

Bulkley TSA Timber Supply Analysis

Integrated Resources Branch
B.C. Ministry of Forests
1450 Government Street
Victoria, B.C.
V8W 3E7

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Preface

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

To determine allowable timber harvesting levels accurately and rationally, the Chief Forester must have an up-to-date assessment of timber supply based on best available information and reflecting current management direction.

Unlike past analyses, which normally assessed the implications of several forest management scenarios, this report focuses on a single scenario – current management practices. This approach will expedite the analysis process, and allow analysis of all timber supply areas in the province to be completed by the end of 1994. An important part of these analyses, however, is an assessment of how results might be affected by uncertainties – a process called "sensitivity analysis." Together, the

sensitivity analyses and the assessment of the effects of current forest management on timber supply will form a solid basis for discussions among stakeholders about alternative timber harvesting levels.

This report reviews the impact of current land base and forest management assumptions on potential timber supplies. Presently, there is an ongoing Land and Resource Management Plan (LRMP) process in the Bulkley TSA, which is looking ahead at land base options and management practices for the future. This timber supply analysis will serve as a valuable baseline reference for decisions being made under the LRMP process.

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

Executive Summary

As part of the provincial Timber Supply Review, the B.C. Forest Service has examined the availability of timber in the Bulkley Timber Supply Area (TSA). The analysis assesses how current forest management practices affect the supply of wood available for harvesting over the next 200 years. It also examines the potential changes in timber supply over a range of uncertainty about forest growth and management actions. It is important to note that the various harvest forecasts included in the report only indicate the timber supply implications of current practices and uncertainty. As such, the forecasts should be used for discussion purposes only; they are not intended to imply any particular allowable annual cut (AAC) recommendations.

The Bulkley TSA covers a total area of 736 000 hectares, of which about 278 000 hectares are considered available for timber harvesting under current management practices. The area is dominated by balsam forest, with significant areas of spruce and lodgepole pine. The current allowable annual cut for the TSA is 895 000 cubic metres per year.

Modeling current management involved the exclusion of sensitive and protected areas, and assignment of forest cover requirements to the entire remaining timber harvesting area. While much of the area is managed for integrated resource activity, one quarter of the land base is assigned special cover requirements to account for wildlife habitat and travel corridors, water conservation, aesthetics and recreation values.

Given current management assumptions, the analysis shows the current AAC can be maintained for another 20 years without causing a sharp drop in future harvest levels below the long-term level. Beginning 20 years from now, harvests must decrease 9% per decade until the long-term harvest

level of 424 000 cubic metres per year is reached 90 years from now.

Although the present AAC is sustainable for another 20 years, the log size and species profile presently harvested is not sustainable in the short term. To maintain the present harvest level, approximately half the present rate of spruce harvest must be replaced with harvests from pine and hemlock stands. Also, at least one third of the total timber harvest must be redirected from sawlog stands to marginal sawlog and pulplog quality stands, as defined in Appendix A.

Given current management assumptions, harvest rates will decrease in the future. If present harvest rates were immediately lowered to the long-term harvest level the initial harvest rate would be 424 000 cubic metres per year. The harvest forecast at this rate maintained significantly higher growing stock volumes, and older forest, than the forecast that starts with a harvest of 895 000 cubic metres per year.

Many of the data and assumptions used in the analysis are subject to varying degrees of uncertainty. Bulkley Forest District staff feel that the volumes used in the analysis are good estimates of existing stand volumes, but that the regenerated yields used in this analysis are too low and as a result the long-term harvest level may be underestimated. Sensitivity analysis was used to examine how these and other data and assumptions impact the results of the timber supply analysis. Short-term timber supply is mainly sensitive to volume estimates for existing stands. Tighter forest cover constraints may also impact short-term timber supply. Higher yield estimates for existing stands and relaxed forest cover requirements permit the present AAC to be maintained for up to four decades. Changes in regenerated yields have no impact on short-term harvest rates although the long-term harvest level is significantly affected.

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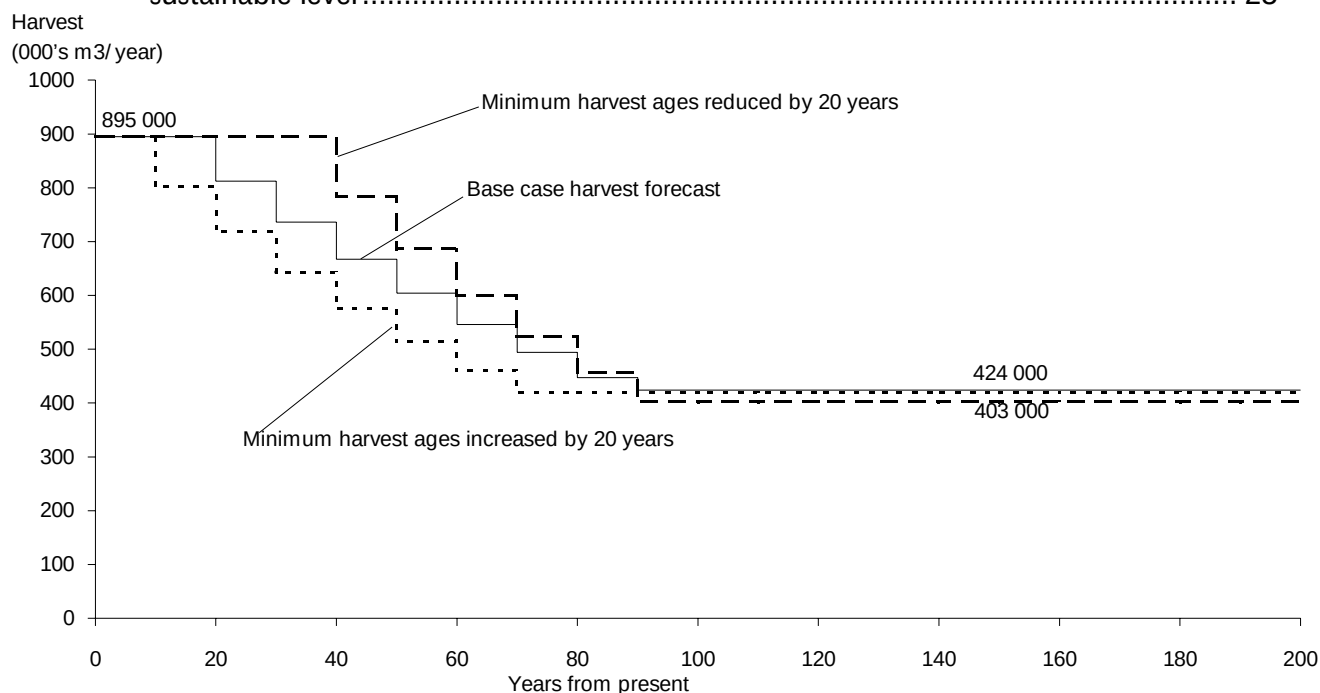


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Introduction

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

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

All of these factors are linked: the financial profitability of harvest operations depends upon the terrain as well as the physical characteristics of the trees to be harvested. Determining the physical characteristics of trees in the future requires knowledge of their growth. The judgment of whether or not a stand is available for harvest will also depend on how its harvest may affect other forest resources, such as wildlife habitat or recreation values.

These factors are also subject to both uncertainty and different points of view. Financial profitability may depend upon changes in world timber markets. 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.

Because of these uncertainties, timber supply is dictated by a particular set of physical, biological, social, and economic conditions. When these conditions change, the timber supply changes. Thus, before interpreting an estimate of timber supply, it is important to understand the set of conditions upon which it is based.

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 planned 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. They remain relevant only as long as the information upon which they are based remains relevant. For example, a Land and Resource Management Plan is presently being developed for the Bulkley TSA, which may change the land base and forest management assumptions of this analysis. It is important that re-analysis occurs regularly using new information and knowledge to update the timber supply picture. The Forest Act now requires that the timber supply for management units throughout British Columbia be reviewed at least every 5 years. This allows close monitoring of the timber supply and the implications for AAC of changes in management practices and objectives.

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

Timber Supply Area (TSA)

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

Allowable annual cut (AAC)

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

Introduction

Timber supply analysis involves three main steps. The first is the collection and preparation of information and data. The B.C. Forest Service forest inventory* plays a major role in this. The second step is using this data along with a timber supply computer model* or models to make projections or estimates of possible harvest levels over time (called harvest flows). 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 Bulkley TSA. Following a brief description of the TSA in section 1, data preparation and formulation of assumptions are discussed in section 2, and 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 brief summary and conclusions.

For the more technically oriented reader, the appendices contain more details about the data and assumptions used in this analysis. They are included

here for completeness, but their review is not necessary to obtaining a basic understanding of the timber supply for the Bulkley TSA.

Forest inventory

Description of British Columbia's forest resource. It includes computerized maps and a database describing the location and nature of forest cover, including size, age, timber volume, and species composition, as well as a description of some non-timber values such as recreation and visual quality

Timber supply model

An analytical (usually computer-based) model that simulates successively harvesting and growing collections of forest stands according to specific data and management assumptions. Timber supply models are of two basic forms: forest estate simulation models, which address "what-if" questions by determining the effects a specified policy or management alternative; and optimization harvest scheduling models, which seek out the policy or management alternative that best attains a specified management objective subject to specified management constraints. This analysis employs a computer simulation model developed by the B.C. Forest Service.

1 Description of the Bulkley TSA

The Bulkley TSA is located on the eastern drainage of the Skeena River in the interior portion of the Prince Rupert Forest Region (Figures 1 and 2). Administered from the Bulkley Forest District office, located in the Town of Smithers, the TSA covers approximately 736 000 hectares, or 7 360 square kilometers. The TSA consists of two major and several minor biogeoclimatic zones: Sub-Boreal Spruce (42%), Engelmann Spruce - Subalpine Fir

(35%), Interior Cedar-Hemlock (6%), Coastal Western Hemlock and Mountain Hemlock (5%) and Alpine Tundra (12%). The dominant tree species groups are balsam (56% of the total forested area), lodgepole pine (21%) and spruce (18%). Hemlock and amabilis fir occur in the areas of coastal influence. Important resource management issues in the TSA are discussed in the introduction to Appendix A.

Figure 1. Key map to the location of the Bulkley TSA

1 Description of the Bulkley TSA

Figure 2. Base map of the Bulkley TSA

2 Information Preparation

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

2.1 Land base inventory

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

Initially, this file is a representation of the land base for the entire TSA. It includes data for areas upon which timber harvesting operations are not expected to take place, and therefore do not contribute to the timber supply of the area. Examples are land that has been set aside for a park, areas necessary for maintaining a certain type of wildlife habitat, or the areas occupied by power lines, highways or town sites. Before this land base file is used to make timber supply projections, it is important that data for these non-contributing areas be removed, to arrive at a file that represents the timber harvesting land base*.

This reduced data file is derived through a computer process that identifies data for non-contributing areas and removes it from the file. When making these reductions, care is taken to make only a single reduction where there are overlaps in categories (for example, where a park area is also suitable for wildlife habitat).

It is important to remember that removal of data for areas not contributing to the timber supply does not imply withdrawal of areas from the TSA. The B.C. Forest Service still manages the entire area of the TSA (except for certain designated lands) as a forest unit that contributes a mix of timber and non-

timber values. The timber supply is managed within this integrated resource context and the timber supply analysis contained herein is consistent with this philosophy.

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

The following areas were not part of the timber harvesting land base. Appendix A describes these categories in detail.

- non-Crown areas – areas not managed directly by the B.C. Forest Service, (e.g. private land, Indian Reserves, and provincial parks)
- non-forest areas – areas not occupied by productive forest cover (e.g., 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 inoperability include steep slopes, high elevation and timber quality.

Timber harvesting land base

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

2 Information Preparation

- environmentally sensitive areas* – areas with high soil sensitivity, including areas with avalanche concerns and potential regeneration problems, plus high value deer and moose habitat in the Bulkley Valley.
- non-merchantable* forest types* – areas occupied by timber stands containing non-merchantable species, stands of low volume or value, and areas with low timber-growing potential (low site index*).
- specific areas exclusions:
 - the Telkwa Bulbous Toe and a portion of the Lower Harold Price Creek watershed - these areas were considered inoperable because of sensitive and unstable soils;
 - the proposed Babine River Wilderness and the proposed Telkwa Wildlife Management Area, because multi-agency agreements are in place and current practice is that no harvesting will occur in these areas;
 - road, skid trail and landing areas – to account for the loss of productive forest land that has occurred during past timber

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 and low stocking.

Forest type

The classification or label given to a forest stand, usually based on its tree species composition. Pure spruce stands and spruce-balsam mixed stands are two examples of forest types.

Not satisfactorily restocked

An area not covered by a sufficient number of stems of desirable species. Stocking standards are set by the Forest Service, Silviculture Branch. If the expected regeneration delay has not elapsed, the land is defined as current NSR. If the expected delay has elapsed, the land is classified as backlog NSR.

harvesting and development. A deduction of 7.5% was applied to all areas currently 80 years old or younger. It should be noted that future losses related to access are deducted as harvesting occurs in the B.C. Forest Service timber supply model.

- Provincial Forest boundary change – arable agricultural land in the Bulkley Valley not available for long-term forest management;

Areas presently deferred from harvesting while awaiting land use decisions, such as Driftwood/Reiseter, Lower Copper and the Howson study area, are not removed from the timber harvesting land base in this analysis. Table 1 summarizes the area reductions by category. Not satisfactorily restocked* (NSR) areas are initially deducted. According to silviculture records, the portion of the total area considered suitable for rehabilitation* and available for timber production is then added back into the timber harvesting land base.

Environmentally sensitive areas

A proportion of the areas considered to be sensitive were deducted from the timber harvesting land base.

Site index

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

Rehabilitation

Removing all non-commercial cover, preparing the site and stocking it with acceptable commercially valuable species.

2 Information Preparation

Figure 3 summarizes the land base categories from Table 1. Two thirds of the total Bulkley TSA area is

Crown forest land, and over half of this area is included in the timber harvesting land base.

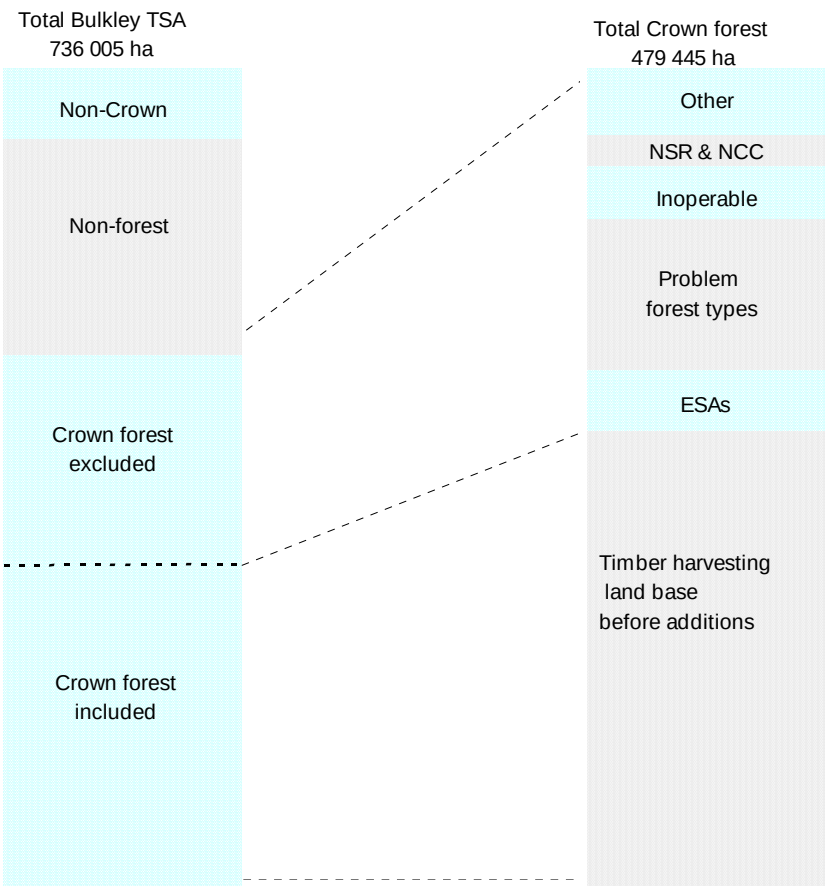


Figure 3. Classification of the gross land base and Crown forest land for the Bulkley TSA

2 Information Preparation

Table 1. Timber harvesting land base for the Bulkley TSA

Classification		Area (ha)	% of total TSA
Total TSA area		736 005	100
Less: Non-Crown		- 62 231	8
Total Crown land		673 774	92
Less: Non-forest		- 194 329	26
Total Crown forest		479 445	65
Reductions:	Gross Area ^a		
Provincial Forest boundary change	22 696		19 565
Special areas:			
Telkwa Bulbous Toe	192		
Lower Harold Price	3 557		
Grazing Lease	152		
Woodlot	409		
Subtotal			4 152
Proposed Babine River wilderness	6 275		5 286
Proposed Telkwa wildlife management area	14 204		4 711
Not satisfactorily restocked	14 774		12 455
Non-commercial cover	9 025		5 835
Non-merchantable forest			
Low site index	23 506		
Deciduous	30 128		
Small trees, poor site	37 557		
Poor stocking	65 305		
Subtotal			88 073
Inoperable forest			
Steep slopes	17 003		
High elevation	52 064		
Subtotal			31 656
Environmentally sensitive	119 972		36 118
Roads, landings and trails			4 282
Total forested reductions		212 133	- 212 133
Reduced Crown forest			267 312
Short-term adjustments:			
Current NSR	4 485		
Backlog NSR	5 883		
Subtotal	10 368	+ 10 368	1
Timber harvesting land base		277 680	38
Losses to future roads		- 15 412	2
Long-term productive land base		262 268	36

^aNote: Gross areas are not mutually exclusive and are included here for information only. The reduction process is sequential in the order displayed; area removed for one reduction category is not removed again when encountered in a subsequent category. For example, of the 14 204 hectares in the proposed Telkwa wildlife management area, 9 493 hectares were removed earlier as non-forested. If the Telkwa reduction followed reductions for non-merchantable forest, inoperable forest and ESA, only 365 hectares of Crown forest would have been removed under the Telkwa category. Regardless of the sequence, however, the total reductions to the Crown forest in the table will add to 212 133 hectares.

2 Information Preparation

Figure 4 shows the current age class distribution, grouped into 20-year classes, for the timber harvesting land base. Approximately half of the total area is over 200 years old, consisting of slow-growing, high-volume stands. The other half is reasonably well-distributed across the younger age classes, compared with many TSAs in British Columbia. This is partially due to a long history of timber harvesting, dating from tie-cutting for construction of the Grand Trunk Pacific Railway in 1913.

