Kingcome TSA
Timber Supply Analysis

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Preface

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

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

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

Assessing the implications of only current practices rather than looking at a number of different management schemes will expedite the analysis process, allowing analysis of all TSAs in the province by mid-1995. An important part of these analyses 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 the timber supply form a solid basis for discussions among stakeholders about alternative timber harvesting levels.

This timber supply analysis for the Kingcome TSA began in December, 1993. The information it contains is independent of the 1995 Vancouver Island Land-Use Plan.

The *Forest Act* requires that within 5 years after the AAC determination made by the Chief Forester as part of the Timber Supply Review, a new AAC must be determined, supported by a new timber supply analysis.

The next analysis will incorporate official land use boundaries and new information based on experience in implementation of specific management practices.

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

Executive Summary

As part of the provincial Timber Supply Review, the British Columbia Forest Service has examined the availability of timber in the Kingcome Timber Supply Area (TSA). The analysis assesses how current forest management practices affect the supply of wood available for harvesting over the both the short (next 20 years) and long (next 250 years) term. It also examines the potential changes in timber supply stemming from uncertainties about forest growth and management actions. It is important to note that the various harvest forecasts included in the report indicate only the timber supply implications of current practices and uncertainty. **As such, the forecasts should be used for discussion purposes only; they are not allowable annual cut (AAC) recommendations.**

The Kingcome TSA consists of a total of about 1.13 million hectares of land on both northern Vancouver Island and the mainland coastal area between the Mid Coast, Strathcona and Sunshine Coast TSAs. About 178 000 hectares of the Kingcome TSA is considered available for timber harvesting and production under current management practices. The area is dominated by hemlock, balsam and cedar forests, with a small amount of Douglas-fir and Sitka spruce.

The AAC for the Kingcome TSA totals 1 798 270 cubic metres per year, which includes an allocation of 139 500 cubic metres per year for harvesting of deciduous stands, low quality sites and woodlots. For the timber supply review only conventional conifer harvesting was assessed. Therefore the AAC used for this analysis is 1 658 770 cubic metres per year.

The results of this timber supply analysis suggest that the current AAC in the Kingcome TSA cannot be maintained for even one more decade without causing severe timber supply shortfalls in the future. Using current forest inventory and timber growth information, and assuming continuation of current forest management practices, an initial harvest of 1 068 600 cubic metres per year can be attained. This is 35% below the current AAC used for this analysis. After the first decade the harvest decreases 10% per decade until decade 4 when it reaches its lowest point of 779 000 cubic metres per year. This level is maintained until decade 15 when the harvest level begins to rise toward the long-term harvest level. The harvest level that is sustainable over the long term — 902 600 cubic metres per year — is reached in 160 years.

The short-term harvest levels are significantly impacted by the forest cover guidelines for visual quality and adjacency. However, it is important to note that even if the forest cover guidelines were not in place the initial harvest level would still be lower than the present AAC and the decline to the long-term harvest level would have to start immediately after the first decade. In fact, harvesting history combined with the current forest cover guidelines and management regime result in a maximum initial harvest level of 1 496 300 cubic metres per year. However, if this level is harvested, the second decade harvest falls to 610 500 cubic metres per year.

It was not possible, given current management assumptions, to develop a harvest forecast that does not fall below the long-term harvest level. Three main factors contribute to the projected trough and the initial harvest level. First, insufficient mature inventory exists to maintain harvests above the long-term level. The maximum long-term harvest level is attained after currently young stands reach a harvestable size. In addition the forest cover guidelines for visual quality and adjacency are a recent change in management practices which contribute to the decline in timber supply. Past harvesting history and patterns have resulted in a large amount of forest initially younger than the green-up ages in all management zones. In fact, currently the retention visual quality objective (VQO) and the modification VQO areas have more than double the maximum area allowed below the required green-up age. The third cause of the trough during decades 4 to 16 is the expectation that managed stands will produce higher volumes per hectare than the present natural stands; this increases the apparent shortfall by raising the long-term harvest level.

Another important consideration is that, over the first 40 years, the extent of forest cover below the green-up age in the visual quality management and IRM zones is equal to or above the allowed maximum area. A combination of the amount currently below the green-up age, as noted above, and the harvesting of Timber Licences over the first 40 years causes the forest cover guideline limits to be exceeded at times during the first 40 years.

The substantial reduction in timber supply over the next several decades, shown in the base case, was predicted in the 1990 timber supply analysis completed for the Kingcome TSA. Although that analysis indicated that continuing at the current rate of harvest would be possible for 10 years, it also showed that a sharp decline in the rate of harvest was imminent, and that the harvest level would eventually have to be reduced to below the long-term harvest level.

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

Several alternative harvest flow patterns, using the base case management assumptions, show limited possibility of increasing harvests in the short term. In fact, increasing the rate of decline from 10% to 20% only increased the initial harvest level by 70 000 cubic metres per year. These steeper rates of decline do not significantly increase the short-term harvest level because the forest cover guidelines limit the amount of area that may be harvested in the short term. Thus any gain in the first decade will result in less timber being available for harvest in the second and third decades.

The results of the sensitivity analysis show that, in general, making the forest cover guidelines less constraining will allow a higher harvest level in the short term if the harvest level is allowed to fall to the same low level as in the base case during decades 4 to 16. Changes to the green-up age requirements, the maximum allowable area below green-up age (or adjacency guidelines), the regeneration delay (which affects the time needed to reach green-up) or the visual quality guidelines all produce initial harvest levels ranging from 8% to 22% higher than the base case initial harvest level. Changes to the green-up age requirements result in the largest changes to the initial level. A 5-year decrease in green-up age results in a 22% increase relative to the base case; a 3-year decrease allows a 20% increase in the initial harvest level.

An alternative harvest flow pattern, when the forest cover guidelines are less constraining, is to start at the same harvest level as in the base case and minimize the trough during decades 4 to 16. Several of the sensitivity analyses show both alternative harvest flow patterns.

The addition of an old-growth forest cover guideline on the timber harvesting land base results in an immediate 16% decrease in the initial harvest level. However, there is a large amount of older timber in the forested areas removed due to integrated resource management or operability requirements which may contribute to meeting old-growth guidelines.

The sensitivity analysis also shows that any changes that lead to more restrictive forest cover guidelines cause initial harvest levels to drop well below the base case. In several cases, the harvest level must start below the long-term level and increase over time to avoid further violation of the forest cover requirements and avoid future timber supply shortages. The initial harvest levels for changes that tighten the forest cover requirements range from 8% to 41% lower than the base case. For example, increasing the regeneration delay by 3 years results in an initial harvest level 8% below the base case. The largest impact, a 41% decrease in the initial harvest level, is seen if the green-up ages are 5 years longer.

Uncertainty around the timber harvesting land base can result in significant changes in the harvest levels. If the area of mature timber is reduced 15%, the total land base (all ages) is reduced about 7%. This change to the land base causes a 13% decrease in the initial harvest level. Conversely, if the mature area is increased 15% the initial harvest level can increase 9% over the base case level.

About 43% of the timber harvesting land base is managed under visual quality guidelines. These visual quality guidelines are relatively new to the Kingcome TSA and have a dramatic effect on the harvest level. If the visual quality areas did not require any special management and all zones were subject only to adjacency guidelines the harvest could increase 27% above the base case level in the first decade, to 11% below the current AAC.

The long-term harvest level is generally proportionately affected by changes to the estimates of regenerated volumes, and changes to the estimated site productivity for regenerated stands after harvesting of existing older stands. In addition, the shortfall during decades 4 to 16 can often be partially offset by these changes.

The results of sensitivity analysis indicate that uncertainty in the assumptions and data used in this analysis may significantly affect the harvest level in both the short and long term. If gains in timber supply from a change relative to current management are used to minimize the projected drop in the harvest level to below the long-term level in decades 4 to 16, very little opportunity is left to increase the short-term harvest. If any timber supply gains are used to increase the short-term harvest level, the harvest level must then fall to the same low point as reached in the base case. Examples of both of these flow types are shown for several sensitivity analysis.

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Introduction

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

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

All of these factors are linked: the financial profitability of harvest operations depends upon the terrain, as well as the physical characteristics of the trees to be harvested. Determining the physical characteristics of trees in the future requires knowledge of their growth. Decisions about whether a stand is available for harvest often depend on how its harvest could affect the growth and development of another part of the forest resource, such as wildlife or a recreation area.

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

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

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

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

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

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

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

Introduction

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

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

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

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

1 Description of the Kingcome Timber Supply Area

The Kingcome TSA consists of a total of about 1.13 million hectares within the Port McNeill Forest District, which is located on northern Vancouver Island, the Queen Charlotte Straits and the mainland coastal area between the Mid Coast, Strathcona and Sunshine Coast TSAs (Figure 1). The Kingcome TSA is administered from the Port McNeill Forest District office in Port McNeill, and is one of eight TSAs in the Vancouver Forest Region. The Kingcome TSA occurs primarily on the mainland from Knight Inlet in the south to Cape Caution in the northwest and inland to Tweedsmuir Park. Smaller portions of the TSA are located at the northern tip of Vancouver Island and adjacent to Brooks Bay on the west coast of Vancouver Island.

Port Hardy, Port McNeill, Port Alice and Alert Bay are the major population centers within the Port McNeill Forest District. However, there are many smaller communities such as Holberg, Winter Harbour, Sointula and Coal Harbour.

There are eleven First Nations Bands with traditional territories and/or reserves located within the Port McNeill Forest District; portions of these areas are in Tree Farm Licences (TFL)* within the forest district. Alert Bay, one of the larger population centers in the area, is composed largely of a first nations reserve.

Natural resource-based industries (forestry, fishing and mining) dominate the economy of the area. Forestry-related activities provide from 17% to 76% of the employment in the different centers within the Kingcome TSA.

Most of the timber harvested in the Kingcome TSA is transported to south Vancouver Island mills, lower mainland mills or to Vancouver for sale on the log market. The remaining timber is processed in the Port McNeill Forest District at the Port Alice pulp mill and Shushartie Log Sales mill near Port Hardy.

Seven Tree Farm Licences (TFL) occupy a large portion of the area in the Port McNeill Forest District. The timber supply in these areas is assessed as part of the TFL planning process, and is not examined in this report. About 66% of the timber harvested in the Port McNeill Forest District is from TFLs.

The Kingcome TSA has highly variable topography, with some flat valley bottoms, and large areas of rugged mountainous upper slopes. Steep terrain in the upper slopes and sensitive soils in the mid-slope gullies often preclude timber harvesting. There is also a large of amount of coastline due to the number of inlets and islands in the TSA. The area is dominated by hemlock, balsam and cedar forests, with a small amounts of Douglas-fir and Sitka spruce.

Tree farm licence (TFL)
Provides rights to harvest timber, and outlines responsibilities for forest management, in a particular area.

1 Description of the Kingcome Timber Supply Area

Figure 1. Map of the Port McNeill Forest District with the Vancouver Forest Region.

2 Information Preparation

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

2.1 Land base inventory

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

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

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

Removal of data for areas not contributing to the timber supply does not imply withdrawal of these areas from the TSA. The B.C. Forest Service still manages the entire area of the TSA (except for certain designated lands) as a forest unit that contributes a mix of timber and non-timber values. Within that integrated resource context, the timber supply is managed.

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

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

The land base recommendations of the Vancouver Island Land-Use Plan have <u>not</u> been included in this analysis. All areas not officially designated as permanent protected areas when this analysis was initiated are assumed to be available for timber harvesting.

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

- areas not managed directly by the B.C. Forest Service — these include non-Crown land, areas managed by other agencies (for example, parks, recreation areas) and forest land not administered as part of the TSA (for example, woodlot licences or TFLs).
- non-forest areas — areas not capable of growing productive forest (for example rock, swamp and alpine areas).
- non-commercial cover areas — areas occupied by non-commercial tree or brush species.
- Klinaklini area — this area in the north-east corner of the Kingcome TSA is removed from the land base due to low value timber and accessibility problems.
- not-satisfactorily restocked areas (NSR)* — these areas are initially removed, but are considered available for timber production and are immediately added back into the timber harvesting land base.

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

- environmentally sensitive areas* — portions of the areas classified as sensitive are considered unavailable for timber harvesting.
- low productivity areas — areas occupied by timber stands with low timber growing potential.
- non-merchantable forest types* — areas in which lodgepole pine or deciduous types are the predominant species in the stand.
- visual quality preservation* areas — all areas identified as having a visual quality objective of preservation.
- inoperable areas* — areas classified as unavailable for harvest for terrain-related or economic reasons. Characteristics used to define operability* include slope, topography (for example presence of gullies or exposed rock), difficulty of road access, soil stability, elevation and timber quality.
- existing roads, trails and landings — forest land lost to future timber production due to past access development and harvesting.
- lakeshore and streamside buffers — areas to protect the lakeshore and streamside ecosystems.
- woodlot — a woodlot has recently been awarded in the Kingcome TSA however, the inventory file has not yet been adjusted to reflect this change in management responsibility.
- future roads, trails and landings — to account for future losses of productive land to development. These areas are initially included in the timber harvesting land base, and are removed as part of the first harvest.

There are three types of additions to the timber harvesting land base. The first is the not satisfactorily restocked areas as noted above. The other two areas are:

- Timber Licence reversions — are a type of old tenure in which the holder has exclusive rights to the existing timber on the licence area. After the timber is harvested these areas return to the TSA and are managed by the B.C. Forest Service. They do not contribute to the AAC when they are first harvested, but all subsequent harvests will contribute to the AAC for the TSA.
- Tree Farm Licence take back areas — administration of these areas was moved to the TSA as part of the Small Business Forest Enterprise Program (SBFEP), however, the inventory information for these areas is not yet on the Kingcome TSA inventory file used for this analysis.

A more detailed description of these categories, including specific criteria for removal, are located in Appendix A, "Description of Data Inputs and Assumptions."

Table 1 summarizes the areas in each category, and shows the area of the timber harvesting land base.

Environmentally sensitive areas
Areas with significant non-timber values or fragile or unstable soils, or where there are impediments to establishing a new tree crop, or areas where timber harvesting may cause avalanches.
Non-merchantable forest types
Stands that are accessible and otherwise available for harvesting but are assumed to be non-merchantable due to stand characteristics such as small piece size, incidence of decay, species composition and low stocking.
Preservation VQO
No visible alterations to the landscape are permitted (see ***Visual quality objective****).*

Inoperable areas
Areas defined as unavailable for harvest for terrain-related or economic reasons. Characteristics used in defining inoperability include slope, topography (e.g., the presence of gullies or exposed rock), difficulty of road access, soil stability, elevation and timber quality. Operability can change over time as a function of changing harvesting technology and economics.
Operability
A classification of the availability of an area for timber harvesting. Operability is determined using the terrain characteristics of the area as well as the quality and quantity of timber on the area.

Table 1. Timber harvesting land base for the Kingcome TSA, 1995.

Classification	Area (hectares)	Per cent of total area	Per cent of productive forest area
Total area on inventory file	1 126 126	100.0	
Not managed by B.C. Forest Service	55 222	4.9	
Non-forest	551 210	49.0	
Total productive forest managed by Forest Service (Crown forest)	519 694	46.1	100.0
Reductions to Crown forest			
Non-commercial cover (brush)	816	0.1	0.2
Klinaklini	35 923	3.2	6.9
Not satisfactorily restocked (NSR)	6 844	0.6	1.3
Environmentally sensitive areas	70 825	6.3	13.6
Low productivity	25 478	2.3	4.9
Non-merchantable forest types	11 451	1.0	2.2
Visual quality preservation areas	7 702	0.7	1.5
Inoperable	201 228	17.9	38.7
Existing roads	3 840	0.3	0.7
Lakeshore buffers	2 720	0.2	0.5
Streamside buffers	1 351	0.1	0.3
Woodlot	401	0.0	0.1
Total current reductions[a]	368 579	32.7	70.9
Initial timber harvesting land base	151 115	13.4	29.1
Additions:			
Not satisfactorily restocked	6 844	0.6	1.3
Timber licences[b]	16 332	1.5	3.1
TFL reversion area[c]	3 718	0.3	0.7
Total current timber harvesting land base	178 009	15.8	34.2
Future reductions:			
Future roads	7 370	0.6	1.4
Long term timber harvesting land base	170 639	15.2	32.8

(a) Reductions were performed in the order shown.
(b) Timber licences revert to Forest Service management after existing mature timber is harvested.
(c) TFL reversion areas are a result of the Small Business Forest Enterprise Program initiative several years ago. However, while these areas are now under Forest Service management, they are not yet included in the inventory file.

2 Information Preparation

Figure 2 represents both the total Kingcome TSA area, and the timber harvesting land base. The total land base chart shows that about 95% of the Kingcome TSA falls within B.C. Forest Service management, and that almost 50% is classified as either non-forest or non-productive forests (i.e., very few trees). The other chart details the categories of productive forest land not within the timber harvesting land base, and shows just under one-third (30.4%) of the productive forest is available for timber harvesting.

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

2 Information Preparation

Figure 3 shows the composition of the timber harvesting land base by tree species and maturity. The timber harvesting land base is dominated by good and medium site hemlock and balsam stands (41%) and poor site redcedar stands (27%). There is also smaller amounts of hemlock/balsam poor quality sites (15%) and good and medium redcedar (14%). There is also a minor component of Douglas-fir and spruce stands (3%). Overall, 47% of the area is older than 120 years (mature) and 53% is immature. However, past harvesting has concentrated on the redcedar and hemlock/balsam good and medium sites resulting in proportionately more immature stands in these species-site groups. In the short term the majority of harvesting will have to take place on the cedar poor and hemlock/balsam sites.

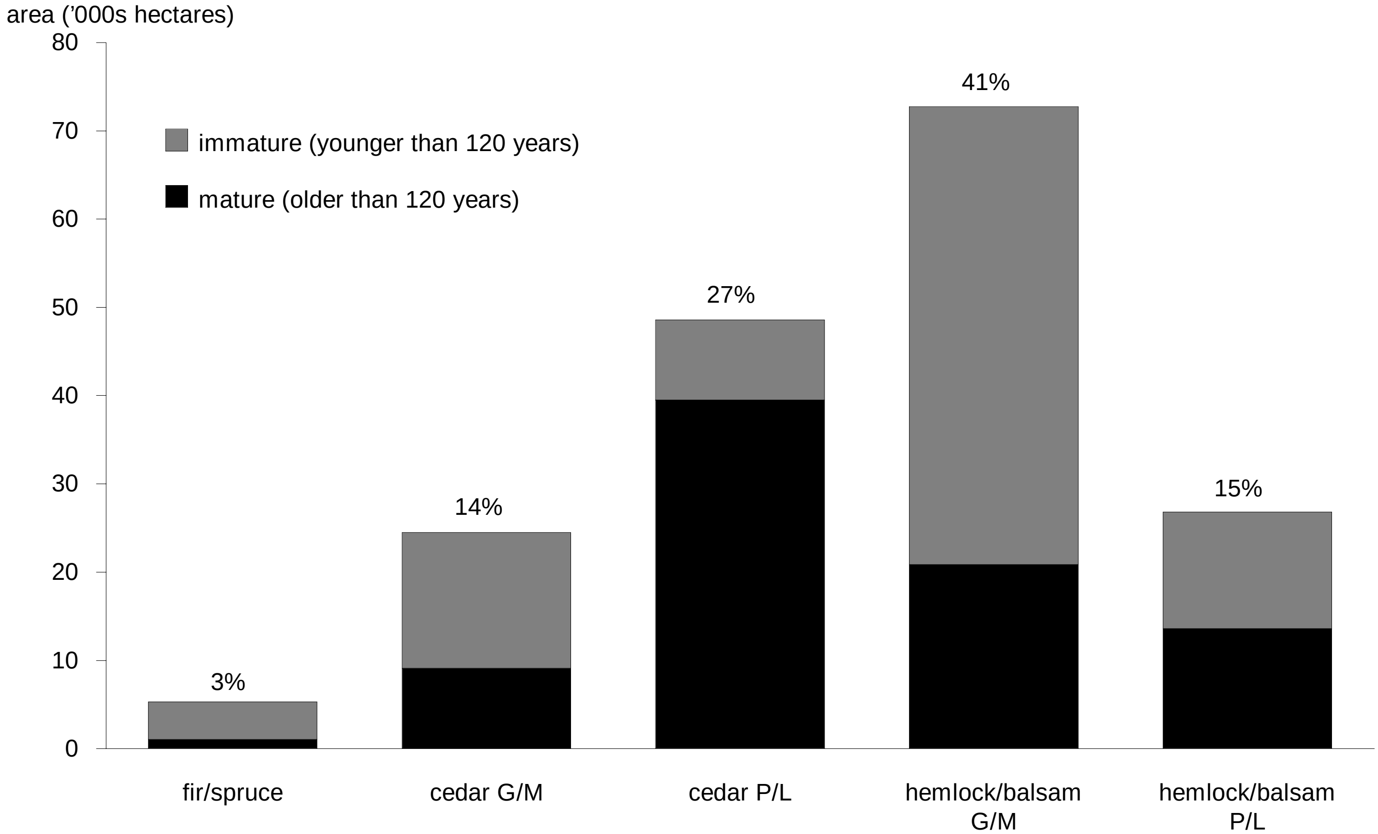

Figure 3. Area by dominant tree species and site productivity — Kingcome TSA timber harvesting land base, 1995.

Figure 4 shows the distribution of different timber growing potential within the timber harvesting land base. There is slightly more area of good and medium sites than there is of poor sites. It should be noted that the majority of the timber harvesting land base has medium or poor quality growing sites; only about 6.5% consists of good quality growing sites.

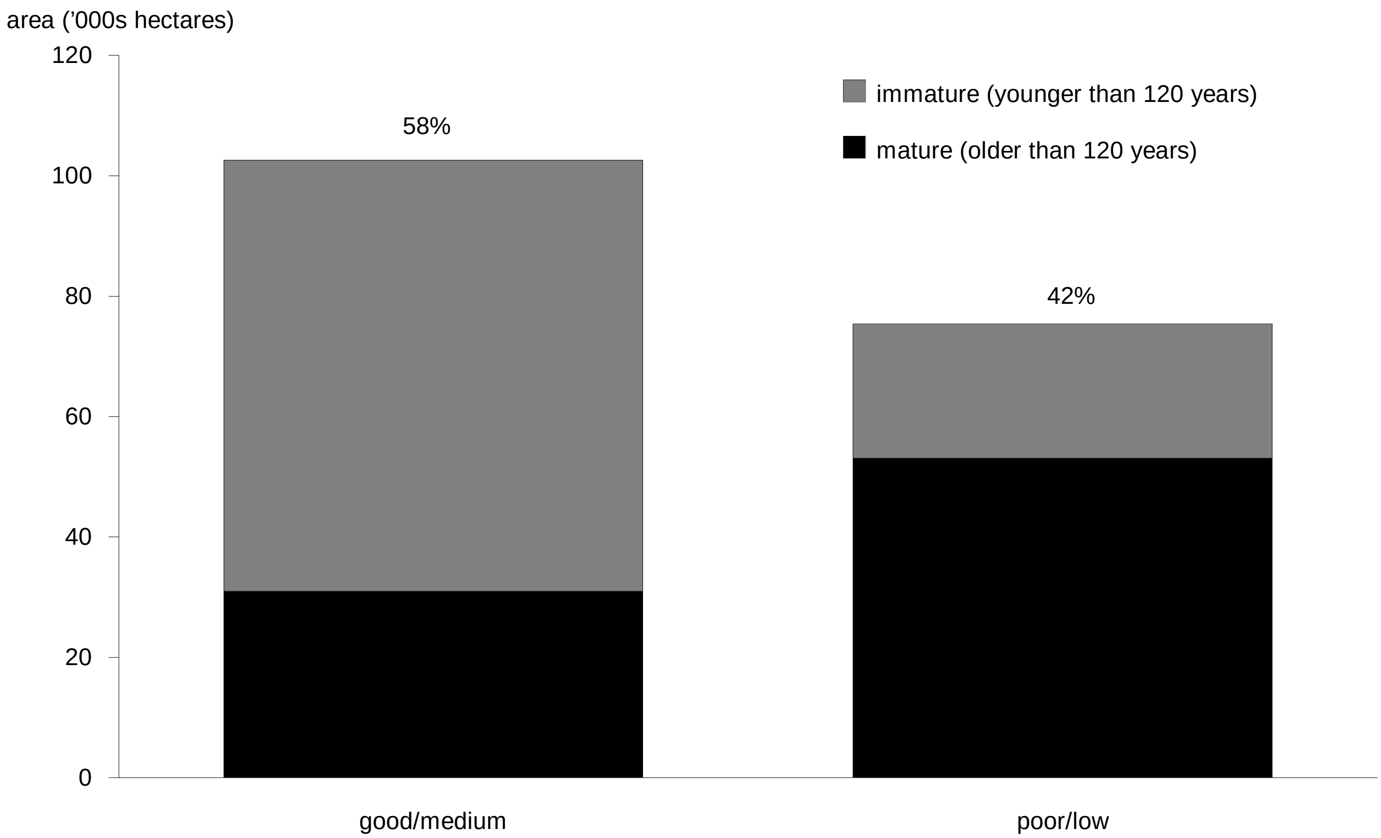

Figure 4. Area by maturity and site productivity — Kingcome TSA timber harvesting land base, 1995.

Figure 5 shows the current age composition of the Kingcome TSA timber harvesting land base. There is a distinct gap between young and older forests. This indicates that an important timber supply issue is the allocation over time of the remaining older forest until currently young areas become old enough to harvest.

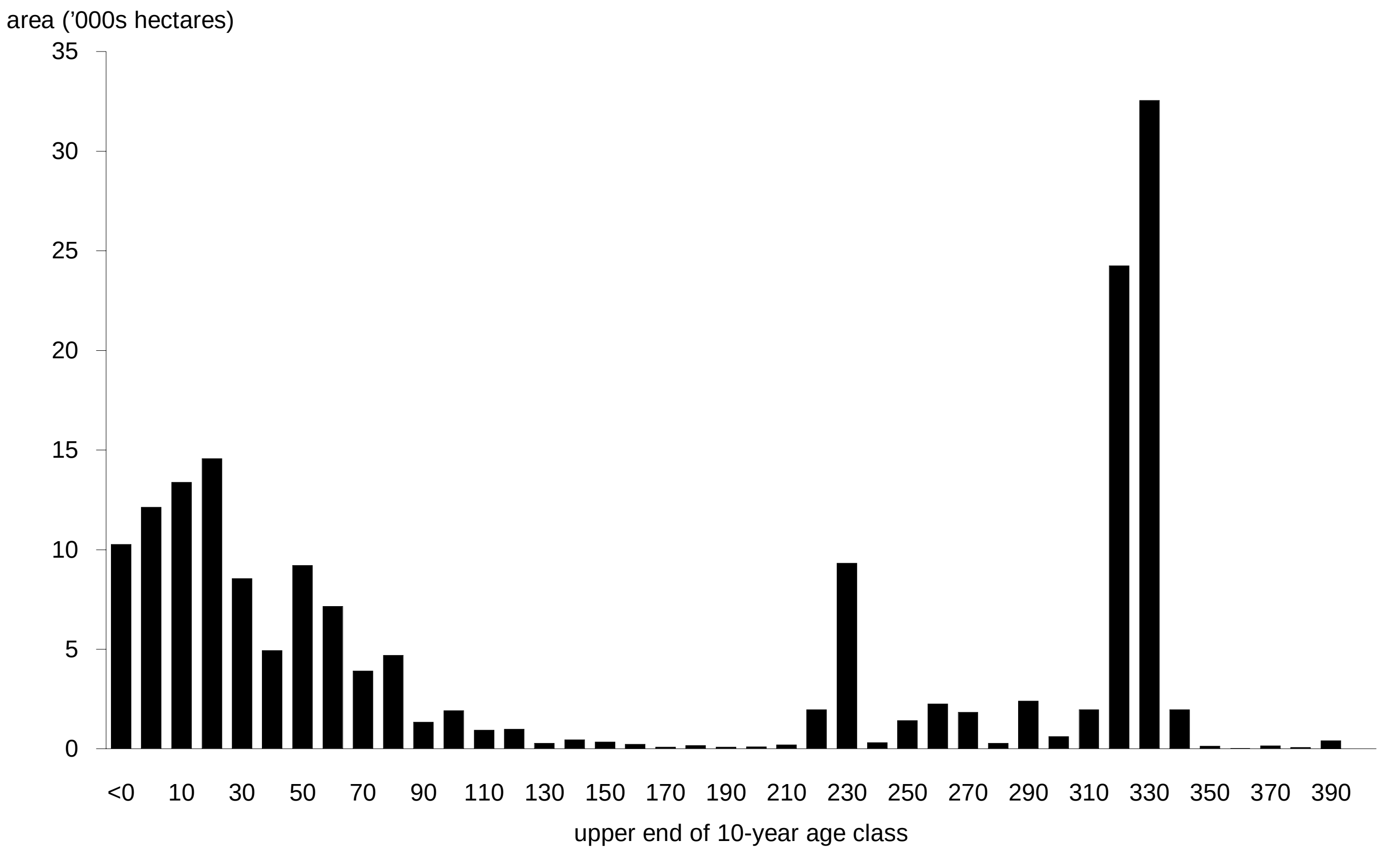

Figure 5. Current age composition — Kingcome TSA timber harvesting land base, 1995.

