Lillooet TSA
Timber Supply Analysis

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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 effect 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 and knowledge 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 best available information and reflecting current management direction.

Unlike past analyses, which normally assessed the implications of several forest management scenarios, this report focuses on a single scenario — current management practices. This approach will expedite the analysis process, allowing analysis of all timber supply areas 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 timber supply area 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. One report summarizes this information to provide a focus for public discussions of possible timber harvest levels. The fourth presents 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 Lillooet Timber Supply Area (TSA). The analysis assesses how current forest management practices affect the supply of wood available for harvesting over the next 200 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 AAC recommendations.**

The Lillooet TSA covers a total area of 1 124 000 hectares, of which about 304 600 hectares are considered available for timber harvesting under current management practices. Total volume of standing timber in the area is about 49 million cubic metres, of which 47 million cubic metres is of merchantable age. The area is dominated by spruce, Douglas-fir and lodgepole pine stands. The current allowable annual cut (AAC) for the Lillooet TSA is 650 000 cubic metres.

Current forest management of the Lillooet TSA includes recognizing areas with significant forest resource values such as aesthetics, wildlife and community water supply. 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 can be maintained for another 30 years without causing a reduction in future harvest levels below the long-term level. After 30 years the harvest begins to decline at 8% each decade until the long-term level is reached in the ninth decade. The long-term harvest level, which is the potential maximum that can be harvested in perpetuity, is 400 000 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, then 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 depends on how much harvest levels are reduced. Reducing the harvest level may result in increased diversity in forest ecosystems in the future. On the other hand, the risk of timber losses to fire, insects and disease would increase.

Many of the data and assumptions used in the analysis are subject to varying degrees of uncertainty. As an example, Lillooet Forest District staff feel that the extent of the land base assumed available for timber harvesting is particularly uncertain. 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 harvest ages and a requirement to maintain old-growth stands. Harvest levels over that period are not sensitive to yield estimates applied to future regenerated stands. The long-term harvest level is sensitive to uncertainty about regenerated stand yields and the land base assumed available for harvesting. But 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 land features of the area under study 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 the growth and development of another part of the forest resource, such as wildlife or a recreation area.

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 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 through British Columbia be reviewed at least every 5 years. This allows close monitoring of the timber supply and the implications for the AAC of 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 on page 36.*

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 Licences (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 Lillooet TSA. Following a brief description of the TSA in Section 1, data preparation and formulation of assumptions are discussed in Section 2. Then analysis methodology and results are presented in Sections 3 and 4. 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 Lillooet Timber Supply Area

The Lillooet Timber Supply Area is located in the Kamloops Forest Region and is administered from the Lillooet Forest District office in Lillooet. The boundaries of the TSA coincide with those of the forest district which covers 1 124 000 hectares.

The TSA is located on the eastern slopes of the Coast mountain range. The area encompasses several drainage systems, including the Stein and Bridge River valleys, all of which drain into the Fraser River. Communities within the Lillooet TSA include Lillooet, Lytton, Spences Bridge and Gold Bridge (Figure 1).

The TSA is characterized by a varied climate and diverse ecology because of its location between the Coast and the Interior and also because of its mountainous terrain. Areas with higher precipitation are classified mainly into the Englemann Spruce-Subalpine Fir and Montane Spruce biogeoclimatic zones. Most of the drier areas are included in the Interior Douglas-fir zone. The diverse ecology of the Lillooet TSA supports a variety of tree species with spruce, Douglas-fir and lodgepole pine predominant. Hemlock, balsam and redcedar also occur but are less common.

Figure 1. Map of the Lillooet TSA.

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 1992. 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 Lillooet 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 computer 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.

The timber harvesting land base derived for this analysis includes only stands with sawlog quality timber. Stands with pulpwood quality timber are not included. The approved provincial park study areas (the Mid-Stein and Spruce Lake) are included in the timber harvesting land base as their status has not been finalized by an Order-in-Council decision.

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.

2 Information Preparation

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

- 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.
- 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 index*).
- deciduous stands.
- non-merchantable forest types — stands of non-merchantable coniferous species, low quality timber or low volume.
- inoperable areas — areas defined as unavailable for harvest for terrain-related reasons. Characteristics used in defining inoperability include steepness of slope and topography.
- forest roads, skid trails and landings — to account for the loss of productive forest land that has occurred during past timber harvesting and development, 12% of all area currently younger than 41 years and 1.5% of the area older than 40 years is removed. As harvesting occurs the B.C. Forest Service timber supply model deducts future losses related to access.
- not satisfactorily restocked* (NSR) areas — these areas are initially removed, but are considered available for timber production and are added back into the timber harvesting land base.
- harvesting update — to update the inventory for harvesting, 9888 hectares are deducted from mature areas. Some of this recently harvested area is now restocked while the remainder is NSR. In either case, the area is added back into the timber harvesting land base.

Not satisfactorily restocked
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.

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.

Site index
A measure of site productivity. Site indices are based on tree height as a function of stand age and are usually expressed graphically as site index curves. A number of site index curves have been developed for British Columbia's major commercial tree species.

2 Information Preparation

Table 1 summarizes the areas represented by these categories. 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, Lillooet TSA

Classification	Area (hectares)	Per cent of total area	Per cent of Crown forest area
Total land base	1 123 827	100.0	
Non-Crown land	110 689	9.8	
Non-forest land	483 869	43.1	
Crown forest land	529 269	47.1	
Reductions to Crown forest:			
Non-commercial cover	680	0.1	0.1
Environmentally sensitive areas	112 702	10.0	21.3
Sites with low timber growing potential	45 366	4.0	8.6
Deciduous types	2 037	0.2	0.4
Non-merchantable stands	14 820	1.3	2.8
Inoperable	38 996	3.5	7.4
Existing roads, trails, landings	8 900	0.8	1.7
Not satisfactorily restocked (NSR)	14 809	1.3	2.8
Harvest update (1987-1992)	9 888	0.9	1.9
Total reduction	248 198	22.1	46.9
Initial timber harvesting land base (less NSR)	281 071	25.0	53.1
Additions:			
Not satisfactorily restocked [a]	12 158	1.1	2.3
Restocked NSR	11 351	1.0	2.1
Total additions	23 509	2.1	4.4
Current timber harvesting land base	304 580	27.1	57.5
Future reductions:			
Future roads, trails, landings	21 386	1.9	4.0
Future timber harvesting land base	283 194	25.2	53.5

[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 Lillooet TSA land base summarized by three major categories. The figure shows that almost half of the TSA is Crown forest land.

Figure 3 shows that 58% of the productive Crown forest is available for timber harvesting. The largest single reduction to the timber harvesting land base is for ESAs.

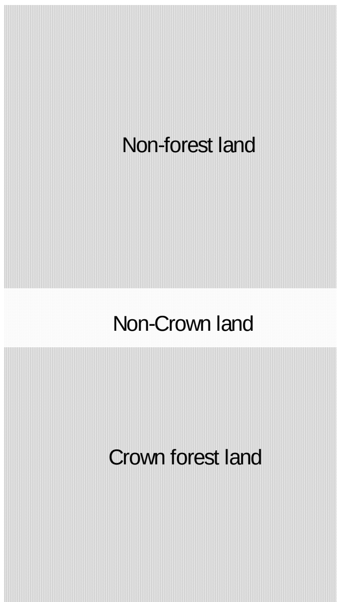

Figure 2. Classification of the total land base for the Lillooet TSA.

Figure 3. Classification of the Crown forest land.

Figure 4 shows the age distribution of the stands of the timber harvesting land base in 20-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.

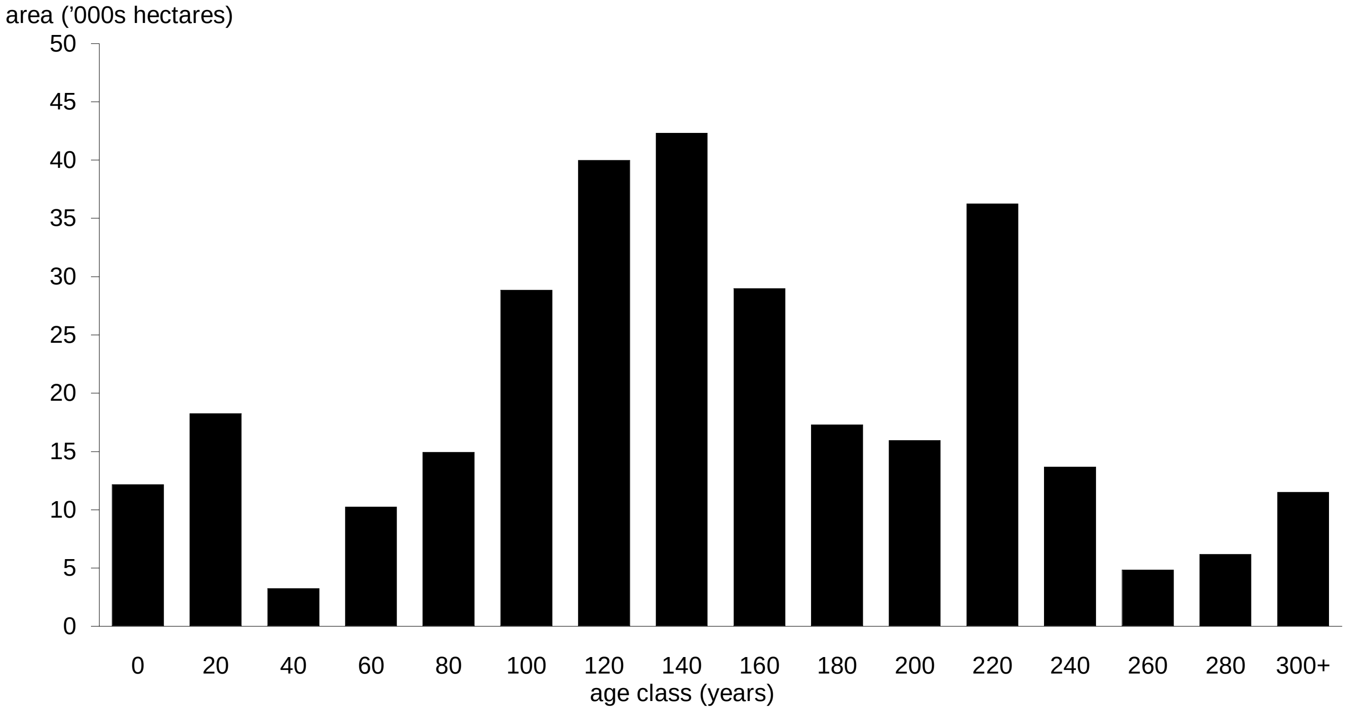

Figure 4. Current age class distribution — timber harvesting land base.

Figure 5 shows the area by species and maturity for the timber harvesting land base. Almost 80% of the land base is classified as mature — over 80 years old for lodgepole pine and 120 years for other species. Mixtures of Douglas-fir, lodgepole pine and spruce are most prevalent. Less common species, shown in parentheses in Figure 5, include balsam, redcedar and hemlock.

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 60% of the area classified as poor and only 9% classified as good.

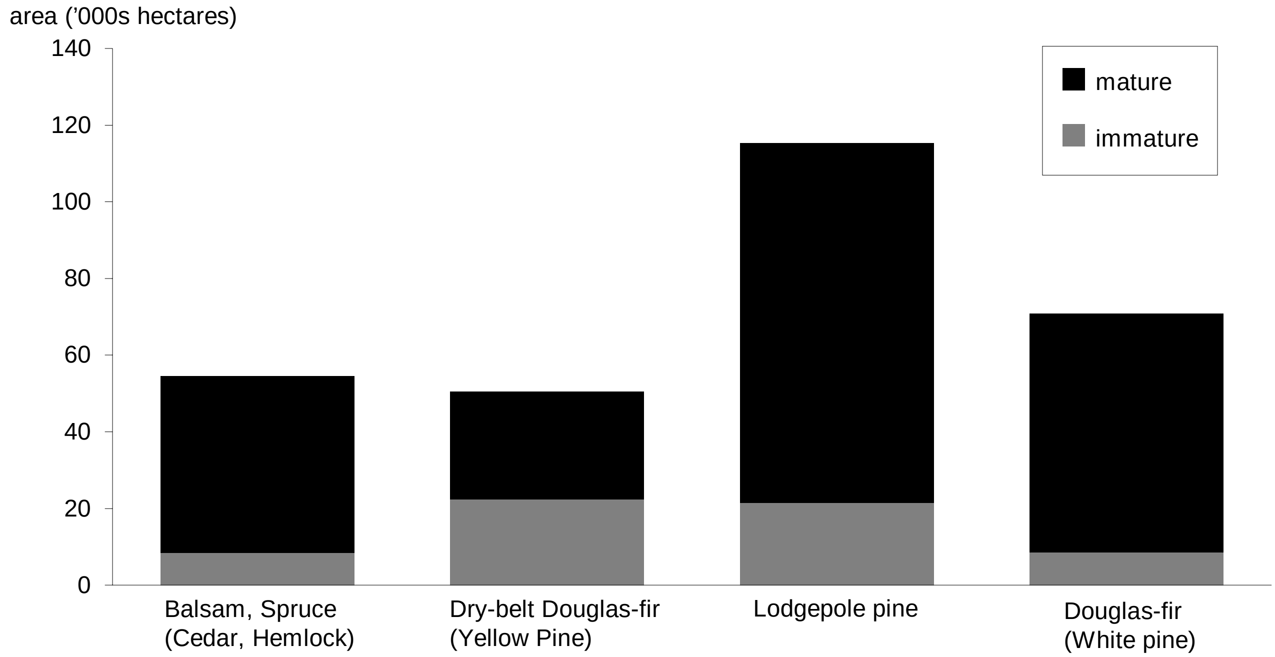

Figure 5. Area by dominant tree species and maturity — timber harvesting land base.

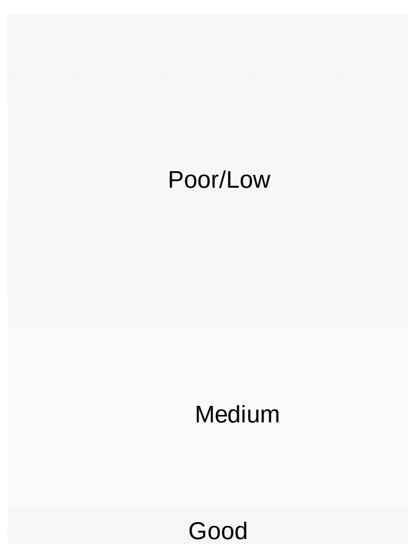

Figure 6. Area by site quality class — timber harvesting land base.

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 which are produced by the Research Branch of the B.C. Forest Service. Sensitivity analysis addresses the possibility that stand volumes may be different from those predicted.

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 Lillooet Forest District and in the Kamloops Forest Region defined these practices as described in the following management assumptions*:

- Basic silviculture levels — reforestation activities required to establish free-growing* stands of acceptable species. In the Lillooet TSA, most areas are harvested using a clear-cut harvesting* system and restocked by planting or natural regeneration. However, in drier parts of the TSA (the Interior dry-belt), a selection management* system is used. Selection management is carried out to aid regeneration by leaving enough trees standing to provide shade in which seedlings can survive. In the Lillooet TSA, it is assumed that 40% of the volume is harvested from a stand during the first entry. After the first entry, it is assumed that a constant volume will be harvested from a stand every 30 years. Eventually, a stand managed in this way will contain trees of various ages (referred to as uneven-aged).
- Forest health and unsalvaged losses — expected timber losses due to fire, pest (insect, disease and animals) and wind damage. For the Lillooet TSA, unsalvaged losses are estimated to be 26 500 cubic metres per year. These losses are deducted from gross harvested volumes to produce the net volumes shown in Sections 4, "Results", and 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 harvest 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 acceptable standard by appropriate means including planting and natural seeding.

Selection management
A silvicultural system used to maintain or create areas containing a wide range of tree ages or sizes. The time interval between harvests in such areas is fairly short (usually less than 30 years) and during these harvests either single scattered trees or small groups of trees are removed from across the entire area.

- Forest cover objectives* — forest cover guidelines applied to account for the management of forest resources such as wildlife habitat or 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, a stand is considered to be disturbed until its regeneration reaches a condition that would allow 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 that must be removed from the site. The utilization levels are presented in Appendix A, "Description of Data Inputs and Assumptions".
- Minimum harvest ages — the time it takes for stands to grow to harvestable size. The minimum harvest age defines the lower 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 NSR.

A more detailed discussion of the management assumptions is included in Appendix A.

2.4 Management zones

In the Lillooet TSA the importance of forest values such as visual quality is recognized. Some areas are of particular concern and these have been defined as separate zones for the analysis. Also, zones have been defined where selection management is used and where no harvesting has occurred over many years. The six management zones defined for the analysis are:

- The Spruce Lake zone — no harvesting has occurred in this area and since 1982 a harvesting moratorium has been in place. As its status has not yet been determined, this analysis assumes the Spruce Lake area is available for harvesting. Because no harvesting has occurred, the age class distribution is significantly different from other areas of the TSA. The forest cover objective for this area allows a maximum 33% of the forest to be less than 3 metres tall at any time. This objective corresponds to a three-pass harvesting system.
- The Mid-Stein zone — similar to the Spruce Lake zone, an official decision regarding the status of this area is pending. This area is also assumed to be available for harvesting in this analysis. Because there is no history of harvesting in the Mid-Stein, the age class distribution differs from the general distribution across the Lillooet TSA. Due to hydrological and other forest values in the area, the forest cover objective assumed is the same as that applied in the Watershed zone: no more than 24% of the forest can be less than 6 metres tall at any time.
- Watershed zone — this zone includes officially designated community watersheds which serve Lillooet, Gold Bridge, Spences Bridge and Lytton. The forest cover objective applied to maintain water quality allows a maximum of 24% of the forest to be less than 6 metres tall.
- Selection management zone — this zone is characterized by low precipitation and is occupied mainly by Douglas-fir stands. Because of the dry conditions, selection harvesting systems are used to aid regeneration. This zone includes some areas with high non-timber resource values such as VQOs. It is assumed that selection management would satisfy the forest cover requirements for these areas.

> ***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.*

- Visual Quality Objective* (VQO) — includes both visually sensitive and highly visually sensitive areas. The forest cover guidelines developed for this analysis specify that no more than 14% of the forest can be less than 6 metres tall at any time.
- Timber zone — this zone includes areas not assigned to the zones listed above. Management guidelines specify that no more than 33% of the forest can be less than 3 metres tall at any time. Forest values such as protection of wildlife habitat and water quality are recognized in the timber zone, however the management emphasis of this zone is timber harvesting.

Note that no special management zones for wildlife such as ungulate winter habitat have been identified for this analysis. However, wildlife needs are accounted for by requiring 20% of the timber harvesting land base to be greater than 80 years old at all times and by ESA reductions described earlier.

- The areas within each management zone are shown in Figure 7. The management zones are described in more detail in the Appendix.