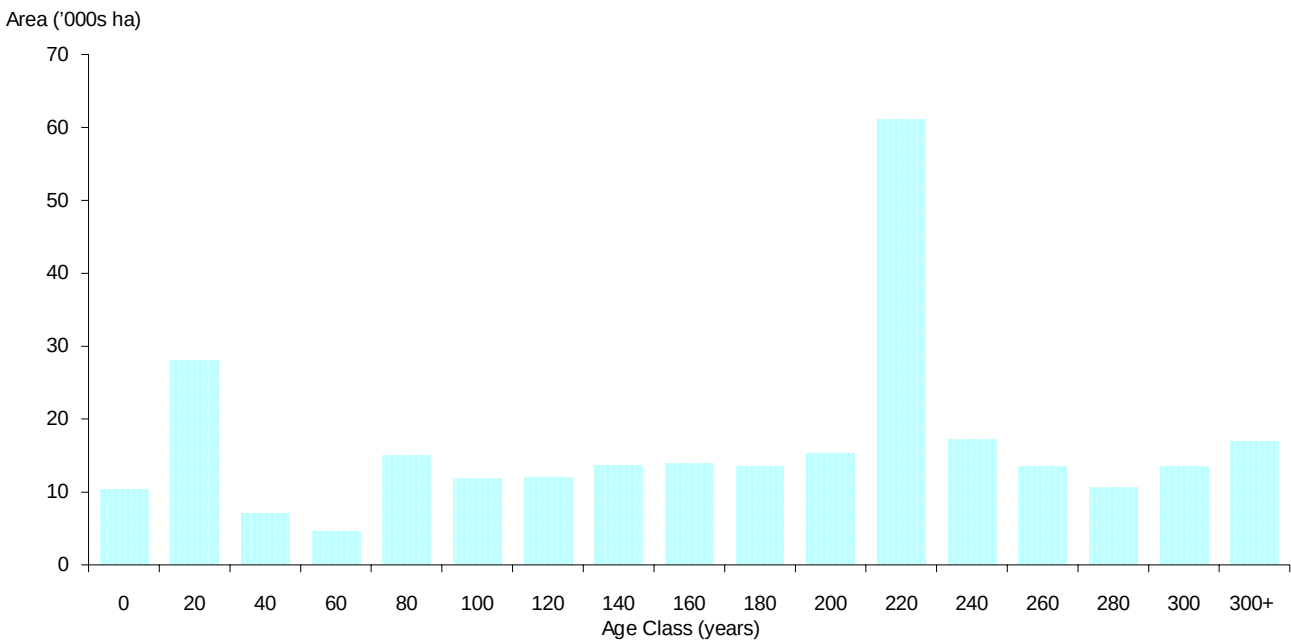


Figure 4. Current age class distribution – timber harvesting land base

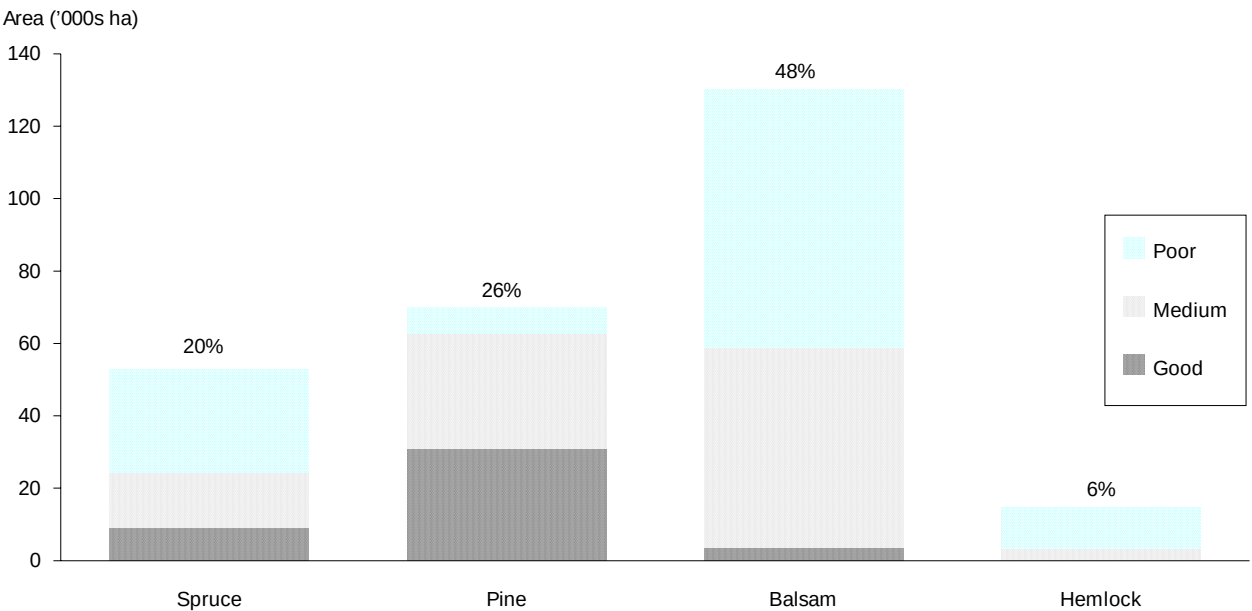


Figure 5. Area by dominant tree species – timber harvesting land base

Figure 5 summarizes the tree species composition on the timber harvesting land base. Approximately half the area is presently stocked with balsam (*Abies*) mixtures, mainly at higher elevations. In the valleys, and the interior plateau portions of the TSA, spruce and lodgepole pine comprise the balance of the inventory. The small hemlock component is located in areas subject to coastal climatic influence.

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 establish minimum size limits for trees and logs that can be harvested and must be removed from a site. Utilization levels specify a maximum stump height and minimum diameters at the tree base and top.

Timber volumes for the Bulkley TSA 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 volumes for existing and regenerated (or future) stands according to their age. Yield estimates used

in the analysis are provided in Appendix A: Description of Data Inputs and Assumptions. Sensitivity analysis addresses the possibility that stand volumes may be different from those predicted.

2.3 Timber quality

In the Bulkley TSA the traditional sawlog harvest profile consists of spruce, lodgepole pine and the taller one-third of the balsam inventory. However, there are also large volumes of balsam and hemlock timber classified as marginal sawlog or pulplog. All three types of timber contribute to the harvest flow potential studied in this analysis. An inspection of harvest flow from the sawlog-only land base was also undertaken for comparison. Figure 6 illustrates the existing merchantable volumes in each timber quality class.

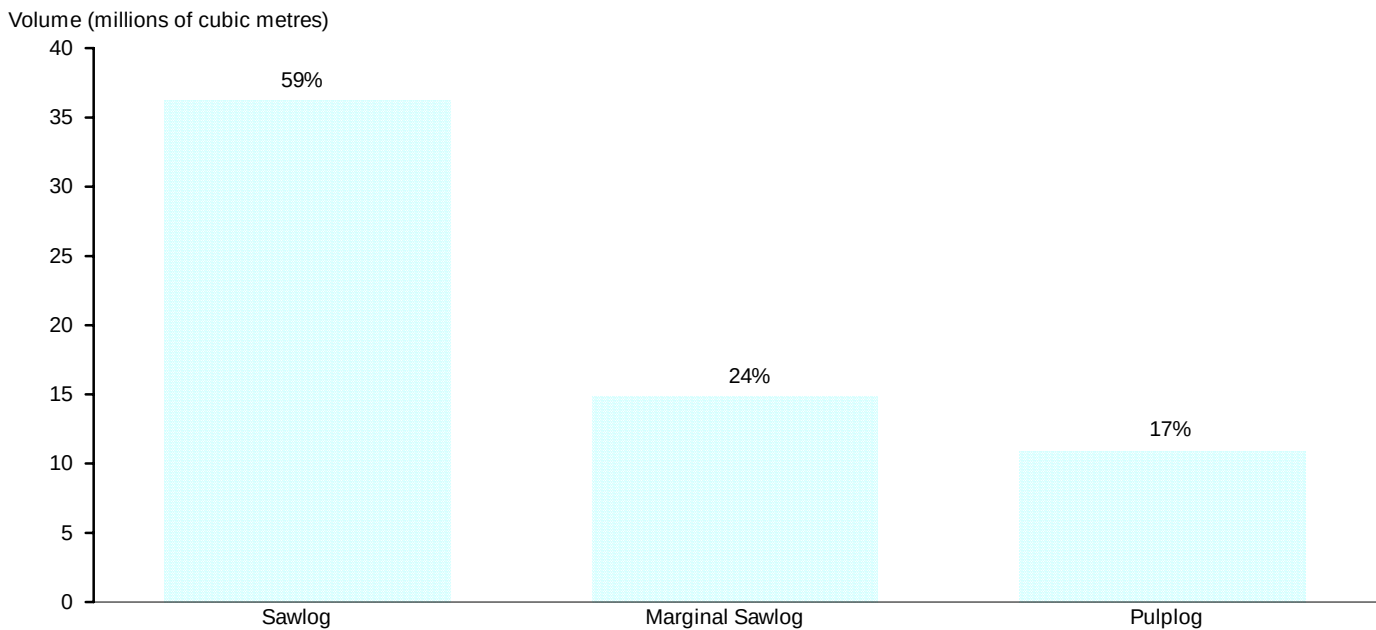


Figure 6. Volume by timber quality class – timber harvesting land base

2 Information Preparation

2.4 Management practices

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 Bulkley Forest District provided descriptions for the following management assumptions*. A more detailed description of these management assumptions can be found in Appendix A.

- **Basic Silviculture** – defines reforestation activities required to establish free-growing* stands of acceptable species after harvesting, as well as the basic silvicultural systems used in the TSA. In the Bulkley TSA most areas are managed using a clearcutting harvest system followed by planting, but selection management* and diameter limit harvesting* are being practiced in some forest stands.
- **Unsalvaged Losses*** – timber losses due to fire, pest (insects, disease, animals) and wind damage. For the Bulkley TSA, unsalvaged losses are estimated to be 32 000 cubic metres per year. These losses are deducted from gross harvest volumes to produce the net volumes shown in Sections 4 and 5.
- **Utilization Level** – defines the species and tree sizes that will be harvested from a forest stand. In the Bulkley TSA all coniferous species over 15.0 cm diameter at breast height are utilized.
- **Minimum Harvest Ages** – the time it takes for stands to grow to harvestable size. The minimum harvest age defines the lower limit for harvesting. In the Bulkley TSA, sawlog stands must reach 150 cubic metres per hectare and an average stand diameter of 25 centimeters at

breast height. Marginal sawlog and pulplog stands must reach 175 cubic metres per hectare and 20 centimeter diameter. Actual harvest age depends on many factors including the ages of other stands, limits on the overall harvest level, and forest cover requirements. Minimum harvest ages range from 70 to 160 years, with an average time to reach merchantable size of approximately 95 years. Stands above minimum harvest age are considered mature, or merchantable, in this analysis.

Selection management

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

Diameter limit harvesting

A silvicultural system used to maintain established understory trees. All trees larger than a specified diameter are removed, with care being taken to not damage the residual stand. Horses are often used to harvest trees under this system.

Unsalvaged losses

The volume of timber killed or damaged annually by natural causes (e.g. fire, wind, insects and disease) and not harvested.

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 cutting ages, utilization levels and standards, integrated resource guidelines and silviculture and pest management programs.

Free-growing

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

2 Information Preparation

- Cutblock Adjacency* and Green-up – guidelines that specify the spatial pattern of cutblocks and amount of time (green-up period*) required for regenerated stands to reach some desired condition before adjacent mature timber may be harvested.
- Forest Cover Objectives – specify the desired distribution of areas by age or size class groupings (for example, at least 70% of the forest area should be over 40 years old). These objectives are used to specify general adjacency and green-up guidelines as well as desired conditions for wildlife habitat and aesthetics.

2.5 Management zones

In the Bulkley TSA the basic forest cover objective for the timber harvesting land base was defined by considering the number of harvest passes and the time to achieve 3-metre green-up. In addition, special management areas (25% of the timber harvesting land base) were identified in which non-timber values are particularly important. Additional forest cover requirements* were applied in these areas, such as taller green-up height criteria, more passes with smaller proportionate area harvested each pass, or maintenance of some old-growth structure. The timber harvesting land base was divided into nine different management zones, described below. Figure 7 summarizes the area breakdown by management zone, and Appendix A contains maps to the location of the zones.

- Integrated Resource Management Zone: all areas not specifically assigned to another zone. Current management is three-pass harvesting; no more than 33% of the land base may be below the green-up height of 3 metres at any time. For reporting purposes this zone is

subdivided into five zones based on tree species and log quality considerations.

- Riparian* Zone: a connected network of lands spanning the length and breadth of the Bulkley TSA. These corridors, mapped in 1992 and ranging from 200 to 400 meters wide, are protected for wildlife habitat and potential travel routes. The cover requirement, interpreted from currently approved harvesting guidelines, is to ensure 70% of the area is always 80 years of age or older.
- Grizzly Zone: based on 1992 mapping of high-quality grizzly bear habitats. These habitats are usually a complex of many high-value patches surrounded by less desirable forested ground, which provides hiding and thermal shelter. The cover requirement is that 50% of the forested area be maintained at 140 years or older.
- Babine Special Management Zone: to maintain the integrity of the Babine Corridor and buffer the Babine River. Cover requirements for this zone are that at most 30% of the forest area may contain timber smaller than 10 metres tall, and at least 30% must be 140 years of age or older.
- Community Forest Zone: the Smithers Community Forest was set aside in order to demonstrate various timber harvesting practices, as well as provide recreational and educational trails. The area is also visible from Highway 16. Timber harvesting will take place, but not at the same rate as in conventional managed areas. The cover requirements are that at most 15% of the area may be smaller than 5 metres, and at least 40% must be older than 100 years.

Forest Cover Requirements

Specify desired distributions of areas by age or size class groupings. These requirements can be used to reflect desired conditions for wildlife, watershed protection, visual quality and other integrated resource management objectives. General adjacency and green-up guidelines are also specified using forest cover requirements.

Riparian area

Areas of land adjacent to wetlands or bodies of water such as swamps, streams, rivers or lakes.

Cutblock adjacency guidelines

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

Green-up period

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

2 Information Preparation

- Visual Quality Objective* (VQO) Zones: three visual quality zones were identified:
 - Retention VQO* Zone: a maximum 5% of the area may be less than 5 metres tall.
 - Partial Retention VQO* Zone: a maximum 15% of the area may be less than 5 metres tall.
 - VQO plus Riparian Zone: to account for significant overlaps between retention, partial retention and riparian areas. The cover requirements are that a maximum of 10% of the area may be less than 5 metres tall, and at least 70% of the area must be aged 80 years or older.
- Future Roads Zone: 7.5% of all areas over 80 years of age in the timber harvesting land base. No cover requirements apply; the area is harvested at a steady rate over a 60-year period, and does not regenerate to forest after harvest.

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.

Retention VQO

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

Partial retention VQO

Alterations are visible but not conspicuous. Up to 15% of the area can be visibly altered by harvesting activity.

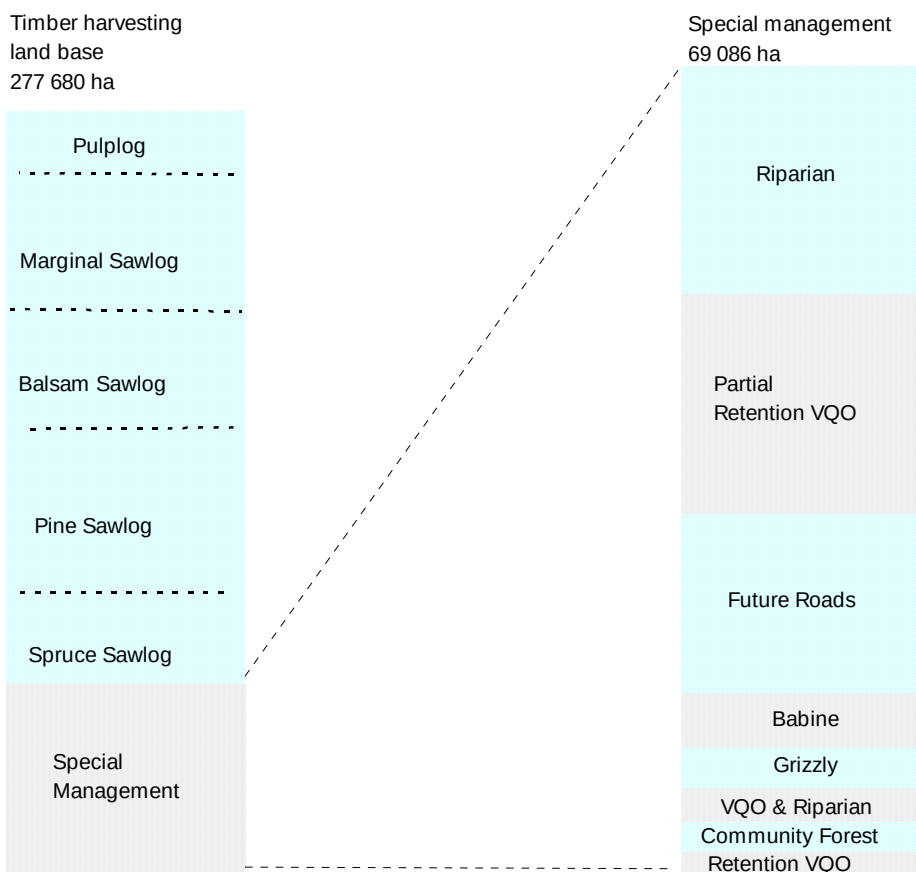


Figure 7. Management zones defined for the Bulkley TSA timber harvesting land base

3 Analysis Methods

The purpose of this analysis was to examine both the short- and long-term timber harvesting opportunities in light of current forest management practices. A timber supply computer simulation model developed by the B.C. Forest Service was used to aid in the assessment. A timber supply model, as distinguished from a growth and yield model, assists in determining how a whole forest, or collection of stands, should be managed in order to obtain a harvest flow, or supply of timber over time. The simulation model uses information about the timber harvesting land base, timber volumes and the management regime to represent how trees grow and are harvested over a period of 0 to 200 years.

Similar to other models, the B.C. Forest Service model assumes that trees grow according to provided volume projections, and are harvested according to either a volume target or a specified objective set by the analyst, such as harvest volume maximization. However, it differs from other models in that it allows the use of forest cover guidelines that specify the desired age composition of the forest. These cover guidelines can be used to examine the effects of cutblock adjacency and green-up prescriptions. For example, guidelines might

specify that no more than some maximum per cent of the area can be younger than a specified green-up age; or that some minimum per cent of the area must be in older age classes to provide wildlife habitat. The B.C. Forest Service simulation model tests such guidelines to examine their effects 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 when determining allowable cuts that will not restrict options of future resource managers, and will allow local B.C. Forest Service staff to administer their programs according to relevant guidelines and principles.

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

4 Results

This section presents the results of the timber supply analysis using the timber harvesting land base and management practices described earlier.

4.1 Harvest forecast

The harvest forecast* based on current management assumptions for the Bulkley TSA is shown in Figure 8. The present AAC of 895 000 cubic metres per year¹ may be maintained for two decades, falling thereafter by 9% per decade to a long-term harvest level of 424 000 cubic metres per year 90 years from now.

The harvest flow pattern illustrated in Figure 8 is based on a modeling assumption of maintaining the present AAC for as long as possible, followed by an orderly decline of approximately 10% per decade to the long-term level, without causing harvests to drop below the long-term level. Note that the harvest forecast shown here provides an upper limit on

timber supply given the land base and management practices discussed above. This forecast is for discussion purposes only and is not meant to suggest a particular AAC.

¹ The current harvest level was increased in 1983 from 650 000 to 895

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.

000 in recognition of non-replaceable timber sales. This additional volume allocation is scheduled to expire in 1995. Refer to Section 4.4.

