAF compiler provided by the MSRM. Sampling weights were estimated using the method recommended by the MSRM.[6] All sampling weights, predicted volumes, and actual volumes are given in Appendix I.

It should be noted that the MSRM has modified their NVAF analysis standards since the project analysis stage began. However, we decided to analyze the data using the original method since it corresponds to the NVAF design proposed by the VRI design committee.

Statistical and graphical analyses were used to determine those groups of trees that had statistically similar NVAF ratios. These groups were based on pre-stratification rules, expert knowledge, and statistical tests. Adjustment ratios were computed for three species groups:

1. Dead trees;
2. Live F-mature trees, and
3. Live (non F-mature) trees.

2.4.2 Elevation Analysis

The preliminary NVAF analysis[1] indicated that H trees may have different adjustment ratios below and above 1,000 m. However, analysis of the entire NVAF sample showed that the adjustment ratios were similar in both elevation strata; therefore, stratifying by elevation was not required.

[5] For this report, net merchantable volume is whole-stem volume less top, stump, cruiser-called decay and waste.

[6] Sit, Vera. 2002. Net volume adjustment ratio based on inclusion probability. Unpublished draft document, April 18, 2002.

3. RESULTS & DISCUSSION

3.1 Dead Trees

3.1.1 Net Merchantable Volume

Ten dead trees were selected for NVAF analysis. Both actual and predicted net merchantable volumes were zero in three of the sample trees. A net merchantable volume was predicted for two trees with an actual volume of zero (Figure 3). This inflated the 95% sampling error to ± 34%. The net merchantable volume showed a bias of approximately 10%. Therefore, the NVAF ratio for dead net merchantable volume (with relative 95% sampling error) was:

Net Merchantable Dead NVAF = 0.898 ± 0.307 (34%)

3.1.2 Whole-stem Volume

The taper equations over-estimated the true whole-stem volume of dead trees by approximately 7% on average (Figure 3). This over-estimation was very consistent across the range of observed volumes. This consistency led to a small sampling error. The NVAF ratio for dead whole-stem volume (with relative 95% sampling error) was:

Whole-stem Dead NVAF = 1.069 ± 0.143 (13%)

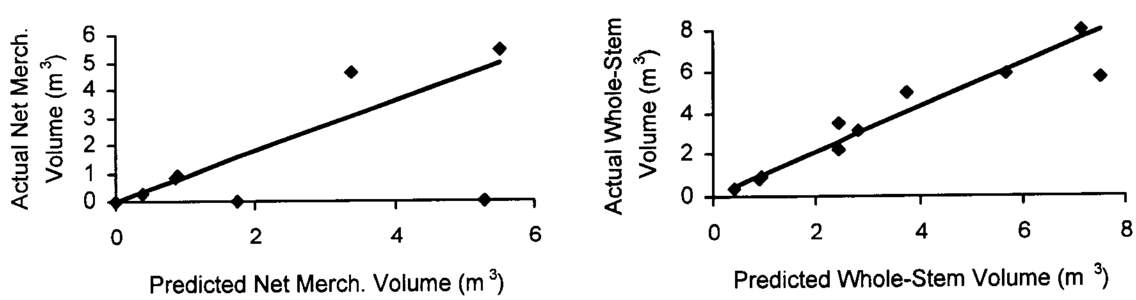


Figure 3. Actual versus predicted net merchantable and whole stem volume for dead trees on TFL 37.

3.2 Live NVAF Ratio Overview

The NVAF ratios and sampling errors were computed by species group, maturity class, and economic status (Table 5). This analysis showed that the NVAF ratios were similar with the exception of F-mature trees. Differences among the different ratio of means can be explained by the sampling variation (as measured by the sampling error).

Table 5. NVAF ratio and sampling error by species group, maturity class, and economic status (A to D).

Spp. Group	Immature			Mature											
	A			B			C			D			Total Mature		
	n	Ratio	E	n	Ratio	E	n	Ratio	E	n	Ratio	E	n	Ratio	E
B				2	0.977	0.717	5	1.008	0.096	1	0.906		8	1.004	0.073
C							2	0.957	0.843				2	0.957	0.843
F	10	1.05	0.082				6	1.193	0.089	3	1.145	0.325	9	1.189	0.079
H	8	0.999	0.282	3	0.33	0.918	15	1.077	0.241	4	0.664	0.619	22	1.028	0.218
Others	2	1.171	0.911												
Y				1	1.388		1	0.881		6	1.032	0.132	8	0.999	0.140
Total	*20*	*1.02*	*0.192*	*6*	*0.924*	*0.267*	*29*	*1.064*	*0.098*	*14*	*0.968*	*0.166*	*49*	*1.048*	*0.085*

Note: n= sample size, E=sampling error.

3.3 Live F-Mature Trees

F trees from clusters located in stands that are at least 100 years old (economic strata B, C, and D) were analyzed separately from the other live trees because the adjustment ratio for these F-mature trees was significantly different. There were nine trees in the live F-mature stratum.

The adjustment ratio for live F-mature trees was exceptionally large due to taper equation bias (Figure 4). The gross merchantable volume estimated by the taper equation was 19% less than the actual gross merchantable volume. The gross merchantable volume bias can only be explained by taper equation bias.

The NVAF ratio for net merchantable volume was similar to the ratio observed for gross merchantable volume. The 95% sampling error around the adjustment ratio was small (7%), indicating a high confidence in the ratio estimate. Therefore, the NVAF ratio for live F-mature net merchantable volume (with relative 95% sampling error) was:

Live F-mature NVAF = 1.189 ± 0.079 (7%)

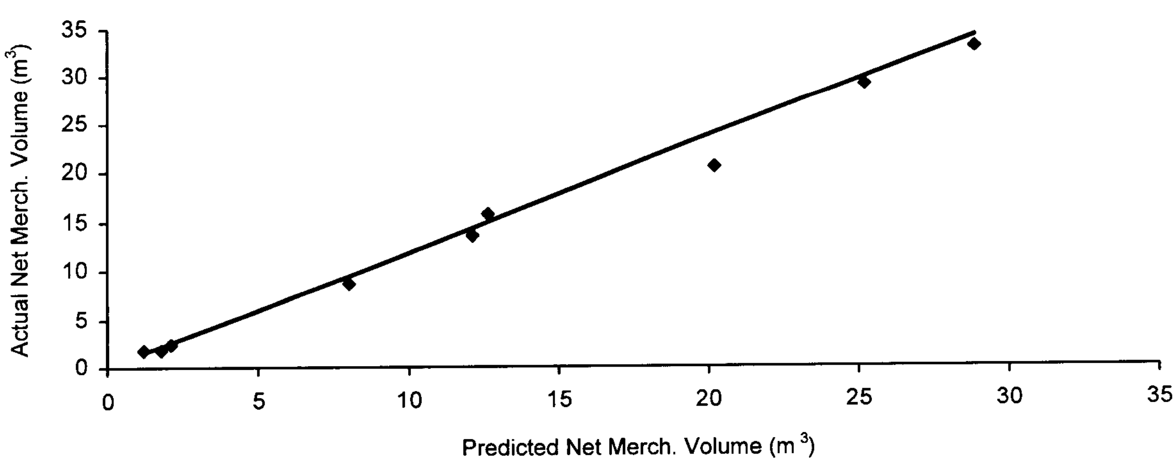


Figure 4. Actual versus predicted net merchantable volume for live F-mature trees on TFL 37.

3.4 Live (Non F-Mature) Trees

All other live trees (non F-mature) had relatively similar adjustment ratios (around 1.0), except for the Other species (approximately 1.17). Since the Other species group represents a minor component of the species composition on TFL 37, it could have been grouped with either the live F-mature or the live (non F-mature) trees without any major impact at the TFL level. After comparing both options, it was decided to put the Other species with the live (non F-mature) trees because its impact on the NVAF adjustment ratio was slightly smaller in this group, and because the NVAF adjustment ratio for the live (non F-mature) trees was more conservative.

There were 60 trees in the live (non F-mature) stratum. The NVAF adjustment ratio was greater than 1.0 mainly because the taper equation under-estimated the gross merchantable volume (Figure 5). The 95% sampling error of the NVAF adjustment ratio for live (non F-mature) trees (8%) was largely due to the variation around the prediction for H, indicating that it was more difficult to estimate decay in H trees than in other species. Therefore, the NVAF ratio for live (non F-mature) net merchantable volume (with relative 95% sampling error) was:

Live (non F-mature) NVAF = 1.013 ± 0.081 (8%)

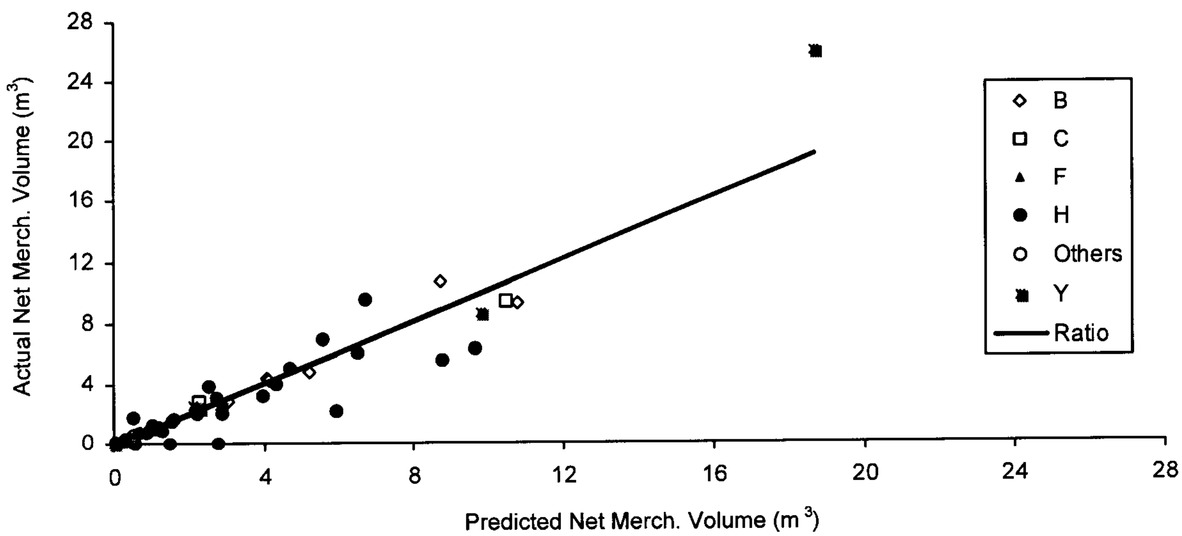


Figure 5. Actual versus predicted net merchantable volume for live (non F-mature) trees on TFL 37.

3.5 NVAF Ratio Summary

A few key points were shown in this analysis. These points include:

1. There was no difference in NVAF ratio between low- and high- elevation H.
2. NVAF ratio in live F-mature trees was significantly different from other live trees.
3. Taper equations appeared to be a major source of bias on TFL 37.
4. Overall, VRI volumes were under-estimated on TFL 37.

3.6 IMPACT OF NVAF RATIOS ON THE ADJUSTED VRI DATABASE

Table 6. NVAF ratios and sampling errors for TFL 37 Young and Old strata.

	Area (ha)	Non F-Mature (%)	Non F-Mature Ratio	Non F-Mature E	F-Mature (%)	F-Mature Ratio	F-Mature E	Overall Ratio	Overall E%
Young	25,953	86.9%	1.013	0.081	13.1%	1.189	0.079	1.035	6.8%
Old	67,545	90.8%	1.013	0.081	9.2%	1.189	0.079	1.028	7.2%
Total	*93,498*							*1.030*	*5.5%*

Only areas that are economical and marginally economical for harvesting, 41 years and older, and in the VT were statistically adjusted on TFL 37.[7] The population was divided into two strata before adjustment: Young (established after 1696) and Old (established in or before 1696). The average NVAF ratios were 1.035 and 1.028 in the Young and Old strata, respectively (Table 6).

The overall relative 95% sampling error for the NVAF ratio was 5.5%. The sampling error translates into a 95% confidence interval of [0.973, 1.087]. Therefore, we have a 95% confidence level that the true net merchantable volume bias was between -3% and 9%. Similarly, we can estimate the 50% confidence interval as [1.011, 1.049]. Hence, we have 50% confidence that the volume bias was between 1% and 5%.

Table 7. Final volumes for the adjusted VRI database.

Stratum	Area (ha)	Adj. Vol. (m^3/ha)	Avg. NVAF Ratio	Adj. Vol (m^3/ha)
Young	25,953	450.8	1.035	466.6
Old	67,545	697.7	1.028	717.2
Total	*93,498*	*629.2*	*1.030*	*647.6*

The NVAF ratios must be applied to correct the adjusted volumes presented in the TFL 37 VRI statistical adjustment report.[7] The preliminary average adjusted volume was 629.2 m^3/ha (Table 7). The average NVAF ratio was 1.030 and the final average adjusted volume increased to 647.6 m^3/ha.

4. RECOMMENDATIONS

The NVAF analysis presented in this report provides unbiased information for TFL 37. We recommend that:

The adjusted VRI database be corrected to account for the NVAF ratio adjustment.

[7] J.S. Thrower & Associates Ltd. 2004. Statistical adjustment of Tree Farm Licence 37 Vegetation Resources Inventory –Version 3.0. Unpublished Report, Contract No. CFW-019, June 3, 2004. 6 pp.

APPENDIX I – SAMPLING WEIGHTS AND NVAF TREE DATA

Table 8. Number of enhanced clusters and total area by economic status.

