

Invermere 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 Invermere TSA began in July, 1994. The information it contains independent of the October 1994 East 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 Invermere 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 document 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 Invermere Timber Supply Area (TSA). The analysis assesses how current forest management practices affect the supply of wood available for harvesting over both the short (next 20 years) and long (next 250 years) term. 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 Invermere TSA covers a total area of about 1 018 000 hectares, of which about 234 000 hectares are considered available for timber harvesting under current management practices. The area is dominated by stands of lodgepole pine, Douglas-fir and spruce. The current AAC for the Invermere TSA is 650 564 cubic metres per year. This does not include 6700 cubic metres apportioned to woodlot licences.

The results of this timber supply analysis suggest that the current harvest level must be reduced immediately by about 12.7% or 82 564 cubic metres to 568 000 cubic metres per year in order to avoid either the need for more rapid harvest reductions over the next few decades, or significant shortfalls in timber supply further in the future. To continue to avoid major harvest shortfalls, harvests must decline from this initial harvest level by about 12% per decade over the next 5 decades to a low of about 315 000 cubic metres per year, which is 12.5% below the steady long-term harvest level. In about 90-110 years, when timber harvesting is projected to occur predominantly in second-growth stands, the harvest level could increase to the steady long-term harvest level of about 360 000 cubic metres per year.

Several factors contribute to the need to reduce harvests from the currently approved level. The most important factor is that the current harvest level is well above the steady, long-term harvest level. In this situation harvest rates must decline toward the long-term level to avoid serious timber supply shortfalls in the future. Also contributing to the

decline, to some extent, are forest cover requirements for forest resources such as wildlife habitat, scenic quality, biodiversity and community watersheds. However, even if these forest cover requirements were removed, harvests would still need to decline in the near future. An additional contributing factor is that significantly less area is available for timber harvesting today than when the last timber supply analysis was completed in 1981. Riparian buffers to protect stream and lake ecosystems, forest ecosystem networks and steep slope sites below the operability line, all areas previously considered available for harvesting, now are not available under current standards of practice.

The above results reflect current knowledge and information on forest inventory and growth. However, it is important to recognize that uncertainty exists about several of the factors that define timber supply. A series of sensitivity analyses indicate that these uncertainties can affect timber supply to varying degrees.

The short-term timber supply is particularly sensitive to yield estimates for existing stands, land base size, forest cover requirements (especially for ungulate winter range), large increases to old-growth requirements, and unsalvaged losses. Minimum harvestable ages, and length of green-up periods are factors that also affect short-term timber supply, but to a lesser degree.

The long-term harvest level is highly sensitive to uncertainty in yield estimates for regenerated stands, the size of the timber harvesting land base and unsalvaged losses. The long-term harvest level is lightly impacted by uncertainty in minimum harvestable ages, length of green-up periods, green-up forest cover requirements, and old-growth requirements.

The need to harvest below the long-term level between decades 5 and 9 can be emphasized or reduced by changes to any of the following factors: initial harvest level and rate of decline, size of the timber harvesting land base, minimum harvestable ages, estimates of existing stand yields, length of green-up periods, and green-up forest cover requirements. The choice of starting harvest rate and rate of decline may also change the harvest level during this time.

Executive Summary

In conclusion, this analysis indicates that using current inventory and growth and yield information, timber harvests in the Invermere TSA must drop over the next few decades even if inventory, growth and yield and management assumptions used in this analysis significantly underestimate timber supply. It

will be important to examine forest cover guidelines, especially for ungulate winter range and visual quality objectives when deciding on a strategy for the transition from the current harvest level to a level sustainable over the long term.

Table of Contents

Preface	iii
Executive Summary	iv
Introduction	1
1 Description of the Invermere TSA.....	3
2 Information Preparation.....	5
2.1 Land base inventory	5
2.2 Timber growth and yield.....	12
2.3 Management practices.....	12
3 Analysis Methods	16
4 Results.....	17
4.1 Base case harvest forecast.....	17
4.2 Area, average volume, and average age harvested	21
4.3 Age class distribution over time.....	24
5 Timber Supply Sensitivity Analyses	28
5.1 Alternative harvest flows.....	28
5.2 Uncertainty in minimum harvestable ages	31
5.3 Uncertainty in existing stand volume estimates.....	34
5.4 Uncertainty in regenerated stand volume estimates	36
5.5 Uncertainty in the size of the timber harvesting land base	37
5.6 Uncertainty in green-up ages	39
5.7 Uncertainty in green-up forest cover requirements	41
5.8 Uncertainty in the ungulate winter range objective	42
5.9 Uncertainty in old-growth requirements	45
5.10 Combined effect of all forest cover requirements	46
5.11 Uncertainty in estimates of unsalvaged losses	48
5.12 Interaction between uncertainties in existing yields and the timber harvesting land base. 49	
6 Summary and Conclusions	53
7 References	54
8 Glossary	55
APPENDIX A Description of Data Inputs and Assumptions.....	59
Introduction	60
A.1 Zone and Analysis Unit Definition.....	61
A.2 Definition of the Timber Harvesting Land Base	66
A.3 Forest Management Assumptions.....	72
A.4 Volume Estimates for Existing and Regenerated Stands	78

Table of Contents

Tables

1.	Timber harvesting land base, Invermere TSA.....	8
A-1.	Land base classification of each analysis zone within the Invermere TSA.....	64
A-2.	Analysis unit characteristics.....	65
A-3.	Total area in each ownership category for Invermere TSA.....	67
A-4.	Per cent area reductions for environmentally sensitive areas.....	68
A-5.	Per cent area reduction for steep slopes.....	69
A-6.	Summary of forest cover polygons included in riparian zones.....	70
A-7.	Per cent area reductions for non-merchantable forest types.....	71
A-8.	Identification of culmination and minimum harvestable age for each analysis unit.....	72
A-9.	Forest cover requirements.....	73
A-10.	Unsalvaged losses.....	75
A-11.	Not satisfactorily restocked (NSR) areas based on silviculture history records.....	76
A-12.	Regeneration assumptions.....	77
A-13.	Volume estimates (cubic metres per hectare) for existing and regenerated stands.....	79

Figures

1.	Map of the Nelson Forest Region.....	4
2.	Classification of the total and productive forest land bases — Invermere TSA, 1995.....	9
3.	Area by dominant tree species — Invermere TSA timber harvesting land base, 1995.....	10
4.	Current age class distribution of forest stands — Invermere TSA timber harvesting land base, 1995.....	11
5.	Major forest management emphases — Invermere TSA timber harvesting land base, 1995.....	15
6.	The base case harvest forecast for the Invermere TSA, 1995.....	18
7.	Changes in timber growing stock over time — Invermere TSA base case, 1995.....	19
8.	Area harvested over time — Invermere TSA base case, 1995.....	21
9.	Average volume per hectare harvested over time — Invermere TSA base case, 1995.....	22
10.	Average harvested age over time — Invermere TSA base case, 1995.....	23
11.	Changes in stand age composition on timber harvesting land base over time — Invermere TSA base case, 1995.....	25
12.	Harvest forecast with initial harvest levels set at the current harvest level and at a constant rate for 120 years — Invermere TSA, 1995.....	29
13.	Harvest forecast with the initial harvest set at 10% below the current harvest level — Invermere TSA, 1995.....	30
14.	Harvest forecast with the initial harvest set to avoid harvests below the long-term level — Invermere TSA, 1995.....	31
15.	Harvest forecasts if minimum harvestable ages are changed by 20 years — Invermere TSA, 1995.....	32

Table of Contents

Figures (continued)

16.	Comparison of average harvested ages following from changes to minimum harvestable ages — Invermere TSA, 1995	33
17.	Harvest forecasts when existing stand volume estimates are changed by 10% — Invermere TSA, 1995.....	34
18.	Harvest forecasts when existing stand volume estimates are changed by 20% — Invermere TSA, 1995.	35
19.	Harvest forecasts if regenerated stand volume estimates are changed by 10% — Invermere TSA, 1995.....	36
20.	Harvest forecasts if the timber harvesting land base is increased 8% and 15% — Invermere TSA, 1995.....	38
21.	Harvest forecasts if the timber harvesting land base is decreased 8% and 15% — Invermere TSA, 1995.....	39
22.	Harvest forecasts if green-up ages are changed by 5 years — Invermere TSA, 1995.	40
23.	Harvest forecasts when forest cover requirements are changed by 5% — Invermere TSA, 1995.....	42
24.	Harvest forecasts if thermal cover requirement is relaxed by 5 and 10 percentage points — Invermere TSA, 1995.....	43
25.	Harvest forecasts if thermal cover requirement is tightened by 5 and 10 percentage points — Invermere TSA, 1995.....	44
26.	Harvest forecast with changes to the old-growth/biodiversity requirement — Invermere TSA, 1995.....	45
27.	Harvest forecast if all forest cover requirements removed — Invermere TSA, 1995.	46
28.	Average age of harvested stands if forest cover requirements removed — Invermere TSA, 1995.....	47
29.	Harvest forecasts if unsalvaged losses were eliminated or increased — Invermere TSA, 1995	49
30.	Additive interaction of increases and decreases in both existing stand yield estimates and the size of the timber harvesting land base — Invermere TSA, 1995	50
31.	Offsetting interaction between decreased estimates of existing stand yields and an increase in the size of the timber harvesting land base — Invermere TSA, 1995.....	51
32.	Offsetting interaction between increased estimates of existing stand yields and a decrease in the size of the timber harvesting land base — Invermere TSA, 1995.....	52

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.

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 Invermere 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.

**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.*

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 Invermere TSA

The Invermere TSA lies within the Nelson Forest Region (Figure 1). It is administered from the Invermere Forest District office, and covers 1 018 351 hectares.

The Invermere TSA is home to the 7300 residents of Invermere, Windermere, Radium Hot Springs, Fairmont, Canal Flats, Edgewater and Parsons, as well as a significant rural population spread between these communities. The forest industry is the major employer in the area with mining, agriculture and a quickly growing tourism industry as important secondary employers. The tourism industry relies in part on significant wildlife values as well as abundant recreational opportunities.

The current AAC totals 657 264 cubic metres per year. Approximately 84.8% of the AAC is allocated to Crestbrook Forest Industries Ltd., Slocan Forest Products Ltd. and small licensees, 12.4% is harvested through the Small Business Forest Enterprise

Program (SBFEP) administered by the B.C. Forest Service and 1.8% of the current AAC is held in a Forest Service Reserve. About 1%, or 6700 cubic metres per year, are apportioned to woodlot licences.

The Invermere TSA straddles the Columbia Trench, bounded on the west by the Purcell Mountain range and on the east by the Rockies. Over a third of the Invermere TSA is covered by rugged alpine terrain and about one-half is considered productive forest land. Forests of the Invermere TSA support a diverse range of commercial tree species: lodgepole pine, Douglas-fir, yellow pine, spruce, larch, balsam, cedar and hemlock are all found within the area. Non-commercial species include birch, aspen and cottonwood. Lodgepole pine and Douglas-fir are the most common species in the Invermere TSA, dominating stands on about two-thirds of the productive forest land.

1 Description of the Invermere TSA

Figure 1. Map of the Nelson Forest Region.

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 came in the form of a computer file prepared by the B.C. Forest Service Inventory Branch in 1994. This file contains a considerable amount of data about the thousands of pieces of forest land that make up a TSA, including the geographic location, area and nature of the forest cover (such as presence or absence of trees, number of trees, species, age and timber volume).

Initially, this file represents the land base of 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. 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).

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 forested sites in these areas are occupied by timber of sufficient economic value, and are not overly environmentally sensitive, so that timber harvesting can be accommodated with due care for other resources.

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

The timber harvesting land base recommendations of the Commission on Resources and 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.

Areas on which timber harvesting is not expected to occur, under current forest management in the Invermere TSA, are:

- areas not administered by the B.C. Forest Service as part of the timber harvesting land base — 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.
- 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.
- environmentally sensitive areas* — a significant portion of areas defined as environmentally sensitive were deducted from the timber harvesting land base.
- steep slopes and areas with unstable soils.
- riparian buffers — to protect streamside and stream ecosystems and lakes.
- some sites with low timber growing potential (low site class).
- non-merchantable forest types* — areas occupied by timber stands of low volume or non-merchantable species (e.g. deciduous stands).
- 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.3.5, "Not satisfactorily restocked (NSR) areas."

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.

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 areas where timber harvesting may cause avalanches.

Non-merchantable forest types

Stands that are accessible and otherwise available for harvesting but are assumed to be non-merchantable due to stand characteristics such as small piece size, incidence of decay, species composition and low stocking.

Not satisfactorily restocked (NSR)

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

- existing roads, skid trails and landings — to account for the loss of productive forest land that has occurred during past timber harvesting and development, 10.5% of all areas occupied by stands currently less than 40 years old is estimated to be unavailable for further timber production.
- forest ecosystem networks (FENs) — areas occupied by mature operable timber falling within the connecting corridors of FENs.
- 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 after the first harvest.

A more detailed description of these categories and the rationale for their removal is located in Appendix A, "Description of Data Inputs and Assumptions." Table 1 summarizes the areas in each category, and shows the area of the timber harvesting land base.

2 Information Preparation

Table 1. Timber harvesting land base, Invermere TSA.

Classification	Area (hectares)	Per cent of total area	Per cent of productive forest area
Total area on inventory file	1 018 351	100.0	
Not administered as part of the Invermere TSA timber harvesting land base (non-Crown)	152 422	15.0	
Non-forest land	363 443	35.7	
Total productive forest managed by B.C. Forest Service (Crown forest)	502 492	49.3	100.0
Reductions to Crown forest:			
Non-commercial cover	803	0.1	0.2
Inoperable	167 692	16.5	33.4
Environmentally sensitive areas	26 939	2.6	5.4
Steep slopes	18 805	1.8	3.7
Riparian areas	3 652	0.4	0.7
Sites with low timber growing potential	7 922	0.8	1.6
Non-merchantable types:			
Deciduous types	3 512	0.3	0.7
Problem forest types	15 429	1.5	3.1
Not satisfactorily restocked (NSR)	20 914	2.0	4.2
Forest ecosystem networks (FENs)	18 946	1.9	3.8
Existing roads, trails, landings	5 033	0.5	1.0
Total current reduction	- 289 647	28.4	57.6
Initial timber harvesting land base (less NSR)	212 845	20.9	42.4
Additions:			
NSR ₁ ^a (timber type unknown)	14 422	1.4	2.9
NSR ₂ (timber type known)	6 492	0.6	1.3
Total additions	+ 20 914	2.0	4.2
Current timber harvesting land base	233 759	23.0	46.5
Future reductions:			
Future roads, trails, landings	- 17 774	1.7	3.5
Future timber harvesting land base	215 985	21.2	43.0

(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 Invermere TSA. The total area chart shows that 49% of the Invermere TSA is Crown forest, that is, managed by B.C. Forest Service as potentially contributing to the timber supply assessed in this analysis. Approximately 47% of the Crown productive forest land is available for timber

harvesting, as shown in the Crown forest chart and Table 1. One-third of the forest land is considered physically or economically inoperable at this time. Overall, almost one-quarter of the total Invermere TSA is available for timber harvesting (see Table 1).

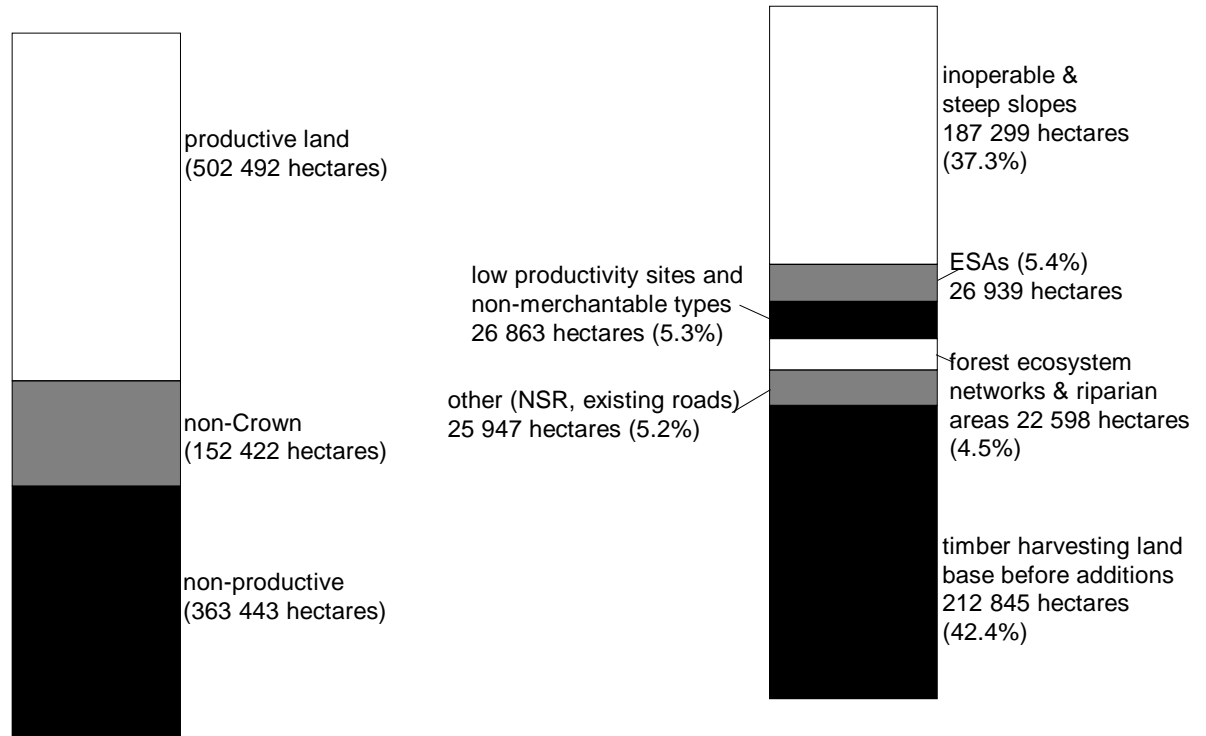


Figure 2. Classification of the total and productive forest land bases — Invermere TSA, 1995.

2 Information Preparation

Several types of forested areas that fall outside of the timber harvesting land base contribute to management for non-timber values. Some inoperable areas and non-merchantable forest stands contribute to management objectives for non-timber values and environmental protection. Further, environmentally sensitive areas, steep slope areas, riparian area buffers, and forest ecosystem networks, also contribute to management for non-timber values. These areas amount to 68 342 hectares, or 13.6% of the total forest area.

Figure 3 summarizes the composition of the timber harvesting land base. Lodgepole pine forest

types are the most prevalent, accounting for 44% of the area, with Douglas-fir and Ponderosa pine (32%), spruce (13%), and larch (7%) dominated stands also being common. Other forest types, including balsam, cedar, hemlock, cottonwood, aspen and birch comprise a minor component (4%) of the timber harvesting land base. Figure 3 also shows that over 50% of the timber harvesting land base is covered by stands currently classified as immature (younger than 80 years for lodgepole pine and 120 years for other species). The species composition of the timber harvesting land base closely represents that of the entire forest area.

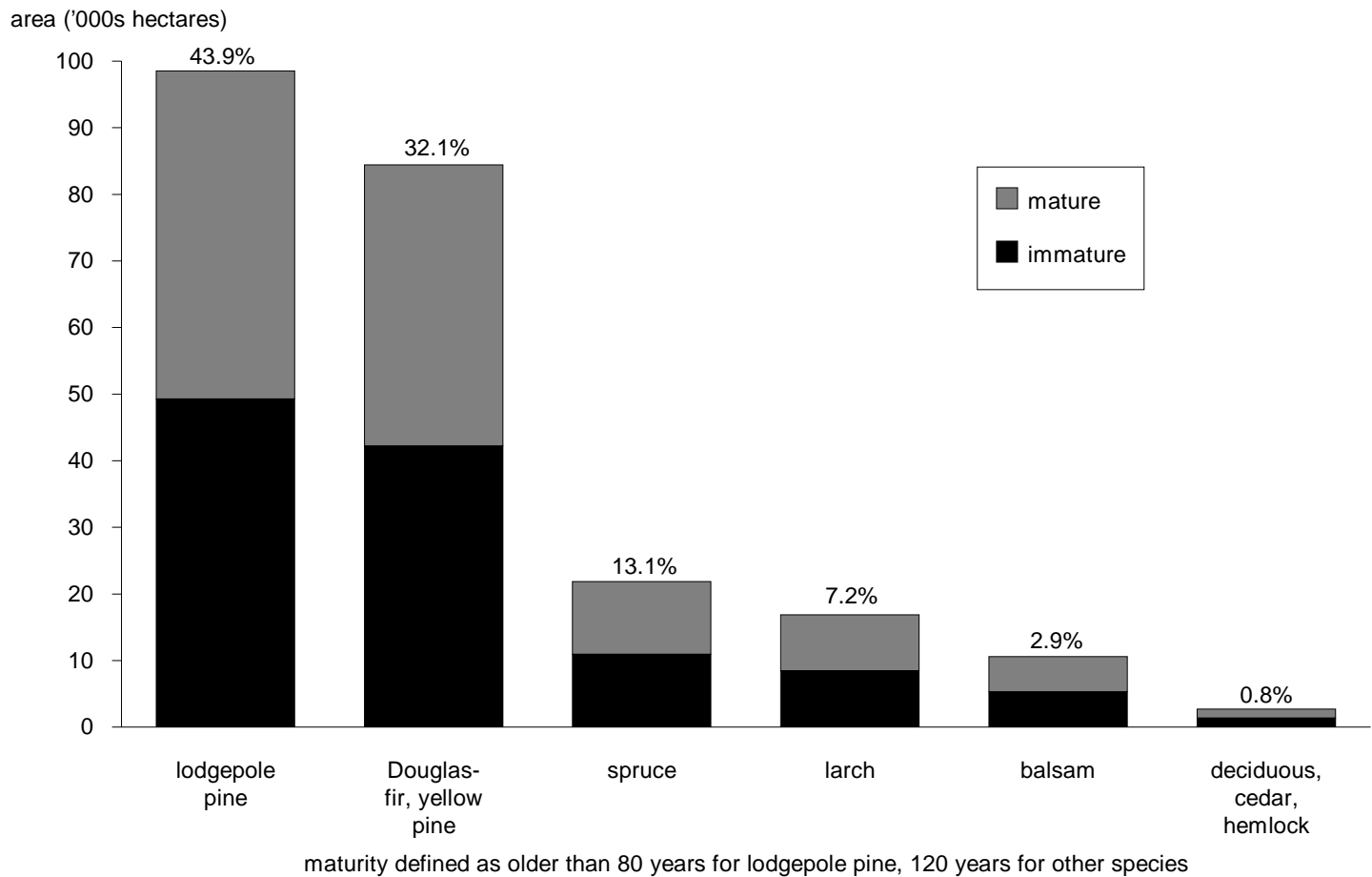


Figure 3. Area by dominant tree species — Invermere TSA timber harvesting land base, 1995.

2 Information Preparation

Figure 4 shows the distribution of stand ages, or age class distribution, on the current timber harvesting land base, hereafter referred to as the timber harvesting land base. For this figure, the timber harvesting land base does not include not satisfactorily stocked (NSR) areas which are added when they reach a free-growing* condition. Stand ages are grouped into 20-year age classes except for

the oldest stands. This figure shows the significant variation in the amount of area among age classes. For example, age class 21-40 years accounts for 4.9% of the timber harvesting land base, as opposed to age class 61-80 years, which accounts for 14.9% of the area available for timber harvesting. A relatively large proportion of stands, about 23%, is older than 140 years of age.

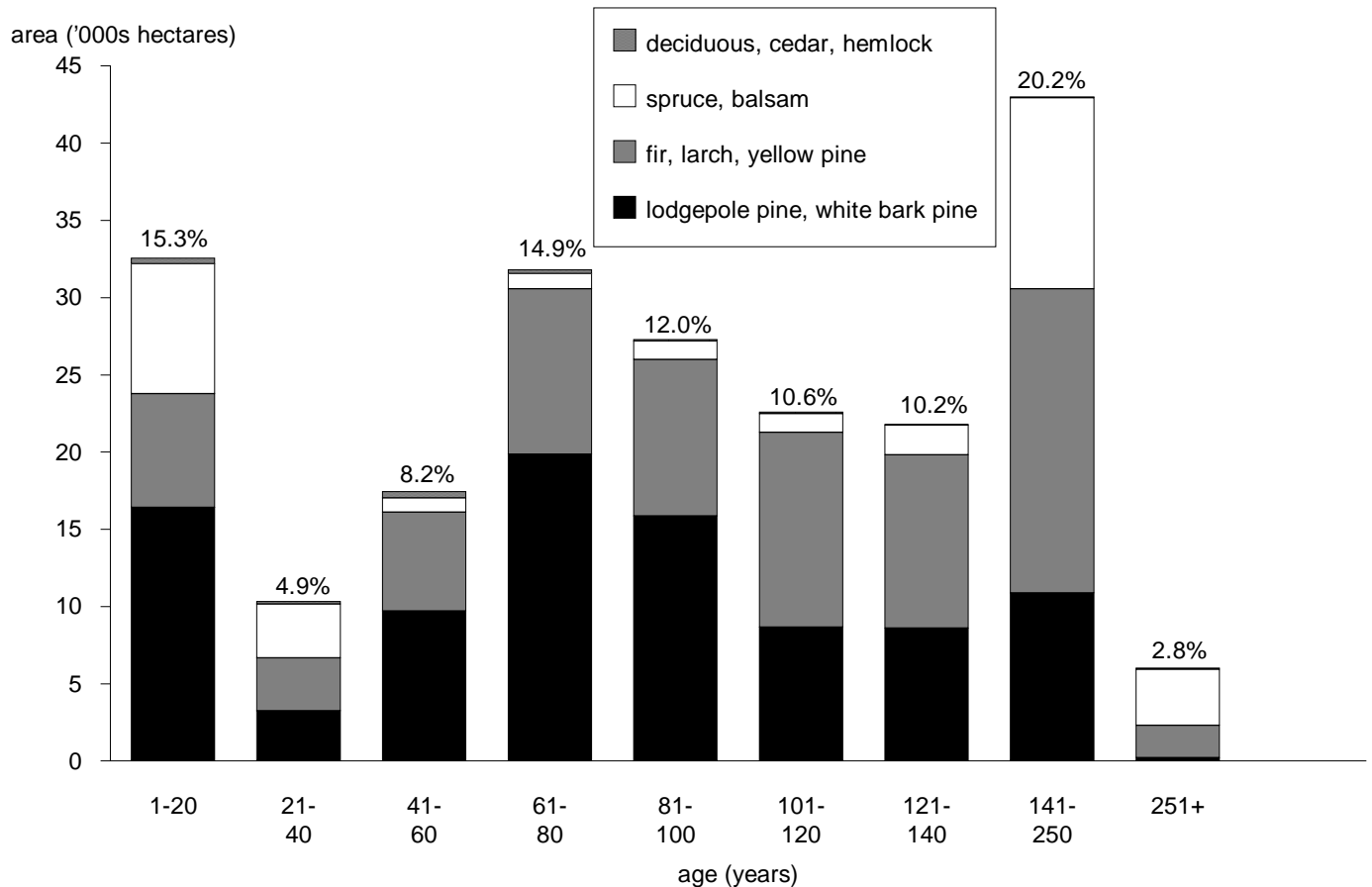


Figure 4. Current age class distribution of forest stands — Invermere TSA timber harvesting land base, 1995.

Free-growing

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

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. See Appendix A, "Description of Data Inputs and Assumptions" for more details on utilization.

Timber volumes applied to existing natural 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 existing and 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 Invermere 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. Areas in the Invermere TSA are harvested using either clearcut harvesting*, or partial cutting systems such as seed-tree* and shelterwood*, and restocked by planting or natural regeneration.
- Forest health and unsalvaged losses — expected losses of merchantable timber due to fire, pest (insects, disease, animals) and wind damage are expected to be 63 597 cubic metres per year. Wildlife trees and seed trees are included in this category.
- Minimum harvestable ages — the time it takes for stands to grow to a harvestable size. The minimum harvestable 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.

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.

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.

Seed-tree system

Removal of most of the mature, merchantable trees in one harvest, except for a small number of trees to provide seed to facilitate establishment of a new stand.

Shelterwood system

Involves leaving a significant proportion of the mature, merchantable trees standing after an initial harvest to provide seed and shelter to assist in establishing a new stand. Usually the shelter trees are harvested after the new stand is well established.

2 Information Preparation

- **Cutblock adjacency*** and **green-up***— when approving forestry operations, the Invermere Forest District employs a guideline specifying that previously harvested stands must reach a height of 3 metres, or green-up, before adjacent mature timber may be harvested. Stands 3 metres or more in height are considered suitable hiding cover for ungulate species.
- **Forest cover objectives*** — specify the desired distribution of areas by age (e.g. at least 50% of the area should be more than 60 years old). These objectives are used to represent general adjacency and green-up guidelines, as well as desired conditions for wildlife, watershed protection and visual quality objectives (VQOs)*.
- **Representation of forest types** — when approving harvesting operations the Invermere Forest District attempts to meet an objective to retain at least 10% of the productive forest in each biogeoclimatic subzone in the area in old-growth conditions, defined as 141 years or older in most forest types, to help maintain some types of biological diversity.
- **Steep slopes below operability line** — about 18 805 hectares of forest area are classified as physically operable in the inventory, but are either too steep or hazardous to be harvested under current standards of practice, or contain unstable soils. These areas were removed from the timber harvesting land base, but contribute to managing non-timber values such as visual quality, watershed protection, and biodiversity.
- **Riparian area protection** — 3652 hectares were removed from the timber harvesting land base to protect riparian areas throughout the Invermere TSA.
- **Forest ecosystem network (FENs)** — 18 946 hectares are excluded from harvesting to account for areas in the timber harvesting land base that fall within connecting corridors that assist in wildlife travel and biodiversity protection.

