



RESOURCE MANAGEMENT

TIMBER SUPPLY REVIEW

Golden Timber Supply Analysis



Province of
British Columbia
Ministry
of Forests

Golden Timber Supply Analysis

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Preface

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

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

Unlike past analyses, which normally assessed the implications of several forest management scenarios, this report focuses on a single scenario—current management practices. This approach will expedite the analysis process, and allow analysis of all timber supply areas in the province to be completed by the end of 1994. An important part of

these analyses, however, is an assessment of how results might be affected by uncertainties—a process called “sensitivity analysis.” Together, the sensitivity analyses and the assessment of the effects of current forest management on timber supply will form a solid basis for discussions among stakeholders about alternative timber harvesting levels.

Analysis results presented in this report do not suggest or promote any particular harvest level for the Golden TSA. The determination of the allowable annual cut*, or AAC, will be made by the Chief Forester after considering many factors, including the results of this analysis.

This report is one 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 results of timber supply and socio-economic analyses. One report summarizes this information to provide a focus for public discussions of possible timber harvest levels. The fourth provides a description of the Chief Forester’s decision and the reasoning behind it.

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.

Executive Summary

As part of the provincial Timber Supply Review, the B.C. Forest Service has examined the availability of timber in the Golden TSA. The analysis assesses how current forest management practices affect the supply of wood available for harvesting over the next 250 years. It also examines the potential changes in timber supply stemming from uncertainties about forest growth and management actions. It is important to note that the various harvest forecasts included in this report only indicate the implications for timber supply of current practices and the associated uncertainty. As such, the forecasts should be used for discussion purposes only; they are not intended to imply any particular AAC recommendations.

The Golden TSA covers a total of 921 000 hectares, of which about 174 600 hectares are considered available for timber harvesting under current management practices. Total volume of timber in the area is about 33 million cubic metres, of which 27.5 million cubic metres is of merchantable age. The area is dominated by spruce, Douglas-fir and lodgepole pine stands. The current AAC for the TSA is 650 000 cubic metres.

Given current management assumptions, the analysis shows the current AAC cannot be maintained without causing a drop in future harvest levels. To avoid this drop, the maximum harvest over the first decade is 605 000 cubic metres per year, 7% below the current AAC. Beginning in the second decade, harvests must decrease 10% per decade until the long-term harvest level of 309 000 cubic metres per year is reached 80 years from now.

Initial harvest levels greater than 605 000 cubic metres per year or rates of decline less than 10% per decade result in harvests falling significantly below the long-term level, usually around 80 years from now. Conversely, if slower rates of decline are desired, the initial harvest must drop below 605 000 cubic metres per year.

Many of the data and assumptions used in the analysis are subject to varying degrees of uncertainty. In particular, Golden Forest District staff believe that the volumes for existing older stands may be optimistic. They also suggest that the regenerated yields used in this analysis may be too low. Sensitivity analysis was used to examine how uncertainty about these and other data and assumptions affect the results of the timber supply analysis.

In the short term, harvest levels are most sensitive to decreased yield estimates for existing stands. Short-term harvest levels are also sensitive to a decrease in the area of mature forest available for harvesting, tightening of forest cover requirements for non-timber values such as visual quality and wildlife, increased yield estimates for existing stands and increased minimum harvest ages.

The long-term harvest level is highly sensitive to uncertainty about regenerated stand yields and tightening of forest cover requirements. It is also very sensitive to uncertainty about the area available for harvesting. In general the long-term harvest level is not very sensitive to uncertainty about other data and assumptions.

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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 on the physical characteristics of the trees to be harvested. Determining the physical characteristics of trees in the future requires knowledge of their growth. The judgment of whether or not a stand is available for harvest might depend on how its harvest may 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 depend upon changes in world timber markets. Unforeseen losses due to fire or pest infestations will alter the amount and value of timber. The appropriate balance of timber and non-timber values in a forest is an ongoing subject of debate, and is complicated by changes in social objectives over time.

Because of this, the timber supply is peculiar to a set of physical, biological, social and economic conditions. When these conditions change, the timber supply changes. When determining the usefulness or relevance of a particular estimate of timber supply, it is important to understand the set of conditions upon which it is based.

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

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

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

The following sections outline the timber supply analysis for the Golden TSA. In the next two sections, the data preparation and formulation of assumptions are discussed. Following that, the results of the analysis are presented. After this, there is a discussion of the sensitivity of these results to uncertainties in the data and assumptions used. The report ends with a summary and conclusions.

For the more technically oriented reader, the appendices contain more details about the data and assumptions used in this analysis. They are included here for completeness, but their review is not necessary to obtaining a basic understanding of the timber supply for the Golden TSA.

Timber Supply Area (TSA)

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

Forest inventory

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

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

1 Golden Timber Supply Area

The Golden Timber Supply Area is located in the Nelson Forest Region and is administered from the Golden Forest District office in Golden. The boundaries of the Golden TSA coincide with those of the Golden Forest District (Figure 1), which covers 921 231 hectares.

The Golden TSA lies in the Rocky Mountain Trench (Columbia River Valley), which is cradled between the Rocky Mountains to the east and the Selkirk and Purcell ranges to the west (Figure 2). The Golden TSA is bordered by five national parks: Kootenay, Yoho, Banff and Jasper on the east, and Glacier on the west. In addition, there is one provincial park, Hamber, in the northeast corner. The town of Golden is the only sizable community within the Golden TSA.

Because of the mountainous terrain, the TSA is characterized by a varied climate and diverse ecology. The area is located in the interior wet belt and thus is classified mostly into the moister biogeoclimatic zones—Engelmann Spruce-Subalpine Fir and the Interior Cedar-Hemlock zones. The Montane Spruce and the Interior Douglas-fir zones are also represented but over relatively minor ranges. The diverse ecology of the TSA supports a variety of tree species with spruce, Douglas-fir and lodgepole pine predominant. Hemlock, balsam and redcedar are less common, but are nevertheless important commercial species.

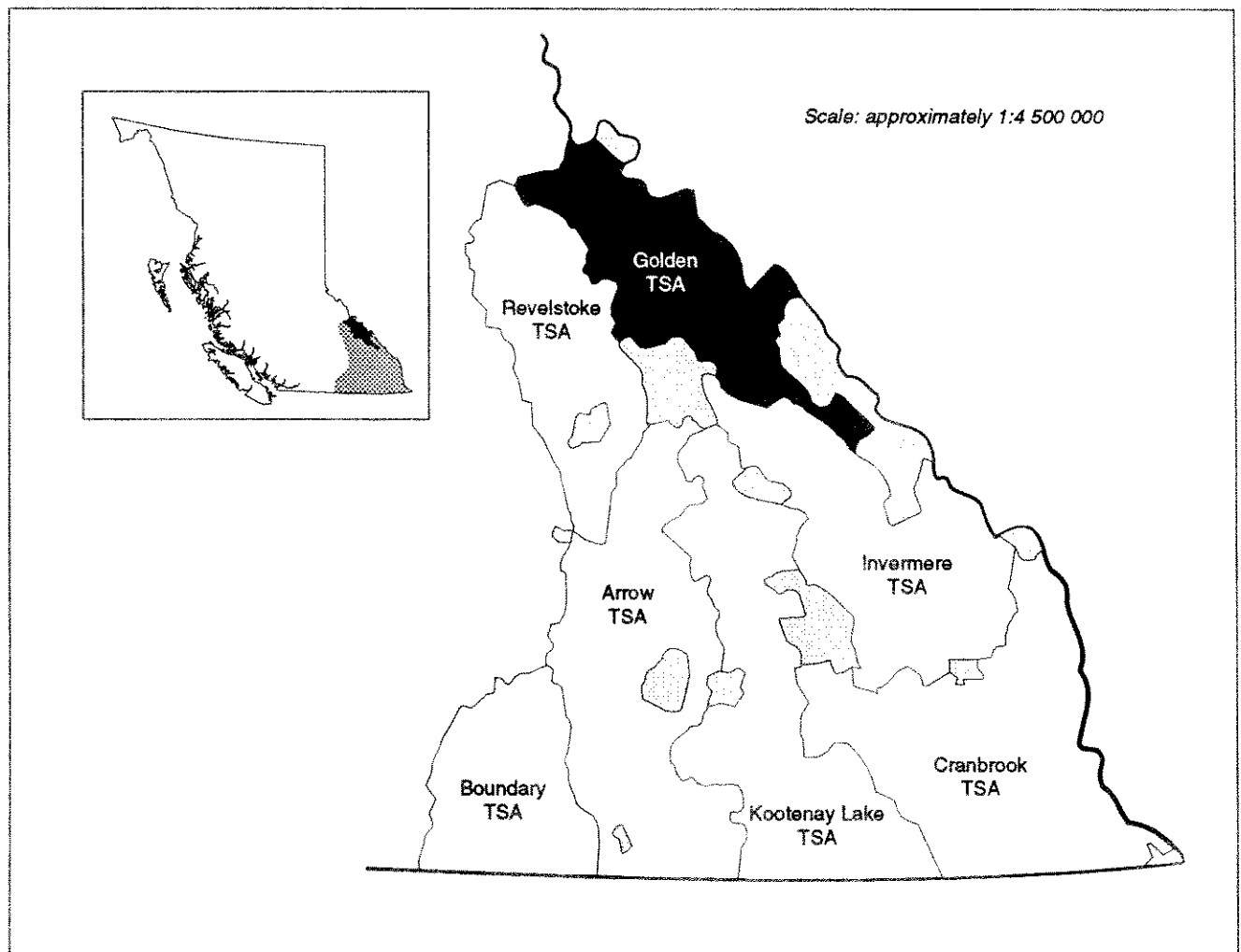


FIGURE 1. The Nelson Forest Region showing the Golden Timber Supply Area.

1 Golden Timber Supply Area

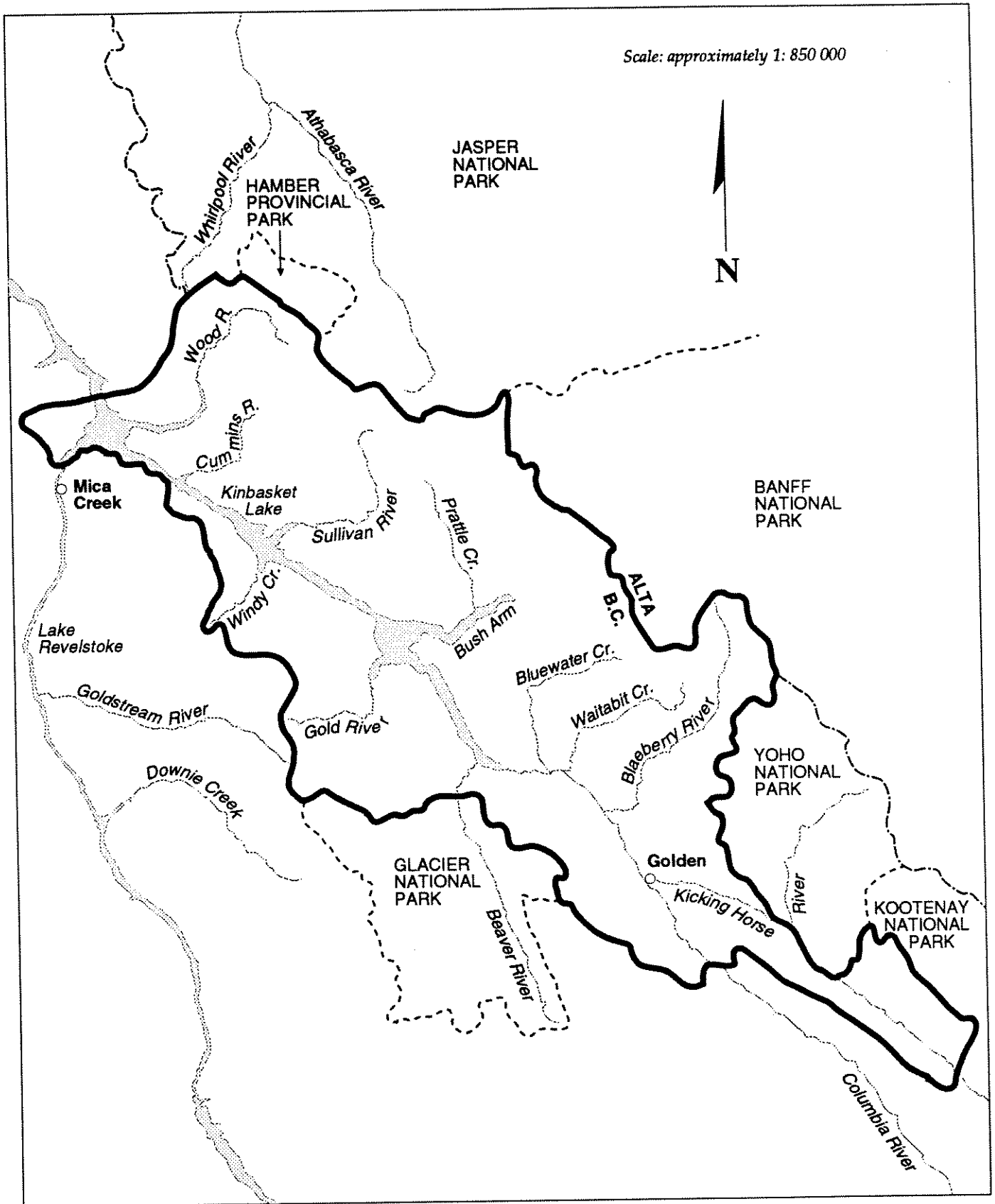


FIGURE 2. The Golden Timber Supply Area.

2 Information Preparation

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

2.1 Land Base Inventory

Land base information comes in the form of a computer file compiled by the B.C. Forest Service Inventory Branch. This file contains a wealth of data about the thousands of pieces of forest land that make up a TSA, including the geographic location, area, and nature of forest cover (such as presence or absence of trees, number of trees, species, age and timber volume). For the analysis, this information has been updated to 1991.

Figure 3 shows the distribution of area of the Golden TSA by major land categories. Of note is the large percentage of non-forest land, which reflects the mountainous terrain.

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

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

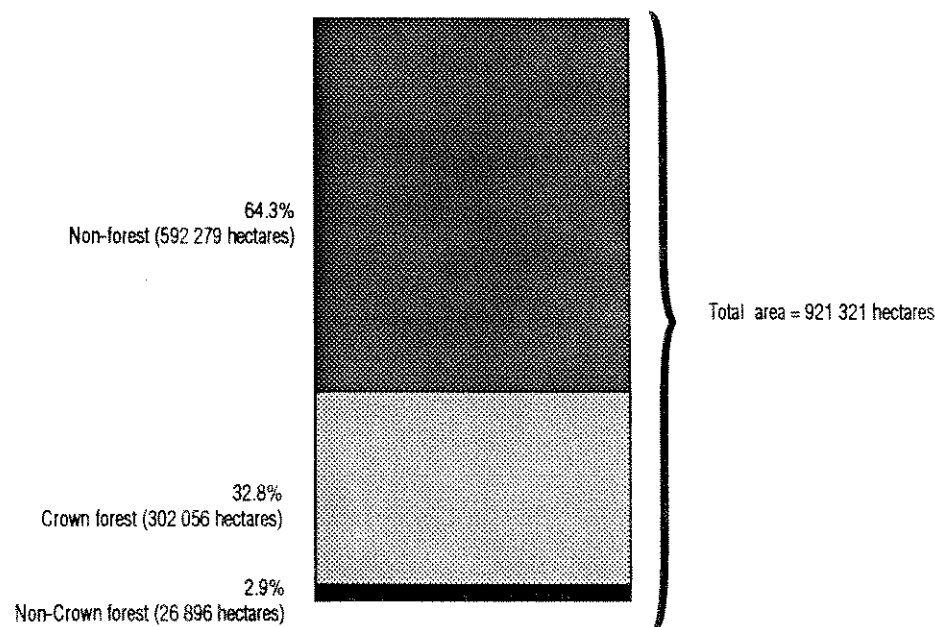


FIGURE 3. Total land base by major land categories, Golden TSA.

Timber harvesting land base

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

2 Information Preparation

It is important to remember that removal of data for areas not contributing to the timber supply does not imply withdrawal of areas from the TSA. The B.C. Forest Service still manages the entire area of the TSA (except for certain designated lands) as a forest unit that contributes a mix of timber and non-timber values. The timber supply is managed within this integrated resource context and the timber supply analysis contained herein is consistent with this philosophy.

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

The following land categories were considered not available or unsuitable for timber harvesting and their associated data were removed:

- non-Crown areas—areas not managed directly by the B.C. Forest Service
- non-forest areas—areas that cannot support productive forest cover (e.g., rock, swamp and alpine areas)
- non-commercial cover areas—areas occupied by brush species
- 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.
- environmentally sensitive areas*, such as important wildlife habitat and recreation sites
- non-merchantable forest types—areas occupied by low-quality or low-volume timber stands, non-merchantable species or land with low timber growing potential
- currently designated old-growth management areas
- minor riparian* areas and buffers along historic and recreational trails
- existing and future road, trail and landing areas—existing and projected losses of productive land due to timber harvesting and other forest activities

The timber harvesting land base was adjusted to account for the area harvested from 1988 to 1990 and for the future reversions of old timber licence* areas to the Crown.