> ***Visual Quality Objective (VQO)***
> *Defines a level of acceptable landscape alteration resulting from timber harvesting and other activities. A number of visual quality classes have been defined on the basis of the maximum amount of alteration permitted.*

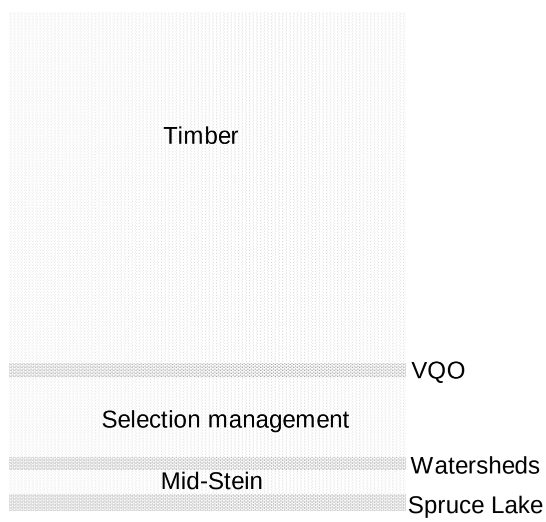

Figure 7. Management zone — timber harvesting land base.

3 Analysis Methods

The purpose of this analysis was to examine both the short- and long-term timber harvesting opportunities in the Lillooet TSA, in light of 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 distinguished from a growth and yield model, assists the timber supply analyst in determining how a whole forest, or collection of stands, could be managed in order to obtain a harvest forecast, or 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 a period of 0 to 400 years. Because the harvest flow remains constant from 200 to 400 years from now, only the results for the first 200 years are shown graphically in this report.

Similar to other 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 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 period, 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 timber harvesting 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. This information gives field staff only very limited guidance in the design of operational activities such as harvesting block location and silviculture planning. It does, however, help ensure that the timber harvest level supports rather than hinders sound 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

This section presents the results of the timber supply analysis for the base case. The purpose of the base case analysis is to indicate the potential maximum harvest levels that can be attained over time. These maximum levels are determined by the characteristics of the timber harvesting land base, yield estimates and current management practices already described. Harvest levels are also affected by the restrictions applied to the harvest flow pattern. In the base case harvest levels are initially maintained at the current AAC as long as possible without causing future timber supply shortages. The long-term harvest rate is established at a maximum that can be maintained indefinitely.

4.1 Harvest forecast

The harvest forecast* for the base case is shown in Figure 8. A harvest level of 650 000 cubic metres per year is held for 3 decades after which the harvest level drops 8% each decade to the long-term level of 400 000 cubic metres per year by decade 9.

The initial harvest rate is 59% higher than the long-term harvest level. It is possible to maintain the initial harvest level for a long time primarily because of the large proportion of older stands that are currently available for harvest. This is illustrated in Figure 9. Initially, the total growing stock volume is 45 million cubic metres with a large proportion (96%) at or above minimum harvest age. Over time, the total volume drops to about 22 million cubic metres with the volume available for harvesting fluctuating between 30 and 70% of the total growing stock. (The growing stock volumes shown do not include volumes from the selection management zone because of the method used to estimate yields from selection management). The volume of the current mature growing stock within this zone is estimated to be 4 million cubic metres).

> ***Harvest forecast***
> *The flow of potential timber harvests over time. A harvest forecast is usually a measure of the maximum timber supply that can be realized, over time, for a specified land base and set of management assumptions. It is a result of forest planning models and is affected by the size and productivity of the land base, the current growing stock, and management objectives, constraints and assumptions.*

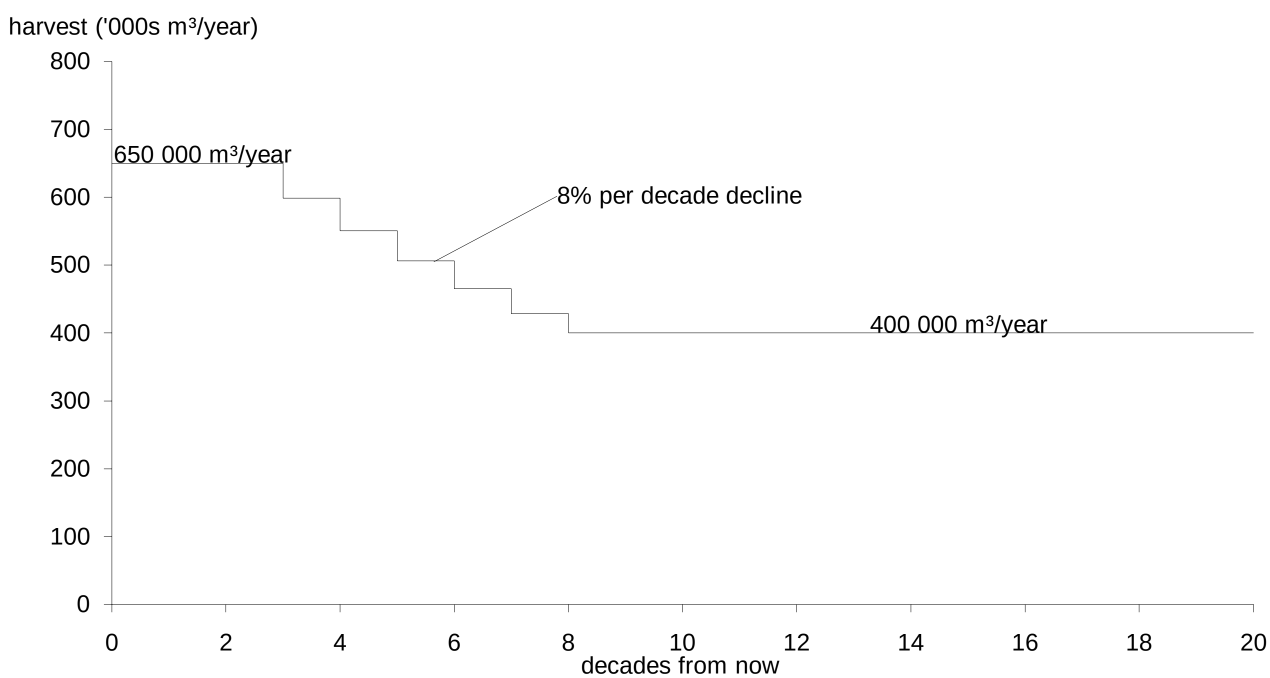

Figure 8. The base case harvest forecast for the Lillooet TSA.

Figure 9 also indicates that the total volume of the growing stock becomes stable after the eighth decade. The stability of the growing stock volume over time is an indication that the long-term harvest level shown in Figure 8 is close to the maximum but does not exceed the timber growing capacity of the land base. A declining trend in total growing stock would indicate that the long-term harvest level could not be maintained in perpetuity.

Another important feature to note in Figure 9 is the shortage of mature timber in decade 13. This is because high harvest rates in the earlier decades deplete a large portion of existing older stands and because most stands are not old enough for a second harvest until decade 14. The shortage of mature volume in decade 13 combined with the harvest flow restrictions applied are the strongest influences on harvest rates in preceding periods.

It is important that the long-term harvest level not be interpreted as being the same as a theoretical maximum sustainable harvest level based on the maximum mean annual increment (MAI)*. The theoretical level, about 430 000 cubic metres per year, is not achievable for several reasons. Areas are not necessarily harvested at ages which would maximize volume yield over the long term. This may result because of the applied minimum harvest ages, forest cover objectives or the imposed harvest flow pattern. Also, harvest forecasts are reduced by the estimated volume losses to fire and other destructive agents.

Note that the harvest forecast shown here, as well as those in Section 5, provide an upper limit on timber supply, given the land base and management practices discussed earlier. **This forecast is for discussion purposes only and is not intended to suggest a particular AAC.**

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.

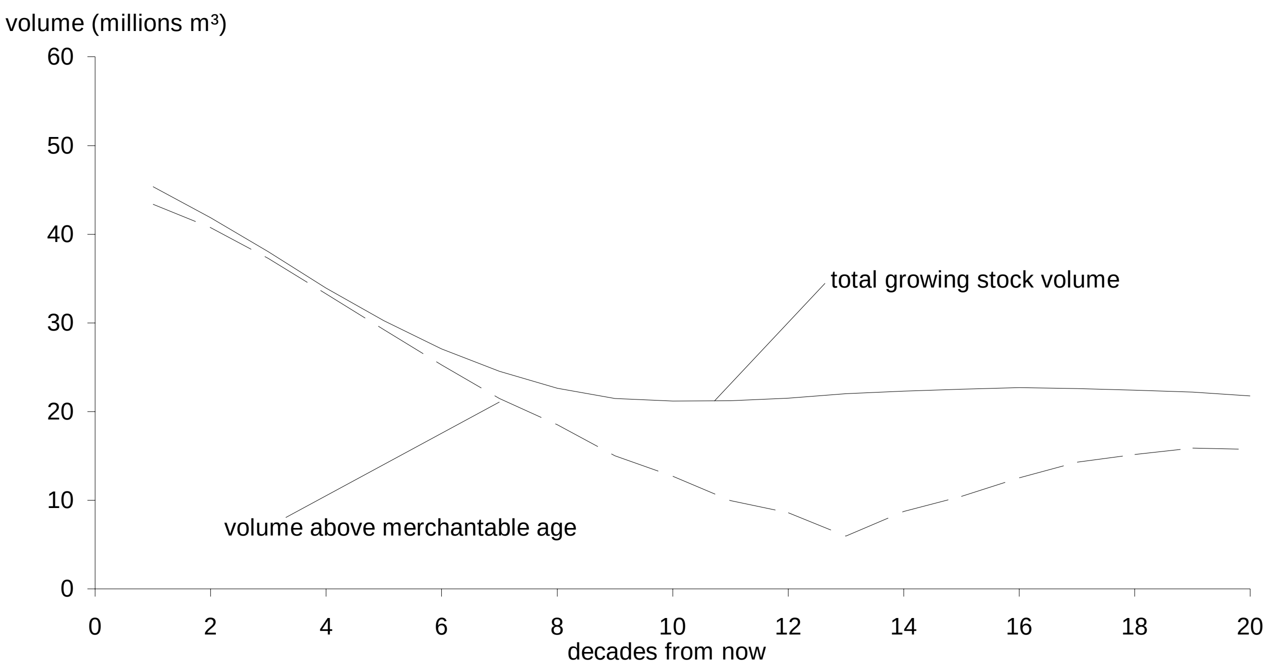

Figure 9. The base case growing stock over time for the Lillooet TSA.

4.2 Age class distribution over time

Figure 10 shows the changes that occur in the forest age class distribution over the 200 year planning horizon. (The dry-belt area of 49 000 hectares is not included in Figure 10 because the stands managed under selection harvesting do not have a defined age. This is because the trees that make up the selection managed stands are all different ages and do not fall into a single age class).

Initially, a large area of older stands (70% is older than 100 years) and a relatively small area of younger stands exist. This age class distribution tends to allow higher harvest levels over the short term because, there is substantial volume above merchantable age and there are relatively few stands below green-up requirements at the start. Over the planning horizon, the age class distribution gradually becomes more balanced. By decade 10, most stands are younger than 140 years and at
200 years, the area within each age range is roughly equal. A small area remains above 140 years of age however. This is caused by the forest cover objective for the VQO zone which effectively extends harvest ages beyond merchantable ages.

Figure 10 includes only those areas within the timber harvesting land base. Note that forest outside the timber harvesting land base also contributes to the area of older-aged forest. Substantial areas of old-growth forests would remain across the Lillooet TSA because a large proportion of the forest has been excluded from the timber harvesting land base for reasons outlined in Table 1.

4 Results

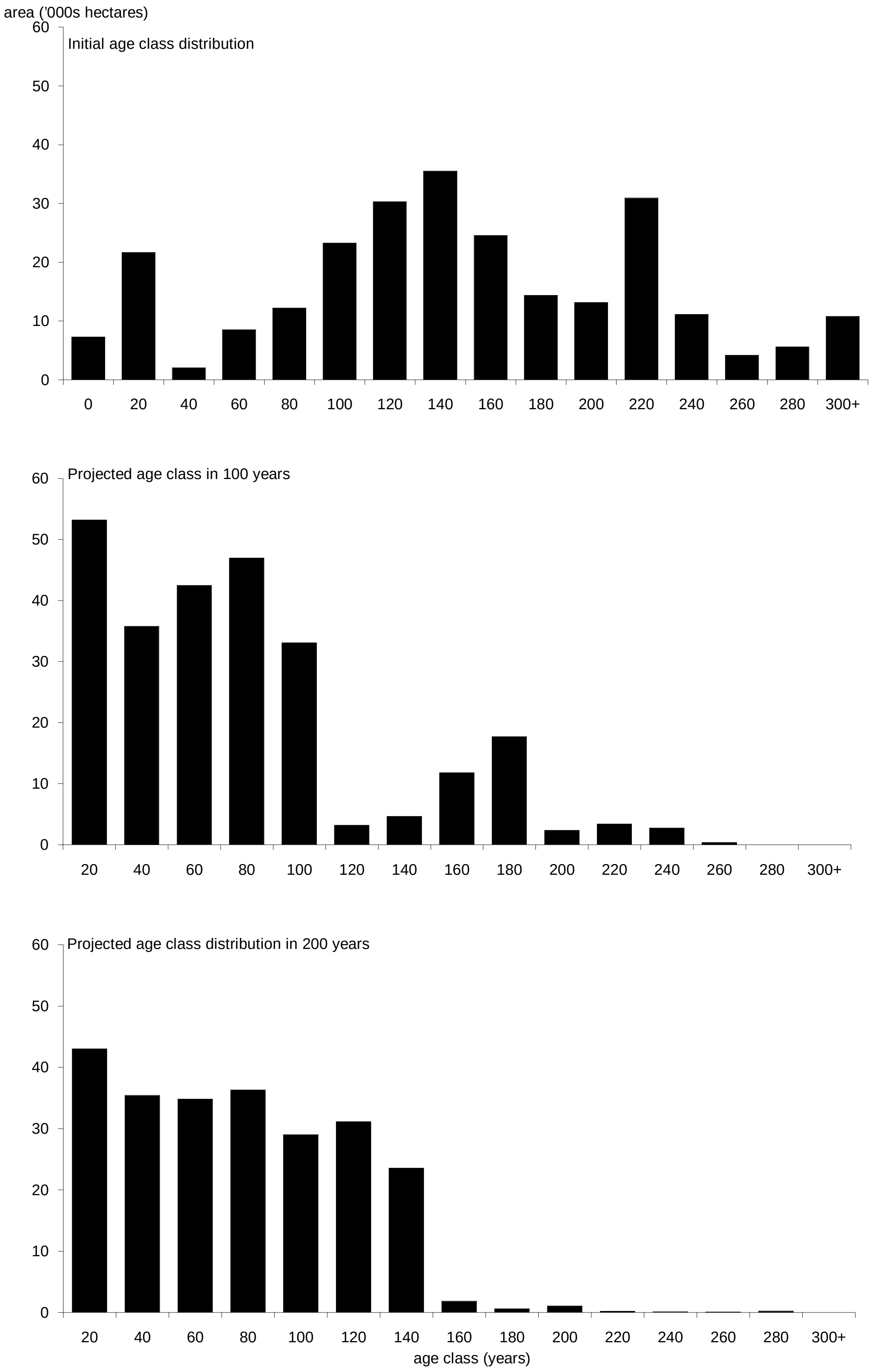

Figure 10. Changes in the age class distribution over time.

4.3 Average area harvested, harvest age, and volume per hectare

Figure 11 shows the trend in area harvested each year for both selection and clear-cut harvesting methods. The clear-cut area increases from 1900 hectares per year in the first decade to almost 2500 hectares per year in decade 3. This peak in area harvested is then followed by a decline to 1500 hectares in the ninth decade, reflecting the reduction in harvest levels over that time. Beyond the ninth decade, the area harvested increases again, reaching a maximum 2100 hectares per year in decade 13. This increase is expected because as trees are harvested at younger ages with lower volumes, more area must be harvested. The large area harvested in decade 13 corresponds to the low average age and the low average yield of harvested stands shown in Figures 12 and 13. Decade 13, as noted earlier, is the decade in which timber supply is most limited. After the thirteenth decade, the area harvested annually fluctuates between 1500 and 1900 hectares. This variability is due to the changing average volume per hectare over time as shown in Figure 13.

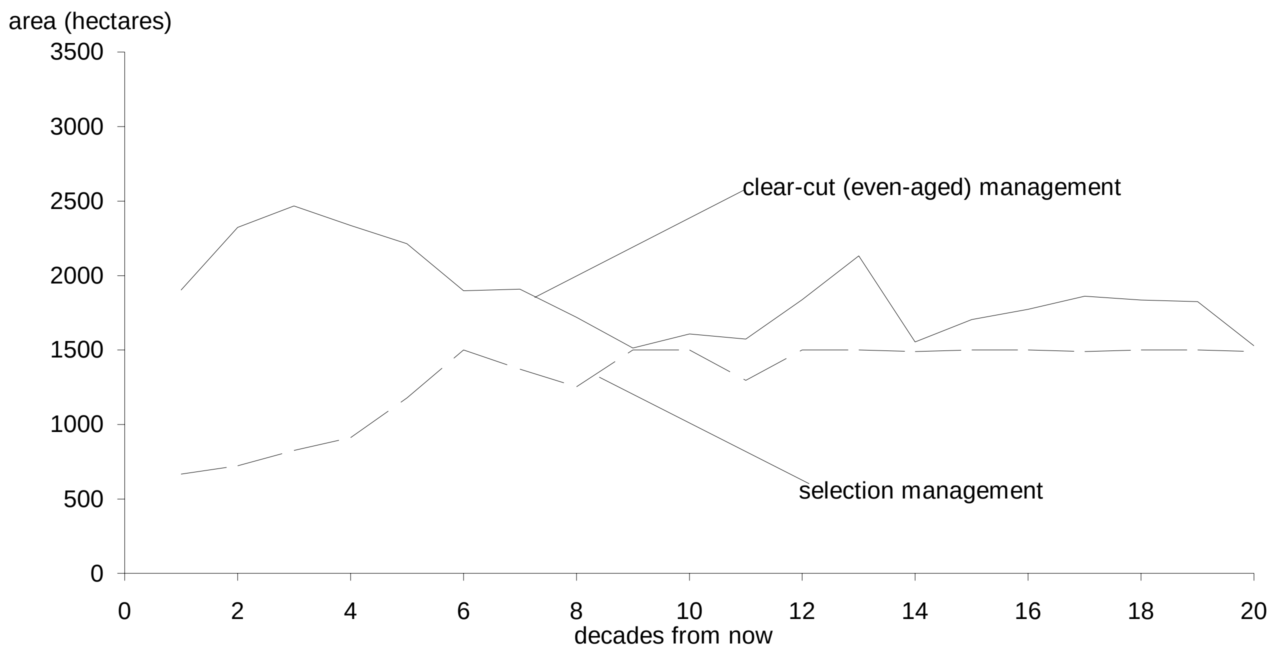

Figure 11. Area harvested annually, base case.

The area harvested with selection methods increases from a low of 670 hectares each year in the first decade to 1500 hectares by decade 6. This increase is due to the lower yields assumed for harvests after the first selection entry. With proportionately fewer stands undergoing the first selection harvest, more area must be harvested to maintain a particular harvest volume. Over the long term, the total area selection harvested is close to 1500 hectares annually. It is important to note the distinction between areas harvested with clear-cutting methods and areas that are selection harvested shown in Figure 11. Clear-cut harvesting removes most of the forest cover and therefore most of the volume is recovered from the site. Under selection management, only a portion of the volume is removed by harvesting individual trees or small patches of trees. Under selection management therefore, much more area must be entered into for harvesting to achieve the same volume as harvested by clear-cutting.

