Robson Valley TSA
Timber Supply Analysis

B.C. Ministry of Forests
1450 Government Street
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V8W 3E7

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Preface

This analysis is part of the provincial Timber Supply Review being carried out by the British Columbia Forest Service. The review is examining the short- and long-term effects of current forest management practices on the availability of timber for harvesting in timber supply areas (TSAs) throughout British Columbia. In many areas of the province, timber supply analyses performed in the early 1980s have not been updated to reflect new inventory information or changes in management practices.

To determine allowable timber harvesting levels accurately and rationally, the Chief Forester must have an up-to-date assessment of timber supply based on the best available information and reflecting current management direction. **The report that follows provides this assessment but should not be construed as a recommendation on permissible harvest levels.**

Unlike past analyses, which normally assessed the implications of several forest management scenarios, this report focuses on a single scenario— current management practices. Current management practices are defined by the specifications in management plans for the timber supply area, and include guidelines for the protection of forest resources, and official land-use decisions made by Cabinet. The current nature and capabilities of the local forest industry are also considered.

Assessing the implications of only current practices rather than looking at a number of different management schemes will expedite the analysis process, allowing analysis of all TSAs in the province to be completed by the end of 1994. An important part of these analyses, however, is an assessment of how results might be affected by uncertainties — a process called *sensitivity analysis*. Together, the sensitivity analyses and the assessment of the effects of current forest management on timber supply will form a solid basis for discussions among stakeholders about alternative timber harvesting levels.

This report is one of four documents that will be released for each TSA in the province as part of the Timber Supply Review. Two of these documents provide detailed technical information on the results of timber supply and socio-economic analyses. Another paper summarizes this information to provide a focus for public discussions of possible timber harvest levels. The fourth outlines the Chief Forester's decision and the reasoning behind it.

Executive Summary

As part of the provincial Timber Supply Review, the B.C. Forest Service has examined the availability of timber in the Robson Valley Timber Supply Area (TSA). The analysis assesses how current forest management practices affect the supply of wood available for harvesting over the next 250 years. It also examines the potential changes in timber supply stemming from uncertainties about forest growth and management actions. It is important to note that the various harvest forecasts included in the report only indicate the timber supply implications of current practices and uncertainty. **As such, the forecasts should be used for discussion purposes only; they are not allowable annual cut (AAC) recommendations.**

The Robson Valley TSA covers a total area of 1 235 821 hectares, of which about 209 365 hectares are considered available for timber harvesting under current management practices. Total current volume of operable standing timber in the area is about 52 million cubic metres, of which 48 million cubic metres is of merchantable age. The area is dominated by spruce and balsam stands with a mix of cedar, lodgepole pine, hemlock and fir stands.

The AAC for the Robson Valley TSA is 596 377 cubic metres per year. This does not account for 3 623 cubic metres that is apportioned to woodlots.

Current forest management of the Robson Valley TSA includes recognizing areas with significant forest resource values such as aesthetics, wildlife, community water supply, and old-growth. These values have been accounted for by excluding some sensitive areas and applying forest cover requirements to the land base that is assumed to be available for timber harvesting.

Given current management assumptions, the analysis shows the current AAC of 596 377 cubic metres per year can be maintained for another 10 years without causing a reduction in future harvest levels below the long-term level. After 10 years the harvest begins to decline at 10% each decade until the long-term level is reached in the sixth decade. The long-term harvest level, which is the potential maximum that can be harvested in perpetuity, is about 351 000 cubic metres per year.

If there is no limit on how quickly future harvest levels decline and harvests are allowed to fall below the long-term level, the current AAC can be maintained for 70 years. However, this would cause a serious timber shortage after 70 years that would last for many decades. If the harvest level were to be reduced immediately and maintained at the reduced level for as long as possible, then the existing growing stock would last longer and forests in the future would be older, on average. The magnitude of these effects would depend on the amount that harvest levels are reduced. Reducing the harvest level may result in the possibility of increased loss of timber to fire, insects and disease.

Many of the data and assumptions used in the analysis are subject to varying degrees of uncertainty. As an example, the extent of the land base assumed available for timber harvesting is particularly uncertain due to potential changes through the Protected Areas Strategy, Forest Practices Code and Land and Resource Management. Sensitivity analysis was used to examine how uncertainty about data and assumptions affect the results of the timber supply analysis.

Over the first 8 to 10 decades harvest levels are most sensitive to a decrease in the amount of mature forest available for harvesting, tightening of forest cover requirements to account for non-timber values and changes to volume estimates for existing timber. Short-term harvest levels are also moderately sensitive to changes in minimum harvestable ages but are relatively unsensitive to changes in yield estimates of future regenerated stands. The long-term harvest level is sensitive to uncertainty of regenerated stand yields and the land base assumed available for harvesting. In general, the long-term harvest level is not very sensitive to uncertainty about other data and assumptions.

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Introduction

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

Assessing the timber supply involves considering physical, biological, social and economic factors for all forest resource values, not just for timber. Physical factors include the area's land features as well as the physical characteristics of living organisms, especially trees. Biological factors include the growth and development of living organisms. Economic factors include the financial profitability of conducting forest operations and the broader community and social aspects of managing the forest resource.

All of these factors are linked: the financial profitability of harvest operations depends upon the terrain as well as the physical characteristics of the trees to be harvested. Determining the physical characteristics of trees in the future requires knowledge of their growth. Decisions whether a stand is available for harvest often depends on how its harvest could affect coincident or adjacent values of the forest for uses such as wildlife or recreation.

These factors are also subject to both uncertainty and different points of view. Financial profitability may change as world timber markets change. Unforeseen losses due to fire or pest infestations will alter the amount and value of timber. The appropriate balance of timber and non-timber values in a forest is an ongoing subject of debate, and is complicated by changes in social objectives over time.

Thus, before an estimate of timber supply is interpreted, the set of physical, biological and socio-economic conditions on which it is based, and which define current forest management — as well as the uncertainties affecting these conditions — must first be understood.

Timber supply analysis is the process of assessing and predicting the current and future timber supply for a management unit (a geographic area). For a timber supply area (TSA)*, the timber supply analysis forms part of the information used by the Chief Forester of British Columbia in determining an allowable annual cut (AAC)* — the permissible harvest level for the area.

Timber supply projections made for TSAs look far into the future — 200 years or more. However, because of the uncertainty surrounding the information and because forest management objectives change through time, these projections should not be viewed as static prescriptions that remain in place for that length of time. They remain relevant only as long as the information upon which they are based remains relevant. Thus, it is important that re-analysis occurs regularly using new information and knowledge to update the timber supply picture. Indeed, the *Forest Act* now requires that the timber supply for management units throughout British Columbia be reviewed at least every 5 years. This allows close monitoring of the timber supply and of the implications for the AAC stemming from changes in management practices and objectives.

**Throughout this document, an asterisk after a word or phrase indicates that it is defined in a box at the foot of the page, as well as in the glossary.*

Timber Supply Area (TSA)
An integrated resource management unit established in accordance with Section 6 *of the* Forest Act.

Allowable annual cut (AAC)
The allowable rate of timber harvest from a specified area of land. The Chief Forester sets AACs for timber supply areas (TSAs) and tree farm licenses (TFLs) in accordance with Section 7 *of the* Forest Act.

Introduction

Timber supply analysis involves three main steps. The first is the collection and preparation of information and data. The B.C. Forest Service forest inventory* plays a major role in this. The second step is using this data along with a timber supply computer model or models to make projections or estimates of possible harvest levels over time. These projections are made using different sets of assumed values or conditions for the factors discussed above. The third step is interpreting and reporting results.

The following sections outline the timber supply analysis for the Robson Valley TSA. Following a brief description of the TSA in Section 1, data preparation and formulation of assumptions are discussed in Section 2. Analysis methodology and results are presented in Sections 3 and 4 and Section 5 examines the sensitivity of the results to uncertainties in the data and assumptions used. The report ends with a summary and conclusions.

The appendix contains further details about the data and assumptions used in this analysis.

Forest inventory
Assessment of British Columbia's timber resources. It includes computerized maps, a database describing the location and nature of forest cover, including size, age, timber volume, and species composition, and a description of additional forest values such as recreation and visual quality.

1 Description of the Robson Valley TSA

The Robson Valley TSA covers approximately 1 236 000 hectares and is located in the Prince George Forest Region (Figure 1). It is administered from the Robson Valley Forest District office in McBride. The boundaries of the TSA coincide with those of the forest district.

The Robson Valley TSA lies mainly in the rocky mountain trench. It straddles the upper reaches of the Fraser River watershed in the north and the Canoe River drainage, a tributary to the Columbia River, in the south. In the northwest a small part of the TSA lies in the headwaters of the Cariboo River. It is cradled between the Rocky Mountains to the east and the Cariboo Mountain range to the west. The TSA is bordered by four provincial parks: Wells Gray and Bowron to the west, Kakwa to the north and Mount Robson to the east. Jasper National Park also forms part of the border to the east. Mount Robson Provincial Park is within the Robson Valley Forest District but lies outside the TSA. The towns of McBride, and Valemount are the major communities within the TSA.

Because of the mountainous terrain, the TSA is characterized by a varied climate and diverse ecology. The area is located in the interior wet belt and is thus mostly classified into the moister biogeoclimatic zones — Englemann Spruce-Subalpine Fir, Interior Cedar-Hemlock, and Sub-Boreal Spruce zones. The diverse ecology of the TSA supports a variety of tree species with spruce and balsam predominant. Cedar, lodgepole pine, hemlock and Douglas-fir are less common, but are nevertheless important commercial species.

The economy of the Robson Valley TSA is based on the forest industry, with mills in McBride, Tete Jaune Cache and Valemount. It is supplemented by agriculture in the Rocky Mountain Trench and tourism centred around Highways 5 and 16. Mt. Robson and Jasper Parks are also significant tourist destinations.

1 Description of the Robson Valley TSA

Figure 1. Map showing location of Robson Valley TSA within the Prince George Forest Region.

2 Information Preparation

Many pieces of information are required for timber supply analysis. Each piece falls into one of three categories: land base inventory, timber growth and yield, or management practices.

2.1 Land base inventory

Land base inventory information used in this analysis comes in the form of a computer file prepared by the B.C. Forest Service Inventory Branch in 1993 with minor adjustments in January 1994. This file contains a considerable amount of data about the thousands of pieces of forest land that make up a TSA, including the geographic location, area and nature of forest cover (such as presence or absence of trees, number of trees, species, age and timber volume).

Initially, this file is a representation of the land base for the entire TSA. It includes data for areas on which timber harvesting operations are not expected to take place and, therefore, do not contribute to the timber supply of the area. Examples are land that has been set aside for a park or the areas occupied by power lines, highways or town sites (such non-contributing areas specific to the Robson Valley TSA are described below). Before this land base file is used to make timber supply projections, data for these non-contributing areas must be removed to ensure that the file represents the timber harvesting land base*.

The reduced data file is derived through a process that identifies information for non-contributing areas and removes it from the file. When these reductions are made, care is taken to ensure that only a single reduction is made where categories overlap (for example, where a park area also has unstable soils).

It is important to remember that removal of data for areas not contributing to the timber supply does not imply withdrawal of areas from the TSA. The B.C. Forest Service still manages the entire area of the TSA (except for certain designated lands) as a forest unit that contributes a mix of timber and non-timber values. The timber supply is managed within that integrated resource context. The timber supply analysis in this report is consistent with this philosophy.

This section describes the types of areas not contributing to the timber harvesting land base. Use of the term *timber harvesting land base* in this report does not mean that an area is open to unrestricted timber harvesting activities. Rather, it implies that forests in the area contain timber of sufficient economic value — and sites with adequate environmental resilience — to accommodate timber harvesting with due care for other resources.

For analysis purposes, all study areas identified under the Protected Areas Strategy are assumed to be within the timber harvesting land base.

Areas on which timber harvesting is not expected to occur, given current forest management in the Robson Valley TSA, are as follows:

- areas not managed directly by the B.C. Forest Service — this includes non-Crown land, areas managed by other agencies (for example, parks, recreation areas) and forest land not administered as part of the TSA (for example, woodlot or tree farm licences)
- non-Crown areas — areas not managed directly by the B.C. Forest Service.
- non-forest areas — areas not occupied by productive forest cover (for example rock, swamp and alpine areas).
- non-commercial cover areas — areas occupied by non-commercial tree or brush species.
- inoperable areas* — areas defined as unharvestable for terrain-related and economic reasons. Characteristics used in defining inoperability include steepness of slope and topography.

Timber harvesting land base
The portion of the total land area of a management unit considered to contribute to, and be available for, long-term timber supply. The harvesting land base is defined by reducing the total land base according to specified management assumptions.

Inoperable areas
Areas defined as unharvestable for terrain-related or economic reasons. Characteristics used in defining inoperability include slope, topography (e.g., the presence of gullies or exposed rock), difficulty of road access, soil stability, elevation and timber quality. Operability can change over time as a function of changing harvesting technology and economics.

- environmentally sensitive areas* — a proportion of the areas considered to be sensitive were deducted from the timber harvesting land base.
- sites with low timber growing potential (low site class).
- deciduous stands.
- non-merchantable forest types — stands of non-merchantable coniferous species, low quality timber or low volume - mature and immature.
- existing forest roads, skid trails and landings — to account for the loss of productive forest land that has occurred during past timber harvesting and development, 5.7% of all area currently younger than 41 years and 5.7% of the area older than 40 years is removed.
- not satisfactorily restocked* (NSR) areas — these areas are initially removed, but are considered available for timber production when restocked and are added back into the timber harvesting land base at that time.
- riparian areas
- essential caribou habitat and visual quality preservation — timber harvesting has not occurred in these areas and in order to maintain their special values, is not expected to occur in the future.
- future forest roads, skid trails and landings — to account for future losses of productive land to development. These areas are initially included in the timber harvesting land base, but are removed after the first harvest.

Environmentally sensitive areas
An area with significant non-timber values or fragile or unstable soils, or in which there are impediments to establishing a new tree crop or timber harvesting may cause avalanches.

Not satisfactorily restocked (NSR)
An area not covered by a sufficient number of tree stems of desirable species. Stocking standards are set by the Forest Service, Silviculture Branch. If the expected regeneration delay (the period of time between harvesting and the date by which an area is occupied by a specified minimum number of acceptable well-spaced trees) has not elapsed, the land is defined as current NSR. If the expected delay has elapsed, the land is classified as backlog NSR.

2 Information Preparation

Table 1 summarizes the areas represented by each of the above criteria. A more detailed description of these categories and the rationale for the removals and additions are provided in Appendix A, "Description of Data Inputs and Assumptions."

Table 1. Timber harvesting land base, Robson Valley TSA

Classification	Area (hectares)	Per cent of total area	Per cent of Crown forest area
Total land base	1 235 821		
Not managed by B.C. Forest Service	42 489	3.44	
Non-forest land	710 924	57.53	
Total productive forest managed by Forest Service (Crown forest)	482 407	39.04	
Reductions to Crown forest:			
Non-commercial cover	2 413	0.20	0.50
Inoperable	127 285	10.30	26.39
Environmentally sensitive areas	69 501	5.62	14.41
Sites with low timber growing potential	32 722	2.65	6.78
Deciduous types	5 710	0.46	1.18
Non-merchantable stands (mature)	7 562	0.61	1.57
Non-merchantable stands (immature)	1 056	0.09	0.22
Existing roads, trails, landings	2 928	0.24	0.61
Not satisfactorily restocked (NSR)	8 554	0.69	1.77
Riparian areas	2 247	0.18	0.47
Essential caribou habitat high	20 258	1.64	4.20
Visual quality preservation areas	143	0.01	0.03
Total reduction	280 379	22.69	58.12
Initial timber harvesting land base (less NSR)	202 029	16.35	41.88
Additions:			
Not satisfactorily restocked [a]	7 336	0.59	1.52
Current timber harvesting land base	209 365	16.94	43.40
Future reductions:			
Future roads, trails, landings	9 023	0.73	1.87
Future timber harvesting land base	200 342	16.21	41.63

[a] All NSR land was initially subtracted. The portion of NSR area considered available for timber production, as recorded in silviculture history records, was then added to the harvesting land base. NSR can be created by natural forces — particularly fire — as well as timber harvesting, and some is not operable for harvesting. This procedure was used because the silviculture records on NSR are considered more accurate than the inventory file.

2 Information Preparation

Figure 2 shows the total Robson Valley TSA land base summarized by three major categories. The amount of land upon which forest operations may occur is 39% of the TSA or 482 408 hectares of Crown forest land. This is referred to as the 'Crown productive forest land base'.

Not all of the productive Crown forest is considered available for timber harvesting. Figure 3 shows that only 41.9% of the productive Crown forest is available for timber harvesting. The largest single reduction to the productive Crown forest land base is for inoperable areas.

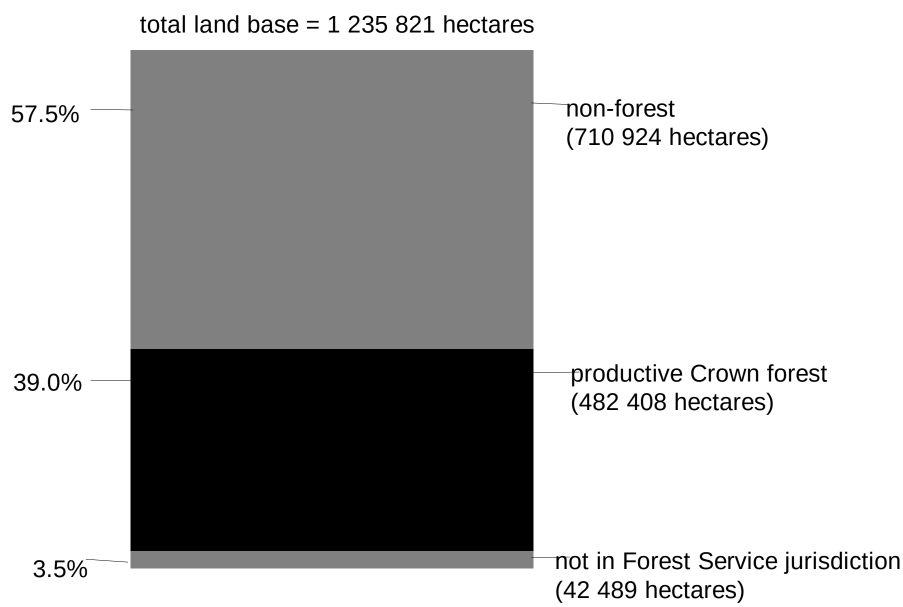

Figure 2. Total land base by major land categories, Robson Valley TSA.

2 Information Preparation

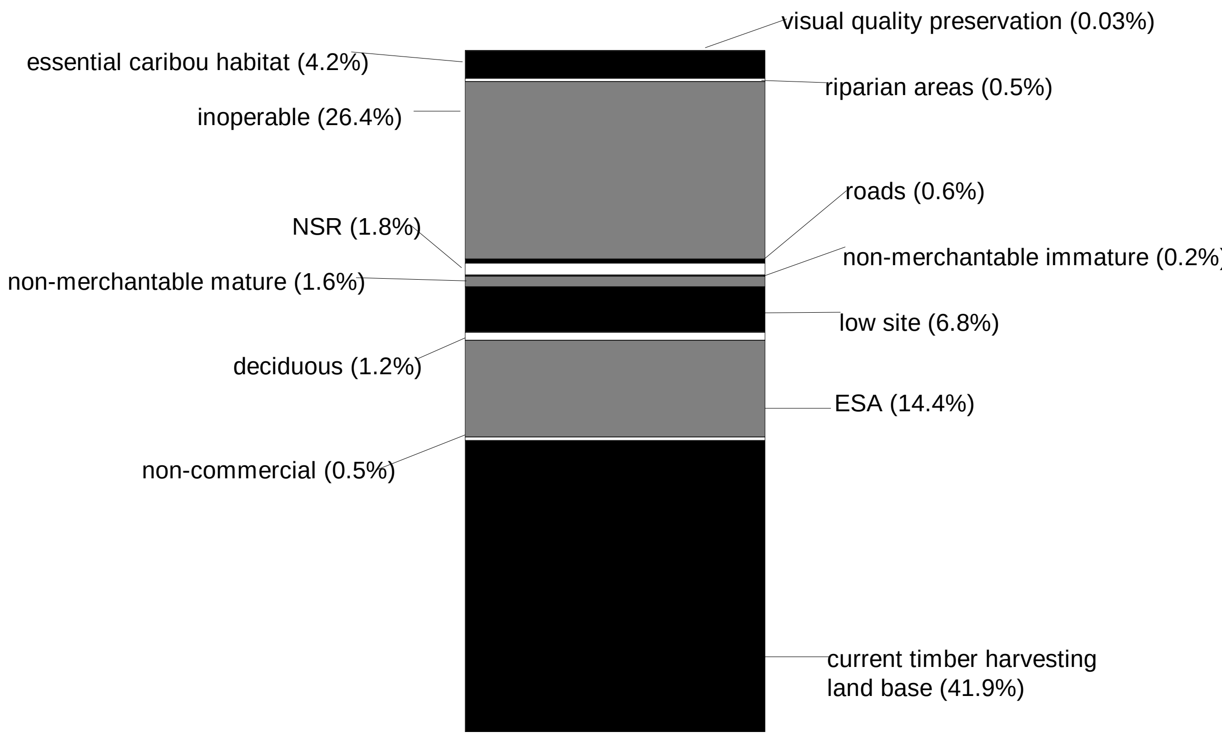

Figure 3. Classification of the productive Crown forest land base, Robson Valley TSA.

The current timber harvesting land base (209 365 ha) contains the most significant biological, visual, and economic richness of the TSA, and is the focus of this analysis. Forest management activities of the timber harvesting land base include (timber harvesting, silvicultural practices, maintenance of visual quality, etc.) are conducted on this portion of the land base. As shown, the timber harvesting land base accounts for 41.9% of the productive Crown forest and 16% of the total area of the Robson Valley TSA.

The timber harvesting land base contains many stands of trees of varying ages. Figure 4 shows the age distribution of these stands by 10-year classes. The figure illustrates the preponderance of older stands. This initial age structure would tend to allow higher harvest levels over the short term because a large part of the forest is now at or close to merchantable age* and only a small part is currently below green-up* criteria.

Merchantable age
The age at which a tree or stand has attained sufficient size, quality and/or volume to make it suitable for harvesting.

Green-up
The time needed after harvesting for a stand of trees to reach a desired condition (e.g., height) to ensure maintenance of water quality, wildlife habitat, soil stability or aesthetics.