Table 1 summarizes the areas represented by these categories. A more detailed description of these categories and the rationale for their removal is located in Section A.2, page 32.

Environmentally sensitive area

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

Riparian areas

Usually found along watercourses, riparian areas have relatively more available water than surrounding areas and thus are inhabited by plants that require or thrive on moister conditions. Generally speaking, these areas provide rich, diverse habitat and sustenance for a wide variety of plants and animals.

Timber licences (or old temporary tenures)

Rights granted in the first half of this century to logging companies to harvest timber on specific tracts of Crown land. As stipulated in the licence documents, these areas are to be returned to Crown administration after the timber on them is harvested. It is assumed that this process will be completed in the Golden TSA 20 years from now.

2 Information Preparation

TABLE 1. Timber harvesting land base, Golden TSA

Classification	Area (ha)	Area (ha)	% of total area	% of productive forest area
Total land base		921 231	100.0	
Non-Crown land		26 896	2.9	
Non-productive		592 279	64.0	
Total productive Crown forest		302 056	37.8	100.0
Reductions to productive Crown forest:				
Not satisfactorily restocked (NSR*)	34 851		3.8	11.5
Non-commercial cover (NC)	2 369		0.0	0.8
Inoperable	81 616		8.8	27.0
Environmentally sensitive (ESA)	11 177		1.2	3.7
Low site	10 243		1.1	3.4
Deciduous types	6 348		0.7	2.1
Non-merchantable	7 066		0.8	2.3
Stream side buffers (riparian)	1 015		0.1	0.3
Designated old-growth area	407		0.0	0.1
Historic/Recreational trails	545		0.0	0.2
Harvesting update (1988–1990)	3 278		0.4	1.1
Roads, skid trails, landings	4 430		0.5	1.5
Total reduction	163 345	163 345	17.7	54.1
Timber harvesting land base (less additions)		138 711	15.1	45.9
Additions:				
NSR ^a	11 805		1.3	4.0
NSR reclassified to stocked ^a	14 784		1.6	4.9
Corrections to inventory file ^b	3 800		0.4	1.3
Timber licence reversions	5 497		0.6	1.8
Total additions	35 886		3.9	11.9
Current timber harvesting land base		174 599	19.0	57.8
Future reductions for roads, trails, landings	10 425		1.1	3.5
Future timber harvesting land base		164 174	17.8	54.3

^a All NSR land on the inventory file was initially subtracted. The NSR figures shown and harvesting update reflect a manual update to 1991 as carried out by district staff.

^b Includes 2200 hectares erroneously designated as not operable and 1600 hectares misclassified as low site.

Figure 4 shows that 58% of the Crown forest area (or 19% of the total land base) is considered available for timber harvesting. Land classified as inoperable is the largest single category of Crown forest that is assumed to be not available for timber production.

Figure 5 shows the tree species composition of the timber harvesting land base. The area has a diverse species mix with spruce, Douglas-fir and lodgepole pine dominant. Spruce is the largest component of the mature forest whereas Douglas-fir is dominant in the immature portion. (Maturity is defined on the inventory file as greater than 80 years for lodgepole pine and greater than 120 years for other species).

Figure 6 shows the area distribution by stand age of the timber harvesting land base. About 30% of the forest is older than 140 years and almost the same percentage is less than 20 years old. (The not satisfactorily restocked (NSR) figure includes the area of timber licences expected to revert to the Crown over the short term).

Not satisfactorily restocked

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

2 Information Preparation

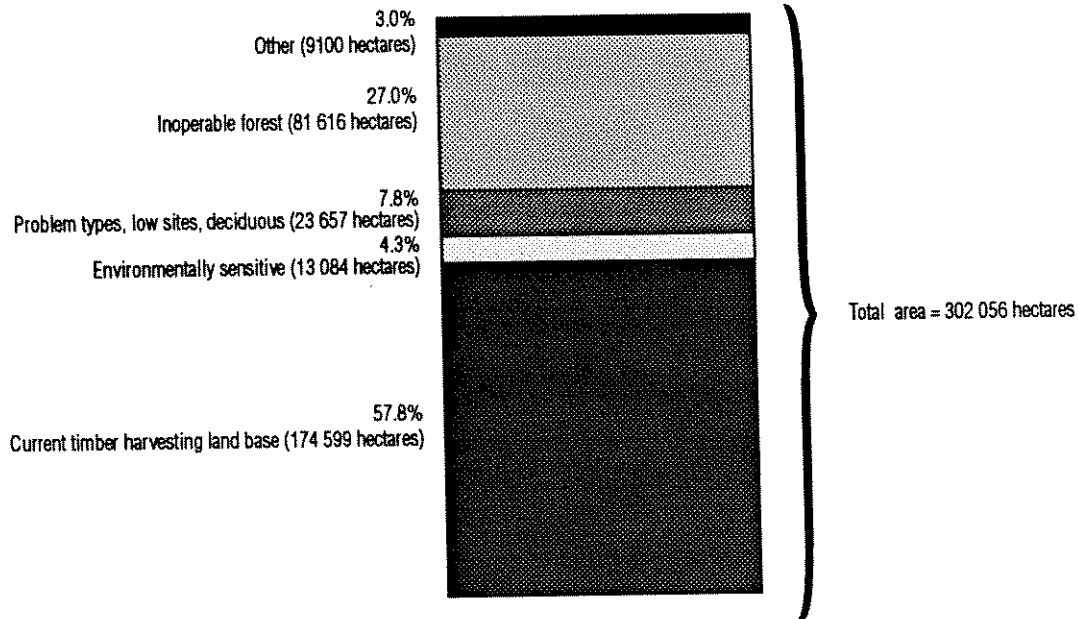


FIGURE 4. Classification of Crown forest land, Golden TSA.

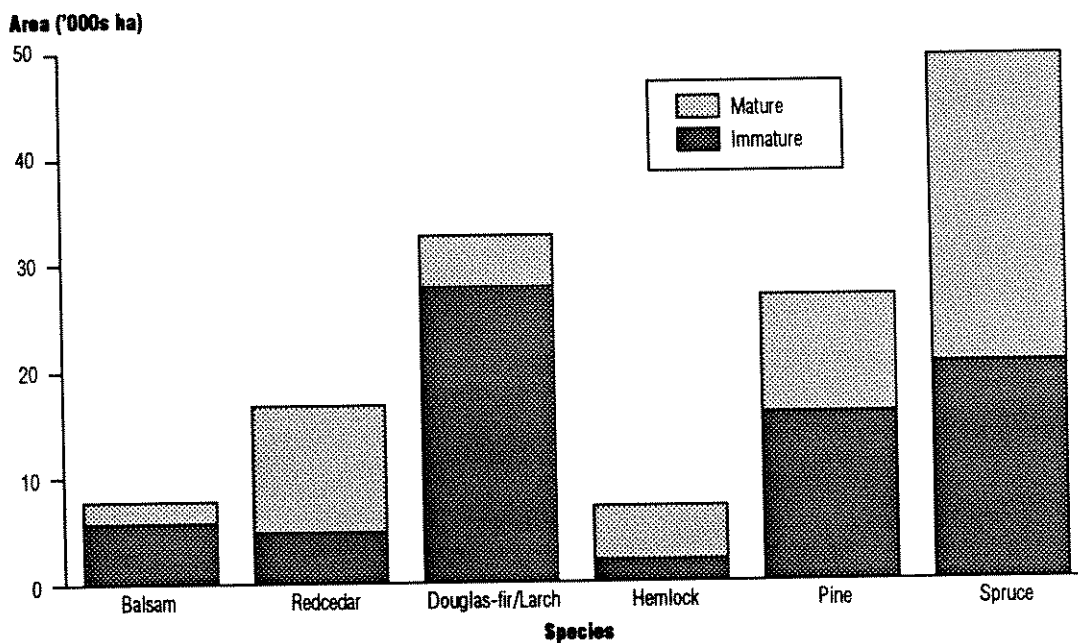


FIGURE 5. Area of timber harvesting land base by tree species and inventory maturity class, Golden TSA.

Figure 7 shows the area distribution of the timber harvesting land base by dominant tree species and site quality class. (Site quality classes are defined by site index* as an indication of tree growing potential. Four site classes are defined: good, medium, poor and low. Low-quality sites were not considered suitable for timber production and therefore have not been graphed). The land base is divided into a fairly even mixture of site classes. Very few lodgepole pine stands occur on poor growing sites,

whereas stands dominated by hemlock occupy few good growing sites.

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.

2 Information Preparation

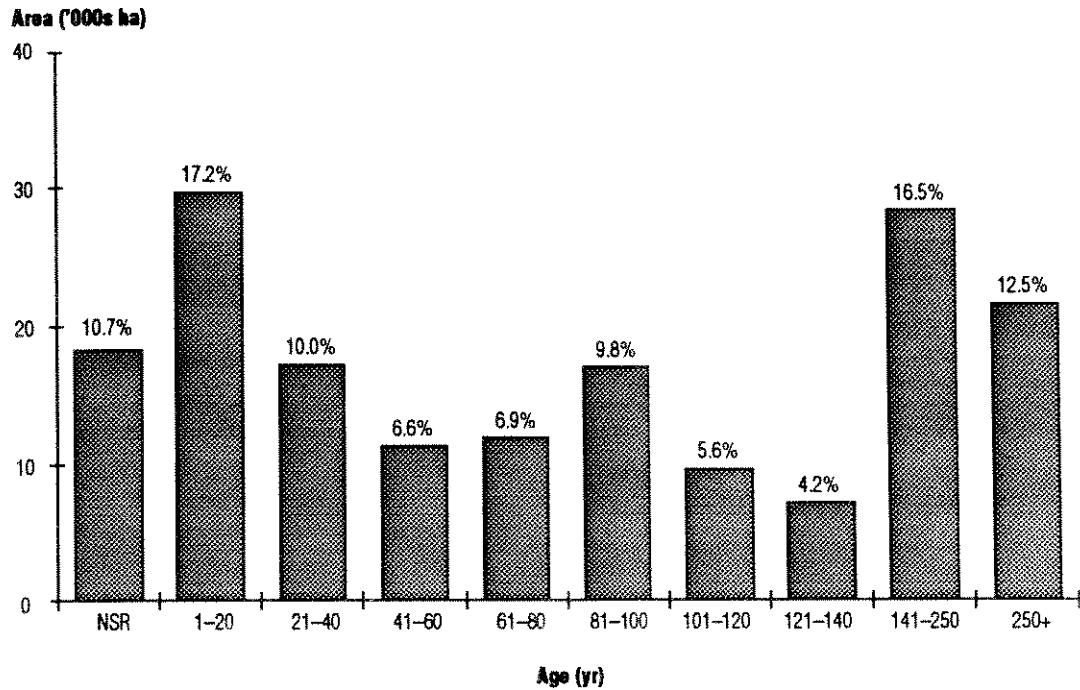


FIGURE 6. Area of timber harvesting land base by age distribution, Golden TSA.

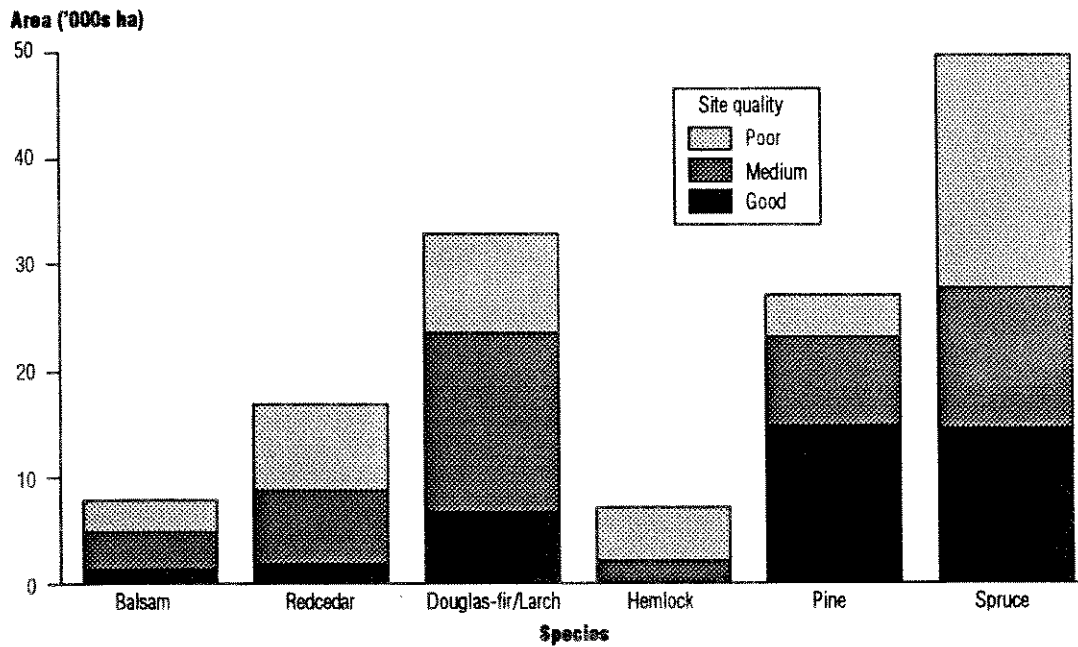


FIGURE 7. Area of timber harvesting land base by major species and site quality (timber growing potential), Golden TSA.

2 Information Preparation

2.2 Timber Growth and Yield

Timber growth and yield refers to the estimate of the growth and development of individual forest stands over time. The most common measure of the amount of standing timber is volume per unit area (in British Columbia, cubic metres per hectare). This measure assumes a utilization level or set of dimensions that establish minimum size limits for trees and logs that can be harvested and must be removed from a site. Utilization levels specify a maximum stump height and minimum diameters at breast height and at the top. Details are presented in Section A.3, Forest Management Practices, page 35.

Timber volumes for the Golden TSA analysis are based on the variable density yield prediction (VDYP) model developed by the B.C. Forest Service Inventory Branch. This model provides estimates of volumes for existing and regenerated (or future) stands. Volume tables are shown in Section A.5, Yield Tables, page 40.

2.3 Management Practices

Timber supply is directly connected to forest management activity. For the timber supply analysis process, therefore, levels of management activity must be defined. The focus of the Timber Supply Review is to describe the timber supply based on current management practices, as implemented in plans for the area. Forest Service staff in the Golden Forest District provided the following descriptions:

- Basic silviculture levels—reforestation activities required to establish free growing* stands of acceptable species
- Unsalvaged Losses—expected timber losses due to fire and major insect attacks
- Forest Cover Objectives—specifies the desired distribution of area by age or size groupings to meet some overall management goal for an area
- Cutblock Adjacency* and Green-up*—guidelines that specify the spatial pattern of cutblocks and amount of time (green-up period) required for regenerated stands to reach some desired conditions before adjacent mature timber may be harvested (e.g., for the maintenance of visual quality and wildlife habitat)
- Utilization Levels—tree and log size limits
- Minimum Harvest Ages—the time it takes for stands to grow to harvestable size

A more detailed discussion of the management assumptions* are provided in Section A.3, Forest Management Practices, page 35.

2.4 Definition of Resource Units

The timber harvesting land base has been divided into six resource units, defined on the basis of differing management objectives. Two resource units (riparian habitat and wildlife winter habitat) are considered to have high wildlife values; two resource units were defined as visually sensitive, and the remaining two included areas not specifically assigned to the other resource units. Details about the management objectives applied to each resource unit are provided in Section A.3. Figure 8 shows the extent of each resource unit within the timber harvesting land base.

Free growing

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

Cutblock adjacency guidelines

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

Green-up period

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

Management assumptions

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

2 Information Preparation

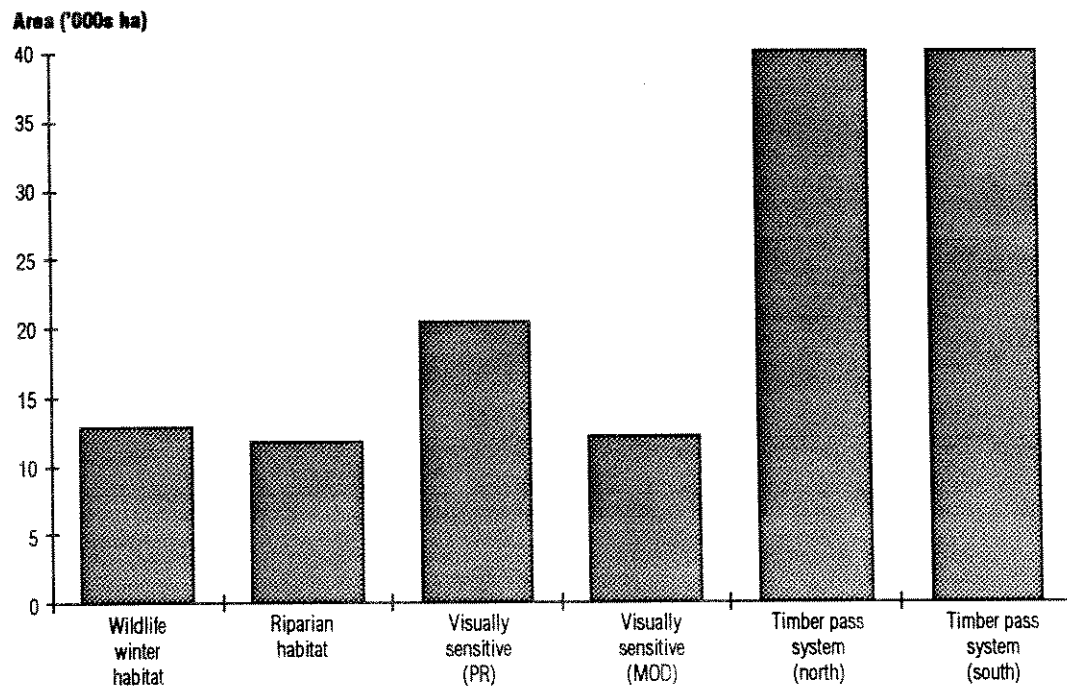


FIGURE 8. Area of timber harvesting land base by resource unit, Golden TSA.