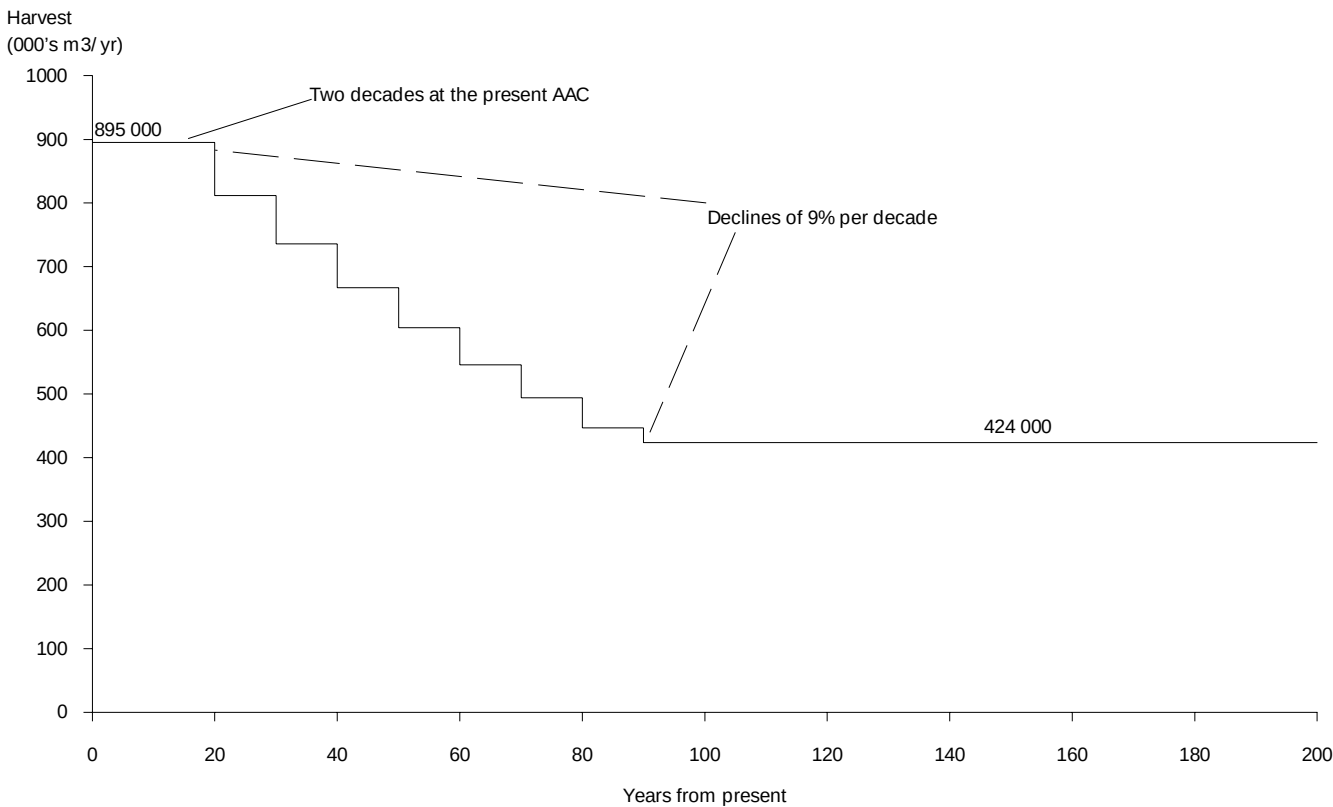


Figure 8. Harvest forecast for the Bulkley TSA

4 Results

Figure 9 illustrates the impact of this harvest flow on growing-stock* volumes in the TSA. The present TSA volume of 65 million cubic metres declines over a 90-year period to a long-term level of approximately 30 million cubic metres. Thereafter, growth matches the harvest rate. The initial drop in growing stock reflects conversion of the timber harvesting land base from an older forest to a younger-aged managed forest. Note in Figure 9 that, largely due to forest cover requirements, the inventory of timber above minimum harvest age is maintained at or above 15 million cubic metres.

4.2 Age class distribution over time

Figure 10 shows the changes that occur in the forest age class distribution over the 200-year planning horizon. Forest harvesting will convert the present wide distribution of ages into a more compact distribution of younger-age forest. Note that the

Crown forest excluded from the timber harvesting land base (Figure 3) is not illustrated in Figure 10.

One hundred years from now, managing under the harvest flow described above, the forest structure will mainly consist of younger stands, with approximately 7% of the timber harvesting land base aged over 200 years. The rising peak on the 100-year bar chart in Figure 10 is a result of the high level of early harvests; refer to Figures 8 and 11. Two hundred years from now, or after approximately two forest rotations, the forest on the timber harvesting land base is approaching an even distribution of area by age, spread over the range from new growth to 120 years of age, with 4% aged over 200 years.

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

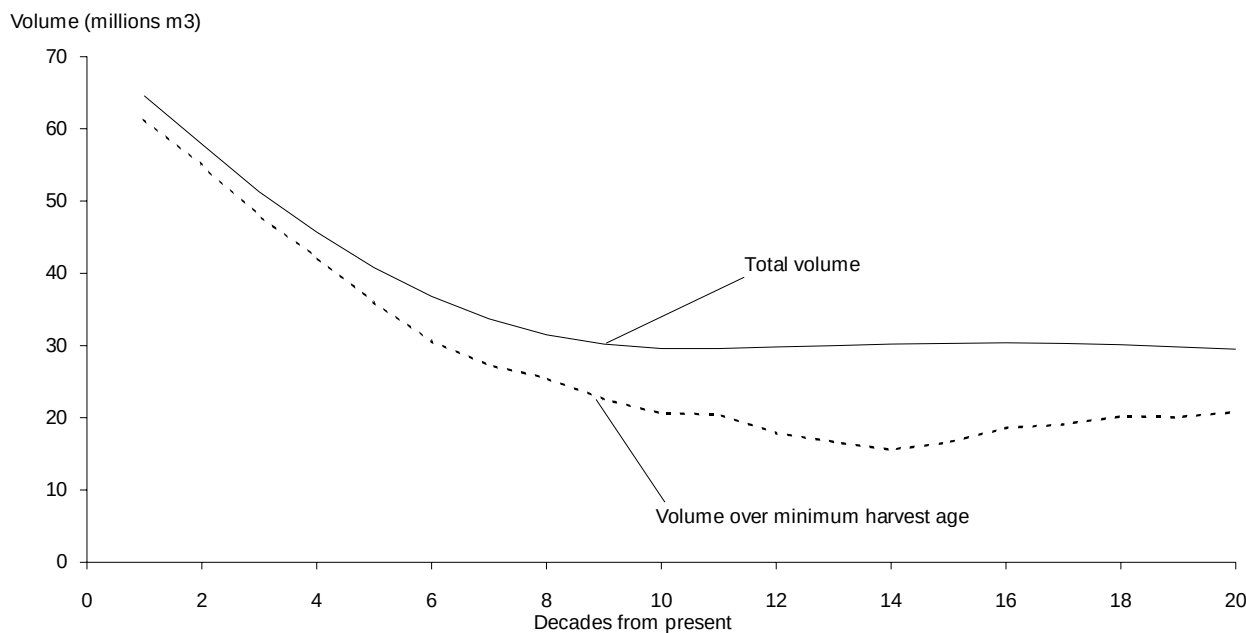


Figure 9. Growing stock over time for the Bulkley TSA

4 Results

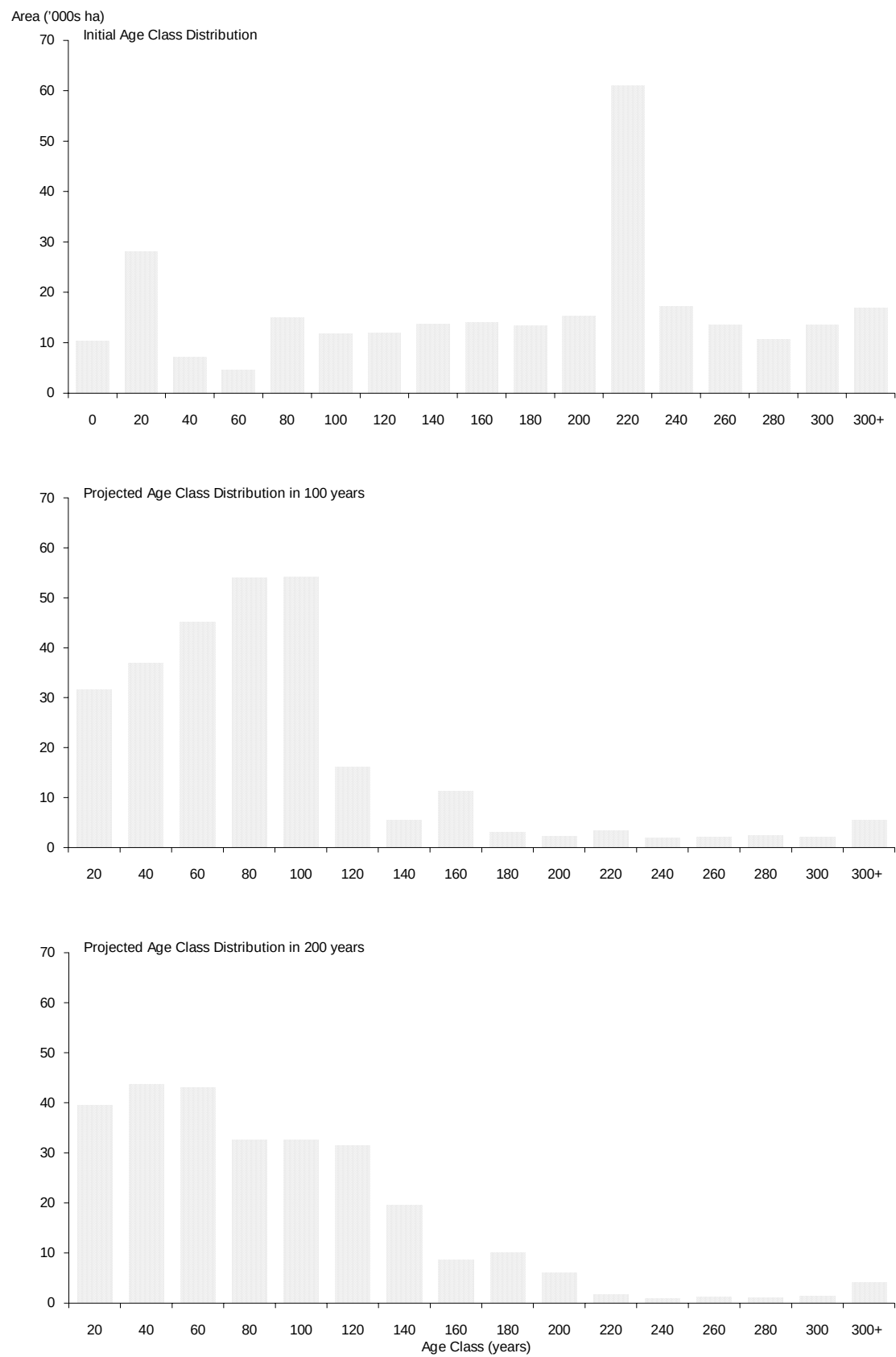


Figure 10. Changes in the age class distribution for the TSA over time

4 Results

4.3 Average area harvested, harvest ages and volume per hectare

Average area harvested, shown in Figure 11, continues at the present level of 2700 to 2800 hectares per year for two decades, then declines steadily to a low of 1500 hectares per year in approximately 90 years. The decline is due to the decreasing harvested volume in decades 2 through 9. After 120 years the presently mature timber has been harvested and the area of regenerated stands harvested to maintain the long-term harvest level will be approximately 2000 hectares per year.

The average age of timber harvested gradually declines as the mature inventory is depleted. The steady decline may be somewhat an artifact of the oldest-first priority rule in the B.C. Forest Service

timber supply model, and actual harvest ages may be more stable over the first forest rotation. Figure 12 shows a rising trend in decades 16 through 20. This is a temporary effect, caused by a bulge in the area of regenerating stands reaching maturity following high initial harvest levels. Eventually the average age harvested stabilizes at 120 to 130 years.

Average volume harvested per hectare over the timber harvesting land base in the Bulkley TSA (Figure 13) is relatively constant at approximately 325 cubic metres per hectare from existing stands, declining to a long-term average of 200 to 250 cubic metres per hectare from planted stands in the second and subsequent rotations. The volumes from regenerated stands are lower because they are harvested at younger ages than the existing inventory.

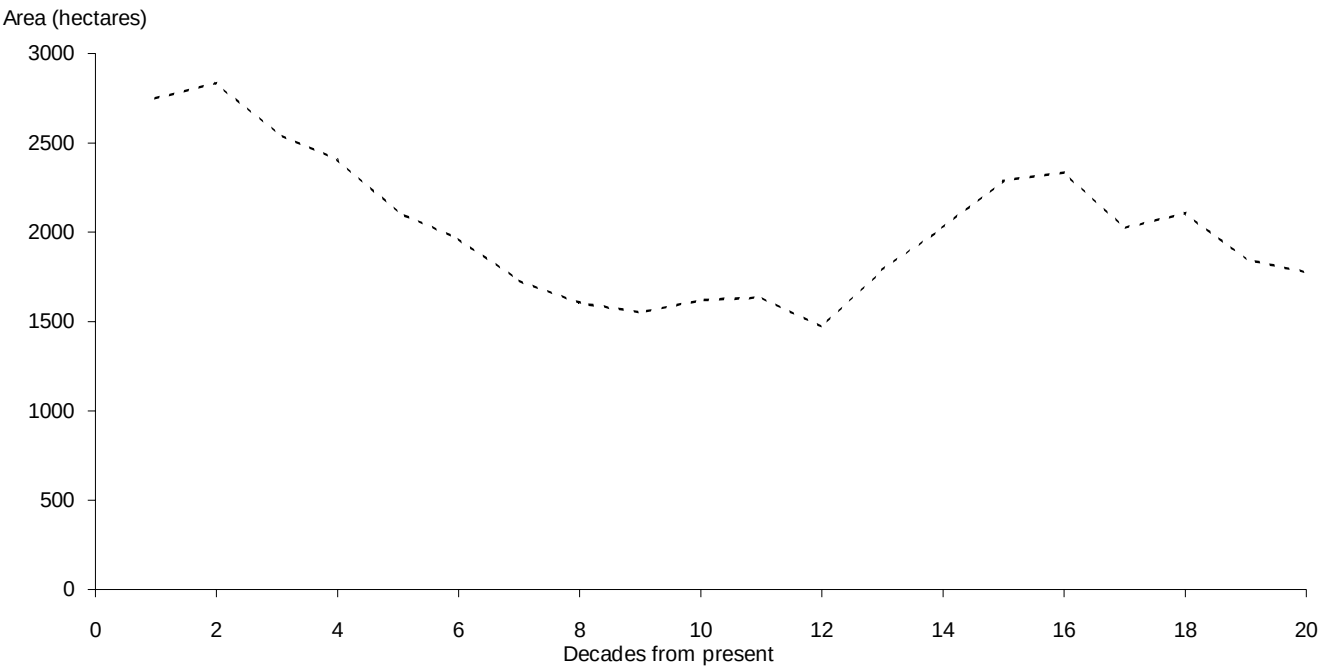


Figure 11. Average area harvested per decade over time

4 Results

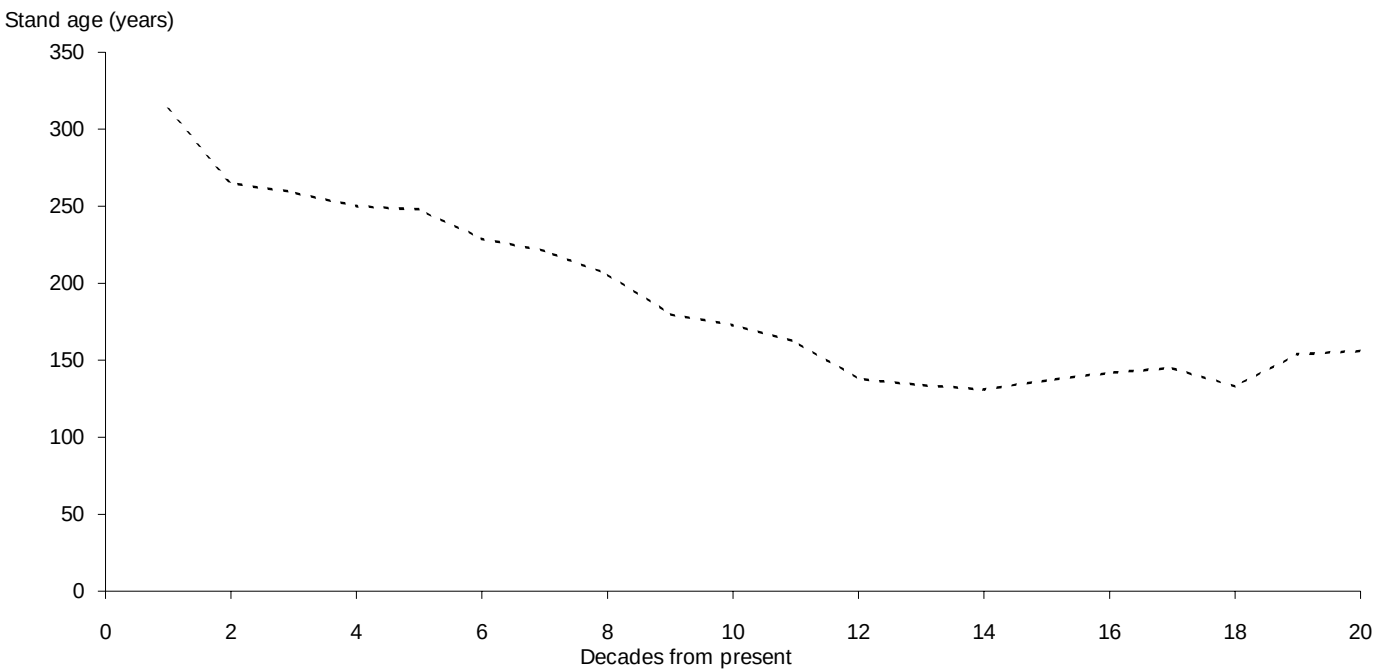


Figure 12. Average harvest age per decade over time

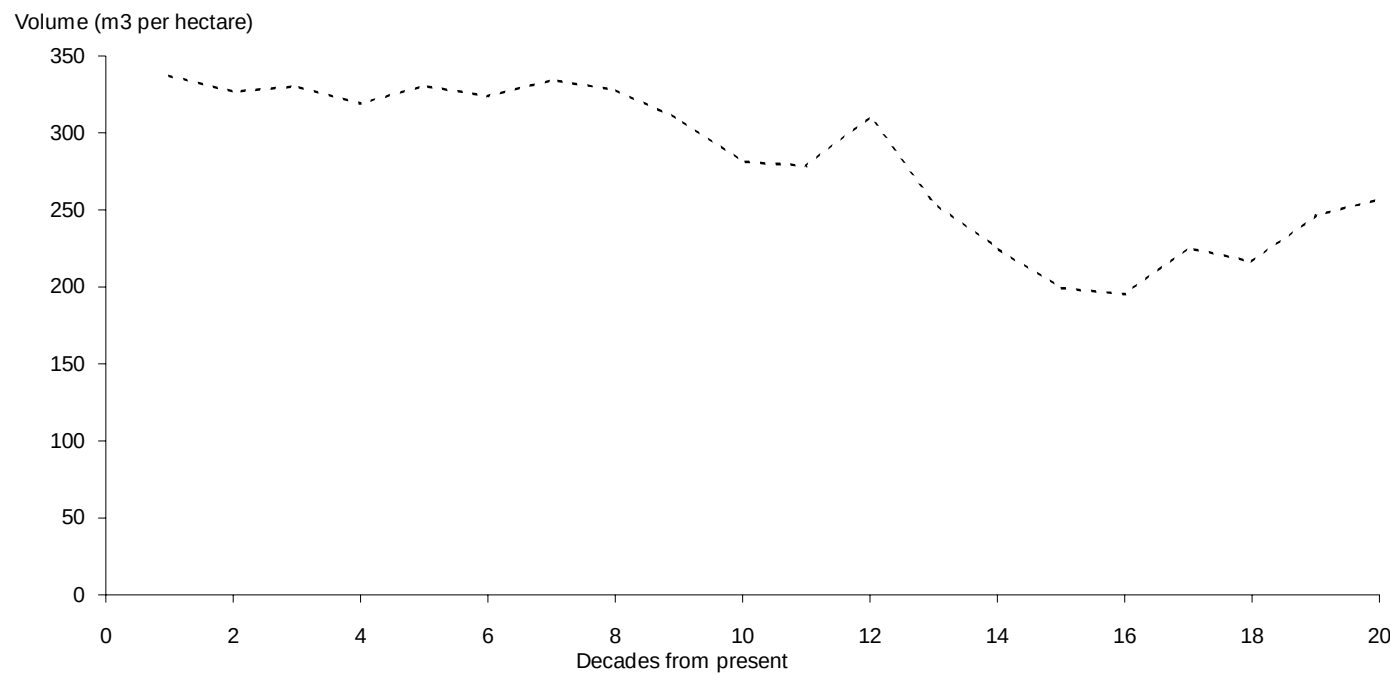


Figure 13. Average volume harvested per hectare over time

4 Results

4.4 Sawlog harvest levels

At the request of Bulkley Forest District staff, the timber harvesting land base was grouped into sawlog, marginal sawlog and pulplog components. The reason for this grouping is that the AAC of 895 000 cubic metres per year is comprised of 650 000 cubic metres per year of traditional Forest Licence harvesting, plus 245 000 cubic metres per year of temporary licence harvesting in stands with lower volumes, smaller tree sizes and less desirable species than the main forest profile. The temporary licences have been in effect since 1983 and 1984. A two-year volume of 200 000 cubic metres is advertised for sale presently and is scheduled to expire in 1995.