2 Information Preparation

Figure 5 shows the composition of the timber harvesting land base by species and maturity. Currently, over 70% of the stands in the timber harvesting land base are 100 years of age. Spruce stands over 100 years account for more than 33% of the current timber harvesting land base.

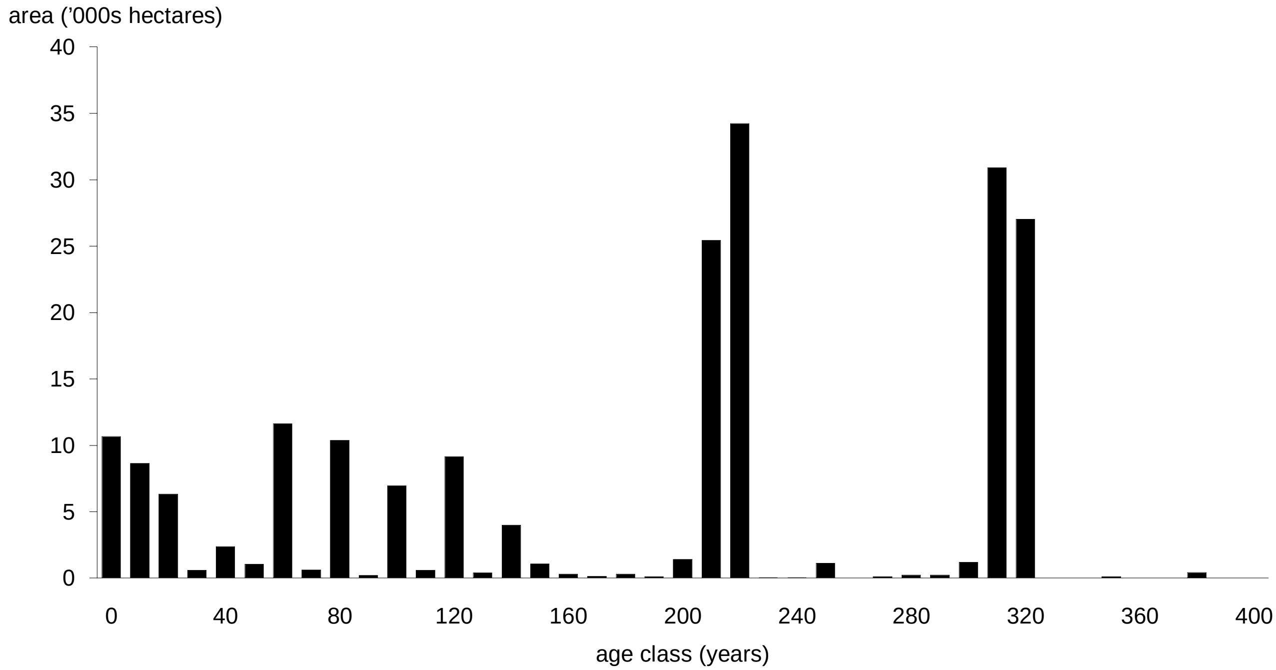

Figure 4. Current age class distribution — timber harvesting land base, Robson Valley TSA.

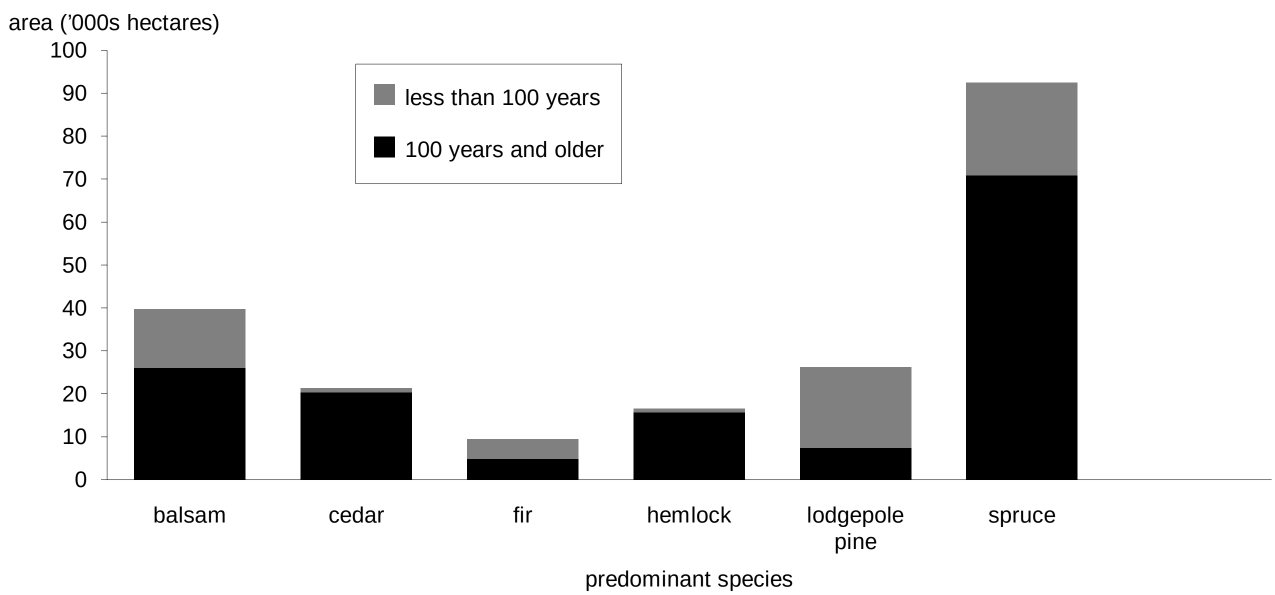

Figure 5. Current species composition — timber harvesting land base, Robson Valley TSA

Figure 6 shows the timber harvesting land base by site quality class. The site quality of the area is skewed towards the poorer rating with almost 54% of the area classified as poor and only 16% classified as good.

2.2 Timber growth and yield

Timber growth and yield refers to the prediction of the growth and development of individual forest stands over time. The most common measure of the amount of standing timber is volume per area (in British Columbia, cubic metres per hectare). This measure assumes a utilization level or set of dimensions that establishes a minimum size limit for trees and logs that must be harvested and removed from a site. Utilization levels specify a maximum stump height and minimum diameters at the tree base and top.

Timber volumes applied to existing stands in this analysis are based on the Variable Density Yield Prediction (VDYP) model developed by the B.C. Forest Service Inventory Branch. This model provides estimates of stand volume according to age. Volumes estimated for future regenerated stands are based on managed stand yield tables produced by the Research Branch of the B.C. Forest Service. Sensitivity analysis addresses the possibility that actual stand volumes may be different than those predicted.

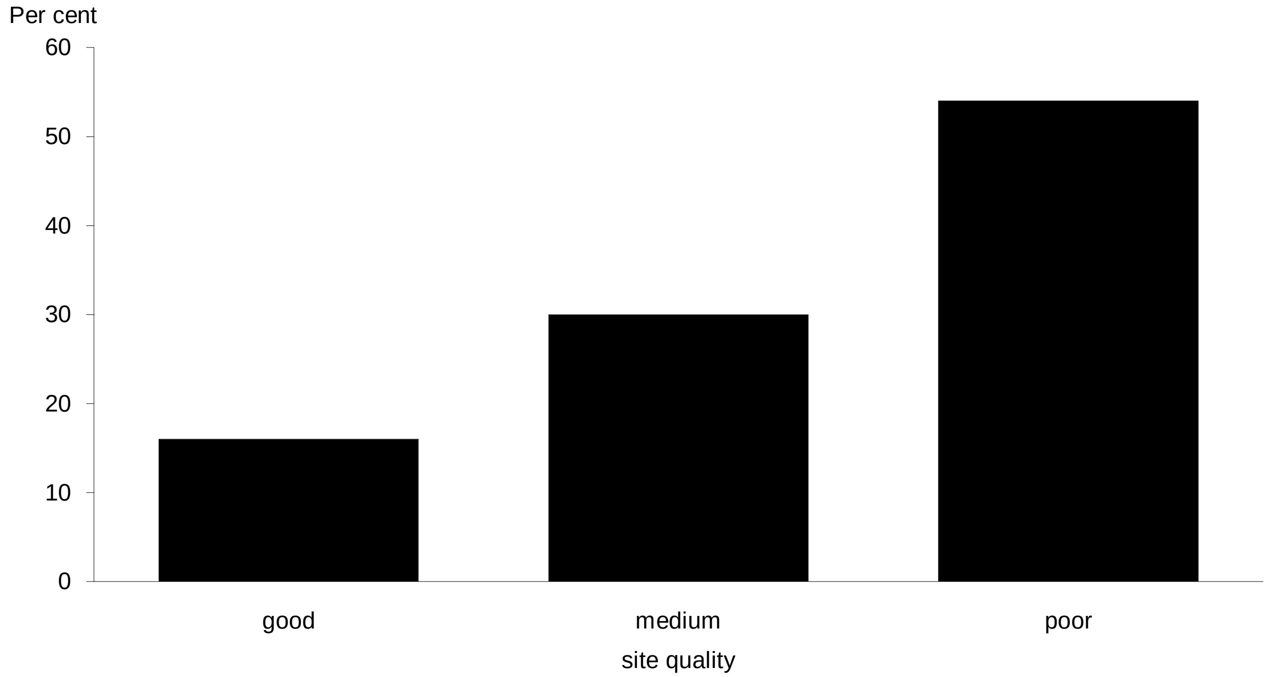

Figure 6. Area by site quality class — timber harvesting land base, Robson Valley TSA.

2 Information Preparation

2.3 Management practices

Timber supply is directly connected to forest management activity. The focus of the Timber Supply Review is to describe the timber supply based on current management practices, as implemented in plans for the area. Staff in the Robson Valley Forest District and in the Prince George Forest Region defined these practices in the following management assumptions*:

- Basic silviculture levels — reforestation activities required to establish free-growing* stands of acceptable species. In the Robson Valley TSA, most areas are harvested using a clear-cut harvesting* system and are restocked by planting or natural regeneration. However, in some parts of the TSA, such as the Valemount watershed, harvesting occurs using a partial-cut management* system, such as selection, shelter, or shelterwood with standards. Partial-cut management is carried out to aid regeneration by leaving enough trees standing to provide shade in which seedlings can survive. In the Robson Valley TSA, it is assumed that 30% of the total volume of a stand is harvested from a stand during the first entry. After the first entry, it is assumed that a constant volume will be harvested from the stand with entries every 30 years. Eventually, a stand managed in this way will contain trees of various ages, also referred to as uneven-aged.
- Forest health and non-recoverable losses — expected timber losses due to fire, wind damage, and pest (insect, disease and animals). For the Robson Valley TSA, non-recoverable losses are estimated to be 70 428 cubic metres per year. These losses are deducted to produce the volumes shown in Section 4, "Results," and in Section 5, "Timber Supply Sensitivity Analyses."

Management assumptions
Approximations of management objectives, priorities, constraints and other conditions needed to represent forest management actions in a forest planning model. These include, for example, the criteria for determining the timber harvesting land base, the specification of minimum harvestable ages, utilization levels, integrated resource guidelines and silviculture and pest management programs.

Free-growing
An established seedling of an acceptable commercial species that is free from growth-inhibiting brush, weed and excessive tree competition.

Clear-cut harvesting
A harvesting method whereby all trees that meet utilization standards are harvested. The harvested site is then regenerated to an acceptable standard by appropriate means; including planting and natural seeding.

Partial-cut management
Includes harvest and renewal operations that provide for visual quality, wildlife habitat, water quality and old growth in a sensitive watershed.

- Forest cover objectives* — forest cover guidelines are applied to account for the management of forest resources to protect wildlife habitat or to maintain visual quality. There are two types of guidelines that can be applied. One specifies the maximum percentage of area allowed to be in a disturbed state and the other specifies a minimum percentage of area that must be older than a prescribed age. When applying the first type of guideline, an area is considered to be disturbed until forest regeneration reaches a condition that allows adjacent mature timber to be harvested. The length of time required to reach the desired condition is referred to as the "green-up period." The second type of guideline is applied to meet the needs of non-timber values such as wildlife habitat and to maintain ecological diversity.
- Utilization levels — tree and log size limits describing what timber must be harvested and removed from the site. Utilization levels specify a maximum stump height and minimum diameters at the tree base and top. The utilization levels are presented in Appendix A, "Description of Data Inputs and Assumptions."
- Minimum harvestable ages — the time it takes for stands to grow to harvestable size. The minimum harvestable age defines the lower age limit for harvesting. Actual harvest age depends on many factors, including the ages of other stands, limits on overall harvest level, and forest cover requirements.
- Rate of restocking of current and backlog not satisfactorily restocked (NSR) areas.

Current NSR is assumed to be restocked within 4 years and backlog NSR is assumed to be restocked over the next 35 years. A more detailed discussion of the management assumptions is included in Appendix A, "Description of Data Inputs and Assumptions."

> ***Forest cover objectives***
> *Desired distributions of areas by age or size class groupings. These objectives can be used to reflect desired conditions for wildlife, watershed protection, visual quality and other integrated resource management objectives.*

2.4 Management zones

This analysis recognizes the importance of forest values such as visual quality, wildlife habitat, old-growth and water quality to the Robson Valley TSA. Some areas are of particular concern and have been defined as separate management zones for this analysis. Also, zones have been defined where partial-cut harvesting systems are used and where no harvesting has occurred over many years. For analysis purposes seven management zones were used to represent current management practices as defined through the local resource use plan process.

Landscape partial retention*
This zone includes visually sensitive areas such as along the Rocky Mountain Trench and other areas where alterations to the landscape may be visible but are not conspicuous. Effective management of partial retention areas is defined to allow a maximum of 10% of the area to be under cover of stands that have not reached green-up conditions. For example, trees 5 metres tall are considered to have met visual green-up conditions. Therefore, at any given time, a maximum of 10% of the area may be covered by trees less than 5 metres tall.

Landscape retention*
Management of retention areas allows a maximum of 3% of the area to be under cover of stands that have not reached green-up conditions. Visually effective green-up height for landscape retention is assumed to be 5 metres.

> ***Landscape partial retention***
> *Alterations are visible but are not conspicuous. Up to 15% of the area can be visibly altered by harvesting activity.*
>
> ***Landscape retention***
> *Alterations are not easy to see. Up to 5% of the landscape can be visibly altered by harvesting activity.*

Caribou habitat medium and caribou corridor
Caribou habitat considered to be of medium significance and caribou corridor areas have similar requirements and are therefore analyzed as one zone. These areas can be altered somewhat by timber harvesting without significantly affecting caribou habitat. In these caribou areas, 33% of the volume may be removed every 80 years. This is roughly equivalent to allowing no more than 33% of the area to be under cover of stands younger than green-up age. this ensures a continuous older forest cover and a mix of younger forest. The green-up height in this zone is 3 metres. Within this zone, a harvested area must be subsequently occupied by trees 3 metres tall before adjacent areas may be harvested.

Partial cut areas
Most of the areas managed under partial cut systems are sensitive watersheds identified in local resource use plans. The silvicultural systems used in these areas include selection, shelterwood and small patch cutting. This zone was analysed by assuming that 30% of the existing volume will be harvested within 80 years. After 30 years, it is assumed that a volume equal to the amount that the area yields annually is removed. This process ensures that at all times a wide mix of ages are present within the zone.

Landscape modification*
Management constraints allow a maximum of 25% of the area to be under cover of stands that have not reached green-up conditions. Visually effective green-up height is assumed to be 5 metres. Therefore, at any given time, a maximum of 25% of the area may be under cover of stands less than 5 metres tall.

Timber emphasis
This is an integrated resource management zone where the main focus of management is timber harvesting. Within this zone a maximum of 33% of a landscape may be under cover of stands that have not reached the green-up height of 3 metres.

Old-growth special management
Current practices for old-growth and biodiversity management in the Lower Morkill/McKale River area specify an average cutblock size of 5 hectares. Within the cutblock, 5% of a variety of tree species and ages must be retained. Management constraints allow a maximum of 25% of the area to be covered by stands less than 3 metres tall and require that a minimum of 5% of the area be covered by stands over 200 years old.

Each management zone has a unique set of guidelines governing timber harvesting operations. Figure 7 shows the area of each zone in the Robson Valley TSA.

Landscape modification
Alterations may dominate the visual landscape, but should blend with natural features. Up to 25% of the area can be visibly altered by harvesting activity.

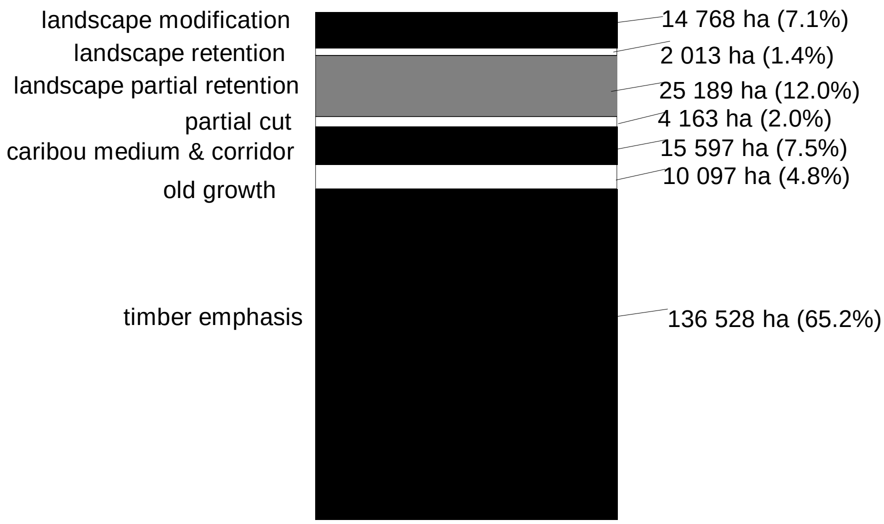

Figure 7. Breakdown of the timber harvesting land base by zone, Robson Valley TSA.

3 Analysis Methods

The purpose of this analysis was to examine both the short- and long-term timber harvesting opportunities in the Robson Valley TSA, given current forest management practices. A timber supply computer simulation model developed by the B.C. Forest Service was used to aid in the assessment. A timber supply model, as distinct from a growth and yield model, assists the timber supply analyst in determining how a whole forest (collection of stands) could be managed to obtain a harvest forecast (supply of timber over time). The simulation model uses information about the timber harvesting land base, timber volumes and the management regime to represent how trees grow and are harvested over an interval of up to 400 years. Because the harvest flow remains constant from 250 to 400 years from now, only the results for the first 250 years are shown in this report.

Similar to other timber supply models, the B.C. Forest Service model assumes that trees grow according to provided yield projections and are harvested according to either a volume target or a specified objective set by the analyst, such as harvest volume maximization. However, the Forest Service model differs from most other models in that it allows the use of forest cover guidelines that specify the desired age composition of the forest. These cover guidelines can be used to examine the effects of cutblock adjacency* and green-up prescriptions. For example, guidelines might specify that no more than some maximum per cent of the area can be younger than a specified green-up age, or that some minimum per cent of the area must be in older age classes to provide wildlife habitat. The B.C. Forest Service simulation model examines the effects of such guidelines on timber supply.

This type of analysis is used to determine the timber supply implications of a particular forest management regime. The results of the analysis are especially important in determining allowable cuts that will not restrict options of future resource managers, and that will allow local B.C. Forest Service staff to administer their programs according to relevant guidelines and principles. **However, the results of the analysis do not recommend any particular AAC.**

The main results of the analysis are forecasts of potential timber harvests and timber inventory changes (ages and volumes) over time. Although this information gives field staff only very limited guidance in the design of operational activities such as cutblock location and silviculture planning, it does help ensure that the timber harvest level supports rather than hinders sustainable forest management in the field.

Cutblock adjacency
Integrated management guidelines that specify the desired spatial relationship among cutblocks. They can be approximated by specifying the maximum allowable proportion of a forested landscape that does not meet green-up requirements.

4 Results

4.1 Base harvest forecast

The harvest forecast based on current management assumptions for the Robson Valley TSA is shown in Figure 8. This forecast is referred to as the base harvest forecast and is used as the basis for comparison for all other harvest forecasts in this report.

The base harvest forecast shows an initial harvest rate equal to the current AAC of 596 377 cubic metres. The initial harvest level can only be held for 1 decade before a decline at 10% per decade must occur in order to avoid major future disruptions in timber supply. The long-term level of 351 000 cubic metres is reached by decade 6 and represents a 41% decline from the initial harvest level. An initial level greater than that of the long-term is possible because of the large proportion of existing older aged stands (Figure 4). These older existing forests have a greater volume per hectare than future forests because future forests are expected to be harvested at younger ages. Harvesting above the long-term level implies an inevitable decline.

The long-term harvest level in this forecast is about 58 000 cubic metres less than the biological maximum based on maximum mean annual increment (MAI*) long-term level of 409 000 cubic metres annually. There are two main reasons why the theoretical long-term level cannot be attained: timing of harvests, and forest cover requirements. Minimum ages are established at ages which are inevitably higher or lower than the maximum MAI. Stands may not be harvested at the age of maximum MAI and therefore bring the long-term level down. Secondly, cover requirements for forest values such as wildlife, visual quality, and old-growth result in areas being temporarily unavailable for harvest and consequently lowering long-term harvest levels.

It should be noted that all harvest forecasts in this report have been reduced by 70 428 cubic metres per year to account for unsalvaged losses due to fire, insects and disease. Several criteria were used to define the base case harvest forecast.

The initial level was defined by attempting to maintain the current harvest level for the Robson Valley TSA (596 377 cubic metres per year) for at least the next 10 years, declining by at most 10% in each of the following decades, and avoiding harvest shorfalls below the long-term level. The long-term level was defined as the harvest level that will maintain timber growing stock at an even level so that harvesting can continue at that rate in perpetuity (Figure 9). A continually declining growing stock* would signify that timber is being harvested above the productive capability of the land. Other possible harvest flows are examined in Section 5.1.

Mean annual increment (MAI)
Stand volume divided by stand age. The stand age at which the MAI assumes its maximum value is called the culmination age. Harvesting all stands at this age results in a maximum average harvest over the long term.

Growing stock
The volume estimate for all standing timber, of all ages, at a particular time.

4 Results

As illustrated by the solid line in Figure 9, the timber harvesting land base currently contains a total of about 52 million cubic metres of standing timber. The dashed line indicates that about 48 million cubic metres of timber is older than the minimum harvestable ages set for each tree species. Similar to the trend seen for the base harvest forecast (Figure 8), both the total growing stock and that above minimum harvestable age are projected to decline over the next 100 or so years before stabilizing. The trend in growing stock over time is again a result of the initial harvest level being higher than the long-term level and the transition from an old forest to a younger forest that yields less volume at harvest.