3 Analysis Methods

The purpose of this analysis was to examine both the short- and long-term timber harvesting opportunities in light of current forest management practices. A timber supply computer simulation model developed by the B.C. Forest Service was used to aid in the assessment. A timber supply model, as distinguished from a growth and yield model, assists in determining how a whole forest, or collection of stands, should be managed in order to obtain a harvest flow, or supply of timber over time. The simulation model uses information about the timber harvesting land base, timber volumes and the management regime to represent how trees grow and are harvested over a period of 0–250 years.

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

younger than a specified green-up age; or that some minimum per cent of the area must be in older age classes to provide wildlife habitat. The B.C. Forest Service simulation model tests such guidelines to examine their effects on timber supply. Forest cover guidelines and the specific areas to which they are applied in this analysis are described in Section A.3, Forest Management Practices, page 35.

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

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

4 Base Case Analysis Results

This section presents the results of the timber supply analysis for the base case. The purpose of the base case analysis is to indicate the potential maximum harvest levels that can be attained over time based on the timber harvesting land base and management practices already described. The base case is also subject to a particular harvest flow pattern: the harvest level is not allowed to decline more than 10% each decade to, but not below, the long-term level. The base case serves as a benchmark against which other results, presented in Section 5, Timber Supply Sensitivity Analysis, page 15, are compared. It is intended for discussion purposes only and does not suggest a particular AAC.

4.1 Harvest Forecast

Figure 9 presents the base case harvest forecast*. The harvest level in the first decade is 605 000 cubic metres per year, about 7% less than the current AAC. After the first decade, the harvest level falls the maximum 10% each decade to the long-term

level of 309 000 cubic metres per year by decade 8. Harvest levels can be held significantly above the long-term level in the early decades because of the large area of old forest in the current inventory (Figure 6). Old forest generally contains higher volumes than the younger stands that will be harvested in the future.

Note that the long-term level is less than the potential maximum harvest that would be calculated based solely on maximum mean annual increment. This theoretical maximum long-term level is estimated to be about 335 000 cubic metres per year. This level cannot be maintained because of two factors. First, volume losses to fire and other agents, (estimated to be 19 000 cubic metres per year) must be deducted. Second, stands are not always harvested at ages that would maximize timber production. This can occur due to imposed harvest flow patterns or when forest cover guidelines are applied.

(Note: All harvest forecasts in this report have been reduced by 19 000 cubic metres per year to account for unsalvaged losses to fire and insects.)

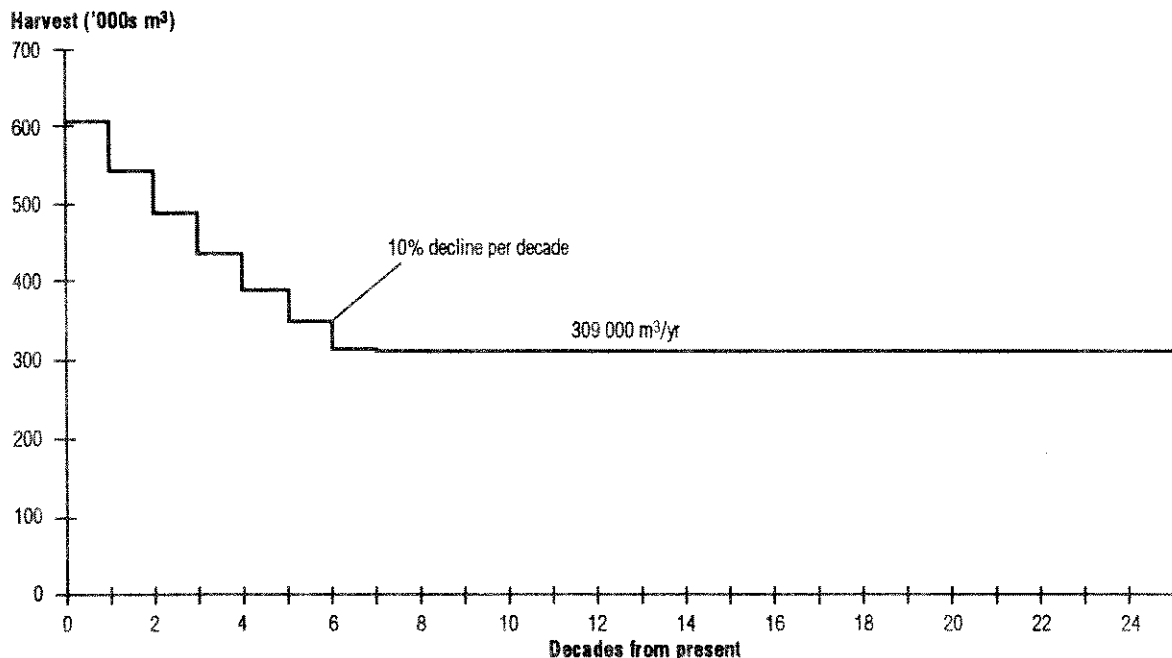


FIGURE 9. The base case harvest forecast for the Golden TSA.

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.

Mean annual increment (MAI)

Stand volume divided by stand age. The stand age at which the MAI assumes its maximum value is called the "culmination age." Harvesting all stands at this age results in a maximum average harvest over the long term.

4 Base Case Analysis Results

4.2 Other Results

Figures 10 to 12 present additional results for the base case. The projection of total timber volume of the timber harvesting land base in Figure 10 shows a reduction from 32 million cubic metres at the start to a stable volume of about 20 million cubic metres over the long term. This trend mirrors the harvest forecast for the base case and the transition of the inventory from the high-volume old forest to a younger forest that yields less volume at harvest. The trend in total available volume over time again shows the transition to a young forest. The available volume (according to the minimum harvesting ages shown in Section A.3) is a large proportion of the total volume at the beginning, dropping to less than half of the total volume over the long term.

The trend in mature volume reaches its lowest point in decades 7 and 8, coinciding with the harvest reaching the long-term level. The relative shortage of mature volume in this period restricts the harvest that can be achieved in earlier decades. If harvest levels are increased before decade 7, the harvest would fall below the long-term level. This outcome would violate the harvest flow guidelines applied in the base case and most other cases analyzed. Note that this critical period affects the harvest levels attainable in earlier decades if the harvest flow guidelines are to be satisfied.

Figure 11 shows the average area harvested each year projected over 250 years in the base case simulation. The area harvested declines from about 1400 hectares annually at the start to a low of 1000 hectares in decade 7. This trend roughly follows the harvest forecast pattern for that period. However, the decline is not as rapid since older stands harvested in the early decades have higher yields than the younger stands harvested later. The area harvested each year increases from decade 7 to 10 even though the volume harvested is the same during the period. This again reflects the trend towards harvesting younger stands that yield lower volumes. Over the long term, the average area harvested fluctuates around an average of approximately 1250 hectares per year.

Figure 12 shows that average volume harvested per hectare decreases from about 425 cubic metres per hectare at the start to a range of 275 to 300 cubic metres per hectare over the long term. (These are calculated from gross harvest volumes, which include 19 000 cubic metres per year of non-recoverable losses.) The reduction in volume yields is due to the trend towards harvesting younger stands. Over time, therefore, more area must be harvested to attain the same volume or, conversely, less volume can be harvested on the same area.

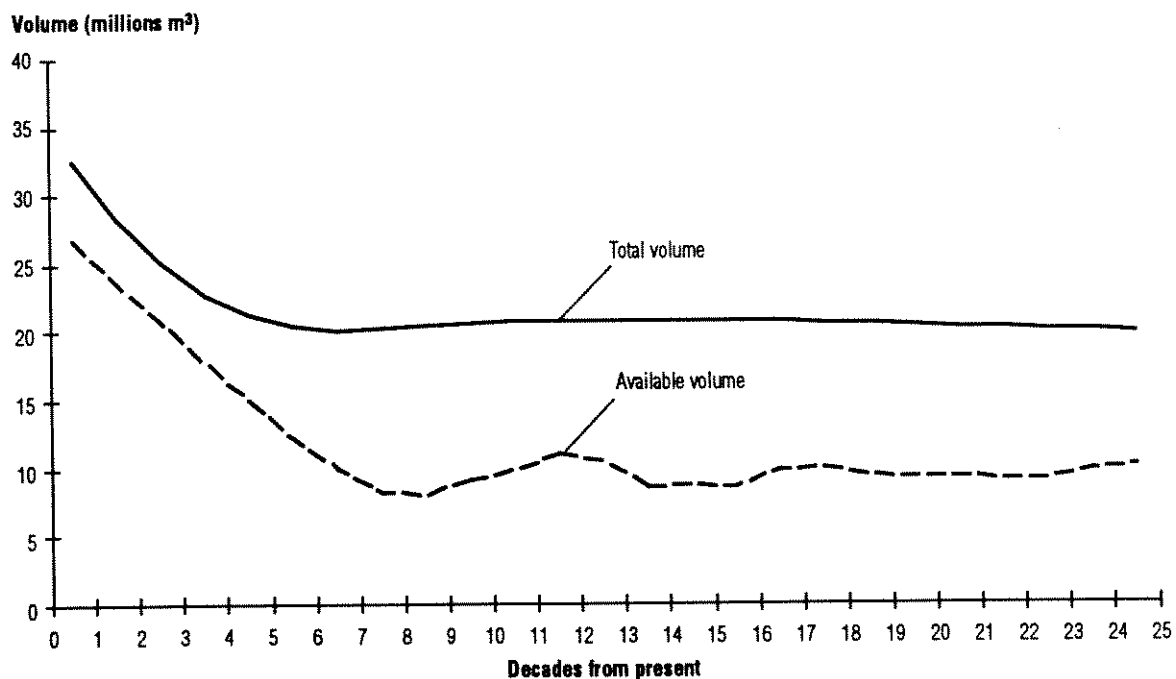


FIGURE 10. Total and mature volume over time for the base case, Golden TSA.

4 Base Case Analysis Results

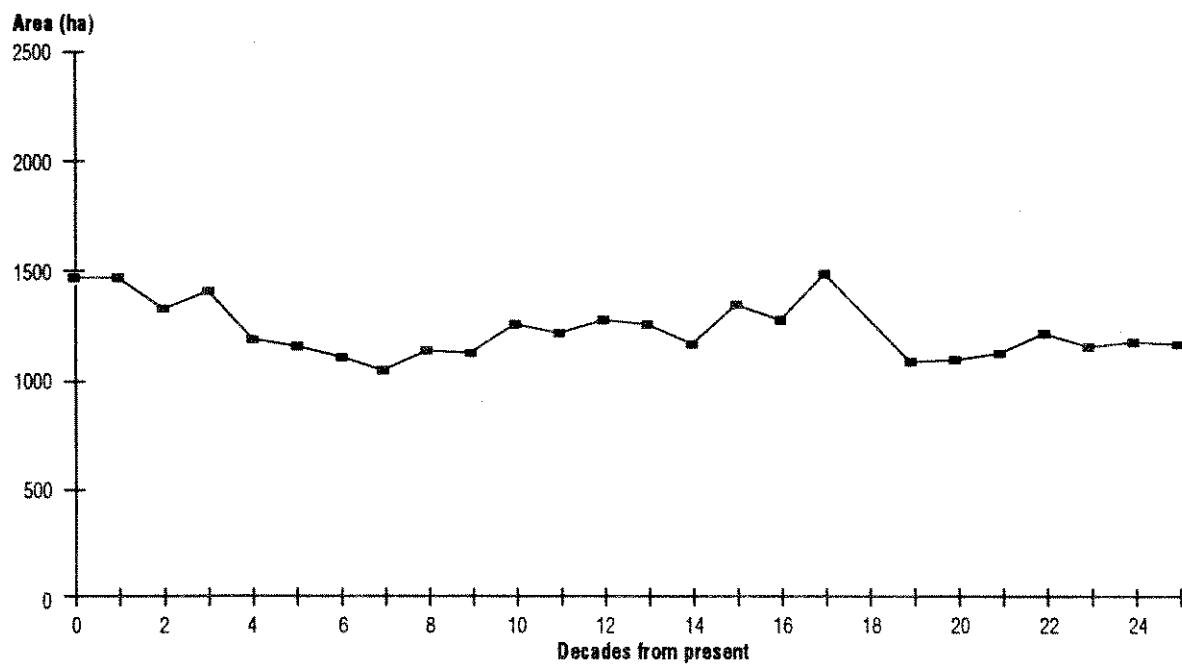


FIGURE 11. Average area harvested annually for the base case, Golden TSA.

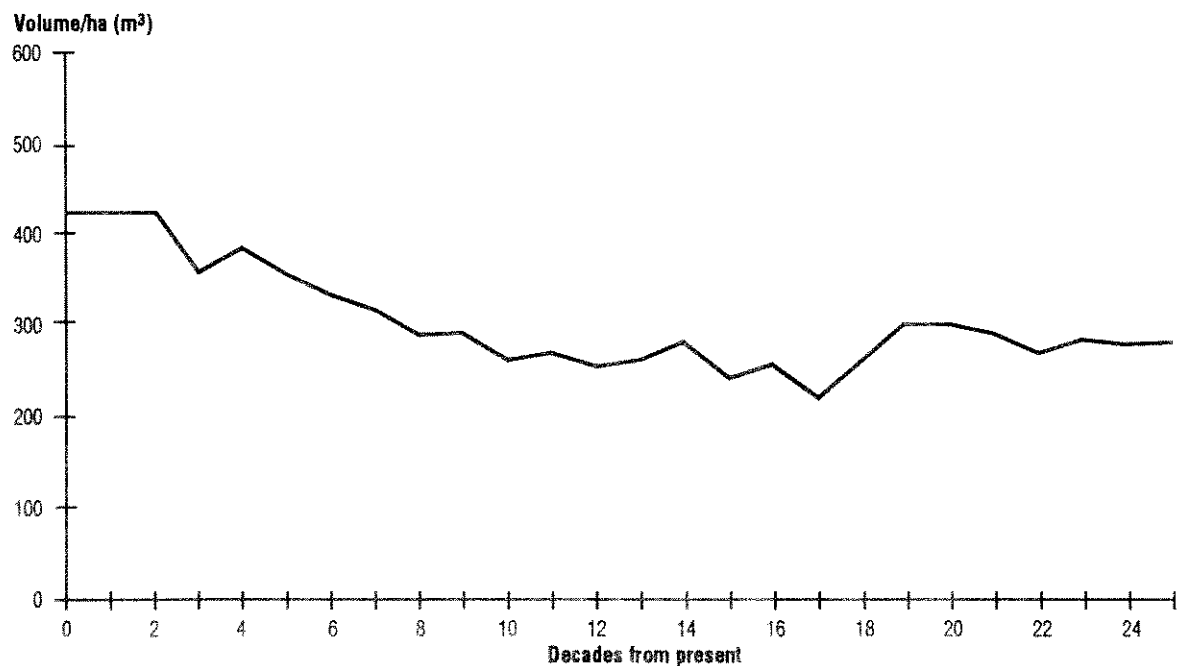


FIGURE 12. Average volume harvested per hectare for the base case, Golden TSA.

5 Timber Supply Sensitivity Analysis

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

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

The sensitivity of results to uncertainties in the data and assumptions is indicated by comparing the resulting harvest forecasts with the base case forecast. Unless otherwise stated, the harvest flow guidelines applied in the base case are also applied in the other cases analyzed: that is, harvest levels are the maximum attainable while allowing a maximum decline of 10% each decade after the first decade to, but never below, the long-term level.

5.1 Alternate Harvest Flow Patterns

The base case harvest forecast started at 605 000 cubic metres per year in the first decade and then declined 10% each decade to the long-term level. Many other harvest flow patterns are possible and this section presents the results of examining three alternatives.