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., top 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

- Visual quality — 33 858 hectares (15%) of the timber harvesting land base are being managed for visual quality. Maintaining visual quality requires that visible evidence of harvesting be kept within limits. Guidelines provided by the Ministry of Forests, Recreation Branch state the maximum proportion of an area that may be less than 6 metres tall (the visual green-up). The proportion depends on the specific visual quality objective (VQO) and visual sensitivity* of the area. Areas managed for visual quality fall into three categories: (1) retention/preservation* where visible evidence of timber harvesting must be minimal; (2) partial retention* where timber harvesting may be noticeable, but not dominant; and (3) modification* where harvesting may be visually dominant, but must blend with the natural landscape. Appendix A, "Description of Data Inputs and Assumptions" contain a detailed description of the specific objectives that apply to these categories.
- Watershed protection — 13 519 hectares (6%) of the timber harvesting land base fall within community watersheds. Harvesting in these areas is limited to ensure that at least 74% of the timber harvesting land base is covered at all times by trees taller than 9 metres.
- Habitat for feature wildlife species — 72 017 hectares (31%) of the timber harvesting land base are being managed to provide or maintain either prime caribou habitat (2169 hectares) or winter range for ungulate species (69 848 hectares). Joint Ministry of Environment, Lands, and Parks and Ministry of Forests harvesting guidelines for wildlife habitat state for winter range the proportion of an area needed as thermal cover (forest taller than 15 metres). For caribou, these guidelines state the necessary representation of older forest types.
- Forage production — 6450 hectares (3%) of the timber harvesting land base in the Columbia Trench are being managed for both forage and timber production. *Trench Integrated Renewable Resource Management Plan Guidelines* state the proportion of area that should be in an open forest condition.

Visual sensitivity

A measure of the level of concern for the scenic quality of a landscape. Visual sensitivity ratings take into account the physical character of the landscape, as well as viewer related factors such as the number of viewers and the angle, position, and distance from which the landscape is viewed.

Retention VQO

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

Preservation VQO

Alterations are generally not visible. Up to 1% of the visible landscape can be visibly changed by harvesting activity. (see visual quality objective)

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)

Modification VQO

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

2 Information Preparation

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

The above discussion outlines four main forest management emphases within the Invermere TSA:

- integrated resource management for which cutblock adjacency, summer range for ungulates, and forest type representation (old-growth/biodiversity) objectives, or forage production objectives apply;
- visual quality management for tourism and outdoor recreation values;
- watershed protection and water conservation in community watersheds; and

- habitat management for feature wildlife species such as caribou, elk and deer.

Many of the current management practices just described for the Invermere TSA meet or exceed anticipated forest practices code standards.

Figure 5 displays the composition of the timber harvesting land base according to the main management emphases.

Appendix A, "Description of Data Inputs and Assumptions" contains a more detailed discussion on how areas in the Invermere TSA were assigned into different forest management emphasis areas, or management zones, to assess the impact of current management practices on timber supply.

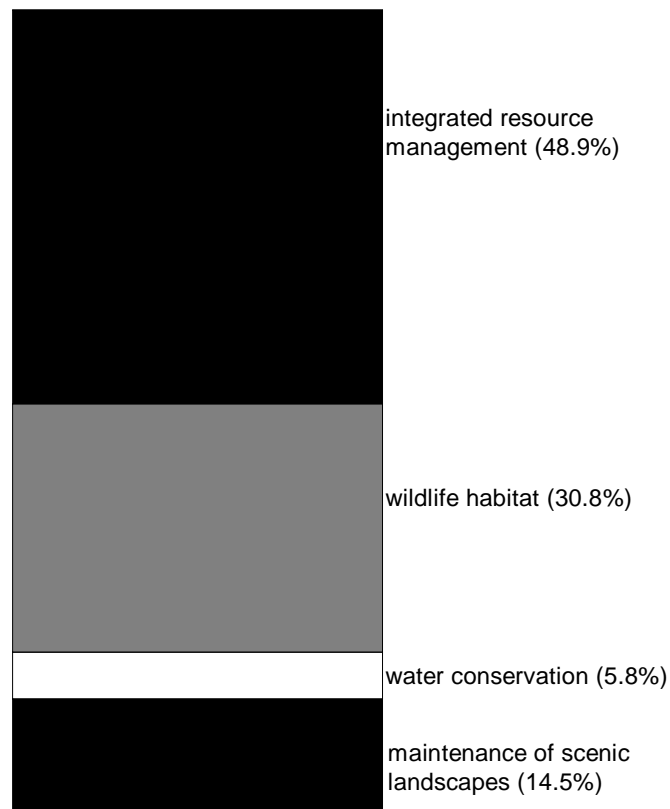


Figure 5. Major forest management emphases — Invermere TSA timber harvesting land base, 1995.

3 Analysis Methods

The purpose of this analysis was to examine both the short- and long-term timber harvesting opportunities in the Invermere 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 250 years are shown graphically in this report because the harvest remains constant after that time.

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 Invermere 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."

4.1 Base case harvest forecast

Figure 6 shows the base case harvest forecast*. The forecast shows an initial level of 568 000 cubic metres per year, 82 564 cubic metres (12.7%) below the current allowable harvest level for the Invermere TSA. After the first decade, the harvest falls by 12% per decade for the next 5 decades to about 315 000 cubic metres per year — 12.5% below the steady long-term harvest level*. The projected harvest remains below the steady long-term level for 4 decades before rising over the next 2 decades to the steady long-term harvest level of 360 000 cubic metres per year. Overall, there is a 37% decline from the initial harvest level to the long-term level achieved in decade 11. The base case long-term level is 45% below the current harvest level of 650 564 cubic metres per year.

The estimated unsalvaged losses to fire and wind of 63 597 cubic metres per year have been subtracted from all harvest forecasts shown in this report.

Several criteria were used to define the base case harvest forecast. Very generally, the initial harvest level was set to avoid causing severe timber supply shortages further in the future or requiring large reductions over the next few decades to avoid such shortfalls. The specific process for defining the base case harvest forecast began by attempting to maintain the current harvest level (650 564 cubic metres per year, which excludes the 6700 cubic metres apportioned to woodlot licences) for at least 10 years followed by declines of 10% in each of the following decades, while avoiding harvest shortfalls below the steady long-term level. In this case, the current harvest level could not be maintained without causing serious future harvest shortfalls; therefore, the harvest was allowed to fall below the long-term sustainable level to a level based on productivity estimates for unmanaged existing stands. Again, the current harvest level could not be maintained, so higher rates of decline were attempted, up to a maximum of 12% per decade, while still starting at the current harvest level. The current harvest level could still not be maintained without resulting in severe future timber supply shortages, so the initial level was lowered to a level that could be maintained for at least 10 years, before declining by 12% per decade.

The steady long-term harvest level was defined as the harvest that maintains timber growing stock* at an even level on average so that harvesting can continue at a constant level in perpetuity (Figure 7). A continually declining growing stock would signify that timber is being harvested above the productive capability of the land.

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.

Growing stock

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

Long-term harvest level

A harvest level that can be maintained indefinitely given a particular forest management regime (which defines the timber harvesting land base and includes objectives and guidelines for non-timber values) and estimates of timber growth and yield.

4 Results

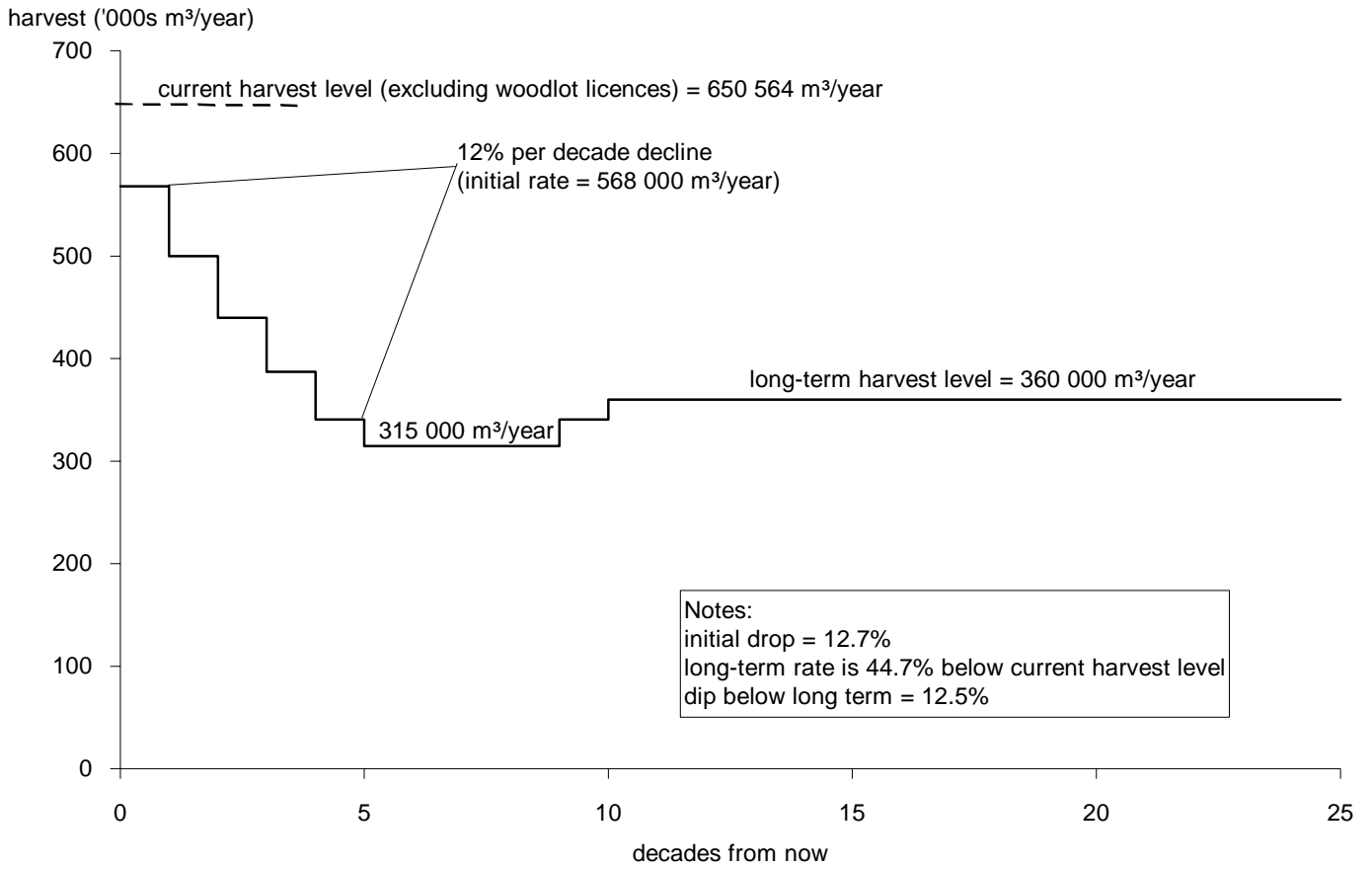


Figure 6. The base case harvest forecast for the Invermere TSA, 1995.

4 Results

Figure 7 shows a declining total growing stock (from an initial level of about 34 million cubic metres) over the first 100 years indicating that the timber inventory is decreasing. Beyond 100 years, the timber inventory gradually increases for 50 years before it becomes relatively constant (at about 28 million cubic metres), corresponding to the time when harvests remain at the long-term level. If harvests over the long term exceed the productive capability of the land, the growing stock would continue to decline, resulting in a shortage of available timber.

The long-term harvest level is about 11% less than the maximum average growth rate of the

Invermere TSA land base. This is because stands are not harvested exactly at the age that maximizes long-term volume production (that is, the age of maximum average annual growth) due to forest cover objectives and practical limitations on scheduling harvests.

Timber productivity in managed second-growth stands is expected to be higher than in existing stands. Growth estimates used in this analysis result in a long-term harvest level about 20% higher than if second-growth stands were expected to grow at the same rate as existing stands.

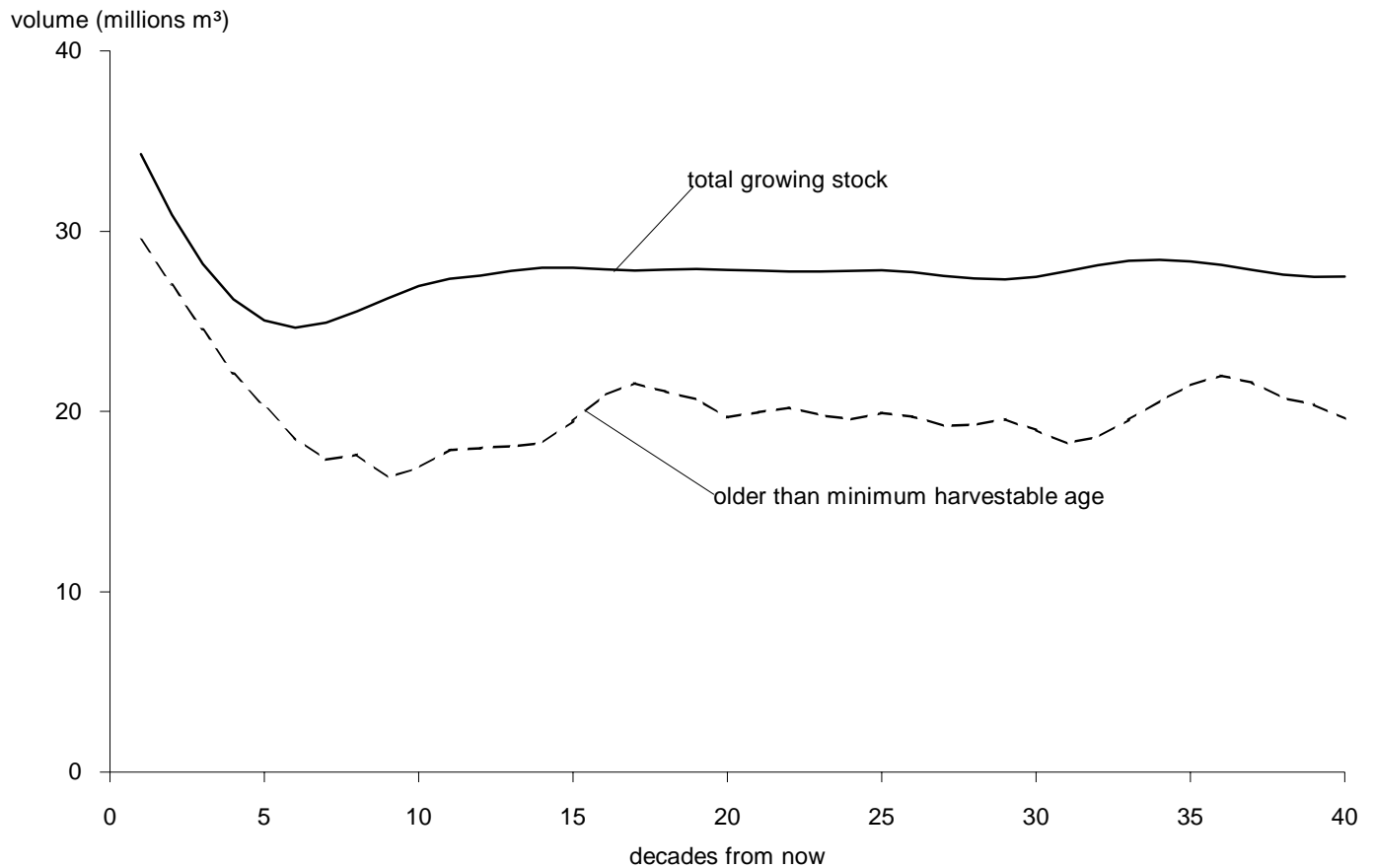


Figure 7. Changes in timber growing stock over time — Invermere TSA base case, 1995.

4 Results

The base case harvest forecast shown is only one of many possible harvest flows given current forest management assumptions. The base case harvest forecast in Figure 6 represents a balance between short- and long-term harvest levels. Any of the following alternative harvest flows over time would result in either more severe timber supply declines in the short term and/or greater shortages in the long term than shown in the base case:

- delaying the decline from the initial level for as long as possible;
- starting the harvest forecast at a higher level;
- immediately dropping to a non-declining harvest rate;
- reducing harvests at a slower rate than 12% per decade, or;
- decreasing the amount by which harvests in the base case fall below the long-term level during decades 5 to 10.

Alternative harvest flows are discussed further in Section 5, "Timber Supply Sensitivity Analyses."

Several factors affect the timber supply forecast. Most importantly, the base harvest forecast in the short term is well above the long-term harvest level and harvests must decline to avoid future timber supply shortfalls. As well, the forest cover requirements for forest resources such as wildlife, water, and scenic values have a significant downward influence on the rate of harvest on 51% of the timber harvesting land base. If normal integrated resource management guidelines (maximum of 40% younger than green-up age) were considered suitable in areas

where wildlife management is given special emphasis (about 31% of the timber harvesting land base), the initial harvest base rate could potentially be increased to the current AAC for 10 years before a decline by 12% per decade to the long term is necessary. Similarly if integrated resource management guidelines were applied in areas where the emphasis is on protecting scenic values the initial harvest level could increase by 6%, if declines similar to the base harvest forecast are implemented after decade 1. See Sections 5.7, "Uncertainty in green-up forest cover requirements" and 5.8, "Uncertainty in the ungulate winter range objective" for more information on the effect of these forest cover requirements. Even if all forest cover requirements were removed, the harvest forecast would still show a decline in the near future (see Section 5.10 "Combined effect of all forest cover requirements").

An additional factor leading to the need for harvest reductions over the next several decades is that less area is considered available for timber harvesting today than was used as the basis for past harvest level decisions. The current timber harvesting land base is 21% smaller than that used in the 1981 AAC determination based on the last timber supply analysis completed for the Invermere TSA.

There is a substantial difference (37%) between the initial and long-term harvest levels in the base case harvest forecast. Timber supply over the next several decades depends primarily on the amount of timber currently available for harvest, and on when second-growth stands reach a harvestable age. Figure 7 indicates the transition to harvesting second-growth stands begins about decade 8.

4 Results

Beginning 8 decades from now about 25% of the harvest is projected to come from second-growth stands. By 20 decades from now second growth is projected to contribute 99% of the harvest. The long transition period during which harvesting shifts from existing stands to managed second growth occurs because existing stands are maintained for a significant period of time to meet forest cover requirements.

Note the harvest forecast here, as well as Section 5, "Timber Supply Sensitivity Analyses" provide an upper limit on timber supply, given the land base and management practices discussed earlier. **This forecast is for discussion purposes**

only and is not intended to suggest a particular AAC.

4.2 Area, average volume, and average age harvested

Figure 8 shows how annual area harvested would change over the next 250 years if the base case harvest forecast were followed.

Figure 9 shows changes in the average timber volume per hectare harvested over the same period. These graphs display a decline for 60 and 40 years, respectively, and a fluctuating pattern afterwards.

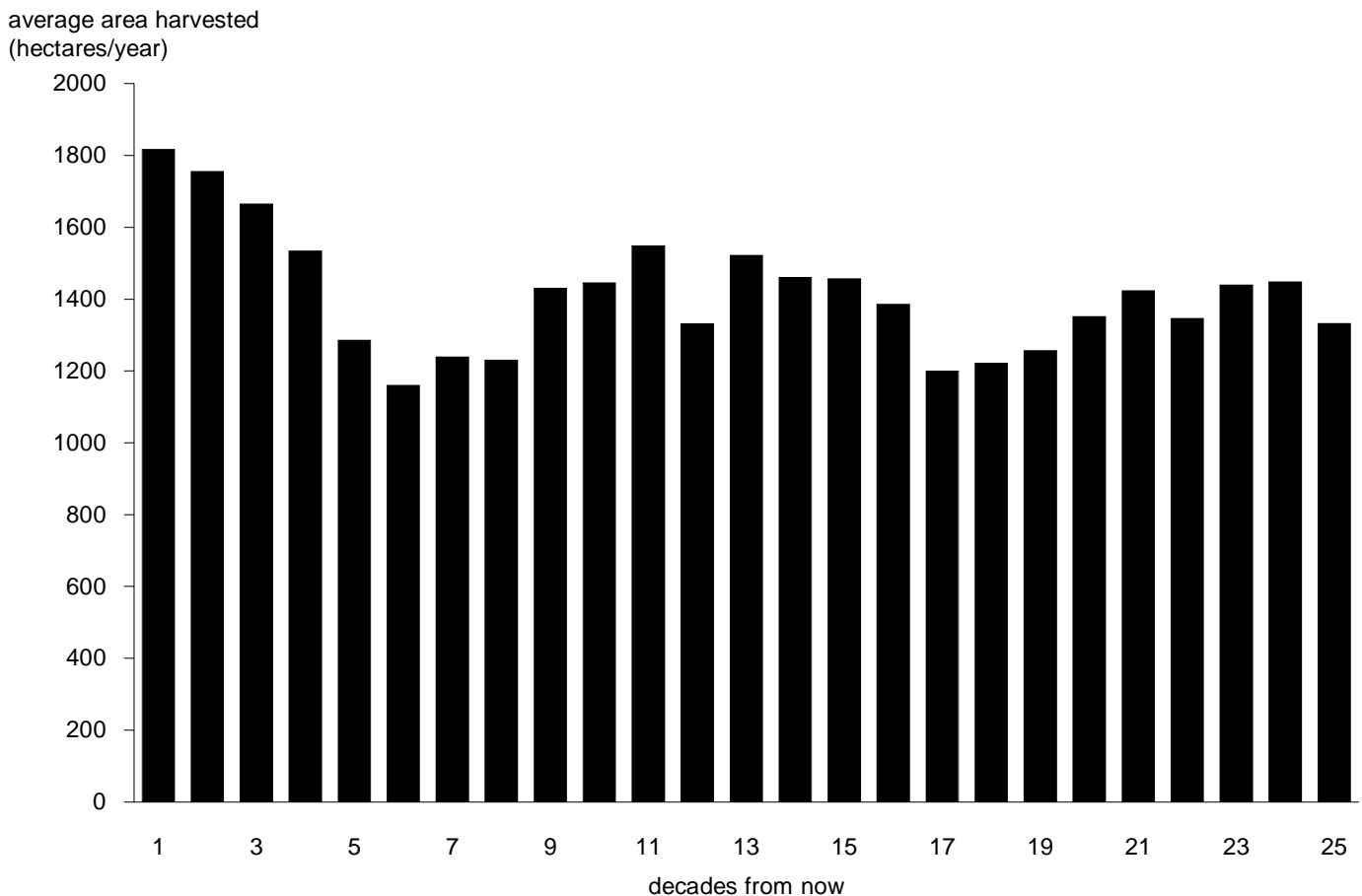


Figure 8. Area harvested over time — Invermere TSA base case, 1995.

4 Results

The declining trend in annual area harvested from decades 1 to 6 mirrors the scheduled decline of the harvest during this time. The declining trend in average volume per hectare during the first 40-year period (Figure 9) reflects in part the concurrent sharp

decline in average harvested age illustrated in Figure 10. Harvested ages start at an average of 248 years in decade 1 and decline to 152 years by decade 4.

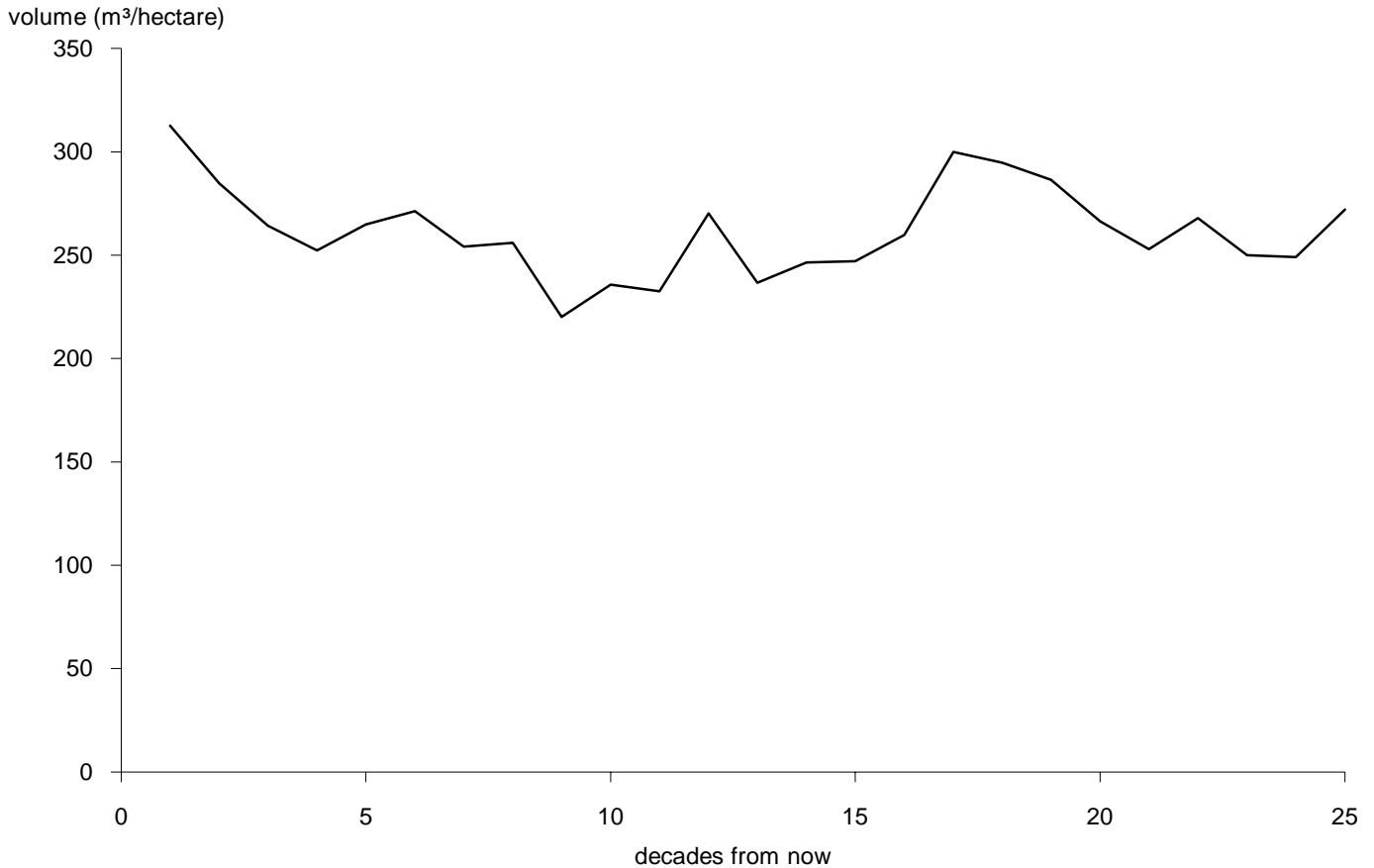


Figure 9. Average volume per hectare harvested over time — Invermere TSA base case, 1995.