Economic Status	VT Area[a] (ha)	No. Enhanced Clusters H, B, C, Y, Others	F
A	70,198	7	7
B	5,566	2	2
C	53,101	7	8
D	17,620	5	6

[a] total VT area differs from VT area in Table 1 due to changes in the population since the initial VRI selection in 2000.

Table 10. Number of plots and polygon area by VRI cluster.

Stratum	Cluster No.	No. Plots	Polygon Area (ha)
A	2	4	20.8
A	17	3	1.3
A	49	4	10.4
A	59	3	8.4
A	61	4	43.6
A	64	3	17.4
A	81	2	4.0
B	40	2	7.3
B	102	4	21.5
C	23[a]	4	3.6
C	35	3	3.9
C	36	4	8.7
C	43	4	22.8
C	55	3	5.2
C	69	3	7.1
C	83	3	26.6
C	85	4	27.4
D	25	4	21.5
D	44	4	3.5
D	45	4	138.8
D	50	2	3.0
D	58	2	41.5
D	96[a]	3	123.6

a: F trees only.

Table 9. MSRM matrix selection for dead trees.

Economic Status	Total No. Trees	No. Sample Trees
A	16	3
B	9	2
C	19	3
D	15	2

Table 11. MSRM matrix selection for live trees (50 trees).

Economic Status	Species Group	Total No. Trees	No. Sample Trees
A	C	0	0
	F	27	9
	H	46	8
	Others	15	2
	Y	0	0
B	C	2	0
	F	0	0
	H	5	3
	Others	14	2
	Y	2	0
C	C	5	2
	F	11	1
	H	45	15
	Others	28	2
	Y	19	0
D	C	0	0
	F	0	0
	H	27	2
	Others	1	1
	Y	41	3

Table 12. JST matrix selection (19 trees).

Species	Elevation Class (m)	DBH Class (cm)	Total No. Trees	No. Sample Trees
C, Y	All	0-60	42	0
		60.1+	22	5
F	All	0-40	17	0
		40.1+	5	5
		Extra	17	4
H, B, Others	> 1,000 m	0-40	10	1
		40.1-60	13	2
		60.1+	9	2
H, B, Others	<= 1,000 m	12.5+	114	0

Table 13. NVAF dead trees sample.

Economic Status	Cluster No.	Plot	Tree No.	Species	DBH (cm)	Basal Area Factor	Cruiser Volume (m^3)	Actual Volume (m^3)	Total Weight	Relative Weight
D	44	S	9	Pw	85.9	20.25	5.2730	0.0000	192,400	3.692
D	44	W	6	Pw	62.9	20.25	1.7439	0.0000	358,831	6.885
C	55	E	10	Yc	88.3	20.25	0.0000	0.0000	463,380	8.892
C	55	N	8	Yc	71.4	20.25	3.3657	4.6153	708,700	13.599
A	61	N	5	Hw	20.0	9	0.3750	0.2886	3,830,523	73.502
A	61	S	5	Hw	31.2	9	0.8828	0.8712	1,574,015	30.203
A	81	W	4	Dr	39.3	9	0.8505	0.8044	1,984,097	38.072
C	83	E	4	Yc	69.0	16	5.5018	5.4820	599,592	11.505
B	102	N	5	Hw	96.8	12.25	0.0000	0.0000	52,115	1.000
B	102	W	7	Hw	73.0	12.25	0.0000	0.0000	91,636	1.758

Total Weight = $W_1 \times W_2 \times W_3$

W_1 = Area (Table 8) / [No. Enhanced Clusters (Table 8) x Polygon Area (Table 10)]

W_2 = Polygon Area (Table 10) x Basal Area factor (Table 13) / [No. Plots (Table 10) x 0.00007854 x DBH^2 (Table 13)]

W_3 = Total No. Trees (Table 9) / No. Sample Trees (Table 9)

Table 14. NVAF sample of live F-mature trees.

Economic Status	Cluster No.	Plot	Tree No.	Species	DBH (cm)	Basal Area Factor	Cruiser Volume (m^3)	Actual Volume (m^3)	Total Weight	Relative Weight
C	23	N	7	Fdc	109.8	20.25	12.1103	13.6026	150,825	4.392
C	35	E	4	Fdc	98.3	25	12.6241	15.6708	801,728	23.344
C	35	I	5	Fdc	75.0	25	8.0160	8.6695	125,204	3.646
C	35	N	3	Fdc	139.5	25	25.1921	29.1295	36,190	1.054
C	35	S	98	Fdc	143.2	25	28.8379	33.1084	34,344	1.000
C	35	S	99	Fdc	119.9	25	20.1746	20.5282	48,990	1.426
D	96	S	1	Fdc	47.4	12.25	1.2433	1.7308	288,810	8.409
D	96	S	6	Fdc	45.8	12.25	1.7874	1.8648	309,341	9.007
D	96	W	2	Fdc	50.5	12.25	2.1387	2.3193	254,440	7.408

Table 15. NVAF sample of live (non F-mature) trees.

Economic Status	Cluster No.	Plot	Tree No.	Species	DBH (cm)	Basal Area Factor	Cruiser Volume (m^3)	Actual Volume (m^3)	Total Weight	Relative Weight
A	2	N	3	Dr	13.5	6.25	0.0447	0.0408	8,210,140	344.766
A	2	W	2	Fdc	28.9	6.25	0.4122	0.3725	716,609	30.092
A	2	W	4	Fdc	25.0	6.25	0.3062	0.3523	957,631	40.214
A	2	W	5	Fdc	18.1	6.25	0.1484	0.1532	1,826,926	76.718
A	17	E	3	Hw	84.1	12.25	8.7362	5.5559	423,865	17.799
A	17	N	1	Hw	63.4	24.5	2.5309	3.8423	1,491,664	62.639
A	17	W	1	Hw	33.7	12.25	1.1063	1.0127	2,639,731	110.850
D	25	E	5	Yc	58.0	9	2.8069	2.5798	410,143	17.223
D	25	E	9	Hw	69.3	9	1.4710	0.0000	283,789	11.917
D	25	N	4	Ba	25.9	9	0.3325	0.3014	150,497	6.320
C	35	E	5	Hw	58.0	25	4.3177	4.0298	717,792	30.142
C	35	N	5	Cw	86.1	25	10.4388	9.3868	271,436	11.398
C	36	E	3	Hm	47.4	20.25	1.5721	1.7278	652,897	27.417
C	36	E	4	Hw	42.7	20.25	0.5578	0.0000	804,536	33.785
C	36	S	4	Hw	39.2	20.25	1.0460	1.3354	954,617	40.087
C	36	W	4	Hw	59.1	20.25	2.7285	3.0234	419,978	17.636
B	40	S	4	Hw	66.5	16	2.7808	0.0000	106,836	4.486
B	40	S	6	Ba	62.6	16	4.0926	4.2432	506,364	21.264
C	43	E	1	Ba	89.4	20.25	8.7129	10.6946	275,307	11.561
C	43	E	4	Ba	61.7	20.25	4.0908	4.3440	1,798,198	75.511
C	43	E	6	Ba	30.9	20.25	0.8959	0.8714	5,121,095	215.049
C	43	E	99	Ba	69.7	20.25	5.1819	4.7757	452,926	19.020
C	43	N	4	Hm	94.2	20.25	6.6725	9.5598	165,310	6.942
C	43	S	3	Hm	27.7	40.5	0.4614	0.3463	3,823,592	160.563
D	44	E	1	Yc	61.5	20.25	2.0879	2.6298	264,249	11.097
D	44	N	3	Yc	56.5	20.25	2.2410	2.3886	972,471	40.837
D	44	S	5	Yc	92.3	20.25	0.0000	0.0000	117,317	4.926
D	45	E	4	Yc	38.4	5.06	0.3415	0.2176	526,062	22.091
D	45	S	1	Hm	42.6	5.06	0.3284	0.4373	422,232	17.731
A	49	E	1	Fdc	22.0	6.25	0.2859	0.3276	1,236,610	51.929
A	49	N	1	Fdc	32.1	12.5	0.7356	0.8577	1,161,711	48.783
A	49	N	2	Fdc	28.0	12.5	0.4330	0.4035	1,526,835	64.116
A	49	N	5	Fdc	24.4	12.5	0.3868	0.3739	2,010,613	84.431
A	49	N	7	Fdc	54.2	12.5	2.0902	2.4867	135,828	5.704
A	49	S	1	Fdc	19.6	6.25	0.2263	0.2484	1,557,995	65.424
A	49	S	4	Fdc	30.6	6.25	0.5601	0.5415	639,198	26.842
D	50	E	2	Yc	120	6.25	0.0000	0.0000	42,844	1.799
D	50	E	3	Hm	42.0	6.25	0.6753	0.7157	516,667	21.696
D	50	N	1	Hm	55.3	12.5	1.2971	0.9397	596,059	25.030
C	55	E	4	Hw	24.7	20.25	0.1906	0.1484	3,205,870	134.623

Economic Status	Cluster No.	Plot	Tree No.	Species	DBH (cm)	Basal Area Factor	Cruiser Volume (m^3)	Actual Volume (m^3)	Total Weight	Relative Weight
C	55	E	9	Hw	68.9	20.25	3.9528	3.2641	412,004	17.301
C	55	N	2	Yc	104.2	20.25	9.8017	8.6381	264,202	11.095
C	55	W	2	Ba	53.7	20.25	3.0126	2.8584	3,165,177	132.915
C	55	W	7	Hm	72.2	20.25	4.6631	5.0296	375,202	15.756
A	59	E	2	Hw	22.1	9	0.3246	0.3392	4,509,635	189.372
A	59	S	3	Dr	31.3	9	0.5116	0.6311	2,932,450	123.142
A	61	N	4	Hw	31.4	9	1.1716	1.0965	1,675,436	70.356
A	61	W	2	Hw	13.3	9	0.0758	0.0669	9,338,646	392.155
A	61	W	3	Hw	36.2	9	1.5201	1.5317	1,260,579	52.935
C	69	E	1	Hw	84.8	40.5	5.5638	6.8814	543,974	22.843
C	69	W	4	Hw	50.0	40.5	0.5305	1.8290	1,564,695	65.706
A	81	N	2	Hw	44.5	9	2.2242	2.0754	1,668,388	70.060
C	83	E	1	Hw	75.9	16	6.4668	6.0973	268,257	11.265
C	85	N	4	Cw	59.0	16	2.2756	2.7623	277,467	11.652
C	85	N	6	Hw	107.5	16	9.6245	6.3370	100,295	4.212
C	85	S	4	Hw	59.2	16	2.9033	2.0186	330,714	13.888
B	102	E	4	Yc	141.6	12.25	18.7069	25.9621	23,814	1.000
B	102	N	4	Ba	88.7	12.25	10.7668	9.2316	96,550	4.054
B	102	S	3	Hw	75.1	12.25	5.8948	2.1646	32,068	1.347
B	102	W	1	Hw	33.0	12.25	0.8532	0.8296	166,081	6.974

APPENDIX D: YIELD TABLE METHODOLOGY AND RESULTS

J.S. Thrower & Associates Ltd. 2003. *Yield Tables for Natural and Managed Stands: Management Plan 9 on TFL 37.* Contract report for Canadian Forest Products Ltd. September 26, 2003 (revised December 6, 2004).

Yield Tables for Natural and Managed Stands: Sustainable Forest Management Plan 9 on TFL 37

Prepared for

Pat Bryant, RPF
Canadian Forest Products Ltd.
Woss, BC

Project: CFW-019

September 26, 2003
(Revised December 6, 2004)

J.S. Thrower & Associates Ltd. *Consulting Foresters*
Vancouver – Kamloops, BC

Executive Summary

Canadian Forest Products Ltd. (Canfor) contracted J.S. Thrower & Associates Ltd. to develop yield tables for natural and managed stands on Tree Farm Licence 37 to incorporate in the timber supply analysis for Sustainable Forest Management Plan 9. These tables provide the most important growth and yield input in the analysis and were delivered to Forest Ecosystem Solutions Ltd. in September 2002. This report documents the models, model inputs, and analytical procedures used to derive the yield tables and provides a summary of yield statistics from the resulting tables.

Yield tables for natural stands (originating before 1961) were predicted with *BatchVDYP version 6.6d* using the Vegetation Resources Inventory (VRI) database. Managed stand yield tables were developed for existing post-harvest regenerated (PHR) stands using silviculture assumptions that reflect the average conditions for stands initiated from 1961 – 1996. Silviculture regimes were developed for future stands to reflect current practice and were used for testing alternative management scenarios for future PHR stands. Volume predictions were made for each eco-polygon defined by the union of the VRI and the Terrestrial Ecosystem Map (TEM). *BatchTIPSY version 3.0a* was used to predict yields for PHR stands. Yield tables for PHR stands included:

1) New estimates of potential site index for existing and future PHR stands based on the results of the 2000 Site Index Adjustment project.
2) Ecologically-based silviculture regimes developed by Canfor staff.
3) Yield gains attributed to genetically improved planting stock.

The resulting yield tables showed that the predicted mean annual increment (MAI) at culmination age in natural stands averaged 3.2 m^3/ha/yr at 135 years with a mean culmination volume of 317 m^3/ha. Existing PHR polygons had a predicted average MAI of 9.9 m^3/ha/yr at 89 years with a mean culmination volume of 813 m^3/ha. Future PHR polygons left untreated had a predicted average MAI of 8.6 m^3/ha/yr at 101 years with a mean culmination volume of 729 m^3/ha.