Figure 13 shows the results of maintaining the harvest level at the current AAC of 650 000 cubic metres in the first decade. As shown, the harvest level must be allowed to decline by 12 to 13% per decade after decade 1. If the rate of decline was limited to 10%, a timber deficit would occur in the period from decade 7 to 9. (This alternative is not illustrated.) These results show that the current AAC cannot be achieved in the first decade under current management practices without relaxing the restrictions on the harvest flow pattern.

This second harvest flow pattern examined how long the harvest could be maintained at the current AAC if the decline in future harvests was not limited. The results are shown in Figure 14. The current AAC of 650 000 cubic metres per year can be maintained for 4 decades but is followed by a rapid decline to a low of 107 000 cubic metres per year by decade 6. The harvest does not reach the base case long-term level until decade 10. These results indicate that the current AAC could be maintained for 40 years, but, as a result, a serious timber shortage would develop after that time.

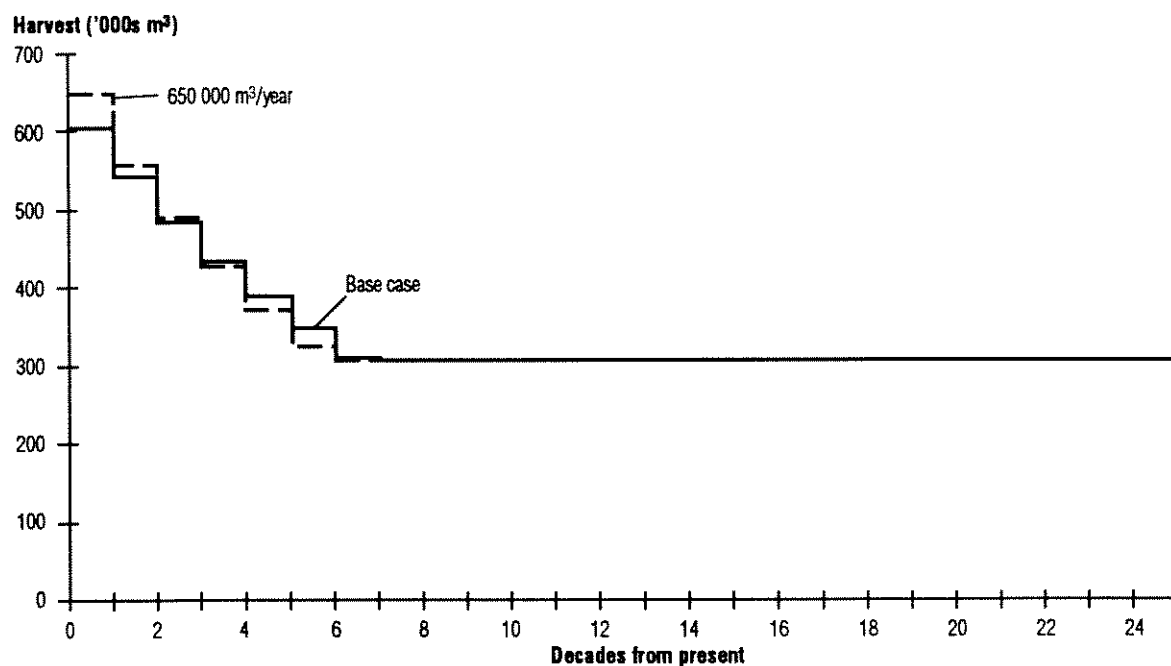


FIGURE 13. Harvest forecast with the current AAC maintained for the first decade, Golden TSA.

5 Timber Supply Sensitivity Analysis

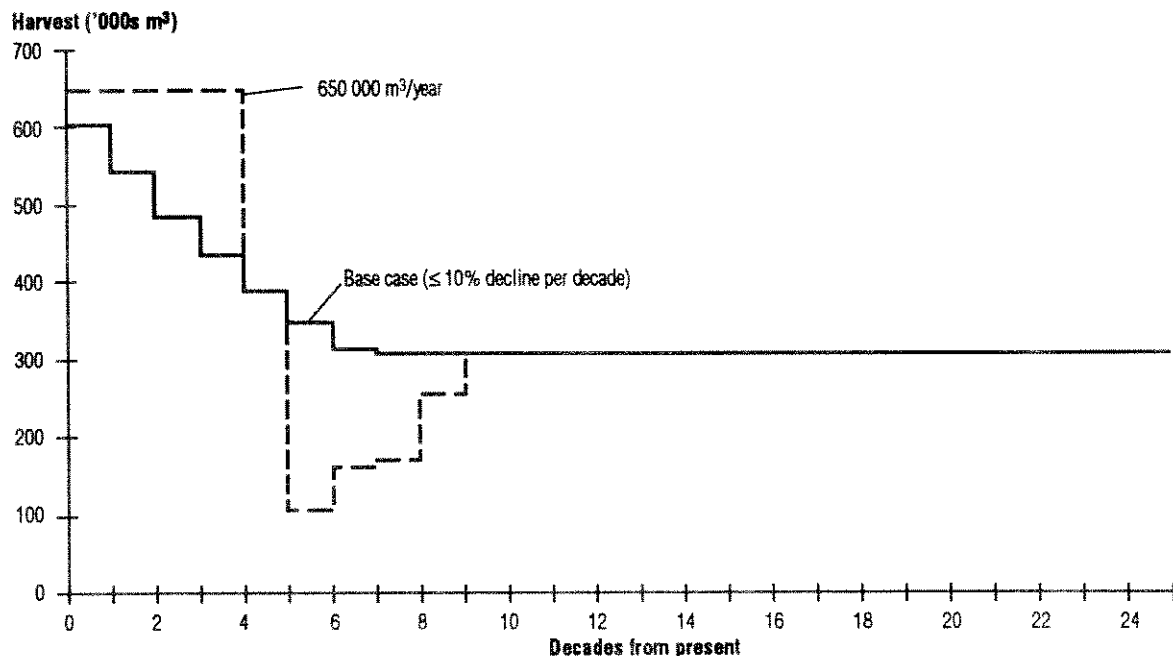


FIGURE 14. Harvest forecast with the current AAC maintained as long as possible and with no limit on the decline in the harvest level, Golden TSA.

A third harvest flow pattern was examined to ascertain what maximum constant harvest level could be maintained over the first 40 years if the decline in the harvest to the long-term level was limited to no more than 10% per decade. The results are presented in Figure 15. Over the 40-year period, a constant 484 000 cubic metres per year can be harvested under these conditions before declining to the base case long-term level. The harvest over the first 4 decades is 26% less than the AAC.

The harvest forecast shown in Figure 15 indicates that the timber supply in the Golden TSA has been reduced considerably since the previous analysis completed in 1988. The reduction is estimated to be in the order of 25% in both the short- and long-term supply. This change is the result of many factors including changes in inventory and volume data, management practices and modelling procedures. These are discussed in detail in Appendix B.

5.2 Overall Forest Cover Guidelines and Adjacency Restrictions

The management objectives for non-timber resources and cutblock adjacency restrictions were modelled in the base case mainly by applying forest cover guidelines as described in Section A.3, Forest Management Practices, page 35. The effect of these guidelines on timber supply was examined by removing the guidelines entirely and comparing the resulting harvest forecast with the base case. Figure 16 shows that without guidelines applied, the first decade harvest level can be increased to 650 000 cubic metres per year—about 7% greater than the base case. The harvest level can also be reduced more gradually at 9% each decade after the first decade. The total of the volume harvested up to decade 8 is 10% greater with no forest cover guidelines applied. During this period, therefore, removing the guidelines increases the volume available for harvesting by approximately 10%.

The long-term harvest level can be increased by 2% to 315 000 cubic metres per year.

These results show that the timber supply is more sensitive in the shorter term to forest cover objectives than over the long term. This difference is due to the trend in the age structure of the timber harvesting land base as well as the decline in harvest levels over time. At the start, the harvest level is at a maximum while a relatively large area is below green-up age. Over time, the age structure becomes more evenly distributed, with proportionately less area younger than green-up age.

5 Timber Supply Sensitivity Analysis

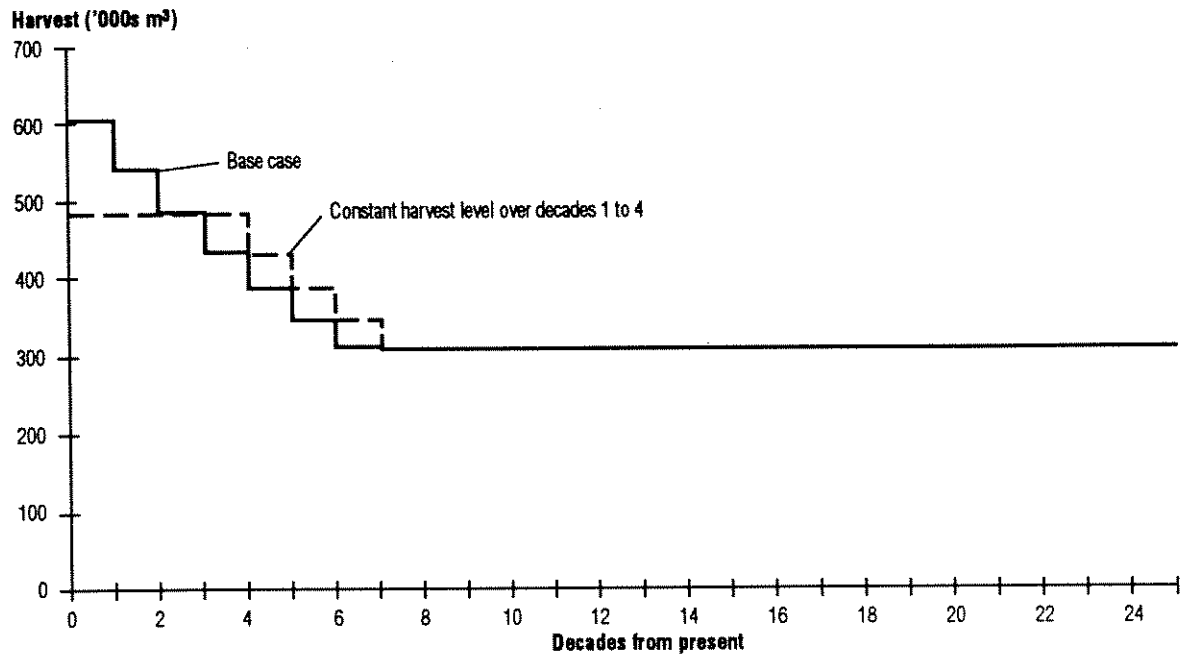


FIGURE 15. Harvest forecast with a constant maximum harvest for the first 40 years, Golden TSA.

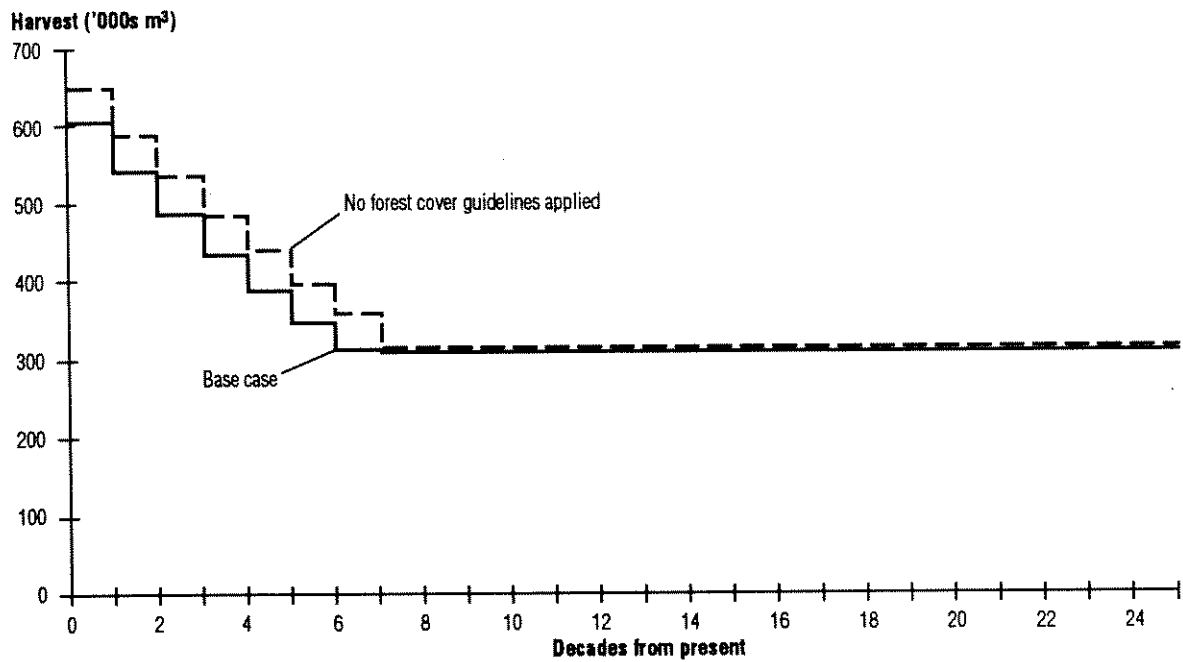


FIGURE 16. Harvest forecast with no forest cover guidelines applied, Golden TSA.

5 Timber Supply Sensitivity Analysis

5.3 Green-up Periods

Green-up periods applied in the base case vary from 15 years for the northern timber pass system resource unit to 80 years for wildlife winter habitat. The green-up periods are derived from estimated stand heights needed to meet specific forest management objectives. These estimates have a degree of uncertainty as the stand height required cannot be estimated exactly. For example, would stands that are 18 metres tall be adequate for wildlife winter habitat or should they be taller than the 20-metre minimum height assumed in the base case? This uncertainty was examined by increasing and decreasing all green-up periods by 20%—for example, a 30-year green-up period was varied by 6 years. Other factors, including the harvest flow restrictions, were left unchanged from the base case.

With green-up periods decreased, a lower proportion of the total inventory area is younger than the green-up ages and therefore more area can be harvested before reaching maximum limits on total area below green-up. The opposite effect occurs when green-up periods are lengthened.

Figure 17 shows that with green-up periods reduced 20%, harvest levels can be increased by 3% to 626 000 cubic metres per year in the first decade and by 2% to 315 000 cubic metres per year over the long term. With green-up periods extended, the rate of harvesting must be reduced relative to the base case. In the first decade, the harvest level is 7% lower at 573 000 cubic metres per year while the long-term level is slightly lower at 302 000 cubic metres per year. Results are most sensitive to this uncertainty in the early decades, especially where

the green-up periods are extended. This is due to the significant area of NSR and younger stands that are below or close to the green-up ages defined for the base case.

It is useful to relate these results to the green-up canopy height criteria that were the basis for the estimates of green-up periods. For 20- to 40-year-old stands, height growth is estimated to be about 0.3 metres per year for the major species. The 20% range of this test would therefore represent an average change in canopy height of 1.2 metres at 20 years and 2.4 metres at 40 years. For example, the upper and lower green-up heights for riparian habitat would be 11.8 and 8.2 metres, respectively.

5.4 Forest Cover Requirements

As discussed in Section A.3, forest cover guidelines applied in the base case vary from 84% of the area within the visually sensitive (partial retention) resource unit to be at or above green-up age to 45% for wildlife winter habitat. These estimates have some uncertainty as it is not possible to define the exact forest structure needed to meet the management objectives for a particular area. This uncertainty was examined by increasing and decreasing forest cover requirements by 10%. Figure 18 shows the results.

With reduced cover requirements, the harvest can be increased 7% in the first decade to the AAC and 2% over the long term. With increased cover requirements, harvest levels are significantly lower than the base case. In decade 1, the harvest is 14% lower at 523 000 cubic metres per year while the

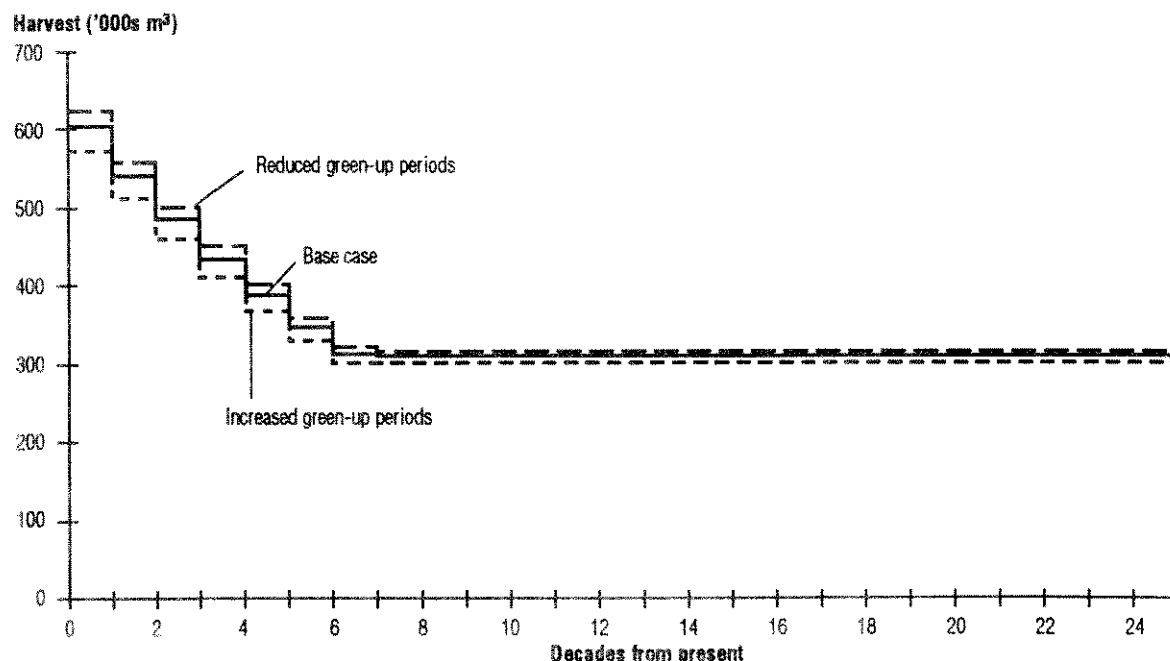


FIGURE 17. Harvest forecasts with changes in green-up periods, Golden TSA.

