

Boundary 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 effects of current forest management practices on the availability of timber for harvesting in timber supply areas (TSAs) throughout British Columbia. In many areas of the province, timber supply analyses performed in the early 1980s have not been updated to reflect new inventory information or changes in management practices.

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

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

Assessing the implications of only current practices rather than looking at a number of different management schemes will expedite the analysis

process, allowing analysis of all TSAs in the province to be completed by early 1995. 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 timber supply analysis for the Boundary TSA began in January, 1994. The information it contains is independent of the October 1994 *West Kootenay Land Use Plan* by the Commission on Resources and Environment (C.O.R.E.). Any land-use decisions by Cabinet, or changes to management practices arising from the C.O.R.E. report will be included in the current management practices defined for the next Boundary TSA timber supply analysis, scheduled to be completed within 5 years.

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

Executive Summary

As part of the provincial Timber Supply Review, the British Columbia Forest Service has examined the availability of timber in the Boundary 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 indicate only the timber supply implications of current practices and uncertainty. **As such, the forecasts should be used for discussion purposes only; they are not allowable annual cut (AAC) recommendations.**

The Boundary TSA covers a total area of 580 000 hectares, of which about 311 000 hectares are considered available for timber harvesting under current management practices. The area is dominated by lodgepole pine forests, with significant areas occupied by stands of Douglas-fir, larch, spruce and balsam. The current AAC for the Boundary TSA is 900 000 cubic metres per year. The present AAC is comprised of the base AAC of 700 000 cubic metres plus a temporary AAC uplift of 200 000 cubic metres to allow prompt salvage of Mountain Pine Beetle infested stands. The temporary AAC uplift is scheduled to expire December 31, 1995. However, the current harvest level has declined to about 700 000 cubic metres as the salvage program nears completion.

There are several management emphases in the Boundary TSA. Much of the area that is considered available for timber harvesting in the TSA is managed for integrated resource activity. Approximately one-quarter of the land base is assigned special forest cover requirements to account for wildlife habitat and travel corridors, protection of water quality, aesthetics and recreation values. Non-clearcutting silvicultural systems are used on a further one-fifth of the land base in order to accommodate non-timber values.

Given current management assumptions, the analysis shows that the harvest level of 700 000 cubic metres per year could be maintained for another 80 years without causing a drop in future harvest

levels below the long-term harvest level. Beginning 80 years from now, harvests would have to decline by 10% per decade until the long-term harvest level of 560 000 cubic metres is reached 100 years from now.

Although the analysis indicates that the current harvest level could be maintained for another 80 years, it cannot be maintained if harvesting continues to be conducted predominately in lodgepole pine stands. To maintain the current harvest level, some of the harvest from pine stands would have to be replaced with harvests from Douglas-fir, larch, spruce and balsam stands. Also, an increased percentage of the pine harvest would have to be taken from dense pine stands containing small diameter timber.

The results of this analysis indicate that under current management assumptions, an even-flow harvest level can be achieved; however, the initial harvest level would have to be lowered immediately to the long-term harvest level of 560 000 cubic metres per year. The analysis results also show that a higher initial harvest rate could be supported given current management. The initial harvest level could be increased to 900 000 cubic metres per year; however, the decline to the long-term harvest level would occur sooner and would be more severe.

Many of the data and assumptions used in the analysis are subject to varying degrees of uncertainty. Sensitivity analysis is used to examine how uncertainty about data and assumptions impact the results of the timber supply analysis. Short-term timber supply is mainly sensitive to tighter forest cover constraints. Volume estimates and large changes in green-up periods may also impact short-term timber supply. Changes in regenerated stand volume estimates have no impact on the short-term harvest level, although the long-term harvest level is significantly affected. Removal of 50% of dense lodgepole pine stands from the timber harvesting land base decreases by one-half the amount of time that the current harvest level can be maintained. All factors evaluated in the sensitivity analyses affect the length of time that the current harvest level can be maintained, and some factors also impact the initial harvest level.

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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 about whether a stand is available for harvest often depend 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 which define current forest management — as well as the uncertainties affecting these conditions — must first be understood.

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

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

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

Timber Supply Area (TSA)

An integrated resource management unit established in accordance with Section 6 of the Forest Act.

Allowable annual cut (AAC)

The allowable rate of timber harvest from a specified area of land. The Chief Forester sets AACs for Timber Supply Areas (TSAs) and Tree Farm Licences (TFLs) in accordance with Section 7 of the Forest Act.

Introduction

Timber supply analysis involves three main steps. The first is collecting and preparing 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 Boundary TSA. Following a brief

description of the area in Section 1, data preparation and formulation of assumptions are discussed in Section 2. Analysis methodology and results are presented in Sections 3 and 4. 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 Boundary Timber Supply Area

The Boundary TSA lies within the Nelson Forest Region (Figure 1). It is administered from the Boundary Forest District office located in Grand Forks and covers 580 110 hectares.

Economic activity in the TSA centres around the towns of Grand Forks, Greenwood and Midway, and is dominated by the forest products industry. The two major mills in the area, located in Midway and in Grand Forks, are both dimension lumber mills owned by Pope and Talbot Ltd. The Boundary TSA supplies most of the wood required for these mills. Other economic activity within the TSA is centred around forage and livestock production, minor forest products, mining, tourism, industrial equipment supply, and service for logging and mining activities.

The current AAC is 900 000 cubic metres per year. Of the base AAC of 700 000 cubic metres, approximately 62% of the AAC is allocated to Pope and Talbot Ltd., 12% is allocated to six other licensees, 25% is harvested through the Small Business Forest Enterprise Program and woodlot

licences administered by the B.C. Forest Service, and 1% of the current AAC is held in a Forest Service Reserve. All harvest from the temporary AAC uplift of 200 000 cubic metres is administered by the Small Business Forest Enterprise Program.

The Boundary TSA is characterized by mountainous topography in the east and rolling topography with flat valley bottoms in the west. Approximately 80% of the Crown productive forest land has medium to good site productivity. Its climate ranges from dry to moist. The TSA supports a diversified range of commercial tree species; Douglas-fir, larch, cedar, hemlock, spruce, balsam, lodgepole pine, white pine, and ponderosa pine are all found within the area. Non-commercial species include birch, aspen, and cottonwood. Lodgepole pine is the most common species in the Boundary TSA and stands dominated by lodgepole pine account for 40% of the Crown productive forest land.

1 Description of the Boundary Timber Supply Area

Figure 1. Map of the Nelson Forest Region showing the Boundary Timber Supply Area.

2 Information Preparation

Many pieces of information are required to conduct a timber supply analysis. Each piece falls into one of three categories: land base inventory, timber growth and yield, and 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 the 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 include land that has been set aside for a park, or areas occupied by power lines, highways or town sites (such non-contributing areas specific to the Boundary 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 these 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. Within that integrated resource context, the timber supply is managed. The timber supply analysis discussed 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 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.

It is important to note that the timber harvesting land base recommendations of the Commission on Resources and the Environment (C.O.R.E.) have not been included in this analysis. All study areas identified under the Protected Areas Strategy are assumed to be available for timber harvesting.

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 deducting non-contributing areas from 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 Boundary TSA, are as follows:

- areas not managed directly by the B.C. Forest Service — these include non-Crown land, areas managed by other agencies (for example, parks, recreation areas) and forest land not administered as part of the TSA (for example, woodlot licences or TFLs).
- non-forest areas — areas not capable of growing productive forest (for example rock, swamp and alpine areas).
- non-commercial cover areas — areas occupied by non-commercial tree or brush species.
- environmentally sensitive areas* — a significant portion of areas defined as environmentally sensitive were deducted from the timber harvesting land base.
- inoperable areas — areas defined as unavailable for harvest for terrain-related or economic reasons. Characteristics used in defining operability* include slope, topography (e.g. the presence of gullies or exposed rock), difficulty of road access, soil stability, elevation and timber quality.
- specific area exclusions — the Troy, Sandner and Texas Creek drainages are excluded from the timber harvesting land base because of inoperability and isolation.
- sites with low timber growing potential (low site index*).
- non-merchantable forest types — areas occupied by timber stands of low volume or

Environmentally sensitive areas

Areas with significant non-timber values or fragile or unstable soils, or where there are impediments to establishing a new tree crop, or where timber harvesting may cause avalanches.

Operability

A classification of the availability of an area for timber harvesting. Operability is determined using the terrain characteristics of the area as well as the quality and quantity of timber on the area.

non-merchantable species. Deciduous stands and stands considered problem forest types fall into this category.

- existing roads, skid trails and landings — to account for the loss of productive forest land that has occurred during past timber harvesting and development, a deduction of 5.0% is applied to all areas occupied by stands that are currently less than 60 years old.
- future roads, trails, and landings — to account for future losses of productive land to development. These areas are initially included in the harvesting land base, and are removed as part of the first harvest.
- not satisfactorily restocked* (NSR) areas — areas designated as NSR in the forest inventory file are initially deducted from the timber harvesting land base but the portion that is considered available for timber harvesting is later added back into the timber harvesting land base. A more complete description of NSR and how it is dealt with in the timber supply analysis is found in Appendix A, Section A.4.5, "Not satisfactorily restocked (NSR) areas."

Table 1 summarizes the areas represented by these categories. A more detailed description of these categories and the rationale for their removal is located in Appendix A, "Description of Data Inputs and Assumptions."

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.

Not satisfactorily restocked

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

2 Information Preparation

Table 1. Timber harvesting land base, Boundary TSA

Classification	Area (hectares)	Per cent of total area	Per cent of productive forest area
Total area on inventory file	580 110	100.0	
Not managed by B.C. Forest Service	(71 867)	12.4	
Non-forest land	(83 173)	14.3	
Total productive forest managed by Forest Service (Crown forest)	425 070	73.3	100.0
Reductions to Crown forest:			
Non-commercial cover	573	0.1	0.1
Environmentally sensitive areas	42 648	7.4	10.0
Inoperable	44 622	7.7	10.5
Specific area exclusions	1 488	0.3	0.4
Sites with low timber growing potential	3 646	0.6	0.9
Non-merchantable types:			
Deciduous types	3 355	0.6	0.8
Problem forest types	14 151	2.4	3.3
Existing roads, trails, landings	3 266	0.6	0.8
Not satisfactorily restocked (NSR)	17 171	3.0	4.0
Total current reduction	-130 920	22.6	30.8
Initial timber harvesting land base (less NSR)	294 150	50.7	69.2
Additions:			
Not satisfactorily restocked ^a	15 251	2.7	3.6
Restocked NSR	1 920	0.3	0.4
Total additions	+17 171	3.0	4.0
Current timber harvesting land base	311 321	53.7	73.2
Future reductions:			
Future roads, trails, landings	-12 330	2.1	2.9
Future timber harvesting land base	298 991	51.5	70.3

(a) All NSR land is initially deducted from the timber harvesting land base. The portion of NSR area considered available for timber production, as determined from the forest inventory file, is then added to the timber harvesting land base.

2 Information Preparation

Figure 2 shows both the total area and the Crown forest area of the Boundary TSA. The total area chart shows that over 70% of the TSA is Crown forest. Approximately three-quarters of the Crown

productive forest land is available for timber harvesting, as shown in the Crown forest chart. Overall, over half (53.7%) of the total Boundary TSA area is available for timber harvesting (see Table 1).

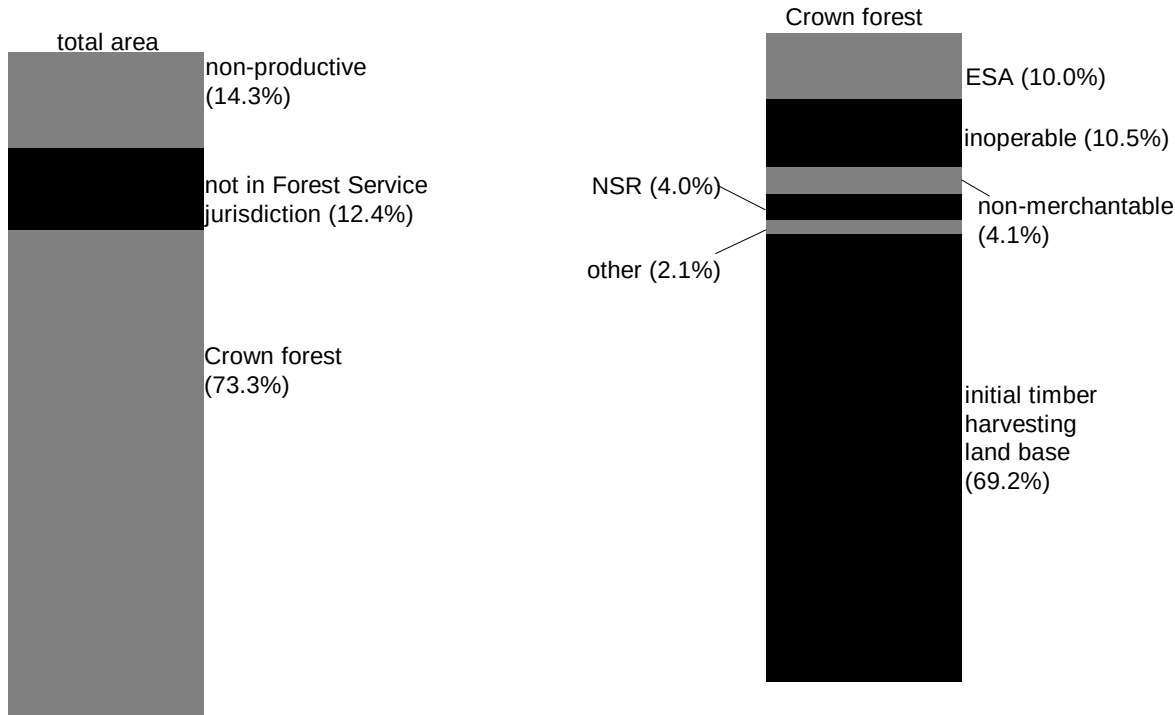


Figure 2. Land base classification, Boundary TSA.

2 Information Preparation

Figure 3 shows the age class distribution of forest stands on the current timber harvesting land base. Stand ages are grouped into 20-year age classes, except for the oldest stands. This figure shows that there is significant variation in the amount of area in each age class. For example, age class 21-40 accounts

for 1.9% of the timber harvesting land base, as opposed to age class 61-80, which accounts for 29.7% of the area available for timber harvesting. The large proportion of stands in age classes 61-80 and 81-100 is a result of the fire history of the area.

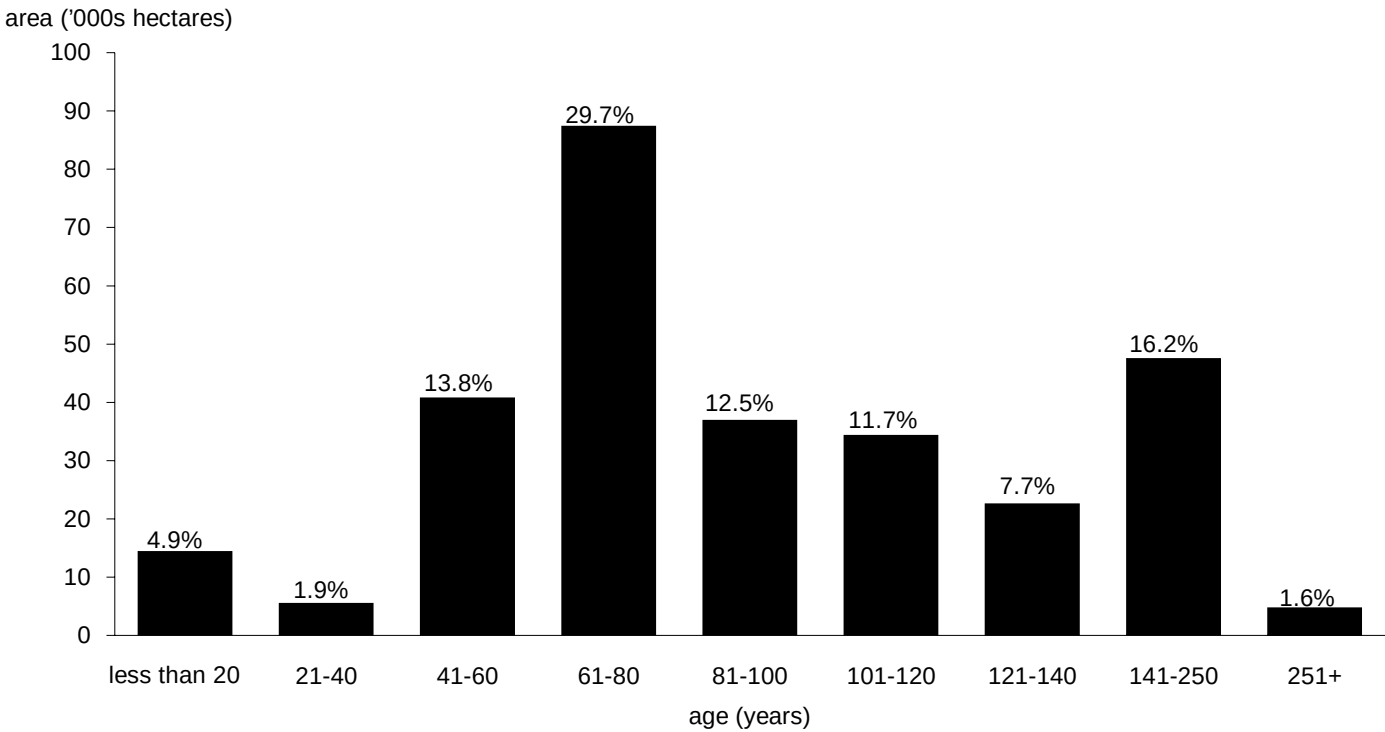


Figure 3. Current age class distribution of forest stands, Boundary TSA timber harvesting land base.

2 Information Preparation

Figure 4 summarizes the tree species composition of the timber harvesting land base. Lodgepole pine forest types are the most prevalent, accounting for 41% of the area, with larch and Douglas-fir forest types the next most common. Other forest types,

including spruce, balsam, cedar, and hemlock, account for about one-fifth of the timber harvesting land base. This figure also shows that a large percentage of the timber harvesting land base (over 63%) is covered by immature stands.

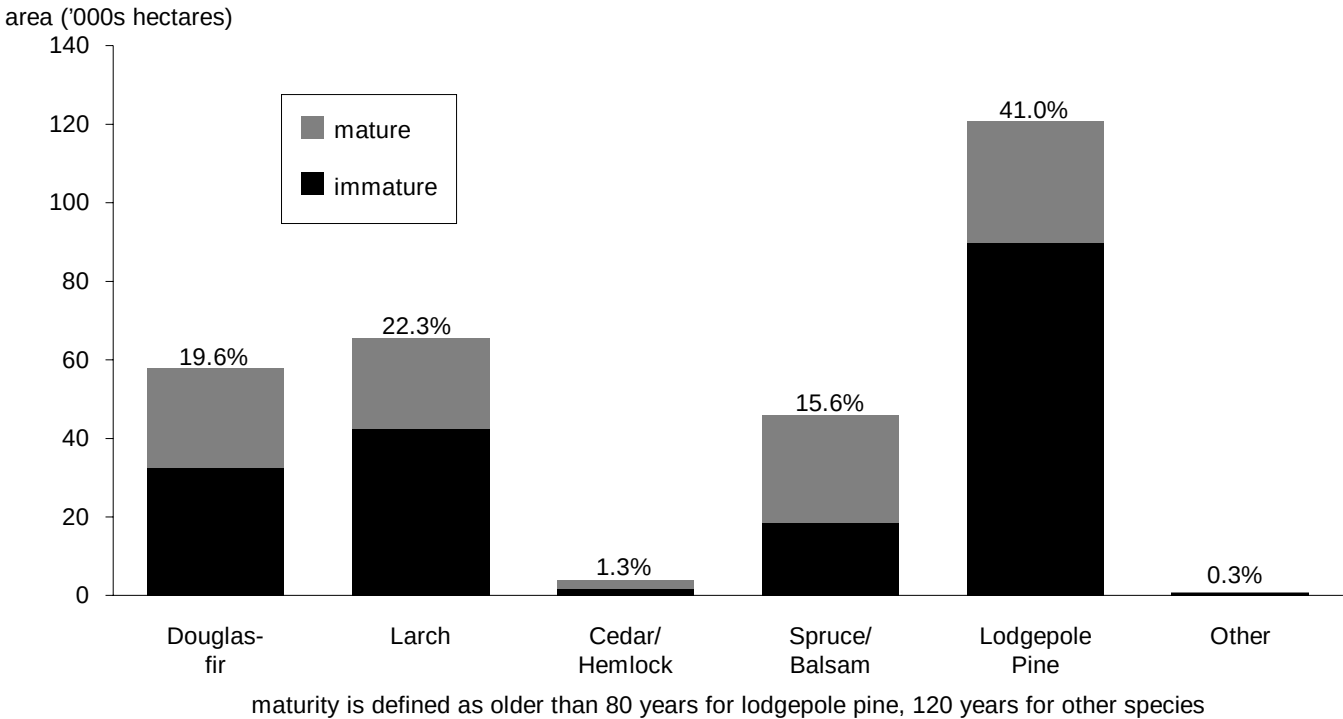


Figure 4. Area by dominant tree species, Boundary TSA timber harvesting land base.

2 Information Preparation

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.

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. Timber volumes estimated for regenerated second-growth stands are based on the Table Interpolation Program for Stand Yields (TIPSY) model developed by the B.C. Forest Service, Research Branch. 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 Boundary Forest District and in the Nelson 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;
- forest health and unsalvaged losses — expected losses of merchantable timber due to fire, pest (insects, disease, animals) and wind damage. Wildlife trees and seed trees are included in this category;
- cutblock adjacency* and green-up*— guidelines that specify that harvested stands must reach a desired condition, or green-up, before adjacent mature timber may be harvested;
- forest cover objectives* — specify the desired distribution of areas by age (e.g. at least 70% of the area should be more than 40 years old). These objectives are used to specify general adjacency and green-up guidelines as well as desired conditions for wildlife, watershed protection and visual quality objectives* (VQOs);

Management assumptions

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

Free-growing stands

Stands composed of sufficient seedlings of an acceptable commercial species that are free from growth-inhibiting brush, weed and excessive tree competition.

