

Fraser TSA Timber Supply Analysis

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Preface

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

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

Unlike past analyses, which normally assessed the implications of several forest management scenarios, this report focuses on a single scenario—current management practices. This approach will expedite the analysis process, and allow analysis of

all timber supply areas in the province to be completed by the end of 1994. An important part of these analyses, however, is an assessment of how results might be affected by uncertainties—a process called "sensitivity analysis." Together, the sensitivity analyses and the assessment of the effects of current forest management on timber supply will form a solid basis for discussions among stakeholders about alternative timber harvesting levels.

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

Executive Summary

As part of the provincial Timber Supply Review, the B.C. Forest Service has examined the availability of timber in the Fraser Timber Supply Area (TSA). The analysis assesses how current forest management practices affect the supply of timber available for harvesting over the next 250 years. It also examines the potential changes in timber supply stemming from uncertainties about forest growth and management actions.

The Fraser TSA covers approximately 1.17 million hectares, of which about 275 000 hectares are considered available for timber harvesting under current management practices. The area is dominated by hemlock/balsam and Douglas-fir stands.

The current allowable annual cut for the Fraser TSA is 1.76 million cubic metres per year. Using current management assumptions, the analysis results indicate that the current harvest level must be reduced immediately by about 12% to about 1.55 million cubic metres per year in order to avoid a more severe decline in the timber supply and harvest levels in the future. From this reduced initial harvest level, the harvest forecast declines by about 10% per decade over the next 3 decades to a steady long-term harvest level of about 1.2 million cubic metres per year. The most important factors contributing to the projected decline in timber supply are:

- 1) The area considered to be available for timber harvesting has been reduced by about 25% since the last timber supply analysis completed for the

Fraser TSA. This change is due primarily to new mapping of the area available for timber harvesting, known as operability mapping. Operability is determined using the terrain characteristics of the area as well as the quality and quantity of timber on the area.

- 2) Approximately 25% of the area that is available for timber harvesting is also being managed for scenic values. Forest cover requirements used to limit the visual impact of timber harvesting significantly limit the rate at which timber may be harvested from these scenic areas. Forest cover requirements for other forest resources such as wildlife habitat and recreation have less significant effects on the short-term harvest forecast.

Uncertainty in the data and assumptions used in the analysis may affect results. The short-term harvest forecast (next 30 years) is most strongly affected by changes in the estimated volume of timber in existing mature stands and in the forest cover requirements used to manage for scenic values. The short-term harvest forecast is also significantly affected by large changes (plus or minus 20 years) to the minimum harvest ages used in the analysis.

Changes to the estimated growth rate of regenerated stands have a strong effect on the long-term harvest forecast, but have no effect in the short-term harvest forecast.

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Introduction

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

Assessing timber supply involves considering physical, biological, and socio-economic factors for all forest resource values, not just for timber. Physical factors include the land features of the area under study in addition to 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 on 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. Deciding whether a

stand is available for harvest often depends on how its harvest could affect another aspect of the forest, such as wildlife or a recreation area.

These factors are also subject to 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 — a debate that 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 the uncertainties affecting those 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).

Introduction

For a timber supply area (TSA)*, the timber supply analysis forms part of the information used by the Chief Forester of British Columbia in determining an allowable annual cut (AAC)*— the permissible harvest level for the area.

Timber supply projections made for TSAs look far into the future — 200 years or more. However, because of the uncertainty surrounding the information and because forest management objectives change through time, these projections should not be viewed as static prescriptions that remain in place for that length of time. They remain relevant only as long as the information on which they are based remains relevant. Thus, it is important that re-analysis occur 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 throughout British Columbia be reviewed at least every 5 years. This allows close monitoring of the timber supply and assessment of the implications on the AAC resulting from changes in management practices and objectives.

Timber supply analysis involves three main steps. The first is the collection and preparation of information and data. The B.C. Forest Service forest inventory* plays a major role in this. The second step is using this information with a timber supply computer model or models to make a projection or estimation of possible harvest levels over time (called harvest forecasts). These

projections are made using different sets of assumed values or conditions for the factors discussed above. The third step in timber supply analysis is the interpretation and reporting of results.

The following sections outline the timber supply analysis for the Fraser TSA. Following a brief description of the Fraser TSA in Section 1, data preparation and formulation of the assumptions are discussed in Section 2. The analysis methodology and results are then presented in Sections 3 and 4. Section 5 examines the sensitivity of the results to uncertainties in the data and assumptions used. The report summary and conclusions are presented in Section 6.

For the more technically oriented reader, the appendix contains further details about the data and assumptions used in this analysis. They are included here for completeness, but their review is not necessary to give readers a basic understanding of the timber supply for the Fraser TSA.

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

Forest inventory

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

1 Description of the Fraser Timber Supply Area

The Fraser TSA is located in the southwest mainland portion of the Vancouver Forest Region (Figure 1). Administered from the Chilliwack Forest District office in Rosedale, it covers approximately 1.17 million hectares. The Fraser TSA is the most densely populated in the province, encompassing the major population centres of the lower mainland and the Fraser Valley.

The forest industry provides a substantial source of revenue and employment in the Fraser TSA, with approximately 112 major timber processing facilities. Although a large proportion of the timber processed within the Fraser TSA is harvested from outside of the TSA, timber harvesting is an

important part of the local economy, especially in the smaller rural communities.

Tourism and recreation is also important in the Fraser TSA. This area provides easily accessible forest recreation opportunities to the major population centres of the lower mainland. Visual quality of the forest landscape is an important concern, especially along the several major highway corridors that transect the TSA.

Forests are dominated by stands of hemlock/balsam (48%) and Douglas-fir (39%). There is a long history of timber harvesting in the Fraser TSA.

Figure 1. The Vancouver Forest Region showing the Fraser Timber Supply Area

2 Information Preparation

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

2.1 Land base inventory

Land base inventory information used in this analysis comes in the form of a computer file prepared by the B.C. Forest Service Inventory Branch in 1992. This file contains a considerable amount of data about the thousands of pieces of forest land that make up a TSA, including the geographic location, area and nature of 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 which therefore do not contribute to the timber supply of the area. Examples are land that has been set aside for a park, areas necessary for maintaining a certain type of wildlife habitat, or the areas occupied by powerlines, highways or townsites. (A description of the areas specific to the Fraser TSA is given below). Before this land base file is used to make timber supply projections, it is important that data for these non-contributing areas be removed, to arrive at a file that represents the timber harvesting land base*.

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

It is important to remember that removal of data for areas not contributing to the timber supply does not imply withdrawal of areas from the TSA. The B.C. Forest Service still manages the entire area of

the TSA (except for certain designated lands) as a forest unit that contributes a mix of timber and non-timber values. The timber supply is managed within that integrated resource context, and the timber supply analysis in this report is consistent with this philosophy.

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

Areas on which timber harvesting is not expected to occur, given current forest management in the Fraser TSA, are as follows:

- Non-Crown areas — areas not managed directly by the B.C. Forest Service.
- Non-forested areas — areas of water, rock, swamp, alpine, etc.
- Non-commercial cover areas — areas occupied by non-commercial tree or brush species.
- Inoperable areas — areas defined as unavailable for harvest for terrain-related or economic reasons.
- Sites with low timber growing potential (low site index*).
- Areas with very high recreation value
- Environmentally sensitive areas* — portions of areas considered to have sensitive soils, high water values, tree regeneration problems or avalanche hazards.

Timber harvesting land base

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

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.

Environmentally sensitive area

An area of significant non-timber values, fragile or unstable soils, problems in establishing a new tree crop or where timber harvesting may cause avalanches.

2 Information Preparation

- Streamside buffers — the estimated area that must be maintained in forest cover alongside fish bearing streams.
- Existing forest roads, skid trails and landings — the area of productive forest land that has been lost to existing forest roads, trails and landings.
- Future forest roads, skid trails and landings — the area of productive forest land that is projected to be lost to future forest roads, trails and landings is initially left in the timber harvesting land base, but is deducted over time.
- Not satisfactorily restocked (NSR) areas* — Areas that have been harvested but are not yet restocked with trees are initially removed, but are assumed to be eventually restocked (see Table 1).
- Timber licences — areas under timber licences, (old tenures that give the licensee rights to an area's existing mature timber), are initially excluded from the land base because the timber harvested from them does not contribute to the AAC. After the existing mature timber has been harvested, the area under the timber licence is

added back into the timber harvesting land base and all future harvests contribute towards the AAC.

Table 1 summarizes the areas excluded from the total land base of the TSA, leaving the land base on which timber harvesting is expected to occur — the timber harvesting land base. The timber harvesting land base is almost 90 000 hectares smaller than was assumed in the last timber supply analysis completed for the Fraser TSA in 1984. This reduction in the area assumed to be available for timber harvesting is an important factor affecting the harvest forecast. A more detailed description of the rationale and method used for each area exclusion and addition is provided in Appendix A.

Not satisfactorily restocked

An area not covered by a sufficient number of tree stems of desirable species. Stocking standards are set by the Forest Service, Silviculture Branch. If the expected regeneration delay (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.

Table 1. Timber harvesting land base, Fraser TSA, 1993

Classification	Area (ha)	Area (ha)	% of total area
Total land base		1 173 616	100
Non-Crown land		229 398	19.4
Non-forest land		373 952	31.9
Total productive forest		570 266	48.7
Reductions to productive forest			
Non-commercial cover (brush)	1 022		—
Inoperable areas	189 836		16.2
Low productivity sites	61 444		5.2
High recreation values	83		—
Environmentally sensitive areas	22 450		1.9
Streamside buffers	5 653		0.5
Existing roads/trails/landings	14 180		1.2
Not satisfactorily restocked	13 989		1.2
Total current reductions	308 658	308 658	26.4
Current timber harvesting land base		261 608	22.3
Future additions			
Current NSR*	13 989		1.2
Total Additions	13 989	13 989	1.2
Future reductions			
Future roads/trails/landings	514		—
Total future reductions	514	514	—
Long-term timber harvesting land base		275 083	23.4

2 Information Preparation

Figure 2 shows the current stand age distribution on the timber harvesting land base. Due to the long history of timber harvesting in the area, the Fraser TSA has a large proportion of younger, regenerated stands that are almost old enough to be harvested for a second time.

Figure 3 shows a breakdown of the timber harvesting land base by tree species, quality of growing site, and stand maturity. The timber

harvesting land base in the Fraser TSA is primarily forested with hemlock/balsam (48%) and Douglas-fir (39%), with significantly smaller areas of cedar, spruce, pine, larch and deciduous stands. The majority of the area of mature stands for all tree species is on the poorer growing sites. The consequence of the relatively lower productivity of the existing mature forest on the timber supply forecast is discussed in Section 4.1.

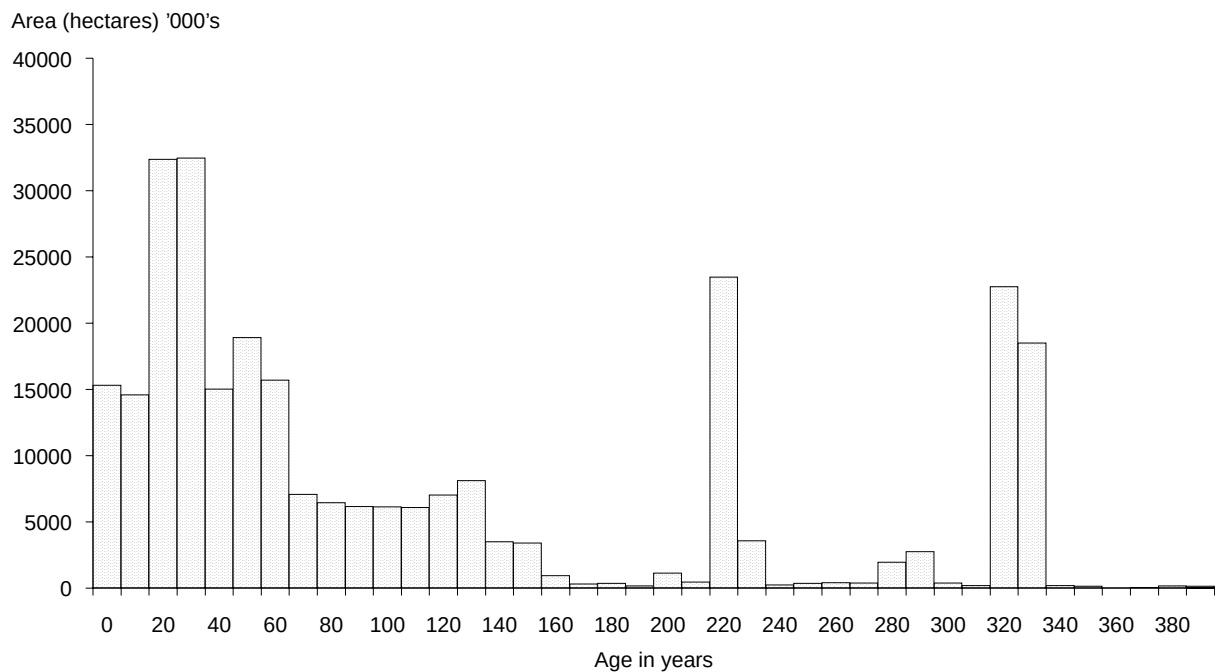


Figure 2. Current stand age distribution – timber harvesting land base

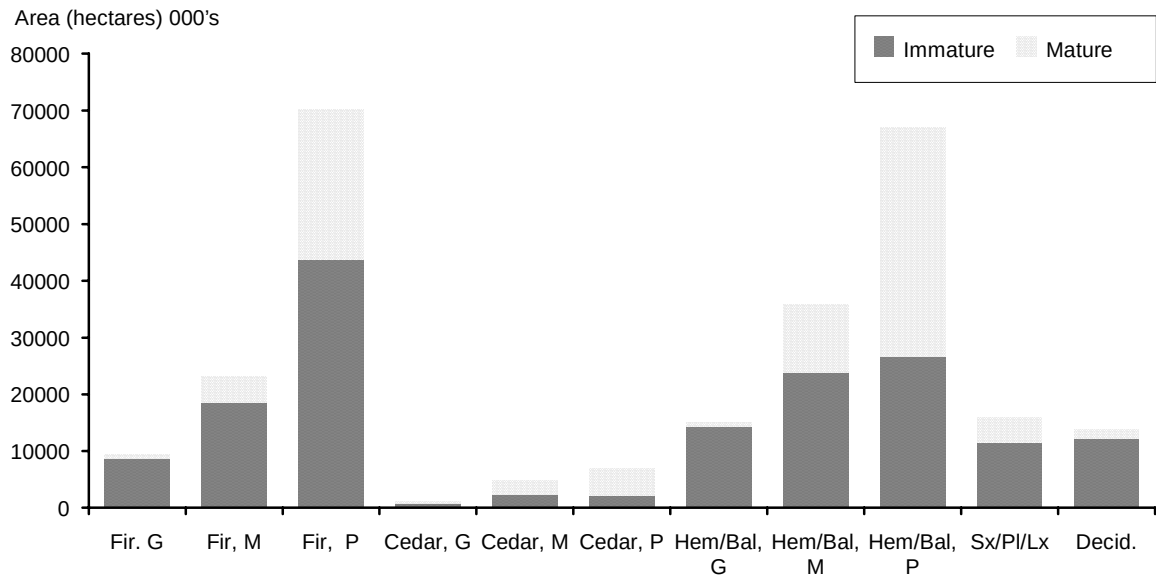


Figure 3. Area by dominant tree species, quality of growing site and maturity — timber harvesting land base

2 Information Preparation

2.2 Timber Growth and Yield

Timber growth and yield refers to the prediction of the growth and development of individual forest stands over time. The most common measure of the amount of standing timber is volume per area (in British Columbia, cubic metres per hectare). This measure assumes a utilization level or set of dimensions that establish a minimum size limit for trees and logs that must be harvested and removed from a site. Utilization levels specify a maximum stump height and minimum diameters at the tree base and top.

Timber volumes for this analysis are based on yield prediction models developed by the B.C. Forest Service, that provide estimates of timber volume over time for existing and regenerated (or future) stands. Sensitivity analysis completed in Sections 5.3 and 5.4 of this review addresses the possibility that volumes may be different from those predicted. Appendix A contains more information on the methods and models used to predict timber volumes.

2.3 Management practices

The following harvesting and silvicultural assumptions reflect current forest management in the Fraser TSA, and are used in the timber supply analysis:

- Basic silviculture — reforestation activities required to establish free-growing* stands of acceptable species after harvesting will be continued over the long term. Areas that have been previously logged, but not satisfactorily restocked with trees either naturally or by planting, will be restocked within 3 to 6 years.
- Forest health and unsalvaged losses — the unsalvaged loss of timber to fire and wind damage in the Fraser TSA is expected to total 17 500 cubic metres annually. No significant loss of timber volume is expected to occur as a result of either forest insects or disease.

- Cutblock adjacency - current forest management in the Fraser TSA ensures that a given area is not logged until the trees in any adjacent previously harvested area are approximately 3 metres tall. An additional goal of current management is to have no more than 25% of the forest less than 3 metres tall at any time. The time required for forest stands to reach this prescribed height is called the green-up period. The purpose of the green-up period is to prevent timber harvesting activities from becoming overly concentrated in any one area at any time. The sensitivity of the harvest forecast to uncertainty in both the required per cent area that may be less than 3 metres tall, and in the estimated time required for regenerated forests to achieve a 3-metre height is examined in Section 5.5. The basis for the cutblock adjacency guidelines is discussed in more detail in Appendix A.
- Visual quality of the landscape — in visually sensitive areas, the green-up requirement is achieved when the average tree height reaches approximately 5 metres. The proportion of each visually sensitive stand that may be less than 5 metres in height at any time depends on the visual sensitivity* of the area. Approximately 72 000 hectares of the timber harvesting land base has visual quality as a management goal. More than half of this area is considered to be highly sensitive. The effect that management for visual quality has on the timber supply forecast is examined in sensitivity analysis in Section 5.6.

Free-growing

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

Visual sensitivity

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

2 Information Preparation

- Special recreational values — timber harvesting is assumed to be compatible with most recreational uses of the forest, as long as the rate of harvesting is limited in areas identified as having special value for forest recreation. This assumption is modelled by limiting timber harvesting so that a maximum of 20% of these areas may be less than 5 metres tall at any time. The effect that uncertainty in these requirements has on the harvest forecast is examined in sensitivity analysis in Section 5.9.
- Deer winter range — to model management for deer winter range, approximately 18 000 hectares of the timber harvesting land base, primarily in Douglas-fir types, is maintained in ages greater than 100 years at all times. This approach is based on the amount of area and forest types presently mapped by the Ministry of Environment as being important for deer winter range, and assumes that present areas mapped as deer winter range may eventually be harvested when alternative winter range areas reach 100 years of age. The effect that management for deer winter range has on the timber supply forecast is examined in sensitivity analysis in Section 5.8.,
- Minimum harvest ages — the time it takes for stands to grow to harvestable size. The minimum harvest ages used in this analysis vary by tree species and site productivity, but were all set at the age at which the trees achieved their maximum mean annual volume increment (maximum MAI*). Harvesting at this age maximizes the amount of timber that is produced over time. All minimum harvest ages used for the base harvest forecast are listed in Appendix A, page 49. The effect that uncertainty in the minimum harvest ages has on the timber supply forecast is examined in sensitivity analysis in Section 5.2.
- Current allowable annual cut (AAC) — the current allowable annual cut for the Fraser TSA (excluding woodlot licences) is 1 755 000 cubic metres per year.

Mean annual increment (MAI):

The average rate of volume growth of a forest stand, calculated by dividing the total timber volume of the stand by the age.