Era	Culmination MAI (m^3/ha/yr)	Culmination age (yr)	Culmination volume (m^3/ha)
Natural	3.2	135	317
Existing PHR	9.9	89	813
Future PHR	8.6	101	729

Acknowledgements

We thank Pat Bryant, *RPF*, Doug Folkins, *RPF*, and Patti Brown, *RPF* of Canadian Forest Products Ltd. for their contributions to the project.

Table of Contents

List of Tables

List of Figures

This page is intentionally left blank.

1. INTRODUCTION

1.1 Background

The timber supply analysis for Canadian Forest Products Ltd.'s (Canfor) Sustainable Forest Management Plan (SFMP) 9 for Tree Farm Licence (TFL) 37 will be completed in the fall of 2003. J.S. Thrower & Associates Ltd. (JST) developed yield tables for natural and managed stands and delivered them to Forest Ecosystem Solutions Ltd. to incorporate into the timber supply analysis. These yield tables predict the volume of natural and post-harvest regenerated (PHR) stands and provide important links to product objectives, silviculture investments, certification initiatives, ecologically-based forest management, and habitat modeling.

1.2 Report Objectives

This report documents the models, model inputs, and analytical procedures used to derive the yield tables for the TFL 37 timber supply analysis. The report also provides a summary of yield statistics for the resulting tables. The intent is to provide the Ministry of Forests (MOF) staff with the information necessary to review and approve the yield tables and associated analysis assumptions.

1.3 Terms of Reference

This report was prepared for Pat Bryant, *RPF* of Canfor. The JST project team included Guillaume Thérien, *PhD* (project manager, biometrician), Craig Mistal, *MPM RPF* (data analyst), and Ian Cameron, *MF RPF* (analysis support). This report will be submitted to Albert Nussbaum, *RPF* of the MOF, Resource Analysis Branch for approval.

2. PROJECT OVERVIEW

2.1 INVENTORY AGE ADJUSTMENT

Canfor recently completed a new Vegetation Resources Inventory (VRI) for TFL 37. The process involved completing photo-interpretation of the target landbase, ground sampling selected polygons, and statistically adjusting the photo-interpreted polygon estimates. Standard VRI adjustment methods did not produce realistic age distributions; therefore JST worked with Sam Otukol, *PhD RPF* (Ministry of Sustainable Resource Management – Terrestrial Information Branch) to develop alternative methodologies (Table 1). The VRI statistical adjustment is described in a separate report.[1]

Table 1. TFL 37 age distribution before and after VRI adjustment.

Age Class	Current Inv. (ha)	Adjusted Inv. (ha)
0	33,227	33,227
1	28,986	28,986
2	24,162	17,197
3	9,278	9,462
4	6,119	5,700
5	933	2,763
6	621	4,289
7	2,392	154
8	4,826	1,555
9	80,123	87,336

2.2 NATURAL STAND YIELD TABLE DEFINITION

Natural stand yield tables (NSYTs) were developed for all natural stands in the productive forest landbase (PFLB) (Appendix I). Natural stands were identified from the adjusted VRI database as polygons originating before 1961 or polygons leading in red alder (Dr). NSYTs were developed using the VRI and *Batch Variable Density Yield Projection (VDYP) (version 6.6d)* (Table 2).

2.3 MANAGED STAND YIELD TABLE DEFINITION

Managed stand yield tables (MSYTs) were developed for existing (originating after 1961) and future PHR stands. Volume predictions were developed for each eco-polygon defined by the union of the VRI and TEM databases. MSYTs incorporated improved estimates of potential site index (PSI) developed from the Site Index Adjustment (SIA) project.[2] Yield for the PHR stands was derived using *Batch Table Interpolation Program for Stand Yields (TIPSY) (version 3.0a)* (Table 2).

The yield table analysis for Management Plan (MP) 8[3] divided existing PHR stands into three eras that reflected different silviculture practices: Era 1 included stands harvested between 1961 and 1970, Era 2 included stands harvested between 1971 and 1980, and Era 3 included stands harvested between 1981 and 1996. The yield table analysis for SFMP 9 combined all three existing PHR eras into one era for simplicity in the timber supply analysis (Section 4.3.2). Future PHR stands are created in the timber supply analysis following harvest of existing natural or PHR stands (Table 2).[4]

---

[1] J.S. Thrower & Associates Ltd. 2003. Statistical adjustment of Tree Farm Licence 37 Vegetation Resources Inventory – Version 2. Contract Report for Canadian Forest Products Ltd., July 31, 2003. 6 pp.

[2] J.S. Thrower & Associates Ltd. 2000. Potential site index estimates for the major commercial tree species on TFL 37. Contract report for Canadian Forest Products Ltd., March 31, 2000. 17 pp.

[3] J.S. Thrower & Associates Ltd. 1997. Managed stand yield tables for timber supply analysis of TFL 37 Management Plan 8. Contract report for Canadian Forest Products Ltd., November 27, 1997. 27 pp.

[4] Stands harvested and regenerated after 1996 were assigned yield tables derived from silviculture regimes (Sec. 0) for the timber supply analysis.

Table 2. Summary of TFL 37 yield table inputs, data sources, and models.

Variable	Natural	Existing PHR	Future PHR
Modeling Unit	VRI Polygon	VRI Polygon	Eco-polygon
Model	*BatchVDYP*	*BatchTIPSY*	*BatchTIPSY*
Inv. Age (yrs)	Before 1961	1961 - 1996	N/A
Area (ha)	109,162	46,270	148,487[5]
PFLB (%)	70	30	100
Stand Description	VRI	VRI and Silv. Assumptions	Silviculture Regimes
Site Index	VRI	▪ PSI from SIA ▪ Inv. SI in MH ▪ Elevation model in CWHvm2	▪ PSI from SIA ▪ Inv. SI in MH ▪ Elevation model in CWHvm2
OAFS 1 & 2	N/A	Section 4.2.5	Section 4.2.5
Genetic Gain (ha)	N/A	N/A	148,487

[5] The difference between the existing (natural and PHR) and future areas (6,945 ha) reflects stands that receive a NSYT but occur in non-productive site series according to the future silviculture regimes, and stands harvested and regenerated after 1996.

3. NATURAL STAND YIELD TABLES

3.1 Description

Natural stands are all polygons originating before 1961 or polygons leading in red alder. The basic modeling unit was the VRI polygon (mapstand) and subzone. Natural stands included 28,160 polygons covering 109,162 ha. Most polygons (46%) were less than 2 ha, and the largest was 166 ha (Figure 1).

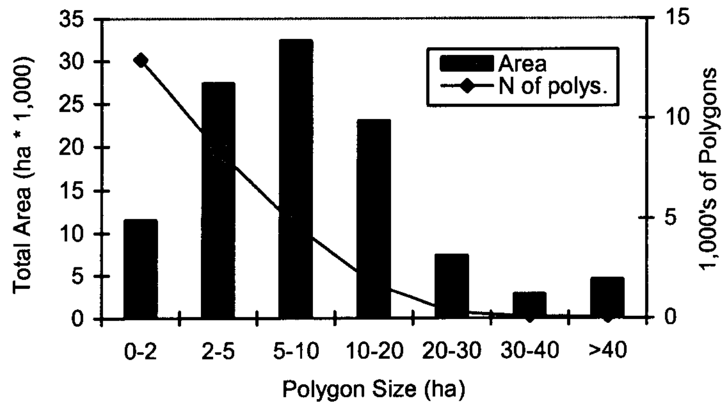


Figure 1. Distribution of polygon size for natural stands.

3.2 BatchVDYP Inputs

Site index, species composition, stocking class, and crown closure values from the VRI database were input into *BatchVDYP.* The weighted average site index for all species in natural stands was 16.7 m (Figure 2). The 10 m site index class contained the most area of the site index classes. Western hemlock (Hw) was the leading species in 53% of polygons while yellow-cedar (Yc), mountain hemlock (Hm), Douglas-fir (Fd), western redcedar (Cw), amabilis fir (Ba), and other species[6] were leading in the remaining polygons. Sixty-eight percent (68%) of the area was in stocking class 1 and mean crown closure was 54% (Figure 2).

3.3 Merchantability Limits

The minimum diameter at breast height (DBH) limit was 17.5 cm for all species. Maximum stump height was 30 cm, and minimum top diameter was 10 cm.

[6] Other species included: cottonwood (Ac), red alder (Dr), broad-leaved maple (Mb), lodgepole pine (Pl), and Sitka spruce (Ss).

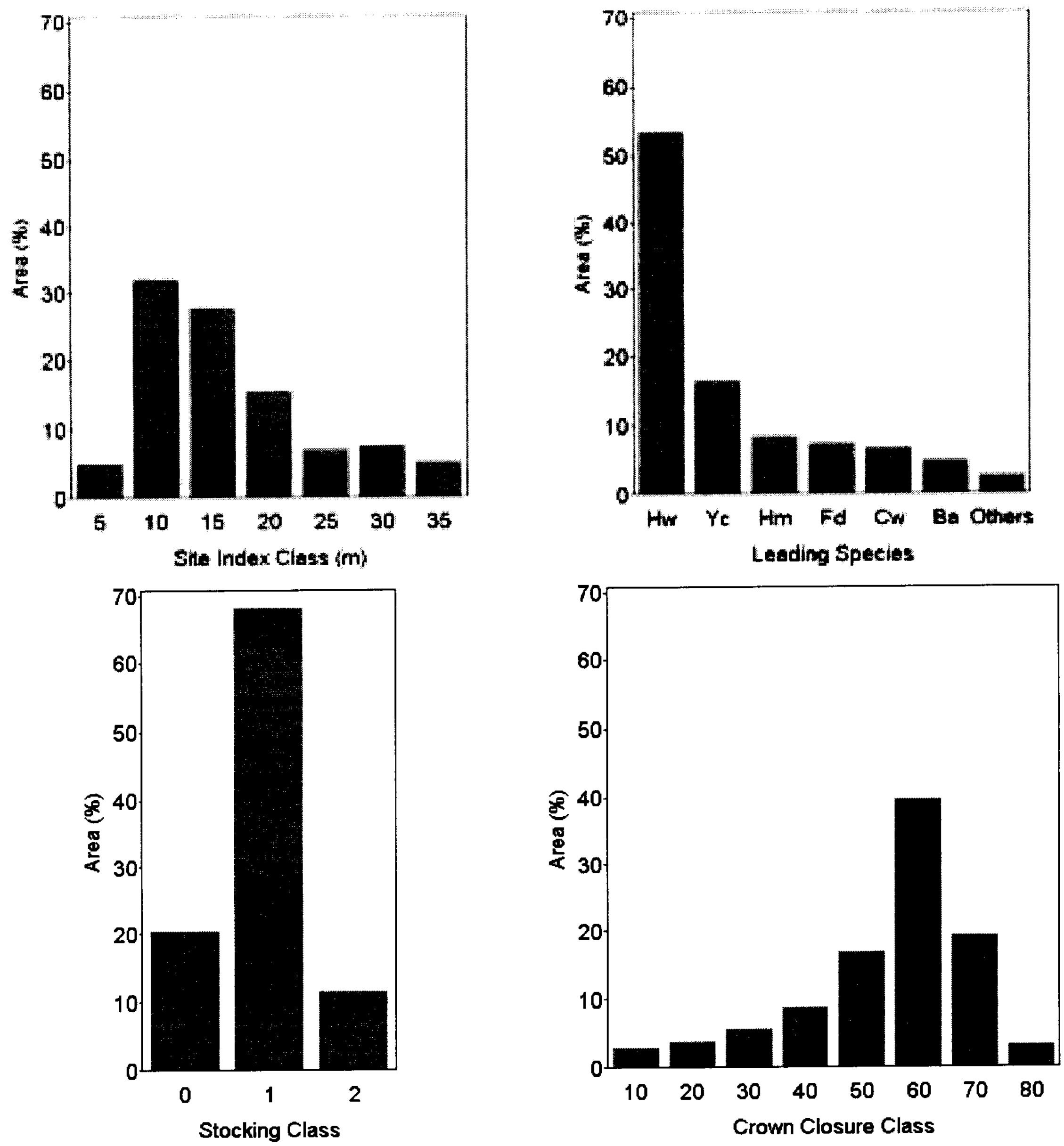


Figure 2. Area distribution of natural stands by site index, leading species, stocking class, and crown closure class.

4. MANAGED STAND YIELD TABLES

4.1 DESCRIPTION

Two management eras were created to develop the MSYTs. The yield table analysis for SFMP 9 combined all three existing eras from the MP 8 analysis into one existing PHR era for simplicity in the timber supply analysis (Section 4.3.2). Existing PHR polygons include those stands harvested between 1961 and 1996.[4] Future PHR stands are those polygons regenerated in the timber supply analysis following harvest of existing natural or PHR stands.

4.2 CHARACTERISTICS COMMON TO ALL PHR ERAS

4.2.1 Modeling unit and yield model

The modeling unit for MSYTs was the eco-polygon formed by the union of the VRI and TEM databases. *BatchTIPSY (3.0a)* was used to predict the yields of each eco-polygon.

4.2.2 Site index

PSI estimates derived from the SIA project[2] were applied to all existing and future PHR eco-polygons in all subzones except the CWHvm2 and MHmm1. For the CWHvm2, an elevation model was developed to predict site index based on site series and elevation.[7] For the MHmm1, the average inventory site index estimates for each site series and species combination were estimated and used as the PSI estimates for the leading species. MOF conversion equations were used to estimate site index of secondary species.