5 Timber Supply Sensitivity Analysis

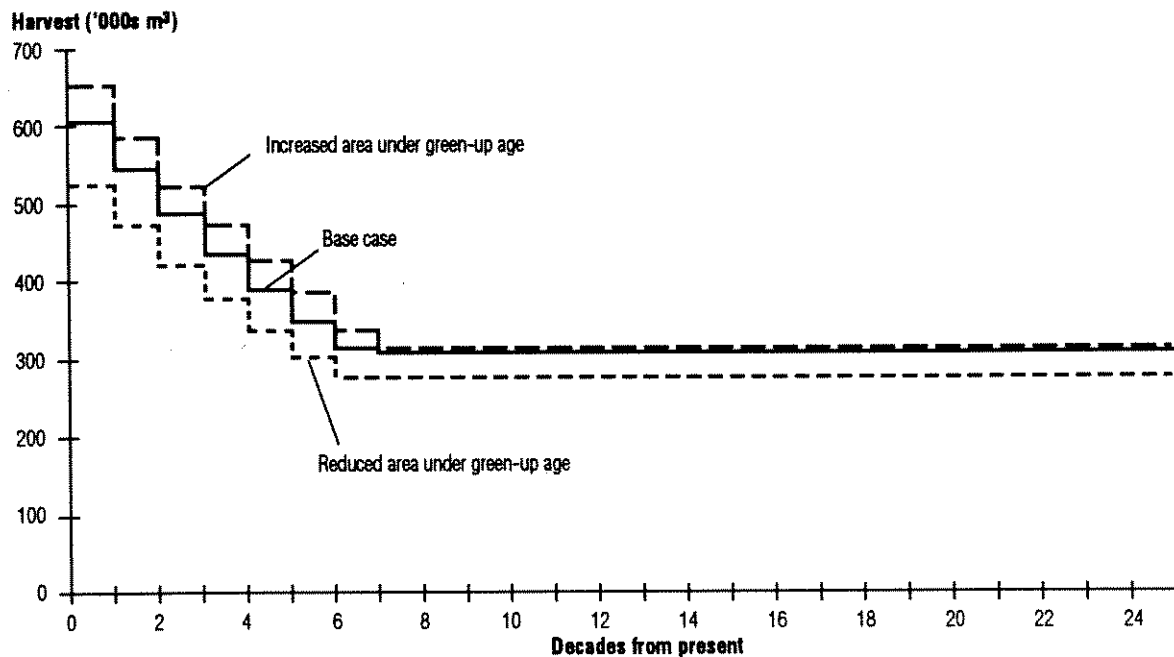


FIGURE 18. Harvest forecasts with forest cover requirements varied plus and minus 10%, Golden TSA.

long-term harvest level is 10% lower at 275 000 cubic metres per year. Harvest levels are therefore more sensitive to changes in cover requirements in the short term and most sensitive to increased forest cover requirements.

The reason for the large impact of increased cover requirements can be shown by considering the northern timber pass system resource unit. In the base case, this area is assumed to be managed under an approximate three-pass system with a 15-year green-up restriction (e.g., 35% of the area can be younger than green-up age at any time). The increased cover requirement in this test results in a four-pass harvesting regime, allowing only 25% of the area to be younger than green-up age. This is a significant change from the base case.

5.5 Volume Estimates

Volume estimates have a degree of uncertainty due to such factors as the statistical process used to develop the growth and yield models, the inventory classification procedures, and the uncertainty about how forest management practices will affect future yields. This uncertainty in volume estimates was examined by assessing the sensitivity of harvest levels to changes in volume data applied in the base case.

Volume estimates applied to both existing and regenerated stands were first increased and then decreased by 10% from the base case levels.

Figure 19 shows the results of these changes. With all volumes reduced 10%, harvest levels had to be reduced correspondingly to 544 000 cubic metres per year in the first decade and 275 000 cubic metres per year over the long term to meet the base case harvest flow restrictions. If all volumes are increased 10%, the initial harvest can be raised 7% to the AAC. The harvest then declines more gradually (9%) to a long-term level of 341 000 cubic metres per year.

Additional analyses were carried out to show the sensitivity of harvest levels to uncertainties in volume estimates for existing stands and regenerated stands separately. Volumes applied to existing stands were increased and decreased by 10% while regenerated stand volumes were left unchanged. Figure 20 shows that if volume estimates for existing stands were increased, the harvest could be set to the current AAC in decade 1 and allowed to decline 9% each decade to the long-term level of 309 000 cubic metres per year.

If existing stand volumes are decreased 10%, the initial harvest declines to 461 000 cubic metres per year, 26% less than the base case harvest level. Harvest levels then decline at 10% each decade, to the long-term level of 309 000 cubic metres per year.

Decreasing only existing stand volumes has a much greater impact on short-term harvest levels than when all volumes are decreased (see Figure 19) because existing volumes must be reserved so that the higher long-term level shown in Figure 20 can be achieved.

5 Timber Supply Sensitivity Analysis

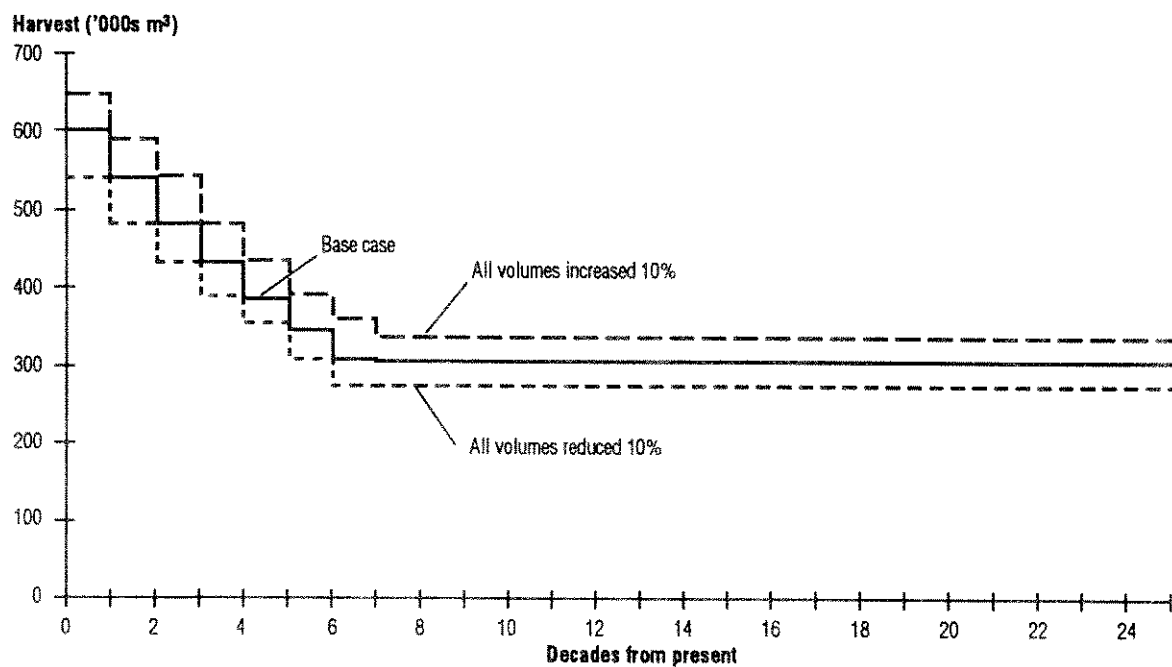


FIGURE 19. Harvest forecasts with all volume estimates varied plus and minus 10%, Golden TSA.

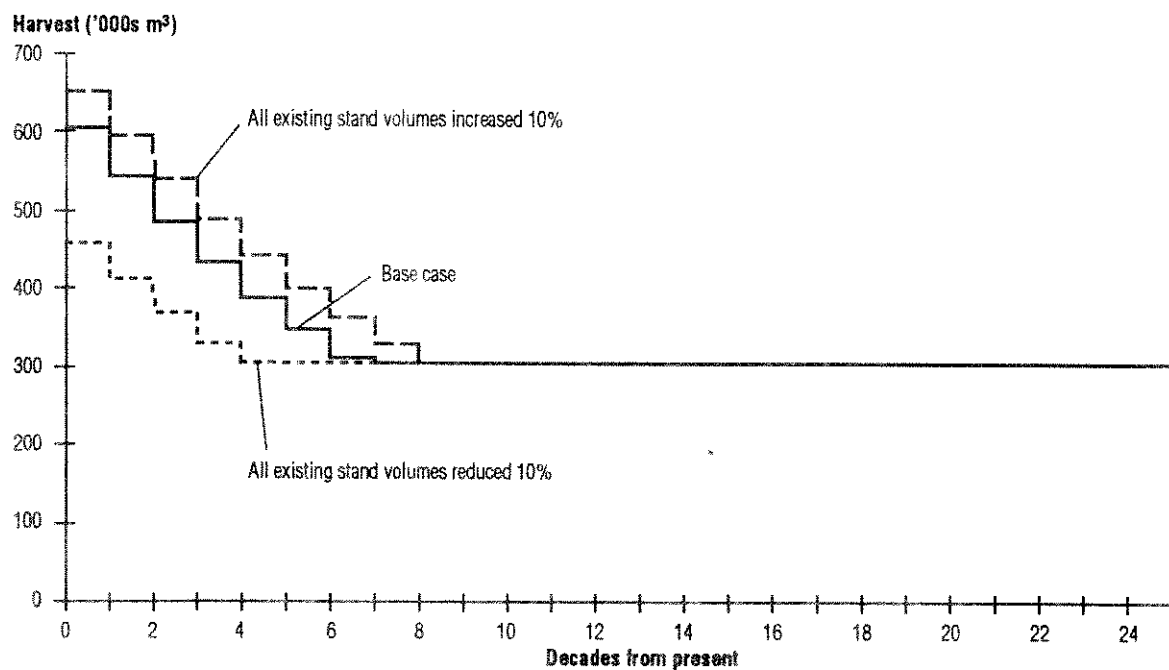


FIGURE 20. Harvest forecasts with volume estimates for existing stands varied plus and minus 10%, Golden TSA.

5 Timber Supply Sensitivity Analysis

Figure 21 shows the sensitivity of harvest levels to uncertainty in the volume estimates applied to future regenerated stands. Volumes were increased and reduced by 10% while existing stand yields (and all other factors) were left unchanged. These changes have little effect on the short-term results. With future volumes reduced by 10%, the long-term harvest must be lowered by an equivalent amount to 282 000 cubic metres per year. The harvest levels over the first 5 decades can be raised slightly in this case. This outcome appears unreasonable as it seems that harvest levels can be increased now if future volumes are lower. This effect occurs because less volume reserve is required to meet the lower harvest level in decades 6 to 9, thereby creating a surplus, relative to the base case. This surplus is therefore available for harvesting in the earlier decades.

If future volumes are increased by 10%, harvest levels after decade 9 can be raised by an equivalent amount to 335 000 cubic metres per year. Note that the harvest level must be allowed to fall below the new long-term level and then increase after decade 9 to capture the increase in future volume yields. Harvest levels cannot be increased in the first 9 decades because future stands to which the increased volumes are applied do not reach harvest-age during that time.

These results indicate that the harvest forecast is sensitive to the uncertainty in the estimates of future yields but only beyond decade 9. During the first 9 decades, harvest levels are not sensitive to this uncertainty.

As stated, the uncertainty in volume estimates arises from a number of sources, including the lack of information on how some management practices affect volume yields. In the Golden TSA, the management of biodiversity on some cut-over sites is considered to be current practice. The objective of promoting biodiversity on harvested sites is to provide habitat for a wide range of plant and animal species. As explained in Section A.3, Forest Management Practices, page 35, this would require silviculture methods that would leave brush species, deciduous trees and large woody debris on the site after harvesting. District staff believe that this type of management would reduce timber production by inhibiting the establishment and early height growth of merchantable trees. They estimate that future yields could be reduced by an average of 4.5%. This was not applied in the base case as there is little empirical evidence to support it. However, if this estimate were confirmed, the long-term timber supply estimate would be reduced proportionately.

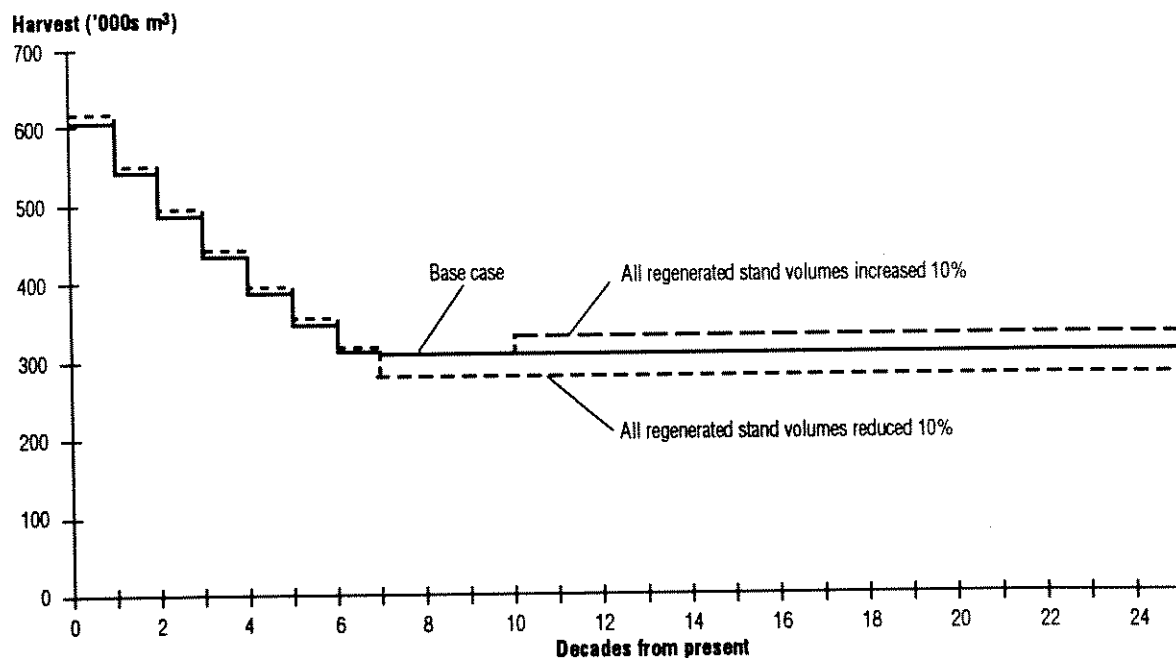


FIGURE 21. Harvest forecast with volume estimates for regenerated stands varied plus and minus 10%, Golden TSA.

5 Timber Supply Sensitivity Analysis

5.6 The Availability of Existing Mature Forest for Harvesting

The estimate of how much of the existing mature forest is available or accessible for harvesting is uncertain due to such factors as the imprecise nature of the inventory data, market fluctuations and the ability of the industry to develop areas of difficult access. A particular concern in the Golden TSA is the proportion of the harvesting that occurs on steep slopes relative to the estimated timber supply on these areas.

This concern was examined by reducing the area of stands in the timber harvesting land base that are currently older than 120 years. A 10% reduction removed 5900 hectares (3.4%) from the timber harvesting land base and 2.5 million cubic metres of timber volume. A 20% reduction excluded 11 800 hectares (6.8%) and 5.0 million cubic metres. The results are compared to the base case in Figure 22. If 10% of the mature area is excluded, harvest

levels must be lowered 7% in the first decade to 567 000 cubic metres per year and 3% over the long term to 299 000 cubic metres per year. With 20% of the mature area removed, harvest levels must be set 14% lower in the first decade at 524 000 cubic metres per year and 7% lower over the long term at 289 000 cubic metres per year. Harvest levels are therefore more sensitive in the early decades than over the long term. This is due, in part, to the increased impact of forest cover guidelines, as there is a smaller proportion of the area above the green-up ages at the start. Additionally, the excluded area would yield higher volumes at the first harvest than in subsequent harvests when harvesting ages are generally lower.