3 Analysis Methods

The purpose of this analysis is to examine both the short- and long-term timber harvesting opportunities in the Fraser 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 distinguished from a growth and yield model, assists in determining how a whole forest, or collection of stands, should be managed in order to obtain a harvest flow, or supply of timber over time.

Similar to other models, the B.C. Forest Service model assumes that trees grow according to provided yield projections, and are harvested according to either a volume target or a specified objective set by the analyst, such as harvest volume maximization. However, the Forest Service model differs from other models in that it allows the use of forest cover guidelines that specify the desired age composition of the forest. These cover guidelines can be used to examine the effects of cutblock adjacency and green-up prescriptions. For example, guidelines might specify that no more than some maximum per cent of the forest can be younger than

a specified green-up age or that some minimum per cent of the forest must be in older age classes to provide wildlife habitat. The B.C. Forest Service simulation model tests such guidelines to examine their effects on timber supply.

This type of analysis is used to determine the timber supply implications of a particular timber harvesting regime. The results of the analysis are especially important when determining allowable cuts that will not restrict options of future resource managers, and 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 should not be viewed as implying any particular AAC recommendation.

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

4 Results

This section presents the results of the timber supply analysis based on the timber harvesting land base and the current management practices already described for the Fraser TSA.

4.1 Base harvest forecast

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

The base harvest forecast shows an initial rate of harvest of 1 550 000 cubic metres per year. This rate of harvest is approximately 12% lower than the current AAC for the Fraser TSA. The harvest level is maintained at 1 550 000 cubic metres per year for the first 10 year period before declining by approximately 10% per decade over the next 3 decades to a steady long-term harvest level of about 1 180 000 cubic metres per year.

Given current management assumptions, the initial rate of harvest could not be set at the current AAC without causing severe timber shortfalls in

later years. The prospect of a future timber shortfall is due to both the decrease in the timber harvesting land base (as discussed in Section 2) and the forest cover requirements used to model management for visual quality, deer winter range, and forest recreation. Although the Fraser TSA maintains a relatively large inventory of timber throughout time (see Figure 5, page 11) the availability of timber for harvesting is significantly limited by the forest cover requirements.

The effect that the forest cover requirements have on the harvest forecast is partly the result of the poor productivity of the existing mature forest. As discussed in Section 2 and shown in Figure 3, page 6, a large proportion of the existing mature forest is on sites that are poor producers of timber.

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.

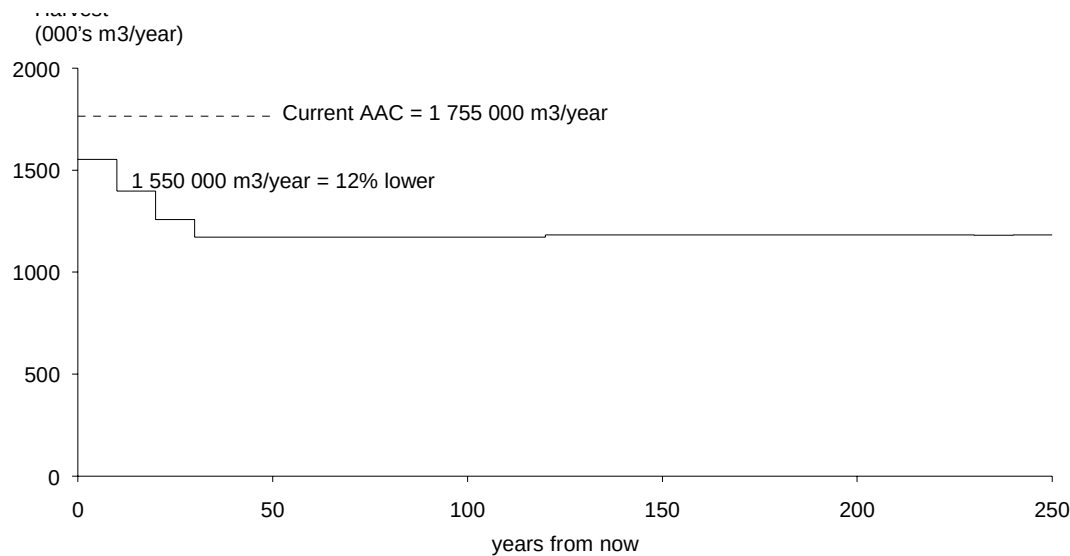


Figure 4. The base case harvest forecast for the Fraser TSA.

4 Results

These poor stands are harvested over the first 20 to 30 years in the model and, in about 130 years, are harvested a second time. The lower yield of timber from each hectare harvested at that time (see Figure 6) means that, when compared to better growing sites, more area must be harvested in order to achieve the required harvest level. However, this increase in the amount of area that must be harvested is limited by the forest cover requirements for visual quality, wildlife and recreation.

Figure 5 shows the projected timber growing stock* in the Fraser TSA. The total timber growing stock is projected to decline from about 88 million cubic metres to about 70 million cubic metres over the next 70 years. The proportion of the total timber

volume that is in stands of a harvestable age is projected to decline significantly over the next 100 years. Starting from about 73 million cubic metres, (approximately 83% of the total volume) the mature timber volume declines to an average of about 35 million cubic metres (approximately 50% of the total volume).

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

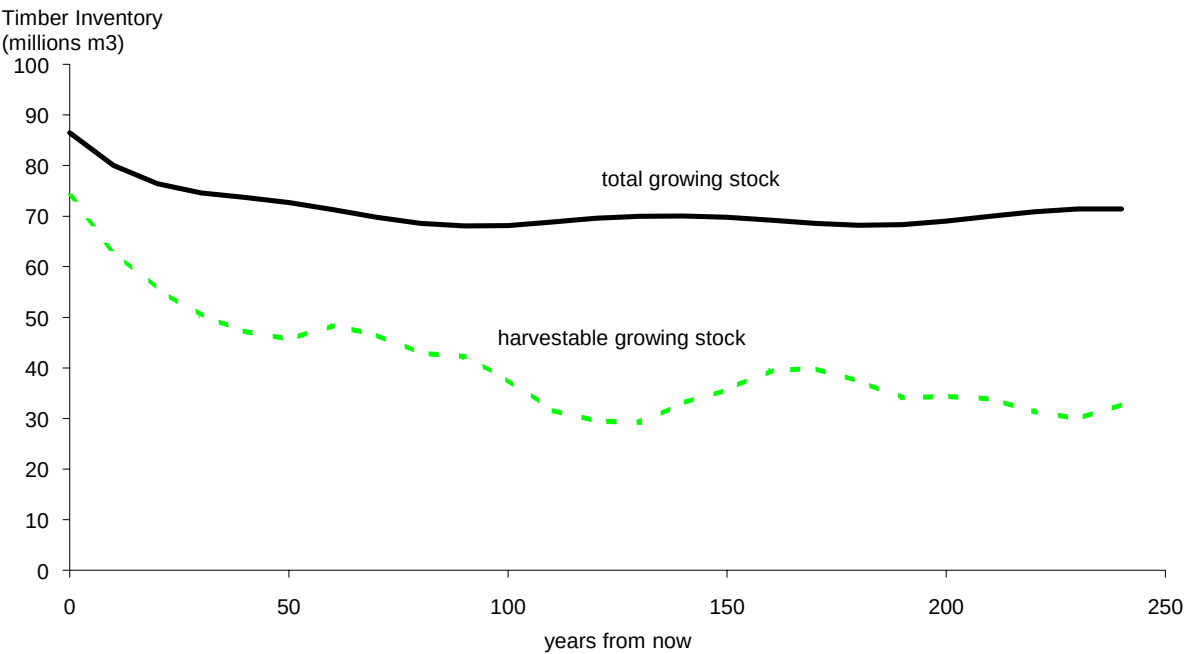


Figure 5. Projected timber growing stock over time for the Fraser TSA.

4 Results

4.2 Harvest and inventory statistics for the base harvest forecast

Figure 6 shows the average volume of timber obtained from each hectare of forest harvested over time. The average volume obtained per hectare harvested is projected to decline over the next 60 years from about 750 cubic metres to about 500 cubic metres per hectare. This decline is the result of harvesting increasingly younger stands as the existing mature inventory is depleted.

The volume obtained per hectare harvested is projected to reach a low of approximately 450 cubic metres in approximately 130 years when the areas of existing mature forest, which are harvested over the next 20 or 30 years, become old enough to be harvested a second time. As discussed in Section

2.1 and shown in Figure 3, page 6, a large proportion of the existing mature forest is on poorer growing sites, which will yield less timber over time.

Figure 7 shows the changes projected to occur in the age distribution of forest stands in the Fraser TSA. Over the 250-year period modelled, the area of older stands is reduced, and the area at each age in the younger forest becomes more balanced. At all times during the 250-year period modelled, a relatively large proportion of the forest area is maintained at 100 to 200 years of age. This older area is a combination of the areas being managed for deer winter range and areas for which the rate of harvest is significantly limited by forest cover requirements for visual quality and recreation.

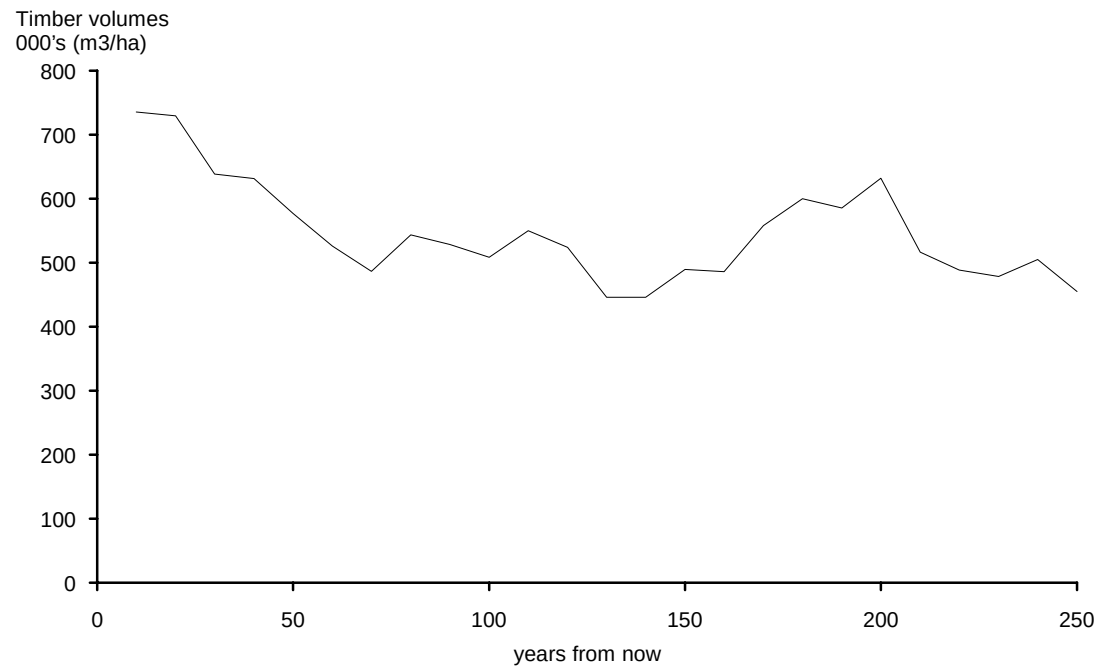


Figure 6. Average volume per hectare harvested over time.

4 Results

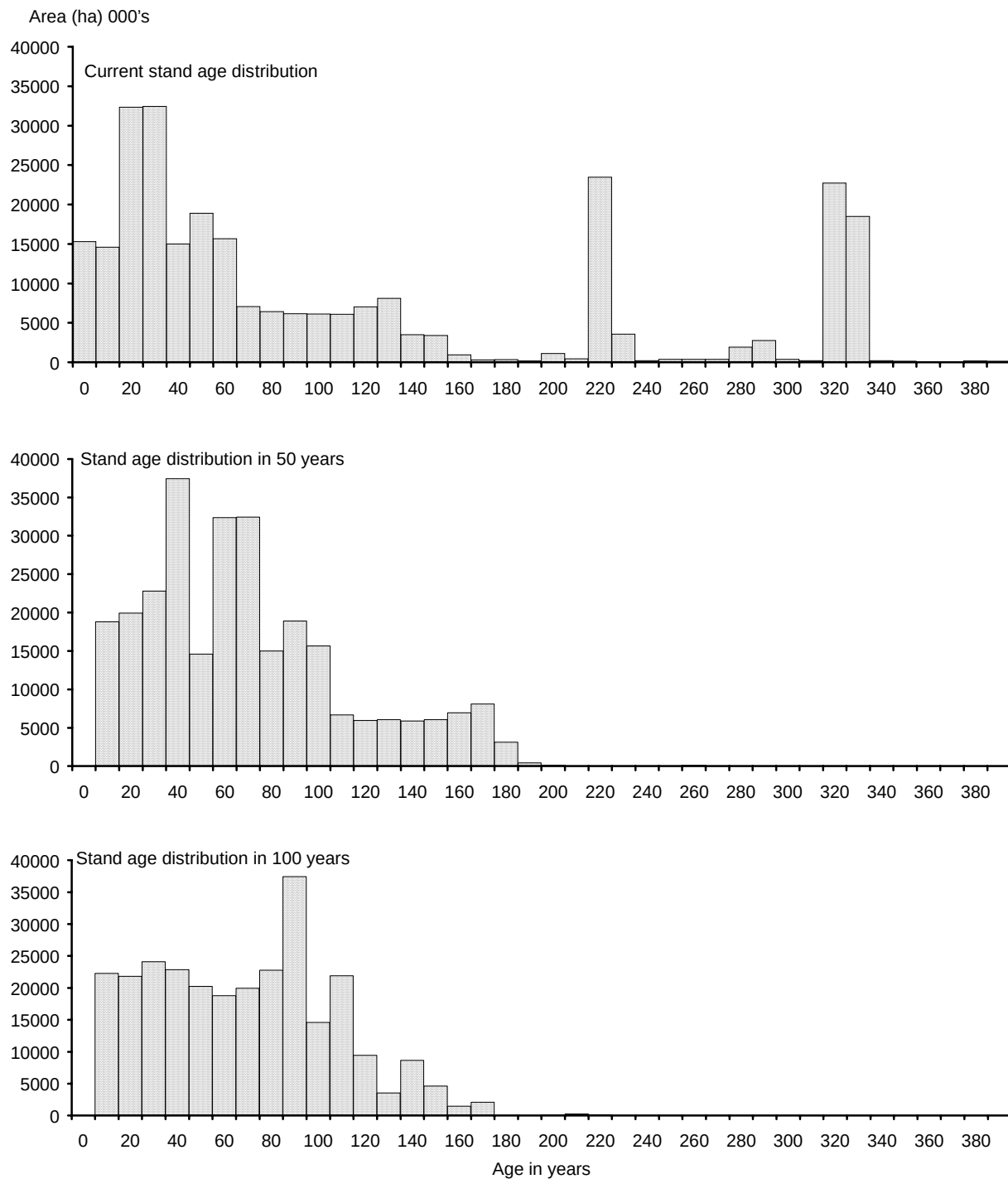


Figure 7. Changes in the age class distribution for the Fraser TSA over time.

4 Results

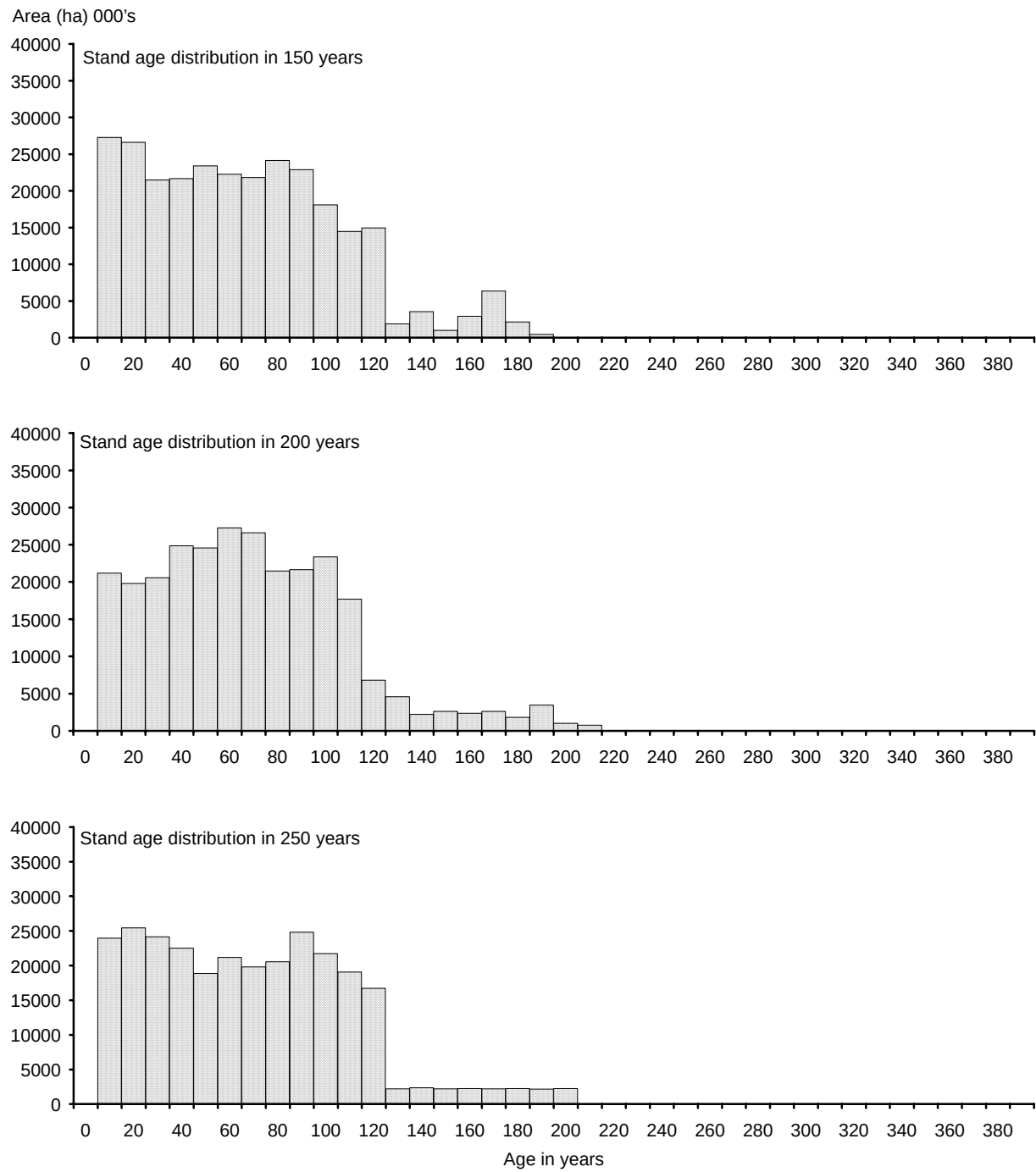


Figure 7. Changes in the age class distribution for the Fraser TSA over time.

5 Timber Supply Sensitivity Analyses

Sensitivity analysis is the exercise of examining how uncertainty in data and assumptions affect the outcome of analysis. The main purpose of timber supply sensitivity analysis is to highlight which variables most affect results. Sensitivity analysis is an important aid to decision making, since uncertainty surrounds estimates of many variables used in timber supply analysis.

The best available information on forest inventories and management practices is used in timber supply analysis. However, small inaccuracies in estimating some variables can have large effects on results, while fairly large inaccuracies for other variables may have negligible effects. Sensitivity analysis can highlight priorities for collecting information for future analyses. As well, it can clarify for decision makers whether current best estimates are safe bases for decisions, or whether high uncertainty around important variables necessitates more conservative decisions.