Figure 14 compares the sawlog-only harvest on the timber harvesting land base with the base case harvest flow forecast and the scheduled harvest flow if no further temporary licences are granted after 1995. The harvest level of 650 000 cubic metres per year is sustainable for seven decades, falling to a long-term harvest level of 424 000 cubic metres per year, if the entire timber harvesting land base supports the harvest. If the harvest comes from traditional sawlog stands only, the maximum sustainable harvest flow is an initial harvest level of 598 000 cubic metres per year, followed by declines of 9% per year to a long-term level of 296 000 cubic metres per year.

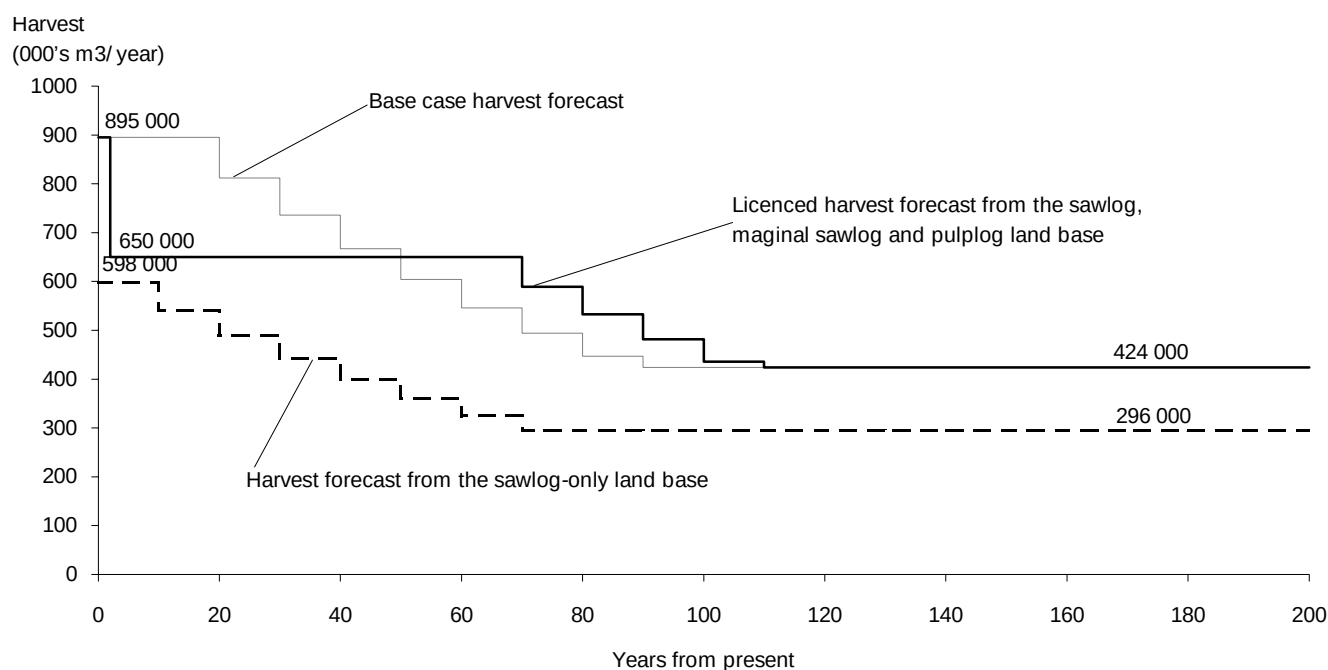


Figure 14. Harvest forecast, sawlog versus the base case

4 Results

4.5 Species harvested for the first twenty years

Figure 15 illustrates the percentage composition by tree species of the short-term harvest. The first bar represents the ratios harvested over the past two years, and desired, for continuity, by processing mills. The second bar represents the harvest profile simulated in the B. C. Forest Service timber supply model, with an oldest-first priority rule. Pine stands receive little harvest activity in the short term, due to their younger average age. Marginal sawlog and pulplog stands contribute 53% to the first 20-year harvest. The third bar represents a proportionate

distribution of the harvest between species/quality classes if the harvest were to reflect the volumes available in the inventory. Recent consumption of marginal sawlog and pulplog stands amounts to 13% of the harvested volume, as opposed to 39% of the available inventory.

Available volumes
The portion of total inventory volumes that is available for harvesting after all management constraints on timber harvesting have been considered, including definition of the timber harvesting land base, age of tree merchantability, deferrals, and any other priorities or constraints on timber harvesting.

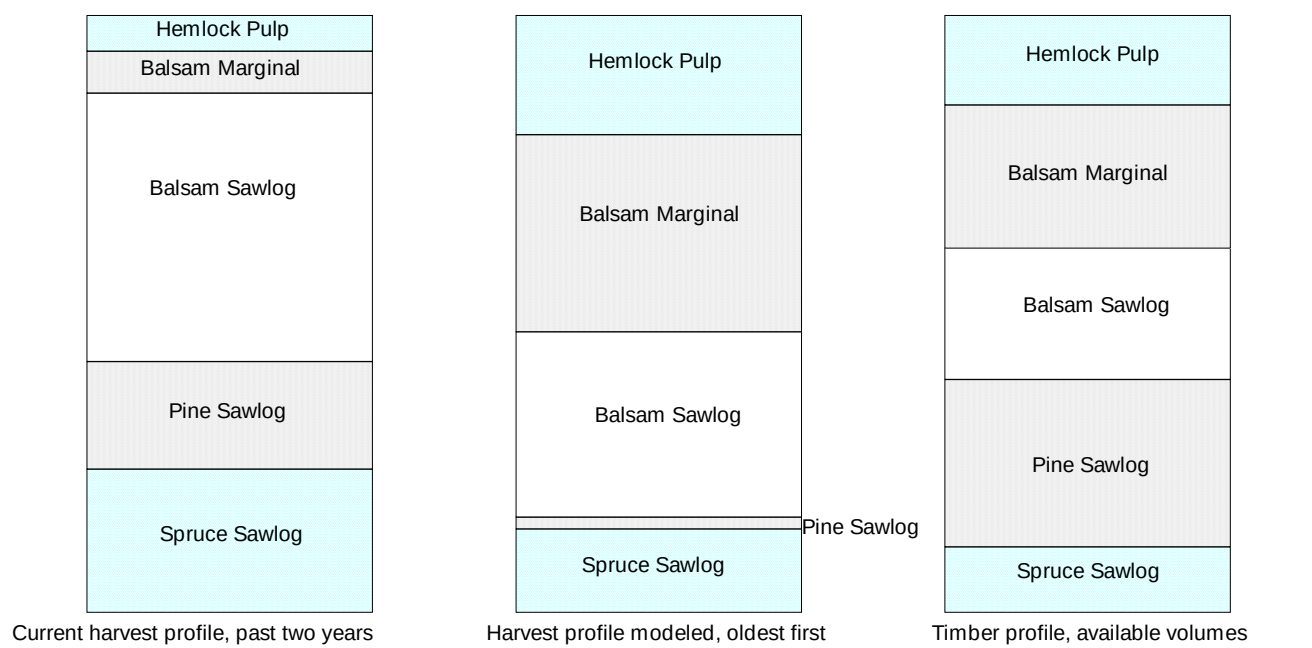


Figure 15. Percentage distribution of harvest by species, first twenty years

5 Timber Supply Sensitivity Analyses

Sensitivity analysis examines how uncertainty in data and assumptions affect the outcome of analysis. The main purpose of timber supply sensitivity analysis is to highlight which variables most affect results. It is an important aid to decision making, since uncertainty surrounds estimates of many variables used in timber supply analysis. The best available information on forest inventories and management practices is used to analyze the implications for timber supply of current performance. However, it is possible that small inaccuracies in some variables could have large effects on results. On the other hand, fairly large inaccuracies for other variables may have negligible effects. Sensitivity analysis can therefore highlight priorities for collecting information for future analyses. As well, it can clarify for decision makers whether current best estimates are safe bases for decisions, or whether high uncertainty around important variables necessitates more conservative decisions.

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

5.1 Changes in harvest flow over time

The base case harvest forecast in this analysis started at 895 000 cubic metres for two decades, then declined by a constant 9% per decade until the long-term harvest level of 424 000 cubic metres per year was achieved in decade nine. Many other harvest patterns are possible. For example, feasible alternatives include one decade at the present AAC, followed by 7% declines per decade, or three decades at the present AAC followed by 13% declines. This section examines the two alternative harvest flows illustrated in Figure 16.

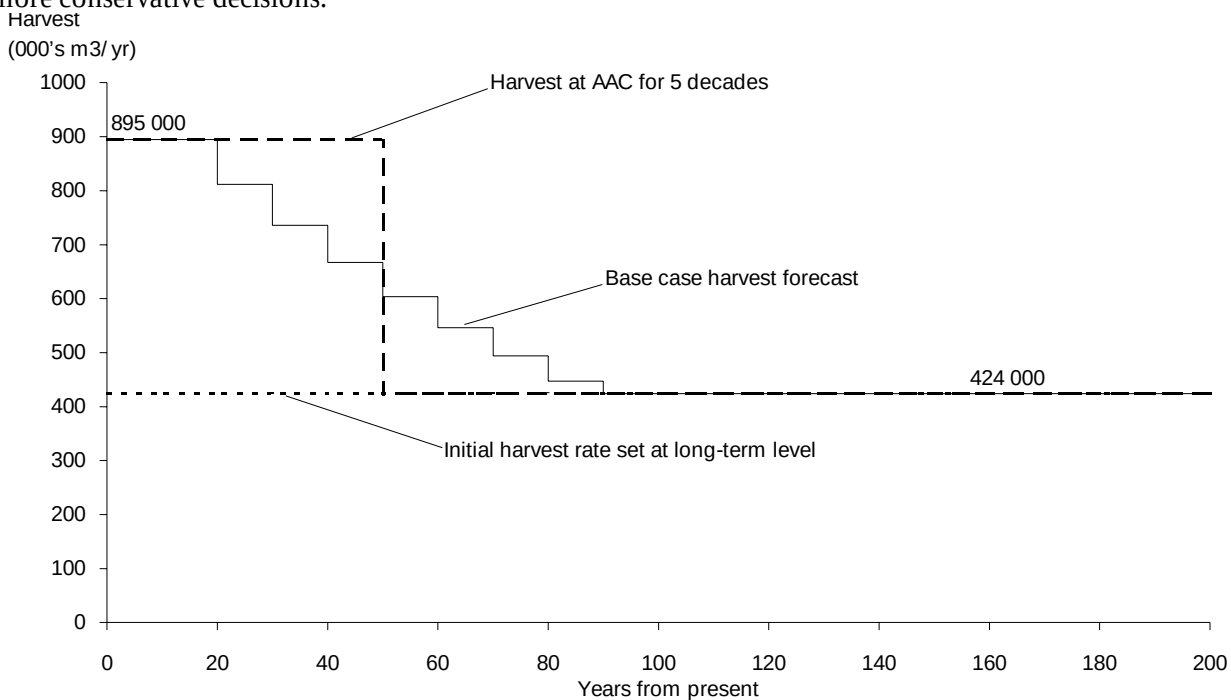


Figure 16. Harvest forecast, alternative harvest flows

5 Timber Supply Sensitivity Analyses

Without a requirement for gradual declines in harvest rates, it is possible to maintain harvests at the present AAC for 5 decades, followed by an immediate decline of 53% to the long-term level. The existing mature volumes which cushion the decline in the base case are harvested between decades 1 through 5 instead of decades 1 through 9. Figure 17 shows that this harvest flow depletes the existing inventory somewhat more rapidly than the base case, however after 9 decades inventory levels are essentially identical.

The other harvest flow evaluated has the initial harvest rate set equal to the long-term level of 424 000 cubic metres per year, and maintained at that level for the entire planning horizon. With this alternative the total volume harvested over 200 years is 21% less than for the base case. If harvests are decreased immediately to the long-term level, growing stock will decline at a much slower rate than for the base case (Figure 17). At the end of 200 years total growing stock is 41 million cubic metres, 35% greater than for the base case.

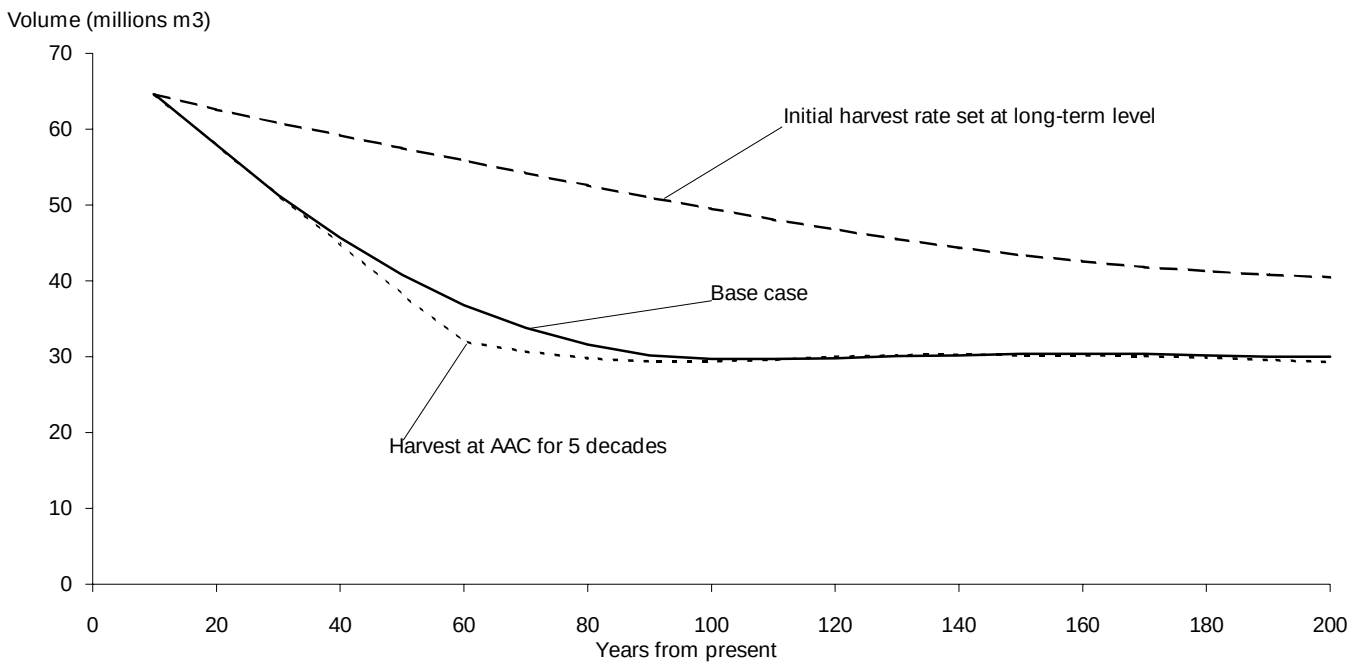


Figure 17. Growing stock over time under alternative harvest flows.

5 Timber Supply Sensitivity Analyses

Figure 18 shows the projected distribution of area by age class in 100 and 200 years. These distributions may be compared with the projections for the base case illustrated earlier in Figure 10. Note that both these figures illustrate the timber harvesting land base only. The impact of setting the initial harvest rate at the long-term sustainable level is that older timber lasts longer and growing stock remains at

higher levels (volume over minimum harvest age is 55% greater in 200 years than under the base case). After 90 years, harvested volume will equal that under the base case, but harvests will consist of older timber, with higher volumes per hectare, smaller annual areas harvested and larger log sizes. However, holding timber to older ages increases the risk of losses to insects, decay, fire and windthrow.

