Mackenzie TSA
Timber Supply Analysis

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Preface

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

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

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

Assessing the implications of only current practices rather than looking at a number of different management schemes will expedite the analysis process, allowing analysis of all TSAs in the province by mid-1995. An important part of these analyses is an assessment of how results might be affected by uncertainties — a process called *sensitivity analysis.* Together, the sensitivity analyses and the assessment of the effects of current forest management on the timber supply form a solid basis for discussions among stakeholders about alternative timber harvesting levels.

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

Executive Summary

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

The Mackenzie TSA covers a total of about 6.13 million hectares of land and water around Williston Lake in the north-central area of British Columbia. About 1.16 million hectares of the area are considered available for timber harvesting and production under current management practices. Lodgepole pine, white and Engelmann spruce, and subalpine fir are the tree species most commonly used by the forest industry in the area.

The results of this timber supply analysis suggest that the current harvest level in the Mackenzie TSA (2.951 million cubic metres per year) can be maintained for up to 30 years without creating severe future timber shortages, if followed by a reduction in the harvest level over the subsequent 20-year period to about 2.64 million cubic metres per year. Harvests could then increase to 2.81 million cubic metres per year — a level sustainable over the long term — about 100 years from now.

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

The uncertainties with the largest potential effects on projected harvests over the next 100 years (that is, greater than 5% cumulative change over the next 100 years compared to the base case results described above) involve estimates of timber volumes in existing stands, the size of the timber harvesting land base, and minimum harvestable ages. An inventory audit completed in 1994 indicated that, for the Mackenzie TSA as a whole, current inventory information together with the timber yield estimation model used for this analysis produced accurate estimates of existing stand volumes. The size of the timber harvesting land base is uncertain mostly due to uncertainty about both the classification of physical operability, and the amount of land to be reserved from timber harvesting to protect environmental values. At this time there is no conclusive information to suggest that the timber harvesting land base is either larger or smaller than defined in the analysis. Until operability limits and environmental protection needs have received further assessment throughout the Mackenzie TSA, the current estimate of the area suitable for timber harvesting constitutes the best available information.

Factors with moderate effects on timber supply over the next 100 years (from 1% to 5% change relative to the base case) include estimates of: site productivity of future managed stands, especially if estimates used in this analysis underestimate actual productivity; regeneration delay, particularly if actual delays are substantially shorter than assumed in the base case; forest cover requirements for management of visual quality, watershed protection, and wildlife habitat when considered cumulatively; forest cover requirements for old-age forest to maintain wildlife habitat; and finally, the minimum age at which stands are assumed to attain old-age characteristics.

Uncertainty about forest cover requirements to maintain visual quality, and the age at which stands reach green-up conditions have a small effect on projected harvests over the next 100 years (less than 1% cumulatively compared to the base case).

The forest inventory and management factors discussed above could affect timber supply over the next 100 years, but uncertainties about these factors would not require reduced harvests over the short term, that is, the next 20 years. The only management uncertainty that could require short-term harvest reductions is related to forest cover requirements in integrated resource management areas. Specifically, application of a 5-pass harvesting system in the integrated resource management areas, rather than the 3-pass system assumed for the base case, would require significant harvest reductions from 11 to 20 years from now, to avoid violating forest cover objectives. Alternatively, the same objective could be met by an immediate but smaller reduction to a steady level over the next 20 years. Analysis showed that uncertainties about other factors can affect cumulative timber supply over the next 100 years, but would not require that harvests drop below base case levels over the next 20 years to avoid either violating cover requirements, or creating severe timber supply disruptions in the future.

Over the long term, that is during the period from 100 to 250 years from now, only site productivity of future stands and the size of the timber harvesting land base have large effects on timber supply. Uncertainty about regeneration delay, forest cover objectives for old-age forest for wildlife habitat, and estimates of the minimum age used to define old-age forest all have moderate effects on long-term harvest levels. Minimum harvestable ages, forest cover requirements for visual quality, green-up ages, adjacency objectives for integrated resources management areas, and estimates of timber volumes in existing stands have little to no effect on long-term timber supply.

In conclusion, this analysis indicates that using current inventory and growth and yield information, timber harvests in the Mackenzie TSA can be maintained at the current allowable level for the next 30 years. Several factors related to the current forest inventory and management regime could affect timber supply over the next 100 years. No conclusive evidence was available prior to completion of this analysis to suggest that significant inaccuracies exist in the information used.

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Introduction

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

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

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

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

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

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

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

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

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

Introduction

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

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

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

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

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

1 Description of the Mackenzie Timber Supply Area

The Mackenzie Timber Supply Area lies in the north-central part of British Columbia within the Prince George Forest Region (Figure 1), and is administered from the forest district office in Mackenzie. The Mackenzie TSA comprises a total of 6 130 604 hectares, surrounding Williston Lake. About one-third of the area is classified as alpine, comprising parts of the northern and central Canadian Rocky Mountains, the southern Omineca Mountains and the Cassiar Range. A further 10% of the Mackenzie TSA is sub-alpine forest not considered productive enough to support timber harvesting. Only about one-half of the TSA is considered productive forest in terms of timber growth. The area includes parts of the spruce-willow-birch, boreal white and black spruce, sub-boreal spruce, Engelmann spruce — subalpine fir, and alpine tundra biogeoclimatic zones. Lodgepole pine, white spruce, and subalpine fir are the dominant tree species in the area.

The topography of the Mackenzie TSA is variable. The Rocky Mountain Trench, with its flat to gentle terrain, runs north-south through the center of the TSA. The rugged Rocky Mountains border the trench along the eastern side. The more rounded Omineca Mountains are found along the western side of the trench. Steep terrain and sensitive soils are widespread and often constrain timber harvesting.

Mackenzie, with 5,800 residents, is the major population center within the TSA. The small remote First Nations communities of Fort Ware and Tsay Keh are located off the north end of Williston Lake. The First Nations community of McLeod Lake is located just outside the southern TSA boundary. In addition, the small settlements of Germansen Landing and Manson Creek are located in the Omineca area on the west side of Williston Lake. Unlike many areas of the province, there is very little dispersed rural settlement in the Mackenzie TSA. Most of the timber harvested in the TSA is processed in the sawmills and pulpmills located in Mackenzie.

1 Description of the Mackenzie Timber Supply Area

Figure 1. Map of the Mackenzie Timber Supply Area and the Prince George Forest Region.

2 Information Preparation

Much information is required for timber supply analysis. This information falls into three general categories: land base inventory; timber growth and yield; and management practices.

2.1 Land base inventory

Land base information used in this analysis came in the form of a computer file compiled by the B.C. Forest Service, Inventory Branch in 1994. This file contains a considerable amount of information on the forest land in the Mackenzie TSA including general geographic location, area, nature of forest cover (such as presence or absence of trees, species, number of trees, age, and timber volume), and other notable characteristics such as environmental sensitivity and physical accessibility (operability). Stand characteristics such as tree height, stocking* and age have been projected to 1993. Also, the file has been updated to account for timber harvesting up to 1993.

The inventory file represents the land base for the entire TSA. It includes information on land that does not contain forest, and other areas where timber harvesting is not expected to occur. Examples are land set aside for parks, areas needed to protect wildlife habitat, and areas in power lines, highways, or town sites. A description of the areas specific to the Mackenzie TSA is provided below. These types of areas do not contribute to the timber supply of the Mackenzie TSA. Before assessing timber supply, information for these non-contributing areas is deducted from the land base to create a file that represents the timber harvesting land base*. When deriving this reduced data file, care is taken to make only a single reduction for areas with more than one characteristic that would make it unavailable for harvesting (for example, where a park area is also suitable for wildlife habitat).

Removing data for areas not contributing to timber supply does not mean the area is also removed from the Mackenzie TSA. The B.C. Forest Service still manages the entire area of the TSA (except for designated areas under the jurisdiction of other agencies) as a land unit that contributes a mix of timber and non-timber values. The timber supply is managed within this integrated resource context, and the analysis described herein is consistent with this philosophy.

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

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

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

2 Information Preparation

For the Mackenzie TSA, the following types of areas were considered not to contribute to the timber harvesting land base.

- non-Crown area — areas not managed directly by the B.C. Forest Service.
- non-forest areas — areas not occupied by productive forest cover (e.g. rock, swamp, alpine areas and water bodies).
- non-commercial cover areas — areas occupied by non-commercial tree or brush species.
- preservation visual quality objective areas — areas where existing visual quality is to be preserved.
- environmentally sensitive areas* — portions of the areas considered sensitive.
- deciduous forest types — areas dominated by deciduous tree species, which currently are not harvested.
- non-merchantable forest types* — areas occupied by timber stands of low volume or non-merchantable species, or with low timber-growing potential.
- inoperable areas* — areas classified as unavailable for harvest for terrain-related or economic reasons. Characteristics used to define operability* include slope, topography (e.g. presence of gullies or exposed rock), difficulty of road access, soil stability, elevation and timber quality.
- existing roads, trails and landings — areas of forest land lost to future timber production due to access development and harvesting to date.
- streamside buffers — 1% of the area otherwise available for timber harvesting (that is, not deducted for previously listed criteria) was assumed to be unavailable for harvesting to provide protection for riparian* and stream ecosystems.
- future roads, trails, and landings — to account for future losses of productive land to development. These areas are initially included in the harvesting land base, and are removed as part of the first harvest.
- specified no-harvest areas — areas being managed for non-forest or specific recreation values and in the process of being removed from the Provincial Forest, including the Germansen Landing and Manson Creek settlement areas, the Black Pine Indian Reserve, and the Pine Pass ski area and Azouzetta Recreation area.

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

Environmentally sensitive areas
Areas with significant non-timber values or fragile or unstable soils, or where there are impediments to establishing a new tree crop, or timber harvesting may cause avalanches.
Non-merchantable forest types
Stands that are accessible and otherwise available for harvesting but are assumed to be non-merchantable due to stand characteristics such as small piece size, incidence of decay, species composition and low stocking.

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

2 Information Preparation

Table 1. Timber harvesting land base for the Mackenzie TSA

Classification	Area (hectares)	Per cent of total area	Per cent of productive forest area
Total area on inventory file	6 130 604	100.0	
Not managed by B.C. Forest Service	– 33 218	0.5	
Non-forest	– 3 043 001	– 49.6	
Total productive forest managed by the Forest Service (Crown forest)	3 054 385	49.8	100.0
Reductions to Crown forest:			
Non-commercial cover (brush)	69 884	1.1	2.3
Areas preserved to protect visual quality	2 072	0.0	0.1
Environmentally sensitive	244 680	4.0	8.0
Deciduous-dominated stands	228 146	3.7	7.5
Non-merchantable	427 552	7.0	14.0
Low timber productivity	31 052	0.5	1.0
Inoperable	855 909	14.0	28.0
Existing roads	6 767	0.1	0.2
Streamside buffers	11 883	0.2	0.4
Settlements (Germansen Landing, Manson Creek)	15 197	0.2	0.5
Black Pine Indian Reserve	112	0.0	0.0
Pine Pass Ski Area, Azouzetta Recreation Area	549	0.0	0.0
Total current reductions[a]	– 1 893 803	– 30.9	– 62.0
Current timber harvesting land base (includes 37 024 hectares not satisfactorily restocked (NSR)* land)[b]	1 160 581	18.9	38.0
Future reductions			
Future roads	– 61 620	– 1.0	– 2.0
Long-term timber harvesting land base	1 098 961	17.9	36.0

(a) Reductions were performed in the order listed in the table.
(b) NSR includes: current NSR, backlog NSR.

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

2 Information Preparation

Figure 2 represents both the total Mackenzie TSA area, and the timber harvesting land base. The total area chart shows that the B.C. Forest Service has management responsibility for more than 99% of the Mackenzie TSA, and of that area about one-half is classified as either non-forest or non-productive forest (i.e. having very few trees). The right-hand chart details the categories of forest land not within the harvesting land base, and shows that about 28% of the forest land in Mackenzie is considered to be physically or economically inoperable at this time. About 38% of the productive forest is considered available for timber harvesting (including NSR). Of the area in the timber harvesting land base, 90% is classified as operable for conventional ground-based, or skidder, harvesting systems, and 6% is operable only for cable harvesting systems (e.g. high lead), while 4% is suitable for a mix of ground-based and cable systems.

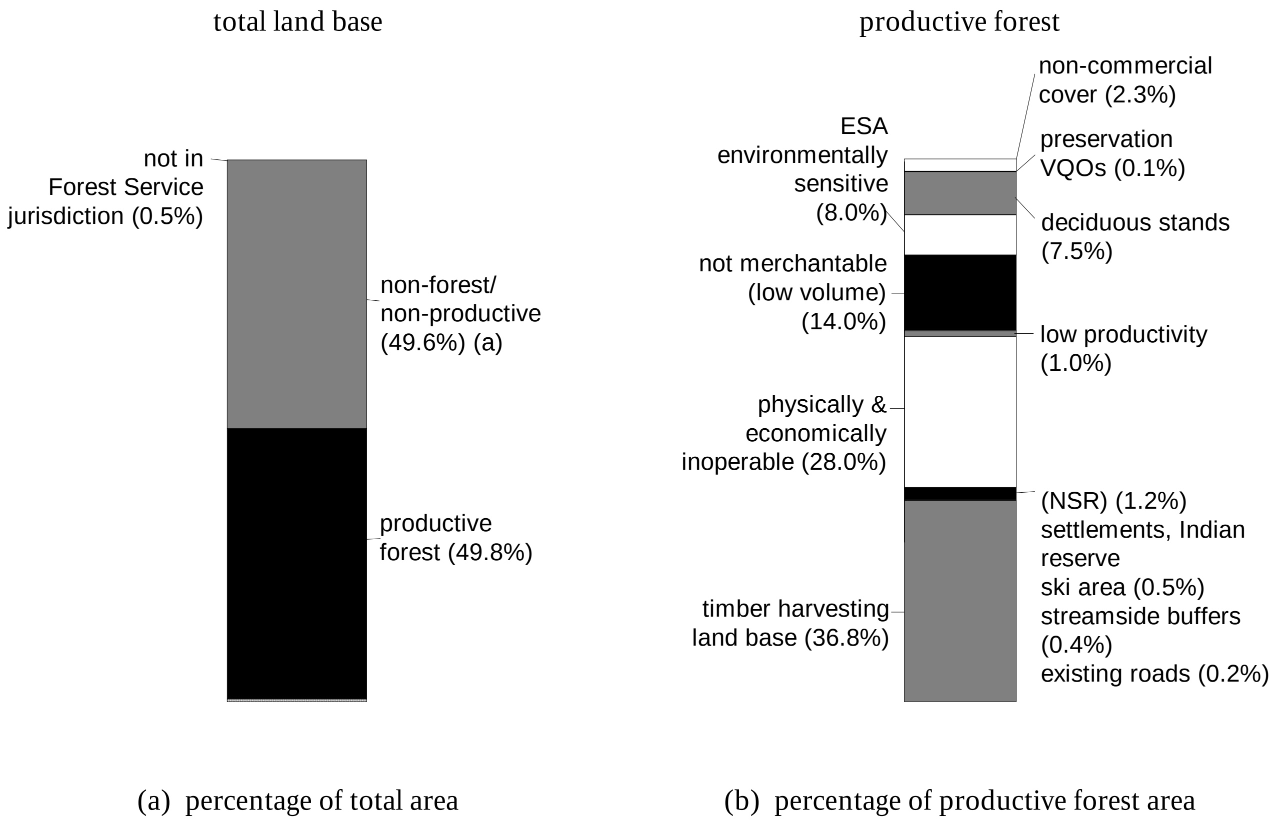

Figure 2. Composition of the total and productive forest land bases — Mackenzie TSA, 1995.

2 Information Preparation

Figure 3 shows the current composition of the timber harvesting land base by dominant tree species. Lodgepole pine is the dominant species in about 49% of stands within the harvesting land base, with spruce leading in 39%, and balsam in 12%. After harvest, stands with a predominance of balsam are planned for regeneration to spruce. Under this management regime, the future forest would consist about equally of lodgepole pine– and spruce-dominated stands.

Figure 3 also shows the proportion of area of each species that is either younger or older than the minimum harvestable age (see Appendix A, "Description of Data Inputs and Assumptions" for details on the minimum harvestable age for each species and site productivity class). In total, almost 77% of stands in the timber harvesting land base are at or above the minimum harvestable age. There is some variation around this proportion for each of the species groupings: 88% of balsam stands, 73% of lodgepole pine stands and 77% of spruce stands are currently older than the minimum harvestable age. The proportion of stands that has reached minimum harvestable age for each tree species relative to total land base could indicate the degree to which harvesting has been spread evenly among species, or alternatively has concentrated on a particular species. In the Mackenzie TSA, it appears that harvesting has been concentrated slightly more on lodgepole pine, however the differences among species are not large. Further, lodgepole pine-dominated ecosystems are often susceptible to naturally-occurring fire. The slightly larger proportion of younger area of lodgepole pine forest is likely due to fire history. The high proportion of area older than the harvestable age for each species indicates that there should be no short-term difficulties in locating merchantable stands of any particular species.

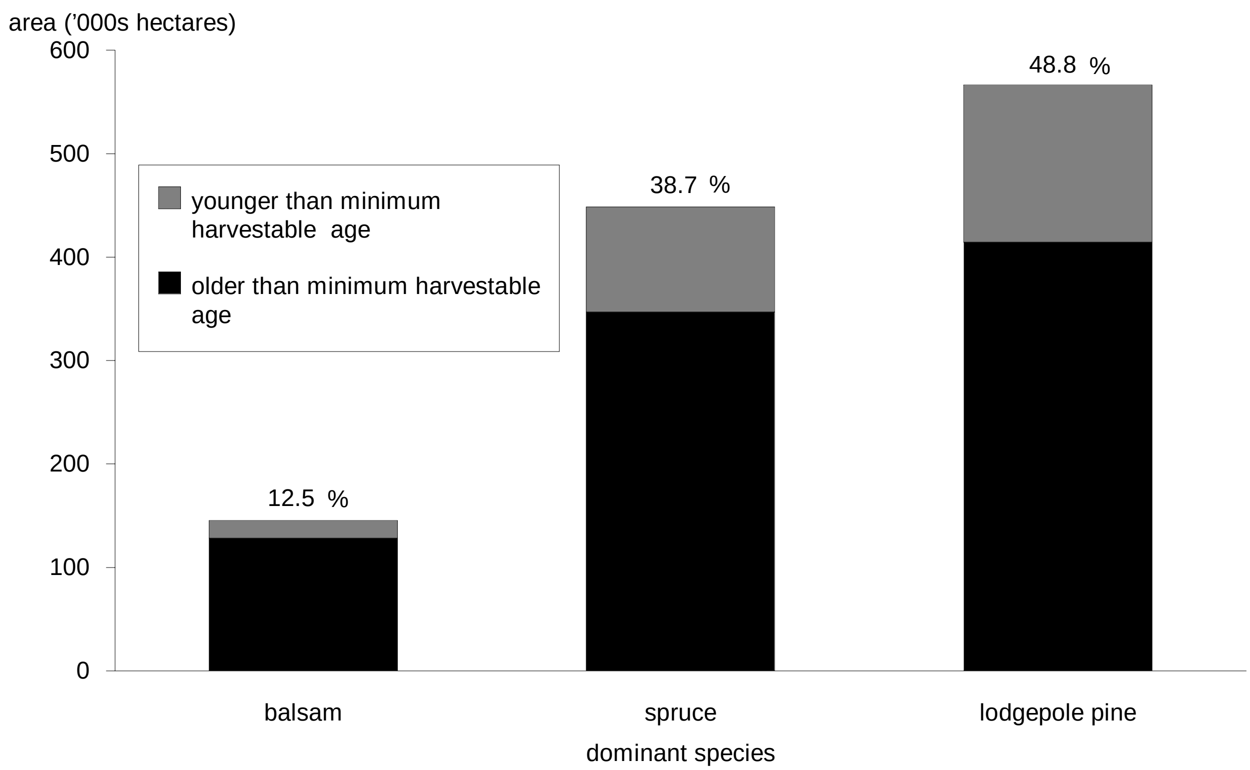

Figure 3. Area by dominant species — Mackenzie TSA timber harvesting land base, 1995.

Figure 4 provides an overview of the distribution of timber-growing potential within the harvesting land base, and the relative amount of area in each class that is older than the minimum harvestable age. Almost half (45%) of the sites in the timber harvesting land base are classified as having medium productivity; 37% have poor or low productivity; and the smallest portion, 18%, have good growing potential. The proportion of area older than minimum harvestable age in each site class indicates that harvesting has concentrated slightly more on good and medium productivity sites than on poor or low sites. However, the differences are not large and a large proportion of stands in each site class is currently old enough to harvest. Therefore, the composition by site class and age does not appear to present a significant issue for timber supply in the short term.

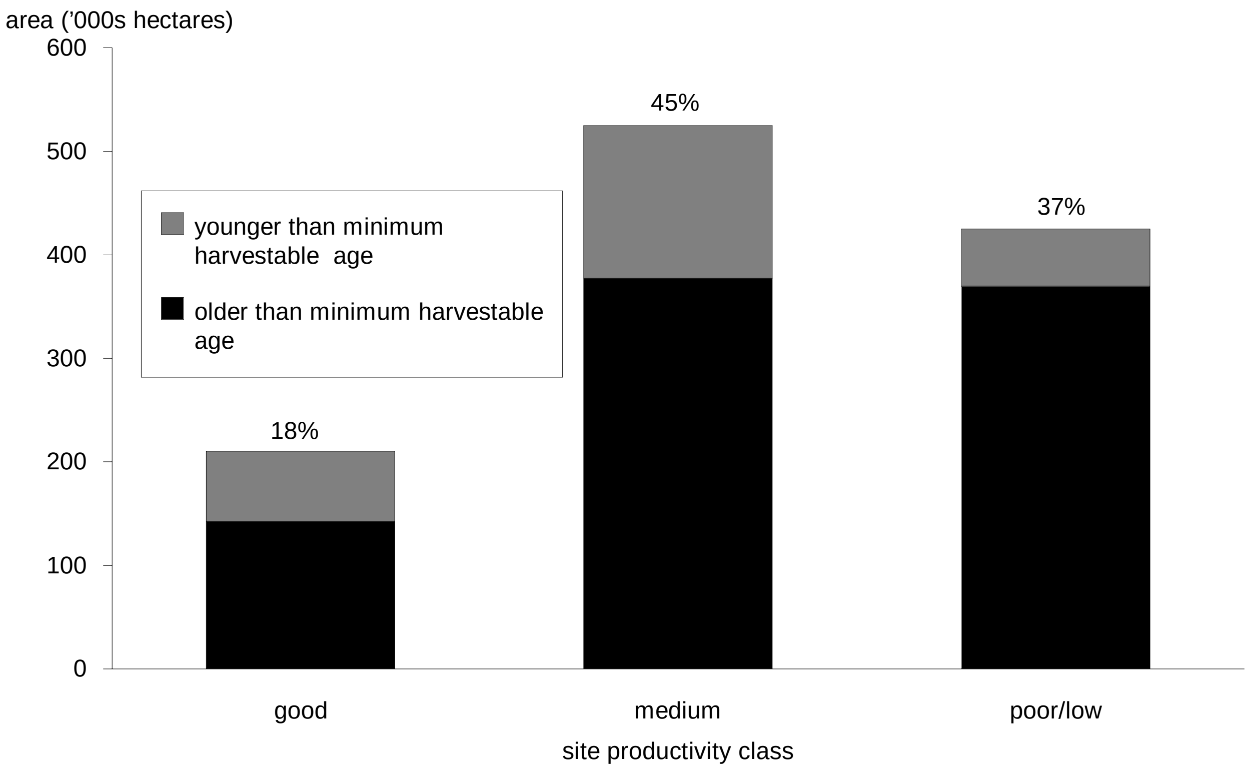

Figure 4. Area by site productivity class — Mackenzie TSA timber harvesting land base, 1995.

Figure 5 shows the current age composition of stands in the Mackenzie TSA timber harvesting land base. A substantial portion (27%) of stands on the harvesting land base are older than 200 years. About 11% of stands are 20 years or younger, 27% are between 21 and 100 years old, and 35% are between 101 and 200 years of age. To reiterate, almost 77% of stands in the timber harvesting land base are at or above the minimum harvestable age applicable to the stand. Given that some area falls in the 60- to 100-year range, additional area will reach minimum harvestable age in the near future. Since the bulk of the harvesting land base is fairly old, an important issue in the Mackenzie TSA will be rationing the timber in these areas over time until previously harvested areas become merchantable. The age composition does not contain any large gaps that would highlight the potential for either short- or longer-term timber supply shortages.

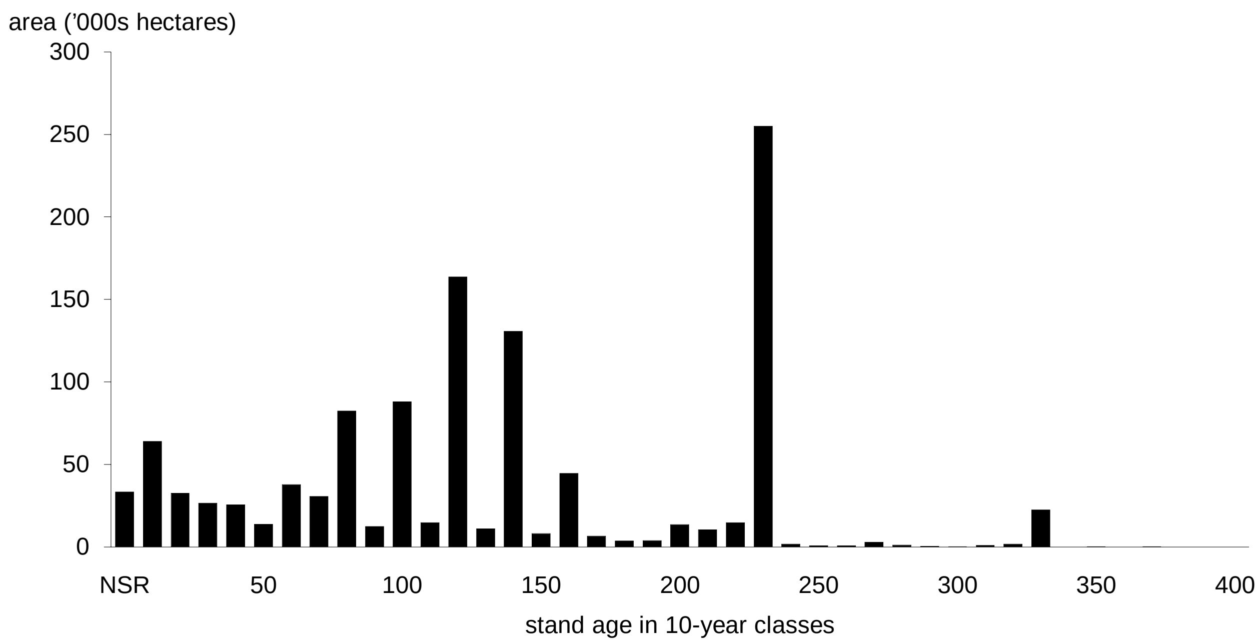

Figure 5. Current age class composition — Mackenzie TSA timber harvesting land base, 1995.

