Sunshine Coast 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 timber supply area, and include guidelines for the protection of forest resources and official land-use decisions made by Cabinet. The current nature and capabilities of the local forest industry are also considered.

Assessing the implications of only current practices rather than looking at a number of different management schemes will expedite the analysis process, allowing analysis of all TSAs in the province 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 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 Sunshine Coast Timber Supply Area (TSA). The analysis assesses how current forest management practices affect the supply of wood available for harvesting over both the short (next 20 years) and long (next 250 years) term. It also examines the potential changes in timber supply stemming from uncertainties about forest growth and management actions. It is important to note that the various harvest forecasts included in the report indicate only the timber supply implications of current practices and uncertainty. **As such, the forecasts should be used for discussion purposes only; they are not allowable annual cut (AAC) recommendations.**

The Sunshine Coast TSA consists of about 1.1 million hectares, of which about 224 000 hectares are considered to be suitable and available for timber harvesting. The total volume of standing timber in the area is about 70 million cubic metres, of which about 55 million cubic metres is old enough to be harvested. Forests in the area are dominated by stands of Douglas-fir, western hemlock and western redcedar. The current AAC for the Sunshine Coast TSA is 1.1 million cubic metres per year.

The results of this timber supply analysis indicate that, given current forest management assumptions, the current AAC can be maintained for the next 10 years before declining by 10% per decade to 876 000 cubic metres per year is reached in approximately 30 years. This rate of harvest, which is 11% below the steady long-term harvest level, must be maintained for approximately 100 years in order to avoid further timber supply shortfalls in the future. In approximately 130 years, after most of the forest is comprised of managed stands, the rate of harvest can be increased to the steady long-term harvest level of 986 000 cubic metres per year.

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

Two important factors affecting the harvest forecast in the Sunshine Coast TSA are forest cover requirements used to manage for visual quality of the landscape and the estimated site indices of the regenerated stands. Uncertainties in either of these factors affect the harvest forecast in both the short- and long-term. In general, sensitivity analyses indicate that, for the same amount of change in a factor (e.g., plus or minus 10%) to an uncertain assumption or piece of data, indicated decreases in the harvest forecast were generally larger than indicated increases.

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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.

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

Timber supply 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 Sunshine Coast TSA. Following a brief description of the area in Section 1, data preparation and formulation of assumptions are discussed in Section 2. Analysis methodology and results are presented in Sections 3 and 4. Section 5 examines the sensitivity of the results to uncertainties in the data and assumptions used. The report ends with a summary and conclusions.

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

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

1 Description of the Sunshine Coast Timber Supply Area

The Sunshine Coast Timber Supply Area lies within the Vancouver Forest Region and is administered from the Sunshine Coast Forest District office in Powell River and a field office in Sechelt. The Sunshine Coast TSA encompasses a total of 1 121 131 hectares northwest of Vancouver. It is within the Southern Pacific Ranges of the Coast Mountains and extends from Howe Sound in the south to Bute Inlet in the north. The major communities within the Sunshine Coast TSA include Powell River, Sechelt, Gibsons, and Lund.

The topography of the Sunshine Coast TSA is generally mountainous, especially in the more inland areas. This mountainous topography and associated high rainfall produce a very diverse climate and ecology which is expressed in a variety of ecosystems ranging from nutrient-rich, moist, flood plains in valley bottoms to high-elevation alpine meadows.

The communities in the Sunshine Coast TSA are predominantly resource based and are especially dependent on the local timber industry. There is a long history of timber harvesting in the area. Timber harvested from the Sunshine Coast TSA is processed both in local mills and in other coastal mills via the coastal log market. Tourism and recreation are also very important to several of the local economies, as the Sunshine Coast TSA offers excellent recreational opportunities. The commercial fisheries sector, while diminishing in recent years, is still an important contributor to the local economy.

1 Description of the Sunshine Coast Timber Supply Area

Figure 1. *Map showing the location of the Sunshine Coast TSA within 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 is a representation of the land base for the entire TSA. It includes data for areas on which timber harvesting operations are not expected to take place, and therefore do not contribute to the timber supply of the area. Examples include land that has been set aside for a park, or areas occupied by power lines, highways or town sites. 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 an inoperable 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.

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

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

2 Information Preparation

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

- areas not managed directly by the B.C. Forest Service — these include non-Crown land, areas managed by other agencies (e.g., parks, recreation areas) and forest land not administered as part of the TSA (e.g., woodlot licences or tree farm licences* (TFL) and small areas of non-contributing provincial forest*).
- non-forest areas — areas not capable of growing productive forest (rock, swamp, and alpine areas).
- non-commercial cover areas — areas occupied by non-commercial forest cover (brush).
- inoperable areas* — areas classified as unavailable for harvest for terrain-related and economic reasons. Characteristics that influence operability* include slope, topography, difficulty of road access, soil stability, elevation and timber quality.
- non-merchantable forest types* — areas occupied by timber stands of low volume or non-merchantable species, or with low timber growing potential.
- environmentally sensitive areas* — areas defined as being sensitive to timber harvesting activities (e.g., areas with fragile soils, significant non-timber values or areas where forest regeneration will be difficult) are assumed to be unavailable for timber harvesting.
- riparian areas* — areas along major streams and lakeshores are assumed to be unavailable for timber harvesting in order to protect water quality and streambank integrity.
- existing roads, trails and landings — forest land lost to future timber production due to past access development and harvesting.
- 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.

Table 1 summarizes the areas in each category discussed above, and shows the area of the timber harvesting land base. The largest reduction from the Crown forest is for inoperable areas, with less significant reductions for non-merchantable stands and environmentally sensitive areas. A more detailed description of the removals and additions used to define the timber harvesting land base is provided in Appendix A, "Description of Data Inputs and Assumptions."

Tree farm licence (TFL)
Provides rights to harvest timber, and outlines responsibilities for forest management, in a particular area.
Non-contributing provincial forest
Generally made up of small water bodies and small areas of non-contributing forest land surrounded by, and included in the forest inventory as provincial forest.
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.
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.
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.
Riparian area
Areas of land adjacent to wetlands or bodies of water such as swamps, streams, rivers or lakes.

2 Information Preparation

Table 1. Timber harvesting land base for the Sunshine Coast TSA

Classification	Area (hectares)	Per cent of total area	Per cent of Crown forest area
Total area on inventory file	1 121 131	100.0	
Not managed by B.C. Forest Service (BCFS)	87 658	7.8	
Non-forest	585 968	52.3	
Total productive forest managed by B.C. Forest Service (Crown forest)	447 505	39.9	100.0
Reductions to Crown forest:			
Non-commercial (brush) cover	77	0.0	0.0
Non-contributing provincial forest	1 543	0.1	0.3
Von Donop Marine Park	443	0.0	0.1
Inoperable areas	144 549	12.9	32.3
Non-merchantable stands	39 963	3.6	8.9
Environmentally sensitive areas	24 672	2.2	5.5
Riparian areas	3 620	0.3	0.8
Existing roads, trails and landings	8 289	0.7	1.9
Total of all area reductions [a]	223 156	19.9	49.9
Initial timber harvesting land base [b] (includes 9 416 hectares of not satisfactorily restocked* (NSR) land)	224 349	20.0	50.1
Future reductions:			
Future roads, trails and landings	5 366	0.5	1.2
Long term timber harvesting land base	218 983	19.5	48.9

a) Reductions were performed in the order shown.
b) All study area's identified under the Protected Areas Strategy are assumed to be available for timber harvesting subject only to the reductions shown in this table.

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.

Figure 2 shows a breakdown of the timber harvesting land base by leading tree species, quality of growing site and maturity. The timber harvesting land base in the Sunshine Coast TSA is comprised mainly of hemlock (western and mountain) (46%), Douglas-fir (46%) and western redcedar (8%). Stands that have balsam and spruce as leading species are a minor component of the Sunshine Coast TSA, and are included in Figure 2 with hemlock leading stands. Note that the majority of the existing forest older than 100 years, which is expected to be the primary source of timber for harvesting over the short term, is mainly on the poorer growing sites.

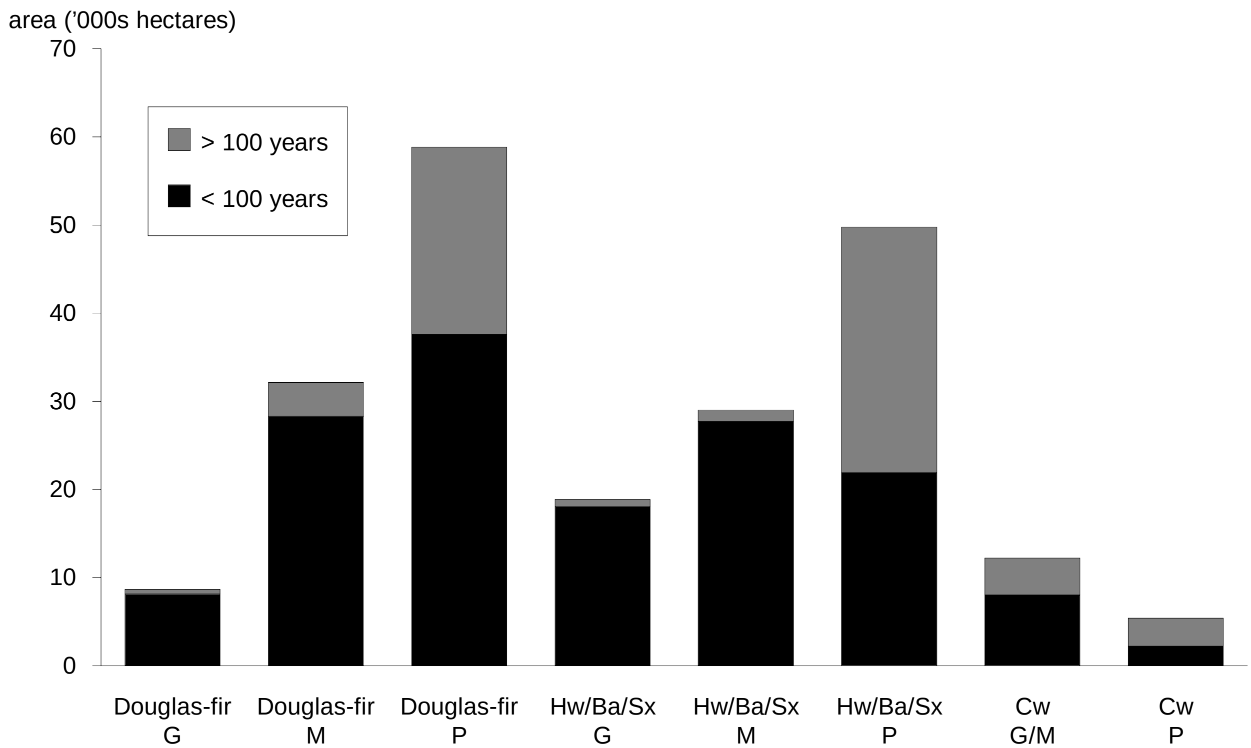

Figure 2. Area by dominant tree species, quality of growing site and maturity, timber harvesting land base — Sunshine Coast TSA, 1995.

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. In British Columbia, the most common measure of the amount of standing timber is 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 removed from a site during harvesting. Utilization levels specify a maximum stump height and minimum diameters at the tree base and top.

Timber volumes applied to existing stands in this analysis are based on the Variable Density Yield Prediction (VDYP) model developed by the B.C. Forest Service, Inventory Branch. This model provides estimates of stand volume according to age. Timber volumes estimated for future regenerated stands are based on the Table Interpolation Program for Stand Yields (TIPSY) model developed by the B.C. Forest Service, Research Branch. Sensitivity analyses address the possibility that stand volumes may be different from those predicted. Appendix A, "Description of Data Inputs and Assumptions," contains more information on the methods and models used to predict timber volumes.

2.3 Management practices

Timber supply is directly related to forest management activity. The focus of the Timber Supply Review is to describe the timber supply based on current management practices, as implemented in plans for the area.

The following assumptions reflect current forest management in the Sunshine Coast TSA, and are used in the timber supply analysis.

- Cutblock adjacency* — timber harvesting is generally not carried out on an area until the young regenerated forest in any adjacent harvested areas has reached an average height of 3 metres. The time required for the regenerated stands to reach the required average height is referred to as the green-up period*. In the Sunshine Coast TSA, cutblock adjacency guidelines generally ensure that no more than 33% of an area being developed for timber harvesting is covered with trees less than 3 metres tall. The sensitivity of the harvest forecast* to both the amount of area that may be covered with trees less than 3 metres tall and the estimated time required for regenerated stands to reach a 3 metre height is examined in Section 5.

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

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

- Visual quality of the landscape — in visually sensitive areas, the green-up requirement is achieved when the regenerated trees on a harvested area reach approximately 5 metres in height. The proportion of each visually sensitive area that may be in harvested stands less than 5 metres in height depends on the visual quality objectives (VQO)* for the area. Visual quality objectives modelled in this analysis include retention* (most restrictive), partial retention* (less restrictive) and modification* (least restrictive), and are an important factor affecting the timber supply in the Sunshine Coast TSA. About 55% of the timber harvesting land base is affected by management for visual quality.
- Minimum harvestable ages — the time required for trees to grow to a harvestable size. The minimum harvestable ages used in this analysis vary by tree species and site productivity, but were all set at or near the age at which the trees achieve their maximum average annual volume growth (often referred to as maximum mean annual increment (MAI)*). Harvesting at this age maximizes the amount of timber that is produced over the long term. It is important to remember that these ages represent a minimum requirement. Management for non-timber forest values (such as visual quality, fish habitat and water quality) may necessitate harvesting stands at ages well above the minimum, resulting in a lower long-term timber yield. The minimum harvestable ages for each tree species and quality of growing site are listed in Appendix A, "Description of Data Inputs and Assumptions." The effect that uncertainty in the minimum harvestable ages has on the timber supply forecast is examined in sensitivity analysis in Section 5.2, "Sensitivity to uncertainty in minimum harvestable ages."

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.
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.

- Basic silviculture levels — reforestation activities required to establish free-growing* stands of acceptable species. Most areas in the Sunshine Coast TSA, are harvested using a clearcut harvesting* system and restocked by planting or natural regeneration.
- Forest health and unsalvaged losses* — losses of merchantable timber due to fire, wind damage and insects are estimated to be 24 200 cubic metres per year. Losses to root rot disease are expected to be significant in regenerated Douglas-fir stands, and are accounted for in the volume estimates for these stands.

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

All forested areas in the Sunshine Coast TSA are divided into main forest management emphases. Figure 3 shows the composition of the timber harvesting land base according to the management emphasis zones.

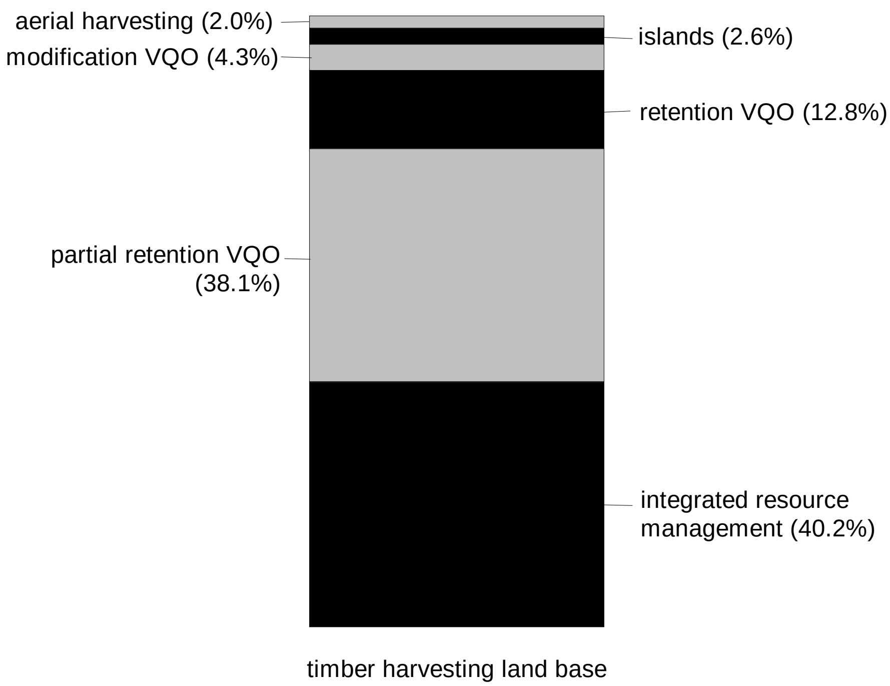

Figure 3. Major forest management emphasis zones — Sunshine Coast TSA, timber harvesting land base, 1995.

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

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.

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

3 Analysis Methods

The purpose of this analysis was to examine both the short- and long-term timber harvesting opportunities in the Sunshine Coast 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 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 this information gives field staff only very limited guidance in the design of operational activities such as harvesting block location and silviculture planning, it does 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 Sunshine Coast 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 long-term venture, uncertainty surrounds much of the information important in determining timber supply. These factors will be discussed in Section 5, "Timber Supply Sensitivity Analyses."