4.2.3 Species composition

Species composition of all existing PHR stands was taken from the inventory records and rounded to the nearest 20%. The total was constrained to 100% by adjusting the portion of minor species. The species composition for future PHR stands was assigned from silviculture regimes (Appendix II). Yellow cedar (Yc) was modeled using redcedar (Cw) in *BatchTIPSY.*

4.2.4 Silviculture assumptions and regimes

Management of the TFL 37 forests began in 1960 and since then, the management practices can be separated into three distinct eras each reflecting differing silviculture practices. Yield table inputs for existing PHR MSYTs were the area-weighted average of the assumptions from the MP 8 analysis. The assumptions and methodologies to produce yield tables for these eras are described in Section 4.3.

Silviculture regimes for future PHR stands were developed by Canfor staff for all site series in the timber harvesting landbase (THLB) using silviculture survey data and the personal experience of Canfor's silviculture foresters (Appendix II). These silviculture regimes were used to develop yield tables for future PHR stands.

4.2.5 Operational adjustment factors

Operational adjustment factors (OAFs) reduce the potential yields predicted by *TIPSY* to levels expected in PHR stands. The MSYTs for MP 8 were generated with an OAF1 of 0.90 (which results in a 10% reduction in yield) to account for the increased area that has been removed from the THLB through the identification of non-productive forest types in the TEM. Canfor believes that OAF1 should remain at 0.90

[7] See memo from J.S. Thrower & Associates Ltd. to Albert Nussbaum (MOF), June 10, 2003.

for SFMP 9 MSYTs. All MSYTs were generated using an OAF2 of 0.95, applied at the yield table development stage.

4.2.6 Merchantability limits

The minimum utilization limit was 12.5 cm DBH for all species. Maximum stump height was 30 cm, and minimum top diameter was 10 cm.

Table 3. Input assumptions for existing PHR stands on TFL 37.

Era	Area (ha)[b]	Density FTG[a] (stems/ha)	Method	Avg. PSI (m)
1	10,889	900	Natural	31.6
2	14,877	950	Planted	29.8
3	20,690	1,100	Planted	26.7
Total	*46,456*	*1,005*	*(Planted)*	*28.8*

[a] FTG is free-to-grow.
[b] Area summary is from a preliminary analysis.[8]

4.3 Existing PHR Yield Table Inputs

4.3.1 Description of existing eras in MP 8 analysis

Reforestation during Era 1 (1961 – 1970) was predominantly through natural regeneration. Fill planting was used to improve stocking, and areas of high site quality were planted immediately after slash burning (about 25% of Era 1 total area). Hw was first planted operationally in 1967. By 1969, planting was primarily a 50:50 mix of Fd and Hw. Increases in the planting programs reduced pre-TFL backlog.[3] Previous MP standards and silviculture survey results show that on average, the stands in Era 1 were naturally regenerated to 900 stems/ha (Table 3).

In Era 2 (1971 – 1980), the reforestation program focused on reforesting areas immediately following harvest. By 1978, Canfor was planting logged areas within one year of harvest. These efforts and backlog reduction resulted in an additional 13.3 million trees being planted on 13,258 ha (more area than was harvested). Canfor planted all NSR areas during this Era. Additional species such as Ba and Cw became available for planting.[3] Review of previous MP standards and silviculture survey results show that on average, all stands in this Era were regenerated to 950 stems/ha (including planted and natural regeneration).

Reforestation policy during Era 3 (1981 – 1996) was guided by the goal of offsetting potential reductions in the AAC. The silviculture program was designed so that all areas were fully regenerated immediately after harvest and maximum merchantable yield and quality would be achieved from all areas in the new forest. During this Era, all backlog NSR was eliminated and Canfor planted 1.5 million trees to a target stocking of 1,100 stems/ha. All stands in Era 3 were assumed regenerated to a density of 1,100 stems/ha (including planted and natural regeneration) based on review of the previous MP standards and silviculture survey results.

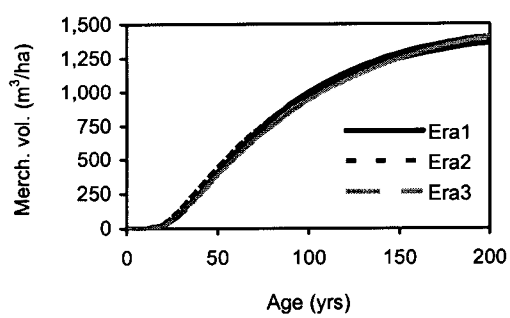


Figure 3. Average existing PHR yield tables in preliminary analysis.

The resulting average yield tables from a preliminary analysis[8] are shown in Figure 3. Average yield tables for the earlier eras were comparable to the later era due to their higher average site indices (Table 3).

4.3.2 Combination of existing eras

TIPSY input assumptions from the three eras described in Section 4.3.1 were combined into one existing PHR era for the SFMP 9 analysis. The area-weighted average input density for all three eras was approximately 1,000 stems/ha (Table 3). We used 1,000 planted stems/ha as the average FTG density for all existing PHR stands. We acknowledge that this may be an overestimate for Era 1 stands and an underestimate for Era 3 stands on a stand-by-stand basis, but the overall effect on timber supply will be negligible.

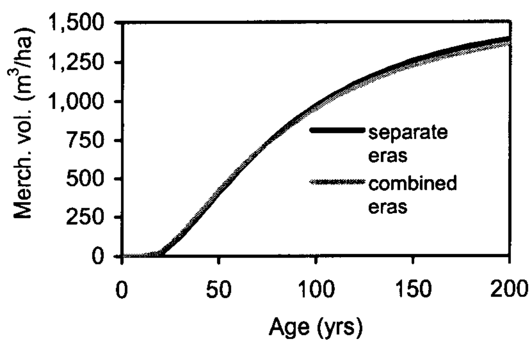


Figure 4. Average existing PHR yield table in preliminary and current analysis.

We compared the average yield table using the average input density for all existing PHR stands to the average yield table for the three eras from the preliminary analysis (Figure 4). The average yield table culmination statistics of both input methods are very similar (Table 4). For example, the average yield table volume for the current analysis at age 93 years will be approximately 860 m^3/ha (assuming a 10 m^3/ha/yr volume increment for the 4 years following culmination age). This is a 1% difference in volume compared to the preliminary analysis.

Table 4. Culmination values for existing PHR stands for each analysis.

Culmination Value	Preliminary analysis	Current analysis
Volume (m^3/ha)	870	820
Age (yrs)	93	89
MAI (m^3/ha/yr)	10.1	10.0

The average site index across all species in the combined Era was 28.0 m (Table 5, Figure 5). The average establishment density was modeled at 1,100 stems/ha.[9] Genetically improved stock was not used in the existing PHR Era.

Table 5. Site index statistics for existing PHR stands.

Ldg. Spp.	Area (ha)	Site Index (m) Avg.	Min.	Max.	SD.
Fd	19,198	32.9	10.0	45.8	5.7
Hw	17,269	25.9	10.0	32.4	4.7
Ba	4,687	21.1	10.0	30.0	4.9
Other	5,117	23.1	7.8	45.8	5.9
Total	*46,270*	*28.0*	*7.8*	*45.8*	*6.9*

Effects of juvenile spacing were not modeled in the current analysis because the average input density for existing PHR stands was relatively low. For example, there is little difference in merchantable volume yield projection with the average FTG density of 1,000 stems/ha compared to a spaced density assumption of 800 stems/ha used in the MP 8 analysis (Figure 6).[3]

[8] J.S. Thrower & Associates Ltd. 2002. Yield Tables for natural and managed Stands: Management Plan 9 on TFL 37. Contract Report for Canadian Forest Products Ltd., November 25, 2002. 36 pp.

[9] The modeled establishment density is 10% higher than the FTG density. This accounts for mortality in the TIPSY model during the establishment to FTG phase of stand development.

Effects of fertilization on TIPSY stand yields are very small when site index exceeds 30 m. Therefore, fertilization was not modeled in this analysis as the average site index for Fd exceeded 30 m (Table 5).

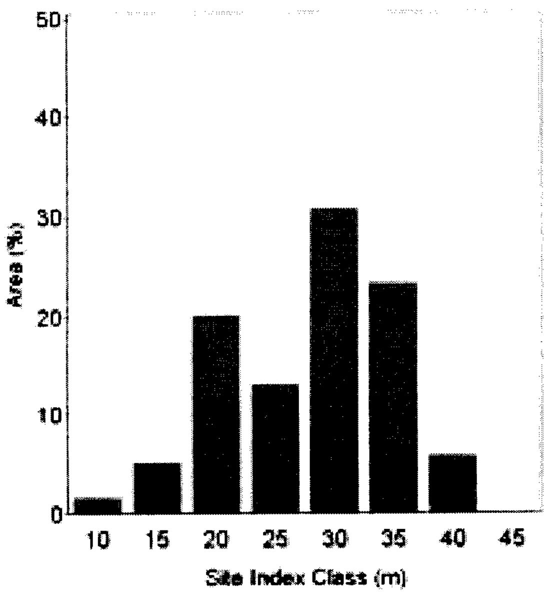


Figure 5. Area distribution for existing PHR stands by site index class.

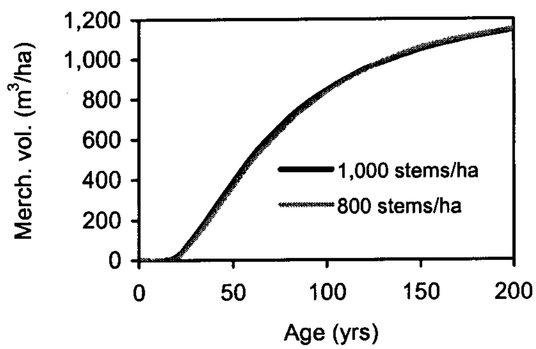


Figure 6. Comparison of Fd stand yields with low input densities (SI = 30 m).

4.4 Future PHR Yield Table Inputs

Canfor foresters used their experience and professional opinion to define the silviculture practices and create silviculture regimes for future PHR stands (Appendix II).

Table 6. Site index for pure Dr silviculture regimes.

Subzone	Site series	Site Index (m)
CWHxm2	09	21
CWHmm1	09	23
CHWvm1	10	25

Three site series (CWHvm1/10, CWHmm1/09, and CWHxm2/09) had silviculture regimes leading in Dr. The MOF recommended that these yield tables be predicted using *VDYP*.[10] Site index estimates for these sites were based on expert opinion and plot data (Table 6).[11] Crown closure was modeled at 90% and other inputs were the same as the NSYTs (Sec. 3).

Planted seedlings came from Canfor's Tree Improvement Program. This program will be in transition between orchard generations over the next 20 years. The gains used in this analysis are a pro-rated estimate of this 20-year transition period only. Low elevation stands (<700 m) will have expected site index gains of 6.5% for Fd, 3.8% for Cw (4.0% gain with 95% availability), 9.3% for Hw, and 7.3% for Yc. Higher elevation stands (>700 m) will have expected gains of 3.4% for Fd, 4.8% for Hw, and 6.6% for Yc

[10] George Harper, *RPF* (Pers. Comm.) Research Scientist, Stand Development . Research Branch, BC Ministry of Forests.

[11] Site index estimates for pure red alder regimes were provided by Paul Courtin, *RPF* (Regional Pedologist, Vancouver Forest Region).

(7.3% gain with 90% availability). Gain values were provided by Canfor (Appendix III) and applied in most of the future landbase (Table 7).

The average site index for all species in the future regimes was 24.3 m (Table 8, Figure 7). The inclusion of more high elevation area (MHmm1 and CWHvm2), where VRI site index estimates and the elevation model were used, accounts for the lower mean site index compared to the existing PHR stands. The average establishment density was modeled at 1,232 stems/ha (Figure 8), and the regeneration delay on all future polygons was one year.[12]

Table 7. Genetic gain in future PHR stands.

Subzone	Genetic gain		No gain	
	(ha)	(%)	(ha)	(%)
CWHvm1	46,527	31	3,851	3
CWHvm2	29,387	20	10,710	7
MHmm1	11,469	8	12,465	8
CWHxm2	18,196	12	251	0
CWHmm1	15,281	10	349	0
Total	*120,860*	*81*	*27,627*	*19*

Table 8. Site index statistics for future PHR stands.

Ldg. Spp.	Area (ha)	Site Index (m) Avg.	Min.	Max.	SD.
Fd	41,745	32.9	11.6	45.8	5.9
Hw	34,045	25.1	10.0	32.4	4.9
Cw	27,252	23.0	10.0	29.8	5.5
Yc	22,182	15.1	10.0	28.4	4.3
Ba	16,042	18.4	10.0	37.0	4.8
Hm	4,316	10.4	10.0	10.4	0.1
Total	*148,487*	*24.3*	*10.0*	*45.8*	*8.5*

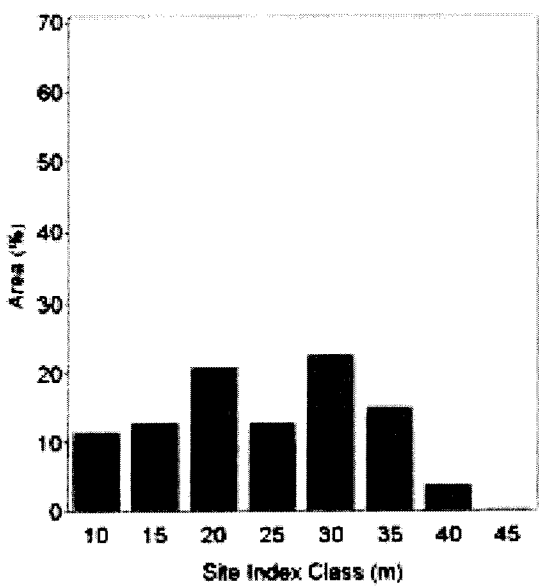


Figure 7. Area distribution for future PHR stands by site index class.