2.2 Timber growth and yield

Timber growth and yield refers to the prediction of the growth and development of forest stands over time. Forest stands have many characteristics that change over time that could be the subject of growth and yield (for example, number of trees per area, tree diameter, tree height, species composition). Since timber supply analysis concentrates on timber volumes available over time, the most relevant measure for this analysis is volume per area (in British Columbia, cubic metres per hectare). An estimate of timber volume in a stand assumes a specific utilization level, or set of dimensions, that establish the minimum tree and log sizes that are removed from a site. Utilization levels used in estimating timber volumes specify minimum diameters both near the base and the top of a tree.

Two growth and yield models were used to estimate timber volumes for the Mackenzie TSA analysis. The Variable Density Yield Prediction (VDYP) model developed by the B.C. Forest Service, Inventory Branch was used for estimating volumes in existing stands. The Table Interpolation Program for Stand Yields (TIPSY), developed by the B.C. Forest Service, Research Branch was used to estimate yields for managed stands. Stands harvested over the last 30 years, and those that will be harvested in the future, are assumed to grow according to managed stand yield estimates from TIPSY.

Volume estimation and prediction is subject to a fair amount of uncertainty due to uncertainty in inventories which form the basis for estimating site productivity, and to limited experience with second-growth in British Columbia. Sensitivity analyses described in Section 5, "Timber Supply Sensitivity Analyses," address the possibility that actual timber volumes may be different from estimates used in this analysis.

Using timber volume estimates for existing stands, the current timber inventory amounts to a total of 239.3 million cubic metres. About 227.9 million cubic metres, or 95.3%, of the total are currently merchantable; that is, older than minimum harvestable age.

2.3 Management practices

Timber supply depends directly on how the forest is managed for both timber and non-timber values. For the timber supply analysis process therefore, levels of management activity must be defined. The focus of the Timber Supply Review is to assess timber supply based on current management practices as implemented in plans for the area. Staff in the Mackenzie Forest District provided descriptions for the following management practices:

- Basic silviculture levels — reforestation activities required to establish free-growing* stands of acceptable tree species.
- Forest health and unsalvaged losses* — timber losses to fire, pest (insects, disease, animals) and wind damage are expected to average 192 000 cubic metres per year.
- Utilization levels — minimum sizes of trees, and logs to be removed during harvesting.
- Stream and riparian protection — 11 883 hectares were removed from the harvesting land base.
- Cutblock adjacency* and green-up period* — in the Mackenzie TSA, approval of harvesting activities is contingent on previously harvested stands reaching a desired condition, or green-up (2.5 metres in height), before adjacent stands may be harvested. Furthermore, the area in the timber harvesting land base that does not meet green-up conditions cannot exceed 33%. The purpose of the green-up period is to prevent timber harvesting from becoming overly concentrated in an area at any time. Review of development plans showed that, to meet these restrictions, harvesting of forests over broad areas, such as watersheds, is occurring over three entries or passes.
- Protection of water quality in the Mackenzie and Germansen Landing watersheds, and wildlife habitat in the Pesika River valley and Schooler Creek — in these watershed and wildlife habitat areas, that total 9318 hectares, or 0.8% of the timber harvesting land base, a maximum of 15% of the total forest area may be younger than green-up age.

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

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

Cutblock adjacency
The desired spatial relationship among cutblocks as specified in integrated resource management guidelines. They can be approximated by specifying the maximum allowable proportion of a forested landscape that does not meet green-up requirements.

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

- Maintenance of old-age forest for wildlife habitat — about 77 111 hectares, or 6.6%, of the harvesting land base are subject to guidelines to retain a minimum proportion of the harvesting land base in old-growth conditions (150 years or older) to help maintain wildlife habitat. These areas include the Kennedy Siding Section 12 Caribou Reserve, and portions of the Mount Selwyn/Canty Lake area, the Russell Range, the Upper Ospika River valley, Phillips Creek, Carina-Tomias Lakes, the Manson Peninsula, and the Wolverine Range.
- Management for visual quality — 26 709 hectares (2.3%) of the timber harvesting land base are being managed for visual quality. Maintaining visual quality requires that visible evidence of harvesting be kept within limits. Guidelines are stated in terms of the maximum proportion of an area that may be less than 3 metres tall (the visual green-up). The proportion depends on the specific visual quality objective (VQO)* and the visual sensitivity*.
- Minimum harvestable ages — the time it takes for stands to grow to a merchantable condition. Minimum ages for this analysis were set at the age at which stands reach 95% of their maximum average growth, or culmination of mean annual increment (MAI)*. The minimum harvestable age defines the youngest age at which a specific type of stand is expected to become harvestable. Actual harvest age may be greater but not less than the minimum, and will depend on ages of other stands, forest cover objectives* (e.g., for adjacency, old growth and visual quality), and overall timber harvest targets.

More detailed descriptions of these management practices and the assumptions used to assess their impacts on timber supply are included in Appendix A, "Description of Data Inputs and Assumptions."

The above discussion outlines the following forest management emphases within the Mackenzie TSA.

- General integrated resource management where cutblock adjacency objectives apply;
- Wildlife and watershed management where the objective is to ensure that the proportion of the area that does not meet green-up conditions does not rise above a maximum limit;
- Wildlife habitat management where the objective is to maintain a minimum proportion of the area in old-age forest;
- Visual quality management.

Visual quality objective (VQO)
Defines a level of acceptable landscape alteration resulting from timber harvesting and other activities. A number of visual quality classes have been defined on the basis of the maximum amount of alteration permitted.
Visual sensitivity
A measure of the level of concern for the scenic quality of a landscape. Visual sensitivity ratings take into account the physical character of the landscape, as well as viewer related factors such as the number of viewers and the angle, position, and distance from which the landscape is viewed.

Mean annual increment (MAI)
Stand volume divided by stand age. The age at which average stand growth, or MAI, assumes its maximum is called the culmination age. Harvesting all stands at this age results in a maximum average harvest over the long-term.
Forest cover objectives
Desired distributions of areas by age or size class groupings. These objectives can be used to reflect desired conditions for wildlife, watershed protection, visual quality and other integrated resource management objectives.

2 Information Preparation

Areas managed for visual quality fall into three categories: 1) retention VQO*, where visible evidence of timber harvesting must be minimal; 2) partial retention VQO*, where harvesting may be noticeable, but not dominant; and 3) modification VQO*, where harvesting may be visually dominant, but must blend with the natural landscape. Appendix A, "Description of Data Inputs and Assumptions" contains detailed descriptions of the specific objectives that apply to these categories.

To facilitate analysis of the different management regimes associated with these emphases, the Mackenzie TSA was divided into management zones.

Figure 6 displays the composition of the harvesting land base according to management emphasis (or management zone).

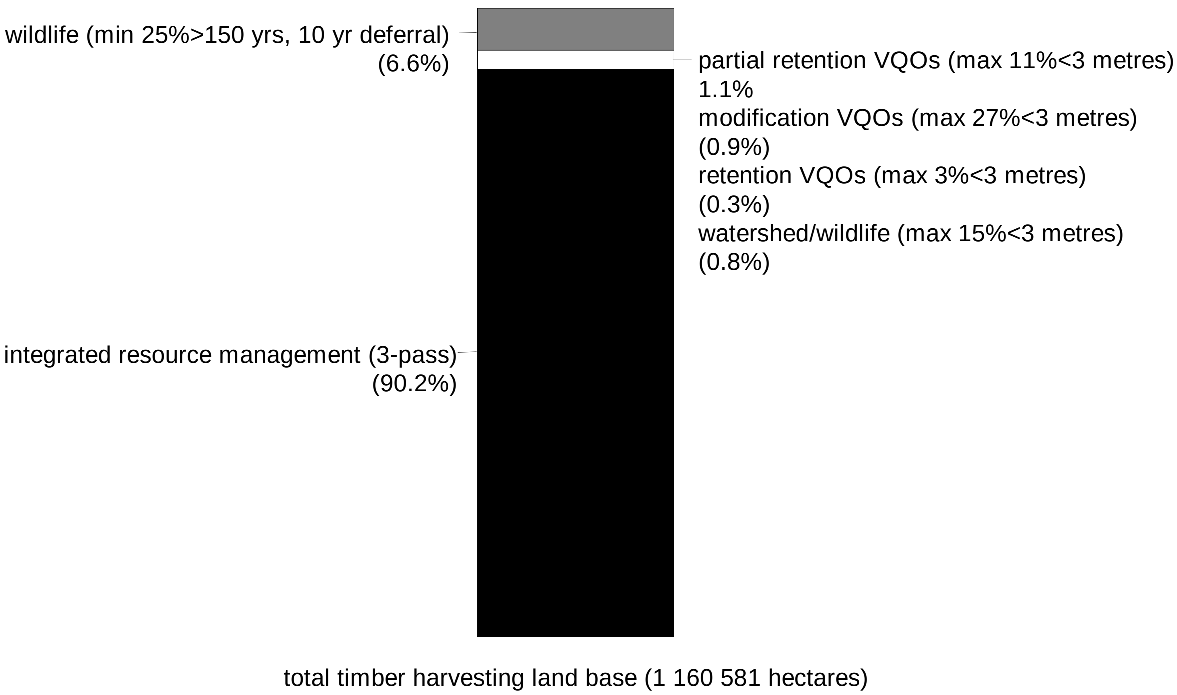

Figure 6. Forest management zones — Mackenzie TSA timber harvesting land base, 1995.

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

Partial retention VQO
Alterations are visible but not conspicuous. Up to 15% of the area can be visibly altered by harvesting activity ***(see Visual quality objective).***

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

3 Analysis Methods

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

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

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

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

4 Results

This section presents results of the timber supply analysis for the Mackenzie TSA. The analysis uses the most recent assessments of current forest management, the land available for timber harvesting, and timber yields as described in Section 2, "Information Preparation." These results will be referred to as the base case because they form the basis for comparison when assessing the effects of uncertainty on timber supply. Because forest management is inherently a long-term venture, uncertainty surrounds much of the information important in determining timber supply. These factors will be discussed in Section 5, "Timber Supply Sensitivity Analyses."

The base case provides only a part of the timber supply picture for the Mackenzie TSA, and should not be viewed in isolation of the sensitivity analysis.

4.1 Base case harvest forecast

Figure 7 shows the base case harvest forecast* for the Mackenzie TSA. The current allowable annual harvest level of 2.951 million cubic metres can be maintained for 30 years without causing severe timber supply shortages in the future, if followed by two equal downward steps of 155 000 cubic metres (5.25% of the current approved level). In this harvest forecast, the potential harvest level between 30 and 100 years from now is 2.64 million cubic metres per year, about 10.5% below the current level. The base case harvest forecast shows the sustainable long-term level of 2.81 million cubic metres per year being reached 100 years from now.

Unsalvaged losses to natural forces such as insects, fire, small mammals, and disease are estimated to be 192 000 cubic metres per year for the entire 250-year horizon, and have been subtracted from all harvest forecasts shown in this report.

An attempt was made to fill in the harvest level depression between 30 and 100 years from now, rather than maintain the current level for 30 years. In other words, it was postulated that by maintaining the current level for only 10 or 20 years, harvests in the medium term (30 to 100 years from now) should be able to increase. However, this proved not to be the case. Even if the current harvest level of 2.951 million cubic metres per year were maintained for only 10 years, harvests would still need to decline to the same level as shown in the base case; that is, 2.64 million cubic metres per year. This counterintuitive result occurs because timber supply depends on both the inventory of standing timber and the growth rate of that inventory, including the timing of availability and timber volumes expected from second-growth managed stands. Existing merchantable timber must be rationed over time until currently young stands become merchantable. In the Mackenzie TSA, managed second-growth stands are expected to produce timber at a significantly more rapid rate than have existing natural stands. Therefore, the more quickly existing old stands are harvested, the more quickly future forests can be expected to produce timber at the higher rate. However, the existing stands cannot be harvested faster than second growth will become available for harvesting, or severe timber supply shortages would occur.

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.

4 Results

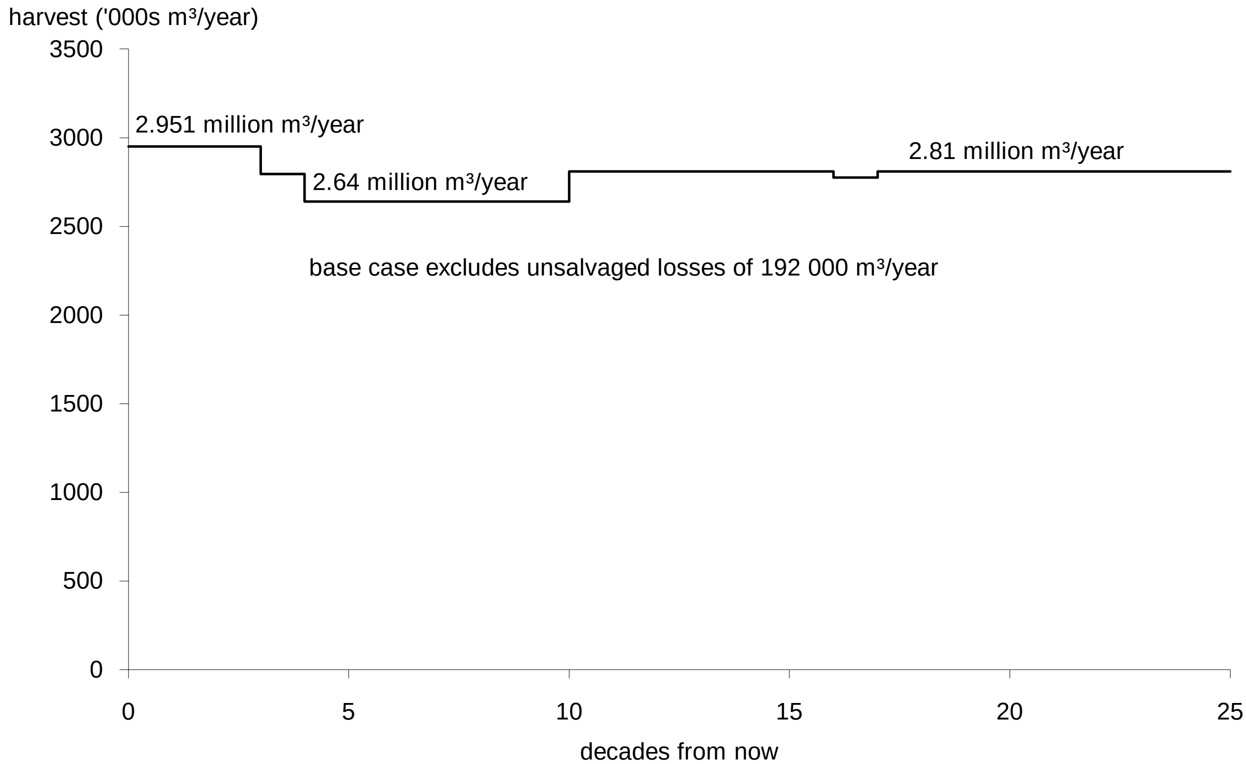

Figure 7. Base case harvest forecast for the Mackenzie TSA, 1995.

In the Mackenzie TSA, a balance between these two factors — rationing of the existing inventory, and expected future production — is achieved by harvesting at the current allowable level for either 10 or 30 years, and then declining to a common lower level. Harvesting at the currently allowable level for 30 years, rather than 10 years, means more area of relatively high productivity second-growth would become available for harvest sooner, since area is converted to second-growth more quickly. If the currently allowable harvest were maintained for 10 years rather than 30 years, less second-growth would be available over the next several decades, meaning that more of the existing merchantable timber inventory would need to be reserved to support harvests.

Several criteria were used to define the base case harvest forecast. An attempt was made to maintain the current harvest level for the Mackenzie TSA (2.951 million cubic metres per year) for as long as possible while avoiding substantial timber supply shortages in the future. The long-term level was defined as the harvest that will maintain timber growing stock* at an even level, on average, so that harvesting can continue at that level in perpetuity (see Figure 8). A declining growing stock would signify that timber is being harvested above the productive capability of the land. Since the average minimum harvestable age for second-growth is 100 years, it was assumed for the base case that the long-term level should be achievable beginning 100 years from now. The attempt was made to maintain harvest levels over the medium term (30 to 100 years from now) within about 10% of the current harvest level, with two equal steps down from the current level to the medium-term level, while increasing the harvest to the long-term level after 10 decades from now (or in 101 years). Harvest levels in the base case were set to avoid causing severe timber supply shortages in the future that would result in large harvest level disruptions. This basic criterion was applied when generating all harvest forecasts in this report.

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

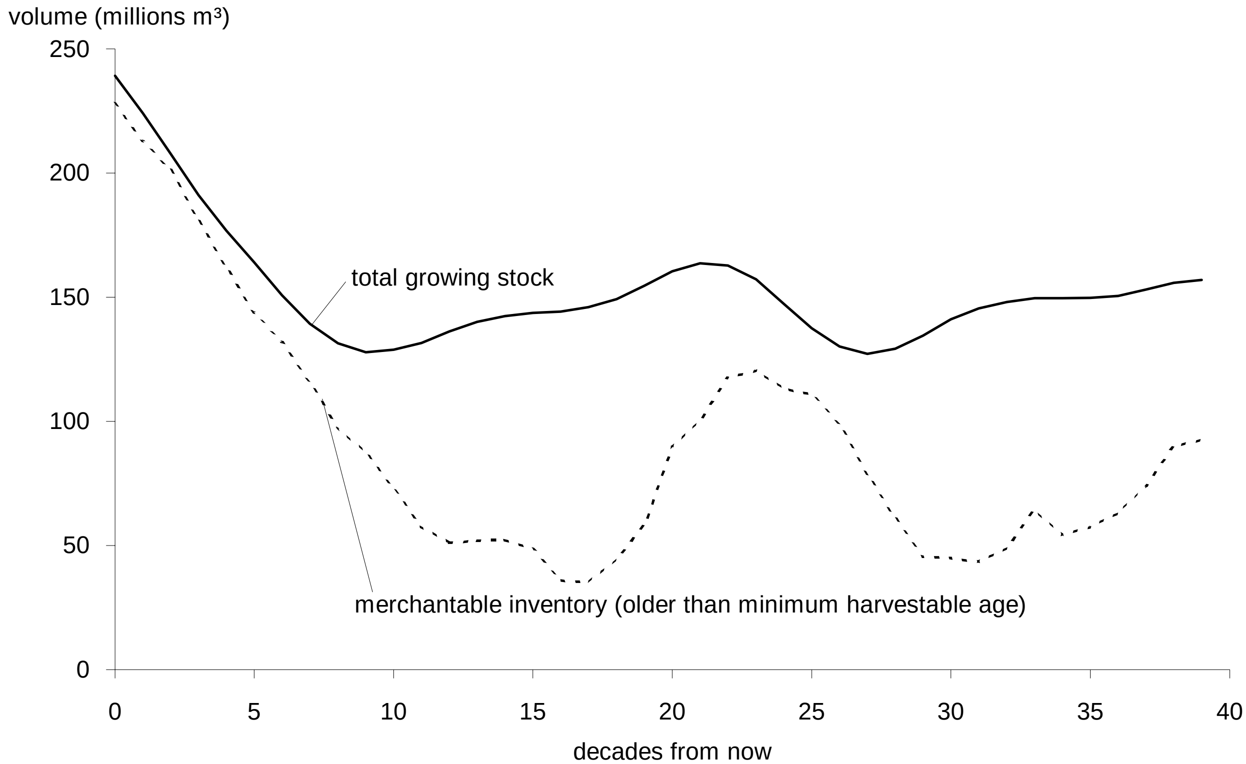

Figure 8. Changes in timber growing stock over time — Mackenzie TSA base case, 1995.

Other harvest flow patterns are possible, for example, with different lengths of time at the current level, different rates of decline, a different medium-term harvest level, and different timing of increase to the long-term level. Some alternatives are described in Section 5.1, "Alternative harvest flow patterns."

The harvest level depression shown in the base case from 30 to 100 years from now, is not so much an indication of a timber supply shortage caused by high past harvests, as a product of the higher growth rates expected in future stands. The base case long-term level is significantly higher than if second-growth stands were expected to grow at the same rate as did the existing inventory. The average growth rate projected over the long term from second-growth is about 2.83 cubic metres per hectare per year, as opposed to about 1.84 cubic metres per hectare per year if harvested stands grew at the same rate as did existing stands. In other words, managed stands on average are expected to produce 54% more timber annually than did existing natural stands. This productivity increase is expected in managed stands, because: stocking levels will be controlled to ensure full site occupancy while avoiding over-stocking that would cause severe competition among crop trees; and the deciduous component of coniferous-dominated stands that currently is not widely used, will be replaced with coniferous crop trees according to assumptions employed in this analysis. While the full benefit of improved management will not occur until most second-growth stands become available for harvesting, in from 50 to 200 years from now, such management does allow maintenance of higher harvests in the medium term than if future stands were expected to grow at the same rate as did existing stands.

4 Results

The long-term harvest level* is 4% less than the average timber growth calculated at minimum harvestable ages. This difference is due in part to forest cover requirements* for visual quality, wildlife, recreation, and watershed values. Forest cover objectives may require that stands be left standing until after the defined minimum harvestable age is reached. A long-term level calculated using minimum harvestable ages that account for forest cover requirements would be about 2% less than the level calculated using the minimum harvestable ages employed in the base case. The long-term level achieved in the base case is a further 2% less than the value calculated when accounting for the forest cover requirements. This is because it is difficult to schedule areas for harvest at a particular age when there is also an objective of maintaining a fairly even harvest flow over time. If dramatic fluctuations in harvests were acceptable, stands could be harvested at their minimum harvestable age, or even at ages of higher average productivity. Harvests at these ages would increase the average over several decades, but would greatly increase the variability in harvest levels.

The harvest forecast includes a small shortfall 160 to 170 years from now. At that time, the available volume of timber — that is, older than the minimum harvestable age and not needed to maintain forest cover objectives — is at a minimum. About 6.3 million cubic metres of timber are forecast to be reserved from harvest during this period to meet adjacency objectives and requirements for old-age forest.

4.2 Area, average volume, and average age harvested

Figure 9 shows how annual area harvested would change over the next 250 years if the base case harvest forecast were followed.

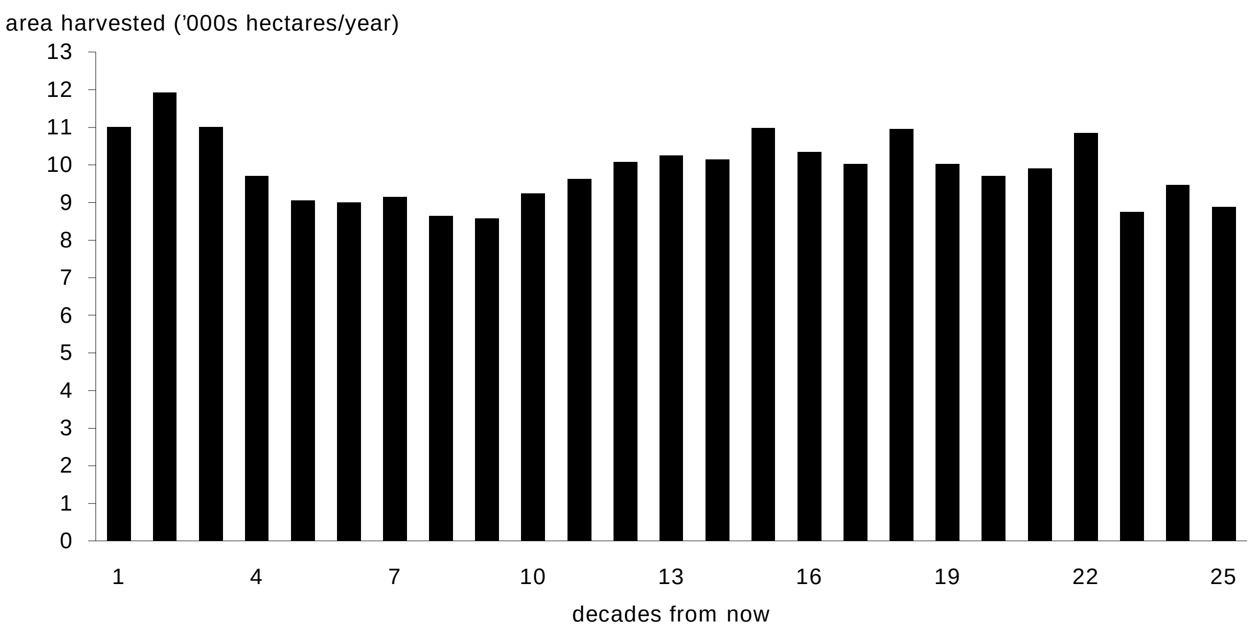

Figure 9. Area harvested over time — Mackenzie TSA base case, 1995.

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

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

Figure 10 shows the average timber volume per hectare harvested over the same period. These graphs display a fluctuating pattern on a cycle of about 160 years, related to differences in minimum harvestable ages for sites of different timber growing capability.