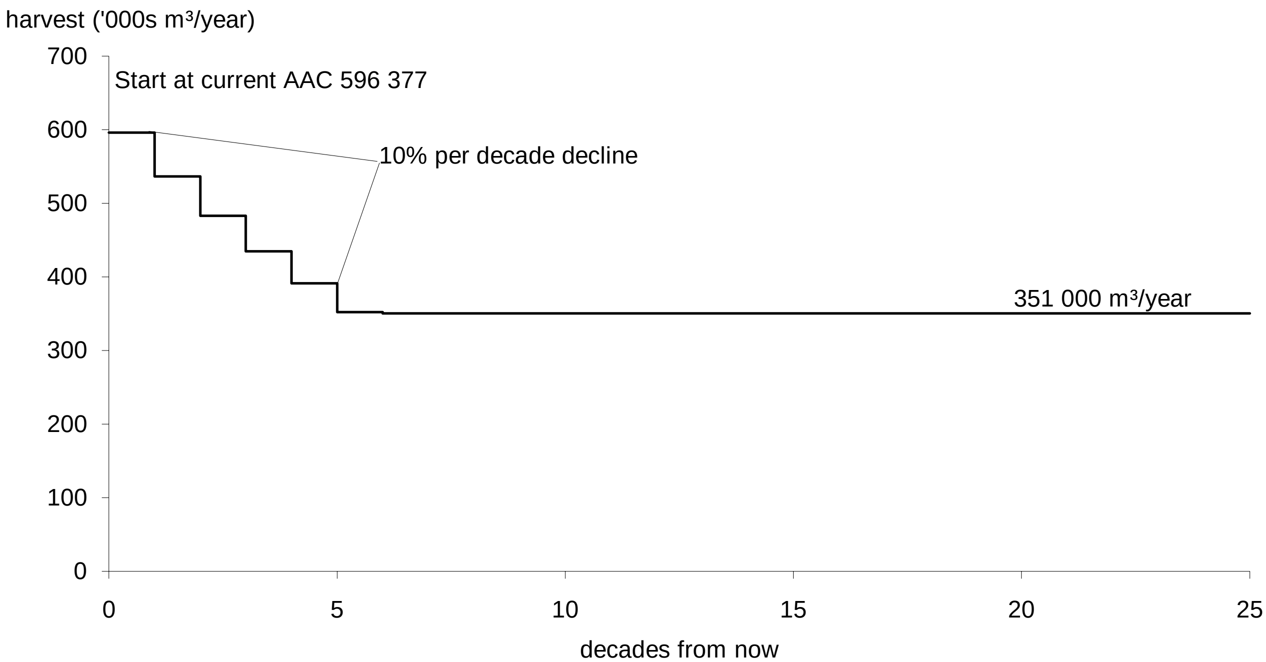

Figure 8. Base harvest forecast, Robson Valley TSA.

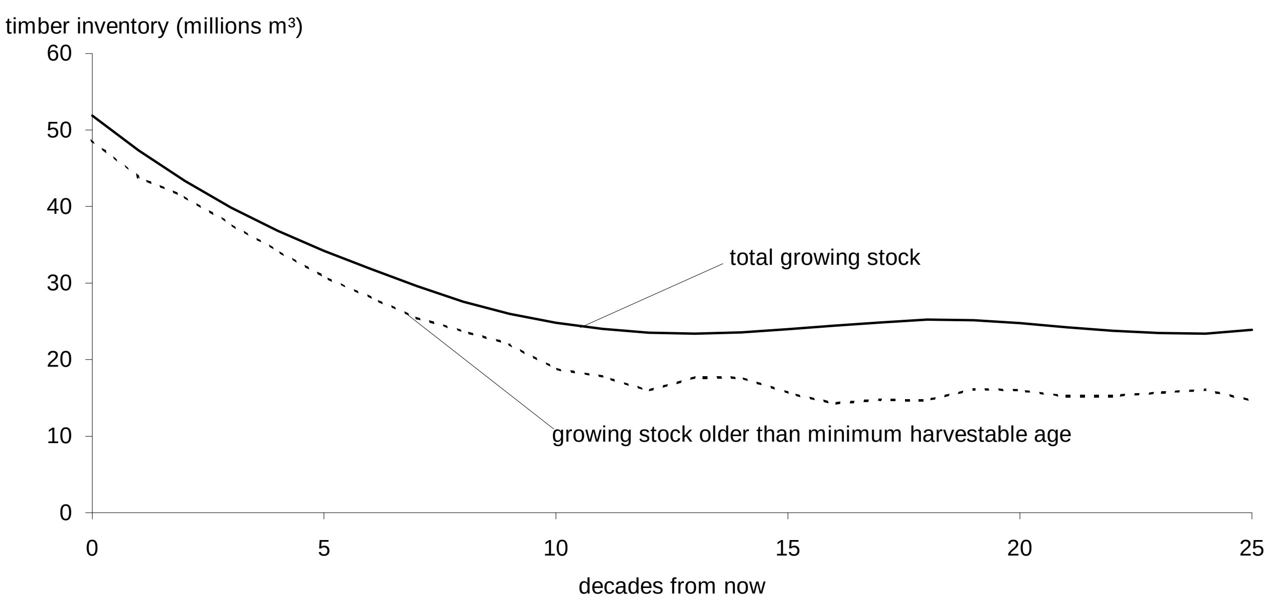

Figure 9. Total growing stock and harvestable growing stock over time, Robson Valley TSA.

4 Results

The relationship between annual volume per hectare harvested and the annual area harvested are shown in Figures 10 and 11. The annual average volume per hectare harvested is initially about 330 cubic metres per hectare and oscillates several times during the 25-decade horizon. The high of about 365 cubic metres per hectare occurs in decade 3 while a low of about 210 cubic metres per hectare occurs in decade 18. These volumes include 70 428 cubic metres per year of non-recoverable losses. There is a general trend toward harvesting lower volumes per hectare which reflects the trend towards harvesting younger stands that yield lower volumes. The oscillations are caused by older forests being unavailable for harvest to meet forest cover requirements until they have aged well beyond that minimum harvestable ages.

Figure 11 shows that the pattern for the annual area harvested is almost the reverse of the pattern of volume per hectare harvested. Average volume per hectare harvested is high when area harvested is low, and low when area harvested is high. This relationship is expected since the timber harvest is constant at 351 000 cubic metres per year for most of the analysis horizon. The annual area harvested is initially about 2025 hectares. A low of about 1215 hectares per year comes in decade 8, when the average volume per hectare is high. When the average volume per hectare decreases, more area must be harvested to attain a given volume.

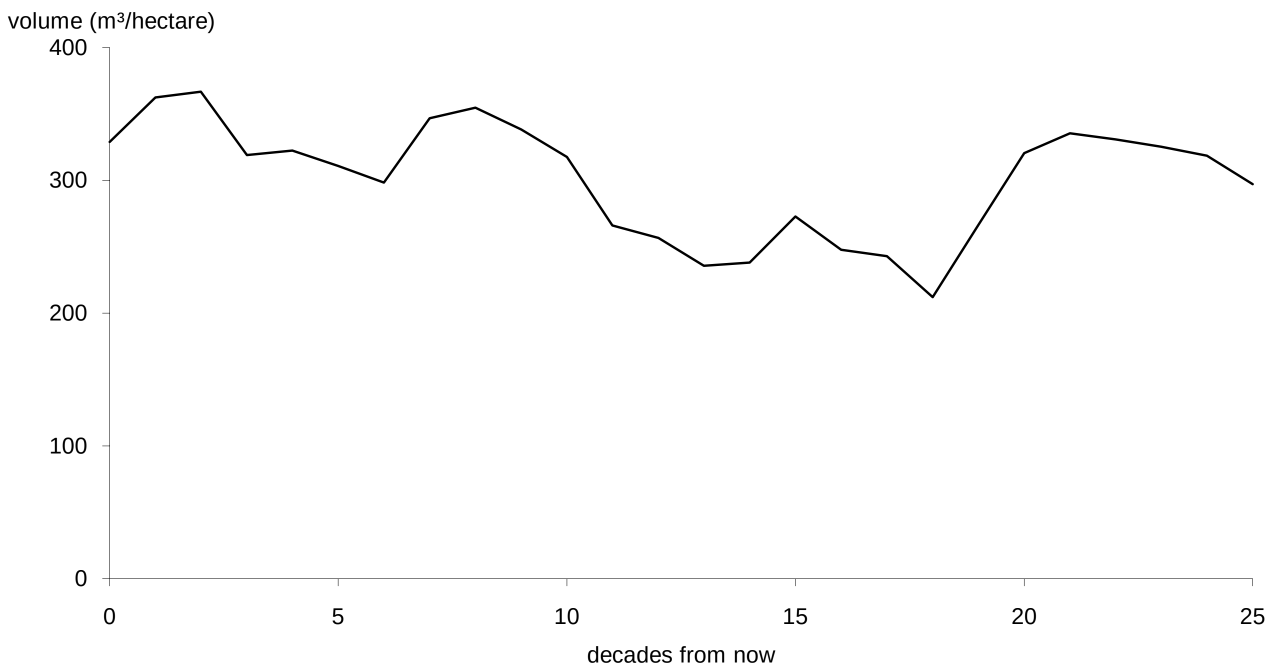

Figure 10. Average volume of timber harvested per hectare over time, Robson Valley TSA.

4 Results

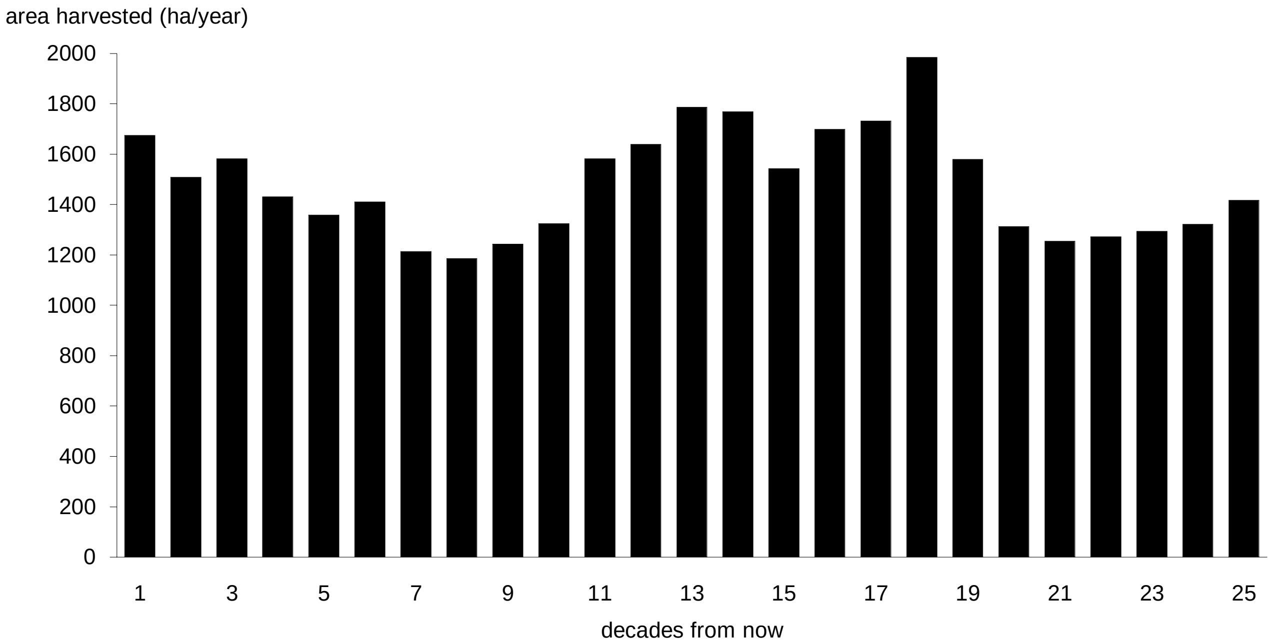

Figure 11. Average annual area harvested over time, Robson Valley TSA.

Given the assumptions in the base harvest forecast for the land base and its management, the following figures illustrate the dynamics of the stand age distribution over time. As indicated in the Figure 12 series, the area covered by stands under 120 years old becomes more evenly distributed over time. Requirements for visual quality, wildlife habitat, and old-growth result in timber being retained in the older age classes.

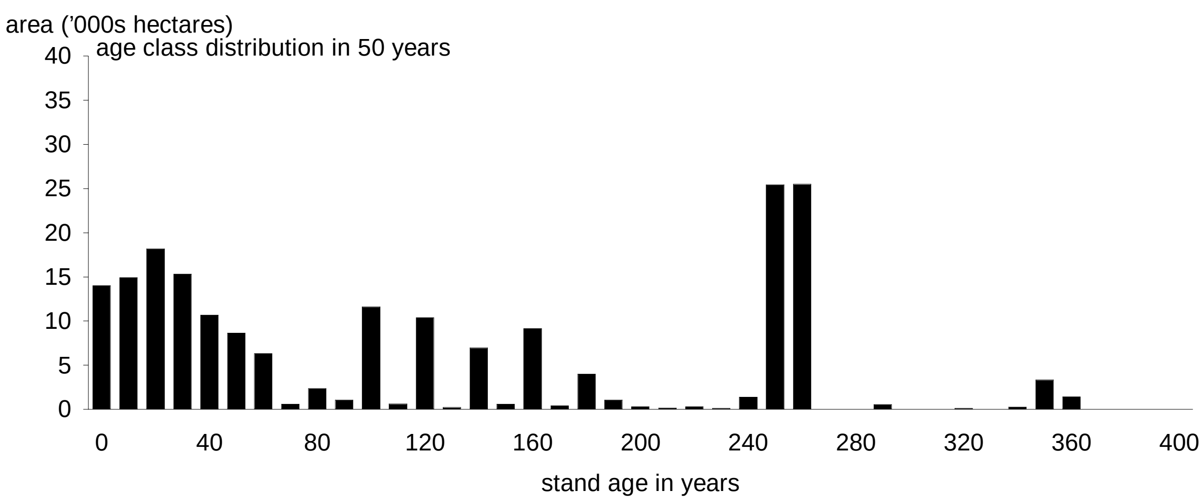

Figure 12. Stand age distribution over time, Robson Valley TSA.

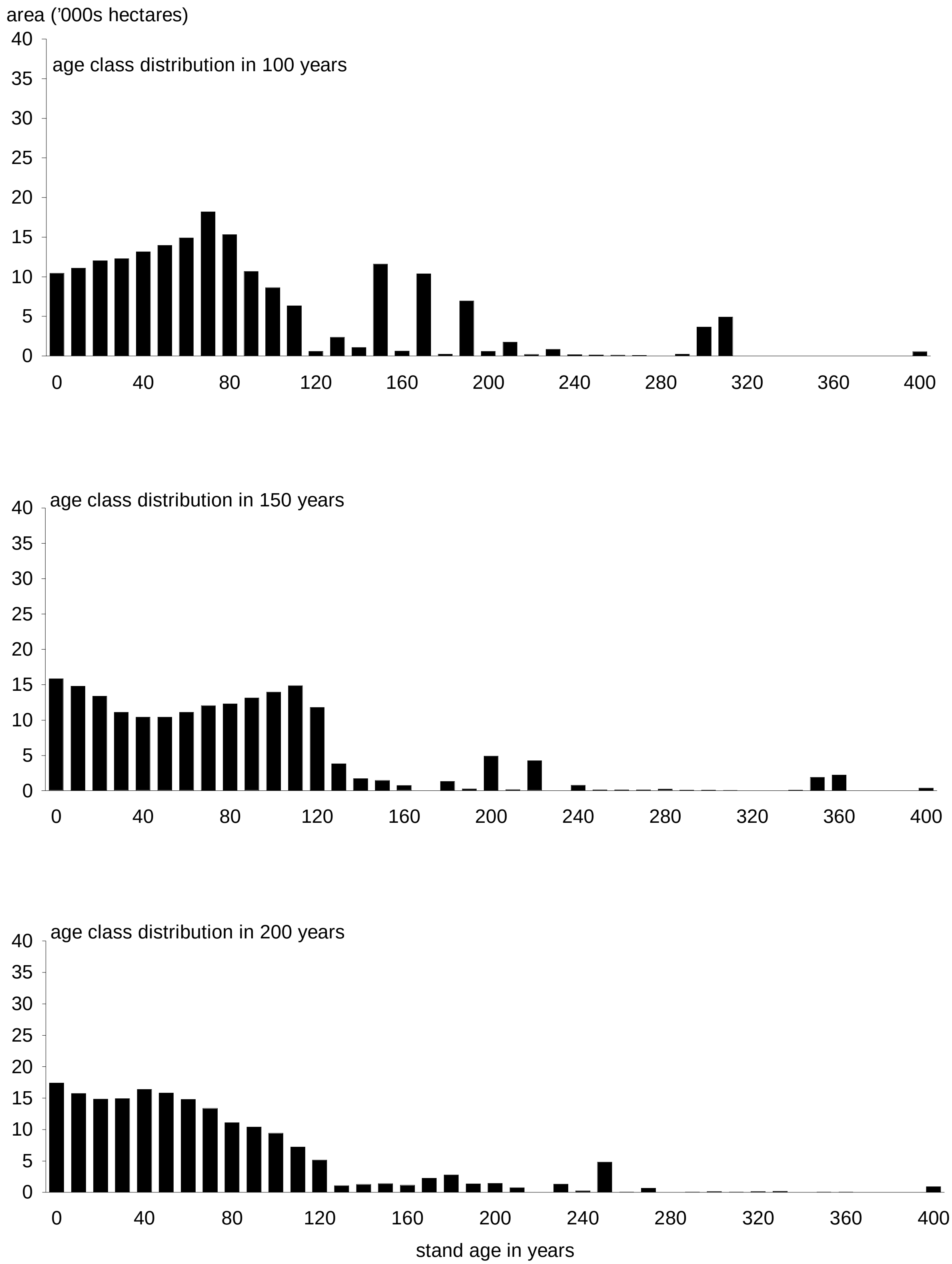

Figure 12. Stand age distribution over time, Robson Valley TSA.

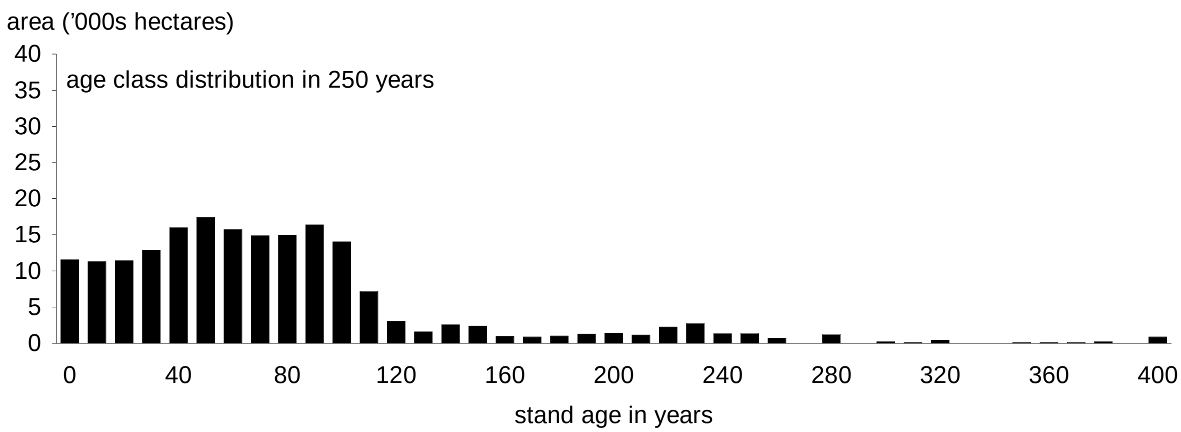

Figure 12. Stand age distribution over time, Robson Valley TSA.

5 Timber Supply Sensitivity Analyses

The best available information on forest inventories and management practices is used to analyse the timber supply implications of continuing with current management. However, forest management is a complicated and ever-changing endeavor that must account for diverse and changing human values, the dynamics of complex ecosystems, and fluctuating and uncertain economic factors. As well, forests grow quite slowly in terms of human time spans, which means that decisions we make today have not only short-term but also long-term effects. In such a context, we cannot be certain that all data accurately reflect the current state of all values in the forest, how the forest will change, or how our management activities will affect the forest.

One important way to deal with this uncertainty is to revise plans and analyses frequently to ensure they incorporate up-to-date information and knowledge. Frequent planning and decision-making can help minimize any negative effects that may occur if decisions are based on inaccurate information. Frequent revision can also ensure that opportunities that become apparent from new information are not missed.

Another important way of dealing with uncertainty is to assess its potential effects on values of interest, for example, timber supply. Every decision either implicitly or explicitly incorporates an attitude towards uncertainty. If we believe that existing information accurately reflects reality, we are being neutral to uncertainty, believing essentially that any inaccuracies probably balance out. Ignoring uncertainty is implicitly neutral. If maximizing timber supply were the goal, someone with an optimistic position toward uncertainty would probably believe that current information probably underestimates timber supply, and that problems can be resolved through human ingenuity and changes to practices. A conservative position would be that current information probably overestimates timber supply, and that decisions should minimize the potential for future timber supply shortages or negative effects on other values.

This report does not advocate any of these positions. One of its goals is to supply information to assist people with different attitudes towards forest management and uncertainty.

Sensitivity analysis is one way of evaluating how uncertainty could affect analysis results, and ultimately, decision-making. One purpose of sensitivity analysis is to highlight which variables most affect results. For example, it is possible that small inaccuracies in estimating some variables could have large effects on timber supply or that fairly large inaccuracies in other variables could have negligible effects. Sensitivity analysis can therefore highlight priorities for collecting information for future analysis. It can also clarify whether current best estimates provide safe bases for decisions, or whether high uncertainty about important variables means more conservative decisions may be wiser.

In this section, results of several sensitivity analyses are discussed. The results that are based on current forest management assumptions (shown in Figure 8) are referred to as the base case.

5.1 Alternative harvest flows

For a given set of forest management assumptions, many different harvest flows are often possible. This section examines alternative harvest flows based on the same set of management assumptions that were used to derive the base harvest forecast.

The base harvest forecast, as shown in Figure 8 and discussed in Section 4, begins at the current harvest level and declines for 6 decades at 10% per decade to the long-term level, about 41% below the initial level. The base harvest forecast is shown (by means of a dashed line) in all graphs in this section for comparison.