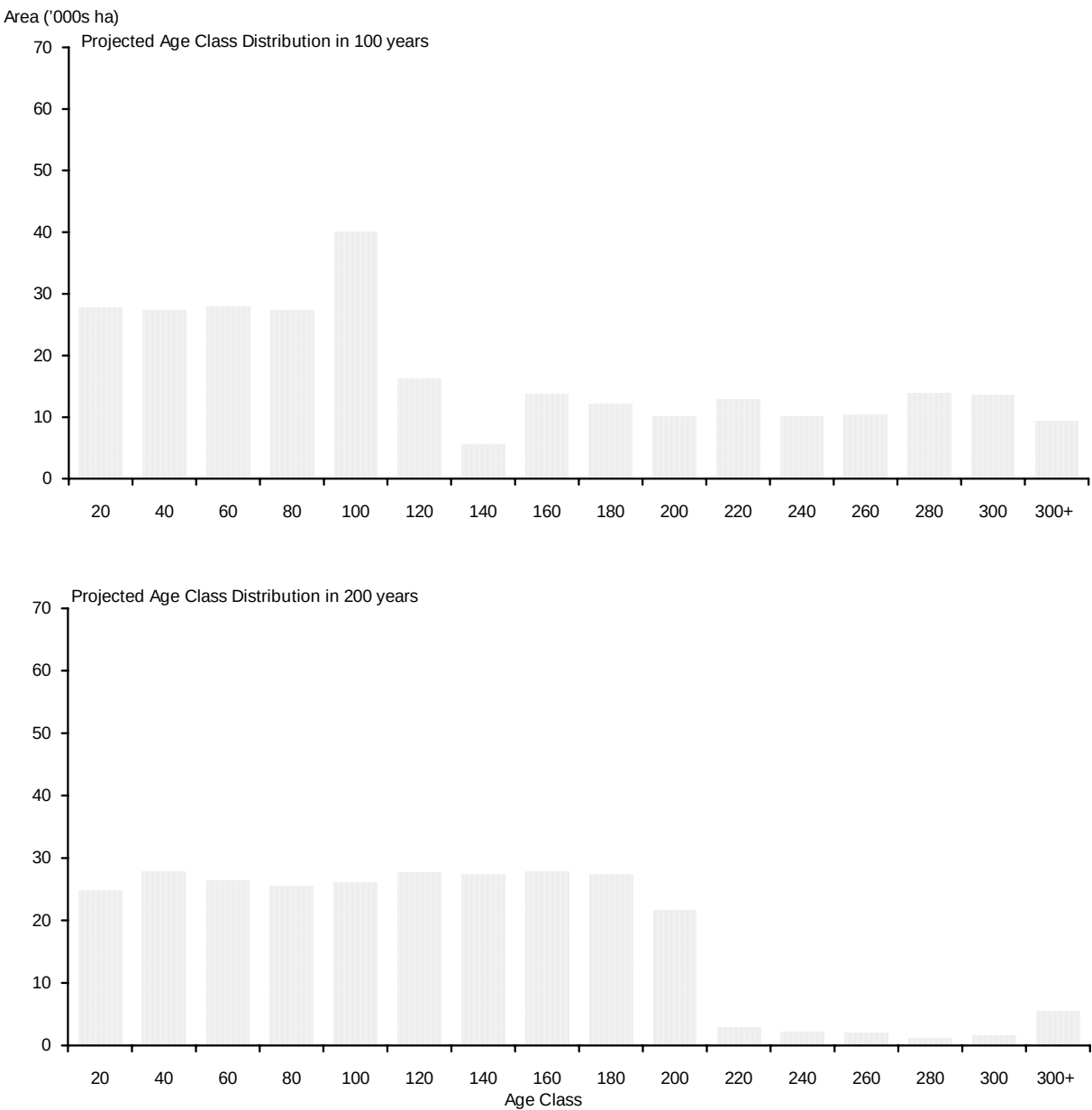


Figure 18. Future distribution of area by age class if the initial harvest level is set at the long-term sustainable level

5 Timber Supply Sensitivity Analyses

5.2 Sensitivity test of minimum harvest ages

Minimum harvest ages were established for each growth type based on the time required to reach minimum volume and diameter requirements. Table A-8 lists the minimum harvest ages specified for the base case. The impact of increasing or decreasing minimum harvest ages by 20 years was inspected. This is approximately equivalent to varying minimum volume requirements by 50 cubic metres per hectare, and varying average stand diameters by 2 centimetres.

Figure 19 shows the impact on the harvest flow of the changes to specified minimum harvest ages. With an increase of 20 years in minimum harvest ages, more time is required before a previously harvested stand becomes available for a second harvest. As a result, the initial depletion of existing growing stock must be slowed, to reserve enough volume to maintain harvest levels through decades 9 to 12. With minimum harvest ages increased by 20 years, the present AAC of 895 000 cubic metres is

maintained for only one decade, followed by 10% per decade drops to a long-term harvest level of 420 000 cubic metres per year. This long-term level is 1% lower than the long-term level in the base case.

Reducing minimum harvest ages allows the present AAC to be maintained for four decades. However, harvests must drop by 12% per decade thereafter, to a long-term level of 403 000 cubic metres per year, 5% below the base case long-term level. The lower long-term harvest level is a consequence of pushing harvests in the early periods to the maximum level permitted by the age constraints. Many forest growth types are depleted to below their culmination age*. Subsequent harvesting continues to capture regenerating stands before they reach their maximum growth potential. The base case long-term harvest level could be ultimately achieved, but only by first allowing harvest levels to decline further than shown in Figure 19. This would allow harvest ages to recover to near culmination age.

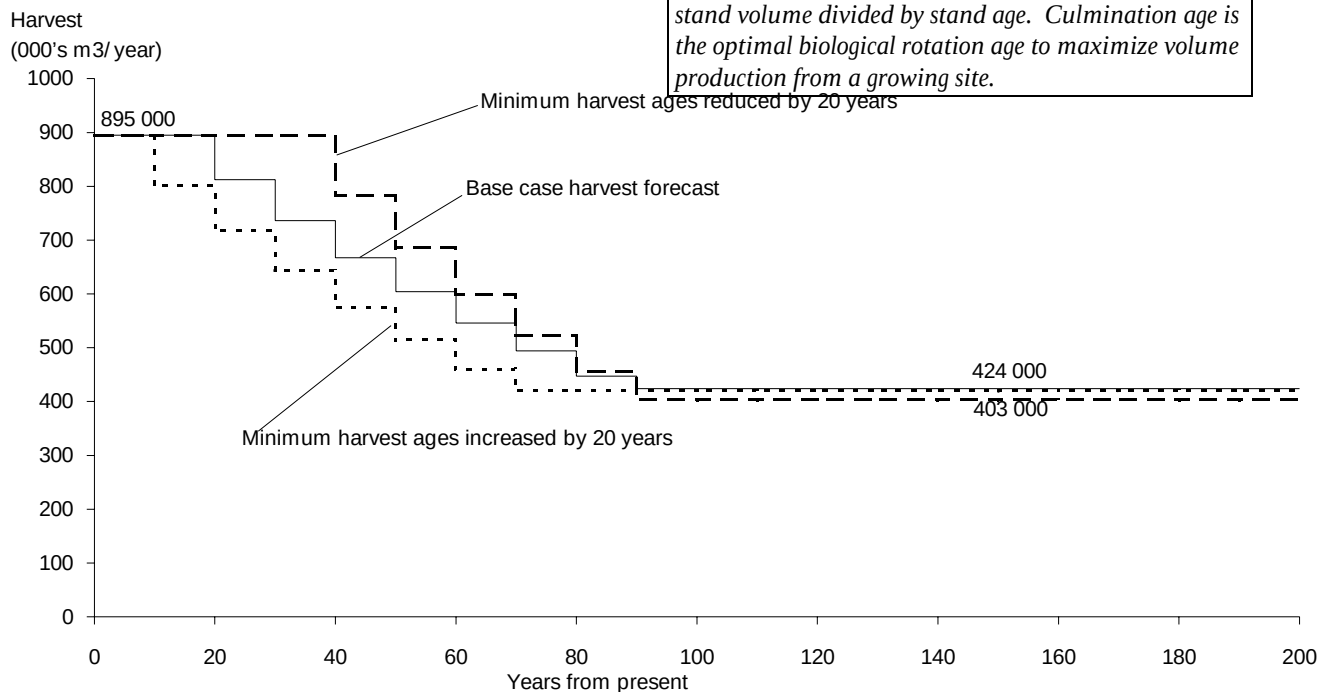


Figure 19. Harvest forecasts if minimum harvest ages are varied by 20 years

5 Timber Supply Sensitivity Analyses

5.3 Sensitivity test of estimated existing stand volumes

Volume estimates* from the variable density yield prediction (VDYP) system were used in the base case for existing stands. Bulkley Forest District staff have verified that the volume estimates used for existing stands in this analysis are close approximations to actual volumes realized in harvest operations. Sensitivity testing is therefore confined to a range of plus or minus 10%.

Figure 20 shows that if current yields are 10% higher than were assumed for the base case, the initial harvest can be maintained at 895 000 cubic metres for four decades, followed by decreases of 10% per decade. If, however, current yields are 10%

lower than was assumed, the initial harvest level must be lowered to 800 000 cubic metres per year, and is sustainable for only one decade before declining at 9% each decade to the long-term harvest level. Note that in both cases changes in estimates of existing stand volumes do not impact on the long-term harvest level.

Volume estimate (yield projection)
Estimates of yields from forest stands over time. Yield projections can be developed for stand volume, stand diameter or specific products, and for empirical (average stocking), normal (optimal stocking) or managed stands. Yield projections can be based on a number of mensurational approaches and procedures, including the use of site index curves and generalized growth models.

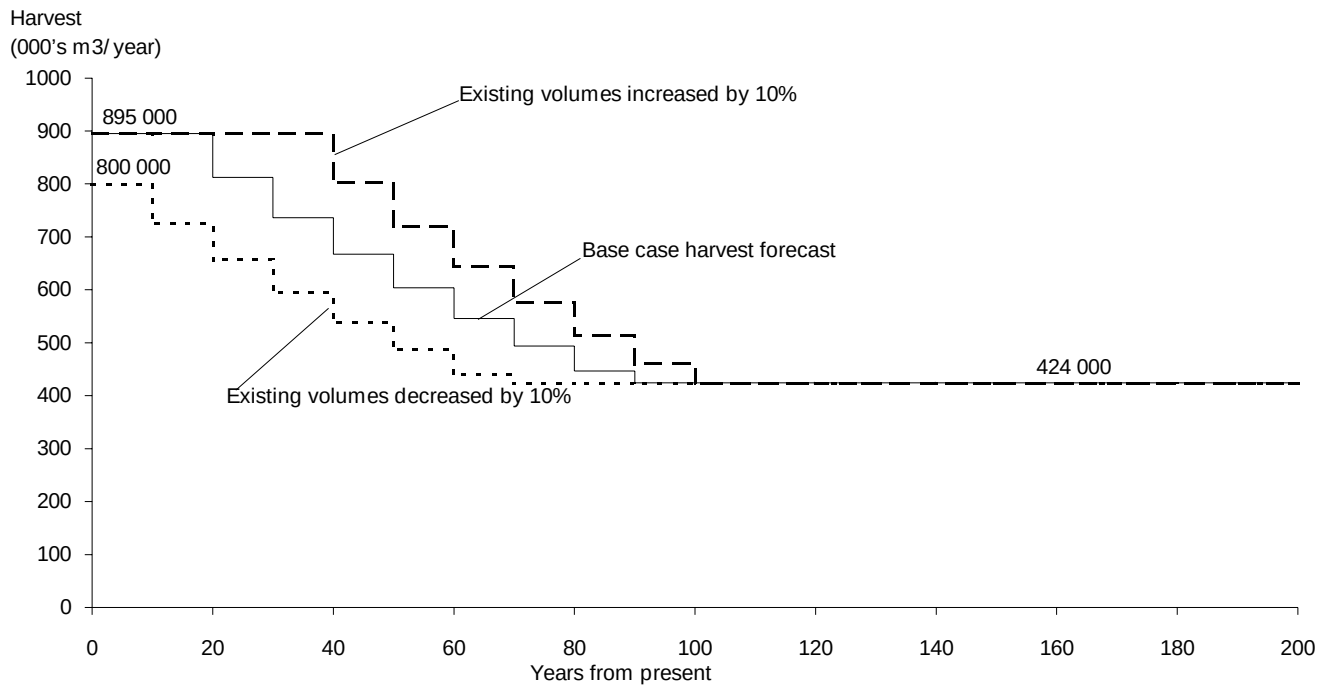


Figure 20. Harvest forecasts if existing volumes are varied by 10%

5 Timber Supply Sensitivity Analyses

5.4 Sensitivity test of estimated regenerated stand volumes

The VDYP system was also used to estimate volume yields for regenerated stands. Regenerated volume curves are roughly 5% higher than volume curves for existing stands due to assumed fuller stocking. There is little on-the-ground verification for these yield curves, however; the oldest plantations in the Bulkley TSA are only 28 years old. Bulkley Forest District staff feel that the growth potential of the land base is considerably greater than indicated by the regenerated stand volume curves. The feeling is that many of the existing timber stands developed in a suppressed environment due to the existence of an overstory and/or excessive stocking. Work is presently underway to calibrate a procedure for estimating site growth potential from soil, moisture and climatic variables, rather than relying on the height and age of existing stands. The sensitivity analysis therefore inspected the impact of a wider range for regenerated volumes, varied by plus or minus 25%.

Figure 21 summarizes the results. The only assumptions changed from the base case were regenerated volumes; minimum harvest ages were kept as in the base case. When regenerated volumes

are lowered 25%, the 9% per decade declines of the base case continue for 12 decades, stabilizing at a long-term harvest level of 307 000 cubic metres per year.

If regenerated stand volumes are 25% greater than those of the base case, the long-term harvest level for the TSA is 533 000 cubic metres per year. The increased volumes, as modeled, do not impact on short-term harvest levels. The effects of the assumed increase are not reflected in greater timber availability for the first 8 decades. Under current management assumptions, if the harvest flow was constrained to not fall below the long-term harvest level, it would be necessary to reserve some of the volume harvested in the first few decades to fill the dip in harvest levels from decades 7 through 14.

If minimum harvest ages are reduced 20 years concurrently with the 25% increase in regenerated stand yields, it is possible to raise the harvested volumes in decades 7 through 14 to 510 000, followed by harvests of 533 000 cubic metres per year. However, this causes growing stock volumes to steadily decrease over the planning horizon, with the implication, as noted in Section 5.2, that filling a supply deficit by reducing minimum harvest ages may negatively impact long-term harvest levels.

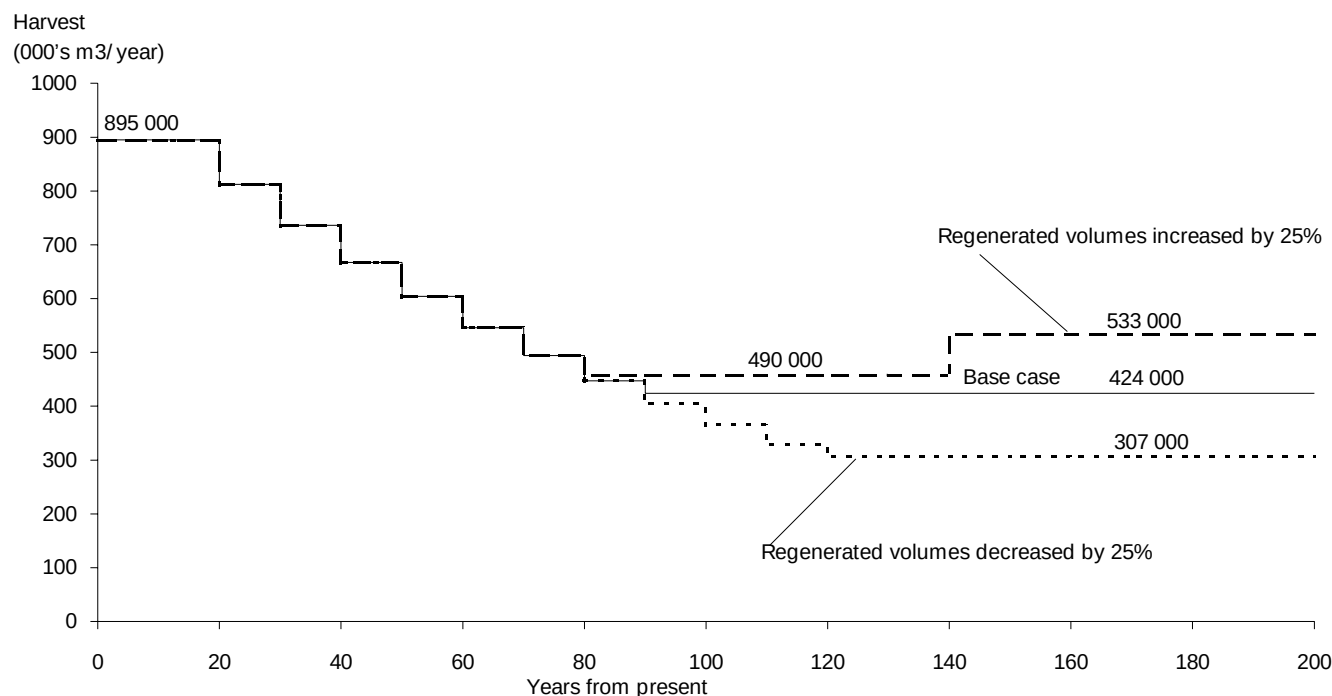


Figure 21. Harvest forecasts if regenerated volumes are varied by 25%

5 Timber Supply Sensitivity Analyses

5.5 Sensitivity test of regeneration delay

The regeneration delay* is the time between harvest of a timber stand and the start of a new crop. Since all harvested areas are planted in the Bulkley TSA, the regeneration delay assigned to all growth types for the base case was 4 years. This sensitivity analysis tests for the impact of all regeneration delays being extended to 10 years, versus there being no regeneration delay at all. Figure 22 shows the results of the test. There is no impact on present harvest levels, or on the rate of decline to the long-term

harvest level. The only impact on harvest yields of varying the regeneration delay is an increase or decrease of approximately 5% in the long-term harvest level. Changed regeneration delays would also change the length of green-up periods (Section 5.7). This compound effect is not explicitly tested here.

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.

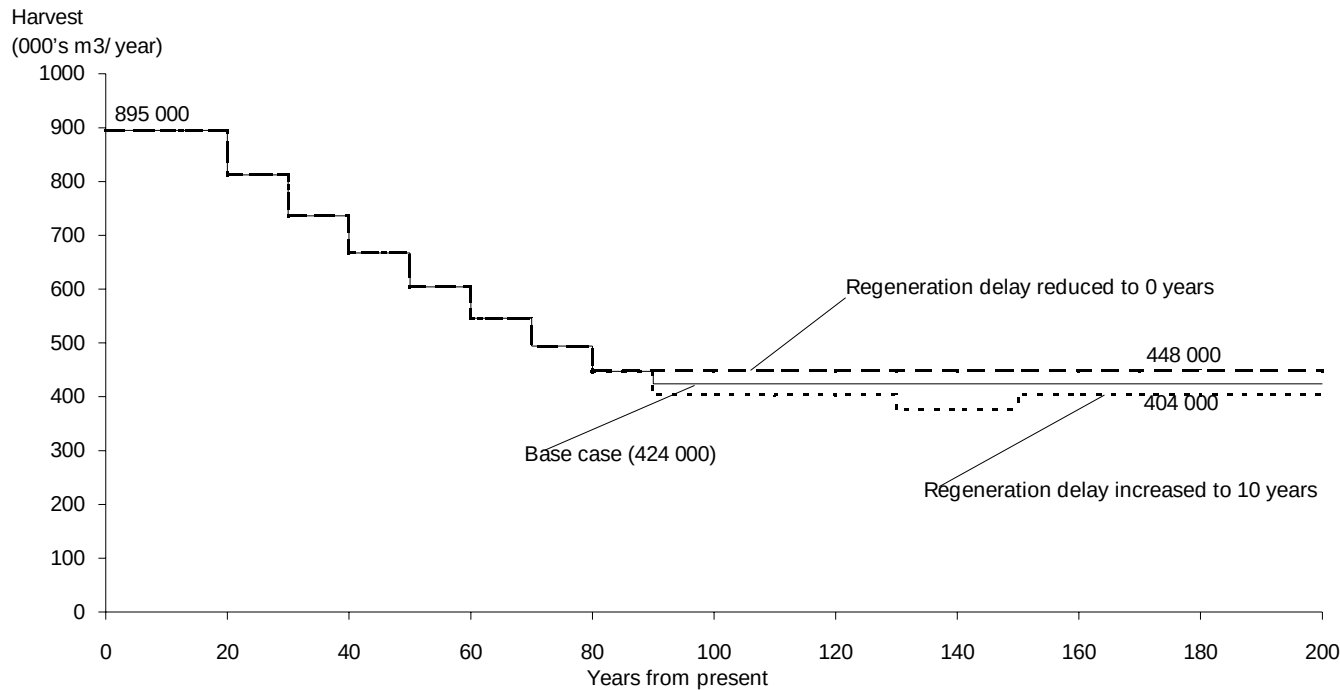


Figure 22. Harvest forecasts if the regeneration delay is varied

5 Timber Supply Sensitivity Analyses

5.6 Sensitivity test of forest cover requirements

Forest cover requirements specify desired distributions of areas by age class groupings. The B. C. Forest Service timber supply model is able to control harvests so as to (i) limit the area which may be younger than a specified age, and (ii) maintain a desired amount of area older than a different specified age. Table A-10 lists the forest cover requirements specified for the base case. Sensitivity testing of the impact of varying the management zone prescriptions for young and old area requirements was divided into three categories:

5.6.1 Maximum area below green-up ages, integrated resource management (IRM) zones

The base case requirement for the IRM zones is that no more than 33% of the zone area be stocked with

stands less than three metres high. Whether the limit is relaxed to permit 40%, or tightened to allow no more than 25% of the zone area below three metre height, there is no change in the forecast harvest flow.