4.1 Base case harvest forecast

The harvest forecast based on current forest management assumptions* for the Sunshine Coast TSA is shown in Figure 4. This forecast will be referred to as the base case and will be used as the basis for comparison for all other harvest forecasts in this report.

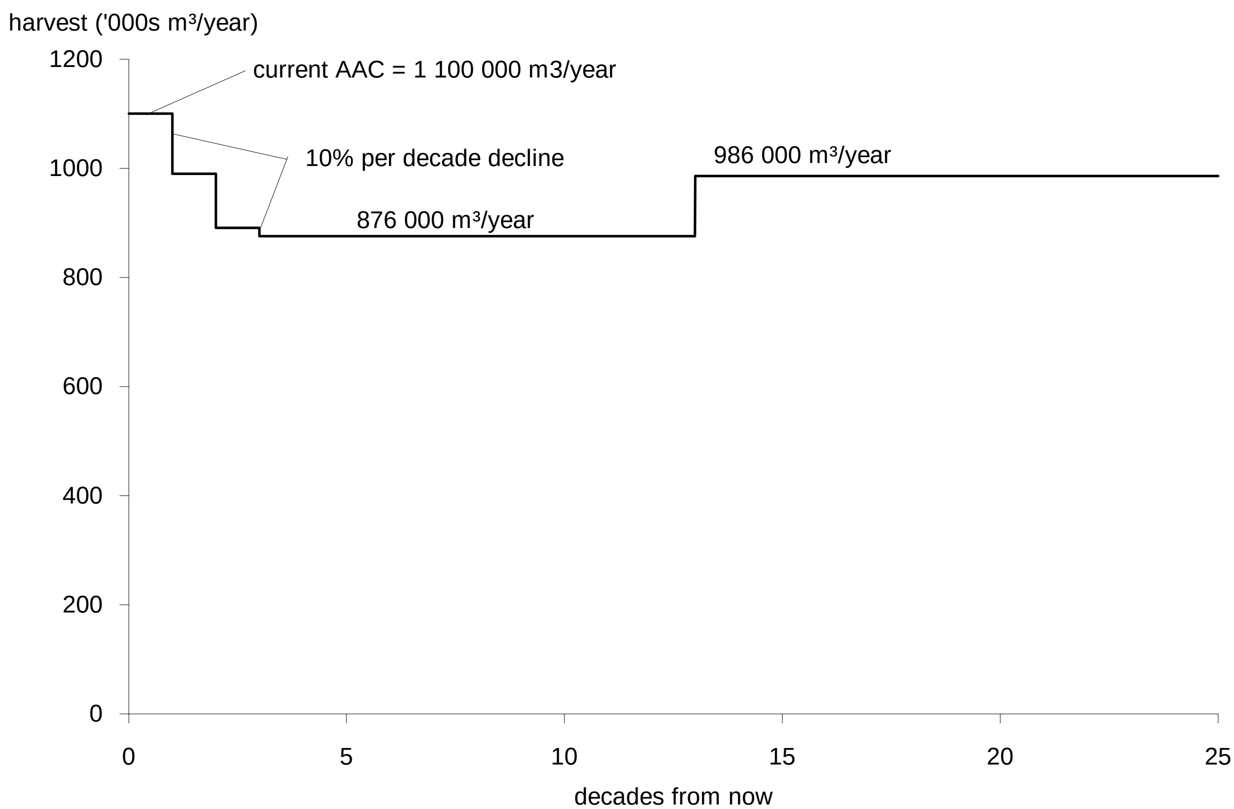

Figure 4. Base case harvest forecast — Sunshine Coast TSA, 1995.

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.

4 Results

The base case harvest forecast shows an initial rate of harvest of 1.1 million cubic metres per year, which is equal to the current AAC. This rate of harvest is maintained for the first decade before declining by 10% per decade over the next 2 decades to about 876 000 cubic metres per year. Once the entire timber harvesting land base is under managed forests (in approximately 130 years) the rate of harvest increases by about 11% to a steady long-term harvest level* of about 986 000 cubic metres per year.

The base case harvest forecast shown is only one of many possible harvest flows given current forest management assumptions. The harvest forecast shown in Figure 4 was chosen as the base case for this analysis as a balance between short- and long-term timber supply interests. Starting the harvest forecast at a higher initial level, delaying the decline, or reducing the rate of decline results in a more severe timber supply shortfall in the future. These and other harvest flow options for the base case are shown in Section 5.1, "Alternative initial harvest levels and harvest flows over time."

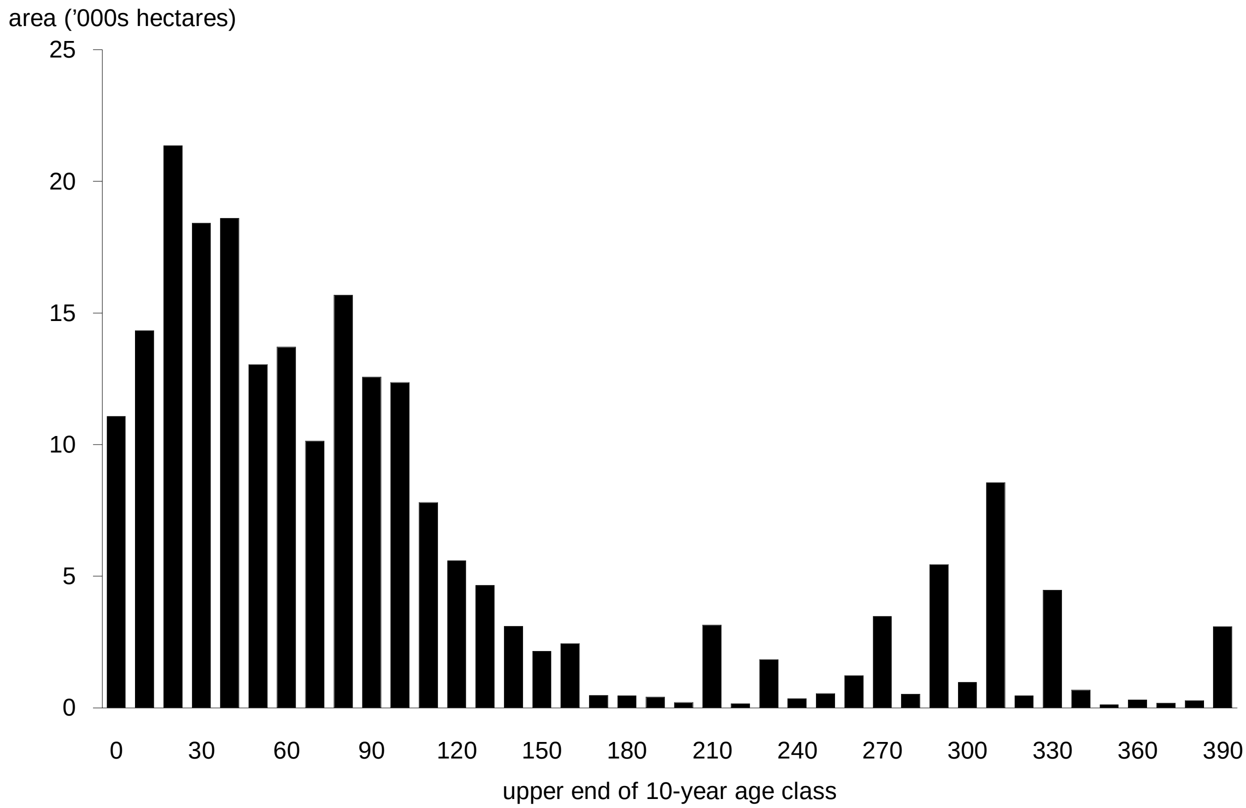

Figure 5. Current stand age distribution — Sunshine Coast TSA, 1995.

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

4 Results

Two important factors affecting the base case harvest forecast are the current level of management for visual quality and the relatively low inventory of mature timber. As noted in Section 2.3, "Management practices," about 55% of the timber harvesting land base is affected by management prescriptions that limit the rate of harvest in order to maintain visual quality in visually sensitive landscapes. The effect that changing these visual quality objectives has on the harvest forecast is examined in Section 5.7, "Sensitivity to forest cover requirement for visual quality." The relatively low inventory of mature timber mentioned above is the result of a long history of harvesting in the Sunshine Coast TSA, which has been characterized by a preference for harvesting stands on better growing sites first. As shown in Figure 5, the majority of forest stands on the timber harvesting land base are less than 100 years old. Section 2.1, "Land base inventory" and Figure 2, show that the remaining mature and old-growth forest on the timber harvesting land base is primarily on the poorer growing sites. As a result, the existing timber inventory is not large enough to maintain the rate of harvest at or above the steady long-term harvest level that will be achieved when the harvest is coming from more productive managed stands.

Figure 6 shows the transition from a predominantly natural to a predominantly managed forest in the Sunshine Coast TSA over time. All stands greater than 20 years old are shown as natural stands in Figure 6. Prior to 20 years ago, the majority of stands were left to regenerate naturally after harvesting. In the future, harvested stands are expected to be more productive as they will be restocked with trees at an optimal density and maintained using spacing, brushing and other silvicultural practices. As shown in Figure 6, the timber harvesting land base is not expected to be mostly in managed forest until about 130 years from now, which corresponds with the time at which the base case harvest forecast is able to increase to a steady long-term harvest level.

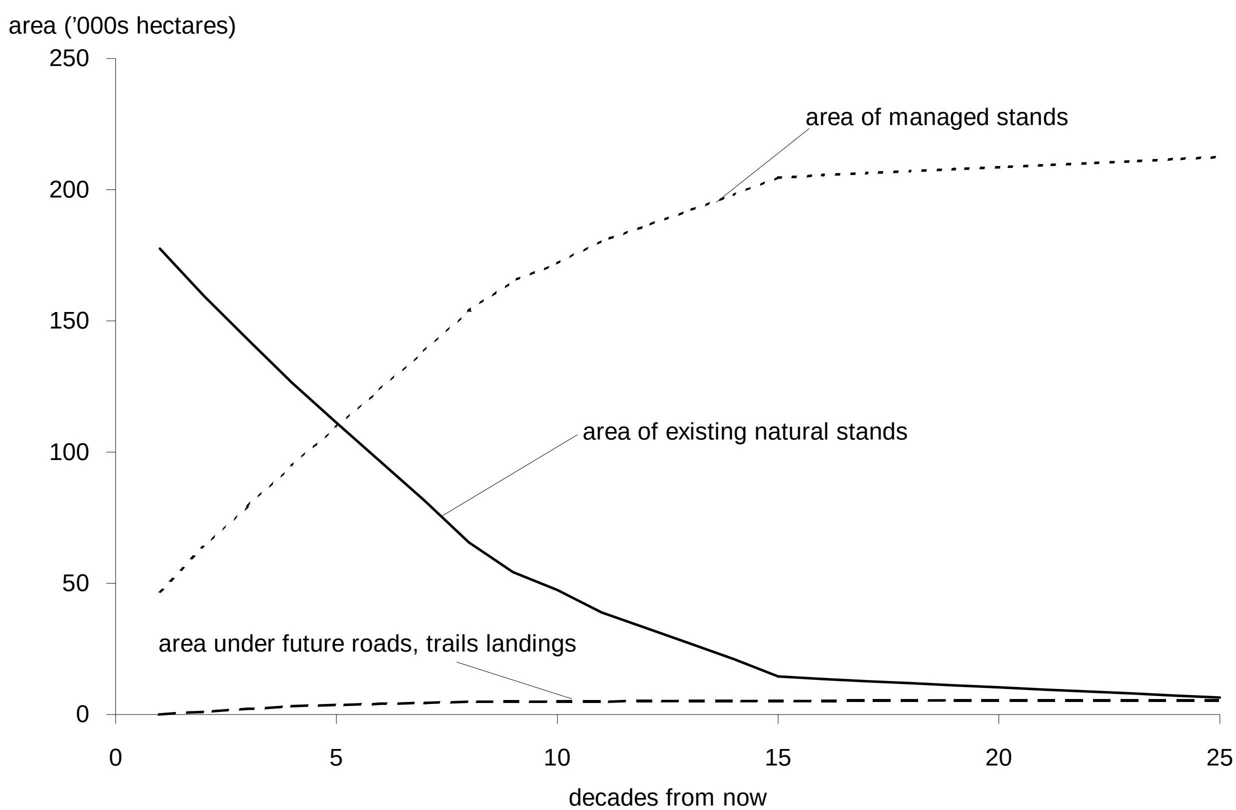

Figure 6. Projected area of managed and natural stands over time — Sunshine Coast TSA, 1995.

4 Results

Figure 7 shows the total and harvestable (older than minimum harvestable age) growing stock* projected over time. There is currently a total of about 70 million cubic metres of timber on the timber harvesting land base. Of the total, about 55 million cubic metres of timber is currently old enough to be considered harvestable. Similar to the trend seen for the harvest levels in the base case harvest forecast, both the total and harvestable timber growing stock are projected to initially decline, then rise to a steady long-term harvest level as more of the forest becomes managed.

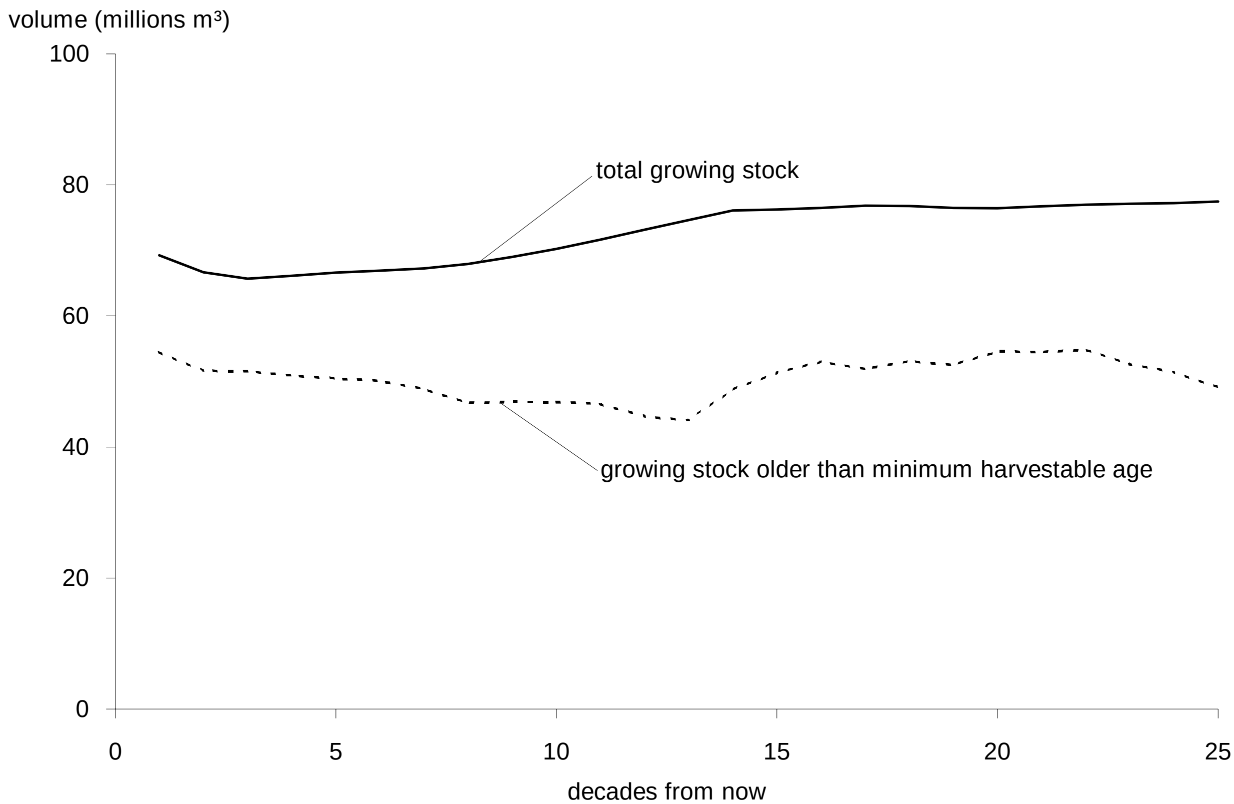

Figure 7. Total and harvestable growing stock over time — Sunshine Coast TSA, 1995.

Figure 8 shows the changes projected to occur in the age distribution of forest stands on the timber harvesting land base of the Sunshine Coast TSA. By 50 years, most of the remaining older stands on the timber harvesting land base are harvested and replaced with regenerated stands. At 250 years from now most of the forest is 110 years old or younger. There are also some stands being maintained at older ages (above 170 years) and a proportion between 120 and 160 years of age. Both of these are a result of the forest cover requirements, particularly in the visual quality areas. This timber will eventually be harvested, but over an extended period of time.