Two harvest flow patterns are shown in Figure 13. As shown, the current harvest level can be maintained for 2 decades. However, a decline of 15% per decade must occur to avoid future shortfalls in wood supply. In order to maintain a steady rate for 3 decades and a maximum decline of 10% per decade, the initial harvest rate would be 500 000 cubic metres, a 17% immediate reduction. In both these cases, the long-term level of 351 000 cubic metres annually is reached in decade 7.

5 Timber Supply Sensitivity Analyses

Two other flow patterns are shown in Figure 14. Without regard for drastic declines in the future, the current harvest level could be maintained for 7 decades as illustrated by the thin solid line. In this case virtually no harvesting is possible in decade 10.

The thick solid line in Figure 14 represents an immediate 8% decrease to 550 000 cubic metres annually which can be maintained for 2 decades and declines 12% per decade until the long-term level of 351 000 cubic metres is reached in decade 5.

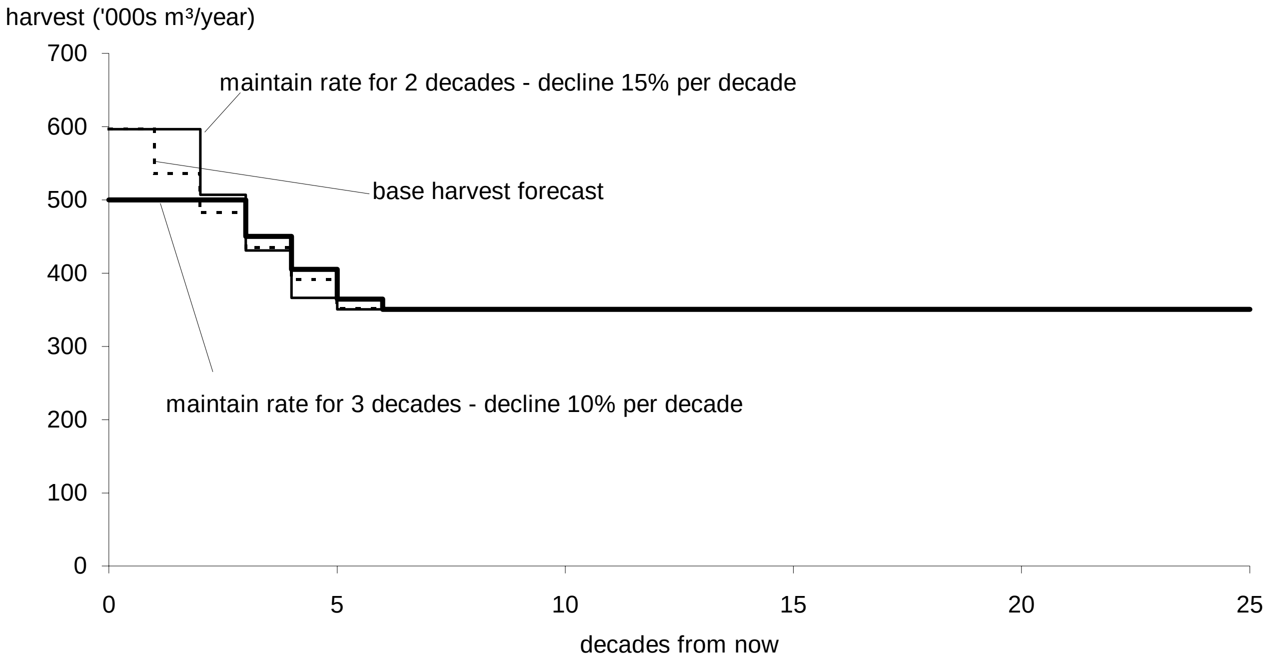

Figure 13 *Harvest forecast with steady harvest rate for 2 and 3 decades, Robson Valley TSA.*

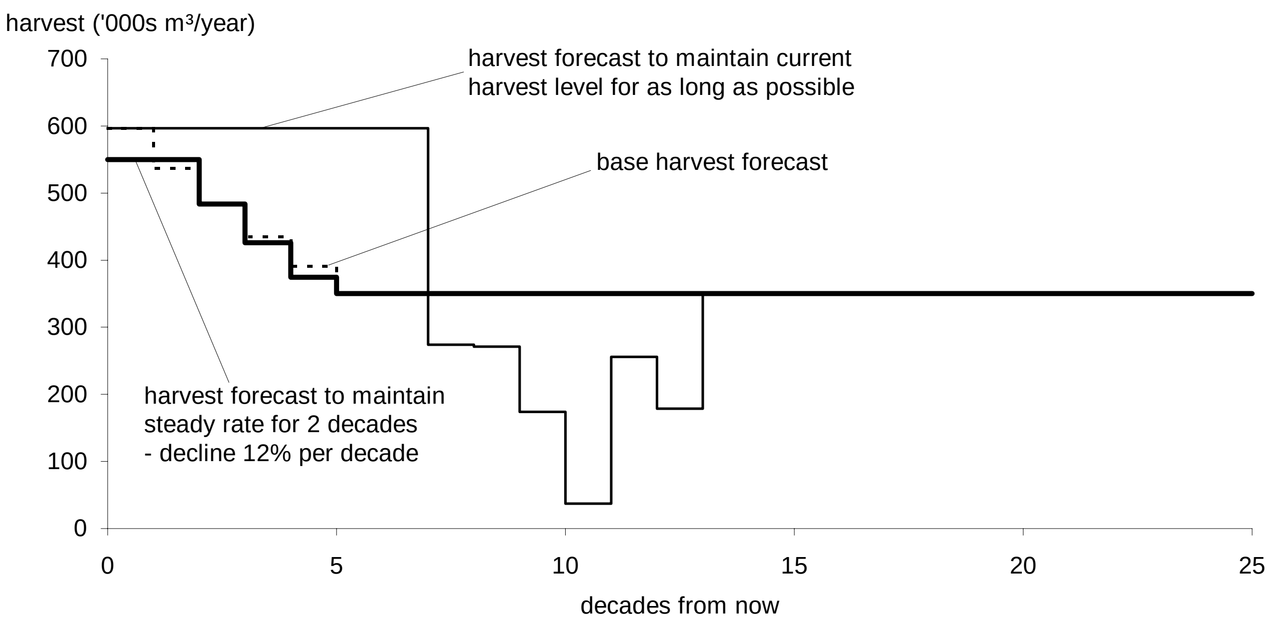

Figure 14. *Harvest forecast with current harvest level maintained as long as possible; and harvest level steady for 2 decades, Robson Valley TSA.*

5 Timber Supply Sensitivity Analyses

The highest non-declining harvest flow possible over the 25 decade period, 360 000 cubic metres annually, is shown in Figure 15. This is about 2.5% higher than the long-term level in the base case and is made possible by the existing abundance of high-volume older stands. The harvest level of Figure 14 must eventually meet with the long-term level of the base case (351 000 cubic metres annually).

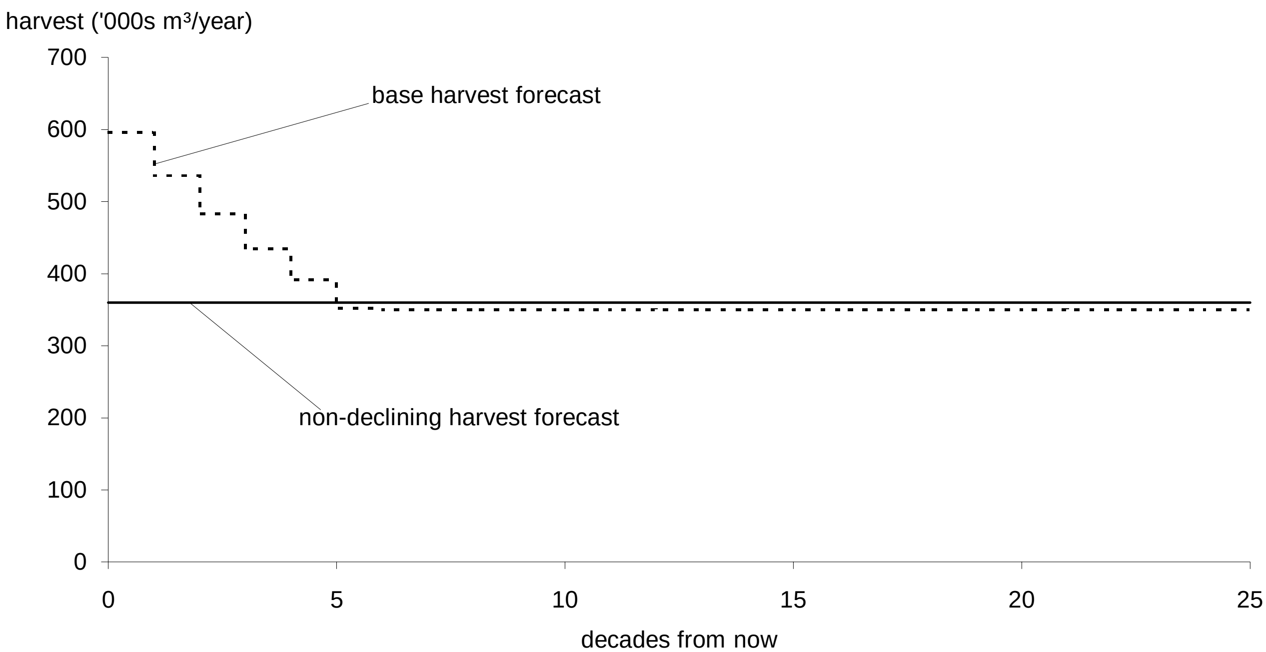

Figure 15. Maximum non-declining harvest forecast, Robson Valley TSA.

5.2 Sensitivity to uncertainty in minimum harvestable ages

The minimum harvestable ages of the base harvest forecast were set with the objective of meeting certain criteria (i.e. harvesting a minimum volume per hectare), and maximizing the timber produced over time. The minimum harvestable ages used in the base case ranged from 80 to 140 years. This section examines the sensitivity of the harvest forecast to minimum harvestable ages for all species being 20 years higher and 20 years lower.

The effect on the harvest forecast of minimum harvestable ages for all forest types being 20 years different is illustrated in Figure 16. The thin solid line illustrates the effect of decreasing all minimum harvestable ages by 20 years. In this case, the current harvest level can be maintained for 2 decades before a decline of 10% per decade must occur in order to avoid future shortfalls. It should be noted that the long-term level is about 4% lower than that of the base harvest forecast. In the long term, trees would be harvested at younger ages with less volume per hectare. In the short term, more stands would have reached minimum harvestable age and therefore would be available for harvest.

The thick solid line represents the effect of increasing the minimum harvestable ages by 20 years. The starting level in this case is 430 000 cubic metres annually, an immediate 28% reduction from the base case initial level. This forecast also declines at 10% per decade. However, a higher long-term level is established in decade 20.

The higher long-term level, about 4% higher than that of the base case, is possible because stand management being practiced today is expected to result in greater volumes per hectare in the future. The higher long-term level is possible because increased minimum harvest ages bring stands closer to culmination age.* In the short term, however, fewer stands meet the minimum harvestable age criteria and less timber is available for harvest.

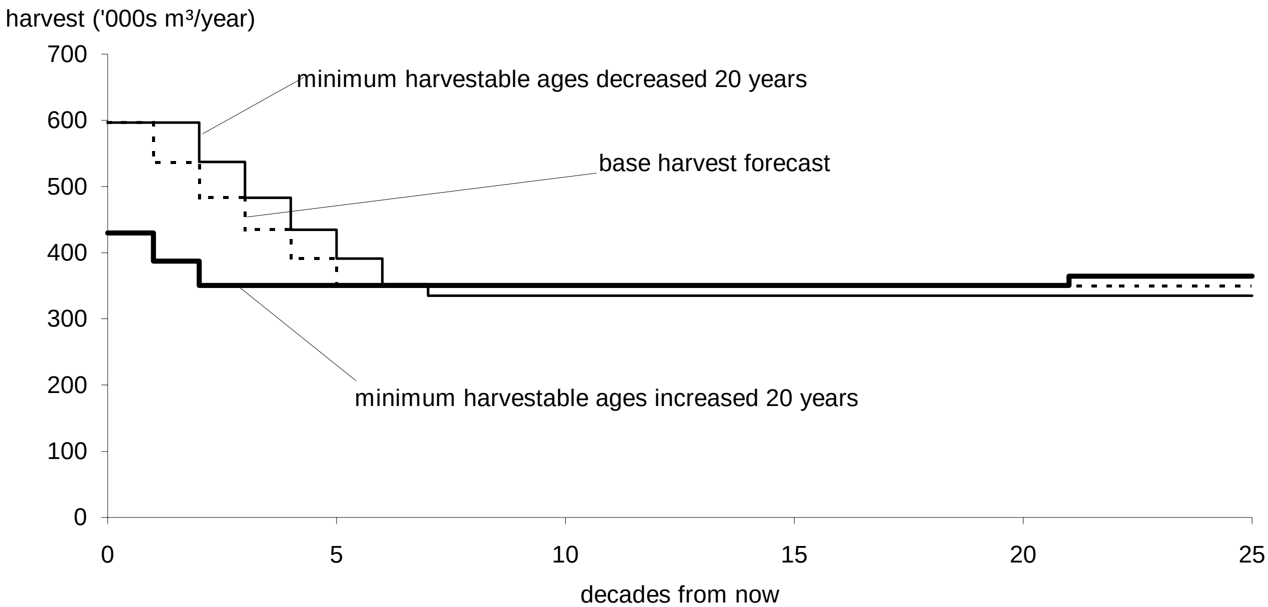

Figure 16. *Harvest forecast with minimum harvestable ages changed by 20 years, Robson Valley TSA.*

> ***Culmination age***
> *The age at which a timber stand reaches its highest mean annual increment (MAI). MAI is calculated as stand volume divided by stand age. Culmination age is the optimal biological rotation age to maximize volume production from a growing site.*

5.3 Sensitivity to uncertainty in green-up ages

As discussed in Sections 2.3 and 2.4, the required green-up ages used in the base forecast are the estimated number of years before the trees on a previously harvested area grow to a required height. Uncertainty in the required green-up age stems from both uncertainty in stand height growth rates as well as the subjectivity of the height requirement before a stand is considered 'greened-up'. The following sensitivity analysis examines the effect that uncertainty in the required green-up age has on the harvest forecast.

The thin solid line in Figure 17 shows the harvest forecast if all green-up ages are reduced by 10 years. More volume is available in both the short- and long-term when the required time for stands to reach green-up conditions is reduced. When the time required for stands to reach green-up conditions is reduced, more volume is available because adjacent timber can be harvested sooner. The initial harvest level is the same as that of the base, however, it can be held for an additional 2 decades before beginning to decline at a rate of 10% per decade. The long-term level is about 3% higher than that of the base forecast.

The thick solid line in Figure 17 shows the effect of green-up ages being 10 years older. Less volume is available over time when green-up ages are greater because it takes longer for areas adjacent to recently harvested areas to become available for harvest. The initial harvest level is about 17% lower and the long-term level is about 3.5% lower than those of the base case. Increasing the required green-up ages makes the forest cover requirements for cut block adjacency and forest cover requirements for visual quality and wildlife habitat much more constraining on the short-term harvest rate.

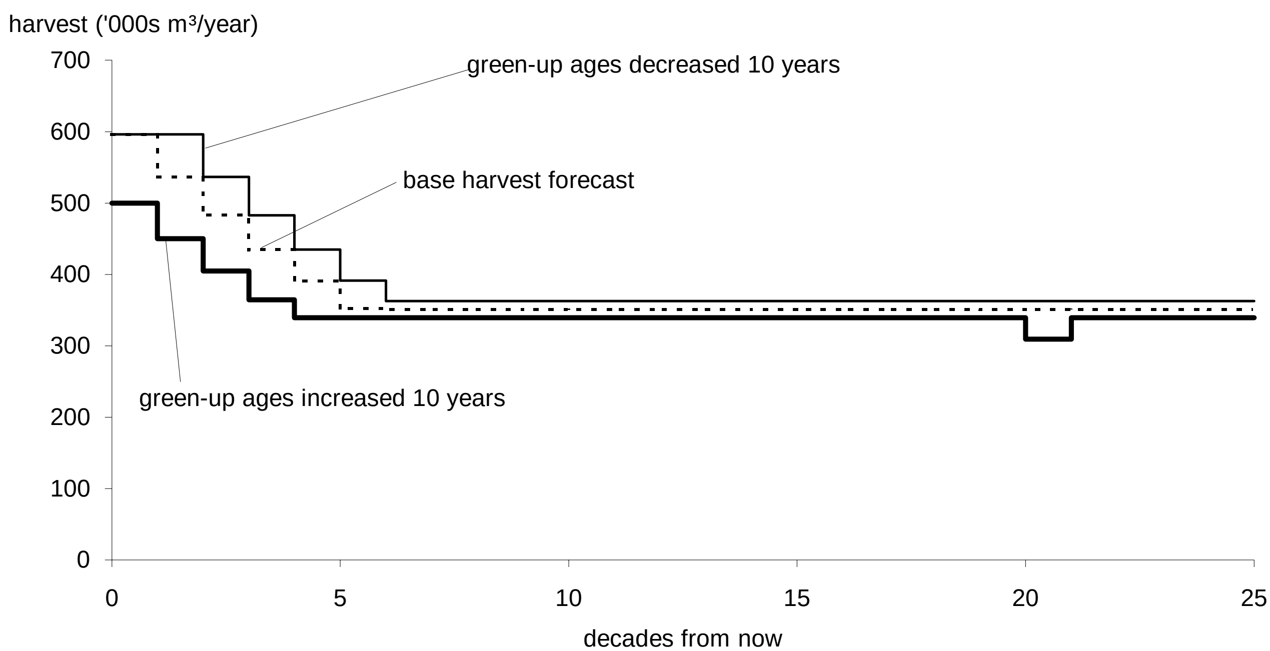

Figure 17. Harvest forecast with all green-up ages changed by 10 years, Robson Valley TSA.

5.4 Sensitivity to cutblock adjacency requirements

In the base case, forest cover requirements used to model cutblock adjacency and green-up were based on the assumption that at any one time a maximum of 33% of the timber emphasis zone may be covered by stands less than 3 metres tall. This requirement should be viewed as an average that applies to areas where no other forest cover requirements are in place to manage for values such as wildlife habitat or visual quality. Site specific forest cover requirements will vary from this average requirement. Uncertainty in the average forest cover requirement used to model cutblock adjacency and green-up in this analysis stems from these site specific variations from the average.

Since the forest cover requirement was not a limiting factor in the base case, relaxing the forest cover requirement to allow more area to be less than 3 metres tall does not alter the harvest forecast. Because there is no change from the base case, this harvest forecast is not shown graphically.

The effect of making forest cover requirements for cutblock adjacency more stringent so that only 25% of the area may be forested with stands less than 3 metres tall is shown in Figure 18. The initial level is about 8% lower than that of the base with a decline of 10% per decade commencing after decade one. The long-term level is essentially the same as the base forecast. However a minor shortfall occurs in decade 23 due to an age-class imbalance. The reduced harvest in the short-term causes a larger inventory of growing stock to be maintained into the later decades.

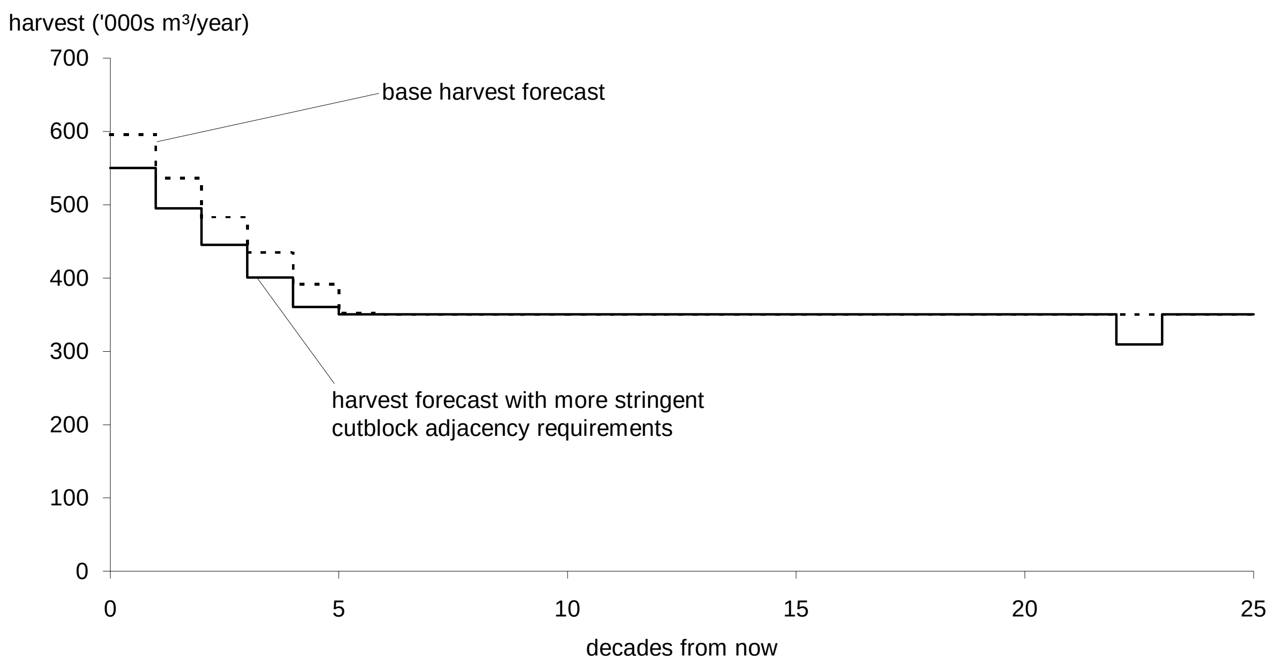

Figure 18. Harvest forecast with more stringent cutblock adjacency requirements, Robson Valley TSA.

5.5 Sensitivity to visual quality requirements

In the base case, forest cover requirements for visually sensitive areas were defined in Section 2.4. to provide three levels of protection for visual quality. In visually sensitive areas, recently harvested areas must be covered by stands at least 5 metres tall before adjacent areas can be harvested. As illustrated in Figure 7, visually sensitive areas account for about 20% of the timber harvesting land base.

The thin solid line in Figure 19 illustrates the effect of allowing 5% more of each visually sensitive area to be covered by stands younger than the green-up age. For example, forest cover requirements for the partial retention areas were relaxed from 10% to 15%. In this case, the initial harvest level of 596 377 cubic metres annually can be held for 2 decades before a decline of 10% per decade occurs. The long-term level of 363 000 cubic metres is about 3.5% greater than that of the base forecast.