These results show that the harvest forecast for the next few decades is very sensitive to the estimate of the extent of the mature forest area currently available for harvesting. The removal of some steep slope areas from the timber harvesting land base would have a significant impact on the short-term timber supply estimate.

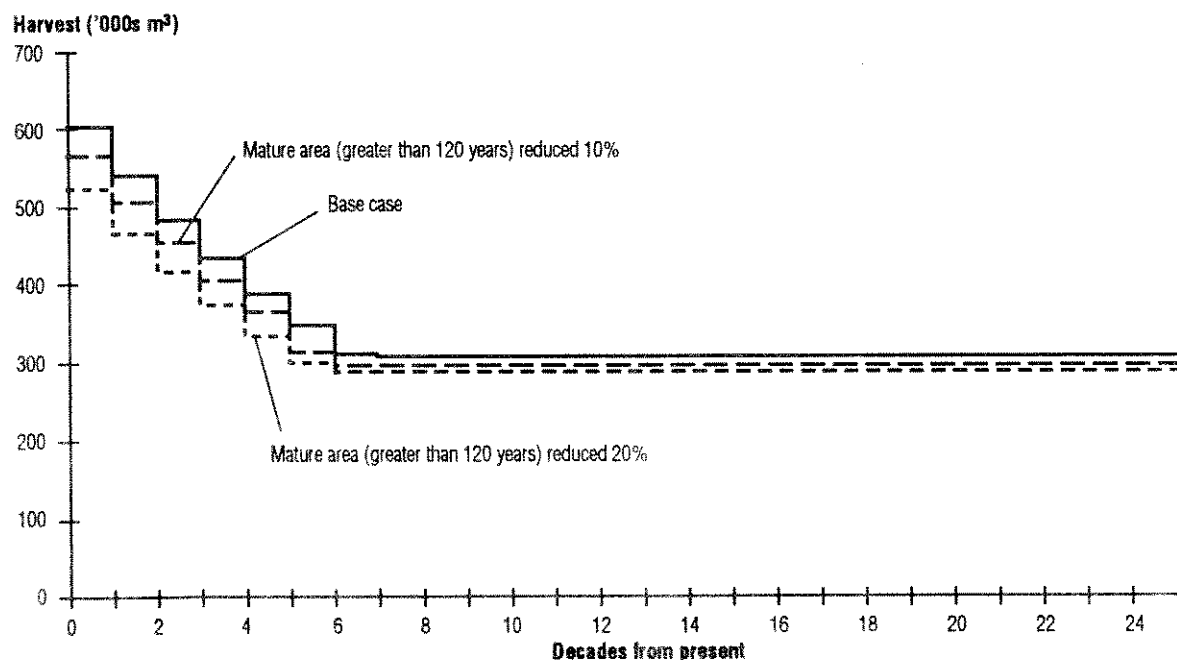


FIGURE 22. Harvest forecast with some existing mature area excluded, Golden TSA.

5 Timber Supply Sensitivity Analysis

5.7 Minimum Harvesting Ages

Minimum harvesting ages chosen for this analysis are shown in Section A.3, Forest Management Practices, page 35. These ages have a degree of uncertainty associated with them as it is not possible to predict the exact age at which a stand reaches its maximum long-term yield nor the exact age at which a stand contains trees of adequate size for milling. The potential effects of this uncertainty were assessed by increasing and decreasing the ages for both existing and future stands by 10 years. The results are shown in Figure 23. Decreasing the ages by 10 years allows more volume to be harvested over the first 7 decades relative to the base case. The first-decade harvest is increased by 5% to 635 000 cubic metres per year. This is due mainly to the increased volume available during the period of

decades 6 through 10, as stands can be harvested at younger ages. The long-term harvest remains at the base case level.

With harvesting ages increased 10 years, harvest levels must be reduced over the first 7 decades but the long-term harvest can still be set to the base case level. The first-decade harvest is reduced 7% to 565 000 cubic metres per year. The explanation for this effect is that less volume is available in the critical period from decades 6 to 10, since areas are harvested at older ages relative to the base case.

Harvest levels in the short term are thus moderately sensitive to the uncertainty in estimating minimum harvesting ages due to a reduction or expansion of the available timber supply in decades 6 to 10. The long-term harvest level is not sensitive to 10-year changes in harvesting ages.

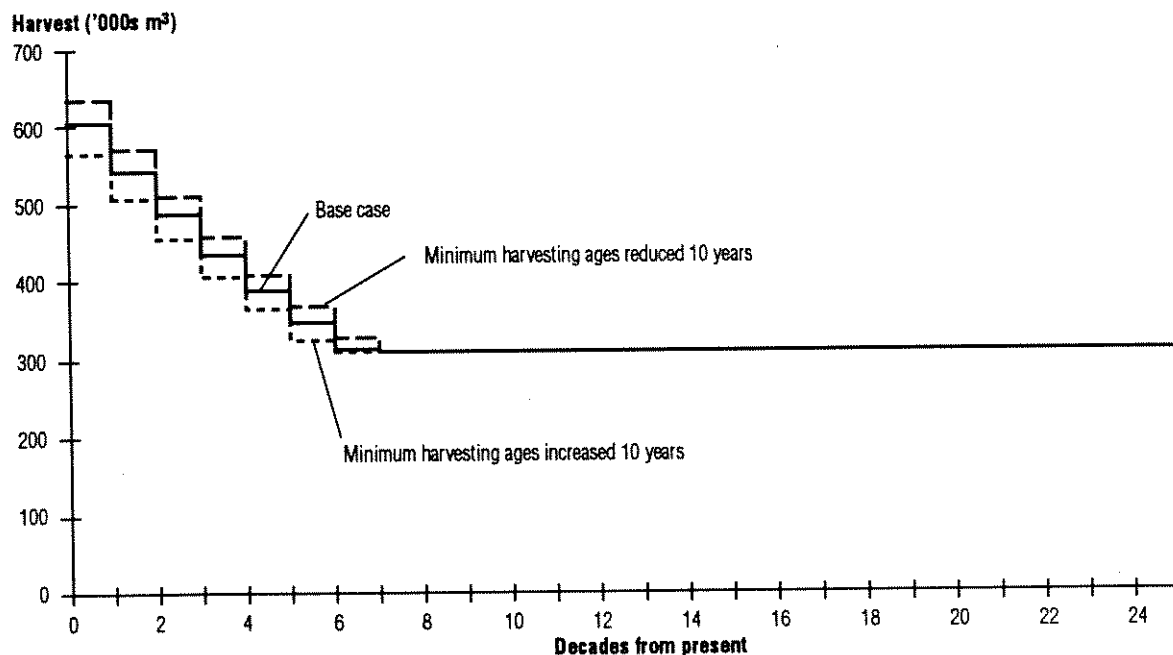


FIGURE 23. Harvest forecasts with minimum harvesting ages varied plus and minus 10 years, Golden TSA.

6 Summary and Conclusions

The analysis for the Golden TSA indicates that, given current management assumptions, an initial harvest of 605 000 cubic metres per year can be maintained for only 1 decade. Harvests must then begin to decline at 10% per decade until the long-term harvest level of 309 000 cubic metres per year is reached in decade 8.

Under current management practices, the initial harvest rate can only be raised above 605 000 cubic metres per year by either allowing rates of decline greater than 10% or by accepting significant timber supply shortfalls in the future. For this reason, the current AAC of 650 000 cubic metres per year is not achievable. Conversely, any attempt to slow the rate of decline requires an immediate harvest reduction below the base case initial harvest. The protection of non-timber values reduces harvest levels by 10% in the short term and by 2% over the long term.

This analysis employs the best current estimates for all variables used to describe forest management in the Golden TSA. However, varying degrees of uncertainty surround most of the estimates. Sensitivity analyses show that short-term timber supply is particularly sensitive to decreased yields for existing stands. Short-term supply is also sensitive to a decrease in the area of existing mature forest available for harvesting, to the tightening of forest cover requirements, and to increased yield estimates for existing stands.

Increased minimum harvest ages and extended green-up periods have more moderate impacts on short-term harvest levels. Changes in regenerated yields have very little impact on short-term harvest rates although the long-term harvest level is significantly affected. The long-term harvest is also highly sensitive to tightening of forest cover requirements.

7 References

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8 Glossary

Allowable annual cut (AAC)	The allowable rate of timber harvest from a specified area of land. The Chief Forester sets AACs for Timber Supply Areas (TSAs) and Tree Farm Licences (TFLs) in accordance with Section 7 of the <i>Forest Act</i> .
Analysis units	The basic building blocks around which inventory data and other information are assembled for use in forest planning models. Analysis units represent the general level of aggregation, or detail, at which a timber supply analysis is carried out. They are normally defined by tree species and site qualities, but may also be defined to incorporate specific geographic areas or areas under a similar set of management practices.
Available volume	The portion of total inventory volumes that is available for harvesting after all management constraints on timber harvesting have been considered, including definition of the timber harvesting land base, age of tree merchantability, deferrals, and any other priorities or constraints on timber harvesting.
Biodiversity (biological diversity)	Diversity of life in all its forms and levels of organization, including genes, species, ecosystems and the evolutionary and functional processes that link them.
Biogeoclimatic zone	A large geographic area with a broadly homogenous climate, a regionally similar mosaic of soils, and a vegetative complex that reflects climate.
Buffer strip	A strip of land (often including undisturbed vegetation) where disturbance is not allowed or is closely monitored to preserve or enhance non-timber values along or adjacent to trails, water bodies and recreation sites.
Cutblock adjacency guidelines	Integrated management guidelines that specify the desired spatial relationship among cutblocks. They can be approximated by specifying the maximum allowable proportion of a forested landscape that does not meet green-up requirements.
Environmentally sensitive area (ESA)	An area with significant non-timber values, fragile or unstable soils, problems in establishing a new tree crop, or where timber harvesting may cause avalanches.
Forest inventory	Assessment of British Columbia's timber resources. It includes computerized maps and a database describing the location and nature of forest cover, including size, age, timber volume, and species composition, as well as a description of some non-timber values such as recreation and visual quality.
Forest planning model	An analytical (usually computer-based) model that simulates the harvest and growth of collections of forest stands over a period of several decades according to specific data and management assumptions. Forest planning models are of two basic forms: forest estate simulation models, which address "what-if" questions by determining the effects of a specified policy or management alternative; and linear programming harvest scheduling models, which seek out the policy or management alternative that best attains a specified management objective (e.g., maximum volume harvested over time) subject to specified management constraints. This analysis employs a computer simulation model developed by the B.C. Forest Service.
Forest type	The classification or label given to a forest stand, usually based on its tree species composition. Pure spruce stands and spruce-balsam mixed stands are two examples of forest types.
Forest type representation	Retaining a representative sample of all naturally occurring forest types.

8 Glossary

Free growing	An established seedling of an acceptable commercial species that is free from growth-inhibiting brush, weed and excessive tree competition.
Green-up period	The time needed for a stand of trees to reach a desired condition (e.g., height) to ensure maintenance of water quality, wildlife habitat, soil stability or aesthetics.
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.
Integrated resource 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.
Management assumptions	Approximations of management objectives, priorities, constraints and other conditions needed to represent forest management actions in a forest planning model. These include, for example, the criteria for determining the timber harvesting land base, the specification of minimum cutting ages, utilization levels and standards, integrated resource guidelines and silviculture and pest management programs.
Maximum modification VQO	Specifies a maximum proportion (%) of a landscape that can be visibly altered by harvesting activity (see Visual quality objective).
Mean annual increment (MAI)	Stand volume divided by stand age. The stand age at which the MAI assumes its maximum value is called the "culmination age." Harvesting all stands at this age results in a maximum average harvest over the long term.
Model	An abstraction and simplification of reality constructed to help understand an actual system or problem. Forest managers and planners have made extensive use of models, such as maps, classification systems and yield projections, to help direct management activities.
Non-merchantable forest types	Stands that are accessible and otherwise available for harvesting but are assumed to be non-merchantable due to stand characteristics such as small piece size, incidence of decay and low stocking.
Not satisfactorily restocked	An area not covered by a sufficient number of tree stems of desirable species. Stocking standards are set by the Forest Service, Silviculture Branch. If the expected regeneration delay has not elapsed, the land is defined as current NSR. If the expected delay has elapsed, the land is classified as backlog NSR.
Regeneration delay	The period of time between harvesting and the date by which an area is occupied by a specified minimum number of acceptable well-spaced trees.
Rehabilitation of non-stocked land	Removing all non-commercial cover, preparing the site and stocking it with acceptable commercially valuable species.
Riparian areas (zones)	Usually found along watercourses, riparian areas have relatively more available water than surrounding areas and thus are inhabited by plants that require or thrive on moister conditions. Generally speaking, these areas provide rich, diverse habitat and sustenance for a wide variety of plants and animals.

8 Glossary

Silvicultural treatments	Activities that ensure the regeneration of young forests on harvested areas and 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, and 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 reducing the total land base according to specified management assumptions.
Timber Licences (or old temporary tenures)	Rights granted in the first half of this century to logging companies to harvest timber on specific tracts of Crown land. As stipulated in the licence documents, these areas are to be returned to Crown administration after the timber on them is harvested. It is assumed that this process will be completed in the Golden TSA 20 years from now.
Timber Supply Area (TSA)	An integrated resource management unit established in accordance with Section 6 of the <i>Forest Act</i> .
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.
Watershed	An area drained by a stream or river. A large watershed may contain several smaller watersheds.
Yield projections (volume estimates)	Estimates of yields from forest stands over time. Yield projections can be developed for stand volume, stand diameter or specific products, and for empirical (average stocking), normal (optimal stocking) or managed stands. Yield projections can be based on a number of mensurational approaches and procedures, including the use of site index curves (see Site index) and generalized growth models (e.g., Chapman-Richards and Ek-Payandeh).

APPENDIX A

Management Assumptions and Data Inputs

Introduction

The following tables and commentary outline the methods and inputs used to derive the timber harvesting land base, and to construct the timber supply model for the Timber Supply Review of the Golden TSA. For purposes of the review, this information represents current forest management in the area. Current performance is the set of land use decisions and forest and stand management practices that are currently implemented and enforced. Future forest management objectives that may be intended, but not currently implemented and enforced, are not included in this appendix. To reiterate, the purpose of the Timber Supply Review is to provide information on the current timber supply picture in each TSA in the province; that is, the effects of current management on both short- and long-term timber supply. Changes in forest management objectives, when and if they occur, will be included in subsequent timber supply analyses after this Timber Supply Review has been completed.

A.1 Analysis Unit Definition

Analysis units were defined geographically by resource units, timber type (species) and productivity rating (site class). Analysis units determine how the resource information is gathered and combined for analysis. The analysis is carried out using the simulation model.

The definition of the six resource units listed below came from work carried out in the Golden Forest District. Resource units were delineated on forest cover maps and subsequently digitized and added to the forest inventory file.

Resource Units

- Timber pass system (north)
- Timber pass system (south)
- Visually sensitive areas (partial retention VQO)
- Visually sensitive areas (modification VQO)
- Riparian areas
- Ungulate winter habitat

To complete the analysis unit definition, resource units were further subdivided into the following species groups and site classes.

TABLE A-1. *Division of resource units by species groups and site classes*

Inventory type groups	Major species	Site class
9-26	Redcedar, hemlock, balsam, spruce	Good, medium
9-26	Redcedar, hemlock, balsam, spruce	Poor
1-8, 27-32	Douglas-fir, all pine (larch)	Good, medium
1-8, 27-32	Douglas-fir, all pine (larch)	Poor

A.2 Definition of the Timber Harvesting Land Base

The timber harvesting land base has been derived by excluding certain categories of land and adjusting some areas.

1. Non-Crown land

Non-Crown land is all land that is not administered or managed by the Forest Service and includes such categories as provincial parks, Indian reserves and areas under federal jurisdiction. This area, which is identified on the inventory file as ownership code not equal to '62 C,' is excluded from the land base. Timber Licence (old temporary tenure) areas are removed at this stage but, since they are assumed to revert to the Crown over the next 20 years, are added back in to the land base as described in a later step.

2. Non-forest land

Non-forest land includes lakes, swamps, mountains and alpine forest and is classified on the inventory file as type identification '6.' These areas are completely removed from the land base.

3. Inoperable areas

Inoperable land is that part of the forested area that is not likely to be accessible for timber harvesting because of the combination of rough terrain, difficult access and economic factors. This information (the 'operability line') was gathered by district staff in cooperation with industry in 1989 by photo analysis and flight reconnaissance. It was added to the inventory file through a digital overlaying process and is identified by the 'operability code' variable. Inoperable areas were removed from the land base by excluding all operability codes not equal to 'A.' (An error involving 2200 hectares of undigitized area was corrected before this step.)

4. Non-commercial cover

Areas with non-commercial cover (brush) were excluded. They are identified on the inventory file as type identity code '5.'

5. Environmentally sensitive areas (ESAs)

Environmentally sensitive areas include areas that have moderate to high non-timber values such as wildlife and water, and areas that are prone to excessive site degradation if harvested, because of geological and topographical conditions. The following ESA categories, which have a high sensitivity rating on the inventory file, were reduced 96.5%:

- soil stability
- wildlife values
- recreation values
- regeneration problems
- avalanche potential
- inoperable

ESAs with a moderate rating were left in the timber harvesting land base.