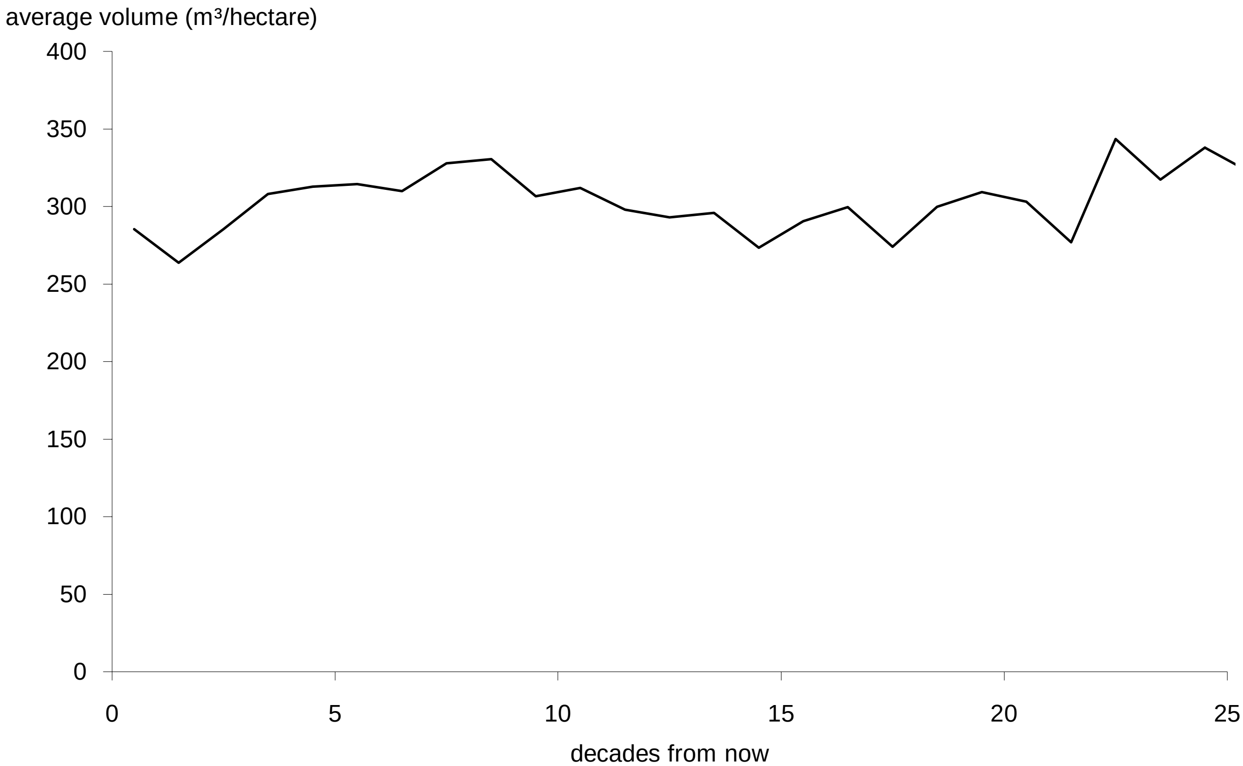

Figure 10. Average volume per hectare harvested over time — Mackenzie TSA base case, 1995.

4 Results

Figure 11 tracks the change in the average age at which stands are harvested under the base case harvest forecast. Average harvested ages decline continuously over the next 150 years from an initial average of 254 years to a low of 84 years between years 150 and 170. The average age then rises quickly to a peak between 180 and 210 years from now. Over the long term — after 100 years from now — harvested age averages about 116 years.

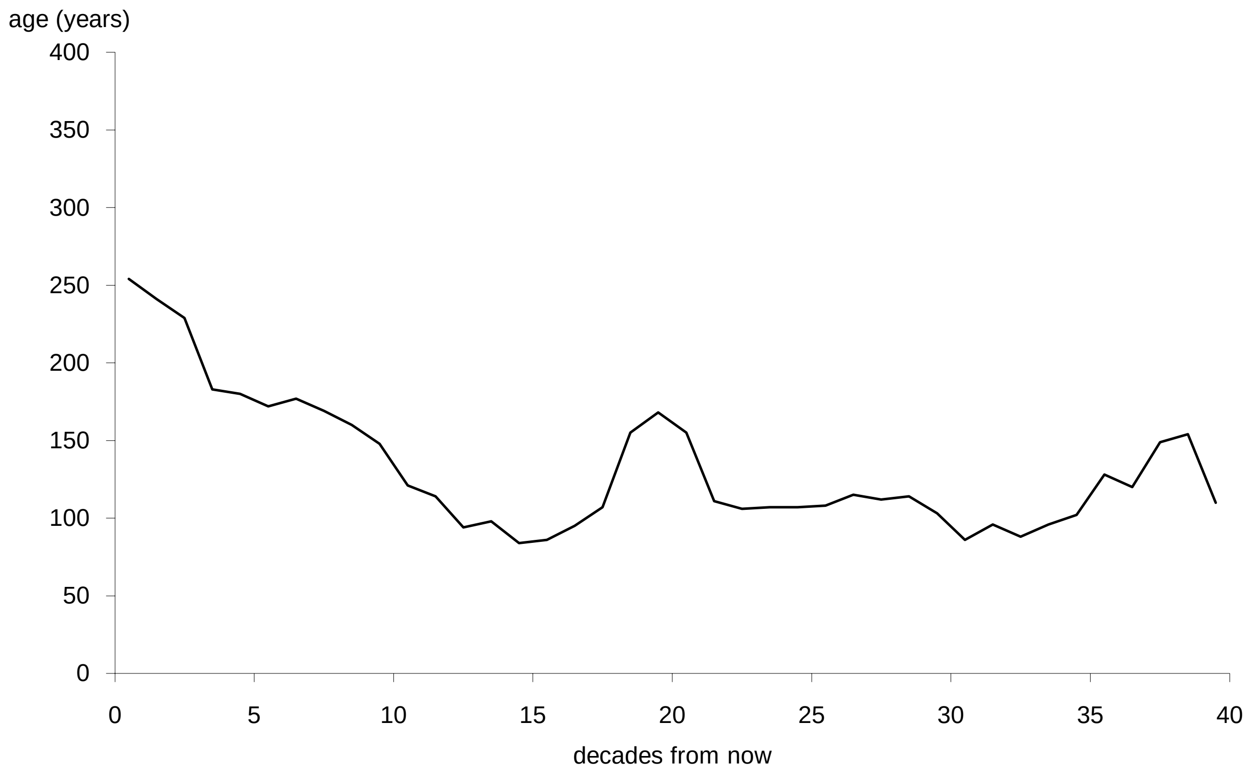

Figure 11. Average harvested age over time — Mackenzie TSA base case, 1995.

The peak in average harvested ages between years 180 and 210, corresponds to a time during which harvests come predominately from poor productivity sites. Poorer sites are expected to take longer to produce stands of merchantable volume, compared to good and medium productivity sites, and consequently their minimum harvestable ages are greater. For example, for spruce stands in the Mackenzie TSA, minimum harvestable ages for poor sites range between 125 and 170 years, while the range is 65 to 70 years for good sites, and 90 to 120 years for medium sites. In the decades prior to the peak in average harvested age, good and medium sites form a larger proportion of the harvest, since poor sites are not yet available. When the poor sites reach minimum harvestable age, they form a large proportion of available stands, and therefore a large component of the harvest.

4.3 Age class composition over time

The charts in Figure 12 show how the age composition of the forest within the timber harvesting land base would change over the next 250 years under the base case harvest forecast. Currently, most of the timber harvesting land base (77%) consists mostly of stands at or above minimum merchantable age.

Forest cover objectives for visual quality and old-age forest (older than 150 years) require that some area remains in old-age forest, which can be seen in the bars representing forest from 150 to 300 years old.

The age-class distribution chart for 150 years from now demonstrates an important determinant of timber supply. At that time, a substantial portion of the timber harvesting land base is forecast to be older than 120 years. This area consists of sites with poorer timber growing productivity that have not yet reached minimum harvestable age. In the subsequent decade, between 160 and 170 years from now, timber growing stock old enough to harvest is at its lowest point of the entire 250-year analysis horizon. The low available growing stock at this time limits harvest levels in previous decades, so that the available inventory is not harvested before the second-growth on the poorer sites is available for harvest. The age composition charts for 200 and 250 years from now show a more even distribution. However, the pattern shown for 150 years from now reappears about 320 years into the future, reflecting a 160 to 170-year cycle of growth and harvest of the less productive sites with older minimum harvestable ages.

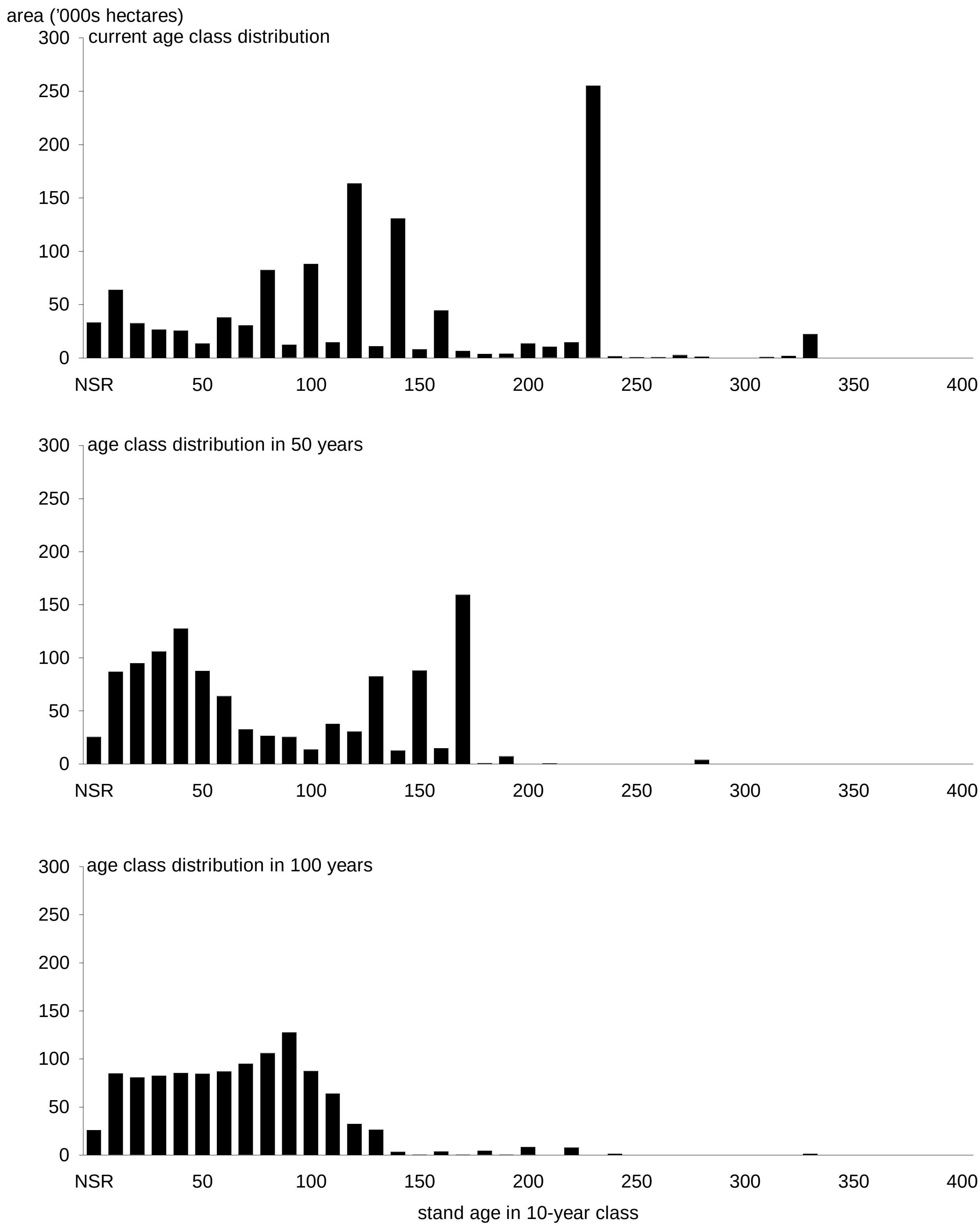

Figure 12. Changes in age composition on timber harvesting land base over time — Mackenzie TSA base case, 1995.

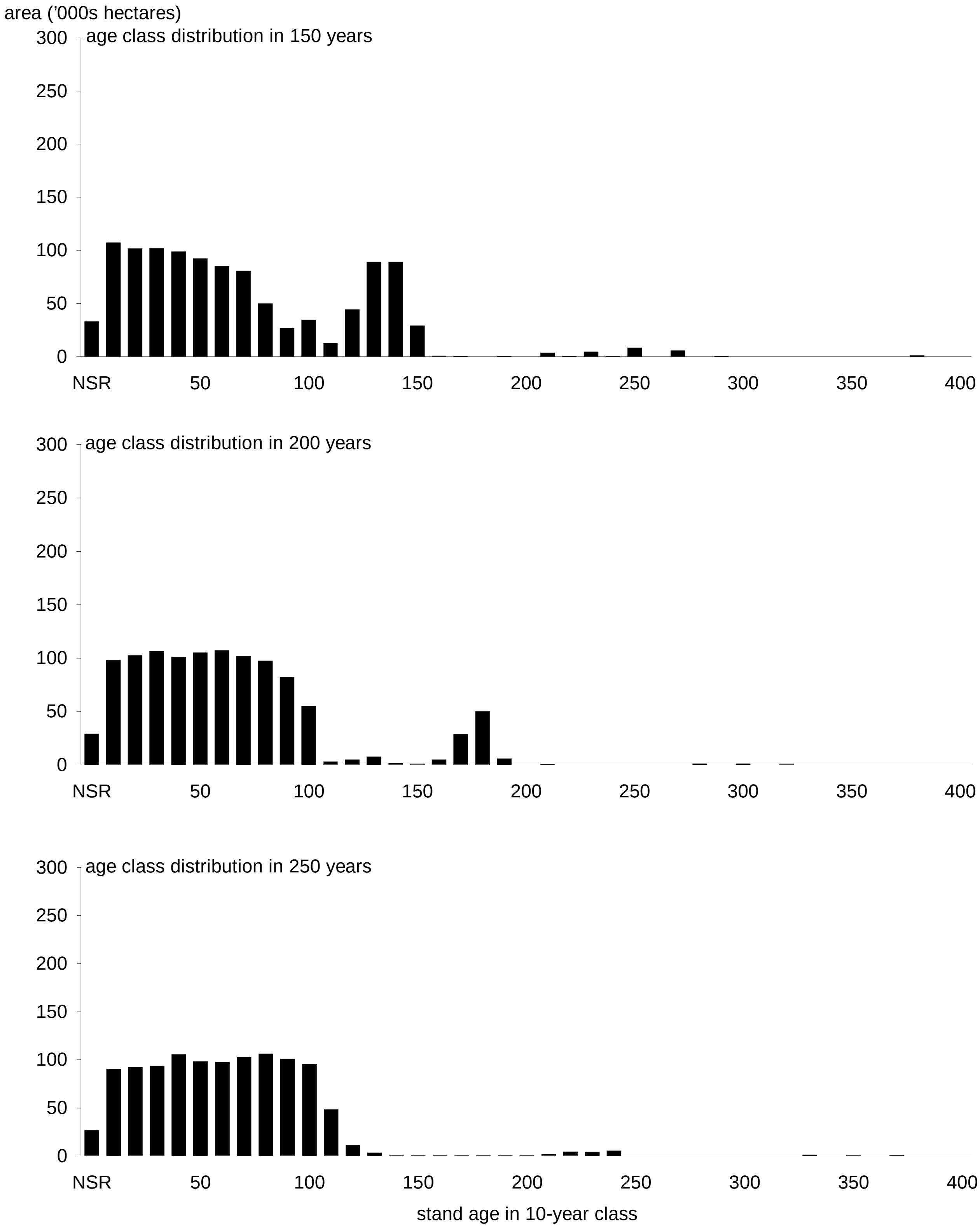

Figure 12. Changes in age composition on timber harvesting land base over time — Mackenzie TSA base case, 1995 (concluded).

5 Timber Supply Sensitivity Analyses

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

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

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

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

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

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

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

5.1 Alternative initial harvest levels and harvest flows over time

The base case harvest forecast shown in Figure 7 was defined using criteria discussed in Section 4.1, "Base case harvest forecast," including attempting to limit the overall decline in harvests to about 10% of the current level, avoiding large and abrupt harvest shortfalls, and maintaining a fairly constant growing stock level over the long term. The last of these criteria is linked to maintaining the productivity of forest land, and is therefore not only a legislated requirement, but also an indictor of sustainability. The other criteria are not requirements, but rather attempts to avoid both excessive changes from decade-to-decade, and significant timber shortages in the future either of which might limit future options. However, there are many possible harvest flows, with different decline rates, starting harvest levels, and potential trade-offs between short-term and long-term harvests.

Figures 13 to 15 compare five harvest flow alternatives to the base case. Figure 13 demonstrates that if harvests are increased to the long-term level in 150 rather than 100 years, the current approved harvest could be maintained for 60 years, compared to 30 years in the base case, without causing severe timber supply disruptions in the future. Under this harvest flow pattern, about 3% more volume could be harvested over the first 100 years than in the base case. Figure 13 also shows a harvest forecast based on a criterion that the harvest be constant over the first 100 years before rising to the long-term level. Over the first 100 years, about 2.5% less volume would be harvested under this flow pattern than in the base case. Comparison of the 100-year even-flow harvest with the base case illustrates that higher harvests over the next few decades, which more quickly bring stands under a management regime that promotes higher timber production than has occurred in natural stands, allows increased harvests over the medium term (first 100 years).

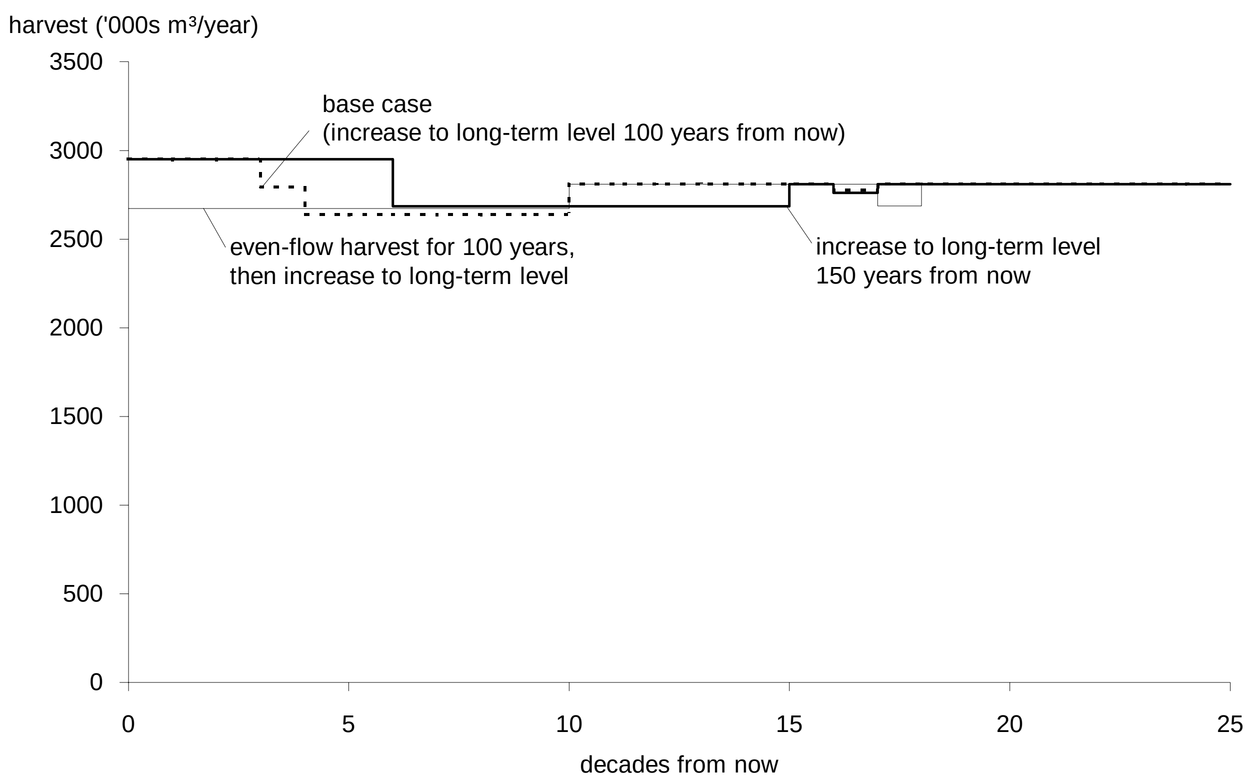

Figure 13. Alternative harvest flow patterns using base case data: rise to long-term level in 150 years and 100-year even-flow — Mackenzie TSA, 1995.

5 Timber Supply Sensitivity Analyses

Figure 14 illustrates the effects on potential long-term harvests if the current AAC were maintained for longer than in the base case. Maintaining the current harvest level for 90 years would result in 4 decades of significant timber supply shortages between 110 and 170 years from now.

These results demonstrate that, given the current management regime and knowledge base, harvests must decline somewhat over the next 100 years, as shown in the base case, to avoid severe future timber supply shortfalls.

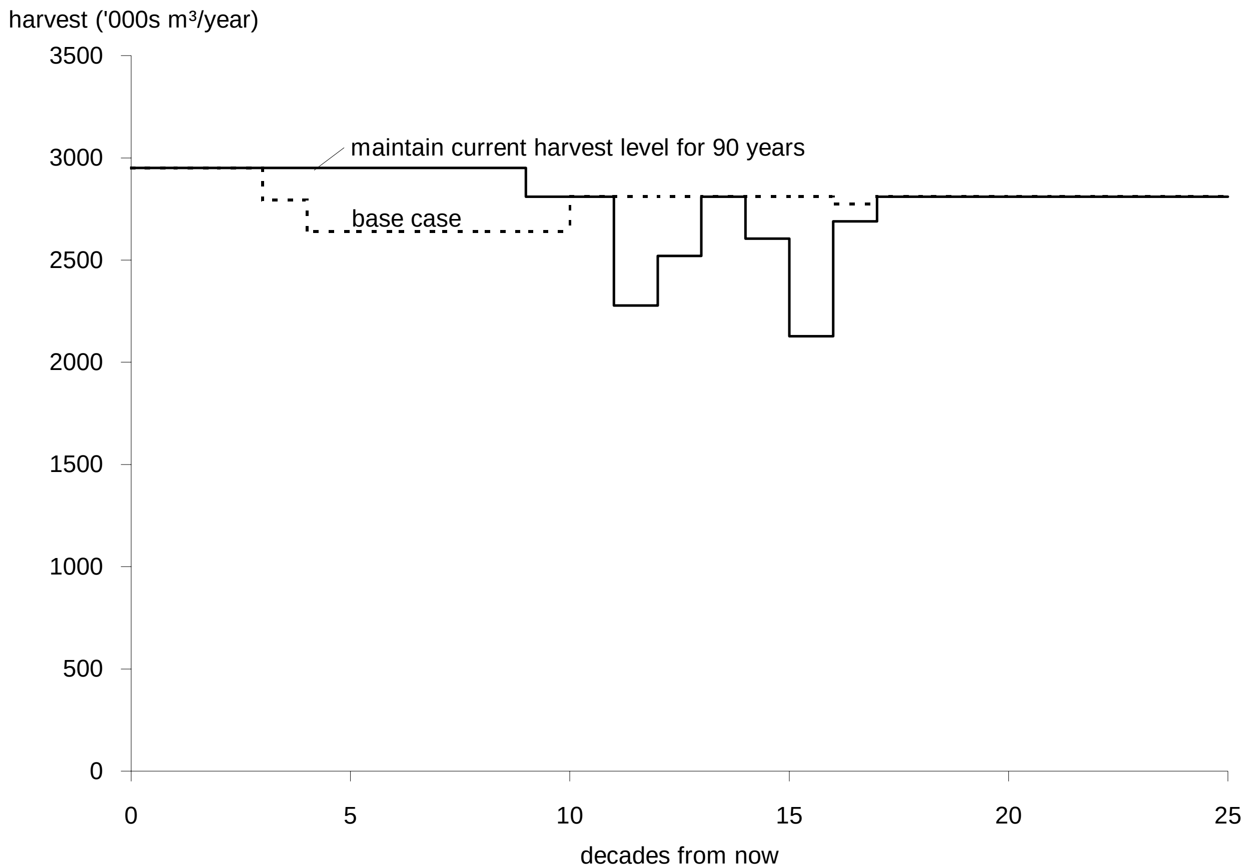

Figure 14. Alternative harvest flow patterns using base case data: maintain current approved level for 90 years — Mackenzie TSA, 1995.

Figure 15 shows two harvest flow alternatives based on a criterion of constant volume decline and increase. If the harvest were to decline by 40 000 cubic metres per decade starting 10 years from now, it would need to fall to 2.59 million cubic metres per year before beginning to rise at the same rate, reaching the long-term level 150 years from now. Under this flow alternative, total volume harvested over the first 100 years would be 0.7% greater than the base case. From 100 to 250 years the total harvest would be 1.2% less than the base case. With a 100 000 cubic metres per decade rate of change, harvests would drop to 2.45 million cubic metres per year 50 years from now, and then rise to the long-term level 90 years into the future. Over the first 100 years, the total harvest under this alternative is 1.8% less than the base case, while from 100 to 250 years from now, the cumulative harvest would be the same as the base case.

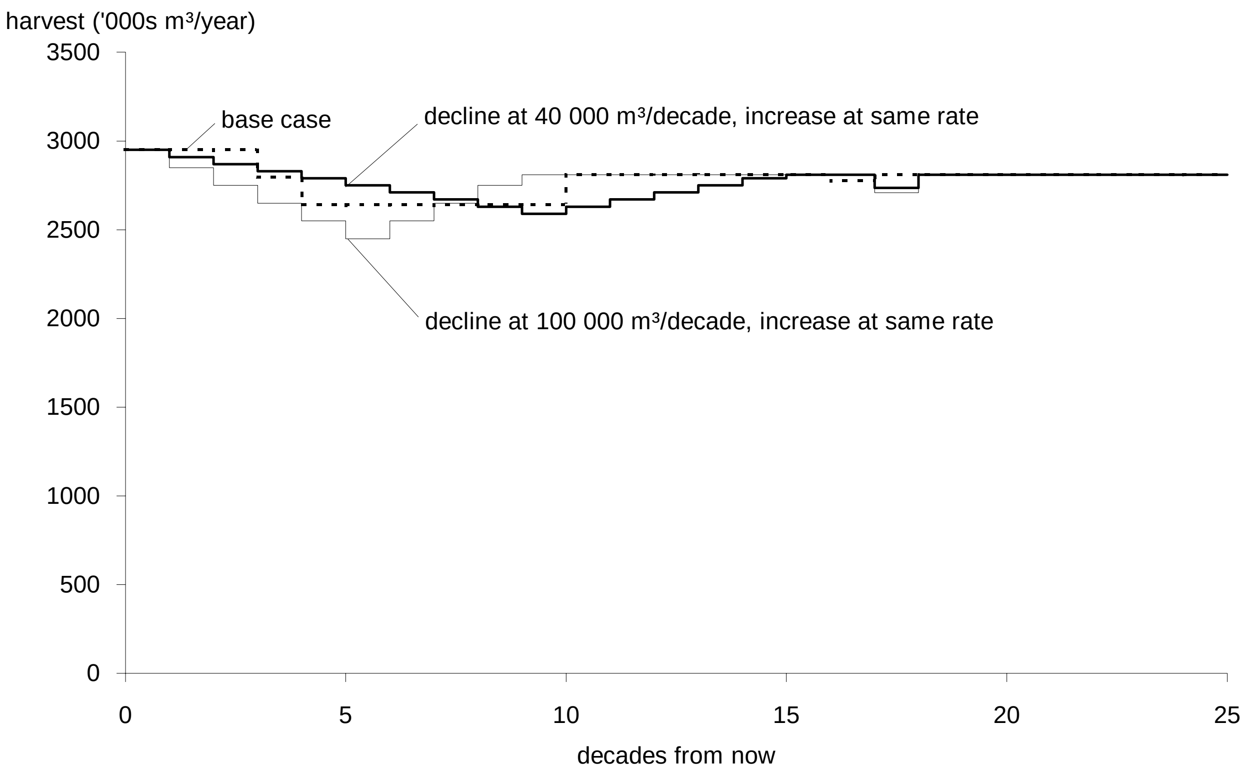

Figure 15. Alternative harvest flow patterns using base case data: constant volume decline and increase — Mackenzie TSA, 1995.