The thick solid line indicates the effect of reducing the area allowed to be under the green-up age in visually sensitive areas by 5%. Tightening the requirement by 5% eliminates harvesting in retention areas (1.4% of the timber harvesting land base) because the base case requirement allows only 3% of the retention areas to be under cover of stands younger than green-up age. The harvest forecast starts about 8% lower than that of the base case and then declines at 10% per decade to a long-term level 5.5% lower than the base forecast.

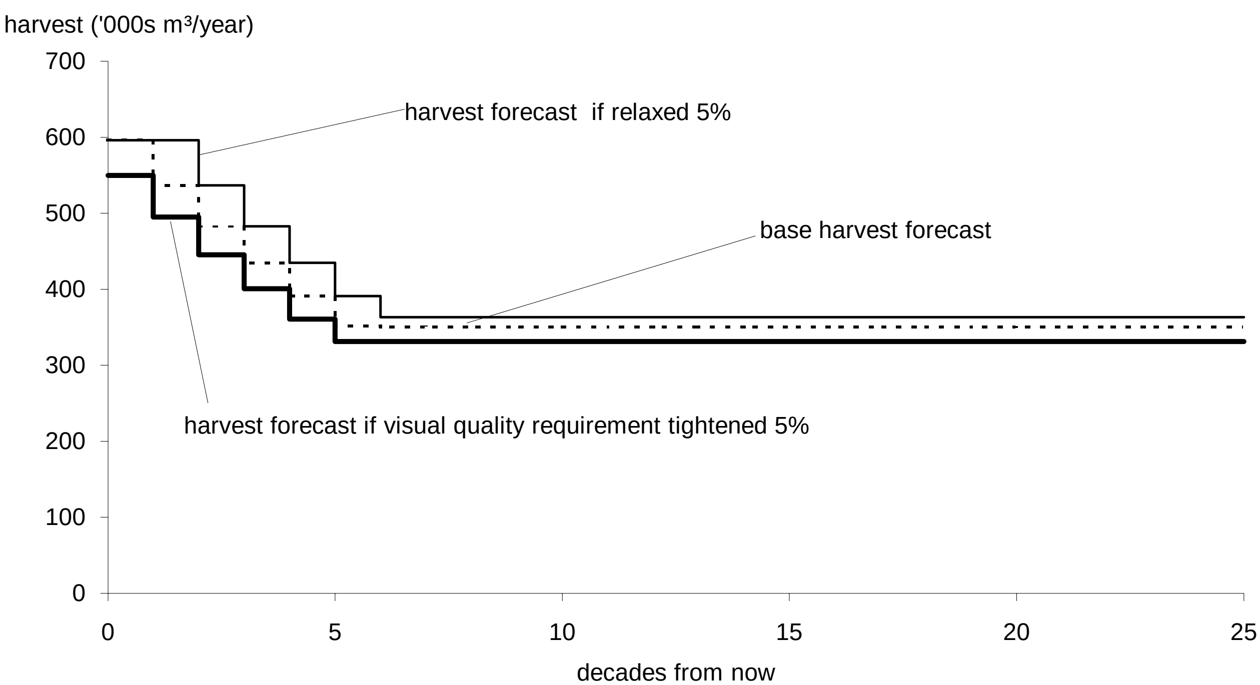

Figure 19. Harvest forecasts with increased and decreased forest cover requirements for visual quality, Robson Valley TSA.

5.6 Sensitivity to uncertainty in existing stand yield estimates

Timber yield estimates have a degree of uncertainty due to such factors as the statistical process used to develop growth and yield models, uncertainty in the forest inventory, and changing timber utilization standards. The following sensitivity analyses examine the effect on the harvest forecast of uncertainty in the volume of timber that currently exists in the timber harvesting land base.

The thin solid line in Figure 20 illustrates the effect on the harvest forecast if the estimated timber yield from existing stands is 10% greater. The initial harvest level of 596 377 cubic metres annually can be maintained for 3 decades before a decline of 10% per decade occurs. Adding 10% more volume, therefore has a large effect on timber volume available for harvest and is primarily due to the short-term preponderance of older forests (Figure 4). Furthermore, relative to the base forecast, more volume is realized from every hectare of area harvested. The long-term level is the same as that of the base harvest forecast because regenerated yield estimates remained unchanged. Although not shown here, an additional harvest forecast was prepared that indicates the initial harvest level could be as high as 750 000 cubic metres (25% higher than the base forecast) and still allow a rate of decline to the long-term level that does not exceed 10% per decade.

The thick solid line and the long dashed line show two harvest forecasts if the estimated timber yield from existing stands are 10% lower than predicted. This change has a direct effect on the short-term harvest forecast because of the reduction in the existing mature inventory of timber that is ready for harvest. Reducing the volume of timber harvested per hectare requires that more forest area than the base case be harvested in order to achieve the same harvest level.

As indicated by the long dashed line, it is not even possible to start at the long-term level of 351 000 cubic metres annually without causing future interruptions in harvest flow. It is possible to start at 318 000 cubic metres, a 47% decrease from the initial level in the base forecast, and return to the long-term level after 9 decades.

The imminent decline below the long-term level implies that many other harvest flows are possible. Alternative flows that make timber available in the short-term have long-term implications. The thick solid line of Figure 20 illustrates one such alternative. Since the harvest level must decline below that long-term level, it is possible for the initial level to be higher than the preceding example. In this case, the initial level is 500 000 cubic metres per year (17% lower than that of the base case) followed by a series of declines at 10% per decade to an interim level of 313 000 cubic metres per year. By decade 14 the forecast returns to the same long-term level as the base case.

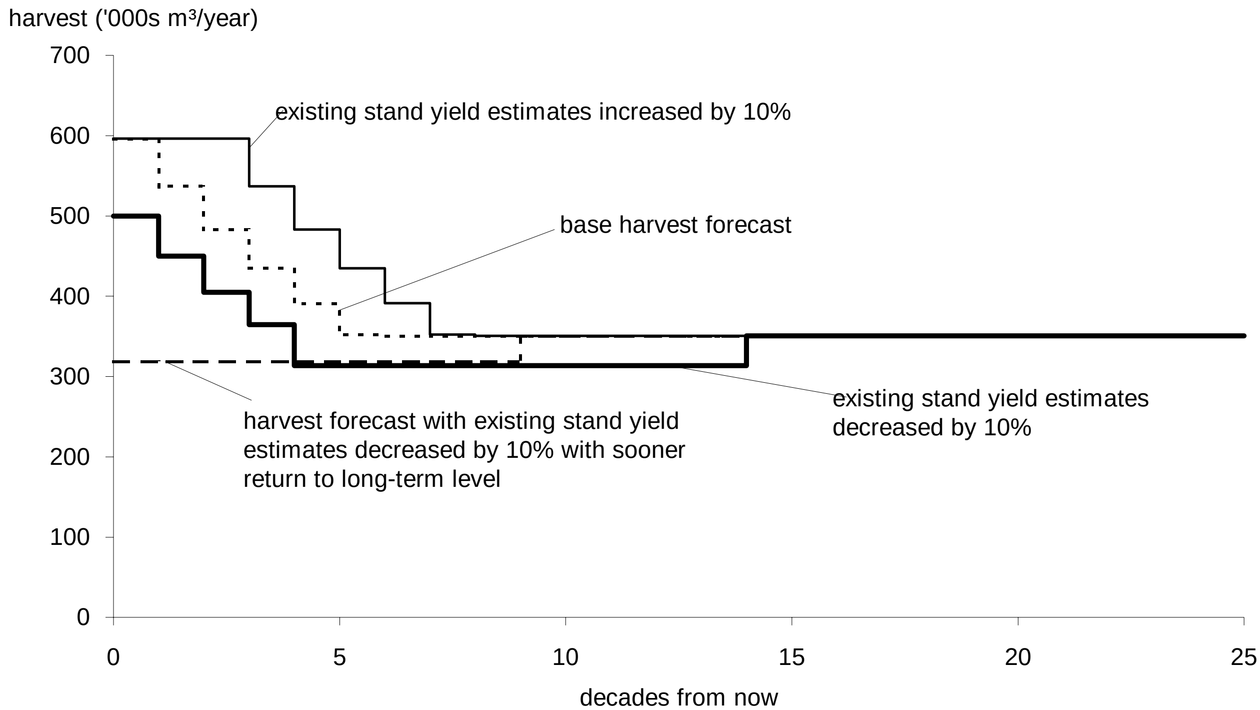

Figure 20. Harvest forecasts with existing stand yields estimates changed by 10%, Robson Valley TSA.

5.7 Sensitivity to uncertainty in regenerated stand yield estimates

Uncertainty in regenerated stand yield estimates is due to factors such as the use of inventory data from existing mature forests to predict the growth and yield of future regenerated stands, the effect of replacing existing forests with different species after harvesting, and the effects of soil degradation, pests and forest disease on future productivity. The following sensitivity analyses examine the effect that uncertainty in the estimated yields from regenerated stands have on the harvest forecast.

The thin solid line in Figure 21 shows the effect on the harvest forecast of increasing the estimated timber yields from all regenerated stands by 10%. Increasing the volume from regenerated stands has no effect on short-term harvest levels because the majority of the timber harvested in the short term is from existing older stands. Moreover, on the continued assumption that harvest levels should not fall below the long-term level, the mature timber would have to be reserved in the short term to fill in the trough between decades 5 and 11 illustrated in Figure 21. This would result in a lower initial harvest level than the base forecast. In this case, however, a new long-term harvest level is established at decade 11 which is about 9% higher than the base long-term level.

The thick solid line shows the effect of decreasing all regenerated stand yield estimates by 10%. This change only affects the steady long-term harvest level, which is reduced by just over 8% from the base harvest forecast.

5 Timber Supply Sensitivity Analyses

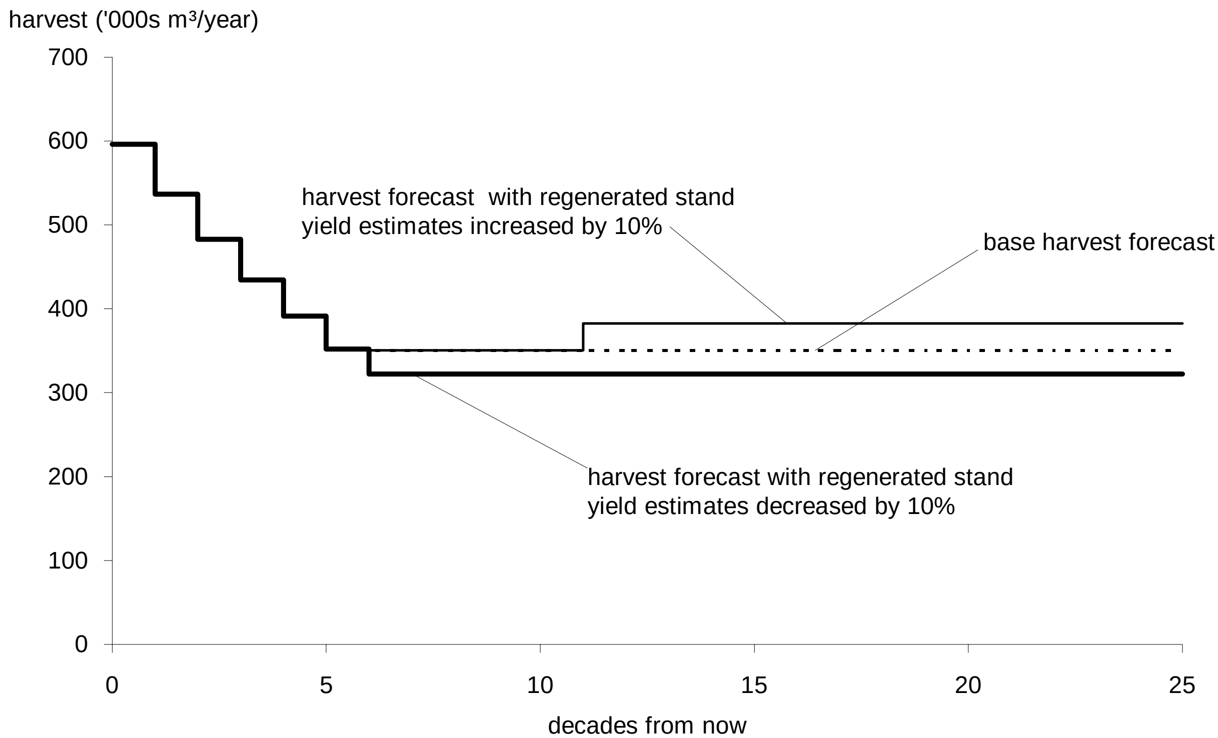

Figure 21. Harvest forecasts with regenerated stand yield estimates changed by 10%, Robson Valley TSA.

5.8 Sensitivity to uncertainty in the size of the timber harvesting land base

The area that is assumed to be available for timber harvesting is one of the primary inputs for timber supply analysis. In the Robson Valley TSA, the timber harvesting land base could be larger or smaller than expected if any of the areas listed in Table 1 are different. There are a number of reasons that these areas could be different from what is expected. The timber harvesting land base could be larger than expected due to improved timber harvesting techniques and equipment, which reduce the cost of harvesting operations or which prevent damage from occuring on sensitive sites. It could also be larger as a result of an increase in the value of currently unmerchantable forest types.

Conversely, the timber harvesting land base could be smaller than expected if, for example:

- harvesting costs increased, reducing the economic feasibility of harvest operations, or
- new guidelines to further protect resources other than timber are imposed, or
- decisions to protect additional areas, such as those considered through the Protected Areas Strategy are made. (It should be noted that the base harvest forecast assumes these area are available for timber harvesting now and in the future.)

5 Timber Supply Sensitivity Analyses

The following sensitivity analyses examine the effect on the harvest forecast of uncertainty associated with the size of the timber harvesting land base. In the following analyses, the timber harvesting land base was increased and decreased by 10% across all stands regardless of age, species or management regime.

The thin solid line in Figure 22 illustrates the effect of increasing the area of the forest operations land base by 10%. It is possible to maintain the initial harvest level (current AAC) for 2 decades before a 10% per decade decline is necessary. A new long-term level of 393 000 cubic metres is established in decade 5 at a level about 11% higher than that of the base harvest forecast.

The thick solid line represents the effect of reducing the area within the timber harvesting land base by 10% in order to avoid major future timber supply disruptions. The initial harvest level must drop immediately by about 8% and continue to decline at 10% per decade for 7 decades to a new long-term level of 306 000 cubic metres annually. The long-term level in this case is almost 13% lower than that of the base harvest forecast.

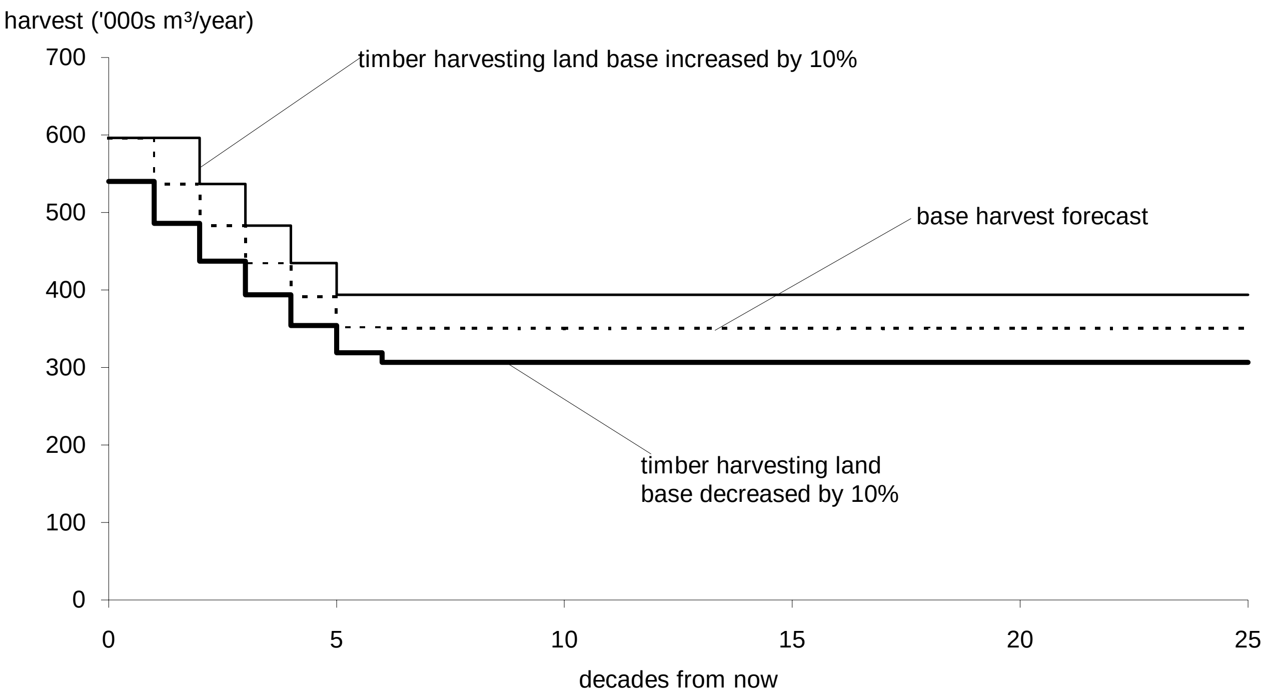

Figure 22. Harvest forecasts with the area of the timber harvesting land base increased and decreased 10%, Robson Valley TSA.

5.9 Sensitivity to removing all forest cover requirements

The following sensitivity analysis examines the effect of altering the forest cover requirements by 10 percentage points. The forest cover requirements for cutblock adjacency, old-growth, visually sensitive areas, and wildlife habitat were varied as were the requirements for old-growth (old-growth special management zone and caribou habitat/corridor zone).

The dark solid line in Figure 23 shows the harvest forecast with the forest cover requirements relaxed by 10 percentage points. In order to relax the requirement for forest cover, it is necessary to increase the amount of area allowed to be in a non-greened up state. In the old-growth special management zone, for example, the cover requirement percentage goes from 25% to 35%. The mature area forest cover requirements are relaxed by decreasing the amount of forest required to be older than the mature age. Thus in the old-growth special management zone there is no longer a requirement to maintain old-growth (there was a 5% requirement in the base forecast). In this case, the current AAC (596 377 cubic metres annually) can be held for 2 decades. The forecast then declines by 10% per decade to a long-term level of 386 000 cubic metres annually, 10% higher than the base long-term harvest level.

Further analysis showed that the initial harvest level could be as high as 675 000 cubic metres with a 10% per decade decline after the first decade. The long-term harvest level in this case would be 386 000 cubic metres.

The light solid line in Figure 23 shows the harvest forecast with the forest cover requirements tightened by 10 percentage points. In order to tighten the requirement for forest cover, it is necessary to decrease the amount of area allowed to be in a non-greened up state and increase the amount of forest required to be older than the mature age. In the old-growth special management zone, for example, the cover requirement goes from 25% to 15% and the requirement to maintain old-growth goes from 5% to 15%. The highest initial harvest level (without causing long-term shortfalls, and maintaining a 10% per decade decline), is 410 000 cubic metres, a 31% decrease from the base case. The forecast then declines at 10% per decade to a long-term level of 300 000 cubic metres annually, 14% lower than the base long-term harvest level.

5 Timber Supply Sensitivity Analyses

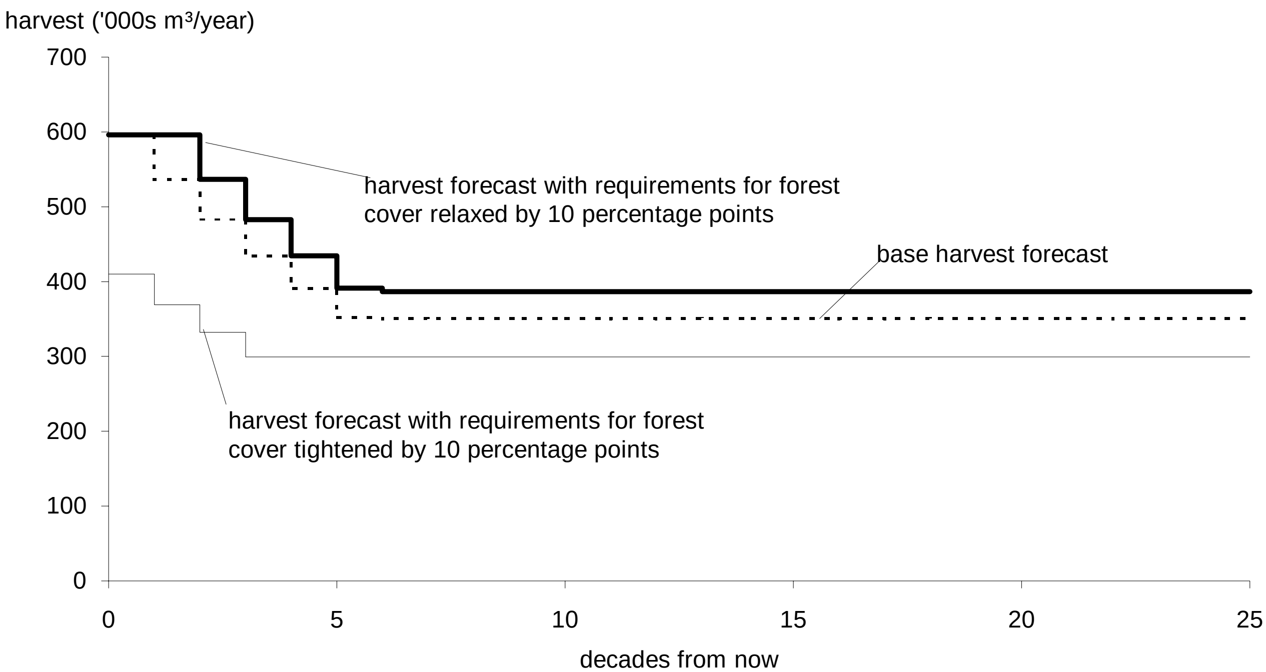

Figure 23. Harvest forecast when forest cover requirements are changed by 10%, Robson Valley TSA.

Note: In order to increase forest cover requirements, it is necessary to decrease amount of area allowed to be less than the green-up age.
In order to decrease forest cover requirements, it is necessary to increase amount of area allowed to be less than the green-up age.