The trend in the average harvest ages for clear-cut harvested stands is shown in Figure 12. (Stands under selection management again are not included here because the trees that make up the selection managed stands are all different ages and do not fall into a single age class). The average harvest age declines from 290 years at the start to about 190 years in decade 5 and remains at this level until the decade 11. The decreasing trend in the earlier periods reflects the depletion of the existing old forest. By the thirteenth decade almost all of the existing forest has been harvested and only young stands remain (as indicated by the low average harvest age shown in Figure 12). Beyond decade 13, the average harvest age remains at about 140 years.

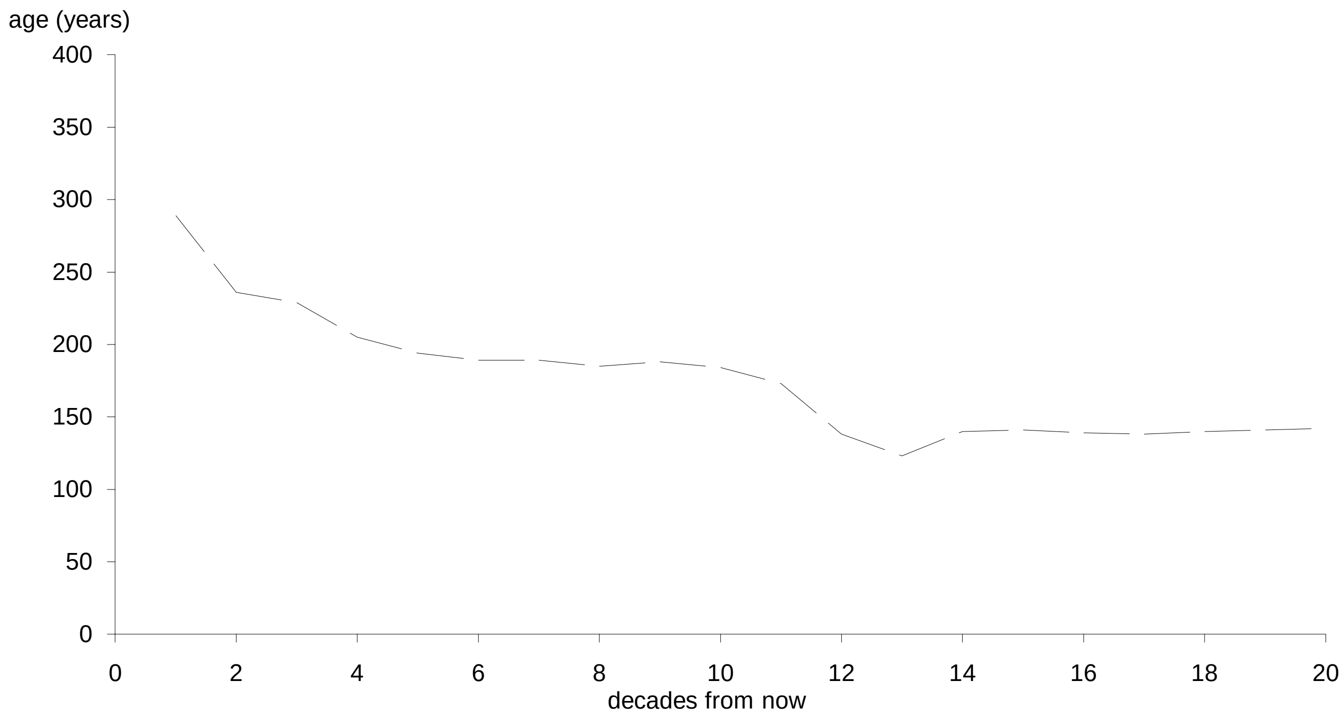

Figure 12. Average harvest age over time, base case.

4 Results

Figure 13 shows the changes in average volume harvested per hectare (or yield) over time for both clear-cut and selection harvested stands. For clear-cut stands, the average yield drops quickly from 327 to 235 cubic metres per hectare by the fifth decade. This trend is due to the decrease in harvest ages over that time as noted earlier. The long-term average yield varies between 200 and 250 cubic metres per hectare. The lowest average yield occurs in decade 13. This observation concurs with other results discussed previously — the lowest supply of mature timber, the youngest harvest age and the most area harvested occurs in decade 13. This decade marks the transition to harvesting mainly regenerated stands.

The trend in harvested volume per hectare under selection management also shows a decrease from 80 cubic metres in the first decade to about 30 cubic metres in decade 7. This declining yield is due to the decrease in first entry harvests over that period. As the volume per hectare is assumed to be lower after the first entry, average yield decreases until the long-term yield of 29 cubic metres per hectare is reached. It is assumed that this volume per hectare is harvested every 30 years from a particular area.

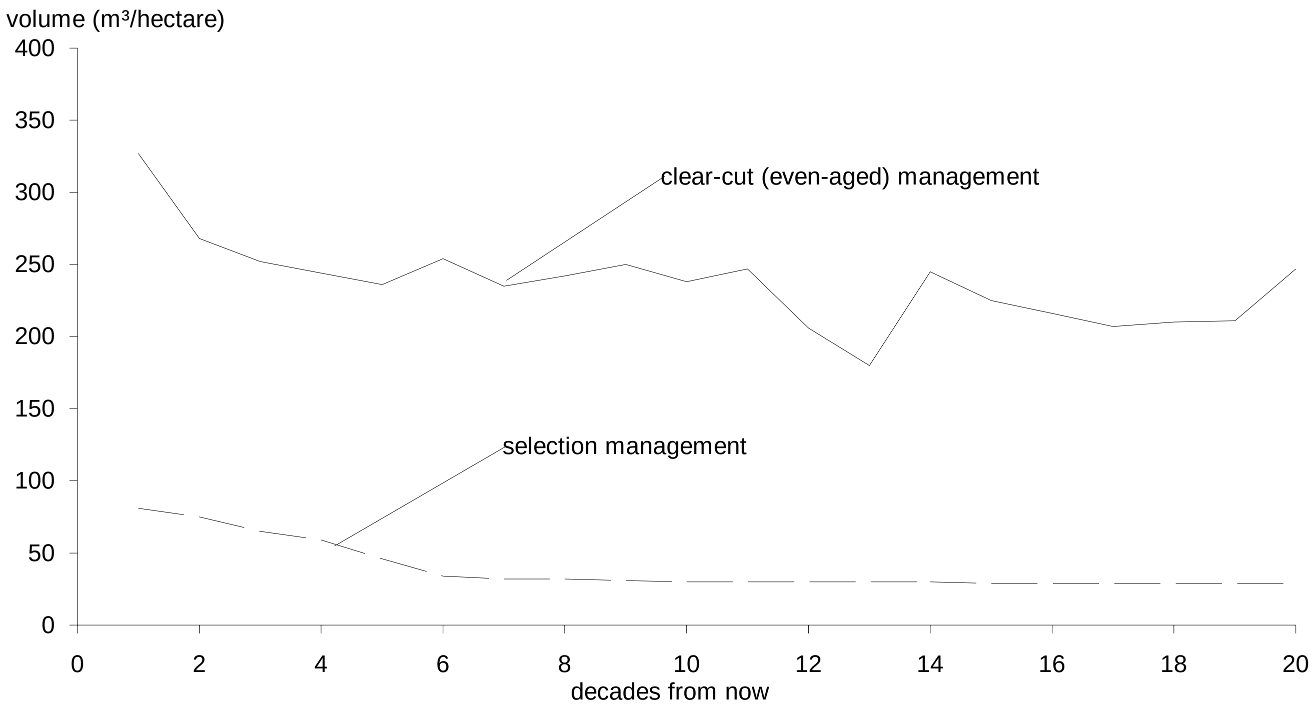

Figure 13. Average volume per hectare harvested over time, base case.

4.4 Species mix for the first two decades

Figure 14 shows the composition of tree species harvested in the first 2 decades compared to the species composition of existing mature stands in the timber harvesting land base and the historical harvest by species in the Lillooet TSA. The historical harvest chart does not include any harvesting from the Spruce Lake or Mid-Stein valley areas because these areas have not contributed to the harvest for many years. The other two charts do include these areas which make up a fairly minor part of the mature timber and the base case harvested volume over the short term.

Figure 14 illustrates an important point — not including the dry-belt Douglas-fir volumes in the selection management zone, the harvest level within each species group in both the base case and the historical harvest do not match the current supply of mature timber. There is significantly more lodgepole pine and Douglas-fir volume and less spruce and balsam volume available in the current growing stock than the proportion that is actually harvested. This imbalance does not appear to affect the overall harvest levels. The historical harvest by species can be achieved over the first 20 years without affecting the base case harvest forecast over the planning horizon. This is possible because of the large volume of timber currently available. Eventually, however, the mix of species in the harvest will have to change to match available species volumes.

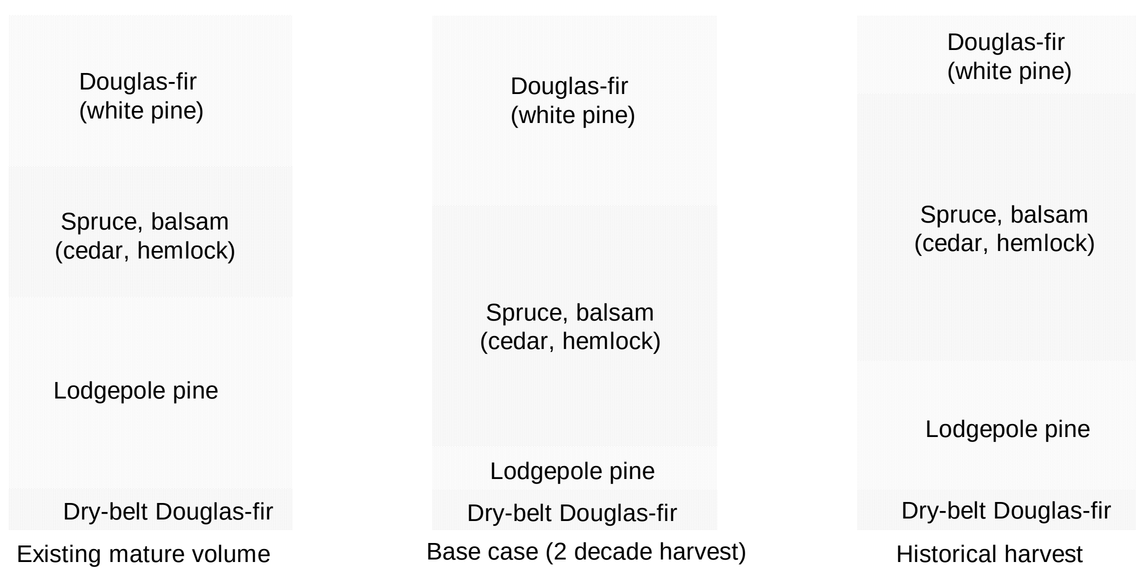

Figure 14. Existing mature, first 2 decades harvest and historical volume by species group.

5 Timber Supply Sensitivity Analyses

Sensitivity analysis is the exercise of examining how uncertainty in data and assumptions affect the outcome of analysis. The main purpose of timber supply sensitivity analysis is to highlight which variables most affect results. Sensitivity analysis is an important aid to decision-making, since uncertainty surrounds estimates of many variables used in timber supply analysis.

The best available information on forest inventories and management practices is used to analyse the implications for timber supply of current management. It is possible, nevertheless, that small inaccuracies in estimating some variables could have large effects on results, or that fairly large inaccuracies for other variables could have negligible effects. Sensitivity analysis can highlight priorities for collecting information for future analyses. As well, it can clarify for decision-makers whether current best estimates are safe bases for decisions, or whether high uncertainty around important variables necessitates more conservative decisions.

In this section results of several sensitivity analyses are outlined. The results that are based on current forest management assumptions (shown in Figures 8 to 14) are referred to as the base case.

5.1 Changes in harvest flow over time

The base case harvest forecast in this analysis remains at 650 000 cubic metres for 3 decades, then declines by 8% per decade until the long-term harvest level of 400 000 cubic metres per year is reached in decade 9. Many other harvest flow patterns are possible. This section examines three harvest flow alternatives shown in Figure 15.

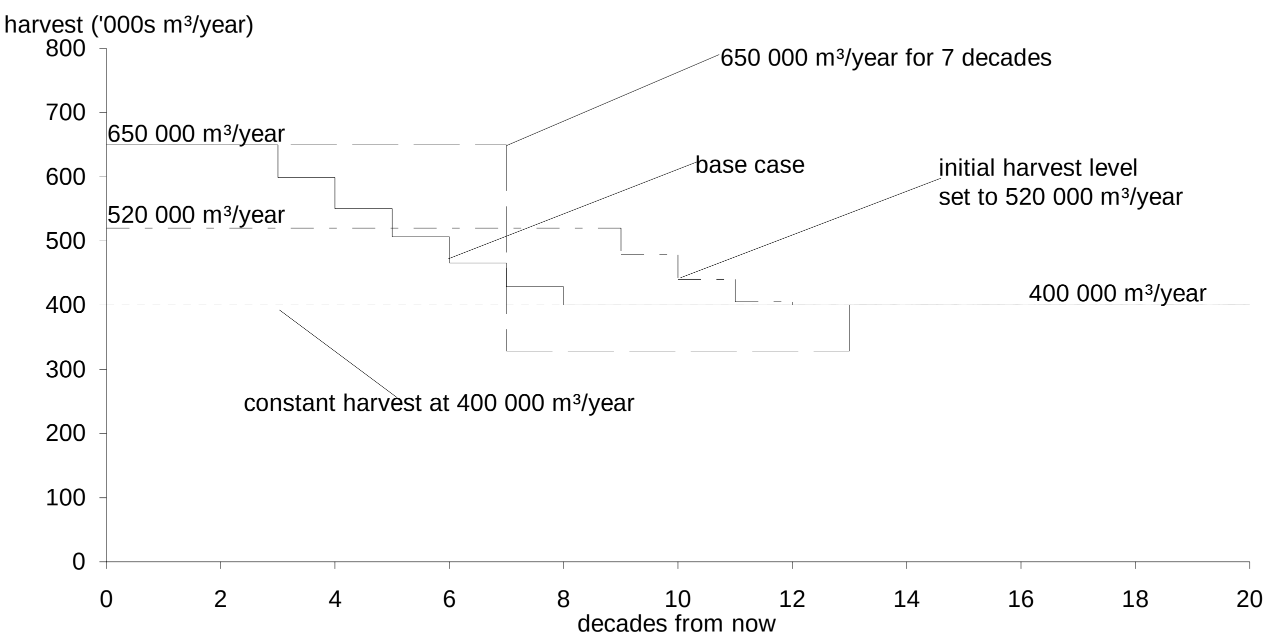

Figure 15. Harvest forecast with alternate harvest flow patterns applied.

If a gradual decline in the harvest to the long-term level is not required, then a harvest rate of 650 000 cubic metres per year can be held for 7 decades. However, this period is followed by an immediate 49% drop to well below the long-term harvest level where it remains until the fourteenth decade. The shortfall in available volume in decades 8 to 13 results from the rapid depletion of volume in the first 7 decades leaving less volume available after that period. Most regenerated stands are not old enough to be harvested before the fourteenth decade and thus cannot be used to make up this deficit. Figure 16 shows the volume of the total growing stock is 15 to 20% lower than in the base case in the period between decades 8 to 13.

A second harvest flow alternative examined the effects of reducing the initial harvest level to 520 000 cubic metres per year (or 80% of the current AAC) and maintaining the harvest at that rate for as long as possible. Figure 15 shows that this harvest level is held for 9 decades before falling 8% each decade until the base case long-term harvest level is reached in the thirteenth decade. In this case, the total growing stock volume remains somewhat higher than the base case until decade 10 as shown in Figure 16. After the tenth decade, the growing stock volume remains close to the base case level of about 21 million cubic metres. The effect of reducing the initial harvest level is to reserve the existing timber supply over a longer period. Associated with this effect are older harvest ages and a larger proportion of older stands in the timber harvesting land base until the long-term harvest level is reached.

The third harvest flow pattern examined was a constant harvest at the base case long-term level of 400 000 cubic metres per year over the planning horizon. The total harvest over the 200-year period is reduced by 13% relative to the base case. As shown in Figure 16, the total growing stock volume declines much more gradually than in the base case and remains 30% larger at the end of the planning horizon.

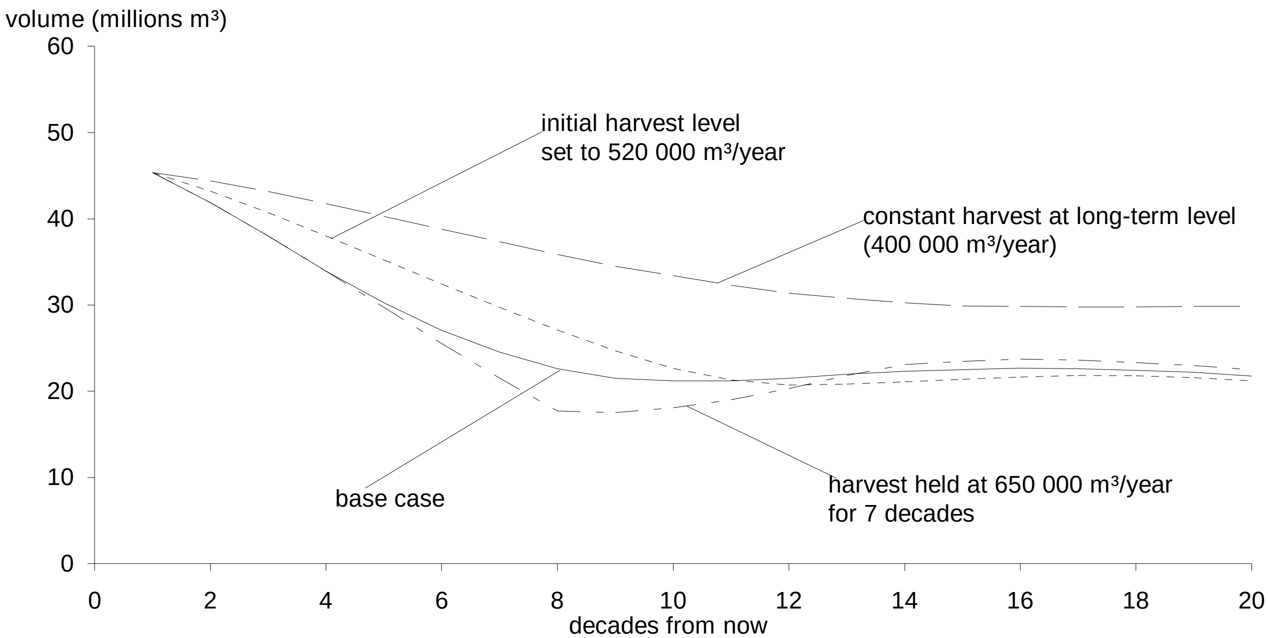

Figure 16. Total growing stock volume with alternate harvest flow patterns.