4 Results

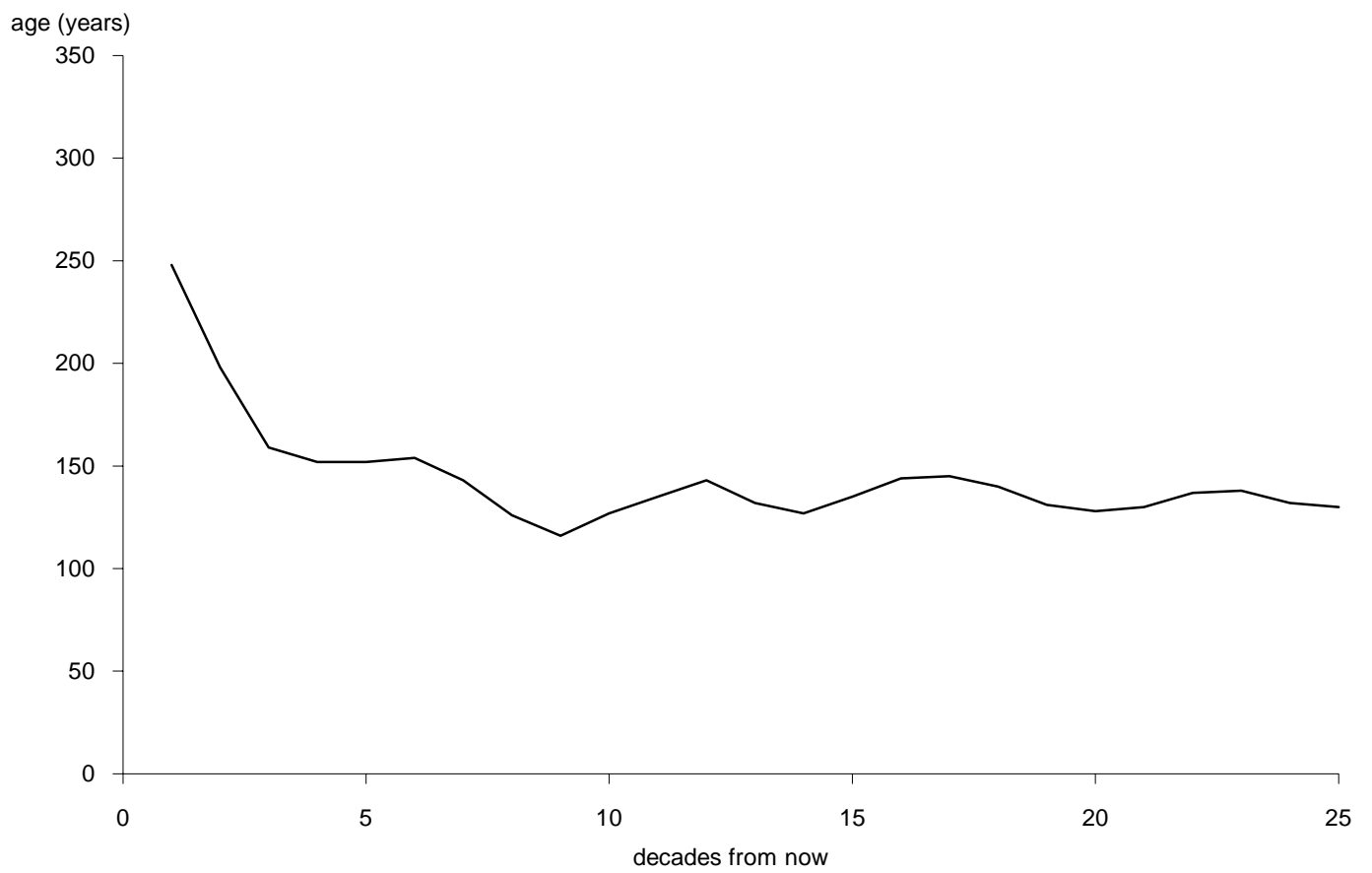


Figure 10. Average harvested age over time — Invermere TSA base case, 1995.

4 Results

4.3 Age class distribution over time

The charts in Figure 11 show how the age composition of the forest within the timber harvesting land base would change over the next 300 years under the base case harvest forecast. Currently, the age composition of the forest spans a wide range of age classes. Over the first 60 years the oldest stands are projected to be harvested, with the result that no stands over 200 years old remain in the timber harvesting land base 60 years from now. Requirements for representation of a full range of

forest types in older ages, and restricted harvest rates in areas where visual management, habitat maintenance or water conservation are emphasized, result in more forest of older ages by 120 years from now. Over the following 180 years, the age composition of the forest becomes more evenly distributed for age classes up to 120 years. During this same period, from 120 to 300 years from now, older forest is also maintained in most ages between 140 and 300 years.

4 Results

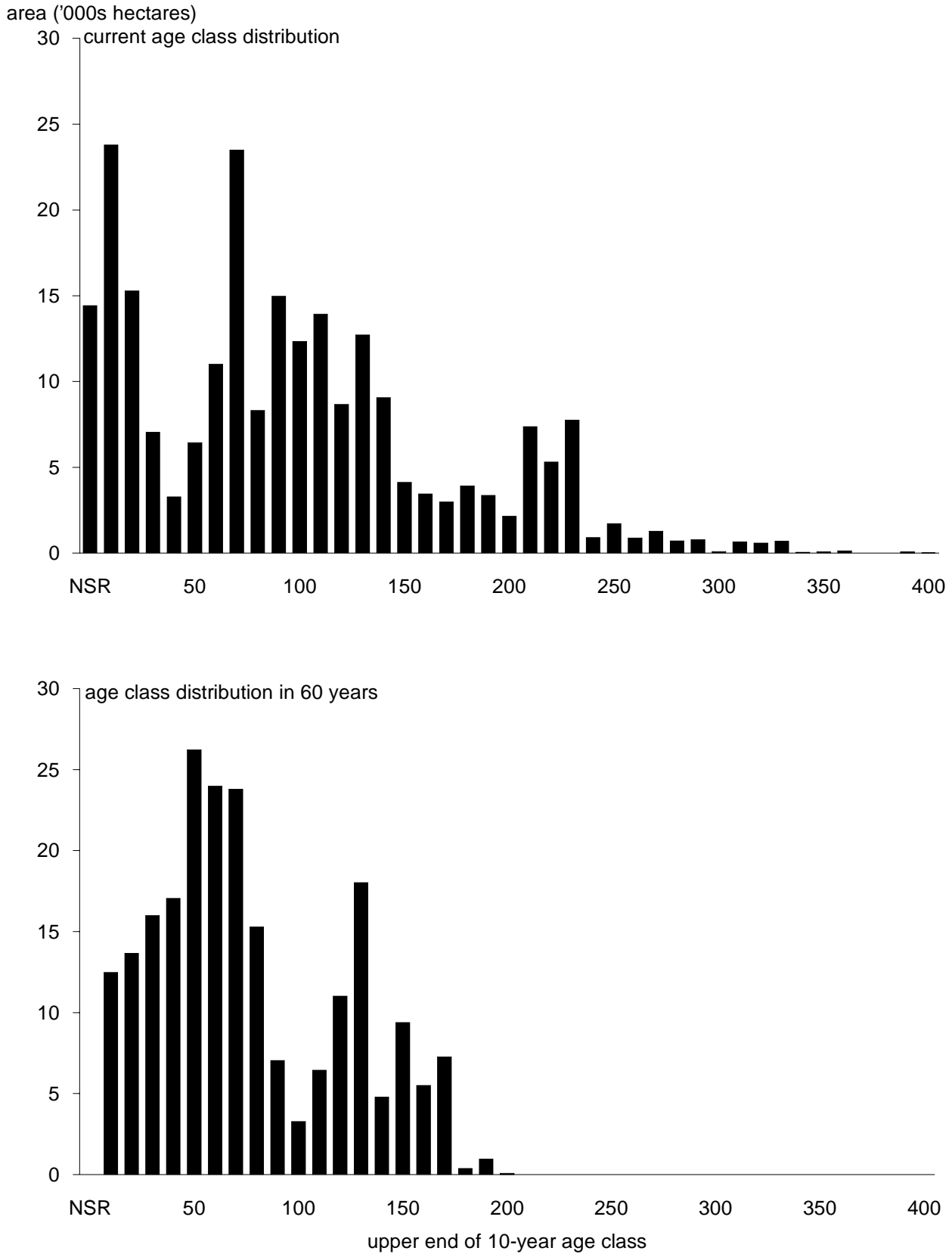


Figure 11. Changes in stand age composition on timber harvesting land base over time — Invermere TSA base case, 1995.

4 Results

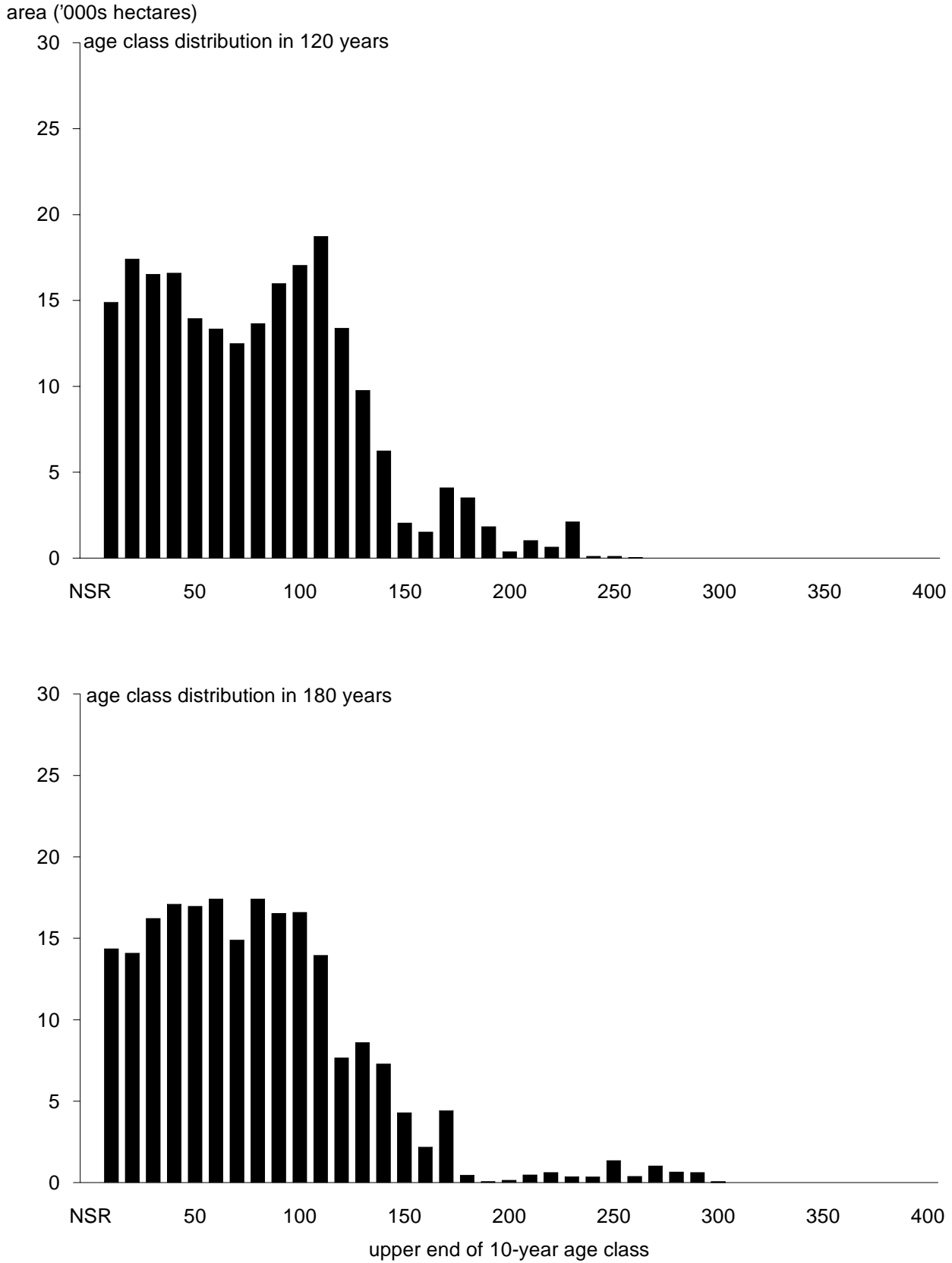


Figure 11. Changes in stand age composition on timber harvesting land base over time — Invermere TSA base case, 1995.

4 Results

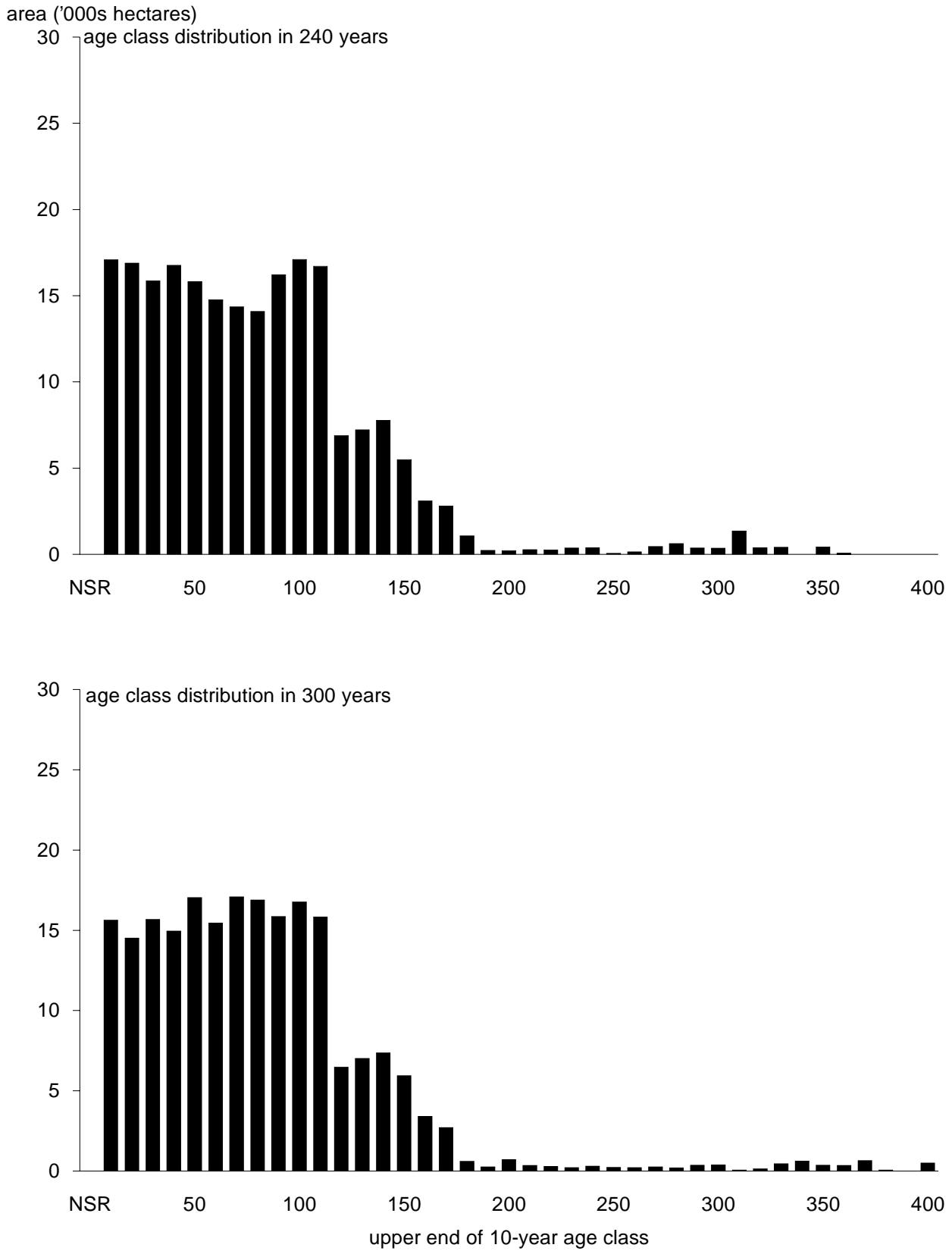


Figure 11. Changes in stand age composition on timber harvesting land base over time — Invermere TSA base case, 1995 (concluded).

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 how values of interest, for example, timber supply, could change if the information used in the analysis is not accurate. Sensitivity analysis is one way of evaluating how uncertainty could affect analysis results, and ultimately decision-making. Sensitivity analysis can highlight that fairly small uncertainties about some variables could have large effects on timber supply projections, or conversely that fairly large inaccuracies in others could have negligible effects. Also, sensitivity analysis could show that some variables affect timber supply more in the short term than in the long term, while others have the opposite effect. Sensitivity analysis can highlight priorities for collecting information for future analyses, and show which variables, and associated uncertainties, have the most significance for decisions. It can clarify whether current best estimates provide safe bases for decisions, or whether high uncertainty about

important variables means more conservative decisions may be wiser.

Some recognition of the potential effects of uncertainty is important because every decision, either implicitly or explicitly, incorporates an attitude towards uncertainty. For instance, someone who feels that existing information accurately reflects reality is, technically speaking, neutral to uncertainty, essentially believing that any inaccuracies probably balance out. Ignoring uncertainty is implicitly neutral. If maximizing timber supply were the goal, someone with an optimistic attitude 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.

In this section, results of several sensitivity analyses are discussed. The results that are based on current forest management assumptions (shown in Figures 6 to 11) are referred to as the base case.

5.1 Alternative harvest flows

The base case harvest forecast shown in Figure 6 was defined using criteria such as maximum rate of decline per decade, avoidance of large harvest shortfalls, and maintenance of a fairly constant growing stock level over the long term. While the last of these criteria is linked to maintaining the productivity of forest land, and is therefore a legislated requirement, the other criteria are not requirements, rather they are attempts to avoid both excessive changes from decade-to-decade, and significant timber shortages in the future which might limit future options. However, there are many possible harvest flows, with different decline rates, starting harvest levels, and potential trade-offs between short-term and long-term harvests.

5 Timber Supply Sensitivity Analyses

The initial harvest level of the base case harvest forecast discussed in Section 4, "Results" is 12.7% below the current harvest level. The thin, solid line in Figure 12 shows that the current harvest level could be maintained for 10 years if harvests declined at 20% per decade over the following 30 years. Maintaining the current harvest level for one decade requires a much sharper decline (8 percentage points higher than the base case) and an extended time during which the harvest level remains below the long-term

level to avoid timber supply shortfalls further in the future. The thick, solid line in Figure 12 shows an alternative harvest flow pattern with a large initial decline of 40% from the current harvest level to a level that can be maintained over the next 120 years. A constant rate of 389 000 cubic metres per year may be maintained for 12 decades before a drop to the long-term level of 360 000 cubic metres per year is required.

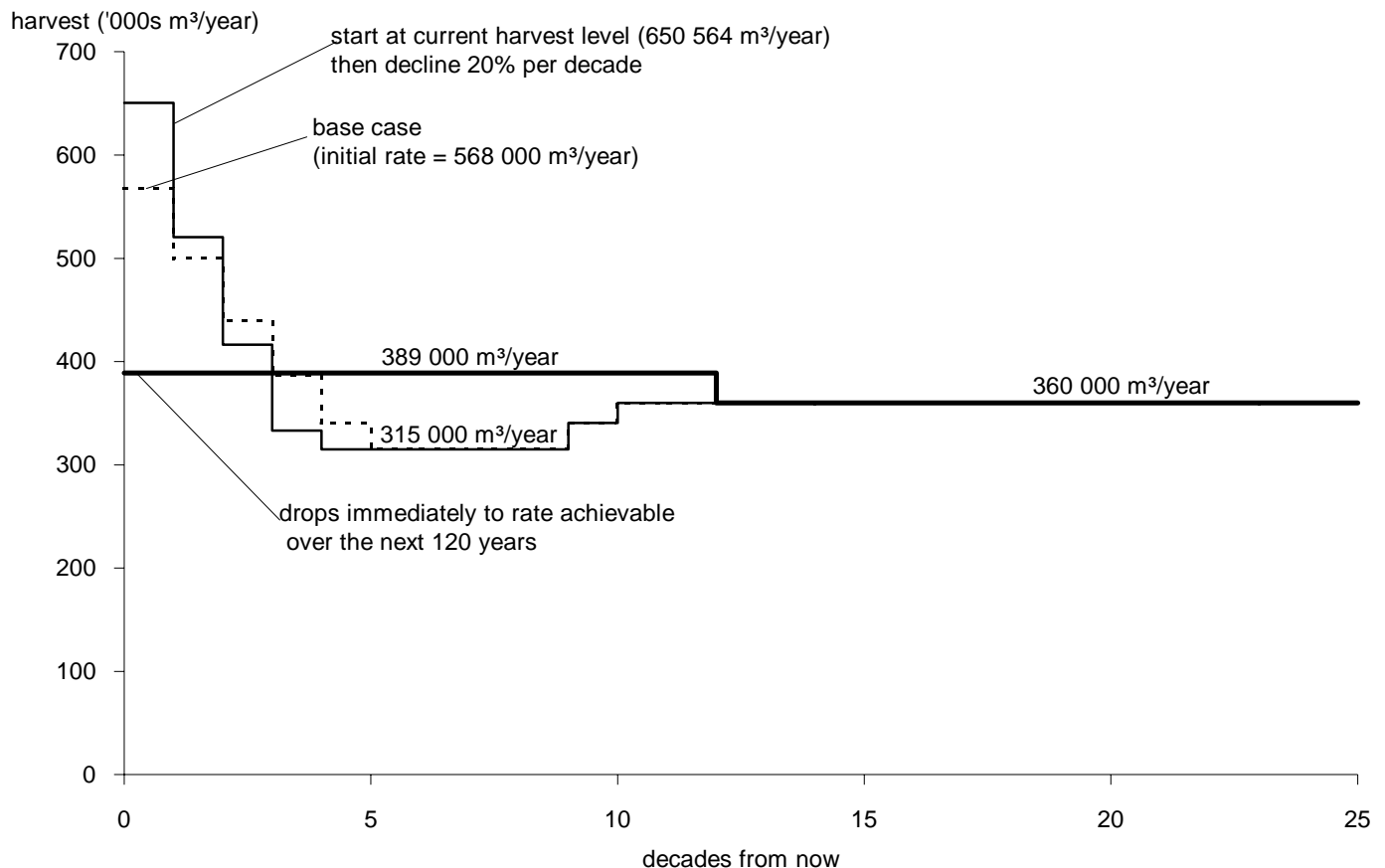


Figure 12. Harvest forecast with initial harvest levels set at the current harvest level and at a constant rate for 120 years — Invermere TSA, 1995.

5 Timber Supply Sensitivity Analyses

The solid line in Figure 13 shows the result of reducing the harvest at a rate of 10% per decade from an initial level 10% less than the current harvest level. Maintaining the slower decline rate and higher starting level than in the base case would result in

shortfalls of merchantable timber during the seventh and ninth decades when older currently existing stands have been harvested, and sufficient second-growth stands have not yet reached a harvestable age to maintain the harvest target.

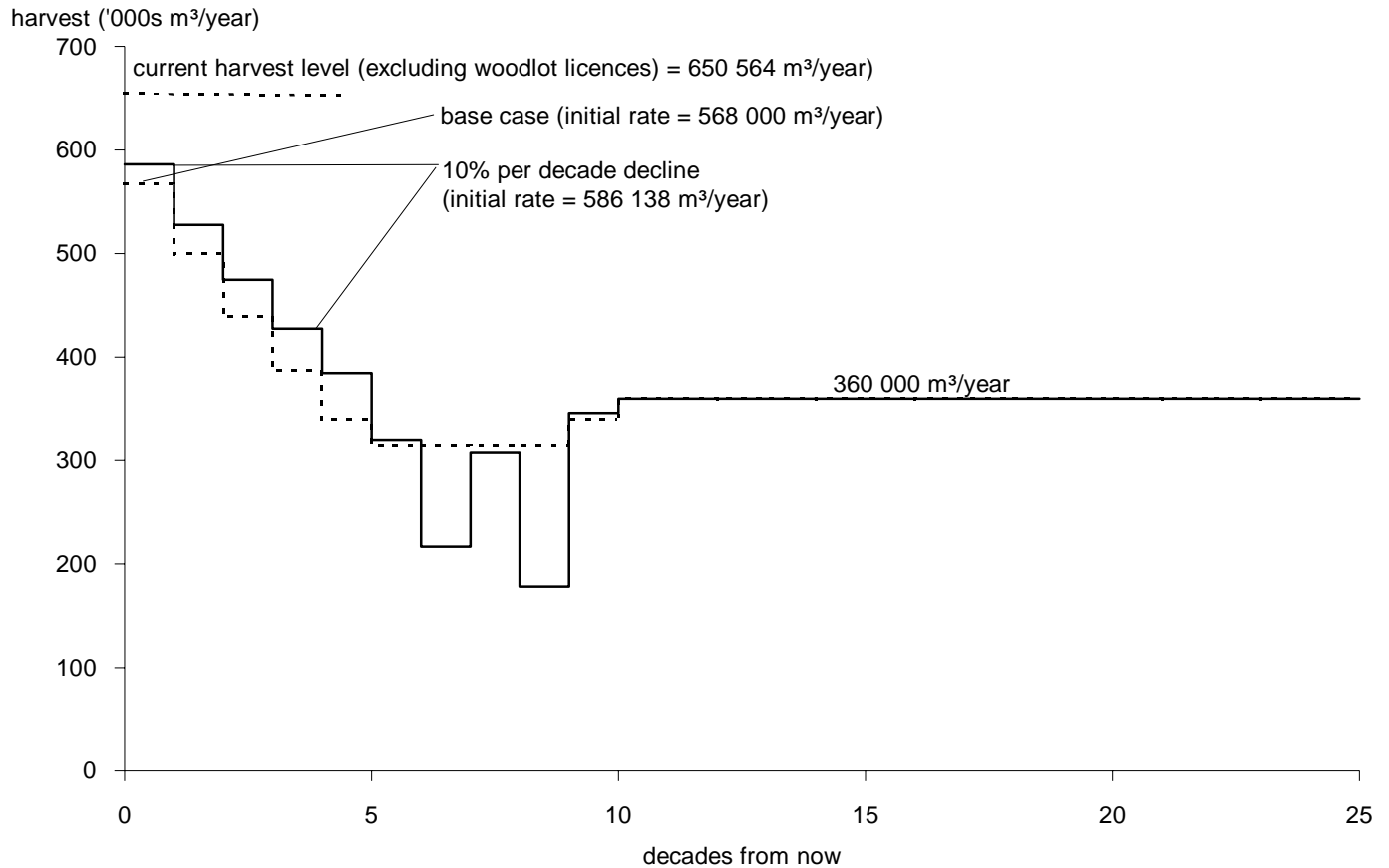


Figure 13. Harvest forecast with the initial harvest set at 10% below the current harvest level — Invermere TSA, 1995.

5 Timber Supply Sensitivity Analyses

The solid line in Figure 14 shows the result of setting harvest levels so that the dip below the long-term level between decades 5 and 9 is avoided.

The initial harvest rate in this case is 520 000 cubic metres per year, which is 8.4% lower than the base rate and 23.3% lower than the current harvest level.

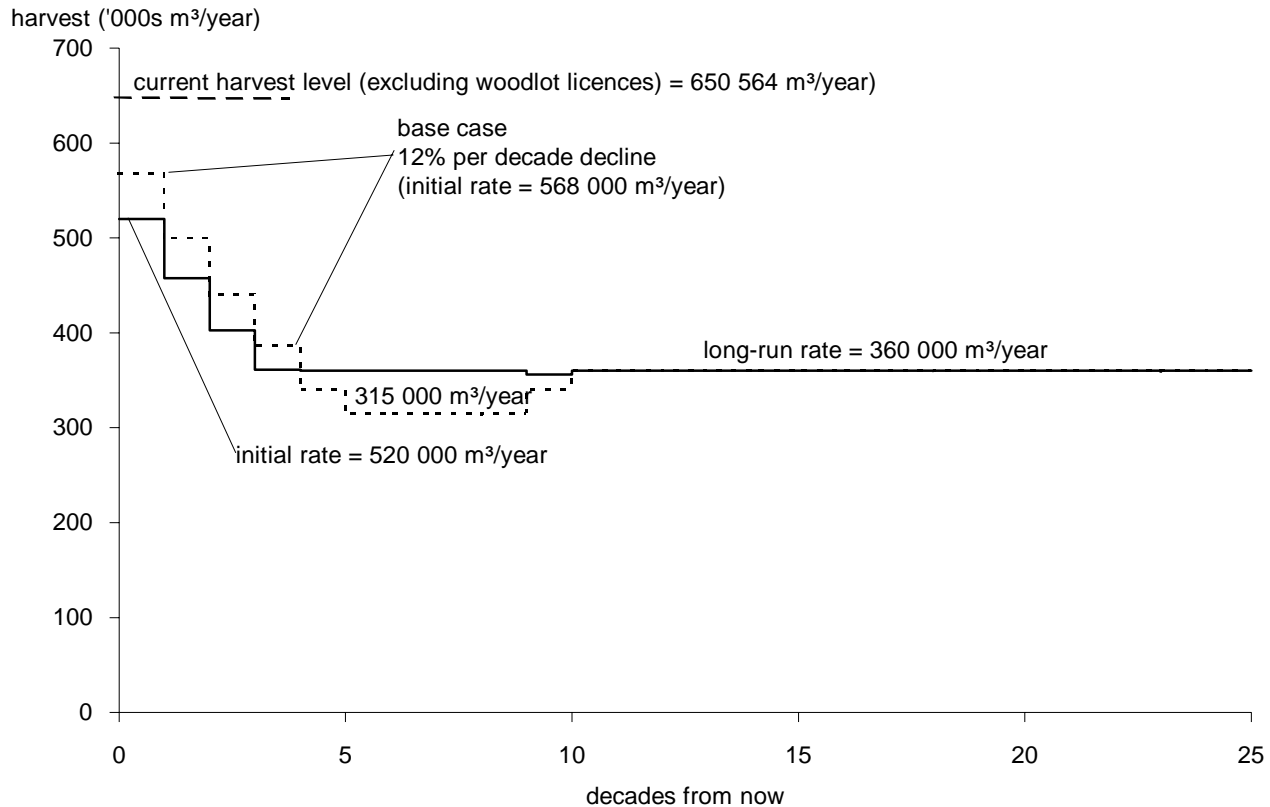


Figure 14. Harvest forecast with the initial harvest set to avoid harvests below the long-term level — Invermere TSA, 1995.

5.2 Uncertainty in minimum harvestable ages

For the base case, minimum harvestable ages were established according to two main considerations: first, trees must reach a size that is economical to harvest; second, the time between harvests must be sufficient to allow sites to recover from previous harvesting-related disturbance. Based on these criteria, minimum harvestable ages were determined by the Invermere Forest District staff to range from 70 to 160 years, depending on the tree species and site productivity. Actual harvest ages are generally higher than the minimums, as indicated in Figure 10. The purpose of this sensitivity analysis was to test the impact of changes to minimum harvestable ages on

the timber supply forecast. This was done by examining the effects of 20-year increases and decreases to the ages used in the base case.