2.2 Timber growth and yield

Timber growth and yield refers to the prediction of the growth and development of individual forest stands over time. The most common measure of the amount of standing timber is volume per area (in British Columbia, cubic metres per hectare). This measure assumes a utilization level or set of dimensions that establishes a minimum size limit for trees and logs that must be harvested and removed from a site. See Appendix A, "Description of Data Inputs and Assumptions" for more details on utilization.

Timber volumes applied to existing stands in this analysis are based on the Variable Density Yield Prediction (VDYP) model developed by the B.C. Forest Service, Inventory Branch. This model provides estimates of stand volume according to age. Timber volumes estimated for regenerated second-growth stands are based on the Table Interpolation Program for Stand Yield (TIPSY) model developed by the B.C. Forest Service, Research Branch. Sensitivity analysis addresses the possibility that stand volumes may be different from those predicted.

2.3 Management practices

Timber supply is directly connected to forest management activity. The *Coast Planning Guidelines, Vancouver Forest Region* are currently used in the Kingcome TSA to guide planning. These guidelines serve as an umbrella document for integrated resource management initiatives and incorporate existing guidelines such as the *Coastal Fisheries/Forestry Guidelines* and the *Landscape Management Guidelines*. Further details on required management practices are found in the *Forest Licence Management Plan Guide, Vancouver Forest Region* and the *Development Plan Guide, Vancouver Forest Region*. 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 Port McNeill Forest District and the Vancouver Forest Region defined these practices as described in the following management assumptions*.

- Basic silviculture levels — reforestation activities required to establish free-growing* stands of acceptable tree species. All harvesting in the Kingcome TSA is done using a clearcut harvesting* system. Harvested sites are restocked by planting or natural regeneration.
- Immature plantation history — existing harvested and restocked areas that have been managed for stocking* levels will be assigned a volume estimate* based on managed stand yield tables.
- Forest health and unsalvaged losses* — losses of merchantable timber to fire are expected to average 16 365 cubic metres per year.
- Minimum harvestable ages — the time it takes for stands to grow to a merchantable size. Minimum ages for this analysis were set at the youngest age at which stands reach within 5% of their maximum average growth. The minimum harvesting age defines the youngest age at which specific type of stand is expected to become harvestable. Actual harvest age may be greater but not less than the minimum, and will depend on ages of other stands, forest cover objectives* (e.g. for visual quality and adjacency) and overall timber harvest targets.

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

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

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

Stocking
The proportion of an area occupied by trees, measured by the degree to which the crowns of adjacent trees touch, and the number of trees per hectare.

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.

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

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

- Cutblock adjacency* and green-up* — the *Coast Planning Guidelines, Vancouver Forest Region* specify that previously harvested stands must reach a free-growing state or 3 metres in height, before adjacent stands may be harvested. A cutblock adjacency requirement of a maximum of 25% of an area being developed for harvesting may be less than 3 metres tall is used in this analysis. This is based on the *Coast Planning Guidelines* requirements for cutblock and leave area size. The purpose of the green-up period and cutblock adjacency requirements is to prevent recent timber harvesting from becoming overly concentrated in an area at any time.
- Visual quality — 43% of the timber harvesting land base is being managed for visual quality. Maintaining visual quality requires that visible evidence of harvesting be kept within limits. Guidelines are stated in terms of the maximum proportion of an area that may be less than 5 metres tall (the visual green-up condition). The proportion depends on the specific visual quality objective (VQO)* and the visual sensitivity*. Areas managed for visual quality fall into three categories: 1) retention* where visible evidence of timber harvesting must be minimal; 2) partial retention* where harvesting may be noticeable, but not dominant; and 3) modification* where harvesting may be visually dominant, but must blend with the natural landscape. Appendix A, "Description of Data Inputs and Assumptions" contains a detailed description of the specific objectives that apply to these categories.

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

Cutblock adjacency
The desired spatial relationship among cutblocks as specified in integrated resource management guidelines. They can be approximated by specifying the maximum allowable proportion of a forested landscape that does not meet green-up requirements.
Green-up
The time needed after harvesting for a stand of trees to reach a desired condition (e.g., top height) to ensure maintenance of water quality, wildlife habitat, soil stability or aesthetics.
Visual sensitivity
A measure of the level of concern for the scenic quality of a landscape. Visual sensitivity ratings take into account the physical character of the landscape, as well as viewer related factors such as the number of viewers and the angle, position, and distance from which the landscape is viewed.

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

All forested areas in the Kingcome TSA are managed according to the *Coast Planning Guidelines, Vancouver Forest Region* with some areas subject to additional management guidelines to emphasize visual quality. The above discussion outlines two main forest management emphases within the Kingcome TSA:

- integrated resource management where cutblock adjacency objectives and a 3 metre green-up height requirement apply;
- visual quality management areas which are divided into the three visual quality objective classes noted above.

Figure 6 displays the composition of the timber harvesting land base according to main management emphasis.

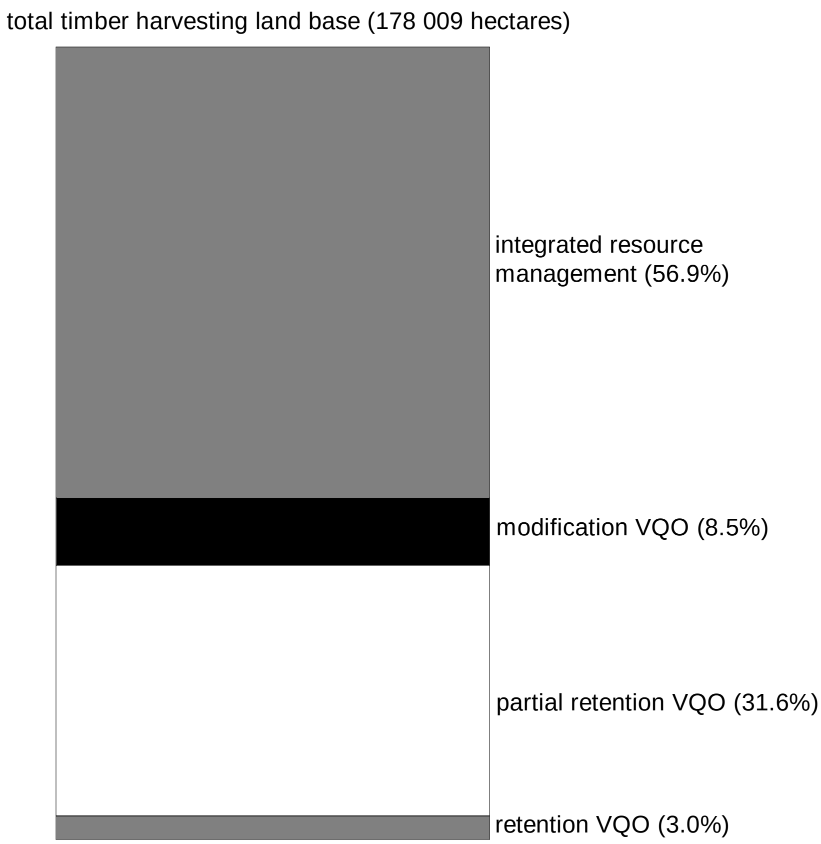

Figure 6. Major forest management emphasis zones — Kingcome TSA timber harvesting land base, 1995.

3 Analysis Methods

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

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

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

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

4 Results

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

The AAC for the Kingcome TSA totals 1 798 270 cubic metres per year, which includes an allocation of 139 500 cubic metres per year for harvesting of deciduous stand, low quality sites and woodlots. For the timber supply review only conventional conifer harvesting was assessed. Therefore the AAC used for this analysis is 1 658 770 cubic metres per year.

4.1 Base case harvest forecast

Figure 7 shows the base case harvest forecast*. The initial level of 1 068 600 cubic metres per year is 35% below the AAC used for this analysis. After the first decade, the harvest falls by 10% per decade until the lowest level of 779 000 cubic metres per year is reached in the fourth decade. This level is maintained through decade 15 after which the harvest level begins to rise toward the long-term harvest level. The harvest level that is sustainable over the long term — 902 600 cubic metres per year — is reached in 160 years.

The estimated unsalvaged losses to fire of 16 365 cubic metres per year have been subtracted from all harvest forecasts shown in this report.

Several criteria were used to define the base case harvest forecast. The initial level was defined as the maximum harvest level that would not cause large harvest shortfalls in the future. The rate of decline used was 10% per decade. The long-term harvest level was defined as the harvest that will maintain timber growing stock* at an even level so that harvesting can continue at a constant level in perpetuity.

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

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

4 Results

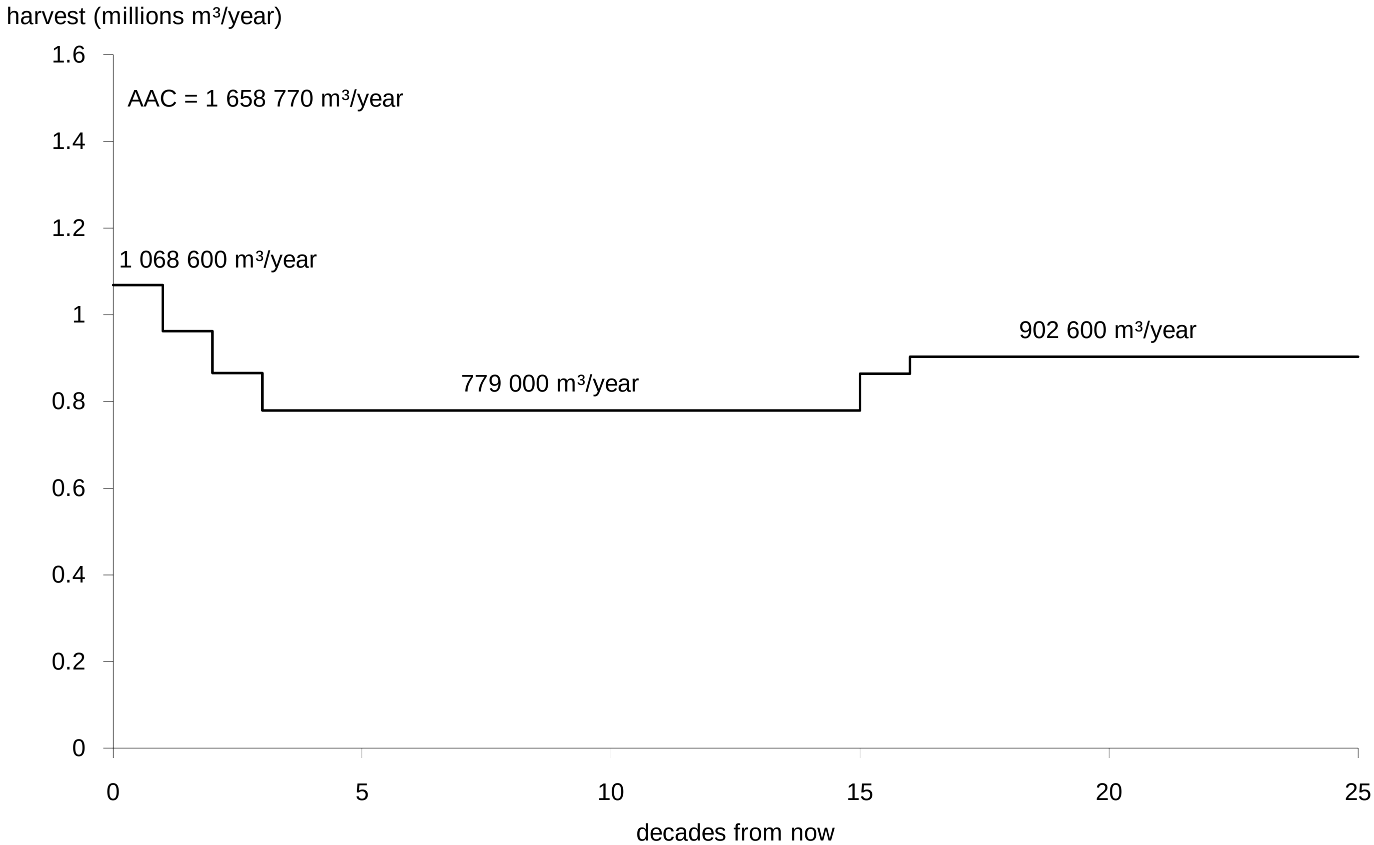

Figure 7. Base case harvest forecast — Kingcome TSA, 1995.

It is not possible, given current management assumptions, to develop a harvest forecast that does not fall below the long-term harvest level. Three main factors contribute to the base case harvest forecast:

- A limited amount of mature timber is available for harvesting over the next 12 decades.
- A large amount of forest is initially younger than the green-up ages in all management zones. In fact, the retention VQO and the modification VQO areas have more than double the maximum area allowed below the required green-up age. As a result there is little harvesting from these areas in the first few decades.
- Managed stands are expected to produce higher volumes per hectare than the present natural stands. However, harvests cannot increase to the long-term harvest level (based on the higher productivity) until second-growth stands reach a harvestable condition well into the future.

Over the first 40 years forest cover in the visual quality management and the integrated resource management zones just meet or sometimes exceed the allowed maximum area below the green-up age. Exceeding the maximum allowable area below the green-up age is caused by a combination of the amount currently below the green-up age, as noted above, and the harvesting of Timber Licences over the first 40 years. The Timber Licences that revert to Crown management total 16 332 hectares or about 3% of the timber harvesting land base. The majority of the Timber Licences revert during the second decade. After the fourth decade the maximum allowable areas below green-up are never exceeded. Harvest levels in the short term cannot be increased without causing further violations of the forest cover guidelines

The earliest that the harvest can begin to rise toward the long-term harvest level, with no significant shortages later, is 12 decades from now. However, to begin the rise to the long-term level at this time, harvests would need to be much lower than in the base case during decades 4 to 12. In order to partially mitigate this large trough, the rise to the long-term level was delayed until decade 16.

The substantial reduction below the current AAC shown in the base case harvest forecast was also predicted in the 1990 timber supply analysis completed for the Kingcome TSA. Although that analysis indicated that continuing at the current rate of harvest would be possible for 10 years, it also showed a sharp decline in the rate of harvest and that the harvest level would eventually have to be reduced well below the long-term harvest level.

Figure 8 shows the projected timber growing stock over time. The total timber growing stock is projected to decline from 71 million to 49 million cubic metres over the next 110 years, although most of this drop occurs within the first 40 years. The total growing stock then increases to about 52 million cubic metres in decade 16, and then decreases to 49 million cubic metres by 300 years from now. The growing stock remains stable after this point, indicating that the long-term harvest level for the base case (Figure 7) is close to the maximum, though it does not exceed the timber growing capacity of the land base.

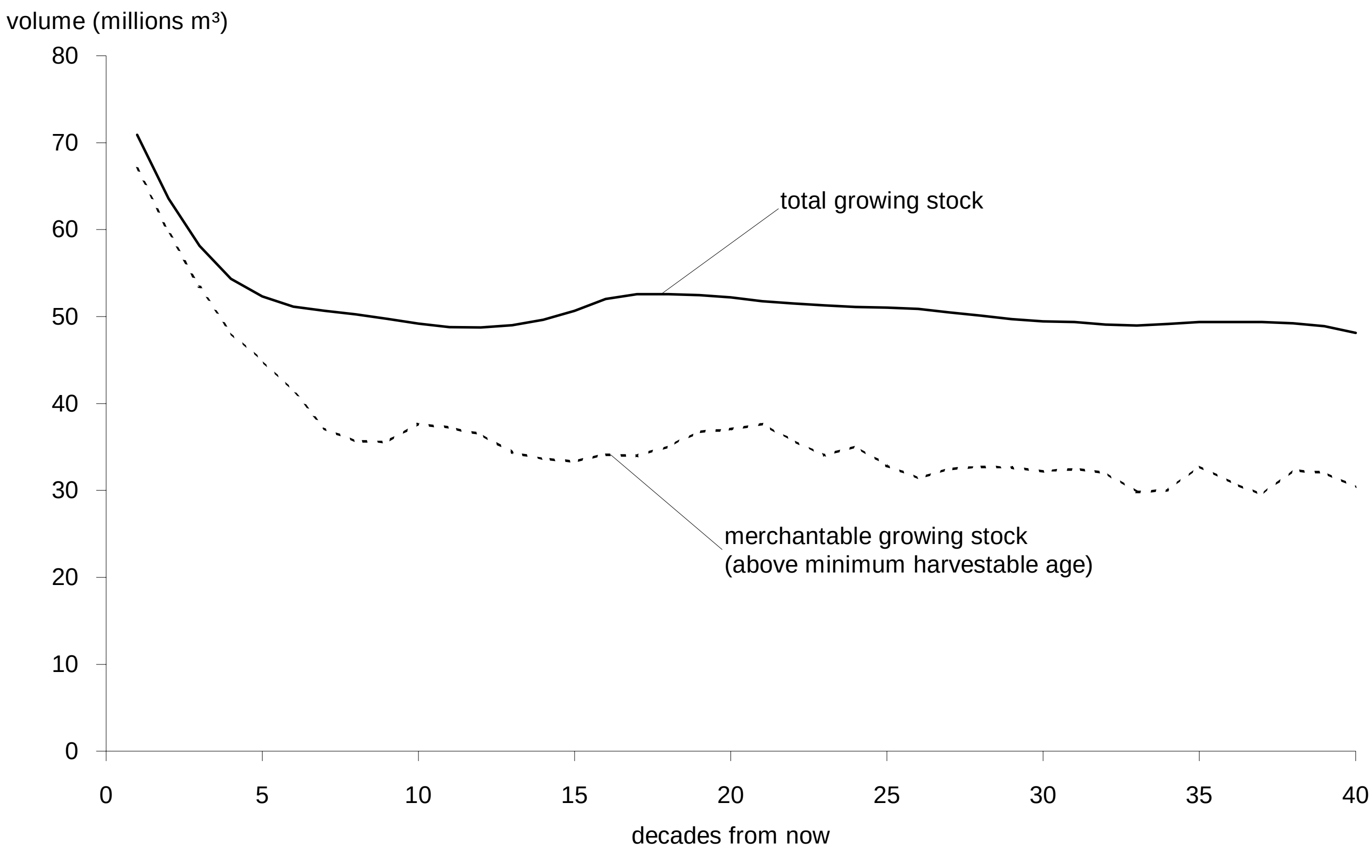

Figure 8. Changes in timber growing stock over time — Kingcome TSA, 1995.

The merchantable growing stock (only stands of harvestable age) declines rapidly over the first 70 years. Starting at about 67 million cubic metres (94% of the total volume), the available volume declines to a long-term average of about 31 million cubic metres (63% of the total volume).

The long-term harvest level is not the same as a theoretical maximum sustainable harvest level based on the maximum mean annual increment (MAI)*. The long-term harvest level* in the base case is about 12% less than the maximum average growth rate of the Kingcome TSA land base. This is because stands are not harvested exactly at the age that maximizes long-term volume production (that is, the age of maximum average annual growth) due to forest cover objectives, applied minimum harvestable ages and practical limitations on scheduling harvests.

As noted above, timber productivity in managed second growth is expected to be higher than in existing timber. Growth estimates used in this analysis result in a long-term harvest level about 39% higher than if second-growth stands were expected to grow at the same rate as existing unmanaged stands. The effect of using existing stand volume estimates for second growth is examined in Section 5.4, "Uncertainty in regenerated stand volume estimates."

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

4.2 Age class composition over time

The charts in Figure 9 show how the age composition of the forest within the timber harvesting land base would change over the next 250 years under the base case harvest forecast. Currently, in the timber harvesting land base about 47% is at or above 120 years old. Most of this area is older than 300 years. A large proportion of the stands are of younger ages, as a result of a long harvesting history in this area. About 17% of the land base is comprised of stands younger than the green-up age. Over time most of the very old forest is harvested, and the bulk of the timber harvesting land bases consists of stands 100 years old or younger.

One of the reasons that the existing distribution of timber limits the harvest over the first 120 years is shown by the age class distribution 50 years from now. There are few stands in the 130- to 250-year age range. Thus the mature timber available at this time must last until younger stands are available for harvest. By 100 years from now a limited amount of stands are over the minimum harvestable age. However, a large amount of timber will become available for harvest within 10 to 20 years. In 150 years from now the age class distribution is beginning to balance, and after this balance is reached the harvest in the base case forecast increases to the long-term harvest level. At 250 years from now most of the forest is 100 years old or younger. The age class distribution also shows some stands being maintained at older ages (above 200 years) and a proportion between 110 and 170 years of age. Both of these are a result of the forest cover requirements* in the visual quality areas. This timber will eventually be harvested, but over an extended period of time.

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

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

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

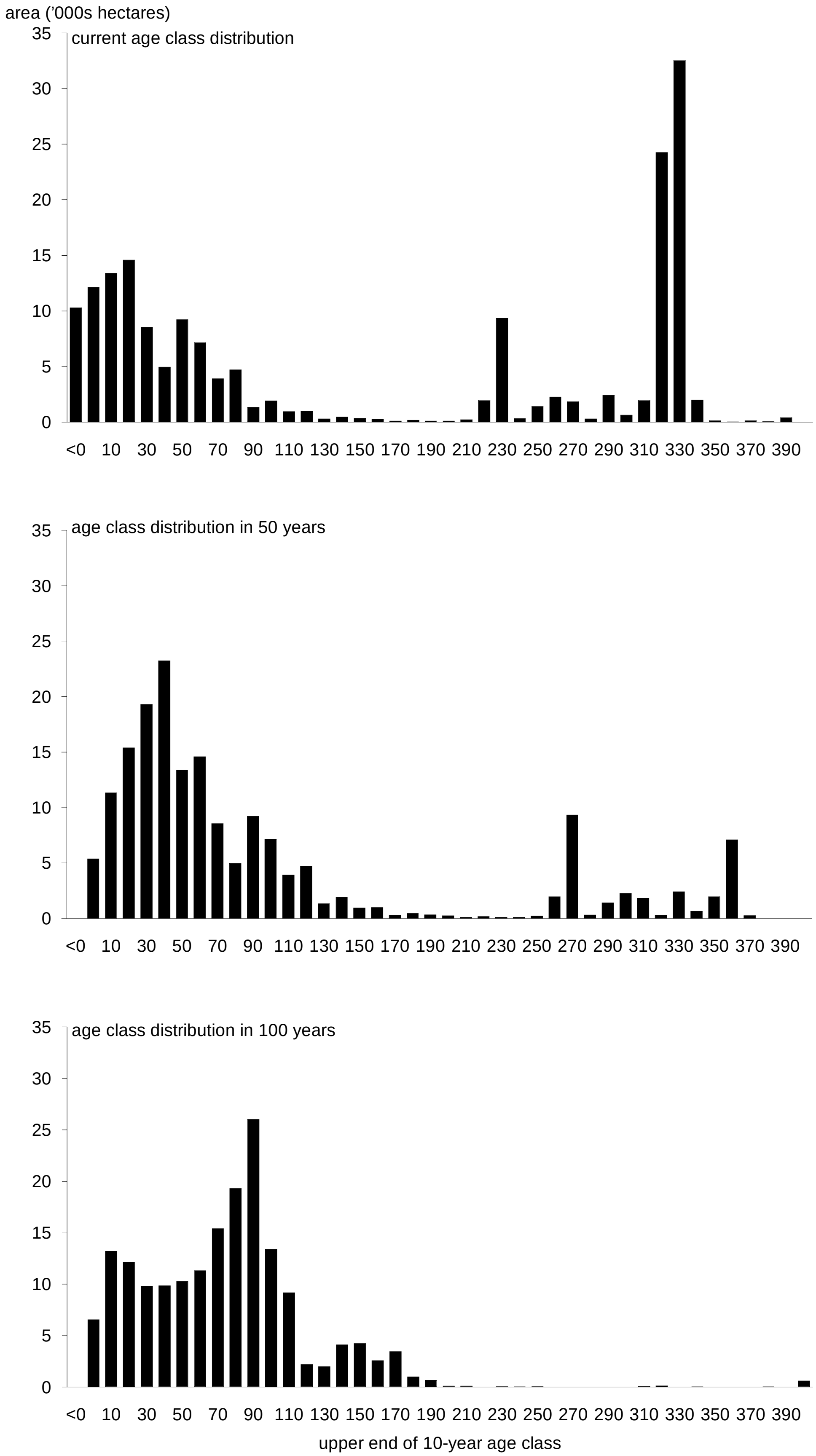

Figure 9. Changes in age composition on the timber harvesting land base over time— Kingcome TSA, 1995.

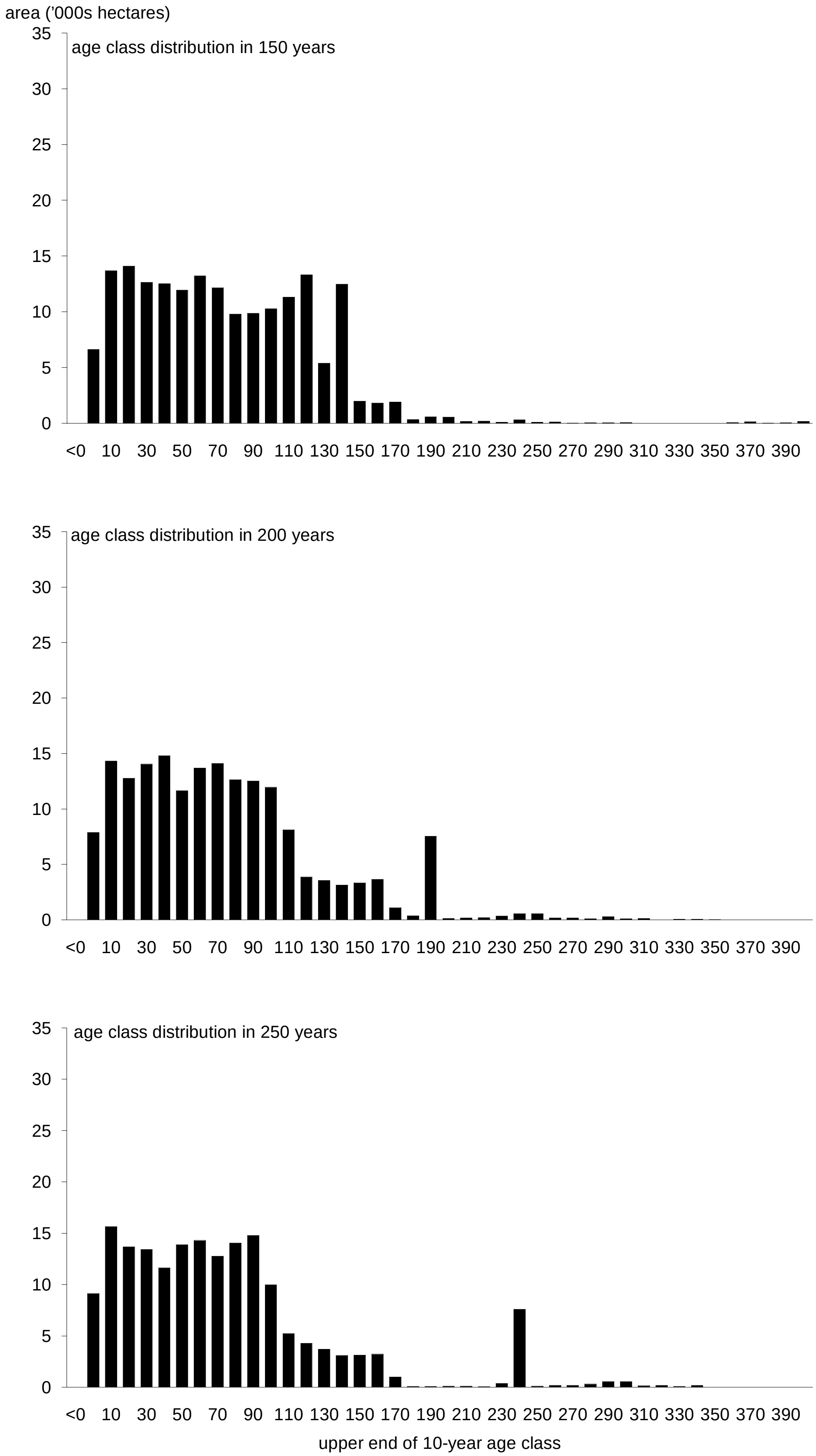

Figure 9. *Changes in age composition on the timber harvesting land base over time— Kingcome TSA, 1995 (concluded).*

4.3 Area, average volume, and average age harvested

Figure 10 shows how annual area harvested would change over the next 250 years if the base case harvest forecast were followed. Figure 11 shows changes in the average timber volume per hectare harvested over the same period. These graphs show a fluctuating pattern which, for example, can be seen during decades 16 and 17. A large amount of area is harvested in decade 16 with a corresponding low volume per hectare being harvested. During decade 17 the area harvested is low with a high volume per hectare harvested. This relationship is expected since the annual timber harvest is constant at 902 600 cubic metres per year at this time.