Cutblock adjacency

The desired spatial relationship among cutblocks as specified in integrated resource management guidelines. They can be approximated by specifying the maximum allowable proportion of a forested landscape that does not meet green-up requirements.

Green-up

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

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)

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.

2 Information Preparation

- utilization levels — minimum size limits for trees and logs that must be harvested and removed from a site. The standard utilization levels for the Interior of British Columbia are used in this timber supply analysis and are presented in Appendix A, "Description of Data Inputs and Assumptions."
- minimum harvestable ages — the time it takes for stands to grow to a harvestable size. The minimum harvest age defines the youngest age at which a specific type of stand is expected to be available for harvest. Actual harvest age may be greater, but not less than the minimum, and will depend on ages of other stands, forest cover objectives (e.g. for adjacency or old growth), and overall harvest level targets. The minimum harvestable age for dense lodgepole pine stands is 40 years greater than that of other pine stands because these dense stands require more time to reach a harvestable size; and
- rate of restocking of current and backlog NSR — the schedule of restocking by species and area can be found in Appendix A, Section A.4.5 (Table A-11).

A more detailed description of the management assumptions is provided in Appendix A, "Description of Data Inputs and Assumptions."

2.4 Management zones

To assess the timber supply impacts of current integrated resource management practices, areas in

the Boundary TSA timber harvesting land base are assigned to one of five management zones (Figure 5). These five zones are established according to the main management concerns and objectives for the area, and are described as follows:

- Community watersheds — areas given a community watershed designation;
- Wildlife corridors and winter range — areas mapped as wildlife corridors and designated as ungulate winter range based on desirable forest stand characteristics;
- Visual quality — areas classified and approved as having a visual quality objective (VQO) of either retention* or partial retention*. The maintenance of scenic landscapes is a management priority in these areas;
- Integrated resource management (IRM) — all areas within the timber harvesting land base not specifically assigned to another zone; and
- Uneven-aged management — areas where dry-belt Douglas-fir, larch, and ponderosa pine forest types predominate; entails the use of a number of non-clearcutting silvicultural systems.

A detailed discussion of the management assumptions applied to each zone can be found in Appendix A, "Description of Data Inputs and Assumptions."

Retention VQO

Alterations are not easy to see. Up to 5% of the visible landscape can be altered by harvesting activity.

Partial retention VQO

Alterations are visible but not conspicuous. Up to 15% of the area can be visibly altered by harvesting activity (see Visual quality objective).

2 Information Preparation

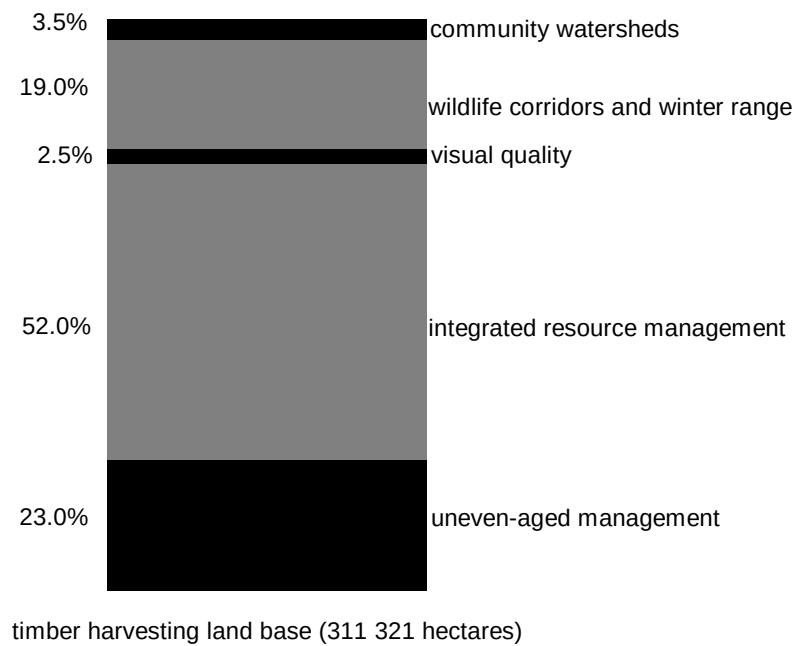


Figure 5. Management zones, Boundary TSA timber harvesting land base.

3 Analysis Methods

The purpose of this analysis was to examine both the short- and long-term timber harvesting opportunities in the Boundary 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 distinct from a growth and yield model, assists the timber supply analyst in determining how a whole forest (collection of stands) could be managed to obtain a harvest forecast (supply of timber over time). The simulation model uses information about the timber harvesting land base, timber volumes, and the management regime to represent how trees grow and are harvested over a period of up to 400 years. Generally, only the results for the first 200 years are shown graphically in this report because the harvest remains constant from 200 to 400 years from now.

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 most other models in that it allows the use of forest cover guidelines that specify the desired age composition of the forest. These 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 percentage of the forest can be younger than a specified green-up age, or that some minimum percentage of the forest 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 are not meant to be taken as recommendations of any particular AAC.**

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

4 Results

This section presents results of the timber supply analysis for the Boundary TSA. The analysis uses the most recent assessments of current forest management, the land available for timber harvesting, and timber yields as described in Section 2, "Information Preparation." These results will be referred to as the base case because they form the basis for comparison when assessing the effects of uncertainty on timber supply. Because forest management is inherently a very long-term venture, uncertainty surrounds much of the information important in determining timber supply. These factors will be discussed in Section 5, "Timber Supply Sensitivity Analyses." The base case provides only a part of the timber supply picture in the Boundary TSA, and should not be viewed in isolation of the sensitivity analysis.

4.1 Harvest forecast

The base case harvest forecast* for the Boundary TSA is shown in Figure 6. The initial harvest level is equal to the current base harvest level of 700 000 cubic metres per year. A harvest forecast that examines the temporary AAC uplift of 200 000 cubic metres for Mountain Pine Beetle harvest is shown in Section 5.1, "Alternative initial harvest levels and harvest flows over time," Figure 15. The temporary AAC uplift

currently in effect was not included in the initial harvest level because its forest management objective has already been achieved and the current harvest is approximately 700 000 cubic metres. Also, the AAC uplift is scheduled to expire December 31, 1995 which almost excludes it completely from the base case forecast period.

The initial harvest level is maintained for as long as possible (8 decades), after which the harvest declines 10% per decade until the long-term harvest level is reached in decade 10. The long-term harvest level is 560 000 cubic metres per year, a 20% decline from the initial harvest level.

The estimated unsalvaged losses due to fire, pests and wind damage, and losses of timber due to retention of wildlife trees and seed trees have been subtracted from all harvest forecasts shown in this report. These losses are estimated to total 50 400 cubic metres per year.

Several criteria were used to define the base case harvest forecast. The initial harvest level was defined by attempting to maintain the current harvest level of 700 000 cubic metres per year for as long as possible, declining by a maximum of 10% in each of the following decades, and avoiding harvest shortfalls below the long-term harvest level.

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.

4 Results

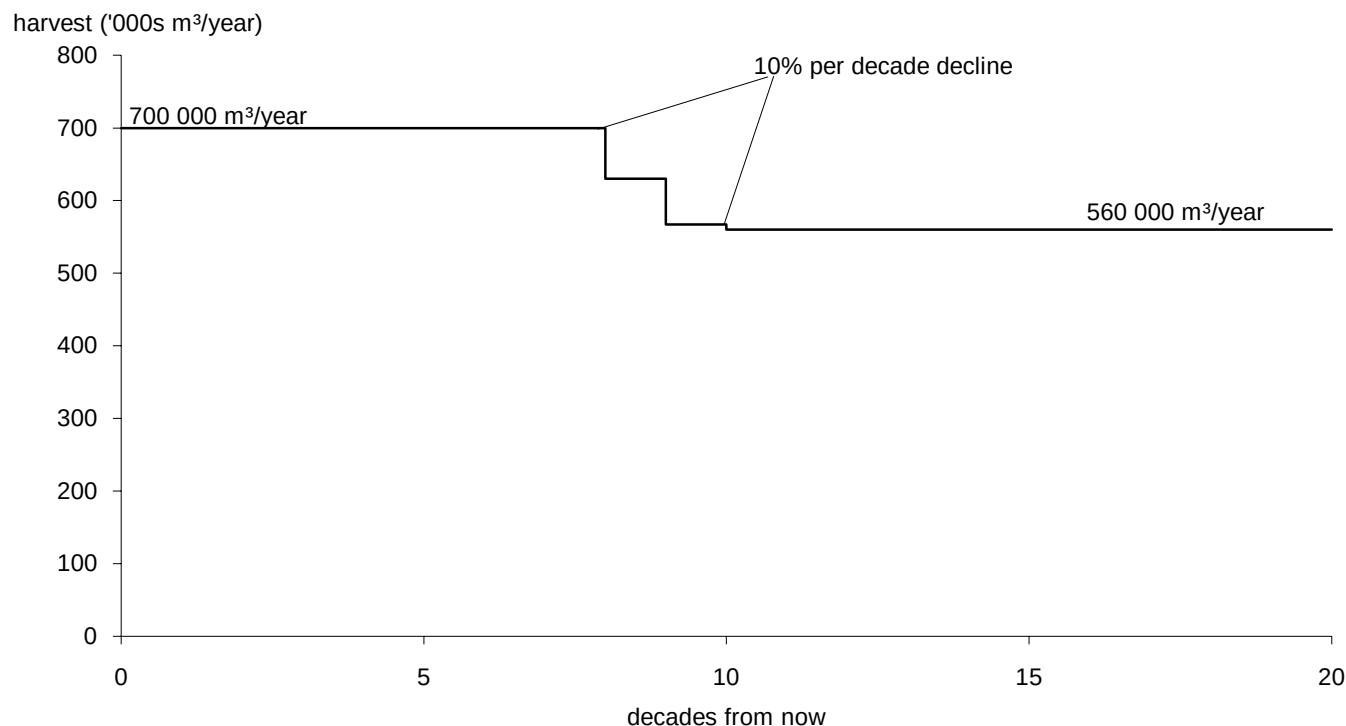


Figure 6. The base case harvest forecast, Boundary TSA.

The long-term harvest level was set to maintain timber growing stock* at an even level once most of the older timber is harvested. Figure 7 shows the growing stock volume over time. A constant volume of growing stock indicates that the long-term harvest level can be maintained in perpetuity. Conversely, a declining volume of growing stock indicates that the long-term harvest level exceeds the productive capability of the land. The available growing stock, which is the growing stock volume of stands above the minimum harvestable age, is also shown in Figure 7.

The total and available growing stock forecasts indicate a declining trend in growing stock inventory between now and decade 10 as the existing mature timber is harvested and replaced by second-growth stands. After decade 10, the growing stock stays

relatively stable for the remainder of the planning horizon.

The long-term harvest level is not the same as a theoretical maximum sustainable harvest level based on the maximum mean annual increment (MAI)*. This theoretical level of about 684 000 cubic metres per year is not achievable, partly because stands are not necessarily harvested at the age that would maximize the volume produced over the long term. The harvest ages vary because of the applied minimum harvestable ages, forest cover objectives, and practical limitations on scheduling harvests. Another reason that the maximum sustainable harvest level is not achieved is that the harvest forecasts shown in this analysis have been reduced by the expected unsalvaged losses of 50 400 cubic metres per year.

Growing stock

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

Mean annual increment (MAI)

Stand volume divided by stand age. The age at which average stand growth, or MAI, assumes its maximum is called the culmination age. Harvesting all stands at this age results in a maximum average harvest over the long term.

4 Results

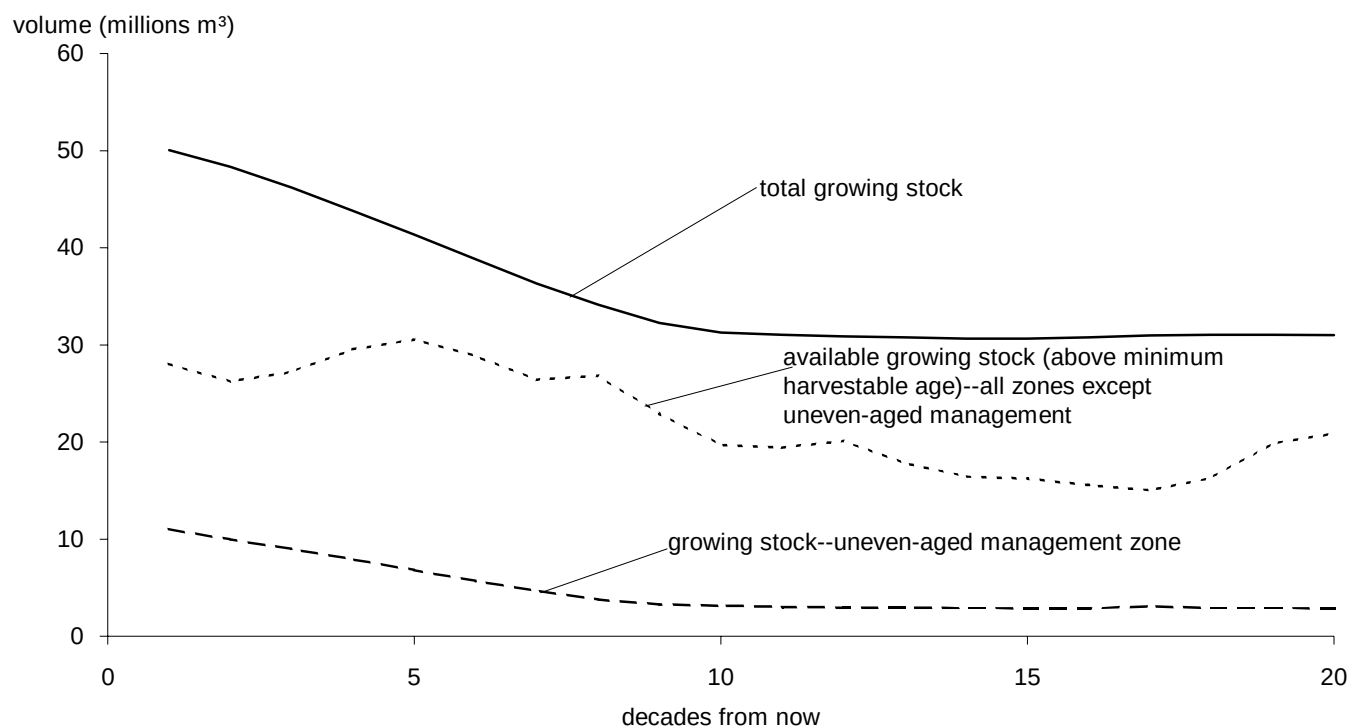


Figure 7. Growing stock over time, Boundary TSA base case.

4.2 Age class distribution over time

Figure 8 shows the changes in the age class distribution of stands on the timber harvesting land base over a 200-year planning horizon. The uneven-aged management zone, which includes Douglas-fir, larch, and ponderosa pine stands, is not included in Figure 8 because these stands do not have a defined age. Stands managed under an uneven-aged management regime consist of trees that are of different ages and thus do not fall into a single age class. Also, Figure 8 does not include those forest stands excluded from the timber harvesting land base due to environmental sensitivity, inoperability, and low commercial value. These stands represent 31% of the Crown forest. Many of these excluded stands are older and if they were included in the timber

harvesting land base, the age class distribution would look different.

Initially, there is a wide range of age classes, but over time the older stands are harvested. After 100 years, the age class distribution is more balanced and there are no gaps in the younger age classes. A balanced age class structure helps in achieving a regular flow of timber because a constant portion of the forest remains at or near the age of maturity and suitable for harvest. After 200 years, stands between the ages of 140 and 200 years still exist, but by then the majority of the forest on the timber harvesting land base is less than 120 years old. The older stands represent the area being managed to meet some of the forest cover requirements. This timber will eventually be harvested, but over an extended period of time.

4 Results

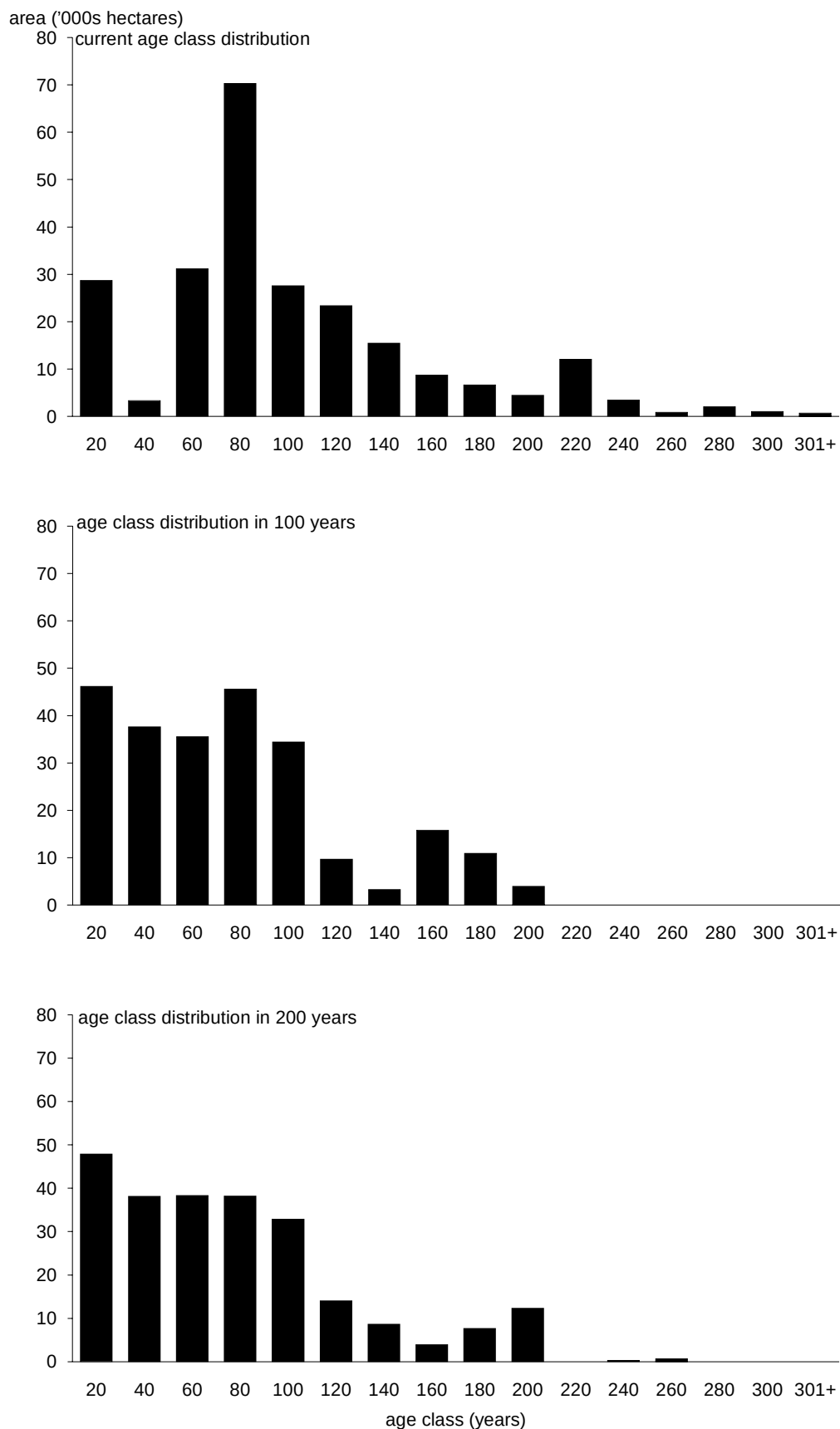


Figure 8. Changes in age class distribution over time, Boundary TSA base case.

4 Results

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

Figure 9 shows the total area harvested each year from the uneven-aged management zone (selection management*) and from all other zones (clearcut harvesting*). Areas depleted as a result of fires, insect infestations, disease, windthrow or other natural factors that are not expected to be salvaged have not been included in this figure.

The area that is clearcut increases from 1650 hectares per year in decade 1 to 1950 hectares in decade 3. Beyond decade 3, the area harvested by this method stays relatively stable, except for a decline between decades 9 and 12 that reflects the decline in overall harvest levels during that time period.

The area harvested under selection management is equivalent to 793 hectares annually for the first 7 decades. Beyond decade 7, the area harvested varies

between 626 and 839 hectares annually, with an average annual harvest of approximately 750 hectares. The area that is harvested by selection management varies according to the availability of eligible stands.

It is important to note the distinction between areas harvested by clearcutting and selection methods. Clearcut harvesting (even-aged management) removes most of the forest cover and therefore most of the volume is removed from the site. Under selection management, by harvesting individual trees or small patches of trees, only a portion of the volume of timber in a stand is removed. Under selection management, therefore, much more area must be entered into for harvesting to produce the same volume of timber as clearcutting.

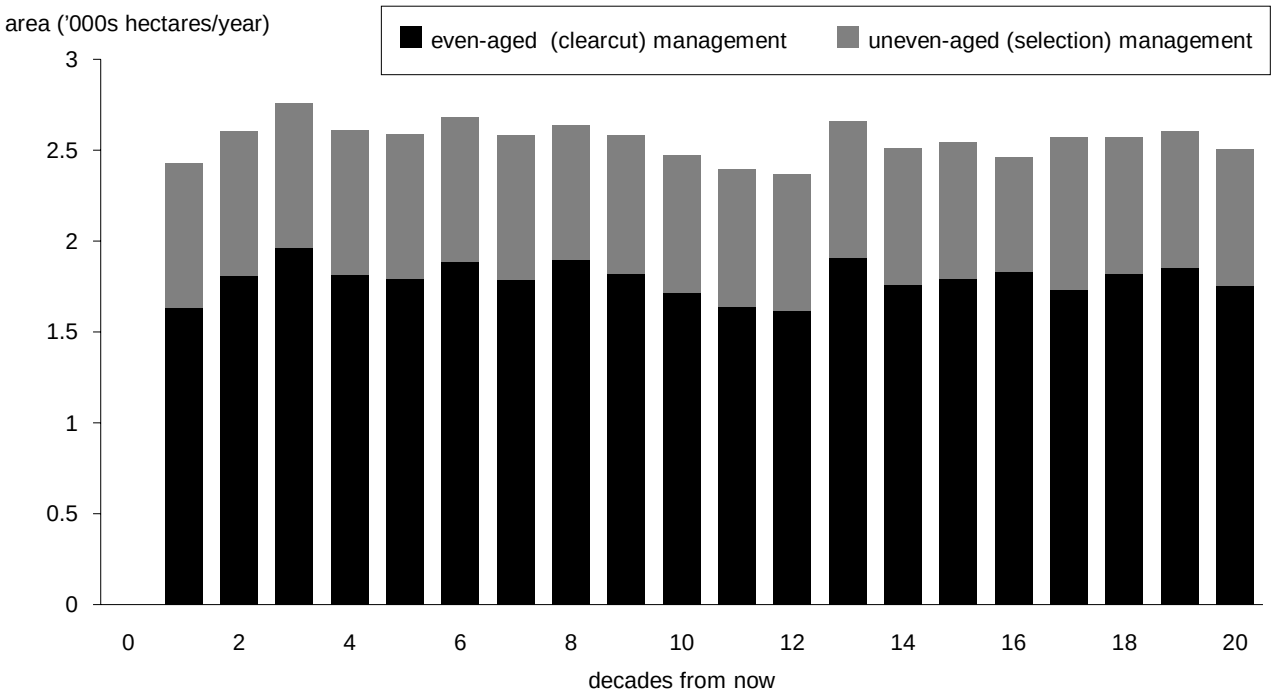


Figure 9. Area harvested annually, Boundary TSA base case.