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

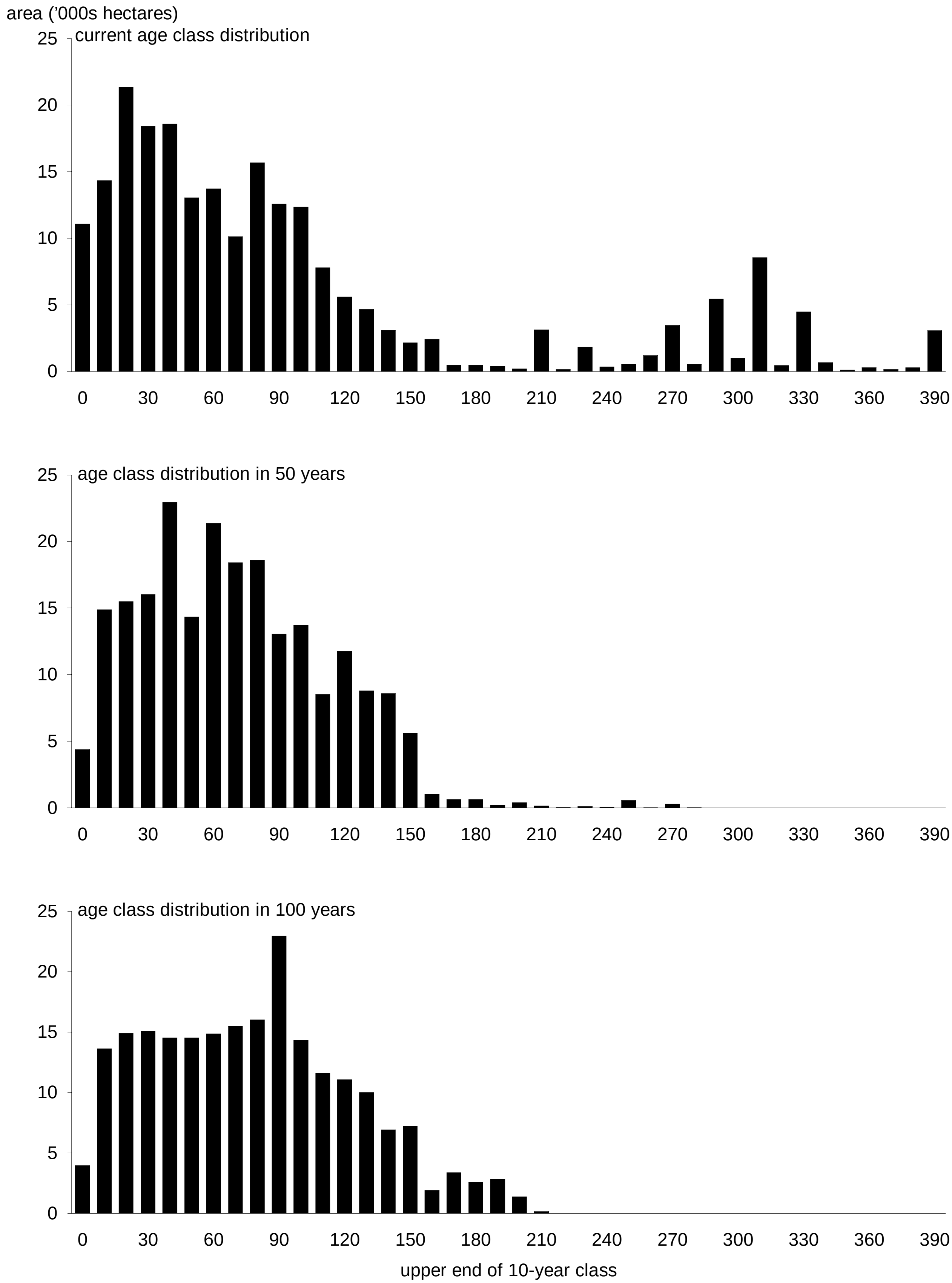

Figure 8. Stand age distribution over time — Sunshine Coast TSA, 1995.

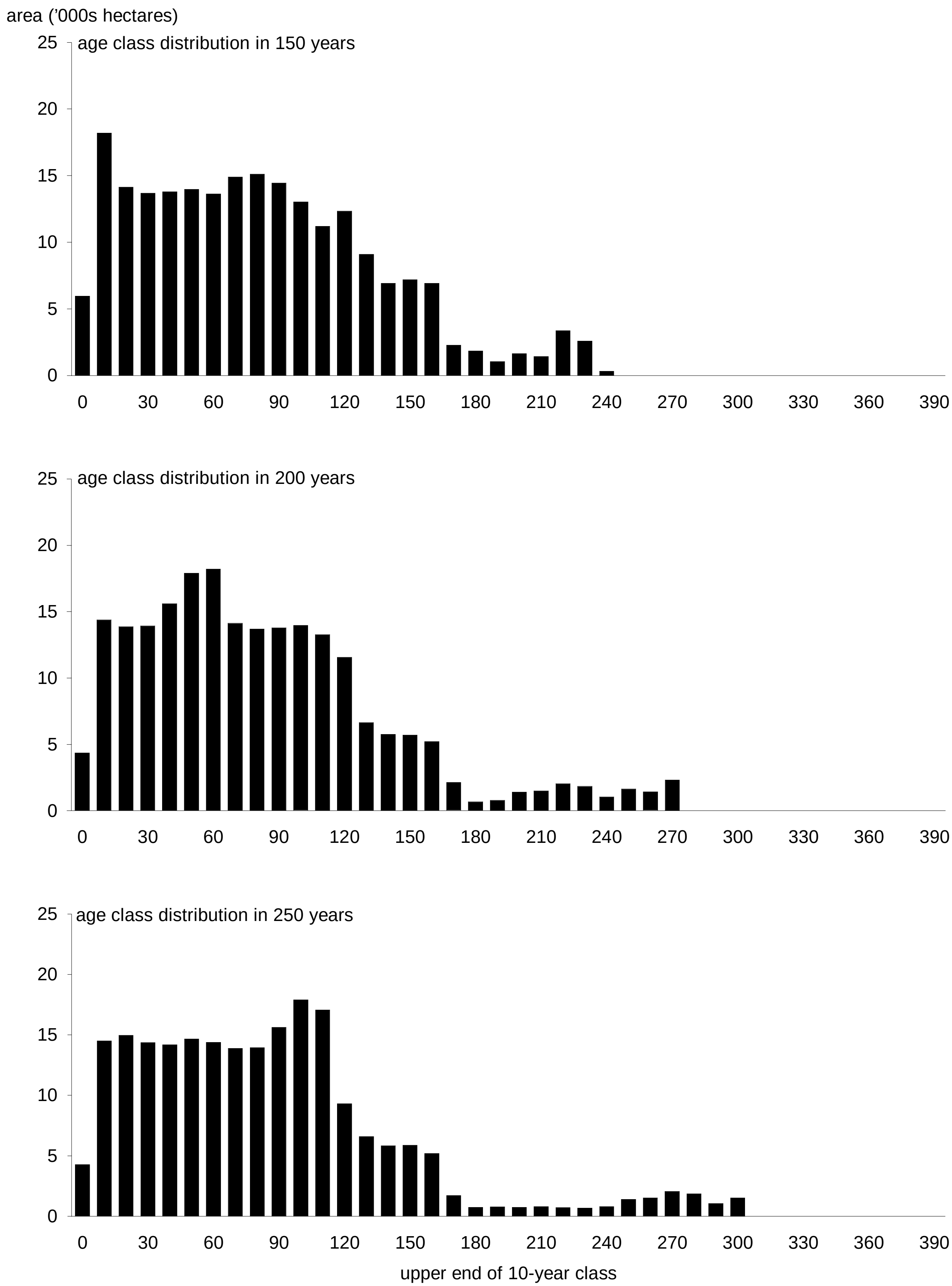

Figure 8. Stand age distribution over time — Sunshine Coast TSA, 1995 (concluded).

5 Timber Supply Sensitivity Analyses

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

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

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

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

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

In this section, results of several sensitivity analyses are discussed. The results that are based on current forest management assumptions (shown in Figures 9 to 12) are referred to as alternative harvest flows for the base case.

5 Timber Supply Sensitivity Analyses

5.1 Alternative initial harvest levels and harvest flows over time

The base case harvest forecast shown in Figure 4 was defined using criteria such as gradual 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, the other criteria are attempts to avoid both excessive changes from decade-to-decade, and significant timber shortages in the future which might limit future options. There are many possible harvest flows, with different decline rates, starting harvest levels, and potential trade-offs between short-term and long-term harvests.

In the base case harvest forecast, the rate of decline was limited to 10% per decade. However, this means that, in terms of cubic metres per decade, the rate of decline will be slightly larger in the short term than it will be in the long term. Figure 9 shows the harvest forecast if the rate of decline is held at a constant volume of 100 000 cubic metres per decade rather than a constant per cent volume per decade. This change has little effect on the harvest forecast because the initial rate of harvest is already relatively close to the steady long-term harvest level. If the initial rate of harvest was significantly higher than the steady long-term level, necessitating a more prolonged period of decline, differences between the two methods of reducing the rate of harvest would be more apparent.

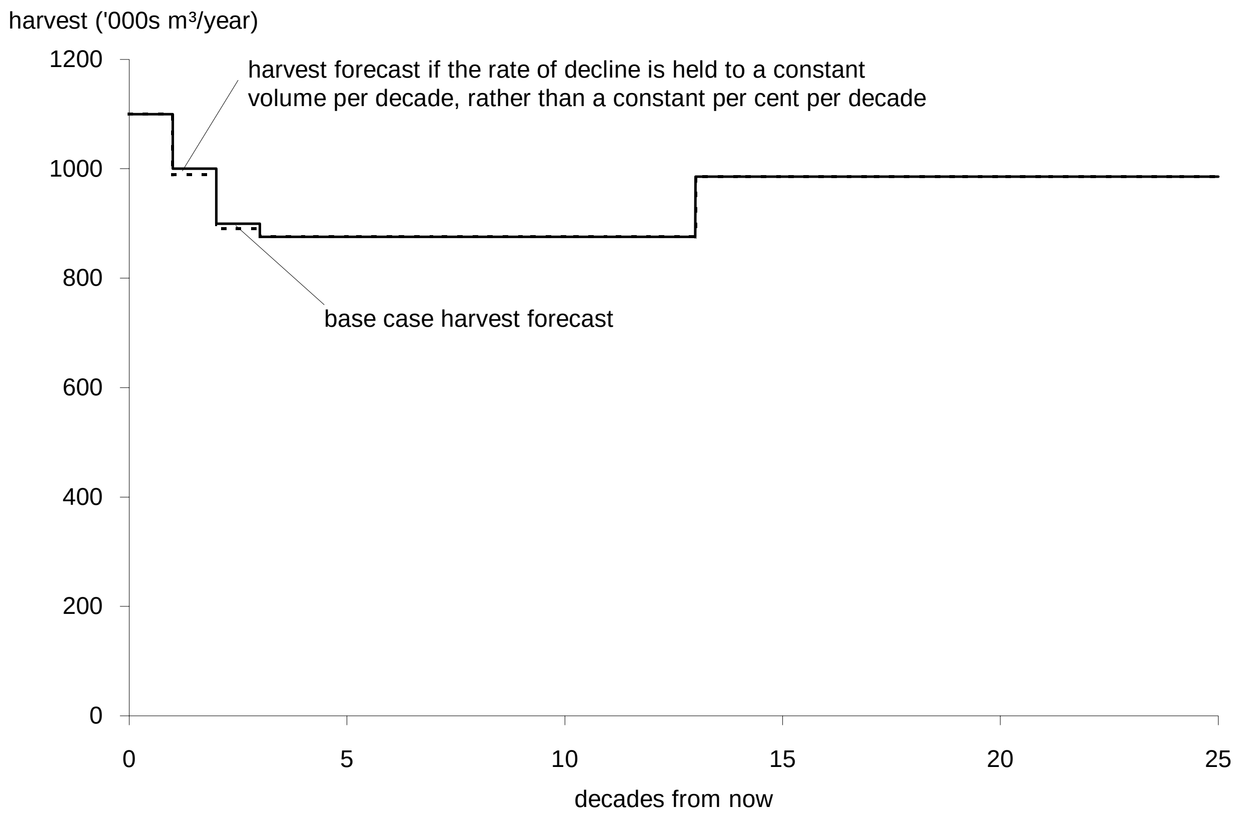

Figure 9. Base case harvest forecast if the rate of decline is limited to 100 000 cubic metres per decade — Sunshine Coast TSA, 1995.

5 Timber Supply Sensitivity Analyses

In the base case harvest forecast, the rate of harvest declines to below the steady long-term harvest level that will be achieved when the harvest comes from managed regenerated stands. Figure 10 shows the harvest forecast if the rate of harvest is reduced by 10% per decade as in the base case, but where an attempt is made to maintain the rate of harvest in the medium term at or above the steady long-term harvest level. The increased rate of harvest in decades 3 through 6 reduces the timber inventory quicker than in the base case and causes a large timber supply shortfall in later decades.

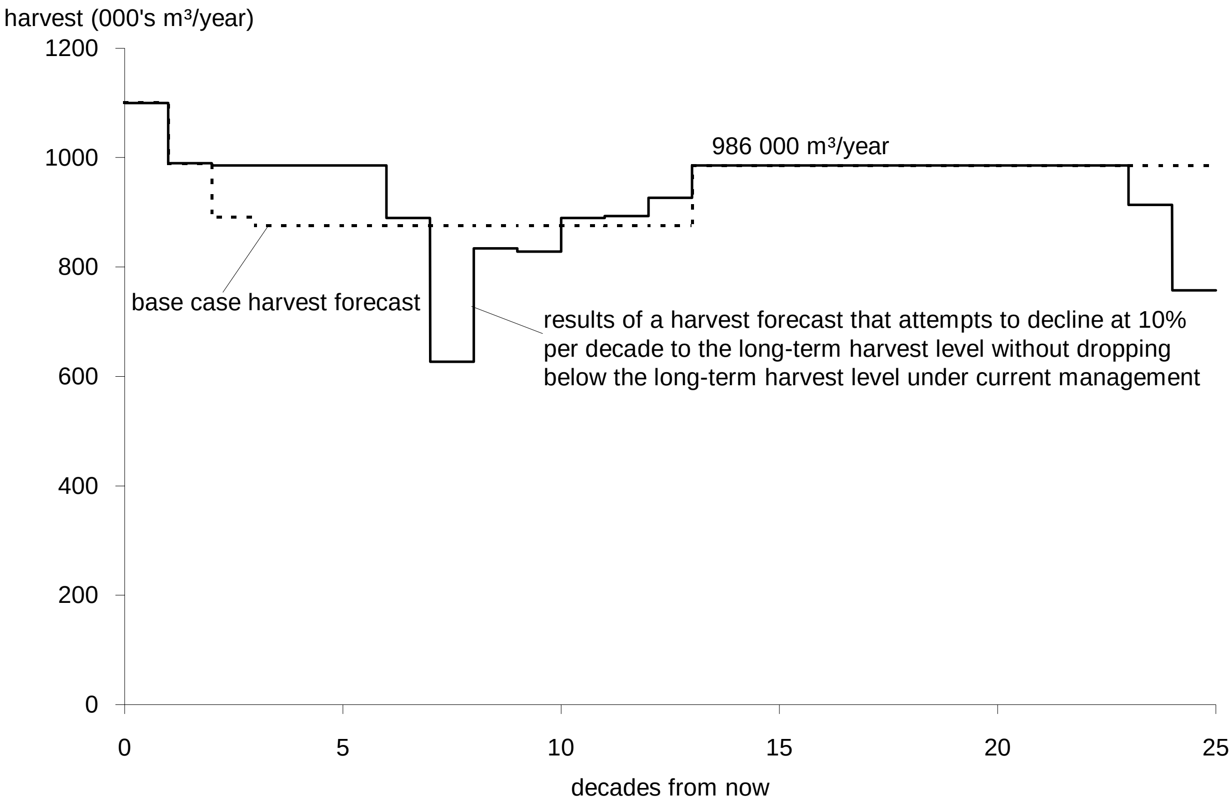

Figure 10. Base case harvest forecast that attempts to maintain the medium-term harvest level equal to the steady long-term level — Sunshine Coast TSA, 1995.

5 Timber Supply Sensitivity Analyses

Figure 11 shows the harvest forecast if the initial rate of harvest is set equal to the steady long-term harvest level. Even with this reduction in the initial rate of harvest, a large timber supply shortfall is projected to occur in decades 7 through 11 unless the rate of harvest is allowed to drop below the steady long-term level earlier. Figure 11 also shows the maximum non-declining harvest flow for the base case. The initial rate of harvest is 18% below the current AAC. This reduced rate of harvest is maintained for 130 years before increasing by about 10% to the steady long-term harvest level of 986 000 cubic metres per year.