In this section, results of several sensitivity analyses are outlined. The results that are based on current forest management assumptions (shown in Section 4) are referred to as the base harvest forecast.

5.1 Alternative initial harvest levels and rates of decline

The base harvest forecast for the Fraser TSA (Figure 4, page 10) shows an initial rate of harvest of 1 550 000 cubic metres per year which is maintained

for 1 decade before declining by 10% to a steady long-term harvest level. However, other harvest flows (patterns of harvest over time) are possible. This section examines some of these alternate harvest flows.

Figure 8 shows the harvest forecast if the initial rate of harvest is left at 1 550 000 cubic metres per year, and the rate of decline is limited to only 8% per decade rather than 10% per decade. This more gradual decline in the harvest forecast results in a quicker depletion of the existing inventory of mature timber, because harvest levels are slightly higher per decade than in the base harvest forecast. A shortage of available timber occurs in decade 13, because of this more gradual decline.

This projected shortage of available timber is in part the result of the poor productivity of the stands being harvested at that time. As discussed in Sections 2 and 4.2, a large proportion of the existing mature forest that is harvested in the first 20 to 30 years is on sites that are poorer producers of timber. In 130 years, when the stands of this area are harvested again, the lower yield of timber from each hectare of forest harvested means that, compared to better growing sites, more area must be harvested in order to achieve a required harvest level.

This increase in the amount of area harvested causes the forest cover requirements for visual quality, wildlife and recreation to quickly become limiting, creating a shortage of available timber.

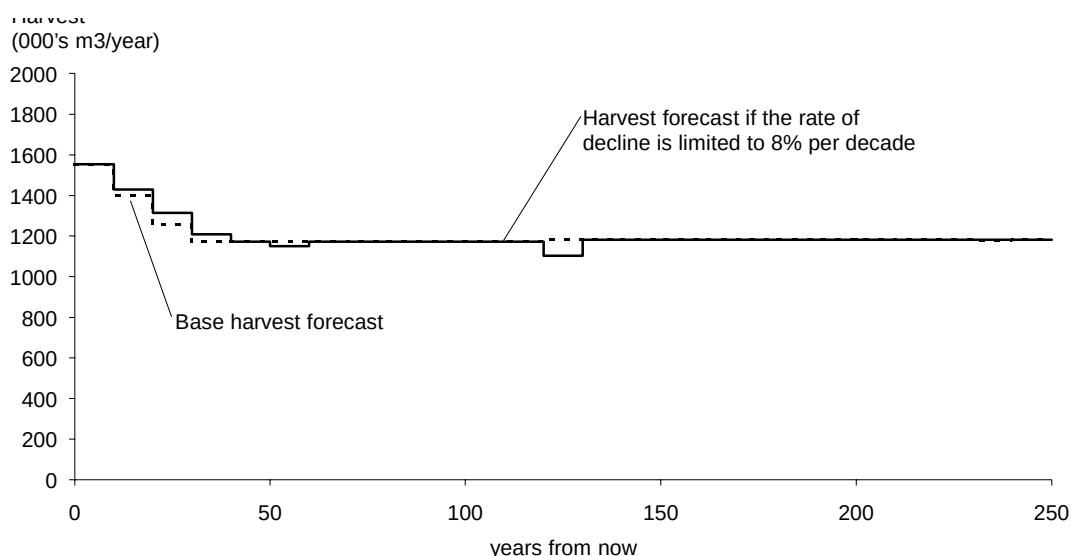


Figure 8. Harvest forecast if the rate of decline is limited to 8% per decade.

5 Timber Supply Sensitivity Analyses

The fine line in Figure 9 shows the harvest forecast if the initial rate of harvest is set at the current AAC for the first decade and the decline in the harvest forecast is limited to 10% per decade. This increase in the rate of harvest over the short-term depletes the existing inventory of mature timber much more quickly than in the base forecast. Acute timber

shortages occur in decades 6 and 13. The harvest level drops to a low of about 800 000 cubic metres per year, well below the steady long-term harvest level. In order to avoid this temporary drop the harvest level, the harvest level must be allowed to decline by 21% per decade after the first decade, as shown by the thick line in Figure 9.

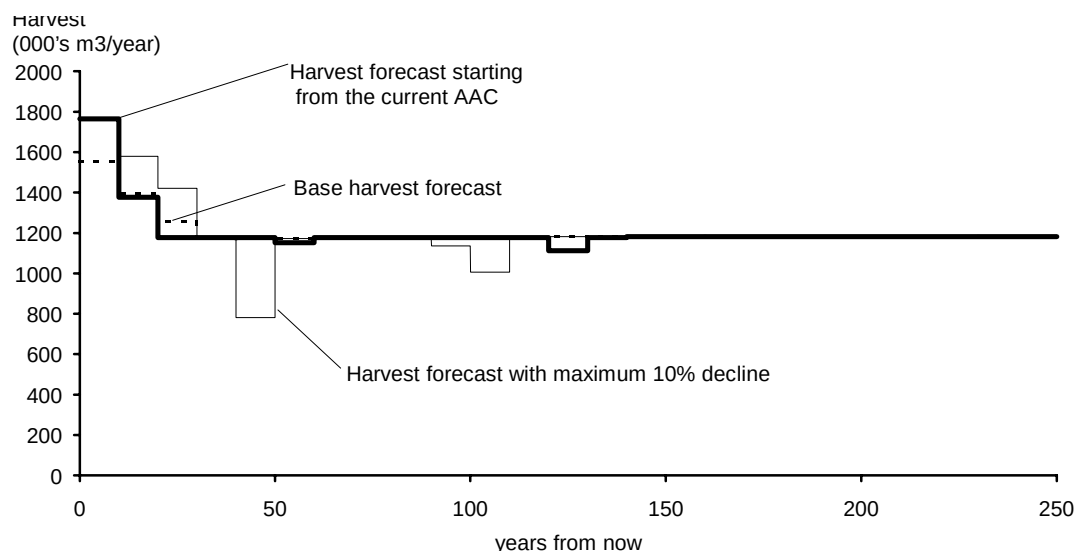


Figure 9. Harvest forecasts if the initial rate of harvest is set at the current AAC.

5.2 Sensitivity to uncertainty in minimum harvest ages

The harvest forecast using minimum harvest ages that are increased for all forest types except deciduous stands, is shown in Figure 10. With an increase in minimum harvest ages, more time is required before a stand previously harvested becomes available for a second harvest. As a result, less timber is available from regenerated stands early in the planning horizon.

The solid line in Figure 10, shows increasing minimum harvest ages by 10 years has a relatively small effect on the harvest forecast. The initial rate

of harvest must be reduced to

1 500 000 cubic metres per year, or approximately 15% below the current AAC, and the decline in the rate of harvest in subsequent years must be increased to approximately 13% per decade.

Decreasing minimum harvest ages by 10 years improves the short-term harvest forecast slightly, as shown by the solid line in Figure 11. The initial harvest level can be increased to about 1 600 000 cubic metres per year. This increased initial harvest level is maintained for the first 10 years before declining by about 10% per decade. The steady long-term harvest level is almost unchanged from the base harvest forecast.

5 Timber Supply Sensitivity Analyses

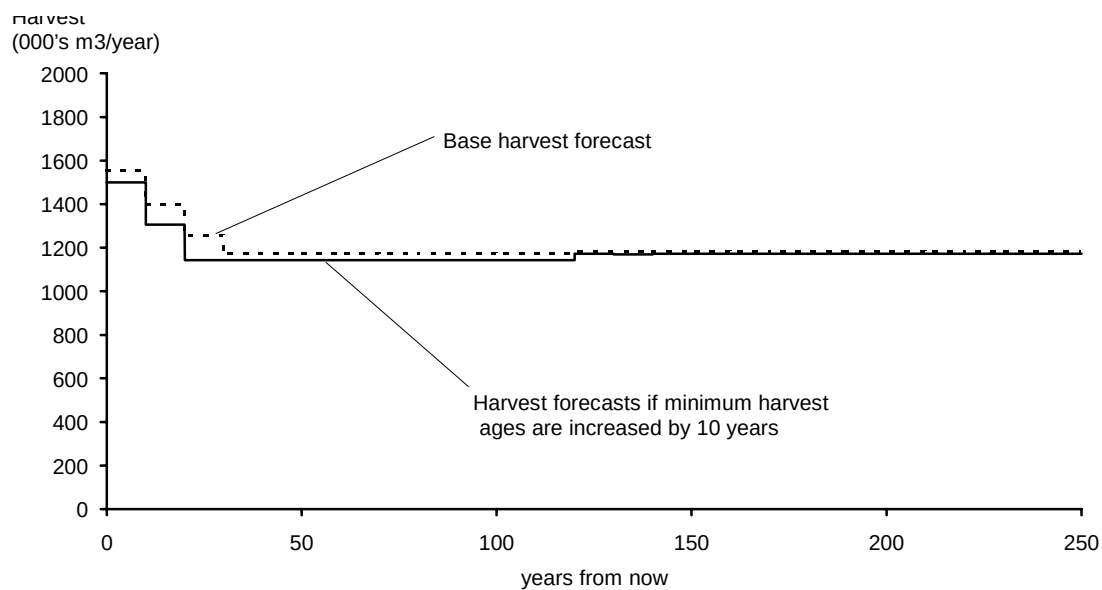


Figure 10. Harvest forecasts if minimum harvest ages are increased by 10 years.

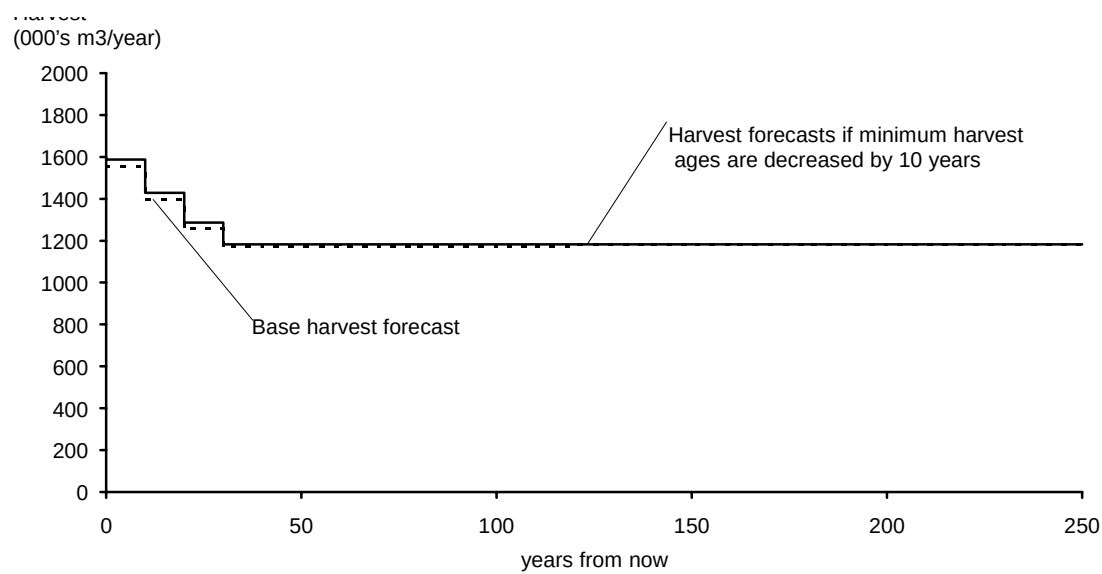


Figure 11. Harvest forecasts if minimum harvest ages are decreased by 10 years.

5 Timber Supply Sensitivity Analyses

Increasing minimum harvest ages by 20 years has a dramatic effect on the harvest forecast, as shown by the solid line in Figure 12. The harvest level must be immediately reduced to about 1.4 million cubic metres per year, approximately 20% below the current AAC. From this reduced starting level, the harvest forecast must still decline by 12% per decade after the first decade until a steady long-term harvest level is reached.

Decreasing minimum harvest ages by 20 years greatly increases the short-term harvest forecast, as shown in Figure 13. The initial harvest level is increased by about 8% to 1 680 000 cubic metres per year, but is still about 5% lower than the current AAC. The harvest forecast declines by about 10% per decade. The steady long-term harvest level, which is reached in the fifth decade, is not affected by this change.

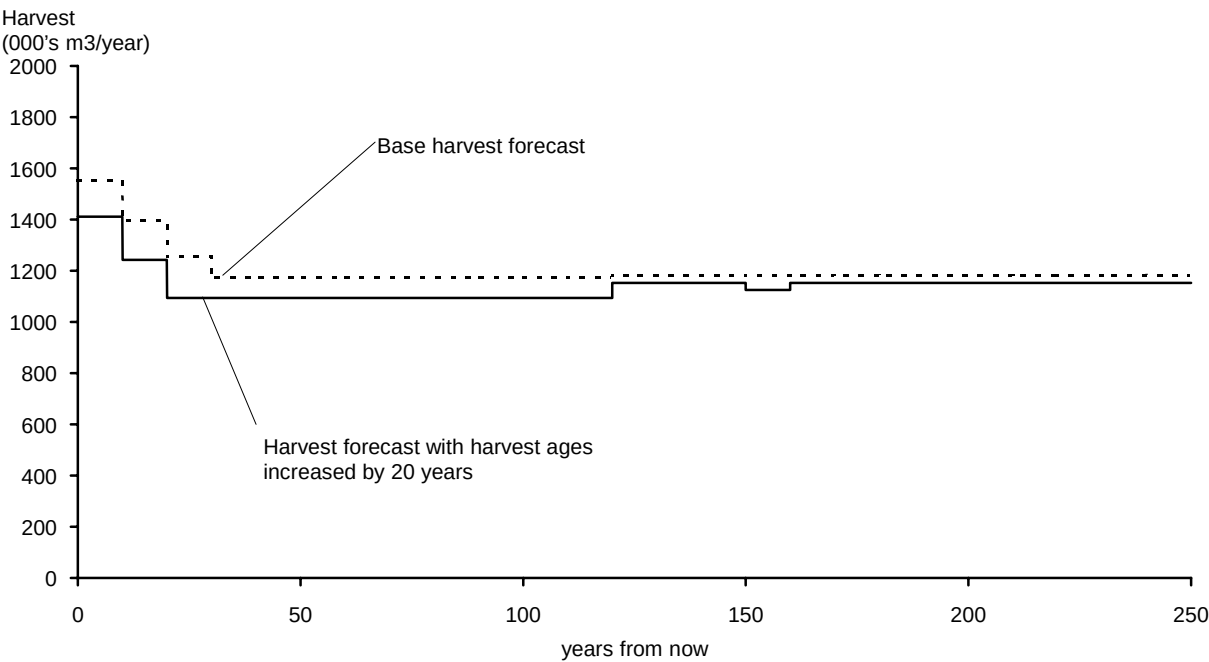


Figure 12. Harvest forecast if minimum harvest ages are increased by 20 years.

5 Timber Supply Sensitivity Analyses

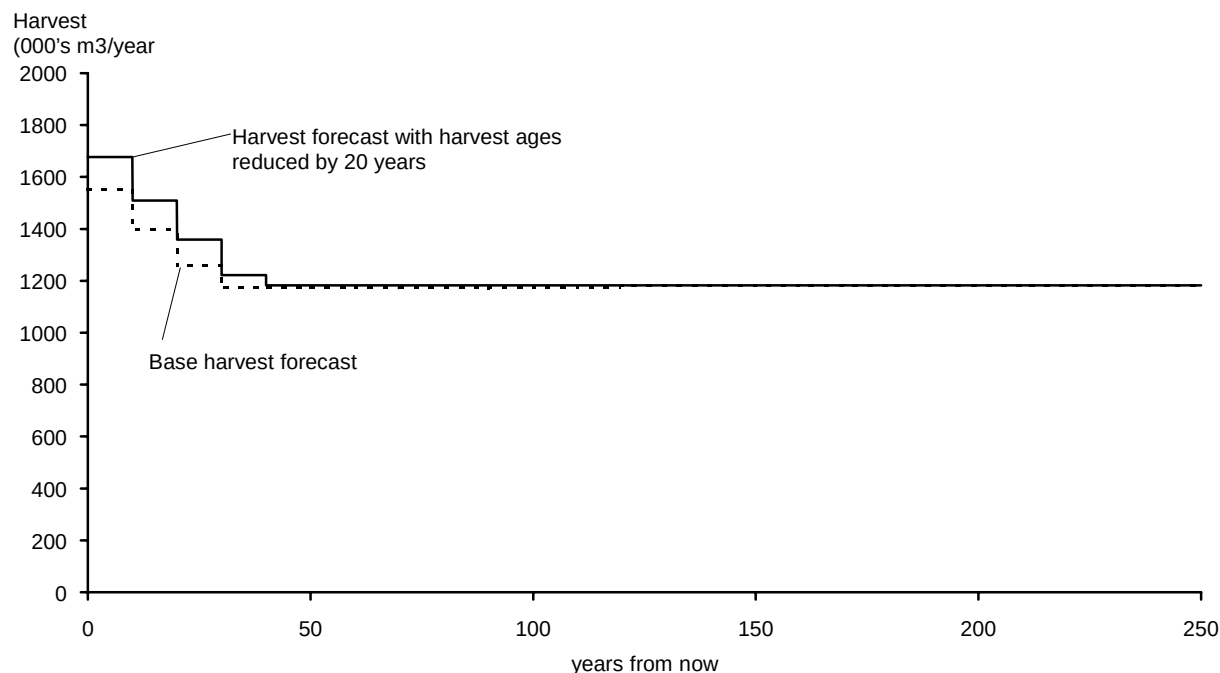


Figure 13. Harvest forecast if minimum harvest ages are decreased by 20 years.

5.3 Sensitivity to uncertainty in existing stand volume estimates

Volume estimates have a degree of uncertainty due to such factors as the statistical process used to develop the growth and yield models and the inventory classification procedures.

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.

The solid line in Figure 14 shows the effect on the harvest forecast of increasing the estimated volume of existing timber by 10%. This change allows the harvest forecast to start at the current AAC of 1 755 000 cubic metres per year, rather than 12% below the current AAC as was necessary in the base harvest forecast. The current AAC is maintained for the first 10-year period before declining by 9% per decade to a steady long-term harvest level of about 1 180 000 cubic metres per year, which is unchanged from the base forecast.

5 Timber Supply Sensitivity Analyses

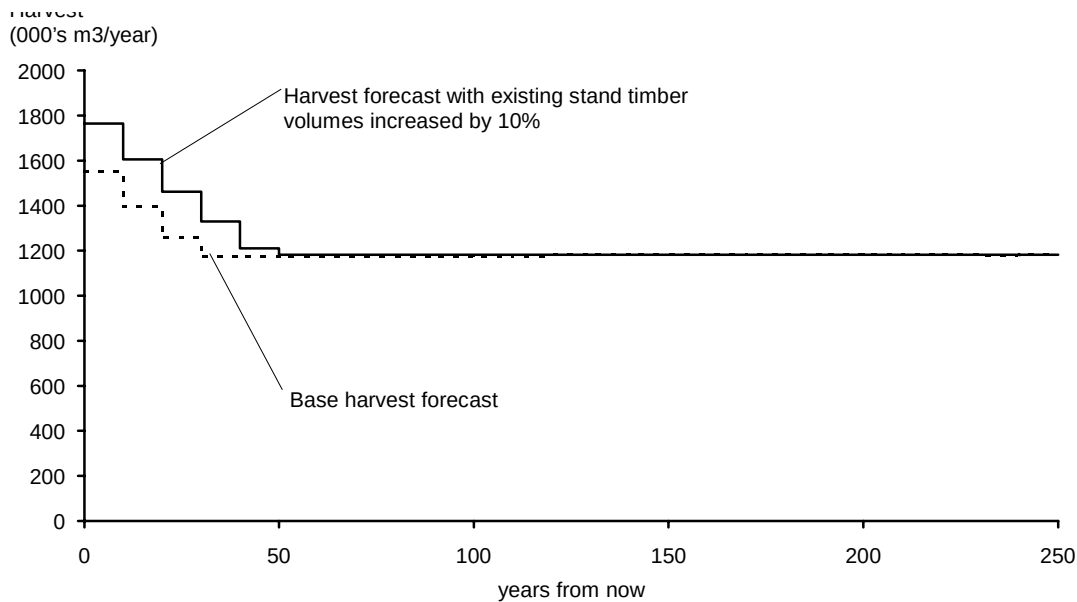


Figure 14. Harvest forecast if existing stand volume estimates are increased by 10%.