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.

Clearcut 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.

4 Results

The change in the average age of harvested stands over time is shown in Figure 10. Stands harvested under an uneven-aged management system are not included here because they consist of trees of a wide range of ages and as a result, the stands do not fall into a single age class. The average harvest age rises from about 195 years in decade 1 to 211 years in decade 2, then rapidly declines to about 130 years in decade 4. The average age then remains relatively stable from decades 5 to 20 at about 131 years.

The changes that are projected to occur in the average age of harvested stands can be explained by

several observations. In decade 1, 50% of the harvest is from lodgepole pine forest types. Due to the scarcity of old lodgepole pine, the pine harvest is taken from younger stands than in the other forest types. These younger pine stands cause the average harvest age to be lower than it might be otherwise. In decade 2, harvesting occurs in the oldest available stands, regardless of forest type, and this results in a higher average harvest age. After decade 2, the average harvest age rapidly declines as the oldest timber is removed and harvesting switches to second-growth stands.

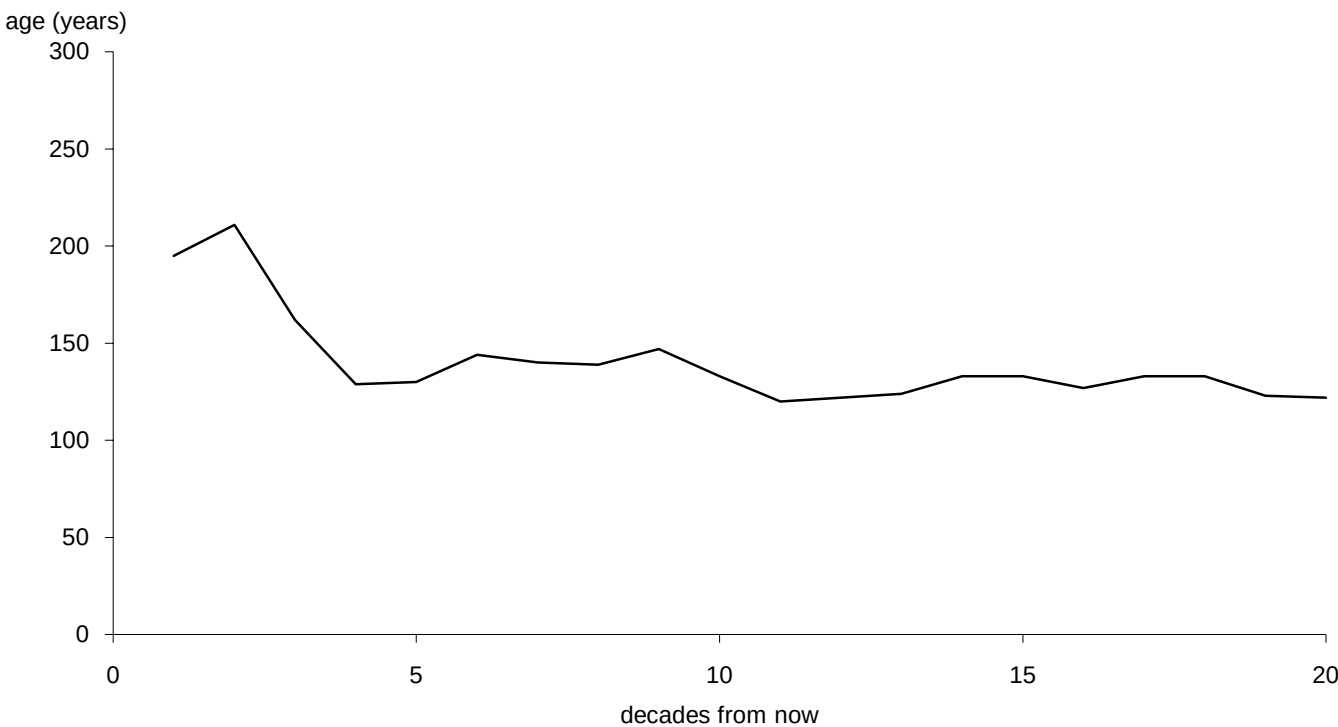


Figure 10. Average age of harvested stands over time, Boundary TSA base case.

Figure 11 shows the changes in average volume harvested per hectare over time. The average annual volume harvested per hectare from clearcut harvested stands is 296 cubic metres per year in decade 1. The average volume declines gradually until decade 13. From decades 14 to 20, average volumes harvested per hectare remain relatively stable at 255 cubic metres per hectare.

Similarly, the harvested volume per hectare under uneven-aged management also shows a decrease from 90 cubic metres per hectare in the

first decade to about 46 cubic metres per hectare in decade 12. The volume per hectare removed from selection management stands is expected to be the highest the first time a stand is subject to timber harvesting (the first entry). The decline in the average annual volume harvested is due to the decrease in first-entry harvests as time passes. The average volume per hectare harvested decreases until it steadies at 46 cubic metres per hectare. At this point, this average volume per hectare is harvested from a stand every 25 to 30 years.

4 Results

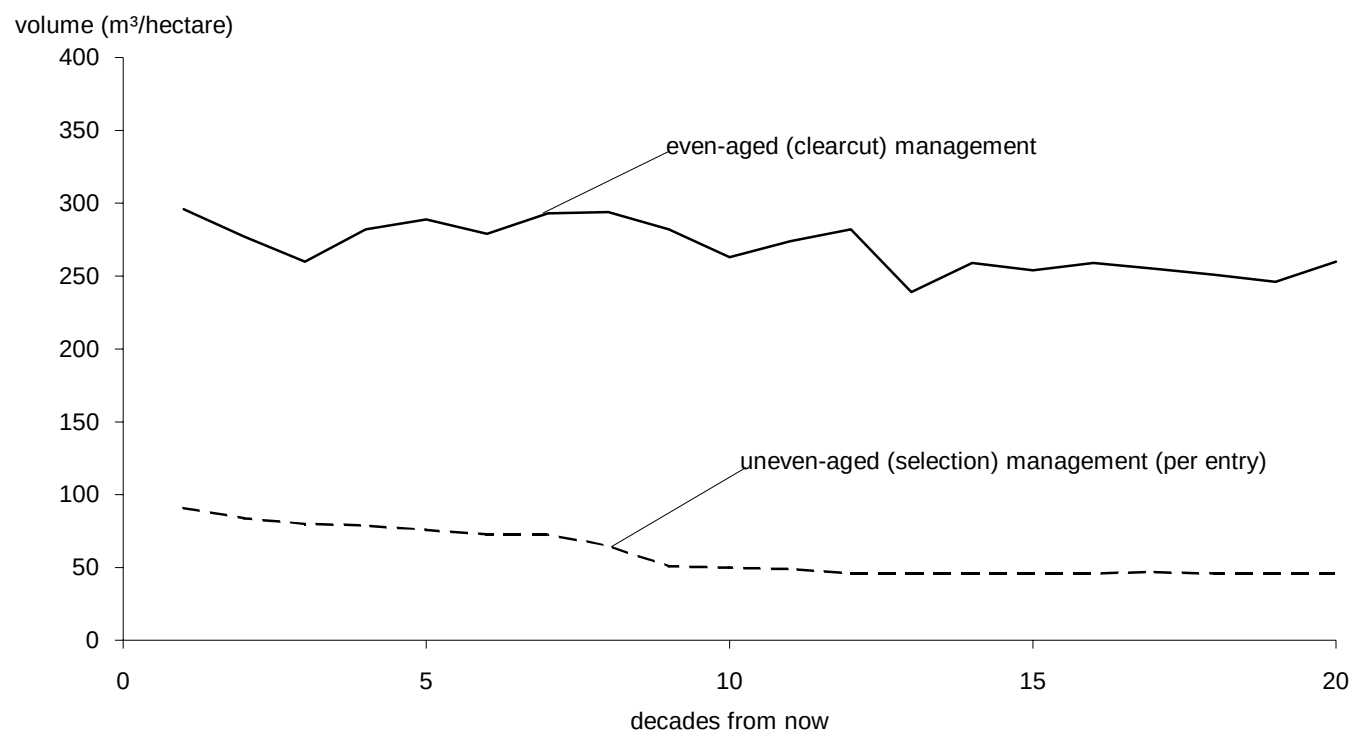


Figure 11. Average harvest yield per hectare over time, Boundary TSA base case.

4.4 Harvest profile

In the past, the percentage of lodgepole pine harvested has exceeded the representation of lodgepole pine forest types in the timber harvesting land base. Pine has historically made up more than 70% of the harvest but only represents 41% of the timber harvesting land base. The harvest has been concentrated in pine stands mainly because this timber is susceptible to mountain pine beetle attack. In modelling this trend for this analysis, 50% of the harvest in the first decade comes from lodgepole pine forest types. After decade 1, the oldest available timber is harvested, regardless of forest type.

Figure 12 shows a comparison between the species composition of the timber harvesting land base, the desired species composition of the harvest, and the actual harvest composition that can be achieved. Only about 34% of the harvest in the first decade is taken from lodgepole pine forest types.

The remaining harvest comes from the oldest stands available in the other forest types. The desired pine component of the harvest cannot be achieved in decade 1 because the majority of existing pine stands are younger than the minimum harvestable age. This situation can be attributed to past logging practices, the fire history in the area, integrated resource management constraints, and the lengthy minimum harvestable age for dense lodgepole pine stands. Forty years was added to the minimum harvestable age for pine stands to reflect the additional time that is required for these dense pine stands to reach a harvestable size.

Figure 13 shows that a wide range of age classes above the minimum harvestable age are represented in the harvest in decade 1. Figure 13 also shows that the stands harvested at younger ages are lodgepole pine forest types. Note that this figure does not include the harvest from the uneven-aged management zone.

4 Results

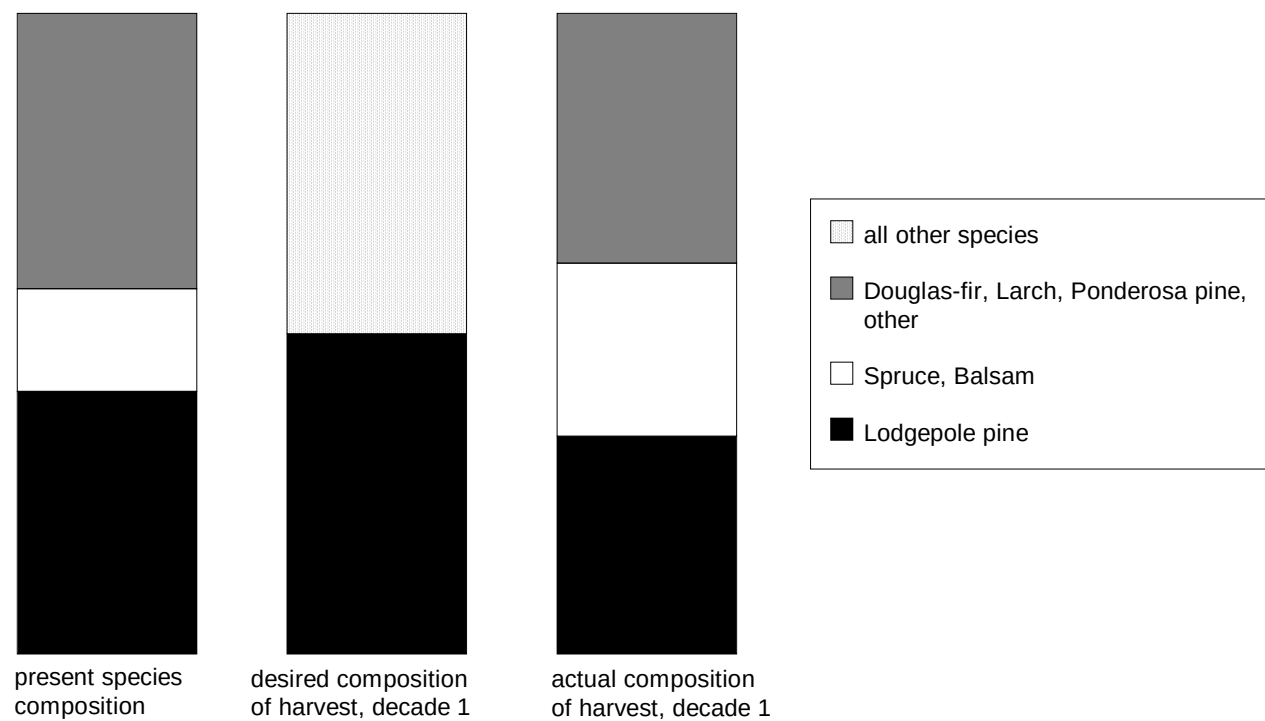


Figure 12. Comparison of the present species composition to the species composition of the harvest in decade 1, Boundary TSA base case.

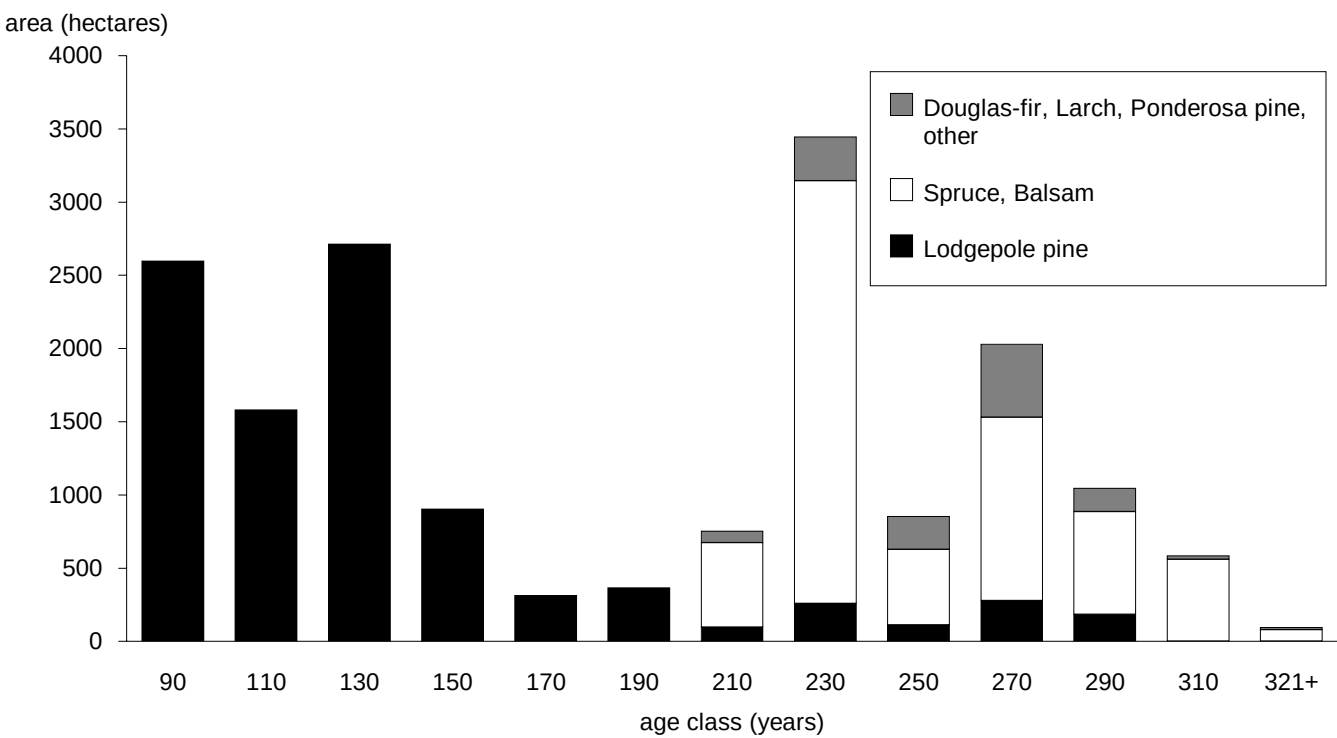


Figure 13. Age class distribution of stands harvested in decade 1, Boundary TSA base case.

5 Timber Supply Sensitivity Analyses

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

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

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

This report does not advocate any of these positions. One of its goals is to supply information to

assist people with different attitudes towards forest management and uncertainty to provide input.

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

In this section, results of several sensitivity analyses are discussed. The results that are based on current forest management assumptions (shown in Figures 6-13) are referred to as the base case.

5.1 Alternative initial harvest levels and harvest flows over time

The base case harvest forecast shown in Figure 6 was defined by maintaining the current harvest level of 700 000 cubic metres per year for as long as possible and then gradually declining to the long-term level for the remainder of the planning horizon. These criteria result in a harvest flow of 700 000 cubic metres for 8 decades and a 10% per decade decline to 560 000 cubic metres per year. However, many other harvest flows are possible, with different starting harvest levels and rates of decline.

Figure 14 illustrates the harvest flow pattern that results when initial harvest rates 15% higher and lower than the base case are used. The 15% higher initial rate of 805 000 cubic metres per year can be maintained for 3 decades before it starts to decline to the long-term harvest level of 560 000 cubic metres per year. The 15% lower rate (595 000 cubic metres per year) can be maintained for 26 decades before declining to the long-term harvest level. Figure 14 also shows an even-flow harvest forecast in which the harvest level is set at the long-term harvest level for the entire planning horizon.

5 Timber Supply Sensitivity Analyses

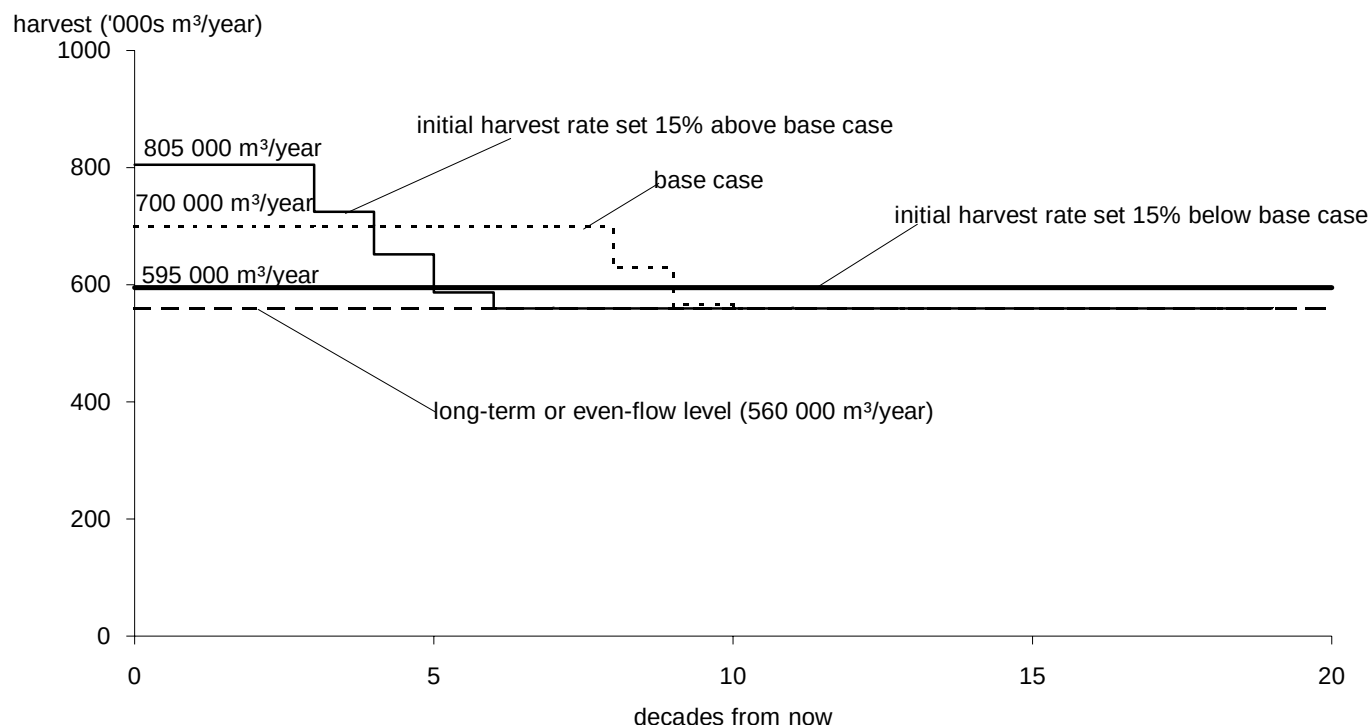


Figure 14. Alternative harvest flow patterns using base case data, Boundary TSA.

Figure 14 shows harvest flow patterns which are feasible based on the current management assumptions used in this timber supply analysis. None of the initial harvest rates shown in Figure 14 result in a significant shortfall in timber supply. However, extraordinary losses to mountain pine beetle, root rot, or a large fire in addition to harvesting at these levels could cause significant shortfalls in future timber supply.