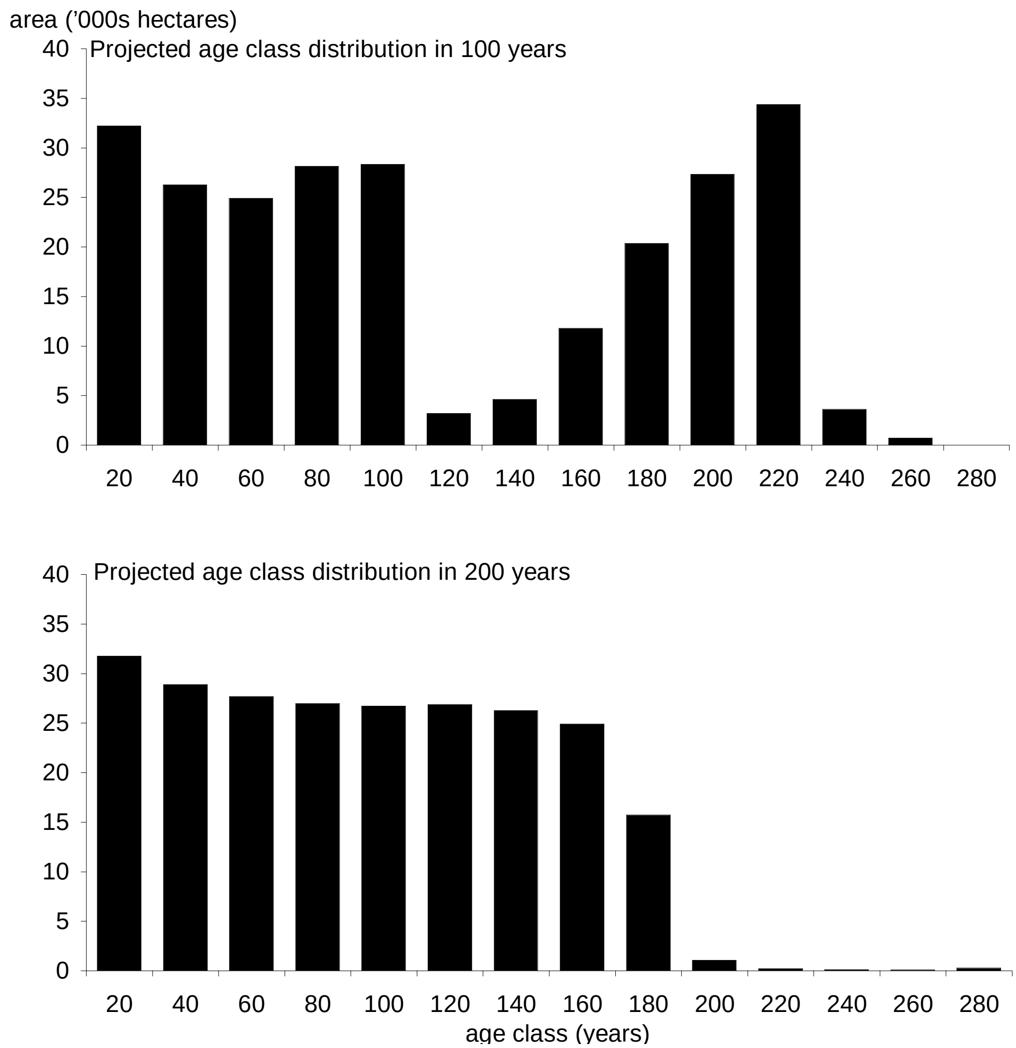

Figure 17. Future distribution of area by age class with a constant harvest at the long-term level.

Figure 17 shows the area by 20-year age classes projected to 100 and 200 years from now for the timber harvesting land base (excluding the selection management zone) with the harvest level held constant at 400 000 cubic metres per year. When compared to the base case projection shown in Figure 10, there is much more area in the older age classes. Even at 200 years, a significant portion of the land base remains older than 150 years. The effect of harvesting at the long-term level is to maintain a large portion of the land base in an over-mature state for a very long time. This may enhance the diversity of the forest ecosystem but would also increase the risk of losses to fire, insects and disease.

5.2 Minimum harvest ages

Minimum harvest ages, which reflect the time it takes a stand to grow to harvestable size, are influenced by changes in timber prices or harvesting costs. Lumber prices fluctuate over time. The introduction of new technology or more efficient procedures may reduce costs, or moving harvesting operations into more difficult terrain may increase costs.

In the base case, the minimum harvest ages outside of the selection management zone were set to 80 years for lodgepole pine and 120 years for other species. Actual harvest ages in the base case were higher as indicated in Figure 12. The effects of varying minimum harvest ages by 10 years are shown in Figure 18.

With harvest ages increased, the harvest rate can be maintained at 650 000 cubic metres per year for 2 decades rather than 3 as in the base case. Harvest levels then decline by 8% each decade to the long-term level. Less volume is available to harvest over the first 9 decades because the timber supply is reduced in decade 13. With harvest ages increased, fewer stands are available in decade 13 for a second harvest. Therefore, to meet the long-term harvest level in decade 13, more volume must be reserved from earlier periods.

The long-term harvest remains at the base case level of 400 000 cubic metres per year. The long-term level is not affected by a 10-year increase in minimum harvest ages because this change does not shift harvest ages substantially from the actual harvest ages in the base case. As shown previously in Figure 12, the average harvest age over the long term in the base case is about 140 years.

As shown in Figure 18, reducing harvest ages allows more volume to be harvested in the first 8 decades. The initial harvest level can be maintained for the first 4 decades before declining 8% each decade to a long-term level of 395 000 cubic metres per year. Harvest levels can be increased in the earlier decades because stands can be harvested for a second time sooner thereby increasing the timber supply. This effect is most critical in decade 13 when timber is in shortest supply. With more area available for a second harvest, less of the existing growing stock must be reserved to attain the long-term level in this decade. Therefore, more volume can be harvested in earlier decades. The slight (1%) reduction in the long-term harvest is due to harvesting stands at ages farther from the ages of maximum long-term volume yield.

Harvest levels are therefore moderately sensitive to minimum harvest ages over the first 90 years. Total harvest over this period is 5% higher or lower with 10-year changes in minimum harvest ages.

Figure 18. Harvest forecast with minimum harvest ages increased and reduced 10 years.

5.3 Existing stand volume estimates

Volume estimates from the Variable Density Yield Prediction (VDYP) system were used in the base case for existing stands. These estimates have a degree of uncertainty due to such factors as the statistical process used to develop the VDYP model, the inventory classification procedures and potential changes in utilization standards due to timber price fluctuations. This uncertainty was examined by increasing and decreasing existing stand yields by 10%. The results are shown in Figure 19.

If current yields are 10% higher than was assumed for the base case, 650 000 cubic metres per year can be harvested for 5 decades — 2 decades longer than forecast in the base case. After the fifth decade, harvest levels decrease 8% each decade to the base case long-term level. If however, volume estimates are 10% lower, the initial harvest rate is maintained for one decade only and the harvest level must decline by 11% each decade until the base case long-term level is reached in decade 6. The uncertainty in existing stand volume estimates does not affect the long-term forecast because most stands harvested after decade 13 are regenerated stands with yield estimates unchanged from the base case.

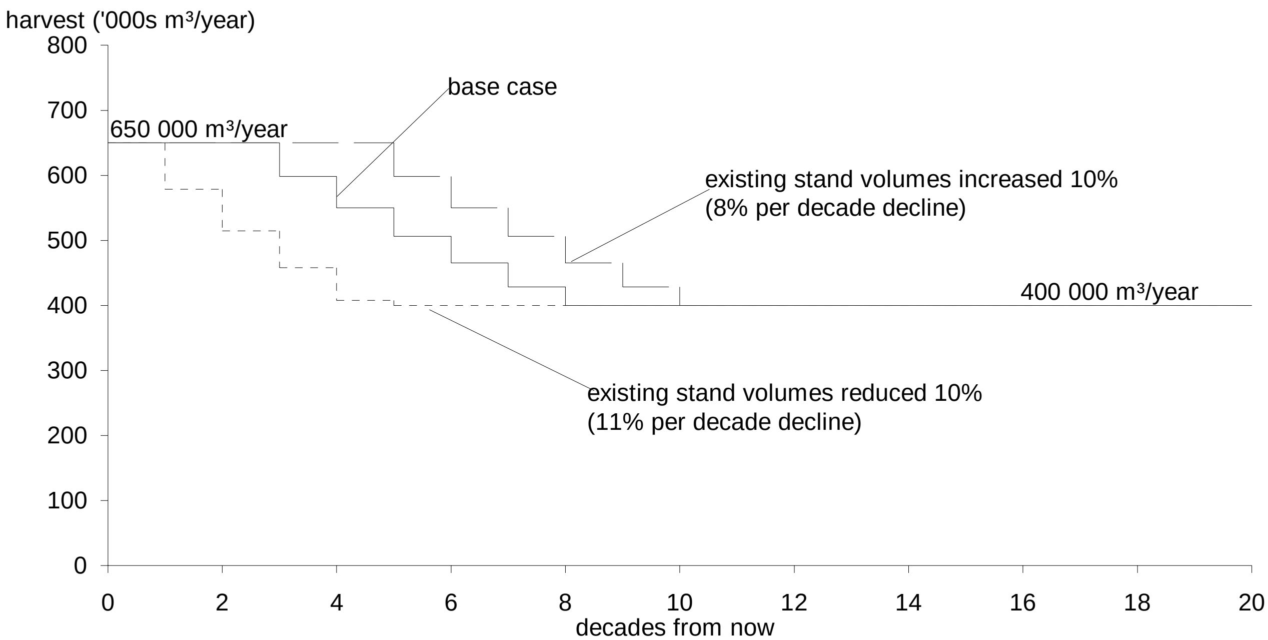

Figure 19. Harvest forecast with volume estimates for existing stands increased and decreased by 10%.

5.4 Regenerated stand volume estimates

Estimates of volume yields for regenerated stands outside of the selection management zone were developed from managed stand yield tables. Volume estimates for regenerated stands applied in this analysis are generally higher than volume estimates for existing stands. Future yields are likely to be higher than existing stand yields because of better stand management techniques such as density control and the planting of genetically improved stock.

However, the estimates of future volumes have a degree of uncertainty because the stands from which these projections are made are very far from harvestable age. The effects of current management practices on forest ecosystems (including the incidence of root rot) are not clear. This uncertainty has been examined by increasing and reducing all future yields (including selection management yields) by 10% while leaving all other factors including existing stand volumes and minimum harvest ages at base case levels. The results are shown in Figure 20.

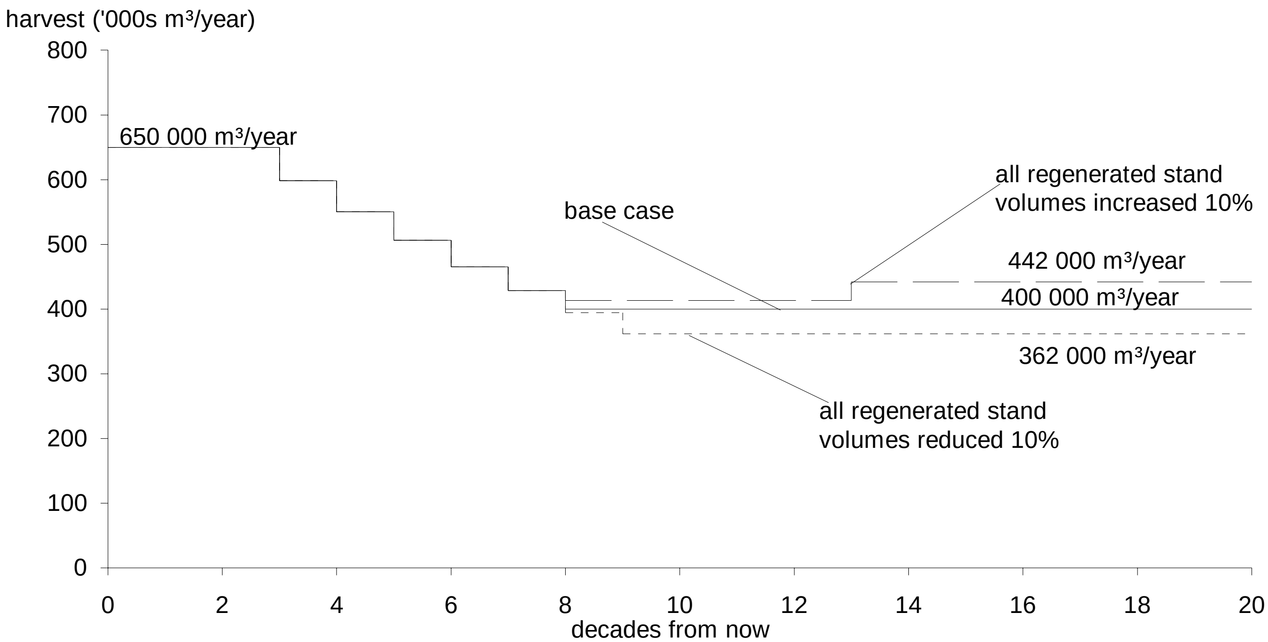

Figure 20. Harvest forecasts with regenerated stand yields 10% higher and lower.

With future volumes reduced by 10%, the long-term harvest must be lowered by an equivalent amount to 362 000 cubic metres per year. Harvests over the first 8 decades remain at base case levels because the reduced yields do not apply to most of the existing stands harvested during that time.

If future volumes are increased by 10%, then harvest levels can be raised by 3% in the 9 to 13 decade period and 10% to 442 000 cubic metres per year over the long term. The reason that harvests can be increased in decades 9 to 13 is that some regenerated stands of lodgepole pine and most selection management areas are available for harvesting during this period. Most regenerated stands, however, are not old enough to be harvested again until decade 14. The full yield increase cannot be realized until that time. Note that the harvest level must be allowed to fall below the new long-term level and then increase after decade 13 to capture the increase in future volume yields. Harvest levels cannot be increased in the first 8 decades in this case because the increased volumes are applied to future regenerated stands.

These results indicate that the harvest forecast is highly sensitive to the uncertainty in the estimates of future yields but only beyond the eighth decade. Up to this time, harvest levels are not sensitive to this uncertainty.

5.5 Forest cover requirements

Forest cover requirements applied in the base case allow no more than 33% of the forest in the timber and Spruce Lake zones, 24% in the Mid-Stein and watershed zones and 14% in the VQO zone to be less than specified green-up heights at any time. Also it was required that 20% of the forest in the entire timber harvesting land base be at least 80 years old at all times. These estimates have some uncertainty as it is not possible to define the exact forest structure needed to meet the management objectives for a particular area. This uncertainty was examined by increasing and decreasing forest cover requirements by 10 percentage points — that is, for example, a 33% forest cover requirement was increased to 43% and decreased to 23%. (The requirement that a minimum 20% of area be at least 80 years old was not changed in these tests). Figure 21 shows the results.

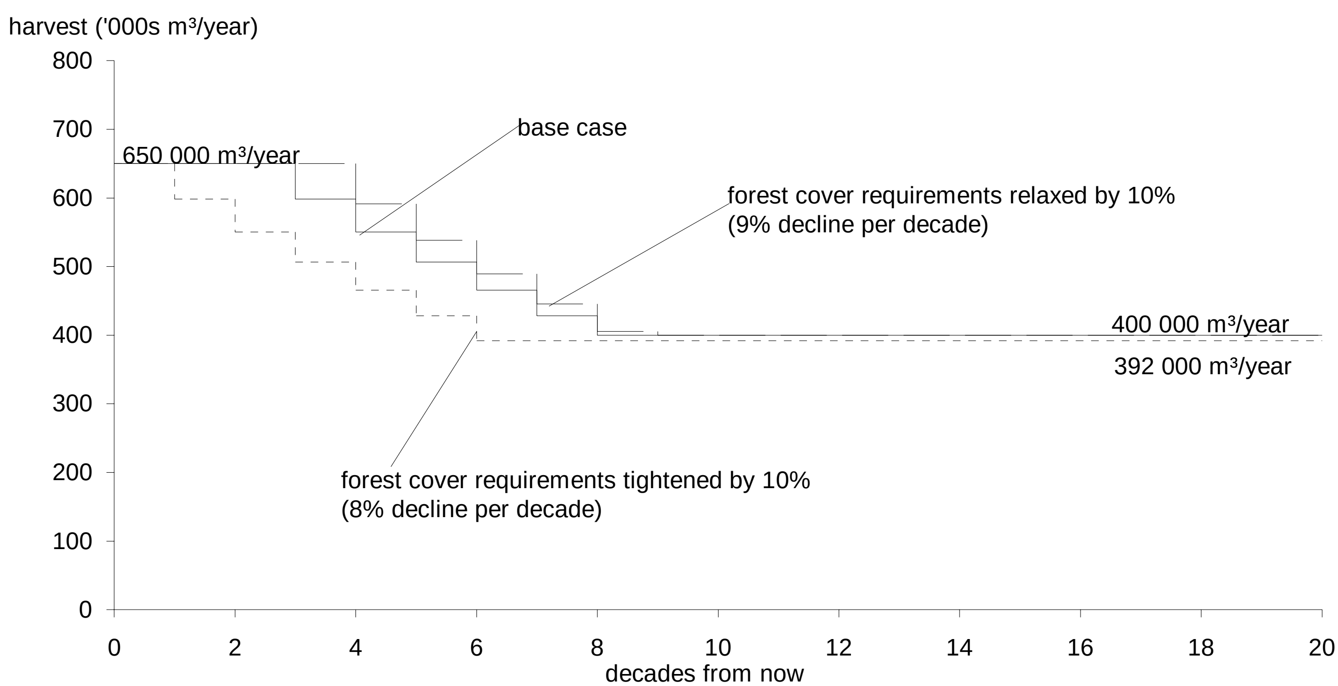

Figure 21. Harvest forecasts with forest cover guidelines relaxed or tightened.

With reduced cover requirements, the annual harvest can be maintained at 650 000 cubic metres for 4 decades rather than 3 as in the base case. However, the rate of decline after decade 4 must be increased from 8% to 9% per decade to avoid supply problems in later periods. The long-term level is unchanged from the base case. Some increase in the long-term harvest level may be expected, however, the effect, if any, was too minor to be demonstrated.

The total harvest over the first 9 decades is 3% greater than the base case harvest. This indicates a low sensitivity to relaxing forest cover requirements. The reason for the low sensitivity is that the base case forest cover requirements do not substantially restrict the total harvest. With the exception of a minor difference in the long-term level, this has essentially the same effect as removing the forest cover requirements entirely as discussed later in this section. Relaxing the forest cover requirements may have an effect on the long-term harvest level. However, this effect was too small to be evident in this case.

With increased cover requirements, harvest levels are significantly lower than the base case harvest in the first 8 decades. The initial harvest rate can be held for the first decade only before declining 8% each decade to the long-term level. Over the first 8 decades, the total harvest is 11% lower than the base case harvest. Over the long term, the harvest is maintained at 392 000 cubic metres per year or 2% lower than forecast in the base case.

The substantial reduction in the harvest in the first 8 decades is due to increased restriction of area available for harvesting in the third and the thirteenth decades. The reason for the large impact of increased cover requirements can be shown by considering the timber zone. In the base case, this area is assumed to be managed under a three-pass harvesting system. Therefore, a maximum of 33% of the forest area can be younger than the specified green-up age at any one time. The increased cover requirement in this test results in a harvesting system somewhat more restrictive than a four-pass harvesting regime, allowing a maximum of only 23% of the forest to be younger than the green-up age, a significant change from the base case.