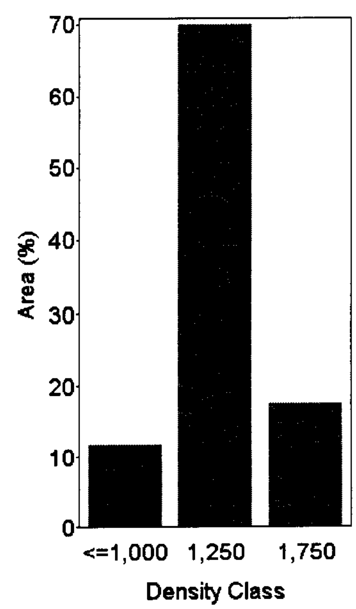


Figure 8. Area distribution for future PHR stands by density class.

[12] Regeneration delay is not applied in the yield tables; instead, it will be applied during the timber supply analysis stage.

5. RESULTS

5.1 Yield Table Process

NSYTs were generated by VRI polygon and subzone combination. Existing and future PHR MSYTs were generated for each site series within each eco-polygon. A single yield table was then produced for each VRI polygon as an area-weighted average of the component productive site series yield tables.

The yield table generation process created 28,160 NSYTs, 17,351 existing PHR MSYTs, and 82,682 future MSYTs. The culmination mean annual increment (MAI) and corresponding culmination ages are summarized in Table 9. Area-weighted tables for the entire PFLB are shown in Figure 9.

Table 9. Summary of culmination statistics for existing and future stands.

Variable	Natural Stands	PHR Stands	
		Existing	Future
Culm. MAI (m^3/ha/yr)	3.2	9.9	8.6
Culm. Age (yrs)	135	89	101
Culm. Volume (m^3/ha)	317	813	729

There were 94,145 combinations of VRI and TEM polygons in the PFLB. Of these, 13,752 polygons were not assigned an existing yield table because they were harvested and regenerated after 1996. However, these polygons were assigned a future PHR yield table for the timber supply analysis.

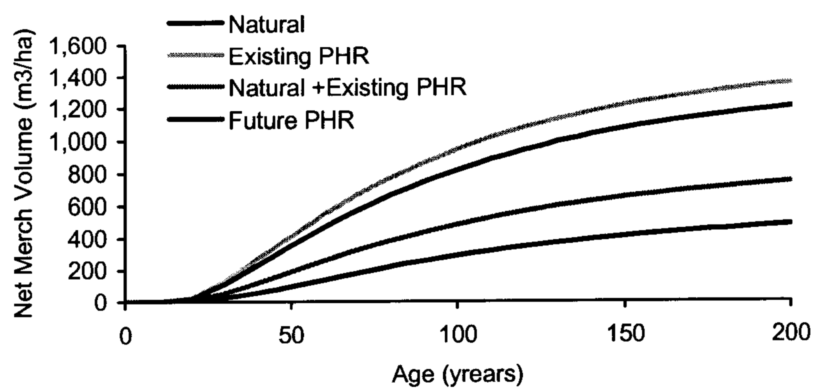


Figure 9. Area-weighted average yield tables for existing and future stands.

it should be noted that the average site index for existing PHR stands (28.0 m) was higher than the future PHR (24.3 m) stands because of inclusion more high elevation area (MHmm1 and CWHvm2 used inventory site index and elevation model)

5.2 Yield Table Summary for Existing Stands

The existing yield tables comprised (by area percentage) 70% NSYTs and 30% existing PHR polygons. The existing tables apply to all polygons in the PFLB except those regenerated after 1996. The overall average culmination MAI for existing stands was 5.2 m^3/ha/yr at 122 years (Table 10). The area distributions by maximum MAI and culmination age for PHR (12.5 cm utilization) and natural stands (17.5 cm utilization) are shown in Figure 10 and Figure 11. The area-weighted average yield tables by subzone for existing PHR stands and natural stands are illustrated in Figure 12 and Figure 13.

Table 10. Area-weighted yield estimates at culmination age for existing PHR and natural stands.

Subzone	Area (ha)	Culm. MAI (m^3/ha/yr)	Culm. Age (yrs)	Volume (m^3/ha)
ATc	866	0.4	219	66
CWHmm1	14,945	9.6	78	706
CWHvm1	49,041	7.3	98	604
CWHvm2	39,912	3.0	139	377
CWHxm2	17,411	7.7	85	585
MHmm1	30,099	1.4	170	214
MHmmp	3,229	0.6	192	102
All	*155,505*	*5.2*	*122*	*464*

5.3 Yield Table Summary for Future Stands

Yield tables for future PHR stands were applied to all areas of the PFLB. The average culmination MAI for future stands was 8.6 m^3/ha/yr at 101 years (Table 11). The area distributions by maximum MAI and culmination age for future yield tables are shown in Figure 14. The area-weighted average yield tables by subzone for future PHR stands are illustrated in Table 11 and Figure 15.

Table 11. Area-weighted yield estimates at culmination age for future PHR stands.

Subzone	Area (ha)	Culm. MAI (m^3/ha/yr)	Culm. Age (yrs)	Volume (m^3/ha)
CWHmm1	15,630	11.4	73	804
CWHvm1	50,378	11.9	75	887
CWHvm2	40,097	5.7	118	651
CWHxm2	18,447	11.4	75	824
MHmm1	23,935	2.5	167	406
All	*148,487*	*8.6*	*101*	*729*

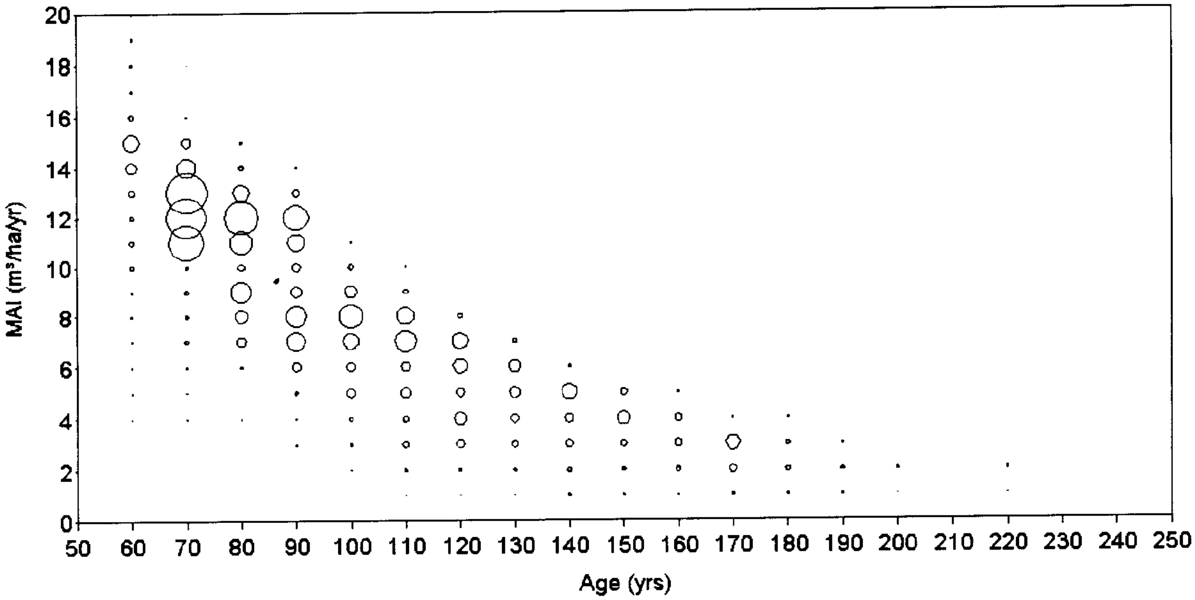


Figure 10. Area distribution by maximum MAI and culmination age for existing PHR stands (12.5+ cm utilization). Bubble size is proportional to the area represented at each point.

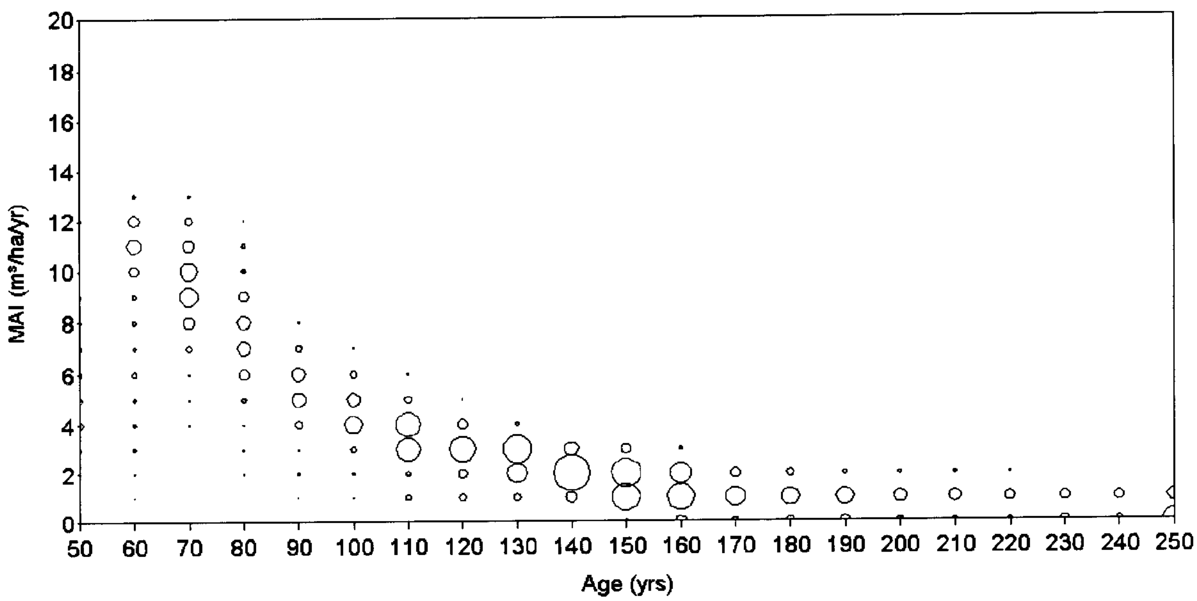


Figure 11. Area distribution by maximum MAI and culmination age for natural stands (17.5+ cm utilization). Bubble size is proportional to the area represented at each point.

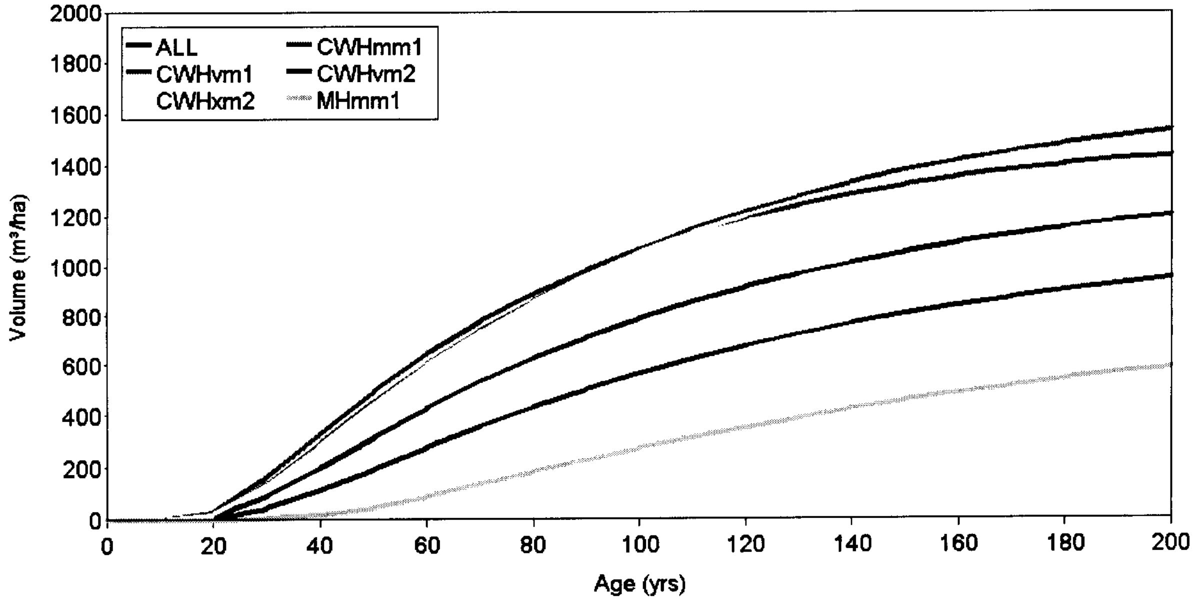


Figure 12. Area-weighted average yield tables for existing PHR stands (12.5+ cm utilization).