In the recent past, actual harvests in the Boundary TSA have been approximately 900 000 cubic metres per year as a result an uplift of 200 000 cubic metres per year to control mountain pine beetle. Figure 15 shows that an initial harvest level of 900 000 cubic metres can only be maintained

for 2 decades before a lack of available mature timber causes a decline in the harvest level. Serious disruptions in the timber supply happen between decades 8 and 14 because of the earlier elevated harvest levels. This figure shows that if this elevated harvest rate were to be reinstated and maintained for several decades, the long-term harvest level could be jeopardized.

These harvest flow alternatives show that the initial harvest level can be increased beyond that of the base case; however, this increase can cause significant drops below the long-term harvest level. Similarly, if the initial harvest level is lower than that of the base case, the timber supply is able to support a slightly higher long-term harvest level.

5 Timber Supply Sensitivity Analyses

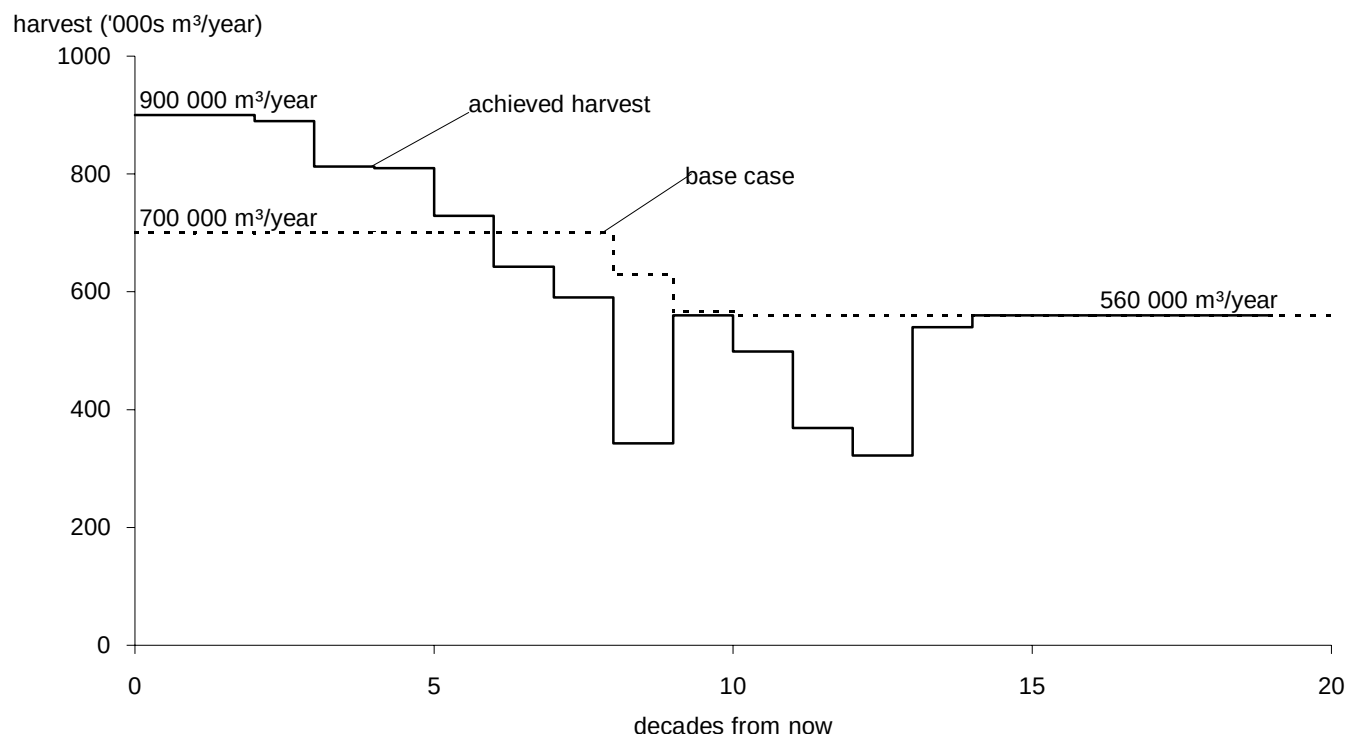


Figure 15. Harvest forecast with an initial harvest level of 900 000 cubic metres per year, Boundary TSA.

5.2 Uncertainty in minimum harvestable ages

In the base case, minimum harvestable ages have been established according to two main considerations. First, for stands to be considered harvestable, they must consist of trees large enough to be harvested economically. Second, sites must be protected from frequent logging disturbances and possible site degradation. Using these criteria, minimum harvestable ages range from 60 to 120 years, depending on the forest type. Actual harvest ages are generally higher, as indicated in Figure 10. The purpose of this analysis is to test the impact of increasing and decreasing minimum harvestable ages by 20 years.

As shown in Figure 16, when minimum harvestable ages are increased by 20 years, the starting harvest level can be maintained for 5 decades before the decline to the long-term harvest level is required. The long-term level of 555 000 is slightly lower than the base case long-term harvest level of 560 000 cubic metres per year because stands are harvested at slightly different ages than in the base case.

When minimum harvestable ages are decreased by 20 years the harvest forecast remains the same as the base case, indicating that the minimum harvestable ages are not limiting to timber supply in the base case.

These results show that timber supply is only slightly sensitive to uncertainty in minimum harvestable ages.

5 Timber Supply Sensitivity Analyses

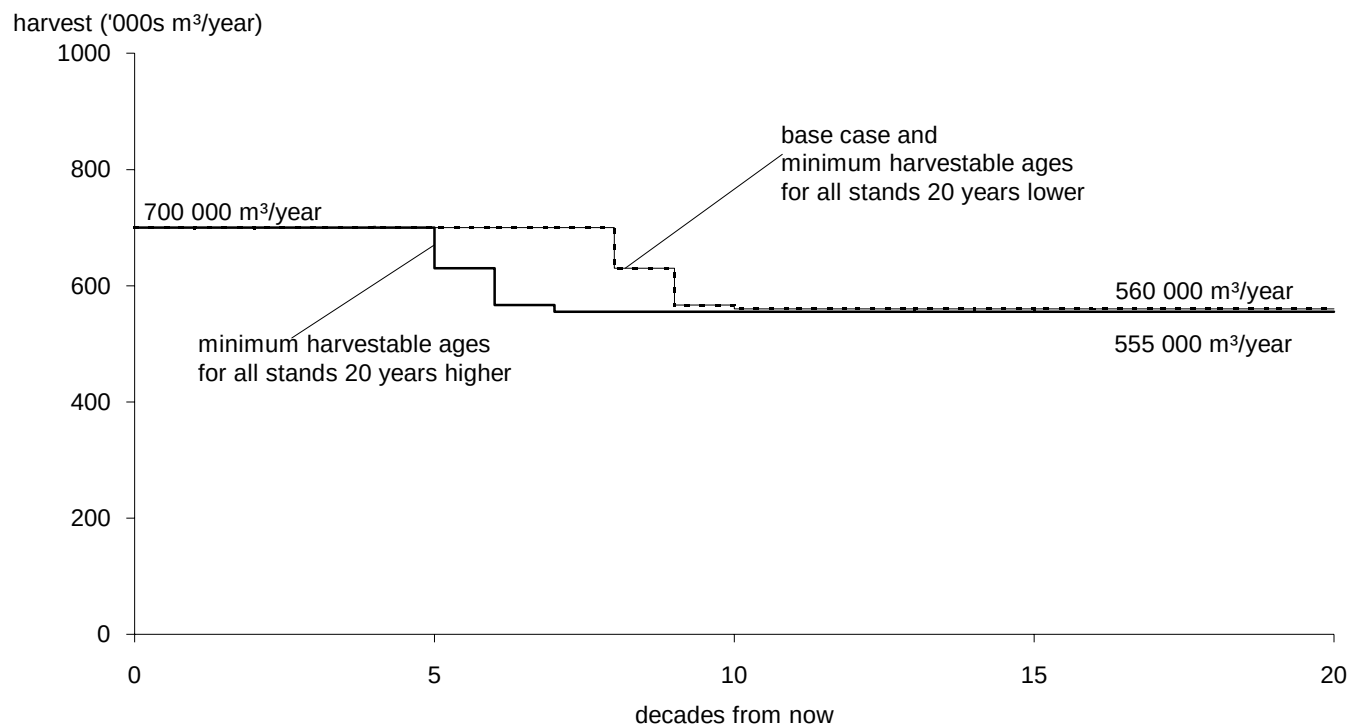


Figure 16. Harvest forecasts when minimum harvestable ages are changed by 20 years, Boundary TSA.

5.3 Uncertainty in existing stand volume estimates

Estimates of timber volumes in existing stands are subject to uncertainty because they are based on statistics from some stands extrapolated to all stands in an area, and on inventory classifications which contain uncertainty. The volumes are more accurate when averaged over large areas than they are for estimating volumes in a specific stand.

This sensitivity analysis examines the effect on the harvest forecast of increasing or decreasing volume estimates for existing stands by 10%. Existing stands include both naturally growing and managed stands. The Variable Density Yield Prediction (VDYP) system was used to produce volume estimates for natural stands, which represent 92% of the existing forest. The Table Interpolation Program for Stand Yields (TIPSY) was used to produce volume estimates for managed stands, which include plantations less than 11 years old and restocked NSR land.

If volume estimates for existing stands are 10% higher than assumed in the base case, the current harvest level can be maintained for 14 decades (Figure 17). On the other hand, if volume estimates are 10% lower, the current harvest level of 700 000 cubic metres per year can only be maintained for 1 decade. The harvest level must then be reduced if the harvest flow objective of avoiding significant declines below the long-term harvest level is to be achieved. The current harvest level cannot be maintained beyond decade 1 mainly because of how the decrease in stand volumes affects the fulfillment of forest cover requirements. If the volume of timber per hectare obtained from each area harvested decreases, then more areas must be harvested to obtain the same total volume. However, forest cover guidelines limit the amount of area that is not greened-up at any given time, and have a significant impact on the short-term timber supply when the total amount of harvested area increases. As a result, the starting harvest level must be reduced much earlier to prevent a shortage of timber in later years.

5 Timber Supply Sensitivity Analyses

The uncertainty in volume estimates for existing stands does not affect the long-term harvest level because most stands harvested after decade 8 or 9 are regenerated stands with volume estimates unchanged

from the base case. However, there is a moderate effect on the timber supply in the short and intermediate terms.

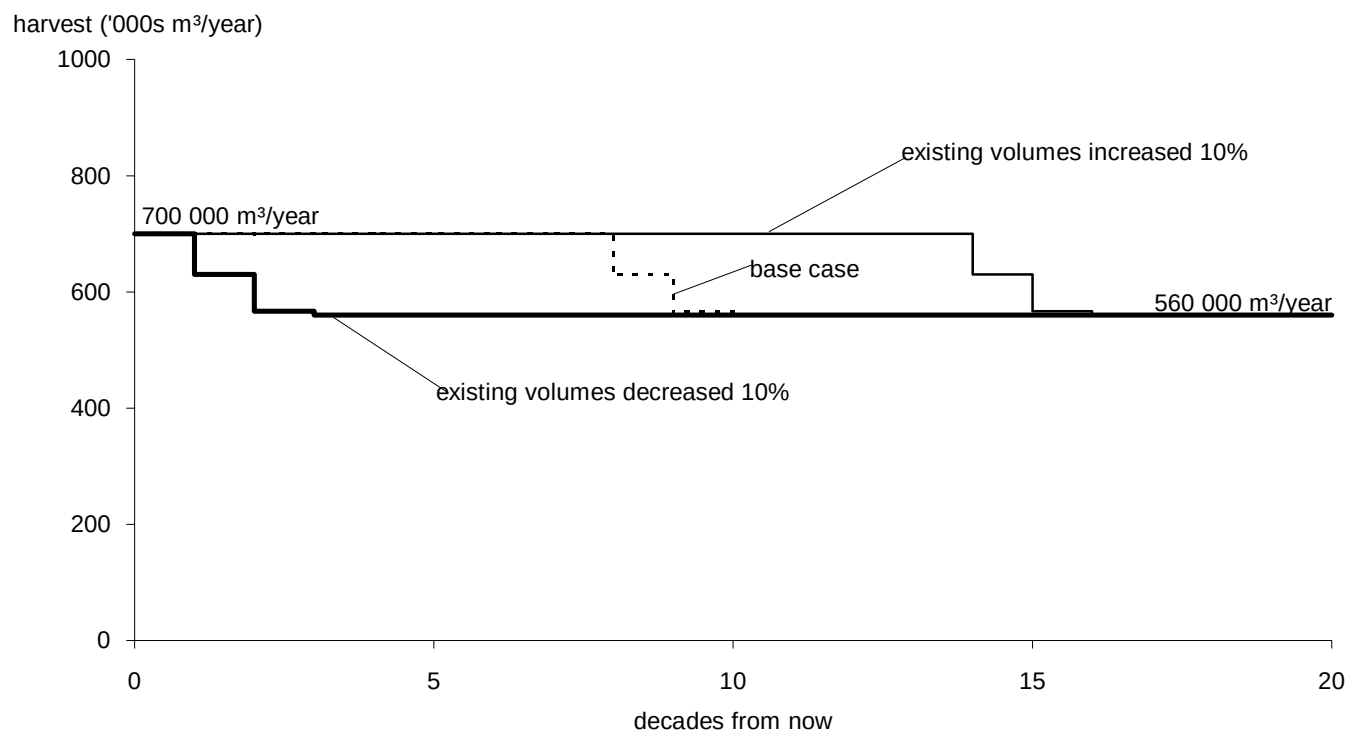


Figure 17. Harvest forecasts when existing stand volume estimates are changed by 10%, Boundary TSA..

5.4 Uncertainty in regenerated stand volume estimates

As previously mentioned, regenerated (future) stand volumes are estimated using the TIPSy growth and yield model. These managed stands are expected to produce more timber volume per hectare than existing natural stands. As a result, in this analysis, volume estimates for regenerated stands are generally higher than existing stand volume estimates.

Aside from the factors discussed in the Section 5.3, "Uncertainty in existing stand volume estimates," volume estimates can be affected further

by management practices. Future stand volume estimates involve more prediction of these factors than do estimates of existing stand volumes. Factors such as the species mix favoured in the future and volumes lost to root rot, for example, increase the uncertainty in future stand volume estimates. This analysis looks at the impact of increasing and decreasing all regenerated stand volumes by 20%. In addition, this sensitivity analysis examines the effect of using the volume estimates for existing stands as the volume estimates for future stands.

5 Timber Supply Sensitivity Analyses

If volume estimates for future stands are 20% lower than assumed in the base case, the current harvest level can be maintained for 6 decades, instead of 8 decades as in the base case (see Figure 18). The long-term harvest level declines from 560 000 to 440 000 cubic metres per year, a level 21.4% lower than in the base case.

If, on the other hand, future volumes exceed base case estimates by 20%, the initial harvest level of 700 000 cubic metres per year can be maintained for 8 decades (light solid line, Figure 18). The harvest then declines by 10% to 630 000 cubic metres per year for 3 decades before rising to a long-term harvest level of 677 000 cubic metres per year. The long-term harvest level is 20.1% higher than in the base case. The drop below the long-term harvest level between decades 8 and 11 occurs because there is a limited

amount of mature timber available during this period. As shown in Figure 3, there is initially a shortage of stands in the 21-40 year age class. These are the stands that would be maturing between decades 8 and 11. Timber would have to be reserved from earlier periods in order to compensate for the shortage of mature timber at this time. The dashed line in Figure 18 shows the effect on the harvest forecast if, rather than maintaining the initial harvest level at 20% above the long-term harvest level for 10 decades, the initial harvest level declines slightly in decade 2. As a result of this decline, the harvest level does not drop below the long-term level. These two harvest forecasts illustrate the potential trade-offs associated with different short- and long-term harvest levels.

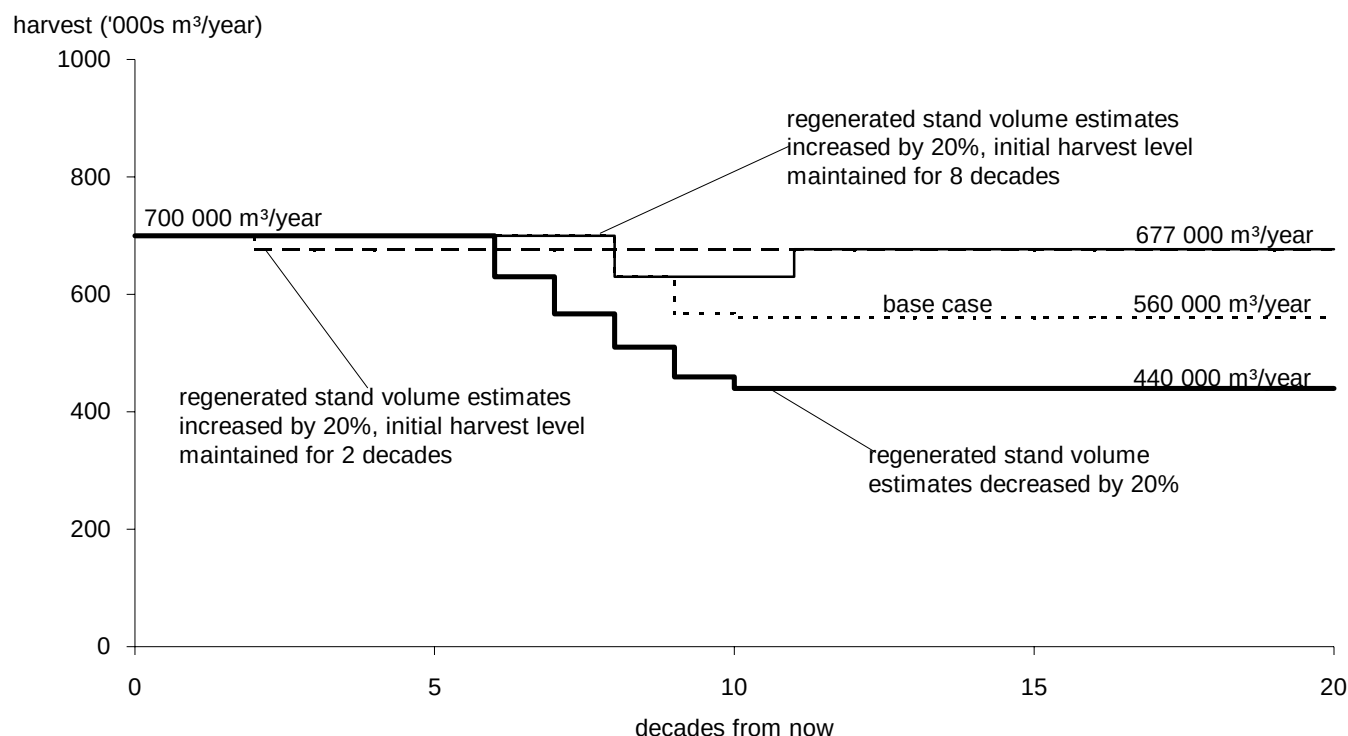


Figure 18. Harvest forecasts when regenerated stand volume estimates are changed by 20%, Boundary TSA.

5 Timber Supply Sensitivity Analyses

Figure 19 shows the impact on the harvest forecast when future stand volumes are assumed to be the same as existing stand volumes. Under this assumption, the current harvest level can be maintained for one decade longer than in the base case before it starts to decline to the long-term harvest level of 515 000 cubic metres per year. The current harvest level can be maintained an extra decade longer than in the base case because the long-term harvest level is less than in the base case (8% lower). As a result, the timber that would

otherwise be used later on to prevent a decline below the long-term level can be used to extend the initial harvest level.

This sensitivity analysis shows that although the short-term timber supply is not affected by changes in regenerated stand volume estimates, the long-term harvest forecast is significantly affected by both increases and decreases in estimates of future stand volumes.

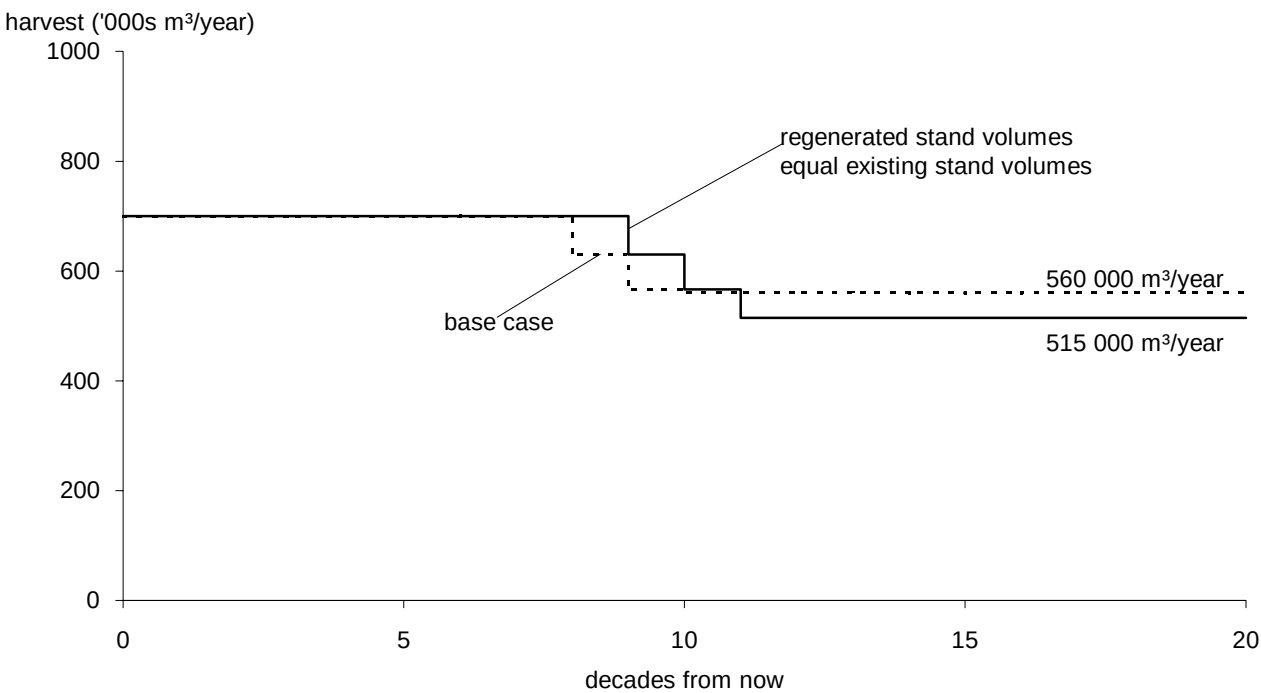


Figure 19. Harvest forecast when regenerated stand volume estimates are equal to existing stand volume estimates, Boundary TSA.