Figure 15 shows the impact of minimum harvestable ages 20 years greater than in the base case. To avoid severe future timber supply shortfalls, the starting harvest level must be reduced to 548 000 cubic metres per year, 3.5% lower than the initial harvest level in the base case, if followed after the first decade by declines of 12% per decade for 4 decades until reaching a harvest level of 315 000 cubic metres. To avoid severe shortfalls further in the future, this rate must be maintained for 5 decades before increasing to the long-term level beginning in decade 10.

5 Timber Supply Sensitivity Analyses

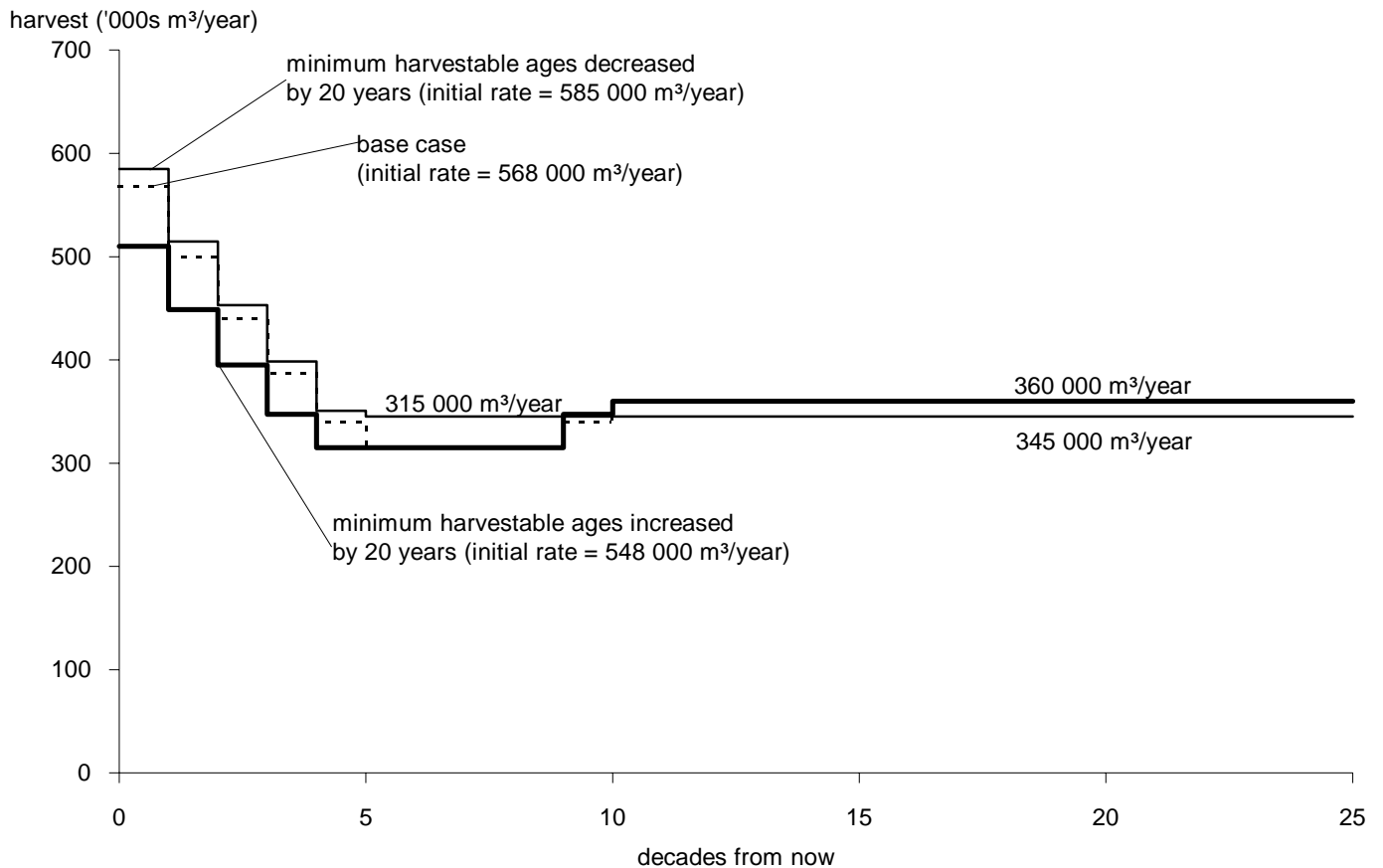


Figure 15. Harvest forecasts if minimum harvestable ages are changed by 20 years — Invermere TSA, 1995.

If minimum harvestable ages are 20 years shorter than in the base case, a starting harvest level of 585 000 cubic metres per year, slightly higher than the base starting level, can be achieved, if harvests decline by 12% per decade after the next 10 years. The long-term level of 345 000 cubic metres per year would be reached in 50 years. Unlike the base case, the harvest does not drop below the long-term level. This is because the number of stands eligible for

harvest between decades 5 and 9 would increase substantially if minimum harvestable ages were lower. The long-term level of 345 000 cubic metres is slightly lower than the base case long-term harvest level of 360 000 cubic metres per year because stands would be harvested at slightly younger ages than in the base case. This means stands would be harvested further from their ages of maximum average annual growth than in the base case.

5 Timber Supply Sensitivity Analyses

As well as affecting timber volumes available for harvest, changes to minimum harvestable age could also affect the age composition of the forest. To emphasize this, Figure 16 compares the ages at which stands would be harvested over time with the different minimum harvestable ages. The average harvested ages when minimum harvestable ages are 20 years greater correspond closely with the base case. If minimum harvestable ages are 20 years lower, however, the average harvested ages differ significantly. This difference occurs because younger stands must be harvested to maintain the harvest at the long-term level between decades 5 and 9, rather than dropping below the long-term level as in the base case forecast.

In this analysis, minimum harvestable ages are not viewed as decisions made to meet forest cover

objectives, but rather approximations of the timing of merchantability. This analysis highlights that timber supply is moderately sensitive to uncertainty about this timing. Whether minimum harvestable ages used in the base case are appropriate, optimistic, or pessimistic is largely a matter of opinion, at least in the absence of clear evidence that second-growth productivity is significantly higher than estimated in the base case. These issues are discussed here because of all variables important to timber supply, minimum harvestable ages are perhaps the most uncertain, at least in areas like the Invermere TSA where most second growth will not be harvested for many years. Other variables are based on sampling data and experience, or management decisions. Minimum harvestable age, however, will depend on technology and markets well into the future.

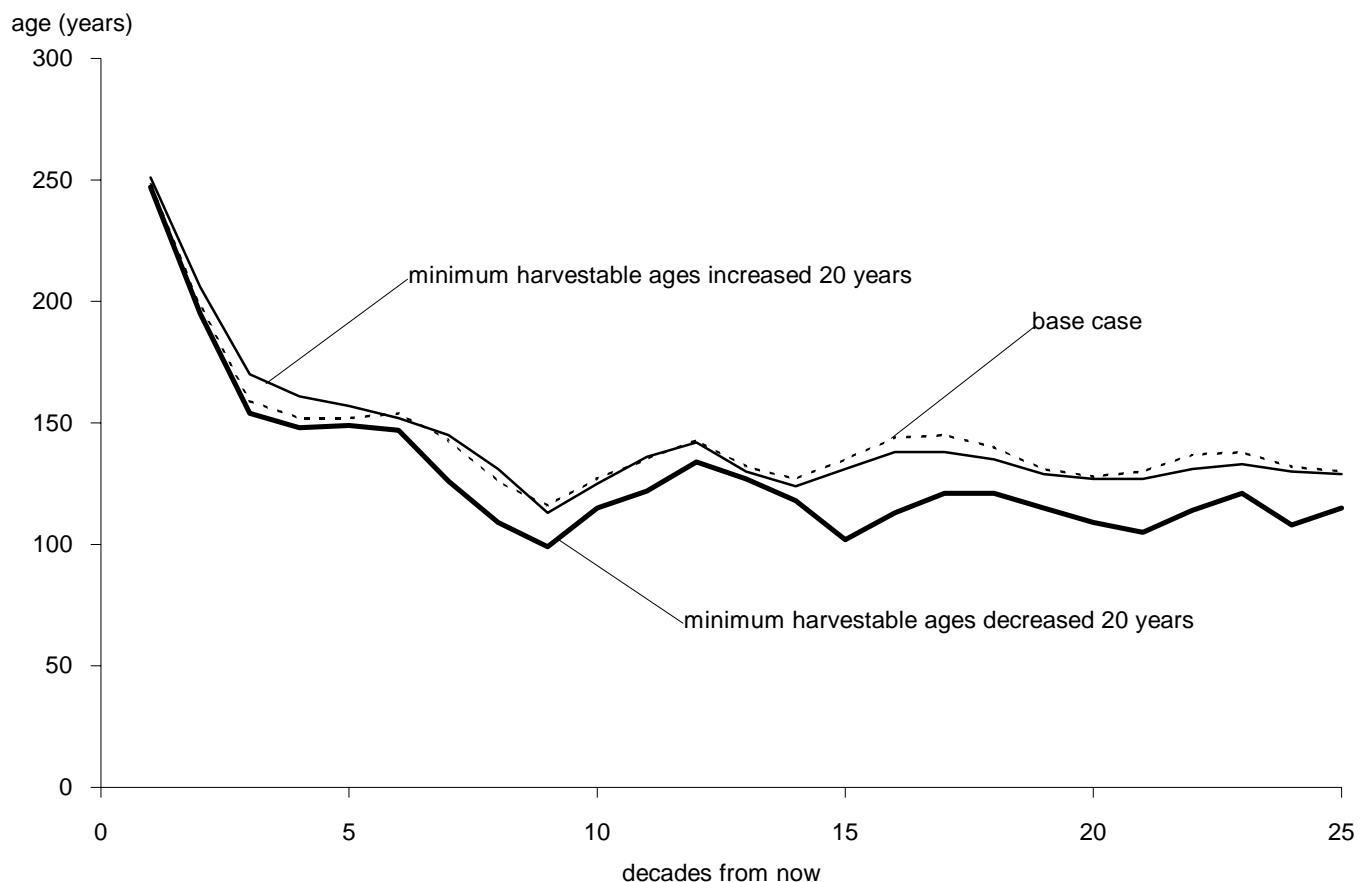


Figure 16. Comparison of average harvested ages following from changes to minimum harvestable ages — Invermere TSA, 1995.

5 Timber Supply Sensitivity Analyses

5.3 Uncertainty in existing stand volume estimates

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

This sensitivity analysis examines the effect on the harvest forecast of uncertainty about volume estimates for existing stands on the timber harvesting land base. Existing stands include both natural growing and managed stands. The Variable Density Yield Prediction (VDYP) system was used to produce volume estimates for natural stands, which represent

77% 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 20 years old and restocked NSR land.

The thin, solid line in Figure 17 shows the effect on the harvest if the yields from existing stands are 10% greater than estimated for the base case. Higher volumes would allow an increase in the short-term harvest and eliminate the need to reduce harvests to below the long-term harvest level. An initial harvest of 625 000 cubic metres per year, 4% below the current harvest level, could be achieved for one decade without causing severe future shortfalls if harvests declined by 10% per decade over the subsequent 40 years.

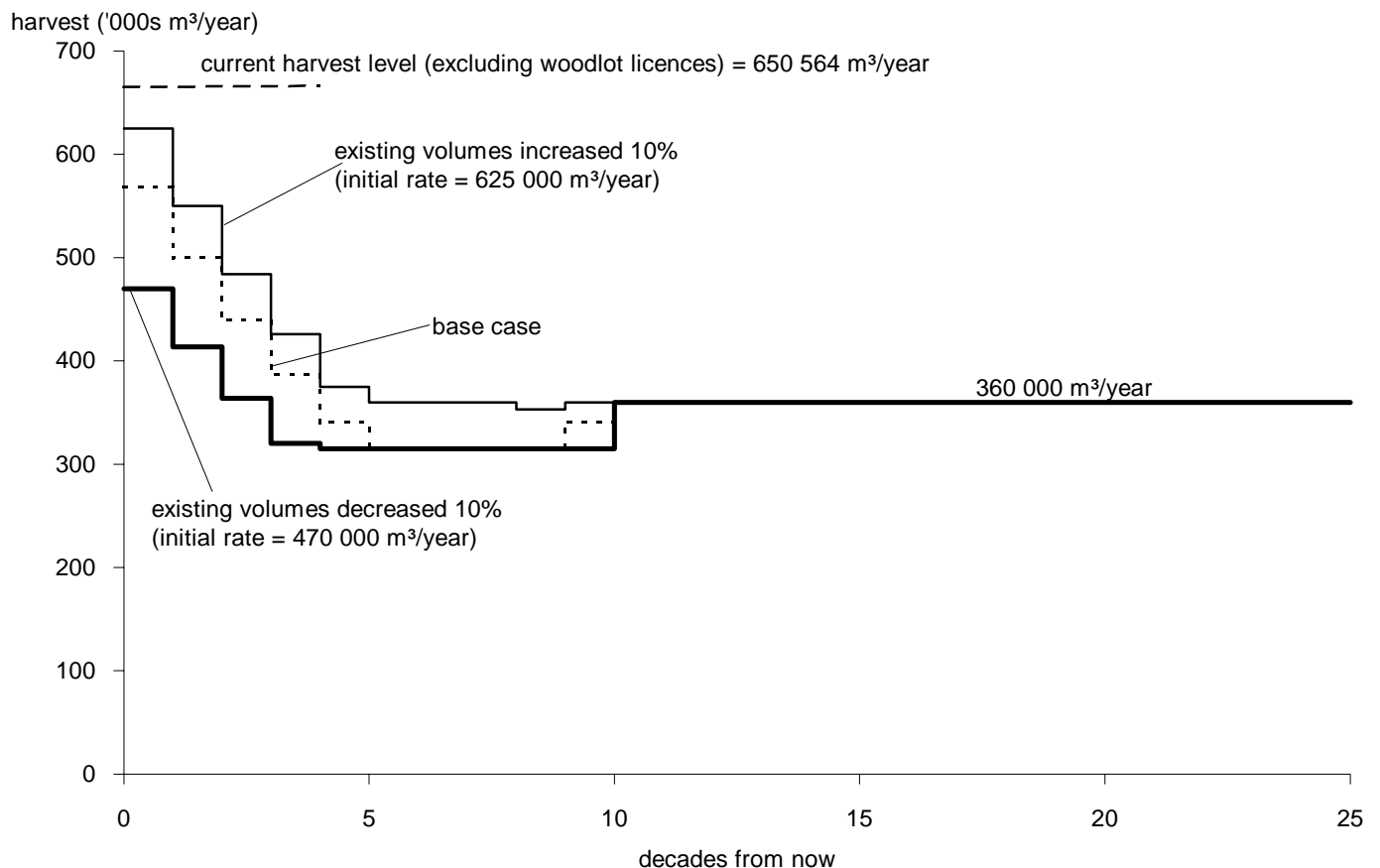


Figure 17. Harvest forecasts when existing stand volume estimates are changed by 10% — Invermere TSA, 1995.

5 Timber Supply Sensitivity Analyses

The thick, solid line in Figure 17 shows how the harvest forecast would change if the timber yields from existing stands are 10% less than estimated in the base case. This forecast shows an initial rate of harvest 17.3% lower than the base case and 27.8% lower than the current harvest level followed by a 12% per decade decline for 3 decades. To avoid timber supply shortages further in the future, harvests would have to stay below the long-term level for 7 decades before rising to the long-term level after decade 10. Lower volumes would have a direct effect on potential short-term harvests because this would reduce the existing inventory of timber ready for harvest over the next several decades until second-growth stands reach a merchantable condition. In addition, lower volumes in harvested stands would require more forest area to be harvested in order to achieve a given harvest level than would be required using the base case yield estimates. Thus, second-growth stands would be harvested earlier, and any attempt to reach the long-term level earlier would result in harvest shortfalls later in the planning horizon.

The effect of a 20% change in volume estimates on the timber supply would be much greater, as demonstrated in Figure 18. If existing volumes are actually 20% greater than those used for the base case, the current harvest level of 650 564 cubic metres per year could be maintained for one decade before declining to the same long-term level as in the base case, at 12% per decade.

Conversely, if existing volumes are in fact overestimated by 20% for the base case, harvests of 315 000 cubic metres per year, the lowest level established for the base case, and less than one-half of the current harvest level could be achieved for 8 decades. Even at this much lower harvest rate, a dip in the potential harvest would occur during decade 9, and the long-term level could not be achieved until decade 14.

This sensitivity analysis shows that the timber supply in the short term is very sensitive to uncertainty about volumes in existing mature stands. However, this uncertainty does not affect the harvest level that could be sustained in the long term.

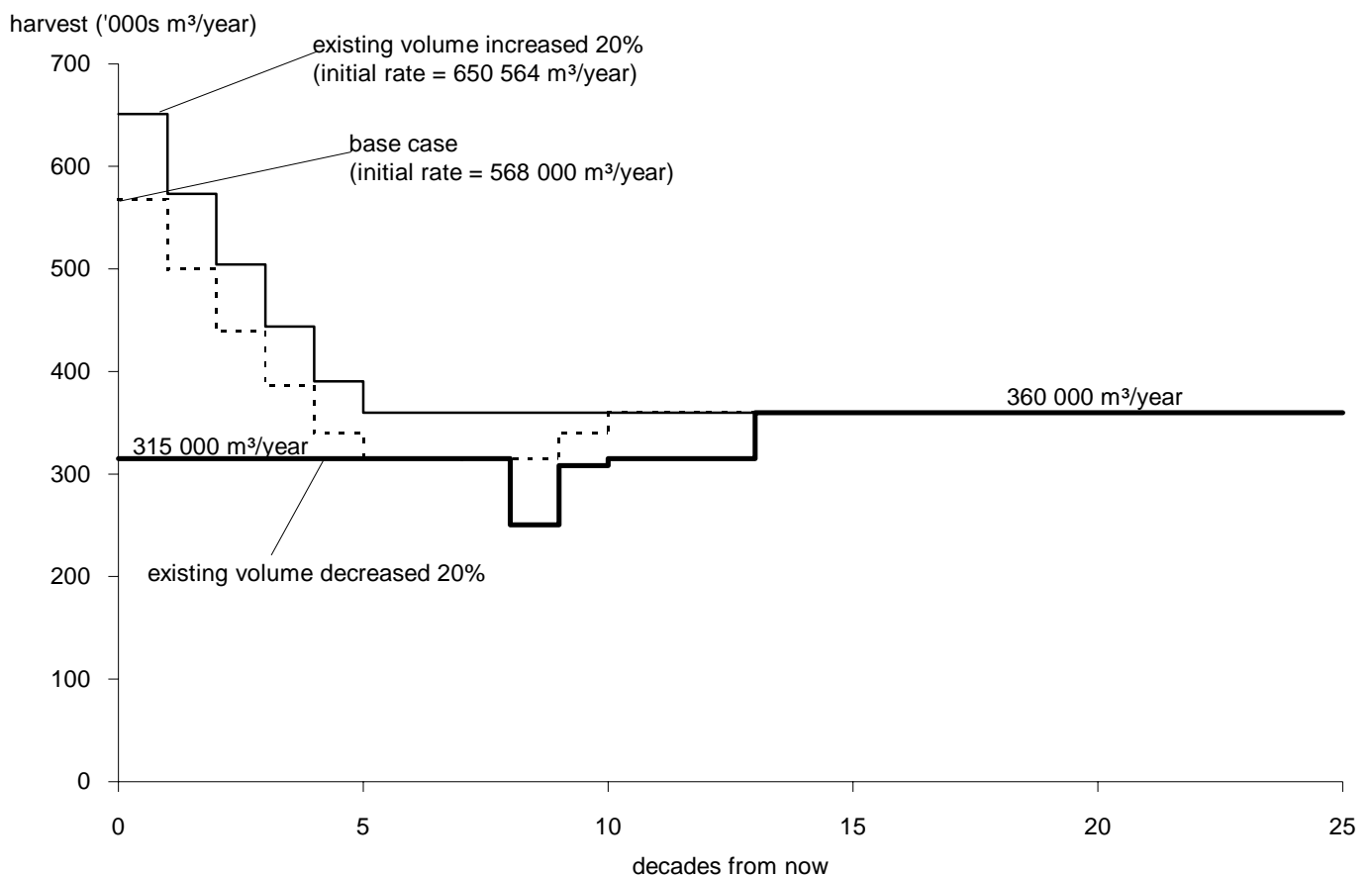


Figure 18. Harvest forecasts when existing stand volume estimates are changed by 20% — Invermere TSA, 1995.

5 Timber Supply Sensitivity Analyses

5.4 Uncertainty in regenerated stand volume estimates

As previously mentioned, regenerated (future) stand volumes are estimated using the TIPSYS growth and yield model. In general, these managed stands are expected to produce more timber volume per hectare than existing natural stands.

Aside from the factors discussed in the Section 5.3, "Uncertainty in existing stand volume estimates" that affect volume estimates and contribute to uncertainty, volume estimates for future stands can also be affected by management practices. Factors such as the species mix favoured in the future and volume lost to root rot, for example, increase the uncertainty in future stand volume estimates. To examine this uncertainty, all regenerated stand volume estimates were increased and decreased by 10% relative to estimates employed in the base case.

If volume estimates for future stands are 10% lower than assumed in the base case, projected short- and medium-term harvest levels would not be affected. However, the long-term harvest level would be 11.9% lower than in the base case, or 317 000 cubic metres per year (see Figure 19). A small dip below the long-term level occurs in decade 9.

If, on the other hand, future volumes exceed base case estimates by 10%, the long-term harvest level would increase to 402 000 cubic metres per year, a level 11.7% higher than the base case. Short- and medium-term levels would remain unaffected.

The changes in the long-term level that result from 10% changes to estimates of future stand volumes do not equal 10% because the long-term levels listed exclude unsalvaged losses. If the losses were included, changes in the long-term level would correspond more closely to changes in future stand volume estimates.

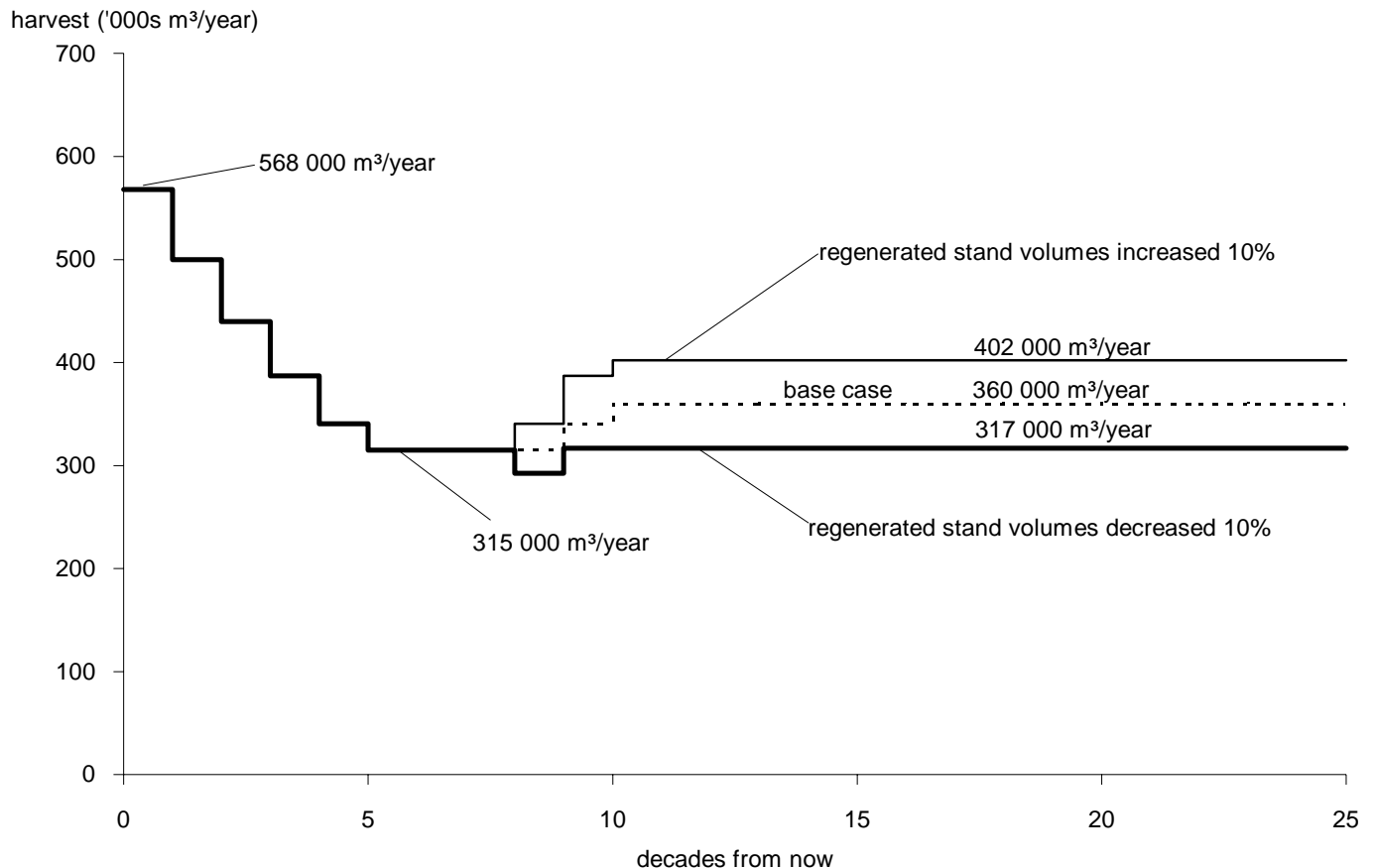


Figure 19. Harvest forecasts if regenerated stand volume estimates are changed by 10% — Invermere TSA, 1995.

5 Timber Supply Sensitivity Analyses

In general, uncertainty in regenerated stand volume estimates has no effect on estimates of the short-term timber supply, but could have a large effect on long-term timber supply.

5.5 Uncertainty in the size of the timber harvesting land base

Defining the timber harvesting land base involves several assumptions about the types of forest land that are available for harvesting. The forest cover inventory, operability classification, and slope classification were used to approximate which stands are merchantable and physically operable. Since approximations were used to define the land base, and because the inventory itself contains uncertainty, there is some uncertainty about how much area actually falls within the harvesting land base under current management.

Other potential sources of uncertainty about the area considered available for timber harvesting include:

- the size of buffers needed to protect riparian areas;
- an old-inventory classification of environmentally sensitive areas that may not reflect current knowledge, practices, and technology;
- the area reserved from harvesting for connecting corridors in forest ecosystem networks;
- the amount of productive forest land lost to roads, landings and skid trails not accounted for in the inventory;

- outcomes of land use planning processes such as CORE. The Timber Supply Review focuses on current forest management, not on future management and land use decisions made in public planning processes. However, the analysis can provide information useful for these processes.

This section discusses the sensitivity of the timber supply to uncertainties in the size of the timber harvesting land base. To assess sensitivity, the land base was increased and decreased by 8% and 15% relative to the base case across all forest management zones and forest types. Figures 20 and 21 show the impact of these changes on the base case forecast.

Figure 20 illustrates that a timber harvesting land base which is 15% larger could support harvests starting at 615 000 cubic metres per year, and declining after one decade by 12% per decade to a level of about 421 000 cubic metres per year in decade 4. Although a 15% larger land base would permit short- and long-term harvests higher than the base case, 8.3% and 16.9% respectively, the harvest could not begin at the current level and avoid dips below the long-term level, unless harvests declined more rapidly than 12% per decade. If a temporary drop below the long-term level were accepted, as in the base case, the current harvest level could be maintained for one decade before a decline would be necessary.

A timber harvesting land base which is 8% larger could support harvests starting at 568 000 cubic metres per year, the same as in the base case, and declining after decade 1 by 12% per decade to a level of about 393 000 cubic metres per year in decade 4, a level 9.1% higher than in the base case.