The solid line in Figure 15 shows the effect on the harvest forecast of decreasing the estimated volume of existing timber by 10%. This change has an extreme effect on the harvest forecast because of the relationship between stand timber volumes and the forest cover requirements. If the volume of timber that is obtained from each area harvested is decreased, harvesting must occur on more area to obtain the same total harvest. However, the forest

cover requirements for visual quality, recreation and wildlife values do not allow the area harvested to increase significantly. As a result, the initial rate of harvest must be reduced to about 1 100 000 cubic metres per year in order to prevent an acute shortage of available timber in later years. The steady long-term harvest level is unchanged from the base harvest forecast.

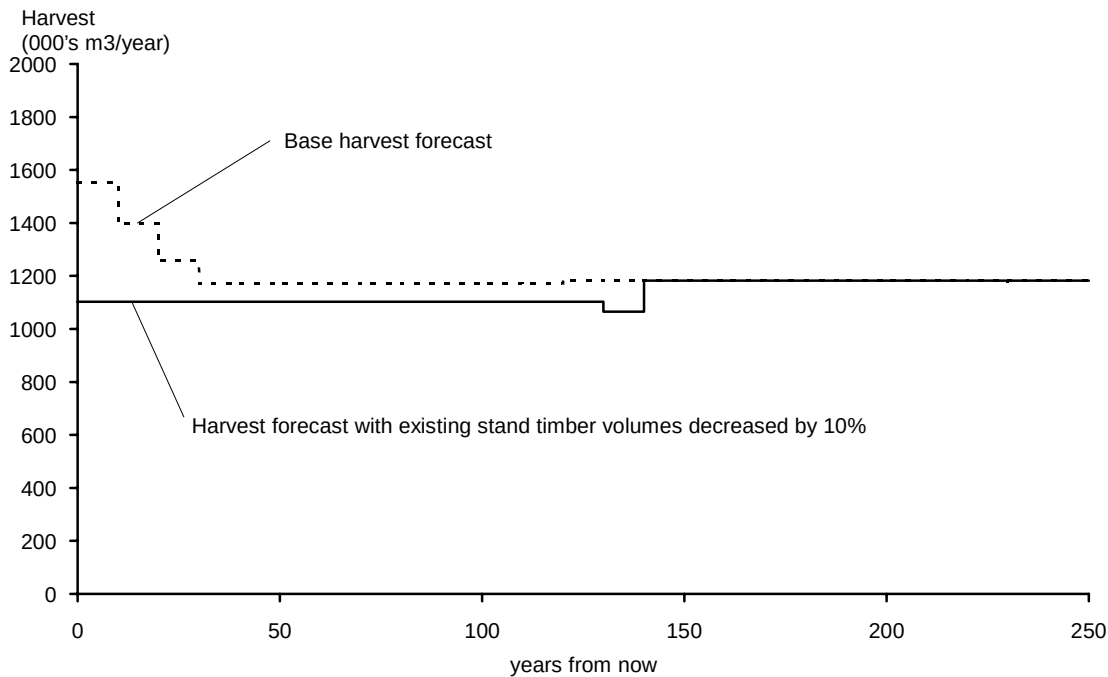


Figure 15. Harvest forecast if existing stand volume estimates are decreased by 10%.

5 Timber Supply Sensitivity Analyses

5.4 Sensitivity to uncertainty in the estimated yields of regenerated stands

A primary input in timber supply modelling is the estimated timber yields from the regenerated forest. The following sensitivity analyses examine the effect that uncertainty in the estimated yields from regenerated stands has on the harvest forecast.

The solid line in Figure 16 shows the effect on the harvest forecast of increasing the estimated timber yields from all regenerated stands by 20%.

In the timber supply model, only a small proportion of the regenerated stands are available for harvesting in the short term. After the first harvest, approximately 80 to 100 years must pass before the regenerated stands are old enough to harvest a second time. Therefore, an increase in timber yields assumed for all regenerated stands does not affect the short-term harvest forecast. The long-term harvest level, which is harvested almost entirely from regenerated stands, is exactly 20% higher than the base harvest forecast.

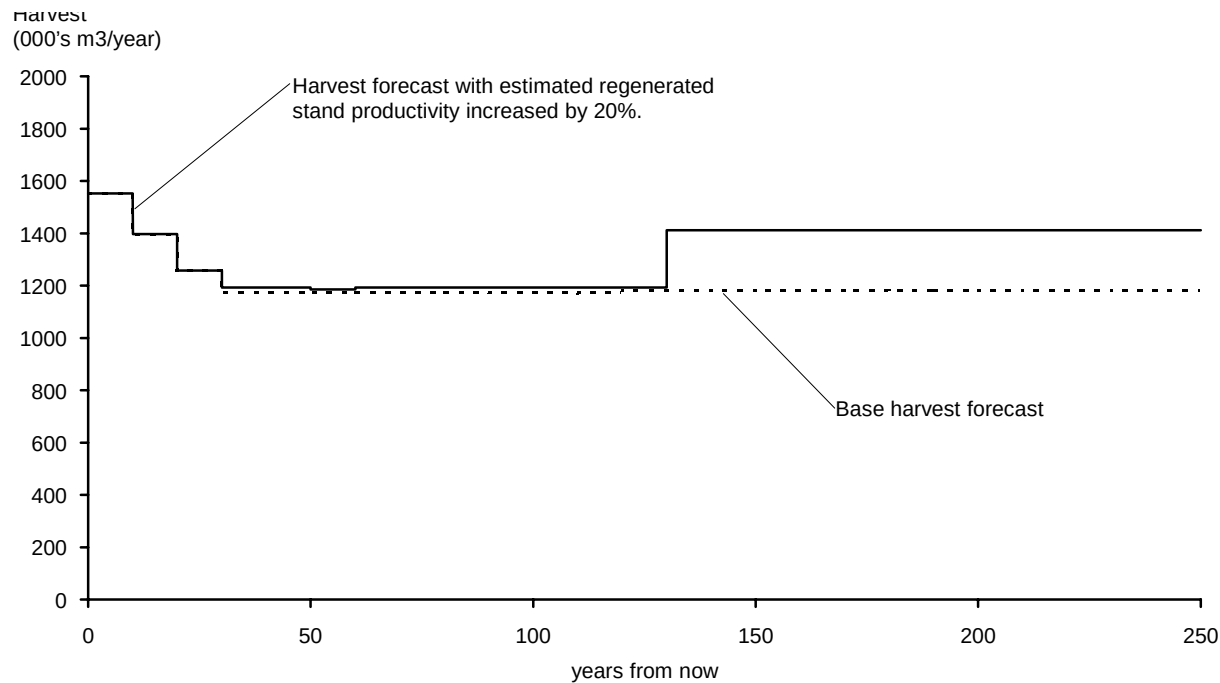


Figure 16. Harvest forecast if the estimated timber yield from regenerated stands volume is increased by 20%.

The solid line in Figure 17 shows the effect of decreasing the estimated timber yields from all regenerated stands by 20%. Because of the time required before most stands are harvested for a second time in the model, decreasing the estimated timber yields from all regenerated stands does not

affect the short-term harvest forecast. The long-term harvest forecast is affected in that the harvest level declines to a steady long-term harvest level of about 940 000 cubic metres per year which is exactly 20% lower than the base forecast.

5 Timber Supply Sensitivity Analyses

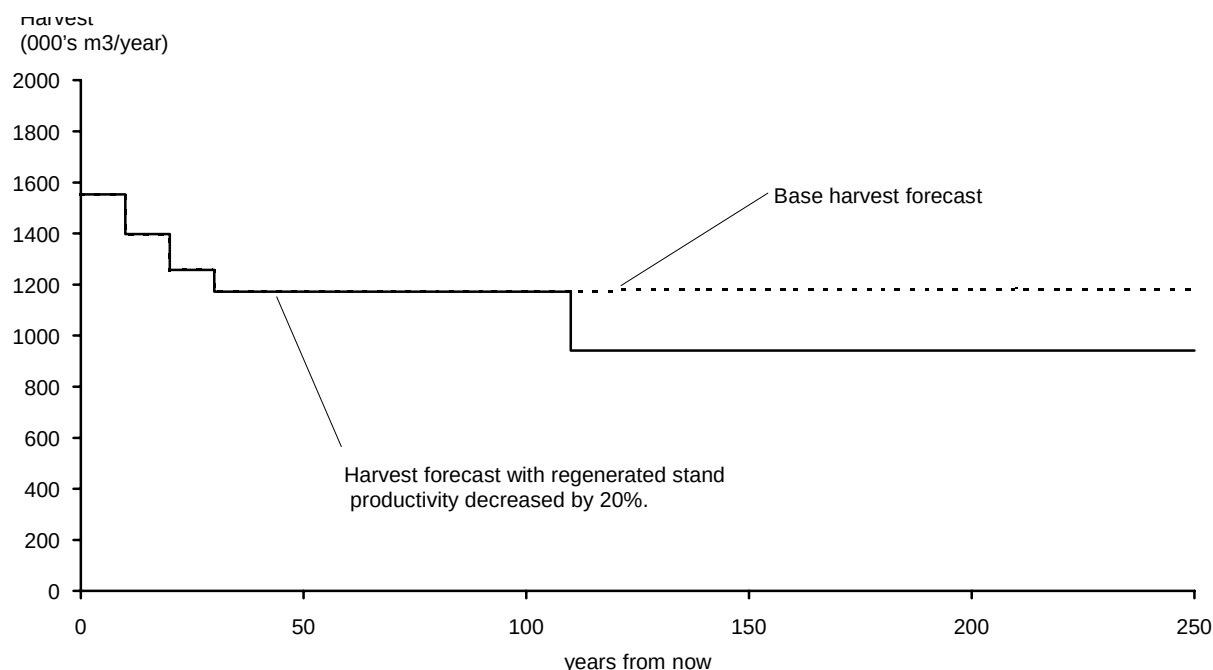


Figure 17. Harvest forecast with estimated regenerated stand timber yields decreased by 20%

5.5 Sensitivity to uncertainty in the forest cover requirements for cutblock adjacency

In the base case timber supply forecast for the Fraser TSA, forest cover requirements used to model cutblock adjacency and green-up were based on the assumption that a maximum of 25% of the timber harvesting land base may be less than 3 metres tall at any time (see Section 2.3, Management Practices, page 7). The following sensitivity analyses examine the effect of uncertainty in the forest cover requirements for cutblock adjacency. Although cutblock adjacency requirements applied operationally will control the rate of harvest that occurs in any area over time, they have little effect

on the harvest forecast for the Fraser TSA as a whole.

The solid line in Figure 18 shows the harvest forecast if the cutblock adjacency and green-up requirements are changed to allow only 20% of the timber harvesting land base to be covered with trees less than 3 metres tall. This 5% change in the forest cover requirement reduces the availability of areas for harvesting and results in a slightly lower short-term harvest forecast. The initial harvest level is approximately 3% lower than the base harvest forecast. The harvest level declines in decades 2 through 4 by 10% per decade. The steady long-term harvest level is approximately 1 160 000 cubic metres per year, about 2% lower than the base harvest forecast.

5 Timber Supply Sensitivity Analyses

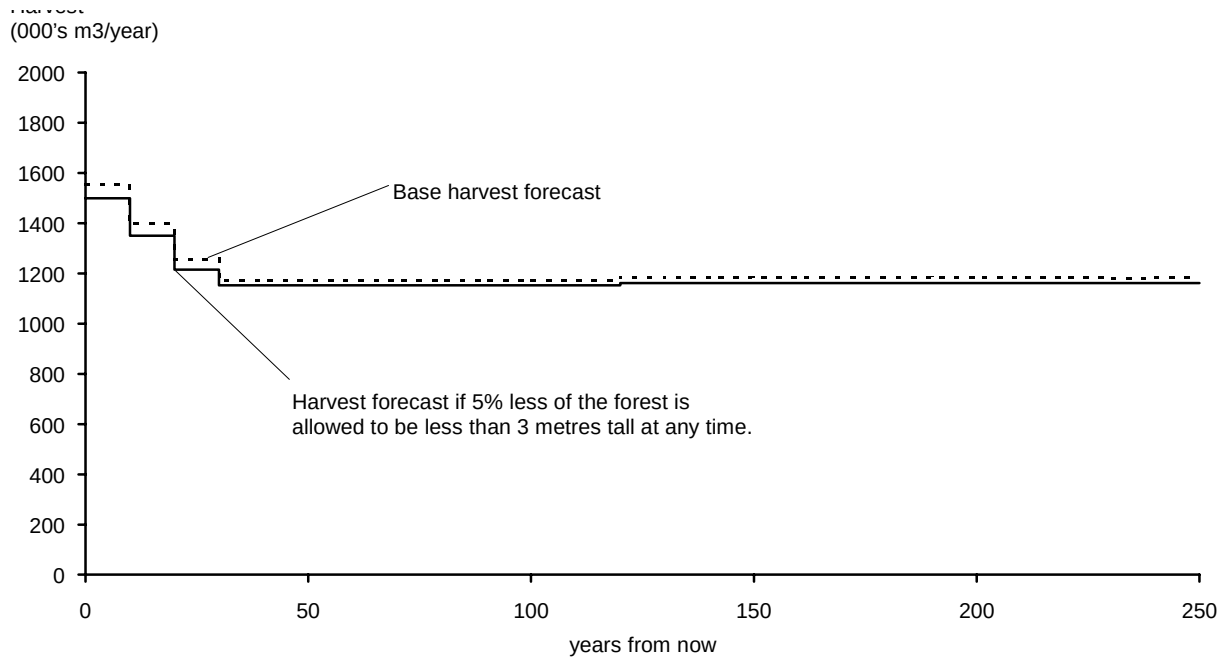


Figure 18. Harvest forecast if the forest cover requirement used to model cutblock adjacency allows 5% less of the forest to be less than 3 metres tall at any time.

The solid line in Figure 19 shows the harvest forecast if the cutblock adjacency and green-up requirements are changed to allow 30% of the timber harvesting land base to be covered with trees less than 3 metres tall. This 5% increase in the amount of area that may be covered with trees less than 3 metres tall increases the availability of areas for harvesting and results in a slightly higher short-term harvest forecast. The initial harvest level is approximately 3% higher than the base harvest

forecast. The harvest level declines in decades 2 through 4 by 11% per decade. The steady long-term harvest level is unchanged from the base harvest forecast. This is because in the base harvest forecast, the forest cover requirement for cutblock adjacency and green-up is not limiting in the long-term. Therefore, relaxing the forest cover requirement further, as this sensitivity analysis does, has no effect on the the long-term harvest level.

5 Timber Supply Sensitivity Analyses

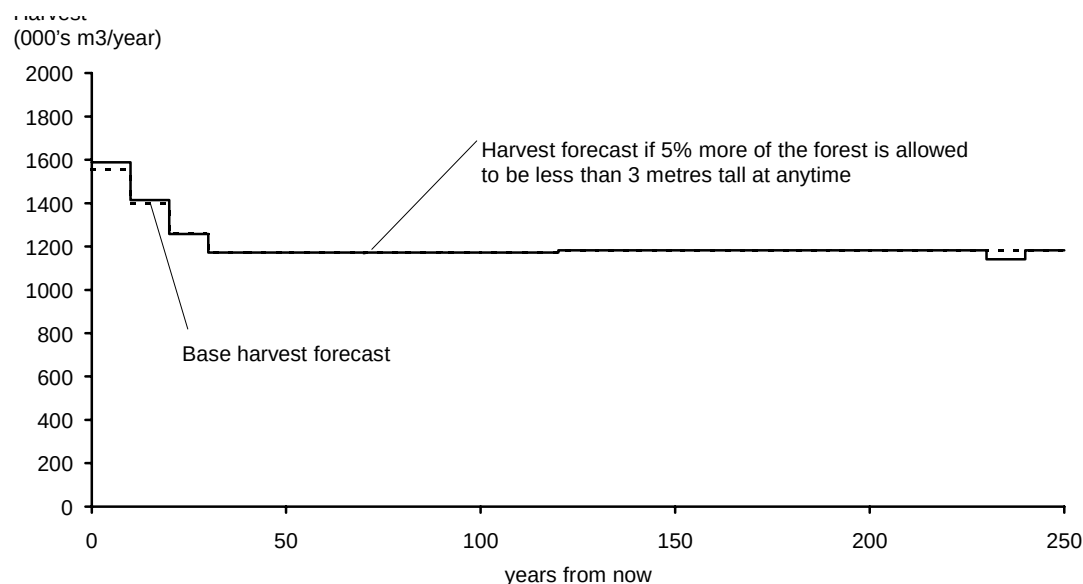


Figure 19. Harvest forecast if the forest cover requirement used to model cutblock adjacency allows 5% more of the forest to be less than 3 metres tall at any time.

5.6 Sensitivity to uncertainty in forest cover requirements for visual quality

As discussed in Section 2.3, forest management in areas where visual quality of the landscape is a priority was modelled using forest cover requirements. The forest cover requirements are based on the sensitivity of each area to changes in the visible landscape caused by timber harvesting, and are summarized below:

- Highly sensitive areas—a maximum of 8% of the area may be less than 5 metres tall at any time.
- Moderately sensitive areas—a maximum of 16% of the area may be less than 5 metres tall at any time.
- Low sensitivity areas—a maximum of 31% of the area may be less than 5 metres tall at any time.

Because a large proportion of the timber harvesting land base is managed for visual quality of the landscape, changes to these forest cover requirements have a large effect on the harvest forecast.

The solid line in Figure 20 shows the effect on the harvest forecast if the forest cover requirements used to model management for visual quality are relaxed to allow 5% more of each visually sensitive stand to be under 5 metres tall at any time. The harvest forecast begins at approximately 1 700 000 cubic metres per year, about 10% higher than the initial harvest level in the base harvest forecast. This level is maintained for the first decade before the forecasted harvest level declines by 12% per decade to a steady long-term harvest level that is slightly higher than the base harvest forecast.