6. Low site

Low sites are areas of low growth potential (productivity), which renders them unsuitable for timber production. These areas are given a site class of 'L' on the inventory file. All stands classified as such, either in the 'new' site class field or the 'special' site class field if special site has been assigned, are excluded.

7. Deciduous stands

As deciduous species are not presently utilized, all stands with deciduous trees as the major component are removed from the land base. Deciduous stands are identified on the inventory file as type group '35' to '42' inclusive.

8. Unmerchantable stands

This category includes stands that are not economical to harvest because of excessive decay or poor stocking. Unmerchantable stands are excluded from the land base as follows:

- 100% of type group 27 (Whitebark pine leading)
- 100% of type groups 12 (Hemlock), 15 (Hemlock-balsam), and 19 (Balsam-hemlock) where the projected age class is greater than or equal to 8
- 100% of type group 20 (Balsam-spruce) where the projected age class is greater than or equal to 8 and height class is less than or equal to 2
- 50% of type groups 13 (Hemlock-Douglas-fir), 14 (Hemlock-redcedar), and 16 (Hemlock-spruce) where the projected age class is greater than or equal to 8

The following three reductions are minor resource units identified by the Golden Forest District staff. These areas were not identified on the inventory file and so these reductions are applied at a more general level (supply block or planning cell).

A.2 Definition of the Timber Harvesting Land Base

9. Riparian areas

The following areas were deducted to account for buffer strips along minor riparian areas:

Supply block	Area (hectares)
A	215
B	100
C	180
D	95
E	185
F	170
G	70

10. Designated old-growth area

Currently there exists 407 hectares that have been designated as old-growth area. Although it is planned to manage this area as a long rotation, because of its small size it has been excluded from the land base as follows:

Planning cell	Area (hectares)
A002	85
A005, A013	192
A014	130

11. Recreation and heritage trails

The harvesting guidelines for the maintenance of recreational and heritage trails call for buffer strips to be left on either side of the trails (average width of 50 metres for recreation trails and 100 metres for heritage trails). The following areas were deducted to reflect this directive.

Supply block	Area (hectares)
A	95
C	20
D	90
E	85
F	195
G	60

12. Logging history update

As a first step in updating the logging history to the end of 1990, areas are deducted from the mature (type identification code = '2') component of the analysis units shown below and by resource unit (Table A-2). These areas are therefore assumed to be currently non-stocked and are included in the timber harvesting land base.

Analysis unit	Area (hectares)
19	96
17	14
18	11
03	641
04	263
01	152
02	51
07	841
08	191
05	199
06	68
11	378
12	60
09	32
10	14
15	214
13	53

TABLE A-2. Area deducted by resource units for logging since 1990

Resource unit	Area logged (ha)			
	Redcedar, hemlock, balsam, spruce		Douglas-fir, pine	
	Good/Medium	Poor	Good/Medium	Poor
Timber pass system (north)	152	51	641	263
Timber pass system (south)	199	68	841	191
Visually sensitive (PR)	21	9	252	40
Visually sensitive (Mod)	11	5	126	20
Wildlife winter habitat	53	0	214	0
Riparian habitat	14	11	96	0

13. Existing roads, trails and landings (site degradation)

District staff estimate that, of the total land made unproductive due to past timber harvesting development, 5630 hectares have not been accounted for on the forest inventory database. They estimate that 1200 hectares occur on land that is currently non-stocked (NSR). This area is excluded during the adjustment of the NSR area described in the following step. The remaining 4430 hectares is excluded from the age classes shown below on a *pro-rata* basis.

A.2 Definition of the Timber Harvesting Land Base

Age class	Area (hectares)
1	1200
2	530
3 to 5	400
6 to 9	2300

(Note: Loss of productive land assumed to occur in the future is accounted for during the simulation procedure as explained in Section A.3. Details on the procedure used by the district to calculate both existing and future losses are given in Section A.4.)

A.2.1 NSR Adjustments

The inventory of NSR from the most recent 1988 forest cover update indicates that approximately 25 420 hectares of the Golden TSA timber harvesting land base is NSR. However, this net forest inventory file did not have an accurate up-to-date listing of stocked areas and forest depletion—all areas surveyed prior to 1986 and many areas logged, planted or surveyed after 1987 have not been entered into the forest inventory system. A reasonable estimate of this listing was required for this analysis. The silviculture history of crop establishment records were used to determine the hectares of previously denuded area that were stocked. As a result, the current NSR status used for this analysis is approximately 13 000 hectares, including roads, trails and landings, which are deducted for this analysis (Table A-3).

TABLE A-3. Calculation of net NSR

Classification	Area (hectares)
Total NSR on the inventory file to 1988	25 420
Additional NSR from 1989-1990 harvest	3 280
Subtotal	28 700
Subtract	
NSR converted to problem forest types	265
NSR converted to inoperable forest	645
NSR converted to mature forest	900
NSR converted to hiding cover (≥ 3 m)	5 265
NSR converted to free growing status (< 3 m)	8 620
Total reduction to NSR area	15 695
Total NSR: 28 700 - 15 695 = 13 005 hectares	

District staff estimate that 1200 hectares of NSR area has been made unproductive due to harvesting operations. Excluding this area results in a net NSR area of 11 805 hectares. This net NSR area is added to the analysis units in the same proportion as the NSR area exists on the net inventory file as shown in Table A-4.

TABLE A-4. Net NSR area by resource unit

Resource unit	NSR status change (hectares)			
	Redcedar, hemlock, balsam, spruce		Douglas-fir, pine	
	Good/Medium	Poor	Good/Medium	Poor
Timber pass system (north)	575	198	3016	1109
Timber pass system (south)	662	222	2208	333
Visually sensitive (PR)	78	6	558	29
Visually sensitive (Mod)	35	43	775	183
Wildlife winter habitat	220	0	899	76
Riparian habitat	48	40	340	152

A.2.2 Timber Licence Reversions

There exists 5497 hectares of timber licence areas (old temporary tenures) in the Golden Forest District. These areas will revert to Crown administration after harvesting, in a fully stocked condition. It is assumed that this will take place over the next 20 years.

For this analysis, therefore, the timber licence areas are added to the timber harvesting land base during the first 2 decades as shown in Table A-5.

TABLE A-5. Addition of timber licence lands to timber harvesting land base by resource unit

Resource unit	Area (hectares)			
	Redcedar, hemlock, balsam, spruce		Fir, pine	
	Good/Medium	Poor	Good/Medium	Poor
Timber pass system (north)	707	822	225	145
Timber pass system (south)	499	414	290	192
Visually sensitive (PR)	206	81	8	0
Visually sensitive (Mod)	191	128	38	84
Wildlife winter habitat	569	650	100	99
Riparian habitat	1	32	0	13

A.3 Forest Management Practices

This section describes forest management as currently practiced in the Golden TSA. The information was provided by the staff of the Golden Forest District.

A.3.1 Utilization Levels

Harvesting is assumed to be carried out to a utilization level of 12.5 cm dbh for lodgepole pine timber types and 17.5 cm dbh for all other timber types.

A.3.2 Utilization Standards

Interior utilization is assumed (30 cm stump and 10 cm top), less decay.

A.3.3 Minimum Harvesting Ages

The district has selected minimum harvesting ages for the 24 analysis units described in Section A.1 with regard to the risk of volume losses to disease and insects, acceptable rotation lengths, and attaining maximum volume yields over the long term. For good/medium site analysis units, culmination ages were found to be acceptable as minimum harvesting ages and are used in the analysis. The culmination ages for poor site analysis units, however, were unacceptably high—between 140 and 180 years. Harvesting at these ages would increase the risk of volume losses to insects and

disease. Ages lower than the culmination ages have been chosen as indicated in Table A-6 below. Note that these are minimum ages and do not necessarily determine the actual harvesting ages in any given decade. For example, forest cover guidelines for wildlife winter habitat will effectively increase the long-term harvesting ages as discussed later in this section.

A.3.4 Unsalvaged Losses

The following table shows the estimated average annual volume loss to catastrophic fires and insect attacks. Regeneration of these denuded areas is expected to occur within the standard regeneration delay period of 4 years.

Cause	Unsalvaged losses (m ³ /yr)
Fire	6 200
Insects (epidemic)	
—Mountain pine beetle	9 800
—Spruce bark beetle	3 000
Total	19 000

TABLE A-6. Minimum harvesting ages by resource unit and forest cover types

Resource unit	Forest cover type	Minimum harvesting age (yrs)	
		Good/Medium site	Poor site
Timber pass system (north)	Spruce, balsam, redcedar, hemlock	100	130
	Douglas-fir, larch, pine	110	120
Timber pass system (south)	Spruce, balsam, redcedar, hemlock	110	130
	Douglas-fir, larch, pine	100	120
Visually sensitive (PR)	Spruce, balsam, redcedar, hemlock	110	130
	Douglas-fir, larch, pine	100	120
Visually sensitive (Mod)	Spruce, balsam, redcedar, hemlock	110	130
	Douglas-fir, larch, pine	100	120
Winter habitat	Spruce, balsam, redcedar, hemlock	110	130
	Douglas-fir, larch, pine	100	120
Riparian	Spruce, balsam, redcedar, hemlock	110	130
	Douglas-fir, larch, pine	100	120

A.3 Forest Management Practices

A.3.5 Site Degradation due to Harvesting Operations

Site degradation includes forest productivity losses to roads, landings and skid trails built during harvesting operations. Studies involving both the Ministry of Forests and industry in conjunction with the Forest Engineering Research Institute of Canada (FERIC) have shown that loss of productive land and yield amounts to 10.4% in the Golden TSA. For this analysis, the existing site degradation due to past harvesting is accounted for by applying the area reductions shown in Section A.2. Site degradation assumed to occur in the future is accounted for by applying a 10.4% reduction to the area of all stands that are currently older than 60 years. Details of the procedure used to estimate site degradation are provided in Section A.4.

It is assumed that stands under 61 years old have been harvested once and the site degradation has been accounted for.

A.3.6 Forest Cover Guidelines for Non-timber Resource Management

District staff identified a number of important resource units within the Golden TSA and defined forest cover guidelines for each. Resource units were delineated on forest cover maps and subsequently added to the inventory file.

Forest cover objectives ensure that a certain portion of a zone is always stocked by timber of a desired condition. The condition is described in terms of average height of the trees in a stand that has been regenerated to acceptable standards of species and number of trees per hectare. For use in the simulation model, estimated green-up time includes the estimated time taken to reach this height plus an allowance for regeneration delay. These are described briefly below.

Winter habitat provides thermal cover and snow interception for ungulate species. This area covers 12 998 hectares of the timber harvesting land base. Management guidelines specify that at least 45% of the area must be greater than 20 metres in height to provide effective snow interception and an additional 27.5% of the area must be greater than 3 metres to provide hiding and thermal cover. It is estimated that the average stand will grow to 20 metres in 80 years and to 3 metres in 20 years. The 20-metre guideline allows a maximum 55% of the area to be harvested in an 80-year period.

Riparian habitats are rich, diverse sites found mainly along watercourses, providing food and shelter for many species of animals. Many of these areas also serve as important winter ranges for ungulate species. This area occupies 11 870 hectares of the timber harvesting land base.

The management guidelines specify that at least 80% of the area must be at least 10 metres in height at any given time. The age at which an average stand attains this height is estimated to be 40 years. This restricts the area that can be harvested within the zone to 20% during a 40-year period. It would thus take 200 years to log the entire area.

Visually sensitive areas are areas that can be seen from major centres and travel corridors and have varying degrees of sensitivity to logging rated by visual quality objectives (VQOs). An area of 32 797 hectares within the timber harvesting land base has been identified as visually sensitive. Two degrees of sensitivity have been recognized within this area: 12 313 hectares is managed under modification guidelines and 20 484 hectares under partial retention guidelines. The guidelines define two distinct zones for the analysis. To meet modification guidelines, at least 70% of the area must be greater than the assumed visually effective height of 6 metres at all times. Since it is estimated that an average stand will grow to this height in 30 years, a maximum 30% of the area could be harvested in a 30-year period. Partial retention guidelines specify that at least 84% of the forest must be 6 metres in height or greater. This allows 16% of the area to be harvested during a 30-year period. The 16% maximum disturbance guideline (seen in plan view) was derived by considering the maximum perspective view disturbance guideline of 6%, the dispersion of inoperable areas in the viewscape, and hidden areas in the viewscape that would not be seen if harvested.

Timber Pass System includes areas not included in the above resource units. This area provides spring/summer/fall habitat for ungulates and year-round habitat for other plants and animals. The management guidelines described below were developed to maintain these habitats.

For this analysis, this resource unit has been separated into the northern and southern timber pass systems because of differing management guidelines. The northern zone covers 74 197 hectares of the timber harvesting land base. Management guidelines stipulate that at least 30% of the area must be a minimum of 30 years old and an additional 35% in the 15- to 30-year range. These guidelines would allow 70% of the area to be harvested over 30 years (first and second pass). The entire area could therefore be harvested once over a 43-year period.

The southern timber pass system covers 42 735 hectares of the timber harvesting land base. Management guidelines specify that at least 40% of this area must be at least 10 metres in height (40 years) and an additional 20% be at least 3 metres tall (20 years). These guidelines would permit harvesting up to 60% of the area over 40 years (first and second pass). The entire zone could be harvested once in a 67-year period.

A.3 Forest Management Practices

There were some overlapping areas identified by the district, but, for this analysis, these areas are assigned to the resource units with the most constraining forest cover objectives.

The six resource units defined for the analysis and their associated forest cover objectives are summarized in Table A-7.

TABLE A-7. Forest cover objectives by resource unit and area affected

Resource unit	Area in timber harvesting land base (ha)	Forest cover objectives		
		Green-up height (m)	Green-up age (yr)	Minimum area above green-up (%)
Winter habitat	12 998	20	80	45
		3	20	27.5
Riparian	11 870	10	40	80
Visually sensitive (Mod)	12 313	6	30	70
Visually sensitive (PR)	20 484	6	30	84
Timber pass system (north)	74 197	free-growing	15	65
		6	30	30
Timber pass system (south)	42 735	10	40	40
		3	20	60

A.3.7 Other Non-timber Resource Concerns

Other resource units considered by the district are minor riparian habitats, designated old-growth areas, recreation and historic trails and provincial park study areas. Minor riparian areas, old growth and recreation and heritage trails were excluded from the timber harvesting land base as described in Section A.2. Provincial park study areas, which cover 2100 hectares, were left in the timber harvesting land base as these areas have not yet been established as parks by Order-in-Council.

The district also addressed within-block diversity management, a harvesting and silviculture system applied to promote habitat complexity in some cut-over areas. This system would leave some large downed logs and deciduous and brush species on

the site after harvesting. It is assumed that within-block diversity management would reduce timber yields in two ways: height growth is expected to be reduced, thus increasing the time required to meet green-up guidelines, and merchantable volumes would generally be reduced by the slower growth and the occurrence of non-merchantable tree species in these stands. According to district estimates, within-block diversity management would reduce height growth by 10% in young stands and reduce future harvestable volume by an average of 4.5%. The estimates are not based on any empirical evidence. They were developed by the district staff in consultation with the Ministry of Environment. Because of the large uncertainty, these estimated effects have not been included as part of the current performance (base case) assumptions in this analysis. Rather, the uncertainty in these estimates is addressed in sensitivity analyses.

A.4 Site Degradation

The following describes the method used by the district to estimate existing and future losses to roads, skid trails and landings (site degradation).

A.4.1 Site Degradation Assumptions

1. Past harvest occupies 25% of the net operable land base.
2. 85% of past harvest has been conventional and 15% has been cable.
3. 60% of past conventional harvest was winter and 40% was summer.
4. 50% of all past conventional harvest has occurred on slopes less than 30% and 50% occurred on slopes greater than 30%.
5. Past harvested areas have an average of 5.5% of their net operable land base occupied by main and secondary roads. Future conventional harvest will have an average of 4.5% of their net operable area occupied by main and secondary roads and 5.0% will be occupied with cable harvest (including any spur roads).
6. Past site degradation levels from secondary roads, landings and summer skid trails are as per the 1988 report "Quantification of Soil Disturbance Following Logging in the Golden TSA."
7. The difference between winter and summer skid road degradation is the same as those taken in the 1991 Nelson Forest Region site disturbance measurements, done for the B.C. Ministry of Forests Site Degradation and Rehabilitation Committee. They indicate that winter conventional harvest areas incur approximately 63% of the detrimental disturbance levels of summer conventional harvest areas.
8. 3.3% of the net operable land base will be occupied by landings.
9. 100% growth loss occurs on main and secondary roads and landings.
10. 40% growth loss occurs on summer skid roads
11. 50% of future conventional harvest will be summer and 50% will be winter.
12. 45% of future harvest will be cable or modified conventional in the winter and 55% will be conventional.
13. Future skid road disturbance will be as per the guidelines for the Nelson Forest Region.