5 Timber Supply Sensitivity Analyses

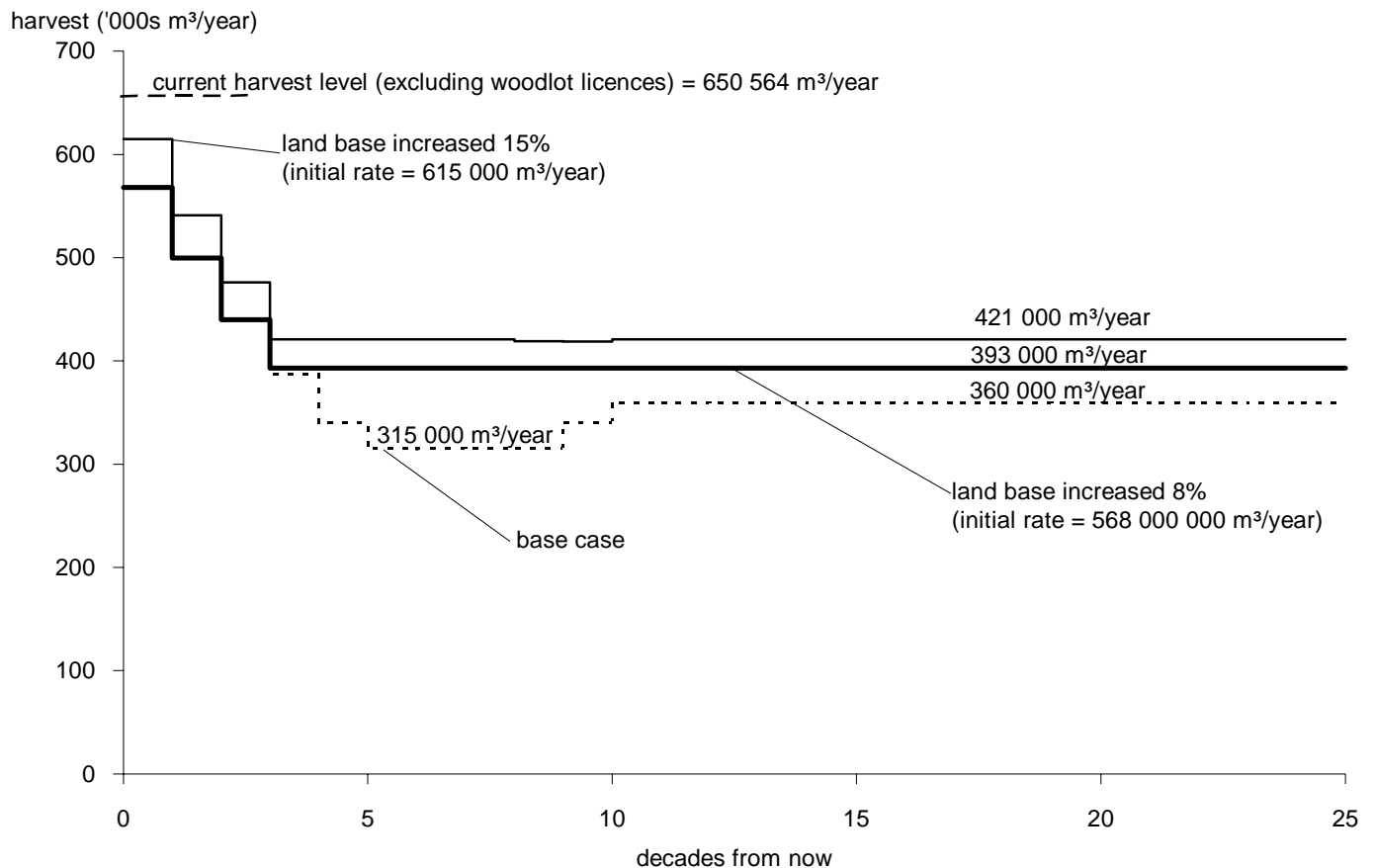


Figure 20. Harvest forecasts if the timber harvesting land base is increased 8% and 15% — Invermere TSA, 1995.

Figure 21 shows that on a timber harvesting land base which is 15% smaller, harvests could start at 435 000 cubic metres per year, declining after decade 1 at 12% per decade to a long-term level of 295 000 cubic metres per year in decade 4. Compared to the base case these rates are 23% and 18% lower, respectively.

An 8% smaller land base could support harvests starting at 490 000 cubic metres per year, declining over 40 years to 315 000 cubic metres per year and rising to a long-term level of 327 000 cubic metres per year, 9.2% lower than the base case, in decade 9.

This analysis shows that the timber supply is very sensitive to changes in the size of the timber harvesting land base, both in the short- and long-term. Short-term harvests are also affected by choice of harvest flow over time: higher short-term rates could be maintained only by reducing medium-term harvests that is, between decades 4 and 10, while higher medium-term rates not falling below the long-term level would require lower short-term harvests.

5 Timber Supply Sensitivity Analyses

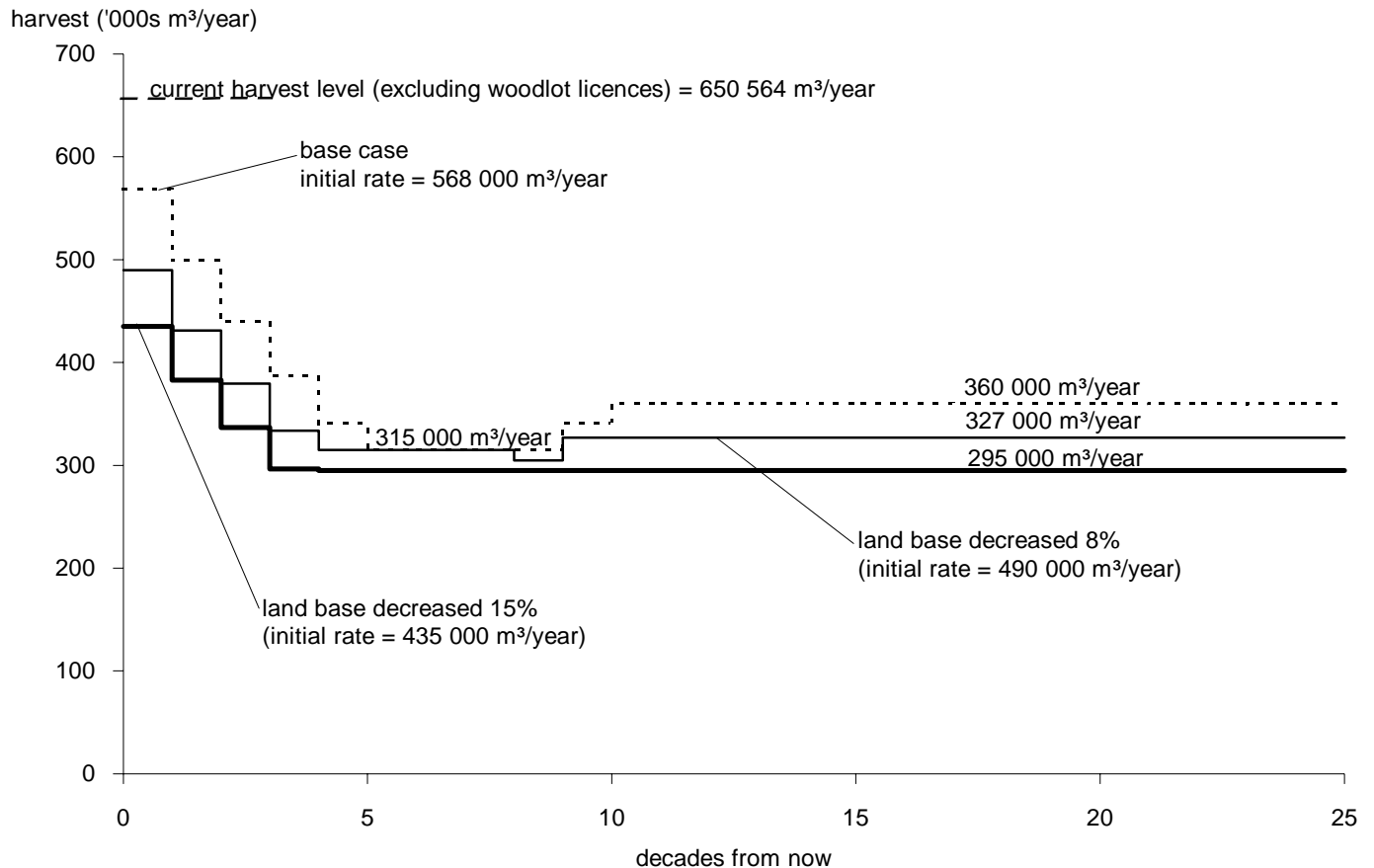


Figure 21. Harvest forecasts if the timber harvesting land base is decreased 8% and 15% — Invermere TSA, 1995.

5.6 Uncertainty in green-up ages

Green-up forest cover objectives require estimates of when second-growth stands will reach green-up conditions, normally expressed as the desired height of a stand. Green-up age, the time needed to reach the desired condition, is determined using a growth and yield model. The green-up period includes both the green-up age and the regeneration delay, or time taken to establish a stand after harvesting. Uncertainty about the green-up age arises because the desired green-up condition may not accurately reflect actual needs and because uncertainties about growth and yield may mean stands will reach the desired condition sooner or later than estimated. This analysis examines how a 5-year difference in green-up ages would affect the harvest forecast. The uncertainty about the percentage of desired forest cover is examined in the following section

(Section 5.7, "Uncertainty in green-up forest cover requirements").

Figure 22 shows that potential short- and medium-term harvests are moderately sensitive to uncertainty about green-up age. If green-up ages used in the base case overestimate by 5-years the time needed to meet green-up conditions, it would be possible to raise the starting level slightly to 575 000 cubic metres per year and still avoid any significant dips below the long-term level. A long-term level of slightly over 1% higher than the base case can be achieved starting in decade 4. Most of the change relative to the base case is associated with shorter green-up ages in the ungulate winter range areas and visual quality objective areas. If green-up ages only for areas subject to adjacency and 3-pass forest cover guidelines were 5 years less than the base case, timber supply would not change significantly.

5 Timber Supply Sensitivity Analyses

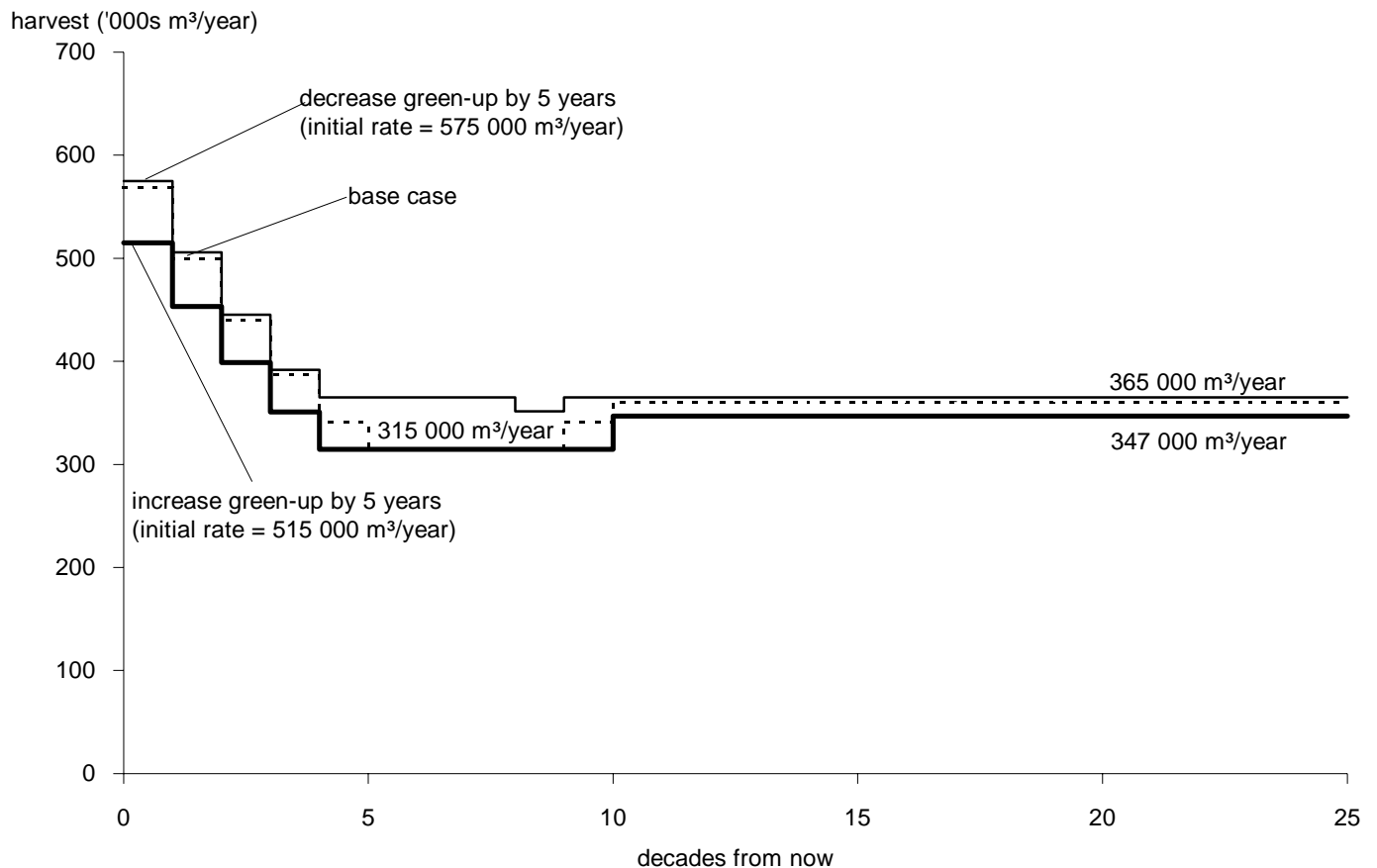


Figure 22. Harvest forecasts if green-up ages are changed by 5 years — Invermere TSA, 1995.

If green-up ages are actually 5 years longer than estimated for the base case, potential harvests in both short- and long-term would be reduced. The harvest during the first decade would have to drop by 9% from the base case level to allow a 12% per decade decline without resulting in severe timber supply shortages further in the future. The long-term harvest level would be 4% lower than in the base case.

Again, most of this impact can be attributed to the changes in green-up ages for the ungulate winter range areas, visual quality objective areas, and to a lesser extent community watershed areas.

Overall, relatively small changes in green-up ages could have a moderate to high effect on timber availability over the next 90 years.

5 Timber Supply Sensitivity Analyses

5.7 Uncertainty in green-up forest cover requirements

Green-up forest cover requirements limit the amount of area occupied by stands that are younger than the green-up age. These guidelines ensure that there is a distribution of different-aged stands in the forest. They specify, for example, that no more than 25% of an area may be occupied by stands less than green-up age.

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.

The sensitivity of timber supply to uncertainty in green-up forest cover requirements was examined by both increasing and decreasing the requirements by 5 percentage points for all management zones.

The thin, solid line in Figure 23 shows the harvest forecast resulting if all green-up forest cover requirements are relaxed so that an additional 5% of each management zone may be younger than green-up age at any time.

An initial rate of harvest of 600 000 cubic metres per year, about 6% higher than in the base case forecast, could be achieved if followed by a 12% per decade decline. The dip below the long-term level in decades 5 through 10 in the base case could be avoided, and harvests could be maintained at the steady long-term rate from decade 4 onwards. The long-term rate is 3% higher than the base case long-term rate. The increase in timber availability over the short term is caused mostly by relaxing forest cover requirements in the retention VQO, partial retention VQO, and ungulate winter range zones. If general integrated forest cover requirements (maximum of 40% younger than green-up age) were applied to the areas managed for visual quality,

timber supply would be sufficient to achieve a harvest forecast almost the same as that shown in Figure 23 for all forest cover requirements relaxed by 5%.

Section 5.8, "Uncertainty in the ungulate winter range objective" describes in more detail the effects of forest cover requirements for wildlife. Forest cover requirements for the modification VQO and integrated resource management zones do not constrain timber availability throughout the harvest forecast. Similarly, the cover requirement for protecting water quality in community watersheds has only a small effect on timber supply. These forest cover requirements have only small effects because they do not require holding stands long past either their minimum harvestable ages (which would affect timber supply over the next several decades), or their ages of maximum average productivity (which would affect the long-term harvest level).

The thick, solid line in Figure 23 shows how the harvest forecast would change compared to the base case if all forest cover requirements were tightened so that 5% less of an area may be younger than green-up age at any time. To avoid causing severe future timber supply shortages the initial harvest rate must be reduced to 475 000 cubic metres per year, 16% lower than the base case initial harvest, for 1 decade before declining at 12% per decade to about 315 000 cubic metres per year by the end of decade 4. Harvest levels must remain at this level for 6 decades before rising to a long-term level of 332 000 cubic metres per year, or about 8% lower than in the base harvest, in decade 10. Slightly more than half of the reduction in timber supply is due to changes in the forest cover requirement for ungulate winter range (see Section 5.8, "Uncertainty in the ungulate winter range objective"). Changes in cover requirements for visual quality cause most of the rest of the reduction, while changes in the requirements for community watersheds have a small impact.

In summary, timber supply shows fairly high sensitivity to changes in the forest cover requirements for green-up, particularly those for ungulate winter range and VQOs.

5 Timber Supply Sensitivity Analyses

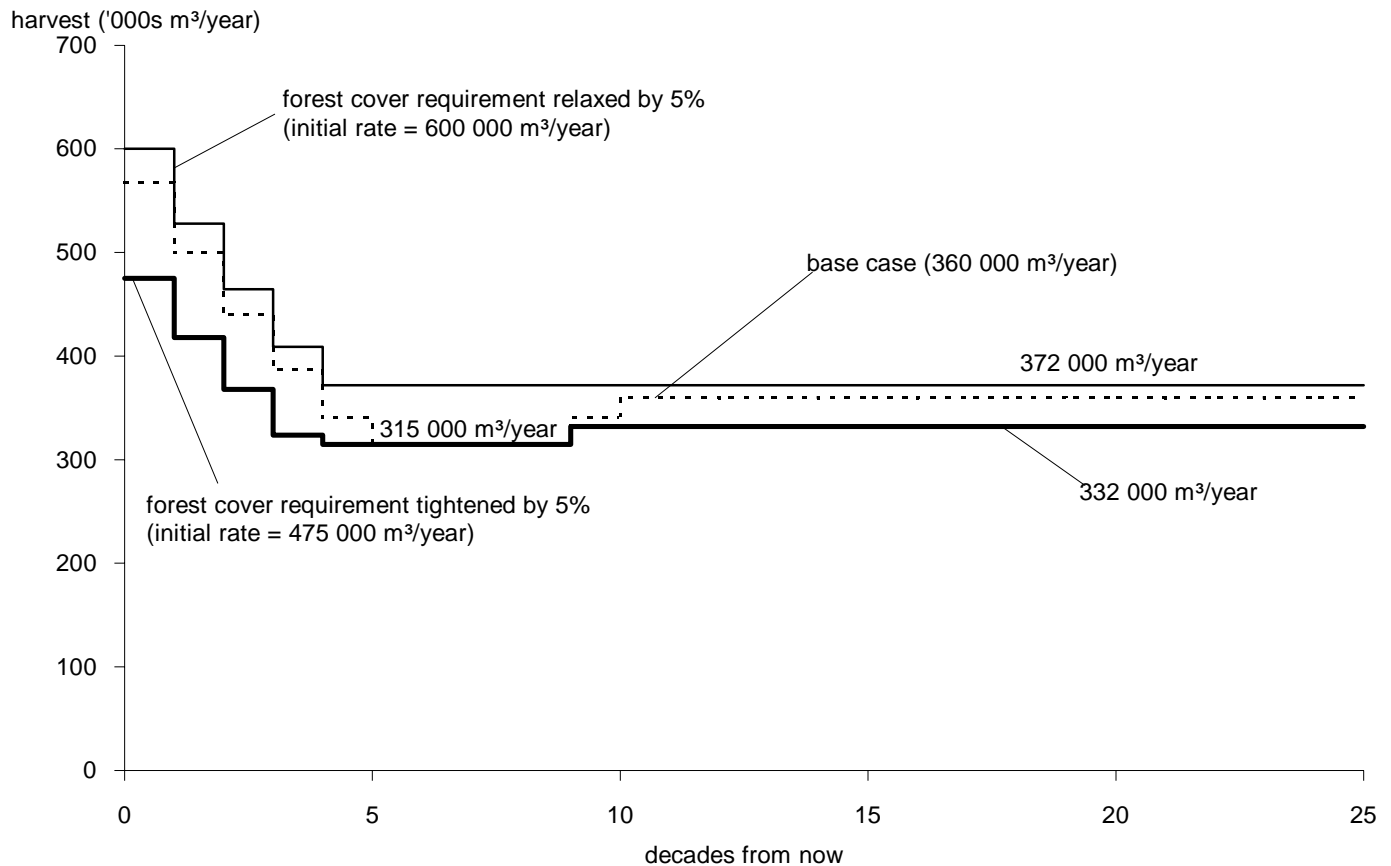


Figure 23. Harvest forecasts when forest cover requirements are changed by 5% — Invermere TSA, 1995.

5.8 Uncertainty in the ungulate winter range objective

The Invermere TSA is noted for its significant wildlife values, and the area's tourism industry relies in part on healthy populations of elk, deer and caribou. Providing and maintaining suitable winter range for these species is an important forest management consideration.

The 30% (69 848 hectares) of the timber harvesting land base falling within the dry-cool-montane spruce biogeoclimatic subzone is considered ungulate winter range. A large percentage of winter range is operable for timber harvesting and is located at middle to lower elevations. Currently, the forest cover objectives for winter range specify

that not more than 33% of the timber harvesting land base is permitted to have forests less than 15 metres tall at any time to meet hiding and thermal cover requirements, and at least 6% of this same land base must have forests at least 141 years old to provide old growth and biodiversity.

The same sources of uncertainty discussed in Section 5.7, "Uncertainty in green-up forest cover requirements" apply to the ungulate winter range objective. In addition, the defining criteria for winter range are subject to uncertainty in forest and range ecosystem classifications. The potential effects of this uncertainty were examined by changing the forest cover requirements for thermal cover by 5 and 10 percentage points.

5 Timber Supply Sensitivity Analyses

The thin, solid line in Figure 24 shows how the harvest forecast would change if thermal cover requirements could still be met by allowing an additional 10% of the range area to be younger than 57 years, the time needed for a stand to reach 15 metres in height. An initial harvest of 610 000 cubic metres per year, about 7% higher than the base case forecast could be maintained for 10 years without resulting in severe future timber supply shortfalls if harvests then declined by 12% per decade. The long-term rate is about 2.5% higher

than in the base case, and a dip below the long-term level between decades 5 and 9 would not be necessary to avoid future timber supply shortages. Allowing an additional 5% instead of 10% to be younger than thermal cover age results in a forecast similar to the base case for the first 40 years, but between decades 5 and 9 harvests below the long-term level are for the most part not necessary.

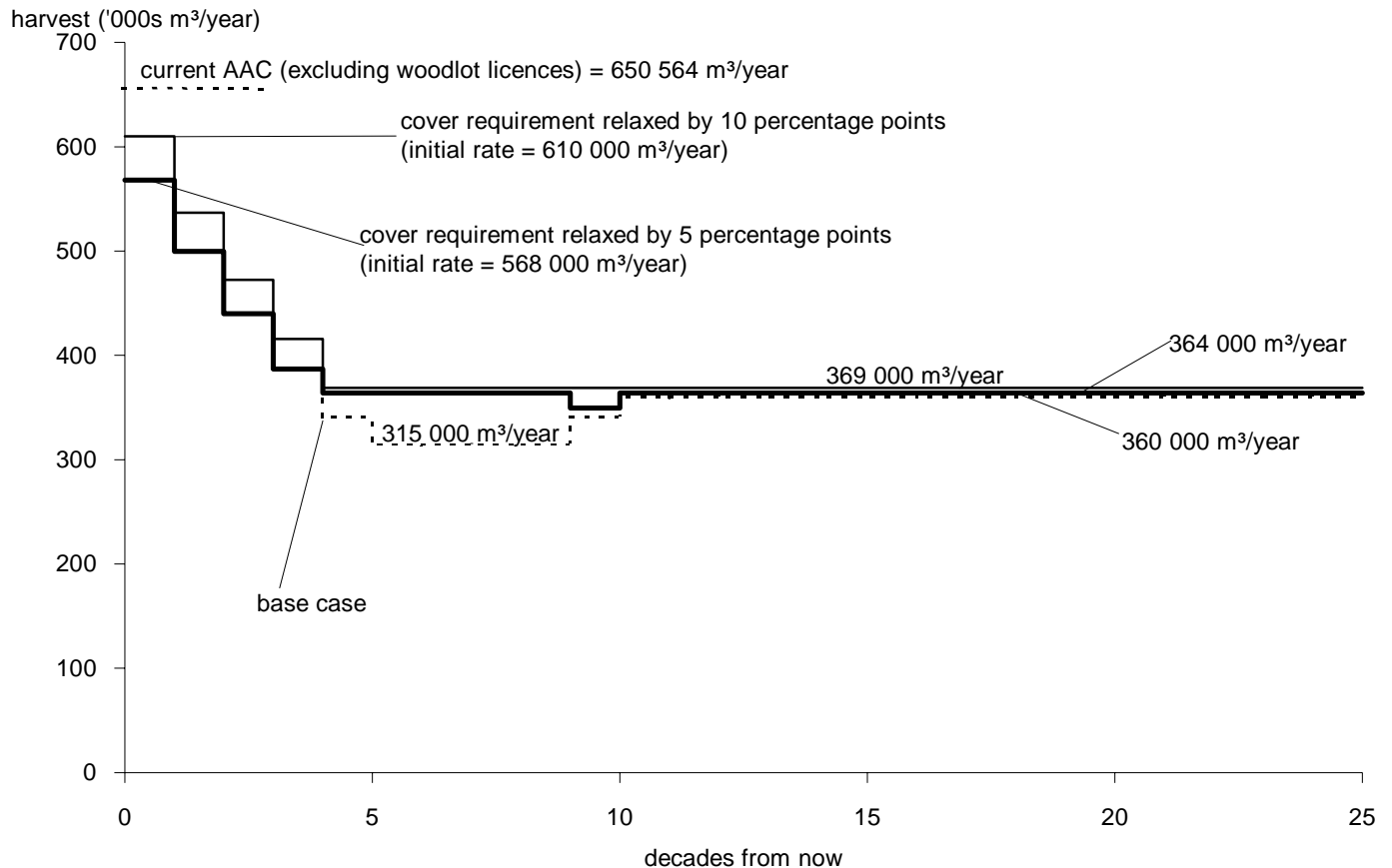


Figure 24. Harvest forecasts if thermal cover requirement is relaxed by 5 and 10 percentage points — Invermere TSA, 1995.

5 Timber Supply Sensitivity Analyses

The thick, solid line in Figure 25 shows the effects on potential harvests if meeting thermal cover objectives required that 10% less of the winter range area than estimated for the base case could be younger than green-up age for thermal cover at any time. The initial harvest would have to drop to 475 000 cubic metres per year, 16% lower than the base case initial level, and could be maintained for only one decade before declining to the long-term level at 12% per decade. The long-term level of 332 000 cubic metres per year is 7.8% lower than the base case long-term level. Allowing 5% less area to be younger than the thermal cover age instead of 10% less would reduce the decline from the initial base

case harvest level, and allow the long-term level to increase from 332 000 to 349 000 cubic metres per year.

While the results of this sensitivity analysis indicate that timber supply would increase if forest cover objectives for ungulate winter range could still be met if less area met thermal cover requirements, this analysis does not suggest that such flexibility in the forest cover requirements actually exists. This analysis employed the best available estimates for forest cover required to meet forest management objectives, and there is no current evidence indicating that these requirements are inaccurate.

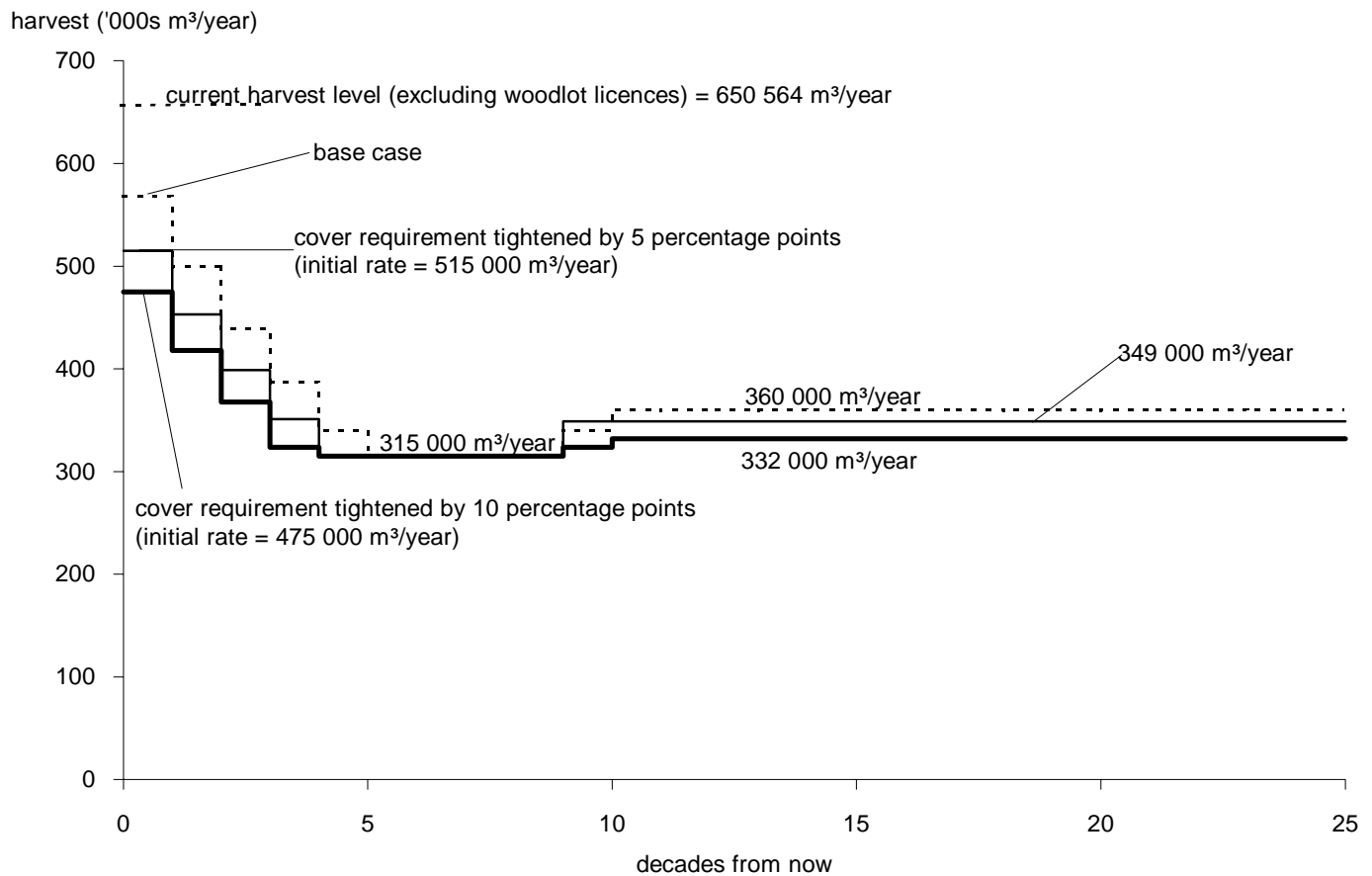


Figure 25. Harvest forecasts if thermal cover requirement is tightened by 5 and 10 percentage points — Invermere TSA, 1995.