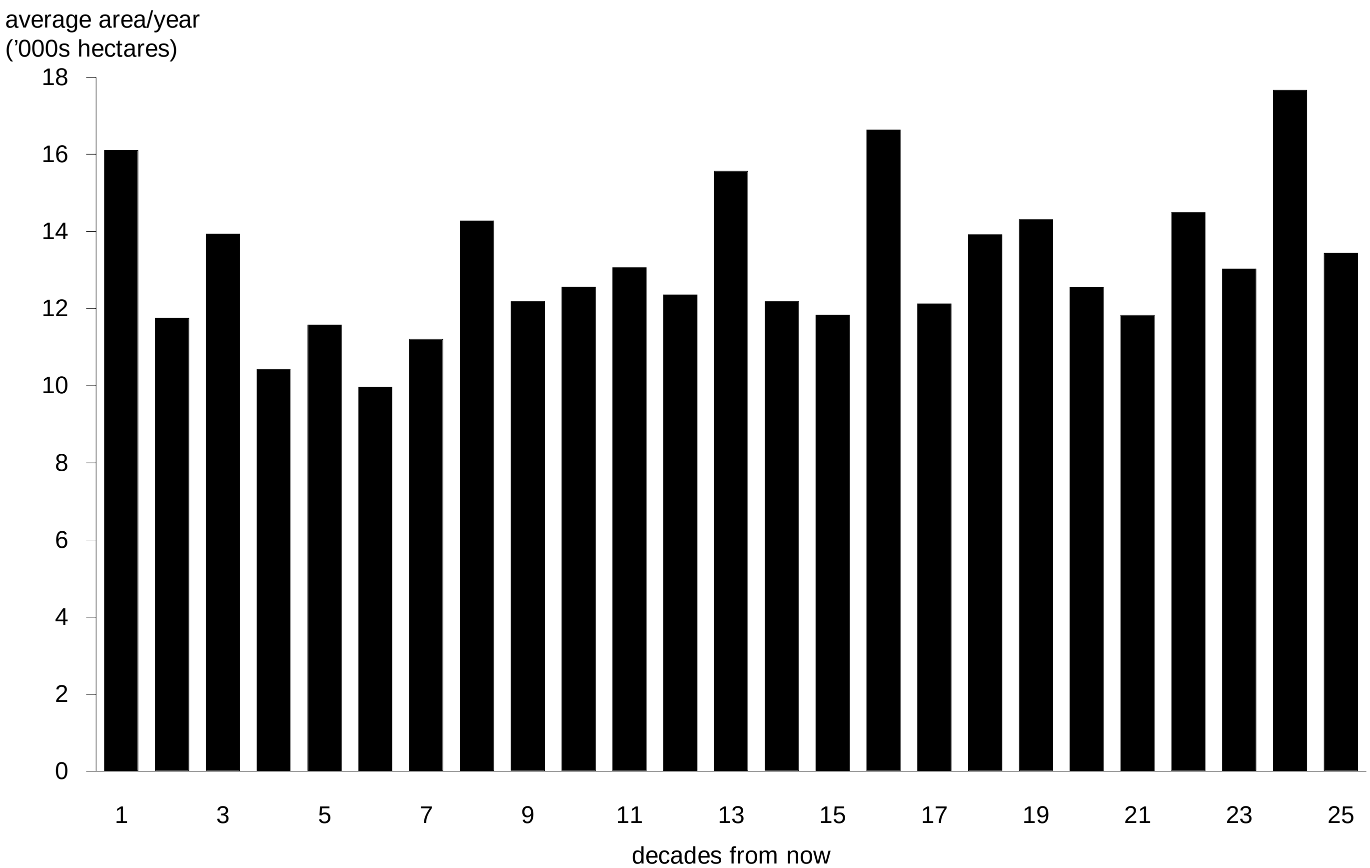

Figure 10. Area harvested over time, including non-recoverable losses — Kingcome TSA, 1995.

This pattern of a relatively high amount of area being harvested periodically is a result of the composition of the existing mature timber. Figures 4 and 5 show that the remaining mature timber is mostly on poor quality sites. Thus in the first decade, 75% of the area harvested is on poor quality sites. The third decade harvest is also predominantly from poor sites (87%). The sets up a recurring pattern, for example in decade 16 the majority of the mature timber is once again on poor sites, and 65% of the harvest occurs on poor sites.

4 Results

Figure 11 shows that the average volume per hectare harvested changes over time. During the first 70 years, when existing older stands are harvested the average is about 728 cubic metres per hectare. During decades 8 to 16 there is a lower average of just over 600 cubic metres per hectare, corresponding to the time during which the harvest level is below the long-term harvest level. After decade 16 the average volume harvested is 672 cubic metres per hectare.

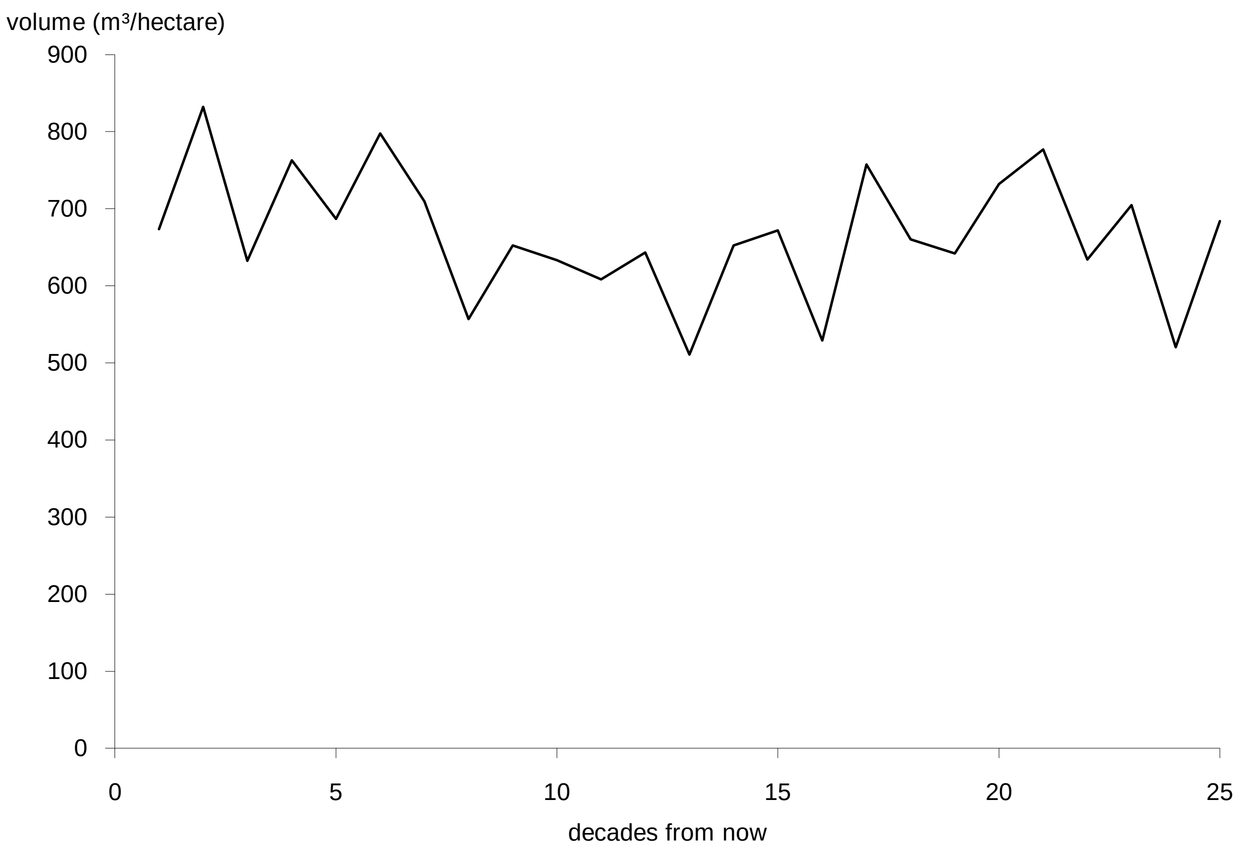

Figure 11. Average volume per hectare harvested over time — Kingcome TSA, 1995.

Figure 12 tracks the change in average stand age harvested for the base case harvest forecast. Over the first 50 years the average harvest age is about 340 years. After the fifth decade the average harvest age drops dramatically. Between decades 5 and 8 there is a rapid transition of harvesting from primarily old existing stands to primarily second-growth stands. The change to harvesting mostly second-growth stands is complete by decade 10 after which the average harvest age is 129 years. The average minimum harvestable age for second-growth stands in this analysis is about 95 years (these ages are shown in Table A-10. in Appendix A, "Description of Data Inputs and Assumptions"), so actual harvest ages are above the minimums most of the time.

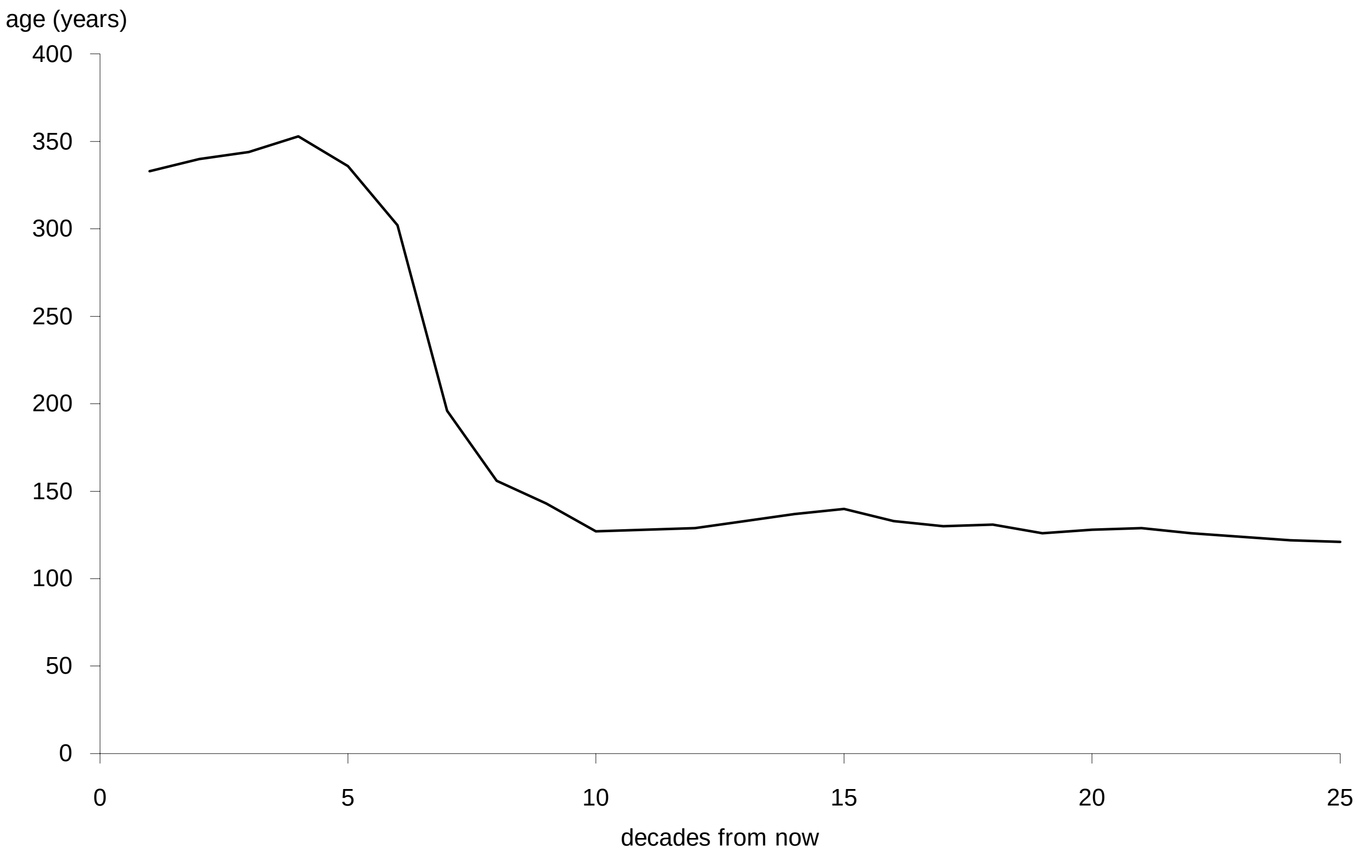

Figure 12. Average harvested age over time — Kingcome TSA, 1995.

As the transition to harvesting of mostly second-growth stands takes place by decade 10 the long-term harvest level should be reached around this same point, but as explained previously it was not possible to start increasing to the long-term level until decade 12 without causing large disruptions in timber supply. The choice to delay the rise to the long-term harvest level until decade 16 means that during a portion of decades 4 to 16 there is a large amount of second-growth stands being harvested.

5 Timber Supply Sensitivity Analyses

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

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

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

Some recognition of the potential effects of uncertainty is important because every decision, either implicitly or explicitly, incorporates an attitude towards uncertainty. For instance, someone who feels that existing information accurately reflects reality is, technically speaking, neutral to uncertainty, essentially believing that any inaccuracies probably balance out. Ignoring uncertainty is implicitly neutral. If maximizing timber supply were the goal, someone with an optimistic attitude towards uncertainty would believe that current information probably underestimates timber supply, and that problems can be resolved through human ingenuity and changes to practices. A conservative position would be that current information probably overestimates timber supply, and that decisions should minimize the potential for future timber supply shortages, or negative effects on other values.

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

In this section, results of several sensitivity analyses are discussed. The results that are based on current forest management assumptions (shown in Figures 7 to 12) are referred to as the base case.

5.1 Alternative initial harvest levels and harvest flows over time

The base case harvest forecast shown in Figure 7 was defined using criteria such as maximum rate of decline per decade, avoidance of large harvest shortfalls, and maintenance of a fairly constant growing stock level over the long term. While the last of these criteria is linked to maintaining the productivity of forest land, and is therefore a legislated requirement, the other criteria are not requirements, rather they are attempts to avoid both excessive changes from decade-to-decade, and significant timber shortages in the future which might limit future options. However, there are many possible harvest flows, with different decline rates, starting harvest levels, and potential trade-offs between short-term and long-term harvests.

5 Timber Supply Sensitivity Analyses

It was not possible to start at the present AAC given current management. Figure 13 demonstrates the results of an attempt to start at the present AAC and decline at 10% per decade to the long-term harvest level under current management assumptions. The maximum initial harvest is 1 496 300 cubic metres per year, 10% below the AAC. The initial harvest level could not be increased beyond this level without further violation of the forest cover requirements. In decade 2 there is a dramatic drop to 610 486 cubic metres per year. This clearly demonstrates that there is limited timber available in the short term, given current management assumptions. There are also several other times when a significant shortage of timber is experienced due to combination of limited availability of mature timber and forest cover guidelines.

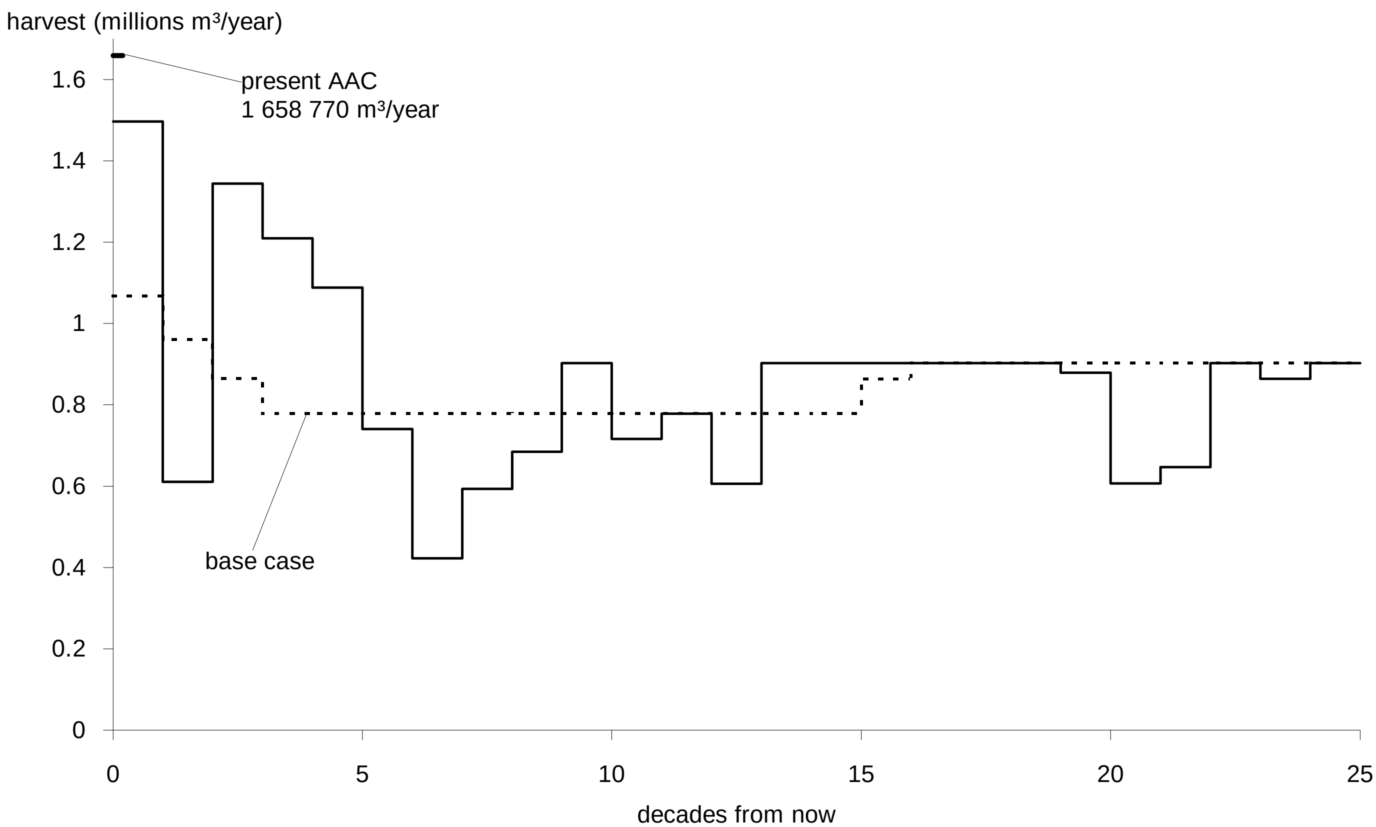

Figure 13. Alternative harvest flow patterns using base case data, attempting to start at present AAC— Kingcome TSA, 1995.

5 Timber Supply Sensitivity Analyses

In the base case harvests declined from the initial level at 10% per decade. Figure 14 compares the base case with harvest forecasts employing two alternative rates of decline (15% and 20%). After the third decade the harvest forecasts are almost the same as the base case. Because forest cover requirements limit availability of timber during the first 2 decades, increasing the rate of decline did not significantly increase the starting harvest level. If a higher level is harvested in the first decade, the second and third decade harvest is lower than that of the base case. If the rate of decline is set at a maximum of 20% per decade, the initial harvest level increases to 1 138 600 cubic metres per year, a 6% increase from the base case. With a rate of decline of 15%, the initial level is 1 108 600 cubic metres per year, a 4% increase from the base case.

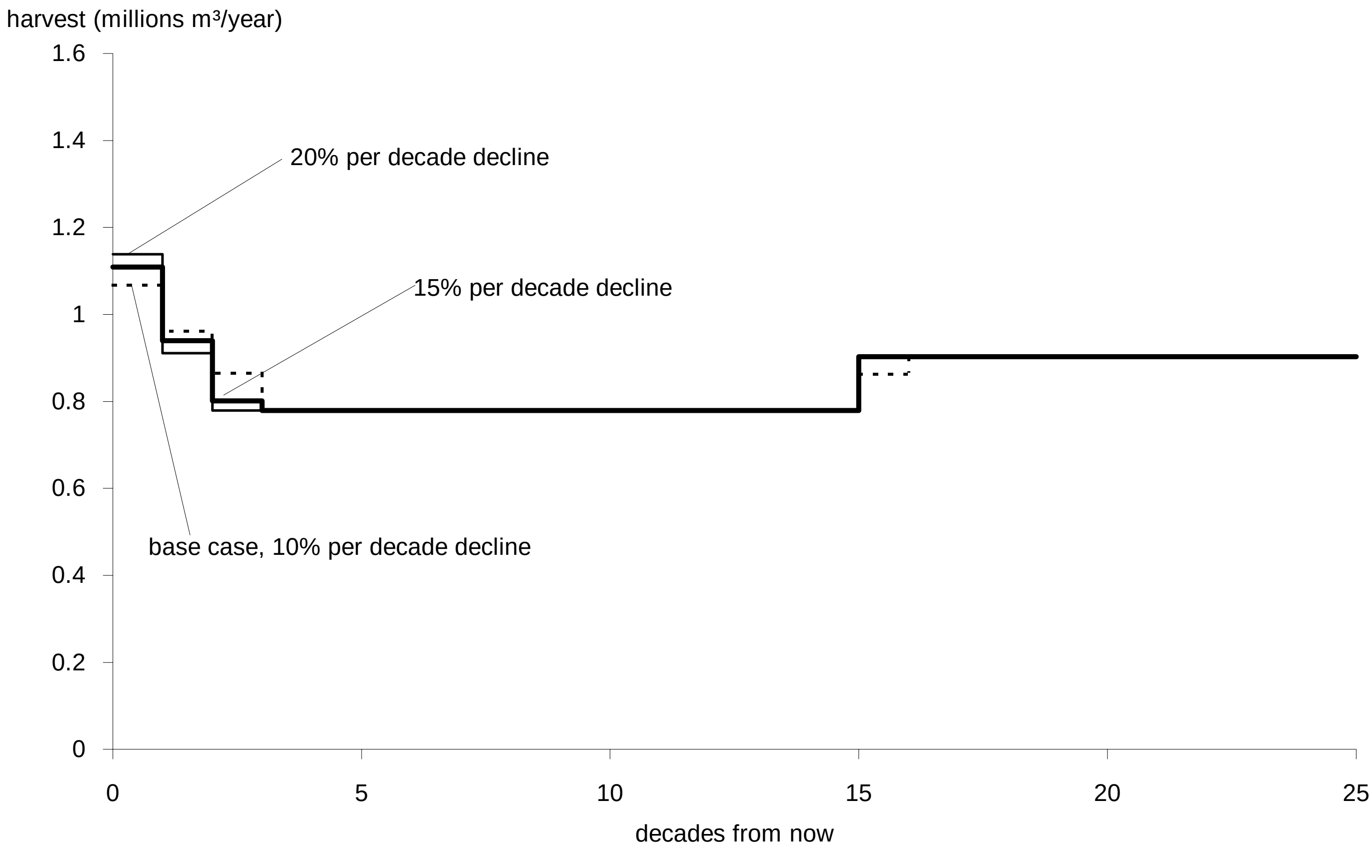

Figure 14. Alternative harvest flow patterns using base case data, different rates of decline— Kingcome TSA, 1995.

As stated in the base case results, it is possible to begin the rise to the long-term harvest level before decade 16. Figure 15 shows a harvest forecast that rises as early as possible without causing large shortfalls in the future. The harvest forecast is the same as the base case for the first 40 years, however after this the harvest level drops another 10% to 701 100 cubic metres per year. The lowest level in this forecast is 22% below the long-term harvest level, compared to 14% in the base case. There is a limited amount of merchantable timber available for harvest between decades 11 and 17. There are two ways to deal with this limitation, one is to harvest less timber during decades 5 to 11 (as in this flow alternative) or maintain the harvest level below the long-term level until after decade 16 (as in the base case). Alternative rates of decline were also tested with this earlier rise to the long-term harvest level, however the short-term harvest levels are the same as shown in Figure 14.

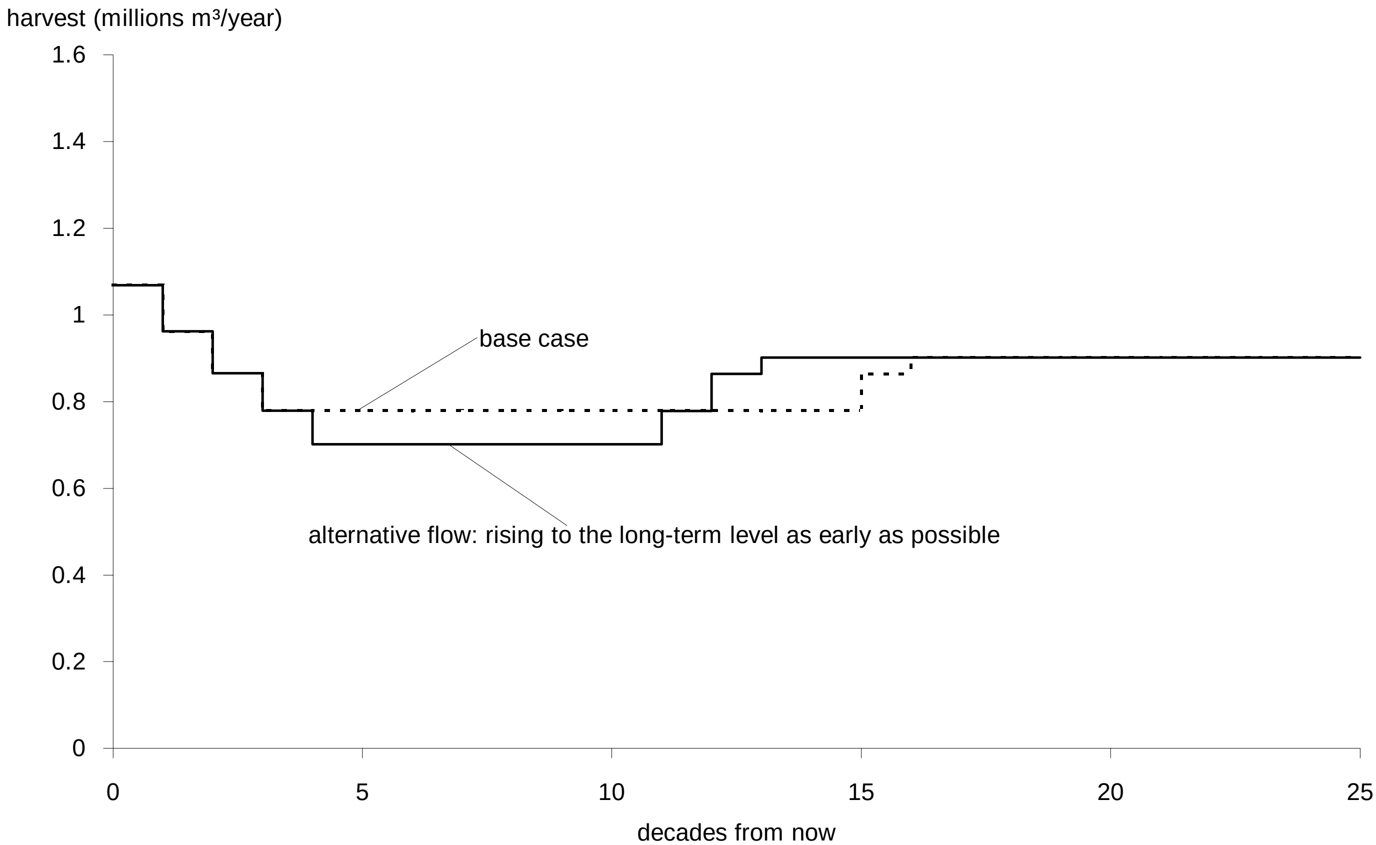

Figure 15. Alternative harvest flow patterns using base case data, rising to the long-term level as early as possible— Kingcome TSA, 1995.

5.2 Uncertainty in the land base available for harvesting

Defining the timber harvesting land base involves several assumptions about the types of forest lands that are available for harvesting. A recent study, used to define the timber harvesting land base for this analysis, by Port McNeill Forest District staff looked at the forest cover inventory and recent forest development plans to determine which stands are merchantable and physically operable. However, there are still several sources of uncertainty about the area considered available for timber harvesting:

- The size of the streamside and lakeshore buffers needed to protect fish habitat. As more experience is gained in using the *British Columbia Coastal Fisheries/Forestry Guidelines* and in understanding the interactions between fisheries and forestry, different buffers sizes may be required.
- There was no direct removal of land, or constraints placed on the timber harvesting land base to account for old-growth protection or biodiversity*.
- Classification of forests and land in the inventory file contain some inherent uncertainty.
- The final outcome of the *Vancouver Island Land Use Plan*. The Timber Supply Review process focuses on current forest management, not on future management or land use decisions that have not been finalized. At the time this analysis was initialized, land use decisions as part of the *Vancouver Island Land Use Plan* had not been made. The detailed implications on forest land use and management still need to be finalized. This analysis provides information that may be useful in assessing some of these implications. However, the effect of the *Vancouver Island Land Use Plan* on the Kingcome TSA will need to be assessed in the next analysis.