The above harvest flow alternatives all assume harvesting of both the existing and future timber supply at a maximum rate while causing no severe timber supply disruptions, and meeting current integrated management objectives. It would be possible to reduce harvests to less than the levels shown here.

It would also be possible to harvest more than the current AAC in the short term, rather than maintain the current level for 30 years. However, since timber supply is shown to decrease somewhat in the medium term, and the long-term harvest level is lower than the current AAC, a short-term increase would then create the need to reduce harvests sooner than shown in the base case to avoid causing future timber supply disruptions.

5.2 Uncertainty in integrated resource management adjacency objectives

Ninety per cent of the Mackenzie TSA timber harvesting land base is subject to general integrated resource management guidelines requiring that a harvested area reach a greened-up condition before adjacent areas may be harvested. Adjacency guidelines are meant primarily to ensure that harvesting-related disturbance does not become overly concentrated in an area. To approximate adjacency guidelines, this timber supply analysis employed a forest cover requirement that a maximum of one-third of the area subject to general integrated resource management guidelines* could be younger than the age at which stands are expected to reach green-up conditions. This is equivalent to a 3-pass harvesting system, since harvesting would need to occur over 3 green-up periods to cover the entire area. There is uncertainty that these forest cover requirements will result in the desired forest conditions. Alternatively they may provide more than enough cover to meet non-timber objectives. There also is uncertainty that a 3-pass system can be physically implemented such that adjacency objectives are met. Some evidence exists that 4— or 5-passes may be required to meet adjacency objectives (Nelson and Errico, 1993).

The 3-pass harvesting guideline applied in the base case does not restrict timber supply. Applying a forest cover requirement to mimic a 2-pass harvesting system, that is, setting a limit that a maximum of 50% of the harvesting land base could be younger than the green-up age, does not increase timber supply.

If a more restrictive 4-pass system (a maximum of 25% of the harvesting land base may be younger than green-up age) more accurately reflects harvesting restrictions needed to meet adjacency objectives, timber supply would decrease by less than 0.1% over both the next 100 years, and from 100 to 250 years from now. Potential harvests over the next 30 years would not be affected.

If a 5-pass system were needed to meet adjacency guidelines, harvests would be limited in the short term, as shown in Figure 16. The current harvest level could be achieved for the next 10 years, but between 11 and 20 years from now, harvests would need to fall to 2.71 million cubic metres per year, or 8.2% less than the current level to avoid violating forest cover requirements. Alternatively, a harvest of 2.82 million cubic metres per year, 4.4% less than the current level, could be maintained for the first 20 years, followed by a slight drop to 2.8 million cubic metres per year between years 21 and 30. Under this second harvest flow alternative for the 5-pass harvesting system, lower harvests for the first 10 years mean that less second-growth would be available 171 to 180 years from now than if the current harvest level were maintained. Therefore, harvests between years 21 and 30 must be lower to ensure sufficient timber would be available to avoid a severe timber supply shortage 17 decades from now. Under a 5-pass system in the integrated resource management areas, the long-term level would be 20 000 cubic metres per year, or 0.7%, lower than in the base case.

Integrated resource management guidelines
Guidelines requiring that forest management activities (such as harvesting, road building and silviculture treatments) be conducted in a special way to protect or enhance timber and non-timber forest resource values.

If a 5-pass system were employed, total harvest volume would be slightly less than 1% lower than in the base case both over the first 100 years, and between 100 and 250 years from now.

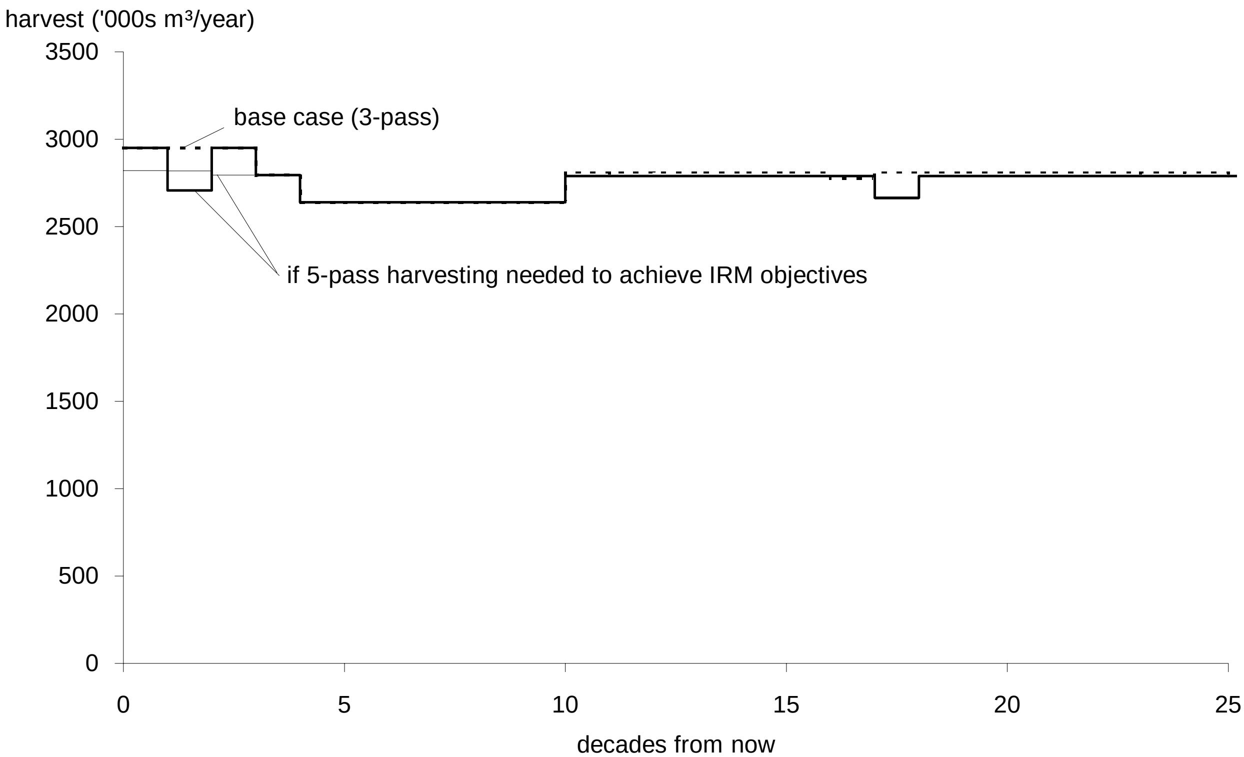

Figure 16. Harvest forecasts if a 5-pass forest cover requirement were needed to approximate adjacency guidelines for integrated management areas — Mackenzie TSA, 1995.

In summary, uncertainty about how well the forest cover guideline for areas under general integrated resource management will meet adjacency requirements does not affect timber supply significantly. Only if a 5-pass harvest guideline was actually needed to meet adjacency objectives would potential harvests be affected in the short term. Long-term timber supply would decrease only slightly.

5.3 Uncertainty in green–up ages

Forest cover requirements for visual quality, watershed protection, wildlife habitat, and adjacency applied in this analysis involve estimates of when stands will reach green-up conditions, expressed as the desired height of a stand. Green-up age, the age at which a stand exhibits the desired condition, is determined using a growth and yield model. The green-up period includes both the green-up age and the regeneration delay*, or time taken to establish a stand after harvesting. Uncertainty about green-up period arises because the desired green-up condition (that is tree height) may either exceed or fall short of actual needs, the period of stand establishment may vary, and uncertainties about growth and yield may mean that stands will reach the desired condition sooner or later than estimated.

Regeneration delay
The period of time between harvesting and the date by which an area is occupied by a specified minimum number of acceptable well-spaced trees.

Figure 17 shows that potential harvest levels over both the short and long terms are not sensitive to uncertainty about green-up ages. If green-up ages were actually 5 years younger than in the base case, that is, base case ages actually overestimated the time needed to meet green-up requirements by 5 years, it would be possible to maintain the current harvest level of 2.951 million cubic metres per year for 10 years longer than in the base. Shorter green-up ages would increase the long-term level, but only by 4000 cubic metres per year, to 0.1% higher than in the base case. Overall, cumulative timber supply would be about 1% higher over the next 100 years if green-up ages were shorter, and the total long-term harvest would be virtually the same as in the base case.

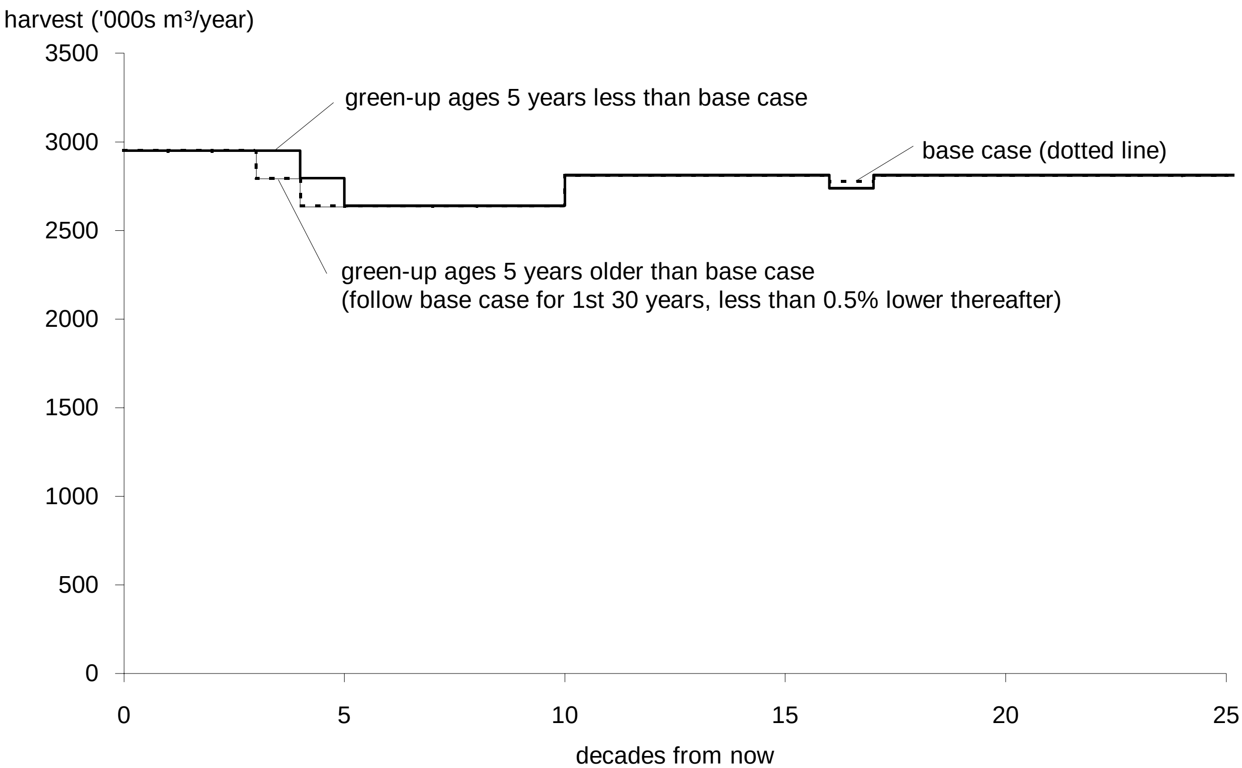

Figure 17. Harvest forecasts if green–up ages were either 5 years longer or shorter than the base case — Mackenzie TSA, 1995.

Analysis results not shown in Figure 17 indicated that if green-up ages were in fact 10 years less than in the base case, the currently approved level could not be maintained any longer than 40 years without decreasing harvests between 50 and 100 years from now, or creating severe future timber supply shortages. Timber supply from 61 to 100 years from now, and over the long term would be 10 000 cubic metres per year higher than in the base case. These results are provided to illustrate further that timber supply shows low sensitivity to decreases in green-up age. In practice, an average 10-year decline in green-up ages would be dramatic, resulting in ages of between 5 and 11 years.

If green-up ages were actually 5 years older than estimated for the base case, timber supply would not change significantly relative to the base case. Reduction of harvests relative to the base case of 4000 cubic metres per year (0.1%) between years 41 and 50, and 7000 cubic metres per year (0.25%) between years 51 and 100, and a 6000 cubic metres per year reduction in the long-term level would be sufficient to avoid severe timber supply shortfalls. Over both the first 100 years and the latter 150 years of the analysis horizon, cumulative harvests would be only about 0.2% lower than in the base case.

A 10-year increase in green-up age would have double the effect discussed above for a 5-year increase. That is, potential harvests would be lower than the base case by 8000 cubic metres per year between years 41 and 50, and 14 000 cubic metres per year between years 51 and 100. The long-term level would be 12 000 cubic metres per year lower than in the base case. A 10-year increase in green-up ages would not require that harvests be reduced from the current level over the next 30 years to meet forest cover objectives.

Overall, uncertainty in green-up ages would have small effects on timber availability over both the short and long terms. One factor likely contributing to the low sensitivity of timber supply to uncertainty in green-up ages is the fairly small portion of the Mackenzie TSA timber harvesting land base subject to forest cover guidelines that currently restrict harvesting.

5.4 Uncertainty in forest cover objectives for old-age forest

Current management as defined for this analysis includes an objective to maintain old-age forest for wildlife habitat in several areas, including Mount Selwyn/Canty Lake, the Russell Range, the Upper Ospika River valley, Phillips Creek, the Kennedy Siding Section 12 Caribou Reserve, Carina-Tomias Lakes, the Manson Peninsula, and the Wolverine Range. These areas cover 77 111 hectares, or 6.6% of the timber harvesting land base. Maintenance of habitat involves a forest cover requirement that at least 25% of the area be in stands 150 years old or older at all times. However, some uncertainty surrounds this requirement since it is possible that habitat objectives could be met by requiring either a smaller or larger percentage of old forest. This section examines the effects on timber supply of this uncertainty.

In total, forest cover objectives for old forest require that at least 19 278 hectares, about 1.7% of the harvesting land base, remain above 150 years of age at all times. Figure 18 shows the implications to timber supply if this objective is either removed or doubled (to 38 556 hectares). Removing the old-growth objective would allow continuation of the current harvest level for 40 years, with harvests between years 51 and 100 years from now at 44 000 cubic metres per year (1.7%) above the base case. The long-term level would be about 1%, or 28 000 cubic metres per year, higher than the base case. Total timber supply would exceed the base case by 2% over the next 100 years, and by about 0.7% between years 100 and 250.

Doubling the objective would not require an immediate change from the current level, but would require that harvests decline to 64 000 cubic metres per year, or about 2.4% below the base case level between years 41 and 100 to avoid severe harvest shortfalls below the long-term level. The long-term level would be 70 000 cubic metres per year, or 2.5%, less than in the base case. Overall, timber supply would be 1.4% less than the base case over the first 100 years of the analysis horizon, and 2.3% less over the latter 150 years.

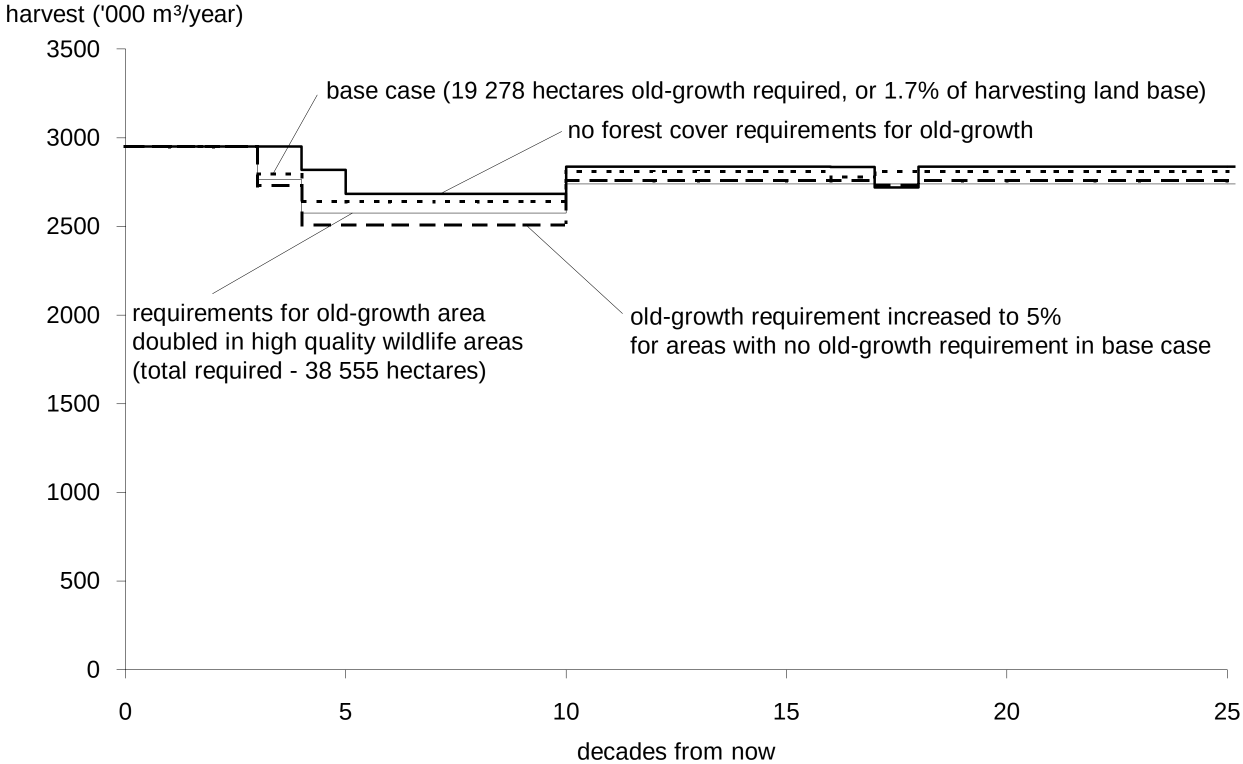

Figure 18. Harvest forecasts if forest cover objectives for old growth were different from the base case — Mackenzie TSA, 1995.

The base case includes requirements for old forest only in some areas with high-value wildlife habitat. It is possible that some older forest may be required throughout the Mackenzie TSA to meet some forest management objectives, for example to maintain biodiversity. Figure 18 shows the effects on timber supply of requiring maintenance of stands at least 150 years old on at least 5% of all areas not assigned an old forest cover requirement in the base case. The old-age forest requirements in the high quality wildlife habitat areas were retained at the base case level.

Applying a requirement for old forest throughout the timber harvesting land base would reduce timber supply relative to the base case during the next 100 years. Results show that harvest reductions would not need to begin immediately to avoid violating forest cover requirements or causing severe timber supply disruptions in the future, but could start after 30 years from now. From 41 to 100 years from now timber supply would be 132 000 cubic metres per year (5%) lower than in the base case, with a long-term level 52 000 cubic metres per year (1.9%) lower. Cumulative timber supply over the next 100 years would be 3% less than the base case, with the total between years 100 and 250 being 1.7% lower. If a 5% old-forest requirement were applied as discussed above, the timber supply reduction would be slightly greater over the next 100 years than if the old-forest requirement were doubled in the high value wildlife habitat areas. Conversely, the long-term level would be very slightly higher.

In summary, timber supply over the next 100 years is affected somewhat by changes to the old-forest requirement. However, effects are not large even if the requirement were removed entirely, or if a requirement were added for 5% of old-age forest in areas not currently subject to an old-forest objective. Furthermore, if old-age forest requirements were increased, any adjustments in harvests needed to avoid causing future timber supply disruptions could occur further into the future, and would not be large.

5.5 Uncertainty in minimum age for defining old-age forest

Forest cover objectives for old-age forest include an estimate of the age at which stands will develop old-growth attributes. This age was estimated to be 150 years for this analysis. Because of our limited understanding about old-growth structure and function, there is some uncertainty about this estimate. For example, it may be possible to create old-growth conditions in younger stands through silvicultural treatments* such as thinning and pruning. Conversely, we may find that old-growth characteristics need longer to develop. This section examines how timber availability is affected by this uncertainty.

Figure 19 shows that timber supply has some sensitivity to changes of 50 years in the definition of old-growth age.

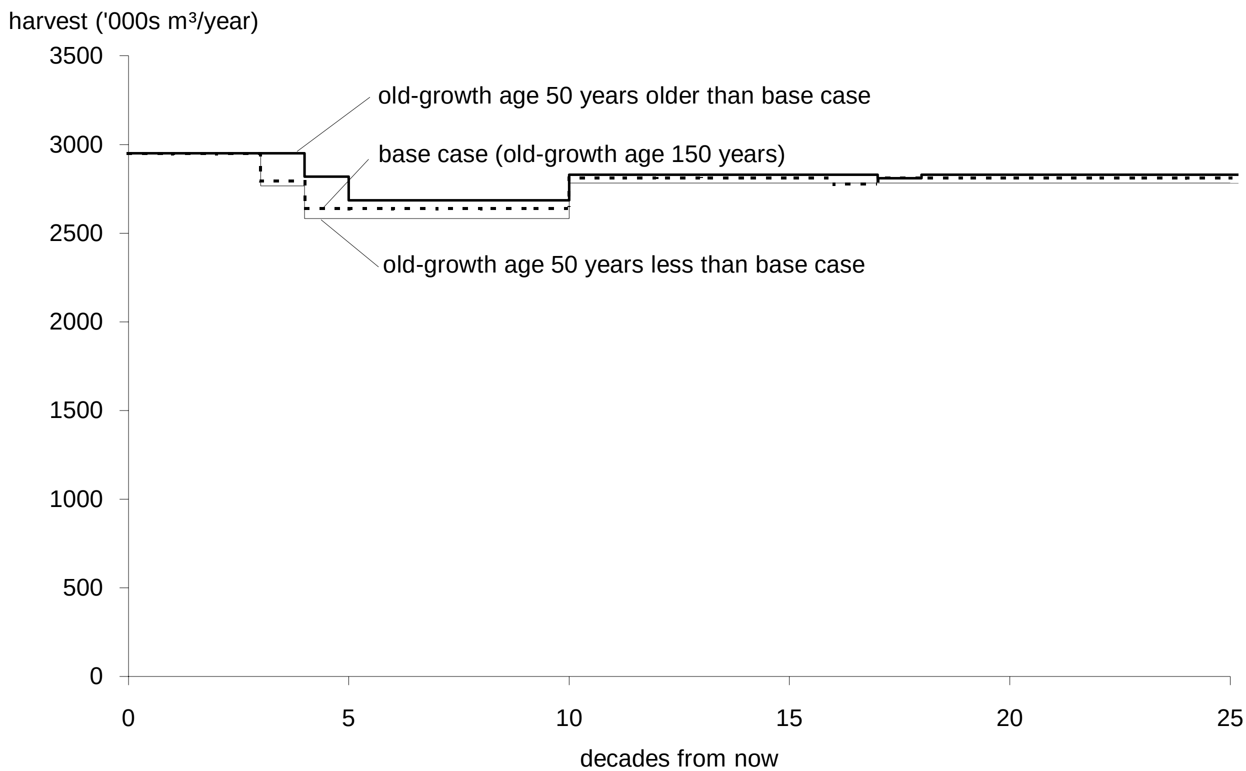

Figure 19. Harvest forecasts if minimum age for defining old growth differed from the base case — Mackenzie TSA, 1995.

> ***Silvicultural treatments***
> *Activities that ensure the regeneration of young forests on harvested areas enhance tree growth and improve wood quality in selected stands. Activities include: site rehabilitation and preparation, planting, spacing, fertilization and pruning.*

If stands actually reached old-age forest conditions at 200 years of age rather than 150 years, harvests could still remain at the current level for the next 30 years, without causing large timber supply disruptions in the future, if followed by a drop to 57 000 cubic metres per year below the base case level between 41 and 100 years from now. The long-term level would be 20 000 cubic metres per year, or 0.7%, less than in the base case. The total timber supply would be 1.25% less than in the base case over the next 100 years if the old-growth age were 50 years older, and about 0.8% lower between years 100 and 250.

If stands actually meet old-age conditions at 100 years rather 150 years, the currently approved harvest level could be maintained for 10 years longer than in the base case (Figure 19). Between years 51 and 100, harvests could remain 46 000 cubic metres per year, or 1.7%, above the corresponding base case level. The long-term harvest level would be 20 000 cubic metres per year, or 0.7%, greater than in the base case. Over the next 100 years, the cumulative timber supply would be 2% higher than the base case, while from 100 to 250 years from now the total would be 0.7% higher.

In summary, timber supply shows a fairly small degree of sensitivity to a large uncertainty in old-growth age (plus or minus 33%). A 50-year reduction in of old-growth age would increase timber availability over the next 100 years by 2%, while a similar increase in the age would reduce timber supply by 1.25%. Uncertainty in the old-growth age had a very small (less than 1%) effect on long-term supply.

5.6 Uncertainty in forest cover requirements for visual quality

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

Uncertainty about forest cover objectives may arise from inventory and classification of land into VQO and sensitivity categories, from estimates of how well different disturbance limits may meet visual objectives, and from estimates of how non-harvestable forest may contribute to visual quality.

Figure 20 illustrates that short-term timber supply is not highly sensitive to uncertainty about current forest cover requirements for VQOs in the Mackenzie TSA. Removing all forest cover requirements for areas with VQOs would allow maintenance of the current harvest level for 40 years, without causing future timber supply disruptions, if harvests subsequently declined at the same rate and to the same levels as in the base case. A long-term harvest of 10 000 cubic metres per year, or 0.4%, above the base case level could be achieved. In total, over the next 100 years, 1% more timber supply would be available for harvest than in the base case, while between 100 and 250 years from now, 0.3% more would be available.