5 Timber Supply Sensitivity Analyses

5.9 Uncertainty in old-growth requirements

Maintenance of biodiversity is a current forest management objective in the Invermere TSA. To meet biodiversity objectives it was estimated by the Invermere Forest District staff that at least 10% of the productive forest area in each management zone except for range should be maintained in ages older than 120 years for lodgepole pine and 140 years for all other species. Older forest found outside of the timber harvesting land base contributes to this biodiversity/old-growth requirement, often reducing requirements for old forest from the timber harvesting land base. In some management zones for instance, where large areas of predominantly old timber were excluded from the timber harvesting land base, the old-growth requirement was reduced to zero. It is uncertain whether all older forest has suitable characteristics and location to fulfill old-growth requirements. For example, it is

uncertain to what extent older forest types classified as inoperable should be treated the same as those situated in the operable forest.

This analysis examines how the timber supply could be affected if a 10% old-growth requirement was applied to the timber harvesting land base rather than to the total productive forest land base. The analysis also assesses what would happen if no old growth was required from the timber harvesting land base.

The heavy, solid line in Figure 26 shows a harvest forecast that would result if at least 10% of the timber harvesting land base in each management zone was required to be above the old-growth age at all times. The initial level must be reduced to 11% lower than the initial rate in the base case, to allow a 12% per decade rate of decline, while avoiding severe future timber supply shortages. This more constraining old-growth requirement results in a slightly lower long-term rate of 351 000 cubic metres per year.

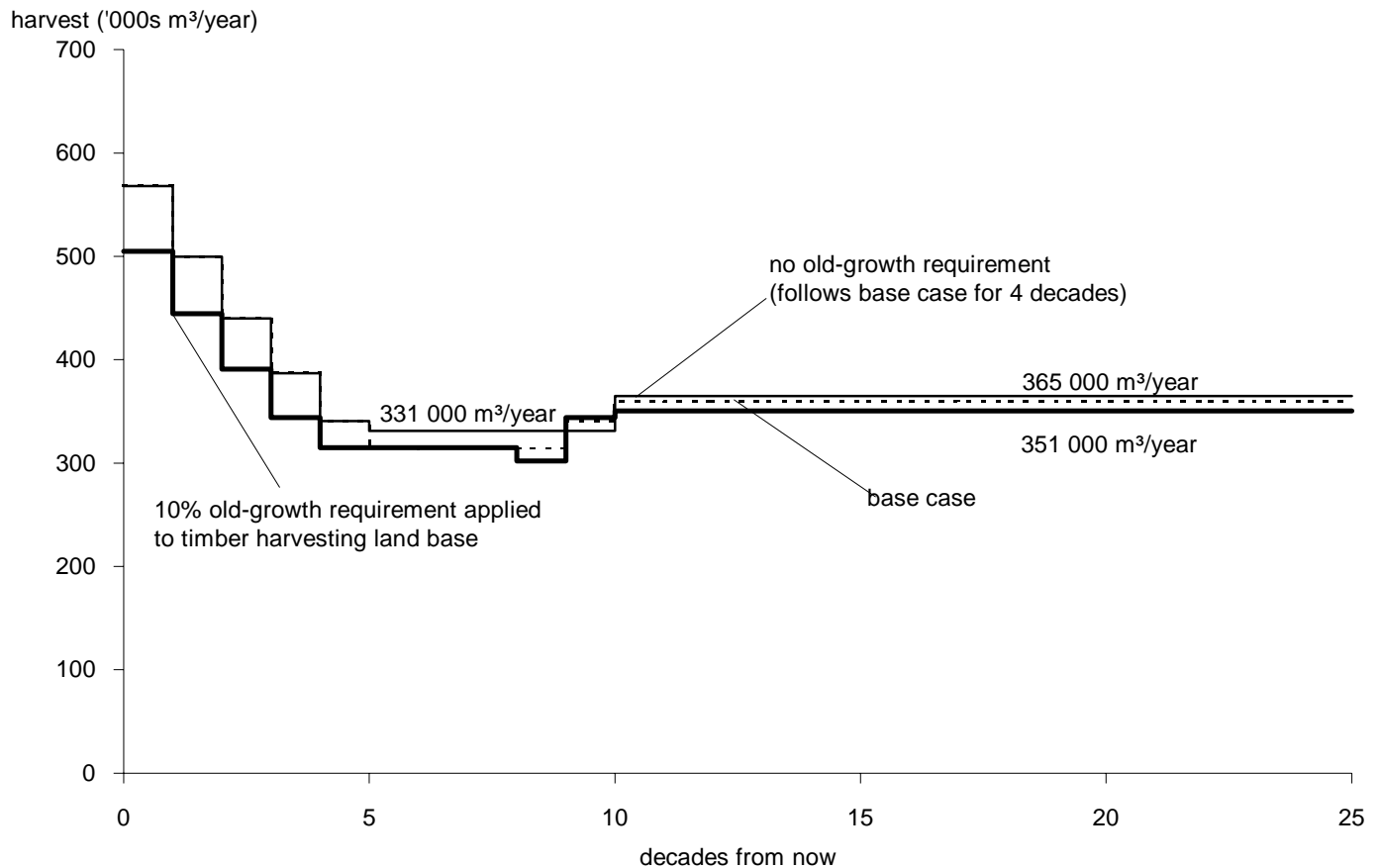


Figure 26. Harvest forecast with changes to the old-growth/biodiversity requirement — Invermere TSA, 1995.

5 Timber Supply Sensitivity Analyses

The thin, solid line in Figure 26 shows that if all old-growth requirements were removed, the dip below the long-term level in the base case harvest forecast between decades 5 and 9 can be reduced. During this period, harvests of 331 000 cubic metres per year can be achieved, compared to 315 000 cubic metres per year in the base case. The long-term level is also slightly higher (5000 cubic metres per year). The old-growth requirement in the base case does not have a large impact on the timber supply because green-up forest cover requirements for retention VQOs, partial retention VQOs, community watersheds, and ungulate winter range cause the average age of harvested stands to be greater than the old-growth age. Therefore, the old-growth requirement does not reduce timber availability significantly beyond the effects of the green-up

requirements. Also, currently there is enough older forest in most areas to meet the 10% old-growth target and still support base case harvest levels.

In summary, timber supply shows a moderate sensitivity in the short-, intermediate- and long-terms to changes in the old-growth requirements for the Invermere TSA.

5.10 Combined effect of all forest cover requirements

Figure 27 illustrates the effect on the harvest forecast of removing all forest cover requirements for management of visually sensitive areas, wildlife habitat, protection of community watersheds, cutblock adjacency, and maintenance of old-growth associated biodiversity.

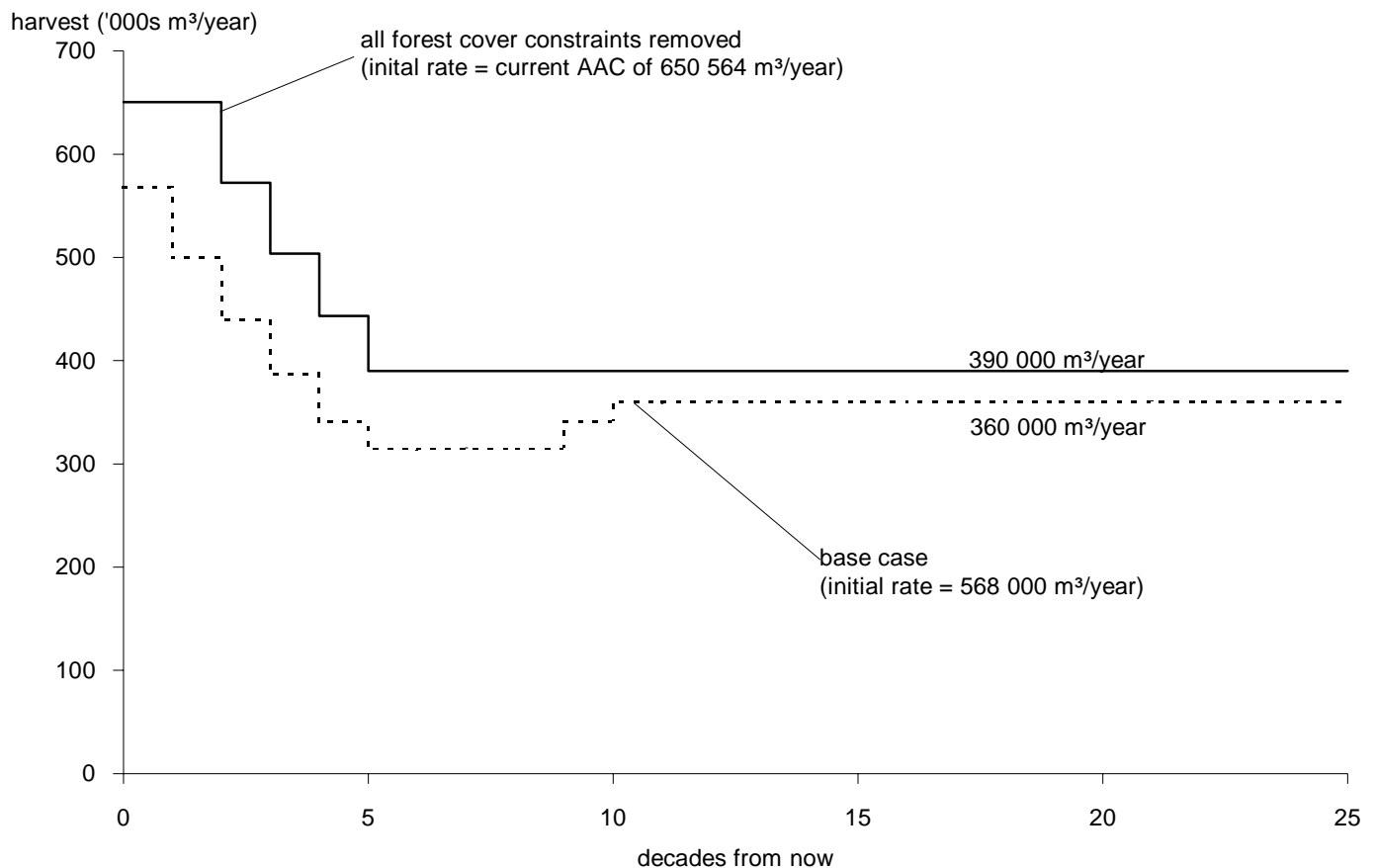


Figure 27. Harvest forecast if all forest cover requirements removed — Invermere TSA, 1995.

5 Timber Supply Sensitivity Analyses

If all forest cover requirements were removed, the current harvest level of 650 564 cubic metres per year could be maintained for 2 decades if harvests then declined by 12% per decade until reaching the long-term level of 390 000 cubic metres per year in decade 6. The long-term harvest level is about 8% higher than in the base case. Besides having a large impact on the timber supply, removing all forest cover requirements would affect the average age at which stands would be harvested in the future. Figure 28 illustrates that after decade 3 stands would be harvested on average at ages significantly lower than in the base case forecast. For example, in the absence of forest cover requirements, in decade 6 the average harvested age of stands is 30 years younger than in the base case. Stands are harvested when they are on average 20 to 30 years younger for the remainder of the analysis horizon.

Since many of the minimum harvestable ages were set at or near culmination age, the age at which

timber yield would be maximized over time, the harvest forecast shown in Figure 27 is probably close to what would be biologically possible if the entire timber harvesting land base was dedicated to timber production. This sensitivity analysis was performed to assess the overall impact of forest cover requirements for visual quality, wildlife habitat, watershed protection, cutblock adjacency and old-growth. Like all of the other results presented in this report, this should not be construed as a recommendation or proposal, but rather as information to help understand the interactions among the many forest values in the Invermere TSA.

Overall, timber supply forecasts are very sensitive to changes in forest cover objectives, both in the short- and long-term. However, the current harvest level could not be maintained beyond 20 years even if all forest cover requirements were removed.

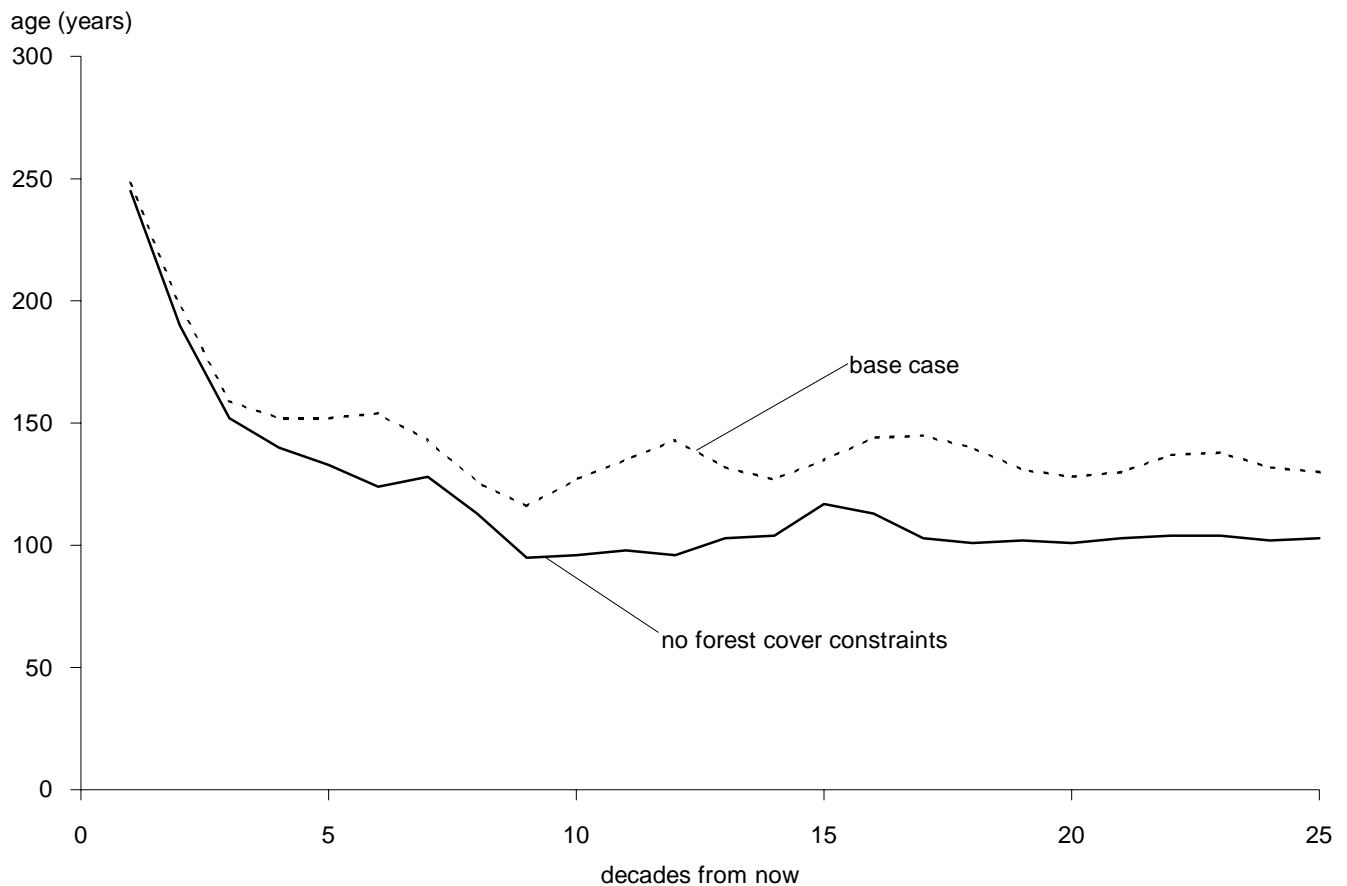


Figure 28. Average age of harvested stands if forest cover requirements removed — Invermere TSA, 1995.

5 Timber Supply Sensitivity Analyses

5.11 Uncertainty in estimates of unsalvaged losses

The base case harvest forecast incorporates an estimate of the volume of timber damaged by fire, insects, disease, or wind, and not salvaged, or left on the site as seed or wildlife trees. The current estimate of these annual unsalvaged losses is 63 597 cubic metres. Therefore, combining the base case initial harvest level of 568 000 cubic metres per year with the unsalvaged losses, the actual volume depleted is 631 597 cubic metres per year. Since the unsalvaged losses estimate is significant relative to harvests projected for both the short- and long-terms (11% and 18% respectively), an over- or under-estimate of losses could have a significant impact on potential harvests. The estimate used in the base case is an average over the last several years for losses to fire, insects, disease, and wind. Uncertainty exists because losses are hard to predict, and potentially, the estimate could be based on an inadequate or unrepresentative time period.

This analysis examines the effect on the harvest forecast if unsalvaged losses were either eliminated or were 50% higher than the estimate used in the base case.

If unsalvaged losses are 50% higher, the starting harvest level would have to decline to 504 000 cubic metres per year, a level 11.3% lower than the base

starting level and 25.9% lower than the current harvest level. To avoid severe future timber supply shortfalls, harvest declines of 12% per decade would be needed until reaching the long-term level of 328 000 cubic metres per year in decade 3. This level is 8.9% lower than the long-term harvest level for the base case.

If on the other hand unsalvaged losses were eliminated, perhaps because of effective protection measures and salvage operations, the starting harvest could be increased from the base case level to 595 000 cubic metres per year, and maintained for one decade before a 12% per decade decline to the long-term level is necessary. The long-term level would increase by 15% compared to the base case, and be reached in decade 4. It would be possible to increase the starting level to 631 597 cubic metres per year if a dip below the long-term level, much like that in the base forecast between decades 5 and 9, was accepted. This higher starting rate, however, would still be 3% below the current harvest level.

This sensitivity analysis shows that the timber supply over the next few decades, could be affected significantly by changes in estimates of unsalvaged losses. The intermediate- and long-term timber supply are particularly sensitive to uncertainty in these estimates, with long-term rates directly affected by any increase or decrease in losses.

5 Timber Supply Sensitivity Analyses

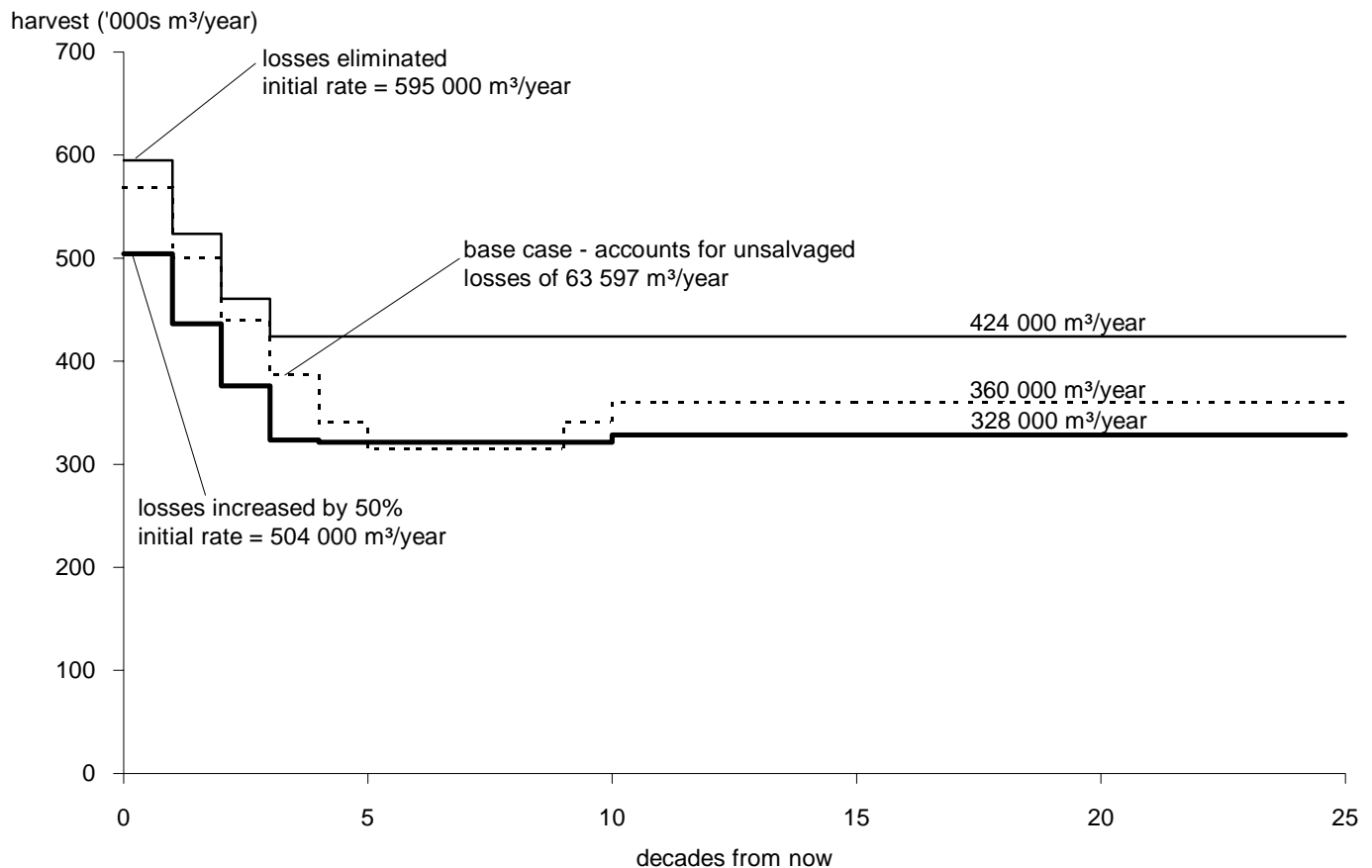


Figure 29. Harvest forecasts if unsalvaged losses were eliminated or increased — Invermere TSA, 1995.

5.12 Interaction between uncertainties in existing yields and the timber harvesting land base

The sensitivity analyses discussed in Sections 5.2 to 5.11 examine the effect on the harvest forecast of altering a single forest management assumption at a time. The following sensitivity analyses examine the effect of coincidental changes to existing stand yields and available land base. The Invermere Forest District staff feel these factors have a high degree of uncertainty about them and are often beyond the scope of forest management decision making. Figures 30, 31 and 32 illustrate the effects on the harvest forecast of changing these factors in the following ways:

- increasing existing stand yield estimates 10% and land base 8% (additive changes upwards);
- decreasing existing stand yield estimates 10% and land base 8% (additive changes downwards);
- increasing existing stand yield estimates 10% and decreasing land base 8% (opposing changes);
- decreasing existing stand yield estimates 10% and increasing land base 8% (opposing changes).

Figures 30, 31 or 32 show that long-term levels generally are affected very slightly by changes in existing yields but are affected more substantially by changes to land base size. Changes to existing stand yields affect long-term rates slightly since some currently existing stands are projected to be harvested throughout the analysis horizon. This occurs because some existing stands are reserved from harvest for several decades to meet forest cover requirements.

5 Timber Supply Sensitivity Analyses

Figure 30 shows that when existing stand yields are decreased 10% and land base is decreased 8% the current harvest rate must immediately drop to 315 000 cubic metres per year with the subsequent rise to the long-term level occurring in decade 14, 5 decades later than in the base case harvest forecast.

Even if yields from existing stands were 10% higher and the timber harvesting land base 8% larger, the current harvest level would be achievable only for one decade before a decline to the long-term level would be necessary.

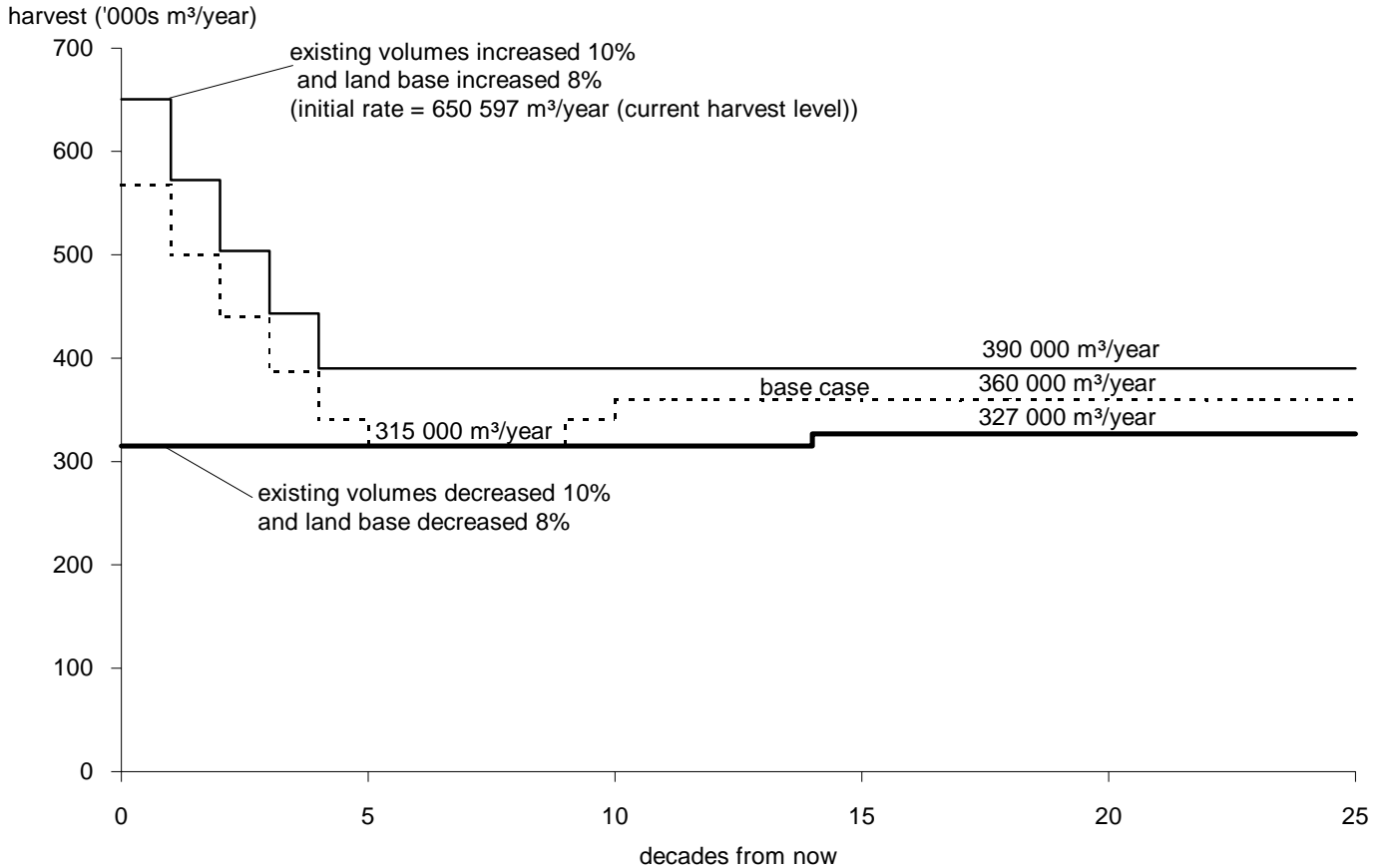


Figure 30. Additive interaction of increases and decreases in both existing stand yield estimates and the size of the timber harvesting land base — Invermere TSA, 1995.

5 Timber Supply Sensitivity Analyses

Figures 31 and 32 illustrate the potential counteracting effects of uncertainties about estimates of existing stand yields and the size of the timber harvesting land base. That is, the effect on timber supply over the next 5 decades of a 10% decrease in estimates of existing volumes is largely offset by an 8% increase in the timber harvesting land base, as

shown in Figure 31. Conversely, Figure 32 illustrates that short-term harvests could follow the base case for 5 decades if existing stand yields were 10% higher while the timber harvesting land base was 8% smaller. In both cases the long-term level increases or decreases in almost direct relation to the change in the size of the timber harvesting land base.