5 Timber Supply Sensitivity Analyses

5.5 Uncertainty in both existing and regenerated stand volume estimates

It is also possible that existing and regenerated stand volumes could concurrently be higher or lower than assumed in the base case. For example, any bias or error in the parameters (e.g. tree height or stand age) used to determine how productive a site is could affect both existing and regenerated volume estimates in a similar way. In this section, the impacts of all volumes being 10% higher or lower are examined.

If all stand volume estimates are 10% higher, the initial harvest level can be maintained for 14 decades (Figure 20). Higher stand volumes also result in a long-term harvest level of 624 000 cubic metres per year. If stand volumes are 10% lower than in the base case, the harvest level must decline to a reduced long-term harvest level (496 000 cubic metres per year) 4 decades sooner than in the base case.

Figure 20 shows that short-term harvest levels are not affected by changes in both existing and regenerated stand volume estimates; however, long-term harvest levels are significantly affected.

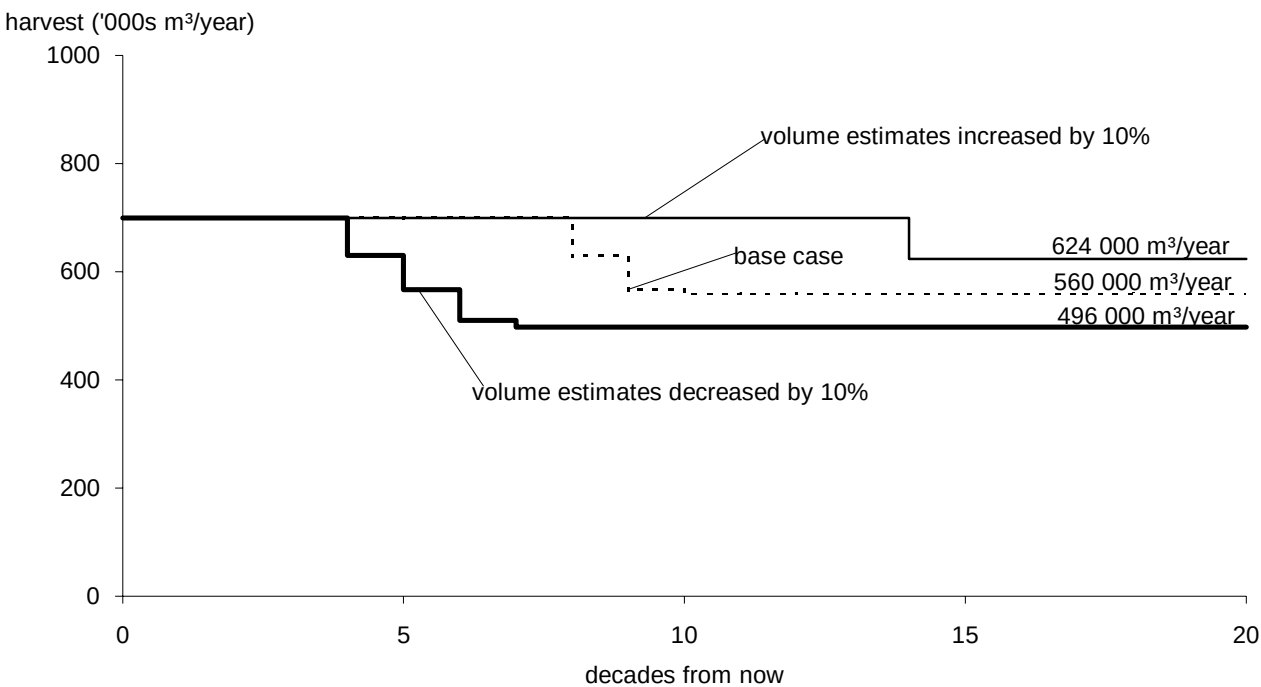


Figure 20. Harvest forecasts when all stand volume estimates are changed by 10%, Boundary TSA.

5 Timber Supply Sensitivity Analyses

5.6 Uncertainty in volume estimates for uneven-aged management systems

The uneven-aged management zone occupies approximately 19% of the timber harvesting land base. This zone incorporates all stands of Douglas-fir, larch, and ponderosa pine forest types that are not part of the VQO, wildlife and community watershed management zones. No volume estimates specific to uneven-aged management were available for this analysis, so volume estimates based on even-aged management were used. It is assumed that the timber volumes produced depend on the growing capacity of a site and will be influenced very little by the choice of management system and that therefore, even-aged and uneven-aged management systems, over time, would produce the same volume of timber. A high degree of uncertainty is associated with these estimates; therefore, this analysis tests the impacts of increasing and decreasing the timber

volumes of stands in the uneven-aged management zone by 25%.

Figure 21 illustrates that both the amount of time the initial harvest level can be maintained and the long-term harvest level are influenced by changes in volume estimates from the uneven-aged management zone. If estimates are 25% higher, the initial harvest level can be maintained for 3 decades longer than in the base case. Conversely, if volumes are 25% lower, the initial harvest rate must be reduced 3 decades earlier than in the base case. In both cases, a 25% change in volume estimates results in a corresponding 5% change in the long-term harvest level.

In summary, uncertainty about the volume estimates for the uneven-aged management zone has no impact on the short-term harvest level and a moderate impact on the intermediate- and long-term harvest levels.

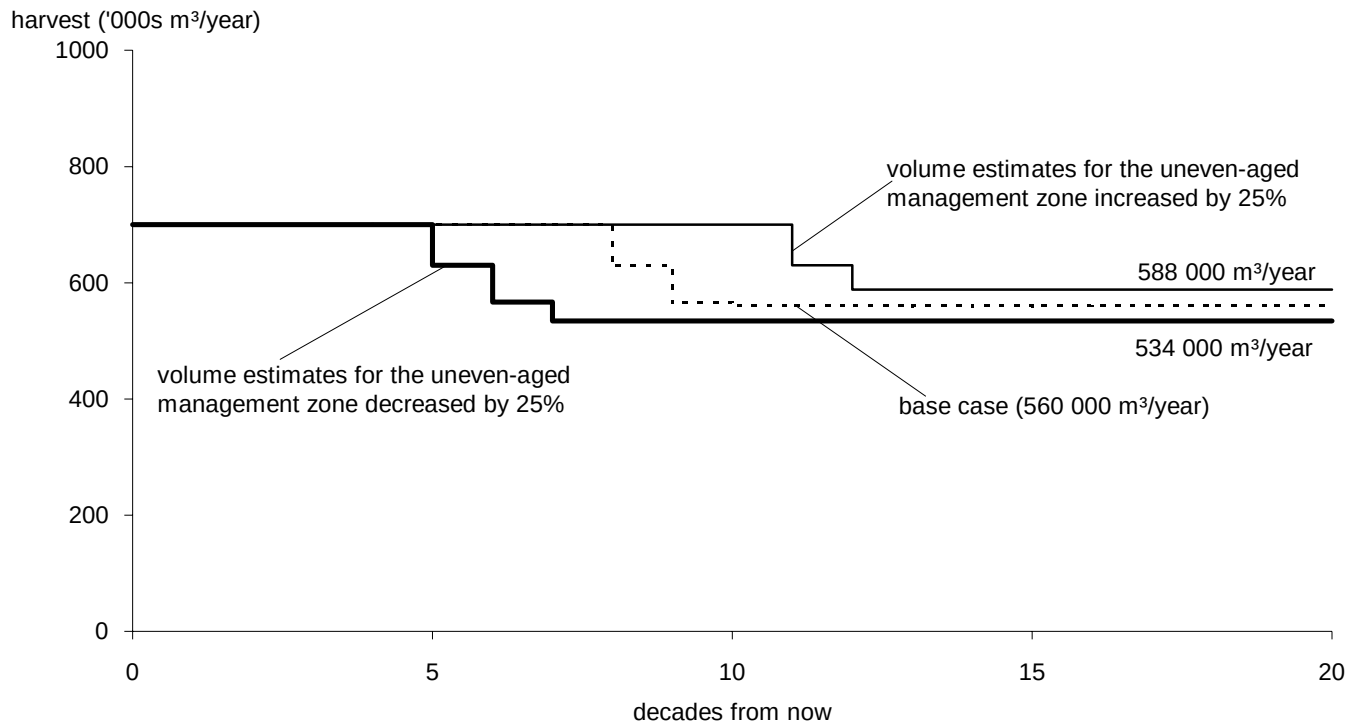


Figure 21. Harvest forecasts with volume estimates from the uneven-aged management zone changed by 25%, Boundary TSA.

5 Timber Supply Sensitivity Analyses

5.7 Uncertainty in green-up periods

Green-up forest cover objectives require estimates of when second-growth stands will reach green-up conditions, normally expressed as the length of time required for stands to reach a desired height. Uncertainty about the green-up period arises because the desired green-up condition may not accurately reflect actual needs. This can be a problem when several management objectives are stated for the same area. Uncertainties about growth and yield may also mean that stands will reach the desired condition sooner or later than estimated. This analysis examines the effect on the harvest forecast of changing green-up periods by 50%. The uncertainty about the percentage of desired forest cover is examined in the following section (Section 5.8, "Uncertainty in forest cover requirements.")

In the base case, the green-up periods used are 20 years for the integrated resource management zone, 22 years for the VQO zone, 34 years for the wildlife zone, and 25 years for the community watersheds zone. To test the sensitivity of the timber supply to uncertainty in green-up assumptions, these periods were increased and decreased by 50%. For

example, the 22-year green-up period in the VQO zone was increased and decreased by 11 years.

The impacts of changing green-up periods can be seen in Figure 22. If the green-up period is 50% longer, the harvest level must decline to the long-term harvest level 7 decades sooner than in the base case. Also, the long-term level is reduced by approximately 4.3% from the base case. If the green-up period is decreased by 50%, the current harvest level can be maintained an additional 6 decades over the base case before declining to a long-term harvest level 2.1% higher than in the base case. The harvest forecast is more sensitive to longer green-up ages. As green-up periods are lengthened, a higher proportion of the forest is non-greened-up, and therefore, less area can be harvested before maximum limits on the total areas below green-up are reached. Shorter green-up periods have less of an impact on the timber supply because other factors become limiting and prevent harvest levels from increasing as much as they might otherwise.

This sensitivity analysis shows that the harvest forecast is sensitive in the short term to changes in the length of the green-up period. The long-term harvest forecast is also sensitive to increases in the length of the green-up period.

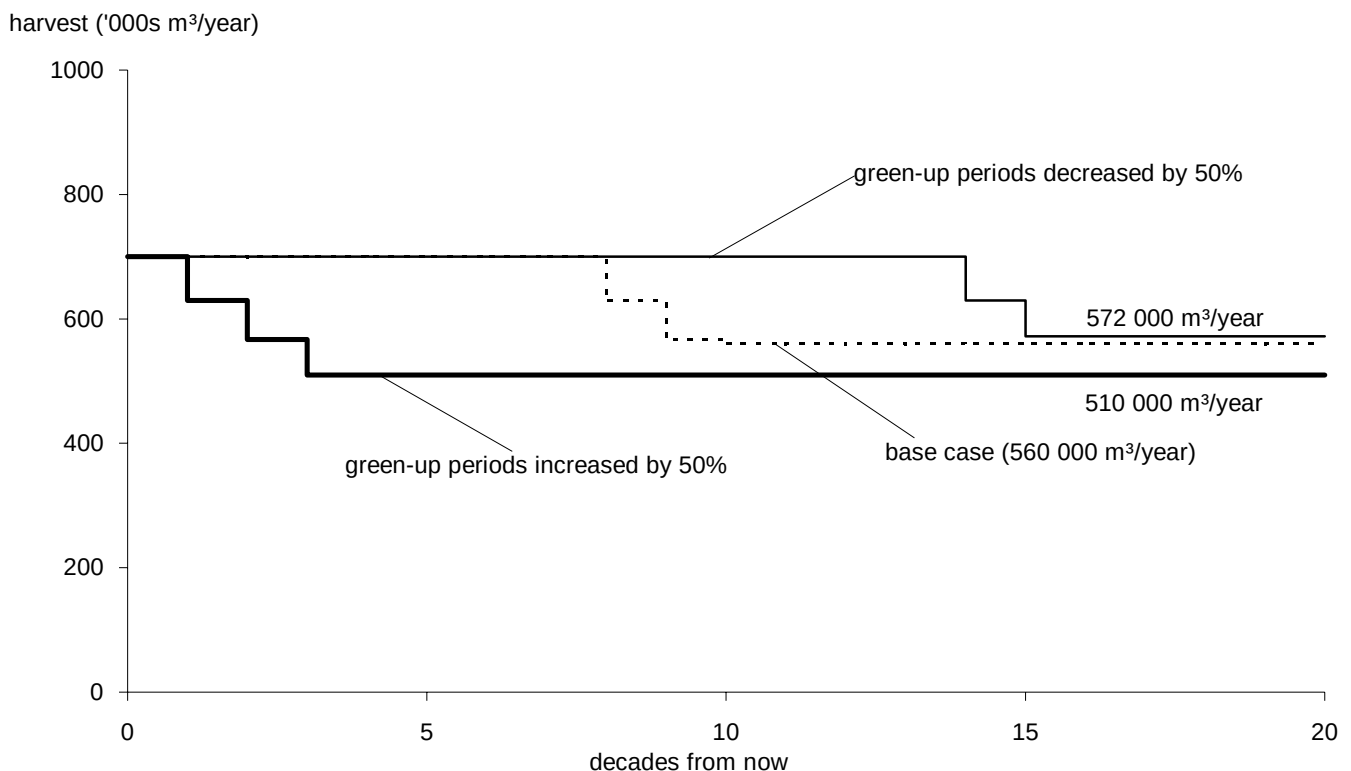


Figure 22. Harvest forecasts when green-up periods are changed by 50%, Boundary TSA.

5 Timber Supply Sensitivity Analyses

5.8 Uncertainty in forest cover requirements

Forest cover requirements limit the amount of area occupied by stands that are younger than the green-up age, and require a minimum amount of area to be covered by stands older than a specified age. These guidelines ensure that there is a distribution of different ages in the forest. They are applied by specifying, for example, that no more than 25% of an area may be occupied by stands less than 18 years old (green-up age) or that at least 10% of an area must be occupied by stands older than 150 years.

It is difficult to define the exact forest structure needed to meet the management objectives for a particular area; as a result, there is a degree of uncertainty about the guidelines. Also, forest cover guidelines are applied only to the timber harvesting land base. In some areas, however, forested land not included in the timber harvesting land base also contributes to fulfilling forest cover requirements. The degree of this contribution varies and is a source of some uncertainty.

This sensitivity analysis examines the effects on the harvest forecast of varying the forest cover percentages for all management zones except the uneven-aged management zone. Forest cover requirements are not applied to the uneven-aged management zone because it is assumed that the forest cover is never completely removed in these areas. To illustrate the sensitivity of the harvest forecast, those forest cover requirements specifying the minimum amount of area to be covered by stands older than green-up age are increased and decreased by 5 and 10 percentage points. For example, a 20%

forest cover guideline is relaxed by 5 percentage points by increasing to 25% the maximum amount of area that may be covered by stands that are not greened-up. The same guideline is tightened 5 percentage points by decreasing to 15% the minimum amount of area that may be covered by stands that have not greened-up. Increasing the percentage relaxes the cover requirement because it allows more of the forest to be non-greened-up. Decreasing the percentage tightens the cover requirement because it allows less of the forest to be non-greened-up.

If the forest cover requirements are relaxed by 5 percentage points, the current harvest level can be maintained for 2 decades longer than in the base case (Figure 23). Relaxing the forest cover requirement by 10 percentage points allows the current harvest level to be maintained for 4 decades longer than in the base case (Figure 24). Relaxing the forest cover constraints in both cases results in a slightly higher long-term harvest level of 570 000 cubic metres per year.

Figure 23 shows that if the forest cover requirements are tightened by 5 percentage points, the initial harvest level drops 2 decades sooner than in the base case. If the forest cover requirement is tightened by 10 percentage points, the initial harvest level has to be dropped immediately to 630 000 cubic metres per year (Figure 24). This initial harvest level is 10% lower than the initial harvest level in the base case, and can only be maintained for 1 decade before declining to the long-term harvest level. The long-term level of 490 000 cubic metres per year is 12.5% lower than in the base case.

5 Timber Supply Sensitivity Analyses

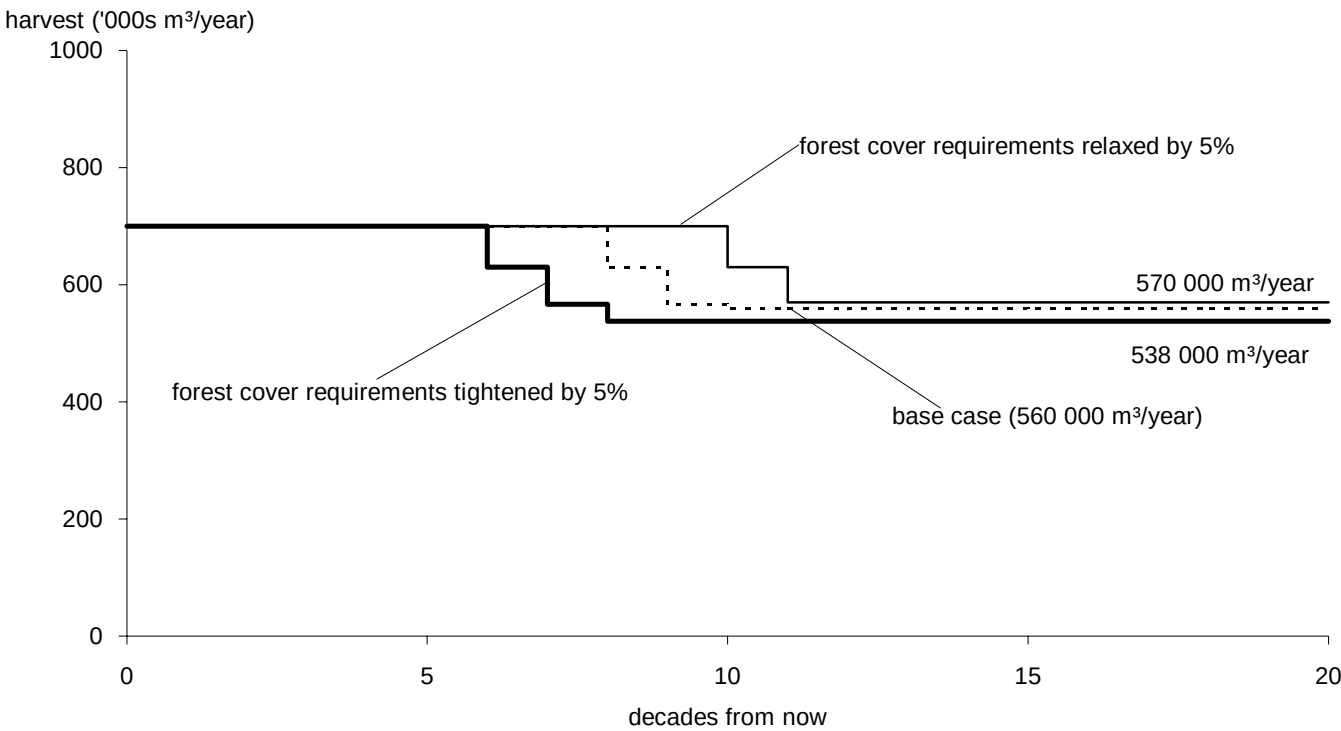


Figure 23. Harvest forecasts when forest cover requirements are changed by 5 percentage points, Boundary TSA.

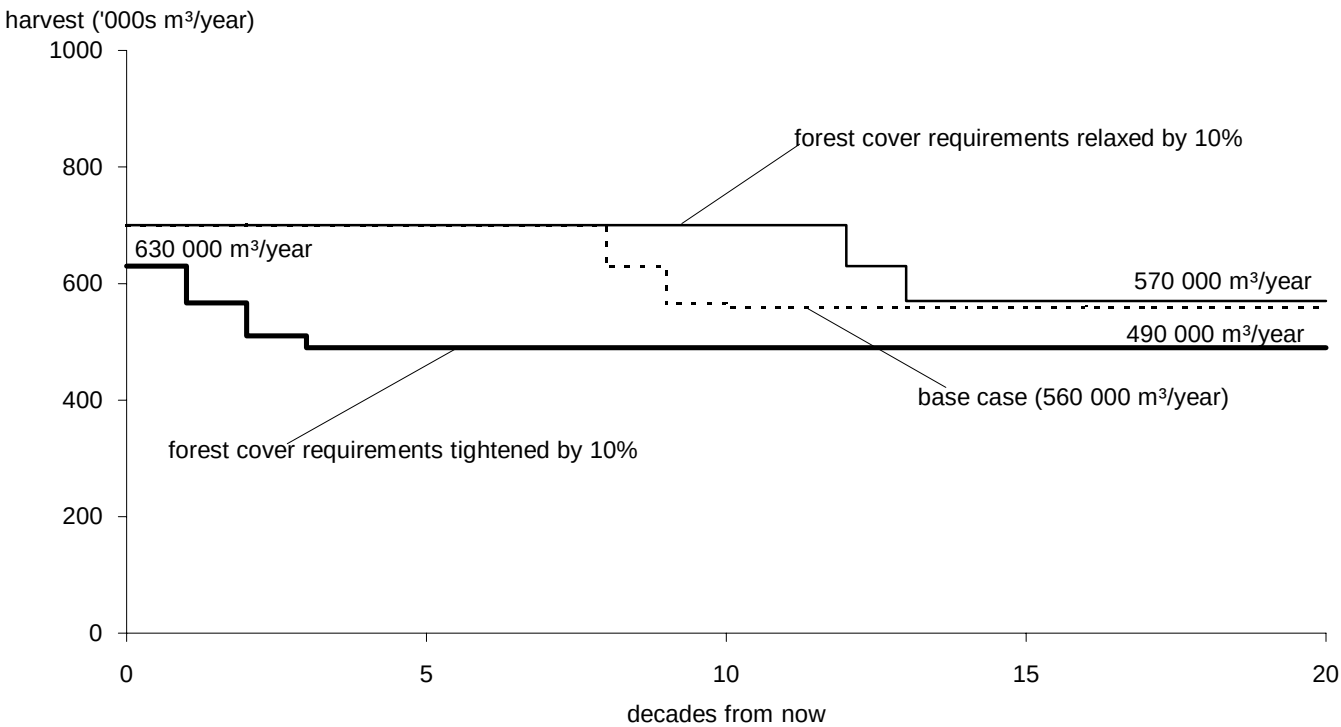


Figure 24. Harvest forecasts when forest cover requirements are changed by 10 percentage points, Boundary TSA.