Decreasing by 5% the maximum area which is allowed to be in a visually disturbed state, (that is, applying more restrictive guidelines by subtracting 5 percentage points from the base case values), would not change timber supply over the next 100 years. The sustainable long-term level, beginning 101 years from now, would be 0.5%, or 14 000 cubic metres per year, below the base case level. In summary, restricting forest cover requirements for visual quality by 5 percentage points would decrease cumulative timber supply between 100 and 250 years from now by 0.6%, and not affect harvests over the next 100 years.

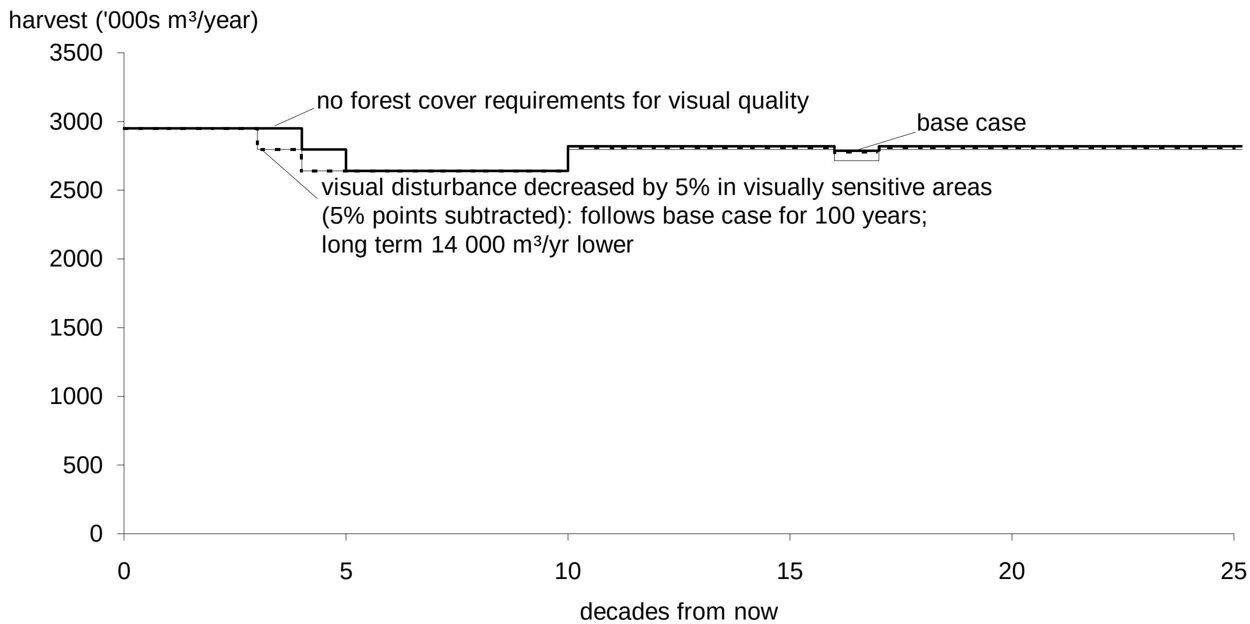

Figure 20. Harvest forecasts if forest cover objectives for visual quality management areas changed by 5% — Mackenzie TSA, 1995.

These results show that uncertainty about forest cover requirements needed to meet currently defined VQOs has only a small effect on timber supply over both the short and long terms. This is primarily because of the small portion of the Mackenzie TSA— 2.3% — on which VQOs apply. If VQOs were set for a larger area, the potential effects of uncertainty about forest cover requirements would be larger.

5.7 Uncertainty in forest cover requirements for wildlife habitat and watershed protection

Current forest management in the Mackenzie TSA includes a forest cover requirement to protect water quality in the Mackenzie and Germansen Landing watersheds, and wildlife habitat in the Pesika River valley and Schooler Creek by ensuring that the area of recent harvesting does rise above a maximum limit. The watershed and wildlife habitat areas total 9318 hectares, or 0.8% of the timber harvesting land base. The forest cover requirement allows a maximum of 15% of the total forest area to be younger than green-up age. Since forest outside of the timber harvesting land base contributes to meeting this requirement, up to 21% of the land base available for harvesting may be younger than green-up age. The wildlife habitat areas to which this forest cover requirement applies are different than those in which old-age forest is required. Some uncertainty surrounds this forest cover requirement since it is possible that the watershed and wildlife habitat objectives could be met if either more or less area does not meet green-up conditions.

Analysis showed that even complete removal of this cover requirement would not increase timber supply relative to the base case. Also, applying a significantly more restrictive forest cover requirement — that no more than 11% of the area may fail to meet green-up conditions at any time — would decrease timber volumes available for harvest by only 0.2% over the next 100 years, and by 0.3% between years 100 and 250. This would involve harvests of 5000 cubic metres per year less than in the base case in years 31 to 40, 10 000 cubic metres per year less between years 41 and 100, and a long-term level of 6000 cubic metres per year (0.2%) less than the base case.

Overall, the forest cover requirement that limits the area not meeting green-up conditions where watershed or wildlife habitat values are high, has little effect on timber supply. In large part, this is because these areas comprise less than 1% of the timber harvesting land base. If the area to which this forest cover requirement applies were increased, timber supply would show increased sensitivity to changes in the requirement.

5.8 Cumulative effect of forest cover requirements

Figure 21 illustrates the cumulative effects on timber supply of the forest cover and old-age forest requirements of current forest management. The impacts of VQOs alone were discussed above in Section 5.6, "Uncertainty in forest cover requirements for visual quality," and are displayed again in Figure 21.

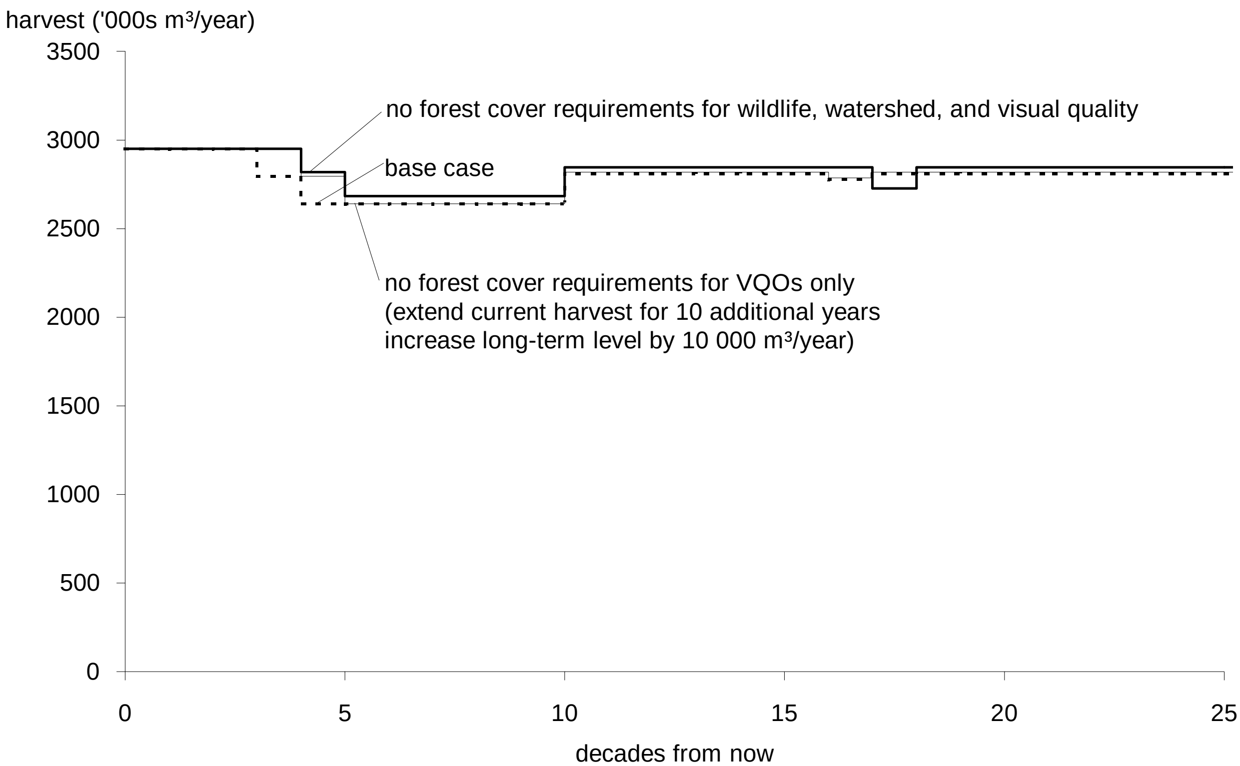

Figure 21. Cumulative effect of forest cover requirements on timber supply — Mackenzie TSA, 1995.

If, in addition, all other forest cover requirements were removed — that is, those for old-age forest for wildlife habitat, and for green-up in areas with high watershed and other wildlife values — timber supply would increase further. If all forest cover requirements were removed, the current harvest level could be maintained for 10 years longer than in the base case, and the long-term level would be 36 000 cubic metres per year, or 1.3%, higher. Between 51 and 100 years from now, removal of forest cover requirements would allow harvests of about 1.7% (44 000 cubic metres per year) higher than the base case level during that time. Overall, total timber supply would be 2% greater over the next 100 years, and 1% higher from years 100 to 250, than in the base case.

These results demonstrate that current forest cover requirements in the Mackenzie TSA do not have a large effect on potential timber harvests. Cover requirements have only a limited effect mostly because the area to which they apply is not large relative to the total timber harvesting land base.

5.9 Uncertainty in deferral time periods for high quality wildlife habitat areas

Areas with high quality wildlife habitat, where an old-age forest requirement is applied in this analysis, were deferred from harvesting for 10 years. These areas include the Kennedy Siding Section 12 Caribou Reserve, and portions of the Mount Selwyn/ Canty Lake area, the Russell Range, the Upper Ospika River valley, Phillips Creek, Carina-Tomias Lakes, the Manson Peninsula, and the Wolverine Range. These areas constitute 77 111 hectares, or 6.6% of the timber harvesting land base.

Analysis showed that deferring harvests in these areas for 10 years does not limit timber supply. Allowing for immediate harvests in these high value wildlife areas would not create potential for increasing harvests above base case levels without causing future timber supply disruptions. Harvesting could be deferred for up to 80 years before causing severe timber supply shortfalls relative to the base case harvest forecast. However, the longer harvesting is delayed, the more activity would have to concentrate in these areas when it does occur. For example, if harvesting were deferred for 50 years, the high quality wildlife habitat areas would have to provide 27% of the total harvest. While such a regime would not violate forest cover and old-age forest requirements, it would reduce management flexibility further into the future.

5.10 Uncertainty in minimum harvestable ages

Minimum harvestable age is an estimate of the time needed for a type of stand to reach a merchantable condition. Minimum harvestable ages determine when second growth will be available for harvest, therefore affecting how quickly existing stands may be harvested. The time at which stands will become merchantable is highly uncertain. This is partly because of uncertainty about the growth of regenerated stands, but more importantly because we cannot foresee future conditions that will determine merchantability.

For this analysis, minimum harvestable ages were estimated as the age at which stands reach 95% of the maximum average growth rate (or culmination* of mean annual increment (MAI)). This method was chosen to ensure that the long-term production of the harvesting land base would be close to its maximum. The minimum harvestable ages are minimums; stands may be harvested at older, but not younger, ages. If necessary to meet management objectives, forest cover requirements would override the minimum harvestable ages. Minimum harvestable ages are meant to approximate the timing of merchantability, and are not legal or policy requirements.

Culmination age
The age at which a timber stand reaches its highest mean annual increment (MAI). MAI is calculated as stand volume divided by stand age. Culmination age is the optimal biological rotation age to maximize volume production from a growing site.

Figure 22 shows how timber supply would change if stands in fact become merchantable either 10 years sooner or later than assumed for the base case.

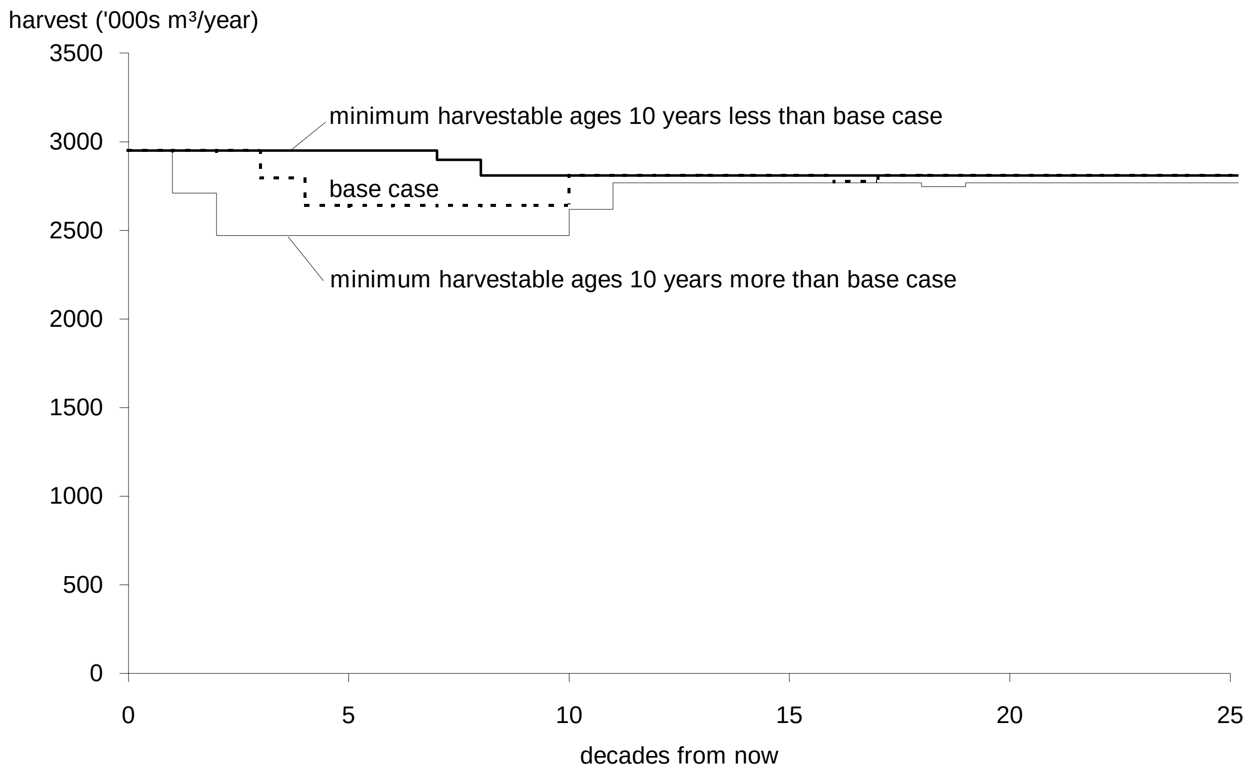

Figure 22. Harvest forecasts if minimum harvestable ages are 10 years younger or older than the base case — Mackenzie TSA, 1995.

If minimum harvestable ages were 10 years older than in the base case, results indicate that to minimize the degree to which harvests must decline over the medium term (between 20 and 100 years from now) harvests would need to begin declining from the current AAC 10 years from now. The lowest level is 16.3% less than the current allowable harvest; and the decrease from the first to the second decade is 8.1% of the current level. If minimum harvestable ages were 10 years older, the long-term level would be 1.5% below that for the base case. An alternative harvest projection would be to maintain the current harvest level for 30 years, then decline to about 19% below the current level by 50 years from now, with the same long-term level. That is, the decline shown beginning after the first 10 years in Figure 22 is not required to avoid violating forest cover requirements or causing severe timber supply disruptions; but reducing harvests at that time rather than in 30 years would minimize the degree to which harvests would have to decline over the next 100 years.

Older minimum harvestable ages reduce the long-term harvest level because, on average, stands would be harvested after they attain their maximum average growth rate. If minimum harvestable ages were 10 years more than in the base case, the average stand age at harvest over the long term (after 200 years from now) would be about 130 years, while in the base case the average is 115 years.

With minimum harvestable ages 10 years older, timber supply over the next 100 years would be 7% less than in the base case. Between years 100 and 250, the total timber supply would be 1.7% less than in the base case.

If minimum harvestable ages were 10 years younger than in the base case, the current harvest could be maintained for 70 years before declining to the same long-term level as in the base case. Younger minimum harvestable ages did not result in a change in the long-term harvest level because, on average, actual timing of harvests over the long term (100 to 250 years from now) with the younger ages and with base case ages resulted in approximately equal average productivity. If minimum harvestable ages were 10 years less than in the base case, stand age at harvest would average 100 years over the long term compared to 115 years in the base case. With the younger minimum harvestable ages, total timber supply would be 6% greater than in the base case over the first 100 years, and the same over the last 150 years of the analysis horizon.

Minimum harvestable ages for the base case were defined by the age at which average timber growth is estimated to reach 95% of the maximum. This methodology was used so that projected harvests occur approximately at stand ages that maximize the productivity of the Mackenzie TSA land base. However, other factors, such as volume per hectare could also be used as a criterion for determining minimum harvestable age. Figure 23 shows the harvest forecast that results if minimum harvestable ages were defined using minimum volume per hectare criteria of 140 cubic metres per hectare for areas harvestable by conventional harvesting systems (skidders), and 250 cubic metres per hectare for areas harvestable only by cable harvesting systems. The overall average minimum harvestable age for second-growth using these minimum-volume criteria is 75 years, compared to 100 years for the base case. For existing stands, minimum harvestable ages for the base case average 92 years, while for the minimum-volume criteria, the average is almost the same, at 95 years.

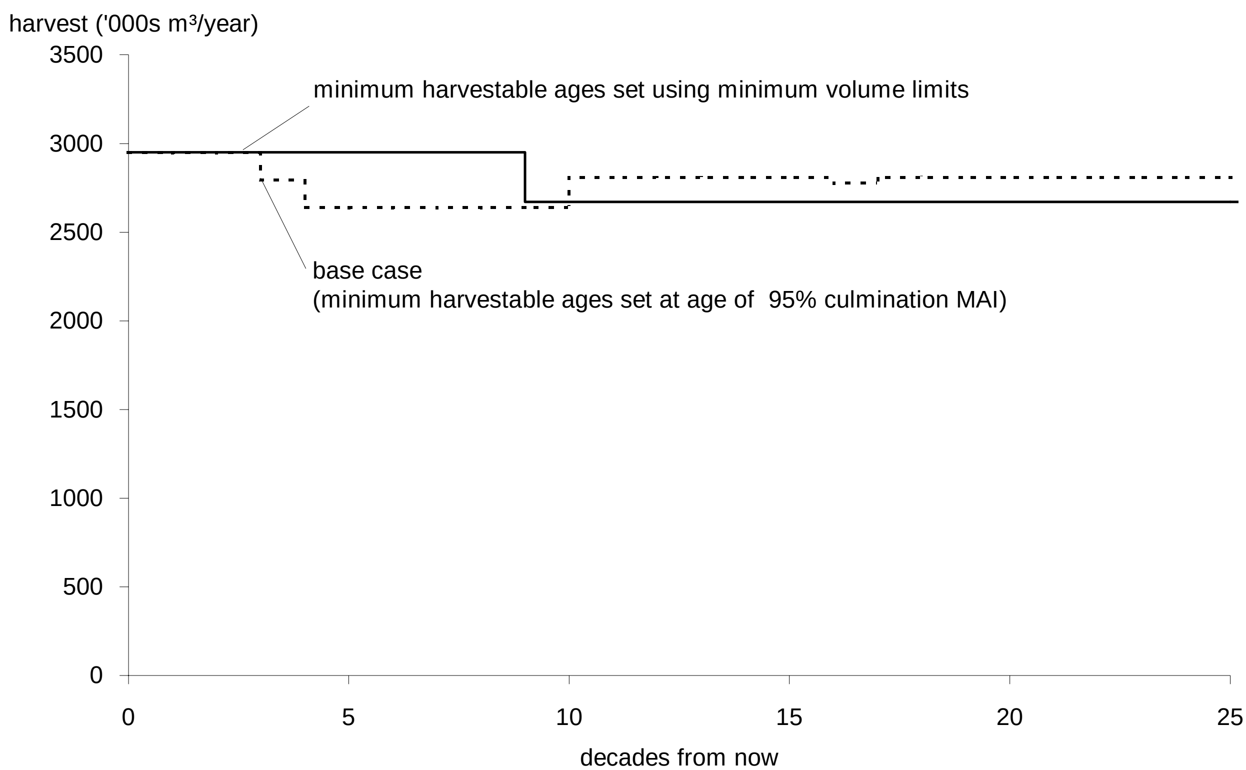

Figure 23. Harvest forecasts if minimum harvestable ages are based on minimum volume/hectare criteria — Mackenzie TSA, 1995.

Results show that the volume-based minimum harvestable ages would increase timber supply over the first 100 years, allowing maintenance of the current harvest level for 90 years. The long-term level would be 5%, or 140 000 cubic metres per year, less than in the base case. Total volume harvested over the first 100 years would be almost 6% greater using the volume-based minimum harvestable ages, while from 100 to 250 years from now, the cumulative harvest would be 4.5% lower than in the base case. With the volume-based minimum harvestable ages, the average harvested age in the long term (after 200 years) would be 90 years, compared to 115 years for the base case. The lower harvested ages means that stands would be harvested before reaching maximum average growth, and therefore the long-term level is lower than in the base case.

These results show that timber supply over the next 100 years is very sensitive to uncertainty in harvest ages for second-growth. Long-term supply shows low sensitivity to this uncertainty. Changes to minimum harvestable ages do not remove the necessity of eventually declining to a level sustainable in the long term.

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

5.11 Uncertainty in regeneration delay

Regeneration delay is the time between harvesting and the establishment of a new stand by either planting or natural regeneration. Current management calls for planting of almost all harvested sites with a regeneration delay of 3 years. This section discusses how timber supply would be affected if stands are actually re-established more quickly or more slowly than assumed for the base case.

Figure 24 demonstrates that a 3-year change in regeneration delay would affect timber supply moderately. If regeneration delays were eliminated, the current harvest level could be maintained for 10 years longer than in the base case, and harvests between 41 and 100 years from now could remain well above (8.7%) base case levels during that time without creating severe timber supply shortages further in the future. The long-term level would be 95 000 cubic metres per year, or 3.4% higher than in the base case. Over the next 100 years, harvests would total 5.6% more than in the base case.

If delays are actually 3 years longer, that is double the base case values, timber supply over the next 100 years would be about 1.7% lower than in the base case. The current harvest level could still be maintained for the next 20 years without causing severe timber supply shortages in the future, or requiring significantly smaller harvests than in the base case between 51 and 100 years from now. The long-term level would drop by 120 000 cubic metres per year, or 4.5%, relative to the base case.

Shorter regeneration delays would increase timber availability moderately over the next 100 years, but longer delays would not require harvest level reductions in the short term. Timber supply over the longer term, after 100 years from now, would also be affected moderately if regeneration delays are either shorter or longer than in the base case. Changes in timber supply stem from changes in the time needed for stands to reach both green-up and minimum harvestable ages.

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

5.12 Uncertainty in land base available for harvesting

Defining the timber harvesting land base for this analysis involved several assumptions about the types of forest land that are available for harvesting. Inventory classifications together with forest development plans were used to approximate which stands are merchantable and physically operable (feasible to access with existing technology). Since approximations were used to define the land base, and because the inventory itself contains uncertainty, there is some uncertainty about how much area actually falls within the harvesting land base under current management.

A concern specific to the Mackenzie TSA, is that an operability classification has not been performed for the area north of 57 degrees latitude, which forms almost one-third of the Mackenzie TSA. To account for the lack of an operability classification, portions of areas north of 57 degrees latitude were deducted from the harvesting land base using factors developed from representative areas south of 57 degrees. This approximation introduced uncertainty into the process of defining the area available for timber harvesting. It should be noted that very little timber harvesting has occurred in the northern areas of the TSA. Mackenzie Forest District staff felt that assuming the entire area is physically operable would overstate the area actually available for timber production and harvest. To assess the sensitivity of timber supply to uncertainty in defining the timber harvesting land base, the area in all stand types and ages used for the base case was both increased and decreased by 5% and 10%.

If the timber harvesting land base were in fact 10% larger than defined for the base case, the current harvest level could be maintained for 50 years before declining slightly, and then rising to a long-term level 10% (281 000 cubic metres per year) higher than in the base case 100 years from now (Figure 25). The higher long-term level could not be achieved until second-growth stands on the larger land base reach merchantable condition (the minimum harvestable ages). Over the first 100 years, the total timber supply in this forecast is 7% higher than in the base case, while over the long term (years 100 to 250), timber supply, in total, is 10% greater.

The timber supply over the first 100 years was not shown to be 10% larger because a different harvest flow pattern over time was followed than in the base case. The cumulative harvest for a land base 10% larger than in the base case could be 10% higher if harvests were 10% above those in the base case in each year; that is, if harvests began at 10% above the current level and followed the same pattern as the base case, including the harvest level dip between 31 and 100 years from now. For this sensitivity analysis, the current harvest level was maintained for as long as possible with as little decline as possible. Therefore, by following the harvest flow pattern over time shown in Figure 25, which minimizes declines in the harvest, the total harvest over the next 100 years would be slightly less than the maximum possible.