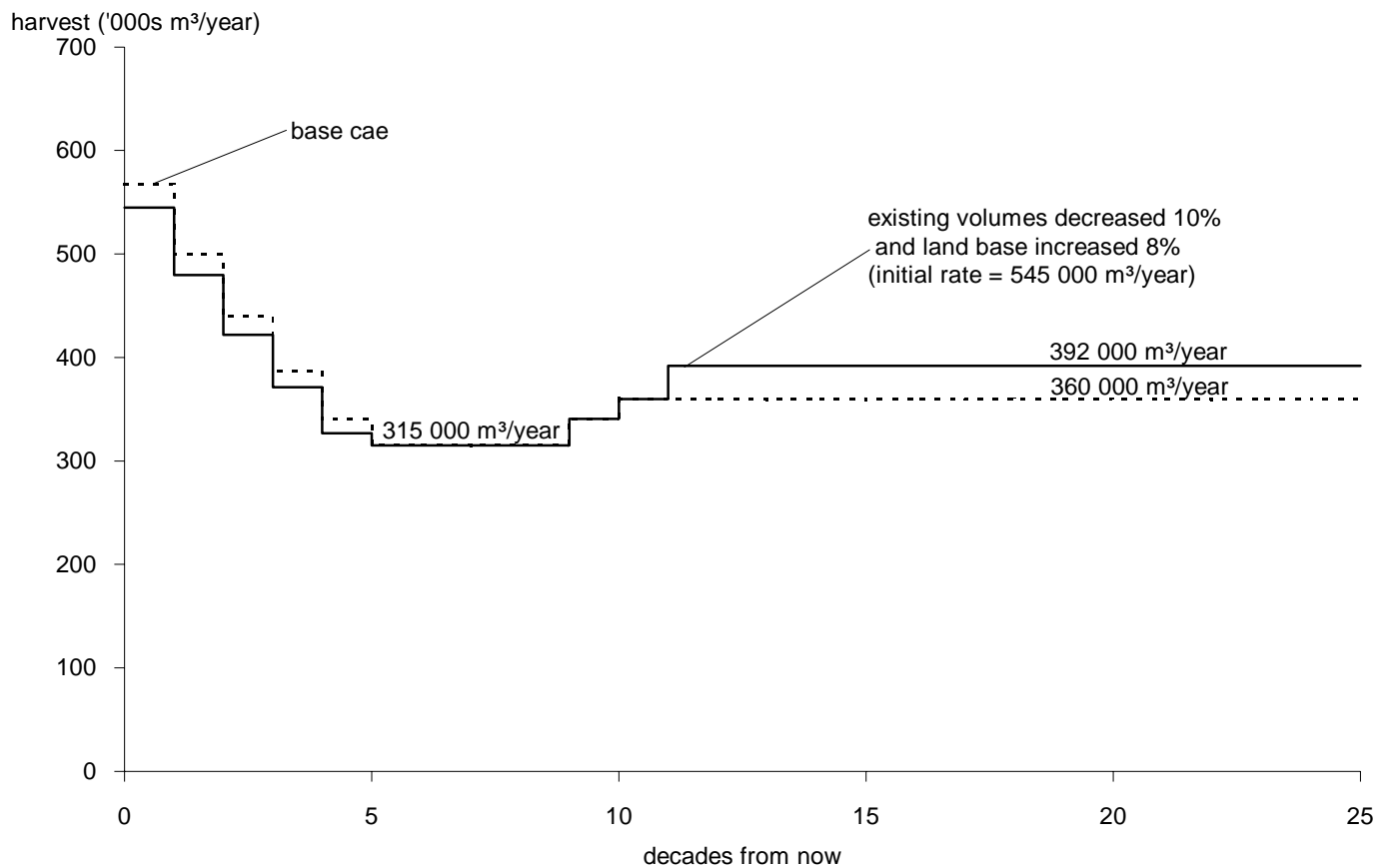


Figure 31. Offsetting interaction between decreased estimates of existing stand yields and an increase in the size of the timber harvesting land base— Invermere TSA, 1995.

5 Timber Supply Sensitivity Analyses

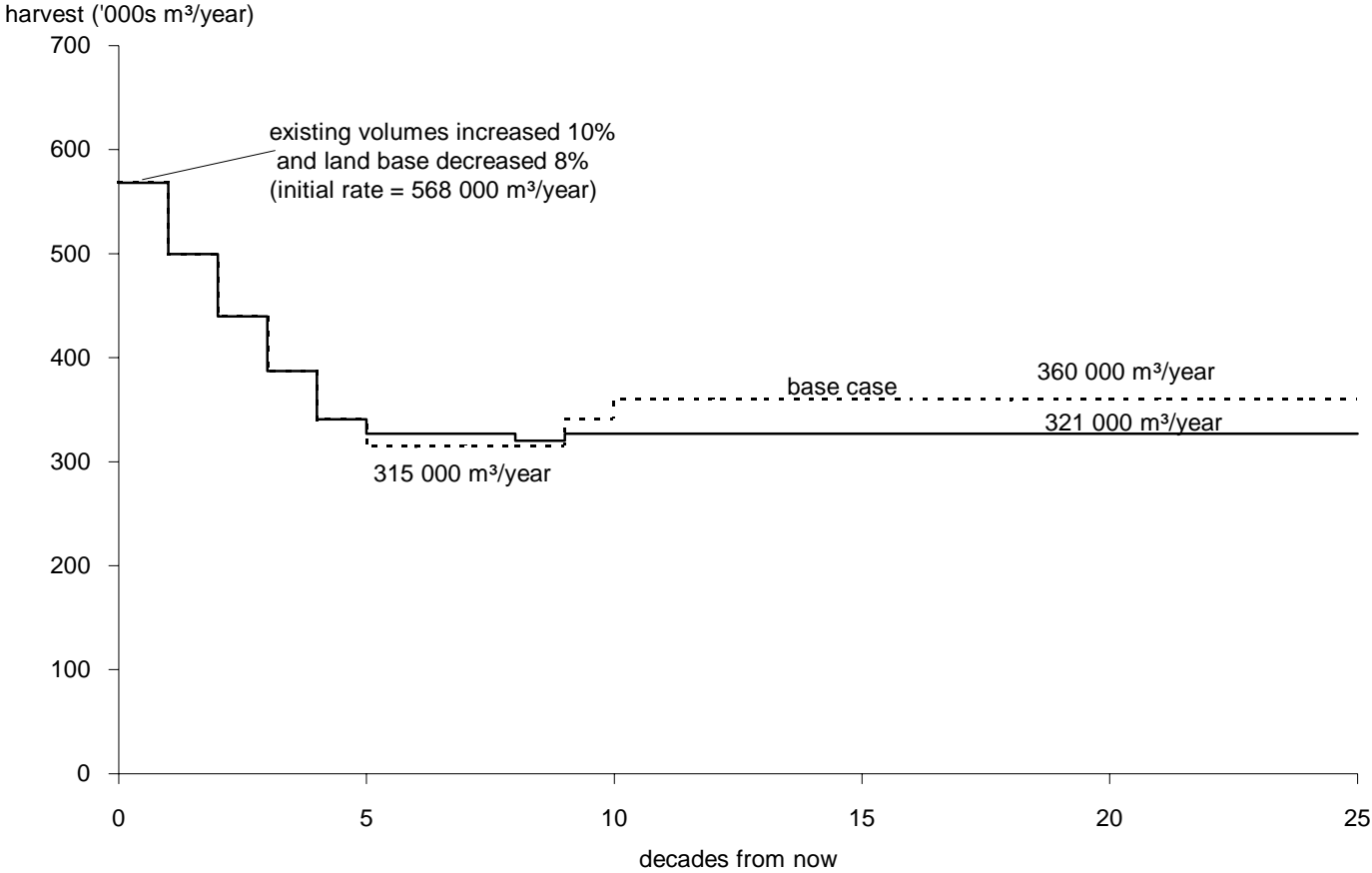


Figure 32. Offsetting interaction between increased estimates of existing stand yields and a decrease in the size of the timber harvesting land base— Invermere TSA, 1995.

6 Summary and Conclusions

The base case harvest forecast presented in this analysis indicates that maintaining the current timber harvesting levels in the Invermere TSA, even for one more decade, will cause severe timber supply shortfalls in the future. Given current management assumptions, an initial harvest of 568 000 cubic metres per year (12.7% below the current level of 650 564 cubic metres per year) can be maintained for one decade, if the harvest level then declines by 12% per decade until decade 5. From decade 5 through 8 harvests of 315 000 cubic metres per year could be supported, and could rise during decades 9 and 10 to reach the long-term level of 360 000 cubic metres per year. The long-term level is 45% lower than the current harvest level.

Several factors contribute to the forecasted decline in timber supply. The most important factor is that the base case initial harvest level is well above the steady, long-term level. In this situation harvest rates must decline towards the long-term level to avoid serious timber supply shortfalls in the future. Also contributing to the decline in timber supply, to some extent, are forest cover requirements for forest resources such as wildlife habitat, scenic values, protection of community watersheds and biodiversity. However, even if these forest cover requirements were removed, harvests would still need to decline beginning 20 years from now. An additional contributing factor is that significantly less area is available for timber harvesting today than when the last timber supply analysis was completed in 1981. Riparian area buffers, forest ecosystem networks and steep slope sites below the operability line, all areas previously not excluded from harvesting, are now not available for harvesting based on current standards of practice.

This analysis employs the best current estimates for all variables used to describe forest management in the Invermere TSA. Nevertheless, varying degrees of uncertainty surround most of the estimates. The results of sensitivity analysis indicate that the short-term harvest level could be increased from the base case forecast by relaxing all forest cover requirements or removing them completely. But only if forest cover requirements are removed entirely would increases in timber supply be large enough to maintain the current harvest level for a

short time. Sensitivity analyses also show that even if existing stand volumes have been underestimated by 20% for this analysis, the current harvest level could be maintained for only one decade before declining to avoid more severe timber shortfalls in the future. Furthermore, even when assuming a 15% increase in the size of the land base, harvests could not be maintained at the current harvest level without allowing future harvests to dip below the long-term level.

The short-term timber supply is particularly sensitive to uncertainty about yield estimates for existing stands, land base size, forest cover requirements (especially for ungulate winter range), and unsalvaged losses, and to large increases to old-growth requirements. Minimum harvestable ages, and length of green-up periods are factors that also affect short-term timber supply, but to a lesser degree.

The long-term harvest level is highly sensitive to uncertainty in yield estimates for regenerated stands, the size of the timber harvesting land base and unsalvaged losses. The long-term harvest level is lightly impacted by uncertainty in minimum harvestable ages, length of green-up periods, green-up forest cover requirements, and old-growth requirements.

The need to harvest below the long-term level between decades 5 and 9 can be emphasized or reduced by changes to any of the following factors: initial harvest level and rate of decline, size of the timber harvesting land base, minimum harvestable ages, estimates of existing stand yields, length of green-up periods, and green-up forest cover requirements.

In conclusion, this analysis indicates that using current inventory and growth and yield information, timber harvests in the Invermere TSA must drop over the next few decades even if inventory, growth and yield and management assumptions used in this analysis have significantly underestimated timber supply. It will be important to examine forest cover guidelines, especially for ungulate winter range and visual quality objectives when deciding on a strategy for the transition from the current harvest level to a level sustainable over the long term.

7 References

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8 Glossary

Allowable annual cut (AAC)	The allowable rate of timber harvest from a specified area of land. The Chief Forester sets AACs for timber supply areas (TSAs) and tree farm licences (TFLs) in accordance with <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 areas 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	An established seedling of an acceptable commercial species that is 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., top 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.
Long-term harvest level	A harvest level that can be maintained indefinitely given a particular forest management regime (which defines the timber harvesting land base and includes objectives and guidelines for non-timber values) and estimates of timber growth and yield.

8 Glossary

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.
Modification VQO	Alterations may dominate the visual landscape, but should blend with natural features. Up to 25% of the visible area can be altered by harvesting activity.
Non-merchantable forest types	Stands that are accessible and otherwise available for harvesting but are assumed to be non-merchantable due to stand characteristics such as small piece size, incidence of decay, species composition and low stocking.
Not satisfactorily restocked (NSR)	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).
Preservation VQO	Alterations are generally not visible. Up to 1% of the visible landscape can be visibly changed 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.
Seed-tree system	Removal of most of the mature, merchantable trees in one harvest, except for a small number of trees to provide seed to facilitate establishment of a new stand.
Shelterwood system	Involves leaving a significant proportion of the mature, merchantable trees standing after an initial harvest to provide seed and shelter to assist in establishing a new stand. Usually the shelter trees are harvested after the new stand is well established.
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.

8 Glossary

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.
Visual sensitivity	A measure of the level of concern for the scenic quality of a landscape. Visual sensitivity ratings take into account the physical character of the landscape, as well as viewer related factors such as the number of viewers and the angle, position, and distance from which the landscape is viewed.

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 Invermere 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 Overview

Information on the forests in the Invermere 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 is based on the characteristics of the area and the planned management regime. The way information is handled corresponds 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.

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.1.2 Zone characteristics

In timber supply modelling, a geographic area, or combination of geographic areas, having the same forest cover objective is called an analysis zone. Analysis zones may be associated with a particular resource emphasis area or landscape unit for the purpose of applying forest management guidelines.

The Invermere TSA is divided into 15 zones so that the impact of current management practices on the timber supply can be modelled. Forest management in three of these zones emphasizes maintaining scenic landscapes and meeting visual quality objectives within the landscapes, in one zone water conservation in community watersheds is emphasized, and in two zones the provision and maintenance of wildlife habitat for feature wildlife populations is emphasized. In nine zones the emphasis is on integrated resource management. Following is a list of the 15 analysis zones:

- Retention VQO — includes landscapes designated in the B.C. Forest Service recreation inventory with a retention visual quality objective;
- Partial retention VQO — includes landscapes designated in the B.C. Forest Service recreation inventory with a partial retention visual quality objective;
- Modification VQO — includes landscapes designated in the B.C. Forest Service recreation inventory with a modification visual quality objective;
- Community watershed — includes watersheds where water use licences have been issued, and each licence includes six or more households;
- Prime caribou habitat — includes areas mapped as being particularly important caribou habitat;
- Ungulate winter range — includes areas falling within the dry-cool-montane-spruce (MSdk) biogeoclimatic subzone;

A.1 Zone and Analysis Unit Definition

- Columbia trench (forest cover less than 50%) — includes open forest areas falling within the Columbia Trench Plan where forage production is a consideration;
- Rockies ESSFdk-H1 — includes heavily logged areas in the east part of the Invermere TSA falling within the dry-cool-Englemann-spruce/subalpine fir biogeoclimatic subzone (some ESSFwm) or interior-cedar-hemlock (ICH) subzone;
- Rockies IDFdm2-H2 — includes heavily logged areas in the east part of the Invermere TSA falling mainly within the Kootenay-dry-mild-interior-Douglas-fir variant biogeoclimatic subzone;
- Rockies ESSFdk-L1 — includes lightly logged areas in the east part of the Invermere TSA falling within the dry-cool-Englemann-spruce/subalpine fir biogeoclimatic subzone (some ESSFwm) or interior-cedar-hemlock (ICH) subzone;
- Rockies IDFdm2-L2 — includes lightly logged areas in the east part of the Invermere TSA falling mainly within the Kootenay-dry-mild-interior-Douglas-fir variant biogeoclimatic subzone;
- Purcells ESSFdk-H1 — includes heavily logged areas in the west part of the Invermere TSA falling within the dry-cool-Englemann-spruce/subalpine fir biogeoclimatic subzone (some ESSFwm) or interior-cedar-hemlock (ICH) subzone;
- Purcells IDFdm2-H2 — includes heavily logged areas in the west part of the Invermere TSA falling mainly within the Kootenay-dry-mild-interior-Douglas-fir variant biogeoclimatic subzone;
- Purcells ESSFdk-L1 — includes lightly logged areas in the west part of the Invermere TSA falling within the dry-cool-Englemann-spruce/subalpine fir biogeoclimatic subzone (some ESSFwm) or interior-cedar-hemlock (ICH) subzone;
- Purcells west IDFdm2 — includes lightly logged areas in the west part of the Invermere TSA falling mainly within the Kootenay-dry-mild-interior-Douglas-fir variant biogeoclimatic subzone.

Procedure to define analysis zones

The computer file initially prepared for this analysis did not contain the necessary information to define the analysis zones. The missing information was supplied by the Invermere Forest District staff at the time the data package for this analysis was prepared, and was incorporated into the inventory data file by the timber supply analyst. This information, which consists mainly of lists of planning cells and forest cover polygons, can be found in the *Invermere TSA Data Package for the 1994 Timber Supply Review*. Because some of these lists were lengthy they are not included here. The procedure to define the analysis zones is as follows:

1. Merge criteria to define geographically specific zones into the forest inventory data file:
 - (a) community watersheds defined using district planning cell listing of important watersheds;
 - (b) riparian areas defined using district listing of forest cover polygons falling within a delineated riparian zone;
 - (c) Columbia Trench area defined using the Invermere Forest District planning cell listing of trench area having open forest;
 - (d) east and west half of the Invermere TSA defined using planning cell listing of these areas;
 - (e) lightly and heavily disturbed areas defined using planning cell listing of these areas.

A.1 Zone and Analysis Unit Definition

2. Assign each forest cover polygon an old-growth unit number based on its biogeoclimatic subzone classification. If a forest cover polygon is classified as:
 - (a) ESSFc--, ESSFc-p-, ESSFwm-, or ESSFwm-p then assign it to old-growth unit 2, or if
 - (b) ICH-a-2, ICH-mk1 or ICH-mw1 then assign it to old-growth unit 3, or if
 - (c) IDF-dm2, IDF-g-1, IDF-g-3 or IDF-un- then assign it to old-growth unit 4, or if
 - (d) IDF-g-2 or PP--dh2 then assign it to old-growth unit 5, or if
 - (e) MS--a-- or MS--dk- then assign it to old-growth unit 6, otherwise
 - (f) assign it to old-growth unit 1 (ESSFdk-, ESSFdk-p, ESSF-p, ESSFbp-, ESSFap-, ESSFa--, ESSFa--, AT---, ZZZZ----).
3. Assign each forest cover polygon to an analysis zone if it falls within a resource emphasis area. If more than one resource is being emphasized in the same area give the resource with the most restrictive forest cover requirement precedence by using the assignment order listed below. If a forest cover polygon:
 - (a) falls within the trench plan then assign it to analysis zone 40;
 - (b) has a modification VQO attribute then assign, or reassign, it to analysis zone 12;
 - (c) has an old-growth unit attribute of 6 (ungulate winter range) then assign, or reassign, it to analysis zone 31;
 - (d) falls within core caribou habitat (planning cells 0157 to 0166) then assign, or reassign, it to analysis zone 30;
 - (e) falls within a community watershed then assign, or reassign it to analysis zone 20;
 - (f) has a partial retention VQO attribute then assign, or reassign it to analysis zone 11;
 - (g) has a retention VQO attribute then assign, or reassign it to analysis zone 10.
4. Summarize forest cover polygons not yet assigned to an analysis zone by east-west designation, light-heavy disturbance, and old-growth unit number. Examine the summary report and group old growth units having sparse representation with similar units: Based on the summary, if a forest cover polygon's old-growth unit is:
 - (a) 1,2, or 3 then assign it old-growth aggregate 1, or
 - (b) 4,5, or 6 then assign it old-growth aggregate 2.
5. Assign any forest cover polygons not yet assigned to an analysis zone to one based on east-west designation, light-heavy disturbance designation, and old-growth aggregate number. If a polygon's attributes are:
 - (a) east, heavily disturbed, and old-growth aggregate = 1 then assign it to analysis zone 41, or if
 - (b) east, heavily disturbed, and old-growth aggregate = 2 then assign it to analysis zone 42, or if
 - (c) east, lightly disturbed, and old-growth aggregate = 1 then assign it to analysis zone 43, or if
 - (d) east, lightly disturbed, and old-growth aggregate = 2 then assign it to analysis zone 44, or if
 - (e) west, heavily disturbed, and old-growth aggregate = 1 then assign it to analysis zone 45, or if
 - (f) west, heavily disturbed, and old-growth aggregate = 2 then assign it to analysis zone 46, or if
 - (g) west, lightly disturbed, and old-growth aggregate = 1 then assign it to analysis zone 47, or if
 - (h) west, lightly disturbed, and old-growth aggregate = 2 then assign it to analysis zone 48, otherwise
 - (i) assign to analysis zone 41.

A.1 Zone and Analysis Unit Definition

A summary of the Invermere TSA land base by analysis zone, as defined using the procedure just described, is shown in Table A-1.

Table A-1. Land base classification of each analysis zone within the Invermere TSA

Analysis zone	Total area	Non-Crown	Non-productive	Productive forest	Timber harvesting land base	Net operable NSR ^a
10	67 720.6	31 468.4	17 128.8	19 123.4	9 914.2	179.1
11	64 270.4	10 939.4	13 437.9	39 893.1	19 963.	2 529.9
12	14 636.7	3 677.4	3 144.4	7 814.9	3 980.4	487.6
20	96 514.2	19 092.5	38 420.9	39 000.8	13 519.1	755.0
30	17 015.2	29.4	8 910.7	8 074.9	2 169.	-
31	121 056.2	7 691.5	9 390.0	103 974.7	69 848.4	3 335.8
40	16 043.3	2 942.0	3 541.4	9 559.9	6 449.9	174.2
41	234 983.1	54 719.1	89 667.6	90 596.4	36 264.6	2 764.9
42	7 090.7	1 476.6	842.5	4 771.6	3 632.4	229.2
43	152 015.9	200.7	69 783.6	82 031.6	28 411.8	1 556.7
44	12 807.8	4 677.1	958.5	7 172.2	5 346.8	231.8
45	68 025.3	4 521.0	42 280.7	21 223.6	4 080.02	152.0
46	20 661.3	7 716.7	1 462.2	11 482.4	8 999.3	723.9
47	113 647.4	488.4	63 757.3	49 401.7	15 173.1	622.5
48	11 868.9	2 782.3	715.8	8 370.8	6 007.7	679.1
Total	1 018 357.0	152 422.5	363 442.5	502 492.0	233 759.7	14 421.7

(a) NSR with timber type designation not included.

A.1 Zone and Analysis Unit Definition

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 Invermere TSA timber supply analysis, and the inventory file variables used to define them, are shown in Table A-2.

Table A-2. Analysis unit characteristics

Analysis unit	Species groups	Inventory type groups	Site index classes	Area within timber harvesting land base (hectares)
01	Douglas-fir, larch, yellow pine	1-8, 32-34	good	9 548.7
02	Douglas-fir, larch, yellow pine	1-8, 32-34	medium	51 618.8
03	Douglas-fir, larch, yellow pine	1-8, 32-34	poor	28 844.1
04	Douglas-fir, larch, yellow pine	1-8, 32-34	low	2 006.6
05	spruce, balsam	18-26	good	4 419.3
06	spruce, balsam	18-26	medium	18 162.9
07	spruce, balsam	18-26	poor	15 102.0
08	cedar, hemlock	09-17	all	510.4
09	lodgepole pine , white pine	27-31	good	23 669.9
10	lodgepole pine , white pine	27-31	medium	58 276.4
11	lodgepole pine , white pine	27-31	poor	20 230.5
12	deciduous	35-42	all	1 370.3
Total				233 759.9

A.2 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 Invermere TSA area in the following order: (1) land not administered as part of timber harvesting land base; (2) non-forest land; (3) non-commercial cover (NCC, i.e., brush species); (4) inoperable areas; (5) environmentally sensitive areas (ESAs); (6) steep slopes; (7) riparian areas; (8) sites with low-timber growing potential; (9) non-merchantable forest types; (10) not satisfactorily restocked (NSR); (11) forest ecosystem networks (FEN); and (12) road, trail, and landing areas.

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.2.1 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 the B.C. Forest Service jurisdiction. Ownership codes as defined by the B.C. Forest Service, 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 Invermere TSA is under the jurisdiction of the provincial government, but not all is managed by the B.C. 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. Sometimes information on TFLs is included in the TSA inventory. This land is managed as part of the TFL, and therefore does not form part of the TSA timber harvesting land base.

A.2 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-3. outlines the total area in each ownership category for the Invermere TSA.

Table A-3. Total area in each ownership category for Invermere TSA

Description	Ownership code	Area (hectares)	Per cent of total
Private Crown grant	40-N ^a	69 282.4	6.8
Federal, federal reserve	51-N	1 335.5	0.1
Federal, Indian reserve	52-N	3 304.5	0.3
Provincial, ecological reserve	60-N	173.6	0.0
Provincial, UREP ^c	61-C ^b	11 488.0	1.1
Provincial, UREP	61-N	2 444.9	0.2
Provincial, forest management unit (Crown)	62-C	599 264.3	58.8
Provincial, provincial park - class A	63-N	350.4	0.0
Provincial, wilderness areas within provincial forest	68-N	50 868.6	5.0
Provincial, Crown or government reserve	69-C	266 670.2	26.2
Provincial, Crown or government reserve	69-N	1 094.9	0.1
Provincial, Christmas tree permit	75-N	8 721.6	0.9
Provincial, TFL unreported ownership	76-N	0.2	0.0
Provincial, woodlot licence, Crown land portion	77-N	2 506.0	0.2
Miscellaneous leases	99-C	840.1	0.1
Miscellaneous leases	99-N	11.8	0.0
Total		1 018 357.0	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.2.2 Non-forest area and non-productive forest area

Areas defined as non-forested or not capable of producing timber of merchantable size within a reasonable length of time (non-productive) are not considered part of the timber harvesting land base. Examples of non-forested and non-productive forest types are areas classified as ice fields, alpine, rock, alpine forest, muskeg, and open range. The type identification variable on the inventory file (TYPID_PRJ variable = 6 or 8) was used to exclude areas from the timber harvesting land base.

A.2 Definition of the Timber Harvesting Land Base

A.2.3 Non-commercial cover

Areas described as denuded but potentially productive forest land that is well covered or occupied by non-commercial brush are excluded from the timber harvesting land base. Non-commercial brush areas are typically more than 60% covered by brush more than 1 metre tall and may have a sparse scattering of commercial tree species throughout. The typed identification code on the inventory file (TYPID_PRJ = 5) was used to exclude these brush areas from the timber harvesting land base.

A.2.4 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. Records with operability level I or N were removed from the timber harvesting land base.

At the time the data package was prepared for this analysis, the Invermere Forest District staff provided a polygon listing of areas having a change in operability classification. This listing is included in the data package. The polygon listing was used to update the inventory file, and the update resulted in a net change of 438 fewer operable hectares.

A.2.5 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, Eh₁, Ew₁) are either excluded or considered only partly available for timber harvesting. Areas rated as moderately sensitive (Es₂, Ew₂) are not excluded from the timber harvesting land base but are considered when establishing forest cover requirements. Table A-4. indicates the per cent area reduction made for the highly sensitive ESA categories. For areas assigned more than one ESA rating, only one reduction is made based on the first highly sensitive ESA category recognized. For example, a 90% reduction would be applied once to an area having both Er₁ and Ep₁ ESA ratings.

Table A-4. Per cent area reductions for environmentally sensitive areas

ESA code	ESA description	Per cent area reduction
Ea ₁	High avalanche concerns	90
Es ₁	High soil and steepness concerns	90
Er ₁	High recreation concerns	90
Ep ₁	High regeneration problems	90
Eh ₁	High watershed values	90
Ew ₁	High wildlife values	90

A.2 Definition of the Timber Harvesting Land Base

A.2.6 Steep slopes

The forest inventory file includes slope class information based on two sources of contour information — TRIM and DND. TRIM is more recent information included with the latest mapsheet updates. Slope classes are used as a basis to exclude those sites below the operability line considered too steep or hazardous for harvesting operations.

Each source of contour information only partly covers the TSA, but what one does not cover the other does. The date updated variable (DATEUPDT) is used to distinguish the two sources in the inventory file. If DATEUPDT = 93 then the source is DND and the slope classes are as follows: codes 000 or 001 = slope class 1; code 002 = slope class 2; code 003 = slope class 3; and code 004 = slope class 4. If DATEUPDT = 94 then the source is TRIM and the slope classes are as follows: codes 000, 001, or 002 = slope class 1; codes 003 or 004 = slope class 2; codes 005 or 006 = slope class 3 and code 007 = slope class 4. Table A-5. indicates the per cent area reduction made for steep slopes and/or hazardous terrain. These reduction factors are based on current performance figures for various terrain and forest type conditions.

Table A-5. Per cent area reduction for steep slopes

Analysis unit	Species group	Site index classes	Per cent area reduction by slope class			
			1 (0-30%)	2 (31-50%)	3 (51-70%)	4 (> 70%)
01	Douglas-fir, larch, yellow pine	good	0	0	10	20
02	Douglas-fir, larch, yellow pine	medium	0	0	20	50
03	Douglas-fir, larch, yellow pine	poor	0	15	50	100
04	Douglas-fir, larch, yellow pine	low	0	100	100	100
05	spruce, balsam	good	0	0	10	20
06	spruce, balsam	medium	0	0	20	50
07	spruce, balsam	poor	0	20	70	100
08	cedar, hemlock	all	0	10	50	80
09	lodgepole pine, white pine	good	0	0	15	30
10	lodgepole pine, white pine	medium	0	0	25	70
11	lodgepole pine, white pine	poor	0	20	70	100

A.2.7 Riparian zones

Table A-6. provides a summary of area by land cover description within riparian zones that is excluded from the timber harvesting land base. Riparian data in the form of a digital overlay was available for this analysis and this information was used to produce a list of forest cover polygons having 50% or more of their area within a riparian zone. These polygons were excluded from the timber harvesting land base.