However, if the young area constraint is tightened to permit no more than 20% of the area in the IRM zones to be less than three metre height (a five-pass harvest system), then the harvest rate for decades 1 and 2 must be lowered to 748 000 cubic metres per year. As shown in Figure 23, this reserves some growing stock which may be harvested over the succeeding seven decades, by raising the harvest in decade 3 to 788 000 cubic metres and then dropping by only 8% per decade to the long-term harvest level of 424 000 cubic metres per year. Even under the restrictive 20% cover requirement, the base case long-term harvest level is sustainable.

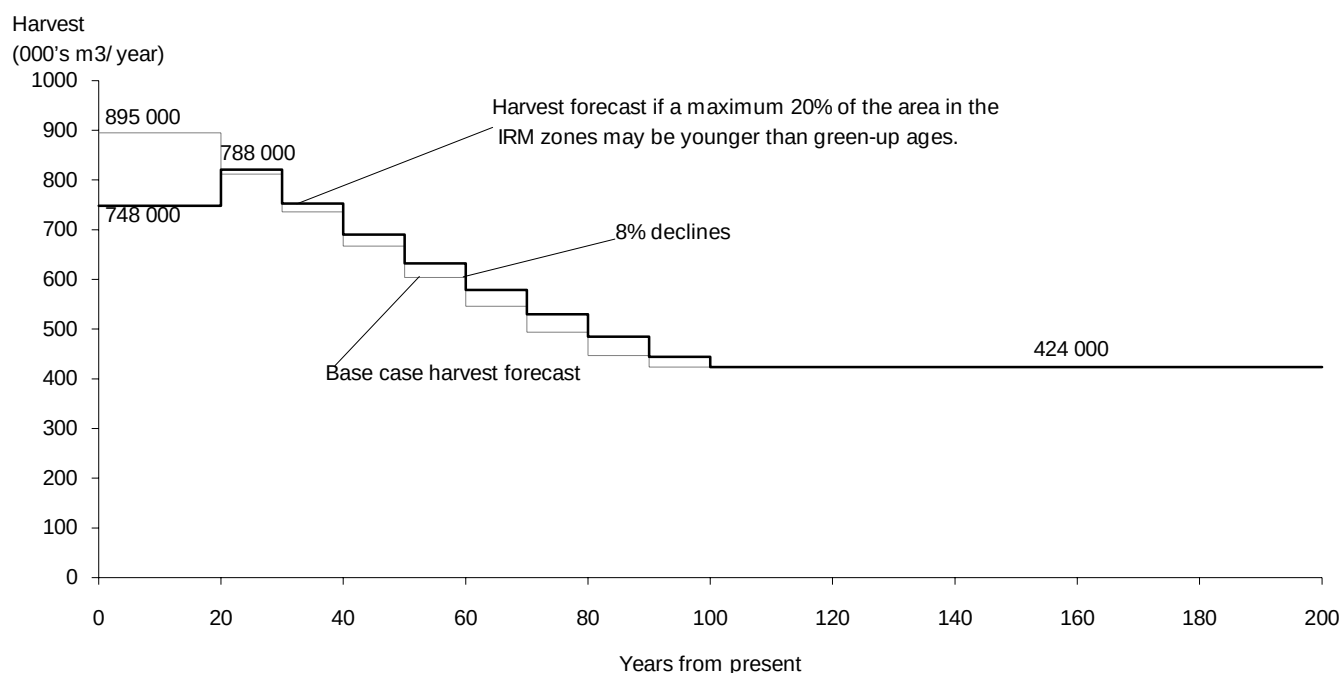


Figure 23. Harvest forecast if the IRM zone is managed under a 5-pass constraint

5 Timber Supply Sensitivity Analyses

5.6.2 Maximum area below green-up ages; special management zones

The young area requirement was relaxed by increasing by five percent the requirements for all Special Zones (e.g. Partial Retention VQO Zone increased to 20%). The result is insignificant, in that the initial harvest rate could be maintained for no more than two decades, and the rate of decline to the long-term harvest level could be no more gradual than the 9% drops of the base case.

Tightening the young area requirement by decreasing by five percent the requirements for all Special Zones (e.g. Partial Retention VQO Zone reduced to 10%) has a minor effect on harvest flow, as shown in Figure 24. Although the initial harvest level of 895 000 may still be maintained for two decades, the rate of decline thereafter increases to

10% per decade, and the long-term harvest level drops by 2% to 415 000 cubic metres per year.

5.6.3 Minimum area over old age criteria, special zones

Sensitivity testing was undertaken by increasing or decreasing by ten percent the old area requirement for all Special Zones (e.g. Riparian Zone raised to 80% or reduced to 60%). Relaxing the old area constraints did not permit increased harvests or slower rates of decline to the long-term harvest level. Tightening the requirements had a similar impact to tightening the young area limit on the Special Zones. The initial harvest level is unchanged from the base case, however the rate of decline increases to 10% per decade and the long-term harvest level declines 2.5% to 413 000 cubic metres per year. The flow pattern is not shown here but is very similar to that shown in Figure 24.

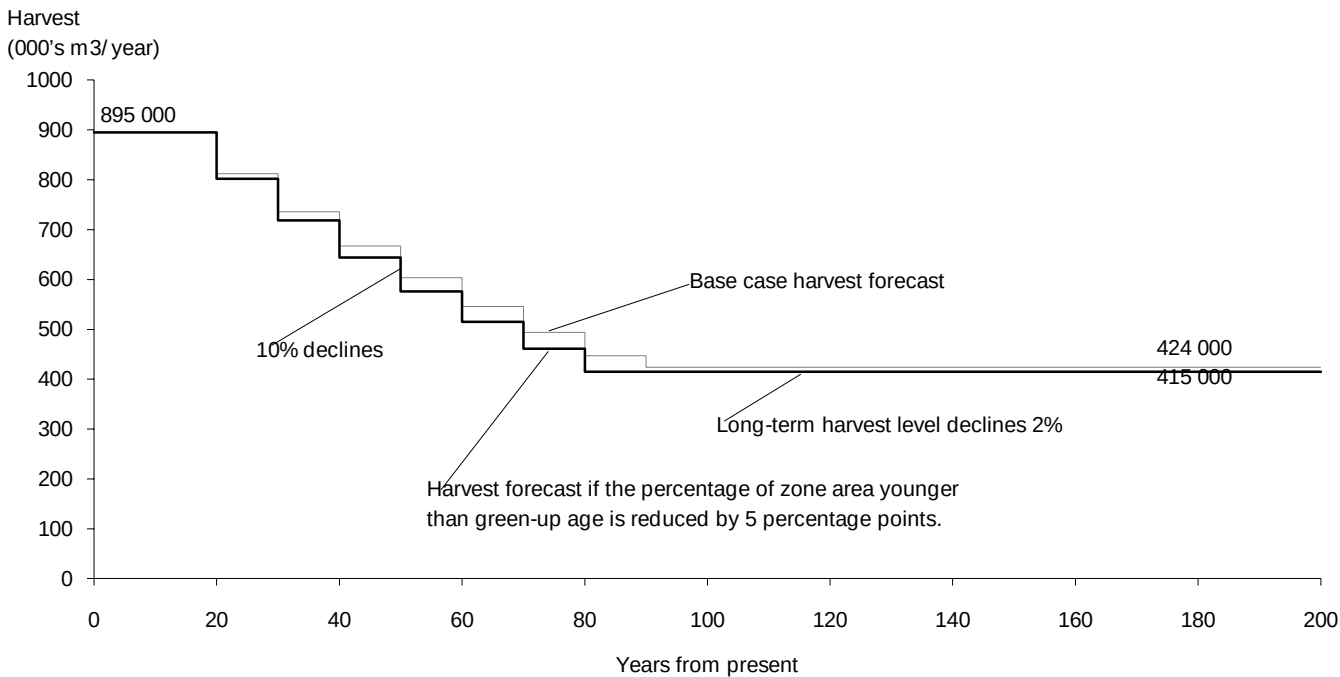


Figure 24. Harvest forecast if the special zones cover percentage requirements are varied

5 Timber Supply Sensitivity Analyses

5.7 Sensitivity test of green-up requirements

Refer to Table A-10 for the base case young and old age criteria. Sensitivity testing was undertaken in the same three groupings as for forest cover area requirements above.

5.7.1 Green-up period, IRM Zones

The assumed time to reach three metres heights in the IRM zones was tested by varying the base case value by 5 years. Reducing the green-up period by 5 years had no effect on harvest flow. It was not possible to extend the initial harvest level for another decade, nor was it possible to reduce the rate of decline to the long-term harvest level. Figure 25 shows that increasing the green-up period by five years causes the initial harvest level to be sustainable for only one decade. Also, after that first decade the harvest rate must drop by 11% per decade to avoid a shortfall of available harvest volume in decade 14.

5.7.2 Green-up period, special zones

The green-up periods for the Special Zones were also tested by increasing or decreasing the criteria by five years. Relaxing the requirements by shortening the assumed green-up period by five years had no effect on the potential harvest flow. Tightening the requirements by extending the green-up periods five years had a minor impact. The initial harvest continues at 895 000 cubic metres per year for two decades, however the rate of decline must be increased to 10% per decade. The long-term harvest level is 424 000 cubic metres, the same as for the base case.

5.7.3 Old age criteria, special zones

The old age requirements were tested by varying the base case old age criteria by ten years. Relaxing the requirements by subtracting ten years from the base case cutoff age did not permit any increase in the harvest flow. Tightening the old age requirement by adding ten years does not change the harvest flow for the first 8 decades, however the long-term harvest level drops by 1% to 418 000 cubic metres per year.

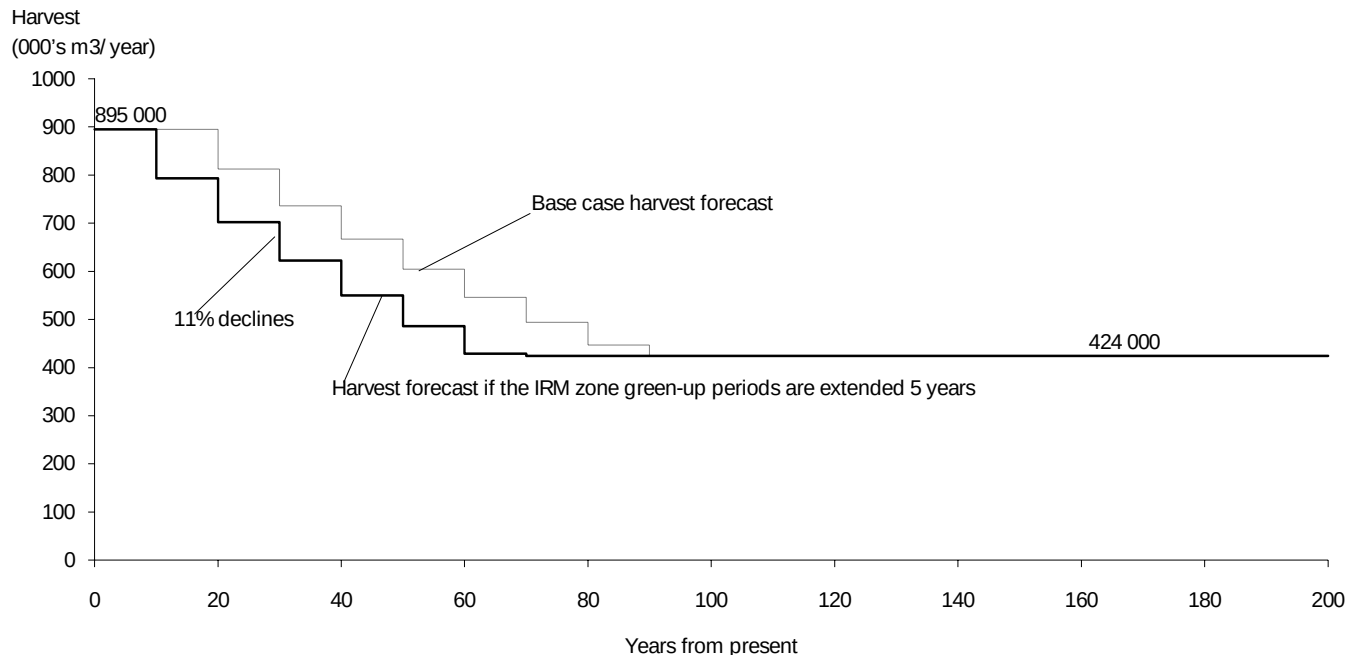


Figure 25. Harvest forecast if the IRM zone green-up period is extended by 5 years

5 Timber Supply Sensitivity Analyses

5.8 Sensitivity to removing all forest cover requirements

In this timber supply analysis, management for forest resources other than timber on the timber harvesting land base is primarily modeled using forest cover requirements. This sensitivity test shows the sum effect of removing all the forest cover requirements for integrated management, wildlife, visual quality and the community forest. Figure 26 shows the harvest forecast with no forest cover requirements. Restricted only by inventory levels

and growth potential, the initial harvest rate of 895 000 may be maintained for four decades, falling thereafter at a rate of 10% per decade to a long-term sustainable level of 441 000 cubic metres per year.

The majority of this increased harvest flow is due to removal of old age requirements. If green-up requirements are maintained as in the base case and only the old age requirements, which apply to 12% of the timber harvesting land base, are removed, then the present AAC may be maintained for 3 decades, followed by 9% declines to a long-term harvest level of 435 000 cubic metres per year.

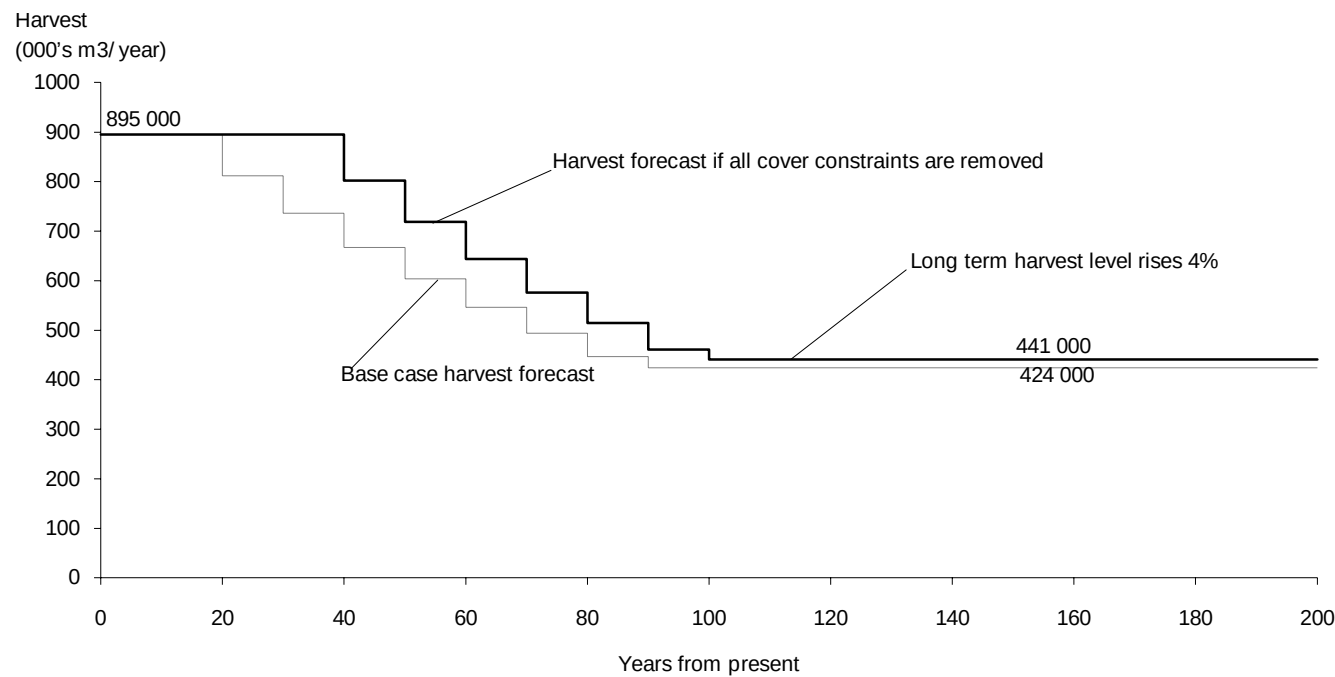


Figure 26. Harvest forecast if all forest cover constraints are removed

6 Summary and Conclusions

The analysis for the Bulkley TSA indicates that given current management assumptions an initial harvest of 895 000 cubic metres can be maintained for two decades. Harvests must then begin to decline at 9% per decade until the long-term harvest level of 424 000 cubic metres per year is reached in decade nine.

Although the present AAC is sustainable for another 20 years, the log size and species profile presently harvested is not sustainable in the short term. Harvesting must shift from spruce stands into pine and hemlock types, and from high quality sawlogs into marginal sawlog and pulplog stands.

If harvest rates are lowered immediately to the long-term sustainable level, 21% less timber will be harvested over the 200-year planning horizon, but the long-term forest will contain 35% more growing stock volume and mature stands will be an average 30 years older than under the base case harvest flow.

Table 2 summarizes the range of initial harvest levels discussed in this report. These harvest levels

apply to the timber harvesting land base as defined. Changed forest management assumptions, and land base additions or withdrawals, would change the values in Table 2.

This analysis employs the best current estimates for all variables used to describe forest management in the Bulkley TSA. However, many of the estimates contain some degree of uncertainty. Short-term timber supply is mainly sensitive to volume estimates for existing stands, and would be impacted by tighter forest cover requirements. Higher yield estimates for existing stands and relaxed forest cover requirements permit the present AAC to be maintained for up to four decades. Changes in regenerated stand yields have no impact on short-term (20-year) harvest rates although the long-term harvest level is significantly affected. A brief summary of the factors which have significant short- or long-term impacts on the harvest forecast are shown in Table 3.