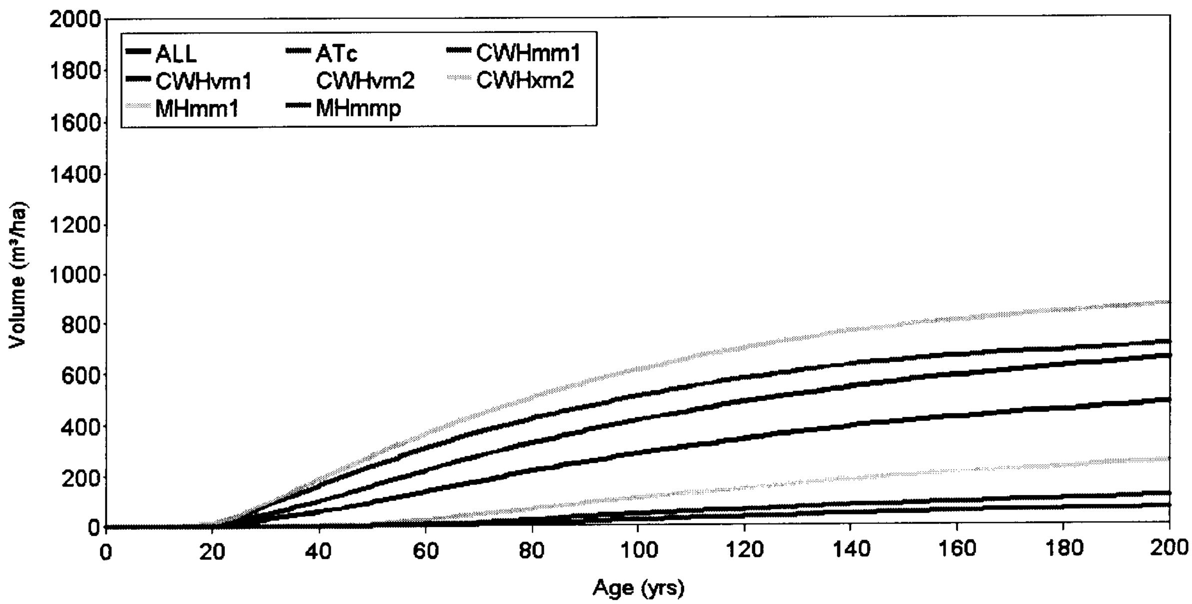


Figure 13. Area-weighted average yield tables for natural stands (17.5+ cm utilization).

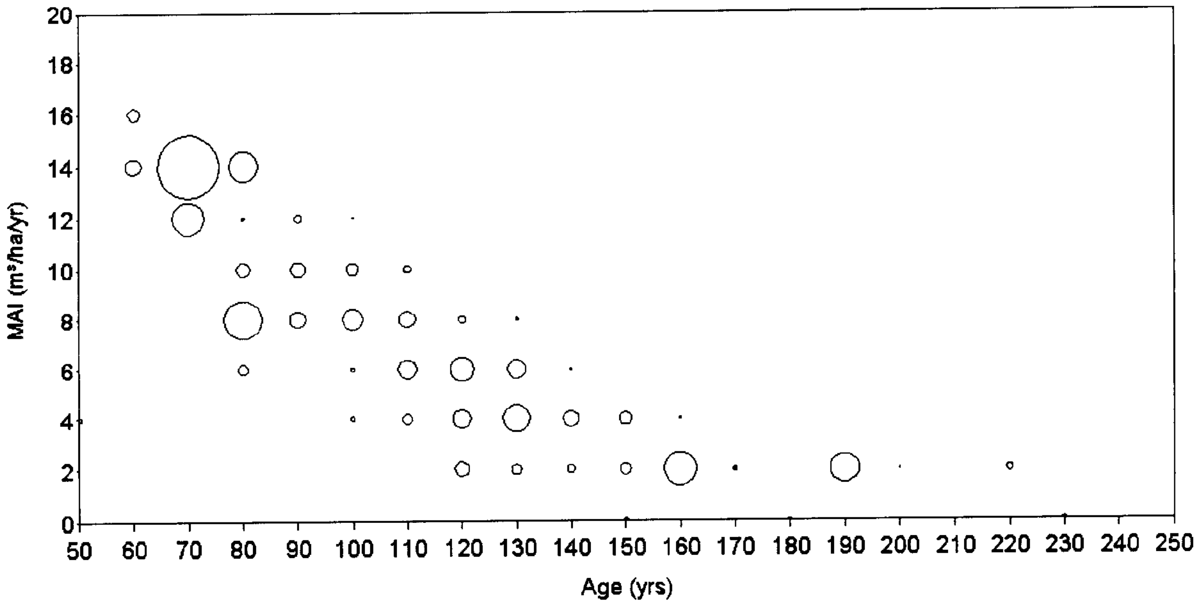


Figure 14. Area distribution by maximum MAI and culmination age for future PHR stands (12.5+ cm utilization). Bubble size is proportional to the area represented by each point.

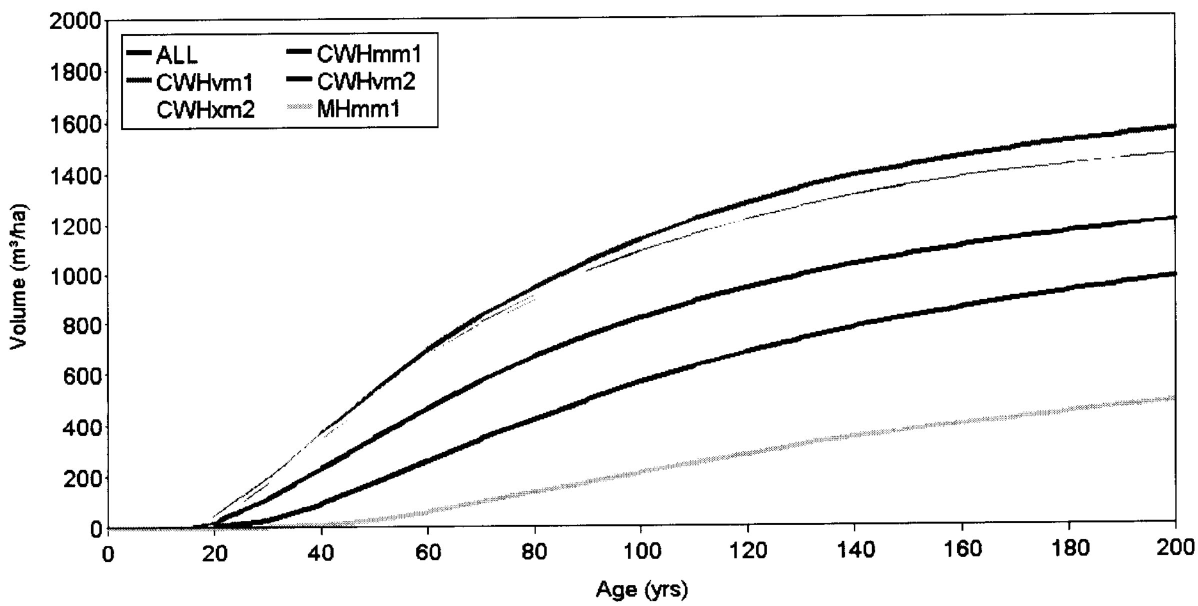


Figure 15. Area-weighted average yield tables for future PHR stands (12.5+ cm utilization).

APPENDIX I – AREA BY SITE SERIES FOR TFL 37

Table 12. Area distribution of PFLB by site series.

Site	CWHmm1		CWHvm1		CWHvm2		CWHxm2		MHmm1		ATc		MHmmp		*Total*	
Series	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	*ha*	*%*
01	8,266	4.4	26,095	13.8	20,042	0.6	7,521	4.0	10,701	5.6					*72,623*	*38.3*
01p	346	0.2	512	0.3	362	0.2	1,534	0.8	351	0.2					*3,104*	*1.6*
01s		0.0	1,117	0.6	268	0.1		0.0		0.0					*1,385*	*0.7*
02	42	0.0	1,065	0.6	734	0.4	550	0.3	7,193	3.8					*9,583*	*5.1*
03	968	0.5	11,179	5.9	11,798	6.2	4,247	2.2	110	0.1					*28,302*	*14.9*
04		0.0	5	0.0	2	0.0		0.0	256	0.1					*263*	*0.1*
05	1,921	1.0	2,845	1.5	663	0.3	1,918	1.0	788	0.4					*8,135*	*4.3*
06	784	0.4	3,807	2.0	4,129	2.2	589	0.3	75	0.0					*9,384*	*4.9*
06p	211	0.1	192	0.1	179	0.1	400	0.2		0.0					*983*	*0.5*
06s		0.0	172	0.1	51	0.0		0.0		0.0					*223*	*0.1*
07	1,918	1.0	3,241	1.7	925	0.5	1,007	0.5	2,485	1.3					*9,576*	*5.0*
08	411	0.2		0.0		0.0	419	0.2	777	0.4					*1,607*	*0.8*
09	154	0.1	291	0.2	561	0.3	251	0.1	1,198	0.6					*2,454*	*1.3*
10		0.0	44	0.0	73	0.0		0.0		0.0					*117*	*0.1*
11	186	0.1		0.0	310	0.2	190	0.1		0.0					*686*	*0.4*
12	423	0.2	25	0.0		0.0	317	0.2		0.0					*765*	*0.4*
13		0.0	149	0.1		0.0		0.0		0.0					*149*	*0.1*
14		0.0	600	0.3		0.0		0.0		0.0					*600*	*0.3*
NP	3,319	1.7	3,584	1.9	5,337	2.8	4,625	2.4	12,029	6.3	6,555	3.5	1,376	2.3	*39,824*	*21.0*
Total	*18,948*	*'0.0*	*54,921*	*28.9*	*45,434*	*:3.9*	*23,566*	*12.4*	*35,964*	*'9.0*	*6,555*	*3.5*	*1,376*	*2.3*	*189,764*	*100*

APPENDIX II – MODELING ASSUMPTIONS FOR FUTURE PHR STANDS

Table 13. Silviculture regimes for future PHR stands.

Subzone	Site Series	Spp1 Pct1	Spp2 Pct2	Spp3 Pct3	Spp4 Pct4	Density (stems/ha)
CWHvm1	01	Fdc 45	Hw 30	Cw 20	Ss 5	1,400
CWHvm1	01p	Hw 80	Cw 20			1,100
CWHvm1	01s	Cw 60	Hw 40			1,300
CWHvm1	02	Fdc 100				700
CWHvm1	03	Fdc 60	Hw 20	Cw 20		1,100
CWHvm1	04	Fdc 60	Hw 20	Cw 20		800
CWHvm1	05	Fdc 30	Hw 35	Cw 20	Ba 15	1,000
CWHvm1	06	Hw 60	Ba 20	Cw 20		1,200
CWHvm1	06p	Hw 60	Ba 20	Cw 20		900
CWHvm1	06s	Hw 60	Cw 40			900
CWHvm1	07	Cw 40	Hw 30	Ba 20	Ss 10	1,100
CWHvm1	09	Cw 40	Hw 30	Ba 20	Ss 10	1,100
CWHvm1	10	Dr 100				800
CWHvm1	12	Yc 50	Cw 40	Hw 10		700
CWHvm1	13	Pl 60	Cw 30	Ss 10		700
CWHvm1	14	Cw 90	Ss 10			600
CWHvm2	01	Hw 50	Yc 30	Ba 20		1,100
CWHvm2	01p	Hw 50	Yc 30	Ba 20		1,100
CWHvm2	01s	Hw 50	Yc 30	Ba 20		1,100
CWHvm2	02	Pl 60	Fdc 40			500
CWHvm2	03	Cw 50	Hw 20	Fdc 20	Yc 10	1,100
CWHvm2	04	Hw 70	Yc 30			900
CWHvm2	05	Ba 60	Yc 40			1,100
CWHvm2	06	Yc 50	Hw 30	Ba 20		900
CWHvm2	06p	Yc 50	Hw 30	Ba 20		900
CWHvm2	06s	Yc 50	Hw 30	Ba 20		900
CWHvm2	07	Ba 60	Yc 30	Hw 10		1,100
CWHvm2	09	Yc 60	Cw 40			700
CWHvm2	10	Yc 100				500
CWHvm2	11	Yc 60	Cw 40			700
CWHxm2	01	Fdc 60	Cw 20	Hw 20		1,200
CWHxm2	01p	Fdc 60	Cw 20	Hw 20		1,200
CWHxm2	01s	Fdc 60	Cw 20	Hw 20		1,200
CWHxm2	02	Fdc 100				600
CWHxm2	03	Fdc 80	Cw 20			1,100
CWHxm2	05	Fdc 60	Cw 40			1,200
CWHxm2	06	Hw 50	Cw 40	Fdc 10		1,100
CWHxm2	06p	Hw 50	Cw 40	Fdc 10		1,100
CWHxm2	07	Fdc 60	Cw 40			1,200
CWHxm2	08	Fdc 60	Cw 40			1,200
CWHxm2	09	Dr 100				800
CWHxm2	11	Cw 100				500
CWHxm2	12	Cw 100				700
CWHmm1	01	Fdc 60	Cw 20	Hw 20		1,200
CWHmm1	01p	Fdc 60	Cw 20	Hw 20		1,200
CWHmm1	02	Fdc 80	Cw 10	Hw 10		1,100
CWHmm1	03	Fdc 80	Cw 20			1,100
CWHmm1	05	Fdc 60	Cw 40			1,200
CWHmm1	06	Hw 50	Cw 40	Fdc 10		1,100
CWHmm1	07	Fdc 60	Cw 40			1,200
CWHmm1	08	Fdc 50	Cw 40	Ss 10		1,200
CWHmm1	09	Dr 100				800
CWHmm1	11	Pl 60	Cw 40			500
CWHmm1	12	Cw 90	Ss 10			700
MHmm1	01	Ba 60	Yc 40			1,100

Subzone	Site Series	Spp1 Pct1	Spp2 Pct2	Spp3 Pct3	Spp4 Pct4	Density (stems/ha)
MHmm1	01p	Ba 60	Yc 40			1,100
MHmm1	02	Hm 60	Yc 40			500
MHmm1	03	Ba 60	Yc 40			1,100
MHmm1	04	Ba 50	Yc 50			1,100
MHmm1	05	Yc 60	Ba 40			1,100
MHmm1	06	Yc 80	Ba 20			1,100
MHmm1	07	Yc 60	Ba 40			1,100
MHmm1	08	Yc 100				1,100
MHmm1	09	Yc 100				600

APPENDIX III – TREE IMPROVEMENT PROGRAM

Table 14. Tree Improvement Program.