5 Timber Supply Sensitivity Analyses

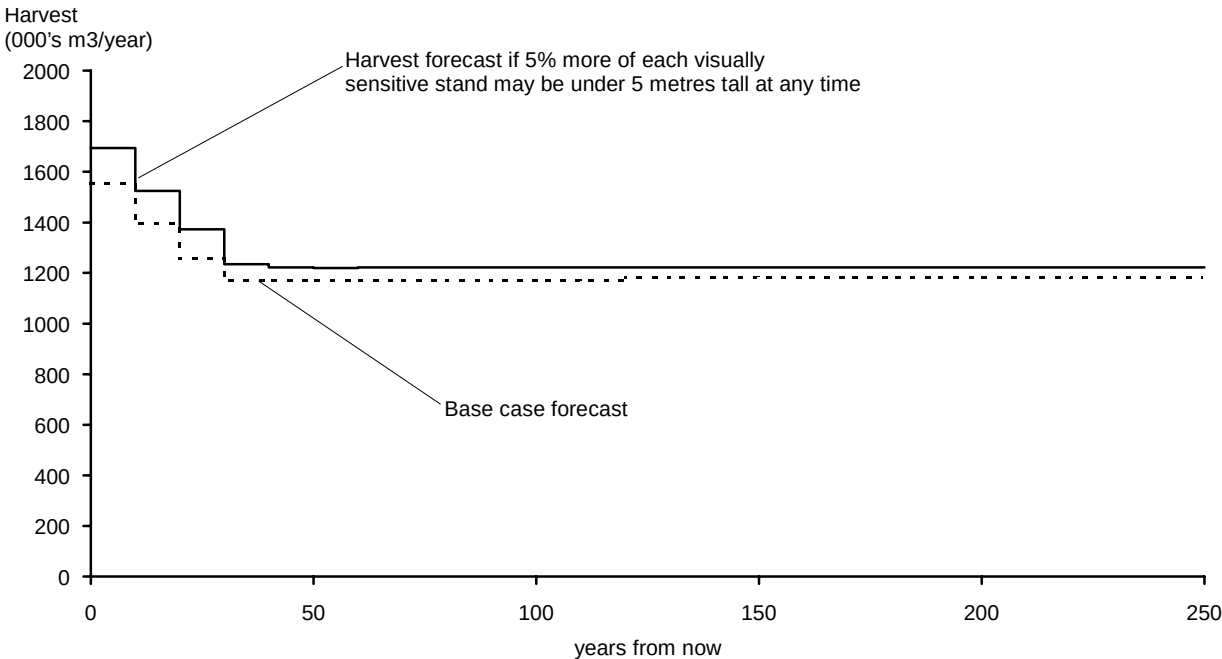


Figure 20. Harvest forecast if 5% more of each visually sensitive stand may be under 5 metres tall at any time.

The solid line in Figure 21 shows the effect on the harvest forecast if the forest cover requirements used to model management for visual quality are increased so that 5% less of each visually sensitive area may be under forest cover less than 5 metres tall at anytime. In order to avoid more acute timber shortfalls in later years, the initial harvest level must be reduced to 1 380 000 cubic metres per year, 22%

below the current AAC. From this reduced initial harvest level, the harvest forecast must still decline by an average of 11% per decade to a steady long-term harvest level. The steady long-term harvest level, about 1 070 000 cubic metres per year, is 8% lower than the long-term harvest level in the base harvest forecast.

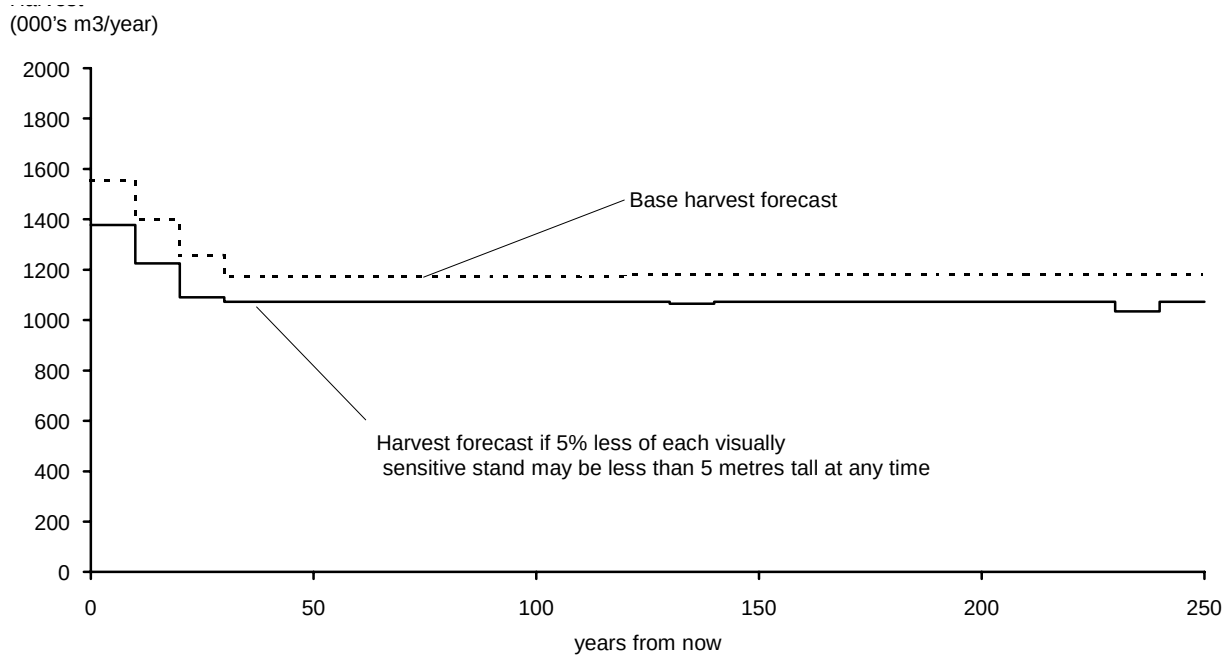


Figure 21. Harvest forecast if 5% less of each visually sensitive stand may be under 5 metres tall at any time.

5 Timber Supply Sensitivity Analyses

5.7 Sensitivity to uncertainty in required green-up periods

As discussed in Section 2.3, Management Practices, the required green-up periods used in the base forecast are based on the estimated number of growing years required before the trees on a previously harvested area reach a required height. The following sensitivity analysis examines the effect that uncertainty in the estimate of the number of years required to achieve green-up condition has on the harvest forecast.

The solid line in Figure 22 shows the harvest forecast if all green-up periods are reduced by 5 years. Decreasing the required green-up period increases the availability of areas for timber harvesting over time. The harvest forecast begins at the current AAC of 1 755 000 cubic metres per year, 12% higher than the base forecast. The current AAC is maintained for the first decade before declining by 12% per decade over the next 3 decades. The steady long-term harvest level of 1 200 000 cubic metres per year is increased by approximately 2% from the base harvest forecast.

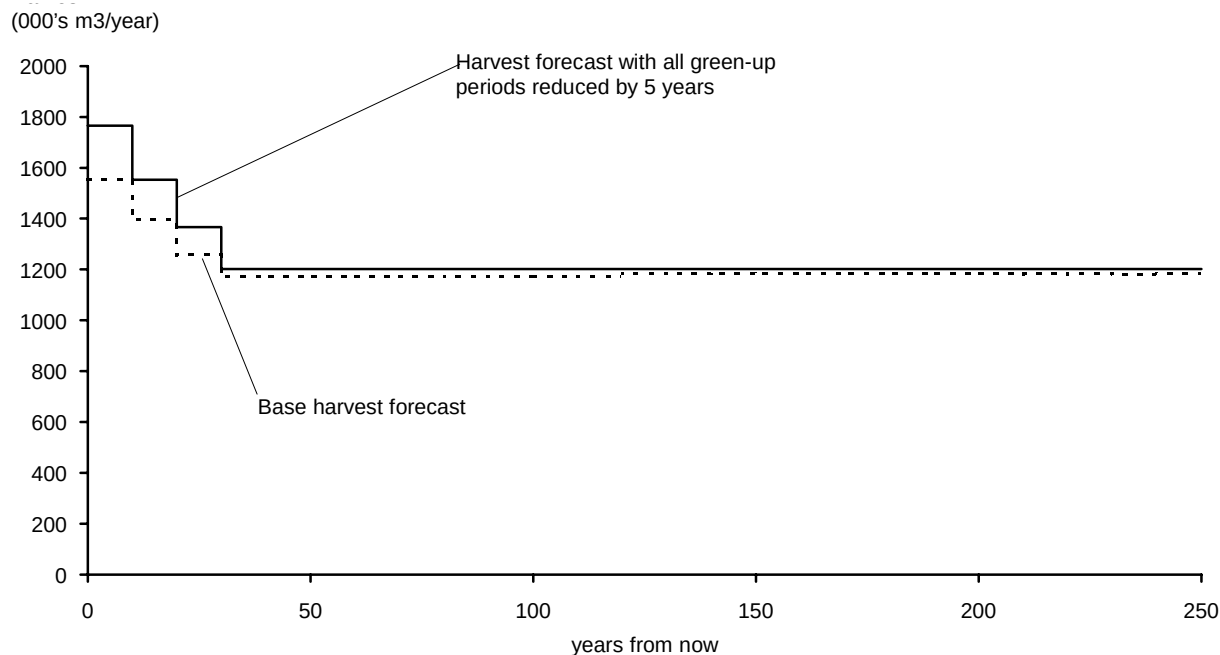


Figure 22. Harvest forecast if all green-up ages are reduced by 5 years.

The solid line in Figure 23 shows the harvest forecast if all green-up periods are increased by 5 years. Increasing the required green-up period reduces the availability of areas for timber harvesting over time to the extent that the initial harvest level must be reduced to 1 500 000 cubic metres per year; approximately 3% lower than the

base harvest forecast and approximately 15% below the current AAC. The harvest forecast declines from the reduced starting level by approximately 12% per decade over the next 3 decades. The steady long-term harvest level of 1 130 000 cubic metres per year is about 4% lower than the base forecast.

5 Timber Supply Sensitivity Analyses

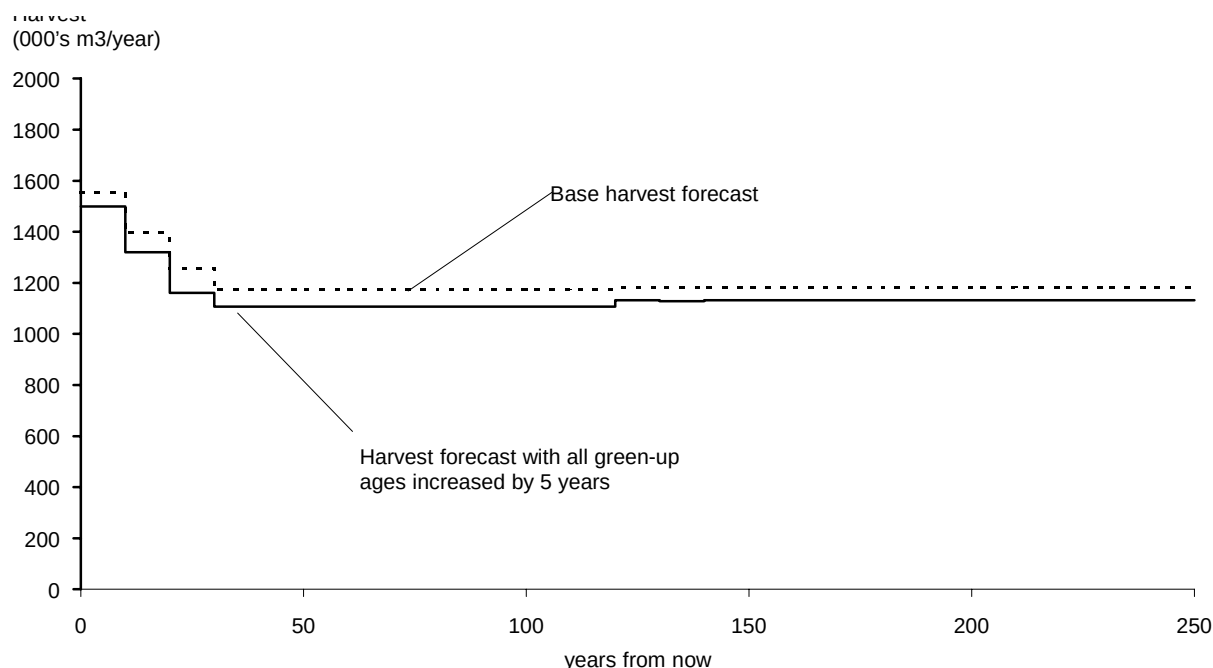


Figure 23. Harvest forecast if all green-up periods are increased by 5 years.

5.8 Sensitivity to uncertainty in the area required for deer winter range

Management for deer winter range was modelled in the base harvest forecast by requiring that a minimum of approximately 18 000 hectares of the timber harvesting land base always be older than 100 years. The effect that changes to this requirement have on the harvest forecast is examined in the following sensitivity analysis.

The solid line in Figure 24 shows the harvest forecast if the amount of area that is managed as deer winter range is doubled. Increasing the amount of area that must be maintained at ages greater than

100 years reduces the amount of area that is available for timber harvesting at any time. Due to the decreased availability of areas for timber harvesting over time, the initial harvest must be reduced to 1 440 000 cubic metres per year in order to avoid a more severe decline in the harvest forecast in later years. This initial harvest level is about 7% below the initial level in the base forecast, and about 18% below the current AAC. Despite the reduced starting level, the harvest forecast must still decline by about 10% per decade in decades 2 through 4. The steady long-term harvest level, which is reached in the fourth decade, is slightly lower than the base forecast.

5 Timber Supply Sensitivity Analyses

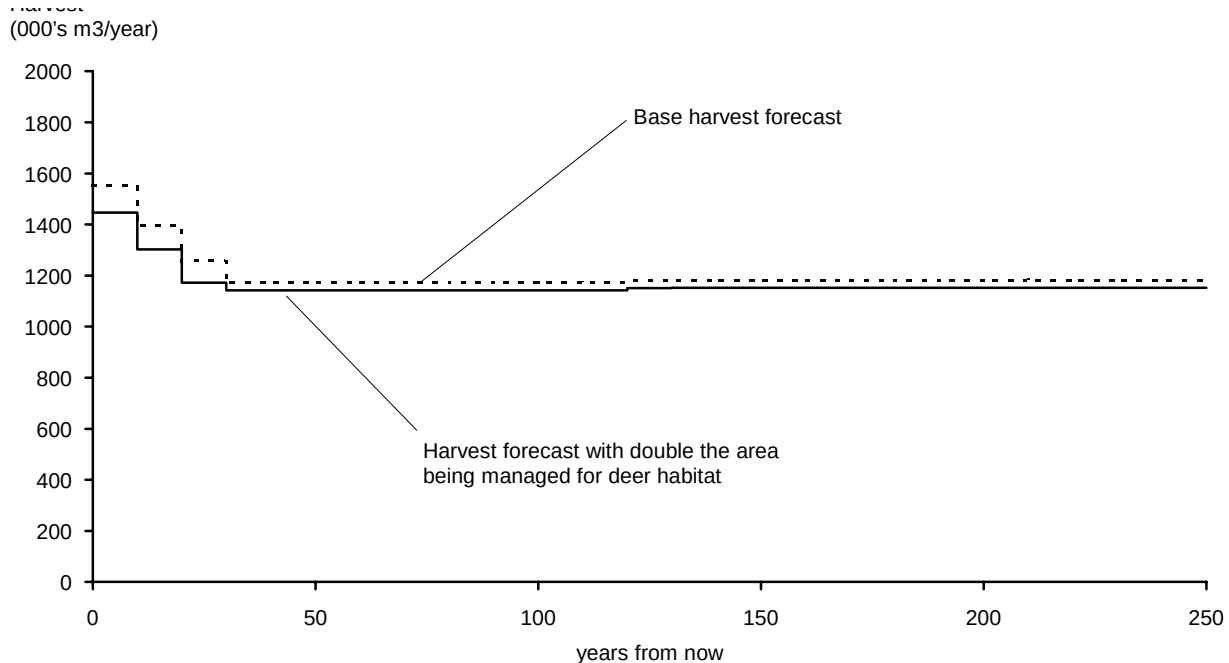


Figure 24. Harvest forecast if the amount of area being managed for deer winter range is doubled.

The solid line in Figure 25 shows the harvest forecast if no area is explicitly managed for deer winter range. Eliminating the forest cover requirement for deer increases the availability of areas for timber harvesting over time and allows a significant increase in the short-term harvest forecast. The initial harvest level can be increased to about 1 620 000 cubic metres per year. This initial harvest level is still 8% below the current AAC, but is approximately 5% higher than the initial harvest level in the base harvest forecast. The steady long-term harvest level is changed very little

from the base harvest forecast. The reason that this change affects only the short-term harvest forecast is that, initially, most of the stands managed for deer winter range are very old and otherwise would be available for timber harvesting. However, in the long-term, much of the deer winter range area is contributed by younger, regenerated stands with minimum harvest ages that are close to or, in some cases, exceed 100 years. Therefore, many of the regenerated stands can meet the criteria for deer winter range (100 years old) and still be harvested at close to their planned minimum harvest age.

5 Timber Supply Sensitivity Analyses

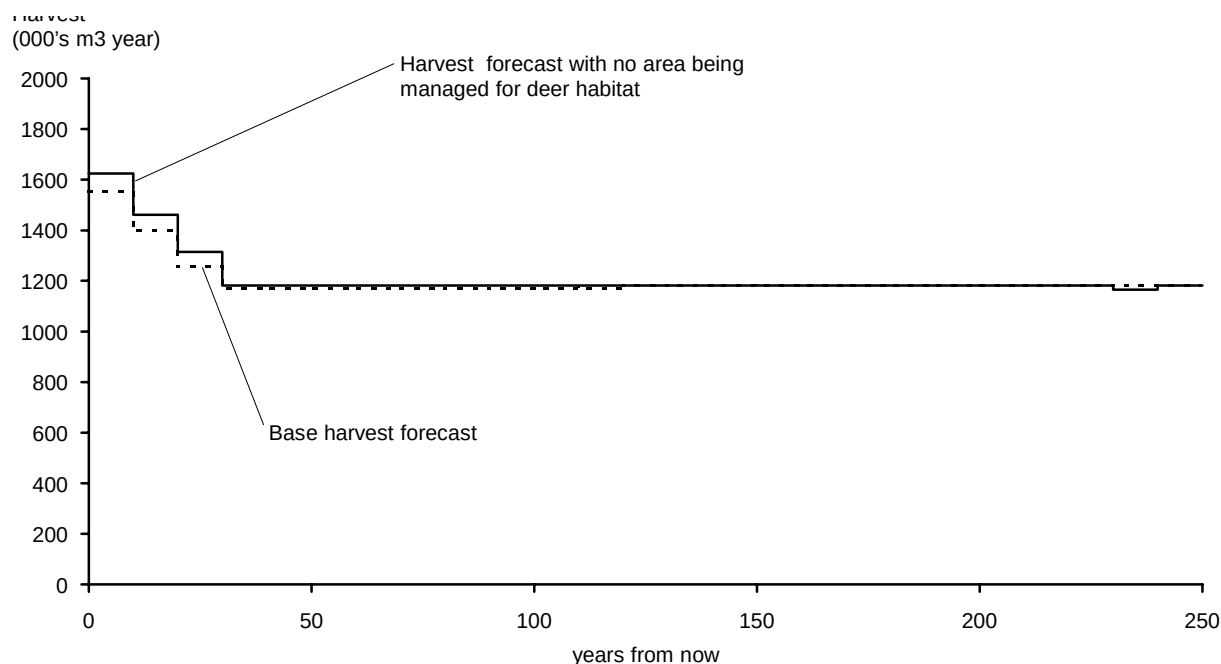


Figure 25. Harvest forecast if no area is managed explicitly for deer winter range.

5.9 Sensitivity to uncertainty in forest cover requirements for special recreation values

As discussed in Section 2.3, timber harvesting is assumed to be compatible with recreation uses of the forest, as long as the rate of harvesting is limited in areas identified as having special value for forest recreation. This assumption is modelled by limiting timber harvesting so that a maximum of 20% of the forest in areas with special recreation value may be less than 5 metres tall at any time.