5 Timber Supply Sensitivity Analyses

Figure 25 shows the change in the average harvest age of stands over time when forest cover requirements are changed. When the forest cover guidelines are relaxed by 10 percentage points, the average age of harvested stands over time is very similar to that projected for the base case. When forest cover is tightened by 10 percentage points the long-term level is significantly reduced. The tightened forest cover guidelines cause many stands

to be harvested at ages older than in the base case. Thus the average age of harvested stands over time stays significantly above base case levels.

Overall, changes in forest cover requirements would have a moderate impact on the short-term timber supply; however, these changes would have an even greater impact in the intermediate and long term.

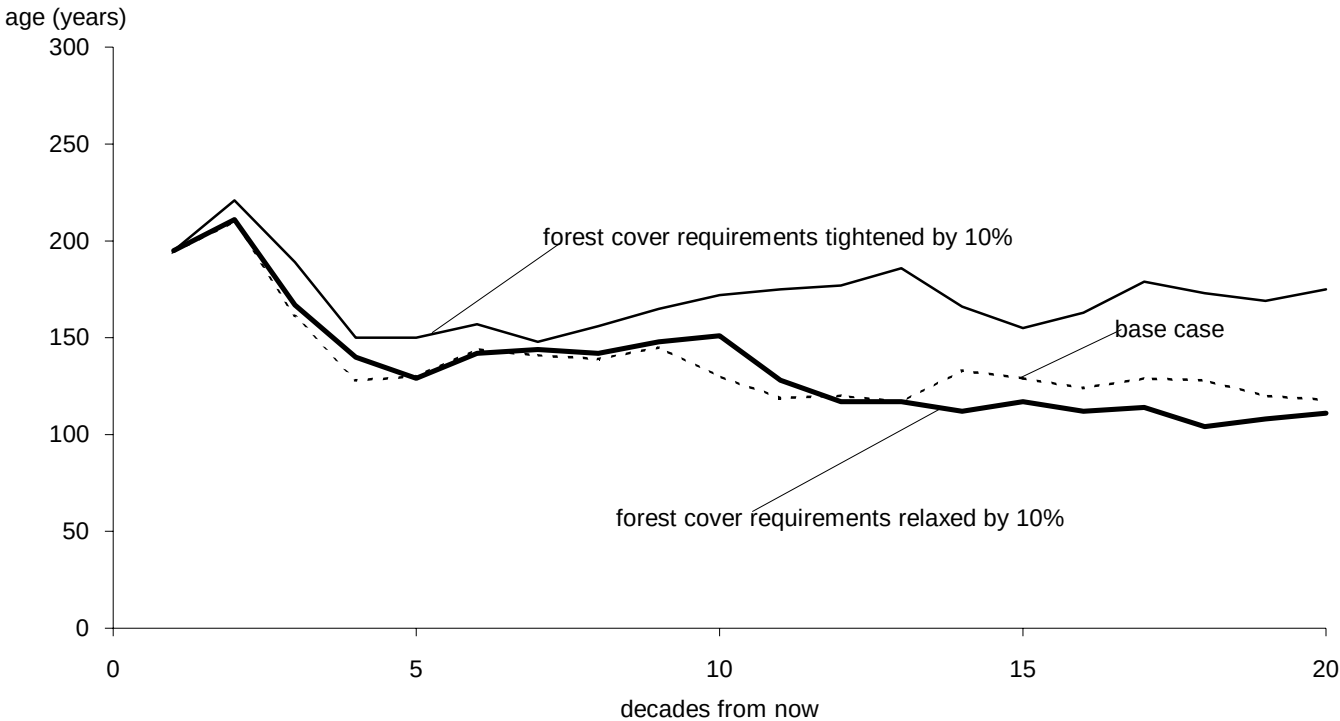


Figure 25. Average age of harvested stands when forest cover requirements are changed by 10 percentage points, Boundary TSA.

5 Timber Supply Sensitivity Analyses

5.9 Uncertainty in old-growth requirements

Increased concerns for biodiversity frequently result in, among other objectives, a desire to maintain a certain proportion of the land base in older age classes. For example, it may be decided that a minimum of 8-12% of all forested area should be over 150 years old. In the base case, an old-growth forest cover guideline was applied in the community watershed zone. This guideline requires that a minimum of 10% of the forest be older than 150 years at all times. This guideline was not applied to any of the other management zones. This sensitivity analysis tests the impact of extending the old-growth guideline used in the community watersheds zone to all the remaining zones (excluding the uneven-aged management zone).

As shown in Figure 26, extending the old-growth forest cover guideline to all zones causes the decline

to the long-term level to occur 4 decades sooner than in the base case. The old-growth guideline also results in a long-term harvest level of 532 000 cubic metres per year, 5% below the base case long-term level. Figure 27 shows that the available growing stock is reduced by an average of 21% in the first 8 decades with the added old-growth requirement. Although an added old-growth requirement would not directly impact the starting harvest level, it would likely affect the location of harvesting operations. Some operational flexibility would be lost if older stands had to be maintained for an extended period of time to meet biodiversity concerns.

In summary, the timber supply shows a high sensitivity in the intermediate term, and moderate sensitivity in the long term, to changes in the old-growth requirements for the Boundary TSA. The short-term timber supply is not affected.

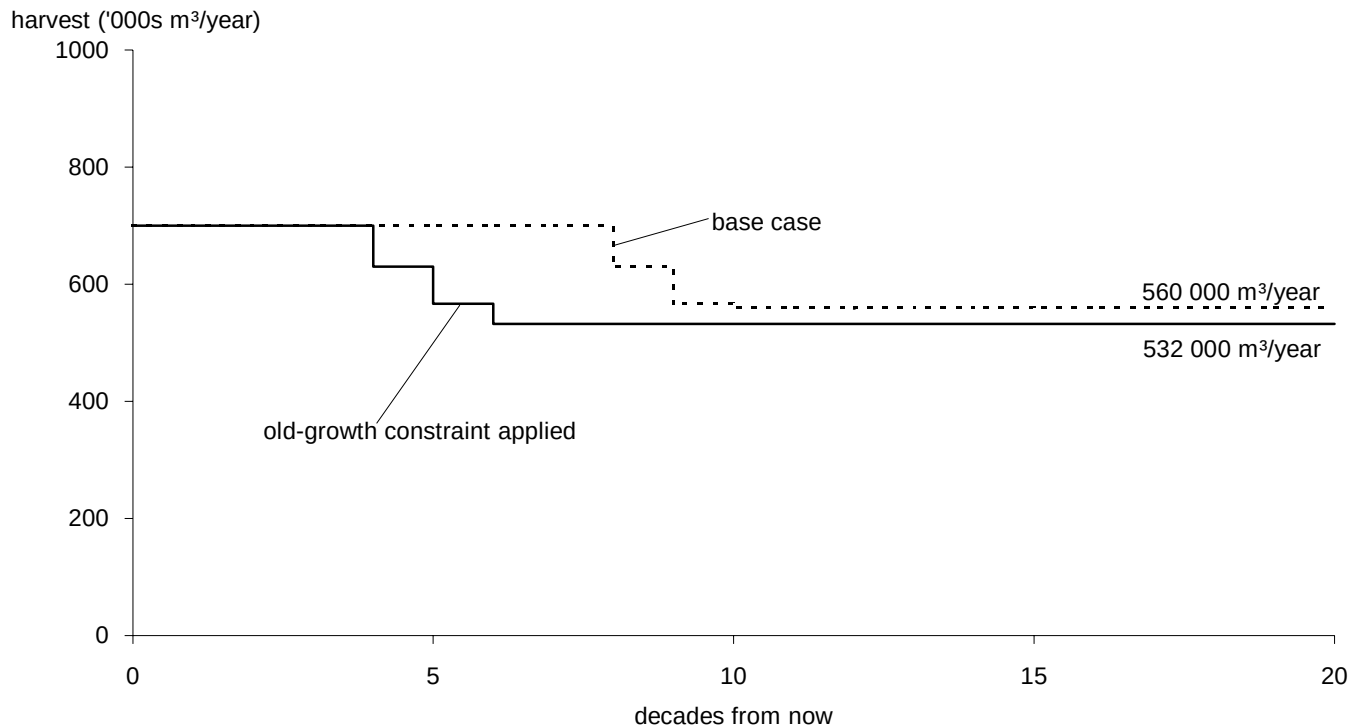


Figure 26. Harvest forecast if an old-growth constraint is applied to the timber harvesting land base, Boundary TSA.

5 Timber Supply Sensitivity Analyses

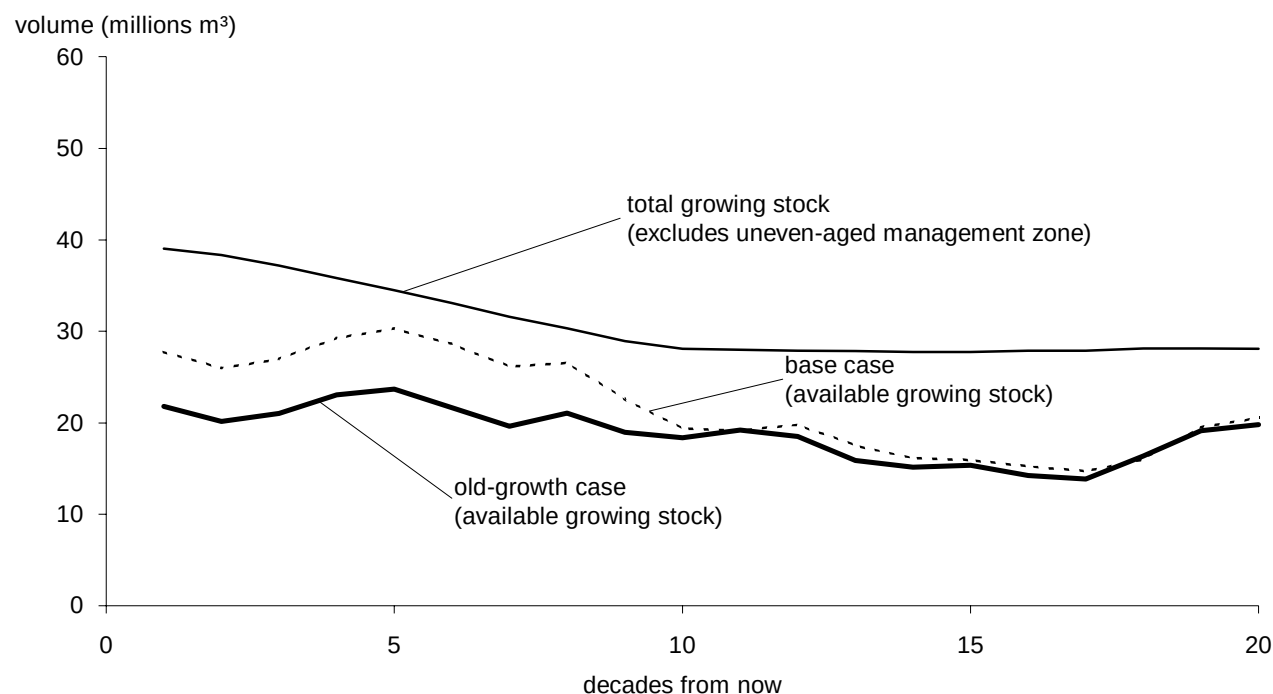


Figure 27. Available growing stock over time, harvest forecast with an old-growth constraint compared to the base case, Boundary TSA.

5.10 Uncertainty in the availability of dense lodgepole pine stands

Dense lodgepole pine stands cover about 23% of the timber harvesting land base. These stands are characterized by many small diameter trees of low commercial value. In previous timber supply analyses these stands were considered problem forest types and excluded from the timber harvesting land base. In this analysis, stands of dense lodgepole pine were separated from the other pine stands. Based on the assumptions that most trees would reach a harvestable size over an extended time, the dense pine stands have been assigned minimum harvestable age that is 40 years longer than that of normally stocked pine stands. The harvesting of these dense lodgepole pine stands is closely related to a fairly recent increase in the market value of these stands. Other problem forest types, now excluded from the timber harvesting land base, may also be harvestable in the future. This leads to uncertainty about the

inclusion and exclusion of dense pine stands and problem forest types.

Figure 28 shows the impact of changing the availability of dense lodgepole pine stands. If 50% of the dense pine stands are removed, the timber harvesting land base is reduced by 35 343 hectares. As a result, the initial harvest level declines after decade 4, and the long-term harvest level is 13% lower than in the base case. On the other hand, if 50% more of these dense lodgepole pine stands were made available, the timber harvesting land base would increase by 35 343 hectares. The initial harvest level with this larger land base can be maintained for 14 decades and the long-term level is 625 000 cubic metres per year, 11.6% higher than in the base case.

These results show that changes in the availability of dense lodgepole pine types would have a significant effect in both the intermediate and long term.

5 Timber Supply Sensitivity Analyses

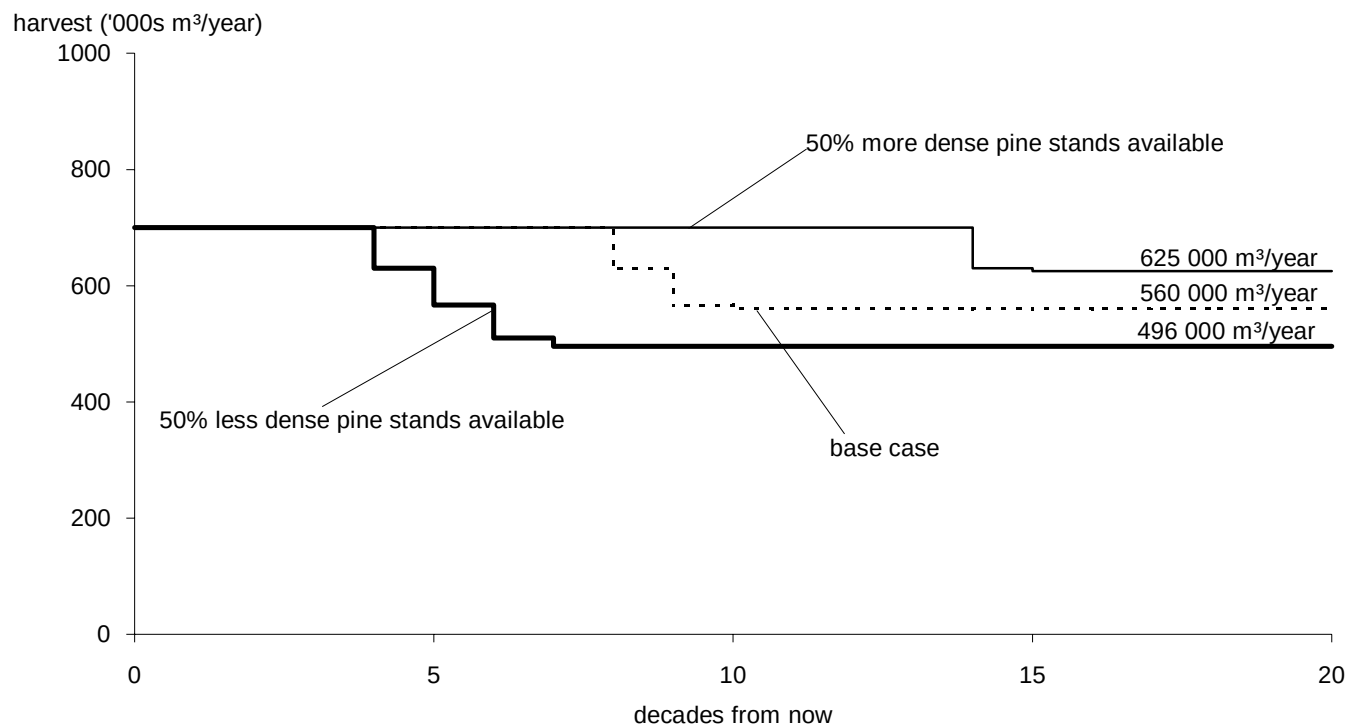


Figure 28. Harvest forecasts if the area of dense lodgepole pine stands available for timber harvesting is changed by 50%, Boundary TSA.

5.11 Uncertainty in the size of the land base

The timber harvesting land base is subject to significant uncertainty because of the possible exclusion or inclusion of areas, changes in operability lines, changes in area classified as problem forest types or environmentally sensitive (ESAs), and changes to the amount of area used for roads, landings and skid trails. This sensitivity analysis examines the impact on the harvest forecast of significant changes in the size of the timber harvesting land base by increasing and decreasing the timber harvesting land base proportionately across all forest types by 20%. Figure 29 shows the impact of these changes on the base case harvest forecast.

A 20% decrease in the size of the timber harvesting land base does not have an immediate impact on the initial harvest level. However, the decline to the long-term harvest level occurs in decade 3, 5 decades sooner than in the base case. The long-term harvest level is 448 000 cubic metres per year, 20% lower than the base case long-term level. A 20% increase in the timber harvesting land base would allow the initial harvest level to increase by 10%. This harvest level could be maintained for 12 decades before declining to a long-term harvest level of 660 000 cubic metres per year, 15% higher than in the base case.

This analysis shows that the timber supply is sensitive to changes in the size of the timber harvesting land base, particularly in the long term.

5 Timber Supply Sensitivity Analyses

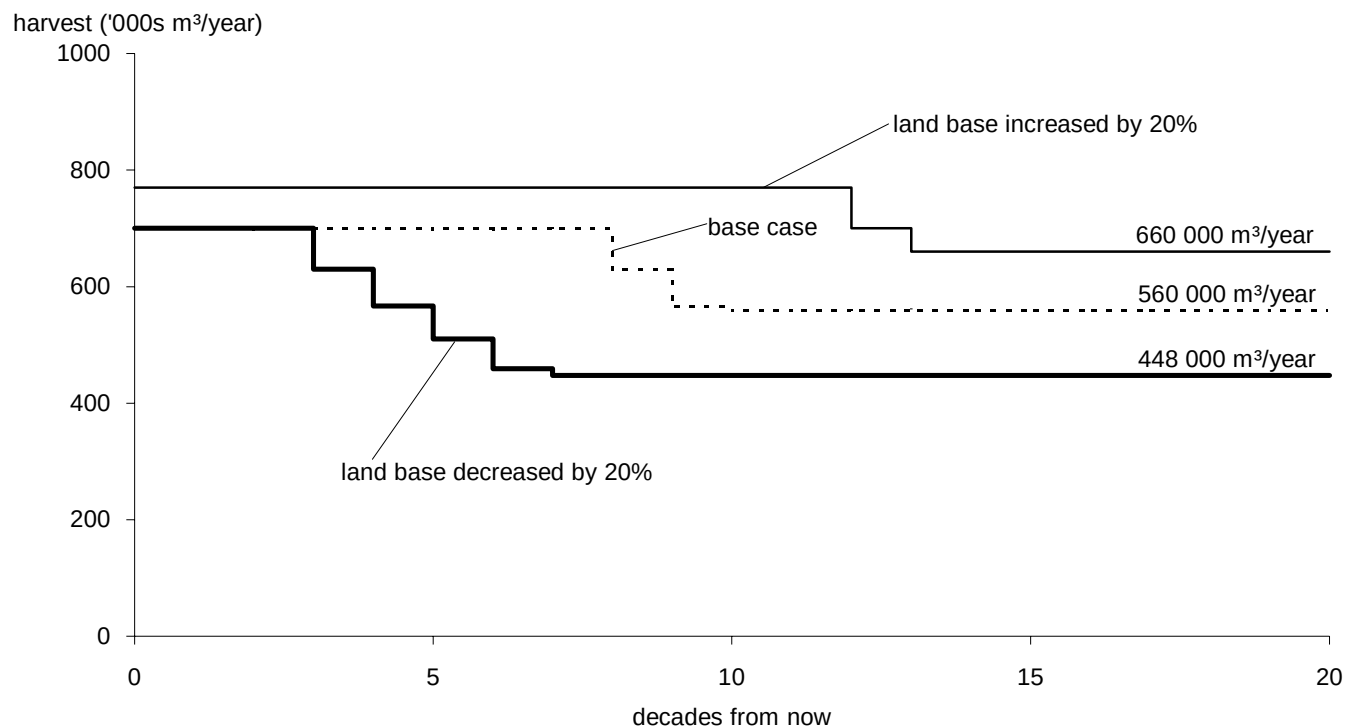


Figure 29. Harvest forecasts when the timber harvesting land base is changed by 20%, Boundary TSA.

5.12 Uncertainty in estimates of unsalvaged losses

The base case harvest forecast incorporates estimates for unsalvaged losses. If the initial harvest level is 700 000 cubic metres per year, then the actual volume depleted, including annual unsalvaged losses of 50 400 cubic metres, is 750 400 cubic metres per year. An over- or under-estimate of unsalvaged losses could have an impact on the harvest forecast. Furthermore, estimating unsalvaged losses is subject to a great deal of uncertainty. Losses due to factors such as fire, insects, disease, windthrow and wildlife trees can vary considerably over time and are hard to predict.

This analysis examines the effect on the harvest forecast of either eliminating or doubling the estimate of unsalvaged losses used in the base case.

If unsalvaged losses are doubled to 100 800 cubic metres per year, the initial harvest level must decline after decade 5 instead of decade 8 as in the base case (Figure 30). The long-term harvest level is reduced by 50 400 cubic metres per year. If losses could be eliminated by protection measures and effective salvage operations, the initial harvest level can be maintained for 12 decades, and a higher long-term harvest level would be possible.

This sensitivity analysis shows that the timber supply, over the next few decades, is unaffected by changes in estimates of unsalvaged losses. However, the intermediate- and long-term timber supply are very sensitive to uncertainty in these estimates.