Table 2. Summary of modeled initial harvest levels for the Bulkley TSA

Harvest flow label	Refer to Section	Initial harvest level (m ³ /year)	Years sustainable
Base case, current AAC	4.1	895 000	20
10% lower existing volumes	5.3	800 000	10
5-pass harvest system	5.6.1	748 000	40
Licensed allocation	4.4	650 000	70
Improved long-term harvest	5.4	533 000	200
Base case long-term harvest	5.1	424 000	200

Table 3. Summary of impacts of sensitivity analyses

Refer to Figure	Factor tested	Varied by	Impact		
			Low	Medium	High
19	Minimum harvest ages	± 20 years	XXXXXXXX		
20	Existing stand volumes	± 10%	XXXXXXXXXXXXXXXX		
21	Regenerated stand volumes	± 25%	XXXXXX		
22	Regeneration delay	0 or 10 years	XX		
23,24	Forest cover requirements	± 5%, 10%	XXXXXXXXXX		
25	Green-up requirements	± 5, 10 years	XXXX		
26	Removing all cover requirements	no constraints	XXXXXX		

7 References

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8 Glossary

Allowable annual cut (AAC)	The allowable rate of timber harvest from a specified area of land. The Chief Forester sets AACs for Timber Supply Areas (TSAs) and Tree Farm Licences (TFLs) in accordance with Section 7 of the <i>Forest Act</i> .
Available volumes	The portion of total inventory volumes that is available for harvesting after all management constraints on timber harvesting have been considered, including definition of the timber harvesting land base, age of tree merchantability, deferrals, and any other priorities or constraints on timber harvesting.
Culmination Age	The age at which a timber stand reaches its highest mean annual increment (MAI). MAI is calculated as stand volume divided by stand age. Culmination age is the optimal biological rotation age to maximize volume production from a growing site.
Cutblock adjacency guidelines	Integrated management guidelines that specify the desired spatial relationship among cutblocks. They can be approximated by specifying the maximum allowable proportion of a forested landscape that does not meet green-up requirements.
Diameter limit harvesting	A silvicultural system used to maintain established understory trees. All trees larger than a specified diameter are removed, with care being taken to not damage the residual stand. Horses are often used to harvest trees under this system.
Environmentally sensitive area	An area with significant non-timber values, fragile or unstable soils, problems in establishing a new tree crop or where timber harvesting may cause avalanches.
Forest cover requirements	Specify desired distributions of areas by age or size class groupings. These requirements can be used to reflect desired conditions for wildlife, watershed protection, visual quality and other integrated resource management objectives. General adjacency and green-up guidelines are also specified using forest cover requirements.
Forest inventory	Description of British Columbia's forest resources. It includes computerized maps and a database describing the location and nature of forest cover, including size, age, timber volume, and species composition, as well as a description of some non-timber values such as recreation and visual quality.
Forest type	The classification or label given to a forest stand, usually based on its tree species composition. Pure spruce stands and spruce-balsam mixed stands are two examples of forest types.
Free-growing	An established seedling of an acceptable commercial species that is free from growth-inhibiting brush, weed and excessive tree competition.
Green-up period	The time needed for a stand of trees to reach a desired condition (e.g., height) to ensure maintenance of water quality, wildlife habitat, soil stability or aesthetics.
Growing stock	The volume estimate for all standing timber, of all ages, in a management unit at a particular time.

8 Glossary

Harvest forecast	The flow of potential timber harvests over time. A harvest forecast is usually a measure of the maximum timber supply that can be realized, over time, for a specified land base and set of management assumptions. It is a result of forest planning models and is affected by the size and productivity of the land base, the current growing stock, and management objectives, constraints and assumptions.
Management assumptions	Approximations of management objectives, priorities, constraints and other conditions needed to represent forest management actions in a forest planning model. These include, for example, the criteria for determining the timber harvesting land base, the specification of minimum cutting ages, utilization levels and standards, integrated resource guidelines and silviculture and pest management programs.
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 and low stocking.
Not satisfactorily restocked	An area not covered by a sufficient number of tree stems of desirable species. Stocking standards are set by the Forest Service, Silviculture Branch. If the expected regeneration delay has not elapsed, the land is defined as current NSR. If the expected delay has elapsed, the land is classified as backlog NSR.
Partial retention VQO	Alterations are visible but not conspicuous. Up to 15% of the area can be visibly altered by harvesting activity.
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.
Rehabilitation	Removing all non-commercial cover, preparing the site and stocking it with acceptable commercially valuable species.
Retention VQO	Alterations are not easy to see. Up to 5% of the visible landscape can be altered by harvesting activity.
Riparian area	Areas of land adjacent to wetlands or bodies of water such as swamps, streams, rivers or lakes.
Selection management	A silvicultural system used to maintain or create areas containing a wide range of tree ages or sizes. The time interval between harvests in such areas is fairly short (usually less than 30 years) and during these harvests either single scattered trees or small groups of trees are removed from across the entire area.

8 Glossary

Site index	A measure of site productivity. Site indices are based on tree height as a function of stand age and are usually expressed graphically as site index curves. A number of site index curves have been developed for British Columbia's major commercial tree species.
Timber harvesting land base	The portion of the total land area of a management unit considered to contribute to, and be available for, long-term timber supply. The harvesting land base is defined by reducing the total land base according to specified management assumptions.
Timber Supply Area (TSA)	An integrated resource management unit established in accordance with Section 6 of the <i>Forest Act</i> .
Timber supply model	An analytical (usually computer-based) model that simulates successively harvesting and growing collections of forest stands according to specific data and management assumptions. Timber supply models are of two basic forms: forest estate simulation models, which address "what-if" questions by determining the effects a specified policy or management alternative; and optimization harvest scheduling models, which seek out the policy or management alternative that best attains a specified management objective subject to specified management constraints. This analysis employs a computer simulation model developed by the B.C. Forest Service.
Unsalvaged losses	The volume of timber killed or damaged annually by natural causes (e.g., fire, wind, insects and disease) and not harvested.
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.
Volume estimate (yield projections)	Estimates of yields from forest stands over time. Yield projections can be developed for stand volume, stand diameter or specific products, and for empirical (average stocking), normal (optimal stocking) or managed stands. Yield projections can be based on a number of mensurational approaches and procedures, including the use of site index curves and generalized growth models.

Appendix A

Description of Data Inputs and Assumptions

Introduction

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

Important forest management considerations in the Bulkley TSA are summarized below, with reference to the table in this appendix that addresses the issue:

- Grizzly bear habitat (Table A-1)
- Moose and mule deer winter range (Table A-4)
- Woodland caribou (Table A-6)
- Babine River corridor (Tables A-1, A-6)
- Retention and partial retention VQOs (Table A-1)
- Lakeshore management, trail corridors (Table A-1)
- Soil stability (Table A-4)
- Green-up and adjacency rules (Table A-10)
- Timber stand quality (Tables A-2, A-5)
- Timber utilization (Section A.4.1)
- Operability: steep slopes, high elevation (Section A.2.3)
- Merchantability criteria (Tables A-5, A-7, A-8)
- Yield curves (Table A-14)
- Regeneration delay (Table A-13)
- Rehabilitation of NSR areas (Table A-12)
- Unsavaged losses (Table A-11)
- Revision to the Provincial Forest Boundary (Table A-6)

A.1 Zone and Analysis Unit Definitions

A.1.1 Definition of zones

A management zone is a grouping of land base areas to which a common forest cover prescription may be applied. Nine different combinations of cover prescriptions necessitated definition of nine zones. For the purpose of reporting, the IRM zone was divided into five zones, based on groupings of analysis units by species and log quality (see the following section). Table A-1 summarizes the area and volume by zone, Section 2.5 in the text describes the management within each zone, Table A-10 lists the base case cover requirements for each zone and the following two pages are maps to the location of the zones.

Table A-1. Total areas and volumes in each management zone

Management zone	Total forested area (ha) ^a	Net area in the timber harvesting land base (ha)	Existing merchantable volume ('000 m3)	% of total volume
IRM Zones:				
Spruce sawlog	61 684	41 316	6 914	11
Pine sawlog	79 843	58 830	8 720	14
Balsam sawlog	41 644	35 567	10 170	17
Marginal sawlog	154 698	52 332	11 189	18
Hemlock pulplog	35 714	20 549	7 385	12
Subtotal IRM zones	373 583	208 594	44 378	72
Special Zones:				
Riparian	40 323	19 442	4 878	8
Grizzly	6 390	3 437	812	1
Babine	6 195	4 694	1 293	2
Retention VQO	4 791	1 875	445	1
Partial retention VQO	46 913	18 762	4 175	7
Community forest	4 474	2 482	421	1
VQO & riparian	5 928	2 952	559	1
Future roads	31 099	15 412	4 348	7
Subtotal special zones	146 113	69 086	16 931	28
Total land base	519 696	277 680	61 309	100

^a All ownership, all site classes, coniferous forest only.

A.1 Zone and Analysis Unit Definitions

Figure A-1. Key map to the location of visual quality objective areas in the Bulkley TSA

A.1 Zone and Analysis Unit Definitions

Figure A-2. Key map to the location of wildlife concern areas in the Bulkley TSA

A.1 Zone and Analysis Unit Definitions

A.1.2 Definition of analysis units

An analysis unit (AU) represents a group of similar stands. Generally an AU contains stands that possess similar tree species compositions and similar timber growing capabilities. In the inventory file the major combinations of species are called type groups and timber growing capability, or site quality, is indicated by a site index or site class. For the Bulkley analysis, site groups were assigned using new site class. The Bulkley inventory was classified into species/quality/site groupings as defined in Table A-2.

The definition of marginal sawlog includes balsam on poor growing sites, plus balsam stands on medium sites that are aged over 140 years and have not reached 24.0 metres height. Due to remote access, timber in the sawlog analysis units in Planning Cell C7 (approximately 500 hectares at the north end of the TSA) were assigned to the marginal sawlog analysis unit.

The definition of pulplog includes all leading hemlock stands, plus leading balsam and spruce stands with a major (over 40%) hemlock component. Amabilis fir, identified as balsam in the Coastal Western Hemlock biogeoclimatic zone, is considered pulplog quality in the Bulkley TSA.

The detailed groupings in Table A-2 were used to aggregate the inventory in the IRM zones. In the special management zones, the inventory was grouped into fewer analysis units, as listed below.

In the larger special management zones (riparian, partial retention VQO and future roads), the inventory is grouped into five analysis units:

AU	Species	Site classes
Spruce sawlog	Spruce	GMP
Pine sawlog	Pine	GMP
Balsam sawlog	Balsam	GM
Marginal sawlog	Balsam	P
Hemlock pulplog	Hemlock	GMP

and in the smaller special zones is grouped into only three analysis units:

AU	Species	Site classes
Sawlog	Spruce	GMP
	Pine	GMP
	Balsam	GM
Marginal	Balsam	P
Pulplog	Hemlock	GMP

Each of the above unique groupings is represented by a volume curve (Table A-14) based on actual inventory information for the growth type in the zonal area.

A.1 Zone and Analysis Unit Definitions

Table A-2. Definition of analysis units

Analysis Unit		Log quality	Type groups	Site class	Age and height criteria	Location
Spruce	G	Sawlog	21, 24-26	Good		
Spruce	M	Sawlog	21, 24-26	Medium		
Spruce	P	Sawlog	21, 24-26	Poor		
Pine	G	Sawlog	28, 30, 31	Good		
Pine	M	Sawlog	28, 30, 31	Medium		
Pine	P	Sawlog	28, 30, 31	Poor		
Balsam	G	Sawlog	18, 20	Good		
Balsam	M	Sawlog	18, 20	Medium	if > 140 yrs must be $\geq$ 24 m	
Balsam	P	Marginal	18, 20	Medium	if > 140 yrs and < 24 m	
			18, 20	Poor		
			21-31	All above		Cell C7 ^a
Hemlock	GM	Pulplog	12-17, 19, 23	Good & Medium		
			18, 20	Good & Medium		CWH ^b
Hemlock	P		12-17, 19, 23	Poor		
			18, 20	Poor		CWH ^b

^a Planning cell C7, at the north end of the TSA.

^b Coastal Western Hemlock biogeoclimatic zone.

A.2 Definition of the Timber Harvesting Land Base

The timber harvesting land base was determined by first deducting from the total TSA area all areas considered to be currently unavailable or unsuitable for timber harvesting. Current NSR areas which will be rehabilitated to productive forest were then added back to establish the current timber harvesting land base. Harvesting operations in presently mature areas will entail the construction of a permanent road network, which is harvested but not regenerated in the model over a 60-year period. All these categories are summarized in Table 1 of the main report.

A.2.1 Non-Crown and non-forest areas

All areas not designated as being ownership code 62C (Crown forest management unit available for long-term integrated resource management) or 69C (Miscellaneous reserves available for long-term integrated resource management) were excluded from the timber harvesting land base. In addition, 27 hectares of ID = 8 (no typing available) were deducted under this category. Table A-3 summarizes area by ownership code in the Bulkley TSA. In total, 62 231 hectares, or 8.5% of the total TSA area is in the non-Crown category.

Non-forested and non-productive areas, designated as type identity 6 on the inventory file, were also excluded from the timber harvesting land base. These areas account for the removal of 194 329 hectares, or 26% of the total TSA area remaining after non-Crown lands are excluded.

Table A-3. Summary of area by ownership code, Bulkley TSA

Description	Ownership code	Area (ha)
Non-Contributing:		
Crown grant	40	55 049
Indian reserve	52	2 930
Ecological reserve	60	162
Use, recreation and enjoyment of public	61	941
Provincial park class A ^a	63	50
Provincial park	67	6
Government reserve (N)	69	295
Woodlots, Crown portion	77	1 561
Miscellaneous leases	99	1 210
Subtotal Non-contributing		62 204
Contributing:		
Crown forest management unit	62	644 613
Government reserve (C)	69	29 188
Sub-total contributing		673 801
Total Bulkley TSA		736 005

^a Note: the Babine Mountains Recreation Area, 32 400 hectares, is not included on the Bulkley TSA inventory file.

A.2 Definition of the Timber Harvesting Land Base

A.2.2 Inoperable areas

Timber in the Bulkley TSA has been categorized into four classes: sawlog, marginal sawlog, pulplog and non-merchantable. Due to economic limitations marginal sawlog and pulplog stands are not harvested on slopes greater than 50 percent, or at elevations greater than 4200 feet. Such areas have been excluded as inoperable. Sawlog areas on both steep slopes and at high elevations have however been harvested, and therefore are maintained in the net operable land base. In addition, two areas with particularly unstable soils but inadequate ESA-soils mapping, the Telkwa Bulbous Toe and a portion of the Lower Harold Price Creek watershed, have been removed as inoperable.

A.2.3 Environmentally sensitive areas

Table A-4 summarizes the area reductions prescribed for environmentally sensitive areas (ESAs). These reductions cover 119 972 hectares, or 16% of the total Bulkley TSA area. 83 854 hectares of ESA are coincident with other reductions, and therefore ESAs reduce the timber harvesting land base only 36 118 hectares (5% of the TSA). The majority (80%) of the ESA reductions are due to soil stability concerns. ESA mapping for recreation was not used; instead sensitive lakes, trails and visual landscapes were identified and incorporated into special management VQO zones. Sensitive wildlife areas are gathered into the Riparian special management zone, however approximately 1000 hectares of prime moose and mule deer habitat on Crown forest land in the Bulkley Valley are excluded from the timber harvesting land base.

Table A-4. Percent area reductions for environmentally sensitive areas

ESA code	ESA description	Percent area reductions
Es 1	High soil sensitivity	100
Es 2	Moderate soil sensitivity	20
Ea 1 & 2	Avalanche concerns	100
Ep 1 & 2	Regeneration problems	100
Ec 1 & 2	Avalanche and regeneration problems	100
Ew1 in SBSdk ^a	High moose and deer habitat, Bulkley Valley	100

^a Sub-Boreal Spruce dry cool biogeoclimatic zone

A.2 Definition of the timber harvesting land base

A.2.4 Non-merchantable forest

Some forest stands are not currently utilized because they either cannot be harvested economically or they contain mostly non-commercial tree species. Examples include older stands that contain low net timber volumes or poor quality trees and stands dominated by deciduous species. Areas of low site quality are also excluded because projected growth rates for second-growth forests are too low. Table A-5 lists the problem forest types for the Bulkley TSA.

Table A-5. Definition of non-merchantable forest

Timber type	Type group	Criteria				Percent area excluded
		Age class	Height class	Site class	Stocking class	
All	All	All	All	Low		100
Hemlock Balsam	12 to 17	7-9	2	Poor		100
Spruce	18 to 20	7-9	2	Poor		100
	21 to 26	7-9	2	Poor		100
Lodgepole pine	28 to 31	5-9	2	Poor		100
Deciduous	35 to 42	All	All	All		100
All	All	All	All	All	2, 3, 4	100

A.2.5 Not satisfactorily restocked areas

All areas on the inventory file assigned a type identity of 4 were initially excluded from the land base. Most of this area is subsequently added back into the timber harvesting land base according to rehabilitation plans of the silviculture program (Section A.3.6).

A.2.6 Existing unclassified roads, trails and landings

Past timber harvesting operations have resulted in a reduction of productive forest land. However many of the existing roads, trails, landings, fireguards and related disturbances are not accounted for in the inventory file. To account for this loss in the area available for timber production a 7.5% reduction was applied to all areas younger than 80 years old (the areas assumed to have a timber harvesting history). Actual measurements were taken in 25 randomly selected cutblocks in the Bulkley TSA, and a weighted average netdown was determined based on estimated productivity losses of 100% for roads and landings, 20% for skid trails, and 15% for fireguards.

A.2 Definition of the Timber Harvesting Land Base

A.2.7 Future roads, trails and landings

There will also be losses in productive area as future harvesting occurs. All existing stands currently over 80 years old will be subject to these losses, which are assumed to be the same as for past harvesting (7.5%). The area that will eventually be lost is not initially excluded from the land base. Instead, 7.5% of all forest stands are aggregated into the Future Roads Zone, which is completely harvested, in the B.C. Forest Service timber supply model, at a steady rate over a 60-year period. After the initial harvest, these areas are set aside in non-productive status.

A.2.8 Exclusion of specific geographic areas

Table A-6 summarizes the remaining areas that were excluded from the timber harvesting land base. The total areas shown in Table A-6 are for the gross land base before any reductions are applied. The net reductions to the Crown land base due to these exclusions are presented in Table 1 of the main report.

Table A-6. *Exclusion of specific geographic areas*

Reason for exclusion	Identifying variables		Gross area excluded (ha)
	Planning cell	Ownership code	
Proposed Babine River Wilderness	C-12	All	6 275
Proposed Telkwa Wildlife M.A.	A-10, A-11	69	14 204
Provincial Forest boundary change	Planning cell listing	62	22 696
Woodlot Licence #102	Polygon listing	62	409
Grazing lease	Polygon listing	62	152

The proposed Babine River Wilderness is a buffer of approximately one kilometer either side of the Babine River. The Ministry of Forests and the Ministry of Environment, Lands and Parks decision, July 1992, was to maintain the wilderness qualities of the area, as recommended in the Babine Local Resource Use Plan. In this analysis, a buffer to the proposed wilderness area, another one kilometer either side, has been aggregated into the Babine Management Zone, with special forest cover requirements.

The proposed Telkwa wildlife management area is mainly for the protection of high elevation forest habitat of woodland caribou and other species. A signed agreement between the Ministry of Forests and the Ministry of Environment, Lands and Parks supports designation, although formal designation requires development of a Wildlife Management Plan.

The Provincial Forest boundary change is in recognition of the Bulkely Valley Agricultural Land Reserve, and removes from the timber harvesting land base areas of arable land which are not available for long-term forest management. Woodlot licence areas and grazing leases do not contribute to the harvest levels modeled in this analysis.

A.3 Forest Management Assumptions

A.3.1 Utilization levels

The utilization level defines the maximum allowable stump height and minimum merchantable diameter by species and is used to calculate merchantable volume. A 10-cm diameter top and a 30-cm stump height is assumed for all species. In the Bulkley TSA, the utilization level currently practiced for all species is based on diameter at breast height of 15.0 cm. Volumes at 15.0 cm utilization were estimated by linear interpolation between volume estimates from VDYP at 12.5 cm and 17.5 cm utilization levels.