Two different methods were used to assess the sensitivity of timber supply to uncertainties in the size of the timber harvesting land base. For the first, the area in old-aged forests (greater than 120 years) was increased and decreased by 15%. In the second forecast the entire land base (all ages) was increased and decreased by 10%.

Figure 16 shows the results of increasing and decreasing the old-aged forest areas by 15%, which changes the overall timber harvesting land base by 7%. An increased old-aged land base allows the harvest to start at 1 175 600 cubic metres per year, a 9% increase over the base case. During decades 4 to 16 there is only a 4% increase over the base case. During this time the amount of mature timber that is available for harvest is limited and since the area of second-growth stands was not changed for this sensitivity analysis the overall availability increases by less than 7%. The long-term harvest level is 7% higher than in the base case.

Biodiversity (biological diversity)
Diversity of life in all its forms and levels of organization, including genes, species, ecosystems and the evolutionary and functional processes that link them.

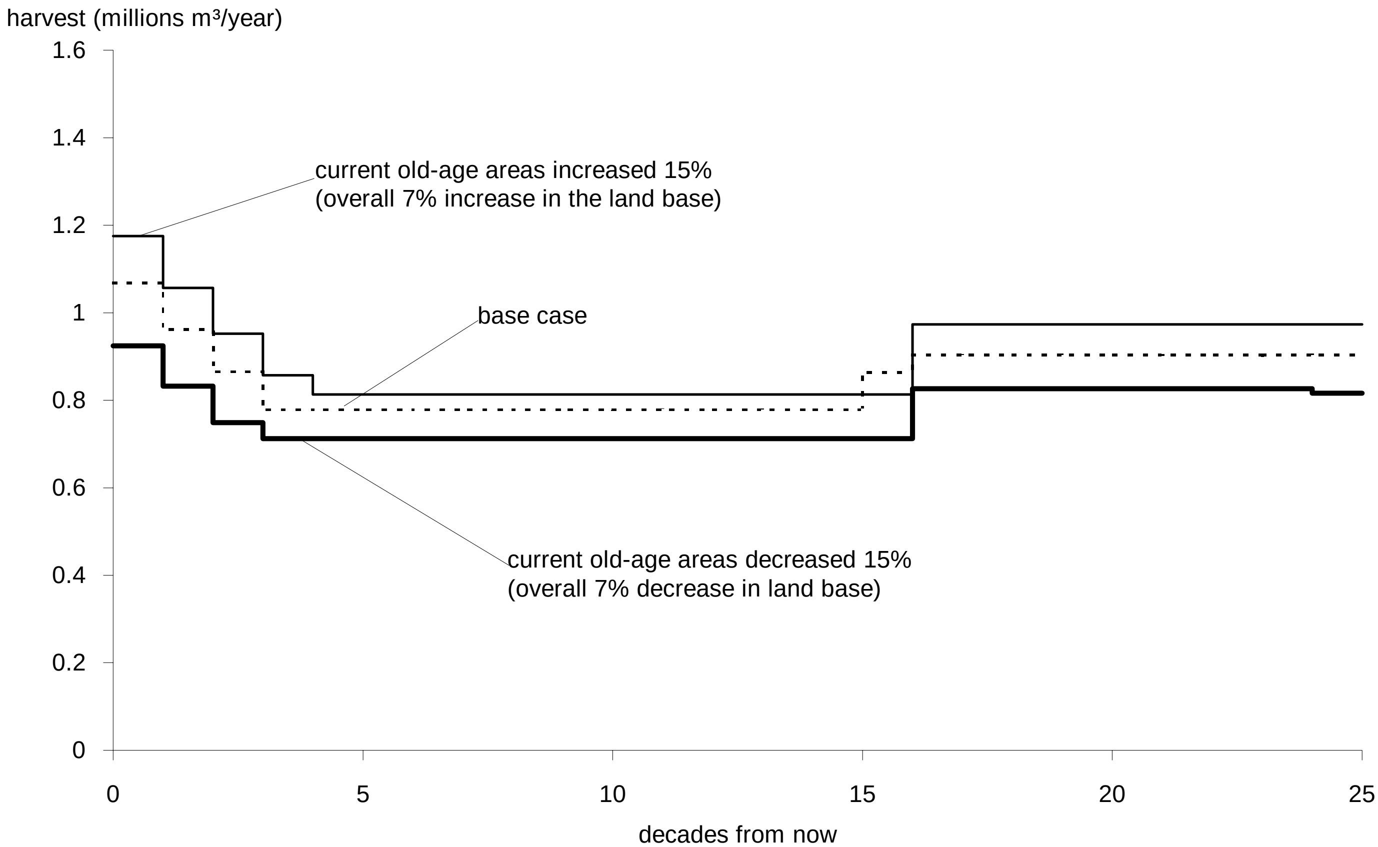

Figure 16. Harvest forecasts with the existing old-aged stands increased and decreased 15%— Kingcome TSA, 1995.

If the old-aged forest area in the timber harvesting land base is decreased by 15%, there is an immediate drop in the initial harvest level to 924 600 cubic metres per year. This level is 13% below the base case mainly because the forest cover guidelines become more limiting than they were in the base case. As the amount of mature area is decreased, the percentage of the current timber harvesting land base below green-up age increases. In addition there are fewer merchantable stands to support the harvest between decades 4 and 16. The harvest level during decades 4 to 16 and in the long term is about 8.5% below the base case. Removing only mature area means that proportionately more poor site cedar and hemlock/balsam stands are removed (see Figure 3). This exacerbates the problems encountered with periodic shortfalls due to harvesting large amounts of poor site in certain decades and results in a larger decrease (8.5%) from the base case in the long term.

In summary, the timber supply is sensitive to changes in the amount of mature timber in the timber harvesting land base. Increasing the amount of old age forest allows a higher initial harvest level and reduces the lowest level reached in the medium term. However, if there is a decrease in the amount of mature timber there is a large immediate impact.

5 Timber Supply Sensitivity Analyses

Figure 17 shows the sensitivity of timber supply to uncertainties in the area of stands of all ages in the timber harvesting land base. To assess the sensitivity, the area in all stands was increased and decreased by 10%.

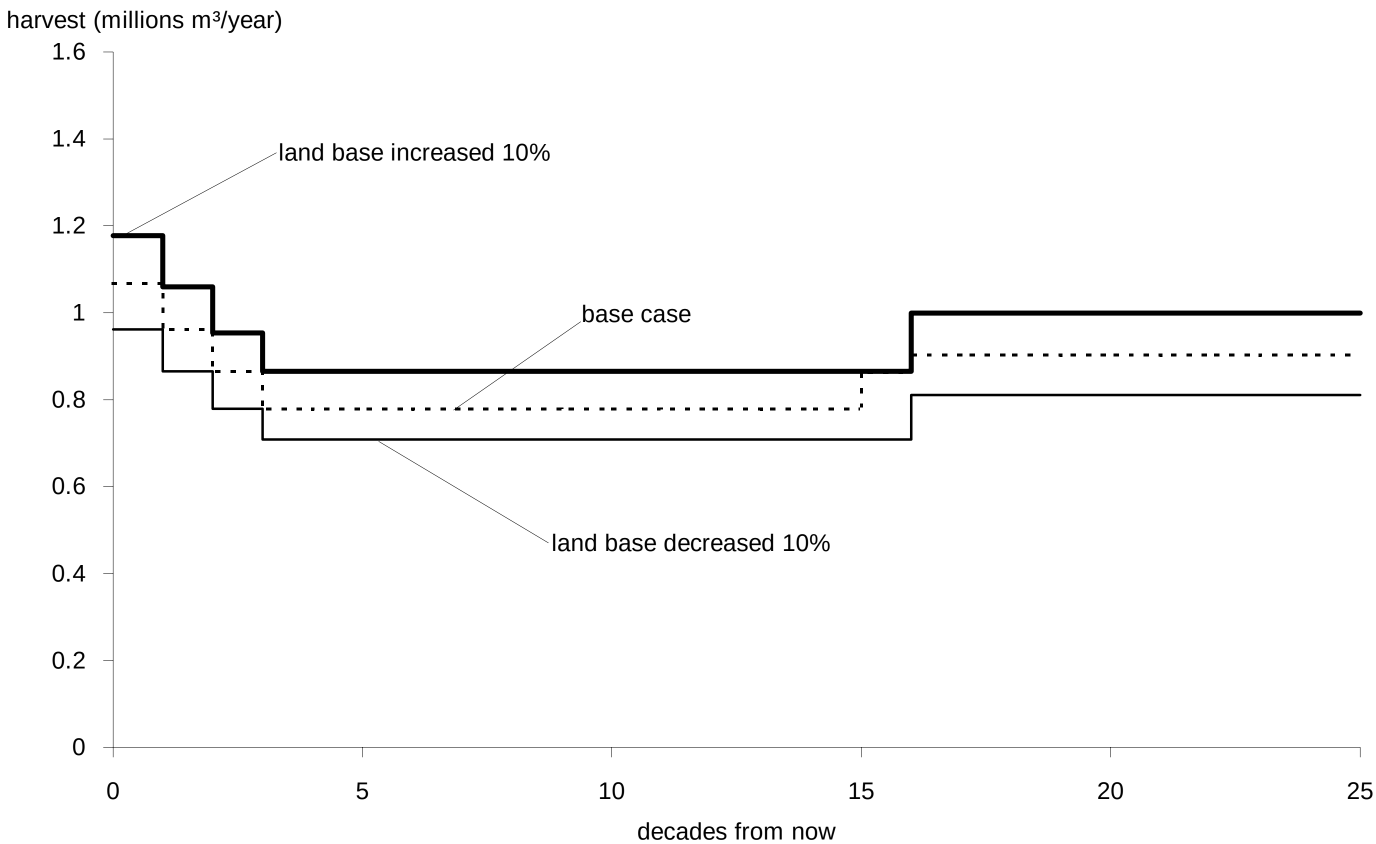

Figure 17. Harvest forecasts with the area in all stands increased and decreased 10%— Kingcome TSA, 1995.

The results show that there is a proportionate increase or decrease in the timber supply when the entire land base is increased or decreased. The difference between these two harvest forecasts and the base case is 9.5% or 10% at all times. Since all ages are increased or decreased there was no change in the effects of forest cover requirements or from the limited amount of merchantable timber available over the next 160 years.

5.3 Uncertainty in existing timber volume estimates

Estimates of timber volumes in existing stands are subject to uncertainty because they are based on extrapolation of statistics from some stands to all stands in an area, and on inventory classifications which contain uncertainty. The volumes are more accurate when averaged over large areas than they are for estimating volumes in a specific stand. Figure 18 demonstrates that timber supply over the first 16 decades is sensitive to uncertainty in existing volume estimates. If the existing volumes are actually 10% greater than those used in the base case the initial harvest level can increase 10% over the base case to 1 178 600 cubic metre per year. As there is a mix of old-aged stands and regenerated stands being harvested during decades 4 to 16, the increase over the base case at this time is only 8%. After decade 16 almost all of the harvesting comes from second-growth stands, the volumes of which were not changed in this sensitivity analysis; thus the long-term harvest level is the same as in the base case.

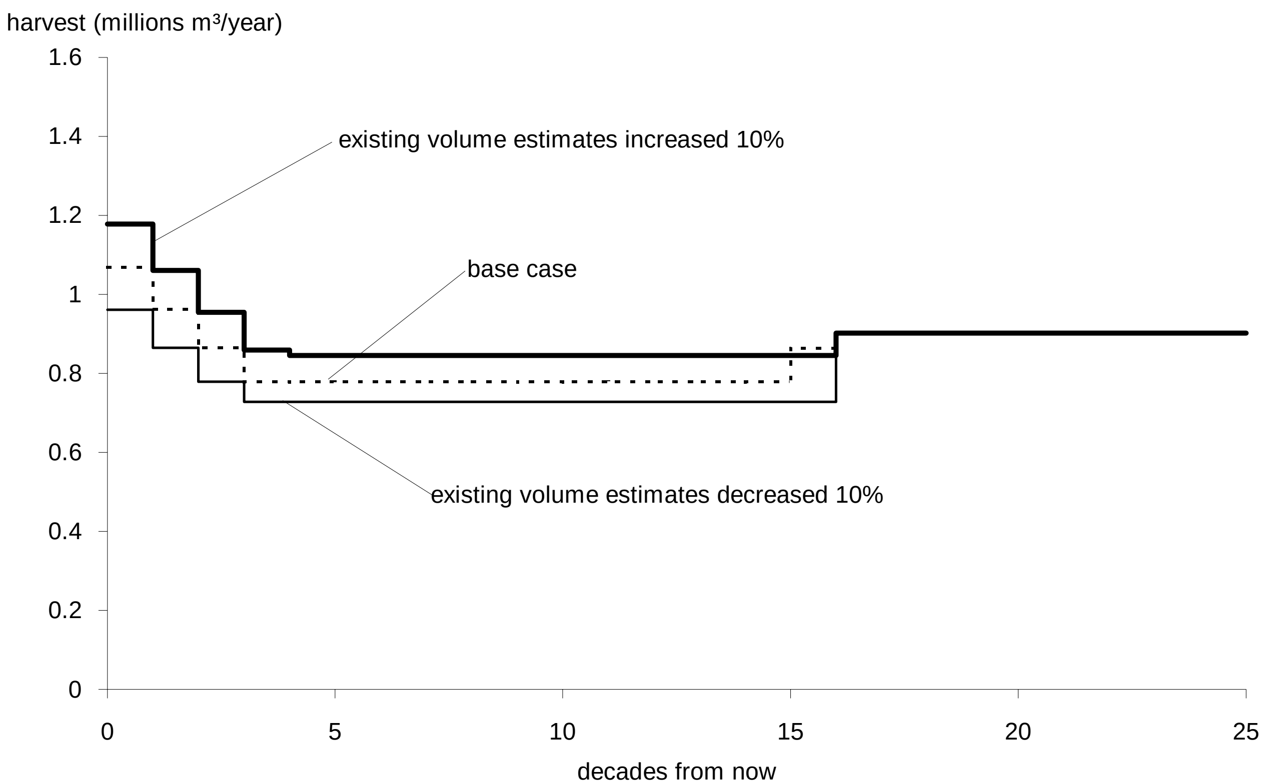

Figure 18. Harvest forecasts with the existing volume estimates increased and decreased 10% — Kingcome TSA, 1995.

If the existing volume estimates are decreased by 10%, there is a corresponding 10% drop in the initial harvest level. Again because of the mix of harvesting regenerated stands and old-aged stands during decades 4 to 16 the harvest level is only 6% below the base case.

5.4 Uncertainty in regenerated stand volume estimates

Estimates of timber volumes in regenerated managed stands are uncertain for similar reasons as in existing volumes, as well as uncertainty around the estimates of site productivity. In this section the effects on timber supply of using managed stand yield tables and their associated uncertainty are shown at two different levels.

For the first analysis the volume estimates for regenerated managed stands were changed by 10%. Figure 19 demonstrates that timber supply over the first 3 decades is not affected by this change. There are minor changes during decades 4 to 16 as there is some harvesting of second-growth managed stands during this time. However, the change is only 2% for both increased and decreased regenerated volumes. The long-term harvest level if the regenerated stand volumes are increased 10% is 1 000 600 cubic metres per year (10% above the base case). If the regenerated stand volumes are decreased 10% the long-term harvest level is 812 600 cubic metres per year (10% below the base case).

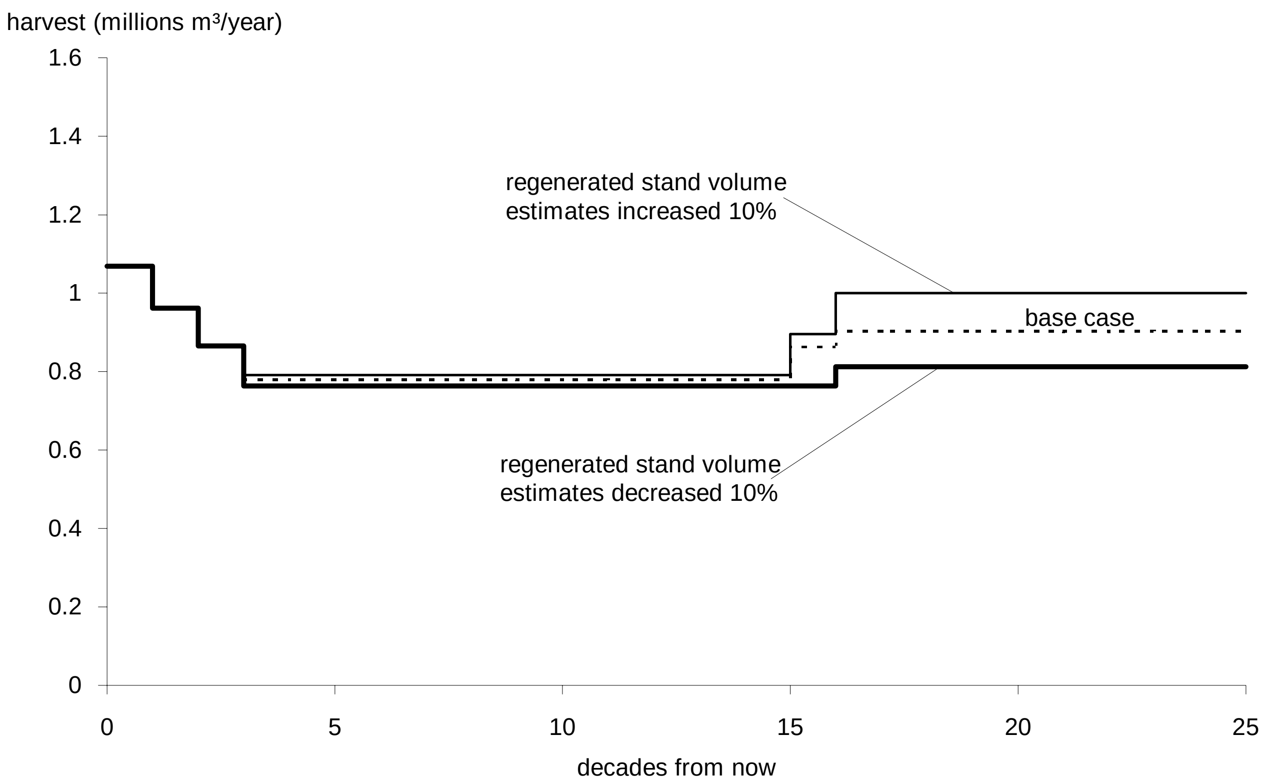

Figure 19. Harvest forecast if regenerated stand volumes estimates are increased and decreased 10%— Kingcome TSA, 1995.

There is a large degree of uncertainty about potential volume increases in regenerated stands. A second sensitivity analysis was done to examine the impact of increasing or decreasing regenerated stand volume estimates by 25%. Figure 20 shows that the results are similar to those from a 10% change in that timber supply over the first 3 decades does not change. There is, however, a larger change during decades 4 to 16. Harvest levels during decades 4 to 16 are 7% higher when the regenerated stand volumes are increased by 25%. When the volumes are decreased, the harvest level is 13% below the base case between decades 10 to 16 and the long-term harvest level is reached earlier. The long-term harvest levels are about 25% above or below the base case levels: 1 129 600 cubic metres per year if the regenerated stand volumes are increased 25%; 680 600 cubic metres per year if the regenerated stand volumes are decreased 25%.

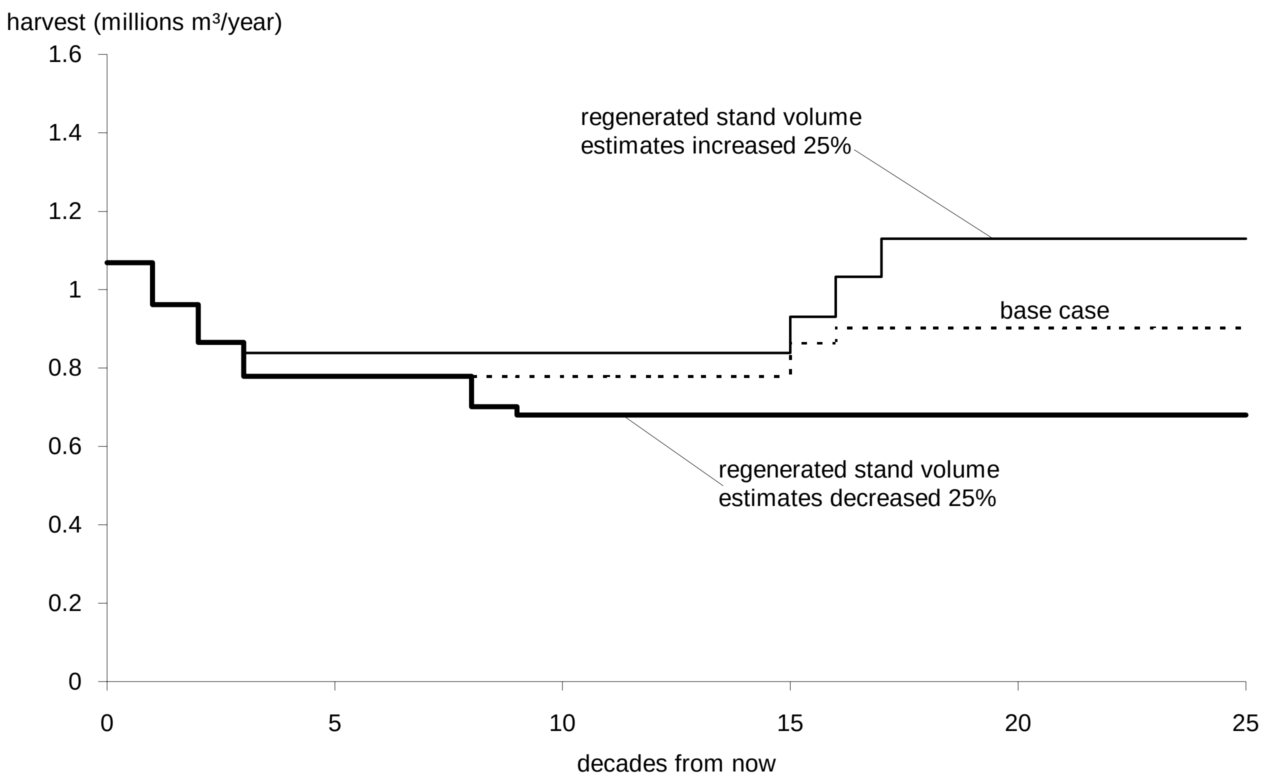

Figure 20. Harvest forecast if regenerated stand volumes estimates are increased and decreased 25%— Kingcome TSA, 1995.

5 Timber Supply Sensitivity Analyses

Figure 21 shows the effects on timber supply if future stands were to grow according to the volume estimates for existing unmanaged stands. In this case the VDYP estimates of volume for existing stands are also used as the volume estimates for regenerated stands. As this harvest forecast involves changing only the second-growth stands there is no change from the base case for the first 14 decades. The long-term harvest level in the base case is 39% higher due to the higher predicted volumes in managed stands.

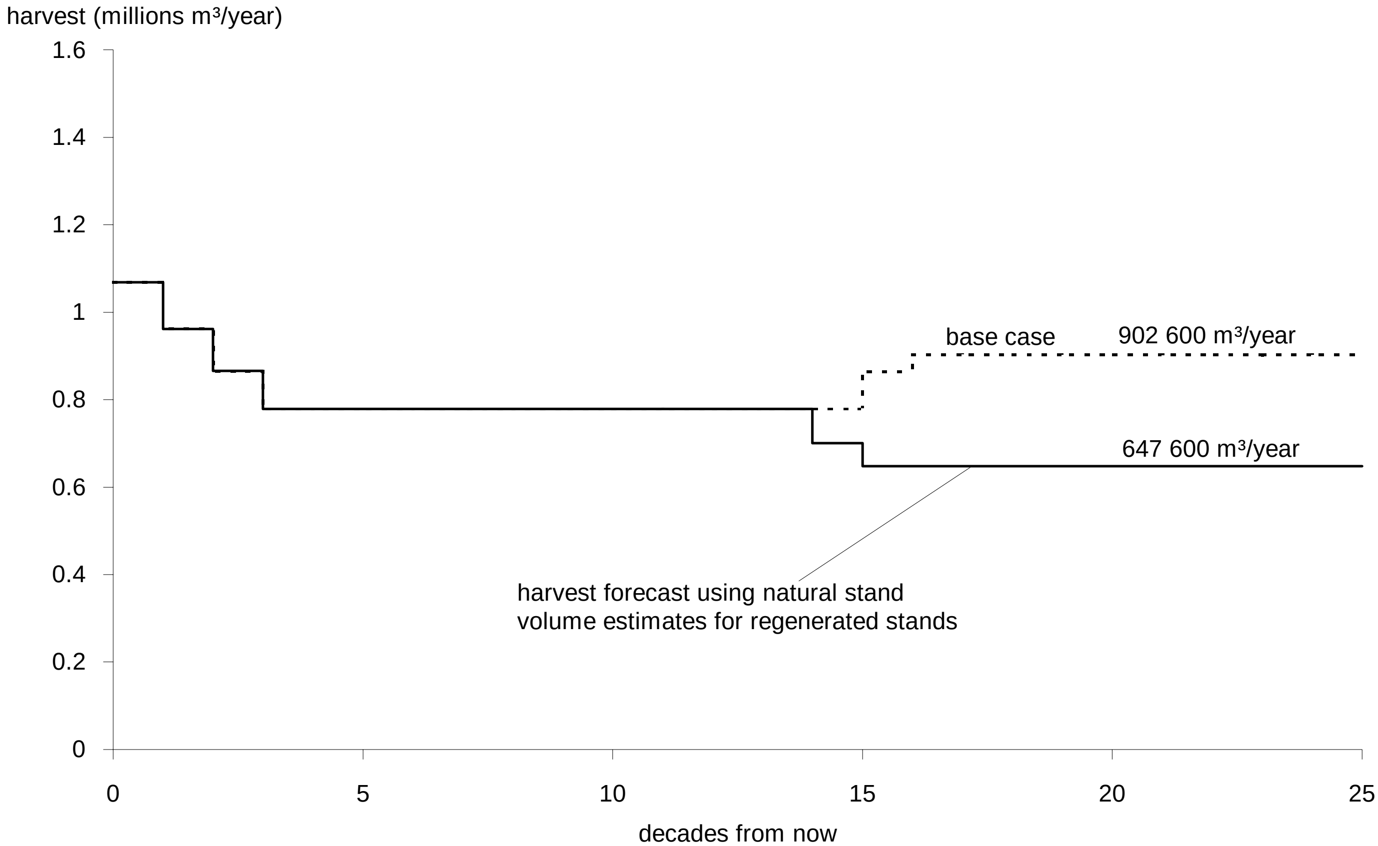

Figure 21. Harvest forecast if natural stand volume estimates are used for regenerated stands— Kingcome TSA, 1995.

In conclusion, the timber supply is only sensitive to changes in regenerated stand volume estimates in the long term. There are no short term changes to the timber supply.

5.5 Uncertainty in minimum harvestable ages

Minimum harvestable age is an estimate of the time needed for a stand to reach a merchantable condition. Minimum harvestable ages define when existing stands and second-growth stands will be available for harvest, and therefore affect how quickly existing stands may be harvested. The time at which stands will become merchantable is highly uncertain, partly because of uncertainty about the growth rates of regenerated stands, but more importantly because we do not know what conditions will determine merchantability in the future.

For this analysis, the minimum harvestable age is estimated to be the age at which the stand reaches an average growth rate within 5% of the maximum (or culmination of mean annual increment (MAI)). This age was chosen because it is very close to the point when the stands have reached a minimum of 350 cubic metres per hectare, and it ensures that the long-term production of the timber harvesting land base is close to its maximum. The minimum harvestable ages are minimums: stands may be harvested at older, but not younger ages. In many cases stands may be harvested at older ages to meet management objectives and forest cover guidelines. Minimum harvestable ages are meant to approximate the timing of merchantability, and are not necessarily legal or policy requirements.

Timber supply showed little sensitivity to increasing or decreasing the minimum harvestable ages by 10 years. The only difference from the base case is a 2% change in harvest levels during decades 4 to 16.

Figure 22 shows how timber supply would change if stands become merchantable 20 years sooner and later than assumed in the base case. This change has no short-term impact, however, when the minimum harvestable ages are decreased 20 years harvests during decades 4 to 16 are 14 600 cubic metres per year higher than in the base case. In addition, the rise to the long-term level of 876 600 cubic metres per year occurs in decade 14. Younger minimum harvestable ages reduce the long-term harvest level because stands are harvested before they attain their maximum average growth rate. Higher harvests in the time before the long-term level is reached mean that existing stands will be harvested more quickly, and that second growth must be harvested at younger ages to meet harvest targets. A harvesting pattern becomes set that requires subsequent harvesting to continue at these younger ages. Overall, younger harvest ages allow slightly higher harvest levels over the next several decades before the long-term level is reached, but at the expense of the long-term harvests.

If reaching merchantable conditions takes 20 years longer than in the base case the short-term and the long-term harvest levels are not changed from the base case. However, during decades 4 to 16 the harvest must fall to a level 5% lower than the base case. As stated in the base case discussion, the availability of mature timber in decades 10 through 16 limits harvests. Therefore, increasing the minimum harvestable ages exacerbates this shortage as less merchantable timber is available during this period.