5.10 Sensitivity to changing several assumptions concurrently

The sensitivity analyses discussed in Sections 5.2 to 5.9 examine the effect on the harvest forecast of altering a single forest management assumption at a time. The following sensitivity analyses examine the effect of changing a number of assumptions concurrently.

The thick solid line in Figure 24 shows the harvest forecast when the following changes to forest growth and forest management are applied:

- all green-up ages reduced by 5 years;
- 5% more visually sensitive area is allowed to be under cover of stands younger than green-up age;
- both existing and regenerated stand yield estimates increased by 10%;
- all minimum harvestable ages reduced by 10 years.

Using all of the assumptions above concurrently has a large effect on the harvest forecast. The initial harvest level of 576 377 cubic metres annually can be held for 4 decades before a decline of 10% per decade is necessary. The long-term level of 424 000 is 21% higher than that of the base harvest forecast.

The thin solid line in Figure 24 shows the harvest forecast when the following changes to yield and forest management are applied:

- all green-up ages increased by 5 years;
- 5% less visually sensitive area is allowed to be under cover of stands younger than green-up age;
- existing and regenerated stand yield estimates decreased by 10%; and
- all minimum harvestable ages increased by 10 years.

Applying these changes concurrently, an initial harvest level 41% less than the base initial harvest level is necessary to avoid major future disruptions in timber supply. This forecast declines at 10% per decade to a long-term level of 277 000 cubic metres annually, 21% less than that of the base harvest forecast.

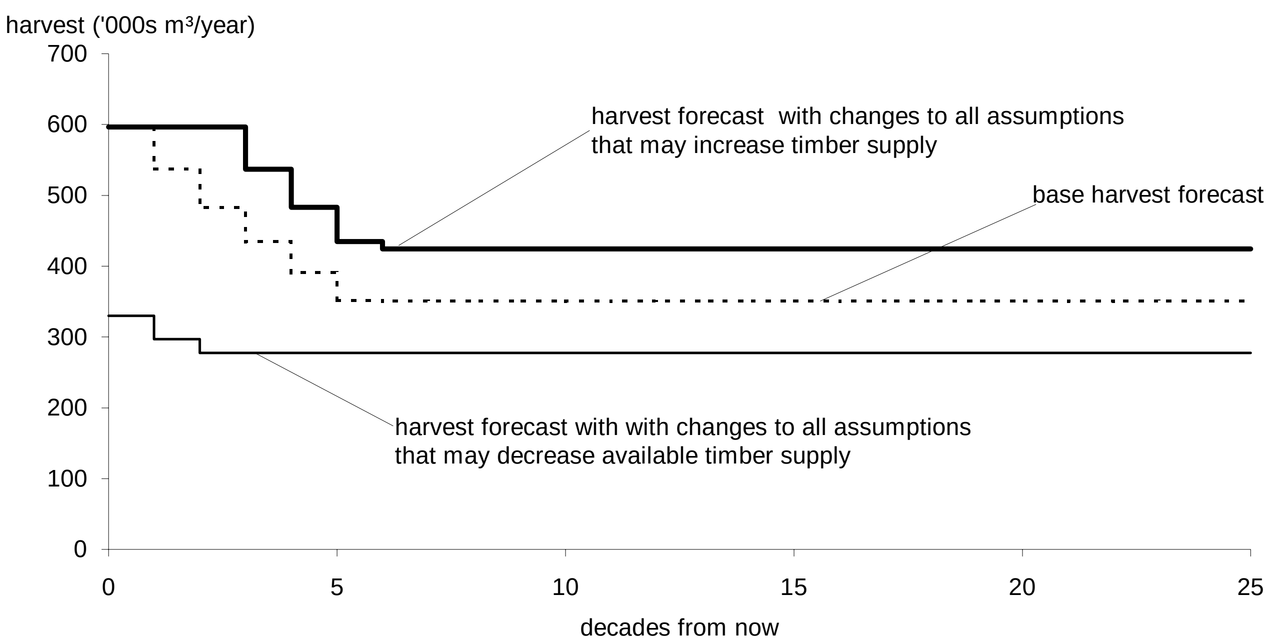

Figure 24. Harvest forecast with changes to several forest growth and management assumptions concurrently, Robson Valley TSA.

6 Summary and Conclusions

The base harvest forecast in this analysis indicates that the current harvest level of 596 377 cubic metres in the Robson Valley TSA can be maintained for 1 decade, and thereafter must decline at a rate of 10% per decade to a long-term level about 40% lower than current levels. This long-term level of 351 000 cubic metres is reached in decade 5. The initial harvest rate can be maintained for 2 decades by either allowing rates of decline greater than 10% or by accepting significant timber supply shortfalls in the future.

Several important factors affect the timber supply forecast. The most important factor is the over-abundance of mature timber in the timber harvesting land base which allows harvesting above the long-term level. As this timber is harvested and replaced by younger forest stands, a decline to the long-term level occurs.

Also contributing to the decline in timber supply are forest cover requirements for other resources such as wildlife habitat, visual quality and old growth. Sensitivity analyses show that the decline would not be as pronounced if forest cover requirements were reduced. Conversely, the decline would be greater if forest cover requirements were increased.

Sensitivity analyses indicate that uncertainty in the assumptions and data used in this analysis may be significant in both the short- and long-term. The short-term timber supply is especially sensitive to changes in volumes for existing stands. Any uncertainty in the method used to derive these volumes is important because even moderate changes in these assumptions result in initial harvests more than 40% lower than the base case or conversely, the initial harvest level being maintained for 3 decades.

Uncertainty about minimum harvestable ages, green-up requirements, and visual quality objectives have moderate impacts on short-term harvest levels. Changes in regenerated yields have no impact on short-term harvest rates although the long-term harvest level is moderately affected.

7 References

B.C. Ministry of Forests and Lands, Inventory Branch, 1987. McBride TSA - Timber Supply Analysis Report. Victoria, B.C.

B.C. Ministry of Forests, Prince George Forest Region. September 1990. Resource Management Plan 1 for the Robson Valley TSA, January 1 1988 to December 31, 1992. Prince George, B.C.

8 Glossary

Allowable annual cut (AAC)	The allowable rate of timber harvest from a specified area of land. The Chief Forester sets AACs for timber supply areas (TSAs) and tree farm licenses (TFLs) in accordance with *Section 7* of the *Forest Act*.
Clear-cut harvesting	A harvesting method whereby all trees that meet utilization standards are harvested. The harvested site is then regenerated to acceptable standard by appropriate means including planting and natural seeding.
Culmination age	The age at which a timber stand reaches its highest mean annual increment (MAI). MAI is calculated as stand volume divided by stand age. Culmination age is the optimal biological rotation age to maximize volume production from a growing site.
Cutblock adjacency	Integrated management guidelines that specify the desired spatial relationship among cutblocks. They can be approximated by specifying the maximum allowable proportion of a forested landscape that does not meet green-up requirements.
Environmentally sensitive areas	An area with significant non-timber values or fragile or unstable soils, or in which there are impediments to establishing a new tree crop or timber harvesting may cause avalanches.
Forest cover objectives	Desired distributions of areas by age or size class groupings. These objectives can be used to reflect desired conditions for wildlife, watershed protection, visual quality and other integrated resource management objectives.
Forest inventory	Assessment of British Columbia's timber resources. It includes computerized maps, a database describing the location and nature of forest cover, including size, age, timber volume, and species composition, and a description of additional forest values such as recreation and visual quality.
Free-growing	An established seedling of an acceptable commercial species that is free from growth-inhibiting brush, weed and excessive tree competition.
Green-up	The time needed after harvesting for a stand of trees to reach a desired condition (e.g., height) to ensure maintenance of water quality, wildlife habitat, soil stability or aesthetics.
Growing stock	The volume estimate for all standing timber, of all ages, at a particular time.
Inoperable areas	Areas defined as unavailable for harvest for terrain-related or economic reasons. Characteristics used in defining inoperability include slope, topography (e.g., the presence of gullies or exposed rock), difficulty of road access, soil stability, elevation and timber quality. Operability can change over time as a function of changing harvesting technology and economics.

8 Glossary

Landscape modification	Alterations may dominate the visual landscape but should blend with natural features. Up to 25% of the visible area can be altered by harvesting activity.
Landscape partial retention	Alterations are visible but not conspicuous. Up to 15% of the area can be visibly altered by harvesting activity.
Landscape retention	Alterations are not easy to see. Up to 5% of the landscape can be visibly altered by harvesting activity.
Management assumptions	Approximations of management objectives, priorities, constraints and other conditions needed to represent forest management actions in a forest planning model. These include, for example, the criteria for determining the timber harvesting land base, the specification of minimum harvestable ages, utilization levels, integrated resource guidelines and silviculture and pest management programs.
Mean annual increment (MAI)	Stand volume divided by stand age. The stand age at which the MAI assumes its maximum value is called the culmination age. Harvesting all stands at this age results in a maximum average harvest over the long term.
Merchantable age	The age at which a tree or stand that has attained sufficient size, quality and/or volume to make it suitable for harvesting.
Not satisfactorily restocked (NSR)	An area not covered by a sufficient number of tree stems of desirable species. Stocking standards are set by the Forest Service, Silviculture Branch. If the expected regeneration delay (the period of time between harvesting and the date by which an area is occupied by a specified minimum number of acceptable well-spaced trees) has not elapsed, the land is defined as current NSR. If the expected delay has elapsed, the land is classified as backlog NSR.
Partial-cut management	Includes harvest and renewal operations that provide for visual quality, wildlife habitat, water quality and old growth in a sensitive watershed.
Timber harvesting land base	The portion of the total land area of a management unit considered to contribute to, and be available for, long-term timber supply. The harvesting land base is defined by reducing the total land base according to specified management assumptions.
Timber Supply Area (TSA)	An integrated resource management unit established in accordance with *Section 6* of the *Forest Act.*

APPENDIX A
Description of Data Inputs and Assumptions

Introduction

The following sections describe the methods and inputs used to derive the timber harvesting land base and to construct the timber supply model inputs for the timber supply analysis of the Robson Valley TSA. For the purposes of this analysis, the information presented in this Appendix represents current forest management in the Robson Valley TSA. Current forest management is defined as the set of land-use decisions and forest and stand management practices that are currently implemented and enforced. Future forest management objectives that may be intended but are not currently implemented and enforced, are not included here. Changes in forest management will be included in subsequent timber supply analyses after this Timber Supply Review has been completed.

A.1 Zone and Analysis Unit Definition

A.1.1 Definition of management zones

The timber harvesting land base was divided into nine zones on the basis of differing forest management practices. Management practices vary between zones because of the emphasis on non-timber resources, the use of different harvesting methods or harvesting history.

Management zones were defined through the use of planning cells and operability. A map of management zones was created and then digitized and overlaid on a planning cell map. A listing of the percentage of each planning cell by management zone was created.

Intersection of management zones with operability and planning cells for the Robson Valley was achieved utilizing GIS technology. Terrasoft software was chosen because operability files where already in this format and Planning cells and management zones where easily translated from an IGDS format to Terrasoft. Each layer was themed and associated attributes where linked to the graphical file. Initially the process of intersecting the entire file was considered. However, the graphical file brought this approach to a stop and an alternative method of intersecting the three layers was developed.

To achieve an intersection we decided to do a report overlay which reports on the centroids of each polygon rather than intersecting all the line work. The upside of this method was that it would be quick and would give a fair representation of the data. The downside was that it wouldn't be 100% accurate as some polygons would not be captured or would be misrepresented (i.e. some small polygons may receive an incorrect coding on management zones and/or planning cells but these errors would only make up about 1-5% of each unit and ensure that there would be no loss of the land base). This was sufficient to achieve the desired degree of precision without having to go down to a detailed prescription like a forest cover polygon.

The end result of the report overlay was a database that contained attributes from the themes: operability, planning cells and management zones. Cross tabular reports were run on the data to summarize areas by planning cell. Only operable areas were considered. The summarized database was then exported into an ASCII file which could be imported into statistical software and further summarized as in Appendix IV of the Data Package.

A brief description of the zones and the forest cover requirements used in the 1994 timber supply review analysis is as follows:

Zone 1. Landscape partial retention

The landscape partial retention zone includes those areas that are visually sensitive along the Rocky Mountain Trench along with several other areas where alterations to the landscape are to be visible but not conspicuous. The local resource use planning (LRUP) process has delineated many of these areas.

It was decided that the effective management of partial retention areas would require a maximum of 10% of the area to be in a non-greened up state. Visual effective green-up height will be considered 5 metres. Through the use of FREDDIE and by weighted averaging it was determined that it would take, on average, 26 years to attain 5 metres in zone 1.

A.1 Zone and Analysis Unit Definition

Zone 2. Landscape retention

A number of landscape retention areas were identified through the LRUP process. It was decided that the effective management of partial retention areas would require a maximum of 3% of the area to be in a non-greened up state. Visual effective green-up height will be considered 5 metres and through the use of FREDDIE, and by weighted averaging, it was determined that it would take on average 26 years to attain 5 metres in zone 2. In practice, selection systems may be used to achieve visual quality objectives.

Zone 3. Caribou habitat high

For analysis purposes, this zone was netted out of the land base. The Caribou habitat zones (high & medium) were assigned by the Ministry of Environment, Lands & Parks. The Caribou habitat high zone includes areas that are essential to Caribou, and as such, will see limited (if any) logging activity in the future. The prime consideration in this zone is the maintenance of high quality caribou habitat.

Zone 4. Caribou habitat medium and Caribou corridor

The medium Caribou habitat zone and caribou corridor areas have similar requirements and are therefore modelled as one zone. These areas can be altered somewhat by logging operations without significantly affecting caribou habitat. On these caribou areas, 33% of the volume may be removed every 80 years. This ensures a continuous older forest cover and a mix of younger forest. Green-up height will be considered 3 metres. Through the use of FREDDIE and weighted averaging it was determined that it would take, on average, 27 years to attain a 3 metre height in zone 4.

Zone 5. Partial cut areas

For the most part, partial cut areas were so designated in LRUP to protect sensitive watersheds. The silvicultural systems to be used in these areas include selection, shelterwood, and small patch cutting. It was decided that the maximum equivalent clearcut area (ECA) will be 20%. This translates to a maximum crown closure reduction of 36% (based on work presented in the *Okanagan Harvest Guidelines*).

If roads are modelled as part of the ECA (as they are also openings in forest canopy), then the 5.7% they account for would have to be deducted. This would mean that 14.3% ECA is available for harvest - which translates to maximum crown removal of 30% below full stocking.

The partial cut zone was modelled as 30% of stand volume removed in a first entry (over a 30 year period), followed by a stand average MAI (2.4 m^3/ha/year) contribution thereafter. It is assumed that all partial cut area will be accessed within 30 years.

Zone 6. Preservation areas

For analysis purposes, this zone was netted out of the land base. The preservation zone includes LRUP areas where forestry operations would significantly impact assigned values. These areas will not be subject to forestry operations now or in the future.

A.1 Zone and Analysis Unit Definition

Zone 7. Landscape modification areas

A number of landscape modification areas were identified through the LRUP process. It was decided that the management constraints would allow a maximum of 25% of the area to be in a non-greened up state. Visual Effective Green-up height will be considered 5 metres and through the use of FREDDIE, and by weighted averaging, it was determined that it would take on average 26 years to attain a 5 metre height in zone 7.

Zone 8. Working forest

The working forest zone is composed of those areas not identified previously. A maximum of 33% of a landscape unit in this zone can be in a non-greened up state. Green-up height will be considered 3 metres and through the use of FREDDIE, and by weighted averaging, it was determined that it would take on average 23 years to attain a 3 metres height in zone 8.

Zone 9. Old-growth special management

Current practice in the Lower Morkill River/McKale River old-growth special management area includes average cutblock sizes of 5 ha. with on block green tree retention of 5% of a variety of tree species and ages. Management constraints allow a maximum of 25% of the area to be in a non-greened up state. Green-up height will be considered 3 metres and through the use of FREDDIE, and by weighted averaging, it was determined that it would take on average 23 years to attain a 3 metre height in zone 9. An old-growth retention requirement to retain 5% over 200 years will be applied to this management zone.

A.1.2 Analysis unit definition

An analysis unit represents a group of similar stands. Generally, an analysis unit contains stands that possess similar tree species composition and similar timber growing capabilities. In the inventory file the major combinations of species are called type groups and timber growing capability, or site quality, is indicated by a site index or site class. For the Robson Valley TSA analysis, site groups were assigned using new site class (NSITE) and (if present) special site class (SSITE). A further refinement was done after reviewing the average site indices as generated by FREDTAB. A split of age classes 8,9 (old) from age classes 1 to 7 (young) was done for some analysis units. If there was considerable area and significant difference in site index for young versus old then a splitting of analysis units was undertaken. Analysis units and the inventory file variables used to define them, are shown in Table A-1.

A.1 Zone and Analysis Unit Definition

Table A-1. Analysis unit definition

Management zone	Analysis unit	Type groups	Age class	Site
3, 5, 6	01 All	All		g,m,p
1, 2, 4, 7, 8, 9	02 F	1, 4 -8	1-7	g,m
1, 2, 4, 7, 8, 9	22 F	1, 4 -8	8,9	g,m
1, 2, 4, 7, 8, 9	03 F, FC, FH	1,2,3, 4-8	all	p
1, 2, 4, 7, 8, 9	04 FC, FH	2,3	all	g,m
1, 2, 4, 7, 8, 9	06 C	9-11	1-7	p
1, 2, 4, 7, 8, 9	26 C	9-11	8,9	g,m,p
1, 2, 4, 7, 8, 9	07 H	12-17	1-7	g,m,p
1, 2, 4, 7, 8, 9	27 H	12-17	8,9	g,m,p
1, 2, 4, 7, 8, 9	08 B	18,19	1-7	g,m,p
1, 2, 4, 7, 8, 9	28 B	18,19	8,9	g,m,p
1, 2, 4, 7, 8, 9	09 BS ESSF	20	1-7	g,m
1, 2, 4, 7, 8, 9	29 BS ESSF	20	8,9	g,m
1, 2, 4, 7, 8, 9	10 BS, ESSF/ICH/SBS	20	1-7	p
1, 2, 4, 7, 8, 9	30 BS, ESSF/ICH/SBS	20	8,9	p
1, 2, 4, 7, 8, 9	11 BS ICH/SBS	20	1-7	g,m
1, 2, 4, 7, 8, 9	31 BS ICH/SBS	20	8,9	g,m
1, 2, 4, 7, 8, 9	13 S ESSF	21,22,24-26	1-7	g,m
1, 2, 4, 7, 8, 9	33 S ESSF	21,22, 24-26	8,9	g,m
1, 2, 4, 7, 8, 9	14 S, ESSF/ICH/SBS	21,22, 24-26	all	p
1, 2, 4, 7, 8, 9	15 S ICH/SBS	21,22, 24-26	1-7	g,m
1, 2, 4, 7, 8, 9	35 S ICH/SBS	21,22, 24-26	8,9	g,m
1, 2, 4, 7, 8, 9	17 SC, SH	23	all	g,m
1, 2, 4, 7, 8, 9	18 SC, SH, P	23	all	p
1, 2, 4, 7, 8, 9	19 Pl	27-31	1-7	g,m
1, 2, 4, 7, 8, 9	39 Pl	27-31	8,9	g,m
1, 2, 4, 7, 8, 9	20 Pl	27-31	all	p

The area within each zone and analysis unit is given in Table A-2. The areas shown include the adjustments to not satisfactorily restocked (NSR) areas described later in this appendix. Note that all analysis units are not represented in every zone.

A.1 Zone and Analysis Unit Definition

Table A-2. Area by zone and analysis unit

	Area (ha) by zone						
A-unit	**1**	**2**	**4**	**7**	**8**	**9**	**Total**
1							*4163.3
2	1727.9	35.2	-	577.8	3001.9	50.1	5392.9
3	225.9	8.6	3.2	99.7	579.0	4.9	921.3
4	183.6	7.3	12.2	50.5	1059.1	26.0	1338.7
6	135.2	-	3.6	112.3	675.5	15.7	942.3
7	86.5	9.0	33.0	63.7	1188.8	60.1	1441.1
8	316.2	25.7	130.5	323.4	1704.8	27.5	2528.1
9	933.4	58.8	272.9	443.7	4167.1	-	5875.9
10	250.9	50.8	89.7	66.2	1771.3	29.4	2558.3
11	647.5	56.3	281.7	341.6	2774.9	492.6	4594.6
13	914.7	65.3	300.4	755.8	8661.2	22.4	10719.8
14	2863.6	448.8	7916.5	1744.1	38187.9	1575.2	52736.1
15	1694.1	172.6	293.2	189.3	7706.9	935.3	12391.4
17	430.6	14.8	69.4	146.5	1221.6	308.8	2191.7
18	577.2	70.2	585.6	330.3	2209.4	1126.2	4898.2
19	7370.7	897.6	558.1	3436.6	9855.0	64.5	22182.5
20	439.2	5.7	9.8	455.3	922.2	25.9	1858.1
22	214.3	29.2	5.1	191.7	1214.4	-	1654.7
26	2574.1	491.1	882.3	1304.3	11791.3	3228.3	20271.4
27	1942.2	152.8	482.6	995.9	10862.2	566.6	15002.3
28	291.8	0.8	760.9	192.1	3444.1	28.0	4717.7
29	101.1	18.7	1410.9	56.3	5358.3	194.4	7139.6
30	728.4	80.6	846.4	504.8	9433.0	214.4	11807.6
31	51.5	-	89.7	72.4	541.7	30.8	786.1
33	141.4	177.7	401.7	200.2	4250.6	541.2	5712.8
35	199.2	36.3	131.2	58.2	2767.8	529.0	3721.7
39	148.4	98.9	26.1	654.9	1177.9	-	2106.2
Total	**25189.5**	**3012.8**	**15596.7**	**14767.6**	**136527.9**	**10097.3**	***209355.1**

*Note: Zone 5 — Partial Cut Zone has 4163.3 ha — Analysis unit 1 and in included in the total

A.2 Definition of the Timber Harvesting Land Base

The final timber harvesting land base was determined by first deducting all areas considered to be currently unavailable for timber production from the total TSA area. All NSR area on the inventory file was also removed at this stage as a first step in updating the NSR figure. The NSR area, updated to 1993, was then added back to establish the current timber harvesting land base. Harvesting operations will subsequently result in the removal of some of that initial area because of long-term productivity losses. All these categories are summarized in Table 1 of the main report.