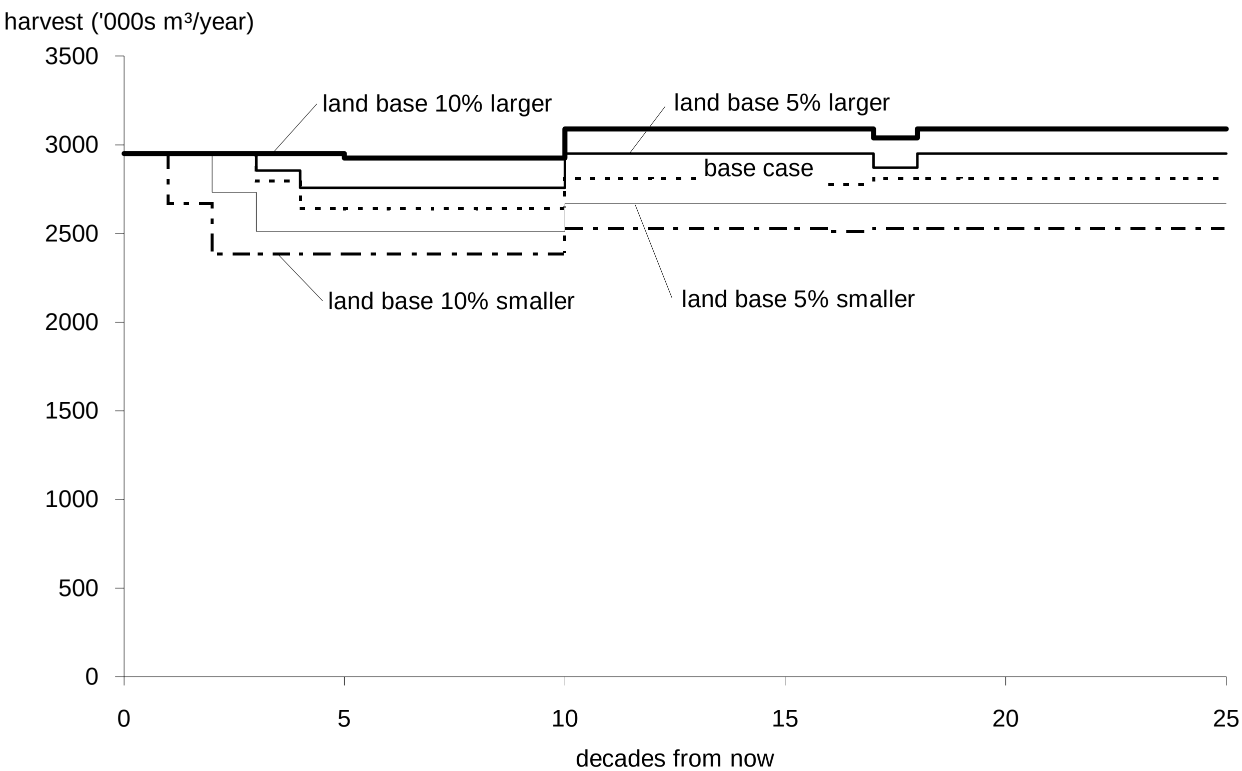

Figure 25. Harvest forecasts reflecting uncertainty in size of the harvesting land base — Mackenzie TSA, 1995.

Figure 25 also shows how a 5% increase in the land base would affect potential harvests. The current harvest level could be maintained for the same length of time as in the base case, while timber supply would be sufficient to maintain harvests higher than base case levels after 30 years from now. Cumulative timber supply over the next 100 years would be 2.8% greater than in the base case, and the long-term harvest would be 5% higher.

Results displayed in Figure 25 indicate that a land base 10% smaller than in the base case could support the current allowable level for the next 10 years, but overall, the total timber supply over the next 100 years would be 10% less than in the base case. The projected harvest shown between 31 to 100 years from now is 19% less than the current level. The current harvest level could also be maintained for 30 years, but harvests would then have to decline to 22% less than the current level during the period from 51 to 100 years from now to avoid creating severe timber supply disruption further in the future. If the timber harvesting land base is 10% smaller, the long-term level and cumulative harvest from 100 to 250 years from now would be 10% lower than for the base case.

On a land base 5% smaller than defined for the base case, the current harvest level could be maintained for the next 20 years. However, timber supply over both the next 100 years and over the long term would be 5% lower than in the base case.

In summary, timber supply is very sensitive to uncertainty about the size of the timber harvesting land base. Changes to long-term supply are proportional to changes in the size of the land base. Over the medium term (next 100 years), timber supply shows slightly less, but still significant, sensitivity to land base changes than over the long term. An increased land base could extend the time over which harvesting could continue at the current level; a smaller land base would require either earlier harvest level reductions, or larger declines further into the future.

5.13 Uncertainty in estimates of timber volumes in existing stands

Estimates of standing timber volumes in existing forest stands are subject to some uncertainty because they are based on extrapolation of statistics from some stands to all stands in an area, and on inventory classifications which contain some uncertainty. The standing volumes are more accurate when averaged over large areas, but may not reflect actual volumes in a specific area. Uncertainty may also stem from estimates of the volume lost to decay in standing trees, and to waste and breakage during timber harvesting, as well as estimates of utilization levels practiced during harvesting.

Figure 26 demonstrates that timber supply over the next several decades is very sensitive to uncertainty in existing volume estimates. If existing volumes are actually 10% greater than those used for the base case, the current harvest level of 2.951 million cubic metres per year could be maintained for almost 110 years before declining to the same long-term level as in the base case. Alternatively, a harvest of 2.981 million cubic metres per year, 1% above the current level, could be maintained for 100 years. The cumulative harvest over the next 100 years would be 8% larger than the base case if existing volumes were in fact 10% higher.

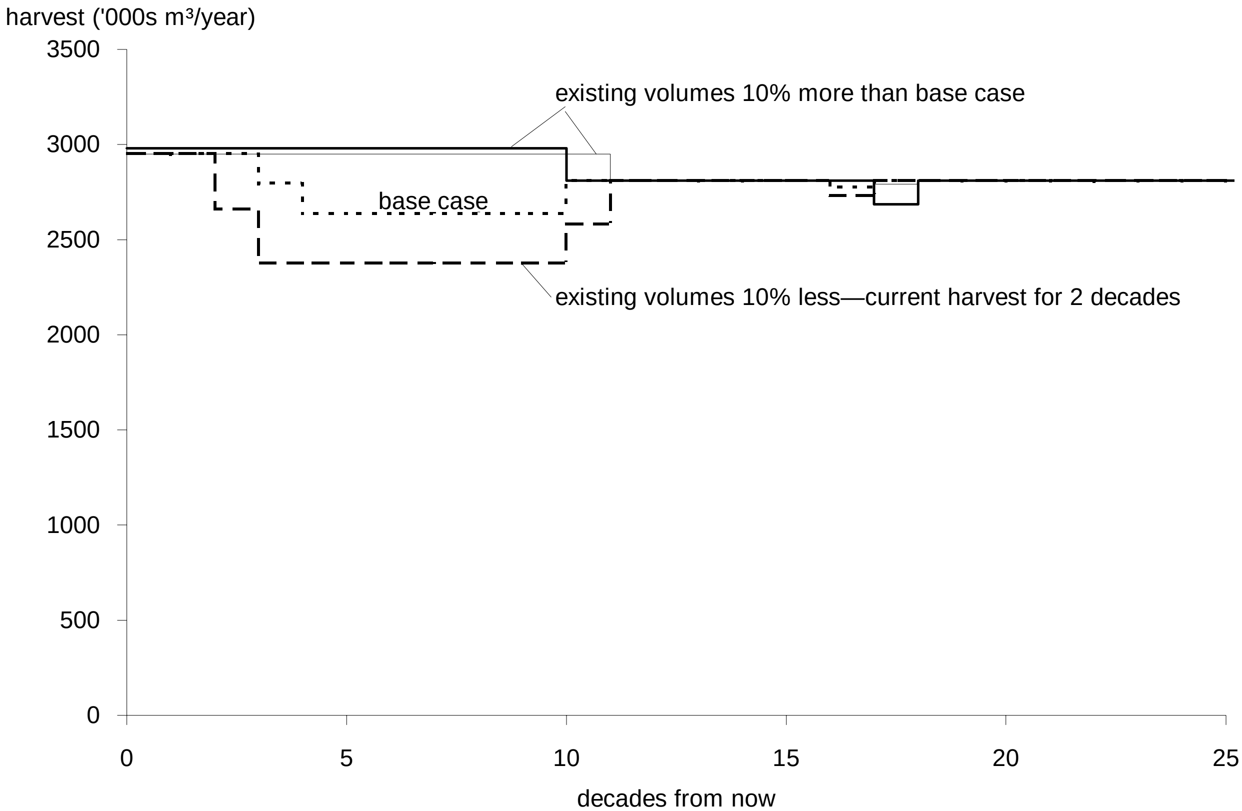

Figure 26. Effect on harvest forecast of 10% uncertainty in existing stand volumes — Mackenzie TSA 1995.

If existing volumes are in fact overestimated by 10% in the base case, the current harvest level could still be achieved, but harvests would need to decline to well below base case levels (about 19%) between 21 and 110 years from now. If existing volumes are 10% lower than estimated for the base case, the total harvest over the next 100 years would have to be about 8.2% less than in the base case to avoid creating severe timber supply disruptions further in the future. The long-term harvest level would not be affected.

In the base case harvest forecast, the average volume per area projected to be harvested over the next 30-year period is 278 cubic metres per hectare. The average over the next 100 years is 305 cubic metres per hectare. Mackenzie Forest District staff felt that these averages were reasonably close to realized harvest volumes. Furthermore, an inventory audit completed in 1994 indicated that, for the Mackenzie TSA as a whole, current inventory information used in conjunction with VDYP (the timber yield estimation model used for this analysis), produced accurate estimates of actual existing standing volumes.

This sensitivity analysis shows that timber supply over the next several decades is very sensitive to uncertainty about standing volumes in existing mature forests. This uncertainty does not affect the harvest level sustainable over the long term. Current evidence indicates that the volume estimates used are reasonably accurate.

5.14 Uncertainty in site productivity estimates

The productivity of a site largely determines how quickly trees will grow. It therefore affects both expectations of timber volumes in regenerated stands, and the age at which those stands will reach merchantable size. The most accurate assessments of site productivity come from stands between 30 and 150 years old. Estimating site productivity in both young and old stands is difficult. Currently, about 56% of the Mackenzie TSA timber harvesting land base comprises stands between 30 and 150 years old. The age composition of the forest in the Mackenzie TSA forms a better basis for estimating site productivity than if most of the area was either very old or young. However a substantial area still lies outside the age range that provides accurate estimates. This section examines how timber supply is affected by uncertainty in site productivity estimates that determine both regenerated stand volumes and minimum harvestable ages.

Uncertainty in site productivity estimation could also affect the time needed for stands to reach green-up conditions. Estimates of the potential effect of site productivity uncertainties on green-up ages for lodgepole pine and white spruce, suggested that site index* at 50 years of age would have to change by 5 to 6 metres to result in a 5-year change in green-up age. There is currently no evidence to indicate the degree to which site index estimates for the Mackenzie TSA may be inaccurate, and therefore no way of determining by how much green-up age could change. Further, a 5-year change in green-up ages had little effect on potential harvest levels (see Section 5.3, "Uncertainty in green-up ages"). Therefore, while it is acknowledged that uncertainty in site productivity estimates would likely affect green-up ages, with consequent effects on timber supply, this effect is not assessed as part of this sensitivity analysis.

Figure 27 displays how timber supply would change if current data underestimate actual site productivity. If regenerated stand volumes are actually 25% greater than base case levels, and minimum harvestable ages are 10 years younger, it would be possible to maintain the current harvest level (2.951 million cubic metres per year) for 100 years, after which harvests could begin to rise to a long-term level of 3.56 million cubic metres per year, 25% higher than in the base case. Over the next 100 years, the total timber supply would be 7.4% more than in the base case.

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

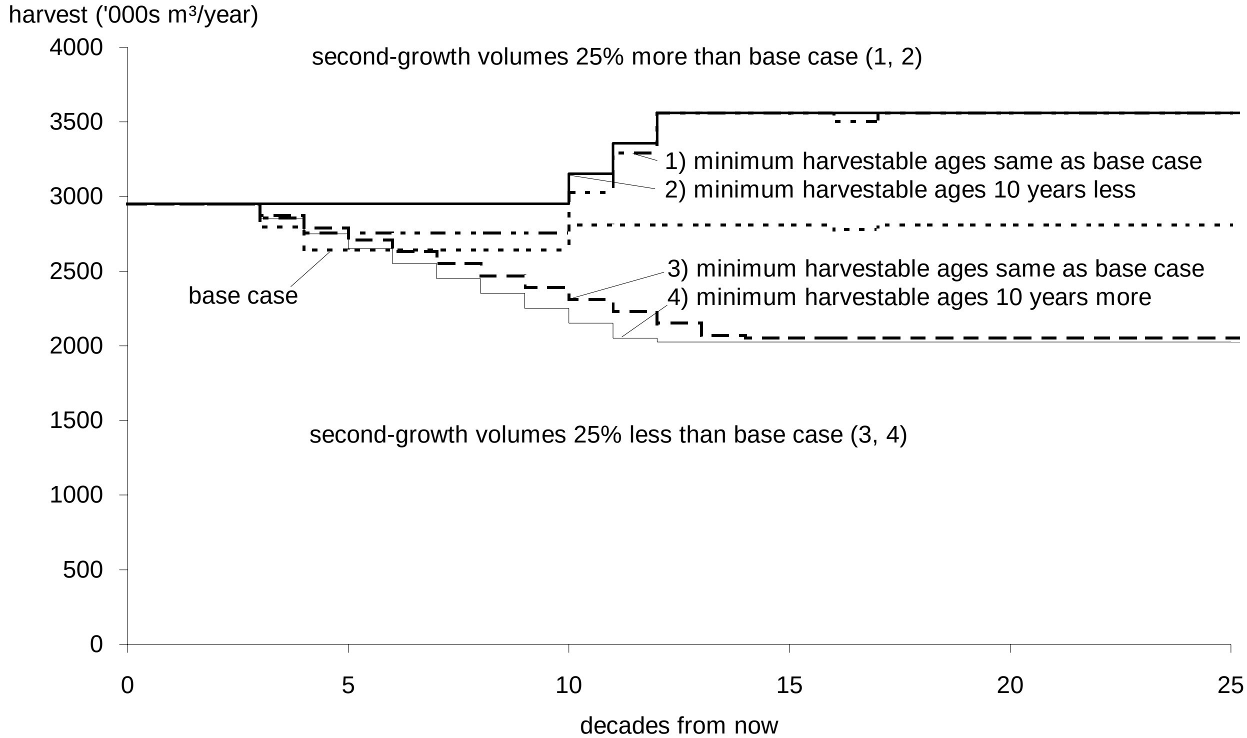

Figure 27. Harvest forecasts if site productivity 25% different than in the base case — Mackenzie TSA, 1995.

If regenerated stand volume estimates alone are 25% higher, but minimum harvestable ages are the same as in the base case, the current harvest level could be maintained for the same length of time as in the base case. Harvests between 31 and 100 years from now could remain above base case levels during that period, but would still need to decline somewhat before increasing to a long-term level 25% higher than in the base case. Over the first 100 years of the analysis horizon, 2.8% more volume would be available for harvest than in the base case. This demonstrates that increased timber supply over the next few decades due to any increase in site productivity would be related mostly to decreased harvestable age, and not only to increased stand volumes.

The increases in timber supply over the next 100 years shown in these results stems from increases in timber volumes in stands available for harvest several decades from now. The volume of timber in stands available for harvest over the next few decades would not change if volumes in managed regenerated stands were different than predicted for the base case. Therefore, any increase in harvests over the short term (next few decades) predicated on expectation of higher volumes in future stands would require lower harvests over the medium term (40 — 100 years from now) to avoid creating severe timber supply disruptions. Furthermore, higher short-term harvests may place medium term timber supply at risk if the higher stand-volume predictions did not actually come to bear.

Figure 27 also shows how reduced regenerated stand volumes, together with increased minimum harvestable ages would affect timber supply. If second-growth stands actually produce 25% less volume than estimated for the base case, and minimum harvestable ages are 10 years older, the current harvest level could still be maintained for 30 years before declining at 100 000 cubic metres per decade to a long-term level about 25% less than in the base case (2.03 million cubic metres per year). Over the next 100 years, cumulative timber supply would be 2.8% less than in the base case. If minimum harvestable ages are the same as for the base case, while future stand volumes are 25% lower, harvests could decline at a slightly slower rate of 80 000 cubic metres per decade. Timber supply over the next 100-year period would be 0.8% less than in the base case.

The results show that if current estimates of site productivity overestimate actual potential, harvests over the next few decades would not need to decline from base case levels to avoid causing severe timber supply disruptions further in the future. While the long-term level would be well below the current harvest level, sufficient volume exists so that harvests could be reduced in a controlled fashion over the next 120 to 130 years to reach a sustainable level

Figure 28 displays how timber supply would be affected if second-growth stands grew at the same rate, and reached merchantable condition at the same ages, as did existing stands. This is similar to the case, discussed in the previous paragraph, in which second-growth stand volumes were lower and minimum harvestable ages were higher than in the base case. Again, while the long-term level would be significantly lower than in the base case, immediate harvest level adjustments relative to the base case would not be required. The current harvest level could be achieved for 30 years, without creating severe future timber supply disruptions, if followed by declines of 90 000 cubic metres per decade between 31 and 150 years from now. The long-term level of 1.81 million cubic metres per year is 36% lower than in the base case. Viewed in reverse, timber production from second-growth as estimated for the base case is 55% higher than from existing stands. This productivity increase is due to management of stands to ensure that sites are fully stocked with merchantable tree species, and that tree crops do not experience extreme competition due to overly-dense stocking, or non-crop trees or shrubs.

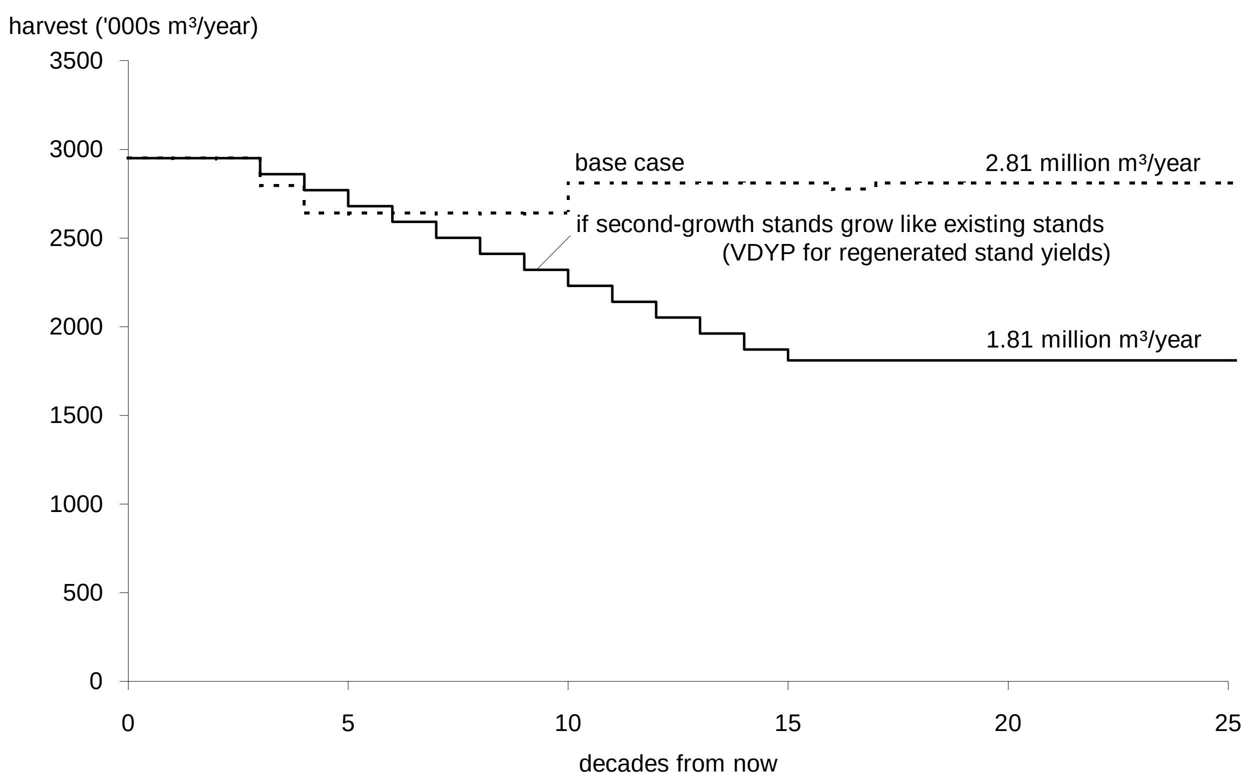

Figure 28. Harvest forecast if future stands grow in the same manner as did existing stands — Mackenzie TSA, 1995.

In summary, uncertainty about site productivity quite dramatically affects long-term timber supply. Timber supply is less sensitive to this uncertainty over the short term. However, increased site productivity could allow maintenance of the current harvest level until sufficient second-growth is available to allow harvests at a higher long-term level, if future stands become available for harvesting at younger ages. The increase in available timber in the short term would be due largely to decreased minimum harvestable age. Decreased site productivity would require continued declines in harvest levels over the next 120 to 150 years, but immediate harvest level reductions relative to the base case, would not be required to avoid severe future timber shortages.

5.15 Summary of sensitivity analysis

Table 2 summarizes the results of the sensitivity analysis discussed in the last several sections. The summary table lists the differences in cumulative timber supply between each sensitivity analysis and the base case over both the next 100 years and between 101 and 250 years from now. These figures provide a quantitative basis for comparing the effects of various uncertainties associated with inventories and management objectives.

Differences between the base case harvest and the sensitivity analysis results over the short term (next 20 years) are not provided for most cases. The analysis showed that in only one case — application of a 5-pass harvesting system in the integrated resource management areas — did forest cover requirements require harvest reductions over the next 20 years. In all other cases where results indicated that uncertainties could reduce timber availability over the next 100 years, harvests did not need to drop below base case levels over the next 20 years to avoid violating forest cover requirements, or causing severe timber supply disruptions further in the future. For example, the results show that if the timber harvesting land base were actually 10% smaller than in the base case, minimizing the total decline in harvests from the current AAC would mean that harvests should begin declining after 10 years from now, followed by a further decline to below the base case levels for years 11 to 100. However, the current level could be maintained for longer if larger rates of decline, and slightly lower harvests further in the future (between 40 and 100 years from now) were accepted. The implication of these results is that in cases where total timber supply over the next 100 years was shown to be less than the base case, the cumulative harvest over that period would have to be less than the base case, but some flexibility would be available as to when to implement any changes.

The figures provided in Table 2 are based on the specific harvest patterns over time shown in this report. If different harvest patterns were followed, the timber supply changes relative to the base case would be slightly different. However, the results shown provide a general indication of the overall magnitude, as well as the relative effects of different uncertainties.

Table 2. Comparison of total timber supply over short- medium-term (1-100 years) and long-term (100-250 years)

Variable/issue	Per cent difference from base case over years 1—100	Per cent difference from base case over years 100—250
Forest cover requirements to approximate adjacency (3-pass in base case):		
2-pass	none	none
4-pass	– 0.1	– 0.1
5-pass	– 0.8 **– 4% over years 1-20**	– 0.7
Green-up ages:		
5 years more than base case	– 0.2	– 0.2
5 years less than base case	+ 1.0	+ 0.1
Forest cover requirement for old-age forest (base case - 19 278 hectares):		
double of base case	– 1.4	– 2.3
none	+ 2.0	+ 0.7
5% requirement for all areas currently with no requirement	– 3.0	– 1.7
Definition of old-age forest (150 years in base case):		
50 years more than base case	– 1.25	– 0.8
50 years less than base case	+ 2.0	+ 0.7
Forest cover requirement for visual quality:		
5% less allowable disturbance than base case	none	-0.6
all requirements removed	+ 1.0	+ 0.3
Forest cover requirement for wildlife habitat and watershed protection (base case: maximum 21% not meeting green-up):		
10% less allowable disturbance	– 0.2	– 0.3
requirement removed	none	none
Cumulative effect of forest cover requirements:		
all requirements removed	+ 2.0	+ 1.0

Base case cumulative timber supply:
years 1–100 — 274.890 million cubic metres
years 101–250 — 421.164 million cubic metres

continued

Table 2. Comparison of total timber supply over short- medium-term (1-100 years) and long-term (100-250 years) (concluded)

Variable/issue	Per cent difference from base case over years 1—100	Per cent difference from base case over years 100—250
Deferral of high quality wildlife habitat areas (77 111 hectares in base case):		
no deferral	none	none
deferral for up to 80 years	none	none
Minimum harvestable ages:		
10 years more than base case	– 7.0	– 1.7
10 years less than base case	+ 6.0	none
Regeneration delay (3 years for base case):		
3 years longer than base case	– 1.7	– 4.5
3 years shorter than base case	+ 5.6	+ 3.4
Size of timber harvesting land base:		
10% smaller than base case	– 10.0	– 10.0
10% larger than base case	+ 7.0	+ 10.0
Existing stand volumes:		
10% lower than base case	– 8.2	none
10% higher than base case	+ 8.0	none
Productivity of second-growth stands:		
volumes 25% lower than base case		
i) base case minimum harvestable ages	– 0.8	– 25.0
ii) minimum harvestable ages 10 years longer than base case	– 2.8	– 27.5
volumes 25% higher than base case		
i) base case minimum harvestable ages	+ 2.8	+ 25.0
ii) minimum harvestable ages 10 years shorter than base case	+ 7.4	+ 25.0

Base case cumulative timber supply:
years 1–100 — 274.890 million cubic metres
years 101–250 — 421.164 million cubic metres

6 Summary and Conclusions

The results of this timber supply analysis suggest that the current allowable harvest level in the Mackenzie TSA of 2.951 million cubic metres per year can be maintained for up to 30 years without either requiring substantial future harvest level reductions, or creating severe future timber disruptions. Using current inventory and timber growth information, and assuming continuation of current forest management practices, harvests could be maintained at the current level for 30 years if followed by a reduction between 31 and 50 years from now to 2.64 million cubic metres per year, or 10.5% below the current level. Harvests could increase to a level sustainable over the long run of 2.81 million cubic metres per year, or 4.8% below the current harvest level, 100 years from now.

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

The uncertainties with the largest potential effects on projected harvest levels over the next 100 years (that is, greater than 5% cumulative change over the next 100 years compared to the base case results described above) involve estimates of timber volumes in existing stands, the size of the timber harvesting land base, and minimum harvestable ages. Several factors were shown to have moderate effects on timber supply over the next 100 years (from 1% to 5% change relative to the base case). These include estimates of: site productivity of future managed stands, especially if estimates used in this analysis underestimate actual productivity; regeneration delay, particularly if actual delays are substantially shorter than assumed in the base case; forest cover requirements for management of visual quality, watershed protection, and wildlife habitat when considered cumulatively; forest cover requirements for old-age forest to maintain wildlife habitat; and finally, the minimum age at which stands are assumed to attain old-age characteristics.

Forest cover requirements to maintain visual quality, and the estimated age at which stands reach green-up conditions have a small effect on projected timber supply over the next 100 years (less than 1% cumulatively compared to the base case).