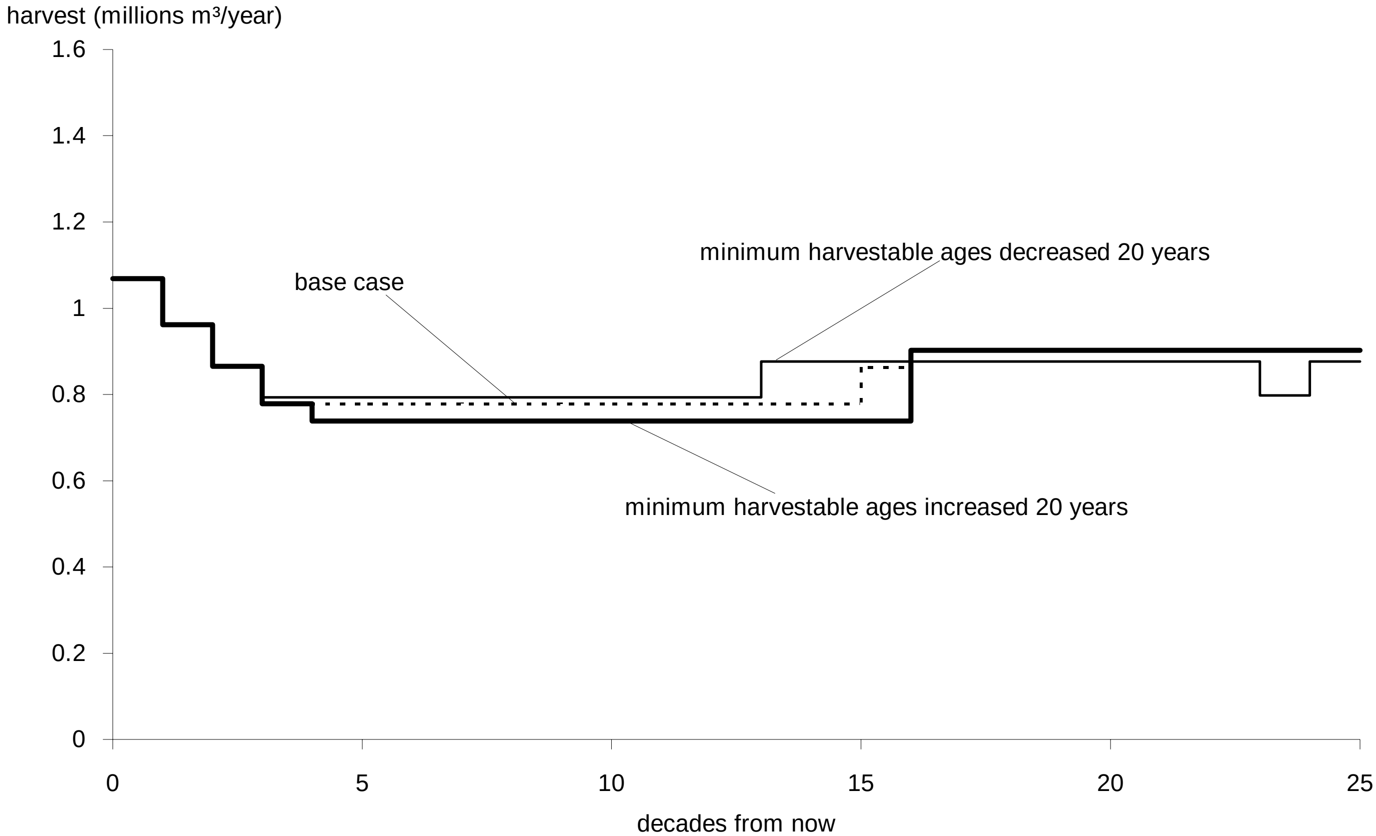

Figure 22. Harvest forecasts if minimum harvestable ages are increased and decreased 20 years— Kingcome TSA, 1995.

5.6 Uncertainty in site productivity

The productivity of a site largely determines how quickly trees will grow, and therefore affects both expectations of timber volumes in regenerated stands, and the age at which those stands will reach merchantable size. The most accurate assessments of site productivity come from stands between 30 and 150 years old. Estimating site productivity in both young and old stands is difficult. Growth in young stands often depends on recent weather, stocking levels (number of trees per hectare), and competition from other vegetation, as much as it does on site quality. Existing old stands have not been subject to management and thus the trees, used to measure site productivity, may have grown under intense competition or been damaged, and therefore do not reflect the actual site potential. The current age class distribution (Figure 5) shows there is a limited amount of the forest in this 30-150 year range. This section examines how timber supply is affected by uncertainty in site productivity estimates that determine both regenerated stand volumes and potentially, minimum harvestable ages. Site productivity could also affect the amount of time required to meet green-up conditions. Changes to the green-up age are evaluated in Section 5.11, "Uncertainty in green-up ages."

5 Timber Supply Sensitivity Analyses

Recent work in some TFLs in the Port McNeill Forest District and in other areas of the province indicates that for some species and sites, the site indices could be 4 metres higher than current inventory information predicts. On average, if this estimate is accurate, regenerated stand volumes would be 30% higher and minimum harvestable ages would be 20 years younger than in the base case. It should be noted that this estimate is not based on extensive field study in the Kingcome TSA. The changes to volumes and minimum harvestable ages used in this sensitivity analysis are broad averages; different species and sites would be affected differently by any changes to site productivity.

Figure 23 shows how timber supply might change if current data underestimated actual site productivity. If regenerated stand volumes are increased by 30% above base case levels, and minimum harvestable ages are decreased by 20 years, long-term harvest level is increased by 29% and in the period between decades 4 and 15 the harvest level is 11% higher than in the base case. There is no change to the short-term harvest levels as the forest cover constraints still limit the amount of area that can be harvested in the first few decades. The lack of a short-term effect is expected because none of the changes made in this sensitivity analysis affect existing stands. If the minimum harvestable ages are not changed and only the regenerated volume estimates are increased, the harvest forecast changes only slightly. This demonstrates that the gains in medium- and long-term timber supply due to increased estimates of site productivity are due primarily to the increased regenerated volumes.

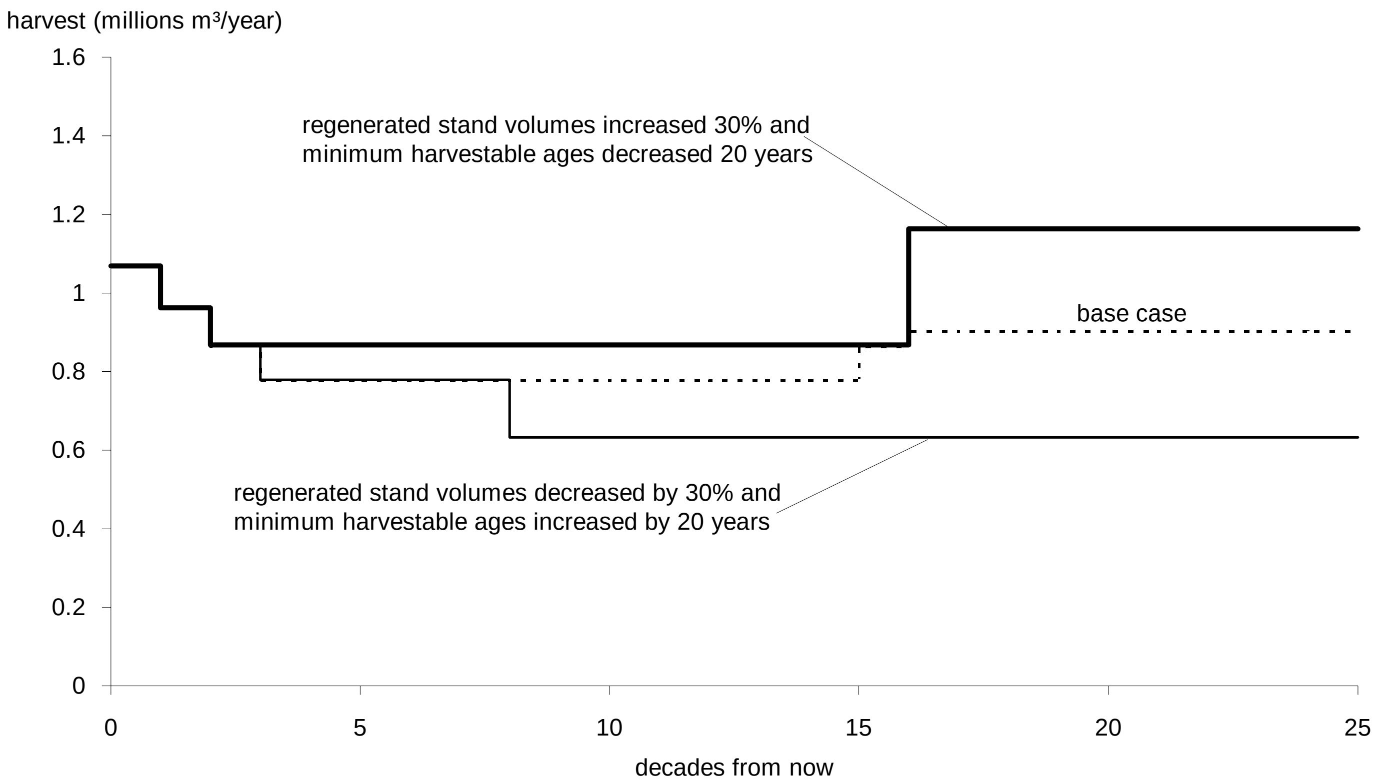

Figure 23. Harvest forecast if site productivity estimates for regenerated stands are increased or decreased — Kingcome TSA, 1995.

While most studies to date suggest that site productivity is underestimated using current inventory data, it is also possible that productivity may be overestimated. For instance, harvesting and road building may result in site degradation; or unforeseen disease, insect, or animal pests may reduce growth. If regenerated stand volumes are reduced by 30% and minimum harvestable ages are increased by 20 years the long-term harvest level would be about 30% below the base case level. However, there is sufficient existing volume for the harvest forecast to follow the base case through decade 7. Thus, even if current estimates of site productivity actually overestimate growth potential, harvests over the next 70 years would not have to decline below the base case levels. A controlled decline could be implemented. It should be noted that no evidence was provided that site productivity might be less than current estimates for the base case. This analysis was performed only to illustrate the implications of uncertainty about site productivity estimates.

5.7 Uncertainty in regeneration delay

Regeneration delay* is the time between harvesting and establishment of a new stand by either planting or natural regeneration. Regeneration delays for the base case are 3 years for fir and spruce stands, 5 years for cedar stands, and 6 years for hemlock and balsam stands. This section discusses how timber supply would be affected if stands are actually re-established more quickly or more slowly than assumed for the base case. Figure 24 shows that if regeneration delays are longer than in the base case, timber supply would decrease. If delays are actually 3 years longer, the initial harvest level is 983 600 cubic metres per year, 8% below the base case. During decades 4 to 16 the harvest level is 4.5% lower than the base case. The long-term harvest level of 875 500 cubic metres per year is 3% below the base case.

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.

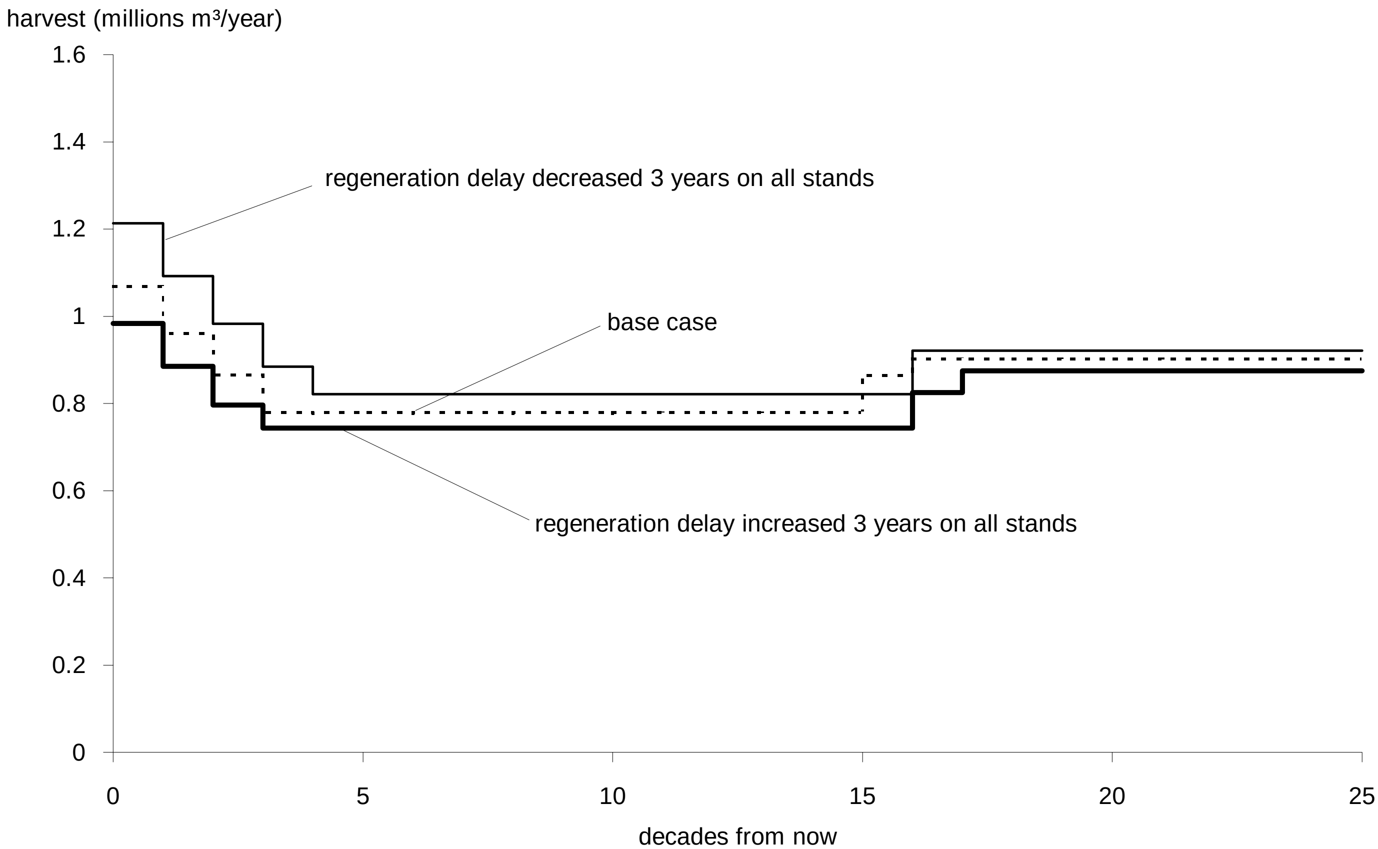

Figure 24. Harvest forecasts if regeneration delays diverge from the base case — Kingcome TSA, 1995.

If regeneration delays are 3 years shorter than in the base case, the harvest level increases by 5% during decades 4 to 16 and 2% over the base case level in the long term. However, the change in the short term is much larger. The initial harvest level increases to 1 213 600 cubic metres per year, 12% above the base case.

The effect on timber supply is due to both changes in the time taken to reach green-up condition and changes in the average land base productivity resulting from longer or shorter regeneration delays. For example, a shorter regeneration delay means that a stand would reach the green-up height and a specific volume in a shorter period than a stand with a longer delay. The harvest for the first several decades is highly constrained by the forest cover objectives, thus reducing the length of time to reach green-up can allow more overall harvest during the short term. In addition, the average production (volume divided by the time between successive harvests) of a stand experiencing a shorter regeneration delay is higher.

5.8 Uncertainty in the method used to represent adjacency objectives

The *Coast Planning Guidelines, Vancouver Forest Region* specify that previously harvested stands must be free-growing (assumed to be 3 metres in height) before adjacent stands may be harvested. In addition, the *Coast Planning Guidelines* place certain conditions on cutblock and leave area size. To ensure that harvesting does not become overly concentrated in any area and to incorporate the cutblock size requirements an adjacency objective was developed to set a maximum limit on the area that has not yet reached the green-up conditions in the integrated resource management (IRM) zone. Specifically a forest cover requirement that a maximum of 25% (4-passes) of an area being harvested may be less than 3 metres tall was used to approximate the adjacency requirements in this analysis.

Because the forest cover requirement is an approximation, it is not certain how accurately it reflects how adjacency affects timber supply.

The 4-pass guideline (a maximum of 25% of the harvesting land base may be younger than green-up age) in the IRM zone limits the second and third decade harvests. Thus, when the IRM zone adjacency guideline is changed to 3-pass, it is possible to increase the short-term harvest level. Alternative 1 in Figure 25 has an initial harvest level of 1 163 600 cubic metres per year, 8% above the base case. The harvest then falls at 10% per decade until the same lower level as in the base case is reached in decade 5. The second alternative attempts to maintain the harvest as high as possible between decades 4 and 16, while still having the same initial level as the base case. Since the base case is only limited by the adjacency constraint in the short term, and because the trough is so long, there is only a 2.5% gain over the base case during decades 4 to 16 in this alternative. Both of the alternative harvest forecasts based on a 3-pass system are not limited by the adjacency guideline, thus employing to a 2-pass system would not further increase timber availability. The long-term harvest level is not affected as the IRM zone adjacency guideline is not a limiting factor during the long term.

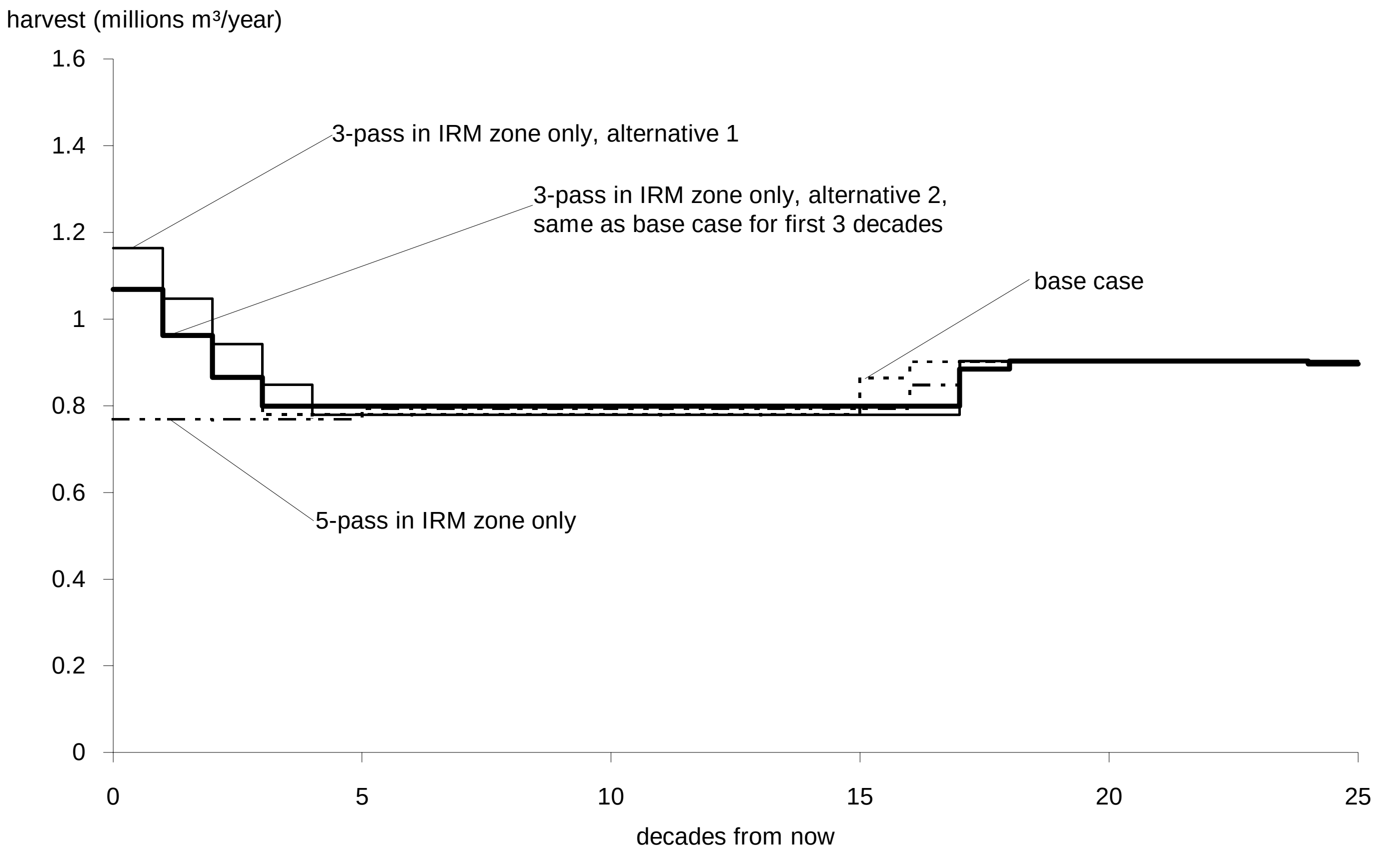

Figure 25. Harvest forecasts if the adjacency requirement to represent adjacency in the IRM zone is tighter or looser — Kingcome TSA, 1995.

There is some evidence that 5-passes may be required to meet adjacency objectives in many areas (Nelson and Errico 1993). Figure 25 shows the impact on timber supply if a 5-pass (maximum 20% of the area allowed below green-up age) guideline is used in the IRM zone. In the IRM zone, 16.5% of the timber harvesting land base currently has stands younger than the green-up age of 14 years. In addition, the second and third decades are already limited by a 4-pass guideline. Thus, there is a large impact in the short term when the forest cover adjacency requirement in the IRM zone is changed to mimic a 5-pass harvesting system. The initial harvest level is 768 600 cubic metres per year, 28%

below the base case. The harvest level increases slightly after the fifth decade to a level just below base case. The harvest level increases again after decade 17 to the same long-term harvest level as in the base case. Overall because the forest cover guidelines for adjacency are already limiting to timber supply in the first few decades there is a much larger decrease in timber supply when this constraint is tightened. Loosening this constraint to a 3-pass guideline results in factors other than adjacency having more of an impact on timber supply.

5.9 Uncertainty in forest cover objectives for visual quality

Visual quality objectives (VQOs) are stated in terms of the degree to which forestry activities may be visible. The B.C. Forest Service, Recreation Branch has provided a range of visible disturbance limits for each VQO category (stated as a maximum per cent area younger than the green-up age). Different disturbance limits will meet a particular objective for visual quality (for example, partial retention), depending on the terrain and forest in the area. For this analysis, determining the forest cover objectives for areas with different VQOs involved a series of calculations to incorporate information on visual sensitivity, and differing degrees to which forest outside the timber harvesting land base can contribute to visual quality objectives (see Appendix A, "Description of Data Inputs and Assumptions").

Uncertainty about forest cover objectives may arise due to uncertainties associated with inventory and classification of land into VQOs and sensitive categories, estimates of how well different disturbance limits may meet visual quality objectives, and estimates of how non-harvestable forest may contribute to visual quality. This section investigates how uncertainty in the forest cover guidelines for visual quality affect timber supply.

There is a large amount of area in VQOs in the Kingcome TSA, Figure 6 shows that 43% of the timber harvesting land base is covered by the three VQO categories. By far the largest of these is the partial retention VQO area at 32% of the timber harvesting land base. To examine the potential effects of uncertainty, forest cover objectives for each VQO category were both increased and decreased by 5% (that is, adding or subtracting 5 percentage points to the forest cover objective used in the base case).

Figure 26 shows that timber supply is very sensitive to uncertainty about VQO forest cover objectives. Increasing the allowable amount of area that does not meet green-up requirements (relaxing the guidelines) in each VQO category by 5% increases the initial harvest level to 1 163 600 cubic metres per year, 8% above the base case. The forest cover objectives for all three of the VQO categories are very limiting to timber supply. Requirements for the retention and partial retention categories, which cover 35% of the timber harvesting land base, limit harvesting in these areas in every decade in the base case. Thus application of a less restrictive VQO forest cover objectives will increase the amount of timber that can be harvested. The trough during decades 4 through 16 is almost eliminated. The harvest level during this period is 868 600 cubic metres per year, only 4% below the long-term level of 908 600 cubic metres per year, and 11.5% above the base case. There is only a small (0.7%) gain in the long-term level because the forest cover requirements do not limit the harvest in the long term to the same degree that they do over the first 16 decades.

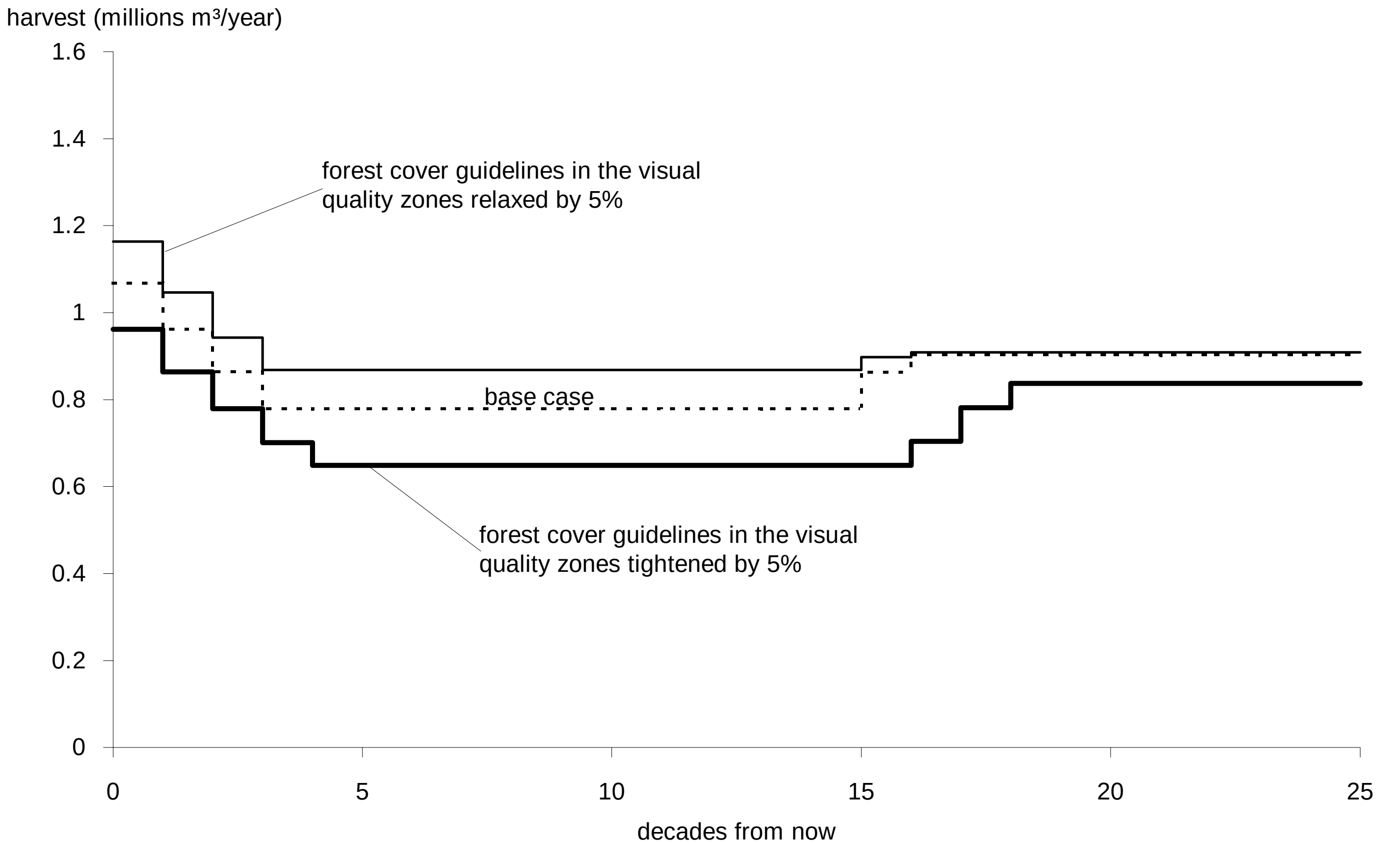

Figure 26. Harvest forecasts if forest cover objectives for visual quality management areas are changed by 5% — Kingcome TSA, 1995.

Decreasing the allowable amount of area that does not meet green-up requirements by 5%, that is employing more restrictive guidelines than in the base case, also has a large effect on timber supply. The initial harvest level must immediately drop 10% below the base case to 961 770 cubic metres per year. This change prohibits harvesting in the retention VQO areas in the timber harvesting land base. In the partial retention and modification VQO management areas the maximum percentage allowed below green-up age is just met or exceeded for most of the first 200 years. As in the base case, there is a limited amount of mature timber available for harvest during decades 10 to 16. The more restrictive cover requirements make less mature timber available and causes the trough to be 17% below the base case level. Due to the increased restrictions of the forest cover requirement for VQOs, the long-term harvest level is 7% below the base case level.