Elev.	Spp.	% Class Availability	% Planting Program	% Gain	Orchard / % Gain / Timing
>700m	Fd	100%A	10	3.4	Orchard#116 = 3% first 5 years Orchard#116 rogued = 8% next 15 years
	Hw	100%A	25	4.8	Orchard#130 = 2% for first 2 years Orchard#130 rogued = 10% for next 19 years
	Yc	90%A	28	7.3	5% for first 3 yrs as increase A usage from 53% in 2002 to 90% in 2004 12% from 2005-2010 with 100% usage 18% for last 12 years (2011-2022)
<700m	Cw	95%A	33	4.0	Orchard#186 = 3% for next 3 years Orchard#186 rogued = 7% next 7 years Orchard#186 replaced = 10% for remaining 10yrs
	Fd	100%A	27	6.5	Orchard#149 & US Sources = 8% first 5 years Orchard #162 & US Sources = 12% next 5 years Orchard#177 = 16% last 10 years
	Hw	100%A	20	9.3	Orchard#133 = 17% for next 10 years Orchard#179 = 20% for last 10 years
	Yc	100%A	1	7.3	As for Yc > 700m

APPENDIX IV – SUBZONE SUMMARIES FOR FUTURE PHR STANDS

The summary statistics and average curves for each subzone are computed as the area-weighted average of all curves in the subzone.

Table 15. Untreated future PHR yield table summary statistics by subzone.

Subzone	Area (ha)	PFLB (%)	Average of Inputs			Average of Outputs		
			Avg. SI (m)	Est. Density	Species Composition	MAI (m^3/ha/yr)	Culm. Age (yrs)	Culm. Vol. (m^3/ha)
CWHvm1	50,378	34	30.1	1,377	$Fd_{39}Hw_{31}Cw_{23}Ba_{4}$	11.9	75	887
CWHvm2	40,097	27	18.7	1,163	$Hw_{35}Yc_{27}Cw_{16}Ba_{15}$	5.7	118	651
CWHxm2	18,447	12	30.7	1,263	$Fd_{60}Cw_{27}Hw_{12}Dr_{1}$	11.4	75	824
CWHmm1	15,630	11	30.7	1,279	$Fd_{56}Cw_{28}Hw_{14}Dr_{1}$	11.4	73	804
CWHxm2	18,447	12	30.7	1,263	$Fd_{60}Cw_{27}Hw_{12}Dr_{1}$	11.4	75	824
MHmm1	23,935	16	12.7	984	$Yc_{48}Ba_{34}Hm_{18}$	2.5	167	406

CWHmm1 12.5+ cm utilization

Table 16. Future PHR average *BatchTIPSY* input values in CWHmm1 (12.5+ cm utilization, untreated).

Attribute	Value
Subzone	CWHmm1
Util. (cm)	12.5
Area (ha)	15,630
Site Index (m)	30.7
Est. Density (sph)	1,279
Prop. of Cw	28
Prop. of Dr	1
Prop. of Fd	56
Prop. of Hw	14
Prop. of Pl	1
OAF1	0.90
OAF2	0.95

Table 17. Future PHR average culmination statistics by site series in CWHmm1 (12.5+ cm utilization, untreated).

Site Series	Area (ha)	Area (%)	Max. MAI (m^3/ha/yr)	Culm. Age (yrs.)	Culm. Vol. (m^3/ha)
01	8,266	53	11.7	70	820
01p	346	2	8.0	90	721
02	42	0	3.1	100	309
03	968	6	6.9	80	555
05	1,921	12	12.6	70	883
06	784	5	13.0	80	1041
06p	211	1	7.8	90	698
07	1,918	12	14.1	60	844
08	411	3	14.8	60	890
09	154	1	5.0	40	201
11	186	1	0.9	150	138
12	423	3	5.1	130	666
Avg.	.	.	11.4	73	804
Min.	.	.	0.9	40	138
Max.	.	.	14.8	150	1041
SD.	.	.	2.5	15	135

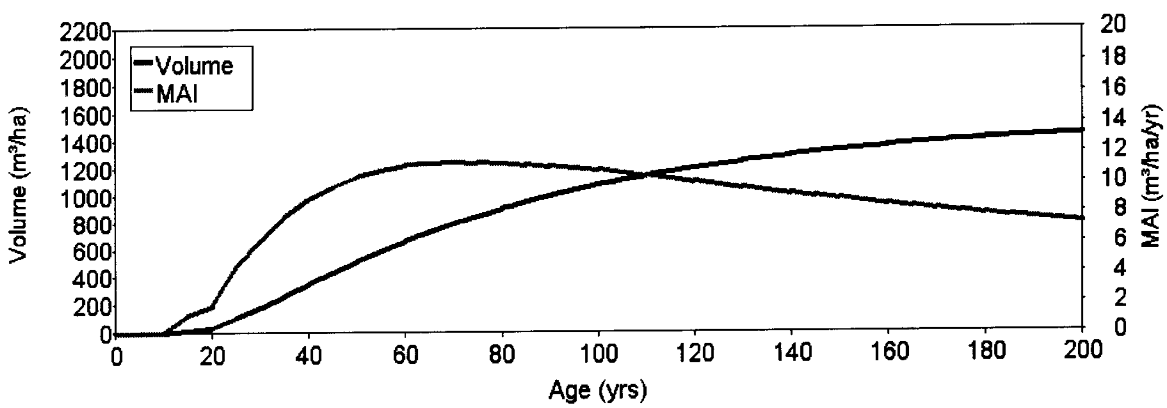


Figure 16. Future PHR volume and MAI over age curves for the CWHmm1 (12.5+ cm utilization).

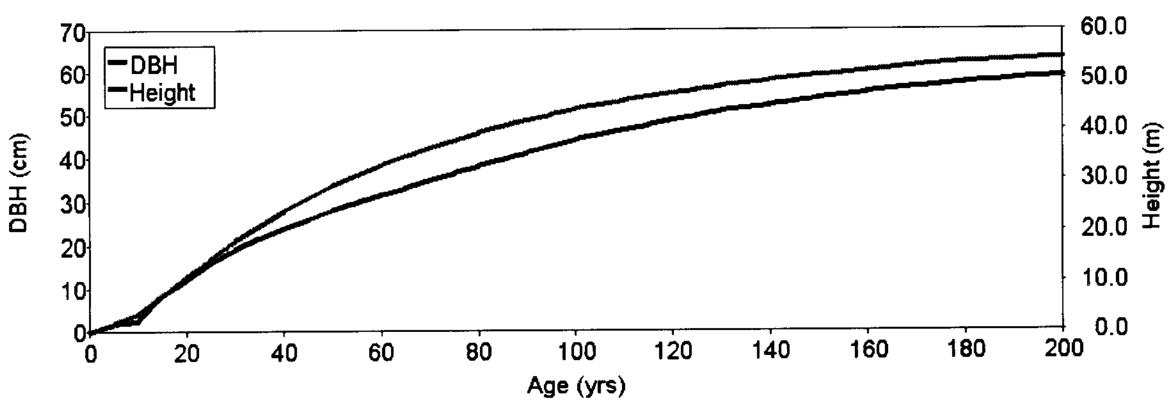


Figure 17. Future PHR DBH and height over age curves for the CWHmm1 (12.5+ cm utilization).

CWHvm1 12.5+ cm utilization

Table 18. Future PHR average *BatchTIPSY* input values in CWHvm1 (12.5+ cm utilization, untreated).

Attribute	Value
Subzone	CWHvm1
Util. (cm)	12.5
Area (ha)	50,378
Site Index (m)	30.1
Est. Density (sph)	1,377
Prop. of Ba	4
Prop. of Cw	23
Prop. of Fd	39
Prop. of Hw	31
Prop. of S	3
OAF1	0.90
OAF2	0.95

Table 19. Future PHR average culmination statistics by site series in CWHvm1 (12.5+ cm utilization, untreated).

Site Series	Area (ha)	Area (%)	Max. MAI (m^3/ha/yr)	Culm. Age (yrs.)	Culm. Vol. (m^3/ha)
01	26,095	52	13.2	70	924
01p	512	1	9.5	90	851
01s	1,117	2	8.7	90	779
02	107	0	4.2	100	425
03	11,179	22	8.8	80	702
04	5	0	9.1	80	729
05	2,845	6	13.3	70	931
06	3,807	8	13.0	80	1042
06p	192	0	7.5	110	830
06s	172	0	7.6	110	837
07	3,241	6	14.0	80	1120
09	291	1	14.0	80	1120
10	44	0	5.8	35	204
12	25	0	6.5	110	711
13	149	0	1.1	170	195
14	600	1	6.5	110	716
Avg.	.	.	11.9	75	887
Min.	.	.	1.1	35	195
Max.	.	.	14.0	170	1120
SD.	.	.	2.2	9	130

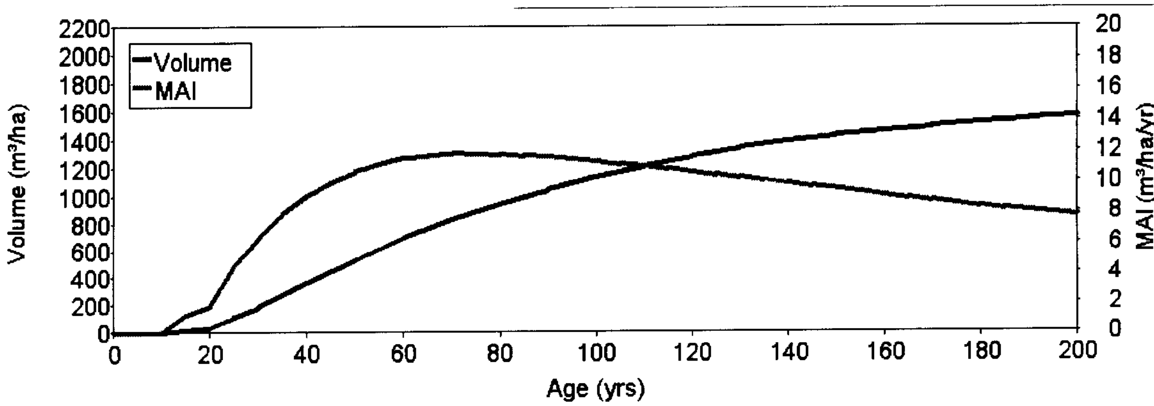


Figure 18. Future PHR volume and MAI over age curves for the CWHvm1 (12.5+ cm utilization).

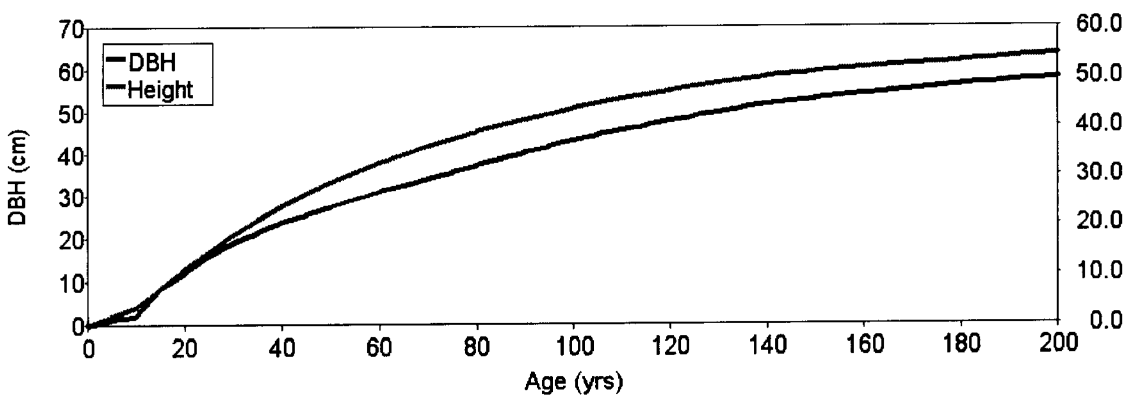


Figure 19. Future PHR DBH and height over age curves for the CWHvm1 (12.5+ cm utilization).

CWHvm2 12.5+ cm utilization

Table 20. Future PHR average *BatchTIPSY* input values in CWHvm2 (12.5+ cm utilization, untreated).

Attribute	Value
Subzone	CWHvm2
Util. (cm)	12.5
Area (ha)	40,097
Site Index (m)	18.7
Est. Density (sph)	1,163
Prop. of Ba	15
Prop. of Cw	16
Prop. of Fd	7
Prop. of Hw	35
Prop. of Yc	27
OAF1	0.90
OAF2	0.95

Table 21. Future PHR average culmination statistics by site series in CWHvm2 (12.5+ cm utilization, untreated).