5 Timber Supply Sensitivity Analyses

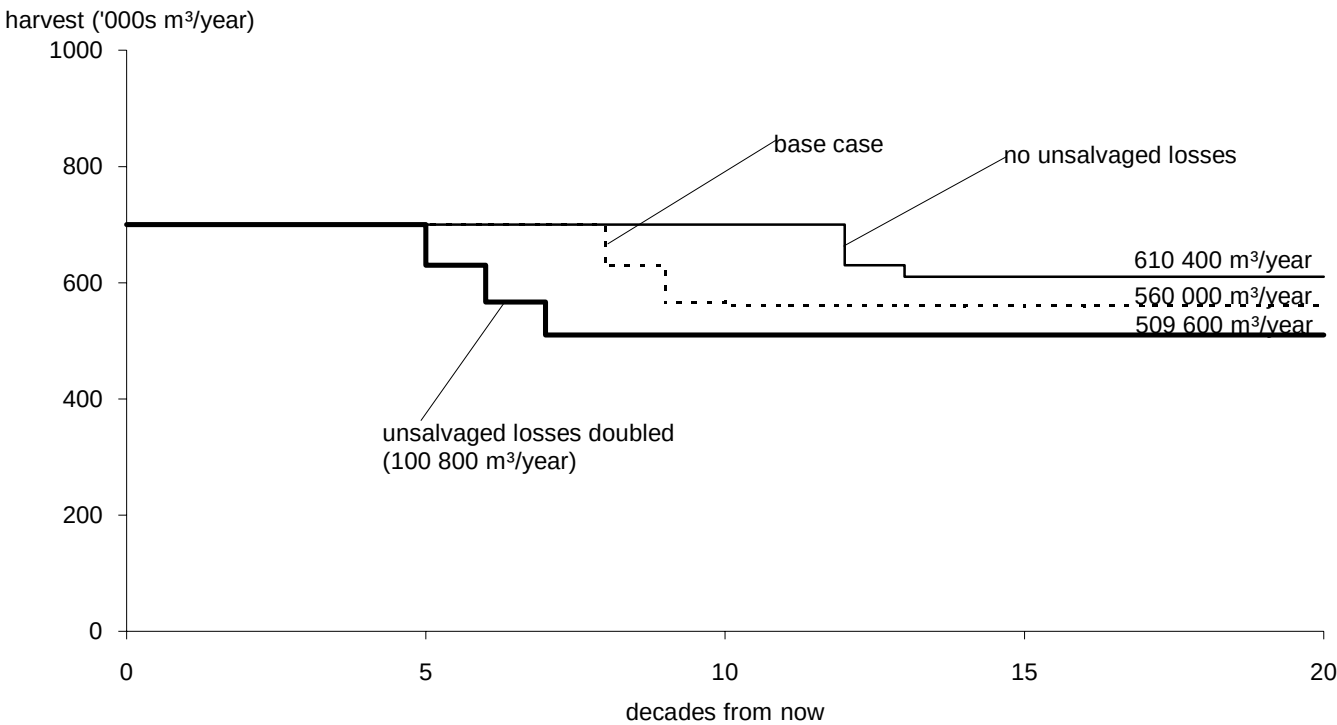


Figure 30. Harvest forecasts when unsalvaged losses are either eliminated or doubled, Boundary TSA.

6 Summary and Conclusions

The timber supply analysis for the Boundary TSA indicates that given current management assumptions, an initial harvest level of 700 000 cubic metres per year (the current AAC) can be maintained for 8 decades. Harvests then begin to decline by 10% per decade until the long-term harvest level of 560 000 cubic metres per year is reached 11 decades from now. The long-term level is 20% below the harvest level.

This analysis employs the best estimates of all variables used to describe forest management in the Boundary TSA. However, many of the estimates contain some degree of uncertainty. Timber supply is mainly affected in the short term by tighter forest cover requirements, lower volume estimates in existing stands and large changes in the green-up period. Changes in regenerated stands yields and unsalvaged losses have no impact on the short-term harvest level, although the long-term harvest level is

significantly affected. Changes to the timber harvesting land base affect both the short- and long-term timber supply. All the factors examined in the sensitivity analyses can influence the length of time the current harvest level can be maintained.

It should be noted that the effects of varying some of the base case assumptions could also be more dramatic if several assumptions were changed concurrently (for example, tighter forest cover requirements and lower regenerated stand yields).

It is also important to note that the base case harvest forecast shown in this analysis likely represents maximum levels given current management practices and data. Between the start and finish of this analysis, integrated resource management guidelines have become more stringent. This trend further emphasizes that the base case harvest forecast represents a maximum for the timber supply in the Boundary TSA.

7 References

- B.C. Ministry of Forests, Inventory Branch. 1992. Variable Density Yield Prediction User Guide. Victoria, B.C.
- B.C. Ministry of Forests, Nelson Forest Region. 1987. Boundary Timber Supply Area Plan, April 1, 1985 - March 31, 1990. Nelson, B.C.
- B.C. Ministry of Forests, Research Branch. 1992. User's Guide for TIPSy: A Table Interpolation Program for Stand Yields - Version 2.0 Beta. Victoria, B.C.

8 Glossary

Allowable annual cut (AAC)	The allowable rate of timber harvest from a specified area of land. The Chief Forester sets AACs for Timber Supply Areas (TSAs) and Tree Farm Licences (TFLs) in accordance with <i>Section 7</i> of the <i>Forest Act</i> .
Clearcut 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	The desired spatial relationship among cutblocks as specified in integrated resource management guidelines. They can be approximated by specifying the maximum allowable proportion of a forested landscape that does not meet green-up requirements.
Environmentally sensitive areas	Areas with significant non-timber values or fragile or unstable soils, or where there are impediments to establishing a new tree crop, or where 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 stands	Stands composed of sufficient seedlings of an acceptable commercial species that are free from growth-inhibiting brush, weed and excessive tree competition.
Growing stock	The volume estimate for all standing timber, of all ages, at a particular time.
Green-up	The time needed after harvesting for a stand of trees to reach a desired condition (e.g., height) to ensure maintenance of water quality, wildlife habitat, soil stability or aesthetics.
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 harvestable ages, utilization levels, integrated resource guidelines and silviculture and pest management programs.

8 Glossary

Mean annual increment (MAI)	Stand volume divided by stand age. The age at which average stand growth, or MAI, assumes its maximum is called the culmination age. Harvesting all stands at this age results in a maximum average harvest over the long term.
Not satisfactorily restocked	An area not covered by a sufficient number of tree stems of desirable species. Stocking standards are set by the B.C. 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.
Operability	A classification of the availability of an area for timber harvesting. Operability is determined using the terrain characteristics of the area as well as the quality and quantity of timber on the area.
Partial retention VQO	Alterations are visible but not conspicuous. Up to 15% of the area can be visibly altered by harvesting activity (see Visual quality objective).
Retention VQO	Alterations are not easy to see. Up to 5% of the visible landscape can be altered by harvesting activity.
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 deducting non-contributing areas from the total land base according to specified management assumptions.
Timber supply area (TSA)	An integrated resource management unit established in accordance with <i>Section 6</i> of the <i>Forest Act</i> .
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 tables and commentary outline the methods and inputs used to derive the timber harvesting land base, and to construct the timber supply model for the Boundary TSA Timber Supply Review analysis. This information represents current forest management in the area. Current management is defined as the set of land use decisions and forest and stand management practices currently implemented and enforced. Future forest management objectives that may be intended, but are not currently implemented and enforced are not included in this appendix. The purpose of the Timber Supply Review is to provide information on the effects of current management on both short- and long-term timber supply in each timber supply area in the province. Any changes in forest management objectives and practices will be included in subsequent timber supply analyses after the Timber Supply Review project has been completed.

A.1 Zone and Analysis Unit Definition

A.1.1 Zone characteristics

The timber harvesting land base is divided into management zones on the basis of differences in forest management. These zones are used in the Forest Service Simulation Model (FSSIM) to facilitate modelling the impacts of current integrated resource management practices on the timber supply. The zones used in the timber supply analysis for the Boundary TSA are listed below:

1. uneven-aged management;
2. integrated resource management;
3. visually sensitive corridors and lakes;
4. wildlife corridors and winter range; and,
5. community watersheds.

In order to assign an area to a zone, any special resource concerns (e.g. wildlife, water) within it are first identified. An area is then assigned a zone based on the forest cover requirements and the resource of most concern. When no special concerns are identified for an area, it is assigned to zone 1 or 2 based on forest type.

As a result of managing for multiple resources, many areas in the TSA have more than one resource management concern; for example, wildlife and water quality. The timber supply model requires that each distinct area be assigned only one management concern. Thus for this analysis, the community watershed zone, with the most restrictive cover requirements, is given precedence over all other zones when overlap occurs. After the community watershed zone, the order of precedence, from highest to lowest is as follows: wildlife corridor and winter range zone, visual quality zone, uneven-aged management zone and integrated resource management zone. Therefore, if there is an area in which both visual quality objectives and water quality concerns exist, the forest cover requirements for the community watershed zone would be applied to the area. In practice, however, management activities would consider both resource concerns.

A.1.2 Analysis unit definition

Information on the forests in the Boundary TSA come in a computer file provided by the B.C. Forest Service Inventory Branch. This file contains a list of land and forest cover attributes — such as tree species present, stand age, tree height, stocking (a measure of number of trees per hectare), environmental sensitivity, and timber growing quality — for a large number of distinct land units referred to as forest cover polygons. Much of the area is not considered available for timber harvesting for several reasons as discussed in Section 2, "Information Preparation" of the report, and further described later in this appendix. If information were analysed separately for each of these forest cover polygons over the 200-year period used for timber supply analysis, not only would the computer model be extremely complex, but also the results would be difficult to check for errors, and to interpret. The main purpose of using computer models (i.e. simplified representations of the real world) is to increase our understanding of complex processes. There is always a trade-off between retaining information on a specific area, and simplifying the information base to allow better understanding. For each analysis, the decision on how to model forest management should be based on the characteristics of the area and the planned management regime. The way information is handled should correspond to the format and precision of the available information, and the type of decision to be made using analysis results. In the case of timber supply analyses, the information applies to a fairly large area, and the decision on overall allowable harvest level provides general, strategic guidance, not operational prescriptions. Therefore, information supplied in the forest inventory file is streamlined for use in timber supply modelling.

A.1 Zone and Analysis Unit Definition

Forest inventory information could be simplified in any of several ways; for example, by combining information for land in a certain geographic area, for land having a particular resource emphasis, or for land with similar forest cover (i.e. tree species and site productivity). For this analysis, the information was simplified based on forest management emphasis, tree species and site productivity.

A.1.3 Analysis unit characteristics

An analysis unit represents a combination of stands dominated by specified tree species with a specified timber growing capability. For example, spruce- and balsam-dominated stands with good timber productivity comprise an analysis unit. Each analysis unit is assigned its own timber volume projection (yield table). Site groups were assigned using new site class (NSITE) or where available, special site class (SSITE). Special site is a field corrected site class that can be assigned when the normal site class does not correctly reflect site quality.

The analysis units used for the Boundary TSA timber supply analysis, and the inventory file variables used to define them, are shown in Table A-1.

Table A-1. Analysis unit characteristics

Analysis unit	Species groups	Inventory type groups	Site index classes	Age/height/ stocking class	Stocking class
01	Douglas-fir, larch, yellow pine	1-8, 32-34	good & medium	any	any
02	Douglas-fir, larch, yellow pine	1-8, 32-34	poor	any	any
03	cedar, hemlock, white pine	9-17,27	good & medium	any	any
04	cedar, hemlock, white pine	9-17,27	poor	any	any
05	spruce, balsam	18-26	good & medium	any	any
06	spruce, balsam	18-26	poor	any	any
07	lodgepole pine (pure stands)	28	good & medium	any	any
08	lodgepole pine (pure stands)	28	poor	any	any
09	lodgepole pine (mixed stands)	29-31	good & medium	any	any
10	lodgepole pine (mixed stands)	29-31	poor	any	any
11	lodgepole pine (dense stands)	28-31	good & medium	310,410,420	3
12	lodgepole pine (dense stands)	28-31	poor	310,410,420 ^a	3

(a) Only 50% of these stands were included.

A combination of stands going into each analysis unit can be further summarized based on management zone. When this is done the representation of all the possible zone by analysis unit combinations, or strata, can be seen. Some strata may not be represented in the timber harvesting land base. In the case of the Boundary TSA, the spruce and balsam analysis units are not found in the uneven-aged management zone. Some strata may be very poorly represented. To avoid attempting to build reliable yield curves for poorly represented strata (i.e. less than 400 hectares), these poorly represented strata are combined with similar ones better represented. Table A-2. shows which strata were combined for this timber supply analysis.

A.1 Zone and Analysis Unit Definition

Table A-2. Strata shifted due to lack of representation

Analysis unit	Zone				
	1 Uneven-aged management	2 Even-aged management	3 VQOs	4 Wildlife	5 Community watersheds
01 F,L,Py - g,m	-	-	-	-	-
02 F,L,Py - p	-	-	-	-	-
03 C,H,Pw - g,m	N/A	-	303 -> 203 ^a	403 -> 203	503 -> 203
04 C,H,Pw - p	N/A	-	304 -> 204	404 -> 204	504 -> 204
05 S,B - g,m	N/A	-	305 -> 205	-	-
06 S,B - p	N/A	-	306 -> 206	-	506 -> 206
07 Pl pure - g,m	N/A	-	307 -> 207	-	507 -> 207
08 Pl pure - p	N/A	-	308 -> 208	408 -> 407	508 -> 208
09 Pl mixed - g,m	N/A	-	-	-	-
10 Pl mixed - p	N/A	-	310 -> 309	410 -> 409	510 -> 509
11 Pl dense - g,m	N/A	-	-	-	-
12 Pl dense - p	N/A	-	312 -> 311	-	512 -> 511

(a) The first digit represents the zone number and the last two digits represent the analysis unit number.

F = Douglas-fir, L = western larch, Py = ponderosa pine, C = western redcedar, H = western hemlock, Pw = western white pine, S = spruce, B = balsam, Pl = lodgepole pine, g = good site, m = medium site, p = poor site

Table A-3. shows management zone by analysis unit combinations that exist after the combining procedure takes place.

Table A-3. Area by management zone and analysis unit

Analysis unit	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Total	Per cent of total
01 F,L,Py - g,m	55 429	-	5 260	31 602	6 550	98 841	31.7
02 F,L,Py - p	16 043	-	901	8 392	866	26 202	8.4
03 C,H,Pw - g,m	-	2 217	-	-	-	2 217	0.7
04 C,H,Pw - p	-	1 809	-	-	-	1 809	0.6
05 S,B - g,m	-	25 818	-	2 257	1 092	29 167	9.4
06 S,B - p	-	16 005	-	1 484	-	17 489	5.6
07 Pl pure - g,m	-	9 703	-	777	-	10 480	3.4
08 Pl pure - p	-	429	-	-	-	429	0.1
09 Pl mixed - g,m	-	46 165	945	5 143	739	52 992	17.0
10 Pl mixed - p	-	773	-	-	-	773	0.3
11 Pl dense - g,m	-	53 735	794	8 747	1 573	54 849	20.8
12 Pl dense - p	-	5 198	-	875	-	6 073	2.0
Total	71 472	161 852	7 900	59 277	10 820	311 321	100.0

F = Douglas-fir, L = western larch, Py = ponderosa pine, C = western redcedar, H = western hemlock, Pw = western white pine, S = spruce, B = balsam, Pl = lodgepole pine, g = good site, m = medium site, p = poor site

A.2 Utilization Levels

The utilization level defines a standard maximum allowable stump height and minimum merchantable diameter by species and is used to calculate merchantable volume.

In practice, however, some of the licensees may be utilizing more than the standard tree and log size limits. Generally, merchantable timber is utilized to a 10 cm. diameter top and a 30 cm. stump height, for commercial species of the following size or greater: 12.5 cm. diameter at chest height for lodgepole pine and white bark pine (except for the Small Business Forest Enterprise Program sales where in most cases all species greater than 12 cm. diameter at chest height are used), and 17.5 cm. diameter at chest height for all other species.

A.3 Definition of the Timber Harvesting Land Base

This section provides the information used to define the land base considered available for timber harvesting for this analysis. The timber harvesting land base is derived by deducting several types of land and forest from the total area.

Areas were sequentially deducted from the total Boundary area in the following order: (1) land not managed by the B.C. Forest Service (non-Crown); (2) non-forest area; (3) non-commercial cover (NCC, i.e. brush species); (4) environmentally sensitive areas (ESAs); (5) inoperable areas; (6) geographically defined areas (Troy, Sandner and Texas Creek drainages); (7) sites with low timber growing potential; (8) non-merchantable forest types; (9) road, trail and landing areas; and, (10) not satisfactorily restocked (NSR).

Operable future roads, trails and landings were removed from further timber production in the timber supply model after being logged for the first time.

A.3.1 Land not managed by the B.C. Forest Service

Ownership codes on the inventory file were used to determine the areas that were not under Forest Service jurisdiction. Ownership codes as defined by Inventory Branch denote both ownership and administrative designation. Areas such as Crown grants and Indian Reserves are mostly out of the jurisdiction of the provincial government. Most land in the Boundary TSA is under the jurisdiction of the provincial government, but not all is managed by the Forest Service; for example, the Ministry of Environment, Lands and Parks administers parks. Furthermore, some forest land administered by the B.C. Forest Service is not managed as part of a timber supply area. For example, woodlot licences, once allocated, are managed as separate units. The AAC for a woodlot initially comes from an AAC determined for a TSA, but upon allocation that allowable harvest is administered as part of the woodlot, not as part of the TSA.

Tree Farm Licence (TFL) areas are managed — and have their allowable annual cuts determined — separately from TSAs. Their area is not normally included in the TSA inventory. However, sometimes when the ownership of land is unreported, it is included in the TSA inventory. This land is managed as part of the TFL, and does not form part of the TSA timber harvesting land base.

A.3 Definition of the Timber Harvesting Land Base

All areas with ownership codes (OWNER,OWNRCHAR) other than 62C or 69C are excluded from the timber harvesting land base for this analysis. Table A-4. outlines the total area in each ownership category for the Boundary TSA.

Table A-4. Total area in each ownership category for Boundary TSA

Description	Ownership code	Area (hectares)	Per cent of total
Private Crown grant	40-N ^a	64 035.0	11.0
Federal, federal reserve	50-N	63.5	-
Provincial, ecological reserve	60-N	0.4	-
Provincial, UREP ^c	61-C ^b	395.1	0.1
Provincial, UREP	61-N	1 115.8	0.2
Provincial, forest management unit (Crown)	62-C	297 109.2	51.2
Provincial, provincial park - class A	63-N	191.3	-
Provincial, provincial park - special or reserve	67-N	188.9	-
Provincial, Crown or government reserve	69-C	211 190.2	36.4
Provincial, Crown or government reserve	69-N	1 428.3	0.3
Provincial, TFL unreported ownership	76-N	148.3	-
Provincial, woodlot licence, Crown land portion	77-N	4 220.2	0.7
Miscellaneous leases	99-N	23.9	-
Total		580 110.1	100.0

(a) N = Land not available for long-term integrated resource management

(b) C = Land available for long-term integrated resource management

(c) UREP = Use for recreation and enjoyment of the public

A.3.2 Inoperable areas

Areas defined as economically inoperable were not considered part of the timber harvesting land base. Characteristics used in defining operability include slope, topography (e.g. the presence of gullies and exposed rock), difficulty of road access, soil stability, elevation and timber characteristics.

The operability classification on the inventory file (OPERABLE variable) was used to exclude areas from the timber harvesting land base.

A.3 Definition of the Timber Harvesting Land Base

A.3.3 Environmentally sensitive areas (ESAs)

The forest inventory file includes a rating of the environmentally sensitive areas (ESAs). Areas rated as highly sensitive (Ea₁, Es₁, Er₁, Ep₁) are either excluded or considered only partly available for timber harvesting. Areas rated as moderately sensitive (Es₂, Ep₂) are for the most part included in the timber harvesting land base. Table A-5. indicates the per cent area reduction made for the highly and moderately sensitive ESA categories. For areas assigned more than one ESA rating, only one reduction is made based on the ESA rating with the highest per cent area reduction. For example, a 90% reduction would be applied to an area having both Er₁ and Ep₁ ESA ratings.

Table A-5. Per cent area reductions for environmentally sensitive areas

ESA code	ESA description	Per cent area reduction
Ea ₁	High avalanche concerns	100
Es ₁	High soil and steepness concerns	100
Es ₂	Moderate soil and steepness concerns	40
Er ₁	High recreation concerns	90
Ep ₁	High regeneration problems	80
Ep ₂	Moderate regeneration problems	40

A.3.4 Problem forest types

Some stands are not currently used because they either cannot be harvested economically or they contain mostly non-commercial tree species. Examples include older stands that contain low net timber volumes or poor quality trees, and stands dominated by deciduous species. Areas of low site quality are also excluded because projected growth rates for second-growth forests on these areas are too low. Table A-6. lists the problem forest types for the Boundary TSA and the percentage reductions applied for each category. The low site reduction was based on new site class (NSITE) except when modified by special site (SSITE).

Table A-6. Per cent area reductions for problem forest types

Inventory type group	Species groups	Criteria				Per cent area excluded
		Age class	Height class	Stocking class	Site class	
all	all	any	any	any	low	100
10-17	cedar, hemlock	≥7	any	any	any	50
18-24	balsam, spruce	≥7	2	any	any	50
28-31	lodgepole pine	any	any	4	any	100
28-31	lodgepole pine	3	1	0	p	50
28-31	lodgepole pine	3	2	0	p	50
28-31	lodgepole pine	4	2	0	p	50
35-42	deciduous species	any	any	any	any	100

A.3 Definition of the Timber Harvesting Land Base

A.3.5 Geographically defined areas

Three drainages were removed from the timber harvesting land base because they are largely inoperable and isolated.

A.3.6 Not satisfactorily restocked areas

All areas on the inventory file assigned to a type identity of 4, 7, or 9 were initially excluded from the land base. All of this area is subsequently added back into the timber harvesting land base (the additions are described in Section A.4.5, "Not satisfactorily restocked (NSR) areas.")