The total effect of the base case forest cover guidelines on timber supply was examined by removing the guidelines entirely and comparing the resulting harvest forecast with the base case. Figure 22 shows that without guidelines applied, a harvest level of 650 000 cubic metres per year is held for 4 decades rather than 3. However, the harvest level must decline by 9% each decade instead of 8% to the long-term level. The total volume harvested up to decade 9 is 3% greater with no forest cover guidelines applied. During this period, therefore, harvest levels have low sensitivity to the removal of forest cover guidelines. The long-term harvest level can be increased slightly to 402 000 cubic metres per year indicating very low sensitivity.

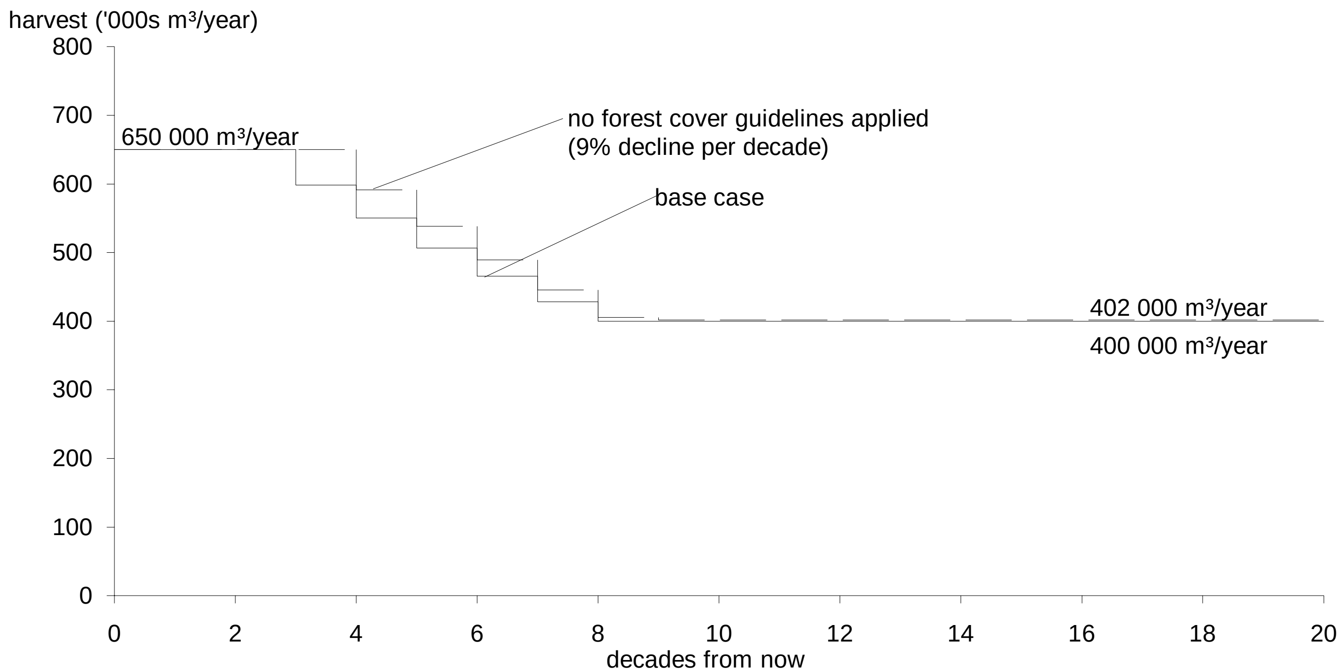

Figure 22. Harvest forecasts with no forest cover guidelines applied.

5.6 Green-up periods

Green-up periods applied in the base case vary from 20 years for the timber zone to 35 years in the Mid-Stein zone. The green-up periods are derived from estimated stand heights needed to meet specific forest management objectives. These estimates have a degree of uncertainty as the stand height required can not be stated exactly. For example, stands that are 5 metres tall may be adequate in visually sensitive areas, but stands may need to be taller than the 6 metre minimum height assumed in the base case. In addition to this uncertainty are the estimates made to achieve the required stand heights. The actual time required to meet specified stand heights may be more or less than current estimates. This uncertainty was examined by increasing and decreasing all green-up periods by
10 years while leaving other factors unchanged from the base case. The 10-year changes were not applied to the minimum age specification for mature forest cover (20% of the forest must be older than 80 years).

With green-up periods shorter, a smaller proportion of the total inventory area is younger than the green-up periods and therefore more area can be harvested before reaching maximum limits of total area below green-up period. The opposite effect occurs when green-up periods are lengthened.

Figure 23 shows that with green-up periods reduced 10 years, 650 000 cubic metres per year can be maintained for 4 decades. However, the decline in harvest levels after decade 4 must be increased from 8 to 10% per decade to avoid future supply problems. As in the base case, the long-term harvest level is reached in decade 9. The total volume harvested over the first 8 decades is 2% greater than harvested in the base case. The long-term harvest is maintained at the base case level. Reducing green-up periods has the potential to allow a higher long-term harvest level, but this effect was too small to be evident in this analysis.

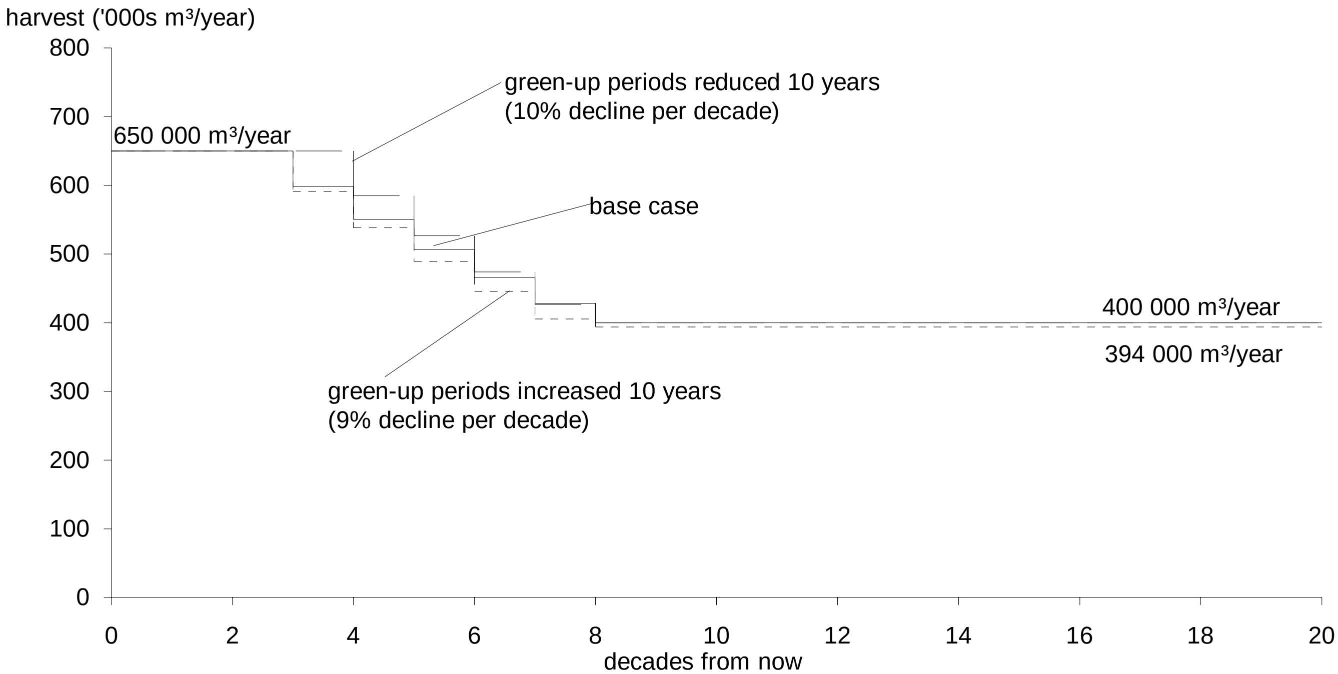

Figure 23. Harvest forecasts with green-up periods extended and reduced by 10 years.

With green-up periods extended, the initial harvest rate is still maintained for 3 decades, but the rate of decline beyond this period must be increased to 9% each decade. As a result, the total harvest over the first 8 decades is reduced by 2% relative to the base case. The long-term harvest level is reduced slightly from the base case to 394 000 cubic metres per year. These results indicate that harvest levels have little sensitivity to the uncertainty in determining green-up periods. The lack of sensitivity is due to the relatively large area of older forest in the current growing stock and the fact that forest cover requirements applied to most of the land base are not highly restrictive.

It is useful to relate these results to the stand height criteria that were the basis for the estimates of green-up periods. In the base case, minimum stand heights of either 3 or 6 metres were required to meet green-up specifications in the various zones. A 10 year reduction of green-up periods is roughly equivalent to reducing the 3 metre green-up height to 1.5 metres and the 6 metre requirement to 3 metres. Increasing green-up periods by 10 years is equivalent to increasing the 3 metre specification to 6 metres and 6 metres to 10 metres. The range of green-up periods applied in this test therefore, represent a substantial variation in stand height specifications.

5.7 Old-growth requirement

Because of concerns about the ecological diversity of future forests, forest district staff require information on maintaining a part of the forest in older age classes. A common old-growth retention principle is to maintain 10% of stands in ages greater than 140 years. Forest area outside of the timber harvesting land base may also contribute to this objective and a smaller part of the timber harvesting land base may be required for old-growth management.

This test examines the sensitivity of harvest levels to maintaining 7% of all zones outside of the selection management area in ages older than 140 years at all times. This replaced the base case requirement that 20% of all zones be older than 80 years. The results of this change are shown in Figure 24. The initial harvest level can be maintained for 2 decades rather than 3 and harvest levels decline by 9% per decade to the long-term level. The total harvest over the first 8 decades is 7% less than the base case harvest indicating moderate to high sensitivity during that period. The long-term harvest is 1% lower than the base case level and therefore has low sensitivity to the old-growth objective applied.

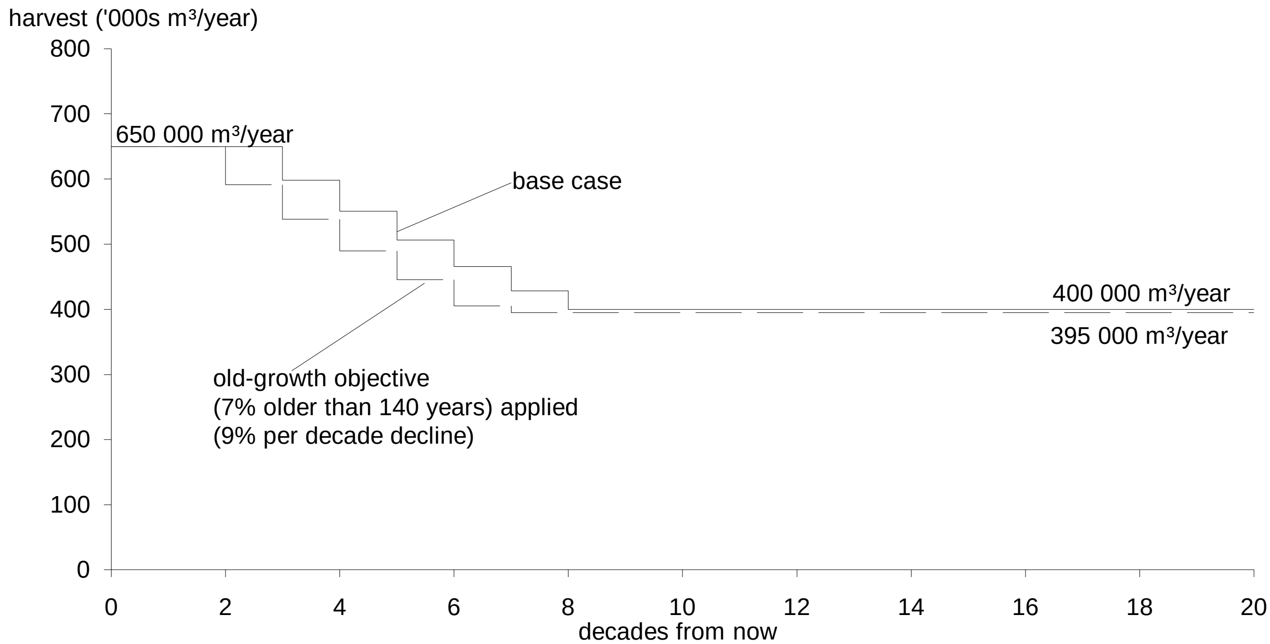

Figure 24. Harvest forecasts with an old-growth objective applied.

5.8 The availability of existing mature forest for harvesting

The estimate of how much of the existing mature forest is available or accessible for harvesting is uncertain due to such factors as the imprecise nature of the inventory data, market fluctuations and problems accessing some timber lands. In addition the status of the Spruce Lake and Mid-Stein areas and operability information add to the uncertainty. This concern was examined by applying a general percentage reduction to the area of all stands in the timber harvesting land base that are currently older than 100 years. For convenience, the area deducted in these tests is referred to as mature in the following discussion. This should not be confused with maturity as defined by minimum harvest ages discussed earlier. Two cases were examined. A 10% reduction applied to the mature area of the timber harvesting land base excluded 21 700 hectares (7%). A 20% reduction applied to the mature area excluded 43 400 hectares or 14% of the timber harvesting land base. The results are compared to the base case in Figure 25. If 10% of the mature area is excluded, the harvest level can be held at the current AAC for 2 decades and then declines 9% per decade to the reduced long-term level of 371 000 cubic metres per year, 7% lower than the base case. With 20% of the mature area removed, the initial harvest level is maintained for the first decade after which harvest levels decline 9% each decade until the long-term level is reached. The long-term harvest is 14% lower than the base case level.

When 10% of mature stands are removed, the total harvest in the first 8 decades is reduced 8% relative to the base case; when 20% is excluded, the total harvest is 14% less during that period. These reductions, as well as the reductions to the long-term harvest are about the same as the per cent area excluded from the timber harvesting land base (7 and 14%).

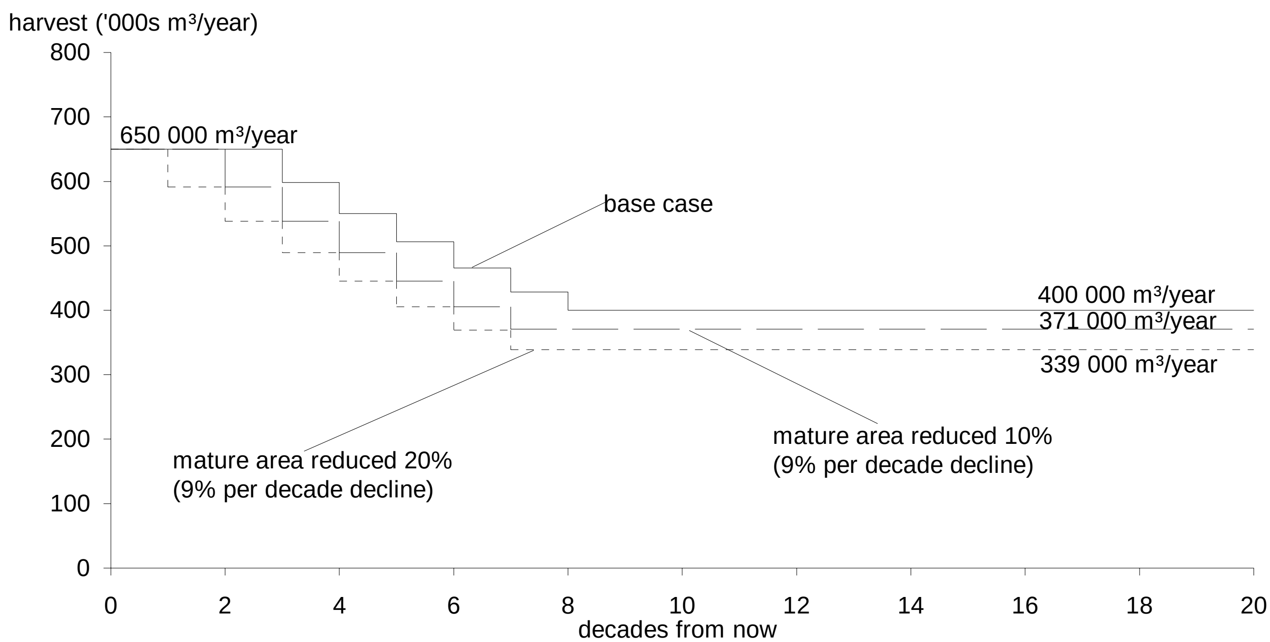

Figure 25. Harvest forecasts with exclusions of mature area.

6 Summary and Conclusions

The analysis for the Lillooet TSA indicates that given current management assumptions, an initial harvest of 650 000 cubic metres per year can be maintained for 3 decades. Harvests must then begin to decline at 8% per decade until the long-term harvest level of 400 000 cubic metres per year is reached in decade 9.

It is possible to maintain the current AAC for 7 decades if there is no limit on the rate of decline and harvests are allowed to fall below the long-term level. However, this causes a serious timber shortage after 70 years that persists 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 be reserved for a longer period of time and forests in the future would be older, on average. The magnitude of these effects depends on the degree to which harvest levels are reduced. At the extreme, with the harvest maintained at the base case long-term level (400 000 cubic metres per year), the timber harvesting land base 200 years from now would still contain a large number of stands older than 150 years. Reducing the harvest level may result in increased diversity in forest ecosystems in the future. The risk of timber losses however, to fire, insects and disease would increase, potentially reducing the timber supply in the future.

This analysis employs the best current estimates for all variables used to describe forest management in the Lillooet TSA. However, varying degrees of uncertainty surround most of the estimates. Sensitivity analyses has shown that the timber supply over the first 8 to 10 decades is particularly sensitive to a decrease in the amount of existing mature forest available for harvesting, tightening of forest cover requirements and changes to yield estimates for existing stands. Harvest levels over that period are also moderately sensitive to changes in minimum harvest ages and a requirement to maintain old-growth stands.

The long-term harvest is highly sensitive to changes to yield estimates for regenerated stands and the exclusion of some existing mature stands from the timber harvesting land base.

7 References

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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 Licences (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.
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.
Harvest forecast	The flow of potential timber harvests over time. A harvest forecast is usually a measure of the maximum timber supply that can be realized, over time, for a specified land base and set of management assumptions. It is a result of forest planning models and is affected by the size and productivity of the land base, the current growing stock, and management objectives, constraints and assumptions.
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 harvest 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.

8 Glossary

Not satisfactorily restocked
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.

Selection management
A silvicultural system used to maintain or create areas containing a wide range of tree ages or sizes. The time interval between harvests in such areas is fairly short (usually less than 30 years) and during these harvests either single scattered trees or small groups of trees are removed from across the entire area.

Site index
A measure of site productivity. Site indices are based on tree height as a function of stand age and are usually expressed graphically as site index curves. A number of site index curves have been developed for British Columbia's major commercial tree species.

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.*

Visual Quality Objective (VQO)
Defines a level of acceptable landscape alteration resulting from timber harvesting and other activities. A number of visual quality classes have been defined on the basis of the maximum amount of alteration permitted.