A.2 Definition of the Timber Harvesting Land Base

Table A-6. Summary of forest cover polygons included in riparian zones

Description of forest cover polygon area falling within riparian zones	Total area (hectares)	Crown productive forest (hectares)
Mature forest	3 080	2 494
Immature forest	2 644	2 184
Not satisfactorily regenerated	153	144
Non-commercial cover	132	92
Alpine and rock	37	-
Alpine forest	121	-
Clay bank	44	-
Non-productive brush, burns etc.	1 083	-
Lakes and rivers	2 434	-
Swamp (muskeg)	11 387	-
Clearing or meadow	482	-
Urban	59	-
Open range	411	-
Total	22 067	4 914

Once reductions are made for non-commercial cover, operability, environmental sensitivity and steep slopes, the riparian reduction amounts to 3652 hectares.

A.2.8 Sites with low timber growing potential

Areas of low site quality are also excluded because projected growth rates for second-growth forests on these areas are too low. The low site reduction was based on new site class (NSITE) except when modified by special site (SSITE). Records with a site classification of L were removed from the land base except for Douglas-fir, analysis unit 04.

A.2.9 Non-merchantable 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. Table A-7. lists the non-merchantable types for the Invermere TSA and the percentage reductions applied for each category.

A.2 Definition of the Timber Harvesting Land Base

Table A-7. Per cent area reductions for non-merchantable forest types

Inventory type group	Species groups	Criteria				Per cent area excluded
		Age class	Height class	Stocking class	Site class	
36-40,42	deciduous	any	any	any	any	60
35,41	cottonwood, aspen	any	any	any	any	80
1-8,32-34	Douglas-fir, larch	5	2	0	m,p	30
1-8,32-34	Douglas-fir, larch	6	2	0	m,p	30
1-8,32-34	Douglas-fir, larch	6	2	2	m,p	30
1-8,32-34	Douglas-fir, larch	7	2	2	m,p	30
1-8,32-34	Douglas-fir, larch	8	2	2	m,p	30
1-8,32-34	Douglas-fir, larch	9	2	2	m,p	30
1-8,32-34	Douglas-fir, larch	4	1	0	m,p	20
1-8,32-34	Douglas-fir, larch	4	2	0	m,p	20
1-8,32-34	Douglas-fir, larch	3	1	0	any	10
1-8,32-34	Douglas-fir, larch	3	2	0	any	10
9-17	cedar, hemlock	8,9	any	any	any	40
28-31	lodgepole pine	3	1	0	m,p	50
28-31	lodgepole pine	3	2	0	any	30
28-31	lodgepole pine	4	1	0	m,p	100
28-31	lodgepole pine	4	2	0	any	40
28-31	lodgepole pine	5-9	2	0	any	80

A.2.10 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.3.5, "Not satisfactorily restocked (NSR) areas.")

A.2.11 Forest ecosystem networks (FENs)

A reduction of 8% was applied to the timber harvesting land base to account for mature operable timber located within connecting corridors of forest ecosystem networks. The percentage was calculated from a sampling of the total resources plans recently completed for the Invermere TSA. The percentage takes into account those areas outside the timber harvesting land base that would also contribute to the FENs (i.e., riparian, inoperable, environmentally sensitive, etc.).

A.2.12 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 10.5% reduction was applied to all forest younger than 40 years old, which are assumed to have existing access.

A.2.13 Future roads, trails, and landings

There will also be losses in productive area as future harvesting occurs. All existing stands currently over 40 years old will be subject to a 10.5% loss.

A.3 Forest Management Assumptions

A.3.1 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.3.2 Minimum harvestable ages for each analysis unit

Table A-8. shows the culmination ages and minimum harvestable ages for each analysis unit for even-aged management areas (clearcutting silvicultural systems). Minimum harvestable ages are the Invermere Forest District estimates based on a combination of past performance data, standards included in silvicultural prescriptions and professional judgment.

Table A-8. 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	120	110	100	100
02	130	120	110	110
03	140	140	120	120
04	160	200	160	160
05	110	100	90	90
06	150	150	110	110
07	170	180	140	140
08	110	140	140	140
09	90	90	70	70
10	100	100	80	80
11	130	130	100	100
12	110	130	110	110

A.3 Forest Management Assumptions

A.3.3 Forest cover requirements

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

Table A-9. Forest cover requirements

Analysis zone	Desired green-up conditions			Older forest representation	
	Age 1 (years)	Height (metres)	Maximum per cent area younger than age 1	Age 2 (years)	Minimum per cent area older than age 2
Retention VQO -10	26	6	6		
Partial retention VQO - 11	26	6	16	141	4
Modification VQO - 12	26	6	33	141	4
Community watershed - 20	36	9	30		
Core caribou - 30	20	3	40/33 ^a		
Ungulate winter range - 31	57	15	33	141	6
Integrated resource management:					
Trench IDF < 50% cover - 40	68	15	50	141	4
Rockies ESSFdk - H1 - 41	19	3	40/33		
Rockies IDFdm2 - H2 - 42	16	3	40/33	141	10
Rockies ESSFdk - L1 - 43	18	3	40/33		
Rockies IDFdm2 L2 - 44	16	3	40/33	141	8
Purcells ESSFdk - H1 - 45	18	3	40/33		
Purcells IDFdm2 - H2 - 46	15	3	40/33	121	11
Purcells ESSFdk - L1 - 47	17	3	40/33		
Purcells IDFdm2 L2 - 48	15	3	40/33	121	11

(a) 40% for 20 years then 33%.

Age 1 was determined by area-weighting the time required to achieve green-up height (height 1) for each analysis unit within the analysis zone. The average site indices for each analysis unit were determined using FREDTAB, a computer program supplied by the B.C. Forest Service, Research Branch. Another 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.

A.3 Forest Management Assumptions

Managing for biodiversity — older forest representation

At least 10% of the productive forest area in each analysis zone should be covered by older forest in order to meet the current forest district biodiversity target. Because most zones have a preponderance of older forest in riparian areas, forest ecosystem networks, environmentally sensitive areas, inoperable areas and in other areas where timber harvesting is not permitted, requirement from the timber harvesting land base is often less than 10%. The calculated requirement from the timber harvesting land base for each zone is shown in Table A-13, in the column titled "Older forest representation". Note that in some zones there is a lack of older forest in areas excluded from timber harvesting, so more than 10% is needed from the timber harvesting land base to meet objectives for the whole area.

Zones 10, 11, and 12 — managing to meet visual quality objectives within designated landscapes

The forest cover requirements for the VQO zones are based on the procedures outlined in *Procedures for Factoring Recreation Resources into Timber Supply Analyses Technical Report 1993:1* and applying forest inventory information on total productive forest and net forested area (green to net ratios) by VQO and zone. The following assumptions were made when determining the per cent denudation for each VQO zone (each visual landscape unit or aggregation of units):

- 40% of area has high visual absorption capability;
- 30% of area has medium visual absorption capability;
- 30% of area has low visual absorption capability;
- 20% of operable forest is dispersed;
- 20% of operable forest is clustered;
- 60% of operable forest is solid.

Zone 20 — protecting community watersheds

This zone includes licensed community watersheds identified by the Ministry of Environment, Lands and Parks and equivalent areas. To protect water quality, quantity and flow rates, a maximum of 30% of these areas are permitted to have forests less than 9 metres tall at any time.

Zones 30 and 31 — provision and maintenance of wildlife habitat

The area in planning cells 0157 through 0166 is considered prime caribou habitat (zone 30). At least 40% of this area must be covered by forest older than 121 years old in order to meet current wildlife guidelines. Because a large portion of this zone is not eligible for harvesting, no older forest is needed from the timber harvesting land base. Current older forest covers 43% of the zone before considering any contribution from the timber harvesting land base.

In zone 31 second-growth stands must reach a height of 15 metres to meet thermal cover requirements.

Zones 40 - 48 — integrated resource management

Adjacency guidelines require that before stands adjacent to cutovers get harvested that the trees in the cutover be allowed enough time to grow to a top height of 3 metres. Three metre trees are considered tall enough to provide summer hiding cover for ungulates. During the next 20 years up to 40% of the mature operable forest may be harvested from an area. The requirement was represented in the analysis by a forest cover requirement that a maximum of 40% of the timber harvesting land in the zone can be younger than green-up age. Beyond 20 years from now the maximum per cent falls to 33%.

A.3 Forest Management Assumptions

The adjacency guideline is the same for zones 41 through 48, but each zone recognizes inherent differences because of elevation and forest types (biogeoclimatic subzones), development history, and geographic distinctiveness. Zone 40 covers the interface area between range and forest land. The forest cover requirement here allows for both forage and timber production.

A.3.4 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 Invermere TSA.

Table A-10. *Unsalvaged losses*

Cause of loss	Annual unsalvaged loss in cubic metres/year
Fire	16 470
Insects:	
mountain pine beetle	16 890
fir bark beetle	389
spruce bark beetle	512
balsam bark beetle	259
Disease:	
armillaria root rot	23 684
mistletoe	2 983
Other (windthrow, seed trees, etc.)	2 410
Total	63 597

A.3.5 Not satisfactorily restocked (NSR) areas

This analysis is based on data found in the forest inventory file prepared in 1994 for the timber supply review. A summary of this data (Table A-1.) shows 14 422 hectares of land within the timber harvesting land base classified as NSR without a species or site class designation. Species and site class needs to be indicated before any area can be assigned to an analysis unit. For this type of NSR, analysis units, and the inherent species and site classes, were assigned using the percentages in Table A-11. For example, Table A-1. shows 2764.9 hectares of net operable NSR within zone 41, 13.6% of this amount is apportioned to analysis unit 02 based on the percentage shown in Table A-11.

Table A-11. is a summary of the total area of current and backlog NSR currently existing in the Invermere TSA based on the major licensee silvicultural information system (MLSIS) and the integrated silvicultural information system (ISIS). Information on openings (areas recently logged and treated) from these systems was downloaded into a database program so that the openings could be sorted into the appropriate analysis units (species by site combinations).

A.3 Forest Management Assumptions

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

Analysis unit	NSR (area in hectares)		Total area (hectares)	Per cent of total
	Backlog	Current		
01	99	294	393	2.2
02	614	1 825	2 439	13.6
03	503	1 495	1 998	11.2
04	12	36	48	0.3
05	101	255	356	2.0
06	227	575	801	4.5
07	1	1 669	1 670	9.4
08	0	53	53	0.3
09	1 812	447	2 259	12.7
10	3 100	3 074	6 174	34.6
11	816	810	1 626	9.2
12	0	0	0	0.0
Total	7 285	10 533	17 817	100.0

The forest inventory files also show 6492 hectares of NSR with a timber type designation, bringing the total to 20 914 hectares. This total differs with the total in Table A-11. (20 914 hectares versus 17 818 hectares) because the information from MLSIS and ISIS is more up-to-date than the information in the data file used for this analysis, and because the definition for timber harvesting land base is specific to this analysis. This area (3096 hectares) has most likely become restocked since information was compiled for the current inventory file. The difference has no effect on the results of the analysis.

It is assumed that for analysis purposes all backlog NSR will be restocked at an even rate within 10 years and all current NSR will be restocked at an even rate within 20 years.

A.3.6 Basic silviculture and regeneration assumptions

The following table shows the regeneration assumptions for each analysis unit. These assumptions provide the inputs required for predicting timber yields from managed stands using the Table Interpolation Program for Stand Yields (TIPSY). Below is a description of the assumptions shown in Table A-12.

- Site index @ 50— an area weighted average site index at breast height age 50. A computer program called FREDTAB was used to generate a site index value for each record on the inventory file;
- Type — type of regeneration method: either planting or natural;
- Per cent — per cent area treated by method type;
- Delay — regeneration delay applied in the model;
- Species 1 — primary or leading species;
- Species 2 — secondary species;
- OAF1 — reduction percentage (operational adjustment factor) to account for small openings and unproductive areas within regenerated stands;
- OAF2 — adjustment factor to account for increased incidence of disease, decay, waste and breakage as stands age. The reduction percentage is referenced to age 100.

A.3 Forest Management Assumptions

Table A-12. Regeneration assumptions

Existing analysis unit	Site index @ 50	Regeneration assumptions													
		Method			Species 1				Species 2				Density (sph)		
		Type	%	Delay	Sp	%	OAF 1	OAF 2	Sp	%	OAF 1	OAF 2	Initial	Thin	
01 F,L,Py G	19.1	Plant	50	4	F ^a	70	15.0	10.8	PI	30	15.0	10.8	1400	no	
		Nat	50	7	F ^a	70	20.0	10.8	PI	30	15.0	10.8	5000	1400	
02 F,L,Py M	16.4	Plant	50	4	F ^a	60	15.0	10.8	PI	40	15.0	10.8	1400	no	
		Nat	50	7	F ^a	60	20.0	10.8	PI	40	15.0	10.8	5000	1400	
03 F,L,Py P	13.0	Plant	30	4	F ^a	60	15.0	8.1	PI	40	15.0	8.1	1400	no	
		Nat	70	7	F ^a	60	20.0	8.1	PI	40	15.0	8.1	5000	1400	
04 F,L,Py L	8.3	Plant	10	4	F ^a	60	15.0	8.3	PI	40	15.0	8.3	1400	no	
		Nat	90	7	F ^a	60	20.0	8.3	PI	40	15.0	8.3	5000	1400	
05 S,B - G	19.8	Plant	80	4	S ^b	70	15.0	5.0	PI	30	15.0	5.0	1400	no	
		Nat	20	7	S ^b	70	15.0	5.0	PI	30	15.0	5.0	5000	1400	
06 S,B - M	15.0	Plant	65	4	S ^b	60	15.0	5.0	PI	40	15.0	5.0	1400	no	
		Nat	35	7	S	60	15.0	5.0	PI	40	15.0	5.0	5000	1400	
07 S,B P,L	10.5	Plant	70	4	S ^b	70	15.0	5.0	PI	30	15.0	5.0	1400	no	
		Nat	30	7	S ^b	70	15.0	5.0	PI	30	15.0	5.0	5000	1400	
08 C,H G,M,P,L	15.5	Plant	70	4	S ^b	50	15.0	5.0	PI	50	15.0	5.0	1400	no	
		Nat	30	7	S ^b	50	15.0	5.0	PI	50	15.0	5.0	5000	1400	
09 PI,Pw G	19.8	Plant	25	4	PI	80	15.0	8.7	F ^a	20	15.0	8.7	1400	no	
		Nat	75	7	PI	80	20.0	8.7	F ^a	20	15.0	8.7	5000	1400	
10 PI,Pw M	16.0	Plant	25	4	PI	90	15.0	8.7	F ^a	10	15.0	8.7	1400	no	
		Nat	75	7	PI	90	20.0	8.7	F ^a	10	15.0	8.7	5000	1400	
11 PI,Pw P	12.3	Plant	25	4	PI	70	15.0	8.7	F ^a	30	15.0	8.7	1400	no	
		Nat	75	7	PI	70	20.0	8.7	F ^a	30	15.0	8.7	5000	1400	
12 Decid. G,M,L,P	17.2	Plant	90	4	PI	70	15.0	5.0	F ^a	30	15.0	5.0	1400	no	
		Nat	10	7	PI	70	15.0	5.0	F ^a	30	15.0	5.0	5000	1400	

(a) May also include larch and yellow pine but all species treated as interior Douglas-fir for modelling purposes.

(b) May include several spruce species or hybrids and balsam but all species treated as white spruce for modelling purposes.

F = Douglas-fir, PI = lodgepole pine, L = larch, Py = ponderosa (yellow) pine, S = spruce, C = cedar, H = hemlock, G = good site, M = medium site, P = poor site, L = low site.

A.4 Volume Estimates for Existing and Regenerated Stands

Batch version 4.5 of the Variable Density Yield Prediction (VDYP) model, developed by the Inventory Branch of the B.C. Forest Service was used to predict timber yields for existing stands, excluding plantations established since 1974. 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-13. under the column header "Existing Natural."

The Table Interpolation Program for Stand Yields (TIPSY) developed by the Research Branch of the B.C. Forest Service was used to predict timber yields for future regenerated stands, plantations established on land currently classified as NSR, and free-growing plantations established since 1974. To construct the tables for the timber supply analysis, the average site index for each analysis unit, the establishment methods and species, and reduction factors used to account for operational conditions described in Section A.3.6, "Basic silviculture and regeneration assumptions" were applied. TIPSY yield tables applied to future regenerated stands are shown in Table A-13. under the column header "Regenerated All."

FREDTAB, also supported by the B.C. Forest Service, Research Branch, was used to generate site index for each record on the inventory file. This site index was used to calculate the average site index for each analysis unit.

A.4 Volume Estimates for Existing and Regenerated Stands

Table A-13. Volume estimates (cubic metres per hectare) for existing and regenerated stands

Analysis unit 1 Douglas-fir, larch, ponderosa pine good site			Analysis unit 2 Douglas-fir, larch, ponderosa pine medium site		
	Existing	Regenerated		Existing	Regenerated
Max MAI (m ³ /ha/yr)	Natural 2.15	All 2.81	Max MAI (m ³ /ha/yr)	Natural 1.64	All 1.94
Age			Age		
10	0.0	0.0	10	0.0	0.0
20	0.0	0.0	20	0.0	0.0
30	3.8	5.0	30	0.3	1.0
40	25.7	24.0	40	11.4	13.0
50	57.0	59.0	50	33.0	33.0
60	89.2	109.0	60	57.8	61.0
70	120.8	163.0	70	82.7	94.0
80	151.3	206.0	80	107.0	130.0
90	180.8	245.0	90	130.6	164.0
100	208.7	280.0	100	153.4	191.0
110	234.8	309.0	110	175.1	213.0
120	258.0	336.0	120	194.8	233.0
130	279.3	359.0	130	212.9	252.0
140	297.6	378.0	140	228.3	268.0
150	311.4	394.0	150	240.5	281.0
160	322.5	407.0	160	250.5	292.0
170	330.8	419.0	170	258.4	303.0
180	337.5	429.0	180	265.1	312.0
190	343.3	438.0	190	270.9	319.0
200	349.2	444.0	200	277.0	326.0
210	354.8	448.0	210	282.8	331.0
220	360.0	452.0	220	288.3	335.0
230	364.9	455.0	230	293.4	338.0
240	369.4	456.0	240	298.3	340.0
250	373.6	458.0	250	302.9	341.0
260	374.1	458.0	260	303.3	342.0
270	374.4	458.0	270	303.7	342.0
280	374.7	458.0	280	304.0	342.0
290	374.9	456.0	290	304.3	342.0
300	375.1	456.0	300	304.5	341.0
310	375.2	456.0	310	304.7	341.0
320	375.3	456.0	320	304.8	341.0
330	375.3	456.0	330	304.9	341.0
340	375.3	456.0	340	304.8	341.0
350	375.2	456.0	350	304.7	341.0

continued

A.4 Volume Estimates for Existing and Regenerated Stands

Table A-13. Volume estimates (cubic metres per hectare) for existing and regenerated stands

Analysis unit 3 Douglas-fir, larch, ponderosa pine poor site			Analysis unit 4 Douglas-fir, larch, ponderosa pine low site		
Existing		Regenerated	Existing		Regenerated
Max MAI (m ³ /ha/yr)	Natural 1.15	All 1.41	Max MAI (m ³ /ha/yr)	Natural 0.47	All 0.47
Age			Age		
10	0.0	0.0	10	0.0	0.0
20	0.0	0.0	20	0.0	0.0
30	0.0	0.0	30	0.0	0.0
40	1.9	3.0	40	0.0	0.0
50	11.5	14.0	50	0.2	0.0
60	27.3	28.0	60	2.1	1.0
70	45.5	50.0	70	7.7	6.0
80	64.0	73.0	80	15.1	12.0
90	82.3	97.0	90	23.8	18.0
100	100.1	120.0	100	32.6	24.0
110	117.3	144.0	110	41.4	32.0
120	133.1	165.0	120	49.5	41.0
130	147.8	182.0	130	57.2	49.0
140	160.6	197.0	140	64.1	56.0
150	171.2	209.0	150	70.3	64.0
160	180.2	220.0	160	75.6	71.0
170	187.6	231.0	170	80.4	77.0
180	194.3	241.0	180	85.0	83.0
190	200.3	249.0	190	89.1	89.0
200	206.4	257.0	200	93.3	94.0
210	212.3	263.0	210	97.3	99.0
220	217.9	269.0	220	101.2	104.0
230	223.2	273.0	230	104.8	109.0
240	228.1	277.0	240	108.4	113.0
250	232.9	281.0	250	111.8	117.0
260	233.3	284.0	260	112.1	120.0
270	233.7	287.0	270	112.3	123.0
280	234.0	289.0	280	112.5	126.0
290	234.2	291.0	290	112.7	129.0
300	234.4	292.0	300	112.9	130.0
310	234.6	292.0	310	113.0	130.0
320	234.7	292.0	320	113.1	130.0
330	234.7	292.0	330	113.2	130.0
340	234.7	292.0	340	113.2	130.0
350	234.7	292.0	350	113.1	130.0

continued

A.4 Volume Estimates for Existing and Regenerated Stands

Table A-13. Volume estimates (cubic metres per hectare) for existing and regenerated stands

Analysis unit 5 Spruce, balsam good site			Analysis unit 6 Spruce, balsam medium site		
Max MAI (m ³ /ha/yr)	Existing 2.37	Regenerated 3.56	Max MAI (m ³ /ha/yr)	Existing 1.51	Regenerated 2.02
Age			Age		
10	0.0	0.0	10	0.0	0.0
20	0.0	0.0	20	0.0	0.0
30	0.9	4.0	30	0.2	0.0
40	14.6	20.0	40	2.0	1.0
50	57.9	63.0	50	11.7	9.0
60	101.1	126.0	60	35.7	22.0
70	140.6	193.0	70	62.5	47.0
80	176.6	252.0	80	90.0	81.0
90	208.1	310.0	90	115.1	118.0
100	235.9	356.0	100	137.9	155.0
110	260.5	388.0	110	158.8	188.0
120	281.9	413.0	120	177.7	218.0
130	301.6	432.0	130	195.7	250.0
140	318.3	448.0	140	211.7	279.0
150	333.0	461.0	150	227.2	303.0
160	345.8	470.0	160	241.3	322.0
170	356.9	478.0	170	254.1	337.0
180	366.7	482.0	180	265.7	351.0
190	375.3	483.0	190	276.3	361.0
200	383.5	485.0	200	286.4	370.0
210	391.1	486.0	210	295.8	378.0
220	398.1	485.0	220	304.5	385.0
230	404.6	484.0	230	312.8	391.0
240	410.6	483.0	240	320.5	396.0
250	416.2	482.0	250	327.7	400.0
260	419.1	480.0	260	331.9	403.0
270	421.8	478.0	270	335.9	406.0
280	424.2	477.0	280	339.5	408.0
290	426.4	475.0	290	342.8	410.0
300	428.4	474.0	300	345.9	411.0
310	430.1	474.0	310	348.7	411.0
320	431.7	474.0	320	351.3	411.0
330	433.1	474.0	330	353.7	411.0
340	434.4	474.0	340	356.0	411.0
350	435.5	474.0	350	358.0	411.0

continued

A.4 Volume Estimates for Existing and Regenerated Stands

Table A-13. Volume estimates (cubic metres per hectare) for existing and regenerated stands

Analysis unit 7 Spruce, balsam poor site			Analysis unit 8 Cedar, hemlock all sites		
	Existing	Regenerated		Existing	Regenerated
Max MAI (m ³ /ha/yr)	Natural 1.39	All 1.78	Max MAI (m ³ /ha/yr)	Natural 1.46	All 2.13
Age			Age		
10	0.0	0.0	10	0.0	0.0
20	0.0	0.0	20	0.0	0.0
30	0.0	0.0	30	1.1	0.0
40	0.6	0.0	40	10.7	4.0
50	3.0	3.0	50	34.9	17.0
60	8.3	9.0	60	62.3	37.0
70	23.2	20.0	70	87.2	70.0
80	46.6	41.0	80	110.3	107.0
90	73.0	72.0	90	129.5	145.0
100	98.8	106.0	100	146.2	180.0
110	122.9	141.0	110	160.9	212.0
120	145.3	172.0	120	173.5	244.0
130	166.9	200.0	130	189.2	274.0
140	186.5	227.0	140	204.5	298.0
150	204.4	254.0	150	218.7	317.0
160	220.8	280.0	160	232.0	333.0
170	235.6	301.0	170	244.4	346.0
180	249.1	320.0	180	256.5	357.0
190	261.4	334.0	190	268.4	366.0
200	273.0	347.0	200	279.8	374.0
210	283.9	357.0	210	290.9	381.0
220	294.1	365.0	220	303.4	387.0
230	303.6	373.0	230	316.0	392.0
240	312.5	379.0	240	328.3	396.0
250	320.8	385.0	250	340.5	399.0
260	326.0	390.0	260	341.3	402.0
270	330.9	394.0	270	342.0	404.0
280	335.3	398.0	280	342.7	405.0
290	339.5	400.0	290	343.4	405.0
300	343.3	401.0	300	344.0	405.0
310	346.8	401.0	310	344.6	405.0
320	350.1	401.0	320	345.1	405.0
330	353.0	401.0	330	345.6	405.0
340	355.8	401.0	340	346.0	405.0
350	358.3	401.0	350	346.4	405.0

continued

A.4 Volume Estimates for Existing and Regenerated Stands

Table A-13. Volume estimates (cubic metres per hectare) for existing and regenerated stands

Analysis unit 9 Lodgepole and white pine good site			Analysis unit 10 Lodgepole and white pine medium site		
Existing		Regenerated	Existing		Regenerated
Max MAI (m ³ /ha/yr)	Natural 2.92	All 3.44	Max MAI (m ³ /ha/yr)	Natural 2.22	All 2.50
Age			Age		
10	0.0	0.0	10	0.0	0.0
20	0.1	0.0	20	0.1	0.0
30	26.1	11.0	30	6.2	2.0
40	79.1	60.0	40	40.5	28.0
50	125.8	119.0	50	78.5	71.0
60	166.6	177.0	60	113.4	115.0
70	202.3	232.0	70	144.4	153.0
80	233.6	274.0	80	172.2	192.0
90	262.8	310.0	90	198.1	224.0
100	289.5	340.0	100	222.0	250.0
110	314.0	365.0	110	244.1	272.0
120	336.9	384.0	120	264.8	290.0
130	358.3	401.0	130	284.4	306.0
140	372.7	414.0	140	297.8	319.0
150	383.5	426.0	150	308.3	330.0
160	391.1	436.0	160	315.8	339.0
170	395.5	440.0	170	320.5	347.0
180	396.8	443.0	180	322.5	352.0
190	395.3	445.0	190	322.0	356.0
200	397.6	447.0	200	324.5	360.0
210	400.2	449.0	210	327.3	363.0
220	403.0	451.0	220	330.1	365.0
230	405.7	452.0	230	332.8	366.0
240	408.3	453.0	240	335.4	367.0
250	410.9	454.0	250	337.9	368.0
260	412.9	454.0	260	339.8	368.0
270	414.8	455.0	270	341.6	368.0
280	416.5	455.0	280	343.3	368.0
290	418.1	455.0	290	344.8	366.0
300	419.6	455.0	300	346.1	366.0
310	421.0	455.0	310	347.4	366.0
320	422.3	455.0	320	348.5	366.0
330	423.4	455.0	330	349.4	366.0
340	424.4	455.0	340	350.2	366.0
350	425.2	455.0	350	350.9	366.0

continued

A.4 Volume Estimates for Existing and Regenerated Stands

Table A-13. Volume estimates (cubic metres per hectare) for existing and regenerated stands (concluded)

Analysis unit 11 Lodgepole and white pine poor site			Analysis unit 12 Deciduous all sites		
	Existing	Regenerated		Existing	Regenerated
Max MAI (m ³ /ha/yr)	Natural 1.60	All 1.48	Max MAI (m ³ /ha/yr)	Natural 0.85	All 1.58
Age			Age		
10	0.0	0.0	10	0.0	0.0
20	0.0	0.0	20	0.0	0.0
30	1.8	0.0	30	0.5	0.0
40	11.3	4.0	40	5.1	8.0
50	34.4	20.0	50	16.6	28.0
60	61.6	40.0	60	31.3	50.0
70	87.3	67.0	70	46.5	77.0
80	110.7	92.0	80	60.3	101.0
90	132.8	114.0	90	73.0	123.0
100	153.4	135.0	100	83.9	144.0
110	172.8	156.0	110	93.5	167.0
120	190.9	176.0	120	101.6	188.0
130	208.3	193.0	130	107.5	206.0
140	220.7	207.0	140	112.3	220.0
150	230.5	218.0	150	116.4	233.0
160	237.8	228.0	160	118.6	244.0
170	242.7	236.0	170	120.4	253.0
180	245.3	245.0	180	122.0	262.0
190	245.6	252.0	190	123.3	271.0
200	248.4	257.0	200	124.7	278.0
210	251.3	262.0	210	126.0	285.0
220	254.1	266.0	220	127.2	291.0
230	256.8	270.0	230	128.3	296.0
240	259.4	273.0	240	129.4	300.0
250	261.8	276.0	250	130.4	304.0
260	263.6	277.0	260	130.8	308.0
270	265.3	279.0	270	131.1	311.0
280	266.9	280.0	280	131.4	313.0
290	268.3	281.0	290	131.6	315.0
300	269.5	281.0	300	131.8	316.0
310	270.6	281.0	310	132.0	316.0
320	271.6	281.0	320	132.1	316.0
330	272.4	281.0	330	132.2	316.0
340	273.1	281.0	340	132.3	316.0
350	273.6	281.0	350	132.4	316.0