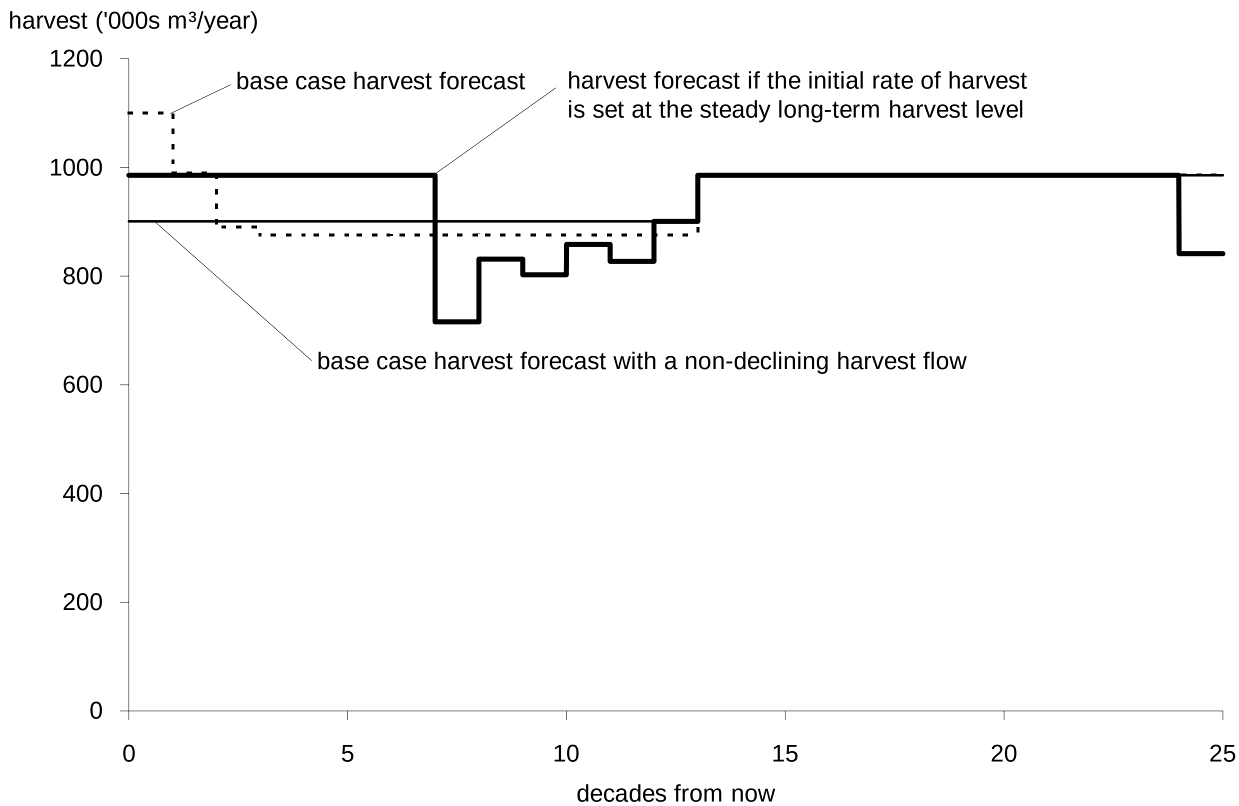

Figure 11. Alternative harvest forecasts using base case assumptions — Sunshine Coast TSA, 1995.

Figure 12 demonstrates the variety of harvest flow options that are possible given the same set of forest management assumptions used for the base case harvest forecast. Each different harvest flow option represents a trade-off between the reduction in the initial rate of harvest and the rate and duration of the decline in the harvest forecast that must follow.

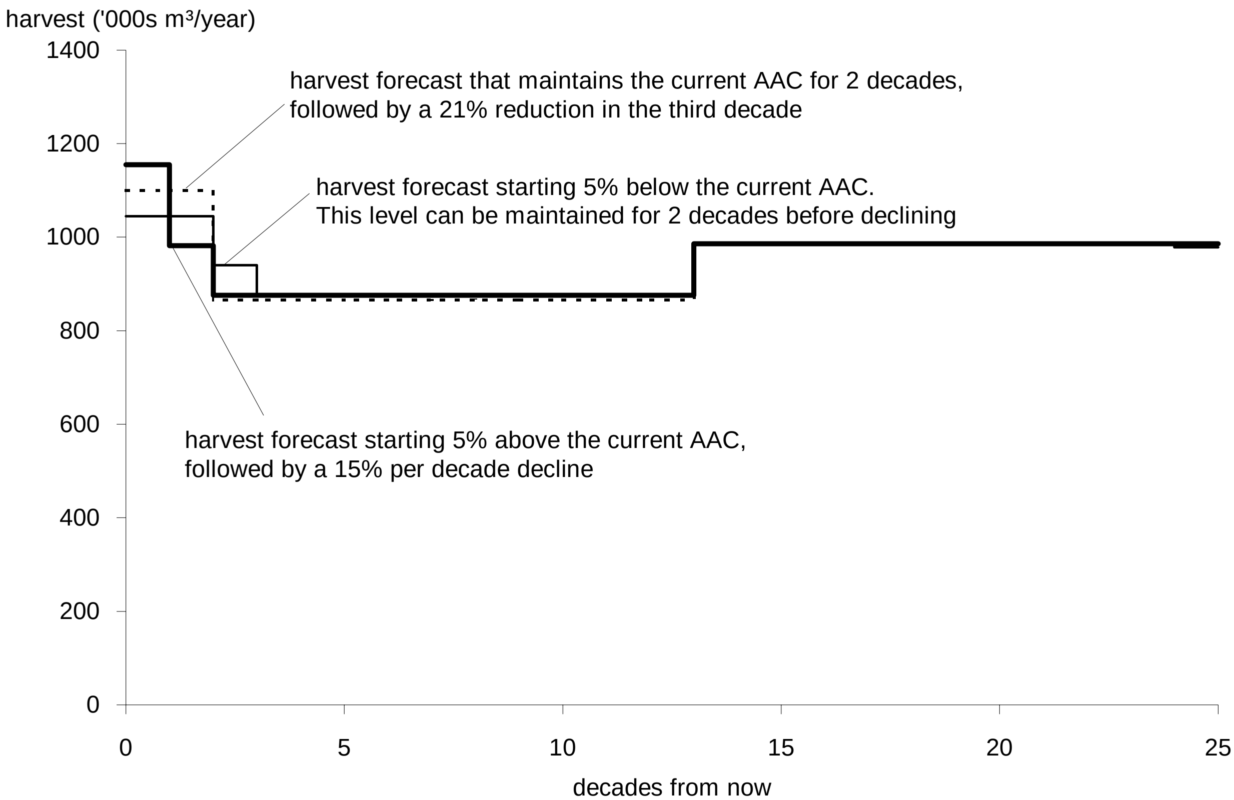

Figure 12. Alternative harvest flows for the base case harvest forecast — Sunshine Coast TSA, 1995.

5.2 Sensitivity to uncertainty in minimum harvestable ages

In the base case harvest forecast, minimum harvestable ages were set with the objective of maximizing the volume of timber produced over time. The minimum harvestable ages range from 60 years on the best growing sites up to 160 years on the poorest growing sites. Minimum harvestable ages are subject to uncertainty because, over time, changes in desired products (quality sawlogs versus pulplogs), changes in timber prices, or changes in stand growth and yield due to intensive silviculture can change the minimum harvestable ages. This section examines the sensitivity of the harvest forecast to changing the minimum harvestable ages for each forest type* by 20 years.

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

Figure 13 shows the effect on the harvest forecast of increasing and decreasing all minimum harvestable ages by 20 years. With an increase in minimum harvestable ages, less timber is available in the short term and the initial rate of harvest must be reduced by 21% to approximately 870 000 cubic metres per year in order to avoid a more severe future timber supply shortfall.

Decreasing all minimum harvestable ages by 20 years has minimal effect on the harvest forecast in the short term (first 2 decades). The only change from the base case is that the harvest level does not have to decline as far below the steady long-term harvest level. An alternative harvest flow that allows the rate of harvest to decline to the same level as in the base case may allow an initial rate of harvest that is higher than in the base case.

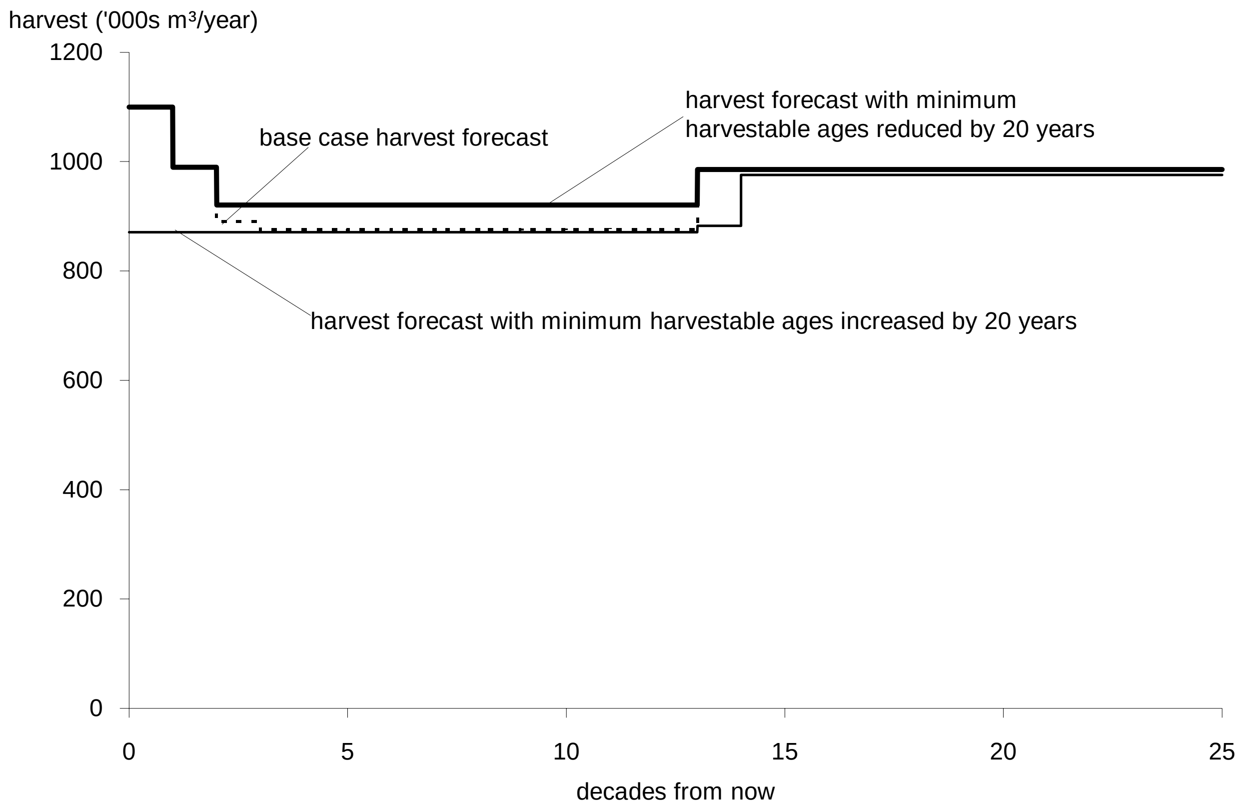

Figure 13. Harvest forecast with all minimum harvestable ages changed by 20 years — Sunshine Coast TSA, 1995.

5.3 Sensitivity to changes in the size of the timber harvesting land base

The area that is assumed to be suitable and available for timber harvesting is one of the primary inputs into a timber supply analysis. In the Sunshine Coast TSA, the timber harvesting land base could be increased in the future by improved timber harvesting techniques and equipment or as a result of increases in the value of currently unmerchantable forest types. Conversely, the timber harvesting land base could be smaller in the future due to increased demand for non-timber forest resources, increased harvesting costs or land use decisions such as parks. The following sensitivity analyses examine the effects on the harvest forecast of increasing and decreasing the size of the timber harvesting land base.

5 Timber Supply Sensitivity Analyses

The majority of areas not included in the timber harvesting land base are poorer-than-average in terms of timber production. With this in mind, the effect of an increase in the timber harvesting land base was examined by modelling the increase of area of poor growing sites. In total, the timber harvesting land base was assumed to increase by 10% or about 22 000 hectares. The harvest forecast resulting from this increase in the timber harvesting land base is shown in Figure 14. Using a harvest flow policy that only allows the rate of harvest to fall to the same level (proportionately) below the long-term harvest level, the short-term harvest forecast is unchanged by this increase in the size of the timber harvesting land base. However, the harvest forecast is increased by approximately 10% in both the medium- and long-term.

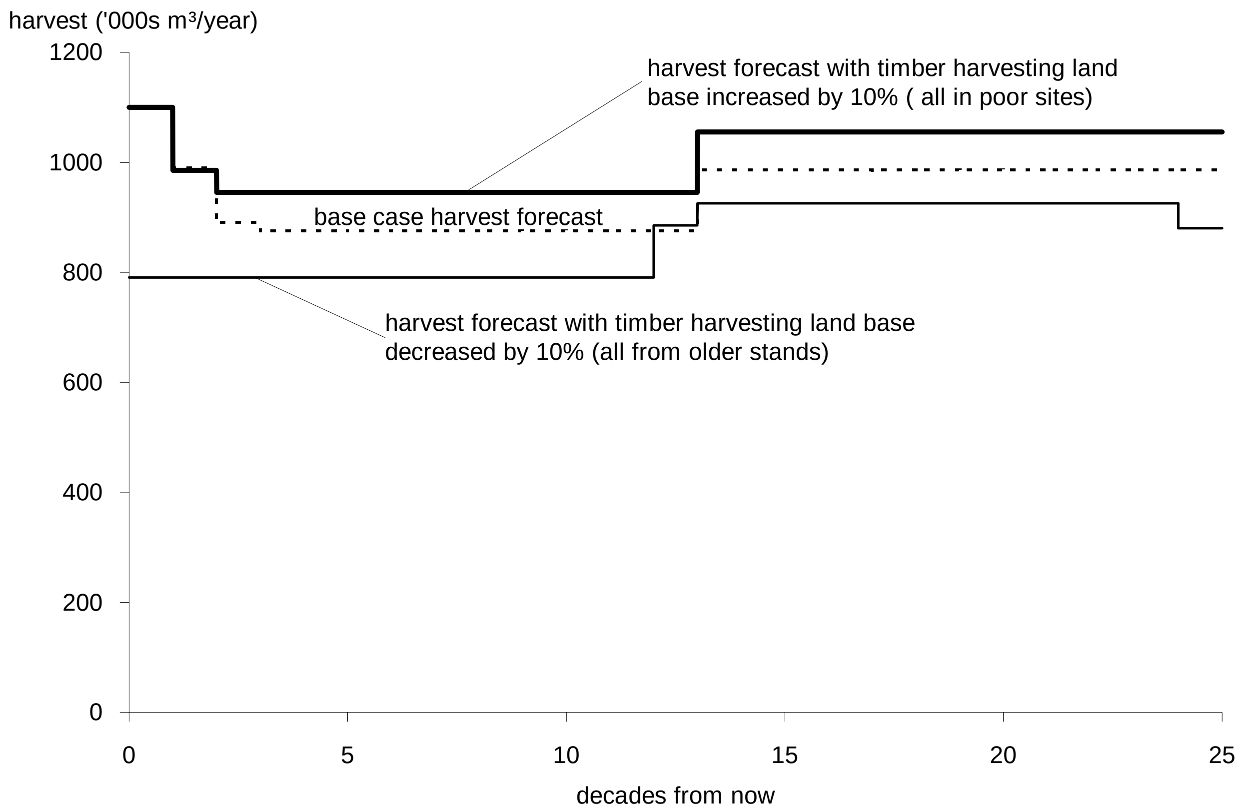

Figure 14. Harvest forecast with the area of the timber harvesting land base increased and decreased by 10% — Sunshine Coast TSA, 1995.

Although new areas that may be added to the timber harvesting land base in the future are likely to be from the poorer growing sites, this is not likely true for areas that may be excluded from the timber harvesting land base in the future. Areas that are excluded from the timber harvesting land base in the future are more likely to be from older forests, regardless of the quality of growing site. Figure 14 also shows the harvest forecast if the timber harvesting land base is decreased by 10% or about 22 000 hectares, all from older forests. The initial rate of harvest is reduced by about 27% to just below 800 000 cubic metres per year. This reduced rate of harvest is maintained for approximately 120 years before increasing to a steady long-term level that is approximately 10% lower than the long-term level in the base case.

5.4 Sensitivity to uncertainty in existing stand volume estimates

Timber volume estimates have a degree of uncertainty due to such factors as the statistical process used to develop growth and yield models, inventory classification procedures, utilization changes, and changes in waste, breakage, and decay estimates. The following sensitivity analyses examine the effect on the harvest forecast of uncertainty in the volume of timber that currently exists on the timber harvesting land base.

Figure 15 shows the effect on the harvest forecast if the estimated timber volumes from existing stands are 10% larger or smaller. Increasing the volume estimates does not necessarily allow an increase in the short term (first 20-30 years) harvest forecast as might be expected. The additional volume of timber instead fills in the projected shortfall to below the steady long-term level instead. If a decline below the long-term level is accepted, as in the base case, the increase in existing available timber would allow an increased short-term harvest forecast (not shown).