Timber supply is very sensitive to uncertainty in forest cover objectives for visual quality. If more restrictive guidelines are needed to meet visual quality objectives, harvests would have to be reduced below the base case initial level immediately. Conversely, if less restrictive guidelines are assigned to the VQO categories the short-term timber supply can increase and the trough is significantly smaller than in the base case.

5.10 Uncertainty to all forest cover objective area requirements

As stated in the previous two sections there is uncertainty about both the number of passes required to meet adjacency guidelines and about the forest cover guidelines in the visual quality management areas. This section investigates how increasing and decreasing the forest cover guidelines by 5% in all management zones would affect timber supply. Increasing the area that does not have to meet green-up requirements by 5% (loosening the constraint) results in a harvest forecast very similar to that shown in Figure 26 when only the visual quality forest cover guidelines were relaxed by 5%. Figure 27 shows that when all forest cover guidelines are loosened by 5% the initial harvest level is 1 183 600 cubic metres, 11% above the base case but only 20 000 cubic metres above the harvest level achieved by changing the forest cover requirements in the visual quality areas only. As stated earlier, the IRM zone forest cover objectives are only limiting in the second and third decades, thus, timber supply increases only slightly when the adjacency requirement is loosened.

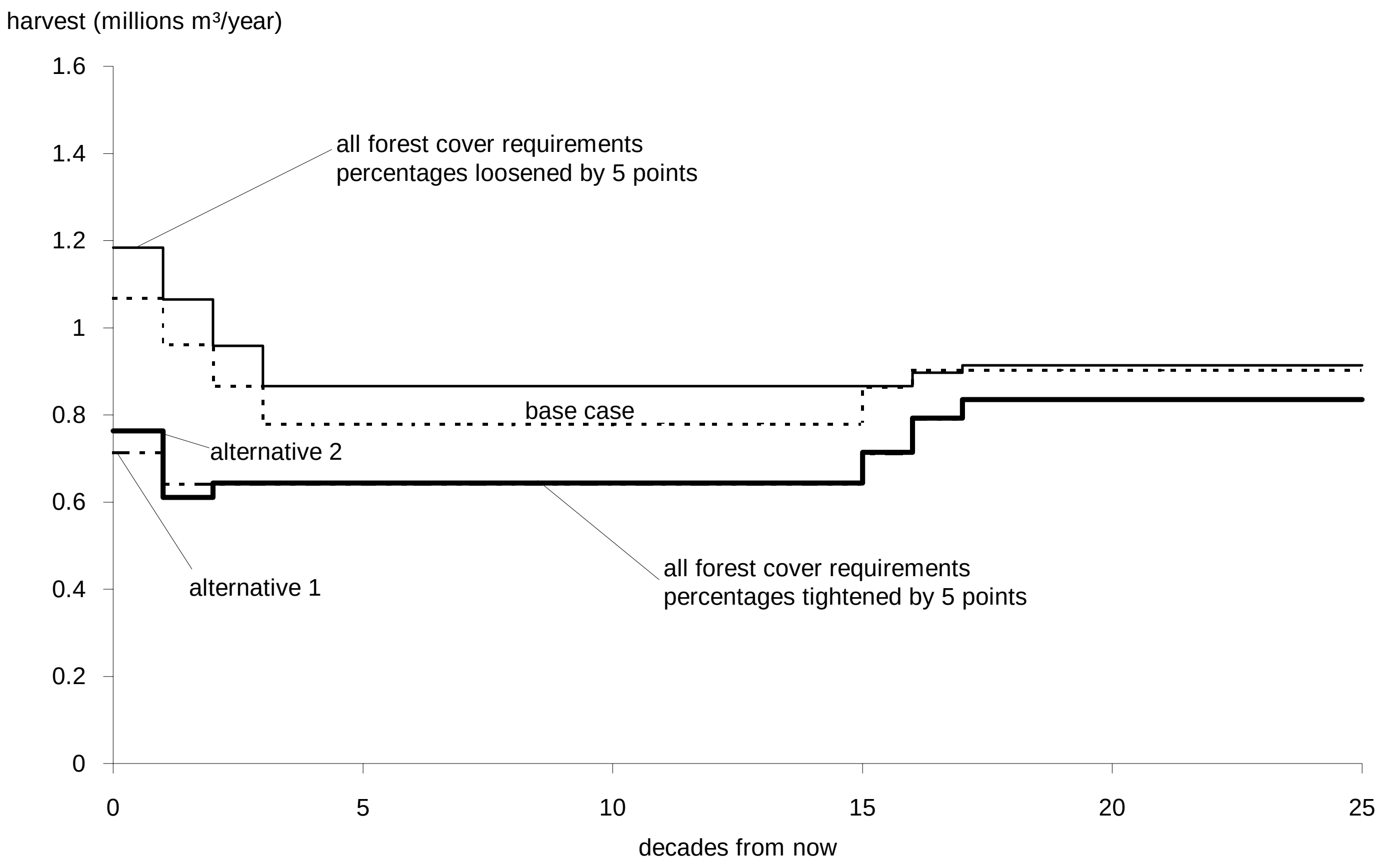

Figure 27. Harvest forecasts if all forest cover objectives are increased and decreased by 5% — Kingcome TSA, 1995.

However, as shown in previous sections, when forest cover requirements are tightened (the allowable amount of area that does not have to meet green-up requirements is decreased) there is a large impact. When all forest cover requirements are tightened by 5% the initial harvest level falls to 712 600 cubic metres per year, 33% below the base case (alternative 1). In the second decade the harvest level must decrease to 641 400 cubic metres per year (also, 33% below the base case). An alternative harvest forecast was generated to determine if a steeper rate of decline would lessen the short-term impact. Alternative 2 has an initial harvest level of 763 600 cubic metres per year followed by a 20% decline to 610 600 cubic metres per year in the second decade. After the first two decades the two alternative harvest forecasts are the same. The tighter forest cover guidelines limit the timber supply during the first 160 years. During decades 4 to 16 the harvest level is 17% below the base case. The harvest can begin to rise to the long-term level in decade 16 but does not reach the long-term harvest level of 835 600 cubic metres per year until decade 18.

5.11 Uncertainty in green-up ages

Forest cover objectives for visual quality and adjacency applied in this analysis involve estimates of when young stands will reach green-up conditions, normally expressed as the desired height of a stand. Green-up age, the age at which trees reach the desired condition, is determined using site productivity estimates. The total green-up period includes both the green-up age and the regeneration delay. Uncertainty about green-up age arises because the desired green-up condition may not accurately reflect actual needs, and because uncertainties about the site productivity estimates may mean that stands will reach the desired condition sooner or later than estimated. However, it is worth noting that according to the site productivity equations (growth estimates), the average site index* of stands would have to increase by about 9 metres to lower the green-up age by 5 years, or decrease by about 8 metres to extend the green-up period by 5 years. Therefore, it is unlikely that uncertainty in site productivity alone would cause large changes in green-up.

Figure 28 shows that the short-term harvest levels are very sensitive to uncertainty about green-up ages. If green-up ages in the base case overestimate the time needed to meet green-up conditions by 5 years, the trough during decades 4 to 16 can almost be eliminated. Alternative 1 in Figure 28 shows that if during the first 3 decades harvests are the same as in the base case, the harvest falls only to 853 600 cubic metres per year during decades 4 to 16, which is 5% below the long-term level of 895 600 cubic metres per year for this forecast. Harvests during these decades are 9.5% above the lowest level in the base case. Alternative 2 shows that if the harvest forecast is allowed to decline to the same level as in the base case during decades 4 to 16, the initial harvest level can increase to 1 363 600 cubic metres per year, 22% above the base case. As shown in previous sections, the harvest level is limited in large part by the forest cover guidelines, particularly in the short term. When green-up age is reached earlier, the forest cover guidelines are effectively loosened and more area, and thus more volume, can be harvested in the short term.

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.

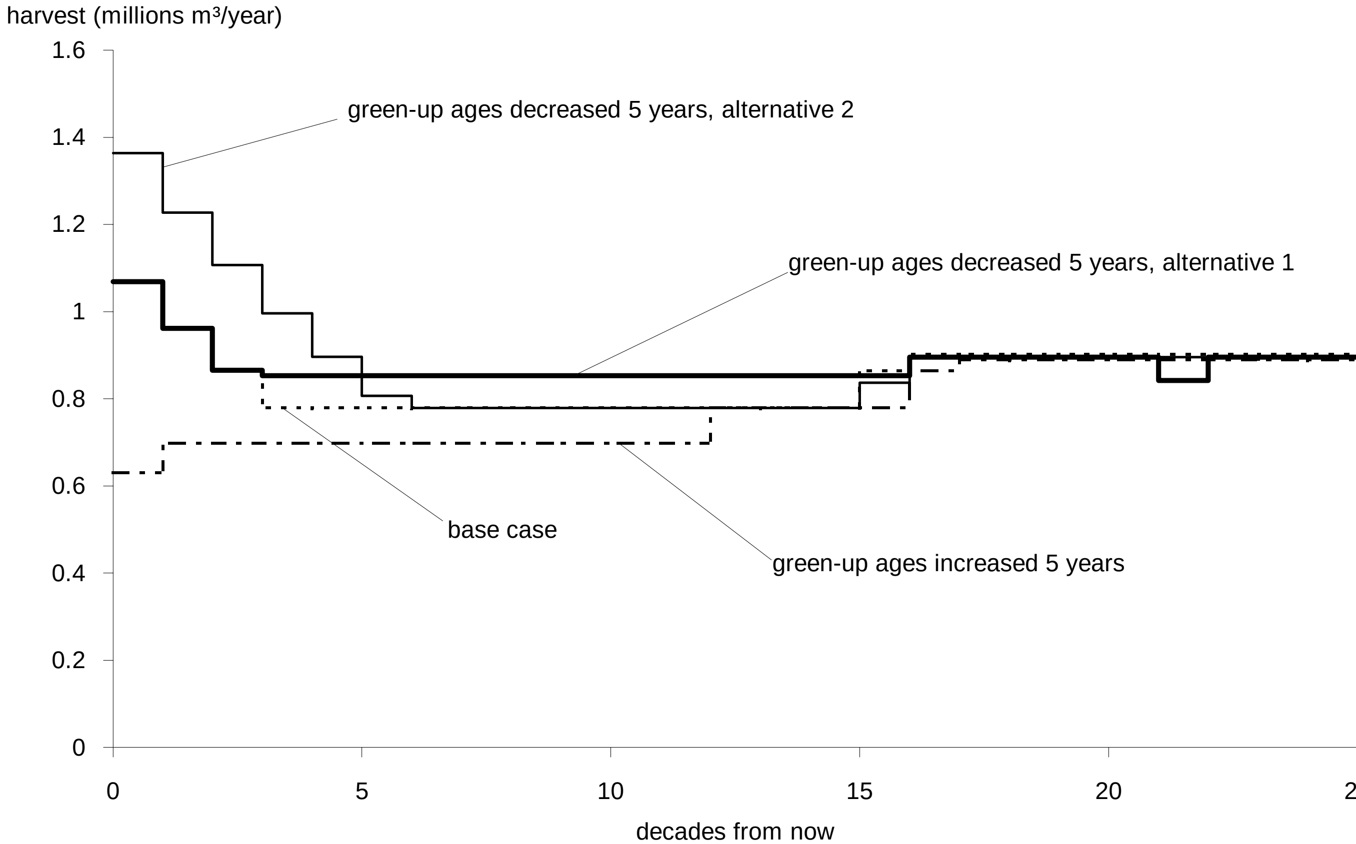

Figure 28. Harvest forecasts if green-up ages are 5 years longer or shorter than in the base case — Kingcome TSA, 1995.

If green-up ages are actually 5 years longer than estimated for the base case, harvests would have to decline to 630 600 cubic metres per year, 41% below the base case to avoid violating forest cover requirements in the short term. After the first decade the harvest level increases to 699 100 cubic metres per year. In decade 13 the harvest increases to the same level as in the base case and follows the base case for the subsequent 4 decades before reaching a long-term harvest level of 888 600 cubic metres per year (1.5% lower than in the base case).

A 5 year increase in the green-up age would on average increase the green-up height requirement in the visual zones from 5 metres to 6.4 metres, and in the IRM zone from 3 metres to 4.6 metres. Decreasing the green-up age by 5 years would decrease the average height from 5 metres to 2.8 metres and from 3 metres to 1.4 metres respectively. Port McNeill Forest District staff feel it would be very difficult to change growth rates to the extent needed to change the green-up ages by 5 years and maintain the existing height requirements. In addition, the forest management objectives for many areas would not be met with decreases in green-up height. As a result a sensitivity analysis that investigates the impact of a 3-year change to green-up ages was done. A 3-year increase and decrease in the green-up age would change the 5 metres green-up in the visual zones to 5.7 metres and 3.4 metres respectively. The 3-metre green-up height requirement in the IRM zone would change to about 3.8 metres and 1.9 metres.

Figure 29 shows that if the green-up age is 3 years shorter and the harvest level is allowed to fall to the same level as in the base case during decades 7 to 16, the initial harvest level is 20% above the base case (1 333 600 cubic metres per year). The harvest then falls by 10% per decade for 6 decades, after which it follows the base case except that the rise to the long-term harvest level starts 2 decades later. If the green-up ages are 3 years longer than in the base case, there is an immediate drop of 23% from the base case (826 600 cubic metres per year) in order to avoid further violation of the forest cover requirements. After the first decade the harvest declines to 743 600 cubic metres per year and remains at this level until decade 10. The harvest then increases to and generally follows the base case after this, but reaches the long-term harvest level 2 decades later.

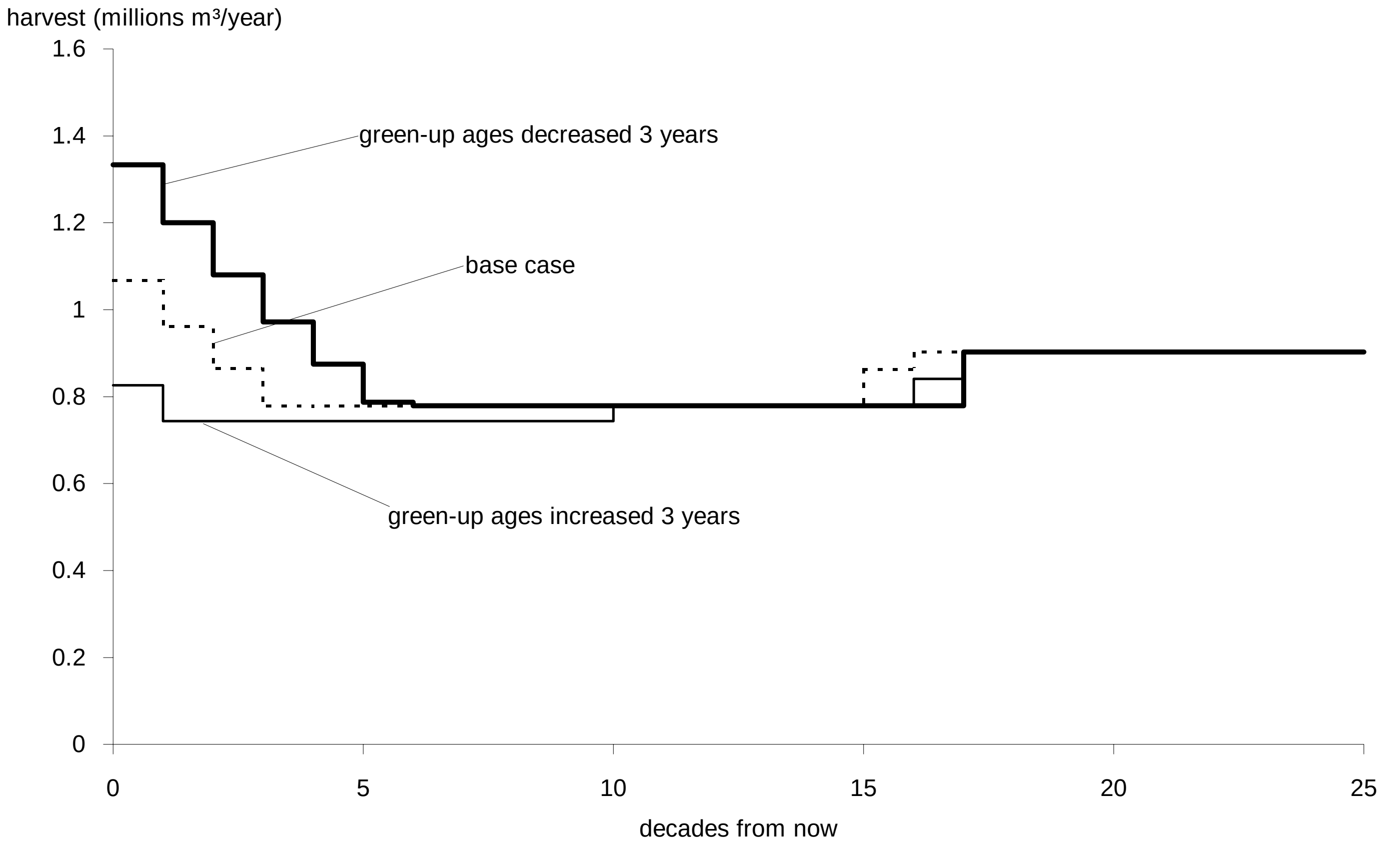

Figure 29. Harvest forecasts if green-up ages are 3 years longer or shorter than in the base case — Kingcome TSA, 1995.

Overall, uncertainty in green-up ages has dramatic effects on timber availability. Harvests in the base case are already highly limited by the forest cover requirements. Thus, decreasing the green-up ages can significantly increase the initial harvest level, while increasing the green-up age can cause a dramatic reduction in the initial level.

5.12 Uncertainty in forest cover objectives for old-age forest

The base case does not include a requirement for old growth or biodiversity. However, the large amount of forest outside of the timber harvesting land base may help meet old growth and biodiversity objectives. The need for an old-growth forest cover guideline or further deductions from the land base has not yet been quantified, resulting in uncertainty around this issue. This section investigates the effect on timber supply of applying an old-growth forest cover requirement to all management zones in the timber harvesting land base — that requires at least 10% of the area in each management zone be older than 140 years at all times

Figure 30 shows that when this forest cover requirement is added, there is an immediate decrease in the initial harvest level to 893 600 cubic metres per year (16% below the base case). By the fourth decade the harvest level has fallen to 713 600 cubic metres per year, which is 8% below the base case level. After decade 16 the long-term harvest level of 853 600 cubic metres per year is reached (5% below the base case). Currently more than 10% of forests in the timber harvesting land base are older than 140 years. However, as shown in Figure 9, the existing mature timber, which makes up just under half of the timber harvesting land base, must last until younger stands have reached a merchantable size. This old-growth forest cover requirement makes less timber available for harvest over the first 11 decades, therefore a lower initial harvest level is required to avoid causing severe timber supply shortages further in the future. The long-term harvest level is lower because many stands are being harvested at ages past the point of maximum rate of growth.

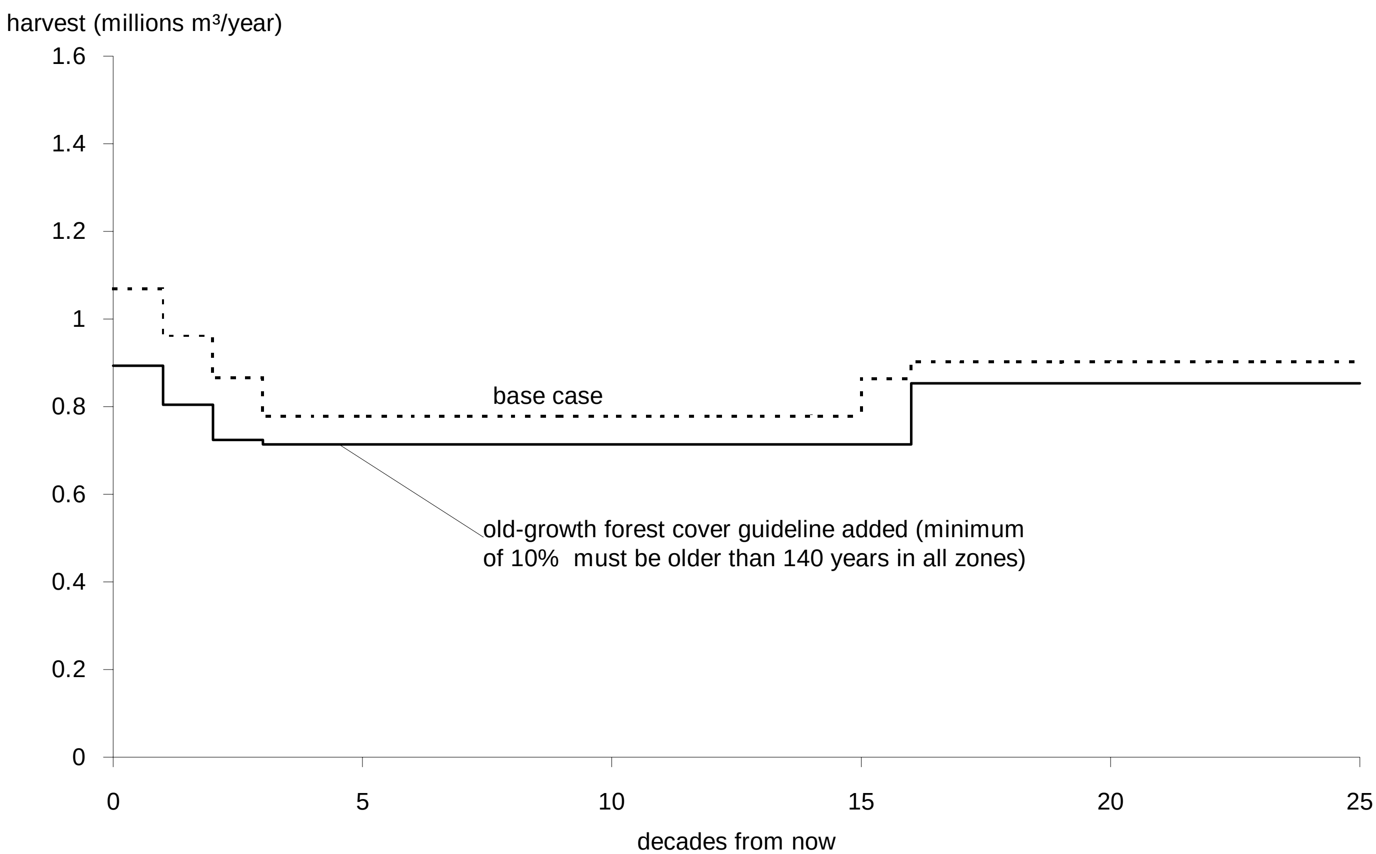

Figure 30. Harvest forecast if a forest cover objective for old growth was added to the base case — Kingcome TSA, 1995.

5.13 Uncertainty in all forest cover objectives

Many of the forest cover objectives for integrated resource management incorporated in this analysis have only been in place for the last few years. Today's management, as represented in this analysis, is substantially different from past practices. Figures 31 and 32 shows the effects on timber supply of uncertainty about the forest cover guidelines. Figure 31 shows the effect of mimicking a 4-pass harvest system with a 3 metre green-up height in all zones. This forest cover requirement is used in the base case for the IRM zone only. Figure 32 shows the effects of changing all zones to a 3-pass harvest system with a 3 metre green-up height. Both of these changes in affect remove the special management concerns for visual quality areas.

Figure 31 shows two alternative harvest forecasts that result when a 4-pass system is applied in all zones. Alternative 1 starts as high as possible while falling to the same level as the base case in the medium term. The initial harvest level is 1 473 600 cubic metres per year, 27% above the base case. The forest cover requirement does limit the first decade harvest somewhat, but the requirement is not limiting to harvest after that. The need to maintain enough mature timber to provide a reasonable rate of decline, and not fall below 779 000 cubic metres per year during decades 7 to 15, is the main factor influencing the harvest forecast. Alternative 2 attempts to fill in the trough in the base case from decades 4 to 16. The first 2 decades are the same as the base case, after which the harvest falls to 891 600 cubic metres per year. This is only 4% below the long-term harvest level of 931 600 cubic metres per year. The harvest rises to the long-term level in decade 14, 2 decades earlier than in the base case.

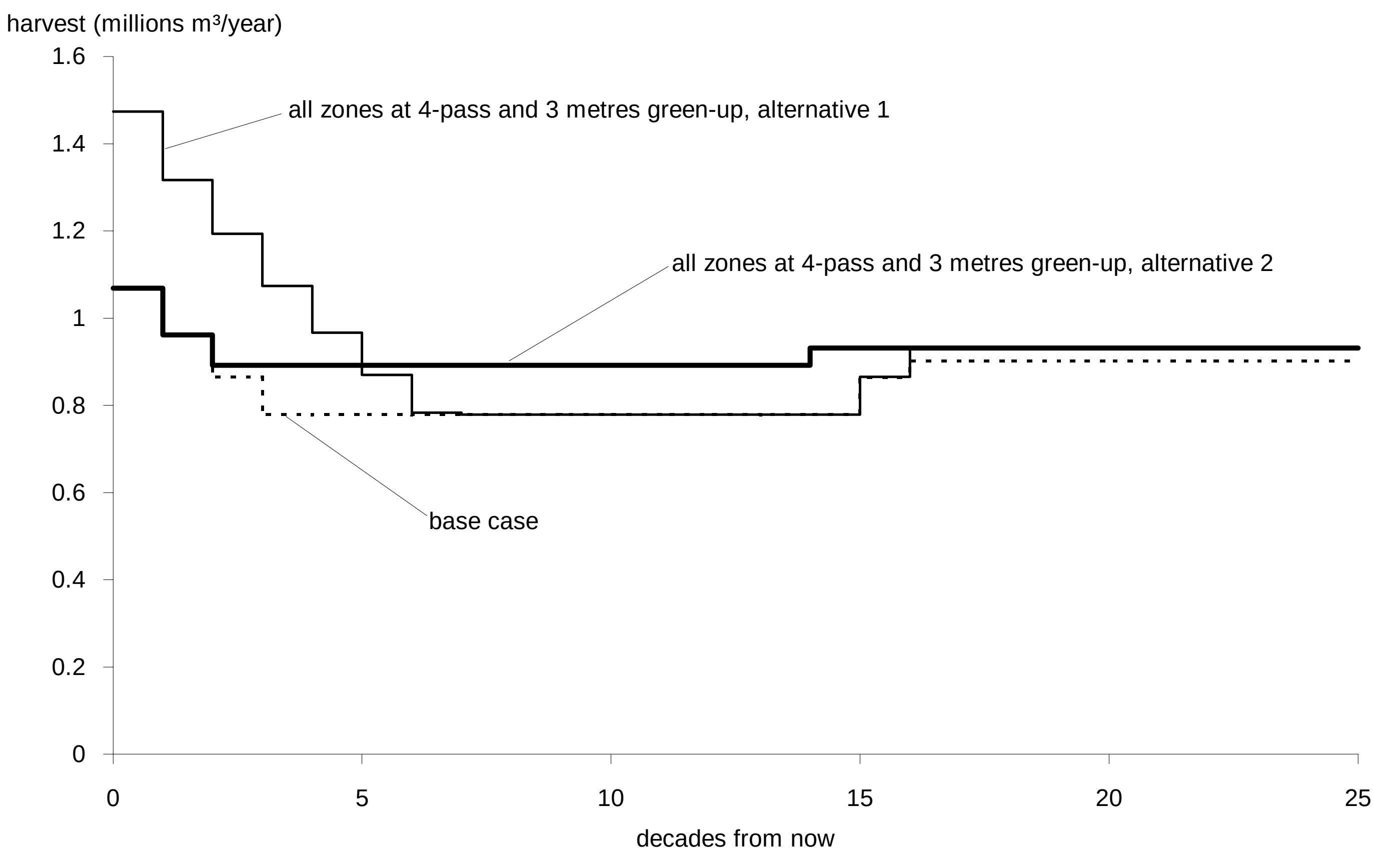

Figure 31. Harvest forecasts if a 4-pass system with a 3 metre green-up requirement is applied in all zones — Kingcome TSA, 1995.

Figure 32 shows two alternative harvest forecasts resulting if a 3-pass system is applied in all zones. Alternative 1 starts as high as possible while not falling below the level in the base case during decades 4 to 16. The initial harvest level is 1 566 600 cubic metres per year, 32% above the base case or 5.5% below the current AAC. The forest cover requirements do not have a significant effect on the harvest forecast in this case. The initial harvest level in this case is 93 000 cubic metres per year higher than the initial harvest level when the 4-pass system is applied in all zones as shown in Figure 31, indicating that the 4-pass forest cover guideline has an effect on the initial harvest level. Again, the need to maintain enough mature timber to provide a reasonable rate of decline and not fall below 779 035 cubic metres per year is the main factor influencing the 3-pass harvest forecast. Alternative 2 attempts to fill in the trough shown in the base case from decades 4 to 16. The first 2 decades are the same as the base case, after which the harvest falls to 893 600 cubic metres per year, only 4% below the long-term harvest level of 930 600 cubic metres per year. The harvest level during decades 4 to 16 is 13% above the base case.