The solid line in Figure 26 shows the harvest forecast if the forest cover requirement used to model management of areas with special recreation value is relaxed so that only the forest cover

requirements for cutblock adjacency apply. Thus, cover requirements specifying that a maximum of 20% of the area may be less than 5 metres tall are changed such that a maximum of 25% of the area may be less than 3 metres tall. This tests the implications of being able to meet recreation requirements with the standard cutblock adjacency guidelines used for this timber supply analysis.

This change has no effect on the harvest forecast. Although operationally, the forest cover requirements used for areas with special recreation value will limit the amount of these areas harvested over time, the harvest level for the whole TSA is not affected. The reduced rate of harvest from areas with special recreation values can be offset by an increase in the rate of harvest from other areas.

5 Timber Supply Sensitivity Analyses

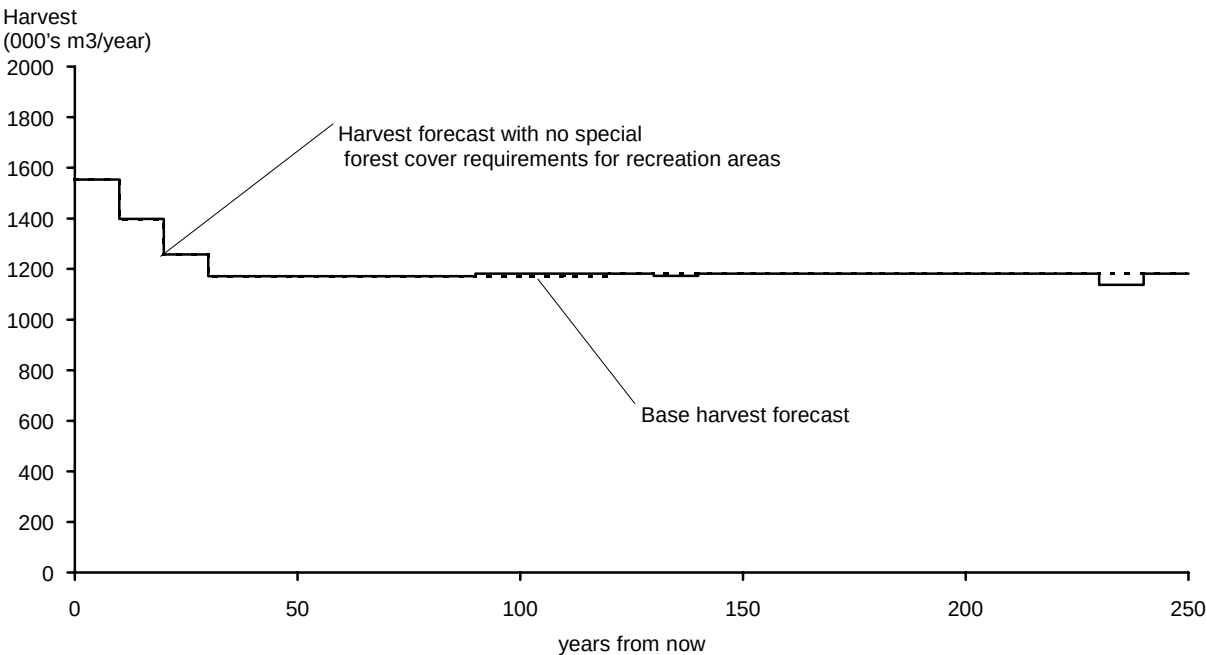


Figure 26. Harvest forecast if the forest cover requirements for moderately important recreation areas are relaxed.

The solid line in Figure 27 shows the harvest forecast if the forest cover requirement used to limit harvesting in areas with special recreation value is more constraining. The per cent of the forest in these areas that may be less than 5 metres tall is reduced from 20% to 16% (which makes the forest

cover requirement equivalent to the forest cover requirements being applied to a moderately visually sensitive area). This change has little effect on the harvest forecast, other than causing a slightly faster rate of decline (12% versus 10% in the base harvest forecast) in decades 2 through 4.

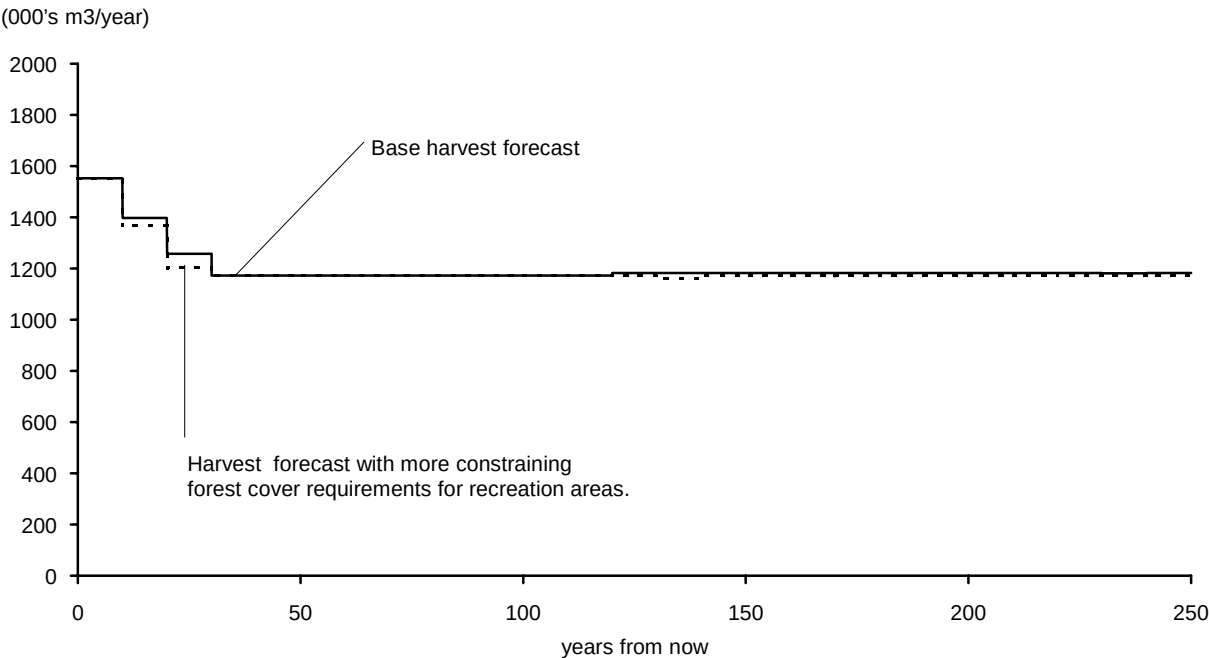


Figure 27. Harvest forecast if the forest cover requirements for moderately important recreation areas are made more constraining.

5 Timber Supply Sensitivity Analyses

5.10 Sensitivity to uncertainty in all forest cover requirements

All of the preceding sensitivity analyses examined the effect on the harvest forecast of changing one assumption at a time.

In the base harvest forecast, various forest cover requirements were used to model the following:

- cutblock adjacency requirements
- visual quality concerns
- deer winter range
- areas with special recreation value

The solid line in Figure 28 shows the effect of removing all forest cover requirements. These changes assume no explicit management for visual quality of the landscape, deer winter range, recreation or restrictions of cutblock adjacency. In other words, requirements for these values are assumed to be met with no special restrictions of timber management activities. Given these changes, the harvest forecast starts at the current AAC, 12% higher than the starting harvest level in the base harvest forecast. The current AAC is maintained for the first decade before declining by only 8% per decade to a steady long-term harvest level. The steady long-term harvest level of about 1 250 000 cubic metres per year is about 6% higher than the long-term harvest level in the base forecast.

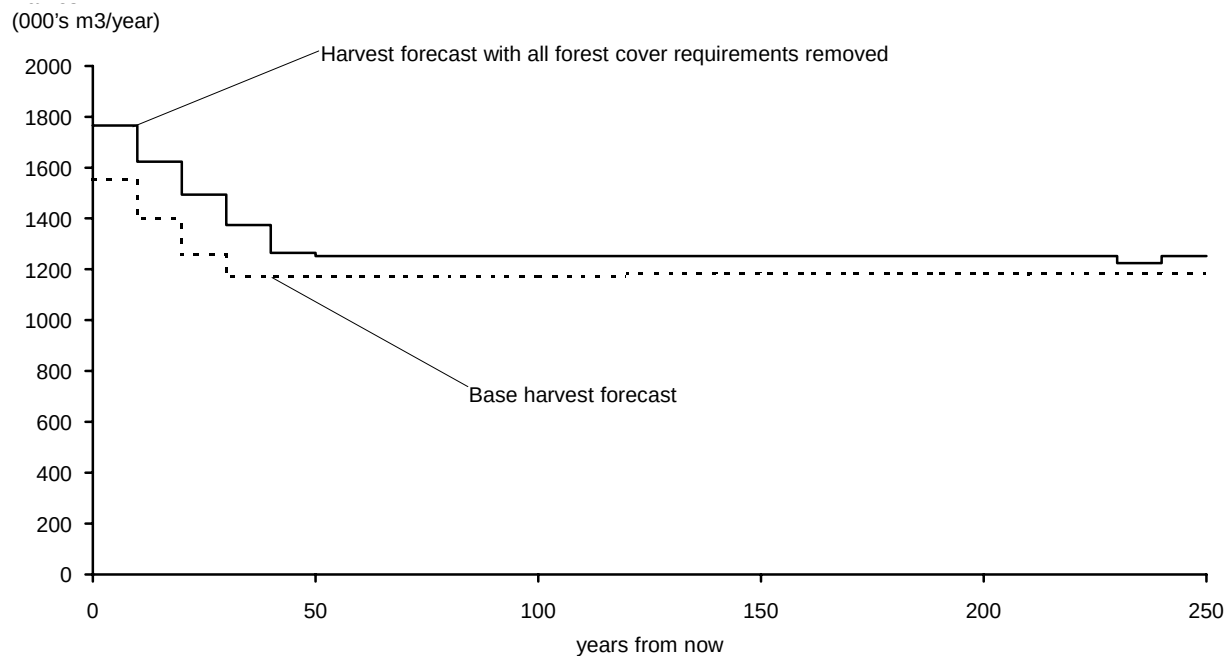


Figure 28. Harvest forecast if all forest cover requirements are removed

5 Timber Supply Sensitivity Analyses

5.11 Sensitivity to uncertainty in all assumptions

The following sensitivity analyses examine the cumulative effect of changing several assumptions concurrently. The solid line in Figure 29 shows the effect of changing assumptions concurrently that increase the timber supply. The specific changes made are as follows:

- All existing stand volumes are increased by 10%;
- the estimated timber yield from all regenerated stands is increased by 20%;

- all minimum harvest ages are reduced by 20 years; and
- all forest cover requirements changed to allow 5% more area to not be in a greened-up state at any time.

These changes greatly increase the harvest forecast in both the short and long term. The harvest forecast begins at the current AAC, which can be maintained for the first 3 decades before declining by only 8% per decade to a steady long-term harvest level. The steady long-term harvest level of about 1 440 000 cubic metres per year is about 22% higher than the long-term harvest level in the base forecast.

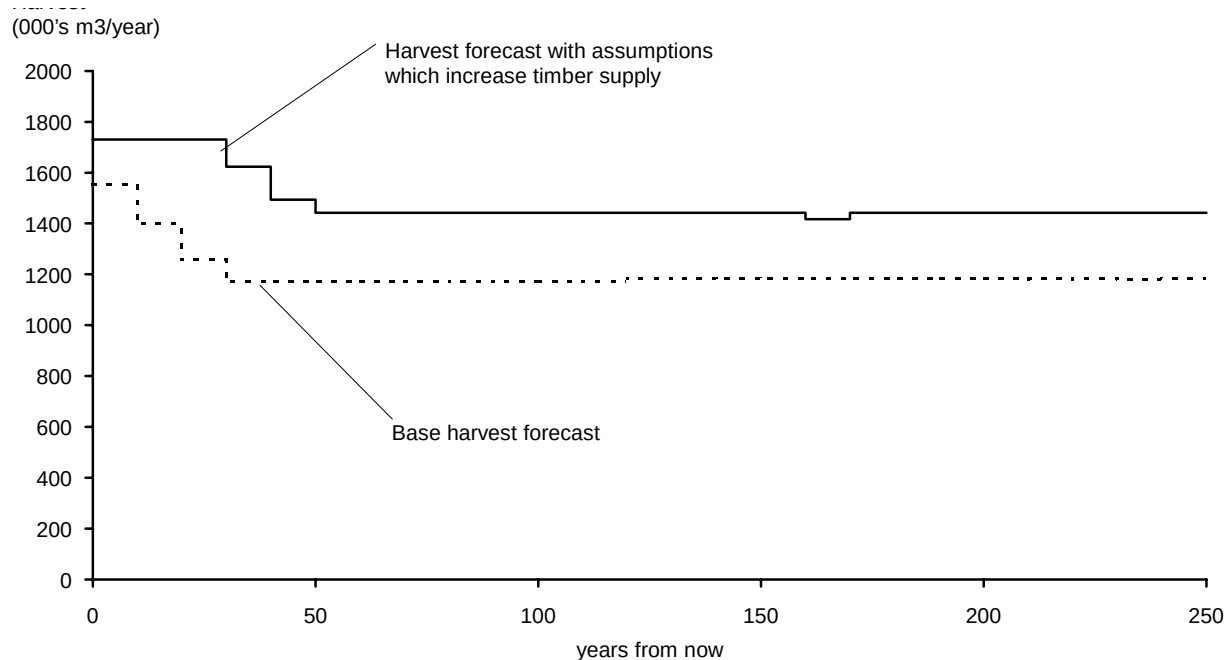


Figure 29. Harvest forecast if changes to assumptions which increase timber supply are made concurrently

5 Timber Supply Sensitivity Analyses

The solid line in Figure 30 shows the effect of changing assumptions concurrently that decrease the timber supply. The specific changes are as follows:

- All existing stand volumes are reduced by 10%;
- the estimated timber yields from all regenerated stands is reduced by 20%;
- all minimum harvest ages are increased by 20 years; and
- all forest cover requirements changed to allow 5% less area to not be in a greened-up state at any time.

With the above changes, the initial rate of harvest must be reduced to 1 180 000 cubic metres per year which is about 32% below the current AAC. This reduced level is maintained for only the first decade before declining further by 10% per decade to a steady long-term harvest level of 867 000 cubic metres per year, which is about 27% below the long-term harvest level in the base harvest forecast.

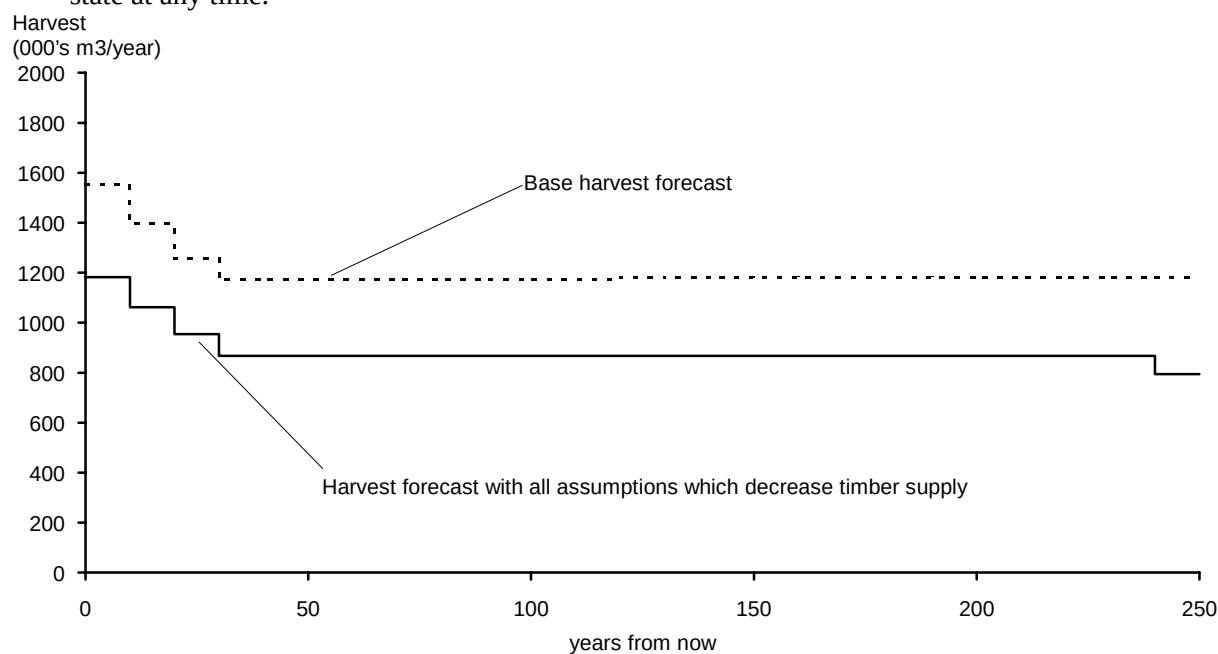


Figure 30. Harvest forecast if changes to assumptions which decrease timber supply are made concurrently

6 Summary and Conclusions

The results of this analysis indicate that the AAC for the Fraser TSA 1 755 000 cubic metres per year cannot be maintained. If current management assumptions as modelled in this analysis are adhered to, the harvest level must be reduced immediately by approximately 12% in order to avoid a more acute shortage of available timber in the future.

An important factor affecting the harvest forecast for the Fraser TSA is the reduced timber harvesting land base when compared to the last timber supply analysis, which was completed in 1984. The area assumed to be available for timber harvesting in this analysis is almost 90 000 hectares smaller than was assumed in 1984. This change is due primarily to the improved mapping of areas that are either physically or economically inoperable for timber harvesting given current harvesting techniques.

A second important factor affecting the harvest forecast for the Fraser TSA is the forest cover requirements that are being applied to account for management of visual quality of the landscape.

Because these forest cover requirements are being applied to such a large proportion of the timber harvesting land base, they have a very limiting effect on the rate of timber harvest from the forest as a whole.

Uncertainty in any of several assumptions and data used in this analysis could have a significant effect on the harvest forecast. The following factors affected the harvest forecast most strongly in the short-term (first 30-50 years) by:

- minimum harvest ages
- existing stand timber volume estimates
- the estimated time that it takes regenerated stands to reach a required green-up height
- forest cover requirements to meet landscape visual quality objectives

Changing the estimated production of regenerated stands affected the long-term harvest level, but did not affect the short-term harvest forecast.

7 References

B.C. Ministry of Forests, Planning and Inventory Branch. 1984. Fraser TSA Analysis Information Report
Victoria, B.C.

8 Glossary

Allowable annual cut (AAC)	The allowable rate of timber harvest from a specified area of land. The Chief Forester sets AACs for timber supply areas (TSAs) and tree farm licences (TFLs) in accordance with Section 7 of the <i>Forest Act</i> .
Environmentally sensitive area	An area of significant non-timber values, fragile or unstable soils, problems in establishing a new tree crop or where timber harvesting may cause avalanches.
Forest inventory	Assessment of British Columbia's timber resources. It includes computerized maps and a database describing the location and nature of forest cover, including size, age, timber volume, and species composition, as well as a description of additional forest values such as recreation and visual quality.
Free-growing	An established seedling of an acceptable commercial species that is free from growth-inhibiting brush, weed and excessive tree competition.
Growing stock	The volume estimate for all standing timber, of all ages, at a particular time.
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.
Not satisfactorily restocked	An area not covered by a sufficient number of tree stems of desirable species. Stocking standards are set by the Forest Service, Silviculture Branch. If the expected regeneration delay (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.
Site index	A measure of site productivity. Site indices are based on tree height as a function of stand age and are usually expressed graphically as site index curves. A number of site index curves have been developed for British Columbia's major commercial tree species.
Timber harvesting land base	The portion of the total land area of a management unit considered to contribute to, and be available for, long-term timber supply. The harvesting land base is defined by reducing the total land base according to specified management assumptions.