Site Series	Area (ha)	Area (%)	Max. MAI (m^3/ha/yr)	Culm. Age (yrs.)	Culm. Vol. (m^3/ha)
01	20,042	50	6.6	110	725
01p	362	1	5.4	120	648
01s	268	1	6.2	110	684
02	734	2	1.1	120	134
03	11,798	29	3.6	120	437
04	2	0	5.5	120	666
05	663	2	9.3	100	934
06	4,129	10	7.1	110	784
06p	179	0	5.1	120	606
06s	51	0	4.9	130	636
07	925	2	7.8	110	859
09	561	1	6.4	120	771
10	73	0	0.9	180	167
11	310	1	4.1	130	529
Avg.	.	.	5.7	118	651
Min.	.	.	0.9	80	133
Max.	.	.	12.6	180	1215
SD.	.	.	2.3	15	198

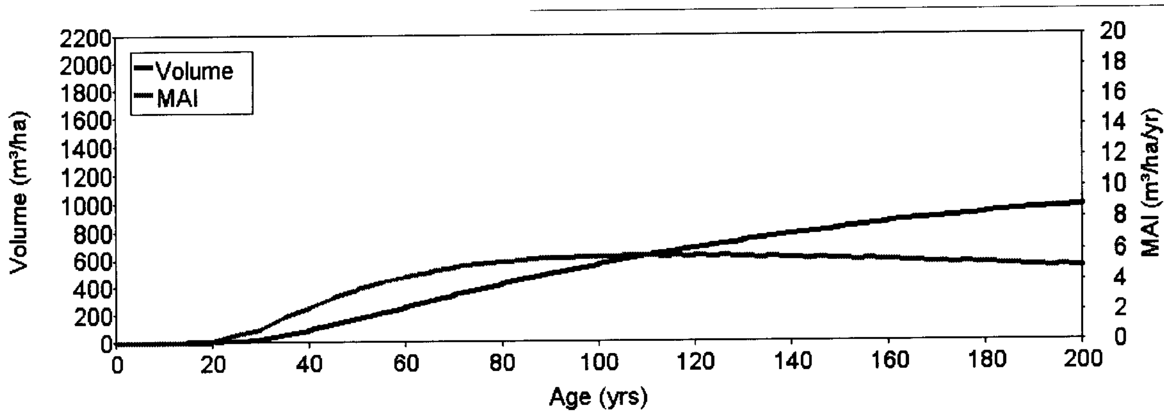


Figure 20. Future PHR volume and MAI over age curves for the CWHvm2 (12.5+ cm utilization).

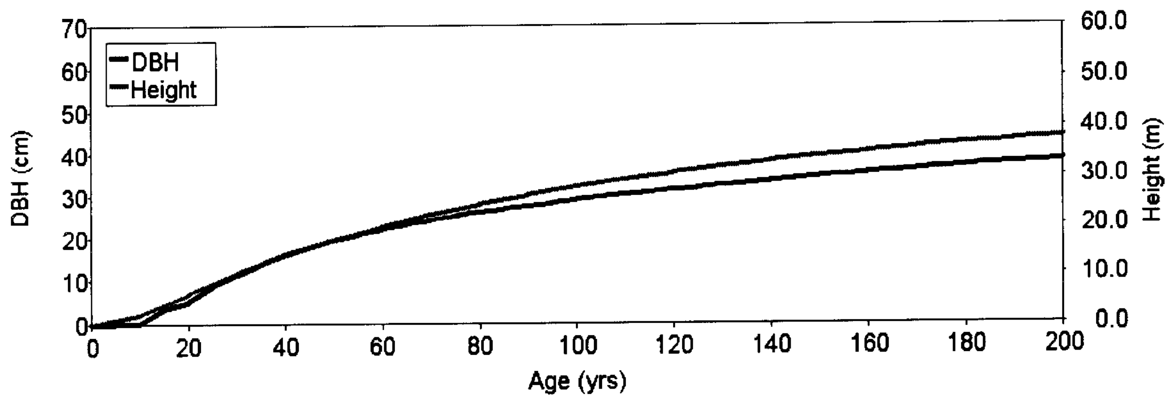


Figure 21. Future PHR DBH and height over age curves for the CWHvm2 (12.5+ cm utilization).

CWHxm2 12.5+ cm utilization

Table 22. Future PHR average *BatchTIPSY* input values in CWHxm2 (12.5+ cm utilization, untreated).

Attribute	Value
Subzone	CWHxm2
Util. (cm)	12.5
Area (ha)	18,447
Site Index (m)	30.7
Est. Density (sph)	1,263
Prop. of Cw	27
Prop. of Dr	1
Prop. of Fd	60
Prop. of Hw	12
OAF1	0.90
OAF2	0.95

Table 23. Future PHR average culmination statistics by site series in CWHxm2 (12.5+ cm utilization, untreated).

Site Series	Area (ha)	Area (%)	Max. MAI (m^3/ha/yr)	Culm. Age (yrs.)	Culm. Vol. (m^3/ha)
01	7,521	41	13.0	70	910
01p	1,534	8	9.3	80	746
02	55	0	4.2	100	416
03	4,247	23	7.2	80	576
05	1,918	10	14.5	70	1012
06	589	3	14.8	80	1186
06p	400	2	10.2	80	819
07	1,007	5	15.6	60	935
08	419	2	16.8	60	1006
09	251	1	4.4	50	218
11	190	1	0.9	230	210
12	317	2	9.3	110	1018
Avg.	.	.	11.4	75	824
Min.	.	.	0.9	50	210
Max.	.	.	16.8	230	1186
SD.	.	.	3.2	18	192

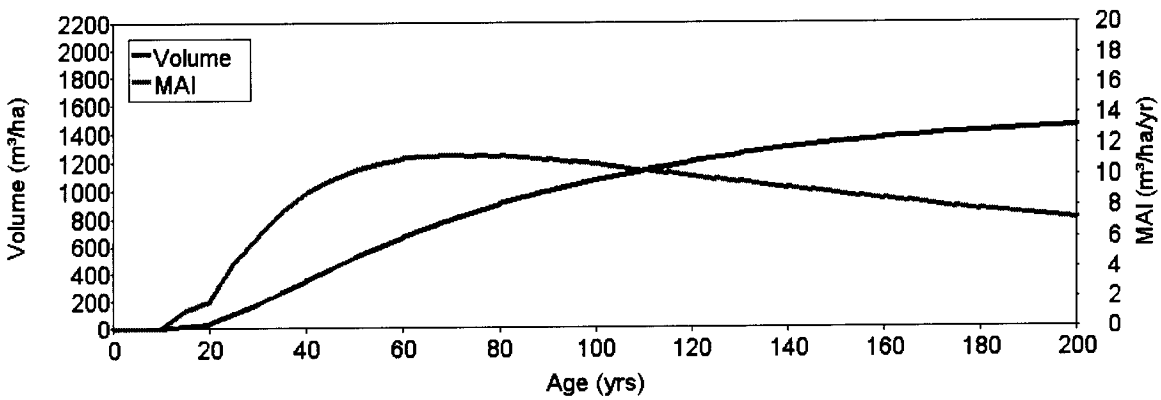


Figure 22. Future PHR volume and MAI over age curves for the CWHxm2 (12.5+ cm utilization).

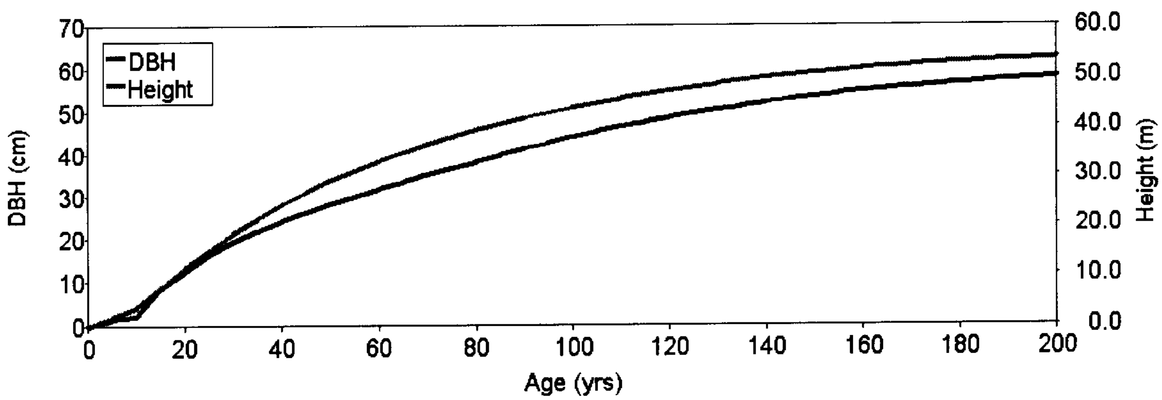


Figure 23. Future PHR DBH and height over age curves for the CWHxm2 (12.5+ cm utilization).

MHmm1 12.5+ cm utilization

Table 24. Future PHR average *BatchTIPSY* input values in MHmm1 (12.5+ cm utilization, untreated).

Attribute	Value
Subzone	CWHmm1
Util. (cm)	12.5
Area (ha)	23,935
Site Index (m)	12.7
Est. Density (sph)	984
Prop. of Ba	34
Prop. of Hm	18
Prop. of Yc	48
OAF1	0.90
OAF2	0.95

Table 25. Future PHR average culmination statistics by site series in MHmm1 (12.5+ cm utilization, untreated).

Site Series	Area (ha)	Area (%)	Max. MAI (m^3/ha/yr)	Culm. Age (yrs.)	Culm. Vol. (m^3/ha)
01	10,701	45	3.0	160	478
01p	351	1	1.7	220	381
02	7,193	30	1.6	190	312
03	110	0	4.6	130	592
04	256	1	3.2	140	450
05	788	3	3.1	150	463
06	75	0	3.2	120	383
07	2,485	10	3.8	130	495
08	777	3	1.5	150	230
09	1,198	5	1.1	190	208
Avg.	.	.	2.5	167	406
Min.	.	.	1.1	120	207
Max.	.	.	4.6	220	592
SD.	.	.	0.8	21	95

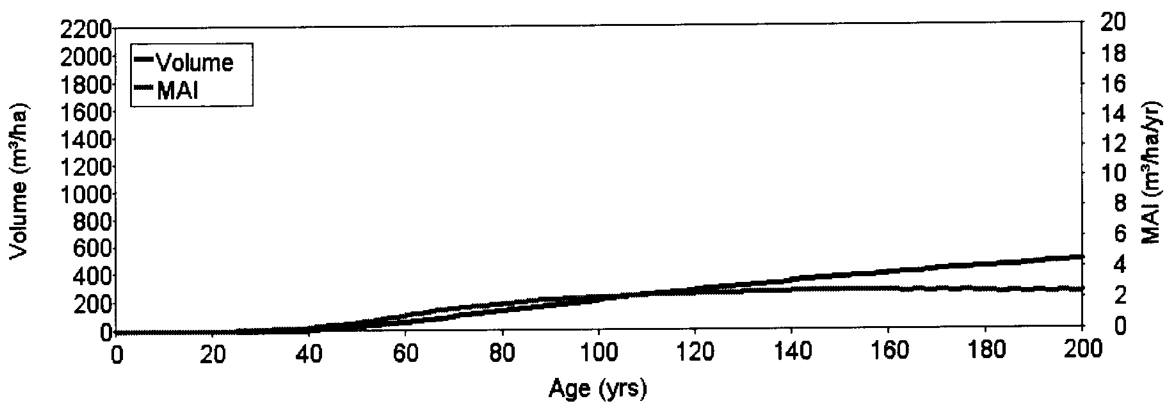


Figure 24. Future PHR volume and MAI over age curves for the MHmm1 (12.5+ cm utilization).

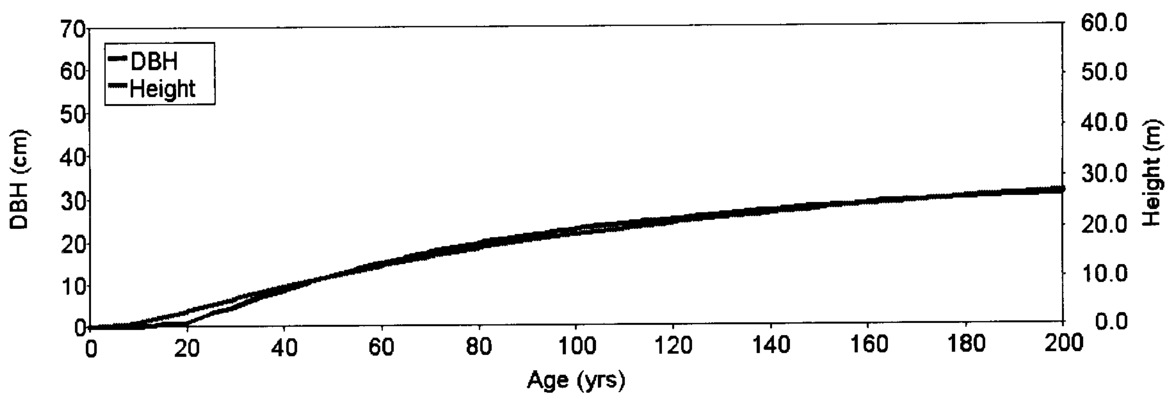


Figure 25. Future PHR DBH and height over age curves for the MHmm1 (12.5+ cm utilization).

APPENDIX E: DIGITAL FILES

This digital data is provided only to the Forest Analysis Branch on separate CDs, for their review of this information package. The data includes:

- Spreadsheet: 00-546_TFL37 SFM plan 9 Cluster Curves.xls
- Database: raw and aggregated NSYTs and MSYTs