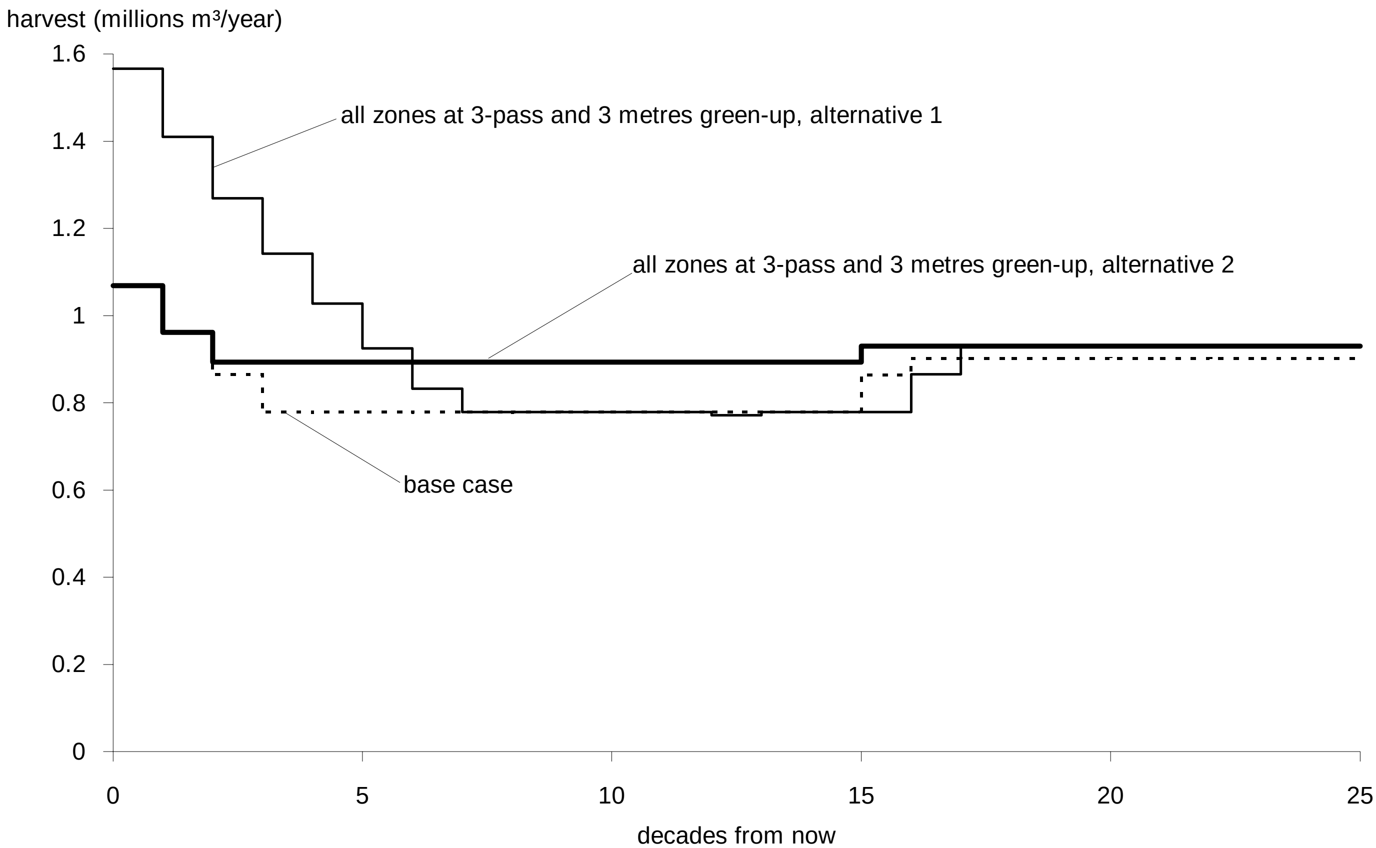

Figure 32. Harvest forecasts if a 3-pass system with a 3 metre green-up requirement is applied in all zones — Kingcome TSA, 1995.

6 Summary and Conclusions

The base case results of this analysis indicate that the current AAC in the Kingcome TSA cannot be maintained for even one more decade without causing severe timber supply shortfalls in the future. Using current forest inventory and timber growth information, and assuming continuation of current forest management practices, an initial harvest of 1 068 600 cubic metres per year can be attained. This is 35% below the current AAC used for this analysis. After the first decade, the harvest decreases 10% per decade until decade 4 when the harvest level reaches its lowest point of 779 000 cubic metres per year. This level is maintained until decade 15 when the harvest level begins to rise toward the long-term harvest level. The harvest that is sustainable over the long term of 902 600 cubic metres per year is reached in decade 16.

The short-term harvest levels are limited by the forest cover requirements for visual quality and adjacency. However, it is important to note that even if the forest cover guidelines were not in place the initial harvest level would still be lower than the present AAC and the decline to the long-term harvest level would have to start immediately after the first decade. Due to harvesting history, a maximum initial harvest level of 1 496 300 cubic metres per year can be achieved given current management requirements. However, if this level is harvested a second decade harvest of only 610 486 cubic metres per year could be achieved without further violation of the forest cover requirements. Steeper rates of decline were investigated but, because the forest cover guidelines limit the amount of area that may be harvested in the short term, there is only a small gain in the first decade, with less timber being harvested in the second and third decades.

It was not possible, given current management assumptions, to develop a harvest forecast that does not fall below the long-term harvest level. Three main factors contribute to the projected trough and the initial harvest level. First the original abundance of mature forest which historically allowed harvest rates well above the long-term level no longer exists. In addition, the forest cover guidelines for visual quality and adjacency are a recent change in management practices which contribute to the decline in timber supply. A long harvesting history and past harvesting patterns have resulted in a large amount of forest initially younger than the green-up ages in all management zones. In fact, currently the retention VQO and the modification VQO areas have more than double the maximum area allowed below the required green-up age. The third cause of the trough during decades 4 to 16 is the expectation that managed stands will produce higher volumes per hectare than the present natural stands; this increases the apparent shortfall by raising the long-term harvest level.

Over the first 40 years forest cover in the visual quality management zones are equal to or above the allowed maximum area below the green-up age. A combination of the amount currently below the green-up age, as noted above, and the harvesting of Timber Licences over the first 40 years causes the forest cover guidelines to be exceeded at times during the first 40 years. The Timber Licences that revert to Crown management total 16 332 hectares or about 3% of the timber harvesting land base.

The earliest that the harvest can begin to rise towards the long-term harvest level, with no significant shortages later, is 12 decades from now, however, this results in a much deeper trough during decades 4 to 12. In order to mitigate this large trough, the rise to the long-term level was delayed until decade 16.

The substantial reduction in timber supply over the next several decades shown in the base case was predicted in the 1990 timber supply analysis completed for the Kingcome TSA. Although that analysis indicated that continuing at the current rate of harvest would be possible for 10 years, it also showed that a sharp decline in the rate of harvest was imminent, and that the harvest level would eventually have to be reduced to below the long-term harvest level.

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

6 Summary and Conclusions

Several alternative harvest flow patterns on the base case all show limited potential to increase harvesting in the short term. In fact, increasing the rate of decline from 10% to 20% only increased the initial harvest level by 70 000 cubic metres per year and resulted in a lower harvest than in the base case during decades 2 and 3.

The results of the sensitivity analysis show that in general making the forest cover guidelines less constraining will allow a higher harvest level in the short term. Changes to the green-up age requirements, the maximum allowable area below green-up age (or adjacency guidelines), the regeneration delay or the visual quality guidelines all produce higher initial harvest levels, ranging from 8% to 22% above the base case initial harvest level. Changes to the green-up age requirements result in the largest change to the initial harvest level. A 5-year decrease in green-up age results in a 22% increase relative to the base case; a 3-year decrease allows a 20% increase in the initial harvest level.

An alternative harvest flow pattern, when the forest cover guidelines are less constraining, is to start at the same harvest level as in the base case and minimize the trough during decades 4 to 16. Several of the sensitivity analyses show both alternative harvest flow patterns.

The addition of an old-growth forest cover guideline also results in an immediate 16% decrease in the initial harvest level. However, there is a large amount of older timber in the areas removed for integrated resource management and due to operability which may offset this decline somewhat.

The sensitivity analysis also shows that more restrictive forest cover guidelines cause initial harvest levels to drop well below the base case. In several cases the harvest level must start below the long-term level and increase over time. The initial harvest levels for changes that tighten the forest cover requirements range from 8% to 41% lower than the base case. For example, increasing the regeneration delay by 3 years results in an 8% lower initial harvest level. The largest impact, a 41% decrease in the initial harvest level, is seen by making the green-up ages 5 years longer. Even changing the green-up ages by only 3 years causes a 23% decrease from the base case initial harvest level. Making the forest cover guidelines in all management zones tighter by 5% results in a 33% decrease in the initial harvest level.

Any changes to the timber harvesting land base result in significant changes in harvest levels. If the area of mature timber is reduced 15%, the overall land base reduction is about 7%. This change to the land base causes a 13% decrease in the initial harvest level. Conversely, if the mature area is increased 15% the initial harvest level can increase 9% from the base case.

About 43% of the timber harvesting land base is managed under visual quality guidelines. These visual quality guidelines are relatively new to the Kingcome TSA and have a dramatic effect on the harvest level. If the visual quality areas did not require any special management, and all zones were subject to the same constraints as in the integrated resource management zone, the harvest could increase 27% above the base case level in the first decade.

The long-term harvest level is generally proportionately affected by changes to the estimates of regenerated volumes, and changes to the estimated site productivity of presently older stands. In addition, the trough during decades 4 to 16 can often be partially offset by these changes.

The results of sensitivity analysis indicate that uncertainty in the assumptions and data used in this analysis may significantly affect the harvest level in both the long and short term. If gains in timber supply from a change relative to current management are used to minimize the projected drop below the long-term harvest level during decades 4 to 16, very little opportunity is left to increase the short-term (first 30 years) harvest. If any timber supply gains are used to increase the short term harvest level, then the harvest level must eventually fall to the same low point as reached in the base case. Examples of both of these flow types are shown for several sensitivity analysis.

7 References

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8 Glossary

Allowable annual cut (AAC)	The allowable rate of timber harvest from a specified area of land. The Chief Forester sets AACs for timber supply areas (TSAs) and tree farm licences (TFLs) in accordance with *Section 7* of the *Forest Act.*
Biodiversity (biological diversity)	Diversity of life in all its forms and levels of organization, including genes, species, ecosystems and the evolutionary and functional processes that link them.
Clearcut harvesting	A harvesting method whereby all trees that meet utilization standards are harvested. The harvested site is then regenerated to acceptable standard by appropriate means including planting and natural seeding.
Cutblock adjacency	The desired spatial relationship among cutblocks as specified in integrated resource management guidelines. They can be approximated by specifying the maximum allowable proportion of a forested landscape that does not meet green-up requirements.
Environmentally sensitive areas	Areas with significant non-timber values or fragile or unstable soils, or where there are impediments to establishing a new tree crop, or areas where timber harvesting may cause avalanches.
Forest cover objectives	Desired distributions of areas by age or size class groupings. These objectives can be used to reflect desired conditions for wildlife, watershed protection, visual quality and other integrated resource management objectives.
Forest cover requirements	Specify desired distributions of areas by age or size class groupings. These objectives can be used to reflect desired conditions for wildlife, watershed protection, visual quality and other integrated resource management objectives. General adjacency and green-up guidelines are also specified using forest adjacency and green-up guidelines are also specified using forest cover objectives (see **Cutblock adjacency and Green-up)**.
Forest inventory	Assessment of British Columbia's timber resources. It includes computerized maps, a database describing the location and nature of forest cover, including size, age, timber volume, and species composition, and a description of additional forest values such as recreation and visual quality.
Free-growing	An established seedling of an acceptable commercial species that is free from growth-inhibiting brush, weed and excessive tree competition.
Growing stock	The volume estimate for all standing timber, of all ages, at a particular time.
Green-up	The time needed after harvesting for a stand of trees to reach a desired condition (e.g., top height) to ensure maintenance of water quality, wildlife habitat, soil stability or aesthetics.

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.
Inoperable areas	Areas defined as unavailable for harvest for terrain-related or economic reasons. Characteristics used in defining inoperability include slope, topography (e.g., the presence of gullies or exposed rock), difficulty of road access, soil stability, elevation and timber quality. Operability can change over time as a function of changing harvesting technology and economics.
Long-term harvest level	A harvest level that can be maintained indefinitely given a particular forest management regime (which defines the timber harvesting land base and includes objectives and guidelines for non-timber values) and estimates of timber growth and yield.
Management assumptions	Approximations of management objectives, priorities, constraints and other conditions needed to represent forest management actions in a forest planning model. These include, for example, the criteria for determining the timber harvesting land base, the specification of minimum harvestable ages, utilization levels, integrated resource guidelines and silviculture and pest management programs.
Mean annual increment (MAI)	Stand volume divided by stand age. The age at which average stand growth, or MAI, assumes its maximum is called the culmination age. Harvesting all stands at this age results in a maximum average harvest over the long term.
Modification VQO	Alterations may dominate the visual landscape, but should blend with natural features. Up to 25% of the visible area can be altered by harvesting activity (see **Visual quality objective**).
Non-merchantable forest types	Stands that are accessible and otherwise available for harvesting but are assumed to be non-merchantable due to stand characteristics such as small piece size, incidence of decay, species composition and low stocking.
Not satisfactorily restocked (NSR)	An area not covered by a sufficient number of tree stems of desirable species. Stocking standards are set by the B.C. Forest Service, Silviculture Branch. If the expected regeneration delay (the period of time between harvesting and the date by which an area is occupied by a specified minimum number of acceptable well-spaced trees) has not elapsed, the land is defined as current NSR. If the expected delay has elapsed, the land is classified as backlog NSR.
Operability	A classification of the availability of an area for timber harvesting. Operability is determined using the terrain characteristics of the area as well as the quality and quantity of timber on the area.
Partial retention VQO	Alterations are visible but not conspicuous. Up to 15% of the area can be visibly altered by harvesting activity (see **Visual quality objective**).

8 Glossary

Preservation VQO No visible alterations to the landscape are permitted (see **Visual quality objective**).

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.

Retention VQO Alterations are not easy to see. Up to 5% of the visible landscape can be altered by harvesting activity (see **Visual quality objective**).

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.

Stocking The proportion of an area occupied by trees, measured by the degree to which the crowns of adjacent trees touch, and the number of trees per hectare.

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

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

Tree farm licence (TFL) Provides rights to harvest timber, and outlines responsibilities for forest management, in a particular area.

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.

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

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 tables and commentary outline the methods and inputs used to derive the timber harvesting land base, and to construct the timber supply model for the Kingcome TSA Timber Supply Review analysis. This information represents current forest management in the area. Current management is defined as the set of land use decisions and forest and stand management practices currently implemented and enforced. Future forest management objectives that may be intended, but are not currently implemented and enforced are not included in this appendix. The purpose of the Timber Supply Review is to provide information on the effects of current management on both short- and long-term timber supply in each timber supply area in the province. Any changes in forest management objectives and practices will be included in subsequent timber supply analyses after the Timber Supply Review project has been completed.

A.1 Zone and Analysis Unit Definition

A.1.1 Zone characteristics

Four management areas or zones were defined for this analysis. Three of the zones are defined by visual quality objective ratings. The zone boundaries were defined using the recreation (RECREATE) field on the inventory file. All area that did not fall into one of the three visual quality areas became the integrated resource management zone (IRM). Table A-1. provides the criteria used for zone definition.

Table A-1. Zone assignment

Zone	Defining variable
1. Retention VQO	RECREATE visual code 07
2. Partial retention VQO	RECREATE visual code 08
3. Modification VQO	RECREATE visual code 09
4. Integrated resource management	All area not meeting the above criteria

There is also some preservation VQO (RECREATE Visual Code 06) area in the Kingcome TSA but, this was removed from the timber harvesting land base.

The inventory file has updated VQO codes for the Vancouver Island portion of the Kingcome TSA. The mainland portion of the inventory file does not have updated VQO codes on it. However, Port McNeill Forest District staff have completed mapping the VQO areas on the mainland and this data is stored in a Geographic Information System (GIS) in the forest district office. Port McNeill Forest District inventory staff summarized all areas on the mainland by six variables and provided the percentage of the three VQO categories and the percentage in the IRM zone for each unique combination of these variables. In order to bring the mainland portion of the Kingcome TSA up to the same standards this information was used to create the zones on the mainland portion of the TSA. The variables used to summarize the mainland VQO information are:

MAPNO: mapsheet number;

TYPEID: type identity class, classifies each stand by non-productive, non-forested and forested by age and disturbance;

I_TYPGRP: inventory type group (by leading species);

AGECL_PR: age class projected, the projected age of each stand on January 1, 1993;

HTCL_PR: height class projected, the projected height of each stand on January 1, 1993;

SITE: site class, classifies site productivity into good, medium, poor or low quality.

A.1 Zone and Analysis Unit Definition

Table A-2. Timber harvesting land base by zone (including timber licence reversions TFL take back areas, and non-satisfactorily restocked areas)

Zone	Area (hectares)	Percentage area (%)
Retention VQO	5 392.1	3.0
Partial retention VQO	56 238.6	31.6
Modification VQO	15 148.0	8.5
Integrated resource management	101 230.3	56.9
Total	178 009	

A.1.2 Analysis unit characteristics

To simplify timber supply modeling given the high number of unique forested stands, as well as to reflect the precision of the inventory sampling, individual stands are grouped into analysis units. Analysis units are defined by forest cover (inventory type group), site quality (new site class) and projected age. Each analysis unit is assigned its own timber volume projection (yield table).

Table A-3. documents the variables used to define each analysis unit. Inventory type groups are B.C. Forest Service, Inventory Branch categories that denote the dominant tree species as well as other species present.

Site quality was determined using the new site index class on the inventory file. Tests using site index assigned using FREDTAB, a computer program supported by the B.C. Forest Service, Research Branch, showed that this class variable was a reasonable representation of the site quality of the stands and thus was used to define the analysis.

In any stand that had a special site class on the inventory file, the special site class was substituted for the new site class.

Analysis units are not specific to a zone; that is each analysis unit is made up of stands from the entire timber harvesting land base. Timber volume tables were developed for each of the 10 analysis units shown in Table A-3.

A.1 Zone and Analysis Unit Definition

Table A-3. Analysis unit characteristics

	Analysis unit	Age range (years)	Inventory type groups	Site class	Initial volume estimate[a]
1	Fir/spruce, all sites	21+	01 - 08 21 - 26	good/medium /poor	VDYP
2	Cedar, good/medium	11+	09 - 11	good/medium	VDYP
3	Cedar, poor	11+	09 - 11	poor	VDYP
4	Hemlock/balsam, good/medium	16+	12 - 20	good/medium	VDYP
5	Hemlock/balsam, poor	16+	12 - 20	poor	VDYP
11	Fir/spruce, all sites	0 - 20	01 - 08 21 - 26	good/medium /poor	TIPSY
21	Cedar, good/medium	0 - 10	09 - 11	good/medium	TIPSY
31	Cedar, poor	0 - 10	09 - 11	poor	TIPSY
41	Hemlock/balsam, good/medium	0 - 15	12 - 20	good/medium	TIPSY
51	Hemlock/balsam, poor	0 - 15	12 - 20	poor	TIPSY

(a) Existing young stands that have been managed were immediately put on a TIPSY volume curve. All remaining existing stands have one harvest based on the VDYP volume estimate and then change to a TIPSY volume estimate for any subsequent harvesting.

There is a very limited amount of "good" site in the Kingcome TSA. Good site totals 11 615 hectares in the timber harvesting land base, however there is only a minor component of each species in good site.

It is acknowledged that error may be associated with assigning site index to both young (less than 30 years) and old (over 150 years) stands. Current data and site estimation methods are most accurate for stands between 30- and 150-year old. In order to address this issue volume curves were developed for each analysis unit based on all stands regardless of age. A second set of volume curves were developed based on stands younger than 140 years and stands older than 140 years. There was no significant difference found in these curves on an analysis unit basis. Thus the analysis units incorporate all ages of stands, with the exception of young managed stands as noted above in Table A-3. For older stands, site index was not reassigned to the site index for currently younger stands. The volume estimation system used for the analysis (Variable Density Yield Prediction) provides satisfactory estimates of volumes currently in older stands. Reassigning site index for older stands to values estimated from younger stands is not statistically valid. It is recognized that uncertainty in site index creates uncertainty about long-term sustainable production. However, timber supply over the next few decades depends mainly on existing timber volumes.

A.1 Zone and Analysis Unit Definition

Table A-4. Timber harvesting land base by analysis unit

Analysis unit	Area (hectares)	Per cent of total
1/11 Fir/spruce, all sites	5 331.0	3.0
2/21 Cedar, good/medium	24 521.0	13.8
3/31 Cedar, poor	48 584.6	27.3
4/41 Hemlock/balsam, good/medium	72 755.4	40.8
5/51 Hemlock/balsam, poor	26 816.8	15.1
Total	178 008.8	

A.2 Definition of the Timber Harvesting Land Base

This section provides the information used to define the land base considered available for timber harvesting in the analysis. The harvesting land base is derived by excluding the areas identified in the following sections from the total area in the inventory file.

A.2.1 Land not managed by the B.C. Forest Service and un-typed lands

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

Tree Farm Licence (TFL) areas are managed — and have their allowable annual cuts determined — separately from TSAs. However, sometimes small areas of TFLs may be included in the TSA inventory. This land does not contribute to the TSA harvesting land base.

All areas with ownership codes (OWNER, OWNRCHAR) other than 62C or 69C are excluded from the timber harvesting land base for this analysis.

In addition, all areas that are untyped (TYPID_PR=8) are excluded from the harvesting land base.

A.2.2 Non-forested land and non-commercial brush species

All areas that are classified as non-forest (TYPID_PR=6) are excluded from the timber harvesting land base. Non-forested areas include areas such as rock, ice, lakes, and salt water inlets. In addition, all areas that are classified as non-commercial brush (TYPID_PR=5) are excluded from the timber harvesting land base.

A.2.3 Klinaklini supply block

The Klinaklini supply block (TSB=F) was removed from the land base as it is uneconomic to develop. The timber is of low quality and accessibility is very difficult or impossible and thus very expensive in this area.

A.2.4 Not satisfactorily restocked (NSR) areas.

Areas designated as non-satisfactorily restocked (TYPID_PR=4 OR 9) are excluded from the timber harvesting land base. These areas are added back into the land base before any timber supply modeling is done. NSR areas are assumed to be restocked according to the schedule shown in Section A.3.5, "Not satisfactorily restocked (NSR) areas."

A.2.5 Environmentally sensitive areas (ESAs)

The forest inventory file includes a rating of the environmental sensitivity of forested areas. Most areas rated as highly sensitive are considered completely unavailable for timber harvesting, except that areas with highly sensitive soils are partially available. Moderately sensitive areas are considered partially available according to the following table.

Table A-5. Per cent of area considered unavailable for timber harvesting because of environmental sensitivity

ESA code	ESA description	Per cent of area unavailable
Es1	High soil sensitivity	90
Ea1	High avalanche problems	100
Ep1	High regeneration problems	100
Ei1	Inaccessible areas	100
Er1	High recreation value	100
Ew1	High wildlife importance	100
Eh1	High hydrological value	100
Er2	Moderate recreation value	50
Ew2	Moderate wildlife importance	50

A.2.6 Low productivity sites

Any forested area with a low productive potential for growing timber is not currently considered part of the timber harvesting land base. All stands with a site class of low (SITE=L) were removed from the land base.

A.2.7 Non merchantable forest types

All leading lodgepole pine stands were removed as they are of low quality and uneconomic to harvest. All leading deciduous stands were removed from the land base as this analysis did not look at the potential harvest from deciduous stands. There is however, currently a 25 000 cubic metre per year AAC set for deciduous stands.

A.2.8 Visual quality objective preservation areas

All areas in the Kingcome TSA that are assigned a visual quality objective of preservation are removed from the land base. There is currently no harvesting taking place in these areas.

A.2 Definition of the Timber Harvesting Land Base

A.2.9 Inoperable areas

Port McNeill Forest District staff started an assessment of operability for the Kingcome TSA in February 1993. This assessment included a detailed check of each licensee's 20 year and 5 year plans. The assessment also included the "use of operability" information included in *Musgamagw-Tsawataineuk Traditional Territory Timber Supply Study*, prepared for International Forest Products in cooperation with MacMillan Bloedel, Mill and Timber and Weldwood of Canada.

Areas defined as inoperable that are not captured by the other land base reductions shown in this section are:

- Fully mature and overmature height class 3 stands are for the most part excluded where there is a significant distance from existing developments and most of the forest cover in the immediate area is marginally operable. However, if height class 3 stands occur in an area that is primarily height class 4 or better they are classed as operable.
- Small and remote stands of height class 4 or better are also excluded unless, a licensee has identified the area as a proposed cutblock. Any areas suitable for helicopter logging that have been identified on the development plans fall under this category. Small stands are also more likely to be included where the leading species is of greater value than the hemlock mixed type typically encountered in these areas.
- Coastal strips of cedar/cypress leading mature and older height class 3 stands are included where stereoscopic examination of air photos shows that the stand in question has sufficient volume to meet forest district standards.

Further details on this study can be found in the Kingcome TSA data package, June 1994 or from the Port McNeill Forest District inventory staff.

All areas labelled as inoperable or not assigned an operability code are removed from the land base (OPERABILITY=I OR N).

The inventory file has updated operability codes for the Vancouver Island portion of the Kingcome TSA. However, the mainland portion of the inventory file does not have updated operability codes on it. Port McNeill Forest District staff have completed mapping operability on the mainland and this data is stored in a GIS system in the forest district office. Port McNeill Forest District inventory staff summarized all areas on the mainland by 8 variables and provided the percentage by operability code for each unique combination of these variables. In order to bring the mainland portion of the Kingcome TSA up to the same standards this information was used to remove the inoperable areas on the mainland portion of the Kingcome TSA. The variables used to summarize operability on the mainland are:

MAPNO: mapsheet number;

OWNER: ownership code;

OWNRCHAR: defines whether the area is available to contribute to the AAC or not;

TYPEID: type identity class, classifies each stand by non-productive, non-forested and forested by age and disturbance;

I_TYPGRP: inventory type group by leading species;

AGECL_PR: age class projected, the projected age of each stand on January 1, 1993;

HTCL_PR: height class projected, the projected height of each stand on January 1, 1993;

SITE: site class, classifies site productivity into good, medium, poor or low quality.

A.2.10 Existing unclassified roads, trails and landings

To account for productive growing sites land lost to date, during timber harvesting and road building, and not reclassified in the inventory file as non-forest land, 7% of areas in the Kingcome TSA with an age of less than or equal to 50 years were considered not to contribute to further timber production.

A.2.11 Estimated area of future roads

To account for the loss of productive forest land during future timber harvesting and development in the Kingcome TSA, 7% of the timber harvesting land base greater than 50 years of age is not considered to contribute to further timber production after it is harvested for the first time.

Future roads are modeled by removing the specified percentage (7%) from all areas not subject to the existing roads reduction after the first harvest on these areas. Harvesting systems that required roads, trails and landings started being used in the Kingcome TSA about 50 years ago.

A.2.12 Lakeshore and streamside management

Streamside Buffers

Linear measurements in kilometers were done on all known class A streams in the Kingcome TSA. The National Topographic Series 1:50,000 scale maps from the Federal Department of Fisheries and Oceans fish habitat inventory for areas 11, 12a, and 27 in the February 1988 to March 1990 inventory were used for measurement. The measurements show that there are 270.15 kilometres of class A streams in the TSA. Class B and C streams are not considered in this analysis as the streamside management zone in these areas is optional and requirements for special protective measures will be determined on a site specific basis.

The *British Columbia Coastal Fisheries/Forestry Guidelines* require that there be a no harvest 10 metres buffer on each side of any class A stream. In the next 20 metres on either side of the stream harvesting can occur but only if the integrity of the streamside area can be maintained. Operationally, this has been translated to mean that 25% of the timber may be removed in this further 20 metre riparian zone every rotation (assumed to be 100 years). For the purposes of the analysis a 25 metre no harvest area buffer was applied to both sides of all class A streams. This results in a reduction to the land base of 1350.75 hectares. It is assumed that the entire stream buffer area is operable. The distribution of streamside buffers within management zones and analysis units is assumed to be proportional to the distribution of these units within the timber harvesting land base.

Lakeshore Buffers

Based on discussions between Port McNeill Forest District staff, the Forest Ecosystem Specialist, Ministry of Environment Lands and Parks, Campbell River, and the District Habitat Officer, Department of Fisheries and Oceans, Campbell River it was assumed that 80% of the lakes in the Kingcome TSA are Class A. The Class A lakes also require buffers that can be approximated by a 25 metre no harvest buffer. The total Kingcome TSA lakeshore buffer area is 6800 hectares.