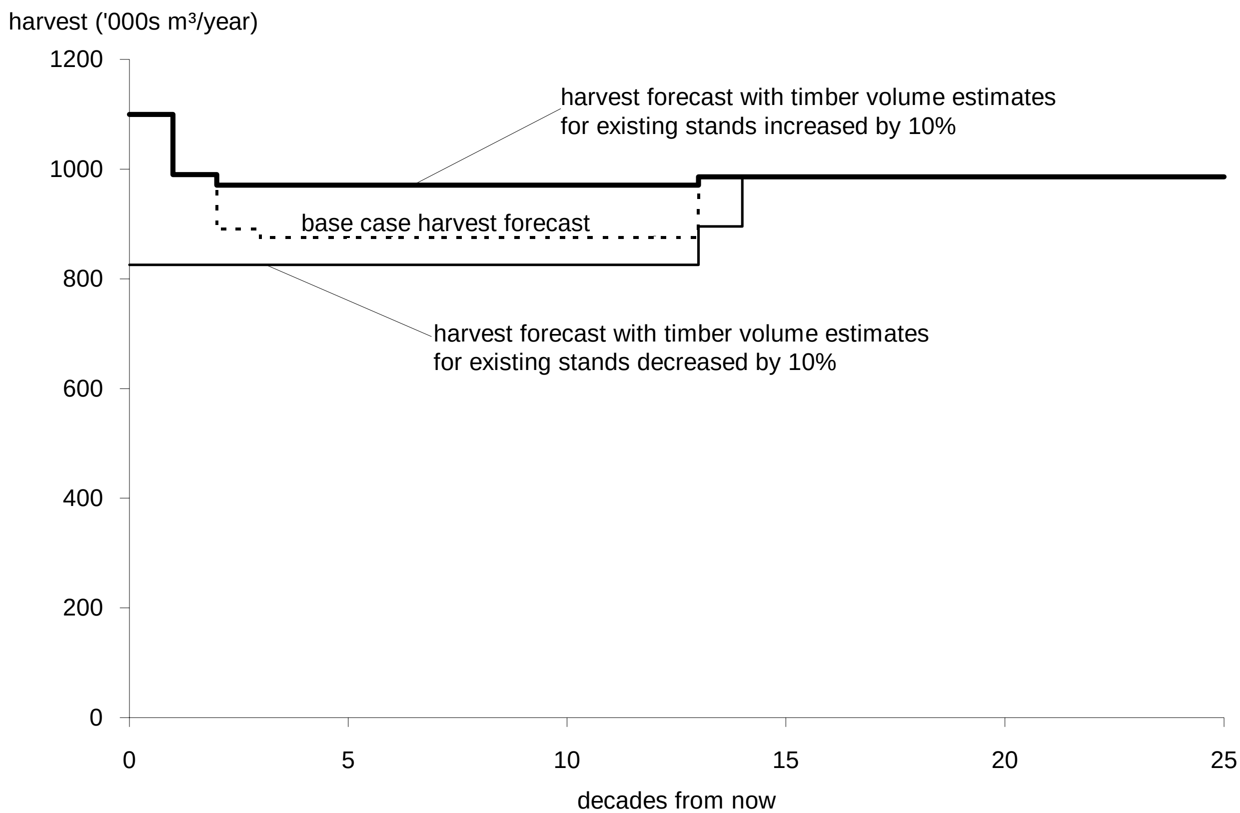

Figure 15. Harvest forecasts with existing stand timber volume estimates increased and decreased by 10% — Sunshine Coast TSA, 1995.

Decreasing the estimated timber volume estimates from existing stands by 10% has a direct effect on the short-term harvest forecast because of the reduction in the existing mature inventory of timber that is currently available for harvest. In addition, a smaller volume of timber per hectare requires more forest area to be harvested in order to achieve a given harvest level than would be required using the base case yield estimates. The forest cover requirements* for visual quality do not allow an increase in the total area harvested to occur. Thus, reducing the estimated volume of existing mature timber makes the forest cover requirements for visual quality more limiting on the short-term harvest forecast. The initial rate of harvest must be immediately reduced to 830 000 cubic metres per year, 25% below the current AAC in order to avoid a severe timber supply shortfall in later decades. After about 130 years, when almost the entire forest is composed of managed, regenerated stands, the harvest level can be increased to a steady long-term harvest level that is unchanged from the base case.

5.5 Sensitivity to uncertainty in regenerated stand volume estimates

The following sensitivity analyses examine the effect that uncertainty in the estimated yields from regenerated stands has on the harvest forecast. Regenerated stand volume estimates have a degree of uncertainty due to factors such as the statistical process used to develop growth and yield models, inventory classification procedures, utilization changes, and changes in waste, breakage, and decay estimates.

Figure 16 shows the effect on the harvest forecast if timber volume estimates from all regenerated stands are 20% larger and smaller. Although a large proportion of the Sunshine Coast TSA is in regenerated stands, many of which are almost old enough to harvest for a second time, increasing the estimated timber yield from regenerated stands by 20% does not improve the short-term harvest forecast if the additional volume of timber created by this change is used instead to reduce the absolute amount of the decline in the base case harvest forecast to below the steady long-term level. In the long term, when almost all harvesting is occurring in regenerated stands, the harvest level is increased from the base case by about 22% to 1.2 million cubic metres per year.

Figure 16 also shows the effect on the harvest forecast if all regenerated stand timber yield estimates are 20% smaller. This change affects only the steady long-term harvest level, which is reduced by about 21% from the base case harvest forecast.

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 guidelines and Green-up period)****.*

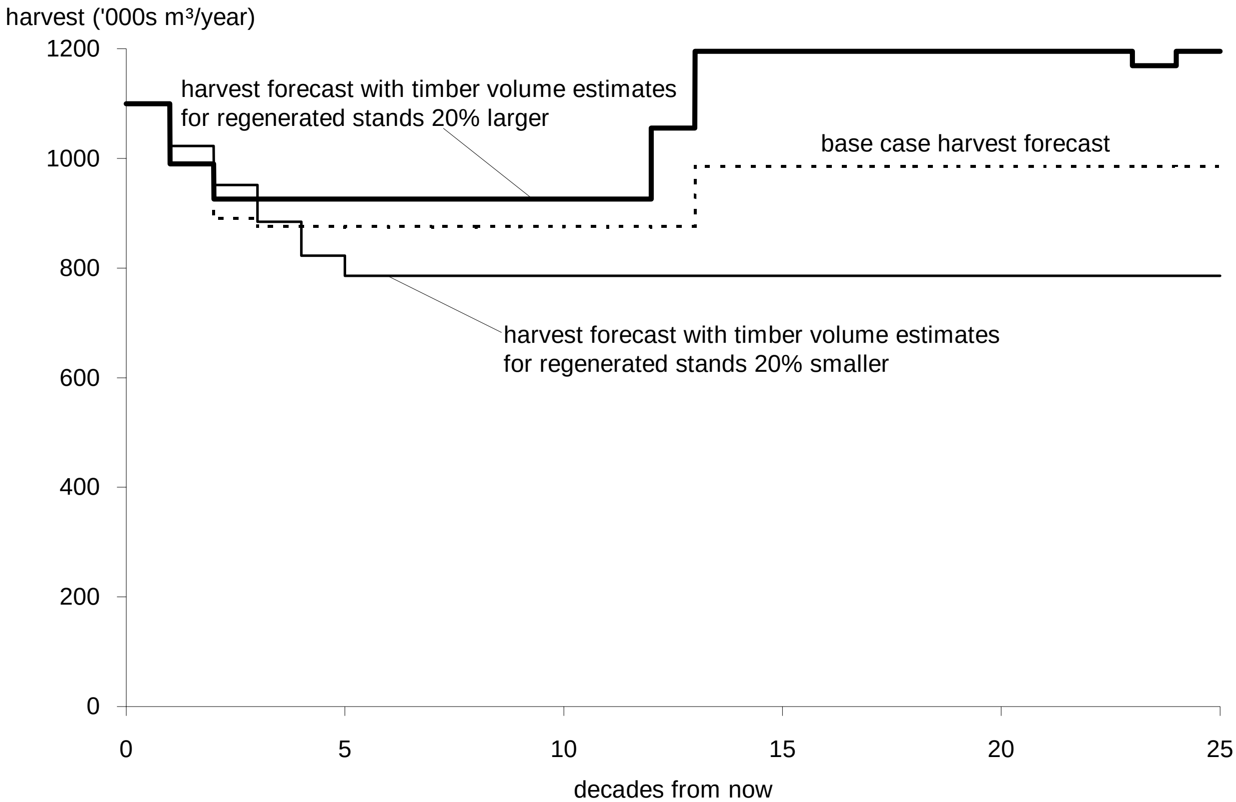

Figure 16. Harvest forecasts with regenerated stand volume estimates increased and decreased by 20% — Sunshine Coast TSA, 1995.

5.6 Sensitivity to uncertainty in regenerated stand site indices

Section 5.5, "Sensitivity to uncertainty in regenerated stand volume estimates" examined only the effect that uncertainty in regenerated stand volume estimates has on the harvest forecast. However, uncertainty in the growth potential of the regenerated stands (as indicated by the regenerated stand site indices) can cause changes in other than just the timber volumes yielded by regenerated stands. The estimated time required for green-up after harvesting may be changed, as well as the minimum age at which the regenerated stands can be harvested.

The effect on the harvest forecast of increasing all regenerated stand site indices is modelled by making the following assumptions: all regenerated stand volume estimates are increased by 10%, all minimum harvestable ages are decreased by 10% and all green-up ages (in both visually sensitive and non-visually sensitive areas) are decreased by 3 years. The harvest forecast resulting from these changes is shown in Figure 17. If the increased timber supply is used to reduce the projected drop in the rate of harvest to below the long-term level the harvest forecast is not increased by these changes in the short term. However, the mid- and long-term harvest forecast is dramatically increased. The steady long-term harvest level of 1.13 million cubic metres per year is 16% higher than in the base case.

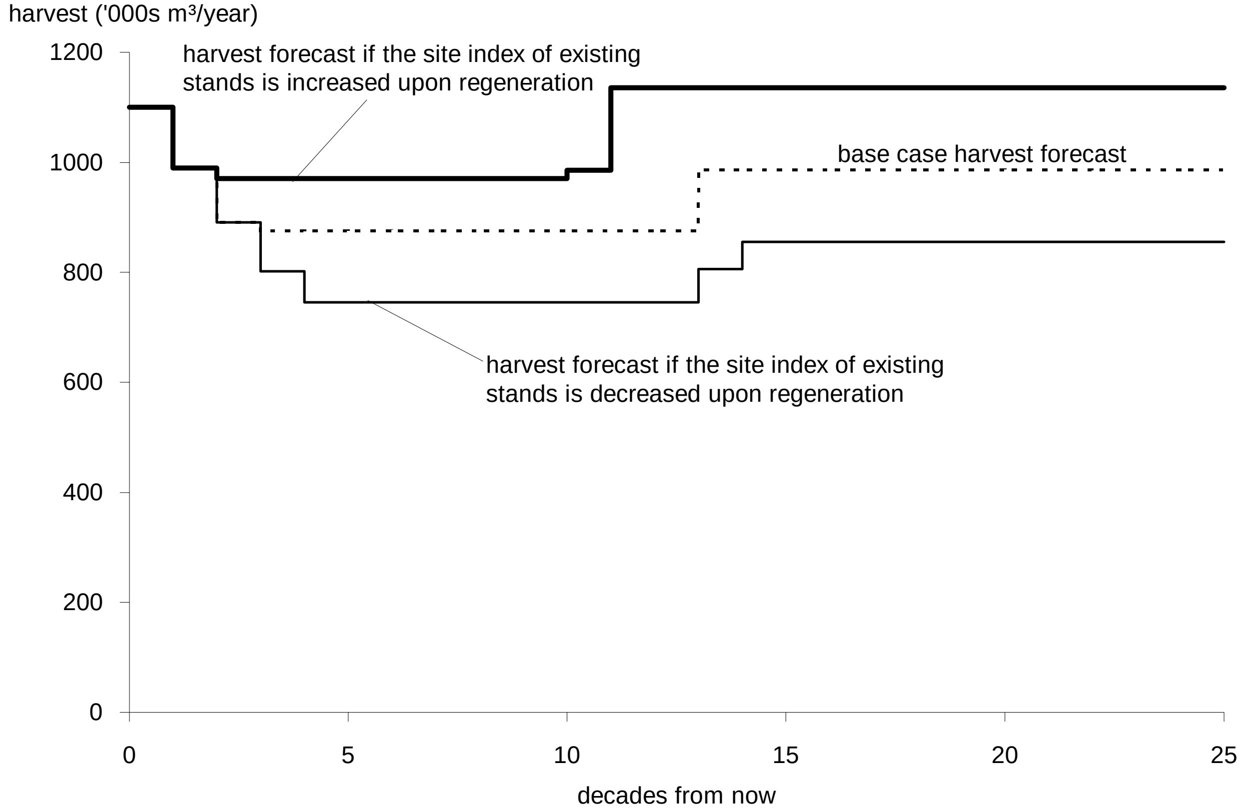

Figure 17. Harvest forecasts with regenerated stand site indices increased and decreased— Sunshine Coast TSA, 1995.

The effect on the harvest forecast of decreasing all regenerated stand site indices is modelled by making the following assumptions: all regenerated stand yields are decreased by 10%, all minimum harvestable ages are increased by 10% and all green-up ages (in both visually sensitive and non-visually sensitive areas) are increased by 3 years (Figure 17). Again, these changes do not affect the short-term harvest forecast, but reduce the mid- and long-term harvest levels by about 14%.

The effect that uncertainty in the regenerated site index* has on the harvest forecast is due primarily to the interaction between site index estimates and forest cover requirements. A higher site index means that the green-up requirement (i.e., 5 metre average stand height in visually sensitive areas) will be met more quickly. As will be shown in Section 5.7, "Sensitivity to forest cover requirements for visual quality" and Section 5.8, "Sensitivity to uncertainty in the required green-up periods," the harvest forecast in the Sunshine Coast TSA is very sensitive to any changes in forest cover requirements.

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.

5.7 Sensitivity to forest cover requirements for visual quality

In the base case, forest cover requirements define the maximum percentage of a visually sensitive forest area that may be less than the greened-up height, (covered with trees less than 5 metres tall). The maximum percentage that may be "non-green" ranges from 5% in the most sensitive areas to 25% in less sensitive areas. As noted in Section 2.3, "Management practices" approximately 55% of the timber harvesting land base is subject to forest cover requirements for visual quality.

Figure 18 shows the harvest forecast if the forest cover requirements are relaxed so that an additional 5% of each visually sensitive area may be non-green at any time. This change allows the harvest forecast to remain almost constant at the current AAC of 1.1 million cubic metres per year. This change represents a very dramatic increase in timber supply from the base case.

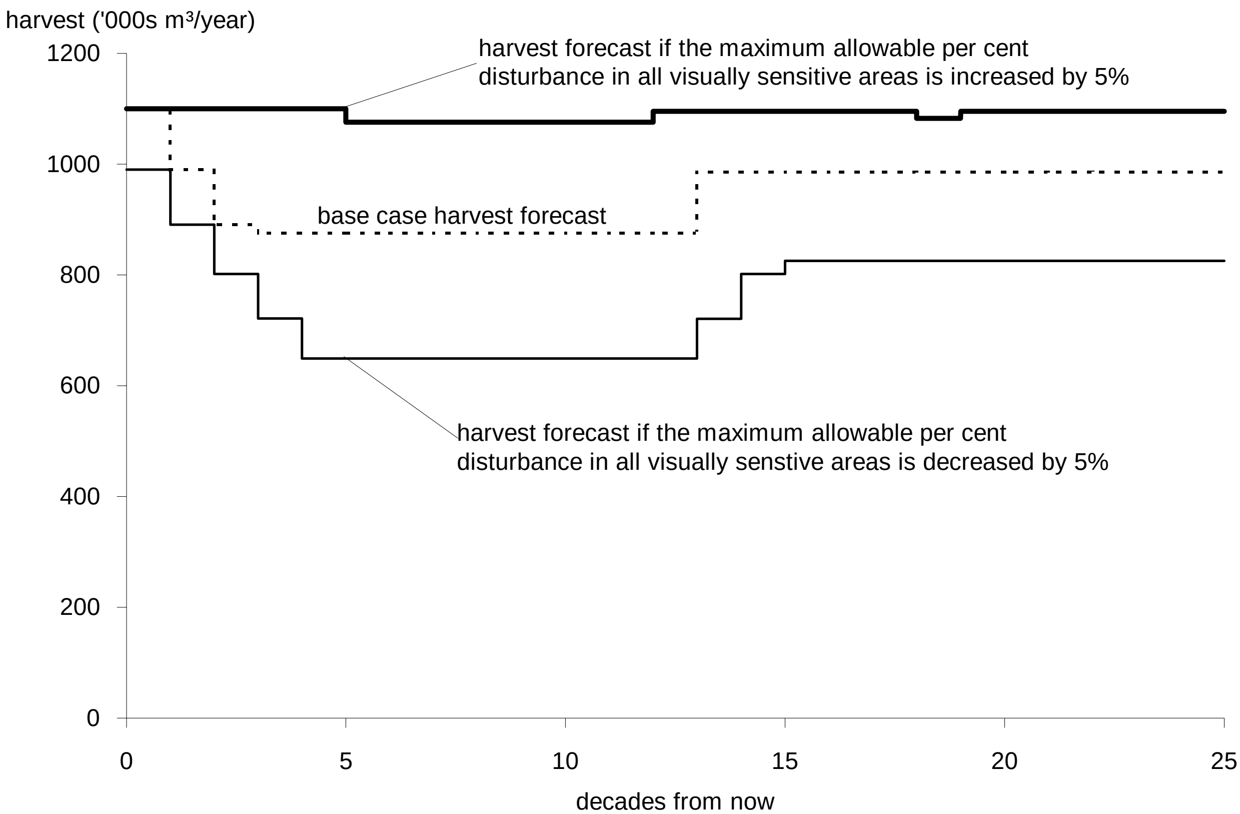

Figure 18. Harvest forecasts with more stringent and more relaxed forest cover requirements for visual quality — Sunshine Coast TSA, 1995.