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 for the timber supply analysis of the Lillooet TSA. For the purposes of this analysis, information represents current forest management in the area. 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 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 six 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 past harvesting history.

Zone 1 is the Spruce Lake approved study area. This area was defined as a separate zone for the analysis as it has no history of harvesting. A moratorium on harvesting has been in place since 1982. As its boundary was not defined on the inventory file, the Spruce Lake area was defined for the analysis by mapsheet, Inventory region and compartment and polygon lists[1] provided by the district staff.

Zone 2 is the Mid-Stein approved study area. This area also has no history of harvesting and, since 1972 there has been a moratorium on timber harvesting. If harvesting were to occur in the Mid-Stein, it is assumed that forest cover objectives would differ from those applied generally because of hydrological and other non-timber concerns. This zone is defined by Inventory region 33, compartment 003.

Zone 3 includes community watersheds for Lytton (Lytton Creek), Lillooet (Town Creek), Spences Bridge (Murray Creek) and Gold Bridge (Ferguson Creek). These areas were defined for the analysis by mapsheet, inventory region and compartment, planning cell and polygon lists[1] provided by the district.

Zone 4 is the selection management area located in the Interior Dry-Belt and is dominated by Douglas-fir stands. It is assumed that this zone is managed under a selection harvesting regime. As the boundary of this area was not included on the inventory file, it was defined by Inventory region and compartment and stand descriptors (type group, age class, height class, stocking class and site class)[1].

Zone 5 includes visually sensitive areas identified by the district staff for this analysis. Both partial retention and retention VQOs are recognized. The boundary for this zone was identified by mapsheet and planning cell lists provided by the district staff.

Zone 6 includes those areas not assigned to Zones 1 to 5. Although no special management is assumed for this area, its value as wildlife habitat and its importance to hydrology are recognized.

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 compositions 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 Lillooet TSA analysis, site groups were assigned using new site class (NSITE). Analysis units and the inventory file variables used to define them, are shown in Table A-1. Small areas of white pine and ponderosa pine were added to analysis units 1, 2 and 3.

[1] Lists are available in the data package prepared for this analysis by the Lillooet Forest District.

A.1 Zone and Analysis Unit Definition

Table A-1. Analysis unit definition

Analysis unit	Species groups	Inventory type groups	Site index classes
1	Douglas-fir (wet-belt)	1-4,8,27	good and medium
2	Douglas-fir (wet-belt)	1-4,8,27	poor
3	Douglas-fir (dry-belt)	1,5-7,32	all
4	Spruce/balsam cedar/hemlock	9-26	good and medium
5	Spruce/balsam cedar/hemlock	9-26	poor
6	Lodgepole pine	28-31	good and medium
7	Lodgepole pine	28-31	poor

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.

Table A-2. Area by zone and analysis unit

Analysis unit	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Total
1 (F - g,m)	0	3 529	2 402	0	2 098	40 138	48 167
2 (F - p)	0	1 734	901	0	896	20 974	24 505
3 (F - dry-belt)	0	0	0	48 625	0	0	48 625
4 (SBCH - g,m)	423	2 440	215	0	1 666	14 803	19 547
5 (SBCH- p)	4 701	4 761	741	0	1 168	28 506	39 877
6 (Pl - g,m)	2 569	303	1 438	0	1 816	30 813	36 939
7 (Pl - p)	2 972	1 942	2 238	0	1 190	78 478	86 924
Total	10 665	14 709	7 935	48 625	8 834	213 812	304 580

A.2 Definition of the Timber Harvesting Land Base

The final timber harvesting land base was determined by first deducting from the total TSA area, all areas considered to be currently unavailable for timber production. 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 1992, was then added back in 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.

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	75
Ep 1	High concern for regeneration problems	50
Ea 1	High avalanche concern	75
Er 1	High recreation value	90
Eh 1	High watershed values or concerns	50
Ew 1	High wildlife value	90
Er 2	Moderate recreation value	35
Eh 2	Moderate watershed values or concerns	35
Ew 2	Moderate wildlife value	35

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. With the exception of stocking class 4 lodgepole pine, all stands classified as such in the new site class field (NSITE) are excluded. The deduction for stocking class 4 lodgepole pine stands is included with the non-merchantable stands reduction.

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.

Table A-4. Per cent area reductions for non-merchantable stands

Inventory type group	Species groups	Age class	Height class	Stocking class	Site class	Crown closure class	Per cent area excluded
1-8	Douglas-fir	6-9	1				100
1-8	Douglas-fir	5-9	2+			4	83
1-8	Douglas-fir	5-9	2+			less than 4	86
9-27	C/H/B/S	6-9	1				100
9-27	C/H/B/S	6-9	2				21
28-31	Lodgepole pine	5-9	1	All			100
28-31	Lodgepole pine	5-9	2+	4			5
28-31	Lodgepole pine	5-9	2+	1-3,R		less than 5	5
32	Yellow pine	5-9				less than 5	100

Note: After completing the timber supply analysis, a minor error was discovered in the computer code that applied reductions shown in Table A-4. The effect of this error was to increase the timber harvesting land base by 180 hectares or .06%.

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. The definition of inoperable area was provided by District staff in the form of lists by mapsheet, planning cell and biogeoclimatic classification (where available). This information is assumed to be current to the end of 1992.

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 12% reduction was applied to all areas younger than 41 years old and an additional 1.5% reduction was applied to stands older than 40 years (the areas assumed to have a timber harvesting history). This estimate was derived from soil disturbance surveys carried out in other interior TSAs especially in the Okanagan TSA.

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 9.6%. This estimate was taken from *Soil Conservation Guidelines for Timber Harvesting - Interior B.C.* As the area over 40 years was already reduced by 1.5% for existing losses, a reduction of 8.1% is applied. 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 8.1% the first time all stands currently over 40 years old are harvested.

A.2.11 Not satisfactorily restocked adjustments

As the inventory file has not been updated for harvesting since 1987, adjustments must be made to reflect areas harvested since that date. The NSR area must also be made to agree with the silviculture history records for the Lillooet 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 14 809 hectares (a 12% reduction for existing roads, trails and landings had been applied). The areas harvested since 1987 were then accounted for by deducting 9888 hectares from the mature (type identification code = 2) component of all analysis units within zones 3, 5 and 6. Note that there is no recent harvesting in zones 1 and 2 and that selection harvesting in zone 4 (dry-belt Douglas-fir) is assumed to not create NSR sites.

According to the silviculture history records, some of the NSR area that existed before 1987 and some NSR created since is now restocked. This area is assumed to be in the 1 to 10 year age range. The area that is not restocked is assumed to be either backlog NSR if it was created before 1987 or current NSR if created since then. 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.

A.2 Definition of the Timber Harvesting Land Base

Table A-5. NSR area adjustments

NSR source	Gross area (hectares)	Net area (less roads, etc.) (hectares)	Net area restocked (hectares)	Existing NSR (net) (hectares)	
				Backlog	Current
Pre-1987	16 828	14 809	7 776	7 032	0
1987-1992	9 888	8 701	3 575	0	5 126
Total	26 716	23 510	11 351	7 032	5 126

The total area of NSR, both backlog and current, is 12 158 hectares. This area is assumed to be restocked within one decade from now and is added back into the timber harvesting land base as indicated in
Table A-6. NSR area is distributed in the same proportion as zones and analysis units occur in the timber harvesting land base.

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

Analysis unit	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Total
	Area (hectares)						
1 (F - g,m)	0	0	129	0	112	2 144	2 385
2 (F - p)	0	0	46	0	47	1 119	1 212
3 (F - dry-belt)	0	0	0	0	0	0	0
4 (SBCH - g,m)	0	0	6	0	89	787	882
5 (SBCH- p)	0	0	21	0	62	1 523	1 606
6 (Pl - g,m)	0	0	74	0	95	1 607	1 776
7 (Pl - p)	0	0	118	0	62	4 118	4 297
Total	0	0	394	0	467	11 298	12 158

The area previously classified as NSR and now assumed to be restocked is 11 351 hectares. This area, assumed to be in the 1 to 10 year age range, is added back into the timber harvesting land base in the same proportion as the stocked area occurs within each zone and analysis unit.

Table A-7. Restocked NSR area additions to timber harvesting land base

Analysis unit	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Total
	Area (hectares)						
1 (F - g,m)	0	0	118	0	103	1 978	2 199
2 (F - p)	0	0	42	0	44	1 034	1 120
3 (F - dry-belt)	0	0	0	0	0	0	0
4 (SBCH - g,m)	0	0	6	0	82	730	818
5 (SBCH- p)	0	0	19	0	58	1 405	1 482
6 (Pl - g,m)	0	0	71	0	90	1 521	1 682
7 (Pl - p)	0	0	110	0	59	3 881	4 050
Total	0	0	366	0	436	10 549	11 351

A.3 Forest Management Practices

This section describes forest management as currently practiced in the Lillooet TSA. The information was provided by the Lillooet District 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 (1.3 metres) for lodgepole pine timber types and 17.5 cm dbh for all other timber types.

A.3.2 Utilization standards

Interior close utilization standards are a maximum 30 cm stump height and a minimum 10 cm inside-bark diameter at tree top, less decay.

A.3.3 Minimum harvest ages

Minimum harvest ages for clear-cut harvested stands are 80 years for lodgepole pine and 120 years for other species. For selection management, the first-entry harvest is assumed to occur at a stand age of 140 years or older. After the first entry, the ages of stands under selection management are not defined.

A.3.4 Existing managed stands

Table A-8 shows the proportions of managed stands within the existing inventory by zone, analysis unit and age. These areas are assigned to managed stand yield tables (MSYTs) described in Section A.4.2, "Yield tables for regenerated stands".

Table A-8. Existing managed stands

Existing Plantations Zone	Analysis unit	Age (years)	Per cent managed
3 Watersheds	1 (F - g,m)	40	60
	2 (F - p)	40	15
	4 (SBCH - g,m)	20	50
	5 (SBCH - p)	20	10
	6 (Pl - g,m)	20	65
	7 (Pl - p)	20	50
5 VQO	1 (F - g,m)	40	60
	2 (F - p)	40	15
	4 (SBCH - g,m)	20	50
	5 (SBCH - p)	20	10
	6 (Pl - g,m)	30	65
	7 (Pl - p)	20	50
6 Timber	1 (F - g,m)	40	60
	2 (F - p)	40	15
	4 (SBCH - g,m)	20	50
	5 (SBCH - p)	20	10
	6 (Pl - g,m)	20	65
	7 (Pl - p)	20	50

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-9. Regeneration assumption

Existing analysis unit	Regenerated analysis units (with per cent)	Unmanaged per cent	Managed per cent	Initial density (stems/hectare)	Regeneration delay (years)
1	1 (80%)	10	90	1000	4
	6 (20%)	20	80	1400	4
2	2 (60%)	20	80	1000	4
	7 (40%)	30	70	1200	4
3	3 (100%)	N/A	N/A	N/A	N/A
4	4 (70%)	20	80	1200	4
	6 (30%)	20	80	1400	4
5	5 (70%)	20	80	1000	4
	7 (30%)	30	70	1200	4
6	6 (90%)	20	80	1400	4
	4 (10%)	20	80	1000	4
7	7 (100%)	30	70	1200	4

A.3.6 Harvest profile

Table A-10 is a summary of the historical harvest profile derived from harvesting records for the past few years.

Table A-10. Historical harvest profile

Zone	Analysis unit	Per cent of total harvest volume
1 and 2 (Spruce Lake, Mid-Stein)	All	0
4 (Selection management)	3 (dry-belt Douglas-fir)	8
3,5,6 (VQO, watersheds, timber)	1,2 (wet-belt Douglas-fir)	15
	4,5 (C,H,B.S)	52
	6,7 (lodgepole pine)	25

A.3 Forest Management Practices

A.3.7 Forest cover requirements

Table A-11 specifies the forest cover requirements needed to achieve the forest management objectives for each zone. In addition to the requirements shown, 20% of each zone is to be maintained in ages older than 80 years.

Table A-11. Forest cover requirements

Zone	Definition of green-up (metres)	Green-up period (years)	Maximum area less than green-up
1 (Spruce Lake)	3	22	33%
2 (Mid-Stein)	6	35	24%
3 (Community watersheds)	6	29	24%
4 (Selection management)	N/A	N/A	N/A
5 (VQO)	6	30	14%
6 (Timber)	3	20	33%

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 from the inventory file and then TIPSY was used to project the required height-age relationships.
Further information by zone follows:

Zones 1 and 2 (Spruce Lake and Mid-Stein):
These areas have no history of harvesting and no formal plans for harvesting development are in place. District staff feel that no special forest management practices would be required for the Spruce Lake zone if harvesting were to resume and so a three-pass harvesting system is assumed. However, because of concerns about the hydrological and other non-timber characteristics of the Stein River valley, the forest cover requirements are the same as applied in the Watershed zone.

Zone 3 (Watersheds):
The green-up criteria for community watersheds were derived based on the following assumptions:
an average 60% of the watershed areas are located above the snow line (defined as areas which normally have at least some snow cover for a significant part of the year). According to harvesting guidelines, no more than 20% of the area above the snow line can be less than green-up height of 8 metres and no more than 30% of the area below the snow line can be less than 3 metres stand height. Weighted average values are therefore 6 metres for green-up height and a maximum 24% of the watershed area allowed below green-up height at any time.

Zone 5 (VQO):
The basic information on the extent and forest cover requirements for visually sensitive areas were derived for this analysis by district Recreation staff. Both Partial Retention and Retention VQO areas were identified as portions of planning cells with significant visual sensitivity. The initial restriction varied between 1 to 5% below green-up for the Retention VQO and 6 to 15% below green-up for the Partial Retention VQO. The actual restriction applied depended on the visual absorption capacity of the area. This value was then further adjusted by considering viewscape dispersion and the contribution of inoperable areas to visual quality. The two VQO classes were combined into one zone for this analysis The forest cover constraint shown in
Table A-11 is an average for the VQO zone calculated by an area-weighting procedure. Although this

procedure can lead to some bias, it was judged that, given the relative small size of the VQO zone (2.9% of the timber harvesting land base), the bias would be insignificant. Visually sensitive areas located in the Selection Management zone were left in that zone as it is assumed that selection management would satisfy VQO criteria.

Zone 6 (Timber):
A 3 metre green-up is required to satisfy free-growing standards and general wildlife habitat needs. A three-pass harvesting system defined by this forest cover objective reflects current management in the Lillooet TSA.

A.3.8 Unsalvaged losses

Table A-12 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-12. Unsalvaged losses

Cause of loss	Gross losses (cubic metres per year)	Unsalvaged losses (cubic metres per year)
Fire	16 107	4 900
Insects	15 559	11 288
Disease	5 830	5 299
Other	10 000	5 000
Total	47 496	26 487

Notes on above categories:

Insects:
Current and projected volume losses can be expected in Douglas-fir stands due to the western spruce budworm. The volume loss estimate was derived by applying a loss factor to the volume of stands currently under attack.

Mountain Pine Beetle and Spruce Bark Beetle losses have been accounted for in the district inventory. In the years since the last inventory there has not been an increase in either of these insect populations to any unmanageable size. All infestations were small and taken care of through harvesting. It is expected that in the future unsalvaged losses to these insects will be minimal within the timber harvesting land base.

Disease:
Volume loss were estimated for root diseases. This loss was based on stands with known root disease and an estimated percent loss factor.

Fire:
The unsalvaged loss estimate due to fire is based on 10 years of district fire reports. The losses in these reports were reduced by 50% so that only the volume loss that occurred in the timber harvesting land base is included in the estimate.

Other:
The "Other" section in this table refers to a minimal amount of unsalvaged blowdown and losses due to landslides.

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-14. These tables were generated for each zone and analysis unit using the Variable Density Yield Prediction (VDYP) system. Yields have been reduced by the proportion of deciduous volumes in each analysis unit. These tables are not applied to the current area of NSR, existing young stands which are assumed to be managed (Section A.3.4, "Existing managed stands") 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".

Volume tables for existing stands, based on close utilization less decay, are reduced for waste and breakage. Aggregated waste and breakage (W_2B) factors are developed from the Inventory Metric Diameter Class Loss Factors Manual by averaging over diameter class and risk group and combining the separate factors for waste and breakage. In this way, a single W_2B factor is developed for each of two age ranges (older immature and mature) and each PSYU, species and utilization level. The W_2B factors shown below are applied in the VDYP aggregation procedure which generates a yield table for each analysis unit.

Table A-13. Waste and breakage factors

Older immature: lodgepole pine: age classes 3, 4
deciduous: age classes 3, 4
other species: age classes 5, 6

PSYU	Utilization level (cm)	Per cent volume reduction by species											
		F	C	H	B	S	Pw	Pl	Py	Pa	Cot	Bi	A
Yalakom	12.5	2.0	4.1	3.0	2.0	2.0	2.0	2.0	2.0	3.1	50.1	4.2	14.9
	17.5	2.0	4.2	3.1	2.0	2.0	2.0	2.0	2.0	3.3	56.7	4.2	14.9
Botanie	12.5	2.0	4.1	3.0	2.0	2.0	2.0	2.0	2.0	3.1	50.1	4.2	14.9
	17.5	2.0	4.2	3.1	2.0	2.0	2.0	2.0	2.0	3.3	56.7	4.2	14.9
Big Bar	12.5	2.0	-	-	2.0	2.0	-	2.0	2.0	3.1	50.1	4.2	14.9
	17.5	2.0	-	-	2.0	2.0	-	2.0	2.0	3.3	56.7	4.2	14.9

Mature:lodgepole pine: age classes 5+
deciduous: age classes 5+
other species: age classes 7+

PSYU	Utilization level (cm)	Per cent volume reduction by species											
		F	C	H	B	S	Pw	Pl	Py	Pa	Cot	Bi	A
Yalakom	12.5	3.4	15.9	5.6	10.51	2.2	3.4	4.0	2.0	3.3	63.4	6.1	18.5
	17.5	3.6	17.0	6.1	1.1	2.4	3.4	4.0	2.2	3.3	63.4	6.1	18.5
Botanie	12.5	2.6	17.0	5.6	10.81	2.1	4.0	4.1	2.0	3.3	76.8	5.3	18.5
	17.5	3.0	18.3	6.1	1.4	2.1	4.4	4.1	2.0	3.4	77.8	5.3	30.5
Big Bar	12.5	3.4	-	-	9.7	2.1	-	4.7	2.0	3.1	50.1	6.1	18.5
	17.5	3.4	-	-	10.8	2.1	-	4.7	2.0	3.3	56.7	6.1	25.1

A.4 Yield Tables

Table A-14. Yield estimates for existing stands

	Analysis unit 1: Douglas-fir - good and medium sites			
Age	**Zone 2**	**Zone 3**	**Zone 5**	**Zone 6**
	(cubic metres per hectare)			
10	0	0	0	0
20	0	0	0	0
30	1	0	1	0
40	15	3	9	6
50	43	13	30	22
60	75	31	54	43
70	107	51	78	66
80	136	71	102	88
90	164	90	124	110
100	191	109	146	130
110	216	127	166	150
120	238	142	184	167
130	258	157	201	183
140	276	171	216	198
150	292	183	229	211
160	306	194	241	223
170	319	204	251	233
180	331	213	261	243
190	343	223	271	253
200	354	232	280	262
210	365	241	289	271
220	375	249	297	280
230	384	257	305	288
240	393	265	312	296
250	402	272	319	303
260	403	272	319	303
270	404	273	320	304
280	405	273	320	304
290	405	273	320	304
300	406	273	320	304
310	407	273	320	304
320	407	274	320	304
330	408	274	320	304
340	408	274	320	304
350	409	274	320	304