Based on a sample of mapsheet files it was assumed that these buffer areas fall within the IRM zone and are comprised of 40% operable timber and 60% inoperable timber. Within the operable buffer areas, 60% is in cedar types, 25% is in hemlock/balsam good and medium sites, and 15% is in hemlock/balsam poor sites.

A.2 Definition of the Timber Harvesting Land Base

The following reductions were made to the timber harvesting land base:

Table A-6. Areas removed for lakeshore buffers in the Kingcome TSA

Zone	Forest type	Area (hectares)
Integrated resource management	Cedar	1 632
	Hemlock/balsam good and medium sites	680
	Hemlock/balsam poor sites	408
	Total	2 720

A.2.13 Woodlot number 072

Woodlot 072 was recently awarded but was not updated in the forest inventory file used for this analysis. Therefore, a reduction must be done to remove the areas of this woodlot which are presently labelled as ownership code 62C on the inventory file. The entire woodlot is located in mapsheet number 092L062. The following forest cover polygons within this mapsheet were removed to account for the woodlot.

Table A-7. Areas covered by woodlot number 072 in the Kingcome TSA

Mapsheet (MAPNO)	Polygon number (POLYGON)
092L062	205
	206
	207
	228
	229
	230
	232
	233
	235
	236
	248
	252
	253
	254
	255
	259
	260
	263
	265
	266
	268
	648
	650
	651
	652
	653
	654
	655

A.2.14 Timber license reversions

Timber licences (TLs) are a form of timber tenure that gives the holder exclusive right to harvest merchantable timber from defined areas of Crown land. After the area is harvested and reaches a free-growing condition the land reverts to Forest Service jurisdiction. The timber cut from TLs is not part of the allowable annual cut of a TSA. There are 16 332 hectares of TLs in the Kingcome TSA that contribute to the timber harvesting land base as defined for this analysis. These areas are anticipated to be harvested over the next 40 years, and will revert to Forest Service management in a stocked and free-growing condition, as per the following table.

Table A-8. Timber licence reversions for the Kingcome TSA

Zone	Analysis unit	Reversion year[a]	Area in timber harvesting land base (hectares)
Visual quality objective retention	Fir/spruce all sites	1996 - 2005	3.4
	Fir/spruce all sites	2006 - 2015	103.5
	Cedar good/medium sites	1990 - 1995	1.0
	Cedar good/medium sites	1996 - 2005	74.2
	Cedar good/medium sites	2006 - 2015	5.9
	Cedar poor sites	1996 - 2005	15.9
	Cedar poor sites	2006 - 2015	0.8
	Hemlock/balsam good/medium sites	1990 - 1995	2.1
	Hemlock/balsam good/medium sites	1996 - 2005	72.1
	Hemlock/balsam good/medium sites	2006 - 2015	166.9
	Hemlock/balsam poor sites	1996 - 2005	20.6
	Hemlock/balsam poor sites	2006 - 2015	61.6
Visual quality objective partial retention	Fir/spruce all sites	1996 - 2005	24.4
	Fir/spruce all sites	2006 - 2015	59.2
	Cedar good/medium sites	1996 - 2005	1095.3
	Cedar good/medium sites	2006 - 2015	270.8
	Cedar poor sites	1996 - 2005	231.6
	Cedar poor sites	2006 - 2015	5.7
	Hemlock/balsam good/medium sites	1990 - 1995	8.6
	Hemlock/balsam good/medium sites	1996 - 2005	907.6

(a) Each timber licence has a reversion year, however, the FSSIM model uses 10 year age classes and has several assumptions regarding the age and area distribution within an age class that make it necessary to combine the TLs into 10 year classes.

continued

Table A-8. Timber licence reversions for the Kingcome TSA

Zone	Analysis unit	Reversion year[a]	Area in timber harvesting land base (hectares)
Visual quality objective partial retention	Hemlock/balsam good/medium sites	2006 - 2015	687.3
	Hemlock/balsam good/medium sites	2016 - 2025	100.9
	Hemlock/balsam poor sites	1996 - 2005	131.4
	Hemlock/balsam poor sites	2006 - 2015	157.5
	Hemlock/balsam poor sites	2016 - 2025	45.5
Visual quality objective modification	Fir/spruce all sites	2006 - 2015	110.1
	Fir/Spruce all sites	2016 - 2025	344.3
	Cedar good/medium sites	1996 - 2005	191.1
	Cedar good/medium sites	2006 - 2015	40.9
	Cedar good/medium sites	2016 - 2025	133.1
	Hemlock/balsam good/medium sites	1990 - 1995	16.3
	Hemlock/balsam good/medium sites	1996 - 2005	405.9
	Hemlock/balsam good/medium sites	2006 - 2015	488.4
	Hemlock/balsam good/medium sites	2016 - 2025	271.1
	Hemlock/balsam poor sites	1996 - 2005	125.9
	Hemlock/balsam poor sites	2006 - 2015	26.3
	Hemlock/balsam poor sites	2016 - 2025	48.6
Integrated resource management	Fir/spruce all sites	1990 - 1995	10.2
	Fir/spruce all sites	1996 - 2005	36.9
	Fir/spruce all sites	2006 - 2015	712.2
	Fir/spruce all sites	2016 - 2025	96.9

(a) Each timber licence has a reversion year, however, the FSSIM model uses 10 year age classes and has several assumptions regarding the age and area distribution within an age class that make it necessary to combine the TLs into 10 year classes.

continued

Table A-8. Timber licence reversions for the Kingcome TSA (concluded)

Zone	Analysis unit	Reversion year[a]	Area in timber harvesting land base (hectares)
Integrated resource management	Cedar good/medium sites	1990 - 1995	259.6
	Cedar good/medium sites	1996 - 2005	2627.8
	Cedar good/medium sites	2006 - 2015	678.6
	Cedar good/medium sites	2016 - 2025	82.3
	Cedar poor sites	1990 - 1995	128.8
	Cedar poor sites	1996 - 2005	1194.3
	Cedar poor sites	2006 - 2015	5.4
	Hemlock/balsam good/medium sites	1990 - 1995	361.1
	Hemlock/balsam good/medium sites	1996 - 2005	965.5
	Hemlock/balsam good/medium sites	2006 - 2015	522.4
	Hemlock/balsam good/medium sites	2016 - 2025	858.5
	Hemlock/balsam poor sites	1990 - 1995	319.9
	Hemlock/balsam poor sites	1996 - 2005	571.6
	Hemlock/balsam poor sites	2006 - 2015	143.4
	Hemlock/balsam poor sites	2016 - 2025	300.5
Total			16 332

(a) Each timber licence has a reversion year, however, the FSSIM model uses 10 year age classes and has several assumptions regarding the age and area distribution within an age class that make it necessary to combine the TLs into 10 year classes.

A.2.15 Tree farm licence SBFEP take back areas

The Ahnuhati, Matsiu, Bolivar and Wahkash drainages have been returned to the Kingcome TSA from Tree Farm Licence (TFL) 45 as part of the Small Business Forest Enterprise Program (SBFEP). The forest inventory file does not yet include these areas, therefore Port McNeill Forest District staff determined the timber harvesting land base contribution by management zone, inventory type group, site class and age class from the licensee's inventory information. The resultant additions to the land base are shown in Table A-9.

Table A-9. Tree farm licence take back areas, Kingcome TSA

Zone	Analysis unit	Age class (years)[a]	Area (hectares)
Visual quality objective retention	Fir/Spruce all sites	44	0.3
	Fir/Spruce all sites	144	9.7
	Fir/Spruce all sites	264	0.9
	Cedar poor	264	1.1
	Hemlock/balsam good/medium	64	6.8
	Hemlock/balsam good/medium	134	0.3
	Hemlock/balsam good/medium	144	8.3
	Hemlock/balsam good/medium	264	0.7
	Hemlock/balsam poor	154	0
	Hemlock/balsam poor	264	4.5
Visual quality objective partial retention	Fir/spruce all sites	44	6.9
	Fir/spruce all sites	54	19.2
	Fir/spruce all sites	114	2.9
	Fir/spruce all sites	124	17.9
	Fir/spruce all sites	134	6.3
	Fir/spruce all sites	144	90.4
	Fir/spruce all sites	154	4.4
	Fir/spruce all sites	264	49.5
	Cedar poor	264	54.2
	Hemlock/balsam good/medium	44	7
	Hemlock/balsam good/medium	54	6.5
	Hemlock/balsam good/medium	64	10.9
	Hemlock/balsam good/medium	94	13
	Hemlock/balsam good/medium	114	37.4
	Hemlock/balsam good/medium	124	5.2
	Hemlock/balsam good/medium	134	5.4
	Hemlock/balsam good/medium	144	145.4
	Hemlock/balsam good/medium	264	162.1

(a) This age represents to top end of a 10 year age class.

continued

Table A-9. Tree farm licence take back areas, Kingcome TSA (concluded)

Zone	Analysis unit	Age class (years)[a]	Area (hectares)
Visual quality objective partial retention	Hemlock/balsam poor	154	13.4
	Hemlock/balsam poor	264	468.4
Visual quality objective modification	Fir/spruce all sites	54	0.4
	Fir/spruce all sites	114	4.6
	Fir/spruce all sites	264	26.6
	Cedar poor	54	1.8
	Cedar poor	264	37.1
	Hemlock/balsam good/medium	264	5.9
	Hemlock/balsam poor	154	1
	Hemlock/balsam poor	264	123.4
Integrated resource management	Fir/spruce all sites	44	2.2
	Fir/spruce all sites	54	84.1
	Fir/spruce all sites	134	4
	Fir/spruce all sites	264	76.8
	Cedar good/medium	264	14.8
	Cedar poor	264	424.2
	Hemlock/balsam good/medium	54	472.9
	Hemlock/balsam good/medium	84	1.5
	Hemlock/balsam good/medium	114	7.4
	Hemlock/balsam good/medium	124	6.8
	Hemlock/balsam good/medium	134	41.6
	Hemlock/balsam good/medium	144	10.4
	Hemlock/balsam good/medium	264	362.9
	Hemlock/balsam poor	54	1.6
	Hemlock/balsam poor	74	2.6
	Hemlock/balsam poor	264	844.1
	Total		3 717.7

(a) This age represents to top end of a 10 year age class.

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 the merchantable volume. A 10 cm diameter top and a 30 cm stump height is assumed for all species.

The utilization level currently practiced for all species in the timber harvesting land base, Kingcome TSA is 17.5 cm diameter at breast height.

A.3.2 Minimum harvestable age for each analysis unit

Minimum harvestable ages define the earliest age at which an area may be harvested, not the age at which harvesting must occur. All stands presently greater than 120 years of age have a minimum harvestable age of 140 years. The remaining areas have minimum ages defined as the age at which 95% of the maximum average growth rate (culmination mean annual increment) is reached. The ages listed below were determined using the VDYP existing volume tables shown later in this appendix for existing stands. The regenerated stands have the minimum harvestable age based on the TIPSY managed stand volume tables.

Table A-10. Minimum harvestable age for each analysis unit

Analysis unit	Minimum harvestable age for existing stands (years)	Minimum harvestable ages for regenerated stands (years)
All stands currently greater than 120 years	140	
1 Fir/spruce all sites	58	89
2 Cedar good/medium	77	85
3 Cedar poor	94	98
4 Hemlock/balsam good/medium	59	83
5 Hemlock/balsam poor	88	121
11 Fir/spruce all sites	87	87
21 Cedar good/medium	84	84
31 Cedar poor	98	98
41 Hemlock/balsam good/medium	84	84
51 Hemlock/balsam poor	126	126

A.3.3 Forest cover requirements

The analysis did not involve an explicit spatial evaluation of timber supply. However, the computer model used (FSSIM) can incorporate forest cover requirements that specify either the maximum proportion of an area allowed in a disturbed condition (usually defined by the height of young trees), or the minimum required area of old-age forest. Pass systems for timber harvesting can be linked to stand-level adjacency concerns; that is, experience may show that a certain number of harvest passes may be necessary to meet adjacency guidelines. Therefore, forest cover guidelines can approximate the effect of adjacency guidelines as well as broader forest level goals. For this analysis forest cover guidelines were assigned based on the *Vancouver Forest Region Coast Planning Guidelines*, and for visual quality management the VQO guidelines provided by the Ministry of Forests, Recreation Branch were used.

Forest cover guideline for 4-pass harvesting cycle, Integrated Resource Management Zone

The *Vancouver Forest Region Coast Planning Guidelines* state that an area cannot be logged until trees in any adjacent logged area have reached a height of at least 3 metres. The harvesting guidelines also call for a maximum cutblock size of 40 hectares. The leave area between cutblocks must also be of economic or comparable size. Based on Port McNeill Forest District staff experience and work done by Nelson and Errico (1993) these three requirements lead to a 4-pass harvesting system with a 3 metre green-up height.

Visual quality management areas

VQO guidelines as reflected in *Procedures for Factoring Recreation Input into Timber Supply Analysis* were used to derive forest cover requirements for the VQO zones.

Visual absorption capacity (VAC) has not yet been assigned in the Kingcome TSA thus the mid-range values for per cent denudations allowed by VQO class was used.

Table A-11. Initial forest cover guidelines (maximum per cent below green-up period by VQO class)

VQO class	Per cent denudation range	Mid-range value used
Retention	1 - 5	3
Partial retention	6 - 15	10.5
Modification	16 - 25	20

These mid-range values were next adjusted to account for the forested areas outside the timber harvesting land base in each VQO class. That is, forest unavailable for harvesting due to physical inoperability, environmental sensitivity or non-merchantability contributes to the visual quality of an area. For this adjustment, a "green-to-net" ratio was calculated by dividing the total forested areas by the timber harvesting land base for each VQO class. Table A-12. lists the green-to-net ratio for each VQO class.

Table A-12. Green-to-net ratio by VQO class

VQO class	Green-to-net ratio
Retention	2.66
Partial retention	2.23
Modification	1.65

A.3 Forest Management Assumptions

The final step in determining the forest cover guideline for each VQO class is combining the initial forest cover guideline with the green-to-net ratio. This step requires an estimate of how forests within the timber harvesting land base are distributed across the landscape. That is, the harvesting land base could be a fairly solid area separated from inoperable areas by a distinct line. Conversely, area both available and unavailable for harvesting could be fairly evenly dispersed. The intermediate condition is that harvestable forest is distributed in clusters within the landscape. Whether the available forest is solid, clustered, or dispersed determines how to employ the green-to-net ratio. In dispersed landscapes the full ratio is used (available and unavailable areas are in cutblock-sized pieces which are essentially adjacent); that is, the initial forest cover guideline is multiplied by the green-to-net ratio. In solid areas, the green-to-net ratio is not used (available and unavailable areas are separated). In clustered areas, the average of the dispersed and solid factors is used. More detail is available in the procedures document referred to above. An analysis was done to determine the average dispersion of the timber harvesting land base within the forested area of each VQO class by using the forest inventory file and a GIS exercise completed by the forest district staff. Sixteen mapsheets were produced that showed the timber harvesting land base within the forested area of each VQO class, from these mapsheets average lower and upper bounds for determining dispersion were determined. These averages were then used to determine the dispersion of the remainder of the Kingcome TSA.

Table A-13. Dispersion class proportions in the Kingcome TSA

Dispersed	Clustered	Solid
18%	20%	62%

The final forest cover guidelines after all adjustments are listed in Table A-14.

Table A-14. Final forest cover guidelines by VQO class

VQO class	Forest cover guidelines (maximum per cent area below green-up age)	
Retention	4.40%	(rounded to 4%)
Partial retention	14.11%	(rounded to 14%)
Modification	23.64%	(rounded to 24%)

A.3 Forest Management Assumptions

Table A-15. summarizes the forest cover requirements and the current condition of each management zone in the Kingcome TSA. The requirements are applied in the form: a maximum of 25% of the area in a zone may be younger than the specified green-up age.

The site index program FREDDIE supplied by the B.C. Forest Service, Research Branch was used to estimate when trees in the Kingcome TSA will reach a height of 3 metres for the integrated resource management zone, and 5 metres for the VQO zones. These height estimates were originally done for each analysis unit and then were area weighted together to determine a zonal green-up age. These green-up ages do not include regeneration delay.

Table A-15. Forest cover requirements and initial conditions for the Kingcome TSA

Zone	Green-up age[a]	Maximum per cent of area allowed below green-up age	Current per cent of area below green-up age
Retention VQO	19	4	9.5
Partial retention VQO	19	14	8.6
Modification VQO	19	24	52.0
Integrated resource management	14	25	16.4

(a) Green-up ages are based on a height requirement of 5 metres in the VQO zones and 3 metres in the IRM zone.

From this table it can be seen that the amount of area below green-up age is beyond the current requirements in the retention and the modification VQO zones. Management for visual quality has only recently been instituted in the Kingcome TSA and existing alterations cause some of the landscape to exceed the new management objectives.

A.3.4 Unsalvaged losses

Unsalvaged losses are timber volumes destroyed or damaged by a natural cause. Wildfire is the main source of timber loss in the Kingcome TSA. Timber volume losses to endemic insects and disease (i.e., that normally occupy a stand) are accounted for through growth and yield or inventory sampling and are incorporated into the volume tables. The purpose of the unsalvaged loss estimate is to account for losses to epidemic infestations and other factors not accounted for in volume estimates.

The estimated average annual unsalvaged loss to wildfire, over the long term on the timber harvesting land base is 16 365 cubic metres per year.

A.3.5 Not satisfactorily restocked (NSR) areas

The inventory file was assumed to accurately reflect the amount of NSR in the Kingcome TSA. Forest district silviculture staff produced figures with the aid of the Major Licensee Silviculture Information System (MLSIS) and the Integrated Silviculture Information System (ISIS) to reflect the current status of NSR areas in the TSA. The total NSR from MLSIS and ISIS was slightly larger than that in the inventory file as these systems are continually updated and the inventory file is only updated to 1993. The total NSR on the inventory file was returned to the timber harvesting land base in the same proportions of NSR by zone and analysis unit from the forest district data. Table A-16. shows the area returned to the timber harvesting land base by zone and analysis unit.

A.3 Forest Management Assumptions

Table A-16. Not satisfactorily restocked areas

Zone	Analysis unit	Years to restocking	Area (hectares)
VQO retention	11	3	2.1
	21	3	0.2
	31	3	0.8
	41	3	4.1
VQO partial retention	11	3	13.7
	21	3	1.4
	31	3	5.5
	41	3	27.4
VQO modification	11	3	13.7
	21	3	1.4
	31	3	5.5
	41	3	27.4
Integrated resource management	11	3	38.9
	21	3	3.8
	31	3	15.6
	41	3	78
VQO retention	21	5	86.1
	41	5	88.9
	51	5	23.2
VQO partial retention	21	5	573.5
	41	5	592.7
	51	5	154.7
VQO modification	21	5	573.5
	41	5	592.7
	51	5	154.7
Integrated resource management	21	5	1634.5
	41	5	1689.1
	51	5	440.9

A.3.6 Basic silviculture and regeneration assumptions

Basic silviculture includes any activities required to establish free-growing stands of commercially valued species. Basic silviculture is assumed to occur over the long term in the Kingcome TSA. Table A-17. shows the assumptions used to describe silviculture regimes by analysis units for the Kingcome TSA.

Table A-17. Silvicultural regimes by analysis unit

Existing analysis unit volume table[a]	Regenerated volume table number	Regeneration delay[b] (years)	Per cent planted	Per cent natural regeneration	Total initial stocking (stems/ha)	Total stocking at free-to grow (stems/ha)[c]
1 Fir (29.5%)	101	3	90	10	1200	2000
Spruce (70.5%)			100	0	1000	2000
2 Cedar good/medium	102	5	89	11	1000	2000
3 Cedar poor	103	5	85	15	900	1200
4 Hemlock/balsam good/medium	104	6	40	60	1200	5000
5 Hemlock/balsam poor	105	6	40	60	900	3000
11 Fir (11.2%)	11	3	90	10	1200	2000
Spruce (88.8%)			100	0	1000	2000
21 Cedar good/medium	21	5	84	16	1000	2000
31 Cedar poor	31	5	85	15	900	1200
41 Hemlock/balsam good/medium	41	6	40	60	1200	5000
51 Hemlock/balsam poor	51	6	40	60	900	3000

(a) Analysis units 11 to 51 are immature managed stands that are immediately put on managed stand yield tables (TIPSY) and thus remain on the same table for the entire planning horizon.
(b) FSSIM takes direct entry of the regeneration delay and thus it is not incorporated in the volume tables.
(c) Total stocking at free-to-grow was used when developing the TIPSY volume tables.

In TIPSY, balsam is assumed to grow the same as hemlock, therefore the volume tables for the analysis units that have these species are based on hemlock only. There are no species changes after harvest. The operational adjustment factors (OAFs) used for all TIPSY volume estimates are:

OAF 1 = 15%;

OAF 2 = 5%.

A.3 Forest Management Assumptions

A.3.7 Starting harvest level

The timber harvesting land base excludes some areas that harvesting is taking place on. The following shows how the AAC or target starting harvest level was determined for the timber harvesting land base used in this analysis.

Total AAC	1 798 270	m^3/year
Less deciduous leading stands	- 25 000	m^3/year
Less low site licence	- 112 000	m^3/year
Less woodlots	- 2 500	m^3/year
AAC for analysis purposes	1 658 770	m^3/year

A.4 Volume Estimates for Existing Stands

The variable density yield projection (VDYP) model, version 4.5, developed by the B.C. Forest Service, Inventory Branch, was used to estimate timber volumes for existing stands.

Before the VDYP model was run any stands that had a special site class available on the inventory file, had the special site substituted for the site class.

Deciduous and lodgepole pine components of forest stands were removed from existing stand volume estimates for this analysis.

A.4 Volume Estimates for Existing Stands

Table A-18. Timber volume tables for existing stands

Age class	Analysis unit 1 Fir/Spruce all sites	Analysis unit 2 Cedar good/medium	Analysis unit 3 Cedar poor	Analysis unit 4 Hemlock/Balsam good/medium	Analysis unit 5 Hemlock/Balsam poor
0	0	0	0	0	0
10	0.5	0	0	0	0
20	17.0	0.1	0	3.9	0.1
30	69.8	20.5	0.2	61.4	0.8
40	152.0	95.4	15.5	163.4	16.3
50	232.4	171.9	58.9	256.4	67.1
60	303.5	244.0	106.7	337.2	121.0
70	365.7	310.0	151.4	407.7	170.8
80	420.9	371.6	193.6	469.5	215.4
90	471.2	428.2	232.8	523.7	255.6
100	517.0	480.7	269.5	571.7	292.1
110	558.2	529.6	304.0	614.2	325.2
120	594.6	569.7	332.2	650.8	354.4
130	628.2	609.7	359.8	686.4	382.4
140	658.5	645.7	384.3	718.6	408.0
150	685.3	677.3	405.6	747.4	431.3
160	709.0	704.5	423.8	773.1	452.3
170	729.6	727.5	438.8	795.9	471.3
180	748.1	752.3	455.3	817.5	489.5
190	767.0	776.2	471.2	837.4	506.7
200	784.9	798.9	486.5	855.9	522.9
210	801.9	820.8	501.1	872.9	538.1
220	818.1	847.2	518.5	888.6	552.4
230	833.4	872.8	535.8	903.2	565.8
240	848.0	897.8	552.5	916.7	578.5
250	861.9	922.0	568.8	929.1	590.4
260	872.3	925.0	570.9	936.5	597.6
270	882.2	927.6	572.9	943.1	604.3
280	891.7	930.0	574.7	949.0	610.5
290	900.7	932.2	576.4	954.3	616.2
300	909.3	934.2	578.0	959.0	621.4
310	917.6	936.0	579.4	963.1	626.3
320	925.5	937.6	580.8	966.7	630.8
330	933.0	939.0	582.0	969.9	635.0
340	940.3	940.3	583.1	972.6	638.8
350	947.3	941.4	584.2	974.9	642.3

A.5 Volume Estimates for Managed Stands

TIPSY (Table Interpolation Program for Stand Yields), supported by B.C. Forest Service, Research Branch, was used to generate managed stand volume tables for this analysis. Table A-17. shows the assumptions made for each analysis unit when developing the TIPSY volume tables.

FREDTAB, also supported by the B.C. Forest Service, Research Branch, was used to generate the site index for each record on the inventory file. This site index was used to generate the managed stand volume tables.

A.5 Volume Estimates for Managed Stands

Table A-19. Timber volume tables for managed regenerated and existing immature stands

Age class	Analysis unit 11 Fir/Spruce all sites existing managed stands	Analysis unit 21 Cedar good/medium existing managed stands	Analysis unit 31 Cedar poor existing managed stands	Analysis unit 41 Hemlock/Balsam good/medium existing managed stands	Analysis unit 51 Hemlock/Balsam poor existing managed stands
0	0	0	0	0	0
10	0	0	0	0	0
20	0	0	0	0	0
30	10.0	5.2	0	8.8	0
40	114.4	126.7	2.8	105.2	0.4
50	282.3	275.4	23.5	241.6	7.2
60	417.9	385.6	79.9	369.2	42.6
70	542.7	507.3	138.1	494.0	92.0
80	684.0	620.6	192.2	594.6	143.4
90	816.8	710.9	246.5	696.6	197.2
100	924.9	805.8	291.8	791.0	245.4
110	1028.3	904.8	327.0	875.0	289.4
120	1125.2	982.4	357.4	941.8	328.4
130	1201.4	1049.1	391.4	1002.6	369.8
140	1267.6	1114.7	425.2	1064.6	407.2
150	1325.3	1172.3	456.0	1119.2	441.6
160	1376.7	1222.3	482.1	1172.2	471.6
170	1420.6	1265.9	507.4	1219.2	498.0
180	1450.1	1303.6	529.7	1260.2	522.4
190	1475.0	1340.7	550.0	1292	544.8
200	1497.0	1375.9	567.3	1320.8	569.2
210	1514.3	1406.9	582.6	1346	591.6
220	1530.5	1447.9	600.6	1375.2	611.4
230	1544.0	1482.2	616.8	1402.4	630.8
240	1555.6	1512.7	630.9	1427.6	647.6
250	1565.3	1540.8	644.9	1450.2	664.6
260	1573.1	1566.3	656.9	1469.8	680.2
270	1579.9	1589.5	668.0	1485.8	694.2
280	1584.9	1613.3	680.0	1500.2	707.8
290	1588.1	1634.2	695.2	1513.2	719.8
300	1589.3	1653.2	710.2	1524.6	730.8
310	1589.3	1653.2	710.2	1524.6	730.8
320	1589.3	1653.2	710.2	1524.6	730.8
330	1589.3	1653.2	710.2	1524.6	730.8
340	1589.3	1653.2	710.2	1524.6	730.8
350	1589.3	1653.2	710.2	1524.6	730.8

continued

A.5 Volume Estimates for Managed Stands

Table A-19. Timber volume tables for managed regenerated and existing immature stands (concluded)

Age class	Analysis unit 101 Fir/Spruce all sites regenerated stands	Analysis unit 102 Cedar good/medium regenerated stands	Analysis unit 103 Cedar poor regenerated stands	Analysis unit 104 Hemlock/Balsam good/medium regenerated stands	Analysis unit 105 Hemlock/Balsam poor regenerated stands
0	0	0	0	0	0
10	0	0	0	0	0
20	0	0	0	0	0
30	0.3	2.1	0	11.8	0
40	72.1	69.1	1.9	114.8	1.4
50	212.2	188.3	13.2	259.0	14.4
60	331.2	309.0	68.7	393.8	50.8
70	435.6	391.6	121.7	522.8	108.0
80	544.7	487.6	171.4	628.0	164.0
90	655.4	577.0	223.5	736.0	219.2
100	753.8	653.6	270.5	834.6	268.8
110	835.7	715.6	306.0	920.0	313.8
120	918.8	783.6	336.1	989.2	357.4
130	992.3	854.5	362.4	1054.8	400.2
140	1051.3	914.7	394.2	1119.2	438.6
150	1102.7	962.6	423.2	1177.2	472.0
160	1149.1	1004.3	449.1	1232.0	502.0
170	1190.3	1043.9	472.1	1280.8	529.4
180	1225.7	1079.7	494.2	1320.2	554.8
190	1252.4	1112.2	513.5	1353.2	582.2
200	1274.2	1139.9	530.8	1382.6	606.4
210	1292.6	1164.3	545.2	1412.0	628.8
220	1307.8	1195.6	564.3	1443.4	650.2
230	1321.8	1224.0	582.6	1472.2	669.6
240	1333.6	1250.3	596.8	1498.0	688.2
250	1344.5	1275.5	609.9	1520.8	705.2
260	1352.9	1302.5	621.9	1539.4	721.2
270	1360.3	1326.6	633.0	1556.4	735.8
280	1366.8	1349.6	643.0	1571.4	748.8
290	1371.5	1370.6	653.0	1584.4	760.4
300	1374.6	1390.5	661.2	1596.4	770.6
310	1374.6	1390.5	661.2	1596.4	770.6
320	1374.6	1390.5	661.2	1596.4	770.6
330	1374.6	1390.5	661.2	1596.4	770.6
340	1374.6	1390.5	661.2	1596.4	770.6
350	1374.6	1390.5	661.2	1596.4	770.6