A.2.1 Non-Crown land

Non-Crown land is all land that is not administered or managed by the B.C. Forest Service and includes such categories as provincial parks, Indian reserves and areas under federal jurisdiction. This area, which is identified on the inventory file as Ownership Code not equal to 62 C or 69 C, is excluded from the land base. In some cases 69-C areas were converted to 69-N so that they would not be considered in the forestry land base. These areas are as follows:

Mapsheet	Polygon		Mapsheet	Polygon	
093H030	0252	Fish and Wildlife	093H040	0274	McBride Peak Interp Forest
093H030	0253	"	093H040	0275	"
093H030	0254	"	093H040	0278	"
093H030	0256	"	093H040	0287	"
093H030	0257	"	093H040	0293	"
093H030	0258	"			
093H030	0259	"	093H048	0417	W. Twin Interpretive Forest
093H030	0260	"			
093H030	0267	"	093H058	0013	G & Y Permanent Sample
093H030	0268	"			
093H030	0298	"			
093H030	0303	"			
093H057	0448	LaSalle Lakes Recreation Reserve			
093H057	0451	"			
093H057	0470	"			
093H057	0473	"			
093H057	0474	"			
093H057	0475	"			
093H057	0476	"			
093H057	0478	"			
093H057	0493	"			
093H057	0397	"			
093H057	0415	"			
093H057	0416	"			
093H057	0013	"			
093H057	0396	"			
093H057	0445	"			
093H057	0446	"			
093H057	0448	"			

A.2 Definition of the Timber Harvesting Land Base

A.2.2 Non-forest land

Non-forest land includes lakes, swamps, mountains and alpine forest and is classified on the inventory file as type identification 6. These areas are completely removed from the land base.

A.2.3 Non-commercial cover

Areas with non-commercial cover (brush) were excluded. They are identified on the inventory file as type identity code 5.

A.2.4 Environmentally sensitive areas (ESAs)

Environmentally sensitive areas include areas which have moderate to high non-timber values such as wildlife, water and areas which are prone to excessive site degradation if harvested because of geological and topographical conditions. Table A-3. shows the percentage area reduction by ESA category.

Table A-3. Per cent area reductions for environmentally sensitive areas

ESA code	ESA description	Per cent area reduction
Es 1	High soil sensitivity	80
Ep 1	High concern for regeneration problems	90
Ea 1	High avalanche concern	90
Er 1	High recreation value	90
Ec 1	Areas with various management problems including: high elevation forest watershed protection forest snow chutes	90
Ew 1	High wildlife value	90
Ei 1	Inoperable areas due to access	100
	** Riparian Zone -> 1% of net land base	

A.2 Definition of the Timber Harvesting Land Base

A.2.5 Low site

Low sites are areas of low growth potential (productivity) which renders them unsuitable for timber production. These areas are given a site class of ’L’ on the inventory file. All stands classified as such in the new site class field (NSITE) are excluded.

A.2.6 Deciduous stands

As deciduous species are not utilized at present, all stands with deciduous as the major component are removed from the land base. Deciduous stands are identified on the inventory file as type group 35 to 42 inclusive.

A.2.7 Non-merchantable stands

This category includes coniferous stands that are available for harvesting but are not economic to harvest because of excessive decay or poor stocking. Non-merchantable stands are excluded from the land base as follows.

A.2 Definition of the Timber Harvesting Land Base

Table A-4. Area Inclusion Factors for Mature Merchantable Forest Types

Type group	Distance zone	Near zone			Medium zone			Tow zone		
	Logging System: Age, Ht & Stock Class	Conv	Mix	Cable	Conv	Mix	Cable	Conv	Mix	Cable
1-8 Doug Fir	Age >= 7, Ht>=3, Stock =1	1*	1	1	1	1	1	1	1	1
	752,852,952,742,842,942	1	1	1	1	1	1	1	1	1
	732,832,932,	1	1	0*	1	0	0	1	0	0
	721,821,921,	0	0	0	0	0	0	0	0	0
	722,822,922	0	0	0	0	0	0	0	0	0
	Age >=7, Ht=1, All Stock	0	0	0	0	0	0	0	0	0
	All stocking, R	0	0	0	0	0	0	0	0	0
9-11 Cedar	Age >= 7, Ht>=3, Stock =1	1	1	1	1	1	1	1	1	1
	Age >=7, Ht<3, All Stock	0	0	0	0	0	0	0	0	0
12 - 17 Hem	Age >=6, Ht>=3, Stock =1	1	1	1	1	1	1	1	1	1
	Age >=6, Ht<3, All Stock	0	0	0	0	0	0	0	0	0
18 - 20 Bal	Age >=6, Ht>=3, Stock =1	1	1	1	1	1	1	1	1	1
	642,742,842,942	1	1	0	1	1	0	1	1	0
	632,732,832,932	0	0	0	0	0	0	0	0	0
	621,721,821,921	0	0	0	0	0	0	0	0	0
	622,722,822,922	0	0	0	0	0	0	0	0	0
	Age >=6, Ht=1, All Stock	0	0	0	0	0	0	0	0	0
	All stocking, R	0	0	0	0	0	0	0	0	0
21-26 Spruce	Age >=7, Ht>=3, Stock =1	1	1	1	1	1	1	1	1	1
	742,842,942	1	1	0	1	1	0	1	1	0
	732,832,932	1	1	0	1	1	0	1	1	0
	721,821,921	1	1	0	1	1	0	1	1	0
	722,822,922	0	0	0	0	0	0	0	0	0
	Age >=7, Ht=1, All Stock	0	0	0	0	0	0	0	0	0
	All stocking, R	0	0	0	0	0	0	0	0	0

continued

*1 = Included in land base *0 = Excluded from land base

A.2 Definition of the Timber Harvesting Land Base

Table A-4. Area inclusion factors for mature merchantable forest types (concluded)

Type group	**Distance zone**	**Near zone**			**Medium zone**			**Tow zone**		
No.	Logging System: Age, Ht & Stock Class	Conv	Mix	Cable	Conv	Mix	Cable	Conv	Mix	Cable
27 - 31 Pine	Age >=5, Ht>=3, Stock =1	1	1	1	1	1	1	1	1	1
	542,642,742,842,942	1	1	1	1	1	1	0	0	0
	532,632,732,832,932	1	1	0	1	1	0	0	0	0
	533,633,733,833,933	1	1	0	1	1	0	0	0	0
	534,634,734,834,934	0	0	0	0	0	0	0	0	0
	521,621,721,821,921	1	0	0	1	0	0	0	0	0
	522,622,722,822,922	0	0	0	0	0	0	0	0	0
	523,623,723,823,923	0	0	0	0	0	0	0	0	0
	524,624,724,824,924	0	0	0	0	0	0	0	0	0
	Age >=5, Ht=1, All Stock	0	0	0	0	0	0	0	0	0
	All stocking, R	0	0	0	0	0	0	0	0	0
35,36 Cot	All Age, Height & Stock	0	0	0	0	0	0	0	0	0
40 Birch	All Age, Height & Stock	0	0	0	0	0	0	0	0	0
41,42 Aspn	All Age, Height & Stock	0	0	0	0	0	0	0	0	0

Data Source and Comments:

Logging system as defined by both physical operability and volume per hectare criteria.
Refer to Appendix III of the Data Package for the Inventory designations for Age, Height and Stocking Class codes.

All stands with a Low site designation will be excluded. Site Class is based on the New Site (NSITE) field in the inventory file unless Special Site (SSITE) has been assigned. If SSITE is present it will be used.

A.2 Definition of the Timber Harvesting Land Base

Distance zones represent the haul distance from the nearest point by road from each inventory compartment within the TSA to the closest milling centre (either McBride or Valemount). The inventory compartment grouping within the zones are as follows:

Table A-4.1. Distance zones for area inclusion factors

Near zone	Region	59	Compartments:	5 to 11,14 to 29, 35 and 36
	Region	42	Compartments:	28 to 37
Medium zone	Region	59	Compartments:	12,13 and 37 to 39
	Region	56	Compartments:	36 and 37
Tow zone	Region	42	Compartments:	21 to 27

Immature good and medium sites are assumed to be within the land base, while immature poor sites are pro-rated based on the mature poor sites.

Table A-4.2. Per cent area inclusions for immature forest stands

Leading species	Age class(es)	Site class(es)	Area inclusion factor
Cedar, Hemlock	>2 & <6	G,M	1
Fir	>2 & <7	G,M	1
Balsam	>2 & <6	G,M	1
Spruce	>2 & <7	G,M	1
Pine	>2 & <5	G,M	1
Fir, Balsam, Spruce, Pine, Cedar & Hemlock	1&2	G,M,P	1
Fir	>2 & <7	P	.6547*
Cedar & Hemlock	>2 & <6	P	.9902*
Balsam	>2 & <6	P	.8807*
Spruce	>2 & <7	P	.9923*
Pine	>2 & <5	P	.4876*
Deciduous	All Type ID = 1	ALL	0
All	All (&Type ID = 1)		0

*Based on mature net/gross

Site Class is based on the New Site (NSITE) field in the inventory file unless Special site (SSITE) has been assigned. If SSITE is present it will be used.

A.2.8 Inoperable areas

Inoperable land is that part of the forested area that is not likely to be accessible for timber harvesting because of the combination of rough terrain, difficult access and economic factors. All areas with inoperable identifier 'I' are excluded from the land base.

A.2 Definition of the Timber Harvesting Land Base

A.2.9 Existing unclassified roads, trails and landings

Past timber harvesting operations have resulted in a loss of productive forest land. However, many of the existing roads, trails, landings and related disturbances are not accounted for in the inventory file. To account for this loss in the area available for timber harvesting a 5.7 % reduction was applied to all areas younger than 41 years old.

A.2.10 Future roads, trails and landings

There will also be losses in productive area as future harvesting occurs. All existing stands currently over 40 years old will be subject to these losses which are assumed to be 5.7%. This estimate was taken from *Soil Conservation Guidelines for Timber Harvesting - Interior B.C.* The area that will eventually be lost is not initially excluded from the land base. The B.C. Forest Service timber supply model simply reduces the areas by 5.7% the first time all stands currently over 40 years old are harvested.

A.2.11 Not satisfactorily restocked adjustments

The NSR area must also be made to agree with the silviculture history records for the Robson Valley TSA. The first step in the adjustment procedure was to exclude all areas that are classified as NSR on the inventory file (type identity codes 4 and 9). As shown in Table 1 of the main report, the area excluded was 8554 hectares (a 5.7% reduction for existing roads, trails and landings had already been applied).

All existing NSR area is assumed to become restocked in the first decade. The following explains how the NSR area was adjusted for this analysis.

Table A-5. NSR area adjustments

Analysis unit	Backlog NSR		Current NSR		Excluded NSR*	Total area in hectares
	Area in ha	Rate of restocking ha/decade	Area in ha	Rate of restocking ha/decade	These areas are small and inaccessible	
09	880	250	2578	2578		3458
10					613.5	613.5
11	880	250	2588.7	2588.7		3468.7
12					613.5	613.5
13			200	200		200
15			200	200		200
Total	1760		5566.7	5566.7	1227	8553.7

*Excluded NSR are those areas which have been denuded and are inaccessible for treatment and are assumed to be in Zones 3 and 6 (netted out of the land base). Area returning to the land base is 8553.7 minus 1227 = 7326.7 ha.

A.2 Definition of the Timber Harvesting Land Base

The total area of NSR, both backlog and current, is 7326.7 hectares. The current NSR area (5566.7 ha) is assumed to be restocked within four years from now (regeneration delay - averaged to two years for model input) and is added back into the timber harvesting land base as indicated in Table A-6. The backlog NSR is assumed to be restocked at a rate of 250 hectares per decade. Again, for modelling purposes, these timeframes were averaged to 5, 15, 25 and 35 years for the backlog NSR to return to the land base. NSR area is distributed in the same proportion as zones and analysis units in the timber harvesting land base.

Table A-6. NSR area additions to timber harvesting land base

Analysis unit	Zone 1	Zone 2	Zone 4	Zone 5	Zone 7	Zone 8	Zone 9	Total
			area (hectares)					
09 - Backlog	106.03	12.66	65.53	17.51	62.1	573.75	42.42	880.00
09 - Current	310.63	37.09	191.96	51.29	181.91	1680.83	124.27	2578.00
11 - Backlog	106.03	12.66	65.53	17.51	62.10	573.75	42.42	880.00
11 - Current	311.92	37.25	192.76	51.50	182.67	1687.79	124.79	2588.67
13 - Current	24.10	2.88	14.89	3.98	14.11	130.40	9.64	200.00
15 - Current	24.10	2.88	14.89	3.98	14.11	130.40	9.64	200.00
Total	882.81	105.42	545.56	145.77	517.00	4776.93	353.18	7326.67

A.3 Forest Management Practices

This section describes forest management as currently practiced in the Robson Valley TSA. The information was provided by the Robson Valley Forest District staff and Prince George Forest Regional staff.

A.3.1 Utilization levels

Harvesting is assumed to be carried out to a utilization level of 12.5 cm diameter at breast height (dbh) (1.3 metres) for lodgepole pine timber types and 17.5 cm dbh for all other timber types.

A.3.2 Utilization standards

For modelling purposes, Interior close utilization standards of a maximum 30 cm stump height and a minimum 10 cm inside-bark diameter at tree top, less decay were used. In practice however, a 15 cm top is used for cedar - the effect of lower utilization will be examined through sensitivity analysis.

A.3.3 Minimum harvestable ages

Minimum harvestable ages used in the analysis were set by Forest District staff after review of volume per hectare requirements, culmination ages and field experience. Minimum harvestable ages are listed in Table A-7. For selection management, (AU 1) the first-entry harvest is assumed to occur at a stand age of 110 years or older. After the first entry, the ages of stands under selection management are not defined.

Table A-7. Identification of minimum harvestable age for each analysis unit

Analysis unit	Priority cutting age (years)	Culmin-ation age VDYP	Culmin-ation age TIPSY	VDYP time to reach 170 m^3 per Ha	TIPSY time to reach 170 m^3 per Ha	Est. min. harvest age VDYP	Est. min. harvest age TIPSY
01 All							
02 F - young	141 +	110	120	60-70	60-70	90	90
22 F - old	141 +	120	140	80-90	90-100	120	120
03 F,FC,FH	141 +	140	140	130	120-130	140	140
04 FC, FH	141 +	130	140	70-80	80-90	110	120
06 C - young	141 +	90	100	60-70	60-70	90	90
26 C - old	141 +	90	140	100-110	90-100	100	100
07 H - young	121 +	90	110	60-70	70-80	90	100
27 H - old	121 +	150	160	100-110	100-110	100	110
08 B - young	121 +	140	130	90	80-90	110	110
28 B - old	121 +	180	180	130-140	110-120	110	110
09 B,S ESSF - young	121 +	100	110	80	70-80	100	100
29 B,S ESSF - old	121 +	160	160	120-130	100-110	120	120
10 B,S ESSF/ICH - Y	121 +	150	150	120-130	100-110	120	120
30 B,S ESSF /ICH- old	121 +	190	200	170-180	130	120	120
11 B,S ICH/SBS - young	121 +	100	110	70-80	60-70	100	90
31 B,S ICH/SBS - old	121 +	150	150	110-120	90-100	120	120
13 S ESSF - young	141 +	110	120	80	70-80	100	100
33 B,S ESSF - old	141 +	120	130	80-90	80-90	110	110
14 S ESSF	141 +	180	180	130-140	120-130	120	120
15 S ICH/SBS -young	141 +	110	90	70-80	60-70	100	90
35 S ICH/SBS - old	141 +	110	110	80-90	70-80	110	100
17 SC, SH	141 +	100	110	70-80	70-80	100	100
18 SC, SH	141 +	170	180	110-120	110-120	100	100
19 Pl - young	100 +	90	80	60-70	50-60	90	80
39 Pl - old	100 +	100	90	70-80	70	90	90
20 Pl	100 +	130	130	110-120	110-120	100	100

A.3 Forest Management Practices

A.3.5 Basic silviculture and regeneration assumptions

The following table shows what analysis units are created after harvesting occurs in existing analysis units. Managed stand yield tables (MSYTs) were created to reflect the proportions of analysis units converted to other analysis units and the percentages of stands that are assumed to be managed. The resultant MSYTs are shown in Section A.4.2. The regeneration assumptions shown below apply to all zones.

Table A-8. Regeneration assumption

Existing analysis unit	Regenerated analysis unit	% Conversion	Per cent natural	Per cent (of area) planted	Regen delay (years)	Initial stocking (sph)
01. All G/M/P	01. All G/M/P	100	0	100	4	1400
02. F G/M	02. F G/M	90	0	100	4	1400
Young	19. Pl G/M	10	30	70	4	1400
22. F G/M	22. F G/M	90	0	100	4	1400
Old	39. Pl G/M	10	30	70	4	1400
03.F,FC,FH	03. F,FC,FH P	70	0	100	4	1500
P	20. Pl P	30	30	70	4	1500
04. FC,FH	04. FC FH G/M	80	0	100	4	1500
G/M	20 F G/M	20	0	100	4	1500
06. C	06. C G/M/P	5	100	0	4	3000
G/M/P	15. S G/M	80	0	100	4	1600
Young	17. SC,SH G/M	15	0	100	4	1600
26. C	26. C G/M/P	5	100	0	4	3000
G/M/P	35. S G/M	80	0	100	4	1600
Old	17. SC,SH G/M	15	0	100	4	1600
07. H	07. H G/M/P	5	100	0	4	3000
G/M/P	15. S G/M	95	0	100	4	1600
Young						
17. H	27. H G/M/P	5	100	0	4	3000
G/M/P	35. S G/M	95	0	100	4	1600
Old						
08. B	08. B G/M/P	10	100	0	4	800
G/M/P	14. S P	80	0	100	4	1400
Young	10. BS P	10	100	0	4	800
08. B	28. B G/M/P	10	100	0	4	800
G/M/P	14. S P	80	0	100	4	1400
Old	30. BS P	10	100	0	4	800

continued

A.3 Forest Management Practices

Table A-8. Regeneration assumption

Existing analysis unit	Regenerated analysis unit	% Conversion	Per cent natural	Per cent (of area) planted	Regen delay (years)	Initial stocking (sph)
09. BS	09. BS G/M	10	30	70	4	1000
G/M	08. B G/M/P	20	100	0	4	2000
ESSF	13. S G/M	70	0	100	4	1600
Young						
29. BS	29. BS G/M	5	30	70	4	1000
G/M	28. B G/M/P	5	100	0	4	2000
ESSF	13. S G/M	90	0	100	4	1600
Old						
10. BS P	10. BS P	10	30	70	4	1400
ESSF/ICH	08. B G/M/P	20	100	0	4	1600
Young	14. S P	70	0	100	4	1400
30. BS P	30. BS P	10	30	70	4	1400
ESSF/ICH	28. B G/M/P	20	100	0	4	1600
Old	14. S P	70	0	100	4	1400
11. BS G/M	11. BS G/M	10	0	100	4	1400
ICH/SBS	08. B G/M/P	10	100	0	4	1600
Young	15. S G/M	80	0	100	4	1400
31.BS G/M	31. BS G/M	10	0	100	4	1400
ICH/SBS	28. B G/M/P	10	100	0	4	1600
Old	35. S G/M	80	0	100	4	1400
13. S G/M	13. S G/M	60	0	100	4	1600
ESSF	09. BS G/M	35	30	70	4	1600
Young	08. B G/M	5	100	0	4	1600
33. S G/M	33. S G/M	90	0	100	4	1600
ESSF	29. BS G/M	5	30	70	4	1600
Old	28. B G/M	5	100	0	4	1600
14. S P	14. S P	80	0	100	4	1500
ESSF/ICH	10. BS P	10	40	60	4	1500
	08. B G/M/P	10	100	0	4	1500
15. S G/M	15. S G/M	90	0	100	4	1600
ICH/SBS	11. BS G/M	5	10	90	4	1600
Young	19. PI G/M	5	0	100	4	1400
35. S G/M	35. S G/M	90	0	100	4	1600
ICH/SBS	31. BS G/M	5	10	90	4	1600
Old	39. PI G/M	5	0	100	4	1400

continued

A.3 Forest Management Practices

Table A-8. Regeneration assumption (concluded)

Existing analysis unit	Regenerated analysis unit	% Conversion	Per cent natural	Per cent (of area) planted	Regen delay (years)	Initial stocking (sph)
17. SC SH G/M ICH/SBS	17. SC SH G/M	60	0	100	4	1600
	15. S G/M	40	0	100	4	1600
18. SC SH P ICH/SBS	18. SC SH P	80	0	100	4	1200
	06. C G/M/P	5	100	0	4	3000
	07. H G/M/P	5	100	0	4	3000
	16. S P	10	0	100	4	1200
19. Pl G/M	19. Pl G/M	100	20	80	4	1400
39. Pl G/M	39. Pl G/M	100	20	80	4	1400
20. Pl P	20. Pl P	100	50	50	4	1400

A.3.6 Harvest profile

Table A-9. is a summary of the historical harvest profile derived from harvesting records for the past few years.

Table A-9. Historical harvest profile

Analysis unit	Per cent of total harvest volume
All	0

A.3 Forest Management Practices

A.3.7 Forest cover requirements

Table A-10. specifies the forest cover requirements needed to achieve the forest management objectives for each zone.

Table A-10. Management zone forest cover requirements

Management zone	Height 1 (metres)	Age 1 (years)	Maximum per cent area younger than Age 1	Height 2 (metres)	Age 2 (years)	Minimum per cent area older than Age 2
1	5	26	10			
2	5	26	3			
3		100%	Excluded			
4	3	27	33		80	67
5		Partial	Cut Zone			
6		100%	Excluded			
7	5	26	25			
8	3	23	33			
9	3	22	25		200	5

The years required to achieve the various heights were based on area-weighting the time required to achieve the specified green-up heights for each analysis unit. The average site indices were obtained through the use of FREDTAB and then FREDDIE was used to project the required height-age relationships.

A.3.8 Unsalvaged losses

Table A-11. shows the estimated average annual volume loss to catastrophic events such as wildfires and insect attacks. Regeneration of these denuded areas is expected to occur within the standard regeneration delay period of 4 years. Estimated annual losses are deducted from the gross timber supply to determine the projected net volumes that will be harvested over time.