A.4 Yield Tables

Table A-14. Yield estimates for existing stands

Analysis unit 2: Douglas-fir - poor site				
Age	**Zone 2**	**Zone 3**	**Zone 5**	**Zone 6**
	(cubic metres per hectare)			
10	0	0	0	0
20	0	0	0	0
30	0	0	0	0
40	0	0	0	0
50	3	1	4	3
60	12	11	14	11
70	27	26	29	25
80	44	42	45	41
90	60	57	60	56
100	76	72	76	70
110	91	86	90	84
120	105	99	104	97
130	118	111	116	109
140	129	122	128	120
150	139	132	137	129
160	148	141	146	138
170	155	150	153	145
180	163	158	161	153
190	169	166	167	160
200	176	173	174	167
210	182	181	181	173
220	188	188	187	180
230	194	195	193	186
240	199	201	199	192
250	204	207	204	198
260	205	207	205	198
270	206	207	205	198
280	206	208	205	198
290	207	208	205	198
300	207	208	205	198
310	207	208	205	198
320	207	208	205	199
330	208	208	205	199
340	208	208	205	199
350	208	208	205	199

A.4 Yield Tables

Table A-14. Yield estimates for existing stands

Analysis unit 4: Spruce/balsam (cedar, hemlock) - good and medium sites					
Age	**Zone 1**	**Zone 2**	**Zone 3**	**Zone 5**	**Zone 6**
	(cubic metres per hectare)				
10	0	0	0	0	0
20	0	0	0	0	0
30	0	0	0	0	0
40	4	10	4	8	5
50	14	37	21	33	26
60	34	80	59	70	62
70	58	124	101	108	101
80	78	162	139	141	135
90	97	195	174	170	165
100	114	225	206	195	192
110	129	251	235	217	215
120	143	273	261	237	237
130	157	295	285	257	258
140	170	315	305	276	277
150	181	333	323	293	294
160	191	349	338	308	310
170	201	363	351	322	324
180	209	376	362	334	337
190	217	388	372	346	349
200	224	399	381	358	361
210	231	410	390	368	372
220	238	419	399	378	382
230	244	429	406	388	391
240	250	437	413	397	400
250	256	445	420	405	409
260	258	449	423	408	412
270	260	452	426	410	415
280	262	455	429	412	418
290	264	458	432	414	420
300	265	461	435	416	422
310	266	463	437	418	424
320	268	466	439	419	426
330	269	468	441	420	428
340	270	470	443	422	430
350	271	471	444	423	431

A.4 Yield Tables

Table A-14. Yield estimates for existing stands

Analysis unit 5: Spruce/balsam (cedar, hemlock) - poor site					
Age	Zone 1	Zone 2	Zone 3	Zone 5	Zone 6
	(cubic metres per hectare)				
10	0	0	0	0	0
20	0	0	0	0	0
30	0	0	0	0	0
40	0	0	0	1	0
50	2	3	0	4	2
60	6	10	2	12	8
70	14	25	11	29	23
80	24	44	33	52	43
90	36	66	60	75	65
100	49	87	90	96	87
110	60	107	118	116	107
120	71	125	145	135	126
130	81	143	170	153	145
140	91	160	193	170	162
150	100	175	214	185	178
160	108	189	233	199	193
170	116	202	250	212	206
180	123	214	265	224	218
190	129	224	278	235	230
200	135	235	291	245	240
210	141	245	304	255	251
220	147	254	315	265	260
230	152	263	326	274	269
240	157	271	335	282	278
250	162	279	345	290	286
260	164	283	352	293	290
270	166	286	358	297	294
280	167	290	364	300	298
290	169	293	369	303	301
300	171	296	375	305	304
310	172	299	379	308	307
320	173	301	384	310	310
330	174	303	388	312	312
340	176	306	391	314	315
350	177	307	395	316	317

A.4 Yield Tables

Table A-14. Yield estimates for existing stands

Analysis unit 6: Lodgepole pine - good and medium sites					
Age	**Zone 1**	**Zone 2**	**Zone 3**	**Zone 5**	**Zone 6**
	(cubic metres per hectare)				
10	0	0	0	0	0
20	0	0	0	1	0
30	3	2	3	17	5
40	28	18	33	58	38
50	65	54	72	102	80
60	98	87	107	140	117
70	128	116	139	174	150
80	154	142	167	204	180
90	179	166	194	231	208
100	202	188	219	256	233
110	223	208	241	278	257
120	243	226	263	299	279
130	262	244	283	319	299
140	275	257	296	333	314
150	285	267	307	344	325
160	293	275	315	352	333
170	297	281	321	357	338
180	299	285	323	360	340
190	299	286	323	359	340
200	301	289	326	362	342
210	304	293	329	365	345
220	306	296	332	368	348
230	309	300	335	371	351
240	311	303	338	374	354
250	314	306	341	377	356
260	316	307	342	379	358
270	318	309	344	381	360
280	319	311	346	382	362
290	321	312	347	384	363
300	322	313	348	385	365
310	324	315	349	387	366
320	325	316	350	388	367
330	326	316	351	389	368
340	326	317	352	390	369
350	327	318	352	390	369

A.4 Yield Tables

Table A-14. Yield estimates for existing stands

Analysis unit 7: Lodgepole pine - poor site					
Age	Zone 1	Zone 2	Zone 3	Zone 5	Zone 6
	(cubic metres per hectare)				
10	0	0	0	0	0
20	0	0	0	0	0
30	1	1	0	0	0
40	5	2	1	2	1
50	25	12	19	19	13
60	49	30	46	43	33
70	72	51	71	67	54
80	94	70	95	89	75
90	114	88	117	110	94
100	132	105	138	130	113
110	150	121	157	148	130
120	166	136	176	166	147
130	182	150	193	182	163
140	193	161	206	194	175
150	202	169	216	204	184
160	209	176	224	211	192
170	214	182	229	217	197
180	217	185	233	219	200
190	217	187	234	220	200
200	220	190	237	223	203
210	223	193	240	226	206
220	226	196	243	229	209
230	229	199	246	231	211
240	231	202	249	234	214
250	233	204	252	236	216
260	235	206	254	238	218
270	237	208	256	240	220
280	238	209	257	241	221
290	240	210	258	242	223
300	241	211	260	244	224
310	242	212	261	245	225
320	243	213	262	245	226
330	244	214	262	246	226
340	244	214	263	247	227
350	245	215	264	247	227

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) 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.

Table A-15. Yield tables for regenerated stands

	Analysis unit 1: Douglas-fir - good and medium sites			
Age	Zone 2	Zone 3	Zone 5	Zone 6
	(cubic metres per hectare)			
10	0	0	0	0
20	0	0	0	0
30	2	2	3	2
40	11	10	12	11
50	28	26	29	27
60	54	51	54	52
70	85	82	85	83
80	118	114	118	116
90	151	146	150	148
100	176	171	175	173
110	200	194	199	197
120	221	215	220	218
130	242	235	240	238
140	261	254	259	257
150	279	271	277	274
160	293	285	291	288
170	306	298	304	301
180	318	310	316	313
190	330	322	327	325
200	341	333	338	336
210	351	343	348	346
220	360	351	357	355
230	368	359	364	362
240	376	367	372	370
250	382	373	378	376
260	387	378	383	381
270	392	383	388	386
280	396	386	392	390
290	399	390	396	393
300	402	393	398	396
310	403	393	399	396
320	403	393	399	396
330	403	393	399	396
340	403	393	399	397
350	403	393	399	397

A.4 Yield Tables

Table A-15. Yield tables for regenerated stands

Analysis unit 2: Douglas-fir - poor site				
Age	Zone 2	Zone 3	Zone 5	Zone 6
	(cubic metres per hectare)			
10	0	0	0	0
20	0	0	0	0
30	0	0	0	0
40	1	1	1	1
50	7	8	8	7
60	17	18	19	17
70	30	33	33	31
80	48	50	50	48
90	66	69	69	67
100	83	87	86	84
110	99	103	102	100
120	115	119	118	115
130	130	134	134	131
140	143	147	147	144
150	155	160	159	156
160	166	171	170	167
170	175	180	179	176
180	183	188	187	184
190	190	196	194	191
200	197	203	201	198
210	203	209	207	204
220	209	215	213	210
230	215	220	218	215
240	220	226	224	221
250	225	231	229	226
260	229	235	232	229
270	232	238	236	233
280	235	241	239	236
290	238	244	242	238
300	241	246	244	241
310	241	247	233	241
320	241	247	244	241
330	241	247	245	241
340	241	247	245	241
350	241	247	245	241

A.4 Yield Tables

Table A-15. Yield tables for regenerated stands

Analysis unit 4: Spruce/balsam (cedar, hemlock) - good and medium sites					
Age	**Zone 1**	**Zone 2**	**Zone 3**	**Zone 5**	**Zone 6**
		(cubic metres per hectare)			
10	0	0	0	0	0
20	0	0	0	0	0
30	3	3	3	4	3
40	15	15	15	18	16
50	39	41	40	44	41
60	77	83	81	84	82
70	124	132	130	134	131
80	171	182	180	183	180
90	211	224	223	224	222
100	249	264	263	263	262
110	286	302	302	302	300
120	313	331	331	330	329
130	336	355	355	354	353
140	355	374	375	373	372
150	369	389	390	388	387
160	381	402	403	401	400
170	391	413	414	412	411
180	401	423	423	422	421
190	408	431	431	430	429
200	413	437	437	436	435
210	418	443	442	441	440
220	422	447	446	446	445
230	426	451	450	450	449
240	426	451	451	450	450
250	427	73	451	452	451
260	427	453	451	451	451
270	427	453	451	451	451
280	426	453	451	451	450
290	425	452	450	450	449
300	424	450	449	448	448
310	424	451	449	449	448
320	424	451	450	449	449
330	424	452	450	449	449
340	424	452	450	450	449
350	425	452	450	450	450

A.4 Yield Tables

Table A-15. Yield tables for regenerated stands

Analysis unit 5: Spruce/balsam (cedar, hemlock) - poor site					
Age	**Zone 1**	**Zone 2**	**Zone 3**	**Zone 5**	**Zone 6**
	(cubic metres per hectare)				
10	0	0	0	0	0
20	0	0	0	0	0
30	0	0	0	0	0
40	1	1	1	1	1
50	6	5	6	6	5
60	14	13	13	14	13
70	25	25	25	27	25
80	46	46	47	49	47
90	72	74	76	77	74
100	99	102	105	105	103
110	127	131	136	135	132
120	152	157	163	161	158
130	175	180	188	185	182
140	196	203	212	207	205
150	219	226	236	231	228
160	241	249	260	254	251
170	258	267	278	272	269
180	274	284	295	288	286
190	286	297	309	301	299
200	297	308	321	313	310
210	307	318	331	323	320
220	315	328	341	332	330
230	323	336	349	340	338
240	330	343	356	347	345
250	336	350	363	354	352
260	341	355	369	359	357
270	346	360	374	364	362
280	350	365	379	369	367
290	354	368	383	373	371
300	357	371	387	376	374
310	357	372	388	376	374
320	357	372	388	376	375
330	357	373	389	377	375
340	358	373	389	377	375
350	358	373	390	377	376

A.4 Yield Tables

Table A-15. Yield tables for regenerated stands

Analysis unit 6: Lodgepole pine - good and medium sites					
Age	Zone 1	Zone 2	Zone 3	Zone 5	Zone 6
	(cubic metres per hectare)				
10	0	0	0	0	0
20	0	0	0	0	0
30	9	9	9	12	10
40	44	42	45	50	46
50	90	89	91	97	93
60	127	126	129	136	131
70	162	161	165	172	167
80	201	200	205	211	207
90	232	232	236	243	239
100	258	258	263	269	265
110	281	281	287	293	289
120	300	300	306	312	309
130	317	317	323	330	326
140	330	330	337	343	339
150	341	341	348	354	350
160	349	349	356	362	359
170	357	357	364	370	366
180	363	364	370	376	373
190	367	368	375	381	377
200	371	373	379	385	382
210	375	377	383	389	385
220	378	380	386	392	389
230	381	383	389	395	392
240	383	385	391	397	394
250	385	387	393	399	396
260	386	388	394	400	397
270	387	389	395	401	398
280	388	390	396	402	399
290	389	391	397	403	399
300	389	391	397	403	399
310	389	391	397	403	400
320	389	391	397	404	400
330	389	392	397	404	400
340	390	392	398	404	400
350	390	392	398	404	400

A.4 Yield Tables

Table A-15. Yield tables for regenerated stands

Analysis unit 7: Lodgepole pine - poor site					
Age	**Zone 1**	**Zone 2**	**Zone 3**	**Zone 5**	**Zone 6**
	(cubic metres per hectare)				
10	0	0	0	0	0
20	0	0	0	0	0
30	0	0	0	0	0
40	4	3	2	3	2
50	20	16	18	18	17
60	41	36	40	40	36
70	62	56	62	61	57
80	87	80	87	86	81
90	108	100	109	107	102
100	124	116	126	124	119
110	139	131	142	139	134
120	154	145	157	154	144
130	167	158	171	167	162
140	178	169	182	179	173
150	191	181	195	191	186
160	201	192	206	202	196
170	210	200	214	211	205
180	217	207	222	218	212
190	222	213	227	223	217
200	228	219	233	229	223
210	232	223	237	233	227
220	236	228	242	237	231
230	240	231	245	241	235
240	244	235	249	244	238
250	247	238	253	248	242
260	250	241	255	251	245
270	252	244	258	253	247
280	254	245	260	255	249
290	256	247	262	257	251
300	258	249	263	259	253
310	258	249	264	259	253
320	258	249	264	259	253
330	259	250	264	259	253
340	259	250	264	260	254
350	259	250	265	260	254

A.4 Yield Tables

A.4.3 Selection management yield tables

The selection harvesting regime assumed for dry-belt Douglas-fir is:

40% volume removal in first entry from stands currently at least 140 years old (see table below)

Re-entry period: 30 years

Volume yield after first entry: 29.1 cubic metres per hectare

Mean annual increment: .97 cubic metres per hectare per year

A.4 Yield Tables

Table A-16. First entry yield table for selection management

Age	VDYP volume (cubic metres per hectare)	Harvest (40% of VDYP) (cubic metres per hectare)
10	0	0
20	0	0
30	0	0
40	3	1
50	8	3
60	20	8
70	35	14
80	50	20
90	68	27
100	83	33
110	98	39
120	110	44
130	125	50
140	135	54
150	145	58
160	153	61
170	163	65
180	168	67
190	175	70
200	183	73
210	190	76
220	195	78
230	200	80
240	208	83
250	213	85
260	213	85
270	213	85
280	213	85
290	213	85
300	213	85
310	213	85
320	213	85
330	213	85
340	213	85
350	213	85

Lillooet TSA
Timber Supply Analysis
Addendum

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March 1995

Lillooet TSA Timber Supply Analysis Addendum

Background

The British Columbia Forest Service released the Lillooet TSA Timber Supply Analysis in December 1993. Since publication of the analysis report, errors were discovered in the computer code used to determine the timber harvesting land base. As well, since the data and assumptions were compiled for the original report, forest management practices have changed within the Lillooet TSA. The Forest Service felt that discussions about alternative timber harvest levels in the Lillooet TSA would be best facilitated by assessing the effects on timber supply forecasts of these errors and changes in forest management practices.

It is stressed that neither the results of this addendum, nor those of the original analysis should be construed as recommendations on the allowable annual cut (AAC). These reports have been produced to facilitate discussion of alternative timber harvest levels among interested parties.

This report is intended as an addition to, not a replacement of, the original Lillooet TSA Timber Supply Analysis Report. It is assumed that the reader is familiar with the original analysis report which contains definitions of terms, describes the Lillooet TSA, and outlines analysis methods.

The first part of this report describes the computer coding errors contained within the original report and their effects on the timber supply forecasts for the Lillooet TSA. The second part of the report presents sensitivity analyses additional to those described in the original timber supply analysis report. Discussion of the sensitivity analyses includes a description of changes to forest management practices within the Lillooet TSA and the resulting effects on timber supply forecasts.

Description of errors

After completion of the Lillooet TSA Timber Supply Analysis Report, errors were noted in the computer programs used to define the timber harvesting land base. The most significant error caused a large area of open-growing Douglas-fir stands with very low timber volumes to be included in the timber harvesting land base. Less significant errors were found in area reductions applied to account for environmentally sensitive areas and low productivity sites. Table 1 shows a summary of the areas excluded, after all corrections, to define the timber harvesting land base.

The numbers in bold highlight the land base deductions that changed relative to those in the original analysis (shown in Table 1, page 6, of the original report) when the error was corrected. The primary difference is in the non-merchantable stands category, in which approximately 40 000 additional hectares are excluded from the timber harvesting land base. However, less area of low site quality is now excluded. The result is a reduction in the current timber harvesting land base of 26 402 hectares, or about 8.7%, most of which is the open-growing Douglas-fir stands noted above.

Impact on timber supply forecasts

Changes in the harvest forecasts resulting from changes in the land base and management regime are discussed in this report. It should also be noted that the area of older stands of Douglas-fir on dry sites with poor productivity will be smaller in all land base and species/site class summaries, shown in Figures 3 through 7 in the original report.

Despite the substantial reduction in the size of the timber harvesting land base, the short-term harvest forecast is unchanged from the original analysis for the base case, and for all sensitivity analyses done for the original report. Figure 1 shows the corrected base case harvest forecast, which starts at the present AAC of 650 000 cubic metres per year. After eighty years, the corrected harvest forecast falls below the original harvest forecast to a new long-term level of 362 600 cubic metres per year, 9.5% below the original long-term level.

The short-term harvest forecast for the Lillooet TSA depends primarily on the existing volume of mature timber on the timber harvesting land base. Although the corrections to the analysis reduce the size of the timber harvesting land base by about 8.7%, they reduce the existing merchantable timber volume available for harvesting by less than 4%. The reduction in mature timber volume is less than that for the area for two reasons. First, the open-growing Douglas-fir stands excluded have lower than average volumes of timber per hectare.

Second, these stands are managed using a selection harvesting system (rather than a clearcut system), and only 40% of the existing timber volume is assumed to be available for harvest. The remaining timber volume is retained as residual growing stock. Although the existing mature timber volume is 4% lower, no harvest level changes relative to those indicated in the original analysis are required over the next 90 years. This is mostly because of the lower long-term level to which the revised harvest forecast declines.

The explanations contained within the original report describing the major factors that determine timber supply over time are still applicable. The reader is advised to refer to the original report for this information. The entire series of corrected sensitivity analysis graphs are available upon request from:

- Lillooet Forest District, Bag 700, Lillooet, phone 256-1200;
- Kamloops Forest Region, 515 Columbia Street, Kamloops, phone 828-4131;
- Timber Supply Branch, first floor, 1450 Government Street, Victoria, phone 356-5947.

Table 1. Corrected timber harvesting land base, Lillooet TSA.