All coniferous species, except whitebark pine, are utilized, but no deciduous species are utilized. Forested areas that are predominantly deciduous are removed from the timber harvesting land base in Table 1, and the deciduous volume component in coniferous stands is not included in the volume estimates in Table A-14.

A.3.2 Minimum harvest ages for each analysis unit

Minimum harvest ages were determined based on achieving minimum tree size and volume per hectare criteria, listed in Table A7 below. To determine the minimum harvest age for each analysis unit, volumes and diameters from batch VDYP were inspected, with results shown in Table A-8 below.

Table A-7. Criteria for identification of minimum harvest ages for analysis units

Analysis Unit	Minimum Volume (m ³ /ha)	Minimum Diameter (cm dbh)
Sawlog	150	25
Marginal Sawlog	175	20
Pulplog	175	20

A.3 Forest Management Assumptions

Table A-8. Minimum harvest ages and volume and diameter at minimum age for each analysis unit

Zone	Analysis Unit	Minimum harvest age (years)	Volume at age (m ³ /ha)	Diameter at age (cm dbh)
Spruce Sawlog	Spruce G	70	175	25
	Spruce M	85	152	25
	Spruce P	118	150	27
Pine Sawlog	Pine G	78	220	25
	Pine M	93	187	25
	Pine P	113	171	25
Balsam Sawlog	Balsam G	67	150	25
	Balsam M	98	150	27
Balsam Marginal	Balsam P	156	175	29
Hemlock Pulplog	Hemlock GM	90	175	26
	Hemlock P	111	175	27
Riparian	Spruce Sawlog	96	150	25
	Pine Sawlog	90	200	25
	Balsam Sawlog	106	150	27
	Marginal Sawlog	159	175	29
	Pulplog	105	175	27
Grizzly	Sawlog	90	163	25
	Marginal Sawlog	157	175	29
Babine	Sawlog	94	162	25
	Marginal Sawlog	149	175	20
Retention VQO	Sawlog	93	172	25
	Marginal Sawlog	137	175	29
	Pulplog	133	175	28
Partial Retention VQO	Spruce Sawlog	92	150	25
	Pine Sawlog	103	215	25
	Balsam Sawlog	99	150	27
	Marginal Sawlog	146	175	29
	Pulplog	83	175	24
Community Forest	Sawlog	77	173	25
	Marginal Sawlog	117	175	28
	Pulplog	105	175	27
VQO & Riparian	Sawlog	91	154	25
	Marginal Sawlog	160	175	29
	Pulplog	85	175	25
Future Roads	Spruce Sawlog	101	150	25
	Pine Sawlog	90	199	25
	Balsam Sawlog	99	150	27
	Marginal Sawlog	161	175	29
	Pulplog	101	175	26

A.3 Forest Management Assumptions

A.3.3 Harvest profile

Table A-9 presents the current (past two years) harvest profile for the Bulkley TSA. This profile is compared with the available and modeled harvest profiles in Section 4.4 of the report.

Table A-9. Profile harvested, 1990-1992

Species and log quality class	Percent of total harvest
Spruce Sawlog	24
Pine Sawlog	18
Balsam Sawlog	45
Marginal Sawlog	7
Hemlock Pulplog	6

A.3.4 Forest Cover Requirements

Specific forest cover requirements are discussed for each management zone in Section 2.5, and summarized in Table A-10 following. The modeling procedure limits the amount of area which may be non-greened up at any time (e.g. Retention VQO Zone) or holds a quantity of older area always greater than the old age (e.g. Grizzly Zone). Generally the old age requirements were provided in years from the Bulkley Forest District. The green-up requirements were described in terms of metres of tree height, and converted to years using site index information from the VDYP model, input to the TIPSYS model for growth of managed stands.

Table A-10. Forest cover requirements by management zone

Management zone	Young cover class			Old cover class	
	Height criteria (metres)	Age criteria (years) ^a	Maximum area (%) ^b	Age criteria (years)	Minimum area (%) ^c
<u>Integrated Resource Management:</u>					
Spruce Sawlog	3	24	33		
Pine Sawlog	3	15	33		
Balsam Sawlog	3	20	33		
Balsam Marginal	3	24	33		
Hemlock Pulplog	3	22	33		
<u>Special Management:</u>					
Riparian				80	70
Grizzly				140	50
Babine	10	46	30	140	30
Retention	5	27	5		
Partial Retention	5	29	15		
Community Forest	5	25	15	100	40
VQO & Riparian	5	27	10	80	70
Future Roads					

^a Includes 4-year regeneration delay.

^b Maximum percentage of zone area permitted to be younger than the young age.

^c Minimum percentage of zone area required to be older than the old age.

A.3 Forest Management Assumptions

A.3.5 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-11 shows the estimated average annual loss for the Bulkley TSA. The total annual loss was rounded to 32 000 cubic metres per year and subtracted from harvest volumes modeled to derive all harvest flow forecasts in this report.

Loss factors were estimated as follows:

- Insects: Mountain pine beetle is a serious insect pest in the Bulkley TSA, and as a result an extensive program is in place to manage the beetle. Data on losses and salvage was collected as part of the program to locate and control infestations. The balsam bark beetle is a significant pest in the TSA, however losses are considered endemic and are not included in Table A-11.
- Fire: Each year fire reports are compiled for all burns declared forest fires. In the process, damages to timber are reported for all fires in excess of four hectares. Fires less than four hectares are thought to be insufficient in intensity to cause full mortality and have not been previously recorded. Inventory volume figures are used to record damage which is assumed to be 100 percent. If the area is determined to be operable then an estimation of the salvageable volume is recorded and entered onto the protection historical data base. A ten-year average from 1982 to 1991 is used in Table A-11.
- Wind damage: Five randomly picked blocks were surveyed to determine the amount of volume lost to blowdown along block boundaries. Blocks ranged in size from 20 to 60 hectares. Results show that for every hectare harvested 8.3 cubic metres of volume is lost to blowdown. The majority of this volume is presently not being harvested.

Table A-11. Annual unsalvaged volume losses

Cause of loss	Gross volume lost (m ³ /year)	Salvaged volume (m ³ /year)	Unsalvaged volume (m ³ /year)
Insects	11 465	4 000	7 465
Fire	7 906	3 812	4 094
Wind damage	20 750	0	20 750
Total losses	40 121	7 812	32 309

A.3 Forest Management Assumptions

A.3.6 Not satisfactorily restocked (NSR) areas

Table A-12 summarizes the total area of current and backlog NSR as derived from the Silviculture History Records for the Bulkley TSA. All good and medium site NSR land will be restocked by the year 2000. The backlog poor sites are generally a result of fire and will not have significant silviculture investments applied to them. As a result they may never reach full stocking. For the first rotation these poor sites (1588 hectares) were therefore grown along a yield curve based on 30% crown closure. After first harvest, these areas return to the regular poor site land base.

Table A-12. Restocking of current and backlog NSR areas

Analysis Unit regenerated	Backlog NSR area (ha)	Current NSR area (ha)	Total area (ha)
Spruce - good	1 278	422	1 700
Spruce - medium	1 302	987	2 289
Spruce - poor	762	380	1 142
Pine - good	687	698	1 385
Pine - medium	1 028	1 500	2 528
Pine - poor	826	498	1 324
Total regenerated	5 883	4 485	10 368

A.3.7 Basic Silviculture and Regeneration Assumptions

Table A-13 shows what species are regenerated after harvesting occurs in existing analysis units in the Bulkley TSA. All sites are planted, with an expected average regeneration delay of 4 years. Although the preferred species are spruce and lodgepole pine, there are biological limitations to the suitability of present balsam and hemlock sites to grow other species. Where species conversion does occur the growth types regenerated are the same site class as the existing analysis unit.

Table A-13. Species regenerated after harvest

Existing analysis unit	Species regenerated (% of area)				Regeneration delay (years)
	Spruce	Pine	Balsam	Hemlock	
Spruce - Good	100				4
Spruce - Medium	100				4
Spruce - Poor	100				4
Pine - Good		100			4
Pine - Medium		100			4
Pine - Poor		100			4
Balsam - Good	45	20	35		4
Balsam - Medium	25	30	45		4
Balsam - Poor	20	30	50		4
Hemlock - Good/Medium	25	20	30	25	4
Hemlock - Poor	25	20	25	30	4

A.4 Yield Estimates for Existing and Regenerated Stands

A batch version of the variable density yield prediction (VDYP, version 4.2b) model, developed by the Inventory Branch of the B.C. Forest Service, was used to predict volume yields for both existing and regenerated stands. The batch VDYP model provides a complete volume curve for every forest stand in the timber harvesting land base, based on the species composition, height, age, stocking and geographic location of the stand. These curves are then aggregated into the analysis unit curves in Table A-14, by averaging the individual curves, weighted by the area of each stand that makes up the analysis unit.

For the existing inventory, only the conifer volumes (excluding whitebark pine) predicted by VDYP are included in the yield curves. For regenerated stands, it was assumed that management would replace or utilize the deciduous component, and therefore all-species volumes from VDYP were used, based on the same site indexes as existing stands. The difference is a lift of from 2% to 6% in the volume curves. Since the two sets of curves are so similar, only the volume curves for existing stands are presented in Table A-14.

A.4 Yield Estimates for Existing and Regenerated Stands

Table A-14. Volume estimates for existing stands

	Integrated Resource Management Zones							
	Spruce Sawlog			Pine Sawlog			Balsam Sawlog	
	G	M	P	G	M	P	G	M
Total area (ha)	8 800	12 514	20 002	26 701	25 481	6 648	2 267	33 299
Total volume ('000 m³)	885	2 403	3 779	3 583	5 262	977	790	9 746
Maximum MAI (m³/ha/year)	2.87	2.05	1.43	2.86	2.06	1.57	2.43	1.59
Age								
10	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	1	0
30	0	0	0	16	2	1	18	3
40	14	2	0	68	24	6	54	15
50	71	21	2	115	60	22	92	37
60	126	61	8	157	94	47	127	62
70	175	100	26	194	125	74	161	91
80	218	136	54	227	153	99	191	113
90	255	168	82	258	179	122	218	134
100	287	197	108	286	203	144	243	154
110	315	222	133	312	226	165	267	172
120	339	245	155	336	247	185	289	189
130	361	266	177	358	267	204	311	206
140	379	284	196	372	281	217	331	222
150	395	299	213	383	291	228	350	238
160	407	312	229	391	299	237	368	252
170	418	323	243	396	304	243	385	266
180	426	333	255	398	307	246	401	279
190	433	341	267	397	307	248	416	291
200	440	349	277	399	310	251	431	303
210	446	356	287	402	313	254	444	314
220	452	363	296	405	316	258	458	325
230	457	369	304	408	319	261	470	336
240	462	374	312	411	322	264	483	346
250	466	379	319	413	325	266	494	356
260	469	382	324	416	327	268	496	358
270	472	386	329	418	329	270	497	359
280	474	388	334	420	330	272	498	361
290	477	391	338	422	332	273	500	362
300	479	393	341	424	333	274	501	363
310	480	395	345	425	334	275	502	365
320	482	397	348	427	335	276	503	366
330	483	398	351	428	336	276	503	367
340	484	400	353	429	337	277	504	368
350	485	401	356	430	338	277	505	369

A.4 Yield Estimates for Existing and Regenerated Stands

Table A-14. Volume estimates for existing stands

	Integrated Resource Management Zones			Riparian Zone				
	Balsam Marginal Sawlog	Hemlock Pulplog		Spruce	Pine	Balsam	Balsam	Hemlock
	P	GM	P	GMP	GMP	GM	P	GMP
Total area (ha)	52 332	8 331	12 217	4 244	4 427	3 320	4 759	2 693
Total volume ('000 m³)	11 890	3 361	4 132	1 017	947	1 017	1 120	954
Maximum MAI (m³/ha/year)	1.13	2.02	1.65	1.77	2.25	1.47	1.10	1.73
Age								
10	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0
30	1	4	1	0	7	3	0	4
40	7	18	6	4	39	12	6	14
50	17	46	20	19	77	30	16	34
60	32	79	44	44	112	53	30	60
70	53	116	74	73	144	81	50	90
80	70	147	103	105	173	102	67	118
90	86	174	129	135	200	122	83	143
100	102	199	153	162	224	141	98	165
110	116	222	174	187	247	158	112	186
120	130	242	193	209	269	174	126	205
130	143	263	213	230	288	191	139	224
140	156	282	231	248	302	206	152	242
150	169	301	247	264	312	221	164	258
160	181	318	262	278	320	235	176	274
170	192	333	277	290	325	248	187	288
180	203	348	290	301	327	260	197	302
190	214	362	302	310	327	272	208	315
200	224	376	314	319	330	284	218	327
210	234	388	325	327	333	295	227	339
220	243	401	336	335	336	306	237	350
230	252	412	346	341	339	316	246	361
240	261	423	356	348	342	326	255	371
250	270	434	365	354	344	336	263	381
260	271	437	371	358	347	338	264	385
270	272	440	376	362	349	339	265	388
280	273	443	380	365	350	340	266	391
290	274	446	385	368	352	342	266	394
300	274	449	389	371	354	343	267	396
310	275	451	393	374	355	344	268	399
320	276	453	397	376	356	345	268	401
330	277	455	400	378	357	346	269	403
340	277	457	404	380	358	347	269	405
350	278	459	407	382	359	348	270	407

A.4 Yield Estimates for Existing and Regenerated Stands

Table A-14. Volume estimates for existing stands

	Grizzly Zone		Babine Zone		Retention VQO Zone		
	Sawlog	Marginal	Sawlog	Marginal	Sawlog	Marginal	Pulplog
Total area (ha)	2 648	788	4 211	483	1 529	295	51
Total volume ('000 m³)	651	181	1 192	111	391	60	18
Maximum MAI (m³/ha/year)	1.94	1.10	1.91	1.17	1.98	1.27	1.35
Age							
10	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0
30	4	1	3	1	4	2	0
40	23	6	20	6	21	10	0
50	48	16	44	16	45	24	1
60	76	31	68	32	74	42	10
70	107	53	94	56	106	65	34
80	136	70	123	76	136	85	63
90	163	86	151	93	165	102	89
100	188	101	178	109	191	119	112
110	211	115	203	123	214	135	133
120	232	128	226	137	236	149	151
130	253	142	248	150	257	164	170
140	269	154	265	164	274	178	187
150	283	167	279	176	288	191	202
160	295	179	291	188	300	204	216
170	304	190	301	200	310	216	229
180	312	201	308	210	318	228	241
190	318	211	313	221	323	239	252
200	326	221	320	231	330	250	263
210	333	231	327	241	337	260	273
220	339	241	333	250	343	270	282
230	346	250	339	259	349	280	291
240	352	259	344	267	355	289	300
250	357	267	350	276	360	298	309
260	360	268	353	277	363	299	316
270	363	269	357	279	366	300	324
280	365	270	360	280	369	301	331
290	367	271	363	282	371	302	338
300	370	272	365	283	373	303	344
310	371	272	368	284	375	304	351
320	373	273	370	285	377	305	357
330	375	274	372	286	379	306	362
340	376	274	374	287	380	306	368
350	377	275	375	288	381	307	373

A.4 Yield Estimates for Existing and Regenerated Stands

Table A-14. Volume estimates for existing stands

	Partial Retention VQO Zone					Community Forest Zone		
	Spruce	Pine	Balsam	Balsam	Hemlock	Sawlog	Marginal	Pulplog
	GMP	GMP	GM	P	GMP			
Total area (ha)	3 819	3 235	4 103	3 702	3 934	1 943	310	228
Total volume ('000 m³)	649	555	1 096	760	1 485	386	60	60
Maximum MAI (m³/ha/year)	1.84	2.09	1.56	1.20	2.21	2.40	1.55	1.74
Age								
10	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0
30	0	5	4	2	2	9	2	4
40	3	32	16	9	18	42	10	16
50	20	68	38	21	52	79	26	36
60	48	102	64	38	91	117	48	60
70	79	132	91	59	130	152	74	87
80	112	159	113	78	164	183	98	114
90	143	185	134	95	194	212	120	141
100	171	208	153	111	220	239	142	165
110	195	230	170	126	244	264	162	186
120	218	251	187	140	265	287	181	206
130	239	270	203	154	287	308	200	225
140	257	283	219	168	306	325	217	243
150	273	293	233	180	324	338	233	260
160	287	301	246	193	341	349	248	276
170	299	306	259	204	356	358	261	291
180	310	309	271	215	369	364	274	305
190	319	309	282	226	382	369	285	318
200	328	312	293	236	394	375	296	331
210	336	314	304	246	406	381	308	343
220	343	317	314	256	417	387	318	355
230	350	320	324	265	427	393	329	366
240	356	323	333	274	437	399	339	376
250	362	325	342	283	446	404	349	386
260	366	327	344	284	451	406	352	390
270	370	329	346	285	457	409	355	393
280	373	331	348	286	462	411	358	396
290	376	333	349	287	466	413	361	399
300	379	334	351	288	470	414	364	402
310	381	335	352	289	474	416	366	404
320	384	336	353	289	478	418	369	406
330	386	337	354	290	481	419	371	408
340	388	338	356	291	485	420	373	410
350	389	338	357	292	488	421	375	412

A.4 Yield Estimates for Existing and Regenerated Stands

Table A-14. Volume estimates for existing stands

	VQO & Riparian Zone			Future Roads Zone				
	Sawlog	Marginal	Pulplog	Spruce	Pine	Balsam	Balsam	Hemlock
				GMP	GMP	GM	P	GMP
Total area (ha)	2 435	314	203	2 548	3 002	3 328	4 530	2 004
Total volume ('000 m³)	497	65	73	713	897	1 007	1 059	767
Maximum MAI (m³/ha/year)	1.84	1.10	2.24	1.66	2.25	1.58	1.09	1.80
Age								
10	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0
30	3	1	2	0	7	4	0	2
40	16	6	14	3	36	15	6	10
50	39	16	43	14	74	37	15	30
60	67	31	81	36	110	62	29	59
70	97	51	123	64	142	90	49	92
80	126	69	160	93	172	113	66	122
90	152	85	192	122	199	133	82	149
100	177	100	221	149	224	153	97	173
110	199	114	247	173	248	171	111	194
120	220	127	269	194	270	188	124	214
130	239	140	292	215	290	205	138	234
140	255	153	312	232	304	221	150	252
150	269	164	331	248	315	236	162	269
160	281	176	348	262	323	250	174	285
170	291	186	363	274	328	263	185	300
180	300	196	377	285	331	276	196	314
190	307	206	390	294	331	289	206	326
200	315	215	402	303	334	300	216	339
210	322	224	414	311	337	312	226	350
220	329	233	425	319	340	323	235	362
230	335	241	435	326	343	333	244	372
240	341	250	444	332	346	344	253	382
250	347	258	453	338	349	353	262	392
260	350	259	459	342	351	355	263	397
270	353	259	464	346	353	357	263	401
280	355	260	469	350	354	358	264	406
290	357	261	474	353	356	359	265	409
300	360	262	478	355	358	361	266	413
310	361	262	482	358	359	362	267	417
320	363	263	485	360	360	363	267	420
330	365	263	489	362	361	364	268	423
340	366	264	492	364	362	365	269	426
350	367	264	495	366	362	366	269	428