8 Glossary

Timber supply area (TSA)

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

Visual sensitivity

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

Appendix A
Description of Data Inputs
and Assumptions

Introduction

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

A.1 Management Zone and Analysis Unit Definition

A.1.1 Information added to the standard inventory file

The following resource inventory information is not on the standard inventory file compiled by Inventory Branch, Ministry of Forests:

- operability for timber harvesting
- deer winter range areas
- visual quality objectives
- recreation management class

Information for the above was mapped and made available after the inventory on a separate inventory file prepared under contract for the Vancouver Forest Region. The information was then merged onto the standard inventory file provided by Inventory Branch on a resultant polygon basis for use in defining management zones in the timber supply analysis.

A.1.2 Analysis units

Within each zone, areas identified in the forest inventory as having similar forest cover and growing site quality are grouped together in the timber supply analysis for the purposes of modelling forest growth and yield and silvicultural treatments. Each of these groupings is referred to as an analysis unit. Table A-1 defines the analysis units used in the timber supply analysis for the Fraser TSA.

Table A-1 Analysis unit definition

Analysis unit	Type groups	Site index - age 100
1 Douglas-fir, good site	1 - 8	43.8 +
2 Douglas-fir, medium site	1 - 8	36.6 - 43.79
3 Douglas-fir, poor site	1 - 8	less than 36.6
4 Cedar, good site	9 - 11	38.6 +
5 Cedar, medium site	9 - 11	31.5 - 38.59
6 Cedar, poor site	9 - 11	less than 36.6
7 Hemlock/balsam, good site	12 - 20	39.7 +
8 Hemlock/balsam, medium site	12 - 20	30.0 - 39.69
9 Hemlock/balsam, poor site	12 - 20	less than 30.0
10 Spruce/pine/larch	21 - 34	all sites
11 Deciduous	35 - 42	all sites

A.1 Management Zone and Analysis Unit Definition

A.1.3 Management zones

The timber harvesting land base is grouped into zones based on differences in forest management. These zones are used in the Forest Service Simulation Model (FSSIM) to facilitate modelling of the different forest management emphasis that exists in each zone. The zones used in the timber supply analysis for the Fraser TSA are listed below:

- Zone 1 - All Douglas-fir types on good growing sites not included in other zones
- Zone 2 - All Douglas-fir types on medium growing sites not included in other zones
- Zone 3 - All Douglas-fir types on poor growing sites not included in other zones
- Zone 4 - All cedar types on good growing sites not included in other zones
- Zone 5 - All cedar types on medium growing sites not included in other zones
- Zone 6 - All cedar types on poor growing sites not included in other zones
- Zone 7 - All hemlock/balsam types on good growing sites not included in other zones
- Zone 8 - All hemlock/balsam types on medium growing sites not included in other zones
- Zone 9 - All hemlock/balsam types on poor growing sites not included in other zones
- Zone 10 - All spruce/pine/larch types not included in other zones
- Zone 11 - All deciduous types not included in other zones
- Zone 12 - Areas with high sensitivity to visible alterations of the landscape
- Zone 13 - Areas with moderate sensitivity to visible alterations of the landscape
- Zone 14 - Areas with low sensitivity to visible alterations of the landscape
- Zone 15 - Areas upon which aerial based harvesting methods will be necessary
- Zone 16 - Area of the timber harvesting land base that will be lost to future roads
- Zone 17 - Areas defined as recreation management class 1

A.1 Management Zone and Analysis Unit Definition

A.1.4 Defining order of priority for zone assignment

Many of the areas in the Fraser TSA inventory file meet the criteria for more than one of the zones listed in Section A.1.3. However, the modelling technique used requires only one management regime or forest cover guideline for each distinct area. A priority list based on the most limiting forest cover guideline that applies to each area is shown in Table A-2.

Table A-2. Priority list for assignment to management zones

-
- | |
|---|
| 1 - Zone 15 - Areas upon which aerial based harvesting methods will be necessary |
| 2 - Zone 12 - Areas with high sensitivity to visible alterations of the landscape |
| 3 - Zone 13 - Areas with moderate sensitivity to visible alterations of the landscape |
| 4 - Zone 14 - Areas with low sensitivity to visible alterations of the landscape |
| 5 - Zone 17 - Areas defined as recreation management class 1 |
-

All areas that do not match any of the above criteria are mutually exclusive and do not require prioritization.

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 Fraser TSA is currently utilized to a 17.5 cm minimum diameter at breast height, a 10 cm diameter top and a 30 cm stump height for all species.

A.3 Definition of the Timber Harvesting Land Base

The following area exclusions were used to define the timber harvesting land base.

A.3.1 Inventory file status

Forest cover polygon information in the Fraser TSA inventory file (age, age class, height, height class, stocking class and identity code) is projected to June 1992.

A.3.2 Non-Crown areas and Crown areas not available to timber harvesting

All areas that are not designated as being ownership codes 62C (Crown forest management unit available for long-term integrated resource management), 69C (Miscellaneous reserves available for long-term integrated resource management) or 70-N (timber licences) are excluded from the timber harvesting land base. Before making these area exclusions, the ownership code corrections shown in Table A.3 were made to the standard inventory file for the Fraser TSA.

Table A-3. Ownership code corrections

Map number	Correction Required
092G010	Change ownership from 69N to 69C
092G037	Change ownership from 69C to 69N
092G038	Change ownership from 69C to 69N
092G040	Change ownership from 69N to 69C
092H011	Change ownership from 69N to 69C
092H031	Change ownership from 69C to 69N
092H032	Change ownership from 69N to 69C

Other specific areas, defined in Table A-4, are incorrectly defined on the inventory file as being ownership code 62C, but are excluded from the timber harvesting land base for this analysis.

Table A-4. Exclusion of areas incorrectly defined as ownership code 62C

Map number	Forest cover polygon(s)	Area excluded (ha)	Reason
92G045	all	all	Lynn Headwaters Park
92G046	586, 587, 588	all	
92G035	all	all	
92G028	2950	160	Golden Ears Park

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

Areas identified as type identities 5 (NC/brush) or 6 (non-forest) are excluded from the timber harvesting land base.

A.3.4 Inoperable areas

Areas defined on the inventory file as inoperable for timber harvesting (operable = I) are excluded from the timber harvesting land base. As noted in Section A.1.1, operability information was merged onto the standard inventory file supplied by Inventory Branch, Ministry of Forests.

A.3 Definition of the Timber Harvesting Land Base

A.3.5 Low site productivity

Areas with low site productivity, as defined in Table A-5 are excluded from the timber harvesting land base.

Table A-5. Exclusion of areas with low site productivity

Inventory type group	Site index
21 - 26, 28 - 31	10 metres, breast height age 50
1 - 20, 27	20 metres, total age 100

A.3.6 Areas with high recreation use

All areas defined as having high value for recreational use (Recreation Management Class = 0) are excluded from the timber harvesting land base.

A.3.7 Environmentally sensitive areas (ESAs)

The areas defined in Table A-6 are excluded from the timber harvesting land base. The reason for this exclusion is that these areas are considered susceptible to environmental damage by timber harvesting.

Table A-6. Environmentally sensitive area exclusions

ESA category	Per cent area excluded
S1 High soil sensitivity	90
H1 High water values	90
P1 or P2 Regeneration problems	90
A1 or A2 Avalanche potential	90
S2 Moderate soil sensitivity	40
H2 Moderate water values	40

For stands assigned more than one ESA code, only one reduction is made for the ESA category that excludes the largest amount of area.

A.3.8 Streamside management areas

Areas being retained to provide forested buffers along streams are estimated to comprise 2% of the timber harvesting land base. This per cent area is excluded from all stands in the timber harvesting land base.

A.3.9 Existing roads, trails and landings

The area of existing roads, trails and landings is determined by multiplying the estimated length of Forest Service, road permit, and non-status roads in the Fraser TSA by an average right-of-way width of 15 metres.

Estimated road length built to date = 7200 km

Estimated average right-of-way width = 15 metres

Estimated area under existing roads = 7200 km * 15 metres = 10 800 hectares

An additional 3380 hectares (approximately 1.2% of the timber harvesting land base) is removed to reflect the productive area lost to landings and trails). The total area removed for existing roads, trails, and landings represents about 5% of the timber harvesting land base.

A.3 Definition of the Timber Harvesting Land Base

A.3.10 Future roads, trails, and landings

Due to its long history of timber harvesting, the Fraser TSA is estimated by Chilliwack Forest District staff to be about 96.5% roaded. The estimated amount of additional road that will be required to completely road the Fraser TSA was based on the the area of existing road as a proportion of the per cent area currently roaded, and works out to 514 hectares. This area is not initially excluded from the land base, but is removed after being harvested a first time in the model, to simulate the volume of timber that will be removed from the right-of-way.

A.3.12 Not satisfactorily restocked areas

All areas on the inventory file assigned a type identity of 4, 7 or 9 were initially excluded from the land base. The operable portions of this area are subsequently added back into the timber harvesting land base (the additions are described in Section A.4.2).

A.4 Forest Management Assumptions

Table A-7 specifies the forest cover requirements that are needed to achieve the forest management objectives for each zone.

Table A-7. Forest Cover Requirements

Zone	Age 1	Max. per cent area younger than age 1	Age 2	Minimum per cent area older than Age 2
1 Douglas-fir, good site	10	25	100	6
2 Douglas-fir, medium site	11	25	100	11
3 Douglas-fir, poor site	13	25	100	17
4 Cedar, good site	12	25	100	--
5 Cedar, medium site	13	25	100	4
6 Cedar, poor site	15	25	100	6
7 Hemlock/balsam, good site	9	25	100	1
8 Hemlock/balsam, medium site	11	25	100	1
9 Hemlock/balsam, poor site	14	25	100	2
10 Spruce/pine/larch	13	25	100	2
11 Deciduous	10	25	100	--
12 VQO high sensitivity	17	8	100	9
13 VQO medium sensitivity	17	17	100	7
14 VQO low sensitivity	18	28	100	10
15 Aerial harvesting	11	25	100	12
16 Future roads	--	--	--	--
17 Recreation areas	17	20	100	5

For Zones 1 through 11 and 15, age 1 is the estimated average age at which a previously harvested stand will achieve a 3 metre height. For zones 12 through 14 and 17, Age 1 is the estimated average age at which previously harvested stands will achieve a 5 metre height. These ages are estimated using the mean area weighted site index for each analysis unit. Because Zones 12 through 15 and 17 contain a mixture of different species and site productivities, Age 1 is the area weighted average age required for all species on all different growing sites to meet the required height. This averaging process was not required for Zones 1 through 11, as they are each composed of a single species/growing site combination.

For zones 1 through 11 and 15, the maximum per cent that may be less than Age 1 is determined by management prescriptions that roughly 25% of each area in which harvesting is occurring will be removed with subsequent harvest. After harvesting has occurred in an area, no further harvesting is allowed to occur in adjacent forested areas until the previously harvested area has reached a height of 3 metres.

For zones 12 through 14 and 17, the maximum per cent area that may be less than Age 1 is determined by provincial visual quality guidelines. These guidelines specify ranges for the maximum per cent area that may be in a cutover state for each visual quality objective (VQO) class, which are then adjusted for the proportion of each visually sensitive area that is already excluded from the timber harvesting land base.

For all zones, Age 2 is the estimated age at which a stand is suitable for deer winter range. The minimum area of each zone that must be older than 100 years (Age 2) at all times corresponds with the proportion of each zone that is currently mapped as deer winter range by the Ministry of Environment. It is assumed that if the required area of suitable habitat is maintained (albeit in different areas over time) wildlife needs will met.

A.4 Forest Management Assumptions

A.4.2 Timber licence reversions

Table A-8 summarizes the area of timber licences that will revert over time to the timber harvesting land base. Areas of timber licences that are younger than 81 years are assumed to have been already harvested and reverted. All areas shown in Table A-8 are assumed to revert to the timber harvesting land base after being harvested and restocked over the next 10 years.

Table A-8. Timber licence reversions

Analysis unit	Area in hectares
1 Douglas-fir, good site	2735
2 Douglas-fir, medium site	1327
3 Douglas-fir, poor site	713
4 Cedar, good site	326
5 Cedar, medium site	196
6 Cedar, poor site	84
7 Hemlock/balsam, good site	178
8 Hemlock/balsam, medium site	493
9 Hemlock/balsam, poor site	3510
10 Spruce/pine/larch	0
11 Deciduous	0

A.4 Forest Management Assumptions

A.4.2 Not satisfactorily restocked (NSR) areas

Table A-9 summarizes the area that has been harvested but is currently not satisfactorily restocked with trees (NSR). All NSR is assumed to be restocked with trees within the first 5 years and is therefore assigned an age of zero at the starting point in the model.

Table A-9. Restocking of NSR area

Zone	Analysis Unit	NSR area restocked
General working forest	1 Douglas-fir, good site	364
General working forest	2 Douglas-fir, medium site	1544
General working forest	3 Douglas-fir, poor site	1544
General working forest	5 Cedar, medium site	91
General working forest	7 Hemlock/balsam, good site	636
General working forest	8 Hemlock/balsam, medium site	2089
General working forest	9 Hemlock/balsam, poor site	2817
VQOs, highly sensitive	1 Douglas-fir, good site	67
VQOs, highly sensitive	2 Douglas-fir, medium site	286
VQOs, highly sensitive	3 Douglas-fir, poor site	286
VQOs, highly sensitive	5 Cedar, medium site	17
VQOs, highly sensitive	7 Hemlock/balsam, good site	118
VQOs, highly sensitive	8 Hemlock/balsam, medium site	387
VQOs, highly sensitive	9 Hemlock/balsam, poor site	521
VQOs, moderately sensitive	1 Douglas-fir, good site	26
VQOs, moderately sensitive	2 Douglas-fir, medium site	111
VQOs, moderately sensitive	3 Douglas-fir, poor site	111
VQOs, moderately sensitive	5 Cedar, medium site	7
VQOs, moderately sensitive	7 Hemlock/balsam, good site	46
VQOs, moderately sensitive	8 Hemlock/balsam, medium site	151
VQOs, moderately sensitive	9 Hemlock/balsam, poor site	203
VQOs, low sensitivity	1 Douglas-fir, good site	7
VQOs, low sensitivity	2 Douglas-fir, medium site	30
VQOs, low sensitivity	3 Douglas-fir, poor site	30
VQOs, low sensitivity	5 Cedar, medium site	2
VQOs, low sensitivity	7 Hemlock/balsam, good site	13
VQOs, low sensitivity	8 Hemlock/balsam, medium site	41
VQOs, low sensitivity	9 Hemlock/balsam, poor site	55
Recreation values	1 Douglas-fir, good site	96
Recreation values	2 Douglas-fir, medium site	406
Recreation values	3 Douglas-fir, poor site	406
Recreation values	5 Cedar, medium site	23
Recreation values	7 Hemlock/balsam, good site	167
Recreation values	8 Hemlock/balsam, medium site	549
Recreation values	9 Hemlock/balsam, poor site	740
Total area of NSR restocked		13 989

A.4 Forest Management Assumptions

A.4.3 Unsalvaged losses

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

Table A-10. Unsalvaged losses

Cause of loss	Gross losses (m ³ /yr)	Annual unsalvaged loss (m ³ /yr)
Fire	16 875	15 000
Windthrow	31 500	2 500
Total	48 375	17 500

A.4.4 Expected harvest profile

The expected harvest profile (mix of species and growing site types harvested) to be harvested over the next 20 years is shown in Table A-11. This expected harvest profile was a harvesting requirement for the first 2 decades in the timber supply model for the base harvest forecast. This requirement was not used as part of any of the sensitivity analyses completed in Section 5.

Table A-11. Expected harvest profile for the first 20 years in the model

Species/site type	Per cent of total harvest
Douglas-fir, good site	1
Douglas-fir, medium site	14
Douglas-fir, poor site	13
Cedar, good site	1
Cedar, medium site	2
Cedar, poor site	1
Hemlock/balsam, good site	3
Hemlock/balsam, medium site	30
Hemlock/balsam, poor site	32
Spruce/pine/larch	0
Deciduous	3

A.4.5 Minimum harvest ages for each analysis unit

Table A-12 lists the minimum harvest age for each analysis unit. Minimum harvest ages are based on the culmination age for each species and growing site.

Table A-12. Minimum harvest age by species and site type

Species and growing site	Minimum harvest age (years)
Douglas-fir, good site	70
Douglas-fir, medium site	80
Douglas-fir, poor site	90
Cedar, good site	80
Cedar, medium site	90
Cedar, poor site	100
Hemlock/balsam, good site	70
Hemlock/balsam, medium site	80
Hemlock/balsam, poor site	110
Spruce/pine/larch	110
Deciduous	50

A.4 Forest Management Assumptions

A.4.6 Basic silviculture and regeneration assumptions

The silviculture program includes the mix of treatments required to achieve success in basic forest management. This level of activity is assumed to be continued indefinitely into the future. Table A-13 shows the expected average regeneration delay (time before an area is restocked after harvesting) for each species and growing site type.

Table A-13. Expected average regeneration delay by species and growing site

Species and growing site	Regeneration Delay (years)
Douglas-fir, good site	3
Douglas-fir, medium site	4
Douglas-fir, poor site	5
Cedar, good site	4
Cedar, medium site	5
Cedar, poor site	6
Hemlock/balsam, good site	4
Hemlock/balsam, medium site	5
Hemlock/balsam, poor site	6
Spruce/pine/larch	4
Deciduous	3

A.4.7 Yield assumptions

The yield tables for existing and regenerated stands were developed using a batch processing version of the Variable Density Yield Projection (VDYP) growth and yield model provided by Inventory Branch, Ministry of Forests. All yield tables assume the utilization levels identified in Section A.2.

The data requirements for the VDYP model are obtained from existing stand information on the 1993 inventory file provided by Inventory Branch.

Regenerated stand yield tables for Douglas-fir on good and medium growing sites were produced using the Table Interpolation Program for Stand Yields (TIPSY) growth and yield model (Version 2.1.3) developed by Research Branch, MOF. These regenerated stand yield tables are based on the following assumptions:

- 1) A pure species composition
- 2) The mean area weighted site index for each analysis unit
- 3) Waste and breakage were assumed to be included in operational adjustment factors used in the TIPSY model inputs. The specific operational adjustment factors used were:
 - Operational adjustment factor 1 — 15%
 - Operational adjustment factor 2 — 4%

A.4.8 Reductions for waste and breakage

Stand volumes and volume yield tables (other than Douglas-fir on good and medium growing sites) based on close utilization less decay are reduced for waste and breakage. Aggregated waste and breakage (W_2B) factors are developed from the Inventory Metric Diameter Class Decay, Waste and Breakage Factors Manual (B.C. Ministry of Forests 1976). A single W_2B factor is developed for each of two age ranges and each Public Sustained Yield Unit (PSYU), species and utilization level.

A.4 Forest Management Assumptions

A.4.9 Response to fertilization of Douglas-fir stands

Approximately half of all Douglas-fir on medium growing sites and almost all Douglas-fir growing on poor sites in the Fraser TSA is fertilized. The expected response to a single application of fertilizer is approximately a 4-per cent increase in timber volume at harvest age. To reflect this increase, the regenerated stand yield estimates used in the timber supply model are multiplied by the following factors:

Douglas-fir on poor sites (all area fertilized) - multiplied by 1.04

Douglas-fir on medium sites (half area fertilized) - multiplied by: $1+(0.5*0.04) = 1.02$

A.4.10 Existing immature plantations of Douglas-fir

To reflect the expected higher productivity of managed Douglas-fir stands resulting from both past and future harvesting, all existing stands of Douglas-fir that are less than or equal to 30 years old are assigned immediately to the regenerated stand yield table in the model.