The forest inventory and management factors discussed above could affect timber supply over the next 100 years, but uncertainties about these factors did not require reduced harvests over the short term, that is, the next 20 years. The only management uncertainty that could require short-term harvest reductions to avoid violating integrated management objectives is related to forest cover requirements for integrated resource management areas. Specifically, application of a 5-pass harvesting system in the integrated resource management areas, rather than the 3-pass system assumed for the base case, would require reduced harvests from 11 to 20 years from now to avoid violating forest cover requirements. Analysis showed that uncertainties about other factors can affect overall timber availability over the next 100 years, but would not require that harvests drop below base case levels over the next 20 years to avoid either violating cover requirements, or creating severe timber supply disruptions in the future.

Over the long term, that is during the period from 100 to 250 years from now, only site productivity of future stands and the size of the timber harvesting land base have large effects on timber supply. Uncertainty about regeneration delay, the forest cover objective for old-age forest for wildlife habitat, and estimates of the minimum age used to define old-age forest all have moderate effects on long-term harvest levels. Minimum harvestable ages, forest cover requirements for visual quality, green-up ages, adjacency objectives for integrated resources management areas, and estimates of timber volumes in existing stands have low to no effect on long-term timber supply.

In conclusion, this analysis indicates that based on current inventory and growth and yield information, and the current management regime, timber harvests in the Mackenzie TSA can be maintained at the current allowable level for the next 30 years. Several factors related to the current forest inventory and management regime could affect timber supply over the next 100 years. No conclusive evidence was available prior to completion of this analysis to suggest that significant inaccuracies exist in the information used.

7 References

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8 Glossary

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

Culmination age
The age at which a timber stand reaches its highest mean annual increment (MAI). MAI is calculated as stand volume divided by stand age. Culmination age is the optimal biological rotation age to maximize volume production from a growing site.

Cutblock adjacency
The desired spatial relationship among cutblocks as specified in integrated resource management guidelines. They can be approximated by specifying the maximum allowable proportion of a forested landscape that does not meet green-up requirements.

Environmentally sensitive areas
Areas with significant non-timber values or fragile or unstable soils, or where there are impediments to establishing a new tree crop, or areas where timber harvesting may cause avalanches.

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

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

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

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

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

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

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

Glossary

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

Partial retention VQO — Alterations are visible but not conspicuous. Up to 15% of the area can be visibly altered by harvesting activity (see **Visual quality objective**).

Regeneration delay — The period of time between harvesting and the date by which an area is occupied by a specified minimum number of acceptable well-spaced trees.

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

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

Silvicultural treatments — Activities that ensure the regeneration of young forests on harvested areas enhance tree growth and improve wood quality in selected stands. Activities include: site rehabilitation and preparation, planting, spacing, fertilization and pruning.

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

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

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

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

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

Visual quality objective (VQO) — Defines a level of acceptable landscape alteration resulting from timber harvesting and other activities. A number of visual quality classes have been defined on the basis of the maximum amount of alteration permitted.

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

Appendix A

Description of Data Inputs and Assumptions

Introduction

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

A.1Zone and Analysis Unit Definition

A.1.1 Management zone characteristics

For this analysis, the Mackenzie TSA was separated into eight management zones each of which has a different forest management regime described as a set of forest cover objectives. Table A-1. describes each zone briefly. Zones were defined using the forest cover polygons available from the forest inventory file. A detailed listing of the polygons in each zone is available from the Timber Supply Branch in Victoria, or in the data package available in the Mackenzie Forest District office. Table A-2. lists the area in each management zone within the timber harvesting land base.

Table A-1. Forest management zones

Zone	Forest management regime	Geographic areas
1 Non-forest uses	100% exclusion from the timber harvesting land base.	- Pine Pass Ski/Azouzetta Lake Recreation Area - Estella - Ed Bird Lakes - Blackpine Indian Reserve - Germansen Landing Settlement Corridor - Manson Creek Settlement Area
2 Watershed and wildlife values	Maximum of 15% of the area may be below 3 metre green-up at any time. Applies to gross forested land base.	- Mackenzie Watershed - Germansen Landing Watershed - Germansen Lake - Omineca River Valley - Pesika River Valley - Schooler Creek
3[a] Wildlife values (old-age 1)	10 year deferral plus a minimum of 25% forest cover older than 150 years (200 year rotation).	- Mt. Selwyn/Canty Lake - Russell Range - Stone's Sheep/Mountain Goat - Upper Ospika River Valley - Philips Creek
4[a] Wildlife values (old-age 2)	10 year deferral plus a minimum of 25% forest cover older than 150 years (200 year rotation).	- Kennedy Siding Section 12 Caribou Reserve - Carina - Tomias Lakes - Manson Peninsula - Wolverine Range
5 Integrated resource management	Maximum of 33% of the forest can be in a non-green–up condition, (2.5 metres or less tree height), at any point in time.	- all areas not in another management zone
6 Retention VQO	Maximum of from 1-5% less than 3 metres in height, depending on visual absorption capacity	- areas with visual landscape concerns: Wasi Lake, Fort Ware, Highways 97 and 39, Estella/Ed Bird Lakes, Tutizzi Lake, Omineca LRUP
7 Partial retention VQO	Maximum of from 6-15% less than 3 metres in height, depending on visual absorption capacity	as above
8 Modification and maximum modification VQO	Maximum of from 16-40% less than 3 metres in height, depending on visual absorption capacity	as above

(a) The timber supply analysis report refers to zones 3 and 4 together as areas with high wildlife values requiring a minimum percentage cover of old-age forest.

A.1Zone and Analysis Unit Definition

Table A-2. Timber harvesting land base by management zone

Zone	Timber harvesting land base (hectares)	Per cent of timber harvesting land base
(2) Wildlife/watershed	9 318	0.8
(3) Wildlife (old-age 1)	43 137	3.7
(4) Wildlife (old-age 2)	33 974	2.9
(5) Integrated resource management	1 047 444	90.2
(6) Retention VQOs	3 722	0.3
(7) Partial retention VQOs	12 971	1.1
(8) Modification VQOs	10 016	0.9
Total	1 160 581	100.0

Note: If zone 1 (non-forest uses) from Table A-1. were included in the timber harvesting land base, it would contribute 15 858 hectares, or 1.4%.

A.1.2 Analysis unit characteristics

To simplify the analysis, individual forest stands were grouped according to dominant tree species (inventory type group — I_TYPGRP) and timber growing capability (site class — NSITE or SSITE).

Table A-3. shows the variables used to define each analysis unit. Analysis units were defined using special site class (SSITE), where available, for areas less than 30 years old; otherwise new site class (NSITE) was used.

A separate timber yield table was generated for each analysis unit (see Table A-17. for existing natural stands and Table A-19. for existing and future managed stands). The analysis units are not management-zone specific; that is, the same yield table for an analysis unit applies to all management zones described in Section A.1.1, "Management zone characteristics."

A.1Zone and Analysis Unit Definition

Table A-3. Analysis unit characteristics

Analysis unit number	Species group	Type groups (I_TYPGRP)	Site classes	Timber harvesting base (includes NSR) (hectares)	Per cent contribution to timber harvesting land base
1	Leading balsam	18,19,20	good	3 964	0.34
2	Leading balsam: 0-140 years old	18,19,20	medium	21 441	1.85
22	Leading balsam: over 140 years old	18,19,20	medium	20 894	1.80
3	Leading balsam: 0-140 years old	18,19,20	poor & low	23 320	2.01
23	Leading balsam: over 140 years old	18,19,20	poor & low	75 879	6.54
4	Leading spruce and Douglas-fir	1 - 8, 21,22,24, 25, 26	good	60 807	5.24
5	Leading spruce and Douglas-fir	1 - 8, 21,22,24, 25, 26	medium	153 202	13.20
6	Leading spruce and Douglas-fir 0-140 years old	1 - 8, 21,22,24, 25, 26	poor & low	50 691	4.37
26	Leading spruce and Douglas-fir over 140 years old	1 - 8, 21,22,24, 25, 26	poor & low	183 970	15.85
7	Leading lodgepole pine	28,29,30, 31	good	145 677	12.55
8	Leading lodgepole pine	28,29,30, 31	medium	329 670	28.41
9	Leading lodgepole pine	28,29,30, 31	poor & low	91 066	7.85
	Total			1 160 581	100.00

A.2 Definition of the Timber Harvesting Land Base

Timber is harvested from only a portion of the total Mackenzie TSA area. One of the first steps in this timber supply analysis was to define the timber harvesting land base. This land base was derived by deducting certain types of land and forest where timber harvesting is not likely to occur under current management. The characteristics of each deduction are discussed below in the order in which they were performed.

A.2.1 Land not managed by the B.C. Forest Service

The ownership (OWNER and OWNRCHAR) codes on the inventory file were used to determine which areas are not managed by the Forest Service. This category includes areas such as parks, ecological reserves, private land and various special use permit areas. Forest in ownerships 62 C (forest management unit) and 69 C (forest reserves) contributes to timber harvesting. Areas with other ownership codes do not contribute to the harvesting land base. Table A-4. outlines the ownership classification for the total Mackenzie TSA land base.

Table A-4. Ownership codes for the Mackenzie TSA

Description	Ownership code	Area	
		Hectares	Per cent of total
Crown grant	40-N	5 090	0.08
Federal reserve	50-N	15	0.00
Indian reserve	52-N	788	0.01
Ecological reserve	60-N	901	0.01
Use, recreation and enjoyment of public (UREP)	61-C 61-N	4 885 654	0.08 0.01
Forest management unit	62-C	6 075 085	99.09
Provincial park, class A	63-N	92	0.00
Provincial park reserve	67-N	43	0.00
Forest service reserve	69-C 69-N	22 370 20 676	0.36 0.34
Miscellaneous leases	99-N	6	0.00
Total		6 130 605	100.00

No area on the inventory file is coded as woodlot (ownership 77). However, a portion of the current allowable annual cut has been apportioned to woodlots. Once a woodlot has been granted, the allowable harvest of that area is administered separately from the rest of the Mackenzie TSA. The allowable harvest apportioned to woodlots is therefore assumed not to be part of the current AAC for timber supply analyses in most TSAs. In this case however, since the current file does not distinguish any woodlot area, the AAC apportioned to woodlots was assumed to constitute part of the current AAC.

A.2 Definition of the Timber Harvesting Land Base

A.2.2 Non-forest land

Non-forest (TYPID_PR = 6) and non-typed (TYPID_PR = 8) areas do not contribute to timber harvesting. These categories include areas covered by such things as sparse alpine forest, ice, swamps, water, and rock.

A.2.3 Non-commercial (brush) cover

Non-commercial brush types (TYPID_PR = 5), were not included in the timber harvesting land base. Deciduous brush species are not used for timber in the Mackenzie TSA, and no rehabilitation of such areas is planned.

A.2.4 Area managed for preservation visual quality objective (VQO)

Some areas where visual quality is an important value are being managed according to a preservation VQO. Under this designation, no timber harvesting should be visible. Accordingly, such areas were deducted from the land base available for harvesting.

A.2.5 Environmentally sensitive areas (ESAs)

The forest inventory file includes a rating of environmental sensitivity for concerns such as wildlife habitat, sensitive soils and recreation. A portion of areas classified as environmentally sensitive were excluded from the timber harvesting land base according to Table A-5.

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

ESA code (1- high sensitivity) (2- moderate sensitivity)	Per cent of area unavailable
Es1 (soils)	90
Es2	50
Ep1 (regeneration difficulty)	90
Ep2	30
Ea (avalanche)	90
Er1 (recreation)	90
Er2	30
Ew1 (wildlife)	90
Ew2	30
Eh1 (watershed)	90
Eh2	30
Ec (management problems – old coding)	90

A.2 Definition of the Timber Harvesting Land Base

The environmentally sensitive area (ESA) factors are based, in part, upon a review of those factors used in the last Mackenzie TSA analysis (November 1988) and a review of the current forest inventory file produced in January 1994. Additional wildlife habitat areas (Ew) not identified in the inventory files were addressed using management zones. Sensitive soils (Es) were dealt with, in part, through the operability mapping completed for the TSA. Sensitive recreation areas (Er) were addressed through recreation reserves identified in the inventory files as well as through specific management zones. The ESA exclusion factors shown in Table A-5. were applied in all management zones.

The ESA definitions are:

- Es — areas with unstable soils that may deteriorate unacceptably after forest harvesting.
- Ep — areas where regeneration will likely be difficult.
- Ea — areas intended to protect human-made structures and valuable natural resources from snow avalanches.
- Er1 — areas where recreational values, including viewing, are exceptionally high.
- Er2 — areas where recreational values are high but less than Er1.
- Ew1 — areas of critical importance to wildlife for food, shelter or reproduction.
- Ew2 — wildlife values are important but less so than Ew1.
- Eh1 — areas identified as watersheds that require special protection or special management to maintain water quality, quantity and seasonal distribution of consumptive use.
- Eh2 — areas where water values are important but less than Eh1.
- Ec — areas with management problems including isolated patches of mature timber, snow chutes, sites with excessive regeneration delay, high elevation forest and watershed protection forest. This classification was used in areas surveyed prior to 1976. After this time "C" was replaced with a specific ESA code (s, r, w, r, h, or a).

A.2.6 Non-merchantable forest types

Several types of forest stands are not currently used because they are dominated by non-commercial tree species, contain low timber volumes, or have low productive potential for timber.

Deciduous-leading stands

All stands dominated by deciduous species were deducted from the timber harvesting land base.

Coniferous-leading stands (mature)

In Table A-6. an area inclusion factor of "0" denotes the coniferous-dominated forest cover types not currently used. Forest cover types with an area inclusion factor of "1" are currently used. The factors in Table A-6. apply to mature stands only, that is, stands 121 years and older for balsam and spruce, and 81 years and older for pine.

A.2 Definition of the Timber Harvesting Land Base

Table A-6. Area inclusion factors for mature stands (0=deducted from harvesting land base)

Type Group No.(s)	Distance zone [a]:	Near			Medium			Far		
	Logging system [b]: age/height/stocking class	**conv**	**mixed**	**cable**	**conv**	**mixed**	**cable**	**conv**	**mixed**	**cable**
18-20	Age≥7,Ht≥3,Stock=1	1	1	1	1	1	1	1	1	0
(balsam)	742,842,942	1	1	0	1	1	0	1	1	0
B, BH, BS	732,832,932	1	1	0	1	1	0	0	0	0
	721,821,921	1	1	0	1	1	0	0	0	0
	722,822,922	0	0	0	0	0	0	0	0	0
	Age≥7,Ht=1,All Stock	0	0	0	0	0	0	0	0	0
	72R,82R,92R	0	0	0	0	0	0	0	0	0
	73R,83R,93R	0	0	0	0	0	0	0	0	0
21-26	Age≥7,Ht≥3,Stock=1	1	1	1	1	1	1	1	1	0
(spruce)	742,842,942	1	1	0	1	1	0	1	1	0
S, SF, SH	732,832,932	1	1	0	1	1	0	0	0	0
SB, SPL,	721,821,921	1	1	0	1	1	0	0	0	0
SDec	722,822,922	0	0	0	0	0	0	0	0	0
	Age≥7,Ht=1,All Stock	0	0	0	0	0	0	0	0	0
	72R,82R,92R	0	0	0	0	0	0	0	0	0
	73R,83R,93R	0	0	0	0	0	0	0	0	0
28-31	Age≥5,Ht≥3,Stock=1	1	1	1	1	1	1	1	1	0
(pine)	542,642,742,842,942	1	1	0	1	1	0	1	1	0
Pl, PlF,	532,632,732,832,932	1	1	0	1	1	0	0	0	0
PlS, PlDec	533,633,733,833,933	1	1	0	1	1	0	0	0	0
	534,634,734,834,934	0	0	0	0	0	0	0	0	0
	521,621,721,821,921	1	1	0	1	1	0	0	0	0
	522,622,722,822,922	1	1	0	1	1	0	0	0	0
	523,623,723,823,923	0	0	0	0	0	0	0	0	0
	524,624,724,824,924	0	0	0	0	0	0	0	0	0
	Age≥5,Ht=1,All Stock	0	0	0	0	0	0	0	0	0
	52R,62R,72R,82R,92R	0	0	0	0	0	0	0	0	0
	53R,63R,73R,83R,93R	0	0	0	0	0	0	0	0	0

(a) Near, medium and far distance zones were defined according to distance from processing facilities in Mackenzie. The near zone comprises areas within 59 kilometres of Mackenzie, the medium zone lies between 60 and 149 kilometres away, and the far zone consists of areas more than 150 kilometres distant. The distance zones were defined by inventory region and compartment (REGION, COMPART) on the forest inventory file. A list of the regions and compartment in each distance zone is available from the Timber Supply Branch in Victoria.

(b) Conv: denotes areas operable with conventional (ground-based) logging technology (OPERABLE=A).
Mixed: denotes areas operable by a mixture of ground- and cable-based logging systems (OPERABLE=M).
Cable: denotes areas operable only with cable logging systems (OPERABLE=C).

Coniferous-leading stands (immature)

Areas with low timber-growing productivity, and between 41 years old and the age of maturity (81 years for pine, and 121 years for other conifers) were deducted from the timber harvesting land base according to site index at 50 years breast height age. Site index for each forest cover polygon was determined using FREDTAB, a computer program supported by the B.C. Ministry of Forests, Research Branch. Any stand with a site index less than that listed in Table A-7. was deducted from the harvesting land base. Stands with site indexes less than those listed will not reach approximately 140 cubic metres/hectare by 140 years of age.

Table A-7. Minimum site index for immature stand inclusion

Leading species	Age (years) (age classes)	Minimum site index @ 50 years
Balsam	41-120 (3 - 7)	8.6
Spruce	41-120 (3 - 7)	7.7
Pine	41-80 (3 - 4)	8.4

A.2.7 Inoperable areas

The inventory file contains an operability classification for most of the approximately two-thirds of the Mackenzie TSA south of 57 degrees latitude. The northern third of the Mackenzie TSA has not been assessed for operability. In addition however, operability has not been classified for some areas south of 57 degrees. To approximate operability in areas with no existing classification, factors were developed from representative areas, with similar tree species, site class, topography, and biogeoclimatic classification. Table A-8. lists the mapsheets for which no operability information exists, and the mapsheets used to develop approximation factors. The table also shows mapsheets with no operability classification which represent high elevation areas near the Mackenzie TSA border, and remote areas that Mackenzie Forest district staff believe are inoperable. These areas were not included in the timber harvesting base.

Table A-8. Mapsheets for which no operability information exists

Mapsheets with no operability classification (OPERABLE=N)	Mapsheet(s) used to calculate operability factors
Mapsheet series 94E,F,K,L (north of 57^{o} latitude)	94C0 51 ,52 ,53 ,54 ,55, 61, 62, 63, 64, 65, 71, 72, 73, 74, 75, 81, 82, 83, 84, 85, 91, 92, 93, 94, 95 94D0 60, 70, 73, 74, 75, 76, 77, 78, 79, 80, 84, 85, 86, 87, 88, 89, 90, 95, 96, 97, 98, 99, 100
093J092	093J093
Unclassified portions of 093O084	classified (non-"N") portions of 093JO084
094B 33, 34, 35, 36, 42, 43, 44, 45	094B025
093N037, 093076, 095D059, 094B052, 53, 62, 72, 81, 82, 91	new factors not calculated; high elevation and remote areas assumed inoperable

The approximation factors were calculated as the proportion in each operability class (conventional — A; cable — C; inoperable — I; mixed — M) by each biogeoclimatic subzone and analysis unit for each of the sample mapsheets. A listing of the factors is available from the Timber Supply Branch in Victoria.

After assigning operability classes as discussed above, land classified as inoperable (OPERABLE=I) was excluded from the timber harvesting land base. However, the inventory file shows that some not satisfactorily restocked (NSR) land in areas with timber harvesting history is classified as inoperable. Prince George Forest Region staff concluded that the operability classification in these areas was inaccurate. Therefore, the inoperability deduction was not applied to NSR on mapsheets in the 93 J/N/O and 94 C series.

A.2.8 Existing unclassified roads, trails, and landings

Many roads, trails and landings constructed for forest access and harvesting are not large enough to be classified on the inventory file. In some areas, the forest inventory may account for smaller roads, trails and landings through the Crown closure variable; that is, developed areas would have a lower Crown closure. To account for roads, trails and landings that have not been accounted for through either inventory classification or a reduction in the Crown closure, 4.7% of areas with logging history (HIST_REF=1), 25 years and younger including NSR, was deducted from the timber harvesting land base. Table A-9. shows how this figure was calculated.

Table A-9. Per cent area reductions for existing unclassified roads and landings

Forested area (not including non-commercial cover) 25 years and younger (hectares)	Total area of unclassified roads, trails, landings (hectares)	Per cent of land base under existing roads, trails and landings (column 2 over column 1)
382 732	18 100	4.7

The area of unclassified roads, trails and landings was estimated from the Major Licensee Silviculture Information System (MLSIS) and History Record databases, annual reports, Pre-Harvest Silviculture Prescriptions (PHSPs), maps and air photos.

A.2.9 Estimated area in streamside buffers

To account for protection of riparian and stream values within the Mackenzie TSA, 1% of the land base remaining after all deductions discussed to this point was excluded from the timber harvesting land base.

A.2.10 Land currently designated as having a use other than timber production

Areas in management zone 1, described in Table A-1., are not available for timber harvesting, and were consequently deducted from the harvesting land base. Some of these areas are in the process of having their land use designations changed from Provincial Forest (for example, Black Pine Indian Reserve, Germansen Landing, and Manson Landing).

A.2 Definition of the Timber Harvesting Land Base

A.2.11 Estimated area of future roads, trails and landings

To account for the loss of productive forest land during future timber harvesting and development, 6% of the timber harvesting land base is not considered to contribute to further timber production after it is harvested for the first time. The 6.0% figure includes 4.7% for unclassified roads, trails and landings, as defined for the existing land base, and 1.3% for areas that will likely be classified as non-forest in future inventories.

Future roads, trails and landings are modelled by removing the specified percentage from all areas not subject to the existing roads reduction. The future roads reduction applies only to areas for which the inventory records no history reference (HIST_REF=0).

A.3 Forest Management Assumptions

A.3.1 Utilization levels

The utilization level defines the maximum allowable stump height, and the breast-height and top diameters used to calculate merchantable timber volumes.

In the Mackenzie TSA, according to cutting permits and pre-harvest silviculture prescriptions, timber is currently utilized to a 12.5 centimeter minimum diameter at breast height, a 10 centimeter top diameter, and maximum 30 centimeter stump height for all species.

Utilization levels are in accordance with Standard Operating Procedure 35-1 from the *Timber Management Manual*, Prince George Forest Region.

A.3.2 Minimum harvestable age by analysis unit

Minimum harvestable age defines the earliest age at which a stand may be harvested, not the age at which harvesting must occur. For this analysis, minimum harvestable ages were defined as the age at which 95% of the maximum average growth rate (culmination of mean annual increment or CMAI) is reached. Table A-10. lists: the Prince George Forest Region priority cutting ages that apply to each analysis unit, which define the earliest age at which currently existing stands may be harvested, and are meant to ensure young stands are not harvested before old stands; the culmination ages for each analysis unit for both existing natural stands and existing and future managed stands; and the minimum harvestable ages for each analysis unit, again for both existing natural stands and existing and future managed stands. For existing natural stands, minimum harvestable age was defined as the lower of the regional priority age and the age at which 95% of CMAI is reached. This applied to poor-site spruce over 140 years old (95% of CMAI at 150 years) and poor-site lodgepole pine (95% of CMAI at 105 years).

A.3Forest Management Assumptions

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

Analysis unit	Species groups	Site class	Regional priority cutting age (years)	Culmination age *(natural/managed)* (years)	Minimum harvestable age *natural* (years)	Minimum harvestable age *managed* (years)
1	Leading B	G	121+	80/70	60	65
2	Leading B 0-140 yrs	M		90/100	70	90
22	over 140 yrs	M	121+	110/140	80	120
3	Leading B 0-140 yrs	P/L	121+	130/140	90	125
23	over 140 yrs	P/L		150/180	110	160
4	Leading S	G	141+	90/80	75	70
5	Leading S	M	141+	120/150	95	95
6	Leading S 0-140 yrs	P/L	141+	150/150	120	130
26	over 140 yrs	P/L		180/190	140	170
7	Leading Pl	G	101+	80/60	60	55
8	Leading Pl	M	101+	100/80	75	70
9	Leading Pl	P/L	101+	130/130	100	80

An assessment of the sensitivity of timber supply to changes in minimum harvestable age was performed for this analysis. Part of this assessment involved examining the effect of defining minimum harvestable ages based on minimum stand volume per hectare. Table A-11. shows the minimum harvestable ages for each analysis unit determined using a minimum stand volume criterion.

A.3Forest Management Assumptions

Table A-11. Minimum harvestable ages based on minimum stand volume

Analysis unit	Species groups	Site class	Minimum harvestable age based on minimum volume (a) *natural* (years)	Minimum harvestable age based on minimum volume (a) *managed* (years)
1	Leading B	G	65	50
	Leading B			
2	0-140 yrs	M	85	65
22	over 140 yrs	M	110	85
	Leading B			
3	0-140 yrs	P/L	105	85
23	over 140 yrs	P/L	140	110
4	Leading S	G	70	45
5	Leading S	M	85	65
	Leading S			
6	0-140 yrs	P/L	110	90
26	over 140 yrs	P/L	140	120
7	Leading Pl	G	60	45
8	Leading Pl	M	75	55
9	Leading Pl	P/L	115	95

(a) Minimum volume criteria are 140 cubic metres per hectare for areas operable with conventional technology (OPERABLE=A) and 250 cubic metres per hectare for other areas.

A.3.3 Harvest profile

The harvest profile describes any characteristics desired from the timber harvest, for example, the proportion of the total harvest made up of a particular tree species. No harvest profile requirements were applied in the Mackenzie TSA analysis.

A.3.4 Forest cover requirements

This analysis did not involve an explicitly spatial evaluation of timber supply. The computer model used (FSSIM Version 4.3) is not capable of scheduling harvests of specific cutblocks according to adjacency criteria, or old-growth requirements, for example. However, the model can incorporate forest cover requirements that specify either the maximum proportion of an area allowed in a disturbed condition (usually defined by the height of young trees), or the minimum required area of old-age forest. Pass systems for timber harvesting are often linked to stand-level adjacency concerns; that is, experience may show that a certain number of harvest passes may be necessary to meet adjacency guidelines. Since site specific adjacency guidelines and forest level cover requirements are linked, use of forest cover guidelines can approximate the effect of adjacency guidelines as well as broader forest level goals. The forest cover requirements applied in this analysis approximate current forest management practices, including forest cover guidelines for visual quality management (VQO guidelines) provided by the Ministry of Forests, Recreation Branch.