Figure 18 also shows the harvest forecast if forest cover requirements for visual quality are made more stringent so that 5% less of each visually sensitive area may be non-green at any time. The initial rate of harvest with this change is about 990 000 cubic metres per year, 10% lower than in the base case harvest forecast. The harvest forecast then declines in decades 2 through 5 to well below the steady long-term harvest level. The steady long-term level of about 830 000 cubic metres per year is 15% lower than in the base case.

5.8 Sensitivity to uncertainty in the required green-up periods

As discussed in Section 2.3, "Management practices," the required green-up periods used in the base case harvest forecast are the estimated number of growing years before the trees on a harvested area reach a required height, thus allowing other adjacent forested areas to be harvested. Green-up periods may be longer or shorter than estimated for the base case due to stand conditions such as the density at which the trees are planted, site degradation problems such as soil erosion or compaction, and uncertainty in forest growth estimates for young regenerated stands. The following sensitivity analysis examines the effect that uncertainty in the required green-up period has on the harvest forecast.

Figure 19 shows the harvest forecast if all green-up periods are 5 years shorter or longer.

Reducing the required green-up period increases the availability of areas for timber harvesting over time, however the starting harvest level is unchanged from the base case if the increase in available timber is used to minimize the projected decline to below the long-term level. However the harvest forecast over the mid- and long-term is dramatically increased. The harvest forecast declines only once by about 8% in the second decade, and eventually increases to a steady long-term harvest that is only about 5% below the current AAC. This result is largely due to the increased rate of harvest that is possible from visually sensitive areas given a shorter green-up period.

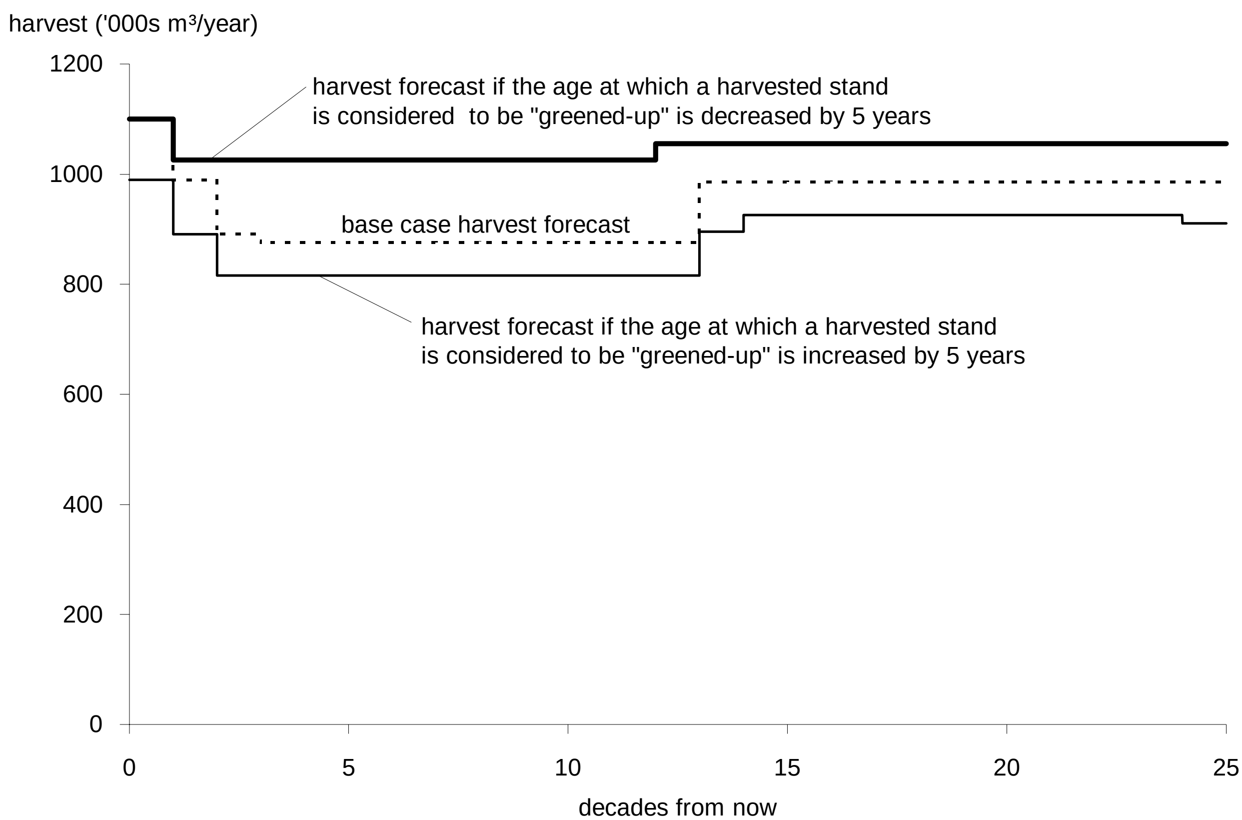

Figure 19. Harvest forecast with all green-up periods increased and decreased by 5 years — Sunshine Coast TSA, 1995.

Increasing all required green-up periods by 5 years has a significant effect on the short-term harvest forecast (Figure 19). Increasing the required green-up periods makes the forest cover requirements, especially those used to manage for visual quality, much more constraining on the rate of harvest in the short term. The initial rate of harvest must be reduced to about 990 000 cubic metres per year, 10% lower than in the base case harvest forecast in order to avoid a more severe timber supply shortfall in later decades. From this reduced initial level, the harvest forecast must still decline by 10% per decade to below the steady long-term harvest level, which is also reduced by about 6% from the base case to about 925 000 cubic metres per year.

5.9 Uncertainty in the method used to represent adjacency objectives

The *Coast Planning Guidelines, Vancouver Forest Region* 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) and aerial harvesting zones. Specifically a forest cover requirement that a maximum of 33% (3-passes) of an area being harvested may be less than 3 metres tall was used to approximate the adjacency requirements in for this analysis. Because the forest cover requirement is an approximation, it is not certain how accurately it reflects how adjacency affects timber supply.

The 3-pass guideline (a maximum of 33% of the harvesting land base may be younger than green-up age) in the IRM zone is not limiting the timber supply. Thus, when the IRM zone adjacency guideline is changed to a 2-pass or a 4-pass harvesting system, there is no change in the harvest forecast from the base case. However, there is some evidence that 5-passes may be required to meet adjacency objectives in many areas (Nelson and Errico 1993). Figure 20 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 and aerial harvesting zones. The first decade harvest level is 1 033 000 cubic metres per year, a 6% decrease from the base case harvest level. The IRM zone initially has about 17% of the area less than green-up age, thus there is a limited amount of timber that can be harvested from this zone when the maximum allowed under green-up is changed to 20%. After the first decade the base case harvest forecast can be attained in all decades.

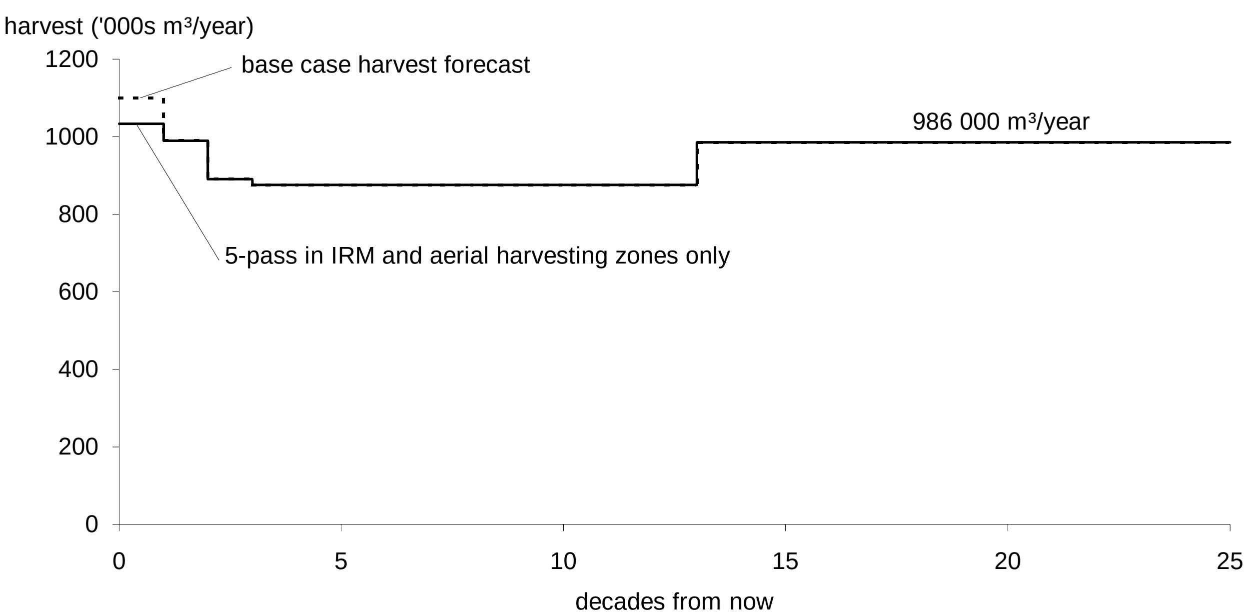

Figure 20. Harvest forecasts if the adjacency requirement in the IRM and aerial harvesting zones is changed — Sunshine Coast TSA, 1995.

5.10 Sensitivity to removing all forest cover requirements

The sensitivity analyses completed in Sections 5.2 to Sections 5.9 examine the effect on the harvest forecast of altering one forest management assumption at a time. The following sensitivity analysis examines the effect that removing all forest cover requirements for cutblock adjacency, green-up, and management of visually sensitive areas has on the harvest forecast. Figure 21 shows the harvest forecast with all forest cover requirements removed. The initial rate of harvest can be increased to just over 1.3 million cubic metres per year, 19% above the current AAC. After the first decade, the rate of harvest declines by about 10% per decade to a steady long-term level that is equal to the current AAC. The harvest forecast does not drop to below this steady long-term level at any point in the 250 year period modelled. This change in the harvest forecast is due primarily to the removal of the forest cover requirements for visual quality.

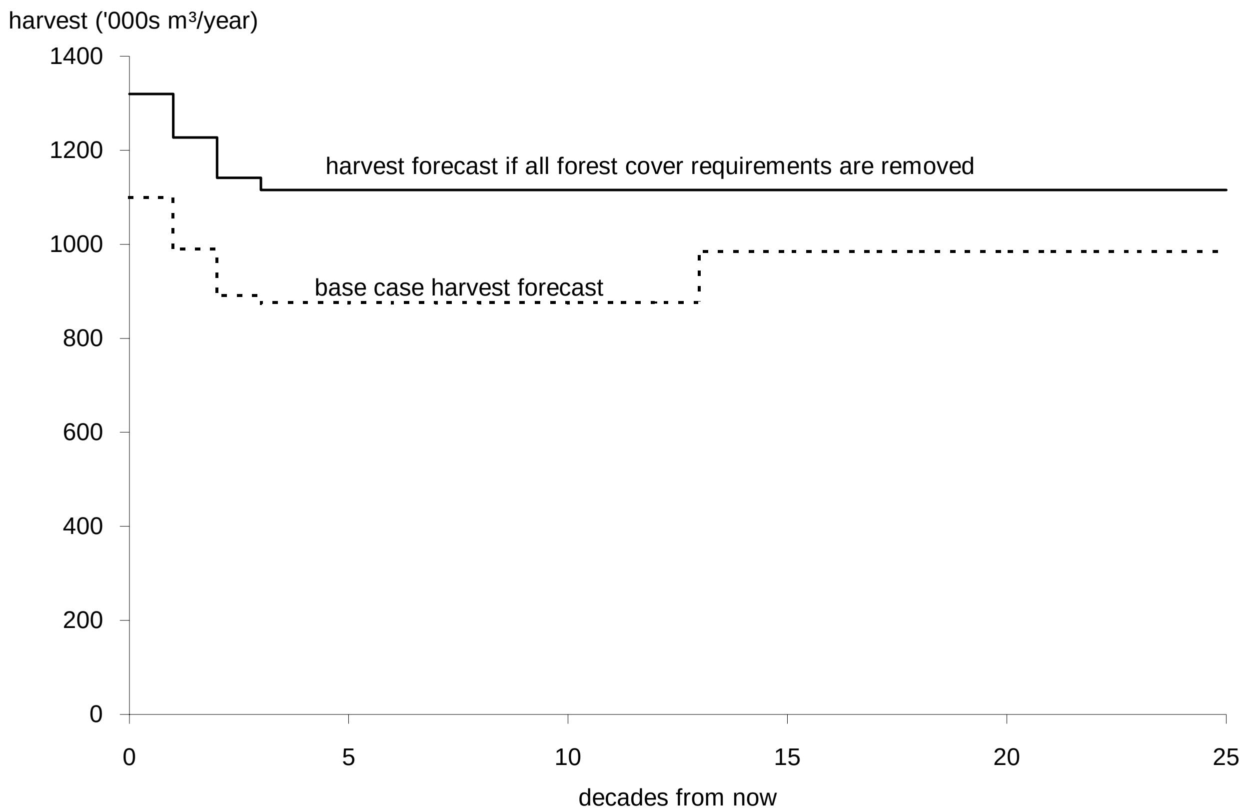

Figure 21. Harvest forecast with all forest cover requirements removed — Sunshine Coast TSA, 1995.

5.11 Sensitivity to changing several assumptions concurrently

The following sensitivity analyses examine the effect of changing a number of assumptions concurrently. Figure 22 shows the harvest forecast with all of the following changes, which increase the harvest forecast, concurrently:

- all green-up periods reduced by 3 years (as in site-index increase, Section 5.6, "Sensitivity to uncertainty in regenerated stand site indices");
- 5% more area allowed to be non-greened-up in visually sensitive areas (as in Section 5.7, "Sensitivity to forest cover requirements for visual quality");
- regenerated stand yield estimates increased by 10% (as in site-index increase, Section 5.6);
- all minimum harvestable ages reduced by 10 years (as in site-index increase, Section 5.6);
- timber harvesting land base increased by 10%, all on poor sites (as in Section 5.3, "Sensitivity to changes in the size of the timber harvesting land base").

The effect on the harvest forecast of using all of the above assumptions concurrently is significant. The initial rate of harvest is increased to just under 1.3 million cubic metres per year which can be maintained indefinitely as a steady long-term harvest level.