Table A-11. Unsalvaged losses

	Cause of loss	Gross losses in cubic metres/year	Net losses in cubic metres/year	Salvaged volume in cubic metres/year	Net annual unsalvaged losses in cubic metres per year
a	Insects	16 940	8 808	2 750	6 058
b	Disease	47 000	22 560	0	22 560
c	Fire	101 396	48 670	15 560	33 110
d	Wind Damage	40 000	19 200	10 500	8 700
e	Other	0	0	0	0
f	Total	205 336	99 238	28 810	70 428

Notes on above categories:

a - Figures are from 1988 to 1992 FIDS report and area logged for beetle control in 1991 - 1992, averaged over five years..

b - Disease figures taken from Summary of Pest Losses - Prince George Region Cozen/Taylor, 1985.

c - Based on five year average from 1988 to 1992 as reported on FS144.

d - Estimate of Pack Saddle Blowdown with Salvage figures from Small Business Five Year Development Plan.

e - Gross losses are reported on gross forest land base.

f - Net losses are reported on net operable land base.

A.4 Yield Tables

A.4.1 Yield tables for existing stands

The yield tables applied to most existing stands in the analysis are shown in Table A-12. These tables were generated for each zone and analysis unit using the Variable Density Yield Prediction (VDYP) system. Through the use of the l_oaf.dat file used by the FSSIM model, the yields will be further reduced by a proportion equal to 75% of deciduous volumes in each analysis unit. These tables are not applied to the current area of NSR, nor to the selection management zone. The yield tables for these areas are presented in Sections A.4.2, "Yield tables for regenerated stands" and A.4.3, "Selection management yield tables".

A.4 Yield Tables

Table A-12. Yield estimates for existing stands

Age	Fir, 1-7 GM 2	F,FC,FH P 3	FC,FH GM 4	C, 1-7 GMP 6	H, 1-7 GMP 7	B, 1-7 GMP 8	BS, ESSF 1-7, GM 9	BS, ESSF ICH, 1-7, P 10	BS, ICH 1-7, GM 11
0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0
30	9.3	0.3	0.7	2.4	2.1	2.9	2.9	0.1	5.1
40	50.5	12.1	14.9	21.6	29.4	17.3	21.1	3.1	29.3
50	96.4	30.1	52.4	56.9	77.8	42.8	50.5	16	62.8
60	140.9	56.3	97.1	94.4	128.6	72.2	78.5	37.3	96.2
70	183.3	84	140.3	128.5	174.5	104.7	107.4	64.9	131.9
80	223.1	110.4	181.1	159.9	216	132.7	131.2	86.4	161.4
90	260.3	135.5	217.1	184.8	249.2	158	152.3	105.9	186.9
100	294.5	159	249.7	205.7	277.2	181.5	171.6	123.9	209.8
110	325	181.1	279.2	223.5	301.1	203.6	189.7	140.8	230.6
120	351.4	200.6	304.4	237.9	321.1	224.2	206.4	156.4	249.4
130	375.5	218.5	330.8	257	345.9	245.6	223.4	171.9	269.5
140	395.8	233.9	354.9	275.3	368.3	265.4	239.3	186.5	288.2
150	413.9	247.8	376.7	292.4	388.9	283.8	254.3	200.3	305.8
160	429.9	260.2	396.5	307.7	407.4	300.6	268.7	213.4	322.2
170	444	271.1	414.4	322	424	316.4	282.5	225.9	337.7
180	456.8	281.6	431.6	335.8	439.3	331.2	295.4	237.7	352.3
190	468	291.2	447.6	348.7	453.3	345.1	307.6	248.9	366.1
200	479.4	300.6	463.4	361.5	467.1	358.9	319.3	259.7	379.3
210	490.1	309.6	478.7	373.8	480.2	372.2	330.4	270	392
220	500.3	318.1	493.3	388.2	492.7	384.9	341	279.8	404
230	509.9	326.2	507.2	402.4	504.6	397.3	351.2	289.3	415.6
240	519	333.9	520.6	416.3	515.5	409.1	360.9	298.4	426.7
250	527.6	341.2	533.6	429.8	525.8	420.6	370.1	307	437.3
260	528.2	342.4	537.4	431.8	531.9	422.6	372.3	309.3	439.8
270	528.8	343.5	540.9	433.6	537.7	424.6	374.4	311.4	442
280	529.2	344.5	544.3	435.3	543.1	426.5	376.3	313.4	444.1
290	529.6	345.5	547.5	437	548	428.2	378	315.3	446
300	529.9	346.3	550.5	438.5	552.7	429.9	379.7	317	447.9
310	530.1	347.1	553.3	439.9	557	431.6	381.2	318.6	449.5
320	530.2	347.7	556	441.1	561.2	433.1	382.5	320.1	451.1
330	530.2	348.4	558.6	442.3	565.1	434.6	383.8	321.4	452.5

continued

A.4 Yield Tables

Table A-12. Yield estimates for existing stands

Age	S, ESSF 1-7, GM 13	S, ESSF ICH, P 14	S, ICH 1-7, GM 15	SC GM 17	SC P 18	Pl, 1-7 GM 19	Pl P 20	F, 8-9 GM 22	C, 8-9 GMP 26
0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0.3	0	0	0
30	0.1	0	0.2	0	0	20.5	2	0.5	0.1
40	5.8	0	15.8	11.7	0	70	12.1	13.9	6.5
50	27.3	2	55.6	50.7	0.5	117.4	32.8	44.4	37.5
60	58.3	7	100.4	104.1	8.4	159.3	60.9	79.8	72
70	87.2	21.8	141.2	157.7	33	196.4	86.8	113.2	103.1
80	121.5	40.9	181.6	206.5	65.8	229.2	110.6	144.4	131.6
90	151.7	68.8	216.8	244.9	103.2	259	132.6	173.3	150.7
100	178.5	94.5	247.2	276	136.1	286.1	152.8	200.3	164.7
110	202.1	118	273.5	301.3	164.7	311	171.6	225.4	174.8
120	223	139.6	296.1	321.6	189.2	333.9	189.1	246.9	181
130	242.5	159.9	316.6	345.1	215.6	355.3	206.2	267.3	196.2
140	259.6	178.7	334.3	366.5	240.2	369.7	218.8	285.3	211.4
150	276.3	196.1	350.4	385.8	262.9	380.9	229	301.5	225.7
160	291.3	212.1	364.3	403	283.7	388.9	237	315.7	239.1
170	304.8	226.8	376.5	418.2	302.9	393.8	243	328.3	251.6
180	316.9	240.4	387.3	432.2	320.6	395.6	246.7	340.4	263.5
190	327.8	252.9	397	444.8	337	394.5	248.1	351.7	274.9
200	338	264.6	405.9	456.8	352.5	397	251.7	362.7	286
210	347.4	275.4	414.1	468	367	399.9	255.3	373.3	296.8
220	356	285.4	421.6	478.5	380.7	402.8	258.8	383.3	309.1
230	364	294.7	428.5	488.3	393.7	405.7	262.1	392.8	321.5
240	371.4	303.3	434.8	497.5	405.9	408.5	265.3	401.9	333.6
250	378.1	311.4	440.6	506.2	417.5	411.2	268.2	410.5	345.5
260	383.2	316.4	444.6	510.4	423.6	413.3	270.3	412.2	347.4
270	387.8	320.9	448.3	514.2	429.2	415.3	272.3	413.8	349.2
280	392.1	325.1	451.6	517.6	434.4	417.2	274	415.3	350.9
290	396	329.1	454.6	520.7	439.1	418.9	275.6	416.6	352.5
300	399.5	332.7	457.4	523.4	443.5	420.5	277	417.9	354
310	402.8	336	459.8	525.9	447.5	421.9	278.3	419	355.4
320	405.8	339	462	528.2	451.2	423.1	279.4	420.1	356.7
330	408.5	341.8	464.1	530.2	454.5	424.3	280.3	421	357.9
340	411.1	344.4	465.9	532.1	457.5	425.3	281.1	421.9	359
350	413.3	346.8	467.5	533.8	460.2	426.2	281.8	422.8	360

continued

Table A-12. Yield estimates for existing stands (concluded)

Age	H, 8-9 GMP 27	B, 8-9 GMP 28	BS, ESSF 8-9, GM 29	BS, ESSF ICH, P,8-9 30	BS, ICH 8-9, GM 31	S, ESSF 8-9, GM 33	S, ICH 8-9, GM 35	Pl, 8-9 GM 39	Selection 50
0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0.3	0.1
30	0.1	0	0	0	0	0.1	0.1	9.1	12
40	1.8	2	1.2	0	4.5	6.5	10	41.5	45.7
50	13.4	10.7	13.5	0.9	21.6	32.5	40.3	85	84.3
60	42.2	29.7	36.6	9.1	47.4	71.2	81.9	123.8	121.3
70	75.9	53.9	66.7	25.1	78.3	114.4	128	158.2	155.6
80	108.6	74.8	90.3	44.1	103	152.6	168.6	188.9	186.8
90	135.2	94.6	111.9	61.4	125.2	186.1	203.6	216.6	215.6
100	157.5	112.9	131.8	77.4	145.5	215.3	234	241.7	241.8
110	176.5	130	150.3	92.2	164.1	240.8	260.3	264.6	265.8
120	192.2	146	167.6	106.1	181.2	263.1	283	285.6	287.5
130	212.1	162.4	184.5	119.6	198.5	283.9	304.3	305.6	307.5
140	230.3	178.2	200.7	132.5	215	302.3	323	319.7	322.4
150	247.2	193.3	216	144.8	230.6	318.6	339.6	331	334.8
160	262.8	207.9	230.5	156.5	245.4	333	354.2	339.5	344.4
170	277	221.8	244.3	167.7	259.5	345.9	367.1	345.2	351.6
180	290.2	235.2	257.5	178.4	272.9	357.4	378.7	348.4	356.7
190	302.1	248.2	270.1	188.7	285.6	367.8	389	349	359.6
200	314.4	260.7	282.1	198.5	297.8	377.2	398.5	352.3	364.7
210	326.3	272.8	293.7	208	309.5	385.8	407.1	355.9	369.7
220	337.8	284.6	304.8	217	320.8	393.6	415	359.3	374.6
230	348.9	296	315.4	225.8	331.5	400.7	422.1	362.7	379.2
240	359.6	307	325.6	234.2	341.9	407.2	428.7	365.9	383.7
250	370.1	317.8	335.5	242.3	351.9	413.2	434.6	368.9	387.9
260	376.6	318.9	338.1	244.8	354.5	416.9	438.3	371.2	389.6
270	382.8	319.8	340.7	247.2	356.9	420.2	441.6	373.3	391.1
280	388.8	320.8	343	249.4	359.1	423.2	444.6	375.2	392.5
290	394.5	321.6	345.2	251.5	361.3	425.9	447.2	377.1	393.8
300	400.1	322.5	347.3	253.5	363.2	428.2	449.5	378.7	395
310	405.2	323.3	349.2	255.3	365	430.4	451.5	380.2	396
320	410	324	351.1	257.1	366.8	432.2	453.4	381.5	397
330	414.4	324.7	352.8	258.8	368.4	433.9	455	382.7	397.8
340	418.5	325.4	354.5	260.4	369.9	435.3	456.3	383.8	398.4
350	422.5	326	356	261.8	371.3	436.5	457.6	384.7	399

A.4 Yield Tables

A.4.2 Yield tables for regenerated stands

Yield tables applied to future regenerated stands, existing managed stands and NSR are shown in the following tables. These tables are based on managed stand yield tables (MSYTs) - TIPSY developed by the Research Branch of the Forest Service. To construct the tables for the analysis, average site productivity (site index) for each analysis unit and the basic silviculture regeneration assumptions described in Section A.3.5, "Basic silviculture and regeneration assumptions" were applied. To account for operational conditions, a 15% reduction was applied to all yield values. Yields were further reduced in older ages by 5% to account for decay, waste and breakage.

A.4 Yield Tables

Table A-13. Yield tables for regenerated stands

Age	Fir, 1-7 GM 2	F,FC,FH P 3	FC,FH GM 4	C, 1-7 GMP 6	H, 1-7 GMP 7	B, 1-7 GMP 8	BS, ESSF 1-7, GM 9	BS, ESSF ICH, 1-7, P 10	BS, ICH 1-7, GM 11
0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0
30	9.2	0.3	0.7	2.4	2.1	2.9	2.9	0.1	5.1
40	49.2	12.1	14.8	20.5	29.3	17.1	21	3.1	29.2
50	93.1	29.8	52	53	77.5	42	50.3	15.9	62.5
60	135.4	55.3	96.4	86.2	127.9	70	78.3	37.1	95.5
70	175.7	82.1	139.4	116	173.4	100.8	107.2	64.5	130.8
80	213.6	107.7	179.9	143.4	214.5	127	130.9	85.9	160
90	249.2	132	215.6	164.7	247.4	150.7	152	105.2	185.3
100	282	154.8	248.1	182.6	275.1	172.6	171.1	123.1	208
110	311.3	176.2	277.4	197.7	298.8	193.4	189.3	139.9	228.5
120	337	195.2	302.5	209.9	318.6	212.8	205.9	155.4	247.1
130	360.5	212.7	328.8	227	343.1	233.1	222.8	170.8	267
140	380.4	227.9	352.7	243.4	365.5	251.9	238.8	185.4	285.6
150	398.1	241.5	374.5	258.8	385.9	269.4	253.7	199.1	303
160	413.8	253.7	394.2	273.1	404.3	285.8	268.1	212.2	319.4
170	427.8	264.5	412	286.5	420.8	301.2	281.8	224.6	334.8
180	440.3	274.9	429.1	299.3	436.1	315.6	294.8	236.4	349.4
190	451.4	284.4	445.1	311.4	450	329.1	306.9	247.6	363.1
200	462.6	293.8	460.9	323.3	463.8	342.6	318.6	258.4	376.3
210	473.2	302.6	476.1	334.8	476.8	355.5	329.8	268.6	388.9
220	483.2	311	490.7	348.2	489.3	367.9	340.4	278.5	401
230	492.7	319	504.6	361.5	501	379.9	350.5	287.9	412.5
240	501.7	326.7	517.9	374.4	511.9	391.5	360.2	297	423.5
250	510.2	333.9	530.8	387	522.1	402.7	369.4	305.6	434.1
260	510.9	335.1	534.6	388.9	528.2	404.6	371.6	307.9	436.5
270	511.4	336.2	538.2	390.7	533.9	406.5	373.7	310	438.8
280	511.9	337.2	541.5	392.3	539.3	408.3	375.6	312	440.9
290	512.3	338.2	544.7	393.8	544.2	410.1	377.3	313.8	442.8
300	512.6	339	547.8	395.3	548.9	411.7	379	315.5	444.6
310	512.8	339.8	550.6	396.6	553.2	413.3	380.5	317.1	446.3
320	512.9	340.4	553.3	397.8	557.3	414.8	381.8	318.6	447.8
330	513	341	555.8	398.9	561.2	416.2	383.1	320	449.3
340	512.9	341.6	558.3	400	564.9	417.6	384.3	321.3	450.6
350	512.7	342.1	560.7	401	568.3	418.9	385.3	322.4	451.8

continued

A.4 Yield Tables

Table A-13. Yield tables for regenerated stands

Age	S, ESSF 1-7, GM 13	S, ESSF ICH, P 14	S, ICH 1-7, GM 15	SC GM 17	SC P 18	Pl, 1-7 GM 19	Pl P 20	F, 8-9 GM 22	C, 8-9 GMP 26
0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0.3	0	0	0
30	0.1	0	0.2	0	0	20.3	2	0.5	0.1
40	5.8	0	14.9	11.7	0	68.2	12	13.9	6.5
50	27	2	51.7	50.5	0.5	113.2	32.3	44.1	37.4
60	57.4	7	92.1	103.5	8.4	152.9	59.7	79.1	71.8
70	85.6	21.6	128.2	156.6	32.6	188	84.8	112	102.6
80	119.1	40.4	164.3	204.5	64.9	219.2	108.1	142.9	130.8
90	148.7	68.1	195.6	241.9	101.9	247.6	129.5	171.5	149.7
100	174.8	93.4	222.8	272.3	134.5	273.5	149.3	198.1	163.5
110	198	116.7	246.3	296.9	162.7	297.3	167.7	222.9	173.4
120	218.5	138	266.6	316.5	187	319.4	184.9	244.3	179.5
130	237.6	158.1	285.5	339.5	213.1	340.2	201.8	264.6	194.6
140	254.4	176.8	301.7	360.4	237.6	354.1	214.1	282.4	209.7
150	270.9	194	316.7	379.4	260.1	365	224.1	298.5	223.9
160	285.8	209.9	330	396.3	280.8	372.8	232	312.6	237.2
170	299.1	224.6	341.7	411.4	299.8	377.6	237.9	325.2	249.6
180	311.2	238.1	352.2	425.1	317.5	379.5	241.5	337.3	261.5
190	322	250.6	361.4	437.6	333.7	378.3	243	348.5	272.8
200	332.1	262.2	370.1	449.4	349.2	380.8	246.5	359.5	283.9
210	341.5	272.9	378	460.4	363.6	383.6	250.1	370	294.6
220	350	282.9	385.2	470.8	377.3	386.5	253.5	380	306.8
230	358	292.2	391.8	480.5	390.2	389.3	256.8	389.5	319.1
240	365.3	300.8	397.9	489.5	402.3	392.1	259.9	398.5	331.1
250	372	308.8	403.4	498.1	413.9	394.7	262.8	407	342.9
260	377	313.8	407.3	502.2	419.9	396.8	264.9	408.8	344.8
270	381.6	318.3	410.9	505.9	425.5	398.8	266.8	410.4	346.6
280	385.9	322.5	414.1	509.3	430.7	400.6	268.5	411.9	348.3
290	389.7	326.4	417	512.3	435.4	402.3	270.1	413.2	349.9
300	393.3	330	419.6	515	439.8	403.8	271.5	414.5	351.4
310	396.5	333.3	422	517.5	443.8	405.2	272.8	415.6	352.9
320	399.5	336.3	424.2	519.8	447.5	406.4	273.9	416.6	354.1
330	402.2	339.1	426.1	521.8	450.8	407.6	274.8	417.6	355.3
340	404.8	341.7	427.9	523.6	453.7	408.5	275.6	418.5	356.4
350	407	344	429.5	525.3	456.5	409.4	276.2	419.3	357.5

continued

A.4 Yield Tables

Table A-13. Yield tables for regenerated stands (concluded)

Age	H, 8-9 GMP 27	B, 8-9 GMP 28	BS, ESSF 8-9, GM 29	BS, ESSF ICH, P,8-9 30	BS, ICH 8-9, GM 31	S, ESSF 8-9, GM 33	S, ICH 8-9, GM 35	Pl, 8-9 GM 39	Selection 50
0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0.3	0.1
30	0.1	0	0	0	0	0.1	0.1	9.1	12
40	1.8	2	1.2	0	4.5	6.5	10	41.2	43.4
50	13.4	10.6	13.5	0.9	21.6	32.2	40.1	84.1	78.2
60	42.2	29.5	36.5	9.1	47.3	70	80.5	122.1	111.6
70	75.9	53.5	66.4	25.1	77.8	112	125.2	155.8	142.5
80	108.6	74.2	89.9	44.1	102.3	149.3	164.7	186	171
90	135.1	93.8	111.3	61.4	124.4	182	198.8	213.2	197.2
100	157.5	112	131.1	77.3	144.5	210.5	228.3	237.8	221.3
110	176.5	128.9	149.5	92.2	162.9	235.3	253.9	260.3	243.5
120	192.2	144.7	166.6	106	179.9	257.1	276	281.1	263.7
130	212.1	161	183.5	119.5	197.1	277.5	296.7	300.9	282.7
140	230.3	176.8	199.6	132.4	213.5	295.5	315.1	314.8	296.7
150	247.2	191.8	214.9	144.7	229	311.6	331.4	325.9	308.3
160	262.8	206.3	229.4	156.4	243.7	325.9	345.8	334.4	317.6
170	277	220.2	243.1	167.6	257.7	338.6	358.6	340.1	324.7
180	290.2	233.6	256.3	178.3	271.1	350	370	343.3	329.7
190	302.1	246.4	268.8	188.5	283.7	360.3	380.2	343.8	332.6
200	314.4	258.9	280.8	198.4	295.9	369.6	389.6	347.2	337.6
210	326.2	271	292.4	207.8	307.6	378.1	398.1	350.7	342.5
220	337.8	282.8	303.4	216.9	318.8	385.9	405.9	354.2	347.2
230	348.9	294.1	314	225.6	329.5	392.9	412.9	357.5	351.8
240	359.6	305.1	324.2	234.1	339.9	399.4	419.4	360.7	356.1
250	370.1	315.8	334	242.2	349.8	405.3	425.4	363.7	360.2
260	376.6	316.9	336.7	244.6	352.4	409	429	366	361.8
270	382.8	317.9	339.2	247	354.8	412.2	432.2	368.1	363.3
280	388.8	318.8	341.5	249.2	357.1	415.2	435.1	370	364.7
290	394.5	319.7	343.8	251.3	359.2	417.8	437.7	371.8	366
300	400.1	320.5	345.8	253.3	361.1	420.2	440	373.4	367.1
310	405.2	321.3	347.8	255.1	362.9	422.3	442	374.9	368.1
320	410	322	349.6	256.9	364.7	424.1	443.9	376.2	369
330	414.4	322.7	351.4	258.6	366.3	425.7	445.4	377.4	369.8
340	418.5	323.4	353	260.2	367.8	427.1	446.8	378.5	370.4
350	422.5	324	354.5	261.7	369.2	428.4	448	379.4	370.9

A.4 Yield Tables

A.4.3 Selection management yield tables

The selection harvesting regime assumed is:

30% volume removal in first entry from stands currently at least 110 years old (see table below)
Re-entry period: 30 years
Volume yield after first entry: 72 cubic metres per hectare
Mean annual increment: 2.4 cubic metres per hectare per year

Table A-14. First entry yield table for selection management

Age	VDYP volume (cubic metres per hectare)	Harvest (30% of VDYP) (cubic metres per hectare)
0	0	0
10	0	0
20	0.1	0.03
30	12	3.6
40	45.7	13.71
50	84.3	25.29
60	121.3	36.39
70	155.6	46.68
80	186.8	56.04
90	215.6	64.68
100	241.8	72.54
110	265.8	79.74
120	287.5	86.25
130	307.5	92.25
140	322.4	96.72
150	334.8	100.44
160	344.4	103.32
170	351.6	105.48
180	356.7	107.01
190	359.6	107.88
200	364.7	109.41
210	369.7	110.91
220	374.6	112.38
230	379.2	113.76
240	383.7	115.11
250	387.9	116.37
260	389.6	116.88
270	391.1	117.33
280	392.5	117.75
290	393.8	118.14
300	395	118.5
310	396	118.8
320	397	119.1
330	397.8	119.34
340	398.4	119.52
350	399	119.7