A.4.2 Site Degradation Calculations

Past harvest net operable area reduction:

Roads

2 700 000 metres of main and secondary roads $\times$ 12 metres average width = 3200 net operable hectares

Landings

40 000 hectares harvested $\times$ 3.3% = 1300 net operable hectares

Summer skid roads

13 600 hectares harvested $\times$ 15.5% of harvested area occupied by skid roads = 2100 hectares in skid roads. 2100 hectares in skid roads $\times$ 40% growth loss = 840 net operable hectares.

Winter skid roads

20 400 hectares harvested $\times$ 15.5% of harvested area occupied by skid roads = 3160 hectares in skid roads. 3160 hectares in skid roads $\times$ 25% growth loss = 790 operable hectares.

Total past harvest net operable area reduction = 6130 net operable hectares reduction due to past roads, landings and skid roads (3.5% of net operable TSA area). Reductions due to fire guards have not been included.

It is estimated that a maximum of 500 hectares of the net operable area reduction due to main and secondary roads have been entered into the forest inventory database. This leaves 5630 hectares of net operable area to be deleted from the forest inventory for past harvesting within this analysis. This area has been deducted as explained in Section A.2.

A.4 Site Degradation

A.4.3 Future Harvest % Net Operable Area Reduction

Summer conventional harvest:

- Landings = 3.3% of net operable hectares harvested
- Main and secondary roads = 4.0% of net operable hectares harvested
- Skid roads = 15% disturbance $\times$ 40% degraded = 6% of net operable hectares harvested

TOTAL = 13.3% of net operable hectares harvested

Winter conventional harvest:

- Landings = 3.3% of net operable hectares harvested
- Main and secondary roads = 4.0% of net operable hectares harvested
- Skid roads = 15% disturbance $\times$ 25% degraded = 3.75% of net operable hectares harvested

TOTAL = 11.0% of net operable hectares harvested

Cable harvest (includes modified conventional harvest in winter):

- Landings = 3.3% of net operable hectares harvested
- Main and secondary roads = 5.0% of net operable hectares harvested (includes any spur roads).

TOTAL = 8.3% of net operable hectares harvested

A.4.4 Total Future Harvest % Net Operable Area Reduction

= {(Summer conventional harvest %) (50%) + (Winter conventional harvest %) (50%)} {(55%)}
{Conventional harvest %} + {Cable harvest %} (45%)

= {(13.3%) (50%) + (11.0%) (50%)} {55%} + (8.3%) (45%)

= 10.4% net operable hectares reduction due to future roads, landings and skid roads. This reduction was made as areas were harvested in the simulation procedure as explained in Section A.3.

A.5 Yield Tables

The yield tables applied to existing and future regenerated stands in the analysis are shown in the following pages by resource unit and timber type. These tables were generated by the Timber Supply Planning Section computer system using the analysis unit definition shown in Section A.1, the timber harvesting land base and the variable density yield prediction system.

Yield tables, based on close utilization less decay, are reduced for waste and breakage. Aggregated

waste and breakage (W_2B) factors are developed from the inventory metric diameter class loss factors manual by averaging over diameter class and risk group and combining the separate factors for waste and breakage. In this way, a single W_2B factor is developed for each of two age ranges (older immature and mature) and each PSYU, species and utilization level. The W_2B factors (Table A-8) are applied in the VDYP aggregation procedure that generates a yield table for each analysis unit.

TABLE A-8. Waste and breakage (W_2B) factors by age range and species

Age range	Utilization level (cm)	Species											
		F	L	C	H	B	S	Pw	Pl	Pa	Cot	Bi	A
Older ¹	12.5	2.0	3.0	4.1	3.0	2.0	2.0	2.0	2.4	3.4	50.1	4.2	14.9
Immature	17.5	2.0	3.0	4.2	2.0	2.0	2.0	2.0	2.4	3.6	56.7	4.2	21.6
Mature	12.5	2.0	4.0	20.5	17.9	10.5	3.0	3.4	2.7	3.4	74.1	5.3	18.5
	17.5	2.4	4.0	21.2	17.9	10.5	3.0	3.6	3.1	3.6	75.5	5.3	26.2

F	=	Douglas-fir
L	=	larch
C	=	western redcedar
H	=	hemlock
B	=	true fir (balsam)
S	=	spruce
Pw	=	western white pine
Pl	=	lodgepole pine
Pa	=	whitebark pine
Cot	=	cottonwood/poplar
Bi	=	birch
A	=	aspen

¹ Lodgepole pine: age classes 4-6
Deciduous: age class 2
Other species: age classes 5-6

A.5 Yield Tables

TABLE A-9. Timber pass system (north)

Age	Analysis unit			
	Redcedar/hemlock balsam/spruce		Douglas-fir, all pine	
	Good/ Medium	Poor	Good/ Medium	Poor
	Volume (m ³ /ha)			
10	0	0	0	0
20	0	0	0	0
30	1	0	8	0
40	25	1	37	0
50	68	10	76	7
60	116	23	115	26
70	162	42	152	48
80	202	65	186	70
90	234	90	218	90
100	261	114	247	109
110	283	135	274	127
120	301	154	298	144
130	323	174	320	159
140	343	192	339	172
150	361	210	355	183
160	378	226	369	193
170	393	241	380	201
180	407	255	391	209
190	420	267	399	215
200	432	280	409	222
210	444	291	418	228
220	456	303	426	235
230	467	314	434	241
240	478	324	442	247
250	489	334	450	252
260	492	339	451	254
270	495	343	452	255
280	497	347	453	256
290	500	351	454	257
300	502	355	455	258
310	503	358	456	259
320	505	361	457	260
330	507	364	458	261
340	509	367	458	262
350	510	369	459	262

TABLE A-10. Timber pass system (south)

Age	Analysis unit			
	Redcedar/hemlock balsam/spruce		Douglas-fir, all pine	
	Good/ Medium	Poor	Good/ Medium	Poor
	Volume (m ³ /ha)			
10	0	0	0	0
20	0	0	0	0
30	1	0	12	0
40	16	1	49	1
50	54	5	92	10
60	101	14	133	30
70	147	29	169	53
80	187	48	203	74
90	222	73	233	95
100	253	96	261	115
110	279	118	287	133
120	303	138	310	150
130	325	158	331	166
140	344	177	348	179
150	361	194	361	190
160	376	210	372	200
170	390	224	380	208
180	401	238	386	216
190	412	250	390	222
200	422	262	396	229
210	431	273	402	236
220	439	284	407	242
230	447	294	412	248
240	454	304	418	254
250	461	313	422	259
260	464	318	424	261
270	467	322	426	262
280	470	327	427	263
290	472	331	429	264
300	474	334	430	264
310	476	338	431	265
320	477	341	432	266
330	479	343	433	266
340	480	346	433	267
350	481	348	434	267

A.5 Yield Tables

TABLE A-11. Visually sensitive areas (partial retention VQO)

Age	Analysis unit			
	Redcedar/hemlock balsam/spruce		Douglas-fir, all pine	
	Good/ Medium	Poor	Good/ Medium	Poor
	Volume (m³/ha)			
10	0	0	0	0
20	0	0	0	0
30	1	0	13	0
40	14	4	48	2
50	45	11	91	12
60	84	24	130	34
70	121	45	167	57
80	155	67	200	81
90	185	91	231	103
100	212	113	260	124
110	236	134	286	143
120	256	152	309	160
130	276	171	331	176
140	293	189	348	190
150	309	206	362	203
160	322	221	374	214
170	334	236	383	223
180	345	249	391	232
190	355	262	397	240
200	365	274	404	248
210	374	285	411	256
220	382	297	418	264
230	390	308	425	271
240	398	319	431	278
250	405	329	437	285
260	408	332	438	286
270	410	336	439	287
280	412	339	440	288
290	414	342	441	289
300	416	344	442	289
310	417	347	443	290
320	418	349	443	290
330	420	351	444	290
340	421	353	444	291
350	422	355	445	291

TABLE A-12. Visually sensitive areas (modification VQO)

Age	Analysis unit			
	Redcedar/hemlock balsam/spruce		Douglas-fir, all pine	
	Good/ Medium	Poor	Good/ Medium	Poor
	Volume (m³/ha)			
10	0	0	0	0
20	0	0	0	0
30	3	0	15	0
40	19	2	54	0
50	46	8	96	8
60	85	25	135	30
70	125	48	171	56
80	162	75	203	79
90	194	102	233	101
100	223	127	260	121
110	248	149	286	140
120	270	170	308	157
130	292	191	329	173
140	312	211	345	187
150	330	229	358	198
160	345	246	369	208
170	359	261	376	216
180	371	276	382	223
190	383	290	386	229
200	393	303	392	235
210	404	316	397	241
220	414	328	403	247
230	423	339	408	252
240	432	350	413	257
250	440	361	418	262
260	443	365	419	264
270	446	370	420	266
280	448	374	422	267
290	451	377	423	268
300	453	381	424	270
310	455	384	425	271
320	456	387	426	272
330	458	390	427	273
340	459	392	427	273
350	461	394	428	274

A.5 Yield Tables

TABLE A-13. *Wildlife winter habitat*

Age	Analysis unit			
	Redcedar/hemlock balsam/spruce		Douglas-fir, all pine	
	Good/ Medium	Poor	Good/ Medium	Poor
	Volume (m ³ /ha)			
10	0	0	0	0
20	0	0	0	0
30	1	0	15	0
40	19	0	52	0
50	61	8	95	12
60	114	26	135	34
70	164	54	172	58
80	208	85	206	82
90	246	113	237	104
100	279	137	265	125
110	308	159	291	145
120	333	178	314	162
130	358	198	336	179
140	380	218	353	193
150	398	235	367	206
160	415	251	379	218
170	429	266	388	228
180	441	280	395	238
190	452	292	399	248
200	463	305	406	257
210	473	316	412	266
220	483	328	419	275
230	492	338	425	283
240	500	349	430	291
250	508	359	436	299
260	512	364	437	300
270	515	368	439	302
280	518	372	440	303
290	520	376	442	304
300	523	380	443	305
310	525	383	444	306
320	527	386	445	307
330	528	389	446	307
340	530	391	446	308
350	531	394	447	309

TABLE A-14. *Riparian areas*

Age	Analysis unit			
	Redcedar/hemlock balsam/spruce		Douglas-fir, all pine	
	Good/ Medium	Poor	Good/ Medium	Poor
	Volume (m ³ /ha)			
10	0	0	0	0
20	0	0	0	0
30	1	0	16	0
40	18	1	57	3
50	58	7	102	11
60	109	17	143	34
70	157	31	180	59
80	201	54	213	83
90	237	78	244	105
100	269	102	271	127
110	297	125	296	147
120	321	145	319	165
130	344	165	340	182
140	364	184	356	196
150	381	202	369	208
160	396	218	378	218
170	409	232	385	227
180	421	246	390	234
190	431	259	392	241
200	441	271	397	248
210	450	282	402	255
220	458	293	407	261
230	466	303	411	267
240	474	313	415	273
250	480	323	420	279
260	484	328	421	280
270	487	332	423	281
280	490	337	425	283
290	492	341	426	284
300	495	345	427	285
310	497	348	428	286
320	498	351	429	286
330	500	354	430	287
340	502	357	431	288
350	503	359	432	288

APPENDIX B

Changes Since the 1988 Timber Supply Analysis

Introduction

This analysis used many of the management assumptions developed for the 1988 timber supply analysis. However, important changes have been incorporated in this analysis in the area of integrated resource management. Also, the inventory and growth and yield data have changed considerably since 1988. These changes affect the timber harvesting land base area, the distribution of area by species and age, yield projections and, ultimately, the analysis results. The following identifies the important changes and explains their effects.

B.1 Changes to Data

B.1.1 Operability Assessment

A digitized "operability line" (as described in Section A.2) replaced the "environmental protection forest" (EPF) used in the 1988 analysis. This has resulted in a larger reduction of mainly mature forest.

B.1.2 Updating Depletion

For the 1988 analysis, the logging history had been updated to about 1983. For this analysis, depletion is updated to 1991, resulting in a reduction in mature volume. All non-stocked area, including backlog NSR, is assumed to be part of the operable land base, whereas, in 1988, backlog NSR was excluded.

B.1.3 Special Site Class

"Special site" designation, where it has been assigned, is used in place of the standard ('new') site class for the "low site" area reduction criterion and in defining analysis units. This change tends to increase the operable area, but mainly in the younger age classes. Also, special sites are generally higher than the standard site classes, raising the indicated overall productivity of the land base.

The changes described above affect the size of the timber harvesting land base. The following table compares the derivation of the timber harvesting land base for this analysis and for the 1988 analysis taken from the 1988 analysis report. Note that changes to the operability data have the largest impact on the timber harvesting land base. On the other hand, the deduction for ESAs is smaller since many of the ESAs excluded in 1988 are now designated inoperable. The net effect of all changes is a 6% reduction in area of the timber harvesting land base.

B.1 Changes to Data

TABLE B-1. Comparison of timber harvesting land base—1988 and 1992

Classification	Area (hectares)	
	Base case (1992)	Option 7 (1988)
Total land base	921 231	922 550
Non-Crown land	26 896	24 931
Non-productive	592 279	594 962
Total productive Crown forest	302 056	302 817
Reductions to productive Crown forest:		
Not satisfactorily restocked (NSR) (includes inoperable NSR)	34 851	
Non-commercial cover (NC)	2 369	24 407 (NC included)
Inoperable	81 616	41 698 (as EPF reduction)
Environmentally sensitive (ESA)	11 177	36 777
Low site	10 243	8 441
Deciduous types	6 348	8 903
Non-merchantable	7 066	8 119
Stream side buffers (riparian)	1 015	-
Designated old-growth area	407	-
Historic/Recreational trails	545	-
Depletion update	3 278	-
Roads, skid trails, landings	4 430	6 141
Total reduction	163 345	133 486
Timber harvesting land base (less NSR)	138 711	169 331
Additions:		
NSR ^a	11 805	9 650
NSR reclassified to stocked ^a	14 784	
Inventory file corrections ^b	3 800	
Timber licence reversions	5 497	6 591
Total additions	35 886	16 241
Current timber harvesting land base	174 597	185 572
Future reductions for roads, trails, landings	10 425	
Future timber harvesting land base	164 174	185 572

^a All NSR land on the inventory file was initially subtracted. The NSR figures shown and depletion update reflect a manual update to 1991 as carried out by district staff.

^b Includes 2200 hectares erroneously designated as not operable and 1600 hectares misclassified as low site.

B.1 Changes to Data

B.1.4 Volume Estimates

The variable density yield prediction (VDYP) model, developed by Inventory Branch, was used in this analysis to derive the volume tables shown in Section A.4. In 1988, the Ek-Payendah model was used. One of the major differences between the two models is that the VDYP model takes into account variations in stand density, whereas the Ek-Payendah model does not. In general, for the Golden TSA, the two models generate similar volumes for old-growth stands. For younger stands, however, VDYP volumes are lower. The impact of the VDYP model would thus be on long-term, rather than short-term, timber supply.

B.1.5 Delineation of Resource Units

Ungulate winter habitat, riparian areas and visually sensitive areas have been identified on the new inventory database and used in the current analysis. This information was not available in the inventory data used in 1988.

In addition, the district has made further modifications to the inventory to correct some inaccuracies in the data. These changes have been incorporated in this analysis.

B.2 Changes to Analysis Procedures and Management Assumptions

In addition to the changes in data, analysis procedures and management assumptions were also modified as described below.

B.2.1 Site Degradation (Roads, Skid Trails and Landings)

In the 1988 analysis, loss of productive land due to past harvesting development was accounted for by excluding 3.5% (6141 hectares) from the operable land base. In this analysis, the reduction is 5630 hectares (3.1%). However, the impact of future harvesting operations on future potential timber production was not completely accounted for. The Golden Forest District estimates that a 10.4% reduction will occur due to roads, landings and skid trails. To account for this impact in this analysis, 10.4% of the area of those stands in the current inventory, which have never been logged (assumed to be all stands greater than 60 years at present), is assumed to be non-productive after the first harvest.

B.2.2 Definition of North/South

For the 1988 analysis, the Golden TSA land base was divided into north and south because of differing access and degree of development. The northern portion was defined as supply blocks A-D while the south consisted of supply blocks E-F. For this analysis, about 21 000 hectares of the timber harvesting land base (the Sue fire area in supply block F) previously assigned to the south, were included in the north.

B.2.3 Analysis Units

In 1988, analysis units were defined geographically by the north/south split explained above and eight species-site class combinations. There were 16 analysis units in total. For the current analysis, analysis units are also defined geographically but into six resource units in order to model different green-up guidelines. The six resource units were further divided into four species-site class groupings bringing the total number of analysis units to 24.

B.2.4 Integrated Resource Management

Integrated resource management guidelines developed by the district staff have been modelled in this analysis by applying land base reductions and forest cover guidelines. In the previous analysis, non-timber resource needs were specifically accounted for only by area reductions applied to ESAs such as wildlife habitat and recreation sites defined on the inventory file.