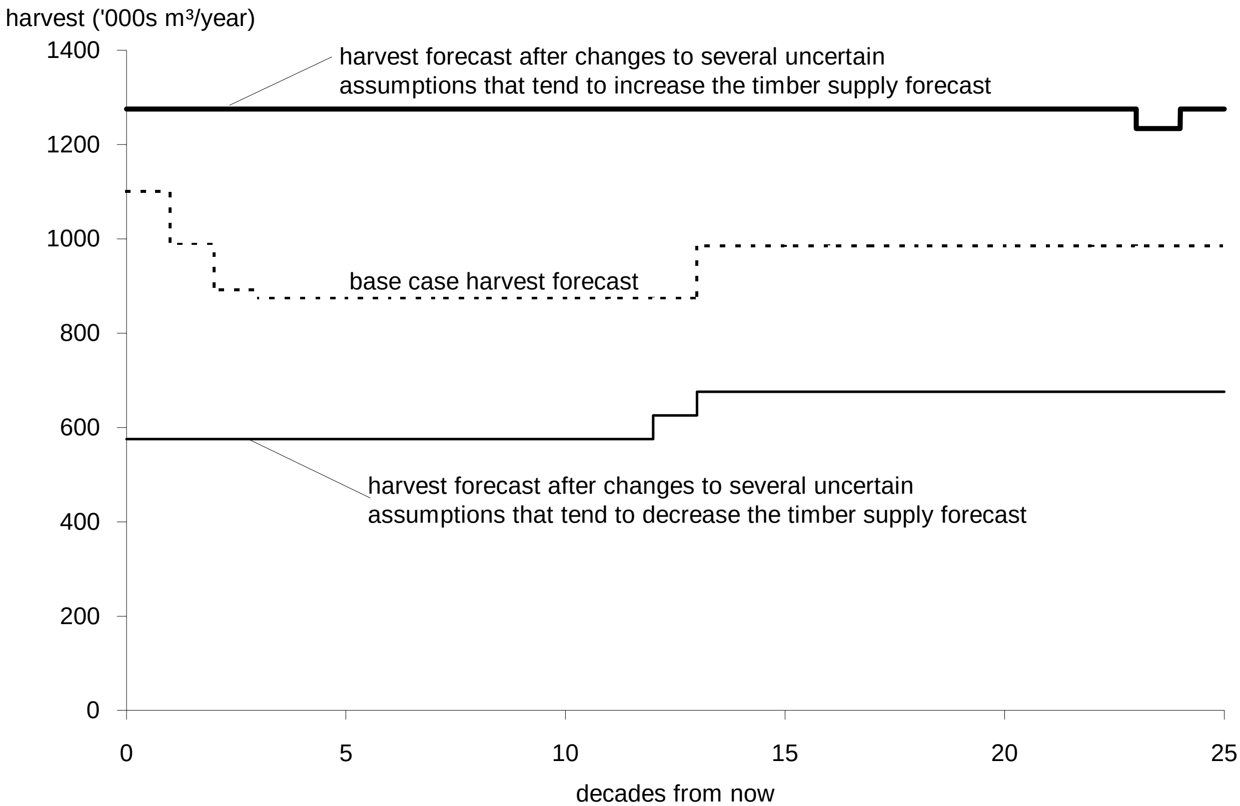

Figure 22. Harvest forecast with several uncertain assumptions that tend to increase and decrease the timber supply changed concurrently — Sunshine Coast TSA, 1995.

Figure 22 also shows the harvest forecast using the following changes which tend to decrease the available timber supply and the harvest forecast, concurrently:

- all green-up periods increased by 3 years (as in site-index increase, Section 5.6, "Sensitivity to uncertainty in regenerated stand site indices");
- 5% less area allowed to be non-greened-up in visually sensitive areas (as in Section 5.7, "Sensitivity to forest cover requirements for visual quality");
- regenerated stand yield estimates decreased by 10% (as in site-index increase, Section 5.6);
- all minimum harvestable ages increased by 10 years (as in site-index increase, Section 5.6);
- timber harvesting land base decreased by 10%, all from older forest stands (as in Section 5.3, "Sensitivity to changes in the size of the timber harvesting land base").

The harvest forecast is decreased dramatically by the above changes. The initial rate of harvest is about 580 000 cubic metres per year, which is 47% below the initial harvest level in the base case (the current AAC). In the mid- to long-term, the harvest forecast is reduced from the base case by about 31%.

Of note is that, given the same absolute amount of change in the assumptions, the harvest forecast is more sensitive to changes that decrease the timber supply than to changes that increase the timber supply. In the short term the harvest level, based on the assumptions that decrease the timber supply, is farther from the base case than is the harvest level based on the assumptions that increase the timber supply.

6 Summary and Conclusions

The results of this timber supply analysis indicate that, given current forest management assumptions, the current AAC of 1 100 000 cubic metres per year an be maintained for the next 10 years before declining by 10% per decade until a low of 876 000 cubic metres per year is reached in approximately 30 years. This reduced rate of harvest, which is 11% below the steady long-term harvest level, must be maintained for approximately 100 years in order to avoid further timber supply shortfalls in the future. In 130 years, after almost the entire forest is in managed regenerated stands, the rate of harvest can be increased to a steady long-term harvest level of 986 000 cubic metres per year.

Alternative harvest flows are also possible given the base case assumptions. Among these alternatives, which are shown and discussed in Section 5.1, "Alternative initial harvest levels and harvest flows over time" are harvest forecasts which show an initial rate of harvest that is 5% higher or lower than the current AAC. The only difference between these forecasts is the subsequent rate of decline in the harvest level that is required.

The most important factors affecting the timber supply forecast in the Sunshine Coast TSA are visually sensitive areas, and site index estimates for regenerated stands. A shorter green-up period in visually sensitive areas, (see Section 2.3, "Management practices" for an explanation of green-up period) by 5 years, increases the steady long-term harvest level and greatly reduces the amount by which the rate of harvest must drop below the steady long-term harvest level. If the green-up period is maintained as in the base case, but the forest cover requirements for visually sensitive areas are relaxed, by allowing more area to be non-greened-up at any time, the rate of harvest can be maintained at or near the current AAC indefinitely. Changing site indices also has a significant effect on the harvest forecast due to the potential changes in both regenerated stand yield estimates and estimated green-up periods (which relates to the effect of visual quality requirements discussed above).

A general trend noted in the results of sensitivity analyses is that, for the same amount of change (e.g., plus or minus 10%) to an uncertain assumption or piece of data, decreases in the harvest forecast were generally larger than increases.

7 References

B.C. Ministry of Forests, Forest Inventory Division Branch. 1976. Inventory Metric Diameter Class Decay, Waste and Breakage Factors Manual. Victoria, B.C.

B.C. Ministry of Forests, Recreation Branch. 1993. Procedures for Factoring Recreation Resources into Timber Supply Analyses. Technical Report 1993:1. Victoria, B.C.

B.C. Ministry of Forests, Vancouver Forest Region. 1993. Coast Planning Guidelines, Vancouver Forest Region.

Nelson, J.D. and D. Errico. 1993. Multiple-pass harvesting and spatial constraints: an old technique applied to a new problem. Forest Science 39(1): 137-151.

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*.
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 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, adjacency, green-up and other integrated resource management objectives. (see **Cutblock adjacency guidelines and Green-up period)**.
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.
Forest type	The classification or label given to a forest stand, usually based on its tree species composition. Pure spruce stands and spruce-balsam mixed stands are two examples.
Free-growing	An established seedling of an acceptable commercial species that is free from growth-inhibiting brush, weed and excessive tree competition.
Green-up period	The time needed 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.
Growing stock	The volume estimate for all standing timber, of all ages, at a particular time.
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.

8 Glossary

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-contributing provincial forest	Generally made up of small water bodies and other small areas of AAC non-contributing forest land surrounded by, and included in the forest inventory as provincial forest.
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.

8 Glossary

Partial retention VQO	Alterations are visible but not conspicuous. Up to 15% of the area can be visibly altered by harvesting activity (see **Visual quality objective**).
Retention VQO	Alterations are not easy to see. Up to 5% of the visible landscape can be altered by harvesting activity (see **Visual quality objective)**.
Riparian area	Areas of land adjacent to wetlands or bodies of water such as swamps, streams, rivers or lakes.
Site index	A measure of site productivity. Site indices are based on tree height as a function of stand age and are usually expressed graphically as site index curves. A number of site index curves have been developed for British Columbia's major commercial tree species.
Timber harvesting land base	The portion of the total land area of a management unit considered to contribute to, and be available for, long-term timber supply. The harvesting land base is defined by deducting non-contributing areas from the total land base according to specified management assumptions.
Timber supply area (TSA)	An integrated resource management unit established in accordance with *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.

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 timber supply review of the Sunshine Coast TSA. This information represents current forest management in the area. Current forest management is defined as the set of land use decisions and forest and stand management practices currently implemented and enforced. Forest management practices and land use decisions that may be intended for the future but are not currently implemented and enforced are not included here. 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

For the purpose of the timber supply analysis, the timber harvesting land base is divided into units with similar forest management concerns. These units are referred to throughout this appendix as "zones." The purpose of dividing the timber harvesting land base into zones is to facilitate modelling of the forest management concerns specific to each zone (for example, concerns about visual quality of the landscape).

The zones used in the timber supply review for the Sunshine Coast TSA are defined below.

Zone 1 — General integrated resource management

This zone is the default and includes all areas that do not fall into other zones.

Zone 2 — Visual quality objective — retention

First two characters of the "recreate" variable on the inventory file are "01" or "02".

Zone 3 — Visual quality objective — partial retention

First two characters of the "recreate" variable on the inventory file are "03".

Zone 4 — Visual quality objective — modification

First two characters of the "recreate" variable on the inventory file are "04".

Zone 5 — Islands

Maurelle Island, Read Island, Cortes Island — region 30, compartments 11,10, and 4;

Lasqueti Island — region 8, compartment 8;

Howe Sound Islands (Gambier, Anvil) — region 28, compartment 2;

Stuart Islands — region 31, compartment 1;

West Redonda Island — region 30, compartment 3.

Zone 6 — Aerial harvesting

The "operable" variable on the inventory file = "C".

The priority for placing areas into zones when an area meets more than one of the above criteria is as follows, ranked from highest to lowest priority: zone 2, zone 3, zone 4, zone 5, zone 6, zone 1.

A.1 Zone and Analysis Unit Definition

A.1.2 Analysis unit characteristics

Within each forest management zone, the forested area is divided into analysis units which are based primarily on the leading tree species and site class.

Table A-1. Analysis unit characteristics

Analysis unit	Inventory type groups	Site index (metres)[a]
1 Fir, good site	1 - 8, 28 - 31	> 32
2 Fir, medium site	1 - 8, 28 - 31	26 - 32
3 Fir, poor site	1 - 8, 28 - 31	< or = 26
4 Hemlock/balsam/spruce, good site	12 - 26	> 25
5 Hemlock/balsam/spruce, medium site	12 - 26	22 - 25
6 Hemlock/balsam/spruce, poor site	12 - 26	< or = 22
7 Cedar, good/medium site	9 - 11	> 17
8 Cedar, poor site	9 - 11	< or = 17

(a) All site indices are referenced to breast height age 50.

A.2 Utilization Levels

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

Timber in the Sunshine Coast TSA is currently used to the following levels:

- all species, greater than 120 years old (mature), 17.5 cm dbh (diameter at breast height; breast height = 1.3 metres), 30 cm stump height, 10 cm top diameter;
- all species, less than 120 years old (immature), 12.5 cm dbh, 30 cm stump height, 10 cm top diameter.

A.3 Definition of the Timber Harvesting Land Base

This section provides the information used to define the land base considered available for timber harvesting 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.3.1 Inventory file status

Forest cover polygon information in the Sunshine Coast TSA inventory file is projected to 1994.

A.3.2 Non-contributing ownership codes

All areas that are not designated as being ownership code 62C (Crown forest management unit available for long-term integrated resource management), 69C (miscellaneous reserves available for long-term integrated resource management), or 70N (Timber Licences) are excluded from the timber harvesting land base. Areas designated as provincial forest with a provincial forest subcode of "0" (non-contributing provincial forest) is also excluded, except for areas with a provincial forest code of "0999".

A.3.3 Non-forested and non-commercial/brush areas

All areas that are classified as non-forested (type identity = 6) and non-commercial/brush (type identity = 5) are excluded from the timber harvesting land base.

A.3.4 Von Donop Marine Park

The Von Donop Marine Park is excluded from the timber harvesting land base by mapsheet and polygon number according to Table A-2.

Table A-2. Area excluded for the Von Donop Marine Park

Mapsheet number	Polygon numbers
092K016	0005, 0006, 0008, 0146, 0147, 0148, 0149, 0150, 0151, 0152, 0153, 0154, 0155, 0156, 0157, 0158, 0159, 0160, 0164, 0165, 0166, 0167, 0168, 0169, 0170, 0171, 0172, 0173, 0178, 0191, 0194, 0195, 0199, 0200, 0201, 0202, 0203, 0204, 0205, 0207, 0208, 0211, 0212, 0213, 0214, 0215, 0216, 0217, 0221, 0222, 0223, 0225, 0226, 0227, 0493, 0545, 0546, 0560, 0562, 0563, 0564, 0579

A.3.5 Inoperable areas

Areas defined on the inventory file as inoperable for timber harvesting (inoperable = I) are excluded from the timber harvesting land base.

A.3.6 Non-merchantable stands

Table A-3. identifies forest types that are not currently utilized and are excluded from the timber harvesting land base.

Table A-3. Per cent area reductions for non-merchantable stands

Type group or species	Criteria	Per cent area excluded
Fir leading types (type groups 1-8)	less than 300 cubic metres per hectare timber volume and site index <= 15.5 metres	100%
Cedar leading types (type groups 9-11)	less than 300 cubic metres per hectare timber volume and site index <= 13.5 metres	100%
Hemlock leading types (type groups 12-20)	less than 300 cubic metres per hectare timber volume and site index <= 11.5 metres	100%
Spruce leading types (type groups 21-26)	less than 300 cubic metres per hectare timber volume and site index <= 8.0 metres	100%
Pine leading types (type groups 28-31)	less than 300 cubic metres per hectare timber volume and site index <= 14.5 metres	100%
Deciduous/other leading types (type groups 27, 32-42)	All	100%

Ministry of Forests' staff identified the non-merchantable stands using the following criteria:

- if a stand has greater than 300 cubic metres of timber volume, it is included in the timber harvesting land base regardless of site index;
- if a stand has less than 300 cubic metres per hectare of existing timber volume, and has such a low site index that it is not projected (based on natural stand growth projections) to achieve 300 cubic metres per hectare of timber volume by age 150, then it is excluded from the timber harvesting land base.

A.3.7 Environmentally sensitive areas

The environmentally sensitive areas are excluded from the timber harvesting land base as per Table A-4.

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

ESA code	ESA description	Per cent area reduction
Es1	very steep sensitive soils	90%
Es2	steep sensitive soils	40%
Er1	recreation — high sensitivity (and not in VQO area)	90%
Er2	recreation — moderate sensitivity (and not in VQO area)	50%
Ew1	wildlife critical habitat	90%
Ew2	wildlife values	40%
Ep1 or Ep2	difficult regeneration	90%
Ea1	avalanche hazard	100%
Eh1 or Eh2	watershed values	90%

- recreation — all Er1 and Er2 in VQO areas will be modelled using forest cover requirements rather than area exclusions;
- wildlife — there is very little wildlife ESA area in the operable land base. Most of the wildlife ESAs identify areas with significant goat and grizzly habitat;
- Ep1 — geomorphological regeneration problems, Ep2 — biotic regeneration problems;
- there are no Ea2 (moderate avalanche hazard) areas on the inventory file.

Previous ESA classifications were considered adequate during the last re-inventory. Individuals reclassifying the inventory were instructed to change ESA classifications only if the previous classifications were inadequate.

Preliminary comparisons were made of areas identified as having steep sensitive soils (Es) from the ESA mapping to areas considered unstable (class 4 and 5) from the terrain hazard mapping. It appears that the terrain mapping is of greater detail than the ESA mapping, for more area was identified as unstable in the terrain hazard mapping than was identified as steep sensitive soils in the ESA mapping. It is likely that more area would have been removed had the terrain hazard mapping been available for the analysis. The ESA mapping does provide a good preliminary assessment of area with unstable soil, though more terrain mapping is required to more adequately identify areas which should be excluded for unstable, sensitive soils in future analyses.

A.3.8 Riparian management areas

An average reduction of 1.6% was applied across the entire forest inventory to account for riparian management areas. The per cent reduction was based on the following assessments:

- total length of all class A streams within the Sunshine Coast TSA;
- the stream lengths were measured on licensee and SBFEP 5 year development plan maps (streams are classified according to *Fish/Forestry Guidelines*, Federal Department of Fisheries and Oceans);
- Department of Fisheries and Oceans stream classification field guides were used to identify class A streams where no other information was available;
- the buffer width required along class A streams for riparian management was assumed to be 30 metres on average (15 metres on either side of the stream);
- FIR (Forest Inventory Report, computer program) was used to estimate the amount of ESA area along class A streams which was already excluded from the timber harvesting land base.

A.3.9 Existing roads, trails and landings

To account for existing roads, trails, landings and other right of ways that are not already accounted for in the inventory file, 5.8% of the area with timber harvesting history (assumed to be all age class 1 through 4 stands - stands 80 years or younger) were excluded from the timber harvesting land base. The per cent reduction was based on the following assessments:

- exclusions to account for existing roads, trails and landings ranged from 3.6 to 8.1% on 9 mapsheets provided for sampling by Sunshine Coast Forest District Engineering staff;
- the "Inventory Specification Program" (INVSPECS) was used to determine the kilometres of existing logging roads and trails;
- road widths were assumed to average 12 metres, and trail widths were assumed to average 6 metres;
- FIR was used to determine previously accessed areas (ADHOC report for area with logging history 1910-1994);

A.3.10 Future roads, trails and landings

The loss of productive forest land due to future timber harvesting and development within the Sunshine Coast TSA are accounted for with a 6.1% reduction to the timber harvesting land base which does not have a timber harvesting history (assumed to be all stands age class 5 and older — stands older than 85 years) after it is harvested for the first time. The future losses are based on a review of losses as predicted in a number of PHSPs (Pre-harvest Silviculture Prescriptions).