Classification	Area (hectares)	Per cent of total area	Per cent of cown forest area
Total area on inventory file	1 123 827	100	
Not managed by B.C. Forest Service	110 821	9.9	
Non-forest	483 854	43.0	
Total productive forest managed by Forest Service (Crown forest)	529 152	47.1	100
Reductions to Crown forest:			
Non-commercial cover (brush)	680	0.1	0.1
Environmentally sensitive areas	**113 895**	**10.1**	**21.5**
Sites with low timber growing potential	**40 311**	**3.6**	**7.6**
Deciduous types	**2 006**	**0.2**	**0.4**
Non-merchantable stands	**54 740**	**4.9**	**10.3**
Inoperable	**32 083**	**2.9**	**6.1**
Existing roads, trails, landings	**7 258**	**0.6**	**1.4**
Not satisfactorily restocked (NSR)	**15 060**	**1.3**	**2.8**
Total current reductions	**266 034**	**23.7**	**50.3**
Initial timber harvesting land base	**263 118**	**23.4**	**49.7**
Additions:			
Not satisfactorily restocked	**15 060**	**1.3**	**2.9**
Total current timber harvesting land base	**278 178**	**24.7**	**52.6**
Future reductions:			
Future roads	**20 357**	**1.8**	**3.9**
Long-term timber harvesting land base	**257 821**	**22.9**	**48.7**

The bolded values are the figures that are changed from the original timber supply analysis report.

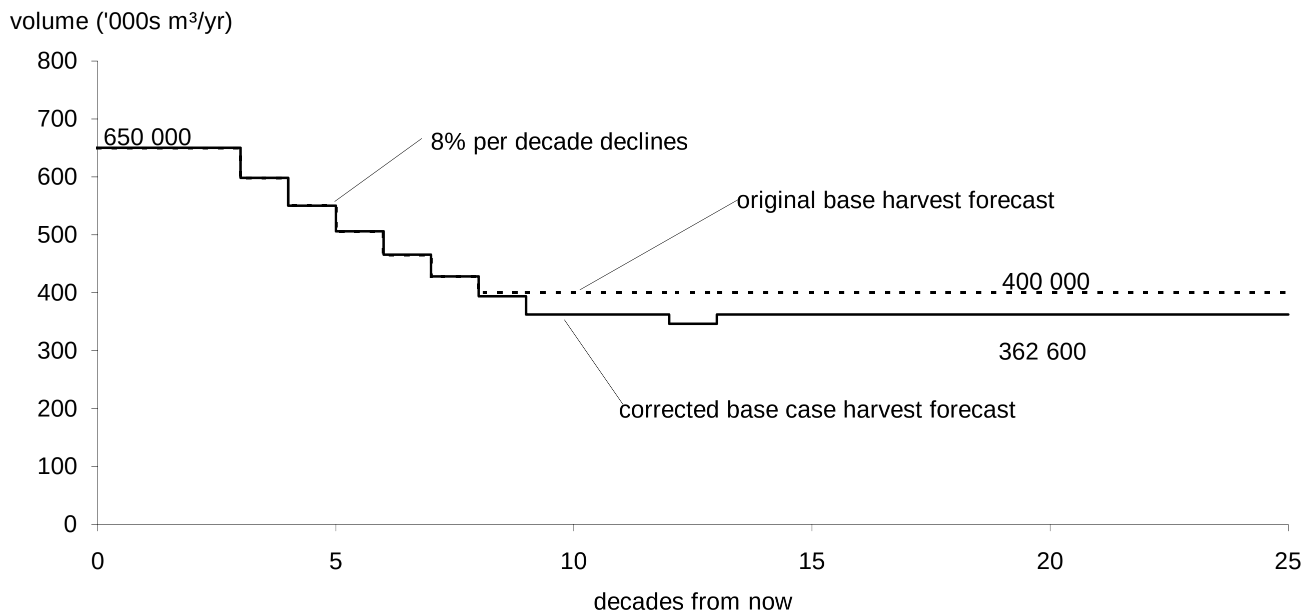

Figure 1. Corrected base harvest forecast for the Lillooet TSA.

Sensitivity Analysis

Forest management is a complicated, ever-changing endeavour, which must account for the dynamics of complex ecosystems, and fluctuating and uncertain social and economic factors. The Timber Supply Review for the Lillooet TSA was initiated during the spring of 1992. Forest management practices in effect during that time were used as the basis for the analysis report released in December of 1993. Since initiation of the original analysis, the *Lillooet Harvesting Guidelines* were introduced. These guidelines require some changes to forest management compared to the regime assumed in the original analysis. One way to deal with such changes is through frequent planning and decision-making to ensure the most up-to-date information is used. Since no decisions resulted from the original analysis, this is a good opportunity to update the analysis to provide the most current assessment of the Lillooet TSA forest management regime. It is also useful to assess, through sensitivity analysis, how data and management uncertainties might affect timber supply. Sensitivity analysis can clarify whether current best estimates provide safe bases for decisions, or whether high uncertainty around important variables means more conservative decisions may be wiser. The following sensitivity analyses examine the effects both of changes to the management regime and of uncertainties. The sensitivity analyses should be used as a supplement to the original analysis as they provide the basis for further discussion around forest management practices and alternative harvest levels within the Lillooet TSA.

Sensitivity to uncertainty in cutblock adjacency requirements

To ensure that harvesting does not become overly concentrated in an area, harvesting guidelines establish a maximum limit on the proportion of the area that does not meet green-up conditions at any time, and also require that a harvested area must reach green-up conditions before adjacent areas may be harvested. This sensitivity analysis examines how timber supply would change if either a 4-pass or a 5-pass harvesting system (rather than a 3-pass system) were required to meet adjacency guidelines within the Lillooet TSA. In a 4-pass system, no more than 25% of the TSA timber harvesting land base may be younger than green-up age, which varies from 20 years in areas with a timber management emphasis, to 35 years in the Mid-Stein zone. A 5-pass harvesting system allows no more than 20% of the area to be younger than green-up age.

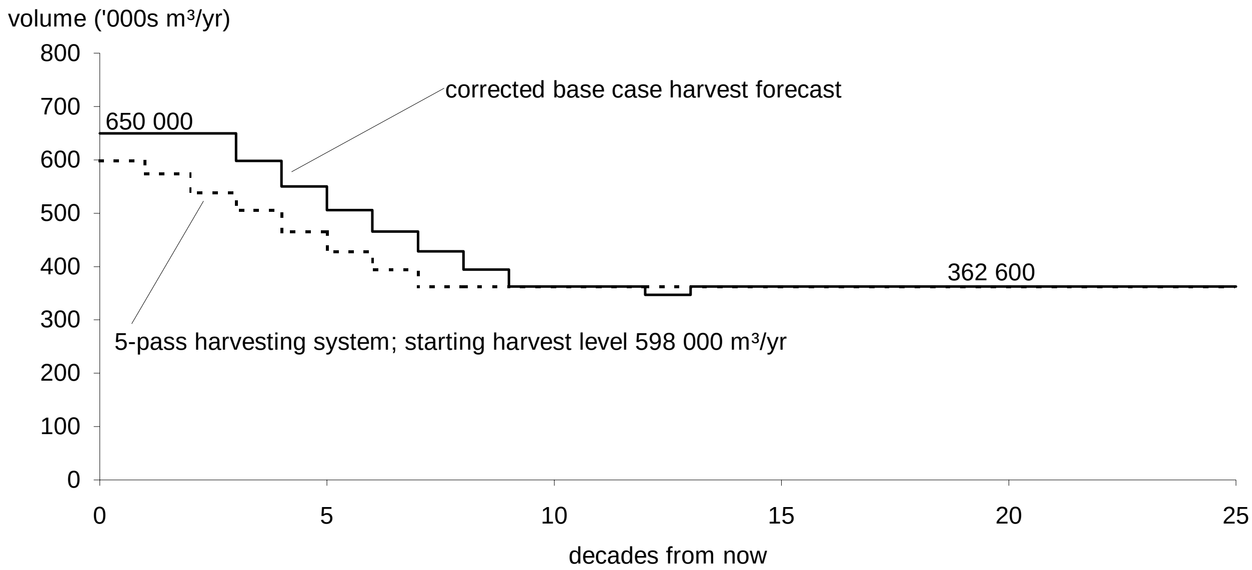

Figure 2. Sensitivity to cutblock adjacency requirements, Lillooet TSA.

Implementing a 4-pass harvesting system within the Lillooet TSA would not change the harvest forecast relative to the revised base case However, if cutblock adjacency guidelines required a 5-pass harvesting system, harvests would need to drop immediately by 8% from the current harvest level, to 598 000 cubic metres per year, in order to meet forest cover requirements (Figure 2).

Sensitivity to uncertainty in the timber harvesting land base

The area that is assumed to be suitable and available for timber harvesting is one of the primary inputs into timber supply analysis. Introduction of the *Lillooet Harvesting Guidelines* and review of the assumptions used to determine the timber harvesting land base for the original analysis presented some concern both that more area may be required to protect non-timber forest values, and that more area may be physically and economically inoperable. Therefore, the timber harvesting land base may be smaller than originally defined. Figure 3 shows the effects of reducing the timber harvesting land base by 10% and 20%.

When the timber harvesting land base is reduced by 10%, the initial harvest level can be maintained for 20 years, 1 decade less than the base case, if followed by 10% per decade declines. The long-term harvest level of 328 500 cubic metres per year, 9% lower than the base case, is reached eighty years from now.

When the timber harvesting land base is reduced by 20%, the starting harvest level must drop immediately by 5%, to 617 000 cubic metres per year, to allow a 10% per decade rate of decline to the long term level. The long-term harvest level of 301 000 cubic metres per year, 17% lower than the base case level, is reached in seventy years.

Sensitivity to uncertainty in cutblock adjacency and the timber harvesting land base

The previous sensitivity analyses have examined the effects on timber supply of individual uncertainties in forest management practices. The following sensitivity analyses focus on the combined effects of these uncertainties as a means to provide further input into timber supply discussions.

Figure 4 shows the effect on timber supply of combining either a 4 or 5-pass harvesting system with a 10% reduction in the timber harvesting land base. Using 4-pass system to represent cutblock adjacency would not cause any reductions in timber supply additional to those resulting if the land base was 10% smaller. The harvest forecast would be identical to that shown in Figure 3, when only a 10% land base reduction is applied.

When cutblock adjacency is constrained to a 5-pass system and the land base is 10% smaller than in the revised base case, an immediate reduction in the initial harvest level to 559 000 cubic metres per year, 14% below the base case, is required. Due to forest cover constraints, harvests decline towards the long-term level at an uneven rate. That is, after 10 years the harvest level declines by 10%, while the decline after 20 years is 6%, followed by 8% per decade declines to the long-term level.

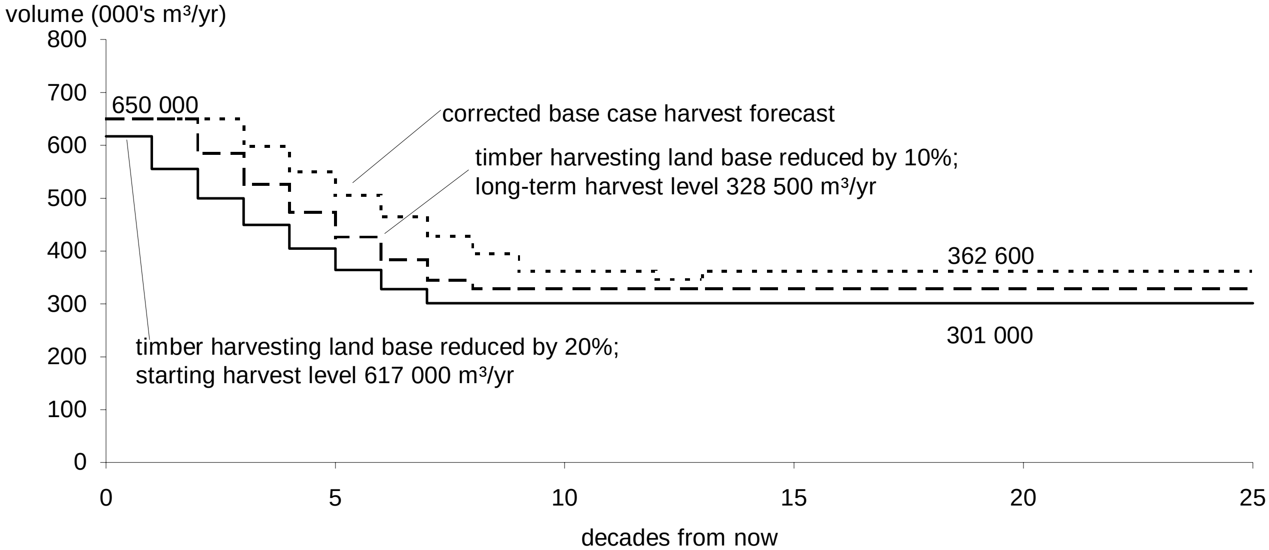

Figure 3. *Sensitivity to changes in the timber harvesting land base, Lillooet TSA.*

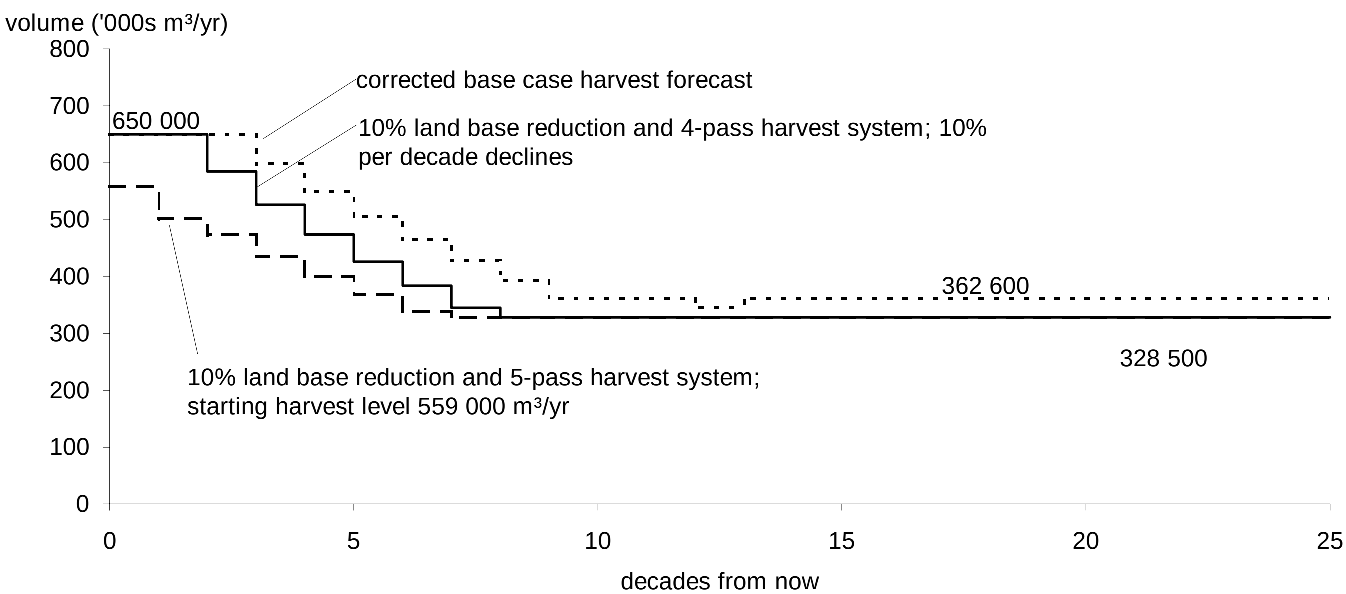

Figure 4. *Sensitivity to a 10% reduction in the timber harvesting land base and an increase in cutblock adjacency requirements, Lillooet TSA.*

Figure 5 shows the effect of combining a 20% reduction in the timber harvesting land base with either a 4 or 5-pass harvesting system. If cutblock adjacency was constrained to a 4-pass system and the land base was 20% smaller, the initial harvest level must decline immediately to 598 000 cubic metres per year, 8% below the base case starting level. As shown in Figure 3 under "Sensitivity to uncertainty in the timber harvesting land base," a 20% reduction in the land base alone requires an immediate 5% reduction in the harvest level. The rate of decline per decade shown for the combination of a 4-pass harvesting system to represent adjacency objectives, and a 20% smaller land base is not constant, due to forest cover requirements. The harvest level falls at a rate of 10% per decade, except between decades 3 and 4 where the decline is only 4%. The long-term harvest level of 301 000 cubic metres per year, 17% below the base long-term level, is reached after eighty years.

When a 20% land base reduction is combined with a 5-pass harvesting system the initial harvest rate declines to 498 000 cubic metres per year, 23% below the base case level. Harvest levels then decline by 10% between decades 1 and 2, and 8% between decades 2 and 3. Between decades 3 and 4, the harvest level can increase by 8% to 446 000 cubic metres per year. The long-term harvest level of 301 000 cubic metres per year is reached, following 8% declines per decade, in year eighty.

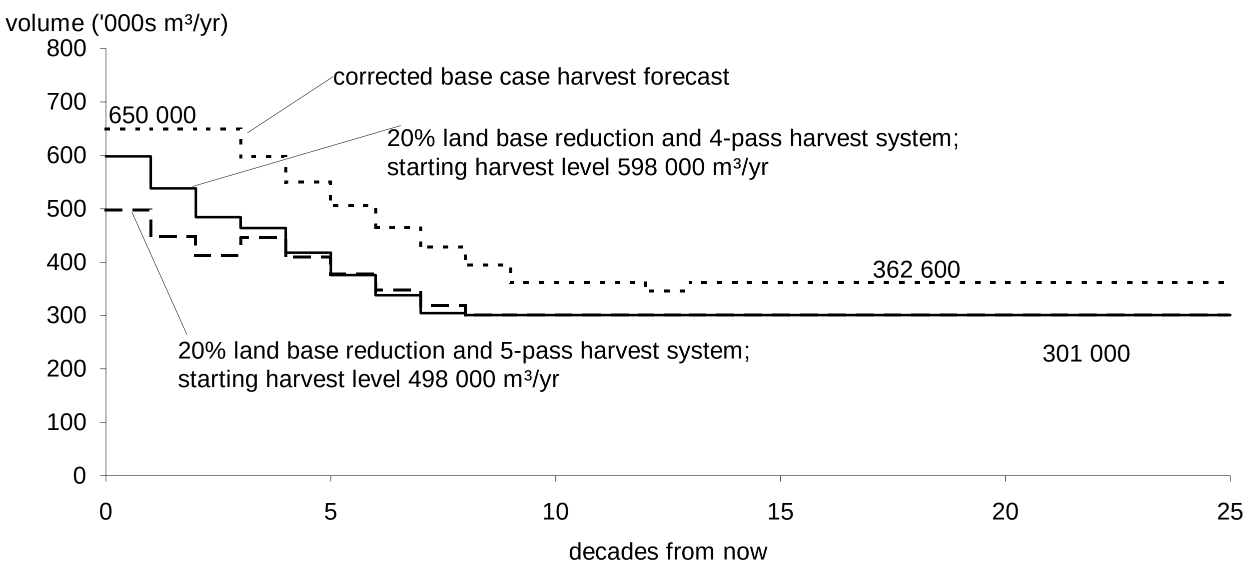

Figure 5. Sensitivity to a 20% reduction in the timber harvesting land base and an increase in cutblock adjacency requirements, Lillooet TSA.