A.5 Volume Over Age Tables for Existing and Regenerated Stands

Table A-14 shows the existing and regenerated volume over age tables for all species and site types in each management zone used in the analysis. For all types except Douglas-fir on good and medium sites, the same volume over age table applies to both existing and regenerated stands. The appropriate regeneration delay, as discussed in Section A.4.6, is applied to regenerated stands in the timber supply model. Increased yields due to fertilization, as discussed in Section A.4.9, are also applied within the timber supply model, and are not reflected in the regenerated volume over age tables for these forest types.

Table A-14 Volume (cubic metres) over age (years) tables for each management zone/species/growing site combination

	General Douglas-fir Good site	General Douglas-fir Medium site	General Douglas-fir Poor site	General Cedar Good site
Age	1 Volume	2 Volume	3 Volume	4 Volume
10	0	0	0	0
20	0	0	0	0
30	118	64	6	77
40	256	188	50	186
50	375	292	119	288
60	477	381	180	383
70	566	458	232	467
80	644	525	277	546
90	711	581	317	609
100	770	631	351	663
110	823	675	383	710
120	869	714	410	746
130	906	746	433	791
140	937	773	451	833
150	962	793	465	869
160	980	808	475	900
170	991	817	481	926
180	997	822	484	953
190	1009	832	490	980
200	1022	842	497	1005
210	1035	852	503	1030
220	1047	861	509	1060
230	1059	871	514	1089
240	1071	880	520	1117
250	1082	888	525	1145
260	1082	889	526	1148
270	1083	890	527	1150
280	1083	891	528	1153
290	1084	891	529	1155
300	1084	892	530	1157
310	1084	892	531	1159
320	1084	893	532	1160
330	1085	893	533	1161
340	1085	894	533	1162
350	1085	894	534	1163

A.5 Volume Over Age Tables for Existing and Regenerated Stands

Table: Age	General Cedar Medium site 5 Volume	General Cedar Poor site 6 Volume	General Hemlock/Balsam Good site 7 Volume	General Hemlock/Balsam Medium site 8 Volume
10	0	0	0	0
20	0	0	2	0
30	26	1	146	32
40	108	37	285	132
50	190	94	404	227
60	267	152	507	312
70	336	205	593	386
80	400	254	667	450
90	452	295	727	504
100	497	330	778	550
110	537	362	821	590
120	567	386	856	623
130	604	415	896	659
140	638	441	933	693
150	667	463	965	723
160	693	482	994	750
170	714	498	1020	773
180	736	515	1043	796
190	757	531	1066	817
200	778	547	1086	836
210	797	561	1105	855
220	821	579	1123	872
230	845	597	1139	888
240	867	614	1155	902
250	889	630	1169	916
260	892	633	1178	925
270	895	636	1186	933
280	897	638	1194	940
290	899	640	1200	947
300	901	642	1206	953
310	903	644	1212	958
320	904	646	1217	963
330	906	647	1221	968
340	907	649	1226	972
350	908	650	1229	975

A.5 Volume Over Age Tables for Existing and Regenerated Stands

	General Hemlock/Balsam	General Spruce/Pine/ Larch	General Deciduous
	Poor site	All sites	All sites
Table: Age	9 Volume	10 Volume	11 Volume
10	0	0	3
20	0	0	33
30	0	6	92
40	15	43	152
50	64	93	200
60	122	139	240
70	180	184	264
80	229	226	285
90	271	263	303
100	309	297	317
110	342	327	330
120	372	354	342
130	402	379	350
140	429	401	357
150	455	420	362
160	478	437	366
170	499	452	369
180	518	464	372
190	537	476	375
200	554	487	378
210	571	498	380
220	586	508	383
230	601	518	386
240	615	527	389
250	628	535	391
260	637	542	392
270	646	549	393
280	655	556	393
290	662	562	394
300	670	568	394
310	677	573	394
320	683	578	395
330	689	583	395
340	695	588	395
350	700	592	396

A.5 Volume Over Age Tables for Existing and Regenerated Stands

	High visual sensitivity Douglas-fir Good site	High visual sensitivity Douglas-fir Medium site	High visual sensitivity Douglas-fir Poor site	High visual sensitivity Cedar Good/medium sites
Table: Age	12 Volume	13 Volume	14 Volume	16 Volume
10	0	0	0	0
20	2	0	0	0
30	132	70	14	49
40	277	191	80	140
50	401	295	158	230
60	507	384	225	314
70	598	461	283	389
80	679	528	333	459
90	747	586	376	515
100	808	636	414	564
110	861	681	448	607
120	908	720	477	640
130	946	753	501	681
140	978	779	521	718
150	1003	800	536	750
160	1021	815	546	778
170	1033	824	552	800
180	1039	828	555	824
190	1052	838	561	847
200	1065	849	568	869
210	1078	859	575	891
220	1091	869	581	918
230	1103	879	587	944
240	1115	888	593	969
250	1126	897	598	994
260	1127	897	599	996
270	1127	898	600	998
280	1128	898	601	1000
290	1128	899	602	1002
300	1128	899	602	1004
310	1128	899	603	1005
320	1128	900	604	1007
330	1128	900	604	1008
340	1128	900	604	1009
350	1128	900	605	1010

A.5 Volume Over Age Tables for Existing and Regenerated Stands

	High visual sensitivity Cedar	High visual sensitivity Hemlock/Balsa m	High visual sensitivity Hemlock/Balsa m	High visual sensitivity Hemlock/Balsa m
	Poor sites	Good sites	Medium sites	Poor sites
Table: Age	17 Volume	18 Volume	19 Volume	20 Volume
10	0	0	0	0
20	0	7	0	0
30	4	144	52	0
40	44	282	160	20
50	103	401	259	74
60	162	503	347	135
70	215	590	424	192
80	266	666	491	242
90	307	726	546	285
100	344	777	592	323
110	376	821	632	356
120	401	856	665	385
130	430	896	702	415
140	456	933	736	442
150	479	965	765	466
160	498	992	791	488
170	513	1017	814	508
180	529	1039	835	526
190	545	1060	856	543
200	560	1080	875	560
210	575	1099	892	575
220	593	1117	909	590
230	611	1133	925	603
240	628	1148	939	616
250	645	1162	953	628
260	647	1169	959	636
270	649	1175	965	643
280	650	1180	970	650
290	652	1184	975	656
300	653	1188	979	662
310	654	1192	983	667
320	656	1195	986	672
330	657	1198	989	677
340	658	1200	992	681
350	658	1202	994	685

A.5 Volume Over Age Tables for Existing and Regenerated Stands

Table: Age	High visual sensitivity Spruce/Pine/ Larch	High visual sensitivity Deciduous
	All sites 21 Volume	All sites 22 Volume
10	0	5
20	0	44
30	1	108
40	21	166
50	56	212
60	94	249
70	132	271
80	170	290
90	204	306
100	236	320
110	264	332
120	291	342
130	315	350
140	332	356
150	346	361
160	356	365
170	362	368
180	365	371
190	367	374
200	371	377
210	374	380
220	378	384
230	381	387
240	384	390
250	387	393
260	389	393
270	391	394
280	392	394
290	394	395
300	395	395
310	396	395
320	396	395
330	397	396
340	397	396
350	397	396

A.5 Volume Over Age Tables for Existing and Regenerated Stands

	Moderate visual sensitivity Douglas-fir Good site	Moderate visual sensitivity Douglas-fir Medium site	Moderate visual sensitivity Douglas-fir Poor site	Moderate visual sensitivity Cedar Good/Medium sites
Table: Age	23 Volume	24 Volume	25 Volume	27 Volume
10	0	0	0	0
20	2	0	0	0
30	132	72	11	62
40	277	194	70	163
50	401	297	144	257
60	508	386	208	346
70	600	460	262	424
80	682	526	310	497
90	751	582	351	557
100	813	631	388	608
110	867	674	420	654
120	916	713	449	689
130	954	744	472	732
140	986	769	491	771
150	1012	789	505	804
160	1030	803	515	833
170	1042	811	521	856
180	1047	815	523	880
190	1060	824	528	904
200	1073	833	534	928
210	1086	843	540	950
220	1099	852	546	978
230	1112	861	551	1005
240	1123	869	557	1031
250	1135	877	562	1056
260	1136	878	562	1059
270	1136	878	563	1061
280	1137	879	564	1063
290	1137	879	565	1065
300	1137	880	566	1066
310	1138	880	566	1068
320	1138	880	567	1069
330	1138	880	567	1070
340	1138	881	568	1071
350	1138	881	568	1072

A.5 Volume Over Age Tables for Existing and Regenerated Stands

	Moderate visual sensitivity Cedar	Moderate visual sensitivity Hemlock/Balsam	Moderate visual sensitivity Hemlock/Balsa m	Moderate visual sensitivity Hemlock/Balsam
Table: Age	Poor sites 28 Volume	Good sites 29 Volume	Medium sites 30 Volume	Poor sites 31 Volume
10	0	0	0	0
20	0	3	0	0
30	5	154	63	0
40	52	296	180	25
50	116	416	285	85
60	177	520	376	151
70	233	607	455	210
80	286	683	523	262
90	329	744	580	306
100	367	796	628	345
110	401	841	670	380
120	427	877	705	410
130	457	918	742	440
140	484	955	776	468
150	507	988	805	493
160	527	1017	831	516
170	542	1042	853	536
180	558	1065	873	555
190	575	1087	893	573
200	590	1108	911	590
210	605	1128	928	605
220	624	1146	944	620
230	642	1162	958	634
240	659	1178	972	647
250	676	1192	985	659
260	678	1201	991	668
270	680	1209	997	676
280	682	1217	1003	683
290	683	1224	1008	690
300	685	1230	1012	697
310	686	1236	1016	703
320	687	1241	1019	709
330	688	1245	1022	714
340	689	1250	1025	719
350	690	1254	1027	723

A.5 Volume Over Age Tables for Existing and Regenerated Stands

Table: Age	Moderate visual sensitivity Spruce/Pine/Larch All sites 32 Volume	Moderate visual sensitivity Deciduous All sites 33 Volume
10	0	3
20	0	30
30	0	87
40	16	144
50	42	189
60	68	226
70	96	250
80	130	270
90	161	287
100	188	302
110	214	314
120	237	324
130	259	333
140	275	338
150	288	343
160	298	347
170	304	350
180	308	353
190	311	356
200	315	359
210	318	362
220	322	365
230	325	368
240	328	371
250	330	374
260	332	374
270	333	375
280	334	375
290	335	375
300	336	376
310	336	376
320	337	376
330	337	376
340	337	377
350	336	377

A.5 Volume Over Age Tables for Existing and Regenerated Stands

	Low visual sensitivity Douglas-fir	Low visual sensitivity Douglas-fir	Low visual sensitivity Cedar	Low visual sensitivity Hemlock/Balsam
	Good/Medium sites	Poor sites	All sites	Good/Medium sites
Table: Age	35 Volume	36 Volume	38 Volume	41 Volume
10	0	0	0	0
20	0	0	0	0
30	85	8	17	67
40	212	59	92	176
50	319	131	171	278
60	410	193	245	367
70	487	246	311	443
80	555	292	373	510
90	613	332	423	564
100	664	366	466	611
110	709	397	504	651
120	749	425	533	684
130	781	447	568	722
140	807	465	600	756
150	827	479	628	786
160	842	489	652	813
170	851	495	672	837
180	854	498	693	860
190	864	504	713	881
200	874	511	732	901
210	883	517	750	920
220	893	523	772	937
230	902	528	794	953
240	910	534	815	969
250	919	539	836	983
260	919	540	839	992
270	920	541	842	1000
280	921	542	844	1007
290	921	543	847	1014
300	922	544	849	1020
310	922	544	851	1026
320	922	545	852	1031
330	923	546	854	1036
340	923	546	855	1040
350	923	547	857	1044

A.5 Volume Over Age Tables for Existing and Regenerated Stands

Table: Age	Low visual sensitivity Hemlock/Balsam	Low visual sensitivity Spruce/Pine/ Larch	Low visual sensitivity Deciduous
	Poor sites 42	All sites 43	All sites 44
	Volume	Volume	Volume
10	0	0	9
20	0	0	51
30	0	5	111
40	17	62	169
50	71	132	214
60	134	193	249
70	193	247	274
80	244	296	296
90	288	336	313
100	327	371	329
110	362	401	342
120	392	426	354
130	422	450	362
140	450	469	368
150	475	485	373
160	498	497	377
170	518	507	379
180	536	514	381
190	554	519	384
200	571	525	387
210	587	530	390
220	602	535	392
230	616	540	395
240	629	543	398
250	641	547	401
260	650	550	401
270	658	552	401
280	665	554	401
290	672	556	401
300	678	558	402
310	684	559	402
320	690	560	402
330	695	561	402
340	699	561	402
350	704	562	402

A.5 Volume Over Age Tables for Existing and Regenerated Stands

Table: Age	Aerial harvesting Douglas-fir Good/Medium sites 46	Aerial harvesting Douglas-fir Poor sites 47	Aerial harvesting Douglas-fir Good/Medium sites 49	Aerial harvesting Hemlock/Balsam Good/Medium sites 52
	Volume	Volume	Volume	Volume
10	0	0	0	0
20	0	0	0	0
30	56	13	5	16
40	176	101	62	89
50	279	186	133	173
60	367	260	199	250
70	442	323	259	318
80	508	379	315	377
90	564	426	362	427
100	613	468	402	471
110	656	505	437	509
120	694	537	464	541
130	725	564	496	575
140	752	586	526	606
150	772	603	552	634
160	786	616	575	659
170	795	623	593	681
180	799	626	613	701
190	809	634	632	721
200	819	643	650	739
210	828	650	667	756
220	838	658	689	772
230	847	665	710	787
240	855	672	730	800
250	864	679	749	813
260	865	680	752	821
270	865	681	754	828
280	866	682	757	835
290	867	683	759	841
300	867	683	761	846
310	868	684	763	851
320	868	685	764	856
330	869	685	766	860
340	869	686	767	864
350	869	686	768	867

A.5 Volume Over Age Tables for Existing and Regenerated Stands

	Aerial harvesting	Aerial harvesting	Aerial harvesting
	Hemlock/Balsam	Spruce/Pine/ Larch	Deciduous
Table: Age	Poor sites 53 Volume	All sites 54 Volume	All sites 55 Volume
10	0	0	5
20	0	3	50
30	0	12	130
40	25	57	193
50	88	124	241
60	154	187	279
70	213	243	303
80	265	293	323
90	310	338	341
100	349	379	356
110	383	417	368
120	413	451	379
130	444	483	389
140	473	508	397
150	499	530	403
160	523	549	409
170	544	564	413
180	564	575	417
190	584	585	421
200	601	596	426
210	618	607	430
220	634	617	434
230	649	627	438
240	663	636	443
250	676	644	446
260	685	652	447
270	693	659	448
280	701	666	448
290	709	673	449
300	715	679	449
310	722	684	450
320	728	690	450
330	733	695	450
340	738	699	451
350	743	704	451

A.5 Volume Over Age Tables for Existing and Regenerated Stands

Table: Age	Recreation Douglas-fir Good site 56 Volume	Recreation Douglas-fir Medium site 57 Volume	Recreation Douglas-fir Poor site 58 Volume	Recreation Cedar Good site 59 Volume
10	0	0	0	0
20	0	0	0	0
30	107	63	11	94
40	237	181	64	209
50	349	281	137	316
60	445	367	200	417
70	529	440	254	508
80	603	504	302	593
90	667	559	344	662
100	724	607	380	721
110	775	649	413	774
120	820	687	442	813
130	856	717	465	863
140	886	743	484	909
150	910	763	499	948
160	928	777	509	981
170	940	786	515	1009
180	946	790	517	1038
190	958	800	523	1067
200	971	809	530	1094
210	984	819	536	1122
220	996	828	542	1155
230	1008	837	548	1187
240	1019	845	553	1218
250	1030	854	558	1249
260	1031	854	559	1251
270	1031	855	560	1254
280	1032	856	561	1256
290	1033	856	562	1258
300	1033	857	563	1260
310	1034	857	563	1262
320	1034	857	564	1263
330	1034	858	564	1264
340	1035	858	565	1265
350	1035	858	565	1266

A.5 Volume Over Age Tables for Existing and Regenerated Stands

	Recreation Cedar	Recreation Cedar	Recreation Hemlock/Balsa m	Recreation hemlock/Balsam
Table: Age	Medium site 60 Volume	Poor site 61 Volume	Good site 62 Volume	Medium site 63 Volume
10	0	0	0	0
20	0	0	3	0
30	23	1	143	30
40	99	28	281	123
50	179	79	399	216
60	253	133	500	299
70	319	183	585	371
80	381	229	658	433
90	431	268	717	486
100	475	302	767	531
110	513	332	809	570
120	543	356	844	604
130	578	383	883	639
140	611	407	919	672
150	639	429	951	700
160	663	446	979	726
170	683	461	1004	749
180	704	476	1027	770
190	725	492	1049	790
200	744	506	1069	809
210	763	520	1088	826
220	786	536	1105	842
230	808	553	1122	857
240	830	569	1136	871
250	850	584	1150	884
260	854	586	1159	893
270	856	589	1166	901
280	859	591	1173	908
290	861	593	1179	915
300	864	594	1185	921
310	866	596	1190	926
320	867	598	1195	931
330	869	599	1199	936
340	871	600	1202	940
350	872	602	1206	944

A.5 Volume Over Age Tables for Existing and Regenerated Stands

	Recreation Hemlock/Balsam	Recreation Spruce/Pine/ Larch	Recreation Deciduous
Table: Age	Poor site 64 Volume	All sites 65 Volume	All sites 66 Volume
10	0	0	1
20	0	1	36
30	1	6	100
40	21	48	158
50	74	97	203
60	134	141	239
70	192	184	257
80	242	224	272
90	285	260	285
100	323	293	296
110	357	322	306
120	386	348	314
130	416	372	320
140	444	394	326
150	470	413	331
160	493	430	334
170	514	445	337
180	534	457	339
190	552	469	341
200	570	480	343
210	586	491	346
220	602	501	348
230	616	511	350
240	630	520	352
250	643	529	354
260	652	537	355
270	661	544	355
280	669	551	356
290	677	558	356
300	684	564	357
310	691	570	357
320	698	576	358
330	704	581	358
340	709	587	358
350	715	591	358

A.5 Volume Over Age Tables for Existing and Regenerated Stands

Table: Age	Future roads All species All sites 99 Volume	Managed stands Douglas-fir Good sites 101 Volume	Managed stands Douglas-fir Medium sites 102 Volume
10	0	0	0
20	2	2	0
30	32	112	43
40	96	252	168
50	171	402	269
60	240	527	374
70	301	641	464
80	355	741	538
90	400	820	608
100	441	886	669
110	476	941	722
120	507	987	765
130	535	1025	802
140	561	1057	834
150	583	1089	863
160	601	1118	888
170	616	1144	908
180	628	1167	926
190	642	1187	942
200	655	1205	956
210	667	1217	967
220	679	1225	977
230	690	1232	986
240	701	1238	994
250	711	1238	1000
260	716	1238	1007
270	721	1238	1014
280	725	1238	1020
290	729	1238	1025
300	733	1238	1029
310	737	1238	1029
320	740	1238	1029
330	743	1238	1029
340	746	1238	1029
350	748	1238	1029