A.4 Forest Management Assumptions

A.4.1 Forest cover requirements

Table A-5. specifies the forest cover requirements which were used to model current forest management objectives within each zone.

Table A-5. Resource unit forest cover requirements

Zone	Green-up age (years)	Green-up height (metres)	Maximum per cent area younger than green-up age
1 General IRM	13	3	33%
2 Rec/VQO-R	16	5	5%
3 Rec/VQO-PR	16	5	11%
4 Rec/VQO-M	18	5	24%
5 Islands	13	3	25%
6 Aerial	14	3	33%

In zone 1, the forest cover requirement is intended to model cutblock adjacency requirements. Given current cutblock adjacency requirements in the Sunshine Coast TSA, roughly one-third of any area in which harvesting is occurring is harvested with each subsequent harvest and forested areas adjacent to any previously harvested area may not be harvested until the previously harvested area has reached at least 3 metres in height.

In zones 2 through 4, the forest cover requirements are based on provincial guidelines for managing forest cover in visually sensitive areas. These guidelines define the maximum per cent of the landscape that may be visually non-greened-up (previously harvested, covered with trees less than 5 metres tall).

The green-up age for all zones with visual quality objectives represents the average time required for regenerated stands to achieve a 5 metre height. The green-up age for all other zones represents the average time required for regenerated stands to achieve a 3 metre height. The maximum per cent of each VQO zone that may be less than green-up is based on the following assumptions:

- Retention VQO — 5% of the gross forested area may be less than 5 metres tall;
- Partial retention VQO — 10% of the gross forested area may be less than 5 metres tall;
- Modification VQO — 20% of the gross forested area may be less than 5 metres tall.

The above per cents are then adjusted using the methods outlined in Recreation Branch, *Technical Report 1993:1, Procedures for Factoring Recreation Resources into Timber Supply Analyses*. The gross green/operable ratio used in the calculation is determined separately for each zone and dispersion default values from the technical report have been used.

Forest cover requirements for zone 5 (Islands) are not based on any specific resource concern. The forest cover requirements applied to zone 5 (Islands) reflect only that development of areas for timber harvesting must proceed more slowly in the Islands zone than in other areas identified for general integrated resource management (zone 1), due to the higher level of concern about timber harvesting in these areas.

Forest cover requirements for zone 6 (aerial harvesting) are the same as for zone 1. The aerial harvesting zone has been created only so that the amount of timber to be harvested via this harvesting system over time can be estimated.

A.4 Forest Management Assumptions

A.4.2 Timber licence reversions

Table A-6. shows the area by analysis unit of Timber Licences (TLs) that have not yet reverted to the Sunshine Coast TSA, and the expected number of years until reversion.

Table A-6. Timber licence reversions

Zone	Analysis unit	Area of TLs reverting (hectares) years until reversion			Total area in hectares
		0 - 5	5 - 15	15 - 25	
1	2	2	0	0	2
	3	40	12	13	65
	5	89	33	0	122
	6	420	108	72	600
	7	92	48	37	177
	8	14	17	0	31
2	3	1			1
	6	4			4
3	2	54	0	9	63
	3	57	18	19	94
	4	14	11	0	25
	5	34	0	0	34
	6	108	28	18	154
	7	31	16	12	59
	8	14	0	0	14
4	5	1	0	0	1
	6	7	0	0	7
6	3	12	0	0	12
	6	9	0	0	9
	7	1	0	0	1
	Total area	1 004	291	180	1 475

Table A-6. includes only the net area of TLs with an age class of 5 or greater. TLs that are less than age class 5 are assumed to have already been harvested, restocked and reverted.

A.4.3 Not satisfactorily restocked areas

Areas designated as forest cover type identity 4 and 9 (NSR) and 7 (disturbed, stocking doubtful) are considered to be NSR areas. All NSR areas are assumed to be restocked within the first decade, according to Table A-7.

Table A-7. Not satisfactorily restocked (NSR) areas

Analysis unit	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Total area
1 Fir G	309	47	157	28	10	5	555
2 Fir M	1 030	157	523	92	32	17	1 851
3 Fir P	412	63	209	37	13	7	740
4 H/B/S G	722	110	366	64	22	12	1 296
5 H/B/S M	1 597	244	811	143	49	26	2 869
6 H/B/S P	670	103	340	60	21	11	1 205
7 C G/M	309	47	157	28	10	5	555
8 C P	103	16	52	9	3	2	185
Total	5 151	787	2 615	460	159	84	9 256

The total area shown in Table A-7. is from silviculture records systems (Major Licensee Silviculture Information System (MLSIS), Integrated Silviculture Information System (ISIS)) and includes backlog NSR. The area was prorated to zone and analysis unit based on the existing zone/analysis unit profile of age class 1 stands in the timber harvesting land base. Regeneration delays as shown in Table A-11. were considered while modelling the restocking of NSR area.

A.4.4 Unsalvaged losses

The purpose of this section is to estimate the average annual unsalvaged volume loss to insect and disease epidemics, fires, wind damage or other agents over the long term on the net operable land base.

Table A-8. Unsalvaged losses

Cause of loss	Gross losses in cubic metres/year	Salvaged volume in cubic metres/year	Annual unsalvaged loss in cubic metres/year
Insects	5 000	500	4 500
Fire	19 000	4 000	15 000
Wind damage	25 500	20 800	4 700
Total			24 200

A.4 Forest Management Assumptions

For comparison purposes, the current AAC in the Sunshine Coast TSA is 1.1 million cubic metres per year.

Modelling of root rot — all regenerated stands of Douglas-fir (analysis units 1-3) will have an operational adjustment factor of 7% applied to model the losses expected due to root rot. This percentage is based on research done in the Vancouver Forest Region, and reflects current management practices such as planting mixtures of species, aimed at reducing future losses to root rot. Note: this 7% volume adjustment is in addition to the 5% Operational Adjustment Factor (OAF2) applied in the regenerated stand yield model Table Information Program for Stand Yield (TIPSY) for other expected volume losses. Losses due to root rot are considered to be incorporated into the existing stand yield estimates as generated by the Variable Density Yield Projection (VDYP) yield model, thus no further adjustment is applied to existing yields.

Average gross annual fire losses (1955-1993) equal 45 000 cubic metres per year. Approximately 4000 cubic metres of timber per year was salvaged. A timber harvesting land base to total forested area ratio of 42 % was applied to determine the gross losses from the timber harvesting land base of 19 000 cubic metres per year average. (214 932 net operable / 514 197 total forest = 42%).

Insects and wind damage estimate is for the timber harvesting land base.

A.4.5 Minimum harvestable age for each analysis unit

Tables A-9. and A-10. identify the estimated minimum harvestable age for each analysis unit, for existing and regenerated stands.

Table A-9. Estimated minimum harvestable age for each analysis unit for existing stands

Analysis unit	Volume at minimum harvestable age (m^3/ha)	Estimated minimum harvestable age (years)	MAI at harvest age (m^3/ha/year)	Maximum MAI/age of maximum MAI
1 Fir/G	531	60	8.86	8.94/70
2 Fir/M	386	60	6.45	6.62/80
3 Fir/P	381	100	3.82	3.84/90
4 Hw/G	483	60	8.06	8.10/70
5 Hw/M	414	70	5.92	6.01/80
6 Hw/P	369	120	3.08	3.11/110
7 Cw/GM	397	80	4.97	4.97/80
8 Cw/P	351	160	2.20	2.35/110

A.4 Forest Management Assumptions

Table A-10. Minimum harvestable ages for managed (regenerated) stands

Analysis unit	Volume at minimum harvestable age (m^3/ha)	Estimated minimum harvestable age (years)	MAI at harvest age (m^3/ha/year)	Maximum MAI/age of maximum MAI
1 Fir/G	534	60	8.90	9.35/80
2 Fir/M	432	70	6.17	6.31/90
3 Fir/P	352	110	3.20	3.20/110
4 Hw/G	715	70	10.21	10.75/100
5 Hw/M	690	100	6.90	7.07/120
6 Hw/P	398	120	3.32	3.46/160
7 Cw/GM	634	90	7.04	7.37/120
8 Cw/P	356	130	2.74	2.81/150

The estimated minimum harvestable ages are determined by the age at which the mean annual volume growth (MAI) is within 5% of the maximum and a minimum volume per hectare of 350 cubic metres per hectare has been attained.

A minimum harvest volume of 300 to 400 cubic metres per hectare reflects current practices.

A.4.6 Basic silviculture and regeneration assumptions

Table A-11. specifies the regenerated analysis unit that each existing analysis unit will regenerate to and specifies the expected regeneration delay following harvesting.

Table A-11. Regeneration assumptions

Zone	Analysis unit	Per cent treated	Establishment	Initial density (stems/ha)	Regen delay
All	1 Fir >32	100	Planted	1200	3
	2 Fir 26-32	90	Planted	1200	3
	2	10	Natural	1200	3
	3 Fir <26	80	Planted	1200	3
	3	20	Natural	1200	3
	4 HBS >25	90	Planted	1200	3
	4	10	Natural	1200	3
	5 HBS 22-25	40	Planted	1200	3
	5	60	Natural	1200	3
	6 HBS <22	40	Planted	1200	3
	6	60	Natural	1200	3
	7 C >17	90	Planted	1200	3
	7	10	Natural	1200	3
	8 C <17	60	Planted	1200	3
	8	40	Natural	1200	3

A.4 Forest Management Assumptions

The silviculture 5 year plan identifies less than 2% of the area to be treated with spacing or fertilization. These treatments are not included in the above table or in the analysis.

Silviculture standards allow a 3 year regen delay on planted areas, and a 6 year regen delay on naturally restocked areas.

A.4.7 Yield assumptions

Yield tables for all existing stands were developed using a batch processing of the Variable Density Yield Projection (VDYP) model provided by the B.C. Ministry of Forests, Inventory Branch. All yield tables assume the utilization levels identified in Section A.2, "Utilization Levels." The data requirements for the VDYP model are from existing stand information on the 1993 inventory file provided by the Inventory Branch. For all existing stands, aggregated waste and breakage (W2B) factors are developed from the *Inventory Metric Diameter Class Decay, Waste and Breakage Factors Manual* (B.C. Ministry of Forests, 1976). A single W2B factor is developed for each of two age ranges for each Public Sustained Yield Unit (PSYU), species, and utilization level.

Yield tables for all regenerated stands were produced using the Table Interpolation Program for Stand Yields (TIPSY) growth and yield model developed by the Research Branch, Ministry of Forests. Regenerated stand yield tables are based on the following assumptions:

- all forest stands are regenerated back to the same species and site class following harvesting;
- a pure species composition is assumed after regeneration;
- mean area weighted site indices of the existing stands are assumed to apply to the regenerated stands;
- operational adjustment factors used in the TIPSY growth and yield model are as follows:

  all stands except Douglas-fir — OAF1 = 15%, OAF2 = 5%;

  for Douglas-fir stands, OAF2 is increased by an additional 7%, to a total of 12%, to reflect the expected increase in the incidence of root rot disease;
- waste and breakage factors for regenerated stands are assumed to be included in the OAF2 used in the TIPSY model inputs;
- silviculture standards allow a 3 year regen delay on planted areas, and a 6 year regen delay on naturally restocked areas.

A.4.8 Existing immature plantations

To reflect the expected higher productivity of managed regenerated stands resulting from both past and future harvesting, all age class 1 (20 years or younger) stands are assigned immediately to managed stand yield tables in the timber supply model.

A.5 Volume Tables for Existing and Regenerated Stands

Table A-12. shows the existing and regenerated stand volume by age tables for each analysis unit (species and site type combination). The appropriate regeneration delay, as discussed in Section A.4.6, "Basic silviculture and regeneration assumptions," is applied to regenerated stands in the timber supply model and is not reflected in the volume by age tables shown below.

Table A-12. Volume by age tables for existing and regenerated stands

Age (years)	Analysis unit 1 existing Douglas-fir good site (cubic metres)	Analysis unit 2 existing Douglas-fir medium site (cubic metres)	Analysis unit 3 existing Douglas-fir poor site (cubic metres)	Analysis unit 4 existing hemlock/balsam/spruce good site (cubic metres)
10	0	0	0	0
20	2	0	0	6
30	142	68	7	135
40	293	192	67	269
50	421	297	140	384
60	532	387	203	484
70	626	463	257	567
80	709	530	304	640
90	780	587	345	701
100	843	637	382	752
110	899	682	414	797
120	948	721	443	834
130	988	754	466	873
140	1 022	781	486	909
150	1 049	802	501	940
160	1 069	817	511	966
170	1 082	826	518	989
180	1 090	831	521	1 010
190	1 104	842	528	1 031
200	1 119	852	534	1 051
210	1 133	862	541	1 069
220	1 147	872	548	1 085
230	1 161	882	554	1 101
240	1 174	891	560	1 116
250	1 187	900	565	1 129
260	1 187	901	566	1 135
270	1 188	902	567	1 140
280	1 188	902	568	1 145
290	1 189	903	569	1 149
300	1 189	903	570	1 153
310	1 189	904	570	1 156
320	1 189	904	571	1 158
330	1 189	904	572	1 161
340	1 190	905	572	1 162
350	1 189	905	572	1 164

continued

A.5 Volume Tables for Existing and Regenerated Stands

Table A-12. Volume by age tables for existing and regenerated stands

Age (years)	Analysis unit 5 existing hemlock/balsam/spruce medium site (cubic metres)	Analysis unit 6 existing hemlock/balsam/spruce medium site (cubic metres)	Analysis unit 7 existing cedar good/medium site (cubic metres)	Analysis unit 8 existing cedar poor site (cubic metres)
10	0	0	0	0
20	0	0	0	0
30	41	3	32	0
40	154	32	112	11
50	252	84	193	50
60	340	139	268	94
70	415	190	335	136
80	481	236	397	174
90	536	275	447	206
100	585	310	490	234
110	628	341	527	259
120	664	369	554	278
130	701	396	590	300
140	736	421	623	320
150	766	444	651	337
160	793	463	675	351
170	817	481	695	363
180	839	497	715	376
190	860	513	735	388
200	880	528	755	400
210	898	542	774	411
220	916	556	797	424
230	932	568	819	438
240	947	580	841	450
250	961	591	862	463
260	969	597	864	465
270	975	603	867	467
280	982	608	869	469
290	987	613	870	471
300	992	617	872	473
310	997	621	874	475
320	1 001	625	875	476
330	1 005	629	876	477
340	1 008	632	877	479
350	1 011	635	878	480

continued

A.5 Volume Tables for Existing and Regenerated Stands

Table A-12. Volume by age tables for existing and regenerated stands

Age (years)	Analysis unit 1 regenerated Douglas-fir good site (cubic metres)	Analysis unit 2 regenerated Douglas-fir medium site (cubic metres)	Analysis unit 3 regenerated Douglas-fir poor site (cubic metres)	Analysis unit 4 regenerated hemlock/balsam/spruce good site (cubic metres)
10	0	0	0	0
20	0	0	0	0
30	83	20	1	66
40	242	137	25	231
50	401	240	91	395
60	534	342	154	558
70	653	432	202	715
80	748	503	244	857
90	821	568	285	967
100	879	624	320	1 075
110	924	670	352	1 174
120	959	706	379	1 262
130	991	735	401	1 329
140	1 020	759	419	1 392
150	1 045	778	434	1 453
160	1 064	792	447	1 507
170	1 080	804	460	1 551
180	1 086	812	470	1 590
190	1 088	818	478	1 633
200	1 088	821	484	1 676
210	1 088	824	490	1 715
220	1 088	824	495	1 749
230	1 088	823	497	1 776
240	1 088	820	499	1 801
250	1 088	818	501	1 823

continued

Table A-12. Volume by age tables for existing and regenerated stands (concluded)

Age (years)	Analysis unit 5 regenerated hemlock/balsam/spruce medium site (cubic metres)	Analysis unit 6 regenerated hemlock/balsam/spruce poor site (cubic metres)	Analysis unit 7 regenerated cedar good/medium site (cubic metres)	Analysis unit 8 regenerated cedar poor site (cubic metres)
10	0	0	0	0
20	0	0	0	0
30	4	0	3	0
40	70	2	76	0
50	181	24	200	7
60	289	74	321	53
70	402	133	423	105
80	502	192	533	155
90	597	245	634	209
100	690	296	712	258
110	775	348	796	296
120	848	398	884	329
130	911	442	956	356
140	973	481	1 017	391
150	1 028	517	1 073	422
160	1 082	554	1 126	449
170	1 133	589	1 172	474
180	1 179	620	1 212	497
190	1 216	650	1 246	518
200	1 248	679	1 277	537
210	1 276	706	1 302	553
220	1 303	729	1 338	571
230	1 333	751	1 376	589
240	1 359	770	1 411	604
250	1 383	787	1 443	617