A.3Forest Management Assumptions

Forest cover guideline for 3-pass harvesting cycle

All area not under a management regime with specific forest cover requirements for visual quality, wildlife habitat or watershed protection was assumed to fall under a 3-pass harvesting system whereby no more than 33% of the timber harvesting land base may be stocked with stands less than 2.5 metres top height.

Forest cover requirements (green-up) for visual quality, wildlife, and watershed protection

VQO guidelines as reflected in *Procedures for Factoring Recreation Input into Timber Supply Analysis* were used to derive forest cover requirements for the VQO zones (6, 7, 8), and the wildlife habitat and watershed protection zone (2).

For VQOs, forest cover guidelines (maximum per cent below green-up age) vary by VQO class and visual absorption capacity (VAC):

VQO	Visual absorption capacity (VAC)		
	High	Medium	Low
Retention	5	3.0	1
Partial retention	15	10.0	6
Modification	25	20.5	16
Maximum modification	40	33.0	26

Both VQO and VAC were assigned when defining management zones, as described in Section A.1.1. Listings of VQO and VAC by planning cells are available from the Timber Supply Branch in Victoria as part of the zone assignment information.

Forest cover guidelines weighted by the timber harvesting land area and VAC were calculated for each VQO class. For example, for the Partial Retention VQO zone:

Weighted % Disturbance = (% High VAC area)*(15%) + (% Medium VAC area)*(10%) + (% Low VAC area)*(6%)

The weighted forest cover requirements for VQOs were:

VQO class	Weighted forest cover guideline (per cent)
Retention	1.96
Partial retention	8.59
Modification/maximum modification	21.13

A.3 Forest Management Assumptions

In areas managed for wildlife habitat and watershed protection, the forest cover requirement was that a maximum of 15% may fail to meet green-up conditions — 3-metre top height — at any time. This requirement was not weighted as it applies to all areas in management zone 2 (Section A.1.1).

Forest cover requirements were next adjusted to account for the forest area outside the timber harvesting land base in each zone class. That is, forest unavailable for harvesting due to physical inoperability, environmental sensitivity or non-merchantability contributes to the visual quality or forest cover of an area. For this adjustment, a "green-to-net" ratio was calculated for the zone class by dividing the total forested area by the timber harvesting land base.

The green-to-net ratios for each management emphasis zone were:

Management emphasis	Green-to-net ratio
Retention VQO	2.88
Partial retention VQO	2.27
Modification VQO	2.10
Wildlife habitat/watershed	2.60

The final step in determining the forest cover requirements was combining the weighted forest cover guideline with the green-to-net ratio. This step required an estimate of how forest within the timber harvesting land base is distributed across the landscape. That is, the harvesting land base could be a fairly solid area separated from inoperable areas by a distinct line. Conversely, area both available and unavailable for harvesting could be fairly evenly dispersed. The intermediate condition is that harvestable forest is distributed in clusters within the landscape. Whether the available forest is solid, clustered, or dispersed determines how to employ the green-to-net ratio. In dispersed landscapes the full ratio is used (available and unavailable areas are in cutblock-sized pieces which are essentially adjacent); that is, the weighted forest cover guideline is multiplied by the green-to-net ratio. In solid areas, the green-to-net ratio is not used (available and unavailable areas are separated). In clustered areas, the average of the dispersed and solid factors is used. More detail is available in the procedures document referred to above.

For this analysis, it was assumed that in 15% of the inoperable and operable areas are evenly dispersed, 20% are clustered, and 65% are solid. These figures were developed for the Fort St. James District, and were felt by the Mackenzie Forest District staff to be appropriate for the Mackenzie TSA.

A.3Forest Management Assumptions

The final forest cover guidelines were calculated as:

Management emphasis zone	Forest cover guideline (maximum per cent area below green-up age)
Retention VQO	2.89 (rounded to 3%)
Partial retention VQO	11.31 (rounded to 11%)
Modification VQO	26.93 (rounded to 27%)
Wildlife habitat/watershed	21.01 (rounded to 21%)

Requirements for old-age forest cover for wildlife habitat

To maintain wildlife habitat in two management emphasis zones (3 and 4), there is a requirement that a minimum proportion of the area be covered by old stands. Ministry of Environment, Lands and Parks staff requested that a 200-year timber rotation be employed to meet wildlife habitat objectives. This analysis employs a forest cover requirement that at least 25% of the area be in stands 150 years old or older, since this would result in an effective cutting cycle of about 200 years. Since the original forest cover objective was expressed as a rotation length, and would therefore apply to the timber harvesting land base, the minimum percentage requirement for old-age forest was not adjusted for the potential contribution of forest outside the timber harvesting land base.

If stands older than 150 years but outside the timber harvesting land base had been assumed to contribute to the old-age forest area in management zones 3 and 4, the requirement would have been that 21% of the timber harvesting land base be at least 150 years old. Given the results of the analysis, which show the fairly minor impact of either removing or doubling the base case requirement for 25% old-age forest in zones 3 and 4, the effects of shifting from 25% to 21% would be very small (less than 0.5% over the next 100 years, no effect in the long term).

Assessing the effects of a 50-year increase in the old-growth age (discussed in the main report, Section 5.5, "Uncertainty in minimum age for defining old-age forest") involved a modification to the simulation modelling procedures used in this analysis. The modification was needed to ensure continual renewal of the area meeting the old-age forest criterion. Without this modification, an area of predominantly poorer productivity stands would be reserved to meet old-age forest requirements, which would not likely occur in practice. To ensure this type of reservation did not occur in this sensitivity analysis, minimum harvestable ages were set at 200 years in the areas where the old-age forest requirement applies.

Summary of forest cover requirements

Table A-12. specifies the forest cover requirements for the Mackenzie TSA. The requirements are applied in the form: a maximum of 33% of the area in a zone may be younger than the specified green-up age.

The Table Interpolation Program for Stand Yields (TIPSY) supplied by the B.C. Forest Service, Research Branch was used to estimate when trees will reach a top height of 2.5 metres for the general pass system, and 3 metres for the wildlife habitat/watershed and VQO zones. Since each area will support a range of growth rates, average green-up ages (based on average zonal site index determined using FREDDIE, B.C. Ministry of Forests, 1990) were used for each zone to simplify the analysis. These green-up ages do not include regeneration delay; the delays are dealt with in the simulation model by giving harvested areas a negative age equal to the regeneration delay.

A.3 Forest Management Assumptions

Table A-12. Management emphasis zone forest cover requirements

Zone	Green-up age (years)	Maximum per cent area younger than green-up age	Old-age forest (years)	Minimum per cent area older than 150 years
Wildlife/watershed	16	21	—	—
Wildlife (old-age 1)	18	33	150	25
Wildlife (old-age 2)	15	33	150	25
Integrated resource management	17	33	—	—
Retention VQO	21	3	—	—
Partial retention VQO	20	11	—	—
Modification VQO	20	27	—	—

Note: Old-age requirements were not determined for any zones other than the high value wildlife habitat areas (zones 3 and 4).

Table A-13. shows that the green-up objective in the retention visual quality area is currently violated. In all other zones the green-up or old-age forest objectives are currently met.

Table A-13. Initial conditions for forest cover objectives

Zone	Adjacency/green-up		Old-age forest	
	Maximum target (per cent)	Current state	Minimum target (per cent)	Current state
Wildlife/watershed	21	2.9	—	—
Wildlife (old-age 1)	33	4.1	25	36.0
Wildlife (old-age 2)	33	6.9	25	26.6
Integrated resource management	33	10.5	—	—
Retention VQO	3	5.6	—	—
Partial retention VQO	11	7.5	—	—
Modification VQO	27	10.2	—	—

A.3.5 Unsalvaged losses

This section outlines the methods used to estimate the average annual unsalvaged volume losses due to insect epidemics, fires, and wind. Timber volume losses to insects and diseases that normally occupy stands (so-called endemic losses) are accounted for in inventory sampling for timber yield estimation. The purpose of the unsalvaged losses estimate is to account for epidemic infestations and other factors not recognized in yield estimates. Table A-14. summarizes the estimate for unsalvaged losses in the Mackenzie TSA used in this analysis.

Table A-14. Unsalvaged losses

Cause of loss	Losses on the total land base (m^3/year) [a]	Losses on the timber harvesting land base (m^3/year) [b]	Amount salvaged (m^3/year) [c]	Annual unsalvaged losses (m^3/year)
Insects	180 000	130 000	40 000	90 000
Fire	80 000	40 000	8 000	32 000
Wind damage	170 000	120 000	50 000	70 000
Total				192 000

(a) For insects, estimates based on FIDS reports. Total unsalvaged losses = (SUM 1980, ’81,’82,’84, ’90, ’91 & ’92)/7.
(b) Amount salvaged is the insect-attacked volume salvaged not green and insect-attacked wood for all species.
(c) Amount salvaged = (0 cubic metres for 1980,81,82,84,90)+(75% of winter 1992/93 for 1991) +(139 000 cubic metres for 1993))/7 = 40 000 cubic metres approximately.

Estimates of losses due to insects and fires are based on Federal Insect and Disease Survey (FIDS) reports and forest district fire reports, respectively.

It should be noted that prior to 1988-89 the levels of spruce beetle infestation were relatively low according to the FIDS reports. After 1989 the populations of spruce beetle increased at a dramatic rate. Over the past 2 years (winter 1991/92 and 1992/93) the salvage efforts have increased correspondingly. During the winter of 1992/93 approximately 1 156 000 cubic metres of priority beetle-infested timber were harvested. This wood comprised approximately 60% spruce of which 20% had been attacked; that is, approximately 139 000 cubic metres of attacked spruce was harvested with the balance being either green spruce or unaffected balsam or lodgepole pine.

A.3.6 Basic silviculture and regeneration assumptions

Basic silviculture consists of any activities required to establish free-growing stands of commercially-valued tree species after harvesting an area. Basic silviculture is a legislated requirement under the *Forest Act,* and is assumed to occur in the Mackenzie TSA. Table A-15. outlines the regeneration regime for each analysis, and specifies the expected regeneration delay following harvesting.

A.3Forest Management Assumptions

Table A-15. Regeneration assumptions

Existing analysis unit	Species group	Regenerated analysis unit(s)	Per cent planted	Initial stocking (stems/hectares)	Regeneration delay (years)
1	Leading Ba good	4 spruce-good	100	1 400	3
2	Leading Ba medium	5 spruce-med	100	1 400	3
3	Leading Ba poor/low	6 spruce-poor/low	100	1 400	3
4	Leading S good	4	100	1 400	3
5	Leading S medium	5	100	1 400	3
6	Leading S poor/low	6	100	1 400	3
7	Leading Pl good	7	100	1 600	3
8	Leading Pl medium	8	100	1 600	3
9	Leading Pl poor/low	9	100	1 600	3

Note: Definitions: Ba = Balsam, S = Spruce, Pl = Lodgepole pine.

For this analysis the total stems/hectare was used rather than the number of well spaced stems/hectare. Regeneration delay is the time to beginning of the growth curve, not the time needed to reach free-growing condition.

A.3.7 Not satisfactorily restocked (NSR) areas

Ministry of Forests' history records and the Major Licensee Silviculture Information System (MLSIS) show a total of 84 172 hectares of NSR land in the Mackenzie TSA (64 416 hectares backlog; 19 756 hectares current). However, after all deductions, only 37 024 hectares of NSR are left within the timber harvesting land base (this is after deducting 4.7% for existing roads). The discrepancy could be due to inclusion in the history records and MLSIS of NSR not related to past harvesting activities, and classified as inoperable (that is, it would have been deducted for inoperability except on mapsheets series 93 J/N/O and 94 C). Another reason could be that the forest inventory file is outdated (in this case, area that the inventory shows in older ages would in fact be NSR), but the file was updated for harvesting to the end of 1993. The discrepancy is too large to have arisen over the last year.

Since no clear reasons were found for the discrepancy, it was assumed that the total NSR area derived during definition of the timber harvesting land base was correct. It was also assumed that the current NSR area derived from the history records and MLSIS (19 751 hectares less 4.7% = 18 823 hectares, which excludes 5 hectares of Aspen NSR) is correct. The remainder, 18 201 hectares, is assumed to be backlog NSR. The backlog NSR area in each analysis unit was retained at the same proportion of the total as shown in the original data package compiled by the Mackenzie Forest District.

A.3Forest Management Assumptions

Current NSR was assumed to be restocked according to average regeneration delays listed in Table A-15. Backlog NSR was assumed to be restocked by 10 years from now.

Table A-16. Not satisfactorily restocked (NSR) areas

Analysis unit	Species group (site class)	Backlog NSR area (hectares)		Current NSR area (hectares)		Total area used in analysis (hectares)
		Area in data package	Area used in analysis	Area in data package	Area used in analysis (4.7% less than in data package)	
1	Leading Ba (G)	0	0	10	10	10
2	Leading Ba (M)	0	0	1 880	1 792	1 792
3	Leading Ba (P)	0	0	310	295	295
4	Leading S (G)	4 000	1 131	1 740	1 658	2 789
5	Leading S (M)	4 500	1 272	8 700	8 291	9 563
6	Leading S (P)	750	212	900	858	1 070
7	Leading Pl (G)	39 500	11 167	1 550	1 477	12 644
8	Leading Pl (M)	13 500	3 817	4 361	4 156	7 973
9	Leading Pl (P)	2 131	602	300	286	888
	Total	64 381	18 201	19 751	18 823	37 024

Note: Definitions: Ba = balsam, S = spruce, Pl = lodgepole pine.

A.3.8 Rehabilitation of problem forest types, and non-commercial cover areas

No rehabilitation activities are planned in the Mackenzie TSA.

A.3.9 Incremental silviculture

Incremental silviculture comprises any activities beyond those required to establish a free-growing stand. To date little incremental silviculture has been practiced in the Mackenzie TSA. With the recently announced Forest Renewal Plan, more incremental silviculture will likely occur. The effects of intensive silviculture will be assessed in future timber supply analyses.

A.4 Volume Estimates for Existing Stands

The variable density yield projection (VDYP) model, Version 4.5 developed and supported by the B.C. Ministry of Forests, Inventory Branch, was used to estimate timber volumes for existing natural stands. All stands aged 10 years and younger were assumed to be managed, that is subject to basic silviculture, and therefore are expected to grow according to volume estimates for regenerated stands, discussed in the following section.

The deciduous components of stands, that is, aspen, birch and cottonwood, are not currently widely used in the Mackenzie TSA. The contribution of deciduous trees was therefore deducted from timber volume estimates for existing stands used in this analysis.

The deciduous component of conifer-leading stands was included in the previous timber supply analysis. The Mackenzie Forest District is currently charging the deciduous component against cut control. However, the Ministry of Environment, Lands and Parks is requiring that the majority of new cutblocks maintain a significant component of live deciduous trees for wildlife. Currently the majority of the deciduous volume is not being utilized.

If the deciduous component of coniferous-dominated stands had been retained in volume estimates for existing natural stands, the initial total and merchantable (older than minimum harvestable age) growing stocks would each be 5.6% larger than determined for the base case in the timber supply analysis.

Table A-17. shows the volume estimates by analysis unit for existing natural stands.

A.4 Volume Estimates for Existing Stands

Table A-17. Timber volume tables for existing natural stands — balsam units

Age	Analysis unit 1 good sites	Analysis unit 2 medium sites (0-140 years old)	Analysis unit 22 medium sites (over 140 years old)	Analysis unit 3 poor sites (0-140 years old)	Analysis unit 23 poor sites (over 140 years old)
10	0	0	0	0	0
20	6	1	0	0	0
30	40	16	5	4	0
40	86	45	18	16	7
50	128	80	40	34	17
60	168	113	67	59	30
70	205	146	95	86	52
80	237	173	117	108	70
90	264	197	137	127	85
100	289	219	155	144	99
110	312	240	171	160	112
120	332	258	186	175	124
130	354	278	202	191	136
140	375	297	218	205	148
150	394	314	232	219	159
160	412	330	246	232	170
170	428	345	258	245	180
180	444	359	271	256	190
190	458	372	282	267	199
200	473	385	294	278	209
210	486	398	305	289	217
220	499	410	315	299	226
230	512	421	325	308	234
240	524	432	335	318	242
250	535	443	344	327	250
260	537	445	346	329	251
270	539	447	348	331	253
280	541	449	349	332	254
290	543	451	351	334	255
300	544	453	352	336	256
310	546	455	353	337	258
320	547	456	355	338	259
330	548	458	356	340	260
340	550	459	357	341	261
350	551	460	358	342	261

continued

A.4 Volume Estimates for Existing Stands

Table A-17. Timber volume tables for existing natural stands — spruce and Douglas-fir analysis units

Age	Analysis unit 4 good sites	Analysis unit 5 medium sites	Analysis unit 6 poor sites (0-140 years old)	Analysis unit 26 poor sites (over 140 years old)
10	0	0	0	0
20	0	0	0	0
30	1	0	0	0
40	29	2	1	0
50	82	29	3	1
60	129	72	14	6
70	171	112	43	16
80	206	148	74	33
90	237	181	103	53
100	264	210	130	75
110	286	236	155	96
120	306	258	177	115
130	324	279	199	134
140	338	297	218	152
150	351	313	236	169
160	361	326	251	185
170	370	338	265	199
180	377	347	277	212
190	383	356	287	224
200	389	364	297	236
210	394	371	307	247
220	399	378	316	257
230	403	384	324	267
240	407	389	331	275
250	411	394	338	284
260	413	398	344	290
270	416	402	349	295
280	418	405	353	300
290	420	408	357	305
300	421	411	361	310
310	423	413	365	314
320	424	415	368	318
330	425	417	371	321
340	426	419	374	325
350	427	420	376	328

continued

A.4 Volume Estimates for Existing Stands

Table A-17. Timber volume tables for existing natural stands — lodgepole pine analysis units (concluded)

Age	Analysis unit 7 good sites	Analysis unit 8 medium sites	Analysis unit 9 poor sites
10	0	0	0
20	0	0	0
30	26	3	0
40	76	37	3
50	120	75	18
60	159	110	44
70	192	141	68
80	222	168	91
90	249	193	113
100	274	216	133
110	297	237	151
120	318	257	169
130	338	276	185
140	351	288	197
150	361	298	207
160	368	306	215
170	372	310	221
180	373	313	224
190	372	312	226
200	374	315	229
210	376	317	232
220	378	320	236
230	381	323	239
240	383	325	241
250	386	327	244
260	388	330	246
270	390	332	248
280	392	333	250
290	393	335	252
300	395	336	253
310	396	338	255
320	398	339	256
330	399	340	257
340	400	341	258
350	401	342	258

A.5 Volume Estimates for Regenerated Stands

WinTIPSY (Windows™ version of the Table Interpolation Program for Stand Yields) version 1.0, supported by B.C. Ministry of Forests, Research Branch, was used to estimate growth and yield from existing and future managed stands. All existing stands aged 10 years or younger were assumed to have been subject to basic silviculture, and therefore to grow according to managed stand yield tables.

Operational adjustment factors (OAFs) used in managed stand yield table generation were: OAF1 of 15% (a constant percentage reduction at all ages to represent incomplete site occupancy, for example, small holes in a stand), and OAF2 of 5% (an increasing reduction, reaching 5% at 100 years of age to represent losses such as decay that increase with stand age).

Table A-18. shows the average site index by analysis unit used to generate managed stand yield tables.

Table A-18. Site index at 50 years breast height age by analysis unit

Analysis unit number	Analysis unit description	Site index @ 50 years, existing natural stands	Site index @ 50 years, (balsam converted to spruce after harvest) existing and future managed stands (a)
1	Balsam - good site	20.67	22.03
2	Balsam - medium site 0-140 years old	15.91	16.50
22	Over 140 years old	12.13	12.13
3	Balsam - poor and low site 0-140 years old	11.72	11.64
23	Over 140 years old	9.29	8.83
4	Spruce - good site	20.35	same
5	Spruce - medium site	15.22	same
6	Spruce - poor and low site 0-140 years old	10.95	same
26	Over 140 years old	8.36	
7	Lodgepole pine - good site	20.02	same
8	Lodgepole pine - medium site	16.27	same
9	Lodgepole pine - poor and low site	11.45	same

(a) Site index conversion equation for existing balsam-dominated stands which will be converted to spruce after harvest: $SI_{Sw} = -1.95 + 1.16(SI_{Bl})$.

A.5 Volume Estimates for Regenerated Stands

Table A-19. displays the volume tables for managed stands. Volumes are assumed to remain constant after 250 years of age.

Table A-19. Timber volume tables for existing and future managed stands — balsam analysis units

Age	Analysis unit 1 good sites	Analysis unit 2 medium sites (0-140 years old)	Analysis unit 22 medium sites (over 140 years old)	Analysis unit 3 poor sites (0-140 years old)	Analysis unit 23 poor sites (over 140 years old)
10	0	0	0	0	0
20	0	0	0	0	0
30	28	0	0	0	0
40	125	23	0	0	0
50	225	86	9	7	0
60	317	157	44	34	1
70	396	221	91	77	11
80	443	277	139	123	38
90	473	338	187	169	71
100	499	383	226	210	105
110	515	414	264	246	138
120	523	437	302	280	173
130	524	453	340	319	203
140	522	468	368	350	230
150	520	480	390	375	256
160	517	489	406	394	282
170	515	495	420	409	310
180	513	501	430	421	334
190	510	502	439	430	353
200	510	501	447	438	370
210	510	500	454	445	383
220	510	499	460	451	393
230	510	497	465	457	402
240	510	494	468	461	410
250	510	491	470	465	415

continued

A.5 Volume Estimates for Regenerated Stands

Table A-19. Timber volume tables for existing and future managed stands — spruce and Douglas-fir analysis units

Age	Analysis unit 4 good sites	Analysis unit 5 medium sites	Analysis unit 6 poor sites (0-140 years old)	Analysis unit 26 poor sites (over 140 years old)
10	0	0	0	0
20	0	0	0	0
30	11	0	0	0
40	89	10	0	0
50	184	59	2	0
60	264	121	21	0
70	346	185	59	8
80	405	238	101	27
90	442	287	144	55
100	468	341	187	87
110	489	380	222	119
120	505	408	255	152
130	516	429	288	184
140	518	444	323	210
150	518	457	351	235
160	517	468	374	259
170	514	478	391	285
180	511	484	404	311
190	508	489	416	334
200	506	493	425	351
210	504	496	432	367
220	501	495	439	379
230	499	494	445	389
240	497	492	450	398
250	497	490	454	405

continued

A.5 Volume Estimates for Regenerated Stands

Table A-19. Timber volume tables for existing and future managed stands — lodgepole pine analysis units (concluded)

Age	Analysis unit 7 good sites	Analysis unit 8 medium sites	Analysis unit 9 poor sites
10	0	0	0
20	5	0	0
30	71	26	0
40	147	75	10
50	211	130	35
60	272	170	61
70	316	209	94
80	351	249	120
90	377	277	139
100	397	300	157
110	412	319	173
120	425	336	188
130	436	348	205
140	444	358	220
150	452	367	233
160	452	375	244
170	452	380	252
180	452	385	260
190	452	389	266
200	452	393	272
210	452	396	277
220	452	398	281
230	452	400	285
240	452	401	289
250	452	403	292

APPENDIX B

Description of Inventory Updates And Supplementary Information

Land Base Changes Since the 1988 Mackenzie TSA Timber Supply Analysis and Information Report

Introduction

Table B-1. shows the total area, the timber harvesting land base and areas considered unavailable for harvesting for both the timber supply analysis and information report of 1988 and this Timber Supply Review (TSR) analysis. The figures in the "Land base change" column represent the effect on the land base of changes since 1988. For areas removed from consideration for harvesting, negative numbers mean more land is removed in the TSR analysis than in the previous analysis. For total and harvestable areas, negative numbers mean the land base is smaller than in 1988.

The overall area reduction from the productive forest land was about 246 625 hectares greater in the TSR analysis than in the 1988 analysis. It is difficult to ascertain the precise reason for the difference, but the new operability classification, and reductions for streamside buffers and non-forest uses such as settlements, would likely account for most of the change.

The 1988 analysis did not incorporate a reduction for inoperability. It appears likely that many areas now classified as inoperable were deducted as non-merchantable in the 1988 analysis.

The current timber harvesting land base for the TSR analysis is 12% smaller than that defined for the 1988 analysis.

B.1 Updates and Supplementary Information

Table B-1. Summary of land base changes since 1988 analysis and information report

Classification	Areas for timber supply review (hectares)	Areas for 1988 analysis report scenario 3 (hectares) [a]	Land base change (hectares) [b]
Total land base	6 130 604	6 090 800	+ 39 804
Reductions to total area:			
Not in B.C. Forest Service jurisdiction	33 218	7 129	– 26 089
Non-forest	3 043 001	3 114 449	+ 71 448
Total productive forest	3 054 385	2 969 222	+ 85 163
Reductions to productive forest area:			
Not satisfactorily restocked	—	21 922[c]	+ 21 922
Non-commercial cover (NCC)	69 884	73 620	+ 3 736
Preservation visual quality	2 072	0	– 2 072
Environmentally sensitive	244 680	162 412	– 82 268
Deciduous types	228 146	209 139	– 19 007
Non-merchantable	427 552	1 069 088	+ 641 536
Low sites	31 052	110 997	+ 79 945
Inoperable	855 909	—	– 855 909
Existing roads, trails, landings	6 767	—	– 6 767
Streamside buffers	11 883	—	– 11 883
Settlement areas	15 197	—	– 15 197
Black Pine Indian Reserve	112	—	– 112
Pine Pass Ski Area	549	—	– 549
Total reductions to forested area	– 1 893 803	– 1 647 178	– 246 625
Current timber harvesting land base	1 160 581	1 322 045	– 161 464
(NSR in brackets)	(37 024)	(100 000)	
Subtract:			
Future roads	– 61 620	—	– 61 620
Long-term timber harvesting land base	1 098 962	1 322 045	– 223 083

(a) The areas are from scenario 3 of the B.C. Ministry of Forests, Mackenzie TSA Timber Supply Analysis and Information Report, 1988. Scenario 3 was chosen for comparison since it used the most up-to-date ESA information available at that time.

(b) The land base change in this column represents either 1) the difference between the area in the TSR analysis compared to the 1988 analysis report (a negative value means the area is now smaller); or 2) the effect of the change in an area reduction on the harvesting land base (a negative value means the reduction is now larger than in the 1988 analysis, and therefore reduces the timber harvesting land base relative to 1988).

(c) The NSR deduction shown was added back into the timber harvesting land base as reclassified backlog NSR. That is, 100 000 hectares of area classified as NSR was found actually to be restocked, and was therefore added as age class 1 (1-20 years old).