A.3.7 Existing unclassified roads, trails, and landings

Past timber harvesting operations have resulted in a loss of productive forest land. However, many of the existing roads, trails, landings and related disturbances are not accounted for in the inventory file. To account for this loss in the area available for timber harvesting a 5.0% reduction was applied to all forest younger than 60 years old, which are assumed to have existing access.

A.3.8 Future roads, trails, and landings

There will also be losses in productive area as future harvesting occurs. All existing stands currently over 60 years old will be subject to a 4.5% loss.

A.4 Forest Management Assumptions

A.4.1 Minimum harvestable ages for each analysis unit

Table A-7. shows the culmination ages and minimum harvestable ages for each analysis unit for even-aged management areas (clearcutting silvicultural systems). Stand merchantability in terms of volume and piece size, and site protection were considered in the determination of the minimum harvestable ages.

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

Analysis unit	Culmination ages for:		Minimum harvestable ages for:	
	Existing stands	Regenerated stands	Existing stands	Regenerated stands
01	130	120	80	80
02	140	140	120	120
03	90	110	80	80
04	140	130	120	120
05	130	130	80	80
06	170	170	120	120
07	90	90	60	60
08	130	130	80	80
09	90	90	60	60
10	130	120	80	80
11	110	100	100	100
12	130	120	120	120

A.4.2 Harvest profile

Lodgepole pine forest types represent 41% of the standing inventory profile. Current practice is to take up to 70% of the harvest from lodgepole pine forest types, partially to protect against mountain pine beetle losses. This practice will be modeled for one decade by requesting that 50% of the total harvest be taken from lodgepole pine types (analysis units 07 - 12).

Table A-8. Harvest profile constraints

Analysis unit(s)	Per cent of total harvest decade 1
01 - 06	50%
07 - 12	50%

A.4 Forest Management Assumptions

A.4.3 Forest cover requirements

Table A-9. specifies the forest cover requirements needed to achieve the forest management objectives for each zone.

Table A-9. Forest cover requirements

Zone	Green-up		Maximum per cent area younger than age 1	Old growth		Minimum per cent area older than age 2
	Age 1 (years)	Height 1 (metres)		Age 2 (years)	Height 2 (metres)	
1 Uneven-aged management	N/A	N/A	N/A	N/A	N/A	N/A
2 Integrated resource management	20	3	33	-	-	-
3 VQO	22	4	25	-	-	-
4 Wildlife	34	9	20	-	-	-
5 Watershed	25	5	20	150	29	10

N/A = not applicable

The green-up period (age 1) is based on area-weighting the time required to achieve green-up height (height 1) for each analysis unit. The average site indices for each analysis unit were determined using batch VDYP (see Section A.5, "Volume Estimates for Existing and Regenerated Stands"). A computer program, (FREDDIE) containing site index equations for B.C.'s commercial tree species was used to project the age at which the desired green-up height was reached.

Zone 1 — Uneven-aged management zone

Precludes traditional clearcutting silvicultural systems and includes silvicultural systems such as single tree selection, group selection, and other forms of partial cutting. Forest cover requirements are not applicable here because of the types of silvicultural systems used; a percentage of trees will be left standing to provide forest cover at all times.

Zone 2 — Integrated resource management zone

Assumes a 3-pass harvesting system, whereby no more than 33% of the zone is covered by forest less than 3 metres tall (non-greened-up).

Zone 3 — Visually sensitive corridors and lakes

Assumes that 50% of the zone will be harvested in 4-passes, whereby no more than 25% of the eligible area is covered by forest less than 4 metres tall. Approximately 50% of the zone is covered by forest suitable for selective harvesting. Also, many areas in this zone have good visual absorption capability.

Zone 4 — Wildlife winter range and corridors

Areas within this zone will be managed such that no more than 20% of the area is covered by forests less than 9 metres tall. This is done to ensure that most of the timber is harvested at ages older than 170 years.

Zone 5 — Community watersheds

The forest cover requirements were based on those contained in the Italy/Sutherland Watershed Management Plan.

A.4 Forest Management Assumptions

A.4.4 Unsalvaged losses

Unsalvaged losses are timber volumes destroyed or damaged by natural causes such as fire and disease. Estimated annual losses are deducted from the gross timber supply to determine the projected net volumes that will be harvested over time. Table A-10. shows the estimated average annual loss for the Boundary TSA.

Table A-10. Unsalvaged losses

Cause of loss	Annual unsalvaged loss in cubic metres/year
Insects	5 800
Disease	30 000
Fire	3 500
Wildlife trees and shrubs	2 600
Wind	5 000
Seed trees not recovered	3 500
Total	50 400

A.4.5 Not satisfactorily restocked (NSR) areas

Table A-11. summarizes the total area of current and backlog NSR currently existing in the Boundary TSA. Data was compiled using information from the History Record System downloaded into a database program. This allowed the openings on the system to be sorted into the appropriate species by site group.

Ninety-six per cent of the current NSR will be restocked within the next 10 years and all of the current NSR will be restocked within the next 20 years. All backlog NSR will be restocked within the next 10 years.

Table A-11. Not satisfactorily restocked (NSR) areas based on silviculture history records

Analysis unit	NSR (area in hectares)		Total area (hectares)
	Backlog	Current	
01	2 602	3 264	5 866
02	502	83	585
03	11	182	193
04	5	0	5
05	289	58	347
06	133	0	133
07	303	2 798	3 101
08	15	0	15
09	738	7 692	8 430
10	18	42	60
11	0	0	0
12	0	0	0
Total	4 616	14 119	18 735

A.4 Forest Management Assumptions

The data in Table A-11. was used to apportion the operable NSR stands, based on the latest Forest Inventory for Planning (FIP) file, into analysis units. The analysis is based on FIP file data, as summarized in Table A-12. FIP file and History Record NSR figures vary slightly (18 735 versus 17 171 hectares) because the History Record System information is more up to date. The differences between the two systems is negligible and has no impact on the analysis.

Table A-12. Not satisfactorily restocked (NSR) area based on inventory records

Analysis unit	Zone (area in hectares)					Total NSR (hectares)
	1	2	3	4	5	
01	705.5	-	397.8	151.6	221.1	1 476.0
02	54.7	-	7.0	-	39.8	101.5
03	-	53.0	-	-	-	53.0
04	-	-	-	7.2	44.3	51.5
05	-	380.7	-	-	-	380.7
06	-	31.2	-	-	-	31.2
06	-	-	-	69.6	-	69.6
08	-	-	-	-	-	-
09	-	14 292.4	478.1	-	237.0	15 007.5
10	-	-	-	-	-	-
Total	760.2	14 757.3	882.9	228.4	542.2	17 171.0

A.4 Forest Management Assumptions

A.4.6 Basic silviculture and regeneration assumptions

The following table shows the analysis units to which stands are regenerated after harvesting. In some cases, despite the analysis unit number remaining the same, the species mix between regenerated and existing stands may change. For example, analysis unit 12 switches from predominately pine to predominately Douglas-fir and analysis unit 03 switches from predominately cedar/hemlock to predominately spruce/pine. Minimum harvestable ages for regenerated analysis units in some cases may reflect the switch in leading species (e.g. analysis unit 12).

Table A-13. *Regeneration assumptions*

Management zone	Existing analysis unit	Regenerated analysis unit & [species mix]	Per cent natural	Per cent planted	Initial stocking (stems/hectare)	Regen delay(s) (years)
1	01	01 [F,Pl,L,Py]	70	30	1 000	4
1	02	02 [F,Pl,L,Py]	70	30	1 000	4
3,4,5	01	01 [F,Pl,L,Py]	70	30	1 000	4
3,4,5	02	02 [F,Pl,L,Py]	70	30	1 000	4
2	03	03 [S,Pl,F,C,H]	20	80	1 000	3
2	04	04 [S,Pl,F,C,H]	20	80	1 100	3
2,4,5	05	05 [S,Pl]	20	80	1 000	3
2,4	06	06 [S,Pl]	20	80	1 000	3
2,4	07	09 [Pl,F,L,S]	60	40	1 000	5
2	08	10 [F,Pl]	60	40	1 000	5
2,3,4,5	09	09 [Pl,F,L,S]	60	40	1 000	4
2	10	10 [F,Pl,S]	60	40	1 000	4
2,3,4,5	11	11 [Pl,F,L,S]	60	40	1 100	5
2,4	12	12 [F,Pl,S]	60	40	1 100	5

F = Douglas-fir, Pl = lodgepole pine, L = larch, Py = ponderosa pine, S = spruce, C = cedar, H = hemlock

A.4.7 Uneven-aged management

Area regulation, implying that approximately the same amount of area is harvested every year, was used in this analysis to approximate uneven-aged management (single tree selection, group selection and other similar silvicultural systems). Under area regulation, annual area targets are provided to restrict the amount of harvesting. For dry-belt Douglas-fir/larch stands growing on good and medium sites about 1% of the stands (or the volume related to this 1%) can be harvested annually. On poor sites about 0.8% of dry-belt Douglas-fir/larch stands (or the volume related to the 0.8%) can be harvested annually.

A.5 Volume Estimates for Existing and Regenerated Stands

A batch version of the Variable Density Yield Prediction (VDYP) model, developed by Inventory Branch of the B.C. Forest Service was used to predict volume yields for existing stands, excluding plantations established since 1983. VDYP yield curves are based on close utilization less decay, and are reduced for waste and breakage. Yields have also been reduced by the proportion of deciduous volumes in each analysis unit. The VDYP yield tables applied to most existing stands in the analysis are shown in Table A-14. under the column header "Existing Natural."

The Table Interpolation Program for Stand Yields (TIPSY) developed by Research Branch of the B.C. Forest Service was used to predict volume yields for future regenerated stands, plantations established on land currently classified as NSR, and free-growing plantations established since 1983. To construct the tables for the timber supply analysis, the average site index for each analysis unit and the establishment methods and species described in Section A.4.6, "Basic silviculture and regeneration assumptions" were applied. To account for operational conditions, a 15% reduction was applied to account for small openings and unproductive areas within future stands. Yields were further reduced on a graduated basis to account for an increased incidence of disease, decay, waste and breakage as stands age. At age 100, this reduction amounts to 10%. Approximately one-half of the 10% reduction may be attributed to root rot and other diseases promoted by intervention. The TIPSY yield tables applied to existing plantations and restocked NSR lands are shown in Table A-14. under the column header "Existing Planted." TIPSY yield tables applied to future regenerated stands are shown in Table A-14. under the column header "Regen All."

A.5 Volume Estimates for Existing and Regenerated Stands

Table A-14. Volume estimates (cubic metres per hectare) for existing and regenerated stands

Analysis unit 1 - zone 1 Douglas-fir, larch, ponderosa pine good and medium sites				Analysis unit 2 - zone 1 Douglas-fir, larch, ponderosa pine poor site		
Max MAI (m ³ /ha/yr)	Existing		Regen	Max MAI (m ³ /ha/yr)	Existing	Regen
	Natural 1.84	Planted 2.24	All 2.19		Natural 1.59	All 1.54
Age				Age		
10	0	0	0	10	0	0
20	0	0	0	20	0	0
30	1	0	4	30	0	0
40	14	2	13	40	3	5
50	38	26	39	50	18	15
60	65	65	75	60	41	36
70	92	108	115	70	65	62
80	120	147	152	80	90	89
90	146	180	183	90	115	117
100	172	211	212	100	139	141
110	196	241	240	110	163	162
120	219	267	263	120	184	181
130	240	290	284	130	205	199
140	258	313	304	140	223	216
150	270	333	321	150	235	230
160	279	350	336	160	244	242
170	284	365	350	170	249	253
180	288	377	360	180	252	263
190	291	388	369	190	254	272
200	294	396	377	200	257	280
210	298	403	383	210	260	286
220	301	411	390	220	263	293
230	304	417	395	230	266	298
240	306	422	399	240	268	302
250	309	426	402	250	270	306
260	309	429	405	260	271	308
270	309	431	406	270	271	310
280	310	431	407	280	271	312
290	310	431	406	290	271	313
300	310	431	406	300	272	313
310	310	431	406	310	272	313
320	310	431	406	320	272	313
330	310	431	406	330	272	313
340	311	431	406	340	272	313
350	310	431	406	350	272	313

continued

A.5 Volume Estimates for Existing and Regenerated Stands

Table A-14. Volume estimates (cubic metres per hectare) for existing and regenerated stands

Analysis unit 1 - zones 3, 4, 5 Douglas-fir, larch, ponderosa pine good and medium sites				Analysis unit 2 - zones 3, 4, 5 Douglas-fir, larch, ponderosa pine poor site		
Max MAI (m ³ /ha/yr)	Existing		Regen	Max MAI (m ³ /ha/yr)	Existing	Regen
	Natural 1.68	Planted 2.24	All 2.19		Natural 1.42	All 1.54
Age				Age		
10	0	0	0	10	0	0
20	0	0	0	20	0	0
30	1	0	4	30	0	0
40	12	2	13	40	3	5
50	35	26	39	50	18	15
60	59	65	75	60	39	36
70	84	108	115	70	61	62
80	109	147	152	80	83	89
90	133	180	183	90	105	117
100	156	211	212	100	126	141
110	179	241	240	110	146	162
120	199	267	263	120	165	181
130	218	290	284	130	183	199
140	235	313	304	140	199	216
150	247	333	321	150	211	230
160	257	350	336	160	220	242
170	264	365	350	170	227	253
180	270	377	360	180	232	263
190	275	388	369	190	237	272
200	281	396	377	200	242	280
210	286	403	383	210	247	286
220	290	411	390	220	252	293
230	295	417	395	230	257	298
240	299	422	399	240	261	302
250	303	426	402	250	265	306
260	303	429	405	260	265	308
270	304	431	406	270	265	310
280	304	431	407	280	266	312
290	304	431	406	290	266	313
300	304	431	406	300	266	313
310	304	431	406	310	266	313
320	304	431	406	320	266	313
330	304	431	406	330	266	313
340	304	431	406	340	266	313
350	304	431	406	350	266	313

continued

A.5 Volume Estimates for Existing and Regenerated Stands

Table A-14. Volume estimates (cubic metres per hectare) for existing and regenerated stands

Analysis unit 3 - zone 2 Cedar, hemlock, white pine good and medium sites			Analysis unit 4 - zone 2 Cedar, hemlock, white pine poor site		
Max MAI (m ³ /ha/yr)	Existing 1.92	Regenerated 2.68	Max MAI (m ³ /ha/yr)	Existing 1.46	Regenerated 1.95
Age			Age		
10	0	0	10	0	0
20	0	0	20	0	0
30	2	5	30	0	1
40	23	22	40	6	8
50	56	57	50	26	20
60	89	100	60	54	45
70	121	146	70	81	78
80	150	191	80	107	112
90	173	230	90	127	145
100	192	266	100	145	174
110	208	295	110	161	203
120	222	317	120	173	231
130	239	334	130	190	253
140	256	348	140	204	271
150	270	360	150	218	285
160	283	369	160	229	296
170	294	376	170	240	306
180	305	382	180	249	314
190	315	387	190	258	321
200	325	390	200	267	326
210	334	389	210	276	330
220	344	388	220	285	334
230	353	387	230	293	336
240	362	386	240	302	337
250	371	384	250	310	338
260	374	381	260	313	338
270	376	378	270	316	337
280	378	375	280	318	334
290	380	372	290	321	332
300	382	369	300	323	329
310	384	369	310	325	329
320	385	369	320	327	329
330	387	369	330	328	329
340	388	369	340	330	329
350	390	369	350	331	329

continued

A.5 Volume Estimates for Existing and Regenerated Stands

Table A-14. Volume estimates (cubic metres per hectare) for existing and regenerated stands

Analysis unit 5 - zones 2, 4, 5 Spruce, balsam good and medium sites				Analysis unit 6 - zones 2, 4 Spruce, balsam poor site		
Max MAI (m³/ha/yr)	Existing		Regen	Max MAI (m³/ha/yr)	Existing 1.17	Regen 1.86
	Natural 1.68	Planted 2.73	All 2.63			
Age				Age		
10	0	0	0	10	0	0
20	0	0	0	20	0	0
30	1	0	0	30	0	0
40	7	0	0	40	1	0
50	28	11	9	50	7	0
60	59	50	43	60	17	2
70	90	103	93	70	36	16
80	118	157	145	80	57	47
90	142	203	192	90	77	83
100	164	247	235	100	96	122
110	184	294	281	110	113	156
120	201	327	315	120	129	187
130	219	353	342	130	145	216
140	234	373	363	140	160	248
150	248	373	380	150	174	276
160	261	389	393	160	187	298
170	272	402	404	170	199	317
180	282	412	413	180	209	330
190	291	421	421	190	219	342
200	300	428	426	200	229	353
210	308	433	430	210	238	360
220	316	436	432	220	247	368
230	323	438	434	230	255	373
240	330	439	431	240	263	377
250	336	436	428	250	270	380
260	339	432	424	260	273	383
270	341	428	420	270	276	385
280	344	423	416	280	278	385
290	346	419	412	290	281	385
300	348	414	407	300	283	385
310	349	409	407	310	285	385
320	351	409	407	320	287	385
330	352	409	407	330	289	385
340	354	409	407	340	290	385
350	355	409	407	350	292	385

continued

A.5 Volume Estimates for Existing and Regenerated Stands

Table A-14. Volume estimates (cubic metres per hectare) for existing and regenerated stands

Analysis unit 7 - zones 2, 4 Pure lodgepole pine good and medium sites				Analysis unit 8 - zone 2 Pure lodgepole pine		
Max MAI (m ³ /ha/yr)	Existing		Regen	Max MAI (m ³ /ha/yr)	Existing	
	Natural 2.90	Planted 3.21	All 2.84		Natural 1.81	All 1.27
Age				Age		
10	0	0	0	10	0	0
20	0	0	0	20	0	0
30	19	28	18	30	5	0
40	71	83	58	40	16	7
50	118	132	102	50	40	22
60	160	177	147	60	70	41
70	197	224	191	70	99	64
80	230	257	226	80	124	84
90	261	285	256	90	149	102
100	289	308	283	100	172	117
110	316	326	305	110	194	135
120	341	341	324	120	215	151
130	364	353	340	130	235	165
140	380	363	353	140	249	176
150	391	371	364	150	259	185
160	399	378	374	160	267	193
170	404	383	381	170	273	200
180	405	387	388	180	275	206
190	402	390	393	190	274	212
200	404	392	397	200	277	217
210	407	393	400	210	280	221
220	409	394	400	220	283	224
230	412	393	400	230	285	227
240	415	393	400	240	288	229
250	417	393	400	250	290	231
260	419	393	400	260	293	232
270	422	393	400	270	295	233
280	424	393	400	280	296	234
290	425	393	400	290	298	234
300	427	393	400	300	300	233
310	429	393	400	310	301	233
320	430	393	400	320	302	233
330	431	393	400	330	303	233
340	432	393	400	340	304	233
350	433	393	400	350	304	233

continued

A.5 Volume Estimates for Existing and Regenerated Stands

Table A-14. Volume estimates (cubic metres per hectare) for existing and regenerated stands

Analysis unit 9 - zones 2, 3, 4, 5 Mixed lodgepole pine good and medium sites				Analysis unit 10 - zone 2 Mixed lodgepole pine poor site		
Max MAI (m ³ /ha/yr)	Existing		Regen	Max MAI (m ³ /ha/yr)	Existing	Regen
	Natural 2.53	Planted 3.15	All 2.84		Natural 1.56	All 1.38
Age				Age		
10	0	0	0	10	0	0
20	0	0	0	20	0	0
30	18	7	18	30	4	7
40	63	64	58	40	15	22
50	104	119	102	50	35	41
60	141	170	147	60	62	64
70	173	218	191	70	87	84
80	202	252	226	80	111	102
90	228	281	256	90	132	117
100	252	305	283	100	152	135
110	274	324	305	110	170	151
120	294	339	324	120	187	165
130	313	352	340	130	203	176
140	327	363	353	140	215	185
150	337	371	364	150	225	193
160	344	378	374	160	233	200
170	348	383	381	170	239	206
180	349	387	388	180	242	212
190	348	390	393	190	244	217
200	351	392	397	200	248	221
210	353	393	400	210	251	224
220	356	394	400	220	254	227
230	358	393	400	230	258	229
240	361	393	400	240	261	231
250	363	393	400	250	263	232
260	365	393	400	260	265	233
270	366	393	400	270	267	234
280	368	393	400	280	269	234
290	369	393	400	290	270	234
300	370	393	400	300	271	234
310	372	393	400	310	272	234
320	373	393	400	320	273	234
330	374	393	400	330	274	234
340	374	393	400	340	275	234
350	375	393	400	350	276	234

continued

A.5 Volume Estimates for Existing and Regenerated Stands

Table A-14. Volume estimates (cubic metres per hectare) for existing and regenerated stands (concluded)

Analysis unit 11 - zone 2, 3, 4, 5 Dense lodgepole pine good and medium sites			Analysis unit 12 - zone 2, 4 Dense lodgepole pine poor site		
Max MAI (m ³ /ha/yr)	Existing 2.30	Regenerated 2.33	Max MAI (m ³ /ha/yr)	Existing 1.79	Regenerated 1.56
Age			Age		
10	0	0	10	0	0
20	0	0	20	0	0
30	5	8	30	0	1
40	42	35	40	14	13
50	82	75	50	43	32
60	117	111	60	73	60
70	149	146	70	100	85
80	178	182	80	126	108
90	205	209	90	150	128
100	230	233	100	172	151
110	253	254	110	194	171
120	275	272	120	214	187
130	296	287	130	233	200
140	310	299	140	246	211
150	321	311	150	256	221
160	328	319	160	264	230
170	332	327	170	268	238
180	333	333	180	270	244
190	332	338	190	270	250
200	334	342	200	272	255
210	336	345	210	275	258
220	339	347	220	277	261
230	341	349	230	280	263
240	343	350	240	282	266
250	345	351	250	284	267
260	347	351	260	286	268
270	349	350	270	288	268
280	351	350	280	290	268
290	352	350	290	291	268
300	353	349	300	292	268
310	355	348	310	293	268
320	356	348	320	294	268
330	357	348	330	295	268
340	357	348	340	296	268
350	358	348	350	296	268

